Practical Electronics

ANUARY 1965 PRICE 2'6

FREE INSIDE!

2 BLUEPRINTS TO BUILD

- HIGH IMPEDANCE VOLTMETER
- DARKROOM TIMER
- ELECTRONIC GUITAR

LUS
MORE
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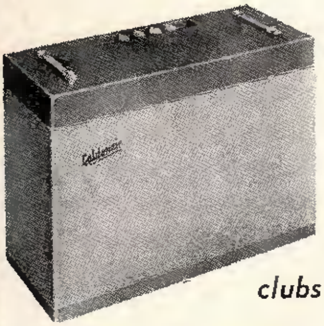
CTRONIC
DATA
OOKLET

GROUP-MASTER 30 WATT GUITAR AMPLIFIER

Goldenair

"THIRTY" HI-FI AMPLIFIER



A VERSATILE UNIT FOR INSTRUMENTALISTS AND VOCAL GROUPS

being suitable for clubs and public address

Ideal for bass, lead or rhythm guitar, and all other musical instruments.

★ The two 12-inch 25-watt heavy duty loudspeakers are specially designed for this type of amplifier, and give outstanding reproduction.
★ Robust attractive two-tone finished cabinet of compact size, 28″ × 20″ × 10½″ fitted with carrying handles.
★ For standard AC mains 50c/s operation.
★ Four inputs provided can be used simultaneously with instrument pickups or mikes.
★ Separate Bass and Treble controls are incorporated.

42 GNS

or deposit of £4.12.0 and twelve monthly payments of £3.12.5. Carriage and insurance 25/- to be sent with deposit.

A high quality 30-watt amplifier developed for use in large halls and clubs, etc. Ideal for bass, lead or rhythm guitars, schools, dance halls, theatres and public address. Suitable for any type of mike or pickup. Valve line-up: two EF86; one ECC83; one GZ34; two EL34.
Four separate inputs are provided with two volume controls. Bass and Treble controls are incorporated. Amplifier operates on standard 50c/s mains. 3 ohm and 15 ohm speakers may be used. Full 12 month guarantee. Factory built and tested. Perforated cover with carrying handles can be provided if required, price 21/-.

16 GNS

or deposit of £1.16.0 and twelve monthly payments of £1.9.2. Carriage 15/- to be sent with deposit.

THE Goldenair 5 WATT AMPLIFIER

IDEAL FOR HOME USE. Suitable for guitars, record decks and microphones. Cabinet size approx. 13 x 18 x 7 in. The cabinet is well made and attractively finished. Volume bass and treble controls incorporated. Price **9 gns.** post paid. Send S.A.E. for leaflet.

THE Goldenair GRAMETTE

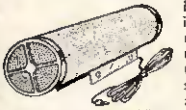
A compact 3-4 watt gram. amplifier that can be used with all types of record players. Fitted with volume and tone controls. Incorporating mains isolating transformer, thus making the unit completely safe. A triode pentode valve and modern silicon rectifier are utilised. Price **3 gns.** P. & P. 5/-. Ready built and tested **£3.19.6.** P. & P. 5/-.

THE Goldenair THREE

A uniquely designed 2 valve 3 watt gram. amplifier, fully enclosed in a compact well ventilated metal case, size 7 x 5½ x 2⅜ in. Three controls provided, Volume, Treble and Bass. A completely safe unit incorporating mains isolating transformer. Price **4 gns.** P. & P. 5/-.

GOLDENAIR 50 WATT MODEL NOW AVAILABLE PRICE 49 GUINEAS OR TERMS. SEND FOR DETAILS

TRANS. RADIO TUBULAR SPEAKER



Booster Speaker. Plugs into earpiece socket of most radios and tape recorders. Gives double the volume and a hi fi stereo effect that will amaze you, size approx. 9 x 2¾ in. Price 25/-. P. & P. 1/9.

TRANS/RECEIVER No. 46

Compactly carried by one man. This has a range of approx. 10 miles, and being crystal controlled tuning is avoided, and operation is as accurate as a telephone. Frequency 3.6-9.1 Mc/s. Complete stations comprising receiver transmitter rod aerial, one set of headphones and mike in canvas carrying bag. The crystal coil units can be supplied for 35/- per set, post free. Brand new in maker's sealed cartons.

Price per station **£4.10.0.** P. & P. 10/- each. Two stations for **£9.10.0.** Post Free.

TYPE 19 SHORT WAVE RECEIVING SET

Works straight off the mains. An excellent short wave receiver, requires only phones for immediate operation. Price **£5.19.6.** P. & P. 10/-. Suitable phones 15/- per pair. P. & P. 2/6.
During an evening's testing of this excellent receiver, we obtained clear reception from scores of stations, many of them thousands of miles distant, including ship stations, government transmissions, maritime broadcasts, etc. and also the short wave Radio Luxembourg broadcasts.

H.R.O. INSTRUCTION HANDBOOK
3/6 each. P. & P. 6d.

No. 19 SET INSTRUCTION HANDBOOK
3/6 each. P. & P. 6d.

1155 INSTRUCTION HANDBOOK
3/6 each. P. & P. 6d.

MICRO ALLOY TRANSISTORS

Mat 100	7/9	Mat 120	7/9
Mat 101	8/6	Mat 121	8/6
VHF Transistor ADT140			15/-

Above MATs postage paid
Ferrite Slab Aerials suitable for transistor sets 3/-. P. & P. 6d.

NEW WALK-ROUND ELECTRONIC EQUIPMENT STORE AT NO. 4 LAMBERTS ARCADE, LOWER BRIGGATE, LEEDS 1 (NEXT TO HALFORDS CYCLE SHOP). OPEN ALL DAY WEEKDAYS AND ALL DAY SATURDAY.

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NO C.O.D. UNDER 30/-
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SONA

FOREIGN & TRADE ORDERS WELCOMED. S.A.E. WITH ALL ENQUIRIES PLEASE
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LEADING STOCKISTS OF MARTIN RECORDAKITS AND AUDIOKITS

MARTIN RECORDAKITS

		Dep.	&	Mthly. pmts. of
HALF TRACK				
TAPE AMPLIFIER FOR STUDIO DECK, with ready wired printed circuit, control and input panels, mains and output transformers, knobs, plans, screws etc.; EF86, ECC83, EZ80, EM85 and 2 EL84. 3 watts output. Magic eye, Radio & Mic. inputs, ext. speaker socket, tone and monitor controls. Can be used as an amplifier	£11.11.0	47/-	8	25/6
COLLARO STUDIO DECK, very latest model, 3 speeds, 3 motors, 7in. spools	£10.19.6	44/-	8	24/6
CASE for above with 8 x 5in. speaker, two tone grey	£5.5.0			
COMPLETE KIT with tape and microphone	£29.19.6	120/-	12	44/-
QUARTER TRACK				
TAPE AMPLIFIER FOR STUDIO DECK, as above.	£12.12.0	52/-	8	27/6
COLLARO STUDIO DECK, fitted Marriott "X" Series heads	£13.19.6	56/-	12	20/6
CASE as above, two tone grey	£5.5.0			
COMPLETE KIT with tape and microphone...	£33.19.6	136/-	12	49/10
TAPE PRE-AMPLIFIERS				
HALF TRACK for **STUDIO** deck, 400m/V out.	£8.8.0	34/-	6	25/8
QUARTER TRACK, as above **SELF POWERED**	£9.9.0	39/-	6	28/4
TAPE HEADS, Bradmatic Half-Track Record/Replay and Erase on plate	£1.19.6	—	—	—

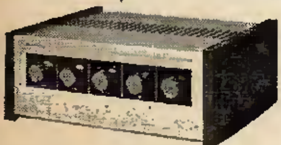
MARTIN AUDIOKITS

The new Martin All Transistor Ten Watt Amplifier kits represent excellent value for money. Each unit is complete, requiring only to be connected to the next. We show only the popular units here. Others available including stereo. The following would make up a **TRANSISTORISED AMPLIFIER 15 ohms MODEL**

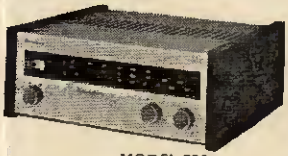
		Dep.	&	Mthly. pmts. of
UNIT 1—FIVE INPUT SELECTOR. Size 3¼ x 3in. Mag. PU, Crystal PU, Radio, Mic., Tape Head	£2.7.6	—	—	—
UNIT 4—PRE-AMPLIFIER AND CONTROL. Size 6¾ x 2½in. Volume on/off, bass and treble control.	£3.2.6	—	—	—
UNIT 7—MAIN AMPLIFIER, 10 watts 6 transistor, transformerless Push Pull output. Mounted on heat sink. L.S. imp. 15 ohms	£6.12.6	—	—	—
UNIT 8—POWER SUPPLY. Gives 18 & 40 volts. Heavy duty transformer, rectifier and smoothing	£2.15.0	—	—	—
CONTROL PANEL for Units 1 and 4	10.6	—	—	—
ALL ABOVE FOUR UNITS WITH PANEL. 15 ohms	£15.8.0	62/-	12	22/6
TRANSISTORISED AMPLIFIER 3 ohms MODEL				
UNIT 5 MAIN AMPLIFIER, as Unit 7 but 3 ohms	£5.12.6	—	—	—
UNIT 6 POWER SUPPLY, as Unit 8 but 18–24 Volts	£2.12.6	—	—	—
ALL FOUR UNITS WITH PANEL 3 ohms	£14.5.0	57/-	12	20/10

SEND FOR LEAFLET OF COMPLETE RANGE

ARMSTRONG AMPLIFIERS AND TUNERS



MODEL 222



MODEL 223

● **STEREO AMP. 222,** 10 + 10 w.	£27.10.0	110/-	12	40/4
● **TUNERS SELF-POWERED**				
224 F.M.	£22.10.0	90/-	12	32/2
223 AM/FM	£28.15.0	115/-	12	42/2
● **TUNER/AMPLIFIERS, MONO**				
127/M AM/FM with 5 watt amp	£26.10.0	106/-	12	38/10
227/M AM/FM with 10 w. amp	£36.15.0	147/-	12	53/10
● **TUNER/AMPLIFIERS, STEREO**				
127/S AM/FM with 5 + 5 w. amp	£37.10.0	150/-	12	55/-
227/S AM/FM with 10 + 10 w. amp	£52.15.0	211/-	12	77/4
226/S as 227/S with Mag. P.U.	£61.0.0	260/-	12	88/-
Shelf mounting Teak Case for any of above	£3.10.0			

MONO AMPLIFIERS

Linear L 45/A, 3 valve, 3 watt.	£6.6.0			
Dulci GA5, Integrated, 5 watts ECL86	£13.2.6	52/6	12	19/3
Tripletone Hi Fi Major, 10 watts 2 EL84	£15.18.9	64/9	12	23/3
Leak TL12, 10 watt **Main Amplifier only**	£20.0.0	80/-	12	29/4
Leak Varislope Mono, Pre-amplifier	£15.15.0	63/-	12	23/1
Dulci DPA15, 15 watt with 2 valve pre-amplifier	£26.5.0	105/-	12	38/6

STEREO AMPLIFIERS

Leak Stereo 20, *Pre-amplifier and Main amplifier complete*	£55.9.0	229/-	12	80/8
Rogers Cadet Mk2 with *Pre-amplifier 4 ECL86 valves*	£26.15.0	107/-	12	39/2
Leak Transistor Stereo 30, Pre-amplifier and main amplifier	£49.10.0	198/-	12	72/7

F.M. TUNERS

Tripletone, F.M. Tuner Less power	£13.19.6	56/-	12	20/6
Tripletone, F.M. Tuner With power	£15.14.6	63/-	12	23/1
Jason JTV/2, F.M. and T.V. sound, Switched, self powered	£22.5.0	89/-	12	32/7

GRAMOPHONE UNITS

B.S.R. UA25, Very latest model with cart.	£6.6.0	—	—	—
Garrard SRP10 Single player, Mono cartridge	£5.10.0	—	—	—
Garrard Autoslim, 4 Speed changer Mono	£7.17.0	33/-	6	24/-
Garrard AT/5/P Improved Autoslim, Stereo	£9.0.0	36/-	6	27/4
Garrard A.T.6 Autoslim de Luxe, mono	£11.9.0	47/-	8	25/3
Garrard AT/5/3000LM as **AT6,** but with slim arm, stereo	£11.12.0	46/6	8	25/9
Garrard 4H/F, Transcription unit Mono	£17.0.0	68/-	12	24/11
Garrard "Deccadek" Single Player with Decca "Deram" cartridge	£15.15.0	63/-	12	23/1
Garrard LAB. "A", Transcription changer Mono	£19.14.9	79/-	12	28/11
Garrard 301 Strobe, Transcription unit	£22.0.0	88/-	12	32/3
Philips AG1016, Stereo cartridge, will change 7in. records with adaptor 10/- extra	£12.12.0	50/6	12	18/6
Goldring GL58, with arm but less cartridge	£17.1.0	69/-	12	24/11
Goldring GL70, with arm but less cartridge	£27.9.4	111/4	12	40/1
Goldring "88", Transcription less arm	£18.18.5	76/5	12	27/8

LEAFLETS ON REQUEST

Hi Fi LOUDSPEAKERS

Goodmans Axiette, 8 in.	£5.5.7	—	—	—
Goodmans Axiom, 10 in.	£6.5.11	—	—	—
Goodmans 5K/20/XL, Tweeter and Crossover	£7.7.0	—	—	—
Goodmans 201, 12in. unit Full range 15 watt	£10.17.6	43/6	8	24/3
Goodmans 301, 12in. unit Full range 20 watt	£15.4.6	61/-	12	22/4
Goodmans X05000, £2.0.11. **X0950**	£5.10.11	—	—	—
W.B. HF812, 8in., 3.75, 7.5 and 15 ohms	£3.16.6	—	—	—
W.B. HF1012, 12in., 3.75, 7.5 and 15 ohms	£4.12.0	—	—	—
Wharfedale Super 3, Tweeter	£5.16.8	—	—	—
Wharfedale Super 5, Tweeter	£5.19.7	—	—	—
Wharfedale Super 8 RS/DD, Full range unit	£6.14.2	—	—	—
Wharfedale Super 10 RS/DD, Full range 10 unit	£10.18.0	44/-	8	24/3
Wharfedale Super 12 RS/DD	£17.10.0	70/-	12	25/8
Wharfedale RS/12/DD, 12in. unit Full range	£11.10.0	46/-	8	25/6

LEAFLETS AVAILABLE ON REQUEST

GUITAR SPEAKERS

Fane, 12in. Heavy duty unit 20 watt	£5.5.0	—	—	—
Goodmans Audiom 51, 12in. 15 watt Bass	£9.2.8	36/8	6	27/8
Goodmans Audiom 61, 12in. 20 watt Bass or Lead	£14.7.8	57/8	12	21/1
Goodmans Audiom 81, 15in.	£25.0.0	100/-	12	36/8
Goodmans Audiom 91, 18in. 50 watt Bass	£27.10.0	110/-	12	40/4
Wharfedale W 12/EG, 12in. 15 watt Lead	£10.10.0	42/-	8	23/6
Wharfedale W 15/EG, 15in. 15 watt Bass	£17.10.0	70/-	12	25/8

WRITE FOR GOODMANS ELECTRIC GUITAR LEAFLET

GUITAR AMPLIFIERS

Linear Diatonic 12 watt 2 inputs	£13.2.6	52/6	12	19/3
Linear Conchord 30 watt 2 inputs with Cover	£19.4.6	77/-	12	28/2
Leak TL 25 25 watts amp and pre-amp	£42.5.0	169/-	12	61/11
Leak TL 50 50 watts amp and pre-amp	£51.5.0	205/-	12	75/2

MICROPHONES AND FLOOR STANDS

Reslo RBH/T, Ribbon High Impedance	£11.2.6	44/6	8	24/9
Reslo RBH/TS, Ribbon with on/off switch	£13.10.0	54/-	12	19/9
Reslo Heavy Duty Floor Stand	£7.0.0	—	—	—
Teisco DM304, Dual Impedance with switch	£4.10.0	—	—	—
Piezo BM3, Crystal with switch, desk stand	£2.10.0	—	—	—
Jap, Floor Stand	£3.3.0	—	—	—

SURBITON PARK RADIO LTD.

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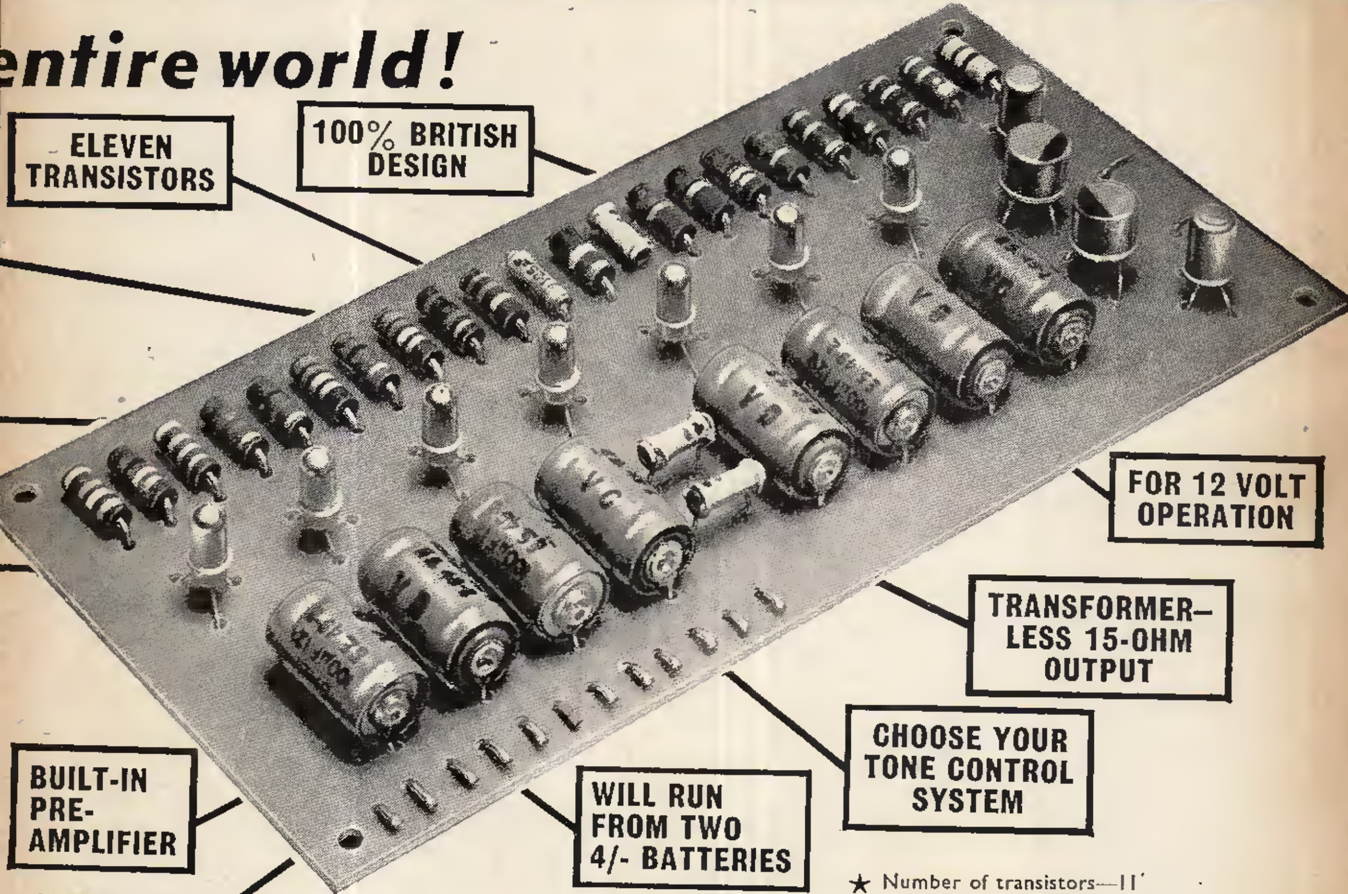
- ***HOURS 9 a.m. to 6 p.m. (1 p.m. Wednesday)***
- ***Easily reached by frequent trains Waterloo to Surbiton***

-10 COMBINED 10 WATT HI-FI AMPLIFIER AND PRE-AMP

entire world!



P.W.M. THE ANSWER

With P.W.M. the audio signal modulates a high frequency square wave "carrier" by varying the mark-space ratio. These variations are converted to energy in the output stage. Being independent of the transfer characteristics of the output transistors, the output is an exact replica of the input signal. The improvement in the quality of reproduction from the loudspeaker is instantly apparent. Transient response is greatly improved, there is no falling off in the higher audio frequencies, no intermodulation distortion and the response curve is so flat that you could draw it with a ruler! A new type of output stage and P.W.M. plus many other refinements result in an amplifier which is compact, rugged, stable, requires no heat sink—and costs so little. The X-10 may be used with low-put pick ups such as Decca Deram, Ortofon, etc., as well as with microphones, tape play-back heads, etc. Used in pairs the X-10 brings new depths to stereo listening.

★ Number of transistors—11
★ Overall size—6" × 3" × ¾"
★ Input sensitivity—1mV into 1K.ohms
★ Total harmonic distortion—less than 0·1%
★ Frequency response—5–20,000 c/s — ±0·5dB
★ Speaker impedance—15 ohms
★ Damping factor—greater than 100
★ Quiescent consumption—75mA
★ Supply voltage—12Volts D.C.

SINCLAIR X-10 MANUAL

Explains how the amplifier functions, how to add volume and tone controls to suit your precise requirements, and how to use the X-10 for stereo. A variety of systems are shown, none of which will add more than a few shillings to the original cost of your X-10. The Manual which is included with every X-10 is available separately for 1/-.

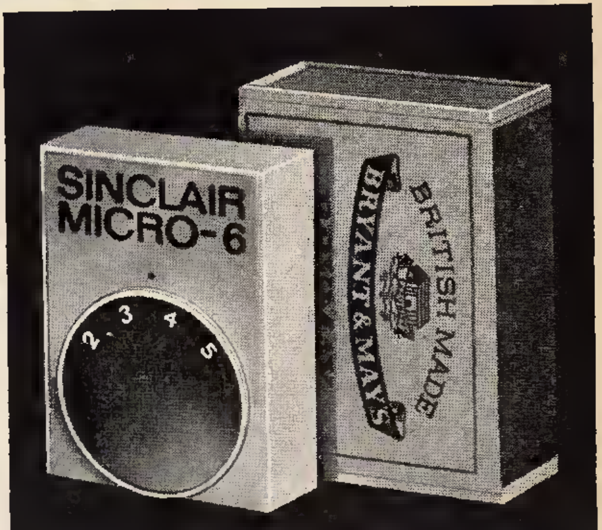
ORDER FORM AND MORE SINCLAIR DESIGNS ON PAGES FOLLOWING

ADIONICS LTD., COMBERTON, CAMBRIDGE Telephone: COMBERTON 682

The smallest, most exciting

NOW IS THE TIME TO BUILD IT

With the days so short, the performance from this amazing 6-stage radio is proving sensational. Stations simply pour in from the Continent with outstanding quality and again and again the Micro-6 is reported to be giving excellent results where other sets cannot be used at all. As the illustration shows, the set is smaller than a matchbox, yet everything including batteries and ferrite rod aerial is contained in the tiny white, black and gold case. The Micro-6 has vernier-type tuning and is switched on by inserting the micro-plug of the earpiece into the socket at the side. This remarkable British receiver cannot be too highly recommended both as an intriguing design to build and a most practical radio to use. It's a set you will be delighted to build and use. IT PLAYS ANYWHERE.

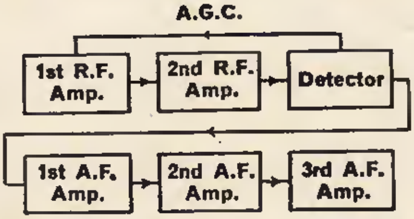


ACTUAL SIZE

SINCLAIR MICRO-6

BRITISH-DESIGNED 6-STAGE RECEIVER

- Size—$1\frac{4}{5}" \times 1\frac{3}{10}" \times \frac{1}{2}"$
- Weight—Under 1 oz.
- Tunes over medium wave band
- Bandspread for easy reception of Luxembourg

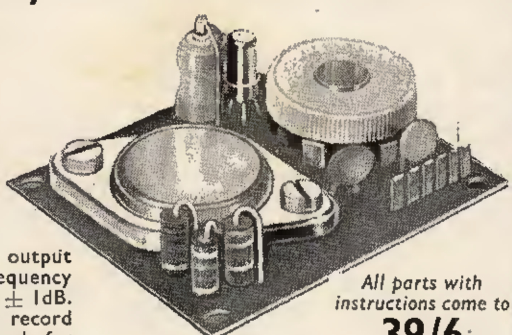


The Micro-6 uses three special Micro-Alloy transistors in a new and original circuit. Two stages of R.F. amplification are followed by an efficient double diode detector which drives a high-gain 3-stage A.F. amplifier. Powerful A.G.C. applied to the first R.F. stage ensures fade-free reception from the most distant stations tuned in.

SINCLAIR TR750 AMPLIFIER

Designed specially for Micro-6 and Slimline users

This amplifier makes a powerful car, portable or domestic radio used with the Micro-6 or Slimline receivers and a plug is included for connecting to these sets. With its own built-in volume control and on-off switch, the TR750 has a full 750 milliwatt transformerless output for 10mV into 10K ohms and a frequency response from 30 to 20,000 c/s ± 1dB. It will also make an efficient hi-fi record reproducer used singly or paired for stereo and there are many other uses for the TR750 which is available for building or ready built.

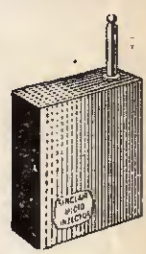


All parts with instructions come to **39/6**

Ready built and tested **45/-**

Trace that fault with a SINCLAIR MICRO-INJECTOR

This ingeniously designed device generates and injects a test signal into any part of audio or radio equipment at any frequency from 1kc/s to 30 Mc/s by means of which it becomes easy to locate faults rapidly and accurately. Measures $1\frac{4}{5} \times 1\frac{3}{10} \times \frac{1}{2}$in. excluding probe. With full instructions. No constructor should be without a Micro-Injector—it's a wonderful aid at all times.



