Practical Electronics

DECEMBER 1966

PRICE 2'6

ALSO
FIRST OF A
NEW SERIES

THE ELECTRONIC ORGAN

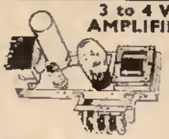
THE MOTORIST'S REV COUNTER
FULLY TRANSISTORISED

Suits 4 or 6 cyl. engines. Would cost at least £8 to buy. Kit contains moving coil movement and all parts including transistors, a circuit diagram and full instructions. Maximum reading 8,000 r.p.m. Send P.O. for 22/-, which includes 2/6 postage.

CYLDON U.H.F. TUNER

complete with PC.88 and PC.86 Valves. Full variable tuning. New and unused. Size $4\frac{1}{2}'' \times 5\frac{1}{2}'' \times 1\frac{3}{4}''$. Complete with circuit diagram. 35/- plus 3/6 P. & P.

3 to 4 WATT AMPLIFIER KIT

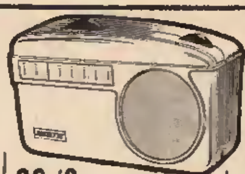


comprising chassis $8\frac{3}{4}'' \times 2\frac{1}{4}'' \times 1''$. Double wound mains transformer, output transformer, volume and tone controls, resistors, condensers, etc. 6V6, ECC81 and metal rectifier. Circuit 1/6 free with kit. 29/6 plus 5/6 P. & P. The above Amplifier built and tested 10/6 extra.

MULTIPLEX DECODER

Now is your chance to benefit in full from the new B.B.C. stereo transmissions with our Multiplex Decoder. Design features: Highly efficient Mullard vinkor pot cores. Two semiconductor diodes. Double purpose valve. Printed circuit type construction high input impedance. Specification: Cross talk minus 26 db at 1 kc/s. Input requirements 0.5 - 1.5 RMS. Stability plus or minus 0.1%. Voltage requirements H.T. 190-250 volts. D.C. at 5 ma. Heaters 6.3 volts A.C. at 300 ma. Self powered unit shortly available, price to be announced. Size $5\frac{1}{2}'' \times 3\frac{1}{2}'' \times 1''$. Fully built and tested, price £4.4.0 plus 3/- P. & P. charges.

"MUSETTE" 6-TRANSISTOR SUPERHET PORTABLE RADIO



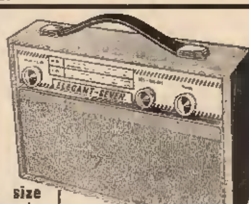
★ $2\frac{1}{2}''$ Speaker.
★ 6 Transistors Superhet Output 200 mw.
★ Plastic Cabinet in red, size $4\frac{3}{4}'' \times 3'' \times 1\frac{3}{4}''$ and gold speaker louvre.
★ Horizontal Tuning Scale.
★ Ferrite Rod Internal Aerial.
★ IF 460 Kc/s.
★ All components Ferrite Rod and Tuning Assembly mount on printed board.
★ Operated from PP3 Battery.
★ Fully comprehensive instructions and point-to-point wiring diagram.
★ Printed Circuit Board.
★ Tunable over medium and long waveband.
★ Car aerial and earpiece socket.

39/6 Inc. carrying strap. Circuit Diagram 2/6—free with parts
P. & P. 3/6

TRANSISTORISED SIGNAL GENERATOR

Size $5\frac{1}{2}'' \times 3\frac{1}{4}'' \times 1\frac{1}{2}''$. For IF and RF alignment and AF output, 700 c/s frequency coverage 460 Kc/s to 2 Mc/s in switched frequencies. Ideal for alignment to our Elegant Seven and Musette. Built and tested. 39/6. P. & P. 3/6.

ELEGANT SEVEN Mk. II



Buy yourself an easy to build 7 transistor radio and save at least £10.0.0. Now you can build this superb 7 transistor superhet radio for under £4.10.0. No one else can offer such a fantastic radio with so many de luxe star features.

ONLY £4.4.0
Plus 7/6 Post & Packing

★ De luxe grey wooden cabinet size $12\frac{1}{2}'' \times 8\frac{1}{2}'' \times 3\frac{1}{2}''$. ★ Horizontal easy to read tuning scale printed grey with black letters, size $11\frac{1}{2}'' \times 2''$. ★ High 'Q' ferrite rod aerial. ★ I.F. neutralisation on each separate stage. ★ D.C. coupled push pull output stage with separate A.C. negative feedback. ★ Room filling output 350mW. ★ Ready etched and drilled printed circuit board back printed for foolproof construction. ★ Fully comprehensive instructions and point to point wiring diagrams. ★ Car aerial socket. ★ Fully tunable over medium and long wave, 168-535 metres and 1250-2000 metres. ★ All components, ferrite rod and tuning assembly mount on printed board. ★ Full after sales service. ★ Parts list and circuit diagram 2/6, free with parts. Price £4.4.0. + 7/6 P. & P. SPECIAL OFFER. For one month only, R. & A. $7'' \times 4''$ 9000 lines P.M. Speaker at no extra charge. Power supply kit to purchasers of 'Elegant Seven' parts, incorporating mains transformer, rectifier and smoothing condenser, A.C. mains 200/250 volts. Output 9v. 100 mA. 7/6 extra.

Shop Hours 9 a.m. — 6 p.m. Early Closing Wednesday
All enquiries stamped addressed envelope

RADIO & T.V. COMPONENTS (ACTON) LTD.
21D, HIGH STREET, ACTON, LONDON, W.3

Currently EX-STOCK are these LOW COST
SILICON PLANAR EPOXY ENCAPSULATED TRANSISTORS

Type	P_{TOT} mW. max.	f_T MHz. min.	h_{FE} @ I_C 2mA., V_{CE} 10v. min.	max.	BV_{CEO} Volts max.	Typical Application or Features	Price *
2N2712	200	200	75	225	18	R.F. Amplifier.	10/8
2N2714	200	200	75	225	18	High speed switch.	7/7
2N2924	200	160	150	300	25	AF and RF amp.	6/9
2N3391	200	160	250	500	25	Low noise (1·9dB)	11/9
2N3390	200	160	400	800	25	HIGH GAIN.	13/8
2N3402	900	160	75	225	25	Power Amp.	12/9
2N3403	900	160	180	540	25	Power Amp.	13/6
2N3662	200	700	PG: 15dB @ 45MHz		18	VHF Amp/Osc.	15/3
2N3663	200	700	PG: 23dB @ 200MHz		30	VHF/UHF Amp/Osc.	14/6
2N3854A	200	300	PG: 30db @ 4·5MHz		30	RF Amp/Osc.	8/9
2N3855A	200	350	PG: 25dB @ 10·7MHz		30	& IF in	9/-
2N3856A	200	375	PG: 21dB @ 45MHz		30	FM & TV, etc.	10/3
2N3854	200	300	PG: 15dB @ 100MHz		18		8/-
2N3877	200	160	20 (minimum)		70	Lamp/Relay driver	17/3
AND ALSO							
2N2926 (Red)	200	200	55	110	18	General purpose	4/-
(Orange)			90	180		RF and AF	4/3
(Yellow)			150	300		applications	4/6
(Green)			235	470			4/9

* DEDUCT 10% from price quoted for 5 or more of any ONE device.

P.S.—Have you received a copy of our current price list of transistors? Over 1,000 items are listed together with an amendment bulletin covering substitutions for types no longer manufactured.

Send a 1/3 P.O. for the above list, OR send 2/- P.O. and receive in addition, brief semiconductor data summaries covering approx. 200 common transistors held in stock. (both amounts are inclusive of being added to our Mailing List) and also details of our SEMICONDUCTOR INFORMATION SERVICE.

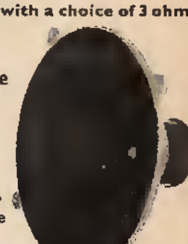
Please add 1/- Postage & Packing on all orders of £2 or less.

MAIL ORDERS ONLY PLEASE. TERMS: C.W.O.

M. R. CLIFFORD & COMPANY (C 5B)
209A, MONUMENT ROAD, EDGBASTON, BIRMINGHAM 16

BAKER 12in. STALWART

The only High Fidelity Speaker available with a choice of 3 ohm or 15 ohm models and may therefore be used with any High Fidelity or Domestic sound equipment.



Maximum Power	15 watts
Bass Resonance	40-50 c.p.s.
Flux Density	12,000 gauss
Voice coil diameter	$1\frac{1}{2}''$
Voice coil impedance	3 or 15 ohms
Voice coil material	Copper
Useful response	45-13,000 c.p.s.
Cone surround	Roll
Chassis material	Solid aluminium
Overall diameter	$12\frac{1}{4}''$

Available from all Radio & Hi-Fi Dealers

5 Gns. Post Free

Send for New catalogue and enclosure plans

Baker Reproducers Ltd. (DEPT. P.E.12)
Bensham Manor Road Passage, Thornton Heath, Surrey. THO 1665

Build the 'SOLETTE,' easily, by Xmas

Only 20 hours to build this organ with our factory made units

Suitable for music of all kinds. Self contained amplifier and loudspeakers. Excellent tone and volume. Five pitches + solo and melodic bass. Fully transistorised and portable. Price £118 complete (terms available).

Other models and a complete range of ready-made units supplied for individual designs.

Harmonics (Bromley) Ltd.
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SINCLAIR STEREO 25

DE-LUXE PRE-AMPLIFIER AND CONTROL UNIT

THE WORLD'S FIRST POCKET TV

THE SINCLAIR MICROVISION POCKET TV RECEIVER provided a world wide sensation when shown for the first time at the 1966 Radio and TV Exhibition. This fantastic British set tunes over 13 channels on bands 1 and 3, operates from six self-contained "Penlite" batteries and measures only 4in. x 2½in. x 2in. Despite the minute proportions of this 30 transistor receiver, quality from the exclusively designed tube and loudspeaker is superb. This amazing Sinclair triumph will be availabie in January 1967 at a cost of 49 gns.

SINCLAIR MICROVISION

Available January, 1967

A revelation in quality and economy

THE SINCLAIR STEREO 25 has been designed specially to ensure the highest possible standards of reproduction when used with two Z.12s or any other first class stereo power amplifier. Best possible components are used in the construction of this superb unit, whilst its appearance reflects the professional elegance characteristic of all Sinclair designs in hi-fi, radio and TV. The front panel of the Stereo 25 is in solid brushed and polished aluminium with beautifully styled solid aluminium control knobs. Mounting the unit is simple, and power is conveniently obtainable from the Sinclair PZ.3 which can also be used to supply two Z.12s to make a complete stereo assembly. Hi-fi enthusiasts seeking the ultimate in domestic listening will find all they want from this combination of Sinclair units. With a Micro FM for tuner, they will have an installation to compare favourably with anything costing from four to five times as much.

FOR USE WITH ANY GOOD STEREO POWER AMPLIFIER

TECHNICAL SPECIFICATIONS

Performance figures obtained with the Stereo 25 fed to two Z.12s and a PZ.3 mains power supply unit.

- **SENSITIVITY** for 10 watts into 1.5 ohms load per channel.
  Mic.—2 mV into 50K ohms.
  Pick-up—3 mV into 50K ohms.
  Radio—20 mV into 4.7K ohms.
- **FREQUENCY RESPONSE** (Mic. and Radio)—25 c/s. to 30 kc/s. ± 1dB extending to 100 kc/s ± 3dB.
- **EQUALISATION**—Correct to within ± 1dB on RIAA curve from 50 c/s to 20 kc/s.
- **TONE CONTROLS**
  Treble + 12dB to —10dB at 10 kc/s.
  Bass + 15dB to —12dB at 100 c/s.
- **SIZE**—6½in. x 2½in. x 2½in. overall, plus knobs.
- **FINISH**—Front panel sectioned in brushed and polished solid aluminium with solid aluminium knobs. Black figuring on front panel.

BUILT, TESTED AND GUARANTEED **£9.19.6**

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SINCLAIR RADIONICS LTD., 22 Newmarket Rd., CAMBRIDGE

Telephone 52996 (STD Code OCA3)

Order form and more Sinclair designs on pages following

2 SETS THAT HAVE CHANGED THE FACE OF RADIO

Nothing has ever equalled Sinclair designs for compactness and efficiency and the Micro-6 and Micro FM are now world famous examples of what can be achieved by specialisation in transistor electronics. Countless thousands of these sets have been built to the delight of constructors all over the world. Each in its class fulfills a very real need in terms of present day listening requirements, and anyone can easily build both sets by following the well prepared instructions supplied with each kit. Proof of their success is found in the never ending stream of enthusiastic letters constructors send us. Here are yet more typical examples.

MICRO FM

"We have now completed installation of the Micro FM after being lost in admiration for the superb construction. Results are beyond praise. The quality is perfect. In fact I haven't done a stroke of work since we finished it. Please thank all for a first class job. We are thrilled with it."

C.E., Lowick, Berwick-on-Tweed

"I should like to express my very considerable satisfaction with the performance of the Micro FM. You have clearly designed a very efficient circuit with first rate overall performance. I am more than pleased."

L.E.H., Harrogate

MICRO-6

"A truly excellent kit. The finish and general quality is very good. It is fantastic that a radio can be so compact."

N.R.C., Bishop's Stortford

"Reception and sound is superb. I found the instructions very easy to understand."

R.R., Spanish Town, Jamaica

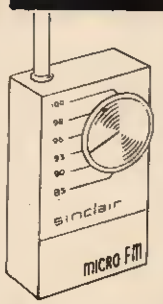
Z.12

"The results are outstanding when used with a good quality speaker."

P.O.S., London, E.13

MICRO FM

7 TRANSISTOR SUPERHET F.M. TUNER/RECEIVER



Complete kit inc. telescopic aerial, case, earpiece and instructions.

£5.19.6

This unique, superbly engineered superhet FM set is completely professional in styling inside and out. Its performance is fantastic. It is the only set in the world which can be used both as an FM tuner and as an independent FM pocket receiver just whenever you wish. Problems of alignment which previously made it almost impossible for a constructor to complete an FM set for himself have been completely eliminated.

This set is ready to use the moment you have built it. The pulse counting discriminator ensures best possible audio quality; sensitivity is such that the telescopic aerial included with the kit assures good reception in all but the very poorest reception areas. The Sinclair Micro FM will give you all you want in FM reception and the satisfaction of building a unique design that will save you pounds.

TECHNICAL DESCRIPTION

Self-contained double-purpose FM superhet using 7 transistors and 2 diodes. The R.F. amplifier is followed by a self-oscillating mixer and three stages of I.F. amplification which dispense with I.F. transformers and all problems of alignment. The final I.F. amplifier produces a square wave which is converted to produce the original modulation exactly. A pulse-counting discriminator ensures better audio quality. One output is for feeding to amplifier or recorder and the other enables the Micro FM to be used as an independent self-contained pocket portable. A.F.C. "locks" the programme tuned in. The telescopic aerial included is sufficient in all but the worst signal areas.

- ★ **Size: $2\frac{13}{16} \times 1\frac{11}{16} \times \frac{5}{8}$in.**
- ★ **Powerful A.F.C.**
- ★ **Pulse counting discriminator**
- ★ **Low I.F. completely eliminates alignment problems**
- ★ **Tunes from 88 to 108 Mc/s**
- ★ **Audio response: 10 to 20,000 c/s ±1dB**
- ★ **Signal to Noise Ratio: 30dB at 30 microvolts**
- ★ **Operates from standard 9V battery**
- ★ **Self-contained**
- ★ **Plastic case with brushed and polished aluminium front and spun aluminium tuning dial**

MICRO-6

SIX-STAGE MEDIUM WAVE A.M. RECEIVER

The smallest radio set in the world!

This is the set against which a matchbox looks enormous. Yet it is completely self-contained, including aerial and batteries and virtually plays anywhere. Its clever six-stage circuit (2 R.F., double diode detector, 3 A.F.) ensures all you want in a radio today—power, range, quality and selectivity. A.G.C. counteracts fading, bandspread brings in Luxembourg like a local station. There is great pleasure to be had in building the Micro-6, and it makes a highly acceptable gift with its white, gold and black case and amazing performance.

- **Size: $1\frac{4}{5}'' \times 1\frac{3}{10}'' \times \frac{1}{2}''$**
- **Weight: One Ounce**
- **Easily built in an evening**

Complete kit with earpiece, case and instructions. **59/6**

FULL SERVICE FACILITIES AVAILABLE TO ALL SINCLAIR CUSTOMERS ●

sinclair

SINCLAIR RADIONICS LTD., 22 Newmarket Rd., CAMBRIDGE

Telephone 52996 (STD Code OCA3)

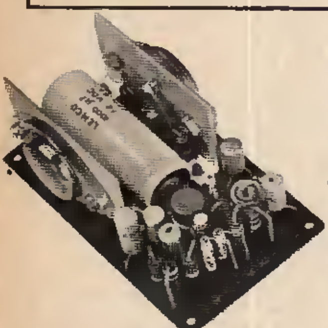
SINCLAIR Z.12

COMBINED 12 WATT HIGH-FIDELITY AMPLIFIER AND PRE-AMP

12 WATTS R.M.S. OUTPUT
CONTINUOUS SINE WAVE (30W. PEAK)

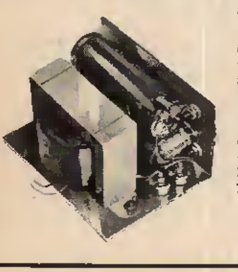
8 TRANSISTOR CIRCUIT WITH CLASS B ULTRALINEAR OUTPUT

IDEAL FOR HI-FI (STEREO OR MONO) CAR RADIO, ELECTRIC GUITAR, P.A., INTERCOM, ETC.



The amazing adaptability and rugged construction of this very powerful and exceptionally compact amplifier make it possible to use just one type of unit with outstanding success in an unusually wide variety of applications. Eight special H.F. transistors are used in a highly original circuit to achieve the characteristics demanded of any quality amplifier irrespective of price, yet this Sinclair unit costs well under £5, including its own integrated pre-amplifier. The Z.12 accepts radio, microphone and pick-up inputs. Detailed instructions for connecting these in mono and stereo are given in the manual supplied with every unit. A number of different control networks are also shown. The Z.12 will operate efficiently from any supply between 6 and 20 V. d.c, making it very convenient to run the amplifier from a car battery. Where it is required to run the Z.12 from mains supply, the PZ.3 is recommended. Those wishing to have a ready made pre-amp control unit can feed inputs via the Stereo 25, which, with two Z.12s will provide the finest stereophonic hi-fi possible—and the saving in cost is fantastic.

SINCLAIR PZ.3
POWER SUPPLY UNIT



This special power supply unit uses advanced transistorised circuitry to achieve exceptionally good smoothing. Ripple is a barely measurable 0.05 v. The PZ.3 will power two Z.12s and a Stereo 25 with ease.

79/6

TECHNICAL SPECIFICATIONS

- Size 3 in. × 1¾ in. × 1½ in.
- Class "B" ultralinear output
- **RESPONSE** 15-50,000 c/s ± 1 dB.
- Suitable for 3, 7·5 or 15Ω speakers. Two 3Ω speakers may be used in parallel
- **INPUT**—2mV into 2kΩ
- **OUTPUT**—12 watts R.M.S. continuous sine wave (24 w. peak); 15 watts music power (30 w. peak)
- Signal to noise ratio better than 60dB.
- Quiescent current consumption—15mA.

Built, tested and guaranteed. Ready for immediate use. With Z.12 manual.

89/6

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If you are not completely satisfied when you receive your purchase from us, your money will be refunded at once in full and without question.

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For which I enclose cash/cheque/money order

NAME..........
ADDRESS..........
..........PE.12

Sinclair Stereo 25

DE-LUXE PRE-AMP. AND CONTROL UNIT
PLEASE TURN TO PAGE 835

HI-FI AMPLIFIERS —— TUNERS —— RECORD PLAYERS

20 + 20W STEREO AMP. AA-22U

GARRARD PLAYER AT-60

TRANSISTOR MIXER. Model TM-1. A must for the tape enthusiast. Four channels. Battery operated. Similar styling to Model AA-22U Amplifier. Kit £11.16.6 Assembled £16.17.6

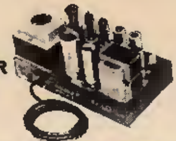
20+20W TRANSISTOR STEREO AMPLIFIER. Model AA-22U. Outstanding performance and appearance. Kit £39.10.0 (less cabinet). Attractive walnut veneered cabinet £2.5.0 extra. Assembled incl. cabinet, £59.15.0

GARRARD AUTO/RECORD PLAYER. Model AT-60, less cartridge £13.1.7. With Decca Deram pick-up £17.16.1 incl. P.T.

Many other Garrard models available, ask for Lists.

HI-FI MONO AMPLIFIER. Model MA-5. A general purpose 5W Amplifier, with inputs for Gram., Radio. Modern functional appearance. Kit £11.9.6 Assembled £15.15.0

10W POWER AMP. MA-12



9 + 9W STEREO AMP. S-99

HI-FI MONO AMPLIFIER. Model MA-12. 10W output, wide freq. range, low distortion. Use with control unit. Kit £12.18.0 Assembled £16.18.0

3 + 3W STEREO AMPLIFIER. Model S-33. An easy-to-build, low cost unit. 2 inputs per channel. Kit £13.7.6 Assembled £18.18.0

DE LUXE STEREO AMPLIFIER. Model S-33H. De luxe version of the S-33 with two-tone grey perspex panel, and high sensitivity necessary to accept the Decca Deram pick-up. Kit £15.17.6 Assembled £21.7.6

HI-FI STEREO AMPLIFIER. Model S-99. 9+9W output. Ganged controls. Stereo/Mono gram, radio and tape inputs. Push-button selection. Printed circuit construction. Kit £28.9.6 Assembled £38.9.6

POWER SUPPLY UNIT. Model MGP-1. Input 100/120V, 200/250V, 40–60 c/s. Output 6·3V, 2·5A A.C. 200, 250, 270V, 120mA max. D.C. Kit £5.12.6 Assembled £7.2.6

Heathkit DAYSTROM — *Make the most of your leisure time . .*

Hear the BBC stereo FM programmes on the TRANSISTOR STEREO FM TUNER

Elegantly designed to match the stereo Amplifier, AA-22U.
Many features including: Pre-assembled and aligned RF tuning unit, 4 stage IF amplifier, Automatic freq. control, printed circuit board, 14 transistor circuit. Available in two units, sold separately, can be built for a

TOTAL PRICE KIT (STEREO) TFM-1S £24.18 incl. P.T.
KIT (MONO) TFM-1M £20.19 incl. P.T. can be converted to stereo with converter kit extra, cabinet also extra.

TRANSISTOR RECEIVERS

Oxford

UXR-1

GC-1U

"OXFORD" LUXURY PORTABLE Model UXR-2. Specially designed for use as a domestic or personal portable receiver. Many features, including solid leather case. Kit £14.18.0 incl. P.T.

TRANSISTOR PORTABLE. Model UXR-1. Pre-aligned I.F. transformers, printed circuit. Covers L.W. and M.W. Has 7" × 4" loudspeaker. Real hide case. Kit £12.11.0 incl. P.T.

JUNIOR EXPERIMENTAL WORKSHOP. Model EW-1. More than a toy! Will make over 20 exciting electronic devices, incl.: Radios, Burglar Alarms, etc. 72 page Manual. The ideal present! Kit £7.13.6 incl. P.T.

"MOHICAN" GENERAL COV. RECEIVER for Amateur or Short Wave listening. Send for leaflet. Kit £37.17.6 Assembled £45.17.6

WELCOME TO OUR LONDON HEATHKIT CENTRE
233 Tottenham Court Road, W.1
We open MONDAY-SATURDAY 9 a.m.-5.30 p.m.
THURSDAY ... ... 11 a.m.-2.30 p.m.
Telephone No.: MUSEUM 7349
WHEN YOU ARE IN TOWN, WE HOPE YOU WILL VISIT US THERE

TEST INSTRUMENTS

Our wide range includes:

3" LOW-PRICED SERVICE OSCILLOSCOPE. Model OS-2. Compact size 5" × 7¾" × 12" deep. Wt. only 9½lb. "Y" bandwidth 2 c/s–3 Mc/s ±3dB. Sensitivity 100mV/cm T/B 20 c/s–200 kc/s in four ranges, fitted mu-metal CRT Shield. Modern functional styling. Kit £23.18.0 Assembled £31.18.0

OS-2

5" GEN.-PURPOSE OSCILLOSCOPE. Model 10-12U. An outstanding model with professional specification and styling. "Y" bandwidth 3 c/s–4·5 Mc/s ± 3dB. T/B 10 c/s–500 kc/s. Kit £35.17.6 Assembled £45.15.0

DE LUXE LARGE-SCALE VALVE VOLTMETER. Model IM-13U. Circuit and specification based on the well-known model V-7A but with many worth-while refinements. 6" Ernest Turner meter. Unique gimbal bracket allows operation of instrument in many positions. Modern styling. Kit £18.18.0 Assembled £26.18.0

VVM, IM-13U

AUDIO SIGNAL GENERATOR. Model AG-9U. 10 c/s to 100 kc/s, switch selected. Distortion less than 0·1%, 10V sine wave output metered in volts and dB's. Kit £23.15.0 Assembled £31.15.0

V-7A

VALVE VOLTMETER. Model V7-A. 7 voltage ranges d.c. volts to 1,500. A.C. to 1,500 r.m.s. and 4,000 peak to peak. Resistance 0·1 Ω to 1,000M Ω with internal battery. D.C. input resistance 11M Ω. dB measurement, has centre-zero scale. Complete with test prods, leads and standardising battery. Kit £13.18.6 Assembled £19.18.6.

RF-1U

MULTIMETER. Model MM-1U. Ranges 0–1·5V to 1,500V a.c. and d.c.; 150μA to 15A d.c.; 0·2 Ω to 20M Ω 4½" 50μA meter. Kit £12.18.0 Assembled £18.11.6

R.F. SIGNAL GENERATOR. Model RF-1U. Up to 100 Mc/s fundamental and 200 Mc/s on harmonics. Up to 100mV output. Kit £13.18.0 Assembled £20.8.0

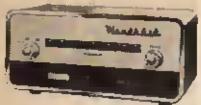
IG-82U

SINE/SQUARE GENERATOR. Model IG-82U. Freq. range 20 c/s–1 Mc/s in 5 bands less than 0·5% sine wave dist. less than 0·15μ sec. sq. wave rise time. Kit £25.15.0 Assembled £37.15.0

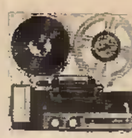
TRANSISTOR POWER SUPPLY. Model IP-20U. Up to 50V, 1·5A output. Ideal for Laboratory use. Compact size. Kit £35.8.0 Assembled £47.8.0

Prices and specifications subject to change without notice

TAPE AMPLIFIERS — TAPE DECKS — CONTROL UNITS


FM TUNER FM-4U


STUDIO-MATIC DECK


TRUVOX DECK


AM/FM TUNER

HI-FI FM TUNER. Model FM-4U. Available in two units. R.F. tuning unit (£2.15.0 incl. P.T.) with I.F. output of 10·7 Mc/s and I.F. amplifier unit, with power supply and valves (£13.13.0). Total Kit **£16.8.0**

STUDIOMATIC "363" TAPE DECK. The finest buy in its price range. Operating speed: $1\frac{7}{8}$", $3\frac{3}{4}$" and $7\frac{1}{2}$ p.s. Two tracks. "wow" and "flutter" not greater than 0·15% at $7\frac{1}{2}$" p.s. **£13.10.0** With TA-1M Tape Pre-amplifier kit **£31.5.6**

HI-FI AM/FM TUNER. Model AFM-1. Available in two units which, for your convenience, are sold separately. Tuning heart (AFM-T1—£4.13.6 incl. P.T.) and I.F. amplifier (AFM-A1—£22.11.6). Printed circuit board, 8 valves. Covers L.W., M.W., S.W., and F.M. Built-in power supply. Total Kit **£27.5.0**

WIDE RANGE OF HI-FI CABINETS, send for details.

TRUVOX D-93 TAPE DECKS. High quality stereo/mono tape decks. **D93/2**, $\frac{1}{2}$ track, **£36.15.0** **D93/4**, $\frac{1}{4}$ track, **£36.15.0**

TRANSISTOR INTERCOM. Models XI-1U and XIR-1U. A time-saving device for office, shop or for the home. Master unit XI-1U will operate up to 5 remote stations. Master, XI-1U Kit **£11.9.6** Assembled **£17.9.6.** Remote, XIR-1U Kit **£4.9.6** Assembled **£5.18.0.** Send for full specification leaflet.

MONO CONTROL UNIT. Model UMC-1. Designed to work with the MA-12 or similar amplifier requiring 0·25V or less for full output. 5 inputs. Baxandall type controls. Kit **£9.2.6** Assembled **£14.2.6**

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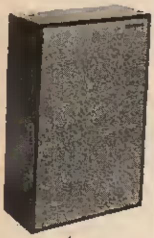
SPEAKER SYSTEMS


SSU-1


Berkeley

HI-FI SPEAKER SYSTEM. Model SSU-1. Ducted-port bass reflex cabinet "in the white". Two speakers. Vertical horizontal models with legs, Kit **£12.12.0**, without legs, Kit **£11.17.6** incl. P.T.

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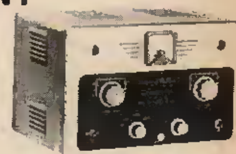
"AMATEUR" EQUIPMENT


DX-40U


RA-1


HM-11U

80-10m TRANSMITTER, DX-40U. Power inputs 75W. C.W., 60W peak CC phone. Output 40W to aerial. Provision for VFO. Kit **£29.19.0** Assembled **£41.8.0**

SSB ADAPTOR, SB-10U Kit **£39.5.0** Assembled **£45.18.0**

AMATEUR BANDS RECEIVER. Model RA-1. To cover all the Amateur Bands from 160-10 metres. Many special features, including: half-lattice crystal filter; 8 valves; signal strength "S" meter; tuned R.F. Amp. stage. Kit **£39.6.6** Assembled **£52.10.0**

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Models for 80, 40 or 20 metre bands.
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(Please write in BLOCK CAPITALS)
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ADDRESS ....
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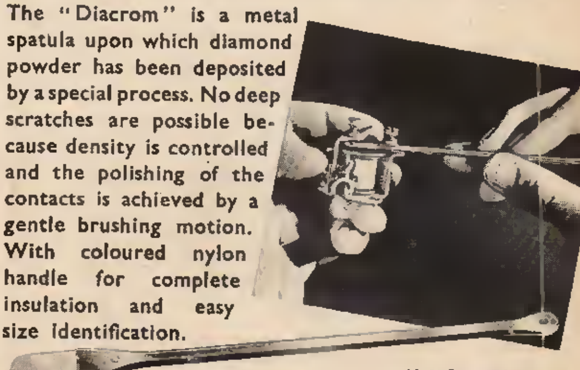

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High class receiver covering 550 kc/s.-31 mc/s. on 4 bands. Incorporates 7 valves plus rectifier, RF stage, illuminated 'S' meter, 1.5µV sensitivity, electrical bandspread on the 80/40/20/15 and 10 metre bands, slide rule dial, aerial trimmer, B.F.O., noise limiter. Output for phones or speaker. Operates on 115/220/240 v. A.C. Supplied brand new and guaranteed with manual. **24 gns.** Carr. 10/-.

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20,000 o.p.v. 0/.1/.5/5/50/250/1,000 v. D.C. 0/2.5/10/50/250 1,000 v. A.C. 0/.05/.5/5/50/250 mA. 0/5K/50K/500K/5 meg. Ω. .0001—.2 mfd.—20—22 db. **£5.19.6.** P. & P. 3/-.

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New 3-speed tape deck, supersedes old Collaro studio deck. 2-track **£10.10.0.** 4-track **£13.10.0.** Carr. Paid.

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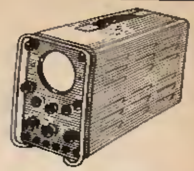

A compact (9″×8″×16½″) general purpose 'scope. T/B 10 c/s-40 kc/s. Band width 1 Mc/s. Mullard DG 7/5 2½″ CRT. For operation on 200/250 v. A.C. Supplied complete with metal transit case, strap, test leads, and visor hood. Brand new. **£22.10.0.** Carr. 10/-. Supplied complete with instructions.

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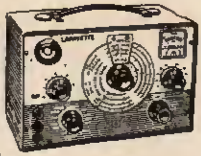

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Transistorised Audio Generator 10-100,000 c/s. Sine or square wave. **£16.15.0.**
Transistorised Signal Generator 150 kc/s. 350 Mc/s. **£10.10.0.**
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1-0-1mA	22/6	500mA.	22/6	300V D.C.	22/6
1mA.	22/6	750mA.	22/6	500V D.C.	22/6
2mA.	22/6	1A D.C.	22/6	750V D.C.	22/6
5mA.	22/6	2A D.C.	22/6	15V A.C.	22/6
10mA.	22/6	5A D.C.	22/6	50V A.C.	22/6
20mA.	22/6	3V D.C.	22/6	150V A.C.	22/6
50mA.	22/6	10V D.C.	22/6	300V A.C.	22/6
100mA.	22/6	20V D.C.	22/6	500V A.C.	22/6
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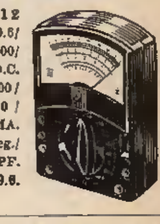
MODEL TE-12
20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 V. D.C. 0 / 6 / 30 / 120 / 600 / 1,200 V. A.C. 0 / 60µA/6/60/600 MA. 0/6K/600K/6 Meg./60 Meg. Ω 50 PF. .2 MFD. **£5.19.6.** P. & P. 3/6.