Parts and instructions come to **27/6**

Ready built **32/6**

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radio set in the world

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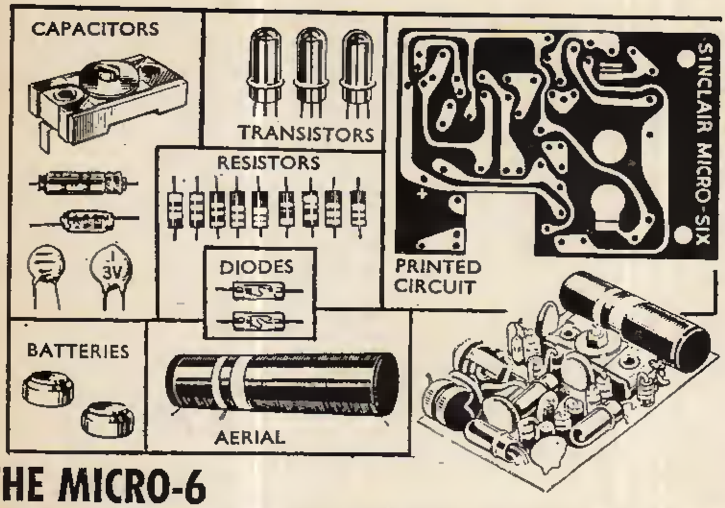

THE MICRO-6 INCLUDES THE SMALLEST COMPONENTS EVER

We show here some of the components (apart from case dial and earpiece) required for building the Micro-6, drawn to actual size. They include the smallest components ever to be made available to domestic set constructors. Being of the kind used in space and computer electronics, they have to be reliable. The tuning system has ingenious vernier control for easy station separation. The batteries (obtainable anywhere) are each smaller than an aspirin tablet and give upwards of 70 hours working life. The 8-page fully illustrated instruction manual shows very clearly how to assemble the Micro-6 step by step, making it easy for anyone to build.

All parts required to build the Micro-6 including lightweight earpiece, case and instructions come to

59/6

"Transrista" nylon strap for wearing the Micro-6 like a wrist watch 7/6

MALLORY MERCURY CELL TYPE ZM312 (2 required) *each* 1/11

Pack of 6 10/6

● **What they say about the Micro-6**

A.F.N., Munich; Holland; France; Germany and many more stations came in without any trouble at all (on Micro-6). At 7.30 a.m. I tuned in Caroline. Kendal is not an ideal reception area.
(Signed) J.A.M., Kendal.

May I congratulate you on a truly splendid design. Keep up the good work.
(4780) (Signed) B.T., Bath.

I am highly satisfied with results. Receives most stations on medium wave band with remarkable volume in a bad signal area.
(5495) (Signed) M.A., Sheffield 6.

SINCLAIR MICRO-AMPLIFIER

Makes an F.M. Transmitter

Makes an Audio or Broad Band R.F. Amplifier

Smaller than a 3d. piece! Frequency response 30 to 50,000c/s ± 1dB. Power gain 60dB (1,000,000 times). Instructions show you how to make a broadband R.F. amplifier, F.M. transmitter or a sub-miniature hi-fi amplifier with an output suitable for any earpiece or even loudspeaker. A fascinating design for experimenters, modellers, etc.

Parts and instructions come to **28/6**

SINCLAIR X-10
10 WATT AMPLIFIER
See preceding pages

This is what the unique Sinclair Guarantee means

Every purchase you make from Sinclair Radionics Ltd. is covered by the following guarantee:

If you are not completely satisfied with your purchase (we are confident you will be delighted) your purchase price will be refunded in full instantly and without question.

FULL SERVICE FACILITIES ARE ALWAYS AVAILABLE TO SINCLAIR CUSTOMERS.

SINCLAIR SLIMLINE

The extra-easy-to-build 4-stage pocket receiver

- Wide range
- Smart appearance
- Easily built in 2 or 3 hours
- Excellent tone and volume

IDEAL FOR NEWCOMERS TO TRANSISTOR SET BUILDING

Here's a fine performing set which is ideal for newcomers to transistor building. It has self-contained aerial and takes standard PP5 batteries. Measures only 2⅞" × 1⅞" × ¾". Tunes over medium waveband by means of vernier type control. The Slimline has great power and quality and will bring in B.B.C. and European programmes. All parts including royal blue and gold case, earpiece and easy to follow instructions come to **49/6**

If you do not wish to cut coupon from page, please mention Practical Electronics, January, when writing.

To SINCLAIR RADIONICS LTD., COMBERTON, CAMBRIDGE

Please send items detailed below:— £ s. d.

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TRANSDUCERS

As specified for use in the Ultrasonic Control System featured in this issue.

Gulton Transducers can be used for simple remote control without cables or electronic links, two units only being required. The Transducers are suitable for both transmitting and receiving. Ideally suited for the experimenter and designer for remote control systems of all kinds. Free TX/RX circuit with each order.

55/- each *or two for £5*

Components for use with the Transducers:

QHF9 Transformer ... ... 4/- each
Set of 7 transistors ... ... at 5/- each
Low current reed relay and coil ... 25/6 each
2 Plugs ... ... at 1/6 each

MICRO-MOTORS

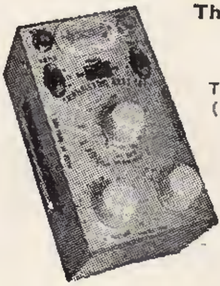
This new Sleyride Motor is precision made and prototype tested by RAE Farnborough. Only 1 in. dia., 2 in. long and weighs only 1.3 oz. Rated 1/1,000 h.p., normal running speed 5,000 r.p.m. Spindle dia. 3/32 in., length 11/32 in. For 1½, 6 or 12 v. Reversible.

25/- each plus 1/6 p. & p.

TRANSISTOR TESTER

The Unique

D.909



Tests Alpha Gain (A.C. Gain) and Beta Gain (D.C. Gain) with transistors in place. Facilities also provided for testing leakage between Collector and Emitter and Collector Base. Exclusive Variable Voltage Smoothed D.C. Power Supply, continuously variable from 0/25 v. up to 25mA. Output voltage can be used as centre-tapped voltage supply enabling modern transistorised receivers to be tested. **£10 each**

Send large S.A.E. for detailed leaflet

EAGLE PRODUCTS AT NEW PRICES

EAGLE STOCKISTS

The following are available:—

TP703	Transistor Tape Recorder	£18.7.6
TI206	Transistor Intercom	£4.6.0
TA790	Telephone Amplifier	£3.4.6
730	Zephyr 7 Transistor Radio	£4.16.0
SA80	8 watt Stereo Amplifier	£10.5.6
100C	Microphone	£1.15.3
DM175	Microphone	£2.2.10
MC70	Microphone	£2.17.0
DM17HL	Microphone	£4.9.5
DM16HL	Microphone	£4.17.0
DS2	Microphone Desk Stand]	£1.12.0
FS3	Microphone Floor Stand	£3.2.4
GT50	Radio Jack	£1.7.0
TD79	Tape Head Demagnetizer	£1.12.0
MM4	Microphone Mixer	£2.13.6
PS35	3.5 mm Plug and Socket	2.8
PS25	2.5 mm Plug and Socket	2.8
P31	Standard Jack Plug	2.8
SP31	Standard Shielded Jack Plug	3.9
OC34	Standard Socket	2.3
SS3271	Sub-min. Slide Switch DPDT	2.3
SS219	Miniature Slide Switch DPDT	2.3
MR4	Earphone, low res.	3.3
MR60	Earphone, with ear hanger	4.4
CR5	Earphone, crystal	4.4
T501	Vernier Dial	13.8
T502	Vernier Dial	15.0
T503	Vernier Dial	17.3
TC801	Turnover Cartridge	11.0
K4/16	Volume Control	3.3
PVC105	Variable Condenser	3.3
LT44/700	Transistor Transformers	(pair) 8.9
TP100	Telephone Pick-up Coil	10.3
SF20	High Resistance Headphone	13.0
BM36R	Lapel Microphone, Magnetic	9.3
MCI	Microphone Crystal Cartridge	4.9
TP26G	2¾" Speaker	9.3
CM16	Guitar Pick-up	13.6
GM35	Guitar Microphone	£3.4.6
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TK20A	1,000 O.P.V. Multimeter	£2.13.6
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MR2P	50 microamp Panel Meter	£2.3.0
MR2P	500 microamp Panel Meter	£1.12.0
MR2P	1 m/a Panel Meter	£1.12.0
MR2P	5 m/a Panel Meter	£1.12.0
MR2P	300 volt Panel Meter	£1.12.0
SR2P	"S" Panel Meter	£1.18.0
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ITI/1	Signal Injector	£1.18.0
RF40	Field Indicator	£3.15.6
AR13	Test Lead Kit	10.3

Trade Enquiries Invited.

TRANSISTORS

AC113	5/6	OA79	3/-	OC74	8/-
AC115	4/-	OA81	2/-	OC75	5/6
AC155	4/-	OA85	3/-	OC76	8/6
AC156	5/6	OA86	4/-	OC78	8/-
AC154	5/8	OA90	3/-	OC79	8/-
AC157	7/-	OA91	3/-	OC81	5/6
AD140	25/-	OA95	3/6	OC82	10/-
AF102	27/6	OC16W	35/-	OC83	4/-
AF114	11/-	OC19	25/-	OC84	8/-
AF115	10/6	OC26	25/-	OC139	8/-
AF116	5/-	OC35	12/-	OC140	19/-
AF117	9/6	OC36	21/6	OC141	31/-
AF118	20/-	OC41	8/-	OC169	10/-
AF124	11/-	OC42	6/-	OC170	8/6
AF125	10/6	OC43	12/6	OC171	6/-
AF126	10/-	OC44	5/-	OC200	10/6
AF127	9/6	OC45	5/-	OC201	20/-
BY100	7/6	OC70	6/6	OC202	24/6
BY114	6/-	OC71	4/3	OC203	13/-
GET113	6/6	OC72	5/6	OC204	19/-
GET114	6/6	OC82	8/-	MAT100	7/9
GET115	9/6	2xOC72 matched pair	16/-	MAT101	8/6
GET116	17/-			MAT120	7/9
OA70	3/-			MAT121	8/6
OA73	3/-	OC73	16/-	ADT140	15/-

SETS OF TRANSISTORS

Set No. 1: comprising OC44, 2 × OC45, OC81, matched pair OC81 20/-.

Set No. 2: comprising OC81, matched pair OC81 12/6.

RECORD PLAYER AND TAPE DECK UNITS

BSR Monarch UA14	£6.6.0
BSR Monarch UA15	£6.19.6
The new BSR Monarch UA15SS fitted with C1 ceramic stereo cartridge	£10.18.11
TD2 Tape Deck, half track	£8.18.0
TD10 Tape Deck half track	£10.5.0
BSR Monarch TU12	£3.10.0
BSR Monarch GU7	£3.17.6
Garrard Autoslim	£7.15.0
Garrard AT6	£11.5.0
Garrard SRP10	£6.0.11

All the above are also available with stereo cartridges at slight extra cost.

SINCLAIR KITS

Sinclair Micro 6	£2.19.6
TR750 Power Amplifier	39.6
Sinclair Micro Injector	27.6
Sinclair Micro Amplifier	28.6
Sinclair X10 Kit	£5.19.6
Sinclair X10 Ready Built	£6.19.6
Mains Unit for above	£2.14.6

MAINS TRANSFORMERS Primaries 200/230/250V

250-0-250v	80mA 0-4-6.3v	4A 0-4-5v	2A	21/9
300-0-300v	80mA 0-6.3v	4A 0-6.3v	1A	22/6
350-0-350v	80mA 0-4-6.3	4A 0-4-5v	2A	21/9
250-0-250v	100mA 0-6.3v	4A 0-5v	2A	27/6
350-0-350v	100mA 0-6.3v	4A 0-5v	2A	27/6
350-0-350v	200mA 0-6.3v	4A 0-5v	3A	55/-

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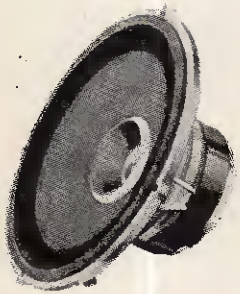
Our latest 1964/65 Catalogue is now available. Copies have been sent to many of our regular customers. If you have not received your copy please drop us a line. Please send 1/- in stamps.

TERMS: Cash with Order or C.O.D. Postage and Packing Charges extra. Single valves 9d. Minimum Parcel Post charges 2/-. Please include sufficient postage with your order. Minimum C.O.D. fees and postage 3/6. These Postal Rates apply to U.K. only. For full terms of business see inside cover of catalogue. Personal shoppers 9 a.m. to 5 p.m. Mon. to Friday, Saturday 10 a.m. to 1 p.m.

ALPHA RADIO SUPPLY CO., 103 Leeds Terrace, Wintoun Street, LEEDS 7

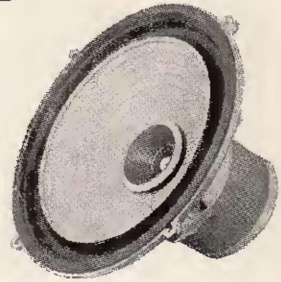
THE WHARFEDALE Super Range

Each loudspeaker in this range is fitted with roll surround for low resonance and double diaphragm assembly for extended HF response.



SUPER 10/RS/DD

Impedance 10/15 ohms.
Flux density 16,000 oersteds.
Max. input 10 watts rms or 20 watts peak.
Frequency range 30-20,000 c/s.
Aluminium Voice Coil.
Bass resonance 38/43 c/s.
Price: 218/8 inc. P.T.

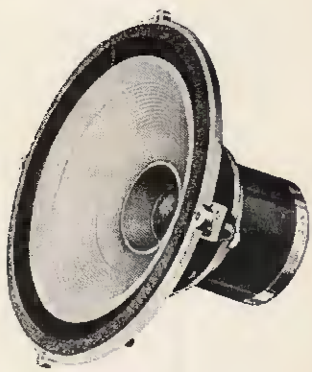


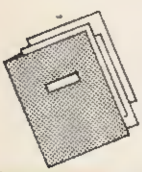
SUPER 8/RS/DD

Impedance 10/15 ohms.
Ceramic Magnet.
Flux density 14,500 oersteds.
Total flux 60,000 maxwells.
Aluminium Voice Coil.
Max. input 6 watts rms or 12 watts peak.
Frequency range 40-20,000 c/s.
Bass resonance 50/60 c/s.
Price: 134/2 inc. P.T.

SUPER 12/RS/DD

Impedance 12/15 ohms.
Flux density 17,000 oersteds.
Total flux 190,000 maxwells.
Aluminium Voice Coil.
Max. input 20 watts rms or 40 watts peak.
Frequency range 25-20,000 c/s.
Bass resonance 26/32 c/s.
Price: 350/- (no tax).





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COTSWOLD

"MALVERN" HI-FI EQUIPMENT CABINET. Will house all your Hi-fi equipment. Left " in the white." Size: 39½ × 32 × 21½ in. Kit £18.1.0

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"COTSWOLD" HI-FI SPEAKER SYSTEMS. Acoustically designed enclosures, complete with 12 in. bass speaker, elliptical mid-range speaker, and tweeter to cover full frequency range of 30-20,000 c/s. Cross-over unit, level control, etc. Left "in the white." **Standard "Cotswold"**, Size: 26 × 23 × 14 in. Kit £23.4.0

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SSU-1 SPEAKER SYSTEM. A practical solution to the problem of a low-price speaker system. Two speakers. Without legs £10.17.6 Kit. With legs £11.12.0 Kit

A wide range of speakers available. Send for details.


FM TUNER


S-99

5 in. FLAT-FACE GENERAL PURPOSE OSCILLOSCOPE. Model IO-12U. An outstanding 'scope. "Y" sensitivity, 10 mV rms per cm at 1 kc/s: Bandwidth 3 c/s to 4.5 Mc/s. T/B 10 c/s to 500 kc/s in 5 steps. Kit £32.12.6. Assembled £41.10.0.

2¾ SERVICE 'SCOPE, Model OS-1 Light (wt. 10½ lb.), compact, 5" × 8" × 14½". The ideal portable for servicemen. Kit £22.18.0. Assembled £30.8.0.

ELECTRONIC SWITCH, Model S-3U. Convert your 'scope to dual trace. Kit £12.18.0. Assembled £18.10.0.


IO-12-U

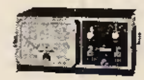

S-3U

HI-FI FM TUNER. Range 88-108 Mc/s. Available in two units, sold separately. TUNER (FMT-4U) 10.7 Mc/s IF £2.15.0 (inc. P.T.). IF AMPLIFIER (FMA-4U) power supply and valves £13.3.0. Total Kit £15.18.0.

9 + 9W HI-FI STEREO AMPLIFIER, Model S-99. Ganged controls. Stereo/Mono Gram., Radio, Tape inputs. P.C. board construction. Attractive presentation. Kit £27.19.6. Assembled £37.19.6.

"OXFORD" LUXURY TRANSISTOR PORTABLE, Model UXR-2. Beautiful solid leather case. Kit £14.18.0

GENERAL COVERAGE RECEIVER, Model RG-1. Freq. coverage 600 kc/s-1.5 Mc/s. 1.7-32 Mc/s in 6 switched bands. Many features incl. ½ lattice crystal filter. Kit £39.16.0 Assembled £53.0.0.


IM-13U


HFW-1

6 in. DE LUXE VALVE VOLTMETER, Model IM-13U. Measures ac and dc volts 0-1.5 to 1,500V in 7 ranges. Res. to 1,000 MΩ in 7 ranges. Modern styling, with gimbal mount. Kit £18.18.0. Assembled £26.18.0.

VALVE VOLTMETER, Model V-7A. DC volts to 1,500, AC to 1,500 rms and 4,000 V pk. to pk. Res. 0.1-1,000 MΩ. Kit £13.18.6. Assembled £19.18.6. RF Probe 309-CU £1.13.6 kit. HT Probe HV.336 £2.19.6 kit. Will extend range of models V-7A or IM-13U.

TV ALIGNMENT GENERATOR, Model HFW-1. 3.6 to 220 Mc/s on fundamentals. Unique electronic sweep oscillator. Built-in fixed and variable marker generators (5 Mc/s crystal). Kit £34.18.0. Assembled £44.10.0.


UXR-2


RG-1

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AM/FM TUNER Covers FM 88-108 Mc/s, AM 16-50, 200-550, 900-2,000 M. Tuning heart (£4.13.6 inc. PT) and IF Amp. Case. Total £26.10.0 Kit

6W STEREO AMPLIFIER. Model S-33H. An inexpensive stereo/mono amplifier. Ideal for use with the Decca Deram lightweight pickup. Modern attractive styling. Kit £15.17.6 Assembled £21.7.6

"GARRARD" AUTO RECORD PLAYER. Model AT.6. A four-speed stereo/mono unit with auto. record selection. Fitted with R.105 crystal pickup £13.12.1. With Decca Deram pickup £14.6.1.

5W MONO AMPLIFIER. Model MA-5. A general purpose amplifier based on model S-33. Separate bass and treble controls, gram and radio inputs. Printed circuit. Kit £10.19.6. Assembled £15.10.0.

JUNIOR ELECTRONIC WORKSHOP, Model EW-1. 20 exciting experiments can be made. Special solderless connections. Kit only £7.13.6.

MULTIMETER. Model MM-1U. Ranges 0-1.5v to 1,500v A.C. and D.C. 150 μA to 15A D.C.; 0.2 to 20 MΩ. 4½" 50 μA meter. Kit £12.18.0. Assembled £18.11.6.


PA-1


AT-6

R.F. SIGNAL GENERATOR, Model RF-1U. Freq. coverage from 100 kc/s-100 Mc/s on six bands, on fundamentals and up to 200 Mc/s on calibrated harmonics. Kit £13.8.0. Assembled £19.18.0.

DECADE RESISTANCE, Model DR-1U. Range 1-99,999Ω in 1Ω steps. Kit £10.8.0. Assembled £14.8.0.

DECADE CAPACITOR, Model DC-1U range. 100 μμF to 0.111 μF in 100 μμF steps. Kit £7.5.0. Assembled £10.8.0.

INTERNATIONAL MAIL ORDER SCHEME covering the American Heathkit range of 250 models. Illustrated American catalogue and full details can be obtained from us for 1/- post paid.

50W PUBLIC ADDRESS AMPLIFIER, Model PA-1. A multi-purpose unit, suitable for vocal and instrumental groups. 4 inputs for guitars, mics, etc. 2 heavy duty speakers, vol. indicator, variable tremolo, modern cabinet. Kit £54.15.0. Assembled £74.0.0.

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"MOHICAN" TRANSISTOR GENERAL COVERAGE RECEIVER, Model GC-1U. Freq. coverage 580 kc/s to 30 Mc/s in 5 bands. Electrical band spread on 5 additional bands covers "amateur" freq. from 80-10 M. B.F.O. Tuning and Zener diode. Send for details. Kit £37.17.6. Assembled £45.17.6.

80-10m AMATEUR TRANSMITTER, Model DX-40U. Crystal controlled. Power input 75w. c.w. 60w. peak controlled carrier phone. Output 40w. Kit £33.19.0. Assembled £45.17.6.

TRANSISTOR INTERCOM, Models XI-1U and XIR-1U. Ideal for home or business. Each master (XI-1U) will operate up to 5 remote stations. 9v. battery operation. XI-1U (Master) kit £10.19.6. Assembled £16.19.6. XIR-1U (Remote) kit £4.7.6. Assembled £5.16.0.

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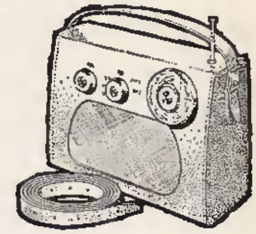


ROAMER SEVEN Mk III

5 WAVEBAND PORTABLE OR CAR RADIO

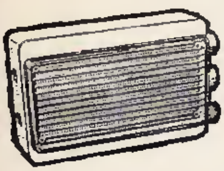
Amazing performance and specification ★ *Now with PHILCO MICRO-ALLOY R.F. TRANSISTORS*

● 9 stages—7 transistors and 2 diodes

Covers Medium and Long Waves, Trawler Band and two Short Waves to approx. 15 metres. Push-pull output for room filling volume from rich toned heavy duty 5in. 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 × 4in. approx. The perfect portable and the ideal car radio. (Uses PP7 battery available anywhere).

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

Parts Price List and easy build plans 3/-



TRANSONA FIVE

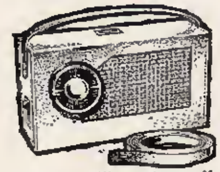
Home, Light, A.F.N., Lux. all at good volume. *G.P. Durham*

● 7 stages—5 transistors and 2 diodes

Fully tunable over Medium and Long Waves and Trawler Band. Incorporates Ferrite rod aerial, tuning condenser, volume control, new type fine tone super dynamic 2¾in. speaker, etc. Attractive case. Size 6¼ × 4½ × 1½in. with red speaker grille. (Uses 1289 battery available anywhere.)

Total cost of all parts now only **42/6** P. & P. 3/6 *Parts Price List and easy build plans 2/-*

MELODY SIX



"... amazed at volume and performance. has really come up to my expectations". S.G., Stockton-on-Tees.

● 8 stages—6 transistors and 2 diodes

Our latest completely portable transistor radio covering Medium and Long Waves. Incorporates pre-tagged circuit board, 3in. heavy duty speaker, top grade transistors, volume control, tuning condenser, wave change slide switch, sensitive 6in. Ferrite rod aerial. Push-pull output. Wonderful reception of B.B.C. Home and Light, 208 and many Continental stations. Handsome leather-look pocket size case, only 6½ × 3½ × 1½in. approx. with gilt speaker grille and supplied with hand and shoulder straps.

Parts Price List and easy build plans 2/- Total cost of all parts now only **£3.9.6** P. & P. 3/-

COMPONENT BARGAINS ALL POST FREE

TRANSISTORS

PHILCO MADT Type 2N1727 Maximum frequency of oscillation 150 Mc/s .. .. 8/6.
PHILCO MADT Type 2N1728 Maximum frequency of oscillation 150 Mc/s ... .. 9/6.
PHILCO MADT (Micro Alloy Diffused) Type 2N503 Maximum frequency of oscillation over 500 Mc/s 15/-
Diodes 1/6
Standard interleaved output transformers for valve output stages 3/6

SWITCHES

Slide, single pole, heavy springs 2/3
Yaxley 6-way, 2 pole .. 4/9

TUNING CONDENSERS

Air spaced fine quality German manufacture with slow motion drive. 0·0005 with oscillator section 9/6
Subminiature similar 00 with tuning and oscillator sections 7/6
Subminiature mica dielectric with trimmers. Tuning 200 pf. Oscillator 50 pf 5/6
Mica dielectric 0·0003 mfd. 3/10

BELLPHONES

Ex-G P.O. Suitable as sound powered telephones. Resistance of coil 60 ohms approx. 3in. U-shaped magnet .. 5/9

HEADPHONES

High fidelity miniature magnetic earpieces (2) on slim band with lead and plug. Easily converted to stereo. American manufacture 13/6
Miniature crystal earpiece with lead plug and socket 6/6

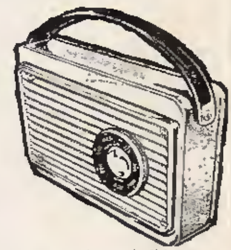
DIALS AND KNOBS

3in. dial with polished brass insert and M/L calibrated disc 6/6
1in. cream knobs with polished brass insert and rim 1/3 each

CASES

Real leather-look cases in chestnut shade with holes punched for tuning, volume control and switch. Also holes punched for car aerial socket and tone control. 9½ × 3½ × 7½in. approx. Complete with carrying straps 35/-
Plastic cases in grey polystyrene with red ornamental grille, 6½ × 4½ × 1½in. approx. 6/9
Telescopic aerials with fixing socket 6/6

TRANSONA SIX



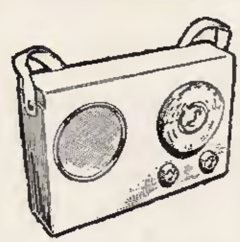
● 8 stages—6 transistors and 2 diodes

This is a top performance receiver covering full Medium and Long Waves and Trawler Band. High-grade approx. 3in. speaker makes listening a pleasure. Ferrite rod aerial. Many stations listed in one evening including Luxembourg loud and clear. Attractive case in grey with red grille. Size 6½ × 4½ × 1½in. (Uses PP4 battery available anywhere.)

Total cost of all parts now only **59/6** P. & P. 3/6 *Parts Price List and easy build plans 2/-*

ROAMER SIX *NEW!!*

NOW WITH PHILCO MICRO-ALLOY R.F. TRANSISTORS



● 6 WAVEBAND!!

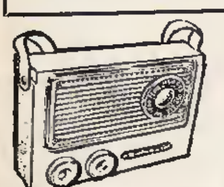
● 8 stages—6 transistors and 2 diodes

Listen to stations half a world away with this 6 waveband portable. Tunable on Medium and Long Waves. Trawler band and three Short Waves. Sensitive Ferrite rod aerial and telescopic aerial for short waves. Top grade transistors, 3-inch speaker, handsome case with gilt fittings. Size 7½ × 5½ × 1½in.

★ Extra band for easier tuning of LUX., etc.

Parts Price List and easy build plans 2/- Total cost of all parts now only **£3.19.6** P. & P. 3/6 (Carrying Strap 2/6 extra.)

SUPER SEVEN



● 9 stages—7 transistors and 2 diodes

Covers Medium and Long Waves and Trawler Band. The ideal radio for home, car, or can be fitted with carrying strap for outdoor use. Completely portable—has built-in Ferrite rod aerial for wonderful reception. Special circuit incorporating 2 RF Stages, push-pull output, 3in. speaker (will drive large speaker). Size 7½ × 5½ × 1½in. (Uses 9v battery, available anywhere.)

Total cost of all parts now only **£3.19.6** P. & P. 3/6 *Parts Price List and easy build plans 2/-*

All components used in our receivers may be purchased separately if desired. Parts price lists and easy build plans supplied free with sets of parts or available separately at fixed prices stated.

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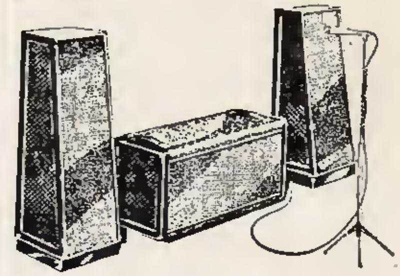

Incorporating Ten High Duty Speakers in two columns of five designed to handle efficiently the full output of Amplifier at frequencies down to 25 c.p.s. Heavily made Cabinet in two-tone Vynair. For 200-250 v. to 50 c.p.s. A.C. Mains operation. Four jack socket inputs and two independent volume controls for simultaneous connection of up to four instrument pick-ups or microphones. Level frequency response throughout the Audible Range. **OUR INCLUSIVE PRICE FOR AMPLIFIER, MIKE, STAND, SPEAKERS, LEADS, ETC., ONLY 35 GNS.**

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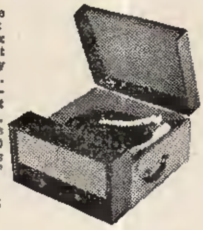

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⅞in.	15 9	1⅜in.	20 -	1in. sq.	31 6
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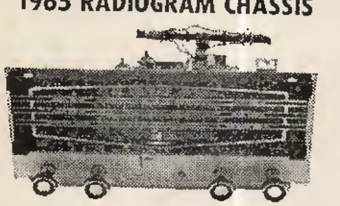
1965 RADIOGRAM CHASSIS



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M.W. 200 m.–500 m. — ECH81, EF89, EBC81,
L.W. 800 m.–2,000 m. — EL84, EZ80
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Size 6½ × 5 × 4in. 200-250 AC double wound mains transformer. Volume and tone controls. Sensitivity 200 mv. Response 25 to 20,000 cps. Price **49/6** *each. Complete with valves, etc. Brand new.*
2 units matched for stereo etc., 89/6.

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STANDARD 250-0-250, 80 mA. 6.3 v. 3.5 a., tapped 4 v. 4 a. Rectifier 6.3 v. 1 a. tapped 5 v. or 4 v. 2 a. 22/6
Ditto 350-0-350 .... 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, 250-0-250 v. 45 mA., 6.3 v. 2 a. 17/6
STANDARD 250-0-250 65 mA., 6.3 v. 3.5 a. 17/6
HEATER TRANS. 6.3 v. 1½ a. 7/6
Ditto tapped sec. 1.4 v., 2, 3, 4, 5, 6.3 v. 1½ amp. 8/6
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GENERAL PURPOSE LOW VOLTAGE. Outputs 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 v. at 2 a. 22/6
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MULLARD "510" MAINS TRANS. TO SPEC. 33/6
300-0-300 120 mA., 6.3 v. CT 4a., 0, 5, 6.3 v. 2 a.

MAINS POWER PACKS. Ready built with Mains Transformers, Rectifiers and Condensers etc., providing H.T. and L.T.
200 v. 20 mA. D.C. ½ wave 6.3 v. 1 a. A.C. 25/6
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250 v. 80 mA. D.C. Full wave 6.3 v. 4 a. A.C. 45/6

"THE POWER MITE" 45/-

PM9 Mains Unit 9 volt for Transistor Radios. Same size as P.P.9 (200-250V.) also Miniature PP3 model........19/6

4 TRANSISTOR PUSH-PULL AUDIO AMPLIFIER

Size 3 × 1¾ × ⅞in.
A ready built miniature push-pull amplifier with Driver and output transformers, 4 transistors. Ideal for use with record players, intercoms, BABY ALARMS, etc., Complete with full instructions and circuit.
Price **47/6** 9 v. Batt. 2/3, 2½in. Speaker 15/-

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Sub Miniature Condensers. 0.1 mFd., 30 v., 1/3. 1, 2, 4, 5, 8, 16, 25, 30, 50, 100 mFd., 15 volt 2/6 each.

TRANSISTOR 4 CHANNEL MIXER with 4 separate input-output controls, 59/6

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Long spindles. Midget Size 5K ohms to 2 Meg. LOG or LIN. L/S 3/-. D.P. 4/6.
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Low loss 5dB per 100ft. at 500 mc/s.
Ideal 625 lines 1/6 yd.

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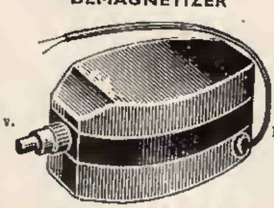

200/250 v. A.C.
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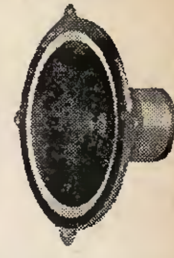
B.T.H. TAPE MOTORS 115 v A.C. 28 w. 12/6 pair, for 200/250 v. (in series)

BAKERS 'Selhurst'



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BASS RESONANCE 80 cps
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12in. STALWART HEAVY DUTY 15w. 3 or 15 ohm voice coils. Unlimited Applications. Response 45-13,000 cps. Magnet 12,000 lines. **5 gns.**

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"W.W." Radio Valve Data	7/6
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TV Fault Finding	5/–
Mullard Audio Amplifier Manual	8/6
Radio Valve Guide, Books 1, 2, 3 or 4 ea.	5/–
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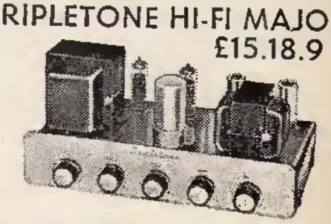
TRIPLETONE HI-FI MAJOR £15.18.9



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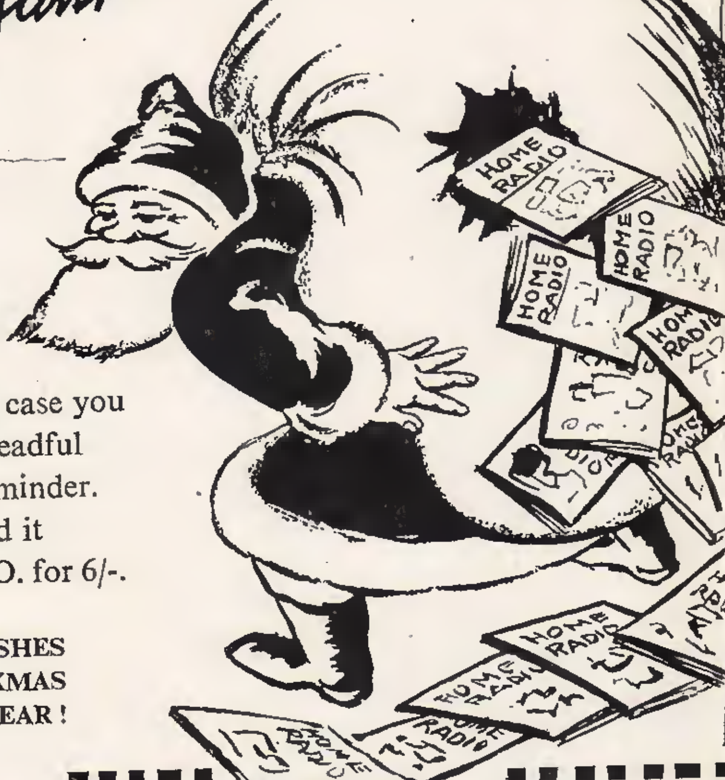

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VOL. 1 No. 3
JANUARY 1965

Practical Electronics

The Thermionic Valve

SIXTY years ago occurred an event that laid the foundation for the future electronics industry. In November 1904, Sir John Ambrose Fleming took out a patent for his oscillation valve—a device making use of the Edison Effect for the rectification of radio and audio frequencies. Thus was born the diode, the first of what was to become a large family of thermionic devices utilising the phenomenon of electron emission.

* * *

From the earliest days the radio industry adopted the thermionic valve as its own, but there were also other applications such as electrical measuring instruments where this device soon proved its worth. With these increasing and diversified uses for the valve, a new industry began to evolve—Electronics was coming into being.

New knowledge and techniques acquired particularly during the war years 1939–45 led to the development of computers and other electronically operated devices quite outside the conventional radio communications field. Ironically, these developments also resulted in research into the properties of semiconductor materials and led in turn to the discovery that would end the reign of the thermionic valve in many fields—but this is another story.

* * *

All of this is, of course, history. What of the position today, and in particular how important is the thermionic valve to the amateur constructor of electronic equipment?

Those who have taken up electronics as a hobby in the last few years and those just starting will probably have little interest in working with valves. But we imagine the valve will continue for some time yet to have its devotees among the older hands who became involved with electronics in the pre-transistor era. A spares box well stocked with "bottles" accumulated over the years is one possible assurance against sudden and total loss of interest in the valve; the plentiful supply of replacements at low prices is another.

Bearing all this in mind, it will be our policy to include a number of valve operated devices amongst our constructional projects, although current trends demand that the major emphasis be given to designs based on semiconductors.

* * *

So, sixty years after its discovery we find the thermionic valve superseded in many fields, but by no means completely eclipsed. What of the future? At least so far as high power work is concerned, it seems likely that modern versions of Fleming's diode and other valves using the cathodic emission principle will continue to play a vital role in electronic engineering for many more years to come.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our February issue will be published on Thursday, January 14

All correspondence intended for the Editor should be addressed to: The Editor, PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Editorial and Advertisement Offices: PRACTICAL ELECTRONICS, George Newnes Ltd., Tower House, Southampton Street, London, W.C.2. Phone: Temple Bar 4363. Telegrams: Newnes Rand London. Subscription Rates including postage for one year, to any part of the world, 35s.

ELECTRONIC POWER

Methods of conversion from non-mechanical energy to electricity

By L. J. Kampel

ENERGY FROM NOTHING—perhaps a scientist's dream! All the laws of science are against it. Scientists are looking for new, efficient and cheaper ways of converting heat energy to electricity.

Thermionic, thermoelectric, magnetohydrodynamic and thermo-photovoltaic principles, the four most significant heat to electricity conversion methods, are reviewed and compared in this article.

Fig. 1 summarises a number of possible electricity producing energy conversion methods. It is a fundamental principle that, although it may be changed from one form to another, energy is indestructible. One common example is the conversion of energy from heated petrol to motion in a motor car.

In a closed thermodynamic system, energy is neither created nor destroyed. There is a limiting factor in the conversion of heat to other forms of energy, known as the Carnot efficiency factor. The greater the temperature change of a heat to electricity converter, the higher will be its conversion efficiency.

THERMIONIC CONVERSION

One of the most common forms of thermionic converter is Edison's "double-life" incandescent lamp. Instead of enclosing a single filament in one envelope he used two filaments. Filament 1 was connected directly to the power source, and filament 2 was connected to the source via an open switch (see Fig. 2). When filament 1 broke down, the switch automatically closed bringing filament 2 into use. Edison's idea amounted to little more than a domestic gimmick, but as it turned out this principle was the first step toward the development of the thermionic valve.

During his experiments Edison connected ammeters in the two separate circuits, as will be seen from the diagram. When filament 1 was energised a small current was registered on ammeter A2 while the switch was still open. Some electrons had moved from the hot filament to the cold one. This phenomenon became known as the "Edison Effect", the principle of thermionic emission.

Later developments of Edison's discovery led to the diode valve. In the simplest type of valve the filament acts as the cathode. Other types have separate cathodes which are heated by the filaments. Fig. 3a shows a simple diode valve circuit.

When the cathode is heated the disturbance of ions due to the high temperature produces a "cloud" of electrons in the vicinity of the cathode. This is known as a space charge.

So far, battery B2 is isolated from the valve by S1. In this condition a state of random activity exists around the cathode with no control over the electrons.

Now, if S1 is closed, battery B2 supplies a potential to the anode, positive with respect to the cathode. Here we have a new condition whereby the negatively charged electrons are attracted to the positively charged anode, causing an *electron* flow in the direction shown in Fig. 3b. If the supply voltage from B2 is increased the anode, having now a greater positive potential, will attract more electrons towards it and so increase the current through the valve. However, this rise in current is *not* directly proportional to the rise in anode voltage due to the retarding effect of the space charge, and therefore does not follow Ohm's Law (Fig. 3c). When the anode voltage is increased to a state whereby the maximum possible current is obtained, the diode is said to be saturated.

One other method of increasing the current is to raise the temperature of the cathode by increasing the filament voltage but this can only be done within the limits of the current carrying capacity of the filament. The effect of this method is shown in Fig. 3c.

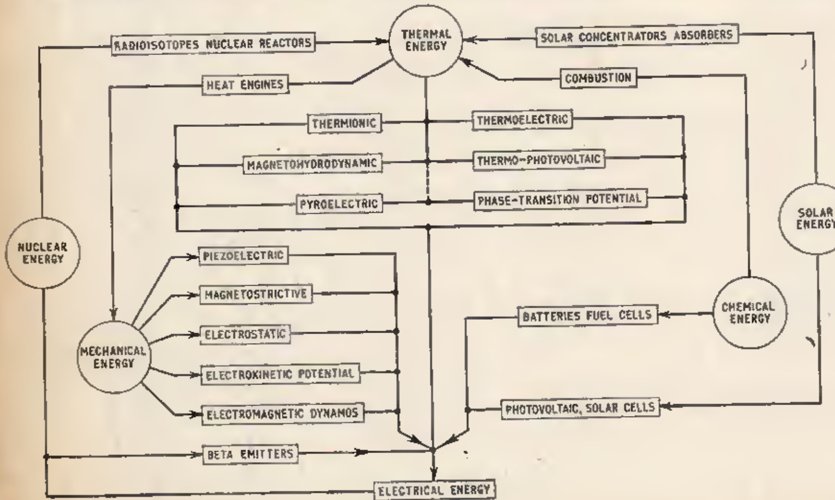


Fig. 1. Chart of energy conversion methods

FIG 2

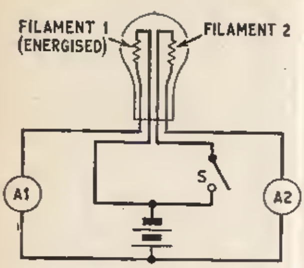


Fig. 2. Edison's "double-life" lamp

FIG 3A

FIG 3B

FIG 3C

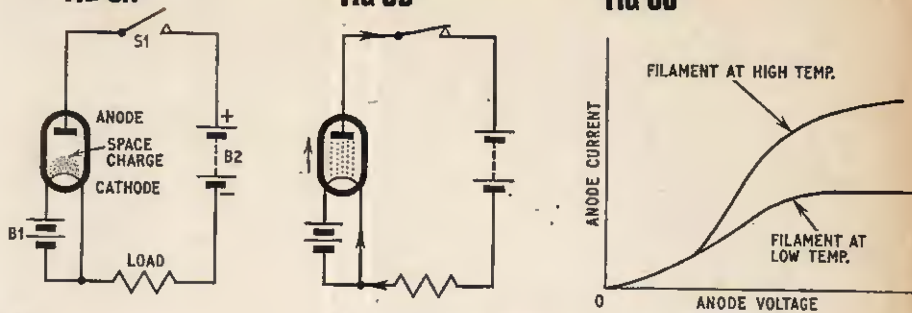


Fig. 3. Simple diode valve circuit and characteristics

REDUCING THE SPACE CHARGE

The retarding effect of the space charge can be considerably reduced by filling the valve tube with an ionised gas. Let us consider the path of a single electron passing through a certain amount of rarified gas or vapour (Fig. 4). During motion the electron will eventually collide with a gas atom (Fig. 4a), producing a new electron and positively charged ion (Figs. 4b and c). These two electrons are attracted towards the anode but on the way they collide with neutral atoms. If collision is great enough to cause ionisation there will be four electrons and three ions (Fig. 4c). This increase of electrons is called an electron avalanche.

The three main classes of thermionic energy converter are illustrated in Fig. 5. The typical diode shown in Fig. 5a is filled with caesium plasma, in which the positive ions neutralise to a great extent the negative electron space charge and permit a free flow of electrons to the anode.

To operate gas filled diodes efficiently the operating temperature should exceed 2,000°C. When filled with caesium vapour, ionisation is achieved more readily, but the high temperature necessary to provide this condition may impair the life of the cathode.

Fig. 5b shows a section of a vacuum close-spaced diode. In this type of energy converter the cathode and anode are very close together—for effective operation they should be about 0·01mm apart.

The third method of reducing the space charge effect is by using crossed electric and magnetic fields (Fig. 5c). Here the heated cathode and the cold anode are in the same plane, and separated by a space less than one-eighth of the width of the electrodes. An auxiliary anode, called the accelerator, is placed parallel to the cathode and anode a short distance away. A magnetic field is placed in such a position that the electrons, after being attracted towards the positively charged accelerator, will be diverted to the true anode. Theoretically, the magnetic triode would seem to be much more efficient than the close-spaced diode—22 per cent compared with 12 per cent under similar operating conditions.

A number of factors determine the efficiency of the system: the scattering of electrons by gas molecules; the reflection of electrons at the anode surface; general electron scattering; non-uniformity of electric and magnetic fields.

THERMOELECTRIC CONVERSION

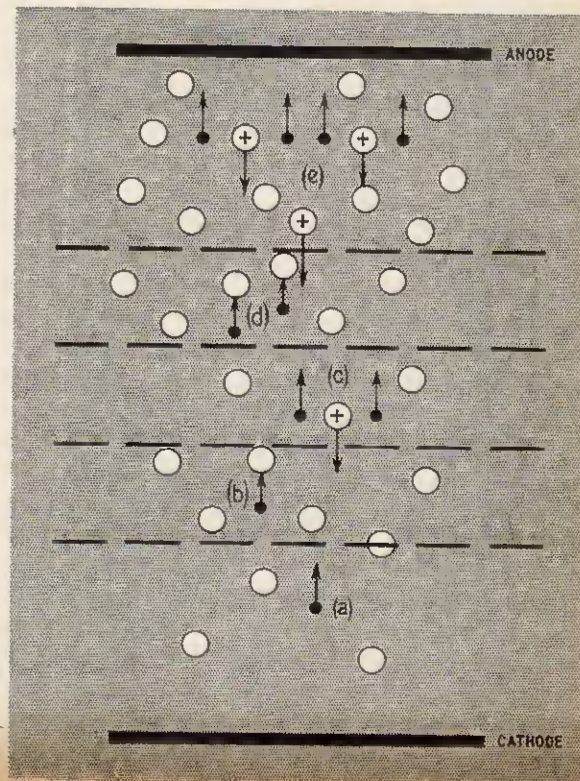
The principle of thermoelectric conversion is that an electric current is produced by a change of temperature in a solid substance. Conversely, as in a thermo-electric refrigerator, if an electric current is passed through a solid the temperature of the solid will change. Thermoelectric effects are reversible physical phenomena.

In 1822, Thomas Seebeck discovered that when the junction of two different metals was heated an electric current was produced. He verified this theory by observing the deflection of a magnetic needle when held close to the junction.

Twelve years later, a Frenchman, John Peltier, discovered that if an electric current was passed through the junction of two different metals, the temperature of the junction increased or decreased depending on the direction of current flow.

Later, in 1857, Thomson (who later became Lord Kelvin) observed that if an electric current is passed through a single solid of homogeneous material, the temperature gradient was in fact matched by a new reversible temperature gradient created and dependent on the direction of current flow.

Fig. 4. Electron bombardment in ionised gas



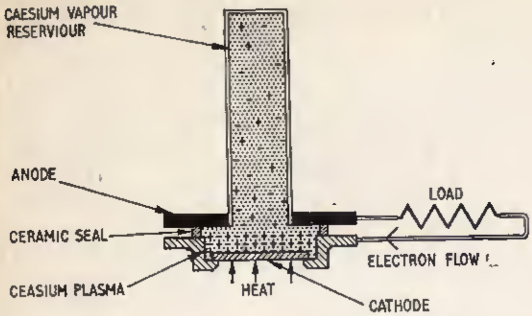


Fig. 5a. Diode filled caesium plasma

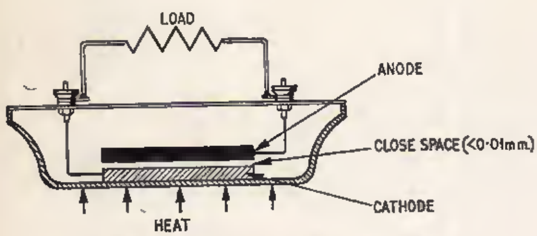


Fig. 5b. Vacuum close-spaced diode

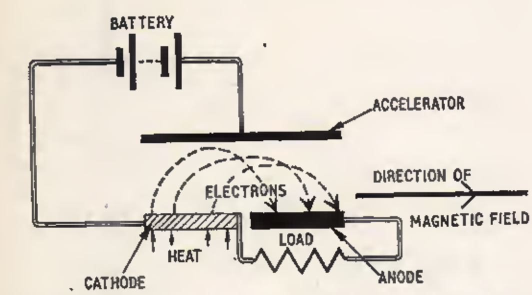


Fig. 5c. Electron flow influenced by crossed electric and magnetic fields

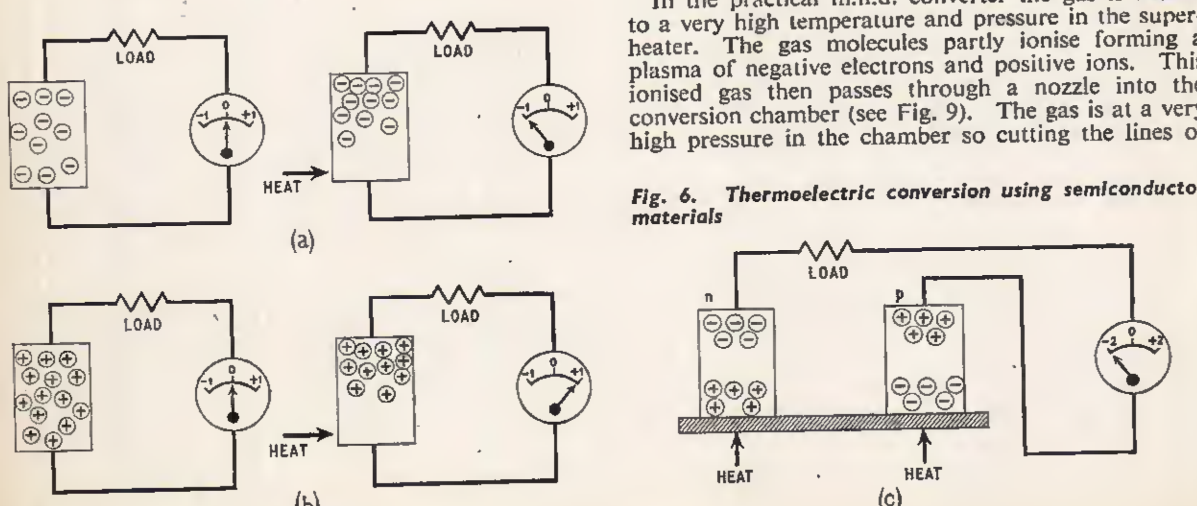


Fig. 6. Thermoelectric conversion using semiconductor materials

All these discoveries led to the development of the semiconductor device. Fig. 6 illustrates the theoretical principles of the *n*-type (6a) and *p*-type (6b) semiconductor material. In Fig. 6a the *n*-type material is negatively charged at ambient temperature with electrons moving at random. The circuit is completed by an ammeter and load resistance. If heat is applied to one end of the material the electrons move towards the cooler part charging it more negatively. The meter would show a deflection indicating the direction of current flow. Similarly the *p*-type material shown in Fig. 6b is positively charged. When heat is applied positively charged particles (holes) are attracted towards the cooler end of the material, but the direction of current flow is reversed.

The effects of combining *p*- and *n*-type semiconductor materials are shown in Fig. 6c, where the combined current produced is theoretically doubled for the same amount of heat applied.

Whilst thermoelectric conversion is very reliable the efficiency is relatively low, from 3 to 16 per cent depending on the material.

MAGNETOHYDRODYNAMIC CONVERSION

Faraday's principle of electric induction is illustrated in Fig. 7. If an electric conductor is moved in a magnetic field an electric current is induced in the conductor. A practical example can be set up by connecting a coil directly to an ammeter. A bar magnet, capable of being inserted in the coil, is held above and in the same plane (see Fig. 7a). While the magnet is held stationary there will be no deflection of the meter needle. If the magnet is now rapidly inserted in the coil as shown in Fig. 7b the meter will register a current in one direction. While the magnet is held inside the coil, no current will flow (Fig. 7c), if the magnet is moved in the reverse direction a current will flow in the reverse direction as shown in Fig. 7d.