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11 meg. input. 7 D.C. volt ranges. 1.5-1,500 v. 7 A.C. volt ranges 1.5-1,500 v. 4,000 Peak to Peak. Resistance .2 ohm to 1,000 megohm. Decibels —10db to +65db. Supplied brand new with instructions, leads and probe. **£12/10/-.** P. & P. 3/6.

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Amazing performance and specification ★ *Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS*

FULLY TUNABLE ON ALL WAVEBANDS ● **9 stages—7 transistors and 2 diodes**

Covers Medium and Long Waves, Trawler Band and three Short Waves to approx. 15 metres. Push-pull output for room filling volume from rich toned 7" × 4" speaker. Air spaced ganged tuning condenser. Ferrite rod aerial for M & L Waves and telescopic aerial for S Waves. Real leather-look case with gilt trim and shoulder and hand straps. Size 9" × 7" × 4" approx. The perfect portable and the ideal car radio. (Uses PP7 batteries available anywhere.)

★ **EXTRA BAND FOR EASIER TUNING OF PIRATE STATIONS, etc.**

Total cost of parts now only **£5.19.6** P. & P. 5/6

Parts Price List and easy build plans 3/- (Free with kit)

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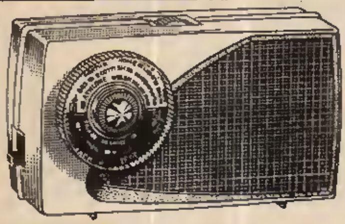

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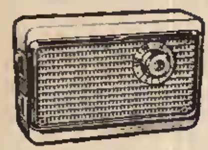

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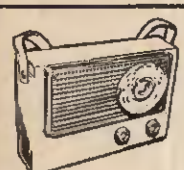

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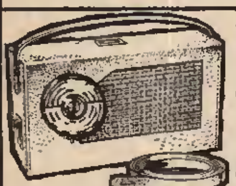

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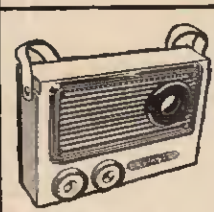

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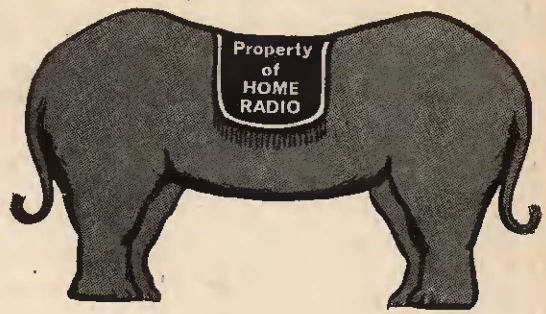

(Seeing the above, our artist said "Yes, preferably 36–24–36").

You may perhaps remember our advertisement "Are you looking for the unusual?" showing a double-headed elephant. (We found him too costly, having to feed two ends, so we exchanged him for the above which doesn't need feeding at all!) We would like to mention in passing one customer who wrote to us, "If you can supply a UX5 valve holder, I will believe you have two-headed elephants in stock!!" *WE SENT HIM ONE BY RETURN OF POST*—a valve holder, not an elephant!!

All this preamble (we hope you are still with us) leads up to the point that we thought we would like to show you a list of the most ordinary items in our current catalogue. Here we go: We start with Aerials, Batteries, Books (over 150 titles listed), Boxes, Cabinets, Chassis, aluminium (over 140 different sizes), Chokes, R.F. and L.F. coils (6 different makes, over 160 different types), Condensers (let's just say this section runs into 17 pages), Connectors (over 96 types), Tag Boards and Tag Strips (over 40 types), Dials and Drives (over 50 types).

Eddystone Receivers and Components (the entire range), Kits (over 200), Knobs (over 80), Lamps, pilot, neon and fittings (5 pages), Lektrokit (the entire range), Miscellaneous (this includes such items as nuts, bolts, washers, grommets, solder tags, Paxolin both sheet or tube, etc.), Pick-ups, Gram Motors, Styli (these last three run to 8 pages), Relays, Rectifiers, Resistors (5 pages), Soldering irons, Loudspeakers, Switches (over 120 different types), Tapes, Tape accessories, Test Gear (5 pages), Tools (3 pages), Transformers, Output, Mains Auto, Battery charger and Transistor (this section runs to 12 pages), Transistors, Transistor holders and heat sinks, Valves and Valve holders, Wire, cable and feeders, finishing up with Z for Zener Diodes.

This is not everything that is in the catalogue but we hope it's enough to show you the scope, and make you grab your pen to fill in the coupon.

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VOL. 2 No. 12
DECEMBER 1966

Practical Electronics

A STIMULANT FOR STUDENTS

ENTHUSIASM for further education abounds each autumn as evening classes commence. Enrolments for vocational and non-vocational courses take place in large numbers at technical colleges and other institutions. Correspondence Schools, although not limited to seasonal sessions, find their intake of students swelling this time of the year.

But alas, past experience warns us that ere the year has ended, numbers of these once ardent seekers after knowledge will have been seduced by rival attractions or will have weakly succumbed to some latent apathy. The initial heat and fire of their enthusiasm will have wilted with the onset of winter.

These early fatalities are partly explained by the fact that the initial stages of many courses of instruction are in certain respects the most formidable. Electronic theory is a case in point. The abstract nature of this subject demands adequate demonstration by practical models to supplement theoretical dissertation, particularly so where the level of treatment precludes extensive mathematical proof.

Unfortunately such demonstration facilities are either very limited or entirely lacking in many courses dealing with electronic principles. These courses usually tend to cater for the needs of examination papers set by the various professional bodies and practical work is rarely called for. On the other hand there is no doubt that practical experimental work adds immeasurably to the interest of the subject.

In this respect, modern techniques help the electronics student to help himself. Between attendances at college or stints at the textbook he can get to grips with the realities of electronics in his home, and at no exorbitant cost in tools, components, and materials. The basic principles he has been taught can be tested in this practical way. From such beginnings he can in due course proceed to construct simple functional devices which are not merely practical exercises in the application of more advanced theory but have some permanent value.

But most important of all, active participation in the *practical* side of electronics will provide an additional stimulant during those precarious first weeks of the autumn session. And once that hazard is passed, the rest is likely to prove (well, comparatively) plain sailing!

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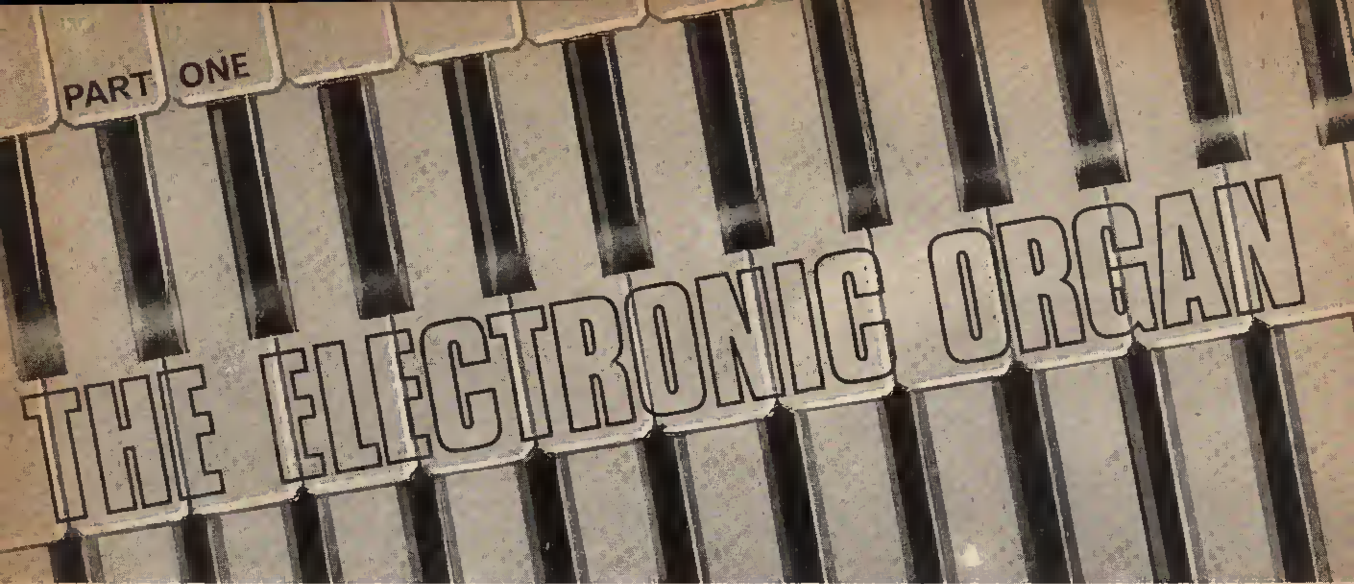


PART ONE

THE ELECTRONIC ORGAN

By ALAN DOUGLAS, Sen. Mem. I.E.E.E.

Our author is a well known authority on electronic organs, and is also widely experienced as a designer and builder of pipe organs. He is president of the Electronic Organ Constructors Society.

A great deal has been written about electronic organs, but they still remain, to most people, something of a mystery. Why are there so many types of organs, using all kinds of generating systems to produce what appear to be the same kinds of sounds? What has one make got that is better than another make? Above all, why do they cost so much?

In this series of articles we will try and explain these things, and to do this we must go back to fundamentals and see how early investigators viewed the art and why some methods were bound to fail. Firstly, however, we must remember that one cannot define an organ of any kind more exactly than to say it is a sustained tone instrument capable of producing a variety of tonal qualities which can be used singly or in combination. What these tonal qualities are, and what other effects may or may not be desirable, depend on whether the instrument is intended for the serious musician, for church or liturgical work; or for home entertainment, where the romantic and popular qualities are predominant. In other words, we find the same situation which has existed for so many years in the pipe organ world; the division between the church organ and the theatre organ.

This first article will give the reader an insight into some of the experiments and devices which led up to the present state of the art; for all readers of this journal are experimentally-minded and it must always be remembered that many of the early workers knew exactly what they wanted, but the materials and processes simply did not exist to interpret their ideas.

The first recorded experiments were by C. E. J. Delezenne in 1837. He used a toothed iron wheel turned by hand in front of an electromagnet, as in Fig. 1.1. By varying the speed he found he could vary the frequency of the e.m.f. induced in the coil, and hence the pitch of the note. The sound was heard in a crude telephone receiver. This idea was put into Delezenne's head by the earlier experiments of Savart, who held a piece of card against the rotating teeth when the pitch of the note could be heard audibly.

Then we come to the monumental concept of Thaddeus Cahill, who in 1895 devised and made a complete series of alternators all driven by belts from pulleys of the correct diameters to give the intervals of the equally tempered scale. But not only did Cahill

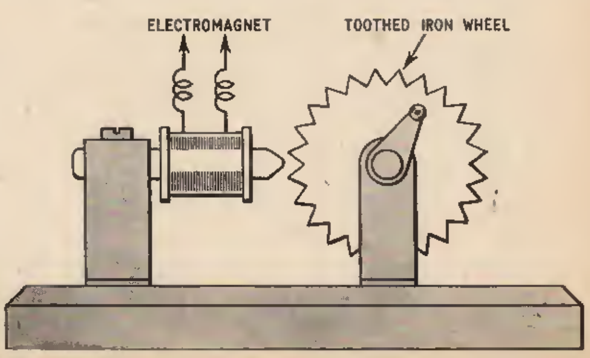


Fig. 1.1. Delezenne's tone wheel

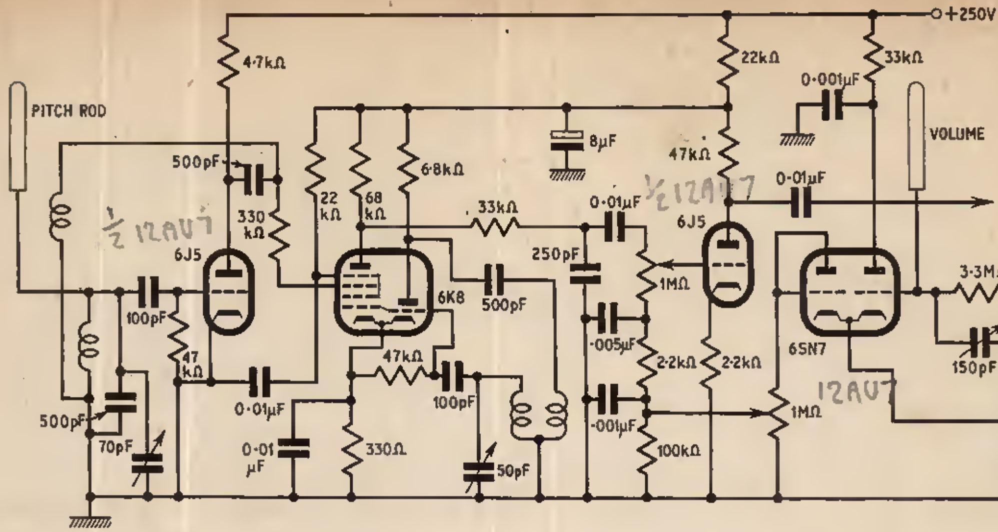


Fig. 1.2. Circuit diagram of the original theremin

provide 73 odd generators, he knew that if some of these frequencies were added together as harmonics of the fundamental note, complex sounds like trumpets and violins could be formed.

Helmholz, Fourier and Rayleigh had already found and analysed the number and strength of these harmonics, so Cahill devised a formidable array of switches and relays to introduce resistors controlling the amplitude of these harmonics. The whole of the arrangement is too complex to draw here, but it can be seen in British patents nos.: 8725, 1897; 3666A, B, C, 1903. Distribution and financial difficulties caused the abandonment of this project, and the reader will have no difficulty in recognising in this invention the fundamentals of the Hammond organ.

Next we move on to 1910, when W. Duddell discovered that an oscillatory circuit connected across an arc lamp could be used to produce musical tones. At that time, the arc was in widespread use for high power radio telegraph transmitters. Obviously this was not a basis for a serious design.

FIRST VALVE ORGAN

With the advent of the three electrode valve and the consequent ability to amplify, coupled with the rapid development of circuits in the 1914–18 war, it was now getting more feasible to reduce the bulk of the apparatus and we find the indefatigable Lee de Forest producing a valve "organ" in 1915. No need for an illuminated console then, as all valves used a tungsten filament with a light output equal to about 6 candlepower!

However, the old bogey of instability was still not conquered, so after a lapse of some years we find the Russian Leo Theremin working on the simple instrument in which the tuning capacitance for the b.f.o. employed was a metal rod like a car aerial. By bringing the hand near to this rod, the pitch could be altered and gliding tones produced. Another rod altered the volume by hand capacity, whilst a foot switch was used to cut off the note (Fig. 1.2). First made in 1924, the "Theremin" has been used until quite recently for solo work with an orchestra.

By this time the stage was set for great expansion in the art, but the first multi-note instrument came from Oskar Vierling in Germany in 1927. He made a two manual and pedal organ using gas tubes as relaxation oscillators, and this seemed to have stimulated other experiments. Coupleux & Givelet in France installed a two manual valve oscillator organ in the broadcast studios of Poste Parisienne.

THE TRAUTONIUM

So far, it is very doubtful if any of the investigators understood how to form musical tone colours from the various waveforms which they produced, and it is fairly certain that it was the novelty of the devices which attracted attention. But in Germany, a great

The two manual organ designed by O. Vierling. This instrument uses neon tubes to generate sawtooth waveforms

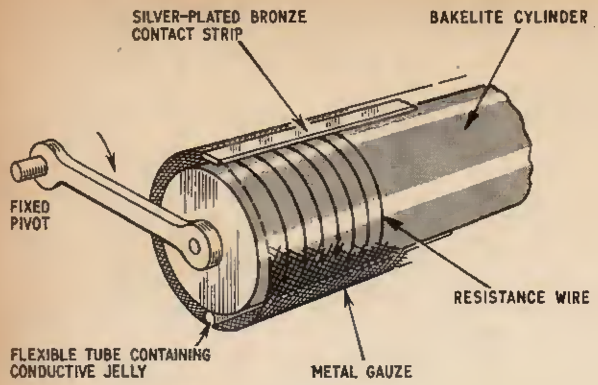


Fig. 1.3. Elements of trautonium frequency control

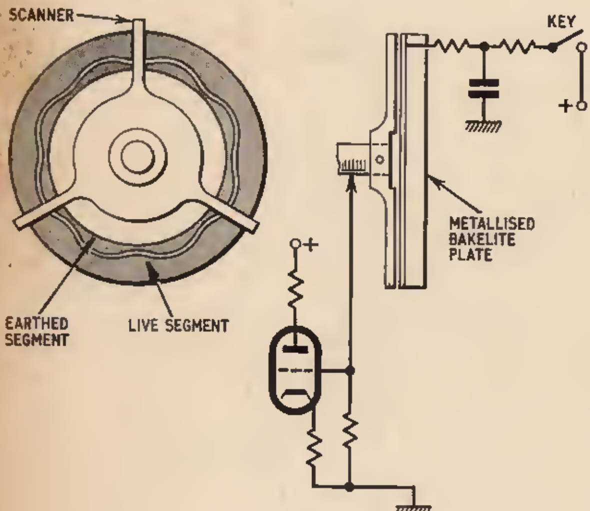


Fig. 1.4. Principle of the electrostatic organ

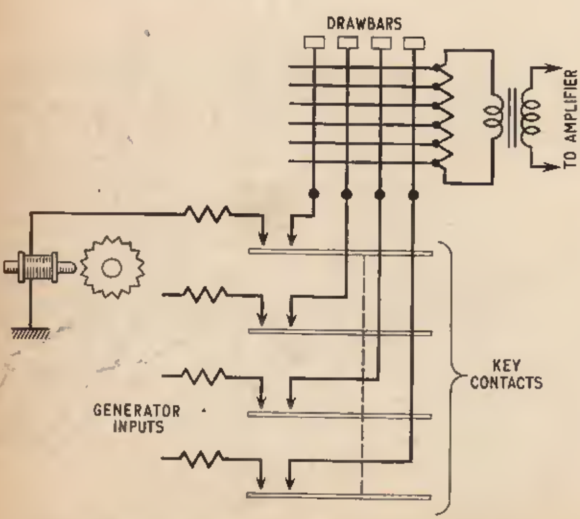


Fig. 1.5. Principle of the electromagnetic organ

deal of work was going on on tonal research in connection with orchestral instruments, and to assist in this Professor F. Trautwein devised the ingenious apparatus which he called the Trautonium (true tone). So advanced was he in his ideas that the instrument is still in use and in fact, seems unlikely to be superseded.

In Fig. 1.3 we can see the elements of the idea. An elliptical rod of bakelite has a spiral groove cut around it, and in this is wound a high resistance wire in coiled form. Above the rod is a metal strip which cannot touch the wire because it is inside a springy metal gauze surrounding the coiled wire. If, however, the outside of the gauze envelope is depressed at any point, the strip contacts the wire and this is used to vary the grid bias of a thyratron relaxation oscillator which—in turn—alters the pitch. Each rod (there are two, one above the other) has a compass of about 2½ octaves. The waveform is a sawtooth. But this is not all; under the rod is a rubber tube like a bicycle inner tube. This contains a jelly-like conductive substance, and since the touch rod and gauze are mounted on springs, it is possible to depress the whole lot further and squeeze the rubber tube; this alters the resistance of the liquid and allows the signal to pass to the amplifier.

Dr Trautwein devised a great many tone forming circuits including percussion and sustain circuits, and the results made every other investigator sit up and take notice. The original patents are dated 1928 but the "Trautonium" is used (with later modifications) for concert work to this day.

The trautonium, it will be noticed again, used gas tubes; this was because at that time, Germany had brought these to a great state of perfection. Now M. Martenot in France appeared with some ingenious ideas. He went back to the melodic instrument, that is, one on which only a single note at a time can be played. His playing keys could move slightly sideways and advantage of this was taken to alter the frequency of a b.f.o. so that some gliding tones could be produced. Then as the keys were depressed further, a resistance was reduced in value, so that the loudness was proportionate to depth of touch. By using the finger to rock a key, rather in the way a 'cellist does with his string, a similar kind of vibrato was produced. Some of these instruments are still in existence.

ELECTROSTATIC GENERATOR

So far as valves were concerned, there was still trouble with instability of pitch and regulation of power supplies, so this type of organ receded into the background.

The greatest advance was that due to the John Compton Organ Co. when in 1932 they devised the electrostatic generator which they still use. By engraving a groove in a metallised disc in the form of a sine or other wave, and rotating a web-like metal electrode just above it, the cyclic changes in capacitance when a potential is applied to the disc can be transferred to a valve and amplified as in Fig. 1.4.

If a series of such scanners is driven by a belt running over properly proportioned pulleys, then we have a musical scale. If there are enough multiples of one particular groove on a disc, then we have octaves of the scale. By adding some of these together, we can have complex tones. There are many practical advantages of this system, apart from the permanence of tuning, and this was the first successful departure from valves—although a few rotating photoelectric generators had seen a brief existence in the interim.

MAGNETIC TONE WHEEL

Continuing the search for stability, Laurens Hammond launched his magnetic tone wheel organ now so well known—and fundamentally unchanged after more than 30 years. The rotating iron discs have a tooth formation giving the nearest possible approximation to a sine wave, and the signals from the pickup coils are fed to contacts under the keys which transfer them to a selector switch mechanism for mixing in a transformer in any desired manner. See Fig. 1.5.

Since the generator is gear driven, tuning is permanent. It is interesting to note that it is not possible, by any economical combination of gear teeth, to produce the exact interval of a semitone. Each alternate note is fractionally sharp and then flat in pitch. It is partly this which gives the characteristic sound to a Hammond.

In later models, many ingenious additions have been made, but historically the foregoing represents the basic organ design.

The reed organ, using wind from foot bellows, was a great favourite in the United States from about 1850 onwards. The reeds used are also noted for constancy of tune, and this led the American F. Hoschke to use wind-driven reeds operating as variable capacitances as in Fig. 1.6. Although the sounds produced were limited in tonal variety, they were extremely pleasing and indeed even today this is a very fruitful field for experiment. Later the Hoschke organ became the Everett Orgatron, and later still, the Wurlitzer organ. This model has only been withdrawn a year or so ago.

Then we must not forget the German Welte photoelectric organ. The Hoschke patents date from 1934, the Welte from 1936. Large glass discs carrying photographically-reproduced copies of ready made waveforms were rotated in front of long photocells. Each playing key operated a small shutter which allowed light from a flashlight bulb to pass through a slit and so scan the waveform, as in Fig. 1.7. Again, constant speed pulleys ensured accuracy of pitch, and in fact this organ was a success.

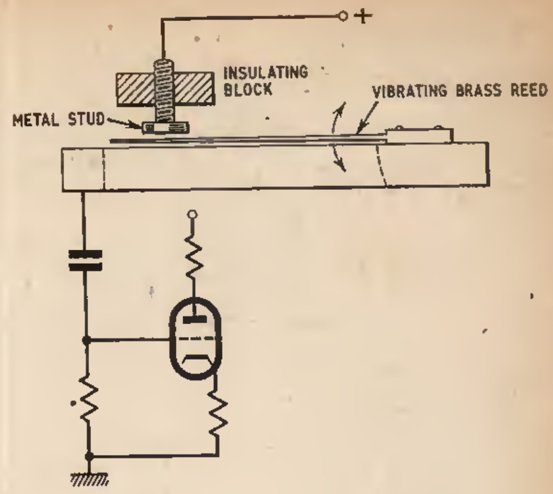


Fig. 1.6. Vibrating reed generator

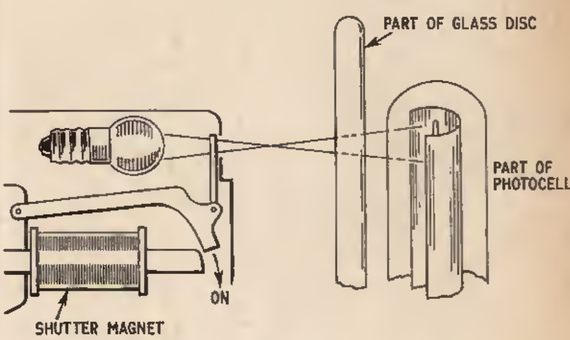


Fig. 1.7. Magnetic shutter for photoelectric organ

POST WAR ADVANCES

But then came the second war, and with it a tremendous advance in component and valve design. Intensive research regardless of cost produced all the parts required to restore the valve organ to the position it looked like losing for ever, and in addition, new magnetic materials, dielectrics and alloys enabled research into many new circuits to succeed. This brief historical survey could not include the many ingenious but hopeless ideas on which so many investigators worked, but we can conclude by mentioning the first successful post-war organs in order of appearance; Constant-Martin, Conn and Baldwin. It is to these companies that everyone owes a debt of gratitude because they laid the foundations of stability, good keying, and successful tone formation.

The present trend is to use transistors, or valves and transistors, although some makers prefer valves for large organs; they have certain advantages still.

In the next article we will try and explain what the basic musical requirements of an organ call for and what the various terms mean. This will lead us to examples of the most modern circuits and in due course to a design for a quite comprehensive organ which will have two manuals and pedals and be transistorised throughout.

The Everett Orgatron shown here uses vibrating reeds as variable capacitances in its tone generating system

Model Train Controller

by L. Huggard B.Sc.

THE circuit outlined below was evolved to provide a model railway enthusiast with a "foolproof" means of controlling an electric train. Besides providing complete protection against overloads, the circuit gives good overall performance and a high degree of control.

OVERLOAD PROTECTION

Let us consider first the performance of a shunt connected d.c. motor; that is one with the field winding in parallel with the armature winding. If the motor is stationary, then, when the supply is switched on the current through it will initially be very high, limited only by the low armature resistance. Once the motor armature starts turning, a voltage is induced in its winding due the the dynamo effect; the winding rotates in the motor field. This back e.m.f. tends to oppose the applied voltage, and hence reduce the supply current.

If unloaded, the motor will run up to some speed such that the armature opposing voltage plus the voltage due to the product of armature current and resistance, is equal to the supply voltage. If the motor is mechanically loaded, the speed falls, and the armature current will increase to maintain the relationship. Conversely if the motor is to be speeded up for a given load, the supply voltage must be increased; the motor will then run faster and draw more current.

There are two possible ways of controlling the motor, firstly by supplying it from a constant voltage supply, and secondly from a constant current supply. In both instances control being affected by altering either the supply terminal voltage or current as appropriate.

In this instance a constant current control was decided upon since it offered the following features:

(a) Maximum current limitation could be readily built in, thus protecting the power supply against short circuits caused by metal objects being placed across the rails;

(b) If the train is overloaded and refuses to start, the current could not rise to a value sufficiently high to damage the motor;

(c) Such a controller will give constant acceleration of the train up to the required speed.

CONTROLLER THEORY

The theoretical circuit diagram is shown in Fig. 1. The a.c. mains supply is stepped down to 20 volts by the transformer T1, then rectified by the diodes D1 and D2, giving a d.c. output smoothed by the large electrolytic capacitor C1. A stabilised voltage of 6·2V is established across R2 and VR1 by the Zener diode D3. Any proportion of this voltage can be applied to the base of transistor TR1 by adjustment of the wiper of potentiometer VR1.

Suppose now that the wiper of VR1 is at the "grounded" end of the track; no voltage is applied to the base of TR1, which is cut off. Thus no current passes through R3, so there is no drive voltage to the base of TR2, which is also cut off. Similarly TR3 is also cut off and no current flows through the load.

If the wiper of VR1 is moved to some other position, a voltage is applied to the base of TR1 causing it to conduct. Its collector current produces a voltage across R3, which drives TR2 on and hence drives TR3 on. Current through the load and R8 builds up until the voltage across R8 almost equals that picked off VR1.

When this state is reached the current remains constant at that value. It is seen that the current through the load is independent of the load resistance.

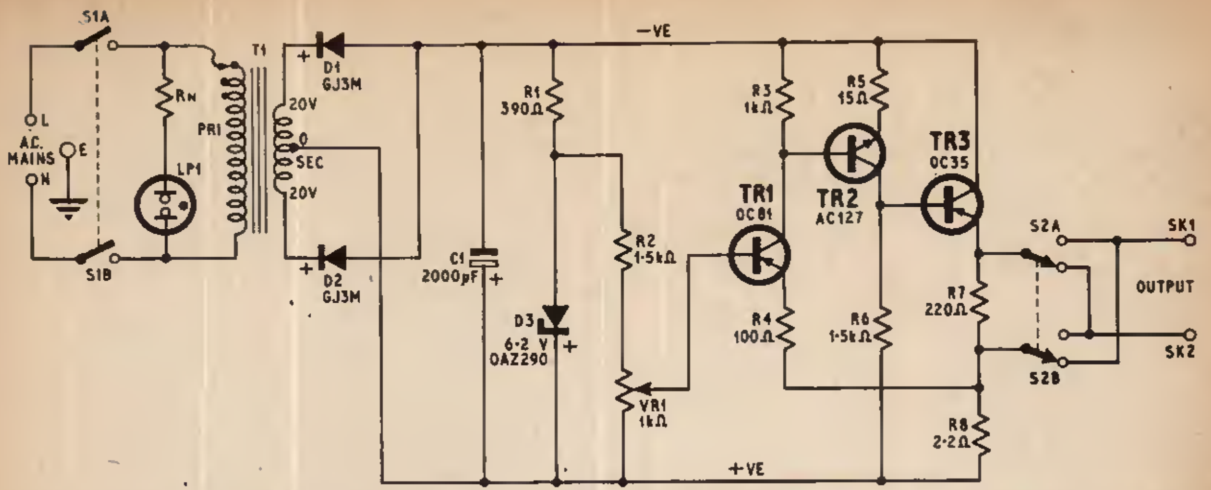


Fig. 1. Circuit diagram of the model train controller. VR1 is the speed control and S2 is the forward/reverse control

If the load becomes effectively a short circuit, then the current through it cannot rise above the value determined by the setting of VR1.

Values of VR1, R2, R8, and the Zener diode D3 are chosen such that the maximum value of voltage which can be applied to the base of TR1 is 2·5V, and hence no more than 1A, producing a 2·2V drop across R8, can flow through the load. The circuit is thus protected against short-circuits across the output terminals. If the engine is overloaded and refuses to start, the maximum current through it cannot exceed 1A

If, however, 1A is considered too much current for safe control, R2 can be increased to reduce the maximum voltage that can be applied to the base of TR1, and hence reducing the maximum current that can flow through R8 and the engine.

PRACTICAL POINTS

There are a few practical points to watch. The final transistor TR3 is a power transistor dissipating, at most, about 6 watts. It *must* be mounted on a heat sink; a suitable one is shown in Fig. 2a. The transistor should be insulated from it by using the customary mica washer, and clamping it on with nylon screws. All holes should be carefully deburred and smoothed so that no damage is inflicted on the mica washer. The mounting face of the transistor and the corresponding area of the heat sink should be smeared with silicon grease to improve thermal conductivity.

Transistor TR2 should be mounted in a copper heat clip, see Fig. 2b. It is quite permissible to leave this free standing as shown in the layout diagram Fig. 3, but it may of course be attached to the chassis or front panel, provided that the case is isolated from the collector of the transistor.

For a power supply of this kind it is essential that the winding resistances of the transformer are low, otherwise there will be a large voltage drop in the windings. The d.c. voltage across C1, at full power output, may fall to a value too low to maintain the Zener diode current. Should this be the case, there will be large changes in load current for variations in the load. Normally large changes in the load should not produce more than small, about 5 per cent, changes in the current through it.

A suggested layout for the components on printed wiring board is shown in Figs. 3 and 5. The Zener diode and its associated resistor R1 should be mounted clear of the board since they can get quite warm. The Zener diode should in this case be mounted on a heat sink.