A new concept of this principle is used in magnetohydrodynamic conversion, but instead of a wire conductor, ionised gas is used. In the conventional power generator, a gas-driven turbine engine causes the armature to rotate cutting the magnetic lines of force and inducing a current in the armature wire (see Fig. 8a). In the m.h.d. generator ionised gas flows directly through the magnetic field inducing a current through the probe wires (see Fig. 8b).

In the practical m.h.d. converter the gas is heated to a very high temperature and pressure in the superheater. The gas molecules partly ionise forming a plasma of negative electrons and positive ions. This ionised gas then passes through a nozzle into the conversion chamber (see Fig. 9). The gas is at a very high pressure in the chamber so cutting the lines of

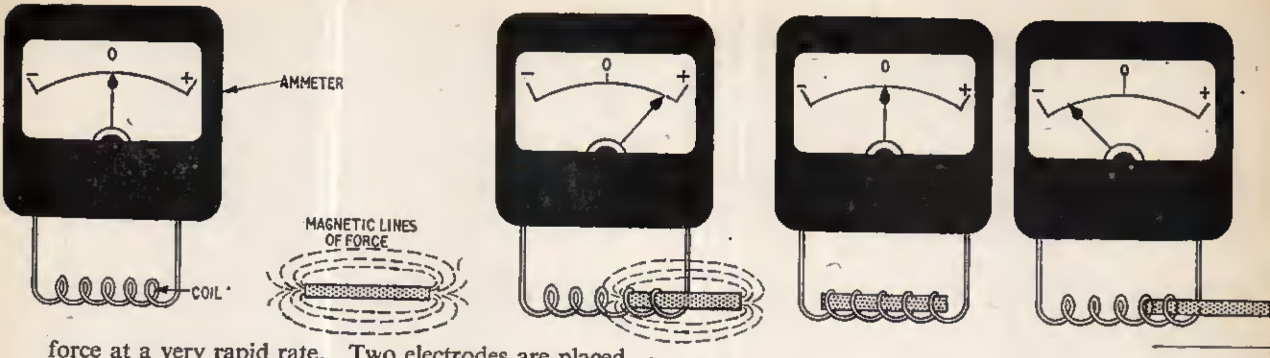


Fig. 7. *Faraday's principle of electric induction*

force at a very rapid rate. Two electrodes are placed one on each side of the gas stream so that the anode picks up electrons deflected by the magnetic field.

The voltage developed between the anode and cathode is dependant on the magnetic field strength, gas velocity, and electrode spacing. The conductivity of the plasma greatly influences the characteristics of the converter. Many gases do not ionise appreciably at temperatures between 2,000 and 3,000 degrees centigrade unless the gas is charged with caesium vapour or potassium.

Magnetohydrodynamic converters have one great advantage over other types described in this article: they can be constructed to produce large quantities of electrical energy for mains distribution. Efficiencies of about 60 per cent are envisaged while the conventional turbogenerator rarely exceeds 40 per cent.

THERMO-PHOTOVOLTAIC CONVERSION

In 1961, Pierre Aigrain delivered a lecture proposing an interesting concept for heat to electricity conversion using an incandescent heat source to excite electrons in a *pn* structure. This system is particularly suitable in environments where there is little sunshine. Fig. 10 shows the theoretical circuit. The photons from an incandescent source are heated to a temperature of more than 1,800°C and are directed towards the converter surface by a parabolic reflector.

Its theoretical efficiency is about 70 per cent, but in practice this may be reduced to about 35 per cent. These figures are based on a system using monochromatic light.

The author is grateful to the American Raytheon Company, the Thermo Electron Engineering Corporation, Avco-Everett Research Laboratory, and Professor H. H. Woodson of the Massachusetts Institute of Technology for their co-operation in the preparation of this article. ★

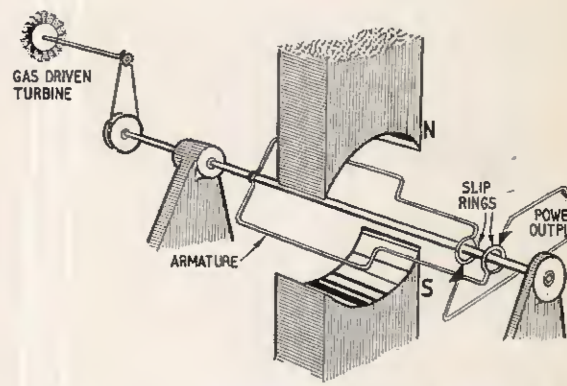


Fig. 8a. *Electromagnetic generator principle*

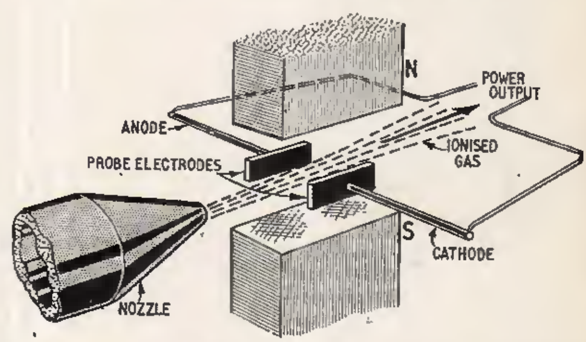


Fig. 8b. *Magnetohydrodynamic conversion using ionised gas*

Fig. 9. *Complete system for m.h.d. conversion* ▶

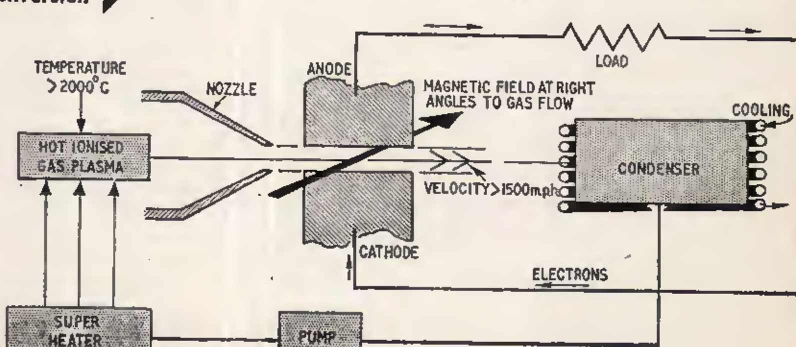
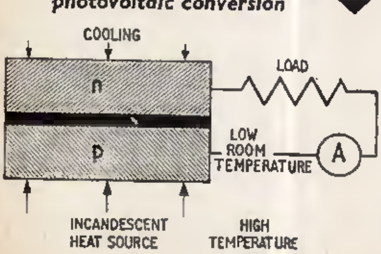
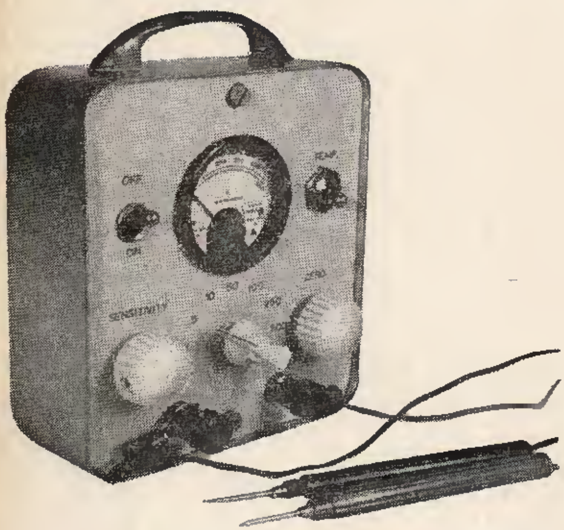


Fig. 10. *Theory of thermo-photovoltaic conversion* ▼



HIGH IMPEDANCE VOLTMETER



By R. E. F. STREET

Most readers will probably be aware of the danger of obtaining misleading results when using most ordinary multimeters to measure potentials in high resistance circuits. For example, if one measured the anode potential of the triode a.f. amplifier in a commercial a.m. superhet, the meter might read 20V instead of the 60V to 80V which one might expect.

The reason for this occurrence is that the meter draws sufficient current through the anode load (which may perhaps be 220 kilohms) that the anode voltage is reduced by the voltage drop across the load. Thus, if the meter took a current of 500μA, the extra voltage drop would be 50 with a 100 kilohm load. Therefore, if the anode potential were 60V, connecting the meter would reduce it to about 10V which would be the reading obtained.

CURRENT TAKEN

If the meter concerned were fully deflected when taking 500μA, it would have a sensitivity of 2 kilohms per volt; the meter described here has a sensitivity of some 50 times this figure—100 kilohms per volt. The current taken (on any range) from the circuit under test in order to secure f.s.d. is thus only 10μA and, of course, if readings are taken below the half-way point on the scale of the meter, then the current from the circuit under test will be 5μA or less.

This design can therefore be used to take readings in circuits where very high resistances are involved without unduly reducing the potentials concerned.

There are available moving-coil multimeters with sensitivities of 100 kilohms/V, and while they give more accurate results than the unit described here, they are considerably more expensive.

In designing this meter, the aim was to produce a unit of high sensitivity which would be comparatively cheap to construct and it was decided that a high order of accuracy was not needed, or practicable, if the cost were to be kept down to a reasonable figure. Generally, where a high impedance meter is required, high accuracy in readings is secondary to the need for the meter to disturb the circuit under test as little as possible.

CIRCUIT

The circuit of the instrument is given in Fig. 1a on the blueprint. Some readers may recognise a degree of similarity to a Mullard circuit which was in fact used as a basis for this design. One transistor is used—an OC75—in a current amplifying circuit.

The indicator is a 500μA meter (M1) which is used in a bridge circuit. When S2 is operated, current flows through TR1 and also through R11 and VR2. VR2 is adjusted so that the potentials at A and B become equal and thus M reads zero. If now a potential is applied to the test terminals, a current flows in the base circuit of TR1 and the collector current increases, unbalancing the bridge and giving a reading on the meter M1.

ACCURACY

The reading on M1 does not increase by equal increments for equal increases in the potential applied to the test terminals, as will be obvious if the circuit is studied. However, the non-linearity is not thought to be serious since the instrument is intended to act as an indicator rather than to give readings of high accuracy.

METER MOVEMENT

The suggested movement is a 2in 500μA type. There is no real point in obtaining an expensive larger meter since the accuracy of the circuit does not really justify the use of such a meter. If a physically larger meter is used, then the layout, and perhaps the mounting box, may have to be changed.

Meters of higher sensitivity can be used, but will be more expensive, though increasing the sensitivity of the complete instrument. Naturally, the values of R1 to R9 will need modifying by experiment if a more sensitive movement is employed.

INTERNAL STANDARD

The "Calibrate" position of S1 needs some explanation. Before using the instrument, it is necessary to calibrate it; R9 and the dry cell BY1 provide a suitable internal reference potential to enable this to be done.

RANGE SWITCHING

A single switch S1 is used for range selection. It should have very good insulation and a ceramic type may be used if available. In the prototype, a Radiospares "Maka-Switch" was employed. A one-pole, 12-way wafer was arranged, by means of the movable "stop", to give a choice of nine ways, as shown in Fig. 3 on the blueprint.

Eight ranges are shown in Fig. 1: 1V, 5V, 10V, 50V, 100V, 250V, 500V, and 1kV. Securing a range of a given f.s.d. (xV, for example) is merely a matter of interposing a resistor of ($100{,}000x$) ohms in the negative test lead, between the base of TR1 and the negative test terminal. Thus, if the constructor wished to add more ranges, or to use ranges with differing f.s.d.'s, the modification would be easy to carry out.

Note that the Key to S1 Positions on the blueprint shows position 7 as 150V; this should, of course, read 250V.

There are also two ways of wiring up the switch S1. In the first, shown in Fig. 1a, and used in the prototype, the multiplier resistors are arranged in a chain around the "ways" of S1. In the second method, shown in Fig. 1b, the resistors are arranged one for each way of S1, and one end of each is joined to the negative test terminal.

The first method has the advantage that the maximum value of resistor required is lower and, consequently, the resistors will, in many areas, be easier to obtain. The second method is perhaps really to be preferred since the multiplier of each range can easily be adjusted to give optimum accuracy, without affecting the values of the other multipliers. However, more will be said of this in the section on the wiring of S1.

CONSTRUCTION

The prototype was built to fit inside a metal box intended for flush-mounting of a control unit for an electric cooker. This box is made by MK Electric Ltd., and the list number is 5120; it can be obtained from electrical suppliers either "off the shelf" or to order. The use of the box gives a professional finish to the meter, as can be seen from the photographs.

The drilling diagram for the panel of the meter is given in Fig. 4 on the blueprint.

BATTERIES

So that the instrument can be entirely self-contained, the batteries are housed in the case and can be seen in Fig. 3, the wiring diagram, and in the illustration on this page. Five 1·5V cells will be required and the type suggested is the Ever Ready D23 or equivalent. The Ever Ready U16 cells are also sufficiently small.

Four of the cells are wired in series as shown in Fig. 2. The method is to place the four cells side by side, alternate cells being inverted as shown, and bind them together with transparent sticky tape. Short pieces of stiff insulated wire are then soldered to the cells to connect them in series. The brass caps must first be cleaned and so must a small area of the zinc at the base of each cell so that the solder will "take" well. A hot iron is essential so that joints may be made very quickly to avoid damage to the cells.

No clips are used to keep the cells in position on the rear of the front panel. Instead, stiff insulated wire is used for all the connections to the cells (except the one to M1 and VR1) and provides enough support, particularly if the wires are kept as short as possible.

WIRING

Wiring of the unit is not at all difficult and plastics-covered wire should be used for all leads. All the wiring shown in Fig. 3 should be carried out except that associated with the multiplier resistors.

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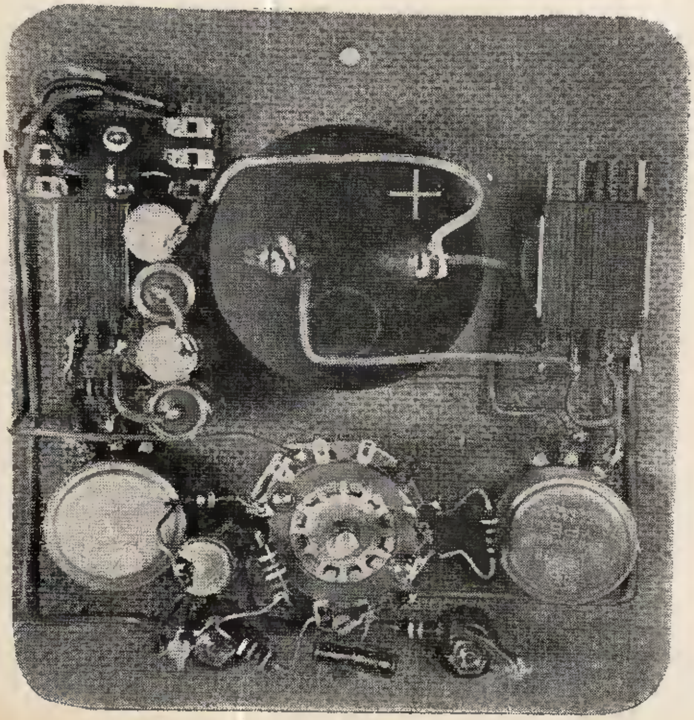
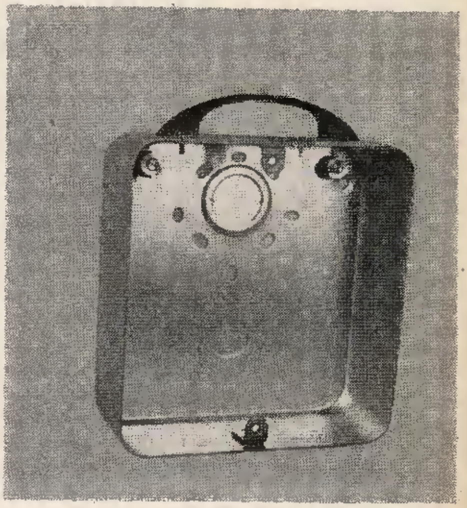




Photograph (left) shows details of wiring and component layout. Photograph (above) shows the cabinet with the front panel and components removed. A piece of felt measuring 5½in × 4¾in is stuck to the back of this box. This felt serves two purposes: it seals the unwanted holes and it prevents any marking of surfaces on which the voltmeter may be placed

INTEGRATED TRANSISTOR AMPLIFIER

THIS FINAL ARTICLE DESCRIBES THE POWER SUPPLY AND GIVES DETAILS OF STEREO ARRANGEMENTS

The d.c. low voltage power supply for the 5 watt integrated amplifier can be obtained from a single type PP9 battery if a low power, high quality output of some 250–300 milliwatts coupled with complete portability is the main consideration as already explained.

However, where high power quality reproduction is required, the d.c. low voltage source of power is obtained with the aid of silicon rectifiers and a suitable step down transformer, the primary of which is connected to the normal 200–240V domestic 50c/s mains supply.

Before describing in detail the power supply unit designed for this amplifier, it will be useful to explain the reasons which lead to the choice of a full wave bridge rectification circuit.

VOLTAGE REGULATION

It is essential that the regulation of the available d.c. voltage should be very stable if distortionless reproduction is to be achieved when using a class B amplifier. With zero signal input the quiescent current is only some 50mA for the combined pre-amplifier and power amplifier; but when the input signal reaches a level of full drive the power output requirements may reach 500mA (or 1 amp if two amplifiers are used for stereo). The load current is drawn through the internal resistance of the power supply. This internal resistance is partly due to the resistance of the silicon rectifiers in the forward direction of current flow (which is fortunately very small) and to a greater extent due to the resistance of the copper wire used in secondary winding of the mains transformer.

Dealing first with the case of the bi-phase full wave circuit, this necessitates a centre-tapped secondary winding. The secondary voltage is chosen so that for an r.m.s. voltage of 20V in each half of the secondary with respect to the centre tap, the rectified output will equal the peak voltage which is obtained by multiplying the r.m.s. value by $\sqrt{2}$. In this instance this equals 28 volts.

It is extremely difficult to centre-tap accurately this winding, and any imperfection of centre tap reflects an unbalance of the current distribution either side of the required neutral point or zero.

It must be clear that there will thus be a small floating potential that is never returned at any instant to true zero. This unbalance is therefore reflected upon the silicon diodes which are effectively in series across the secondary with respect to a.c. and in parallel with respect to the d.c. line. This voltage never is tied exactly to a finite neutral point and varies continuously according to the power load requirements.

ADVANTAGE OF BRIDGE CIRCUIT

The full wave bridge on the other hand consists of four silicon rectifiers used in a self-balancing circuit and supplied by a simple untapped winding of heavier gauge copper wire (with a correspondingly lower d.c. copper resistance) and the difficulties associated with a centre tap are entirely eliminated.

This system is therefore totally adequate in its ability to provide the instantaneous varying demand of the class B output amplifier. Its regulation is inherently good and it is self-balancing with respect to earth. The ripple after rectification is very low and there is, therefore, less chance of electrolytic capacitor failure.

The complete circuit of the power supply unit is shown in Fig. 10. The 20V secondary winding of T1 supplies the bridge circuit composed of four silicon

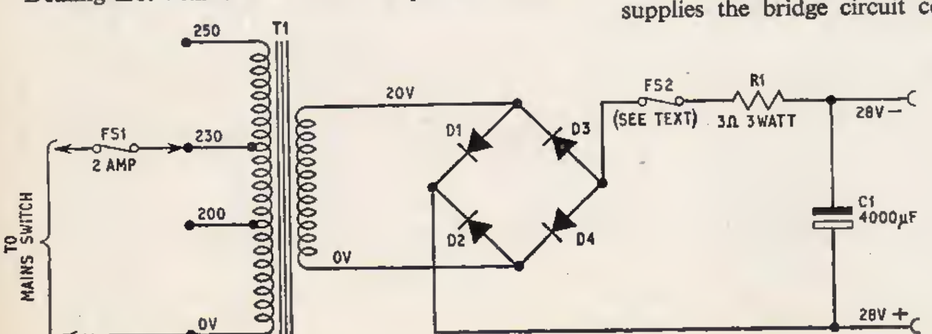


Fig. 10. Circuit diagram of the power supply unit

rectifiers D1–D4, and the pulsatory d.c. output is filtered by C1 and R1. Protection against over-load is provided by FS1 in the primary side of the mains transformer, and by FS2 in the negative d.c. line. FS2 should be 1 amp for monaural and 2 amp for stereo applications.

The mains transformer may appear to be of somewhat generous proportions, but it should be explained that this has been selected with the object of meeting the requirements of a pair of 5W integrated amplifier units—such as would be used in a stereo set-up. Furthermore this is a standard type of component and is readily available.

CONSTRUCTION DETAILS

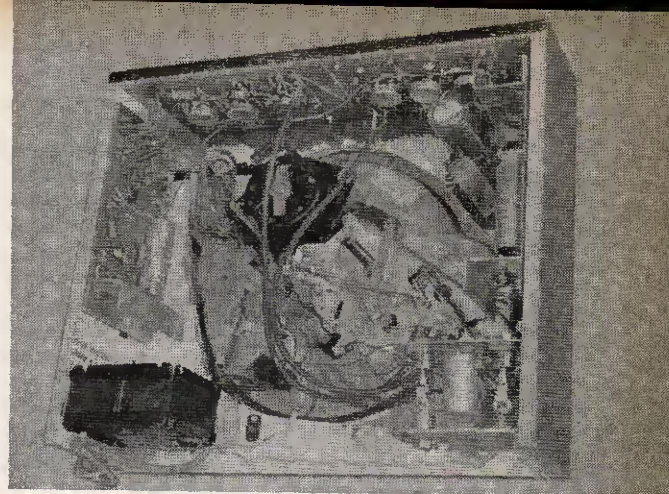
All components are assembled on a piece of ⅜in plywood measuring 7¾in × 4in. Output connections are made via a pair of sockets on a panel situated at one end of the unit. At the opposite end is another panel carrying the two fuses and the mains transformer voltage adjustment.

Each pair of silicon rectifiers is mounted on an angle bracket fashioned from 16 s.w.g. aluminium, see Fig. 11. The rectifiers have threaded bushes and are secured by means of the washers and nuts provided.

STEREO REPRODUCTION

The integrated quality amplifier has not been designed *solely* for stereophonic reproduction as it is felt that a great number of music lovers have decided views regarding the restriction imposed by the positioning of loudspeakers in relation to the listener and the difficulty in obtaining good stereophonic reproduction in the average lounge or living room.

There is also the sad medical fact that a large number of music lovers do not possess identical hearing in both ears, and it was the latter fact that influenced the choice of the single-ended monaural amplifier. This presents two entirely separate amplifiers to the stereophonic user, each channel being individually adjustable for tone and volume and so enabling the most satisfactory balance to be obtained.



Photograph of the author's stereo arrangement. The two pre-amplifiers and power amplifiers are mounted on the front and two sides of the cabinet respectively

COMPONENTS . . .

Resistor
R1 3Ω 3W wire-wound

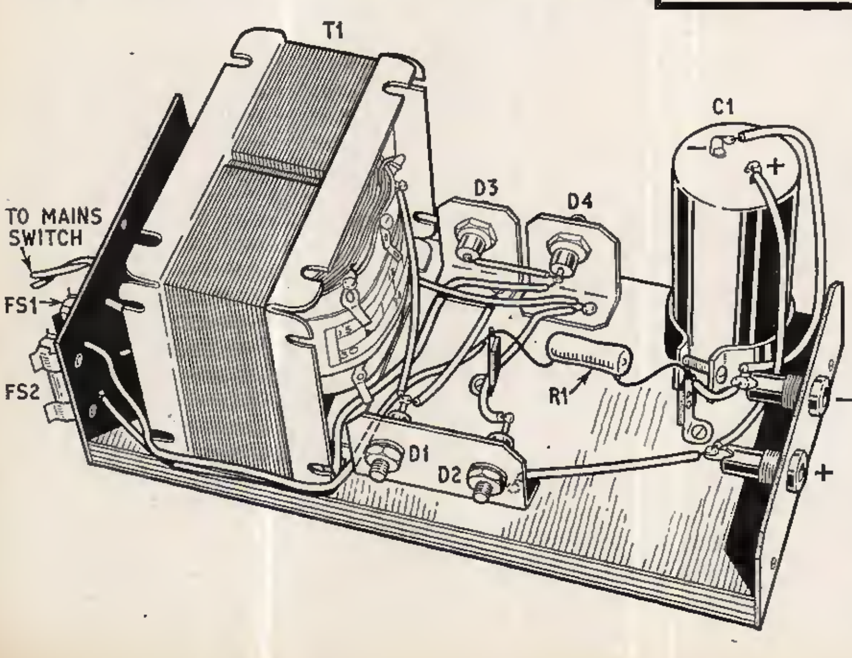
Capacitor
C1 4,000μF elect. 40V (Mullard C431 series)

Rectifiers
D1–4 BYZ13 silicon (Mullard) 4 off

Transformer
T1 Mains transformer. Secondary 0–20V (Douglas)

Fuses
FS1 Mains fuse 2 amp
FS2 H.T. fuse 1 amp (2 amp for stereo)

Miscellaneous
Paxolin mains panel incorporating fuse holders; pair PK8A red and black plugs and sockets; capacitor clip; piece of paxolin 4in × 1½in; baseboard 7¾in × 4in plywood; connecting wire and sleeving; brass wood screws



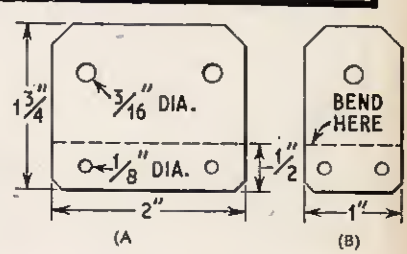


Fig. 11 (above). Drilling details of the 16 s.w.g. aluminium angle brackets for mounting the silicon rectifiers. D1 and D2 are mounted on bracket A and D3 and D4 are mounted on two brackets to the dimensions of B

Fig. 12 (left). Layout of components and wiring on plywood baseboard

To obtain stereophonic reproduction, assign one amplifier unit to the right-hand channel, and another to the left-hand channel. The output from each power amplifier is then fed to the correctly positioned right-hand and left-hand loudspeakers. The two outputs from the stereo pick-up head are fed to the correct right-hand and left-hand pre-amplifier inputs.

The volume from each loudspeaker can be individually adjusted to suit the listener's comfort and the desired tonal balance obtained by varying the setting of the bass and treble controls.