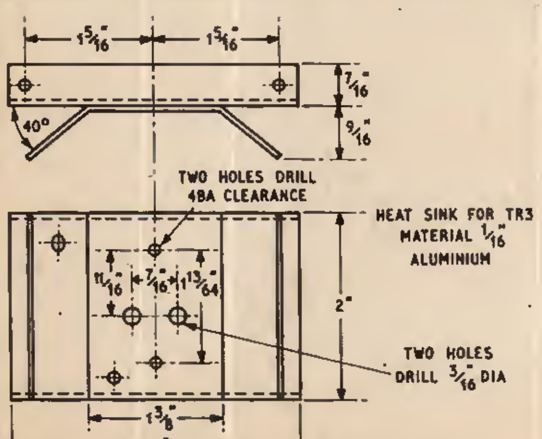


Fig. 2a. Construction of the heat sink for TR3

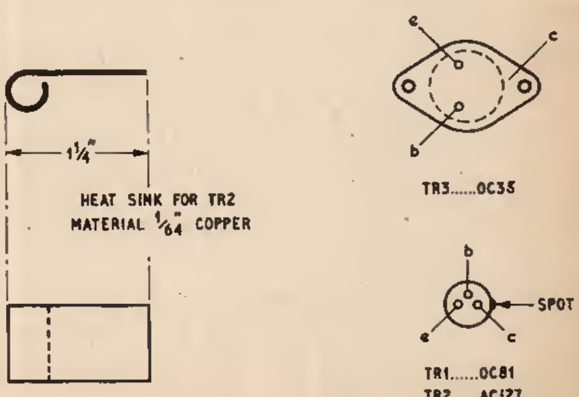


Fig. 2b. Details of the cooling clip for TR2 and transistor connections (looking at the wire ends)

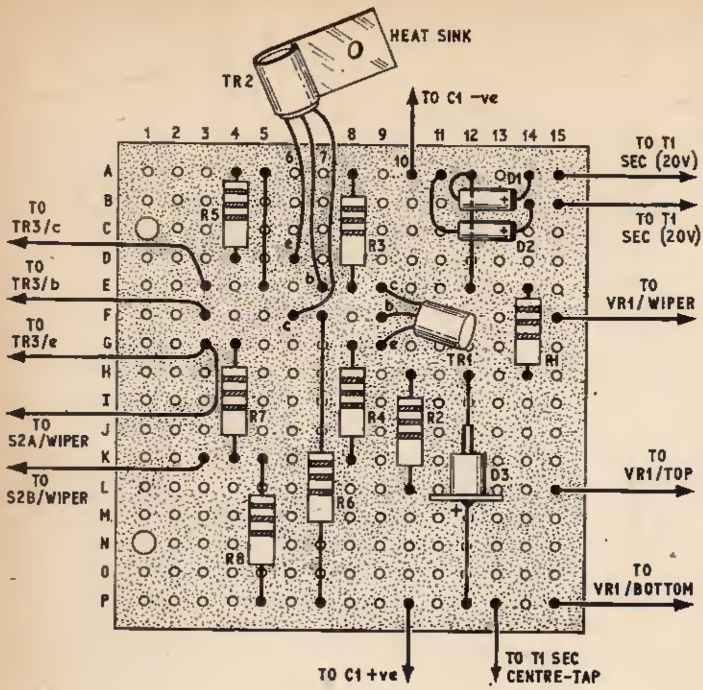


Fig. 3a. Layout of components on the board

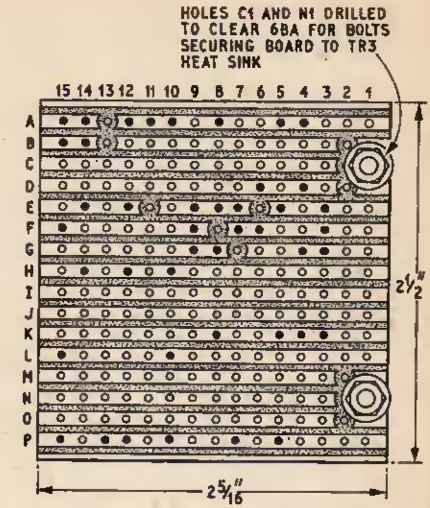


Fig. 3b. Connections and breaks on the copper strip side of the board

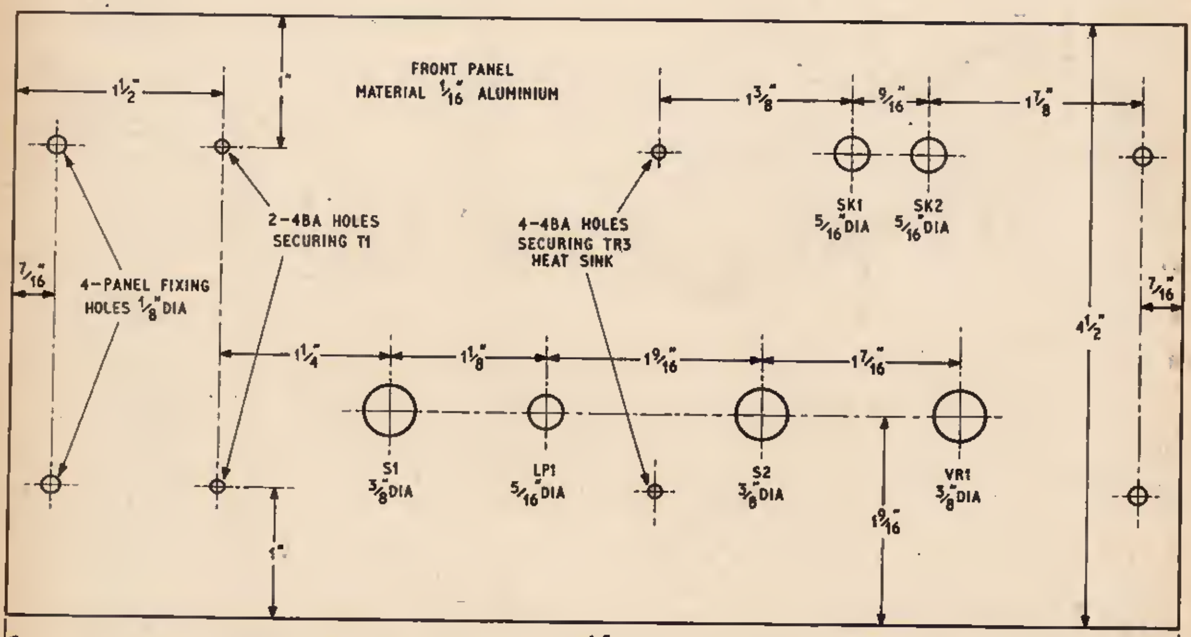


Fig. 4. Drilling details of the front panel

COMPONENTS . . .

Resistors
R1 390Ω 1·5W R4 100Ω R7 220Ω 1W
R2 1·5kΩ R5 15Ω R8 2·2Ω 5W
R3 1kΩ R6 1·5kΩ
All 10%, ¼W carbon except where otherwise stated

Potentiometer
VR1 1kΩ linear carbon

Capacitor
C1 2,000μF elect. 50V

Transistors
TR1 OC81 TR2 AC127 TR3 OC35 (Mullard)

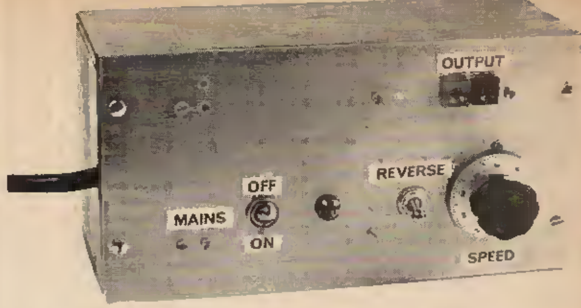
Diodes
D1, D2 GJ3M or ZR11 (2 off)
D3 OAZ290 (6·2V 7W Zener)

Transformer
T1 Mains transformer. Pri: 0–205, 225, 245V; Sec. 20–12–0–12–20V r.m.s., 0·7A (d.c. rating) (Radiospares)

Switches
S1 Double pole on/off toggle switch
S2 Double pole change over toggle switch

Lamp
LP1 Neon indicator with series resistor R_X mounted in holder

Miscellaneous
Veroboard 0·15in square hole matrix, 2½in × 2$\frac{5}{16}$in
Aluminium sheet 16 s.w.g., 8½in × 4½in, and 3in × 3in
Copper cooling clip for TR2
Plywood for box 8½in × 4½in × 2½in
Mounting clip for capacitor C1
Mica washer, nylon screws, silicon grease for TR3
SK1 and SK2 output sockets



The whole can be mounted on the front panel (Figs. 4 and 5) fitted with mains switch S1, neon warning light LP1, and a reversing switch SW2.

Before putting into service the following electrical checks should be made. Check that the collector (case) of TR3 is insulated from the heat sink. With the mains supply connected and switched on, check that the voltage across R7 varies with adjustment of VR1. Connect a 15 ohm 15W resistor across the output terminals, and set VR1 to maximum output voltage. Monitor the voltage across R8, which should be about 2·2V (current 1A). Short circuit the output terminals and check that the voltage across R8 changes by not more than about 5 per cent.

The unit is now ready for service. It is not advisable to provide full output to the train immediately otherwise a derailment may result. Careful operation of the control, by increasing the output slowly, is quite adequate to give the desired realistic effect. Similarly, always slow down the train, using VR1, before reversing direction. These points are common knowledge to most model railway operators but do tend to be overlooked by some. ★

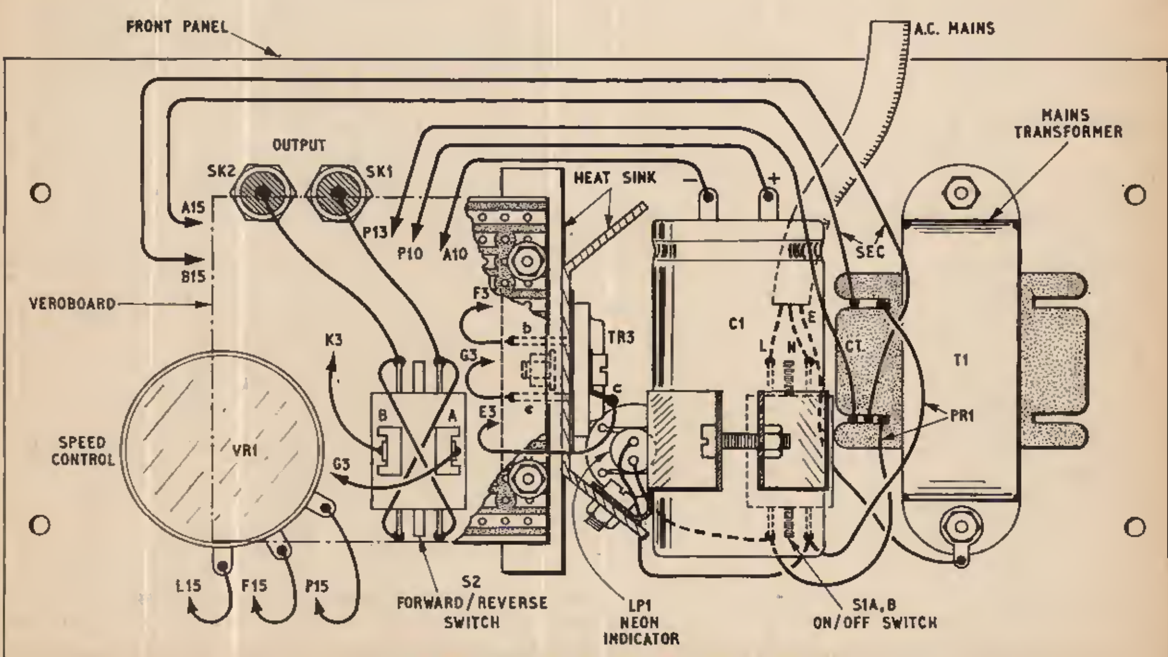


Fig. 5. Panel mounted components and their connections to the component board

the 73 page by Jack Hum G5UM

"No Royal Road", said Mr Smith

In "The 73 Page" last time some attention was paid to the variety of fields open to the practical electronician to till today, with special reference to the attractions of amateur radio transmitting. To enthusiasts prepared to pursue morse and theory sufficiently intensively to be able to pass the required examination in each, the acquisition of a transmitting permit is not difficult.

Yet this was not always so; and the following Christmas Tale, appropriate to the season at which this number of PRACTICAL ELECTRONICS appears, tells a story of "what used to be", that may well surprise many members of the younger generation.

Le-Grand

Towering above the narrow streets of the City of London—for this was before the war had swept many of them away and long before the minarets of the new Barbican business section were thought of—the central Post Office building of St. Martins-le-Grand had a forbiddingly granite look to the young person in his middle teens who presented himself there one Saturday morning forty years ago to take a morse code test.

The "le-Grand" bit itself was intimidating enough. And to set foot on its massive staircase seemed an impertinence indeed. No wonder the ascent to the upper floor where the test was to be taken was accompanied by a corresponding descent in morale. "Screw up your courage to the sticking point" Shakespeare had said, so he did just this, and his school cap as well, emblem of inferiority and immaturity and best stowed into the jacket pocket.

Twenty minutes later the great staircase took on quite a different look: it might as well not have been there as the schoolboy candidate lolloped down it three at a time oblivious of anything but the fact that *he had passed*.

No piece of paper told him so: it was sufficient to have it by word of mouth from the diffidently pre-occupied elder of the Post Office who had thumped the big brass morse key at him in that upper room, sending him odd sentences from the *Morning Post* to discover if he could *receive* at that speed of "ten per" (anyone could *send*).

Self Training in Morse

Yes, ten words a minute was all he had to send and receive (it is twelve in 1966). To attain this speed posed no problems to the short wave listener of a generation ago, for most of what there was to listen to came in morse anyway, and if you hoped to get anything out of your listening, well, you just had to learn it.

What this meant in actuality was that most of the candidates who presented themselves for the Post Office morse test had already served a self imposed and willingly accepted apprenticeship in copying telegraphy over a period of—quite often—many years, not to mention the "old sweats" from World War One who, learning it in battle, never forgot it.

In the early days of British broadcasting the transmitting stations of the BBC used GPO-allotted amateur type callsigns. Probably the most famous of these was 2LO, a self-evident callsign for the capital city's first broadcasting station, situated at the top of Marconi House in the Strand. This official BBC picture shows the original 2LO transmitter with its football-size valves and much exposed high voltage wiring! This transmitter is now preserved at the BBC London Region transmitting station at Brookmans Park in Hertfordshire.

All in all, the morse test held few fears except the normal psychological one of "examination nerves". Climbers of the St. Martins-le-Grand staircase generally carried with them a few extra words per minute above the required ten to overcome *that* particular hazard.

To pass the morse test, although a landmark, watershed, milestone, or, perhaps more electronically, marker pip in the career of aspirants to a transmitting permit, was in reality "the end of the beginning".

What, then, of the "start of the beginning"? To this question we bent some attention last time in our review of the random pulses that trigger off in an individual the initial interest in amateur radio. Forty years ago, just as today, it could be the chance overhearing of an amateur transmission which sets his footsteps on the road to the transmitting licence.

Strange Voices

This is how it had been with our young climber of the St. Martins-le-Grand stairway all those years ago. Ever since the day, years before that, when his father bought a wireless set, he had been intrigued by the strange voices that he could hear mingling with the transmissions of the British Broadcasting Company on the medium wave band.

Who were 2SO and 2QC and 5KA to be heard at tuning points not very far from 2LO and 5IT? They and others like them operating quite legitimately on the 220 and 440 metre wavelength, then allotted to amateurs, were a source of interest and delight to the nation's 200,000 "wireless enthusiasts", avid for new stations and new voices to log.

Even more to the point, could one of them advise him how to go about getting *his* feet on the start of that road to the transmitting licence? And so he wrote to Mr Smith of Herne Bay. He liked Mr Smith. He had heard him so frequently that he felt he almost knew him.

His reply, though full of helpful information, contained a cryptic sentence to the effect that there was no royal road to becoming a transmitting amateur, a remark that sent our young hopeful to his dictionary. "Royal road: a way of attaining without trouble" it said.

And that seems to be where we came in—and where we must pick up this story (this *true* story) next time.

by G. WAREHAM

SHORT CUTS in CALCULATION

PART FOUR—RESISTANCE CHARTS

In an earlier "Short Cut" (September issue) we saw how the value of resistances in parallel can be estimated easily, by turning each resistance into a combination of resistances of the same size. This is not *always* possible: resistance values are sometimes awkward. So let's look at some graphical aids which take most of the labour out of the process.

CLASSICAL APPROACH

Any number of resistances in parallel can be dealt with two at a time, by repeated application of the formula $R_{tot} = R_1R_2/(R_1 + R_2)$. But the arithmetic involved may be rather tedious: what is needed is a way of avoiding calculation altogether.

Since

$$\frac{1}{R_{tot}} = \frac{1}{R_1} + \frac{1}{R_2} + \frac{1}{R_3} \ldots \text{etc.}$$

we can find $1/R_{tot}$ by adding together the reciprocals of all the individual resistances, and then take the reciprocal of $1/R_{tot}$ which is equal to R_{tot}. This can be done with the aid of a table of reciprocals, or, more conveniently, with an "inversion chart" (Fig. 1).

When using this chart, both resistances must be in the same factorial units, and if one goes from upper to lower scale in one half of the calculation one must go from lower to upper in the second half.

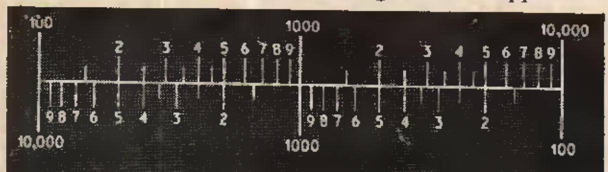


Fig. 1. Inversion chart for finding the combined value of two resistances in parallel

Example: What is the equivalent of 1 megohm and 100 kilohms in parallel? Converting 1 megohm into 1,000 kilohms and going "upper to lower" we read from the chart: 1,000 units for the 1,000 kilohms and 10,000 units for the 100 kilohms. Adding these gives 11,000 units, and the reciprocal of this (from the chart) will give the answer in kilohms.

Since the chart does not include 11,000 it cannot be used directly. But it can be extended as required: the rule is: *multiply* one scale and *divide* the other by the same number. We want 11,000 on the lower scale, so we multiply by 10, and 11,000 is now left of centre. The corresponding value on the upper scale, as marked, is 910, and this must be divided by 10 to produce the required answer of 91 kilohms.

LADDERS AND WALLS

One kind of problem often found in maths textbooks is based on two ladders placed against two facing walls. Given the lengths of the ladders and the distance between the walls, you may be asked to find how far above the ground the ladders cross. Reduced to its essentials, the problem is shown in Fig. 2, and the general solution is found from

$$d = \frac{ab}{(a + b)}$$

The lengths a and b can be found by applying Pythagoras' Theorem. Now, this equation is identical, except for the choice of letters, to the parallel resistance formula.

$$R_{tot} = \frac{R_1R_2}{(R_1 + R_2)}$$

This means that the same geometrical construction can be used to solve the "two resistances in parallel" problem. The method of finding R_{tot} is as follows:

1. Draw a horizontal line c of any convenient length. (The ground.)
2. Draw a pair of parallel lines at right angles to it. (The walls.)
3. Mark off on the vertical lines distances corresponding to the resistances R_1 and R_2 (e.g., 2·7 inches for 270 ohms).
4. Draw in the cross-lines. (The ladders.)
5. Measure the perpendicular R_{tot} which is the parallel equivalent of R_1 and R_2.

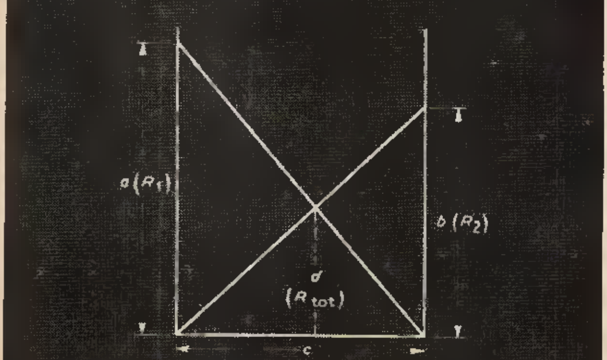


Fig. 2. "Wall and ladder" method of finding the total resistance of two in parallel

Exactly the same procedure can be used for capacitances in series, since $C_{tot} = C_1C_2/(C_1 + C_2)$ which has the same form as $R_{tot} = R_1R_2/(R_1 + R_2)$. And inductances in parallel have a similar arrangement $L_{tot} = L_1L_2/(L_1 + L_2)$.

D.C. Amplifiers

BY G. D. HOWAT

A CERTAIN ambiguity must be cleared up at the start: this concerns the initials d.c. as used in the title and elsewhere throughout this article. These letters can mean one of two things: *direct current* amplifiers, or *directly-coupled* amplifiers. The former meaning refers to circuits which are intended primarily for amplifying steady voltages, that is devices with input and output terminals where a steady voltage of 1 volt across the input produces, say, 10 volts across the output, 2 volts in gives 20 volts out, 3 volts in gives 30 volts out, and so on. Such a device has a value of gain (10 in this case) which is entirely analogous to the gain of any a.c. amplifier.

The second meaning, directly-coupled amplifiers, refers to the electronic configuration of the circuit instead of its purpose. A directly-coupled amplifier has no coupling capacitors or transformers between the stages, but instead, the anode of one valve is connected to the grid of the next either directly, or via a network containing only resistance and/or inductance.

These two names are not inter-changeable. Many direct current amplifiers *are* directly coupled, but there are other types that are not. Directly-coupled amplifiers certainly will amplify direct current but they can also be used for a.c. signals. This article is concerned with direct current amplifiers of the directly-coupled type, but a few brief comments on other forms of direct current amplification will be given at the end.

A SIMPLE DIRECT CURRENT AMPLIFIER

The simplest possible direct current amplifier (hereafter called d.c. amplifier) is shown in Fig. 1a. When no signal is applied to the input a certain amount of anode current flows in the valve thus developing a fixed voltage across the anode load R_a. If a fixed negative voltage is applied to the valve grid the anode current decreases and the voltage across R_a falls. By connecting a voltmeter across R_a this system could be calibrated by applying known input voltages to the grid and drawing a graph of these input voltages against the rise in anode voltage. The circuit could then be used as a voltmeter, unknown input signals being found by noting the rise in anode voltage and reading off from the graph the input voltage required for such a rise.

A circuit such as this would certainly work, and by using high resistances in the grid circuit (R_g in Fig. 1a) an electronic voltmeter of extremely high input resistance is produced. However there are several undesirable features about such a simple arrangement. For example in one way it "works backwards" in the sense that increasing the input actually decreases the output voltage: although this is of no consequence electrically, it is aesthetically displeasing.

More important from the electrical point of view is the mere presence of the no-input voltage in the output. A more satisfactory arrangement is one where no input signal gives no output, a voltage appearing across the output only when something is applied to the input. This may be accomplished by using a bridge network as in Fig. 1b. In this case the steady d.c. across the anode load is balanced by an equal voltage taken from the appropriate point on a bleeder circuit across the h.t. supply. In the absence of any input on the grid, a voltmeter is connected across the output terminals and adjusted to read zero by the Set-Zero control. Any voltage now applied to the grid will cause a reading on the meter by changing the anode voltage and unbalancing the bridge. Many valve voltmeters work on this or a similar principle.

This example of a valve voltmeter was discussed in some detail as it illustrates the whole point of a d.c. amplifier. A small voltage applied to the input produces a larger voltage across the output, altering the input causes the output to change in direct proportion.

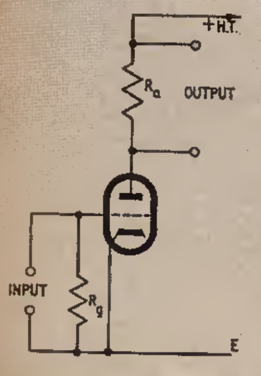


Fig. 1a. The simplest form of direct current amplifier. The output is negative "going"

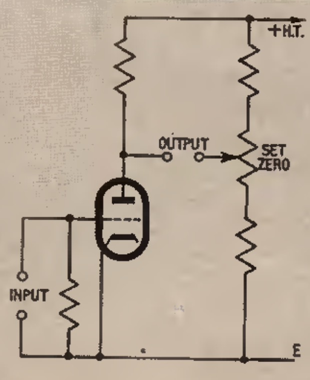


Fig. 1b. Bridge circuit. An input signal produces a "positive" output

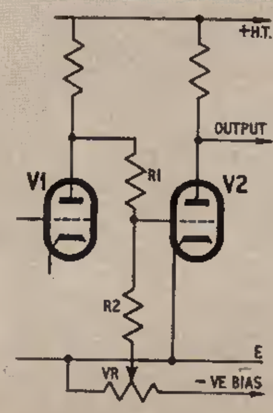


Fig. 2. Large negative bias voltage on V2 grid

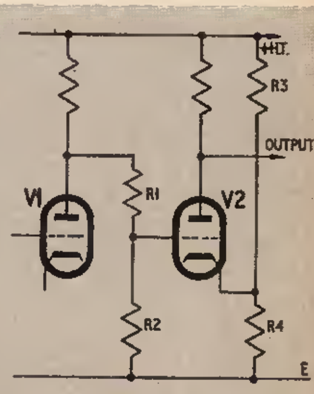


Fig. 3. An alternative arrangement (to Fig. 2) is to return the cathode of V2 to a point above earth

In Fig. 1 only negative input signals can be satisfactorily amplified, a positive input would cause grid current to flow and although amplification would still occur, the input/output characteristic would be unlinear. To make possible amplification and measurement of positive or negative inputs the grid must be biased negative with respect to the cathode. The various ways of doing this will be discussed in some detail shortly.

MULTI-STAGE AMPLIFIERS

So far we have considered only one-valve circuits used as voltmeters. There are many applications where the voltage gain provided by one valve is insufficient, this being partly due to the comparatively low gain of each stage. It is then necessary to build multi-stage amplifiers and a number of new problems arises. In conventional amplifiers of a.c., especially those dealing with audio frequencies, multi-stage amplifiers are fairly simple, the coupling between consecutive valves being accomplished by resistance and capacitance. The capacitor connected between the anode of one valve and the following grid will pass the a.c. signals with little attenuation, but prevents the high d.c. potential on the anode from being transferred to the grid of the next valve.

When amplifying d.c. it is impossible to use coupling capacitors between stages since obviously these would not pass a d.c. signal. It is here that directly-coupled amplifiers are useful since they do not use capacitors to transfer the signal from one stage to the next. The anode of one valve is connected to the grid of the next and the great difficulty arising as a result of this is preventing the high voltage on the anode from reaching the grid of the following valve, which must be negative.

One way of doing this is given in Fig. 2. Here a negative bias is used of approximately the same voltage, but opposite polarity, as the h.t. supply. In the absence of any input to the amplifier the potentiometer VR is adjusted so that the grid of V2 is a few volts negative with respect to the cathode. As the anode of V1 rises and falls in potential so the grid of V2 also rises and falls in sympathy; however, while the anode swings, say, 200 $\pm$ 10 volts, the grid of V2 swings $\pm$ 5 volts around a steady negative voltage of, for example, 10 volts.

This is then one way of directly coupling the stages in an amplifier which overcomes the problem of the potential difference between the anode and grid. However it does so at a price, and this price is the attenuation of the signal. In the example given the negative bias is about equal to the h.t. voltage and for V2 grid to be 10 volts negative the slider of VR must be slightly more negative than the anode of V1 is positive.

Under these conditions the coupling resistors R1 and R2 will be equal and the signal appearing at V2 grid will be half that at V1 anode. If the bias is made twice as negative as the h.t. is positive, then for the same bias on V2 grid R2 = 2R1; so only a third of the signal is lost in transfer. This idea can be taken further of course but is limited by the practical difficulties in obtaining a very high negative bias, and by the fact that the setting of VR becomes more critical as the bias is increased.

If making the grid negative is impractical then the converse can be tried, that is making the cathode positive. This is done simply by returning the cathode to h.t. as well as to earth as in Fig. 3. The value of R3 will be several times that of R4 and it is usually only practical to run the cathode at up to one-eighth of the h.t. voltage. Beyond this point the effective h.t. supply to the valve becomes so reduced that distortion, in the form of non-linear input/output response, begins to appear. Since the anode of V1 will almost certainly be at least half the h.t. voltage or higher, it is necessary to make R1 several times the value of R2 in order to drop V2 grid to below the potential of the cathode. This attenuates the signal to such an extent that the voltage gain between V1 anode and V2 anode is a mere 2–4 times.

A modification of Fig. 3 uses a double triode with one half acting as signal amplifier while the other half passes a heavy current to keep the common cathode potential high. This circuit is given in Fig. 4 and there is little to say about it as the general characteristics are those of Fig. 3.

Although the "positive cathode" stage as in Fig. 3 is of little use in the later stages of an amplifier, it can be very useful in the input stage. Here the input on the grid must be kept down to plus or minus a few volts, and returning the cathode to h.t. so as to maintain it a few volts positive provides an efficient high impedance input stage. Fig. 5 is the circuit of a working d.c. amplifier with a voltage gain of about 75. Used to drive a 6in cathode ray tube, this gave a spot deflection sensitivity of ½ volt/cm, or about $\pm$ 4 volts to move the spot from top to bottom of the screen.

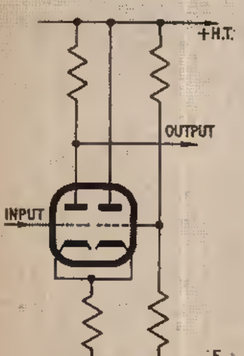


Fig. 4 (left). This is a development from Fig. 3. A double triode is used, one half as a signal amplifier, while the other passes heavy current to maintain the common cathode at a high potential

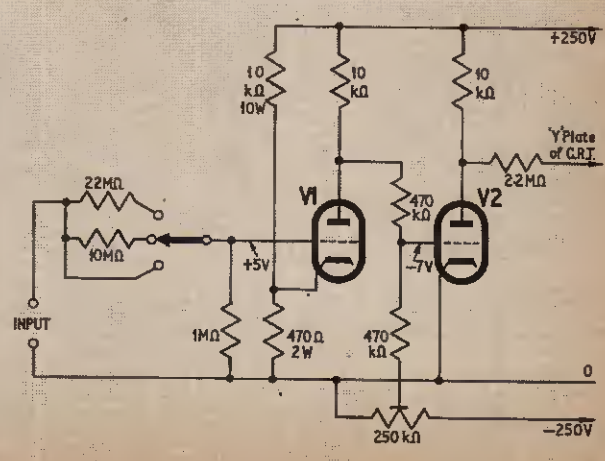


Fig. 5 (right). A practical two stage d.c. amplifier. The voltage gain is about 75

SEPARATE POWER SUPPLIES

If cost is no problem in building a d.c. amplifier, then several simple stages may be put in series using an independent power supply for each stage. Such an amplifier is shown in Fig. 6. With careful design this arrangement can be made very effective and efficient as there are no coupling resistors to attenuate the signal, also each grid except the first automatically receives the required negative bias due to the standing current in each anode load. The most obvious difficulty with this "stepped" system is the necessity of providing separate power supplies for each stage. Each individual supply is small but the cost of building one for each stage tends to mount up over a multi-stage system.

It is possible to use a single power supply and incorporate a series of potential dividers to give several series-connected supplies, each being of a much lower potential than the original. This is a wasteful method as a lot of power is dissipated as heat in the potential dividers and also interaction between stages with effectively a common power supply can produce unwanted feedback with resultant complications.

GAIN CONTROL PROBLEMS

Unless the amplifier is required for one specific purpose only, it is customary to incorporate a gain control somewhere in the circuit. In conventional a.c. amplifiers a gain control can be incorporated almost anywhere in the circuit but unfortunately this is not the case with d.c. amplification. Suppose that the resistors R1 and R2 in Fig. 2 and Fig. 3 were replaced by a potentiometer track and the slider connected to V2 grid; altering the setting of this potentiometer would vary the amplification by, in effect, varying the ratio of R1 and R2. However, it would also alter the bias point of V2 which must be kept constant in order to prevent the grid from either going positive (R1 too small) or going too negative and cutting off the valve (R1 too large).

An alternative method of gain control in a.c. amplifiers is to have one stage as a cathode follower, using the track of the potentiometer as the cathode resistor, and tapping off the required amount of signal on the slider. This method too is of no direct use in d.c. amplifiers for the same reason as before, i.e. altering the setting of the control would still alter the bias point of the next stage.

Up to a point these problems can be solved by using a ganged potentiometer, one half acting as in an a.c. circuit while the other half somehow cancels out the changing bias. Fig. 7 is a simple way of using a cathode follower as part of the gain control in a d.c. circuit: VR1b selects a negative bias which cancels out the effect of voltage across VR1a. The output is at a constant potential unless some input is applied to the valve grid.

A better solution is to have all the required gain controls connected between the amplifier input terminals and the first valve grid. As explained before, and shown in Fig. 5, the input stage of a d.c. amplifier usually uses a "positive cathode" arrangement rather than biasing the grid negative.

LIMITATIONS DUE TO "DRIFT"

Any audio amplifier has a certain minimum signal which it can amplify; below this level the noise inherent in the circuit makes amplification useless. The lower limit of input for a d.c. amplifier is set by the stability of the circuit, and this in turn is dependent on temperature changes in components, slow changes in component values with age, and variations in the supply voltages. The slow variations in these factors produce a slow change in the supposedly fixed amplification of the circuit, this manifests itself in, for example, frequent re-adjustment of the Set Zero control.

Such slow changes are known as drift and are usually more marked in d.c. than a.c. amplifiers. Drift is clearly undesirable and can be minimised by such methods as using high wattage, close tolerance resistors, using a stabilised power supply, and having a well ventilated chassis to keep down temperature changes. A small drift in any d.c. potential in the input stages will be amplified by later stages as a signal, so every effort is needed to ensure a very stable input stage.

Despite all precautions there is always drift to a certain extent and this places a definite upper limit to the complexity of a d.c. amplifier. Using directly-coupled stages of the types described so far, it is very difficult to use more than three stages of amplification; beyond this limit even a few millivolts of drift in the first stage are amplified to the extent of overloading the final stage. Even with three directly-coupled stages the bias and/or h.t. may need to be stabilised to ensure drift-free operation.

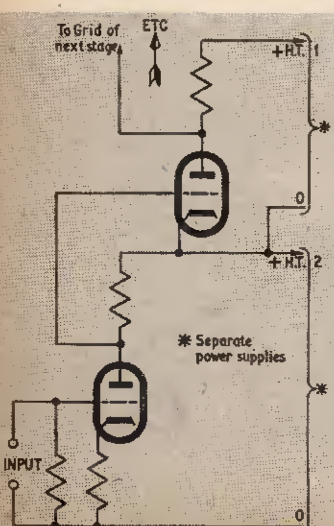


Fig. 6 (left). A "stepped" amplifier system using several stages in series

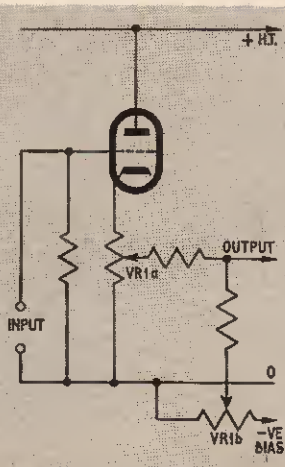


Fig. 7. Cathode follower as part of gain control

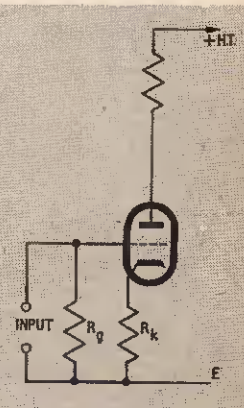


Fig. 8. Absence of decoupling capacitor across R_k causes negative feedback

OUTPUT ARRANGEMENTS

The type of output stage employed depends on the purpose for which the d.c. amplifier is intended to fulfil. The output signal appears as a variation in the anode voltage of the output stage valve. If this is to run a cathode ray tube in an oscilloscope the anode can usually be coupled direct to one of the Y plates; if the amplifier is acting as a voltmeter then the output is better taken from between the anode and a backing-off network as in Fig. 1b.

Sometimes the circuit has to be arranged so that the output terminal is at earth potential when no signal is applied and varies above and below earth with positive and negative inputs to the amplifier. In this case it is necessary to use an output similar to the coupling method of Fig. 2, the output coming from the junction of R1 and R2 and being set to zero in the absence of any input by VR. The chief snag about this kind of output is its extremely high output resistance, this being several megohms in some cases.

NEGATIVE FEEDBACK

We have already said that the voltage gain of d.c. amplifiers of the types discussed here is not very high, a net gain of 5–10 times being fairly average. This is due partly to the loss across the coupling resistors, but it is aggravated by the inevitable addition of negative current feedback. This problem can now be considered in some detail.

One of the unusual features of d.c. amplifiers is the virtual absence of capacitors anywhere in the circuit. In most audio equipment cathode resistors are by-passed by capacitors of various values, but this is not so in the amplifiers mentioned here so far. Suppose we consider just what happens to a signal when amplified by a valve not having a cathode by-pass capacitor. This will show just where the signal is lost.

In Fig. 8, suppose that the grid is made more negative with respect to the chassis, then the valve passes less current so the voltage across R_k falls. This drop in voltage across R_k means that the grid-to-cathode voltage change is less than the input voltage change between grid and earth because some of the input has been cancelled out by the change in potential of the cathode. In the case of an a.c. amplifier the cathode capacitor keeps the voltage across R_k almost constant, so the grid-to-cathode swing is almost the same as the input grid-to-chassis swing. It is these two drawbacks, the loss across coupling resistors and the inevitable negative feedback which reduce the gain of this type of d.c. amplifier to low values. Obviously capacitors across the cathode resistors will have no effect on d.c. signals.[1]

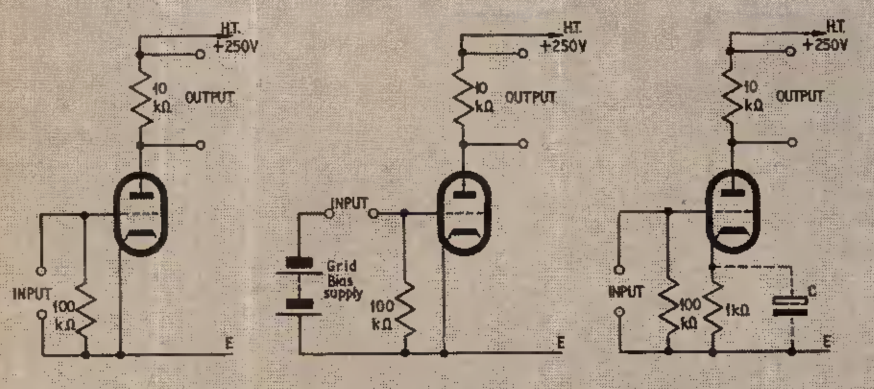
DETERMINING THE LOSS OF GAIN

It would be interesting to discover how much each of these factors affects the gain. The loss due to the coupling resistors can be found from simple potential divider theory; to find the effect of negative feedback the following set of experiments was performed.

First, using the circuit of Fig. 9a the voltage gain was measured for d.c. signals driving the grid negative, this gain was measured as the change in voltage across the anode load divided by the change in grid voltage which caused this. In this circuit, where there is no cathode resistor and hence no feedback, the voltage gain was almost exactly 10. Next, a battery was inserted in the grid circuit biasing the grid 6 volts negative (the effective internal resistance of the battery was only a few ohms). The voltage gain of this arrangement, shown in Fig. 9b, was measured by the same technique using positive and negative inputs but taking care not to run the grid positive. There was still no feedback due to a cathode resistor, but some feedback did occur as a result of the internal resistance of the battery. The voltage gain now dropped slightly, to 9·7.

At this stage a 1 kilohm resistor was inserted in the cathode circuit as in Fig. 9c. Initially this was unbypassed and the voltage gain for d.c. was measured and found to be 4·8. Using a 50c/s a.c. signal from the valve heater circuit the a.c. gain at this frequency was also measured; it turned out to be 5·0. Then a $16\mu F$ electrolytic capacitor was connected across the cathode resistor and both a.c. and d.c. gain re-measured. The a.c. gain was now 10, but the d.c. gain was unaffected though there was now a noticeable time needed for the circuit to settle down after the d.c. was applied; that is, when the d.c. was applied to the grid the anode rose slowly to its new value instead of rising sharply as it did when C was absent.

The results of these experiments can be summarised as follows: In the absence of negative current feedback



(a) No feedback, voltage gain 10 *(b) Some feedback due to internal R of battery* *(c) With cathode resistor. Add C to increase gain*

Fig. 9. Circuits used to determine the effect of negative feedback

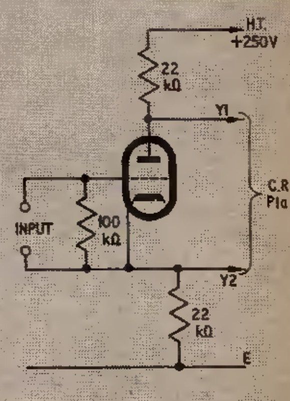


Fig. 10. Simple phase splitter for d.c. operation

the (negative-going) d.c. gain was 10, this value representing the maximum gain attainable using this particular set of component values. The addition of an un-bypassed cathode resistor introduced a degree of negative current feedback which reduced both a.c. and d.c. gain to about half their original values. By-passing the cathode resistor with a large-value capacitor restored the a.c. gain to its former value but had no effect on the absolute d.c. gain, though it introduced a delaying factor in the amplifier.

All this gives a somewhat paradoxical result as far as the design of d.c. amplifiers is concerned. If a cathode resistor is inserted in the amplifier stage this provides some bias for the grid but reduces the gain of the stage by negative feedback. The cathode resistor can be omitted by returning the grid to a negative bias supply but this automatically causes attenuation of the signal across the coupling resistor. Directly-coupled amplifiers of this type of circuit are therefore of necessity something of a compromise between several evils.

A note at this point on the measuring of the 50c/s gain of the amplifier as in Fig. 9c. As in the d.c. experiments, the gain is measured as output signal voltage across anode load divided by input signal voltage between grid and chassis. The input voltage can be found easily with an ordinary a.c. voltmeter but measurement of the output a.c. is complicated by the standing d.c. across the anode load. To measure the output an a.c. voltmeter in series with a large-value capacitor is connected across the anode load—the capacitor blocks the d.c. allowing only the wanted a.c. to reach the meter. To be strictly accurate the a.c. voltage drop across the capacitor should be taken into account, and this can easily be found from the equation giving the impedance of a capacitor at a given frequency.

A.C. PERFORMANCE

The question might well be asked—to what extent do the d.c. amplifiers described here amplify a.c.? The quick answer to this is—not very much. In designing simple apparatus to deal with d.c. only, no attempt is made to eliminate or neutralise stray inductance and capacitance, so for frequencies from a few hundred cycles per second upwards there is a steady falling off of the a.c. response. This does not mean that it is impossible to build a circuit which will amplify a.c. as well as d.c. Modern oscilloscopes sometimes incorporate amplifiers which have a response from d.c. to 50Mc/s or more, but these work on principles rather more complex than those described here. It is of course very useful to extend the response as far as possible up the frequency scale in order to avoid rounding off sharp pulses which include very rapid potential changes.

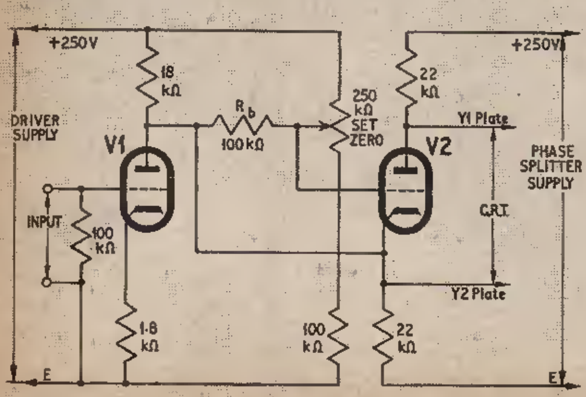
D.C. PHASE SPLITTER

Before concluding this article it would be interesting to consider a few variations on the ideas so far given.

In order to drive a cathode ray tube to give optimum results it is usual to employ push-pull deflection of the plates and to do this some form of phase splitter is required, analogous to that used in an audio amplifier to drive a push-pull output stage. A simple d.c. phase splitter is shown in Fig. 10 and is similar to the a.c. circuit called the split-load phase splitter. With the grid connected to the cathode, about 100 volts is present across each 22 kilohm resistor, and when the grid is 10 volts negative with respect to the cathode this falls from 100 to 25 volts per resistor. The difference, from 200 volts down to 50 volts, is enough to drive most oscilloscope tubes.

The real problem with this type of circuit is finding a suitable driver stage to work it. The most obvious solution is to connect the anode of the driver direct to the grid of the phase splitter, via a potential divider to adjust the voltages if necessary. Such a circuit in practice loses so much signal due to negative feedback in the very large cathode resistor that the gain is barely above unity. Whatever the voltage swing between earth and anode of driver, the swing between grid and cathode of the phase splitter is only a fraction of this and the output voltage changes across both 22 kilohm resistors is quite inadequate for driving anything but the most sensitive cathode ray tubes. After a great deal of trouble the only satisfactory way of driving the phase splitter was found to be the use of a bridge network in the anode of the driver which was run from an independent power supply.

Fig. 11. A bridge network is used here to drive the phase splitter



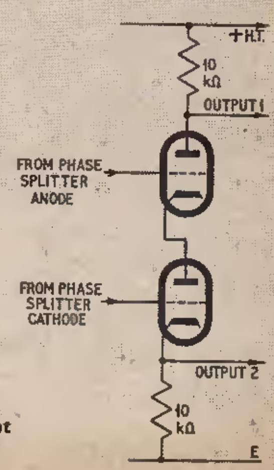


Fig 12. Cascode arrangement following the phase splitter

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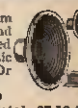

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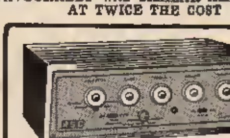

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The bridge circuit action, as described at the beginning of this article and shown in Fig. 1b, gives no voltage across the output unless there is an input applied to the valve. When using the bridge network to drive the phase splitter as in Fig. 11, the Set Zero control is adjusted so that there is no voltage across the 100 kilohm bridge load resistor (R_b in Fig. 11) when V1 grid is a few volts negative of its cathode, and signals of either polarity can then be accepted. V1 in Fig. 11 can be preceeded by any type of d.c. amplifier, but this must be run from the same power supply as V1 itself. V2 must have its own separate supply.

Of course we are really doing things in a somewhat absurd fashion here, using a form of phase-splitter as the output section; in conventional audio equipment the phase splitter only has the job of supplying power to, usually, a symmetrical push-pull output stage. The reply to this is that there is nothing simple in d.c. circuitry which is analogous to an a.c. push-pull output stage. The following arrangements have been attempted, all based on a form of cascode arrangement.

CASCODE ARRANGEMENTS

Fig. 12 applies the outputs from the phase splitter to the two halves of a twin triode in cascode, again taking the outputs from one cathode and one anode.

Another idea was to use two such cascodes and strap both grids together. The output from the cathode of the phase splitter went to the grids of one such cascode pair which had no cathode resistor but retained the anode load and took the output from the "top" anode. The anode output from the phase splitter went to both grids of the other cascode pair, this had no anode load but retained the cathode load at the bottom and took the output from this.

Both these ideas worked in the sense that they provided some output when a signal was applied to the phase splitter. Unfortunately both were non-linear and one acted as an attenuator instead of an amplifier!

CHOPPER-TYPE D.C. AMPLIFIER

There are, of course, other types of d.c. amplifier than those discussed here. Other forms of coupling between stages can be used, there are several forms of coupling found in transistorised circuits, including the so-called long-tailed pair, which are very useful in this respect. Alternatively the d.c. input can be made to modulate an a.c. signal which is then amplified and measured in the usual a.c. way. This modulation is carried out in a chopping device which may be either mechanical or purely electronic, and the complete circuit is called a chopper-type d.c. amplifier.

This article should have outlined the simpler design features of d.c. amplifiers of one type. It is a field of study with considerable scope for experimental work since the uses of d.c. amplifiers are numerous. They can be used to amplify the output of photo-electric tubes and other units which produce small, fairly steady, d.c. voltages. They are used in computers of some kinds and in various forms of research, often as parts of oscilloscopes. Bearing in mind the considerable difficulties involved, the study and construction of this type of circuit presents something of a challenge which is very interesting to attempt to meet.

Reference

1. For a much fuller discussion of this type of feedback see the article "Impedance and Negative Feedback" by the same author, published in Practical Electronics, May 1966.

★

THE basis of this instrument is a flip flop circuit which is triggered by pulses generated in a multivibrator. The use of a flip flop ensures that the pulses are of constant width. The pulses are then clipped by a Zener diode before being fed to a meter which measures the average current flowing in the output stage.

The reading on the meter is dependent on three things: the frequency, amplitude, and the width of the pulses. Now the width of the pulses depends on the time constant of the flip flop and, in turn, the time constant of the flip flop depends on the amount of capacitance present in the circuit; it follows therefore that if the frequency and the amplitude are held constant then the reading on the meter will be a direct measure of the capacitance present in the flip flop, and also the meter will have a linear scale.

It was decided to include in the meter comprehensive self-check facilities, so that the calibration of the instrument can accurately be checked on all four ranges at the turn of a switch and also the internal battery voltage can be measured. The four ranges have full scale deflections of 0·001μF, 0·01μF, 0·1μF and 1·0μF. The leakage of the capacitor under test can also be assessed.

The overall result is a linear scale capacitance meter that is easy to use and check, and which enables quantitites of capacitors to be checked very quickly. The author feels that this item of test gear would be a very useful addition to anybody's workshop.

THE CIRCUIT

The circuit of the linear scale capacitance meter is shown in Fig. 1. The first two transistors TR1 and TR2 form a conventional symmetrical multivibrator. The frequency of the multivibrator is controlled by sections a and c of the range switch S1, which switch in pairs of capacitors. The output of the multivibrator is differentiated by C13 and fed to the first stage of a flip flop, TR3.

For the time being we will assume that the function switch S2 is in the CALIBRATE position, i.e. position 1, and that the master switch S3 is in the ON position, i.e. position 2. Under these conditions S2a allows the calibration capacitor selected by Sld to be used as the time constant of the flip flop circuit. The output from TR4 is clipped by the Zener diode D2 before being fed to the meter M1 via S3b and S3c. The meter is set to full scale deflection by the variable resistor selected by S1b.

So it can be seen that all that is necessary in order to calibrate the instrument is to set S2 to the CALIBRATE position and set the range switch to each position in turn and adjust the appropriate calibration resistor VR1–4 for full scale deflection on M1.

With the capacitor to be tested (Cx) connected across the test terminals and the appropriate range selected on S1, the switch S2 is placed in the READ position, position 2. S2a disconnects the calibration capacitor and S2a, b and c bring into circuit Cx as the flip flop time constant capacitor. The meter will now read the value of Cx.

LEAKAGE TEST FACILITY

If it is desired to assess the leakage rate of Cx, then S2 is set to position 3 LEAKAGE. This switch, incidentally, is spring loaded to this position and if released returns to position 2. One side of Cx is connected, via position 3 of S2b and the current limiting resistor R6, to 9 volts negative. The other side of Cx is connected via position 3 of S2c to the meter. The diode D1 will not appreciably affect the meter reading as it is now reverse biased. The meter is connected to the positive supply line via one of the calibration resistors, and because of this the meter will read slightly different leakage rates depending upon which range is selected, but as this function of the instrument is only meant as an *indication* and not a *measurement* it was thought not to be worthwhile to provide an extra way on S2 to connect the meter directly to the positive line on this function.

POWER SUPPLY

The capacitance meter is powered by a 9 volt battery, such as type PP6. The battery voltage is reduced to 6·2 volts and stabilised by the Zener diode D3 and resistor R10.

All that remains to be discussed now are positions one and three of S3. Position one of this switch is the OFF position, the negative side of the BY1 battery is disconnected by S3a and a short circuit is placed across the meter by S3b and c in order to damp the movement for protection in transit.

Position 3 of S3 is for measuring the battery voltage. The negative side of the meter is connected to the negative side of the battery via S3b, the meter multiplier resistor R9, and S3a. The positive side of the meter is connected to the positive line by S3c.

LINEAR SCALE CAPACITANCE METER

By B. CRANK

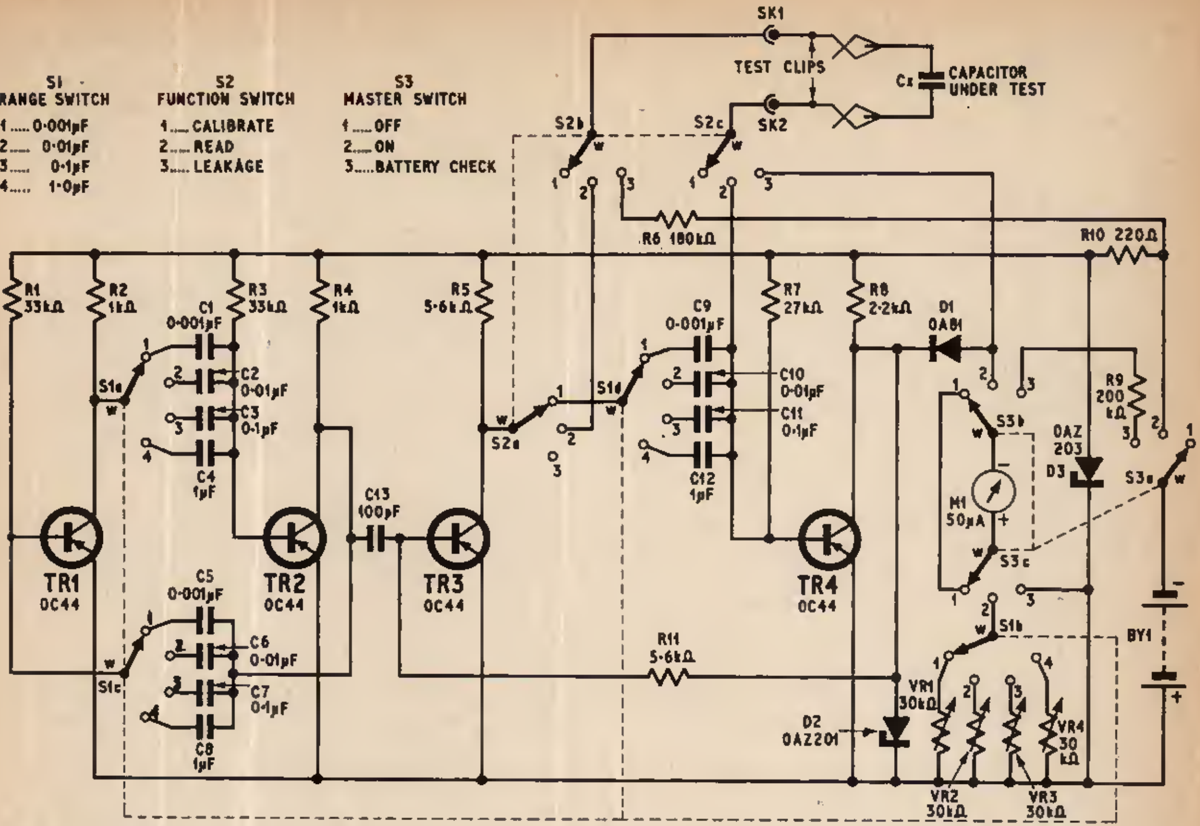


Fig. 1. Circuit diagram of the linear scale capacitance meter

COMPONENTS

All the components used are standard items. There are however one or two points that are worth mentioning in this connection.

The capacitors C9, 10, 11 and 12 should be as accurate in value as possible. C9 presents no problem in this respect as one per cent components are easily obtainable. The other three may present a little more difficulty, and if the constructor has no facilities for selecting accurate components, a useful method to adopt will be suggested under calibration.

The switches used for S2 and S3 are lever operated wafer types. They lock in two positions and are spring loaded to return to centre from the third. The spring loaded positions are used in the BATTERY CHECK and LEAKAGE functions of the instrument.

The switches were obtained from the Specialist Switch Company and it is recommended that beginners especially who wish to follow the point-to-point wiring instructions use the switches specified, since the contact arrangements on other switches may not be the same and could lead to confusion.

The meter can be any 50µA moving coil movement, the physical size of which will be determined by the constructor's pocket. If possible, obtain a meter scaled 0–10, but otherwise a paper scale can easily be made up and glued over the original.

CONSTRUCTION

The first task to be tackled is the case. The author used a metal box with hinged lid measuring 8½in × 5½in × 3¾in deep. This is actually a readily available item since it is marketed by large stores as a "lunch box".

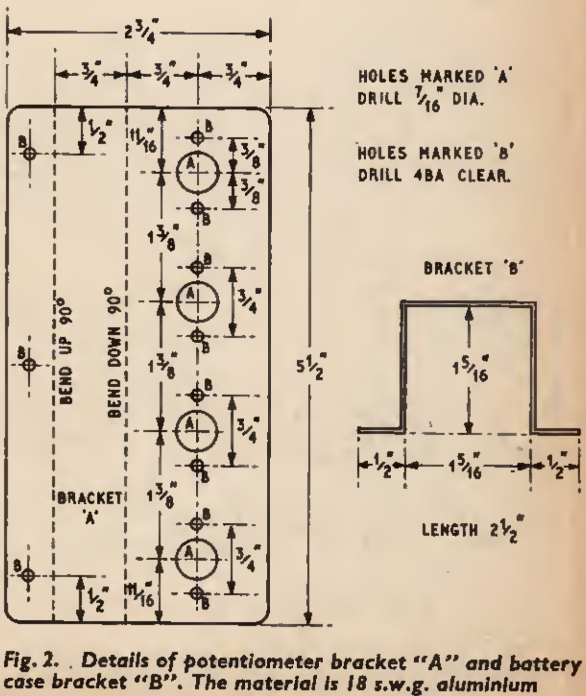


Fig. 2. Details of potentiometer bracket "A" and battery case bracket "B". The material is 18 s.w.g. aluminium

A piece of black Lantex should be cut to fit the recess in the face of the lunch box and then placed on one side.

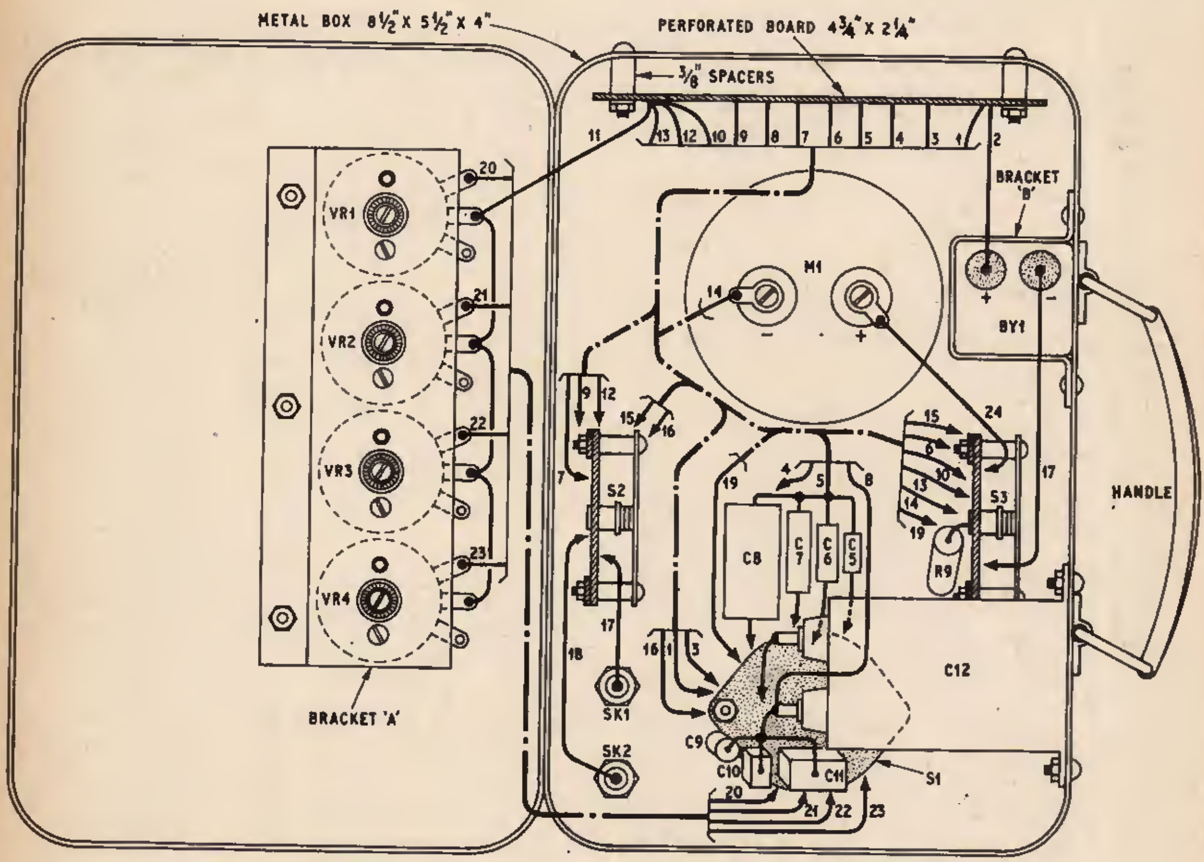
Brackets "A" and "B" are made up from 18 s.w.g. sheet aluminium as shown in Fig. 2. The "bottom" of the case is then drilled to take the parts in the positions shown in Fig. 2. Ensure that there is adequate clearance when the box lid is shut.

Remove all the components from the box. Place the previously cut sheet of black Lantex in position and mark the back of it for the necessary holes, using the drilled case as a template. Drill the Lantex front panel. Note that the screws which hold S2 and S3 do not protrude through the front panel, but the back of this panel is recessed to take them. The panel is held in place by the meter flange and by sockets SK1 and SK2—this prevents the appearance of the instrument being spoiled by visible screws.

Readers may be interested in two tools the author has recently acquired which have been useful in construction work of this kind. The first is a pair of pop riveting pliers, which enables items to be quickly riveted in place from one side of the work only without hammering. The second is a "Monodex" sheet metal cutter, and this enables circles to be cut from metal after drilling only one ¼in hole without distorting the metal—saves all that laborious drilling and filing.

PERFORATED BOARD

The next stage in construction is to mount the components on the piece of perforated board as shown in Fig. 4. The positive and negative rails are made from 18 s.w.g. copper wire. It will be noticed that all points on the board have a letter and figure reference.



WIRING SCHEDULE								
WIRE No.	FROM	TO	WIRE No.	FROM	TO	WIRE No.	FROM	TO
1	PB/K2	S1c/w	9	PB/K25	S2c/2	17	S2b/w	SK1
2	PB/Q1	BY1/+VE	10	PB/Q40	S3c/3	18	S2c/w	SK2
3	PB/K5	S1a/w	11	PB/Q40	VR1/SLIDER	19	S3c/2	S1b/w
4	PB/K8	C1,2,3 & 4	12	PB/C40	S2b/3	20	VR1	S1b/1
5	PB/K11	C5,6,7 & 8	13	PB/A40	S3a/2	21	VR2	S1b/2
6	PB/O21	S3b/2	14	M1 -VE	S3b/w	22	VR3	S1b/3
7	PB/K22	S2a/w	15	S2c/3	S3b/2	23	VR4	S1b/4
8	PB/K25	C9,10,11 & 12	16	S2a/1	S1d/w	24	M1 +VE	S3c/w

Fig. 3. Interior of the capacitance meter case. Wiring cable forms are shown and each individual connection is listed in the accompanying wiring schedule. For clarity it has been necessary to omit capacitors C1–C4 inclusive which have a common connection wire 4—see Fig. 5

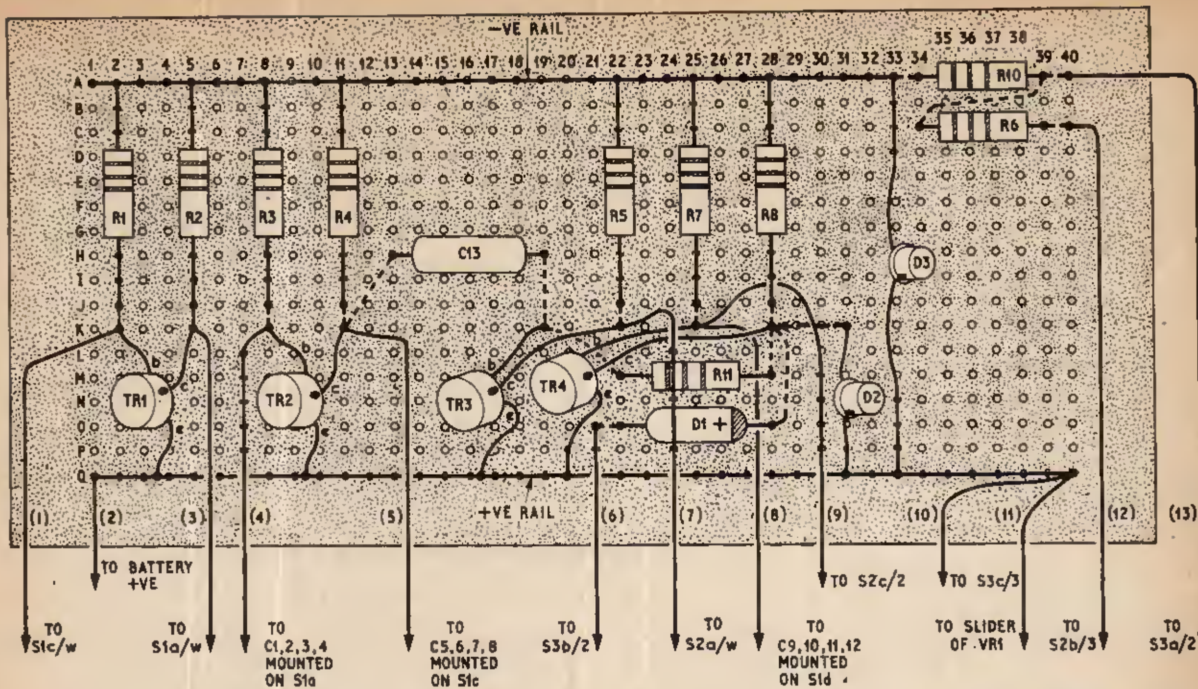


Fig. 4. Assembly of components and wiring on the perforated laminated plastics board which measures 4¾in × 2¼in. Numbers in brackets identify individual connecting wires as listed in the table given in Fig. 3

COMPONENTS . . .

Resistors

R1	33kΩ	R 7	27kΩ
R2	1kΩ	R 8	2·2kΩ
R3	33kΩ	R 9	200k 1%
R4	1kΩ	R10	220Ω

All ±10%, ¼W unless otherwise specified

Potentiometers

VR1–4 30kΩ wire wound, preset (4 off)

Capacitors

C1	0·001µF	C 8	1·0µF	
C2	0·01µF	C 9	0·001µF 1%	
C3	0·1µF	C10	0·01µF	see text
C4	1·0µF	C11	0·1µF	see text
C5	0·001µF	C12	1·0µF	see text
C6	0·01µF	C13	0·0001µF	
C7	0·1µF			

All high quality paper or plastics dielectric, 150V working.