A COMPACT INSTALLATION

It is not proposed to discuss in detail arrangements for housing these units. No real problem exists here, for the very compactness of the equipment simplifies this matter, and readers will have their own ideas concerning the type of installation they prefer.

It does, however, seem of general interest to include an illustration of one particular stereo set-up which has proved highly satisfactory. As can be seen (on page 179), all the electronic equipment is installed inside the table top cabinet which houses the record player.

TABLE 1

5W OUTPUT

TR1	Ve	1·5V	TR6	Ve	1V
TR2	Vc	4V	TR7	Ve	14V
TR3	Vc	1·5V	TR8	Vc	0·5V
TR4	Vc	3V	TR9	Vc	—28V
TR5	Ve	1·5V	TR10	Vc	—14V

D.C. Supply 28V
Total current—quiescent 50mA; max. drive 500mA
Measured on 20,000Ω/V meter. Volume control at minimum

The two pre-amplifier sub-assemblies are separately mounted on the front side of this cabinet, and the power amplifiers one on either side of the cabinet. A modified form of construction has been employed for the power supply unit. The mains transformer is mounted in the left-hand rear corner, while the remaining parts are grouped in the opposite corner.

TABLE 2

300mW OUTPUT

TR1	Ve	0·5V	TR6	Ve	0·3V
TR2	Vc	1·3V	TR7	Ve	9V
TR3	Vc	0·5V	TR8	Vc	0·2V
TR4	Vc	0·8V	TR9	Vc	—9V
TR5	Ve	0·5V	TR10	Vc	—4·5V

D.C. Supply 9V
Total current—quiescent 4mA; max. drive 50mA
Measured on 20,000Ω/V meter. Volume control at minimum

SCREENED LEAD

From the above account, it will be apparent that it is not essential to fix the pre-amplifier and the power amplifier assemblies together to form a single unit. But if they are separated, it is most important to use a screened lead between the pre-amplifier output terminal and the power amplifier input.

One final point concerning the combined assembly: check carefully that components or connection points on the facing surfaces of the two plastics panels do not come into contact with one another. There should be no risk of this happening if the specified types of components are used. If larger components are employed, it may be necessary to increase the separation between the two panels. ★

Lord Bowden Opens Mullard Exhibition

ALL the current plans for a new technological revolution will come to nought without an accompanying revolution in the field of education. For this to be brought about automation must not be confined to industry and the factory floor, but must be applied in the classroom, with teaching machines, tape recorders, closed circuit television and other visual aids replacing more and more the teacher.

At least there is no doubt that this is the trend of education in the future as seen by the new minister for Education and Science, Lord Bowden.

Performing his first public function since his appointment as a minister in the new government, Lord Bowden opened the Mullard Educational Service 10th Anniversary Exhibition in London on 11 November 1964. The minister stressed the vital importance of increasing the efficiency of education—in terms one would apply to industry—by obtaining a higher output of students per teacher. For this to be achieved, "programmed learning" must be employed far more extensively than before.

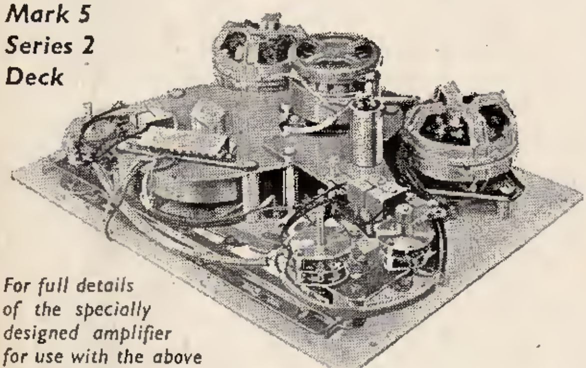
Lord Bowden speaks as an authority on technological and electronic matters. Prior to entering Parliament he was Principal of Manchester College of Science and Technology; Dean of the Faculty of Technology Manchester University; Chairman of the Electronics Research Council of the Ministry of Aviation; and President of the Science Masters Association.

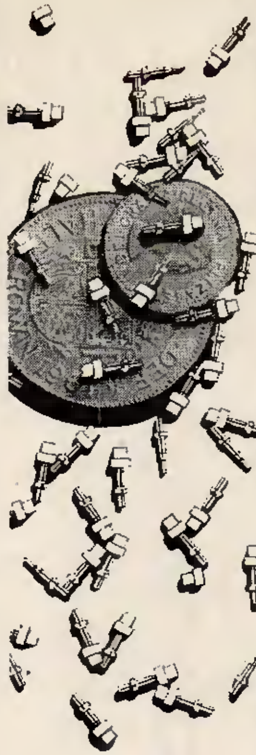
The exhibition set out to show how the Mullard Educational Service assists the school, the technical college, the university and the industrial training school to teach physics and electronic engineering. One section of the exhibition featured more than seventy demonstrations and experiments.

Each piece of equipment has been specifically designed for use in schools and technical colleges. Some idea of the extent of the subjects covered may be gained from the following short selection of working models:

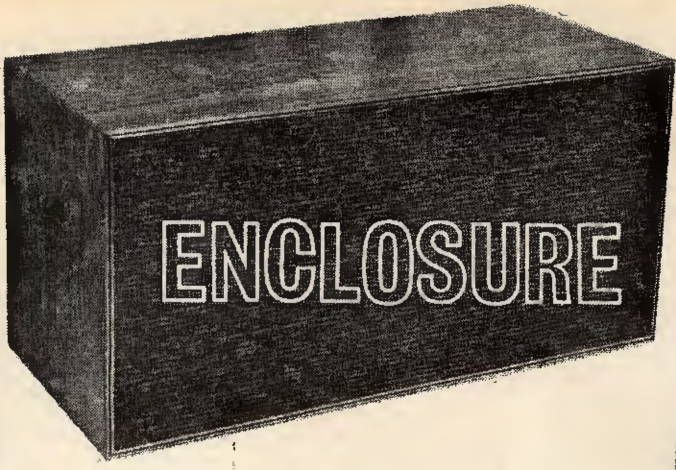
Determination of e/m, using magnetron effect;
Light controlled oscillator, energy conversion;
Velocity of sound, echo technique method;
Van de Graaf generator, a source of very high voltage;
Hysteresis loop displays, using an oscilloscope and coils;
Slow running multivibrator operating down to ¼c/s;
Geiger-Muller probe, detection of β and γ radiation;
Binary adder/subtractor—adds or subtracts digits and numbers up to a maximum of 127.

Lord Bowden (left) talking to Mr. S. R. Mullard at the Mullard Educational Service Exhibition





COMPACT LOUDSPEAKER ENCLOSURE



By K. F. RUSSELL
A.M.I.E.E.

PART ONE...: THE DESIGN

THOSE of us who have enjoyed high quality sound reproduction over the last decade or so have sometimes been embarrassed by the size of the enclosures housing our loudspeakers. In addition to the understandable reaction of the ladies to large and sometimes ungainly pieces of furniture, we have also been subjected to a number of entertaining articles, with references to "concrete ovens" and "Beethoven stalking you in the linen cupboard". There are, of course, very good reasons for using concrete and for building enclosures of large volume, but most of us have to live in small rooms where two large loudspeaker enclosures could not be accommodated, and we have to make sure that we are getting the best possible results from the size of cabinet we choose.

IMPORTANCE OF ENCLOSURE SIZE

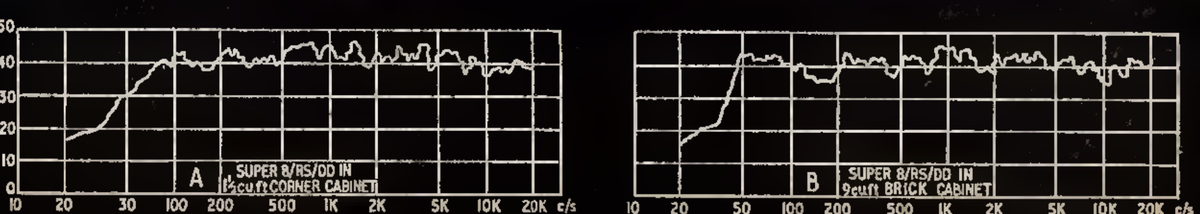
Generally speaking, the volume of the enclosure affects only the low frequency performance of the loudspeaker. This can be seen quite clearly from Fig. 1, which shows the response curves of an 8in loudspeaker in cabinets of $1\frac{1}{2}$ cu ft and 9 cu ft respectively, at A and B. In both cases the performance remains substantially constant at the treble end up to 20kc/s, but at the bass end the 9 cu ft cabinet adds a whole octave to the performance of the loudspeaker compared with the $1\frac{1}{2}$ cu ft cabinet. The main object of enclosure design is to maintain the frequency response of the system as flat as possible from the centre of the spectrum (say 1kc/s) down to the lowest audible frequency, and from the response curve it will be obvious that the size of enclosure is of great importance.

If we use a full-range cone loudspeaker without a cabinet, the lowest note it will produce is dependent on the size of the baffle on which it is mounted. The positive and negative pressure waves produced instantaneously at the front and rear of the cone will cancel one another if the path length from front to rear is appreciably less than half the wave length at the frequency being produced. Frequencies in the 50c/s region would require a path length of the order of 11ft, and baffles with dimensions less than this will produce partial cancellation at low frequencies. Because of the large size of baffle required to obtain efficient bass performance, it is more usual to enclose the rear of the loudspeaker to prevent the front radiation from interfering with the radiation from the back of the cone, and to improve the efficiency of coupling the loudspeaker to the air load at low frequencies. There are three basic methods of treating the enclosure, all of which have their advantages and disadvantages, and these will be briefly considered.

TOTAL ENCLOSURE

If the enclosure is completely sealed apart from the loudspeaker opening, there is no air path between the front and rear of the loudspeaker, and by suitably treating the interior of the cabinet with absorbent material, it is possible to eliminate substantially all the rear radiation. With this type of enclosure, the volume enclosed determines the lowest frequency produced by the system. This is because the smaller

Fig. 1. Response curves of a full range 8in loudspeaker in a $1\frac{1}{2}$ cu ft enclosure and a 9 cu ft enclosure



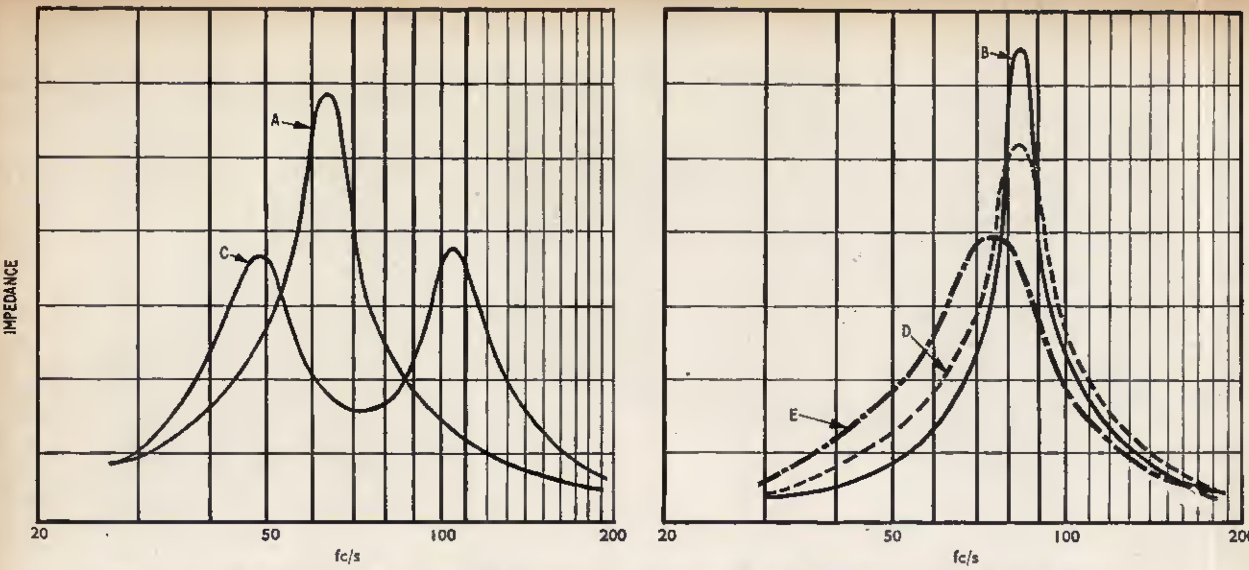


Fig. 2. Impedance curves of a full range unit in a 1 cu ft enclosure. A—open back; B—total enclosure; C—reflex tuning; D—acoustic resistance small area; and E—acoustic resistance optimum area

the volume of the enclosure, the harder it is for the cone to move against the pressure built up inside it. Total enclosures of 12 cu ft or more are very good indeed, and the bass performance remains quite acceptable in total enclosures down to about 4 cu ft. Below this, the low frequency roll-off point rapidly rises from around the 50c/s mark to 100c/s, and with enclosures of ½ cu ft or less the efficiency is very poor below 150c/s or so.

The effect of the enclosure on the low frequency performance can be seen from Fig. 2, which shows impedance/frequency curves of an 8in loudspeaker in enclosures of 1 cu ft capacity. Curve A shows the rise in impedance at the resonance point of the loudspeaker mounted in such a cabinet, without a back panel fitted. This is therefore equivalent to the open baffle resonant frequency of the unit, and is in the region of 63c/s. Putting the rear panel in position and sealing the enclosure immediately raises the resonant frequency of the system to 84c/s, as seen from curve B, and the Q of the system is also increased slightly. The new resonant frequency of 84c/s represents the point at which the low frequency output of the system begins to disappear. Because of the steepness of the resonance peak, the system sounds objectionable unless a considerable amount of sound absorbent material is inserted in the enclosure. This has the effect of lowering the impedance of the loudspeaker at the resonance point, and it also spreads the hump in the impedance curve over a wider range of frequencies. The result is more pleasant to listen to, but the efficiency of the system is reduced.

REFLEX ENCLOSURES

Apart from horn loading, reflex cabinets tuned correctly give the best reinforcement to the low frequency output of loudspeakers. Any sized loudspeaker enclosure can be tuned to resonate after the manner of a Helmholtz resonator by providing an opening, sometimes in the form of a tunnel or pipe, of the appropriate dimensions, and the result is called a "reflex" or "bass reflex" enclosure.

The elastic nature of the air inside the enclosure produces a resonating system with the mass of the air in the vent, and the frequency of resonance is entirely determined by the dimensions. If the resonant frequency of the enclosure is matched to that of the loudspeaker, the system becomes very efficient at that frequency. This is beneficial when the resonant frequency is low because it is always difficult to generate enough power at the lowest frequencies of audibility. At the resonant frequency, the output from the vent and the front of the cone are in phase, which further adds to the efficiency at this frequency, even though at other frequencies the two are out of phase and some cancellation can take place.

The disadvantage of the tuned reflex cabinet is that, like the untreated total enclosure, the resonance point is rather pronounced, and is often audible. Again, internal treatment of the cabinet can largely overcome this defect. It will be seen by referring to curve C of Fig. 2 that, by appropriate design of the vent in the reflex version of the enclosure, the resonance of the system has been lowered from 63c/s to less than 50c/s. Audibly this means that lower frequencies can be reproduced and that there is less distortion in the low frequency range. Fig. 3 shows the waveform of the vent output from a 1 cu ft tuned reflex enclosure fitted with an 8in unit, and it can be seen that even at 30c/s, the waveform is reasonably clean.

There is a second resonance peak in the impedance curve of a reflex system, which is clearly shown in curve C of Fig. 2. In this case the secondary peak appears at a little over 100c/s, and causes a slight rise in output from the system at that frequency. A second peak can be rather annoying audibly, and sometimes is quite difficult to remove.

ACOUSTIC RESISTANCE

The use of an acoustic resistance in a resonant enclosure is analogous to the use of electrical resistance in an electrically resonant circuit. The resistance usually takes the form of a piece of cloth which covers an opening in the enclosure—in some cases the tuning vent itself. One effect is to lower the Q of the tuned system. The resistance also controls the phase shift at the vent, spreading the vent output over a wider range of frequencies and at the same time suppressing the upper resonance peak which appears on curve C in Fig. 2.

With a small area of acoustic resistance, the tuned frequency of the system is similar to that of a total enclosure, but the Q is rather lower. This is seen at curve D in Fig. 2. With a larger resistance area, it is possible to reduce the tuned frequency of the system until it approaches the resonant frequency of the loudspeaker itself, and at the same time to maintain a reasonably sized hump in the impedance curve. The optimum acoustic resistance treatment for the 1 cu ft cabinet fitted with the 8in unit under test is shown as curve E in Fig. 2. The peak of the curve is in the region of 75c/s, but the curve itself is comparatively shallow, resulting in a useful reinforcement of output over a fairly wide band of frequencies. The upper resonance peak of the reflex enclosure has been eliminated.

The acoustic resistance in this case was provided by a number of fairly narrow slots cut in the back of the cabinet, and covered on the inside with a soft woollen cloth. In the case of curve D, four slots were used, and in the case of curve E, 12 slots. The low frequency output of this cabinet is satisfactorily clean, and efficiency is maintained below 50c/s. Low frequency waveforms are shown in Fig. 4, and show little distortion even at 30c/s with an input of 1 watt.

The 1 cu ft design using the acoustic resistance type of loading has been chosen as the subject of the remainder of the article, being the most suitable compromise providing adequate low frequency performance, good sensitivity and compact dimensions, in keeping with the 5 watt integrated transistor amplifier described in this and the two previous issues of PRACTICAL ELECTRONICS.

Having ensured that the enclosure is capable of a smooth and efficient performance at the low frequency end of the spectrum, the next important thing is to choose a loudspeaker unit with suitable characteristics.

CHOICE OF LOUDSPEAKER

To maintain a good output at low frequencies, it is necessary to move a large amount of air, and this requirement can be most easily met by a unit with a fairly large cone area. In the case of the 1 cu ft enclosure mentioned above, a speaker unit of not less than 8in in diameter is desirable. It is important to choose a unit with a free suspension, so that the fundamental mechanical resonance is reasonably low in frequency. The free suspension is, however, more important in that it will allow a large excursion of the cone at low frequencies, enabling the unit to move a good volume of air and so maintain its efficiency in the low frequency range.

Most well designed units with free cone suspensions also employ long speech coils, which are designed to maintain a constant number of turns in the magnetic gap, even with the longest cone movement. This makes sure that the drive to the cone is in linear relationship with the applied signal. It is also important that the loudspeaker is fitted with a rigid chassis, which will not vibrate on its own account, nor easily distort to throw the speech coil and cone out of alignment. Usually die-cast chassis are better in this respect, but if a pressed steel chassis is employed, it must be of adequate gauge.

The efficiency and overall performance of a loudspeaker are decided to a very large extent by the magnet. A magnet providing high flux density in the speech coil gap is essential to good high frequency response and clean transients. Similarly, a high flux density controls the movement of the coil more efficiently at low frequencies, with the result that the low frequency performance tends to be cleaner.

Fig. 3. Waveform of vent output in a 1 cu ft reflex enclosure fitted with an 8in unit and an input of 1 watt

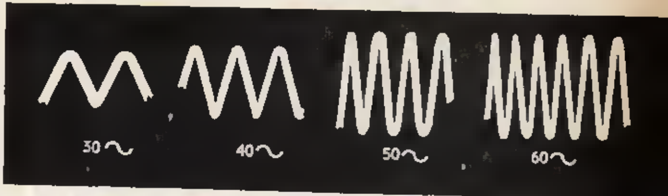


Fig. 4. Waveform of the output of an 8in unit in a 1 cu ft enclosure with slotted back and an input of 1 watt

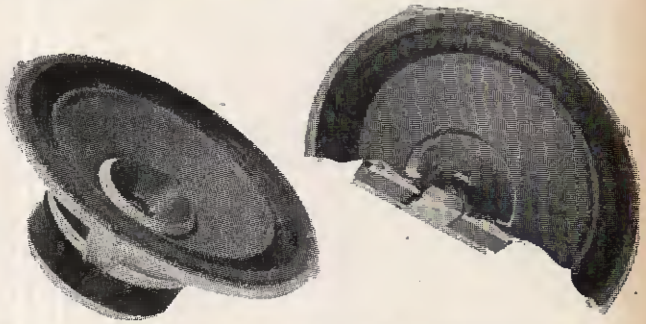
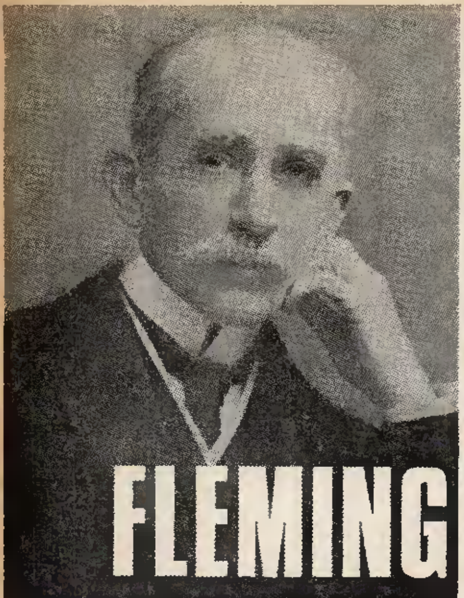


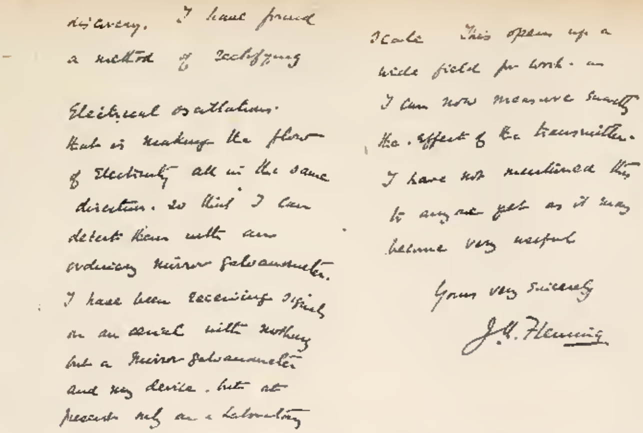
Fig. 5. A full range 8in loudspeaker showing (A) usual appearance and (B) cut away view of the edge suspension and ceramic magnet

Efficiency, too, is related to flux density, so that all in all, a large magnet is of the greatest importance in a high performance unit. This does not mean a slug magnet with a large decorative cover over it. Slug magnets represent a fairly cheap way of providing flux densities up to about 10,000 gauss with high efficiency, but flux densities in excess of this usually demand ring magnets of considerable size and weight. The best units with a diameter of 8in or so are fitted with either Alcomax or ceramic ring magnets providing flux densities in the gap of 14,000 to 16,000 gauss.

A typical high performance 8in unit is shown in Fig. 5. The magnet is of the ceramic type, which is very shallow in depth, and produces a flux density of 14,500 gauss in the gap. The cone is suspended at the edge by an annulus of flexible material with a U-shaped cross section. The main cone generates frequencies up to 10,000c/s, where the small cone takes over. The small cone is directly coupled to the speech coil and carries the response of the unit to above 20kc/s, which is generally regarded as the limit of audibility. The speech coil is wound with aluminium wire in the interests of lightness in the moving parts. The performance of this loudspeaker, as seen from the response curves of Fig. 1, shows quite clearly the effectiveness of the free suspension and the powerful magnet at the two ends of the audible frequency scale.

Next month's article will deal with the construction of a 1 cu ft design using acoustic resistance loading




discovery. I have found
a method of rectifying
electrical oscillations.
that is making the flow
of electricity all in the same
direction. so that I can
detect them with an
ordinary mirror galvanometer.
I have been receiving signals
on an aerial with nothing
but a mirror galvanometer
and my device. but at
present only on a laboratory
scale. This opens up a
wide field for work – as
I can now measure exactly
the effect of the transmitter.
I have not mentioned this
to anyone yet as it may
become very useful

Yours very sincerely

J.A. Fleming

FLEMING...AND THE DIODE

60th Anniversary of the Invention of the Thermionic Valve by Sir Ambrose Fleming, F.R.S.

THE "Fleming Oscillation Valve", the forerunner of today's vast range of specialised valves, was discovered by Sir Ambrose Fleming just 60 years ago, in November 1904. Perhaps one of the most important electronic discoveries of the century, this invention heralded the birth of the electronics industry.

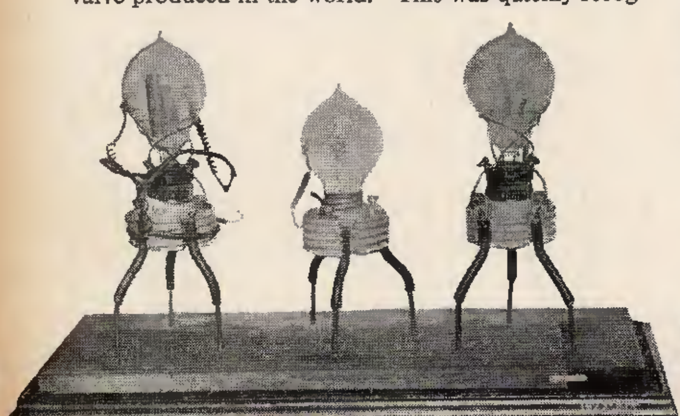
At the time of his discovery, Sir Ambrose was Professor of Electrical Engineering at University College, London, and since 1899 had been Scientific Adviser to The Marconi Company. He was very closely associated with Marconi himself and had played a leading part in the design of the powerful transmitting equipment at Poldhu in Cornwall, with which Marconi made his first successful wireless transmission across the Atlantic in 1901.

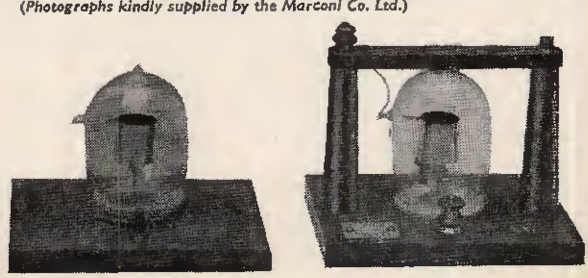
In his search for better methods of detecting electromagnetic or wireless waves, Sir Ambrose, recalling the results of earlier research involving the passage of electric currents through rarefied gases, conducted a series of experiments utilising some of his original apparatus. This new work led him to the discovery of the "Fleming Oscillation Valve", the first thermionic valve produced in the world. This was quickly recognised by the Marconi Company and the "valve" was soon put into full production.