Semiconductors

TR1–4 OC44 (4 off)
D1 OA81

Switches

S1 Wafer, normal rotary type: 4-pole, 4-way
S2 Wafer, lever operated, one side spring biased to centre: 3-pole, 3-way. Type SS/106/3
S3 As S2
All three switches obtainable from Specialist Switches Ltd., 23 Radnor Mews, London W.2.

Miscellaneous

BY1 9 volt battery, PP6 or equivalent
M1 Moving coil meter, 50µA f.s.d.
SK1, 2 Wander sockets, with plugs (2 off)
Two crocodile clips. One pointer knob. Perforated plastics board 2¼in × 4¾in Case: lunch-box 8½in × 5¼in × 3¾in (Woolworths). Black Lantex sheet (*Home Radio*, Cat. No. ZA69). Aluminium sheet. Screws, wire, sleeving, etc

ASSEMBLY OF COMPONENTS

The switch S2 is wired before fitting to the case, reference to Fig. 5 will show how the tags on the wafer switches are identified.

Connect a2 to b2.

Connect a length of wire to the following contacts and mark for future identification.

aW, a1, bW, b3, cW, c2, c3.

Mount all the components in the case with the exception of the battery case bracket "B". Carefully note the way in which S1 is orientated—this is easily done by checking the position of the blank tags. The switches S2 and S3 are mounted so that the spring loaded position is to the rear.

WIRING UP PROCEDURE

During the wiring up operation, reference should be made to Fig. 1 and Fig. 3. Tick off each stage as it is completed, line by line as given below; this prevents parts being omitted and makes it easy to see how far one has got if interrupted during the process.

C1 to S1a/1
C2 to S1a/2
C3 to S1a/3
C4 to S1a/4
} Sleeve as necessary.

Join free ends of these four capacitors together.

C5 to S1c/1
C6 to S1c/2
C7 to S1c/3
C8 to S1c/4
} Sleeve as necessary.

Join free ends of these capacitors together.

R9 between S3b/3 and S3a/3

S3b/1 to S3c/1	S3c/2 to S1b/w
S2c/3 to S3b/2	S3c/3 to PB/Q40
S3b/2 to PB/O21	S3c/w to M1 positive
S3b/w to M1 negative	S3a/2 to PB/A40

S2a/1 to S1d/w
S2b/3 to PB/C40
S2a/w to PB/K22
S2c/2 to PB/K25
S2b/w to SK1
S2c/w to SK2

S1a/w to PB/K5
Junction of C1–C4 to PB/K8
S1c/w to PB/K2
Junction of C5–C8 PB/K11

Wipers (centre tag) VR1–VR4 together and to PB/Q40
Upper tag VR1 to S1b/1
Upper tag VR2 to S1b/2
Upper tag VR3 to S1b/3
Upper tag VR4 to S1b/4

S3a/w to negative battery clip
PB/Q1 to positive battery clip.

If you have known accurate components for C9–C12, these may now be fitted on S1d; if not proceed as follows.

CALIBRATION

Fit the battery case bracket "B" and insert and connect the battery.

Label switches as follows:

S1	S2	S3
0·001μF	CALIBRATE	OFF
0·01μF	READ	ON
0·1μF	LEAKAGE	BATTERY CHECK
1·0μF		

Make up a pair of short test leads using wander plugs and crocodile clips.

Switch S2 to READ and S3 to ON.

Bring the meter to mechanical zero using the adjusting screw.

Switch S1 to 0·001μF and connect a 0·001μF one per cent capacitor C9 across the test leads. Adjust VR1 until the meter reads full scale deflection.

Switch to the 0·01μF range and adjust VR2 until the meter reads 1 (one tenth full scale).

Remove C9 from the test leads. Select a 0·01μF capacitor and connect across test leads. Note meter reading; if not full scale, connect further small capacitors in parallel until meter reads exactly full scale. *Do not* touch VR2. The combination of capacitors so formed is C10.

Switch to the next range up with C10 still across test leads. Adjust VR3 till meter reads one tenth full scale. Connect a 0·1μF capacitor and pad with parallel capacitors until full scale results. The resulting combination is C11.

Proceed in a similar manner for the 1μF range, so forming C12.

Connect the so-formed capacitors C9 to C12 to the appropriate positions on S1d. Join the free ends of these capacitors together and connect to point PB/K25.

FINAL TEST

With the capacitance meter switched on and the CALIBRATE position selected, the meter should read full scale in any position of the range switch. Any errors that may creep in due to temperature changes, etc. can be corrected using the appropriate potentiometer.

With the master switch set to BATTERY CHECK the meter should indicate the battery voltage.

With the function switch set to LEAKAGE and the test leads shorted together the meter should read near full scale; if it does not, connect a fairly large value resistor in parallel with R6. ★

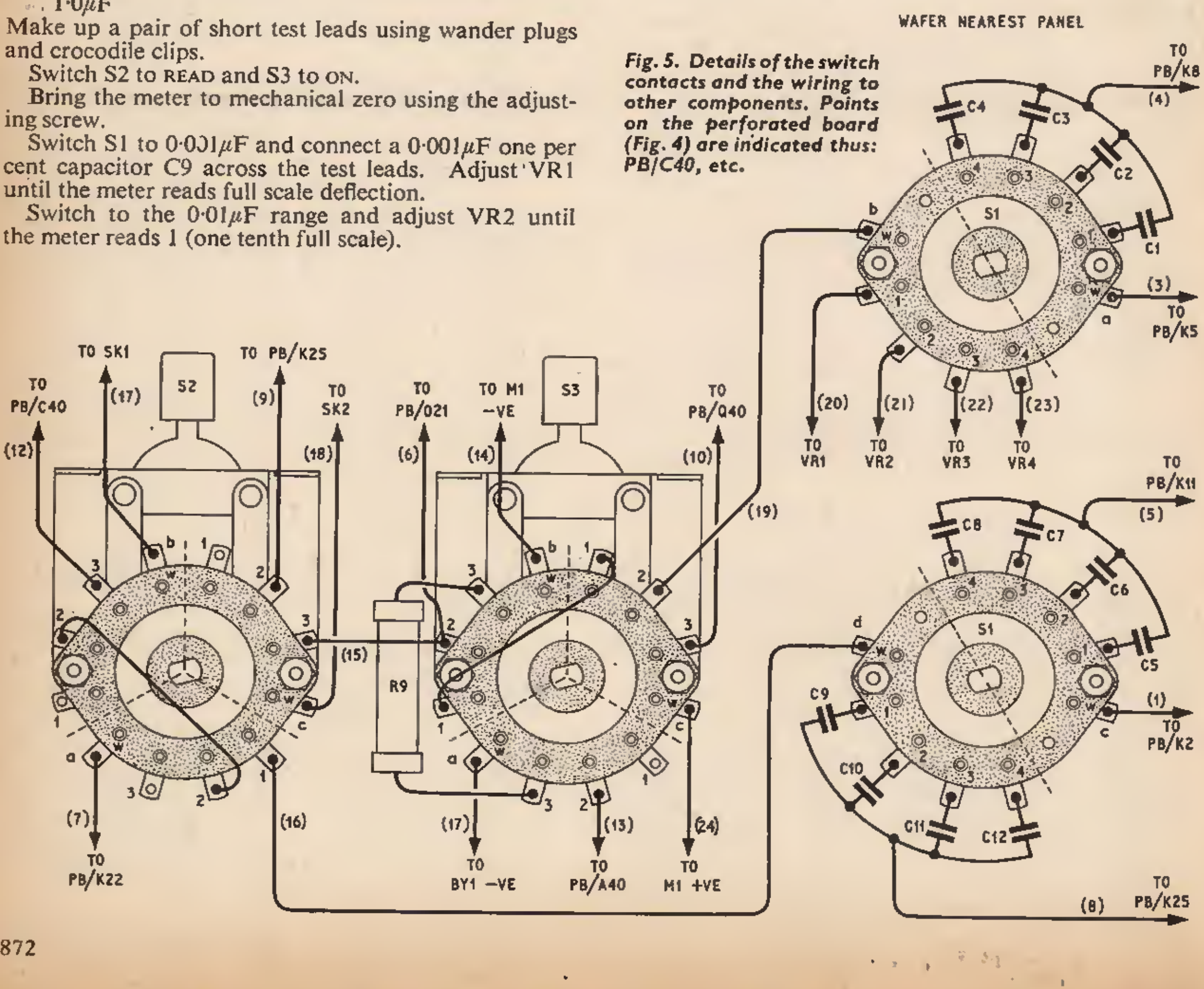


Fig. 5. Details of the switch contacts and the wiring to other components. Points on the perforated board (Fig. 4) are indicated thus: PB/C40, etc.

INPUT SENSITIVITY for full rated output
250mV at "PHONO" input
250mV at "TUNER" input
5mV at "MIC" input

INPUT IMPEDANCE
50MΩ at "PHONO" input
50MΩ at "TUNER" input
10kΩ at "MIC" input

CROSSTALK
Better than 75dB at 1kc/s

Integrated Stereo Amplifier

TONE control—bass
+18dB, −15dB at 40c/s

TONE control—treble
+18dB, −18dB at 15kc/s

BALANCE control
20dB total between channels

SIGNAL-TO-NOISE RATIO
Better than 90dB at full rated output

FREQUENCY RESPONSE
20c/s to 18kc/s ± 2dB

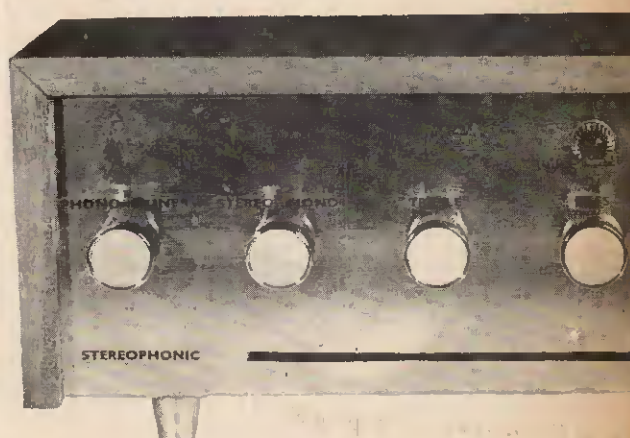
OUTPUT to feed tape recorder
300mV r.m.s. at 5·6kΩ

OUTPUT per channel
15 watts r.m.s. maximum in 15 ohms

TOTAL HARMONIC DISTORTION
Less than 0·3% at 10 watts

By. R. Hirst

PART ONE



SINCE the advent of transistors in 1948 a great deal of work has been done to bring a new technique to the state of the art as it is today. It wasn't until the middle fifties however that very much use was made of the transistor with regard to the high fidelity market, this being promoted initially by H. C. Lin of America.

Transistor high fidelity equipment in this country is only a relatively recent achievement and this has usually been in the form of commercially built units. There have however been theoretical descriptions of a few original circuits but the amateur constructor has had little to choose from in the way of complete constructional amplifiers.

It is, therefore, appropriate that the design described in this article incorporates modern techniques in achieving a high performance compatible with a professional appearance. One unique feature, for example, is the use of the field effect transistor to obtain a very high input impedance, particularly useful for matching ceramic or crystal cartridges with negligible change of the input signal.

The wide range frequency response is obtained by omitting audio signal transformers and relying as far as possible on direct interstage coupling. Negative feedback is necessary in high quality amplifiers and has been fully employed here. Consequently, it was necessary to compensate for the resulting loss of gain by adding extra amplifying stages. Power amplification is derived from the use of complementary symmetry output stages feeding a pair of 15 ohm loudspeakers.

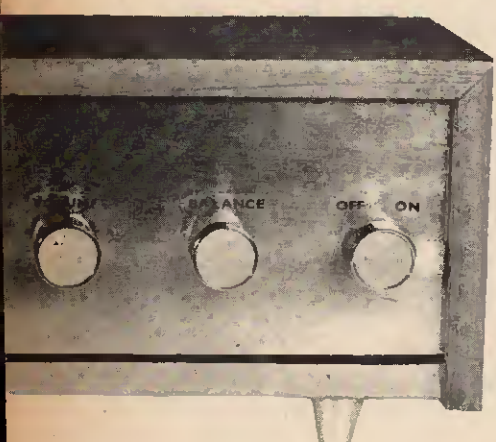
The metal-work requires only the facility to produce a right-angled bend in sheet aluminium and some means of cutting and drilling the required holes in the material in the first instance. The chassis itself acts as the heat-sink for the output transistors and supports the entire arrangement of plugs, sockets and controls, the only separate item being the component assembly board. The final assembly and wiring instructions are given and the finished unit is shown in the photographs both with and without the wooden encasement.

FIELD EFFECT TRANSISTOR

When using transistors difficulty has been encountered when trying to provide a very high input impedance to cater for capacitive output elements such as the crystal and ceramic transducers that are to be found on the majority of modern disc replay units.

With the introduction to the market of the field effect transistor this problem has been reasonably well overcome. These devices are still relatively new to the commercial domestic market and still tend to be on the expensive side, although not prohibitively so. If the constructor does not require the 50 megohm input impedance, resulting from the inclusion of the field effect transistor in the front end, then an alternative circuit has been indicated using conventional transistors giving an input impedance in the order of 5 megohms (see Fig. 1).

This alternative circuit uses the same component structure as the configuration designed around the field



effect transistor (Fig. 2), but with minor differences in the value of one or two components.

The circuitry around TR2a and TR2b using the f.e.t. has only a very small degree of gain but the considerable amount of feedback over TR2 and TR3 reduces the distortion to a minimum. This feedback, in conjunction with the bootstrapping arrangement, establishes the very high input impedance.

With an input impedance of 50 megohms it is possible to reproduce, quite linearly, frequencies of the order of 15c/s when the transducer has a capacitance in the region of 500pF. However in the alternative circuit (Fig. 1), where a transistor replaces the f.e.t., the response from a similar capacitive source will be 3dB down at about 65c/s; still quite adequate for the majority of users.

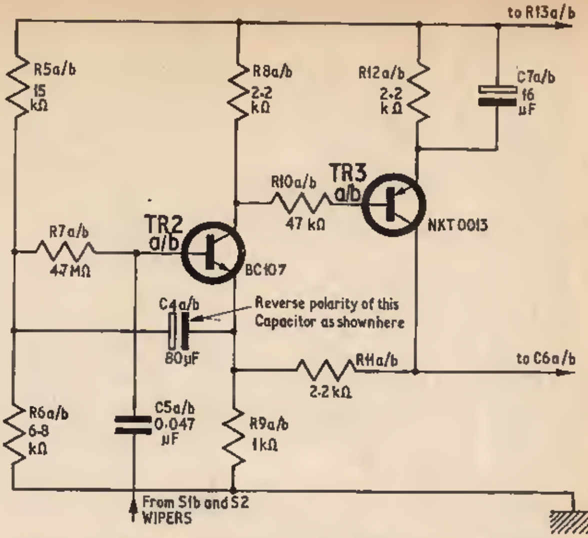


Fig. 1. Transistor stage to replace the f.e.t. circuit if very high input impedance is not required

CIRCUIT DESCRIPTION

The main power amplifier of each channel contains six Transistors TR4–9, five of which are directly coupled and shown in Fig. 2. This coupling of the output stages and driver transistor assists in maintaining a relatively accurate d.c. operating point which, under normal conditions, would tend to change due to temperature variation if the d.c. feedback is omitted.

Tracing this compensating action through TR5, TR6, TR7, TR8, and TR9, it will be noticed that, if the leakage current in TR5 increases, then the collector voltage of this transistor will tend to go more positive, thus biasing TR6 in such a fashion that the collector voltage of this transistor biases TR8 on. Consequently the collector of TR8 and the emitter of TR9 promote a rise towards the positive rail at the junction of the emitter of TR9 and the collector of TR8.

We can see that this change in voltage is fed back via the preset potentiometer VR5 to the base of TR5. As the voltage goes more positive at the base of TR5 then this transistor makes an effort to decrease the current flowing in its collector circuit, restoring the collector voltage to its original condition.

The lower output pair of transistors TR7 and TR9 also assist in this compensating action in a slightly different manner. As the collector of TR5 rises towards the positive rail, then both TR7 and TR9 emitters rise in the positive direction. This rise is reflected back to the base of TR5 once again reducing the collector current flow in TR5 and restoring the circuit to its earlier condition.

This feedback path also acts upon the a.c. signal linearising the response over the output configuration. However, this feedback is presented in the form of shunt feedback and tends to lower the input impedance of TR5. Unless fed from a substantial current source it would introduce distortion and attenuation that would not be compatable with the quality of performance required. In order to reduce this effect, a further stage TR4 was introduced, whereby the further phase shift over this stage enabled the use of a series form of feedback. This not only increased the input impedance of the main amplifier as a whole but reduced the distortion occasioned by inter-transistor coupling.

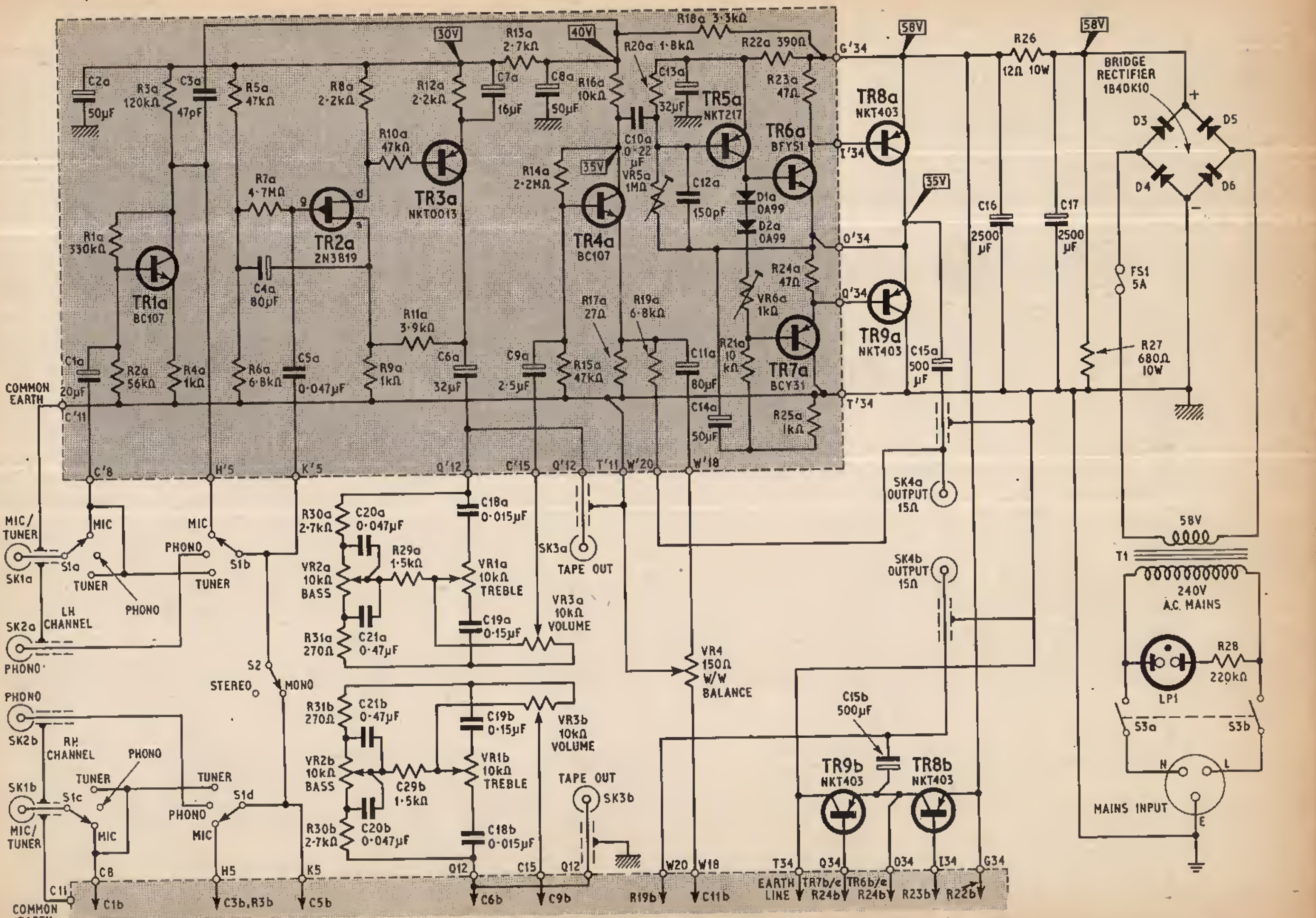


Fig. 2. Complete circuit diagram of one channel, power supplies and inter-channel control. The second channel is a duplicate of the first shown within the dotted area

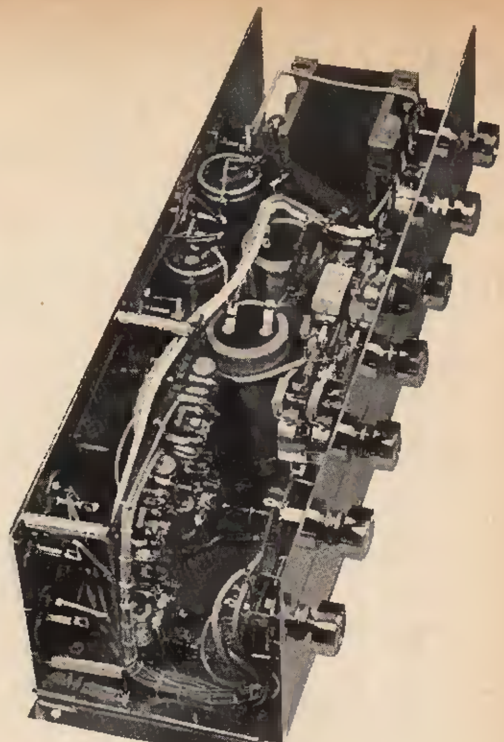
At this point the amplifier is conducive to accepting tone correction networks that are not affected to any great degree by spurious loading of the following circuitry.

The a.c. working of the main amplifier is similar in many ways to the standard common emitter configuration in as much as TR4 and TR5 follow this principle. However TR5 is the initial stage of a directly coupled circuit feeding a cascaded common emitter pair in the form of TR6 and TR8 the resultant output being out of phase to the input of TR5.

TR5 also feeds a further cascaded pair, TR7 and TR9 this time connected in the common collector configuration. The output of this pair is in phase with the input to TR5. Therefore it can be seen that phase inversion has taken place in the output circuitry by virtue of TR6 and TR7.

The main amplifier is terminated in a 500μF capacitor feeding directly to the 15 ohm loudspeaker. From the junction of this output capacitor and the loudspeaker, a sample of the output signal is fed via R18 back to the emitter of TR4 providing about 26dB of negative feedback over the entire configuration. As previously explained this feedback not only linearises the response as a whole but tends to increase the input impedance of the amplifier.

The main amplifier has an input impedance in the order of 100 kilohms and a sensitivity of about 20 millivolts for an output power of 10 watts and at this output power the distortion was in the order of 0·3 per cent being measured as the total harmonic content (Fig. 3).



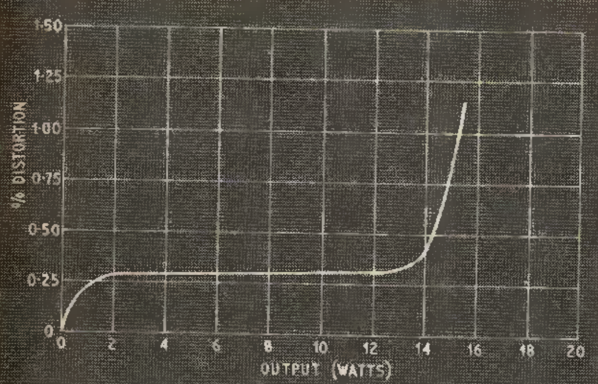


Fig. 3. Graph of the output power plotted against distortion

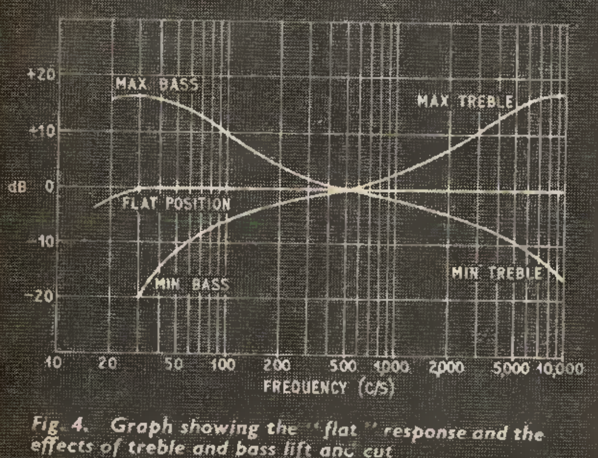


Fig. 4. Graph showing the "flat" response and the effects of treble and bass lift and cut

The tone controls are of an established pattern with approximately 18dB change (except bass cut 15dB) in both the upper and lower frequency levels above and below the flat response, indicated in Figure 4.

D.C. CONDITIONS

The a.c. conditions of the pre-amplifier stage in relation to the high impedance input point have been explained in an earlier paragraph. However the d.c. conditions again revolve around a directly coupled configuration promoting temperature compensating action of a similar nature to that indicated in the explanation of the output stages.

In this particular case the "drain" of the field effect transistor, TR2, would tend to move towards the negative rail as a result of an increase in temperature, biasing TR3 into the on condition and taking the collector of TR3 in a more positive direction.

This positive movement, unlike the action of the main amplifier, is fed into the "source" path of the f.e.t. and causes the "source" to move in a more positive direction. This action in effect is similar to making the "gate" circuit more negative, thus closing the "gate" circuit and reducing the "drain" current. This reduction in "drain" current causes the "drain" voltage to move in a positive direction, once again restoring the circuit to its original condition.

The introduction of a further stage is necessary to obtain the input sensitivity that is required to drive the amplifier to its full output when a microphone is the source of the signal input. In this instance the input has been arranged to cater for a low impedance microphone, such as a moving coil type. Any microphone with an impedance of up to 10 kilohms is eminently suitable as long as the output voltage is greater than 5 millivolts r.m.s. under normal user conditions.

COMPONENTS . . .

Where component numbers are suffixed a and b, one is required for each channel

Resistors

R1a and R1b	330kΩ
R2a and R2b	56kΩ
R3a and R3b	120kΩ
R4a and R4b	1kΩ
R5a and R5b	47kΩ
R6a and R6b	6·8kΩ
R7a and R7b	4·7MΩ
R8a and R8b	2·2kΩ
R9a and R9b	1kΩ
R10a and R10b	47kΩ
R11a and R11b	3·9kΩ
R12a and R12b	2·2kΩ
R13a and R13b	2·7kΩ
R14a and R14b	2·2MΩ
R15a and R15b	47kΩ
R16a and R16b	10kΩ
R17a and R17b	27Ω
R18a and R18b	3·3kΩ
R19a and R19b	6·8kΩ
R20a and R20b	1·8kΩ
R21a and R21b	10kΩ
R22a and R22b	390Ω
R23a and R23b	47Ω
R24a and R24b	47Ω
R25a and R25b	1kΩ
R26	12Ω 10W wirewound
R27	680Ω 10W wirewound
R28	220kΩ (with neon lamp)
R29a and R29b	1·5kΩ
R30a and R30b	2·7kΩ
R31a and R31b	270Ω

All 10% $\frac{1}{4}$ watt high stability carbon except where otherwise stated

Potentiometers

VR1a and VR1b	10kΩ log carbon twin ganged
VR2a and VR2b	10kΩ log carbon twin ganged
VR3a and VR3b	10kΩ log carbon twin ganged
VR4	150Ω linear wirewound
VR5a and VR5b	1MΩ linear carbon preset
VR6a and VR6b	1kΩ linear carbon preset

Capacitors

C1a and C1b	20µF elect. 16V
C2a and C2b	50µF elect. 40V
C3a and C3b	47pF ceramic
C4a and C4b	80µF elect. 2·5V
C5a and C5b	0·047µF polyester
C6a and C6b	32µF elect. 10V
C7a and C7b	16µF elect. 10V
C8a and C8b	50µF elect. 40V
C9a and C9b	2·5µF elect. 16V
C10a and C10b	0·22µF polyester
C11a and C11b	80µF elect. 2·5V
C12a and C12b	150pF ceramic
C13a and C13b	32µF elect. 64V
C14a and C14b	50µF elect. 40V
C15a and C15b	500µF elect. 50V
C16	2,500µF elect. 64V
C17	2,500µF elect. 64V
C18a and C18b	0·015µF polyester
C19a and C19b	0·15µF polyester
C20a and C20b	0·047µF polyester
C21a and C21b	0·47µF polyester

Transformer

T1 Mains transformer: pri. 0-240V; sec. 0-58V at 50mA
(Belclere Limited, 385 Cowley Road, Oxford)

Transistors

TR1a and TR1b	BC107 (Newmarket)
TR2a and TR2b	2N3819 (Texas)
TR3a and TR3b	NKT0013 (Newmarket)
TR4a and TR4b	BC107 (Newmarket)
TR5a and TR5b	NKT217 (Newmarket)
TR6a and TR6b	BFY51 (Mullard)
TR7a and TR7b	BCY31 (Mullard)
TR8a and TR8b	NKT403 } (Newmarket) Matched
TR9a and TR9b	NKT403 } pairs at 1A d.c.

Diodes

D1a and D1b	OA99 (Mullard)
D2a and D2b	OA99 (Mullard)
D3-D6	1B40K10 bridge rectifier (Texas)

Plugs and Sockets

SK1a-4a and SK1b-4b single pin coaxial phono sockets with plugs (8 off)

PL5 3-way mains plug (chassis mounting) with socket (type P73 Bulgin)

Fuse and Lamp

FS1 5A cartridge fuse and holder

LP1 Neon indicator with 220kΩ resistor

Miscellaneous

Front panel 18 s.w.g. aluminium 14in × 8$\frac{1}{4}$in
Rear panel 18 s.w.g. aluminium 14in × 4$\frac{3}{8}$in
Fixing brackets 24 s.w.g. aluminium 3$\frac{1}{2}$in × 1$\frac{1}{16}$in (2 off)
Capacitor clips to suit C16 and C17
Perforated s.r.b.p. sheet 0·1in square matrix of holes 5in × 3$\frac{1}{2}$in
Softwood and veneer for case
Modern style knobs (7 off)
Capacitor half clips for C15a and C15b
Mica washers, nylon screws, silicon grease for transistors
Mounting feet $\frac{3}{4}$in high
Nuts and bolts, Letraset lettering for panels
Tinned copper wire, 22 s.w.g. and 12 s.w.g.

Alternative components for transistor BC107 used in second stage (see Fig. 1).

Resistors

R5a and R5b	15 kΩ
R11a and R11b	2·2 kΩ

Transistors

TR2a and TR2b	BC107 (Newmarket)

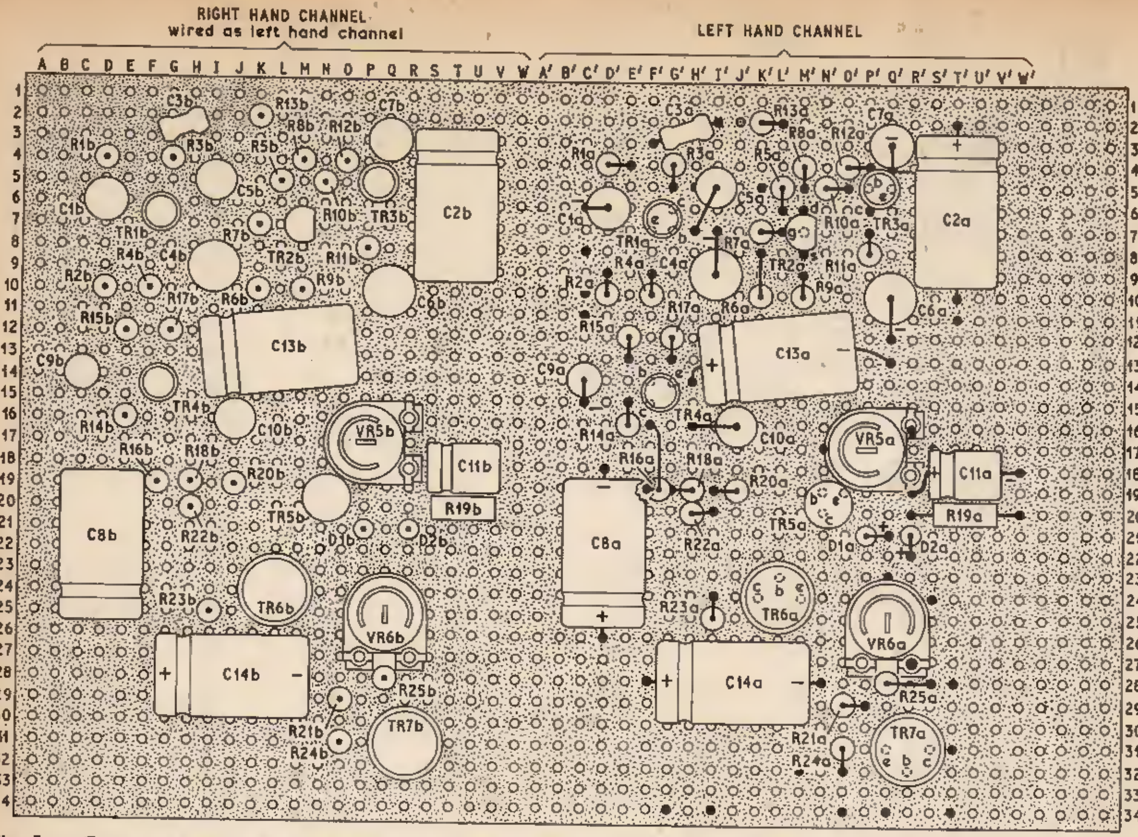


Fig. 5a. **Component assembly of one channel. The components of the second channel are shown with connections**

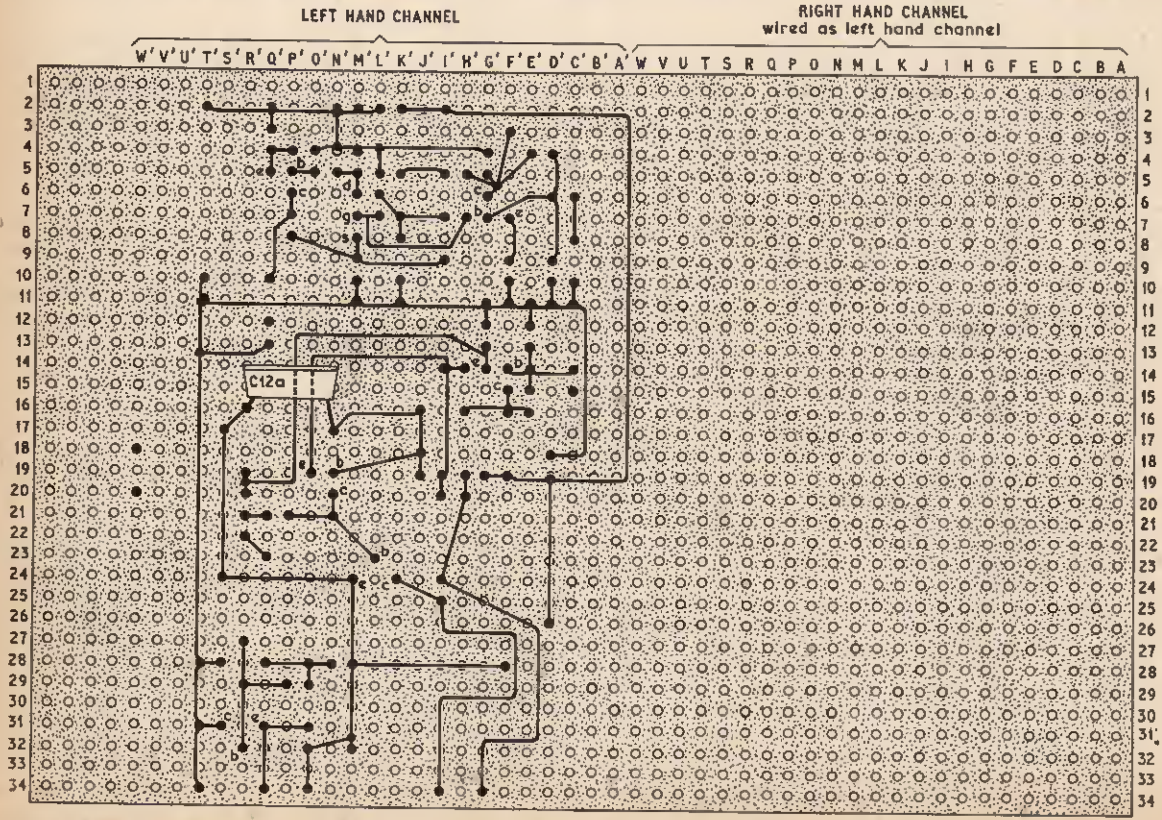
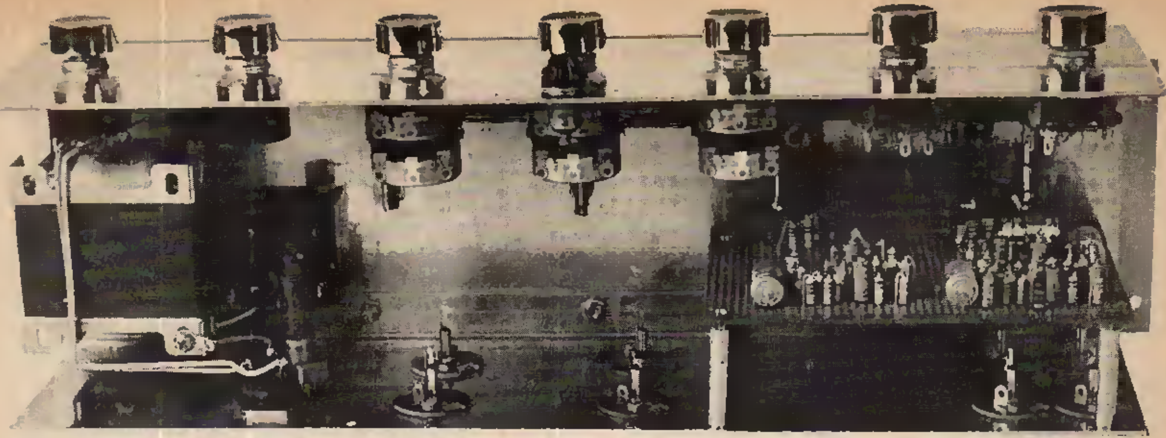


Fig. 5b. **Inter-component wiring. The other channel is to be wired up in an identical fashion on the other half**



Half-way stage in assembly, showing the component board in position. Some of the chassis mounted components are still to be fitted and wired. Some wires should be extra thick (see text)

This stage from a d.c. point of view is of a standard nature where the temperature stability depends upon the emitter to base voltage constancy. The inclusion of an emitter resistor obviously tends to promote some form of compensation.

As the temperature rises the emitter current of TR1 tries to increase thus dropping a greater voltage across the emitter resistor, making the emitter potential more positive or, in other words, the base potential more negative. This action closes down the V_{be} characteristic and reduces the current through the emitter circuit restoring the circuit to its original condition.

The a.c. gain in this configuration could be considerably greater than that achieved, but has been deliberately reduced by the introduction of series feedback by virtue of the emitter resistor that has been left undecoupled. This has given rise to a much higher input impedance and reduces the distortion in the stage by a considerable degree.

Yet due to the relatively high gain transistor used in this stage, it still provides a gain in the order of 36dB. This results in an input sensitivity in the order of 5mV for full output when the gain control is in the maximum position. The signal-to-noise ratio is still very high, the noise being some 70dB below the signal.

TRANSISTORS

With reference to the Mullard devices, there is no direct equivalent without some slight modification to the circuitry of the amplifier. The manufacturers state that these transistors are obtainable from their distributors.

The only unit that may pose a problem, is the f.e.t. 2N3819. In this instance there are near replacement types that can be used, these being TIXS 41, TIXS 42, TIS 34, TIS 14 and the 2N 3821 series, as supplied by the manufacturers, Texas Instruments, Manton Lane, Bedford. All the Newmarket transistors are ex-stock.

BOARD CONSTRUCTION

The main amplifier board in this particular instance is a perforated s.r.b.p. sheet with a hole matrix of 0·1 in. The interconnecting wiring is made up from 20 s.w.g. tinned copper wire (Fig. 5b).

It is essential that all joints are mechanically sound prior to soldering because, should any semi-soldered or dry joints be present in the final construction, they could quite easily result in totally different performance figures being obtained upon test.

This in the main is due to the rather heavy current operation that is found in a transistorised amplifier handling some considerable power. Any poor joints represent an impedance which can conceivably promote positive or negative feedback over some of the stages with disastrous results. This factor cannot be too strongly stressed as the whole performance of the instrument depends upon very low impedance supply return paths.

After the amplifier board has been fixed in position two pieces of 12 s.w.g. tinned copper wire have been introduced in order to ensure that the return path to the chassis should contain as little impedance as possible. Should these pieces of copper wire be omitted then the input sensitivity of the microphone input stage deteriorates by as much as 20dB and also promotes instability in this particular stage.

It is worthwhile checking the component board two or three times prior to final fixing to the rear chassis as any removal of this item would be a tedious operation once the amplifier is completely wired.

From a mechanical point of view the board was fitted with hank bushes so that there should be no necessity to hold nuts and washers while trying to screw up the fixing bolts, and while this is not strictly necessary it will prove to be of considerable help in the final construction.

For those who have the required facilities it will be quite easy to make the board as a printed circuit proper; quite obviously this will save a great deal of time in the construction.

Next month: Constructional details, assembly and testing.

ELECTRONORAMA

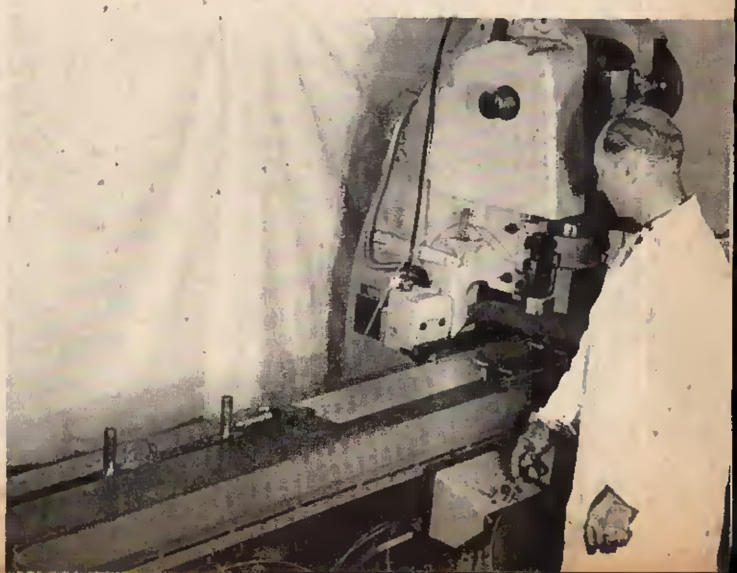
HIGHLIGHTS FROM THE CONTEMPORARY SCENE

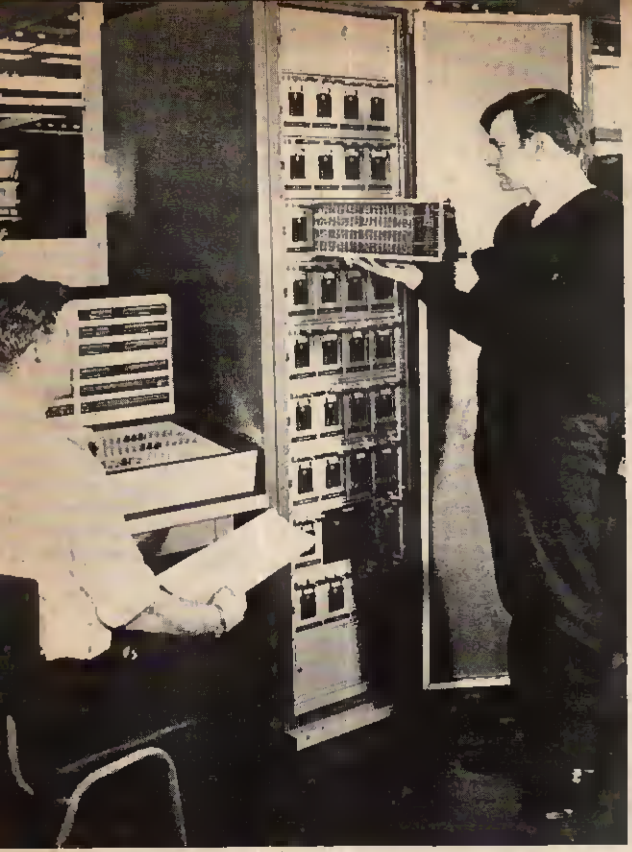
New Factories Opened

THIS young lady (above left) is assembling "time interval" units in the new Hewlett-Packard plant near the Forth road bridge in Scotland. Keeping a watchful eye is Lord Hughes (centre), Joint Parliamentary Under-Secretary of State for Scotland, who performed the inaugural ceremony of the new plant.

ON 24th October the Earl Mountbatten of Burma opened a new clean air zone, a dust free assembly line, at Dover where Avo valve testers and other instruments are being assembled (above right).

NOW occupying new premises at Chandlers Ford is the factory of Vero Electronics. Below we show two pictures of the manufacturing process of Veroboard. On the left is a press and indexing mechanism with a sample sheet mounted under it. This machine can be programmed to pierce a known matrix of holes in the copper clad material. On the right, the milling machine cuts away the unwanted copper between each row of holes to leave the familiar copper strip pattern of Veroboard.





West London Traffic Control

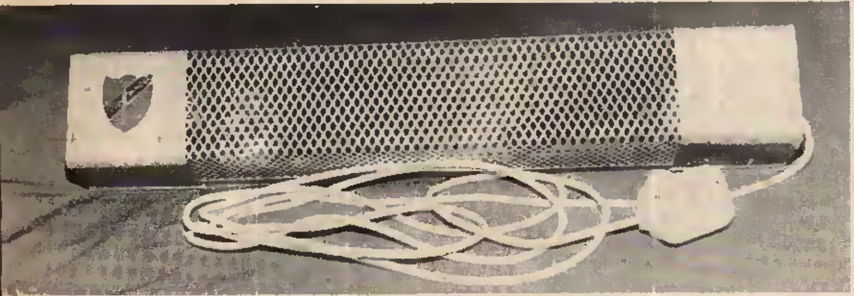
AMONG new traffic control systems now developed is this Plessey XL9 on-line computer. Two such systems are being installed for the Ministry of Transport in West London. They will form part of what is claimed to be the world's most advanced fully integrated computer controlled traffic system.

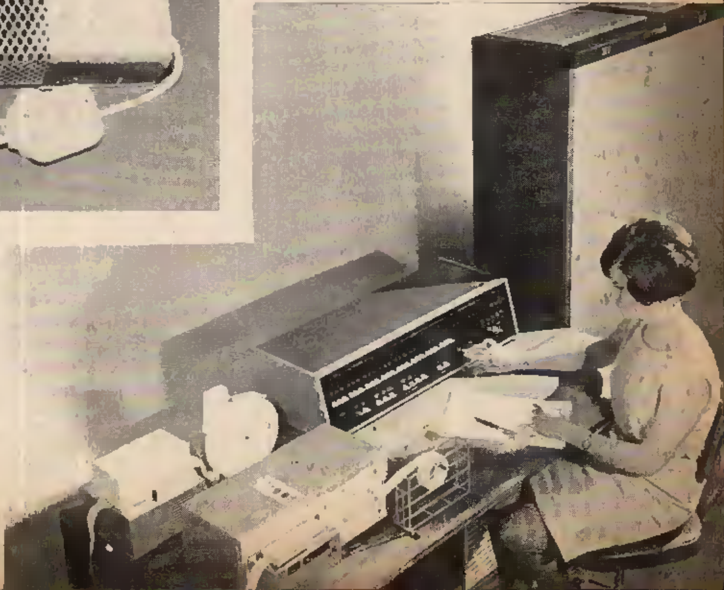
Laser Gyro

THREE ring lasers illuminate the face of a technician who makes final inspection of an advanced laser gyroscope developed by Honeywell Systems and Research scientists in past 12 months. Each ring uses two contra-rotating beams of coherent light to sense angular attitudes in one axis.

Myriad II

THIS new microelectronic computer (below), Myriad II is a simpler version of Myriad I developed by Marconi.





Smoke Alarm

ALTHOUGH this "cage" (above) may seem unimportant to look at, it holds the secret of a new type of fire alarm developed by the Vigilante Fire Alarm Company of Shoreditch, London. This device sets off a powerful alarm immediately a small amount of smoke is detected. Hence, the alarm is raised earlier than with many conventional heat or flame detecting devices.

THE LUMOSTAT

by M.L. MICHAELIS M.A.

PART TWO

CONTINUING from the penultimate paragraph of last month's article . . .

There is no need to change any control settings when making a long series of pictures from film strips at the same enlargement factor and on the same type of paper, since a darker denser negative will automatically reduce the photocell current, making the capacitor take longer to charge up to cut-on for the univibrator and thus leading to the correctly increased time of exposure. The actual time of exposure is immaterial as far as mental considerations are concerned. When the picture has been aligned, it is merely necessary to press the start switch and then wait until the lamp goes off again of its own accord after the correct exposure has taken place.

PERFORMANCE SPECIFICATION

FUNCTIONS

(a) Enlarger and Photocopy Unit Exposure Control, Auto and Timer functions.
(b) Precision voltage stabiliser for Enlarger.
(c) Switchboard for Safelights, etc.

INPUT VOLTAGE

A.C. Mains.

SWITCHED OUTPUTS

Black & White Safelight
Colour Processing Safelight
Red Safelight
Subdued White Light
} A.C. Mains, via individual toggleswitches

Photocopy Unit 400W, via Exposure Control Circuit, A.C. Mains.

STABILISED OUTPUT

185/245V 400mA d.c. for Enlarger, Stabilised, via Exposure Control Circuit.

CHARACTERISTICS OF STABILISED D.C. OUTPUT FOR ENLARGER

(a) Any output voltage between 185V and 245V d.c. may be set with VR1.
(b) The set output voltage is constant to better than:
$\pm$ 125mV for input mains voltage (a.c.) changes $\pm$ 30V about nominal value.
$\pm$ 350mV between no-load and full load.
(c) Output impedance = approx. 10 ohms.
(d) Ripple on output: NO LOAD: 25mV r.m.s.
FULL LOAD: 50mV r.m.s.
(e) Surge performance:
The cold resistance of a lamp filament is approx. 10% of working hot resistance. The switch-on surge of a 75W lamp is thus 750W peak. This surge causes a maximum dip of 6V with a mean recovery time of 7 milliseconds. The dip and recovery are dead-beat, without any overswing or damped oscillation.
The output voltage is disturbed for a maximum time of 10 milliseconds (half a mains period) and to a maximum extent of 6V, due to lamp switch-on surges. (Oscilloscope measurements).

CHARACTERISTICS OF EXPOSURE TIMER FUNCTION

Coarse Control: 0·5 to 30sec in 11 approx. logarithmic steps.
Fine Control: 0·25 to 2·5 times (multiplication factor).
Resulting Total Range: ⅛sec to 75sec.
Accuracy and Reproducibility: $\pm$5% (within tolerance of all photographic materials). The timer runs via the stabilised d.c. supply and is thus unaffected by even large mains voltage fluctuations

CHARACTERISTICS OF AUTOMATIC EXPOSURE FUNCTION

Same total range ⅛sec to 75sec as for timer, on automatic basis for wide range of paper speed and picture size settings.
Leakage time in *slowest* setting: at least 120sec, photocell connected but completely dark.
Leakage time in *fastest* setting, photocell disconnected: at least 60sec (wiring insulation check).

The automatic exposure function runs via the stabilised d.c. supply and is thus unaffected by even large mains voltage fluctuations.

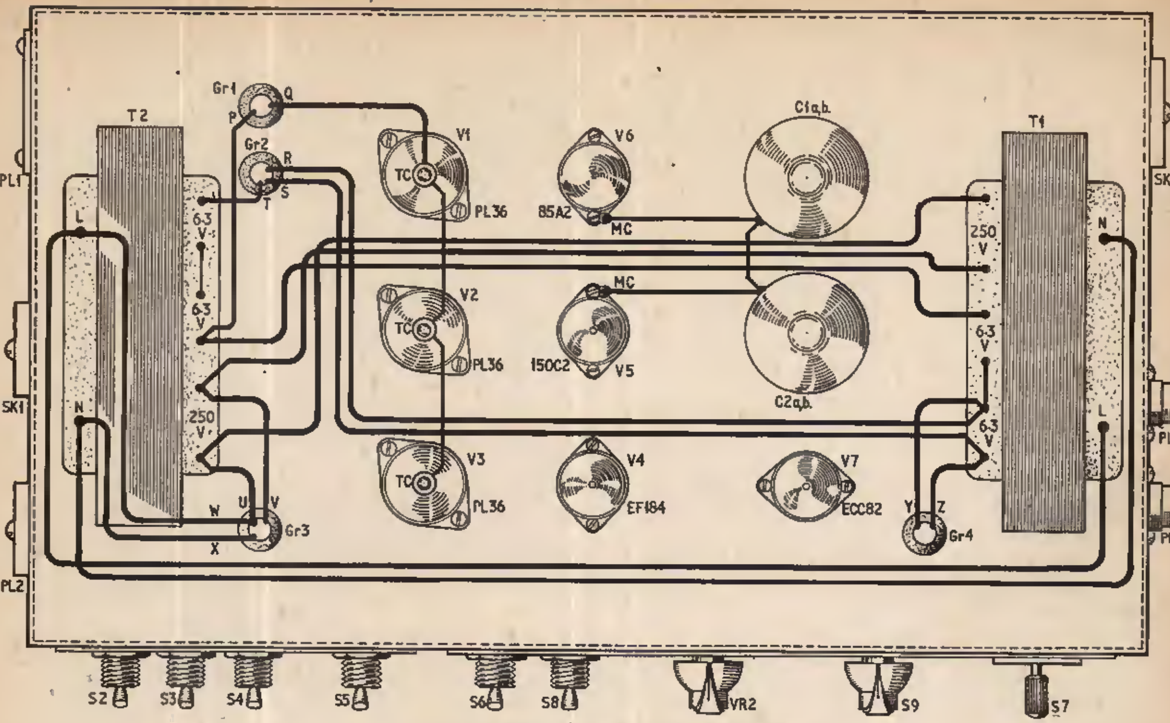


Fig. 2. Above chassis layout and wiring

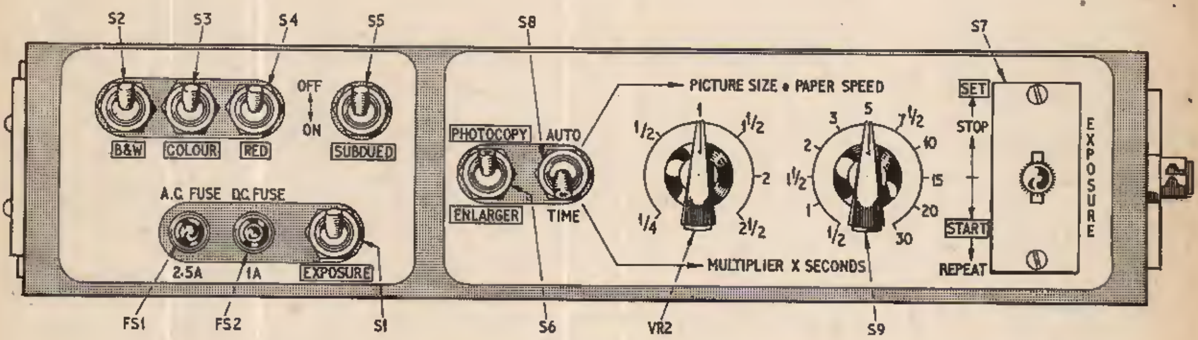


Fig. 3. Front panel details, with engraving as on prototype

AUTOMATIC EXPOSURE SEQUENCE

Contact 2 of RLB rests shorting V7 grid pin 2 circuit to chassis when the relay RLB is de-energised, as it always is except during an exposure. Its positive supply line is interrupted at contacts 5,6 of the exposure control switch (a GPO keyswitch) S7. The negative side of the coil of RLB is connected straight through to the rectifier D5–D8, whilst the positive supply from C6 via R16, R17 and the closed contact of RLC/1 reaches centre contact 5 of S7 via resting contacts 8,9 of S7. Between contacts 5 and 6 the circuit is still open, so that RLB is not energised. The exposure is started by momentarily pressing down the keyswitch S7 and releasing it again immediately (it does not latch in this direction). This makes contacts 5,6 without breaking 8,9, so that the energising circuit for RLB is completed and this relay pulls in. So also does the main circuit breaker RLA which switches-on the lamp, because it receives its positive through connection via 5,6 and 2,3 of S7. Both relays RLB and RLA now remain energised even when S7 is released because as soon as RLB is energised its contact 1 moves over and bridges 5,6 of S7. Contact 2 of RLB has also opened, so that the grid circuit pin 2 of V7 is now free for the selected capacitor to begin to charge up positively. Conditions remain steady as far as the relays are concerned, with the lamp on, until grid pin 2 of V7 reaches cut-on. This results in RLC dropping off momentarily, which in turn causes RLB and RLA to drop off since the contact of RLC interrupts their common positive line. The holding contact A on RLB is immediately lost, so that the relays do not re-energise when RLC pulls in again after the brief response pulse of V7. The lamp remains off and the grid capacitor is discharged via RLB contact 2. A new exposure sequence can take place only when S7 is momentarily pressed down anew.

CONTINUOUS LIGHT AND INTERRUPTION OF EXPOSURE

In between exposures, the enlarger lamp is required to be switched on continuously for setting-up the next

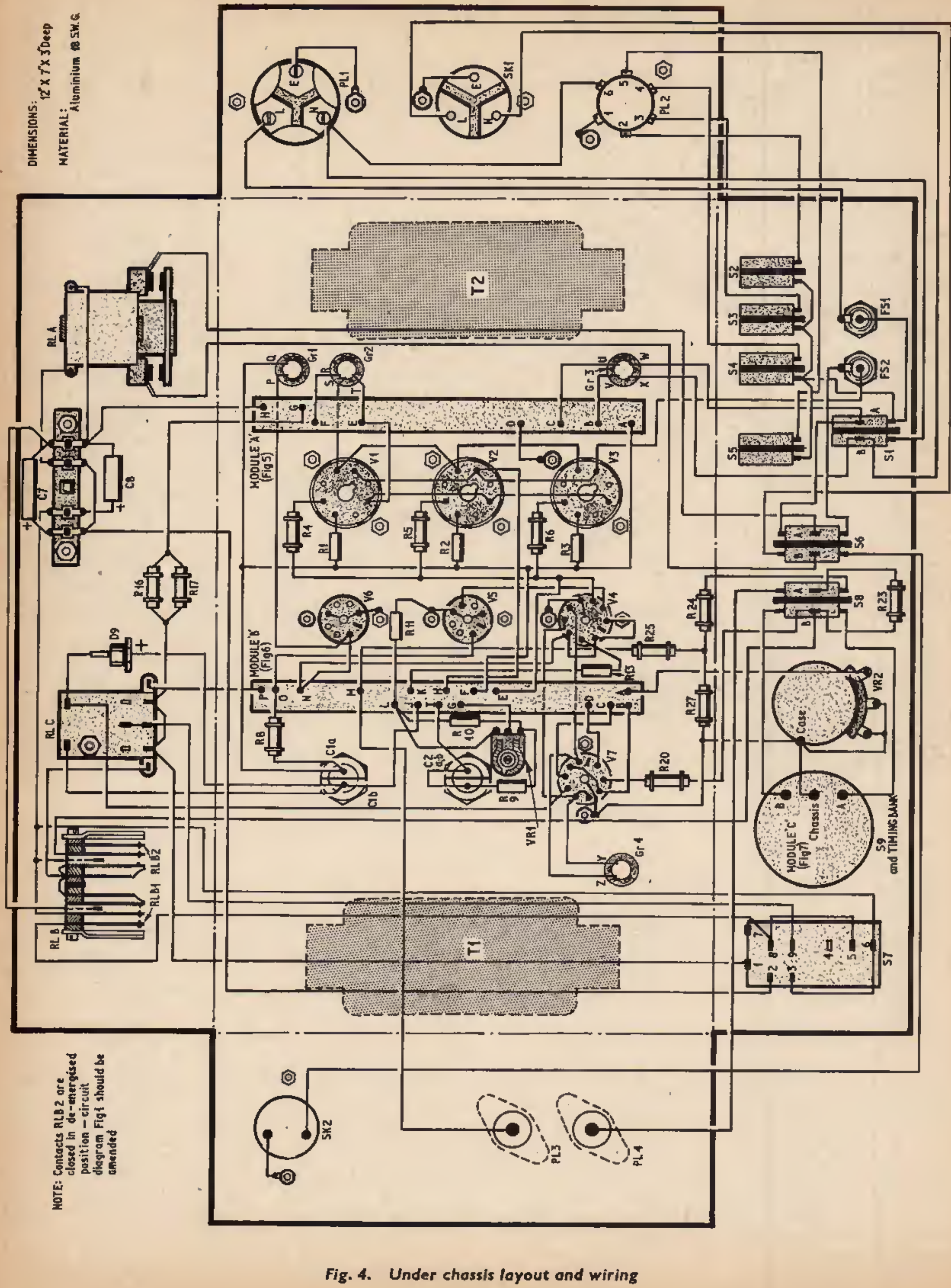


Fig. 4. Under chassis layout and wiring

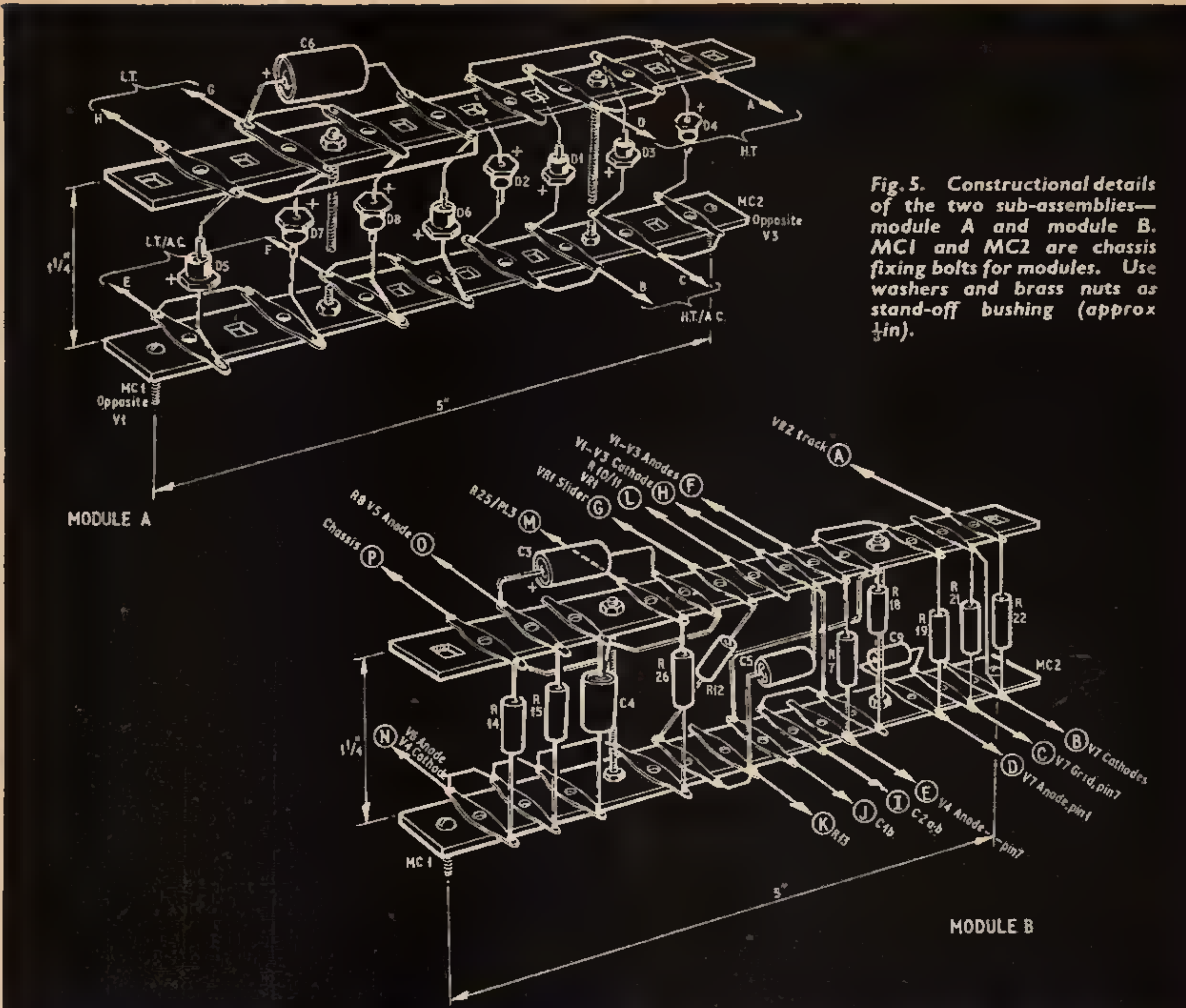


Fig. 5. Constructional details of the two sub-assemblies—module A and module B. MC1 and MC2 are chassis fixing bolts for modules. Use washers and brass nuts as stand-off bushing (approx ⅛in).

picture. This facility is provided by the upward movement of the keyswitch S7. All GPO keyswitches of this kind have three positions—a centre one and a "down" as well as an "up". The down position is here non-latching and was used to start an exposure. The up position latches and provides continuous light by giving the circuit breaker RLA direct positive feed via 1 of S7.