The immediate effect of Fleming's diode was to improve the sensitivity of the early wireless telegraphy receiving apparatus which previously had been dependent upon coherers or crystal detectors. But the subsequent developments were even more momentous.

One man's discovery frequently inspires other workers in a similar field. This was so in the case of the thermionic valve. Following on the success of Fleming's invention, three years later Lee de Forest of America patented a thermionic valve with a third electrode. The invention of the triode (Lee de Forest originally called it the "audion") made possible both the generation and the amplification of alternating currents; it brought to an end the era of the spark transmitter, and ushered in the wireless telephone. Soon many further potentialities of the valve were perceived . . .

Sir Ambrose died in his 96th year on 18 April, 1945, at Sidmouth, where he had spent the last few years of his intensely active life in retirement.





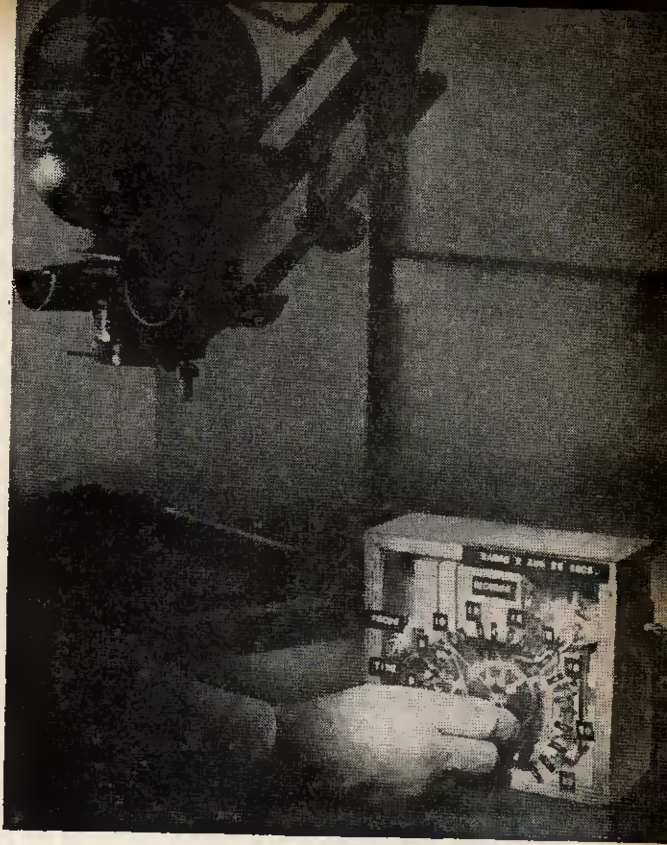
(Left) Three early Fleming diodes
(Right) Two early Marconi production models of the Fleming diode
At the top of the page appears a reproduction of the end of a letter from Fleming to Marconi informing him of this discovery which "may become very useful"
(Photographs kindly supplied by the Marconi Co. Ltd.)

By G. J. FLANAGAN

In photographic enlarging it is necessary to switch the mains powered enlarger on for a known length of time and to do this reasonably accurately.

The timer unit described has been tested during long periods of photographic work and has the advantages of being completely self-contained and, as usual with transistor apparatus, quite small.

The design of the time circuit gives time delays of up to 45 seconds, which is longer than normal exposure times usually required during enlarging.



darkroom timer

PERHAPS the easiest way of considering the working of this circuit is to split it into three distinct parts, the CR time constant circuit, the transistor amplifier which operates the relay, and the actual switching of the mains to the apparatus required.

THE CR TIMING CIRCUIT

If a capacitor is charged from a battery, and then connected to a resistor, the time taken for the charge to decay is a simple function of the original charge stored in the capacitor and the value of the associated resistor. As may be expected, the larger the charge stored in the capacitor the longer the time it will take to decay; and also the larger the value of the resistor, the less current that can flow, and the longer the time taken for the charge to decay. The amount of charge stored in a capacitor is proportional to the value of the capacitance and the voltage to which it is charged.

The timing circuit uses a constant charging potential, that of the battery supply, applied across a large capacitor C using a variable resistor VR to obtain the variable delays. The time constant of the circuit can be obtained by the product of $C \times R$ where C is expressed in *farads* and R in *ohms*. This gives the approximate delay in seconds. For transistor circuitry, or circuits using large time constants, it is more convenient to think in terms of $1\mu F \times 1$ megohm = 1 sec.

Referring now to the circuit diagram of the complete unit—see Fig. 1 on blueprint—with the variable resistor VR1 at minimum and the switch S2 in position 1, we have

$1{,}000\mu F \times 1/1{,}000$ megohm (1 kilohm) = 1 sec

and, with the variable resistor at maximum

$1{,}000\mu F \times 26/1{,}000$ megohm (26 kilohm) = 26 sec

In position 2 by similar multiplication, the times are 27 sec and 53 sec. In practice these values are very slightly reduced because of the current taken by the circuit.

TRANSISTOR RELAY DRIVE

One essential consideration in designing the relay drive is that the time constant obtained from the CR network should be changed as little as possible, that is to say that the current drawn by the base of the first transistor should be much smaller than that passing in the CR circuit. Now the input impedance of the d.c. amplifier circuit (TR1 and TR2) is:

$$Z_{in} = R_b + \beta_1 R_e$$

Where R_b is the physical resistance of the base-emitter diode of the transistor, R_e is the emitter resistance ($= 25/I_e$ ohms, I_e in milliamps), β_1 being the current gain of the first transistor.

Thus, for high input impedance we must use a large emitter resistance between the silicon emitter follower transistor TR1 and the germanium output transistor TR2. In the latter stage the transistor is used in the grounded emitter configuration so that voltage gain is obtained.

A silicon transistor is used for TR1 because of the low leakage current characteristic of this type. The variable 5 kilohm resistor VR2 across the base emitter junction of TR2 enables adjustment to be made to compensate for the differences in the current gains of transistors used in the circuit. VR2 is set to maximum and then reduced till the maximum time on range 1 is 25 seconds.

The diode D1 across the relay RLA prevents the reverse voltages, developed when the output stage is switched off, from damaging TR2.

SWITCHING CIRCUITS

This section deals with the circuit required to switch a photographic enlarger but, as stated previously, the timer could be used with almost any apparatus requiring to be timed, by suitable changes to this section to suit individual requirements.

In enlarging, the basic course of events are:

(1) Switch on and focus the enlarger, adjust iris for exposure.
(2) Switch off enlarger.
(3) Insert photographic paper and expose.

This cycle is then repeated for each enlargement. The timer in this circuit is only capable of a maximum time of 45 seconds, so that it is clear that for the focusing of the enlarger we must be able to switch on the enlarger independently of the timer. This is most simply done by putting a second switch S3 in parallel with the timer switch. If this is a double-pole double-throw switch it can also be used to switch off the timer supplies when focusing or when the unit is not in use. The arrangement of the relay switching contacts to do this and to charge the capacitor are shown in Fig. 1.

CONSTRUCTION DETAILS

As can be seen from the photographs, the original unit was constructed on a plywood baseboard and this was fitted with a perspex top. The mounting of the resistors and transistors on the miniature tagstrip is shown in Fig. 5. A 2-pin socket was attached to the original, and also a mains lead, so that the unit when needed could be simply inserted between the mains supply and the enlarger, as would be a piece of extension flex.

The reason for fixing the time range switch and variable resistor to the top of the box, was to enable a long pointer to be used so as to obtain more accurate positioning of the variable resistor, and hence of the chosen time. The second range was expected, from the values chosen, to be 25 seconds greater than the first range which was timed with a stop watch. Spot checks showed this to be correct at the lower end of the scale, but to be about 2 seconds less than this at the longest time. All wiring was cableformed to make a much neater finished unit.

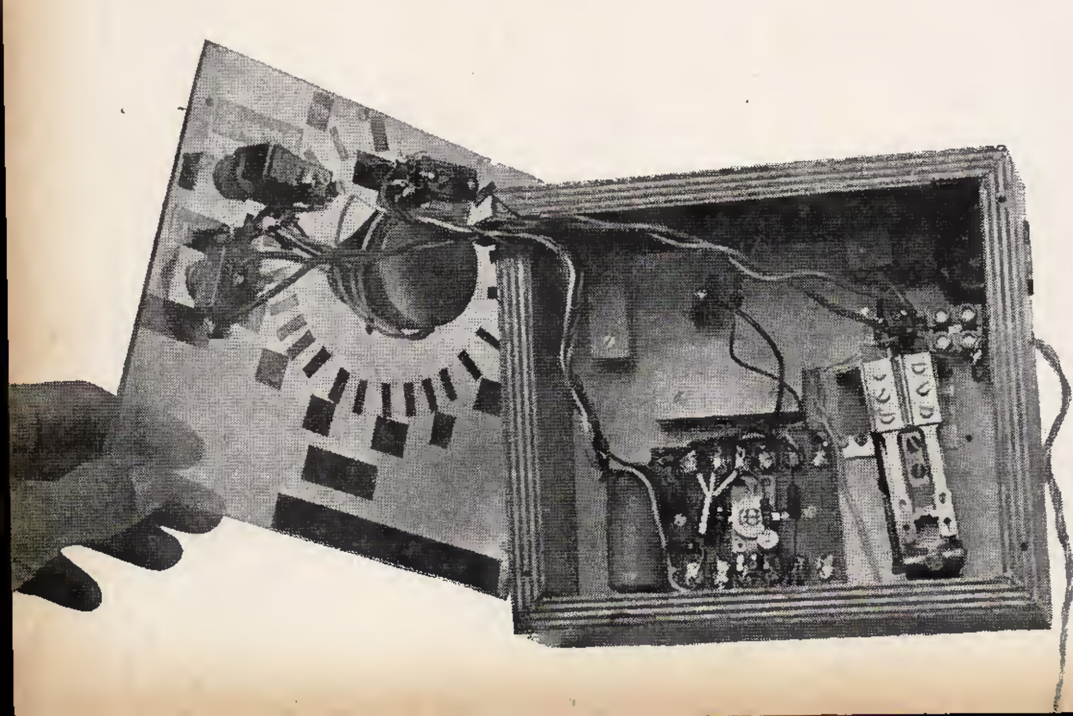
The timer may be powered by a 9V battery, or the mains operated supply unit depicted in Fig. 2 could be employed.

SAFETY PRECAUTIONS

Any switch controlling the mains supply to apparatus should be fitted in the line side of the mains, so that when the switch is in the off position, the appliance in question is not live. This should be adhered to with this circuit. Since this means that the switch contacts on the timer will always be line while the timer is plugged in, some form of complete cover for the unit is essential. That is to say the circuit should not be built up and left on an open chassis. A cover like the original is ideal but a metal box could also be used, though this should be adequately earthed. This is important as the equipment will be used in near darkness with damp hands.

The timer should give long trouble free service, and save hours of clock watching.

★



Photograph of the timer showing components mounted on the perspex front panel and layout inside the cabinet.

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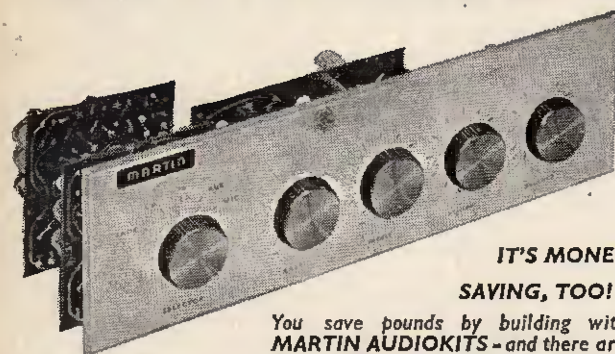

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Incorporating 4 Sp. Garrard Auto-Slim unit and Mullard latest 3 watt printed circuit amplifier (ECL86 and EZ80), vol., bass and treble controls, with 8 x 5in. 10,000 line speaker. Contemporary styled two-tone cabinet, charcoal grey and off-white with matching blue relief. Size 17½in. x 16in. x 8in. A stylish unit capable of quality reproduction. Circuit and const. details 2/6 (free with kit).

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TRIMMERS, Ceramic (Compression Type)—30pF, 50pF, 70pF, 9d.; 100pF, 150pF, 1/3; 250pF, 1/6; 600pF, 1/9.
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METAL RECTIFIERS. STC Types—RM1, 4/9; RM2, 5/6; RM3, 7/6; RM4, 16/-; RM5, 21/-; RM4B, 17/6; Mullard BY100, 10/6.

TUB-ELECTROLYTICS-CAN

25/25v. 50/12v. 1/9; 8+8/450v. 4/6; 50/50v. 100/125v. 2/-; 32 + 32/275v. 4/6; 8/450v. 4/350v. 2/3; 60/50/350v. 6/6; 16 + 16/450v. 5/6; 60/250/275v. 12/6; 32 + 32/450v. 6/6. 100 + 200/275v. 12/6.

TRS Est. 1949

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THO 2188. *Terms C.W.O. or C.O.D. Post and Packing up to ½ lb. 9d.; 1 lb. 1/3; 3 lb. 2/3; 5 lb. 2/9; 8 lb. 3/6.*

Readout—
A SELECTION FROM OUR POSTBAG

"Just what I have been seeking"

Sir—I feel certain that you will receive many letters praising your excellent new magazine, and wonder whether mine will be noticed among them, but I would like to say, all the same, how much I appreciate it.

I am thinking of taking up electronics as a career, and this publication is just what I have been seeking, from which to find general information, practical projects and the like. I am sure that it will be widely read and appreciated by electronics enthusiasts everywhere.

Thank you again for a fine magazine.—Yours faithfully,

DAVID JONES,
Pwllheli, Caerns.

Aid to homework

Sir—I wish to congratulate you on your new publication and wish it well for the future. I found the subject matter worthwhile and the booklet and resistance colour card worth the money. Even the Greek alphabet helped me with my son's homework. I hope you will continue along transistor lines, since the field is wide open to you relative to other publications.

I would privately welcome an attempt to list transistor equivalents—even if only approximate—and to give relative characteristics, i.e. type with type. Even if you don't get down to this I shall continue to take your publication. I wish you well.—Yours sincerely,

G. T. C. MORRIS,
Carshalton.

Roding Boys' Society

Sir—May we be so bold as to offer our congratulations regarding your new Journal. It should be just the thing for modern youth, and for that matter anyone with an up-to-the-minute mind.

Our own Society is dedicated to spreading science, electronics and similar activities for boys, as we think such things are sadly neglected in the Youth Programme of this country. However, many other things of great interest to lads are pursued . . . camping, expeditions, visits, etc.

There may be many of your new readership who would be very interested in the work of our Society, either as keen lads who might like to join in, or as patrons who feel like helping to spread this movement. We hope you think our activities worth mentioning in the pages of "P.E."—Yours sincerely, (signed)

D. MOERE, R. PHIPPS,
R. MARCHANT, A. JONES
(members) and
K. L. SMITH, B.Sc.,
G3JIX, Leader R.B.S.

Beginners . . .

Sir—I have just read the first issue of your magazine and I must say I am impressed by your approach to beginners in radio and electronics—this I may say has been long awaited by many youngsters I know.—Yours faithfully,

H. S. YORKE, A.I.P.R.E.,
Dunfermline, Fife.

. . . Start here

Sir—First of all may I congratulate you on a first rate magazine. However, may I plead as a technical man myself that the magazine (or a portion of it) will not "talk" to us as though we were about fourteen years old.

I would appreciate the inclusion of articles dealing with radio control.—Yours faithfully,

R. F. POTTER,
Middleton, Kings Lynn.

Conflicting points of view! Maybe some newcomers to electronics would like to express their opinions of the manner in which this series is presented?

Mains stabiliser

Sir—Congratulations on a publication which seems very likely to be the much needed bridge between the other "Practicals". I am much impressed by the start, and hope that the continuation will be as good or better.

May I make a suggestion for early inclusion in "Constructional Projects"? Many readers would, I know, be glad to be able to build a mains voltage stabiliser suitable for use with electronic equipment, using components in relatively cheap supply. The following is the probable spec: Input 200–250V, 50c/s; Output 230–240V, 50c/s; Loading 0–25W. This type of unit would be of such great use with very many types of electronic gear that it may be worth an early priority in the series.—Yours faithfully,

C. A. HARLING,
Cheltenham.

We can almost certainly promise you a mains voltage stabiliser of this kind before long.

Electronic ignition

Sir—I should like to congratulate you on your new magazine. What a boon it will be to enthusiasts who are interested in electronics other than radio and television, subjects which are already well catered for by your sister magazines.

I was very interested in your article "Semiconductor Devices for Automobiles" especially the section dealing with transistor assisted ignition. If it is possible could you please let me know the value of the individual components in this circuit as I should like to attempt constructing one. Thank you very much for some very interesting reading.—Yours truly,

J. R. FENN,
Stratford, London, E.15.

This was essentially an introductory article. It is our intention to publish more detailed design information on transistor ignition systems in the future.

Garage door control

Sir—With reference to your remarks about garage door control you may be interested to hear that I have constructed a mechanism operated by simple low frequency magnetic induction. A ferrite rod is mounted behind the wall and has its coil connected to a two stage d.c. transistor amplifier. This operates a relay when a signal is received.

Readout—
A SELECTION FROM OUR POSTBAG

continued

A simple oscillator comprising another ferrite rod, power transistor, capacitor, and battery is housed in a plastics torch case and this is carried in the glove box of the car. To operate, the "torch" is pointed through the windscreen at the brick wall.

I wish to take this opportunity of wishing you and PRACTICAL ELECTRONICS every success.—Yours faithfully,

T. J. KELLY,
Worcester Park, Surrey.

Magnetic induction systems are often used for control and communications purposes, but it must be noted that such systems are subject to the Wireless Telegraphy Act, and require a G.P.O. licence.—J. Valence.

Future projects

Sir—Congratulations! PRACTICAL ELECTRONICS is a really fine magazine, well presented, well illustrated and readable!

Can I dare hope for a readers' letters page, in the near future, and *please*, plenty of articles on *inexpensive* electronic apparatus for the constructor, test-gear, receivers, amplifiers, etc., both valve and transistor, in each issue.

Yes, a grand magazine, worthy of every enthusiast's support—my regular order has already been placed.—Yours sincerely,

H. E. CHAMBERLAIN,
Newark-on-Trent, Notts.

Sir—Congratulations on your very forward-looking journal. I am very pleased that you will be concentrating on the solid-state physics of tomorrow.

I would like you to consider giving us constructional articles on the following: Electronic Flashgun (transistorised circuit) and a battery portable tape recorder based on the Garrard battery-operated tape deck. Other articles which I would personally find very interesting would be a continuation of your "Electronic Didjeridoo" to include a square wave tone generator, attack and decay control, and a vibrator or tremolo oscillator and amplifier. All these must be circuits using transistors of course.

Perhaps a more ambitious series of articles on making an oscilloscope using transistors could be considered, as also an electronic organ. A photo-electric light meter using light sensitive transistors would not come amiss either.

Enough for the moment on suggestions for future subjects. I am sure this magazine will be a great success.—Yours faithfully,

H. R. DUBASH,
London, S.E.4.

Our thanks to all those readers who have offered suggestions for future constructional articles. We have a busy and exciting time ahead!

Simple geiger-muller ratemeter

Sir—I like the first copy of PRACTICAL ELECTRONICS and have placed a regular order. Will you kindly ask Mr. Rowles whether an equivalent to the HC4 may be used for his ratemeter? May the MX168 be used instead. Perhaps Mr. Rowles would compare these two tubes for me.—Yours faithfully,

H. S. KING,
Head of Science Dept.;
Saint Ivo School,
St. Ives, Huntingdon.

The ratemeter described was designed for use with halogen quenched type Geiger tubes. As the MX168 is of this type it is quite in order to use this tube. The working voltage of this and other Mullard MX tubes is 420V, hence no alteration to the circuit as published is required. (But please note the correction to the values of R1 and R2 given on page 129 of last month's issue). The author has tried the MX168, MX115, MX108 and a surplus type tube PET 40 in the ratemeter, all giving satisfactory results.—J. F. Rowles.

School's report

Sir—Having had a chance to look over the first issue of PRACTICAL ELECTRONICS since yesterday, I am sure that you will be pleased to know that I approve very much its content and general layout and will have no hesitation in bringing it to the attention of pupils and colleagues.

I am especially pleased with the article on the simple Geiger-Muller ratemeter (possibly because we have just made one ourselves which might stand a little modification) and I was surprised and delighted to find the promise of a follow-up with some basic experiments. I am also rather surprised, but very pleased to find the inclusion of such articles as "Beginners Start Here" and "New look at the Electron". These and the comments of "Detached Particles" and the other news and comment articles give, in my view, an excellent balance to the constructional projects.

For the future, I would like to see a series dealing with binary counters and simple computing elements.

In this type of magazine I think the adverts are an essential part of the reading material. You are probably as well aware of this as I am, but I think it does bear repeating that the adverts form an important consumer service—particularly in the electronics field which is ever expanding and where we often require components that we, in the provinces, cannot expect to obtain locally and which could be extremely expensive if we were not able to obtain surplus or second-hand items.—Yours faithfully,

R. MITCHELL, B.Sc.,
Science Dept.,
Buckhaven High School,
Buckhaven, Fife.

"Mathematical snobbery"

Sir—I have just read through the first number of PRACTICAL ELECTRONICS and must write to congratulate you on this production. There are only one or two small points I would criticise:

(1) The unnecessary introduction of somewhat advanced mathematical formulae into the midst of an otherwise useful practical article by J. F. Rowles. There is a kind of mathematical snobbery which demands a mathematical appendix to scientific articles in more theoretical papers but it is out of place in the present context.

(2) I do not follow the transistor biasing arrangements in the same article—However I was brought up on valves.—

Yours faithfully,

R. W. SAWYER, B.Sc.,
Head of Science Dept.,
The Grammar School,
Ilminster, Somerset.

VALVE ON-OFF CIRCUITS

By G. D. Howat

THERE are three electronic circuits, all based on a common symmetrical configuration, which can be applied to a very wide range of problems. They form, in effect, three variations on a theme, and comprise the multivibrator, the monostable switch or flip-flop, and the bistable switch. It is the purpose of this article to discuss briefly the properties of the first and last of these circuits, and to investigate the flip-flop in more detail. Also it will be explained how these principles were applied to a particular design problem.

The theme and variations are set out in Fig. 1. It is seen that the first and last variations are symmetrical but the flip-flop is not.

MULTIVIBRATOR

The multivibrator, probably the best known of the three, is a free-running oscillator which produces a square wave output at each anode. It is very useful as a signal generator and signal tracer because of the high harmonic content of the square wave output. It also finds uses in timebases, audio frequency equipment (tone generators, organs) and in various specialised applications including pulse radar techniques.

The multivibrator action consists of the alternation of two complementary astable states. In case there is any confusion about the meaning of the term "astable state", a mechanical model may help to clarify the problem. A sphere resting anywhere on a sloping surface as in Fig. 2a is an astable system since it will not remain in this condition but will roll down the slope. If two such systems are arranged as in Fig. 2b we have the mechanical analogy of a multivibrator with the sphere continually changing over from one astable state to the other.

At any instant one of the valves (V1 in multivibrator) conducts and its anode is at a potential below the h.t. The grid of V2 is negative, making the valve non-conducting. C2 charges up via R2 and R3 to almost the full h.t. voltage. At the same time C1 is slowly discharging and the voltage on its lower end is rising towards earth. At a certain point on this rise V2 starts to conduct and the potential on the top end of C2 begins to fall. Since this capacitor has most of the h.t. voltage across it the falling potential at the anode end of C2 pushes the voltage on the grid of V1 below earth. This results in an "avalanche process": the anode end of C1 rises in potential as V1 cuts off and the grid of V2 becomes even more positive. More voltage appears across R3 and, via C2, the grid of V1 is pushed more negative still until finally the valve is cut off. The second half-cycle is now in progress and is a mirror image of the first, i.e. V2 is now conducting and will continue, via C2, to hold V1 cut off until a sufficient amount of the charge on C2 has leaked away through R2. When this has happened another change-over occurs, identical with the first, and returns the circuit to its original state. Since each anode alternates between being cut off and conducting at constant current, the output waveform at the anodes will be the familiar square shape.

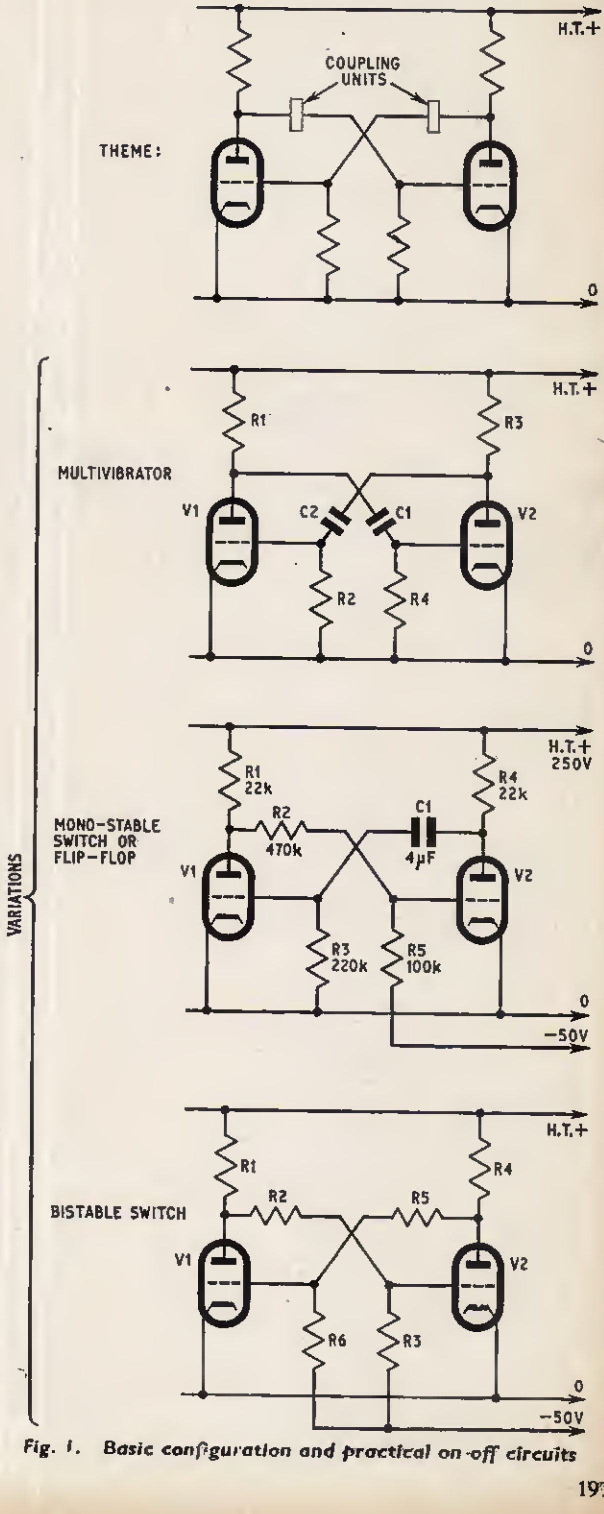


Fig. 1. Basic configuration and practical on-off circuits

MECHANICAL ANALOGY

Before going on to discuss the remaining two circuits, it is necessary to explain the meaning of some more of the terms used, especially monostable, bistable, and quasi-stable states. These are demonstrated by the models drawn in Fig. 3. Fig. 3a shows a cone resting on a sloping surface—this being an example of a monostable system: if the cone is pushed it will always roll back to the same position. That is, it only has one position where it will remain stationary although, unlike the astable system, it will remain on the slope. If this model is modified as in Fig. 3b then the result is rather different. There are now two independent stable positions which the cone can take up—one on each side of the model. If the cone is pushed uphill it will change over from one stable state to the other, by simply rolling over the top. A second push will cause it to move back again. This is then a system with two stable states and is thus called a bistable system as distinct from a monostable one.