The second upper contact 9 of S7 serves the purpose of permitting premature termination of an exposure. The contacts should be bent such that a very slight upward movement of the toggle breaks 9, long before 2 moves over to 1 in the fully latched-up position. Contact 9 is directly in series with the contact of RLC and thus has the same effect. It terminates the exposure and zeroes the computer when it is momentarily opened.

The keyswitch S7 thus provides a very convenient and neat "joystick" control of the lamp. An exposure, whether by time or automatic compution, is started by briefly depressing the toggle. It can be terminated prematurely at any moment by lightly tipping the toggle upwards, and continuous set-up light is obtained by latching the toggle right up. If the toggle is held down, a new exposure is commenced as soon as a previous one is completed, in continuous sequence as long as the toggle is held down. This is the "repeat" function where required.

SAFETY MEASURES

Relay RLA is required because neither RLB nor the keyswitch will make or break a 75W d.c. lamp circuit without considerable danger of exciting a non-extinguishing d.c. arc. Both components will normally switch 75W a.c. at 220V, but not d.c. A special type of relay with a very fast snap action, large substantial contacts and two-point interruption is necessary for efficient interruption of the d.c. circuit. The type of circuit-breaker relay used for switching-on a rotary transformer set via a small switch on the dashboard of a motor vehicle carrying electronic equipment is very suitable. A 24V model is here required, as originally intended for vehicles with a 24V accumulator battery. The contacts will normally switch 220V just as efficiently as 24V; no trouble whatsoever was here experienced with the prototype.

The anode current of V7 pin 6 depends upon the setting of VR2. D9 was thus added in order to nevertheless maintain nominal operating voltage across RLC. This is important to prevent overheating in the higher current settings, since RLC is energised continuously except during the brief response pulses terminating an exposure. At the same time D9 bypasses inductive surges when V7 anode pin 6 current is cut off suddenly. This bypass function is under-

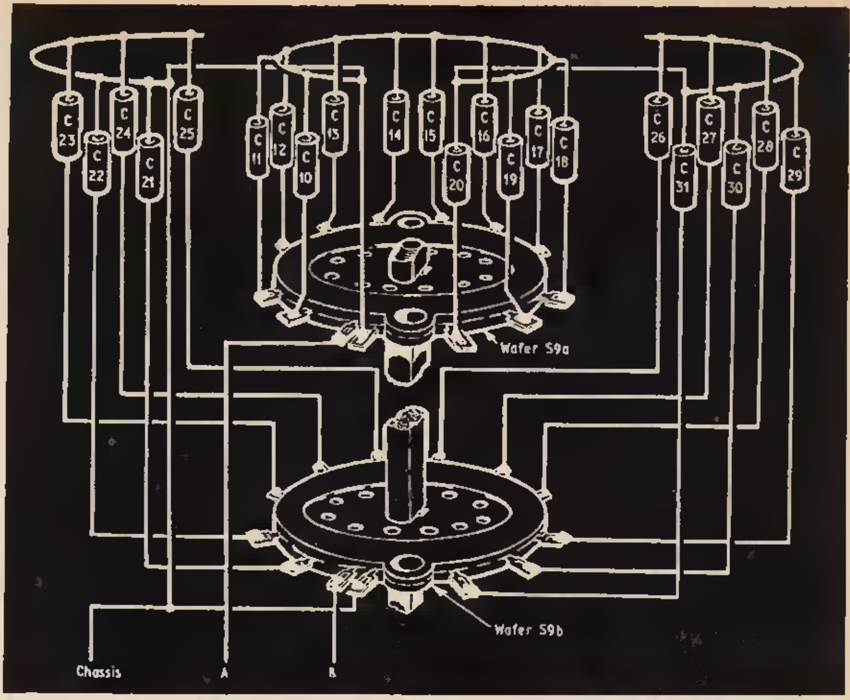


Fig. 6. Timing bank switch assembly built up from two 12-way wafers (Radiospares "makaswitch"). Since only 11 positions are required an 8 B.A. screw should be inserted in one of the holes in the index plate to stop the switch at position "2". The spare tag at position "1" is used to anchor the earthing ring: this should be made of 16 or 18 s.w.g. tinned copper wire

taken by C7 and C8 respectively for RLA and RLB. R16 and R17 were added to stop spitting at the contacts of S7 which formerly took place due to the instantaneous transfer of charge from C6 to C7 and C8.

THE TIME FUNCTION

When S8 is switched over to the time function, the other wafer of S9 with larger capacitors is brought into circuit, so that the required times of charge are obtained with smaller charging resistors. The virtual resistance of the photocell may take on values up to a 1,000 megohms or more in feeble light, which are not conveniently realisable with standard carbon resistors on the time function. Thus whilst quite small capacitors ranging from about 1,000pF to 0·1μF are required in conjunction with the photocell, values some 10 times greater are required for the time function in conjunction with the largest values of conveniently obtainable carbon resistors.

In contrast to the automatic function via the photocell, the time of charge of the capacitors via ordinary resistors is exponential, not linear, and is strongly dependent upon the applied input voltage to the top end of the resistor chain. This aiming voltage is thus stabilised, coming from the neon tube V6. Chiefly R25 and R27 constitute a bleeder for this input voltage on the time function only, feeding some lower voltage to R24 + R23 as actual charging resistors. A set of 11 logarithmically staggered capacitors between 15nF and 1·0μF will give a set of logarithmically staggered times of run from 0·5 seconds to 30 seconds with VR2 set mid-way. The range of control of VR2 considered as time multiplication factor is some 0·25 to 2·5 with the specified component values.

For initial calibration, set VR2 exactly mid-way and then adjust the value of R27 by adding other series and/or parallel resistors until the time of run is exactly 30 seconds with the 1μF capacitor in circuit. Then without moving VR2 trim the other capacitors by judicious selection and/or parallel additional capacitors until the sequence 0·5/1/1·5/2/3/5/7·5/10/15/20 seconds is obtained for the other switch positions. Then find the positions of VR2 which quarter, halve, ×1·5, double, and ×2·5 these times, and mark them on a multiplication factor scale attached to VR2. The action of VR2 is to shift the cathode potential of V7 and thus the voltage to which the capacitors must charge before pin 2 grid cuts on and brings a response pulse.

The total range of calibrated times is thus from an eighth of a second to 75 seconds, covering all exposure times required for enlarger and film-to-film as well as photocopy work. The very short times are best calibrated in the "repeat" function whilst holding S7 down and counting the time taken for 10 sequences. Subtract one second for the 10 response pulses of 0·1 seconds duration each and divide the remainder by 10. The result is the duration of one run, and if not correct, modify the relevant capacitor value.

CALIBRATING THE AUTOMATIC FUNCTION

It is convenient to mark the scales of S9 and VR2 only in seconds and time multiplication factors as described above for the time function, since only these times are an unambiguous attribute of the Lumostat. The particular settings corresponding to a definite paper speed and picture size in the automatic function setting will also depend upon the geometry of the enlarger system. It is therefore a good procedure to prepare a table of "seconds" setting of S9 for each type of paper or copy film used in conjunction with a fixed set-up, and another table giving "factor" setting of VR2 appropriate for each picture size. The settings according to these two tables will be found to be mutually independent for all normal purposes.

The final instalment of this article next month will contain constructional details of the photocell sensing unit as used in the automatic function, and also a general discussion concerning the operation of the Lumostat.

BSR UA70
now with cueing device

BSR add yet another plus feature to the remarkable UA70 automatic/manual turntable unit by including an integral mechanical cueing device — and without increasing the price. This cueing device allows the pick-up arm to be raised or lowered at any selected point on a record during manual play. Raising the cueing lever lifts the pick-up arm which may then be positioned above the record at the chosen point. The stylus is lowered gently to the groove by returning the lever to the rest position.

Now, more than ever, the UA70, with its wealth of outstanding design features, fine engineering and high performance, provides the selective listener with a turntable unit of quality unsurpassed in this price range.

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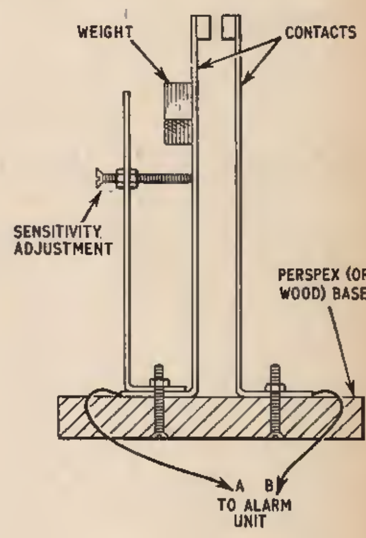
IN THIS feature we hope, from time to time, to be able to publish suggestions submitted by some of our readers on the possible improvement of projects previously described in PRACTICAL ELECTRONICS; short contributions on other subjects may be included. The aim is not to find fault or undermine the abilities or knowledge of our contributors. It may well be that the original article is *par exellence* but it could be improved or adapted to suit individual requirements. The views expressed by readers are not necessarily those of the Editor.

TREMBLER BURGLAR ALARM

This burglar alarm is easily constructed from readily available components and the layout is in no way critical. It comprises two separate units; the alarm unit and a remote trembler unit. The relay is a surplus Post Office type with all but two sets of make contacts removed. The spare contacts are used to make the trembler units.



Trembler Unit

The trembler unit is shown in Fig. 1. Two contacts are bent and mounted vertically on a base cut from Perspex or wood. A brass nut, used as a weight, is soldered to one of the contacts to encourage it to tremble. The sensitivity of the unit is controlled by the adjustment of a bolt fixed through a metal L-piece mounted on the base board. Two wires, each connected to one of the contacts, lead to the alarm unit.

Alarm Unit

The wiring and function of the alarm unit is best described by reference to Fig. 2. A slight movement of the trembler unit will cause the relay to close.

The first set of relay contacts will lock the relay in the closed position. This action also closes the second pair of contacts and causes the bell to ring. The bell will continue to ring until either the alarm unit is switched off or the battery runs down.

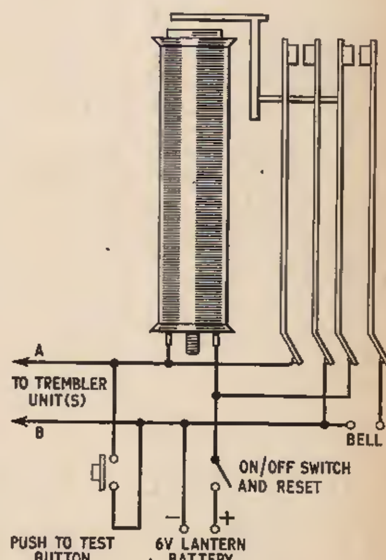
Once the alarm is set off any interference with, or even the complete removal of, the trembler unit will not stop the bell from ringing. The trembler unit can be adjusted so that any attempt to interfere with it will set off the alarm.

Setting Up

The trembler unit can be screwed to a door or window or fitted to the front gate. The alarm unit is installed well inside the house in an occupied room. Once the trembler unit is installed the sensitivity can be adjusted by experiment. Care should be taken not to make it too sensitive as it may then be liable to be set off by accident.

In one location the vibrations of a passing vehicle were sufficient to trigger the alarm. Experiment showed that the alarm could be set off by dropping a drawing pin on to a table from a height of six inches.

Adjustments must be made with the alarm unit switched off. Apart from adjusting the bolt the function of the trembler can be varied by experimenting with different weights. The unit will operate in any position but its final position will depend on the type of movement it is to detect. For the detection of slight vibrations it is most sensitive in the vertical position.

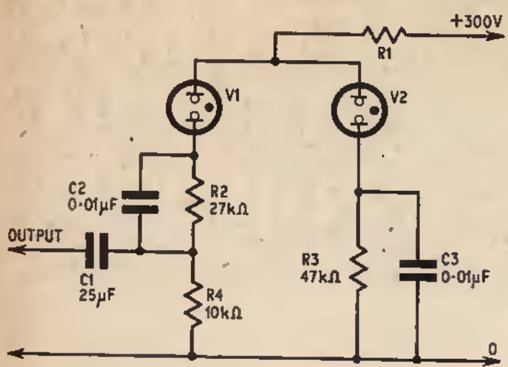


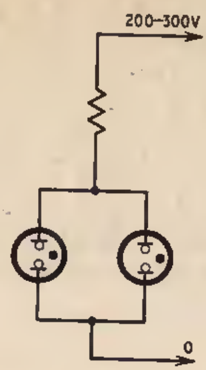
Test Switch

The test switch is simply a bell push wired in parallel with the wires leading to the trembler unit. It allows the alarm to be tested without having to visit the remote trembler unit. The circuit does not draw current from the battery until the alarm is sounded. The life of the battery is obviously prolonged and it was for this reason that it was decided to incorporate the test switch. It enables a quick check to be made and the serviceability of the battery is not taken for granted. After testing, the alarm is reset by switching off and on again.

Sgt. F. Crimmins,
Hong Kong.

NEON MULTIVIBRATOR





THE series *Neon Novelties* included several oscillators but not a multivibrator. The circuit here (Fig. 1) is very sensitive to voltage and the frequency of operation changes with the supply voltage. Here the frequency of oscillation is about 1kc/s.

The value of R1 may need to be found by experiment but should be between 600 kilohms and 850 kilohms for oscillation to occur. V2 fires at a lower voltage which can be found with the circuit in Fig. 2. The mark/space ratio can be adjusted by variation of C2–R2 and C3–R3.

H. V. Sparrow,
Deal,
Kent.

FULL CONTROL

I WAS prompted to find another source of supply for the thyristor at a much reduced cost, and to provide the facility of increasing the range of speed control (*Thyristor Control Unit*, June 1966). There are three possible methods of providing control over the full mains sine wave.

1. A triac may be used, this is a bi-directional thyristor, and apart from the excessive cost, entails complete redesign of the unit.

2. A full wave bridge rectifier may be used to convert the mains sine wave into positive going excursions, over which the thyristor may have control. This means four silicon rectifiers which must be mounted on a heat sink inside the control unit. The peak repetitive current through the rectifiers would have to be about 3A and the peak surge current in the order of 10A. In view of this and the cost of four rectifiers, this method was rejected.

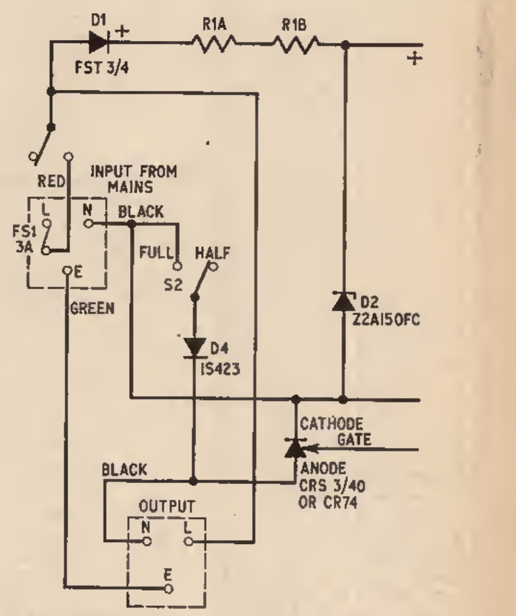
3. The third method was adopted, and consists of one silicon rectifier shunting the thyristor in the negative direction, and brought into circuit by the half/full switch.

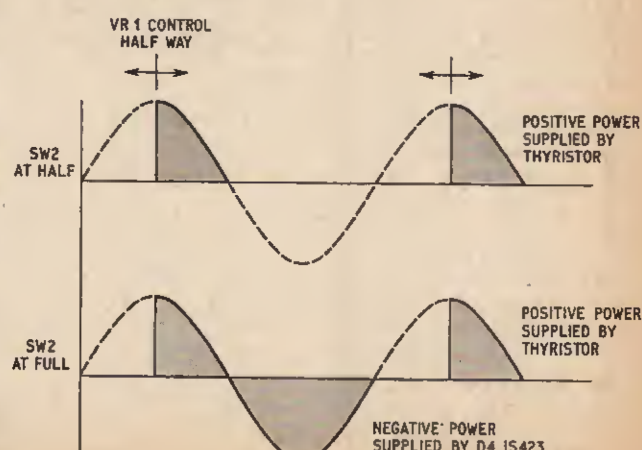
With the switch in the "half" position control is exercised over the positive half cycle; the negative half cycle is unused. With the switch in the "full" position, the negative half cycle is used complete and the positive half cycle is controlled by the thyristor. Therefore the speed of the drill or other device may be controlled from near zero to the maximum for normal mains input. Fig. 1 shows the modified circuit diagram, and Fig. 2 shows the load waveform.

The rectifier chosen to carry this out is the Texas 1S423, which is 400V p.i.v., at 10A. This is obtainable from LST Components, 23 New Road, Brentwood, Essex. The thyristor type CR74 is also obtainable from LST Components, and has an increased current rating, the maximum power handling capacity of the unit is increasec to 1·25kW. The price of the rectifier is 14s 9d and the thyristor is £1 7s 6d.

If the unit is to be left switched on for long periods, then a few ventilating holes may be drilled in the side of the box near the resistors R1a and R1b

A. Thomas,
Potters Bar,
Middlesex.





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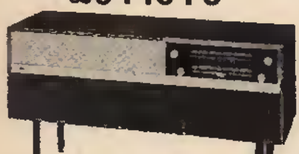

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Some New Semiconductor Devices

by D.G.WHITEHEAD B.Sc.

RECENTLY there have been a number of semiconductor devices developed which promise to increase considerably the role played by solid state elements at high frequencies. Three such devices are the *Step Recovery Diode*, the *Hot Carrier Diode*, and the *Metal Base Transistor*. These are described in this article.

THE STEP RECOVERY DIODE

The step recovery diode is especially useful as a multiplier for the generation of microwaves, but can also be used for the production of extremely fast pulses. In fact, as a generator of powerful nanosecond (10^{-9} second) pulses it has no equal.

All conventional semiconductor diodes conduct in the reverse direction for a short period of time immediately following forward conduction. This conduction results from carriers which have been injected and stored during forward conduction and will cease when all the stored charge has been removed. The step recovery diode has a large stored charge but has the remarkable property of switching from reverse conduction to its cut-off state at a speed little short of instantaneous. A typical diode, the Hewlett Packard hpa 0104 will switch from a reverse conduction of 100mA to its cut-off state in 200 picoseconds, i.e. 2×10^{-10} seconds. Indeed, some diodes now available have transition times measured in femtoseconds (10^{-15} second). This combination of switching speed and current level is not attainable with any other device known at present.

The effect can be observed by applying an alternating voltage across the diode and observing the current flowing through it by means of an oscilloscope. Fig. 1 shows a comparison between an ordinary semiconductor diode and a step recovery diode. The negative going current is the stored charge flowing out of the diode before conduction ceases.

Fig. 1a. Test circuit for diode

Fig. 1b. Current through a typical semiconductor diode

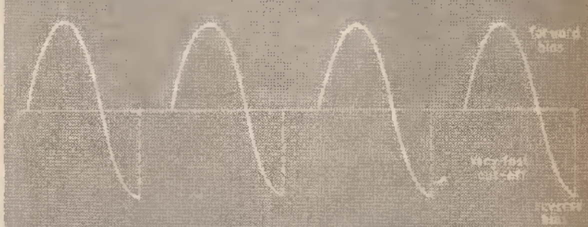

Fig. 1c. Current through a step recovery diode

To operate the device as a frequency multiplier, the sudden change in current is made to give a high Q tuned circuit a "kick". The tuned circuit will ring at its resonant frequency and if the kicks from the diode are arranged to arrive at the correct time an oscillation will build up.

For example, if we wish to derive a 2,000Mc/s signal from a 100Mc/s source we must arrange that the diode is switched on and off by the 100Mc/s excitation and the resulting fast current edge will, if fed into a high Q tank circuit tuned to 2,000Mc/s, produce a 2,000Mc/s signal, power being fed into the tank circuit every 20 cycles. Fig. 2 shows the simplicity of this method. Output powers of 100mW at 2,000Mc/s have been obtained by this method using commercially available diodes. In the near future it is expected that diodes will be available

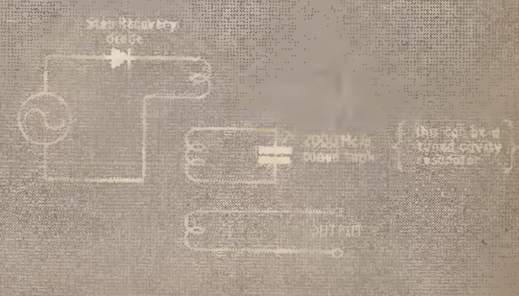

Fig. 2. Step recovery diode employed as a frequency multiplier

to provide output power of the order of a watt in the range 1–2Gc/s and 50 to 100mW in the range 8–12Gc/s. (Gc/s = 10^9c/s.)

Extremely fast pulses can also be produced quite simply. If the diode is allowed to conduct in the forward direction (see Fig. 3) and is then switched off, reverse current will flow through the diode and hold point *A* just slightly negative. When the diode ceases to conduct, point *A* will fall rapidly to a voltage determined by the resistors. This voltage fall can occur in picoseconds. If now an output is taken via a small capacitor from *A*, a negative going pulse of extremely fast rise time and several volts in amplitude is produced. Pulse circuits of this nature are now finding a use in sampling oscilloscopes to provide the necessary fast sampling pulses.

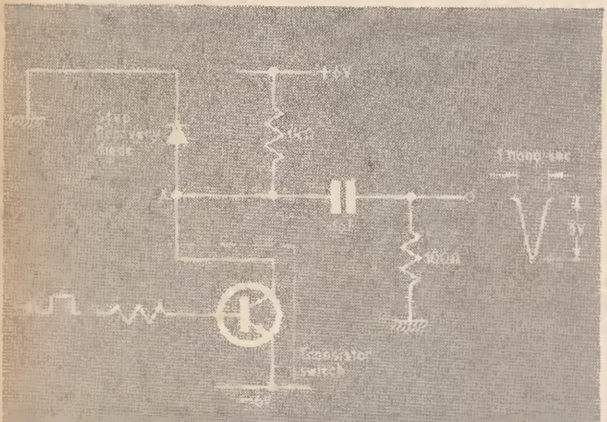

Fig. 3. Production of extremely fast pulses is achieved by this circuit arrangement

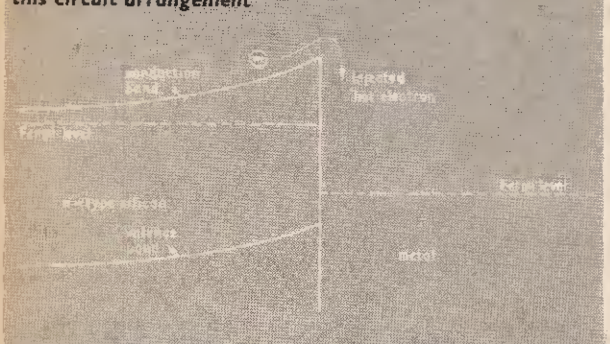

Fig. 4. Band structure of metal n type silicon semiconductor barrier

THE HOT CARRIER DIODE

The hot carrier diode has characteristics almost opposite to those of the step recovery diode. This device is also known as a *metal-silicon diode* or a *Schottky barrier diode.*

As mentioned earlier, all semiconductor diodes conduct slightly for a short time in the reverse direction due to the stored charge being removed. This stored charge sets a high frequency limit to the usefulness of the diode. The metal-silicon diode does not have this drawback. The principle behind it is not new, but it is only recently that production techniques have been developed to make the diode a commercial possibility.

The theory of operation may be seen by referring to Fig. 4. The device consists of a small area of metal evaporated onto an *n* type piece of silicon. When the diode is forward biased, electrons are injected from the semiconductor into the metal. These electrons have a much higher than average energy in the metal, hence the term "hot carrier". The electrons lose energy in the metal mainly by inter-electronic collision and when the polarity of the bias is reversed no appreciable number can be withdrawn into the semiconductor, carrier storage being virtually eliminated. Accordingly, hot carrier diodes can be used effectively in pulse and high frequency applications such as detection, mixing and limiting at microwave frequencies and the clamping and gating of fractional nanosecond pulses.

THE METAL BASE TRANSISTOR

Finally there is the metal base transistor. This has been suggested as a possible successor to the present transistor.

The theory states that transistor action can be produced by sandwiching a very thin layer of metal such as gold, between two pieces of semiconductor. The metal, which should be less than 2×10^{-6}cm thick, forms the "base" of the transistor. At the semiconductor-metal emitter junction "hot carriers", i.e. electrons with a high energy content, can be injected into the metal base. As the base region is very thin, most of the electrons pass through and reach the other junction with sufficient energy to surmount the energy barrier present and be "collected" by the semiconductor collector.

It should be apparent that this action is very similar to that performed by the holes in a normal transistor. The important difference is that the current flow is maintained by electrons which have a much higher mobility in the metal base than holes do in a semiconductor base. This means that the transit time through the device, which with present day transistors limits their application to frequencies less than 1,000 Mc/s, is very much less and calculations predict that the metal base transistor should be capable of working at frequencies well into the S-band. ★

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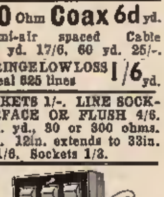


Brand New. Includes 11ft. 7-way cable, Mullard OA81 2 pots., 3 switches, 5 resistors

NEW ELECTROLYTICS FAMOUS MAKES

TUBULAR		TUBULAR		CAN TYPES	
2/350 v.	2/3	100/25 v.	2/-	8/500 v.	9/6
4/350 v.	2/3	250/25 v.	2/6	16/500 v.	12/6
8/450 v.	2/3	500/15 v.	3/-	16+16/500 v.	7/6
16/450 v.	3/-	8+8/450 v.	3/6	32+32/450 v.	6/-
32/450 v.	3/9	8+16/450 v.	3/9	50+50/350 v.	7/-
25/25 v.	1/9	16+16/450 v.	4/3	60+100/350 v.	11/6
50/50 v.	2/-	32+32/350 v.	4/6	100+200/275 v.	12/6

PAPER TUBULARS
350v.-0.1 9d., 0.5 1/9; 1 mfd. 3/-; 2 mfd. 150v. 3/-.
500v.-0.001 to 0.05 9d; 0.1 1/-; 0.25 1/6; 0.5 3/-.
1,000v.-0.001, 0.0022, 0.0047, 0.01, 0.02, 1/6; 0.047, 0.1 2/6.
E.H.T. CONDENSERS. 0.001mfd., 7kV., 6/6; 20kV., 10/6.

SUB-MIN. ELECTROLYTICS. 1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 250 mfd. 15v. 2/6; 500, 1000 mfd. 15v. 3/6; 2000 mfd. 25w. 7/-.
CERAMIC. 500 v. 1 pF. to 0.01 mfd., 9d.
PULSE CERAMICS 10 pF. to 180 pF., 12 kV., 2/6.
SILVER MICA. Close tolerance (plus or minus ½ pF.), 5 to 47 pF. 1/-; ditto 1% 50 to 800 pF. 1/-; 1,000 to 5,000 pF., 2/-.
TWIN GANG. "0-0" 208 pF.+176 pF., 10/6; 365 pF., miniature 10/-; 500 pF. standard with trimmers, 9/-; 500pF. midget less trimmers, 7/6; 500 pF. slow motion, standard 9/-; small 3-gang 500 pF. 18/6. Single "0" 365 pF. 7/6.
SHORT WAVE. Single 10 pF., 25 pF., 50 pF., 75 pF., 100 pF., 160 pF., 5/6 each. Can be ganged. Couplers 9d. each.
TUNING. Solid dielectric. 100 pF., 300 pF., 500 pF., 3/6 each.
TRIMMERS. Compression ceramic 30, 50, 70 pF., 9d.; 100 pF., 150 pF., 1/3; 250 pF., 1/6; 600 pF., 750 pF., 1/9.

BEST BRITISH PVC RECORDING TAPES

L.P. 7in. 1800ft.	19/6	D.P. 7in. 2400ft.	29/6
L.P. 5¾in. 1200ft.	14/6	D.P. 5¾in. 1800ft.	24/6
L.P. 5in. 900ft.	11/6	D.P. 5in. 1200ft.	18/6

Spare Spools 2/6. Tape Splicer 5/-. Leader Tape 4/6.
Tape Heads: Collaro 2 track 28/6 pair. B.S.R. 4 track 70/-.

MAINS TRANSFORMERS

Post 2/6 each

250-0-250, 80 mA. 6.3 v. 3.5 a. Rectifier 6.3 v. 25/-; 1 a. or 5 v. 2 a; Ditto 350-0-350, 29/6.
MT. 310/300-0-300 v. 120 mA., 6.3 v. 4 a. 29/6
MINIATURE 200 v. 20 mA., 6.3 v. 1 a. 10/6
MIDGET 220 v. 45 mA., 6.3 v. 2 a. 15/6
SMALL, 300-0-300 v. 70 mA., 6.3 v. 4 a. 19/6
HEATER TRANS. 6.3 v. 1½ a., 7/6; 6.3 v. 4 a. 10/6
Ditto tapped sec. 1.4 v., 2, 3, 4, 5, 6.3 v. 1½ amp. .. 10/6
GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 25/-
Ditto, 1 amp., 5, 10, 15, 20, 25, 30, 35, 40, 55, 60.. 29/6
Sub-Min. Mains to 9 v. 80 mA. 1 × 1½ × 1¼in. 7/6
AUTO TRANSFORMERS 0-115-230 v. Input/Output, 60w. 18/6; 150w. 25/-; 500w. 82/6

CRYSTAL MIKE INSERTS

1½ × ⅜in. 6/6; BM3 1 × ⅜in. 7/6; ACOS 1½ × ⅜in. 8/6
TANNOY CARBON MIKE with Switch 5/6
MOVING COIL HEADPHONES 100 ohms (ex. Govt.) 12/6
HIGH RESISTANCE HEADPHONES 2000 ohms 12/6
HIGH RESISTANCE HEADPHONES 4000 ohms 15/-
H.R. HEADPHONES 2000 ohms Super Quality 25/-

1966 GRAM CHASSIS

£10.10

Three Wavebands: Long., Med., Short. Five Valves: ECH81, EF89, EBC81, EL84, EZ80, 12-month guarantee. A.C. 200-250 v. Ferrite Aerial 5 watts 3 ohm. Chassis 13½in. × 7in. × 5in. dial size 13in × 4in. Two pilot Lamps. Four Knobs. Aligned calibrated. Chassis isolated from mains **£10.10**

HIGH GAIN TV. PRE-AMPLIFIER BAND I B.B.C. Tunable channels 1 to 5. Gain 18 dB. ECC84 valve. Kit price 32/6 or 55/- with power pack. Details 6d.
BAND III I.T.A.—same prices. Tunable channels 7 to 13. Band I or III. Coils and circuit only, 9/6. Chassis 4/9.
B.B.C. 2 SUPER BOOSTER transistor model, Ready built 75/-.

BLANK ALUMINIUM CHASSIS. 18 s.w.g. 2½in. sides, 7×4in., 5/6; 9× 7in., 6/6; 11×3in. 6/6; 11×7in. 7/6; 13×9in. 9/6; 14×11in. 12/6; 15×14in., 15/-.
ALUMINIUM PANELS 18 s.w.g. 12×12in. 5/6; 14×9in. 4/6; 12×8in. 3/6; 10×7in. 2/9; 8×6in. 2/-; 6×4in. 1/6.

STELLA RECORD PLAYER AMPLIFIER

4 watt. 2 stage. 3 to 7 ohm. Neg. feed back. UCL82. UY85. 200-250v. A.C. tapped input. Chassis size 8 x 2½ x 4in. high. Gold/Walnut knobs. Volume and Tone controls on separate Polished Wood Panel 6 x 2in. Brand new with makers' guarantee. BARGAIN PRICE P. & P. 1/6. **78/6**

ADD-ON BABY ALARM UNIT

All Transistor. For any make of T.V. or Radio. Only three connections. Made by K.B., R.G.D. and Regentone. Circuit provided and instructions for use with all makes. No battery required. Ready built and guaranteed. With microphone. BARGAIN PRICE. Post Free. **30/-**

THE INSTANT BULK TAPE ERASER AND RECORDING HEAD DEMAGNETISER

Leaflet S.A.E.
200/250 v. A.C. **35/-**

BAKER 12 in. STALWART

An inexpensive loudspeaker for High Fidelity. 3 ohm or 15 ohm models

Max. Power .... 15 watts
Bass Res. .... 40/50 cps.
Flux .... 12,000 gauss.
Voice Coil .... 1½ in.
Response .... 45-13,000 cps.
Chassis Solid Aluminium
Overall dia. .... 12½ in.
Overall depth .... 6 in.

PRICE 5 GNS. POST FREE
(State 3 or 15 ohm)

CATALOGUE S.A.E.