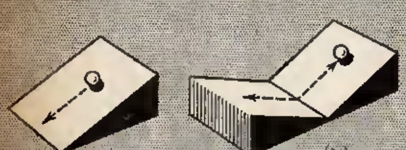


FIG. 2

FIG. 3

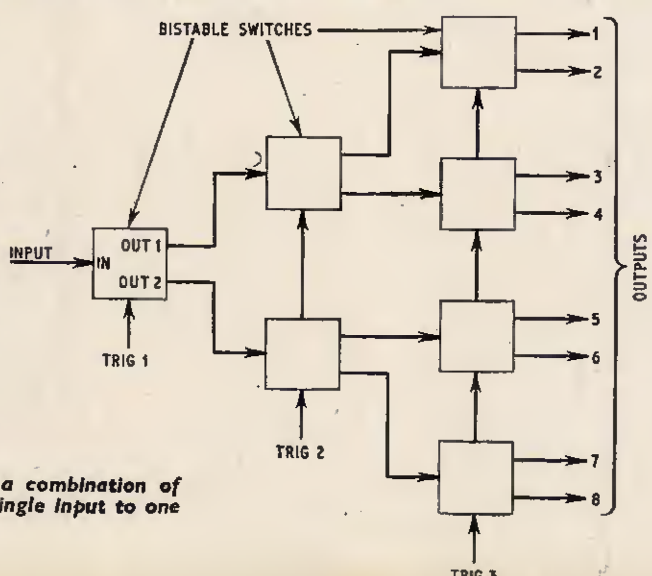
Figs. 2 and 3. Mechanical analogy of the circuit principles

If the top of the wedge in Fig. 3a is almost, but not quite, flattened as in Fig. 3c then we have a situation part way between the above two. If the cone is pushed it will roll up the plain area of 3c onto the dotted area. It will remain here for a short time, moving very slowly, but since the dotted area is slightly tilted it will ultimately roll back down to its initial position on the front (unmarked) section. This shows the action of a system with one stable and one quasi-stable state. When the cone is pushed it moves from the stable condition (blank front region) to the quasi-stable condition (on the dotted area) and stays here for a short time. Unlike the bistable system, however, it then reverts to the initial condition without the action of any external agent.

BISTABLE SWITCH

The bistable model described above has an analogy in electronics in the form of the bistable switch. The basic circuit of this is shown in Fig. 1. The mode of operation of a bistable switch is quite simple and in some ways resembles that of a multivibrator. At any time one of the valves in Fig. 1 is conducting so there is a voltage across its anode load. Suppose V1 is conducting, then a voltage exists across R1. The potential divider action of R2, R3 results in a negative voltage being applied to the grid of V2 keeping it cut off. Because of this there is no equivalent voltage across R4 and the other potential divider, formed by R5 R6, cannot bias V1 to cut off as the top of R5 is nearly at h.t. voltage. V1, therefore, continues to pass current. This represents one stable state—one valve conducting and the other one held cut off by it. Unlike the similar situation in the multivibrator, however, it will remain in this state indefinitely. The other stable configuration is the mirror image of the above one with V2 conducting and the voltage across its anode load keeping V1 cut off. In order to make the switch change over a suitable triggering pulse must be applied to the grid of the conducting valve. A negative pulse is required and it momentarily cuts the valve off, allowing the other one to take over the conducting state.

Since the bistable switch will remain in either of its stable states indefinitely it has the property of being able to "remember" one single bit of information. As such it is used sometimes in the memory units of computers. Digital computers work on binary arithmetical methods, that is mathematics based on only two numbers. One bistable switch can therefore remember the entire numerical system of binary arithmetic, by letting one stable condition represent one digit and the other stable state the other one. In binary then one switch can remember 0 and 1, two switches can remember 0, 1, 2 and 3, three can remember 0 to 5 and so on. Any number can thus be stored in a sufficient number of bistable switches in binary arithmetic.



SWITCHES TRIGGERED	OUTPUT LINE OPERATING
0	1
1 ONLY	5
2 ONLY	3
3 ONLY	2
1 AND 2	7
1 AND 3	6
2 AND 3	4
1,2,3	8

Fig. 4. An example of how a combination of switch settings connects the single input to one of eight different outputs

Now if a certain computation or calculation is required these signals can be combined in a pre-determined manner by using gates. There are five principle kinds of gate operations: AND, OR, NAND, NOR, NOT. The circuits of two of these are shown in Fig. 11. The AND circuit combines the input signals (corresponding to noughts and ones by multiplying them together. The OR circuit combines them by addition. NOT denotes a negative quantity. The NOR circuit combines the functions of both NOT and OR, while NAND combines NOT and AND functions.

Binary code

Suppose we want to add two numbers. For simplicity we will take 27 and 14. 27 is broken down to values of the power of 2:

$$\left.\begin{array}{r} 2 \times 2 \times 2 \times 2 = 2^4 = 16 \\ 2 \times 2 \times 2 = 2^3 = 8 \\ 0 = 0 = 0 \\ 2 = 2^1 = 2 \\ 1 = 2^0 = 1 \end{array}\right\} \text{added together} = 27$$

The binary coded values would then be

$$\begin{array}{ccccc} 2^4 + & 2^3 + & 0 + & 2^1 + & 2^0 \\ 1 & 1 & 0 & 1 & 1 \end{array}$$

All positions from the highest power of 2 down to 2^0 must be filled. In this case 2^2 is not used so must be entered as 0.
Now let us break down 14 as follows:

$$\left.\begin{array}{r} 0 = 0 = 0 \\ 2 \times 2 \times 2 = 2^3 = 8 \\ 2 \times 2 = 2^2 = 4 \\ 2 = 2^1 = 2 \\ 0 = 0 = 0 \end{array}\right\} \text{added together} = 14$$

Here 2^4 and 2^0 are not used and must be represented by 0. The binary values would be

$$\begin{array}{ccccc} 0 + & 2^3 + & 2^2 + & 2^1 + & 0 \\ 0 & 1 & 1 & 1 & 0 \end{array}$$

By adding the two series of digits the same rules apply as in ordinary arithmetic except that when the answer is a 2 or more the remainder is written down and the quotient carried to the next column on the left. For instance if the answer is 2, divide by 2, carry this answer to the next column on the left and write down the remainder (0).

11011 (representing 27)
01110 (representing 14)

101001

It will be seen that all even numbers are represented by 0 and odd numbers by 1. Now converting back to a decimal number

$$\begin{array}{l} 1 \quad 0 \quad 1 \quad 0 \quad 0 \quad 1 \\ 2^5 + 0 + 2^3 + 0 + 0 + 2^0 = 41 \\ 32 + 0 + 8 + 0 + 0 + 1 = 41 = 27 + 14 \end{array}$$

★

VALVE CHARACTERISTICS

A.C. Resistance

The a.c. resistance of a thermionic valve is equal to a *small change* in anode voltage divided by a *small change* in anode current.

$$r_a = \mathrm{d}V_a/\mathrm{d}I_a$$

where d denotes the small part in the V_a/I_a characteristic which is almost linear—see Fig. 9 on page 3 (last month's issue).

Mutual Conductance

The mutual conductance of a valve is an expression of the effect of changes in anode current due to changes in grid voltage.

$$g_m = \frac{\mathrm{d}I_a}{\mathrm{d}V_g}$$

where d denotes the small part of the I_a/V_g characteristic which is almost linear—see Fig. 9 on page 3 (last month's issue).

Amplification Factor

The ratio of V_a to V_g is called the amplification factor (μ).

$$\mu = \frac{\mathrm{d}V_a}{\mathrm{d}V_g}$$

where d denotes the small parts of the characteristics which are used.

Stage or Amplifier Gain

Stage gain is given as the ratio of a.c. signal voltage at the output to that at the input.

$$\text{Voltage gain} = \frac{\text{output signal voltage}}{\text{input signal voltage}} = \frac{\mu v_{in} R_L}{R_L + r_a} \Big/ v_{in} = \frac{\mu R_L}{R_L + r_a}$$

where v_{in} is the input signal voltage and R_L is the anode load. This is often converted to decibels by using the following expressions:

$$\text{Voltage gain} = 20 \log_{10} \left(\frac{\text{output voltage}}{\text{input voltage}}\right) \text{dB}$$

$$\text{Power gain} = 10 \log_{10} \left(\frac{\text{output watts}}{\text{input watts}}\right) \text{dB}$$

Corrections to Data Booklet—2 (last month's issue)

page 2, *Theory*
Expression in the second line should read: $I_a \propto V_a^{3/2}$

page 4, *Applications*
The last line in the first paragraph should read:
"... between anode and *grid*, known as the Miller Effect."

MICROPHONES

Microphones can be divided into four basic types according to their polar sensitivity patterns. The correct use of directional characteristics in microphone placement reduces the effects of extraneous noises and reverberation.

Fig. 1. Cardioid

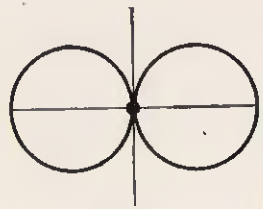


Fig. 2. Bidirectional

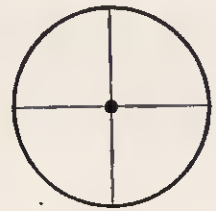


Fig. 3. Omnidirectional

Unidirectional

The most popular type of unidirectional microphone is the cardioid, the polar characteristic of which is shown in Fig. 1. This characteristic is achieved by combining the principles of a velocity and a pressure microphone. Typical front to back sensitivity ratios are of the order of 15dB but a single-element ribbon type has been developed with a ratio of 20dB. Unidirectional microphones are particularly useful for public address work where the risk of acoustic feedback has to be minimised.

Bidirectional

The polar characteristic shown in Fig. 2 is typical for a bidirectional velocity ribbon microphone. Sound is picked up from the front and rear of the microphone at approximately equal intensities.

Omnidirectional

The sensitivity of an omnidirectional microphone, as can be seen in Fig. 3, embraces a circular area around it. Crystal and dynamic microphones can be made omnidirectional and are particularly suitable for recording large orchestral concerts and stage productions.

Polydirectional

This type of microphone can provide a choice of two or three directional characteristics or a continuously variable characteristic.

Impedance Matching

Carbon, ribbon and dynamic (electromagnetic) microphones usually have low impedance and require a matching transformer for linking to a high impedance amplifier input. It should be remembered that the ratio usually quoted on a transformer is the voltage ratio. The impedance ratio is the square of the voltage ratio.

Erasure is effected by passing a high frequency current through the coil of a similar head, which has a gap about 20 times the size of the recording head gap. The magnetised particles of oxide on the tape are saturated by the field produced by the erase current. Due to the very high frequency used the resulting signal is inaudible.

COMPUTER PRINCIPLES

The most common kind of computer makes use of a binary code, i.e. numbers are identified whether they are odd or even and how many times two can be divided into them. In order to be able to store such information or perform mathematical calculations, the computer has to recognise the information or number fed into it by noughts and ones. Calculation takes place by combining a series of noughts and ones in accordance with the binary code. These noughts and ones are usually stored in the computer in a logical manner by using bistable circuits (flip-flops). (These circuits are explained elsewhere in the January issue of PRACTICAL ELECTRONICS.) From this it can be seen that a circuit can be conditioned to pass one of two signals or, in the case of the computer, a nought or one.

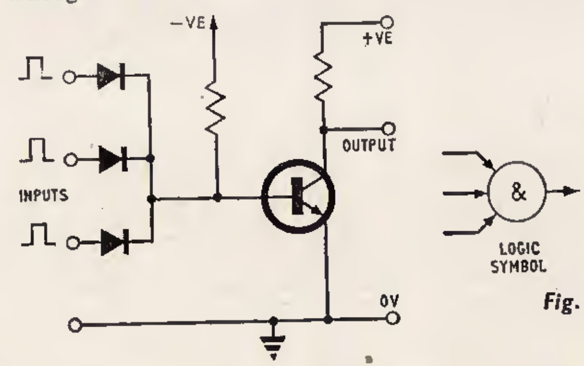


Fig. 11a. AND gate

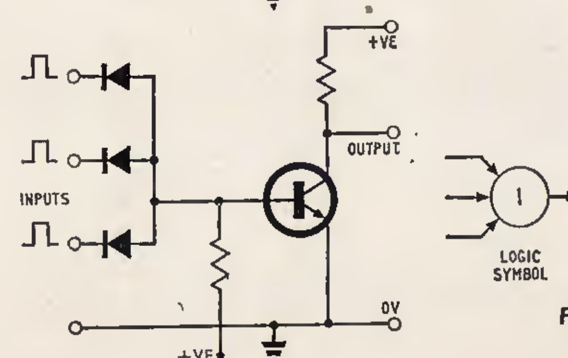


Fig. 11b. OR gate

A flexible arrangement of controlling treble and bass by using only two controls is shown in Fig. 9. A more severe degree of correction can be achieved by using the negative feedback principle. There are a number of books available which give more details of tone correcting circuits.

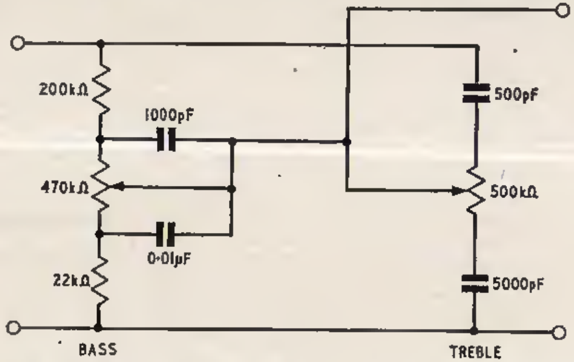


Fig. 9. Combined variable bass and treble, cut and boost circuit

MAGNETIC TAPE RECORDING

Current, in the form of a.c. signals, is fed through a coil wrapped round a soft iron or ferrite core (see Fig. 10). The core is so arranged that the gap between the pole faces is only about 0·0001in maintained by the insertion of a non-ferrous shim. Each minute particle of magnetic oxide on the tape which passes the gap is magnetised when current flows through the coil. The direction and magnitude of flux in selected particles is shown in Fig. 10 when a sine wave is recorded.

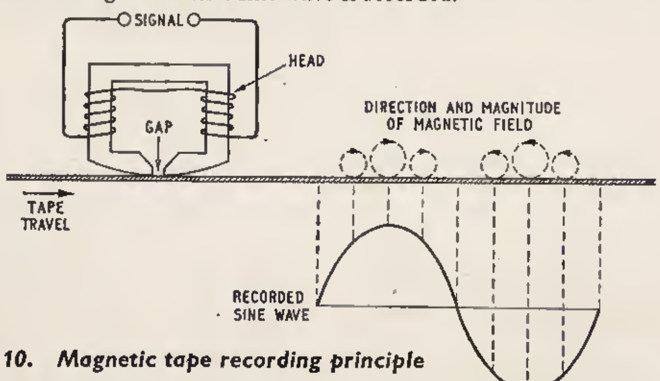


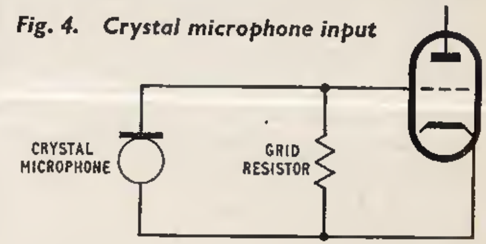
Fig. 10. Magnetic tape recording principle

Due to the partial non-linearity of the magnetic characteristic of the core a high frequency bias current is applied at the same time as the signal current to magnetise the head on the linear portion of the characteristic.

The nominal impedance of a microphone is usually quoted as being the electrical impedance at 1,000c/s since the impedance of such a non-linear device increases with frequency. For example, the range of impedance of a microphone may be from 19 to 75 ohms; the rated impedance would be 38 ohms at 1,000c/s.

Crystal microphones are high impedance devices and can be connected direct to the high impedance input of an amplifier. The crystal is effectively a capacitor which may be considered to be in series with the generated voltage and following grid resistor (see Fig. 4) which should be from ½ to 5 megohms. Too low a resistance may have the effect of attenuating low frequencies.

Fig. 4. Crystal microphone input



LOUDSPEAKERS

The most common loudspeaker in use today is the dynamic (moving-coil) type (see Fig. 5) which has to a large extent superseded the old mains energised type. The electrostatic loudspeaker is becoming more widely used but is relatively expensive. Public address systems sometimes use horn type loudspeakers where high efficiency is more important than quality of reproduction.

In the moving-coil loudspeaker the greater proportion of high frequencies are reproduced by the centre area of the cone. As a result small loudspeakers (up to about 5in diameter) will reproduce high frequencies better than low frequencies.

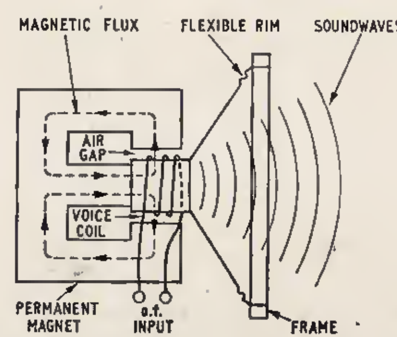


Fig. 5. Diagrammatic section of a dynamic moving-coil loudspeaker

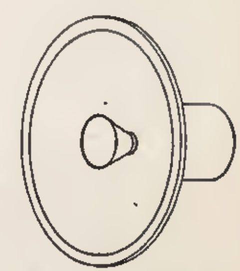


Fig. 6. Typical dual concentric loudspeaker

Medium size loudspeakers (6 to 10in diameter) will produce a better low frequency response but may still be restricted below about 100c/s. Large loudspeakers (12 to 15in diameter) will reproduce these lower frequencies but because of the mass of the cone, free vibration at high frequencies is restricted and does not give the best results.

Crossover Networks

It follows from the previous paragraphs, therefore, that the ideal set-up is to have three loudspeakers of different sizes to cope adequately with the entire audio frequency range. However, many people compromise by using one large loudspeaker (woofer) and one small loudspeaker (tweeter) which give very satisfactory results. These two units should be close to each other to avoid undesirable pseudo-stereophonic effects. This is catered for by some manufacturers who make dual concentric loudspeakers (see Fig. 6). Here the small horn shaped tweeter is mounted concentric with the cone of the woofer.

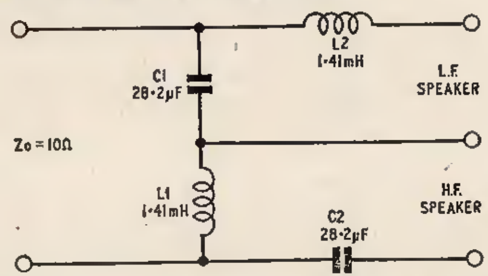


Fig. 7. Simple crossover network

If a two or three loudspeaker system is used it is desirable that each should be fed mainly with the range of frequencies which it will handle. To achieve this a crossover network is employed. Fig. 7 shows a simple circuit for series connected loudspeakers at a crossover frequency of 8C0c/s and giving 10dB per octave drops. Values for components at other impedances can be determined by:

$$L = Z_0/2\pi f\sqrt{2} \text{ and } C = 1/2\pi f Z_0\sqrt{2},$$

where

L = inductance of L1 and L2 $\quad Z_0$ = speech coil impedance
C = capacitance of Cl and C2 $\quad f$ = crossover frequency

PICK-UPS

Much of what has already been said under microphones applies also to pick-ups and their connections to amplifiers.

Electromagnetic pick-ups

They are usually low impedance devices requiring matching transformers. These can be sub-divided into three types:

(a) A moving iron pick-up has a steady field supplied by a permanent magnet with an iron armature in the gap.

(b) A moving coil pick-up has a stylus attached to the coil which is allowed to move in the magnetic field.

(c) Magnetostriction pick-ups make use of the principle of tension and compression of certain ferromagnetic metals (such as nickel, iron, cobalt and manganese alloys) when placed in a magnetic field. If subjected to this treatment the magnetic reluctance changes. The stylus is attached to a wire or rod of this material.

Piezo-electric pick-ups

This is the technical term for the more familiar crystal pick-up. The crystal is subjected to twisting or bending which produces electrical charges on some of its surfaces. The voltage produced is higher than that from most magnetic pick-ups. The characteristic impedance is also high enabling it to be connected directly to a high impedance valve amplifier. The frequency response is not as good at high frequencies above about 9kc/s or low frequencies below about 100c/s, compared with that of electromagnetic pick-ups.

Capacitance pick-ups

This type is self explanatory in that the stylus causes a mechanical variation of the distance between two plates so varying the capacitance in an oscillator circuit. The output is usually very low, hence it needs a very high gain amplifier. However, the frequency response is very good up to about 30kc/s.

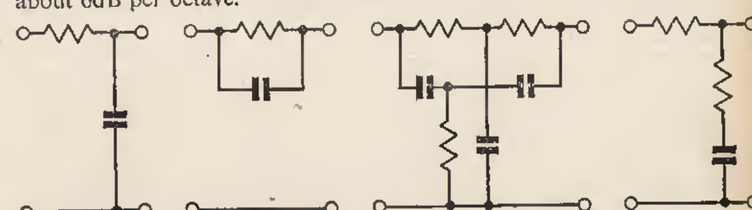
Other types

Ribbon pick-ups operate on the same principle as ribbon microphones. In eddy-current pick-ups the stylus moves a high resistance vane close to the inductor of a resonant circuit in an oscillator.

Strain gauge pick-ups are based on the principle that the resistance of a conductor changes when the conductor is strained.

TONE CONTROLS

For a number of very good reasons some audio reproducing devices give signals which haven't level (or flat) frequency response characteristics. In order to correct for this an equaliser has to be used. The simplest kinds of fixed equaliser are shown in Fig. 8. These circuits, known as passive equalisers, give only a limited amount of boost or cut, usually about 6dB per octave.



(a) Treble cut (b) Treble boost (c) Bass cut (d) Bass boost
Fig. 8. Fixed tone control circuits

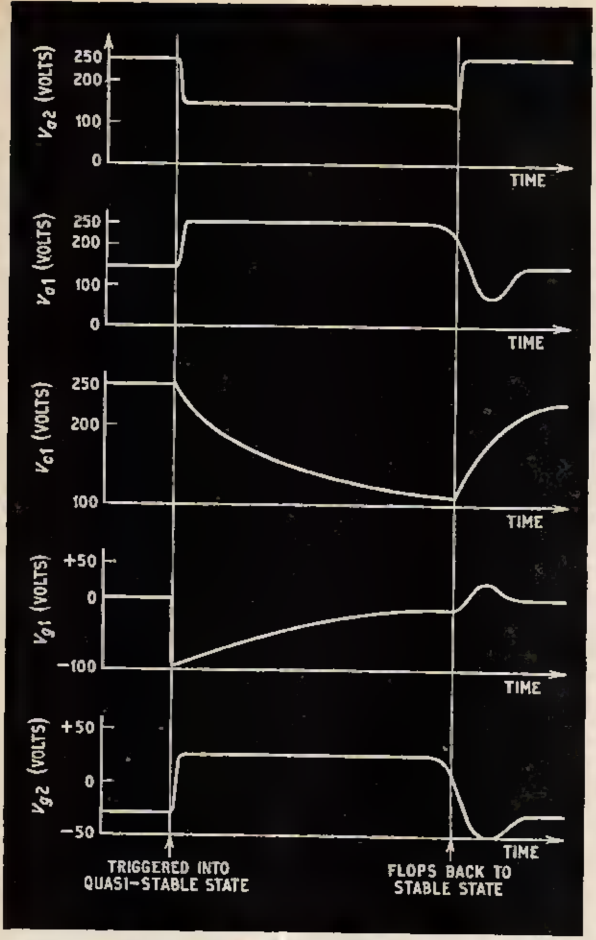
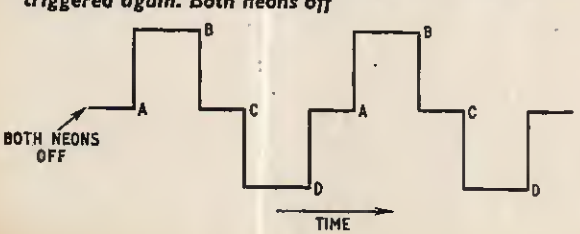


Fig. 5. Graphs of a flip-flop which took 30 seconds to revert to the stable state after being triggered

It is possible to "gate" two amplifiers with a bistable switch, i.e. arrange for two amplifiers to operate alternately, one in each stable condition of the switch. By connecting the inputs of the two gated amplifiers together, we have a two-way electronic switch where an input to the system will be passed to one of the two outputs when the switch is set one way, but will appear at the other output when the switch changes over. In this respect it operates just like an ordinary mechanical change-over switch, but differs in being able to switch over in a millionth of a second or less. As the output

Fig. 6. Two complete cycles required for a flashing display
A—Unit switched on, V1a conducting. Neon 1 switched on
B—V1a cut off. Flip-flop triggered into quasi-stable state. Both neons off
C—Flip-flop changes over. Neon 2 switched on
D—Multivibrator changes back to original state. Flip-flop triggered again. Both neons off



of one switch can be connected to the input of another, very complex switching networks can be produced. Fig. 4 is an example, each combination of switch settings connects the single input to a different one of the eight outputs.