GROUP MODELS FOR VOCALS BASS, LEAD and RHYTHM GUITARS
30-10,000 cps. Voice Coils 15 ohms. Heavy duty

'Group 25' 12in. 25w. **5gns.** **'Group 35'** 12in. 35w. **8½gns.** **'Group 50'** 15in. 50w. **18gns.**

LOUDSPEAKERS P.M. 3 OHMS. 2½in., 3in., 4in., 5in., 7in. × 4in., 15/6 each; 8in. 22/6; 6½in. 18/6; 10in. 30/-; 12in. 30/-; (15 ohms 35/-); 10 × 6in. 22/6; 8 × 5in. 21/-; E.M.I. Double Cone 13½×8in., 3 or 15 ohm models, 45/-. W.B. 10in. HF1012, £5.10.0.; 8in. HF812, £4.10.0. Crossover 35/-. Horn Tweeters 2-16 Kc/s. 10 w 29/6; 20 w 20 Kc/s. 99/6.
JACK SOCKETS Std. open-circuit 2/6, close-circuit 4/6. Chrome Lead Socket 7/6. DIN 3-pin 1/3; Lead 3/6.
Phono Plugs 1/-. Socket 1/-. Banana Plugs 1/-. Sockets 1/-.
JACK PLUGS STANDARD. Chrome 3/-. DIN 3-pin 3/6.
WAVE-CHANGE SWITCHES WITH LONG SPINDLES. 2p. 2-way, or 2 p. 6-way, or 3 p. 4-way 3/6 each; 1 p. 12-way, or 4 p. 2-way, or 4 p. 3-way, 3/6 each.
Wavechange "MAKITS" 1 p. 12-way, 2 p. 6-way, 3 p. 4-way, 4 p. 3-way, 6 p. 2-way. Prices include click spindles, adjustable stops, spaces, etc., 1 wafer, 10/6; 2 wafer, 15/-; 3 wafer, 19/6; 4 wafer, 24/-; 5 wafer, 28/6; extra wafers, 4/6.
TOGGLE SWITCHES, s.p., 2/-; d.p., 3/6; d.p.d.t., 4/-.
SPEAKER-FRET. Tygan various colours, 52in. wide from 10/-ft.; 26in. wide from 5/- ft. Samples, large, S.A.E.
EXPANDED METAL. Gold or Silver 12×12in. 6/-.

AM TUNER MEDIUM WAVE. Three Transistor Superhet. Ready built. Printed Circuit. Ferrite Aerial. Size 5½" × 3½" × 1½". Ideal for Tape Recorders. **79/6**

FM TUNER 88-108 Mc/s Six Transistor. Superhet. Ready built. Printed Circuit. Calibrated slide dial tuning. Size 6" × 4" × 2½". **£8**

3 WATT QUALITY AMPLIFIER. 4 Transistor Push-Pull Ready built, with volume control **75/-**

NEW MANUFACTURERS SURPLUS UHF BBC 2 AERIALS
BBC 2 Double Gold Ring Set Top Model 22/6
BBC 2 Five Element Loft Model..............................32/6
BBC 2 Five Element Outdoor Wall Mounting 42/6

★ RADIO BOOKS ★ (Postage 9d.)

Radio, T.V. Valves, Diodes, Transistor equivalents	10/6
High Fidelity Speaker Enclosures and Plans	5/-
Transistor Superhet Commercial Receivers	7/6
Mullard Audio Amplifier Manual	8/6
Radio Valve Guide, Books 1, 2, 3, 4, or 5 each	5/-
Practical Radio Inside Out	4/6
Transistor Audio Amplifier Manual	6/-
Shortwave Transistor Receivers	5/-
Transistor Communication Sets	6/-
International Radio Stations List	2/6
Modern Transistor Circuits for Beginners	7/6
Sub-Miniature Transistor Receivers	5/-
Wireless World Radio Valve Data	9/6
At a glance valve equivalents	6/-

RESISTORS. Preferred values, 10 ohms to 10 meg. ¼ w., ½ w., 1 w., 20% 4d.; 1½ w. 8d.; 2 w. 1/-; ½ w. 10% 6d.
HIGH STABILITY. ½ w. 1% 2/-. Preferred values. 10 ohms to 10 meg. Ditto 5%, 10 ohms to 22 meg., 9d.

5 watt	0.5 to 8.2 ohm 3 w.	1/6
10 watt	WIRE-WOUND RESISTORS	1/9
15 watt	10 ohms to 6,800 ohms	2/-

10K, 15K, 20K, 25K, 10W. 3/-
MAINS DROPPERS. Midget. With sliders. 0.3 a., 1K., 0.2 a., 1.2 K., 0.15 a., 1.5 K., 0.1 a., 2 K., 6/- each.
LINE CORD 100 ohms ft. twin plus resistance. 1/- ft.

ALL PURPOSE TRANSISTOR PRE-AMPLIFIER
14 db gain. 250v. or 9v. input. Ready built with Mu Metal matching transformer for Mikes, Pick-Ups, Tuners. Instructions and circuit supplied. Post Free. **15/-**

WIRE-WOUND 3-WATT POTS. Miniature T.V. Values 10 ohms to 30 K., 3/3, Carbon 30 K. to 2 meg., 3/-.

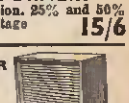
WIRE-WOUND 4-WATT STANDARD SIZE POTS. LONG SPINDLE VALUES 50 OHMS to 100 K., 7/6.

ARDENTE TRANSISTOR TRANSFORMERS
D3035, 7.3 CT : 1 Push Pull to 3 ohms for OC72, OC81.. 11/-
D3034, 1.75 : 1 CT. Push Pull Driver for OC72, OC81 .. 11/-
D3058, 11.5 : 1 Output to 3 ohms for OC72, OC81... ... 11/-

C.R.T. BOOSTER TRANSFORMERS

for heater cathode short or falling emission. 25% and 50% boost, 200/250v. AC input. State tube voltage required, 2 or 6 or 13 v. **15/6**

BRAND NEW QUALITY EXTENSION LOUDSPEAKER



In tough cream plastic cabinet with 20ft. lead and adaptors. For any transistor radio, intercom, mains radio, tape recorder, etc. 3 to 15 ohm matching
Size: 7½" x 5½" x 3" **30/-** Post Free

RETURN OF POST DESPATCH *Minimum P.P. Charge 1/6 unless otherwise stated. C.O.D. 5/- extra. Full List 1/-.* *CALLERS WELCOME*

RADIO COMPONENT SPECIALISTS 337 WHITEHORSE ROAD, WEST CROYDON

Written guarantee with every purchase. *(Export: Send remittance and extra postage, no C.O.D.) Buses 133, 68 pass door. S.R. Stn. Selhurst.* **Tel.: THO 1665**

Book reviews

FUNDAMENTALS OF RELIABLE CIRCUIT DESIGN

By Mel Xlander
Published by Iliffe Books Ltd.
Volume 1: 197 pages, 8½in × 5½in. Price 30s.
Volume 2: 138 pages, 8½in. × 5½in. Price 27s 6d

MEL XLANDER is obviously a circuit designer with a high degree of philosophical perception. His logical and remarkably simplified approach to the subject of circuit analysis is well exemplified by this two volume book.

Volume 1 describes how Ohm's Law and Kirchhoff Laws can be used as the basic tools for equating linear d.c. circuit values, whether they be simple parallel circuits or more complex series parallel circuits with more than one d.c. supply source.

The next logical stage is to bring in capacitance and inductance, star and delta networks, tolerances, and control circuits.

A fully descriptive appendix gives definitions and algebraic equations which keeps the level of comprehension within the bounds of most readers of PRACTICAL ELECTRONICS.

The reasoning applied in Volume 1 is expanded in Volume 2 to provide a better understanding of diodes and transistor circuit design.

Specific practical electronic circuits are avoided because once the *method* of design analysis is grasped the rest should come with ease. After all semiconductors are basically resistive components and can be treated in d.c. circuits as pure resistances in networks similar to those given in Volume 1.

For students in electronic engineering and design these two volumes, although a little expensive for paperbacks, will provide a greater understanding of their studies. The purpose behind them is to encourage one to think clearly and logically; a valuable asset to subsequent research work. A.M.

TELEVISION RECEIVER THEORY PART I

By G. H. Hutson
Published by Edward Arnold (Publishers) Ltd.
238 pages, 10in × 7¼in. Price 35s

THIS is an excellent book. The author is Senior Lecturer in Radio & Electronic Engineering at Canterbury Technical College, and he has written it "for technicians engaged in the servicing or manufacture of television receivers and for students of television generally". It is not a guide to fault-finding, but an explanation of how television receivers work, written on the assumption that unless you know how they *should* work you are not well equipped to find out what has gone wrong with a faulty one.

The people for whom this book is written will never be called upon to design receivers, and for this reason mathematics is virtually excluded. On the other hand, it is not an elementary textbook: circuits and their operation are gone into with thoroughness and in great detail. Both transistor and valve circuits are included.

This is the first of two volumes. It begins with an explanation of television in general terms, and then goes on to examine the following circuits in detail: vision detectors, video amplifiers, synchronising pulse separators, and differentiators and integrators. There is a detailed chapter on interlacing, and another on "field processing circuitry", i.e. the parts which handle the frame pulses.

This leaves (for the next volume) the "front end" and i.f. stages, the time bases, audio section, and c.r.t. circuitry.

The present volume is well printed and illustrated, and the price is relatively modest. G.W.

BEGINNERS GUIDE TO PRACTICAL ELECTRONICS

By R. H. Warring
Published by Lutterworth Press
192 pages, 8¼in × 6in. Price 18s 6d

THE author states that the emphasis throughout this book is on *practical* electronics for beginners. "No special theoretical knowledge is necessary in order to understand the projects described".

And yet from his writing it *must* be assumed that the reader *does* know what, for example, capacitors and inductors do, and what kilocycles, microfarads, Ferroxcubes, and many other terms really mean.

Here is compiled, in a somewhat haphazard sequence, a compendium of information and projects which, one feels, can only leave the absolute beginner in a certain amount of confusion.

The idea of writing a book of this nature is to be commended. It could have been a useful aid to the practical man, but it is unfortunate that errors appear. For example, a transistor collector is connected directly to its own emitter in one circuit, while its equivalent wiring diagram shows no emitter wire at all.

It appears that the diameter of wire used for coil winding is determined "by its stiffness" rather than looking up the current ratings on a later page. Perhaps we should "guesstimate by comparing with a similar coil" as he suggests?

However perhaps it would be a good idea to be guided by the various Mullard designs throughout the book; then perhaps we can build some of the projects even if we don't fully understand how they work. M.A.C.

REGULATIONS FOR THE ELECTRICAL EQUIPMENT OF BUILDINGS

Published by the Institution of Electrical Engineers
242 pages, 8¼in × 6in. Price 17s 6d

THIS is the fourteenth edition of the familiar "Wiring Regulations" which took effect from October 1 1966. The increasing use of ring mains in domestic installations as well as the use of a wider variety of appliances makes this book almost essential to the householder, particularly those contemplating undertaking their own wiring.

Special attention is drawn to the earthing arrangements via water pipes, now not recommended in view of the increasing use of plastics for piping.

A new section on caravan and caravan site installations is included following the withdrawal of the hitherto separate publication.

MANCHESTER . . . . . . ELECTRONICS ON SHOW AT MANCHESTER . . . . . . ELECTRONICS

THE current credit squeeze is having little effect on the electronics industry. Although imports of foreign goods are restricted many overseas Companies avoid such difficulties by setting up factories in this country. The same is also true of British Companies.

Although a few glum faces were evident at the 21st Annual Exhibition and Convention of the Institution of Electronics, held in Manchester in September, the atmosphere generally was more of an intellectual rather than a sell or buy nature. A continuous programme of films and lectures ran concurrent to the exhibition.

This is the time when Northerners come together for their own smaller brand of components show. Hence the presence of wholesalers and lesser known firms than one expects to find at an Olympia type of exhibition in London. Some larger Companies were exhibiting their usual wares.

On arrival our reporter was told that there was little really new to be found there. In fact many of the exhibits could have been seen in London during the past twelve months or more.

Nevertheless, students from Manchester schools obviously showed an interest in what they saw, even if the exhibition *was* on a small scale.

Of particular interest was a range of visual study aids shown by A. M. Lock & Company of Oldham. These aids to teaching electrical and electronic theory are necessarily of large proportions for classroom demonstration and include meters (about 12in high), a wave demonstration machine (about 2ft long), a transformer kit, and other electro-magnetic devices, the likes of which are imported from the U.S.S.R. because, we are told, of the "limited equipment manufactured in this country".

Some particularly interesting transducers, based on the electro-magnetic variable reluctance principle, were shown by Associated Engineering Limited of Rugby. A new version about ¼in long was included. These particular devices were being demonstrated by their insertion into the wall of a piston of an internal combustion engine. They will detect the proximity of metallic materials about 0·020in from the transducer face. In this example, minute irregularities in the machined cylinder can be detected, as well as giving a warning of excessive wear or vibration.

Belling and Lee have introduced a new version of the familiar flexible terminal block in moulded p.v.c. The clamping screws have rotating pressure pads on the tips to prevent the risk of cutting the wire strands.

NEW PORTABLE ELECTRONIC ORGAN KIT

THE "MAYFAIR" portable electronic organ, is fully polyphonic (i.e., chords may be played). Ten tone colours are available operated by rocker tabs above the 49-note fully-sprung keyboard: 16′, 8′ and 4′ pitches are available on each key, employing six octaves of generated tones. Vibrato is tab-controlled and a spare tab is provided for fitting percussion as an optional extra. Two pre-amplified outputs are fitted, overall volume being controlled by foot-operated expression control. The console dimensions are 30¼in × 15½in × 9in and weight 35 pounds.

Based on semiconductors (170 transistors and diodes) and printed circuit boards throughout, a fully illustrated instruction manual and conventional circuitry simplifies matters for any new constructor in this field. Twelve master oscillators are tuned to the chromatic scale, the remaining frequencies being obtained by binary division. After distribution and isolation, frequencies are keyed by 4-pole gold alloy switches under the playing keys, passed to the tone forming unit for waveform modification and finally to pre-amplifiers and expression pedal.

Designed primarily for use in schools, groups and for home entertainment, organists used to two manuals and pedals might be somewhat critical of the "Mayfair" organ but, at the price of a monophonic keyboard and in view of it's portability (legs may be detached and stowed), this instrument is a compromise: a large and comprehensive organ is proportionally expensive whereas a solo keyboard is musically unsatisfactory. A 13-note pedal board may be fitted as one of the extra items offered with the kit.

A demonstration model is on show at the showrooms of Henry's Radio Limited, 303 Edgware Road, London, W.2. The complete kit for building costs 99 guineas.

K.L.S.

Meetings . . .

ELECTRONIC ORGAN CONSTRUCTORS SOCIETY

LONDON

Date: December 10
Time: 2.30 p.m. (Admission By Ticket Only)
Address: St. David's Church Hall, Lough Road, London, N.7.

Applications should be made to the Hon. Sec. E. Kirk, 66, Arnold Crescent, Isleworth, Middx.

JOINT MEETING

Date: November 22
Title: Colloquium on "Sound On Film"
Time: 9.30 a.m.
Address: I.E.E. Savoy Place, London, W.C.2.

This is a joint conference sponsored by the Institution of Electrical Engineers, British Kinematograph Sound & Television Society and the Television Society. Tickets are available from I.E.E. Savoy Place, London, W.C.2.

EXHIBITION

LONDON

Date: December 2–3
Title: Eighteenth Exhibition of Cardio-Pulmonary Apparatus
Time: 2–9 p.m. Friday, 9 a.m.–1 p.m. Saturday
Address: Piccadilly Hotel, Piccadilly, London, W.1.

Tickets available from the Exhibition Secretary, The Society of Cardiological Technicians Ltd., Guy's Hospital, London, S.E.1.

COURSES

LONDON

Days: Tuesday Evenings
Subject: Electronic Music
Time: 7.30 p.m.
Address: Streatham & Tooting Institute, Hillcroft School, Beechcroft Road, London, S.W.17.

25 AMP ON/OFF SWITCH. Mains heavy duty type rotary with control knob. 5/6 each.

MAINS TRANSFORMER Upright mounting with primary tapped 200, 220, 240 v. H.T. secondary is 250-0-250 v. at 100 mA. and it has two L.T. secondaries of 6·3 v. 1½ amp.—unused (removed from equipment), 15/- plus 3/6 post and insurance.

HI-FI SPEAKER BARGAIN

12in. High fidelity loudspeaker. High flux permanent magnet type with either 3 or 15 ohm speech coil. Will handle up to 10 watts. Brand new by famous maker. Price 29/6 with built-in tweeter 35/-, plus 3/6 post and insurance.

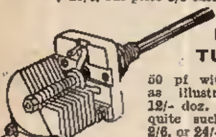
SPOT OR FOG LAMPS

Made by Lucas. Flat or Pencil beam 36 wt. Suitable for car, boat, caravan, etc., Complete with 6 v. or 12 v. bulb, flex cables and fixing bolt. Remarkable bargain 12/6, plus 3/6 post and insurance.

LUMINOUS CORD SWITCH

This can hang on the end of a flex or it can be inserted into a flex. It has a built in neon which makes it luminous in the dark. Made for electric blankets but ideal in dark rooms, etc. Normally 10/6, our price 6/6 each or £3 doz.

FINE TUNERS



50 pf with long spindle as illustrated, 1/6, or 12/- doz. Twin 50 pf not quite such long spindle, 2/6, or 24/- doz.

12 v. INVERTER

Fully transistorised for operating a 20 watt fluorescent tube or other 20 watt mains device. Size 6" long by 1¾" × 1¾". £3/10/0 post and ins. 3/-.

THOUSANDS OF TRANSISTORS

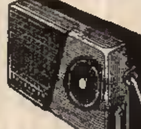
at cut prices

(e.g. Silicon N.P.N. 5/-.) Send 1/6 for latest list and equivalent chart, and circuits. S.C.Rs. (Thyristors) 100 v. 1 amp 6/6, 3 amp 7/6, 12 amp 15/-; 400 v. 1 amp 15/-, 3 amp 17/6, 5 amp 22/6, 25 amp £3; 50 v. 1 amp 6/6, 3 amp 7/6, 10 amp 10/-, 25 amp 30/-.

DON'T MISS THIS it will save you £100

9 v. Nickel Cadmium Battery type PP3 (fits all popular pocket transistors). *Can be recharged 800 times.* Price with transformer type battery charger, only 52/6 p. & i. 3/-. Chargeable replacements also in stock for U7 12/6, U11 23/-, U12 32/-.

NO SOLDERING POCKET 3



Lots of fun to build and good results when finished — complete kit with detailed instructions and crystal earpiece — batteries 1/2 extra — £5 value only 19/6 plus 3/- post and ins.

MISCELLANEOUS BARGAINS

5 amp car battery charger rectifier 10/6 (post 3/6); Reed switch with magnet 6/6; ½ meg pots 6/- doz., ditto with d.p. sw. 10/- doz.; Silicon Rect. BY100, 350 v. 250mA, 4/6 each, 3 for 12/-; Miniature pick-up with Cosmocord Crystal cartridge and sapphire stylus 3/6; 4 transistor audio amplifier 19/6; turret tuner, less bottom cover and valves 7/6 each; Neons (Midget) 1/6 each, valve type 10/6 doz.; slide switch miniature 1/6, mains type 2/-; toggle switch 2/3; 30 amp relay for controlling heating 39/6; 80 watt fluorescent kit 17/6 (post 3/6), 4 pole change-over switch for series parallel working 4/6.

S.C.R. Light Dimmer. Can also be used to control the speed of Motors, drills and the heat from or to critical instrument circuit recently described in *Practical Electronics*. Mains operation this fits into 13 amps socket outlet box. All the components including the silicon controlled rectifier. Available. as a kit. Price £4/10/0, plus 2/9 post and ins.

BE FIRST THIS YEAR

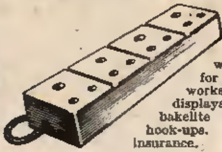
SEED AND PLANT RAISING

Soil heating wire and transformer. Suitable for standard size garden frame. 19/6 plus 3/6 post and ins.

INFRA RED HEATERS

Make up one of these latest type heaters. Ideal for bathroom, etc. They are simple to make from our easy-to-follow instructions—use silica enclosed elements designed for the correct infra-red wavelength (3 microns). Price for 750 watts element, all parts, metal casing as illustrated, 21/6, plus 3/6 post and ins. Pull switch 3/- extra.

MULTI-MAINS BOX



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ELECTRONIC CONTROLLER FOR MODEL LOCOMOTIVES. A device to overcome jerky stopping and starting is described in *Wireless World* Oct. All components including five transistors, 4 diodes, mains transformer, etc., to build this circuit is available as a kit price £4, post and ins. 2/6.

NOUGHTS AND CROSSES MACHINE This machine described in Sept. (65) *Practical Electronics* is impossible to beat and will provide endless fun at home and considerable attraction (and profit) at charity do's and fetes, etc. It employs 19 switches and 9 bulbs and these and the other components necessary to make this are available, price £4/10/0 post and ins.

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JOHN VALENCE

RECRUITING DRIVE

The R.A.F. College Cranwell was open for inspection by some 150 guests from the academic world recently during a technical symposium.

The purpose of this grand gathering with an abundance of top brass was to make clear to the educational authorities the considerable opportunities the modern Air Force has to offer in its engineer branch to young men qualified in the applied sciences. Such candidates can obtain engineer cadetships leading to permanent commissions as Engineer Officer. The chance to follow a career as a professional engineer with all the very real advantages experienced by the serving officer must sound attractive to many technically minded youngsters.

The Engineer Branch (formerly the Technical Branch) is divided into two sections—mechanical and electrical, and it is the latter section of course which includes radio, radar and the other specialistic electronic devices and systems.

It was with particular pleasure and anticipation that yours truly made a return visit to Cranwell: in rather different circumstances, I might add, to a previous "visit". With a group of fellow scribes, I listened to part of the morning session. Afterwards we were shown around the fine contemporary building known as Trenchard Hall which houses the applied science technical training laboratories.

The aerodynamic, engine, and weapon laboratories were well featured, but I was disappointed at the rather meagre amount of electronics we were allowed to see.

Incredible as it may sound, not a single transistor or other solid state specimen manifested itself during these wanderings. The black boxes we did see, such as airborne navigational equipment, were completely enigmatic so far as their innermost parts were concerned.

. . . Perhaps it was lack of something of a real technical appeal that caused my mind to wander back to the days when the old No. 1 Electrical and Wireless School occupied the neighbouring area. . . . My reverie of those far off days was however short lived. Looking down at the stiletto marked floor tiles (barely six months old) in the corridors I was brought back abruptly to 1966. The W.A.A.F.s of those earlier days were issued with a sturdier and less incisive kind of footwear than that worn (apparently) by the present day secretarial staff. Then, the "stiletto", like the transistor, had yet to be invented. Now, both have left their mark on our civilization and things will never be the same.

SUCCESS STORY

Thanks in part, no doubt, to you industrious constructors, the makers of a certain well known wiring board have had to open up another factory. This new building near Southampton devoted largely to the production of Veroboard, was officially opened last month by the Regional Controller of the Board of Trade.

This product is a good example of the seemingly obvious—when you know how! The story of its invention is not without interest, since the firm originally responsible, Vero Precision Engineering Ltd., was not directly concerned with electronics. Two of their engineers thought up the idea of pre-made printed wiring and used this for their own purposes in the course of some work concerned with electronic equipment for machine tool control. Somebody in the Company was sufficiently foresighted to appreciate the commercial potentiality of this board, and now the whole electronics industry it seems is beating a path to their doorstep.

It says: "Be sure to keep your head down"

Now why can't *I* think up something like that! Sentiments wistfully echoed by many of my readers, I have no doubt.

BATTLE COURSE

That Battle of 900 years ago that we English in our own peculiar way insist on *celebrating* has been making the news in one way or another over the past month. As much as I would like to be in the fashion, I confess seeing little justification for introducing either King Harold or The Conqueror on this page, inconsequential though these notes may often be.

But wait!—a colleague has just come to my rescue with an account of a visit he paid the other week to Aldermaston Court. This grand 19th Century manor house is the headquarters of the British Institute of Engineering Technology, who run correspondence courses for a large range of subjects, including electronics. From some background notes provided by this organisation, it appears that the present building is the third to occupy this site. The original manor built nearly 1,000 years ago was held by King Harold and it then passed into the possession of William after that rather famous affair near Hastings.

Back to more relevant matters. My colleague tells me he was much impressed by the scale of operations conducted by this organisation in the field of postal tuition, although as he mentions, this particular method must fall short in certain respects when compared with direct tuition. Still for those in remote areas, a correspondence course is often the only practical way to acquire knowledge and pass professional examinations.

Readout—
A SELECTION FROM OUR POSTBAG

Sideways etching

Sir—In your October issue you have published a letter on electrolytic etching. As most experimenters will use a 12V model railway transformer for this I would like to warn them of a pitfall.

To limit the current to about an ampere a bulb or resistor must be placed in series with the bath. When all the unprotected copper has been etched away 12V will appear between the edges of the protected board and the solution. This is quite sufficient to cause rapid sideways etching of the copper and ruin the board. My advice is to watch the process closely and switch off immediately the etching is finished. If this is not done a blank piece of s.r.b.p. will result. I know I've done it!

N. D. Benyon,
Penrith,
Cumb.

By thunder . . .

Sir—I have just read your very interesting article on *Thunderstorms* (October 1966), and would like to make one or two observations on this subject.

As a science graduate in the early 1920's I had a 40ft high single wire aerial with a 60ft horizontal top, over water-logged soil in North Wiltshire. Varnished glass insulators were used.

When a rain storm, or wide area shower, approached from the North West it was often preceded by several small "outrider" clouds. Before the rain arrived these, passing overhead, allowed me to draw ½in sparks from the aerial, or light the Geissler tubes fairly common early in the century.

Generally this was not possible after the rain arrived, and no other observation indicated the possibility of lightning or thunder, i.e. your diagram Fig. 2 might be changed to show this electrification type.

As a senior chemistry master, now retired, I have not had complete satisfaction from theories of "free" electrons and the valency theory. About 20 years ago I distilled some mercury under water-pump vacuum, in home-made apparatus with an air cooled condenser. The glass was all in one piece for batch distillation. During distillation at intervals an electrical discharge appeared to travel the length of the condenser from receiver to distillation flask.

Such appearance may be a delusion as far as direction goes, but it always reminded me of the possibility of evaporation below and condensation above producing lightning flashes. I intended to repeat this condensation with a spiral condenser so that magnetic fields might enable electrical quantities to be measured. However, in retirement I might have a go with steam to see whether such phenomena are present.

Reading the voluminous natural facts in your article I wondered whether investigation of the phenomenon noted above could help with future thunderstorm explanation. I know of no quantitative data on such evaporation-condensation cause of electrical discharge, and offer my apologies if such data is in your possession.

R. T. Dale,
Bridford,
Devon.

Your observations of light flashes in mercury vapour columns when distilling mercury under vacuum are in fact a well-known phenomenon which virtually always occurs under such conditions. In modern research equipment requiring reasonably high vacuum one often uses a mechanical pump backed by a mercury distillation pump. The latter is virtually always flashing away merrily and indeed the electromagnetic radiation therefrom can be troublesome in causing interference to some sensitive experiments.

Your comments regarding your aerial are extremely interesting. I have frequently found shower conditions where the character of the radioactivity digressed from that for ordinary rain, in the direction of the thunderstorm character but "not quite making it". The weather as such did not visibly suggest thunder character, but rather just sharp showery conditions. In many cases but not all, there was sharp medium-wave radio interference of the thunder-atmospherics type.—M.L.M.

. . . and lightning

Sir—I noticed with regret the over-all title given to the six projects in the October issue; is it really necessary for this excellent journal to follow the "pop" idiom of mini-cars, mini-dogs, mini-mice, mini-skirts, etc.?

Perhaps herein lies a cause of the so called "Brain-drain"—Mini-think. (with apologies to George Orwell.)

S. A. Hardy, A.S.E.R.T.,
R.A.F., Lyneham,
Chippenham, Wilts.

CAN YOU HELP?

Letters for inclusion under this heading should be as brief as possible. Replies should be made direct to the readers concerned.

Sir—I would be grateful if any reader could sell or loan me the January and February 1965 issues. Need not be in immaculate condition.
D. A. Searson, 12, Perlethorpe Avenue, Sneenton Dale, Nottingham

Sir—I would be very grateful if any reader could sell or loan me the October 1965 issue.
A Rowland, 12, Adey Road, Lymm, Cheshire.

Sir—I require all of Volume 1 and Volume 2 up to July 1966 with blue prints if possible.
H. Stephens, 11/45 Saint Clements Road, Nechells, Birmingham, 7.

Sir—I urgently require Part Three of P. Cairns' article *Inexpensive Oscilloscope* (May 1965) and should be grateful if any reader could sell or loan me a copy.
R. Russell, 96, Binsteed Road, Portsmouth, Hants.

Sir—Could any reader supply me with the following issues: November 1964 to February 1965 inclusive?
D. R. Wakefield, 5, Beauvale Road, Meadows, Nottingham.

Sir—Could any of your readers supply me with the January to May 1966 issues with blueprints?
I. R. Wheeler, Avondale Cottage, Bullwodd, Dunoon, Argyll.

Sir—Would any reader care to sell me a July 1965 issue?
A. H. Tansley, "Cornerways", Lealands Avenue, Leigh, Nr. Tonbridge, Kent.

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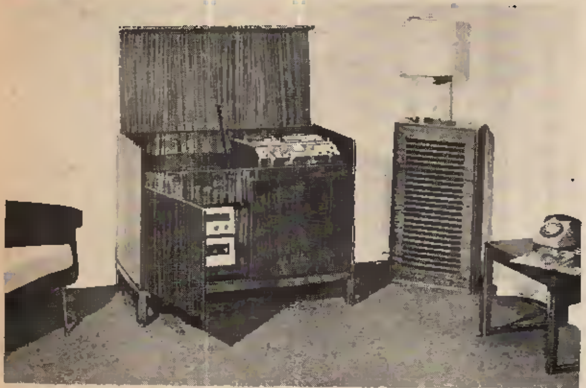

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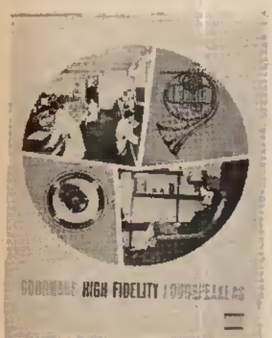

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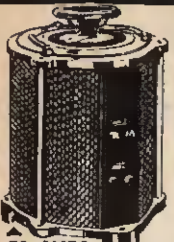

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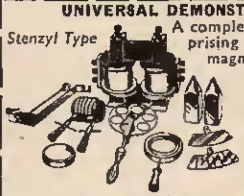

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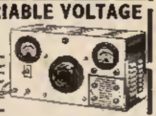

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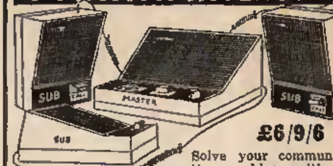

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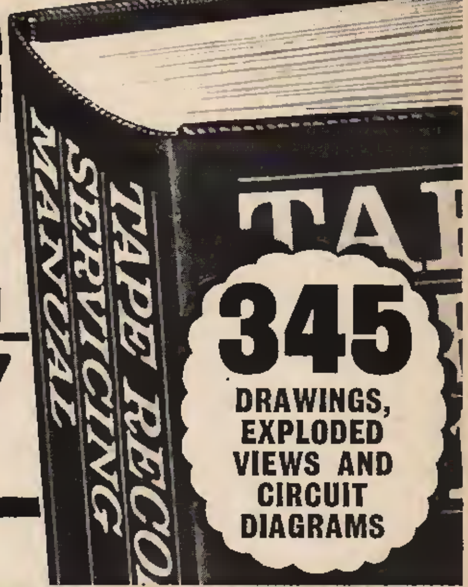

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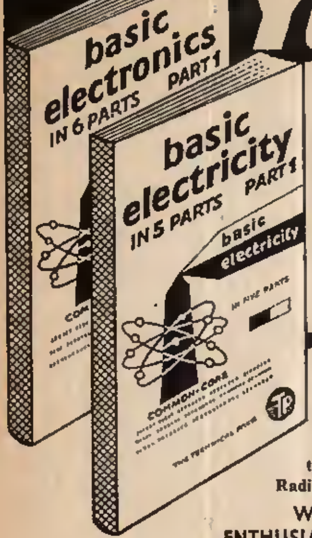

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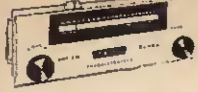

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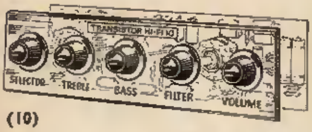

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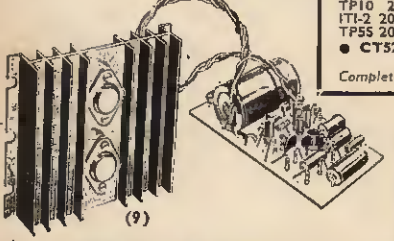

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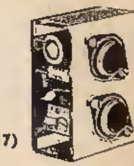

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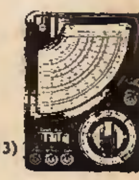

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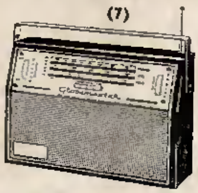

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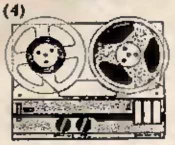

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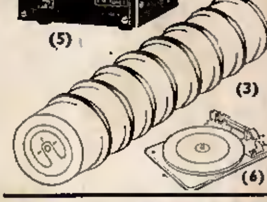

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