Clearly, the bistable switch is a very useful circuit element. Unfortunately, in order to build a computer very large numbers of them are required and for this reason it is usually impractical for amateurs to attempt the construction of a digital computer. Even if the units are transistorised the cost of building several hundred or even thousand switches makes the idea impracticable. Modern digital computers are transistorised and at the present time a considerable amount of research is going on to try to build bistable units capable of operating in the shortest possible time; certain solid state circuits now switch over in much less than 10^{-8} second.

FLIP-FLOP

The final variation on the theme is the flip-flop, the circuit diagram of which is shown in Fig. 1. The circuit is seen to be "half-way" between a multivibrator and a bistable switch, with one grid-anode coupling via an RC network and the other via a resistor to a negative bias line.

In the stable condition V1 is conducting and a voltage exists across the anode load R1; the potential divider action of R2, R5 maintains the grid of V2 negative, keeping the valve cut off. Its anode is then at h.t. potential and, since V1 grid is at earth potential, C1 charges up to the full h.t. voltage. Suppose a negative-going pulse is now applied to the grid of V1. Its anode will rise towards h.t. as the valve cuts off, and the voltages at all points on the resistor chain (R1, R2, R5) rise. Because of this V2 grid now goes positive, the valve passes a heavy current and the anode potential falls sharply. Since C1 is charged to h.t. voltage, the sudden fall in potential of its upper plate causes the other plate to fall the same amount below earth. This results in V2 remaining cut off although the original triggering pulse has passed.

The flip-flop is now in the quasi-stable state: V1 is cut off and V2 is conducting. Unlike the bistable switch, however, this is not a second stable state because something is happening—C1 is discharging. The upper end of C1 is held at the anode potential of V2, which is more or less constant, but at the lower end the potential is rising towards earth. At a certain point, when V1 grid is about 12 volts negative, the valve begins to conduct and an "avalanche process" takes place, as in the multivibrator. As V1 conducts to an increasing extent the voltage across R1 increases due to anode current, so all the points on the R1, R2, R5 chain fall in potential, causing V2 to pass less current. The voltage at the upper end of C1, connected to V2 anode, rises pulling up with it the potential at its lower end, causing V1 grid to go even less negative. The whole system is now in effect an amplifier with positive feedback. The end result of all this is that V2 cuts off completely, its grid being driven very negative. V1 grid, on the other hand, is now positive, C1 having "dragged" the voltage up. It is the heavy anode current passing through R1 which keeps V2 cut off via R2. Finally, as C1 recharges to h.t., V1 grid returns to earth potential.

This shows how a flip-flop, when triggered, temporarily changes from a stable to a quasi-stable state, but always reverts to the stable state of its own accord

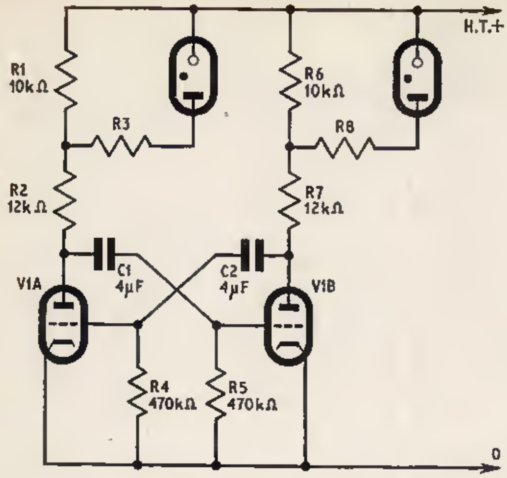
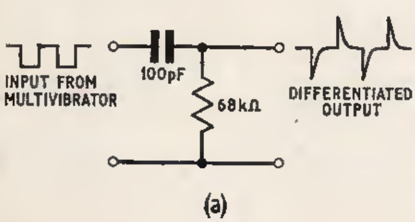


Fig. 7. A multivibrator with two alternately flashing neons connected in the anode circuits

after a definite time. This time is determined mainly by C1 and R3, and to a certain extent by R2 and R5.

In order to test the validity of this explanation, the author constructed a flip-flop which took 30 seconds to revert to the stable state after being triggered. By connecting a voltmeter to various points on this prototype,

Fig. 8b. Complete triggering circuit for switching a flip-flop ▶



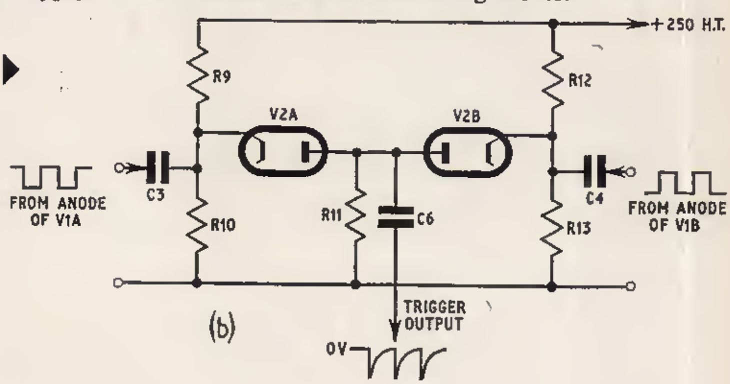


Fig. 8a. Basic differentiating circuit

the graphs shown in Fig. 5 were obtained. An examination of these shows that the expected waveforms are actually observed in practice.

For some reason flip-flops are unpopular but the author believes that they can provide the answer to a number of problems. Possibly their main use lies in their property of possessing a time delay factor which can be anything from microseconds to minutes. They find uses in the production of very short pulses, in simple timing machines, for example photographic timers or even egg timers! It is possible to obtain from one flip-flop a pulse capable of triggering a chain of subsequent flip-flops, each unit being triggered as the previous one flops back from the quasi-stable state. In this way a sequence of events can be controlled, each separate step being independently controllable from one flip-flop. This circuit can be used to switch in a number of operations during the manufacture of a particular product. Like the bistable switch the flip-flop can store one "bit" of information, but only for a limited time. It can therefore be used as a short-term self-resetting memory unit. Where a production line is in operation, such a circuit can stop one article from following another too closely by holding back the second for a pre-determined time after the first has passed.

PRACTICAL CIRCUIT

So far, mainly theoretical aspects of these three circuits have been discussed. To conclude this article it will be explained how a particular design problem was solved by the use of the principles outlined above. What was required was a display unit illuminated at each end by a lamp. The two lamps were required to flash on and off alternately with a time delay between one extinguishing and the other one lighting. This is easily seen by looking at Fig. 6. Both the overall cycle time and the delay time had to be infinitely and independently variable. The lamps used were neon bulbs since these can be worked directly from the circuits. As high speeds were required relays could not be used.

The basic circuit used was a multivibrator with the neons connected in the anode circuits (see Fig. 7). Each neon struck at 80 volts which was present across R1 and R6 in the anode loads. R3 and R6 are ballast or safety resistors. Using this arrangement the lights just flashed alternately and further circuitry was needed to interrupt the neon voltage supply briefly each time the multivibrator changed over.

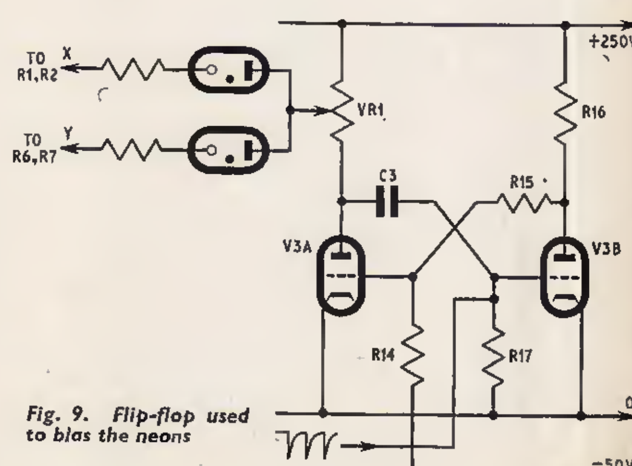


Fig. 9. Flip-flop used to bias the neons

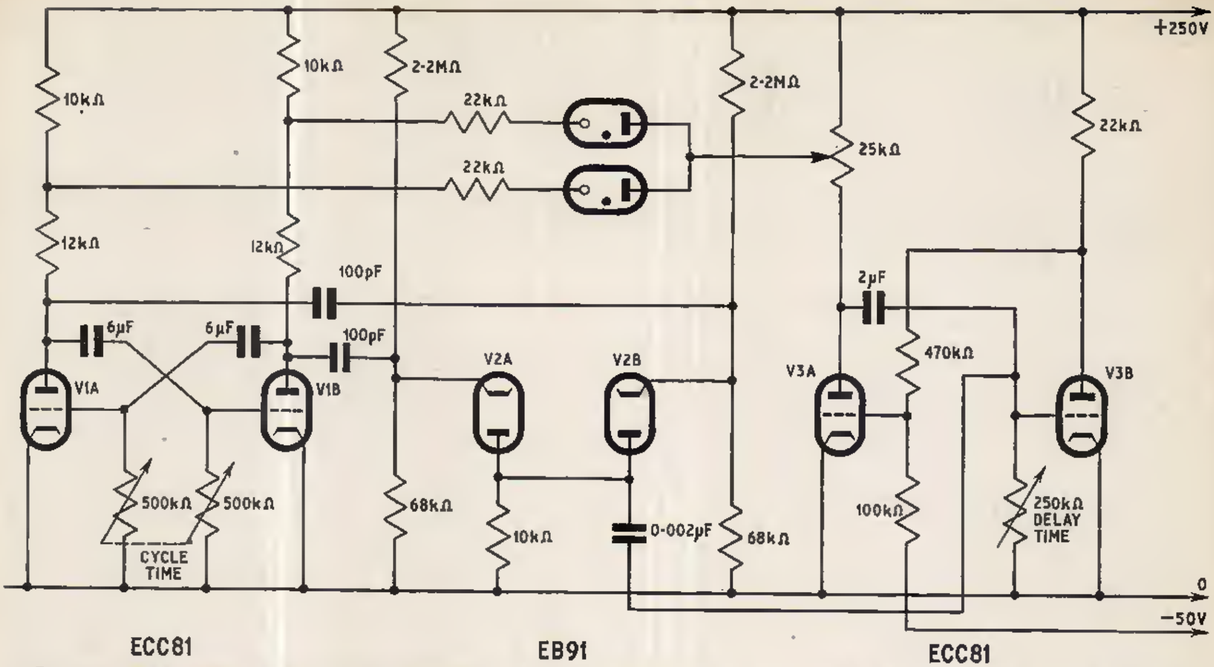


Fig. 10. The complete circuit for the display unit with added refinements to control the cycle time and delay time

A triggered flip-flop is suitable to control the flashing, the triggering device being fed by two square waves, 180 degrees out of phase, from the anodes of the multivibrator (see Fig. 8b). In order to provide a sharp pulse to trigger the flip-flop the square wave has to be differentiated by a simple RC circuit such as that shown in Fig. 8a. C3, R10 and C4, R13 are the differentiating components in Fig. 8b, their outputs being fed to the diodes which are arranged to pass only negative pulses. The pulses trigger the valve which is conducting in the stable condition of the flip-flop.

Referring now to Fig. 9, the anode of V3a is held at h.t.; the valve is not conducting. A negative pulse fed into the grid of V3b causes the voltage on the anode to rise and biases V3a to conduct. V3a anode voltage falls producing a current through the anode load, VR1, which can be adjusted to provide a common voltage on the anodes of the neons of, say, h.t. minus 40 volts (i.e. 210 volts).

In this condition one anode of the multivibrator is not conducting and is held at h.t. The voltage across the relevant neon will be only 40 volts which is insufficient to cause it to strike.

However, the anode voltage of the other multivibrator valve will be at h.t. minus 80 volts (i.e. 170 volts). The other neon, therefore, will also have only 40 volts across it, and will fail to strike. Only when the flip-flop returns to the stable condition will the second neon strike, when the relevant multivibrator valve and V3a are not conducting. The entire cycle of operation is depicted in Fig. 6.

The final circuit used is shown in Fig. 10 with some added refinements to control the cycle time and delay time. ★

NEWS BRIEFS

P.E. Amplifier at Tape and Hi Fi Club

A MEETING of the North London Tape and Hi Fi Club took place at Bush Hill Park School on 21 October 1964, with some 30 members in attendance. The Chairman, Mr. J. Wilson, extended a warm welcome to the guest speakers, Mr. Denis Horner and Mr. Alan Nash of Cosmocord Ltd., who gave a most interesting and enlightening lecture on the growth of Rochelle salt crystals from seeds, describing the technological process involved up to the completed crystal wafer as used in the manufacture of the Acos crystal cartridge pick-up and the crystal microphone.

In the limited time available after the lecture a demonstration of hi fi reproduction was given. The equipment consisted of a Garrard transcription 301 player unit with a Warden articulated tone arm and Acos S1/1 ceramic cartridge, the amplifier chosen being the 5W integrated amplifier recently featured in PRACTICAL ELECTRONICS. The system was completed by two Tannoy Chatsworth 15 ohm loudspeakers.

Transistorised Hi Fi

A MEETING of the newly formed Society of Electronic and Radio Technicians will be held on Thursday 14 January 1965 at 7.15 p.m. when Mr. D. M. Chave of the Lowther Manufacturing Company will talk about "Transistorised Hi Fi". The meeting will be held at the London School of Hygiene and Tropical Medicine, Keppel Street, Gower Street, London, W.C.1.

Further details may be obtained from the Society at 9 Bedford Square, London, W.C.1.

ELECTRONORAMA

HIGHLIGHTS FROM THE CONTEMPORARY SCENE

Time Without Ticks

THE long admired ingenuity and skill of the watchmaker in working with minute parts appears to have been equalled by the electronic engineer, at any rate the expertise of these previously unassociated technologies have been successfully combined by a Swiss company to produce the world's first electronic wristwatch. This is the Bulova Accutron—an instrument which has been described as the first significant advance in time keeping in 300 years.

Instead of the traditional balance wheel, hairspring and escapement mechanism, the Accutron incorporates a precision tuning fork as its basis of time measurement. An accuracy of within 2 seconds a day (99·9977 per cent) is guaranteed.

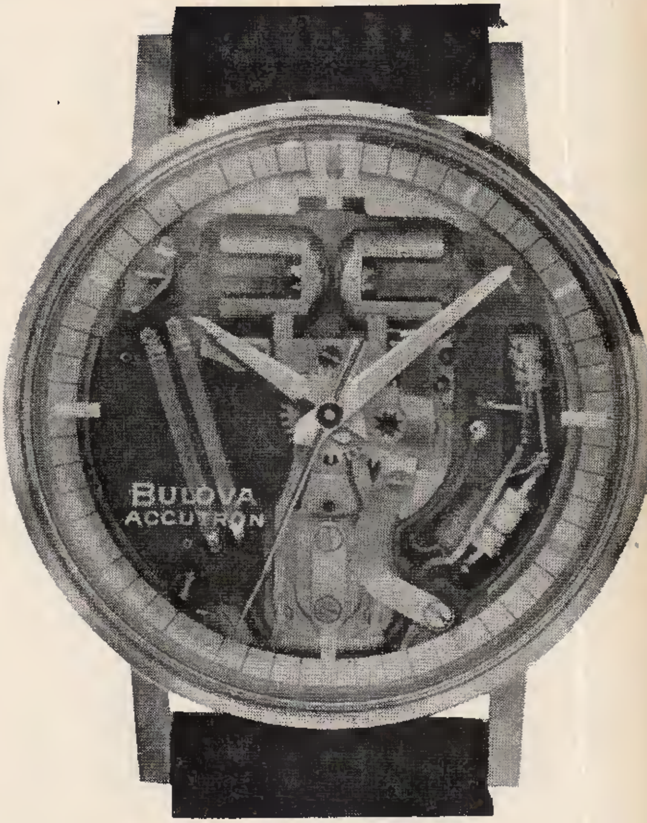
The electronic heart of the watch is a transistor oscillator which converts the d.c. energy from a tiny power cell into pulses of current. These pulses energise coils which actuate the tuning fork 360 times per second. One tine of the fork is linked by a ratchet-and-pawl indexing mechanism to a conventional gear train, which drives the hands.

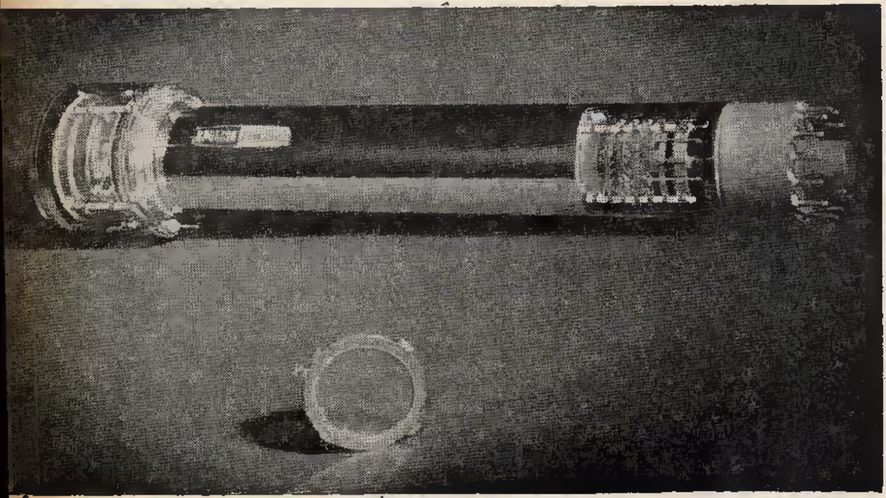
The transistor, resistor and capacitor can be seen in their plastics compartment in the right hand part of the watch case; the drive and phase sensing coils are visible at the top of the case. These coils are wound from copper wire 0·0006 in diameter (one-fifth the diameter of an average human hair). Each watch uses 700 feet of this wire.

Current consumption is $6\mu A$. The miniature cell will power the watch for a minimum period of one year, and is easy to replace.

In addition to its appeal as a personal timepiece, Accutron mechanisms have found a role in a variety of special applications. In a special case and with extra gears and switches added this watch has been used as a signal cut-off timer or "satellite-silencer" within four families of satellites—*Explorer*, *Tiros*, *Telstar* and *Syncom*.

It is currently being evaluated for use on *Nimbus*, the meteorological satellite, the Orbiting Astronomical Observatory scientific satellite, and several others.





Stable Pictures

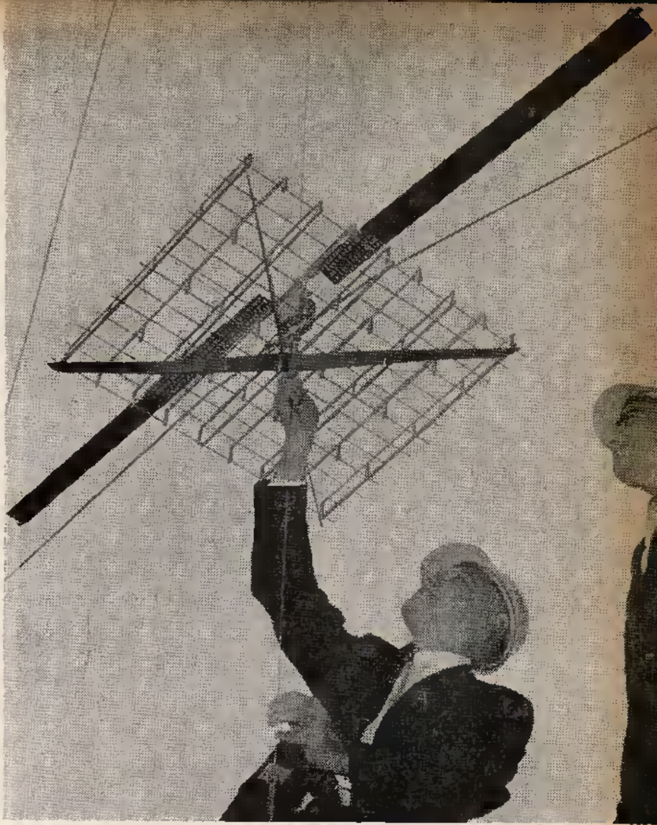
A NEW material known as ELCON has been developed which gives prolonged life to image orthicon camera tubes. The ELCON target introduces electronic conduction in transferring the charge pattern from the image side to the beam side. Ion migration is therefore virtually eliminated. This means that sensitivity and stability of contrast reproduction remains constant and there is complete freedom from "sticking".

This picture shows the new English Electric ELCON target beside a 3 in image orthicon television camera tube.

Remote Power

HERE is one example of electronic energy conversion which is being developed in the Raytheon Spencer Laboratory, America. Microwave energy, similar to that used in radar, is beamed from a parabolic antenna on the ground upward to a small helicopter. The rectifying antenna, mounted under the helicopter, is actually an array of thousands of tiny diodes, each less than half an inch long. When the microwave energy strikes the diodes, an immediate flow of direct current takes place to drive the motor for the rotor blades.

The "helicopter" hovers within the guy ropes, keeping it positioned over the microwave beam.



Keeping in Touch

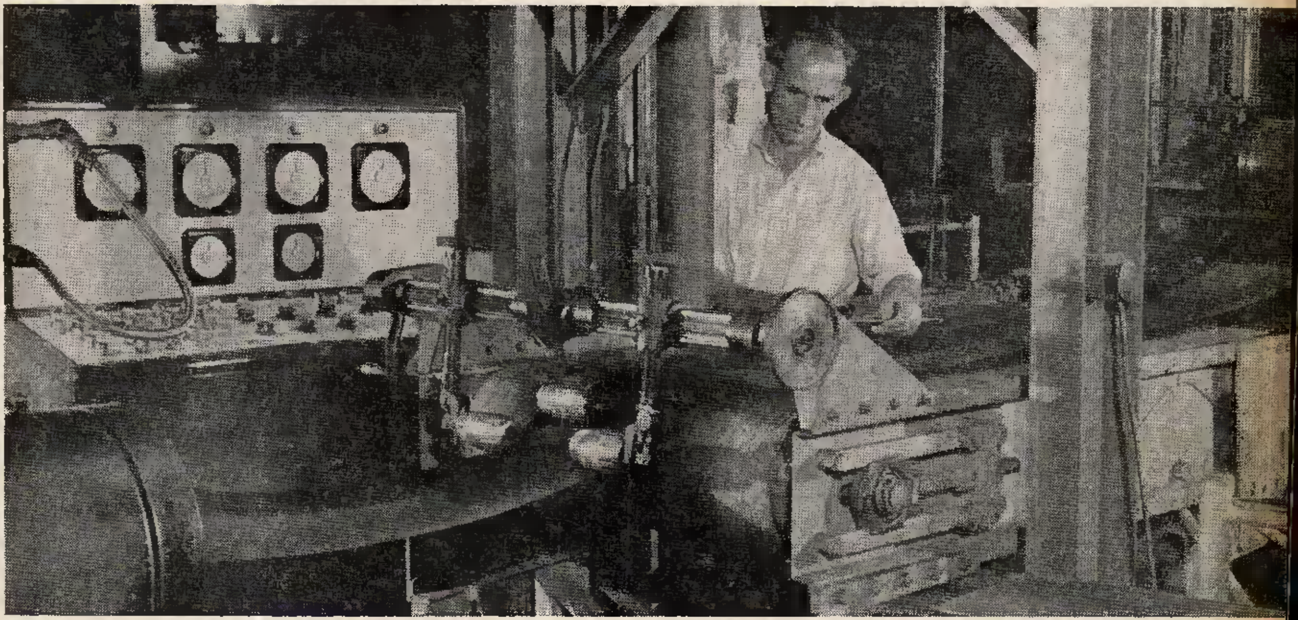
SCIENTISTS in Russia have been working on an artificial hand which imitates the principle of the human hand and can "feel" with the fingers. The human sense of touch is detected in the brain by impulses from the nerves and sensory cells.

Transducers made of electro-conductive rubber or thin wire and sensitive to pressure are fixed on the tips of the fingers. Under influence of the pressure on the transducers, based on the grasping effort of the fingers, signals from them modulate the output from a vibrator fitted on the hand near a nerve going direct to the brain.

The new hand overcomes a shortcoming of prosthetic appliances controlled by electric signals from the muscles when the hand carries out grasping motions, but so far it cannot be used freely without the user looking at what his fingers are doing.

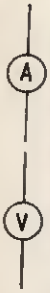
Automatic Tyre Tread Control

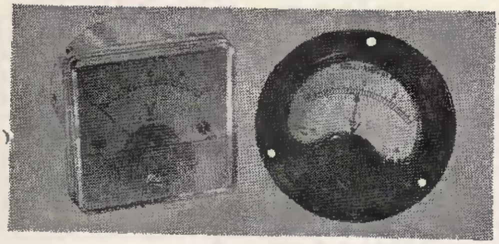
THE tread on a rubber road tyre is designed to withstand a multitude of driving conditions. It is essential, therefore, that the manufacturing process should be controlled to fine limits. To prevent distortion of the tread Lancashire Dynamo Electronic Products has installed thyristor controlled plant at the Pirelli factory to control the calendar and conveyor systems. Silicon controlled rectifier units are used to supply the calender and conveyor drive motors. Here the rubber tread strip is seen travelling from the extruder through the calender shaping process.



BEGINNERS start here . . . 3

An Instructional Series for the Newcomer to Electronics





MOVING COIL METERS

Shown here are typical examples of a left-to-right reading meter, and a centre-zero meter

CIRCUIT SYMBOLS

This is the general symbol for a meter or galvanometer. Sometimes the function of a meter is indicated as in the two symbols given above:

A = ammeter (current)

V = voltmeter (voltage, potential difference)

OUR experimental section this month deals with the construction of a very simple device which will give an indication of current flowing in a circuit. Meters are usually delicate and expensive items of equipment, their prices ranging from £1 to £3 or even more. There are a number of retailers who stock a wide selection of meters with various ranges and different degrees of accuracy; it will be instructive to look at the advertisements on other pages. One should certainly not rush into purchasing an instrument of this nature without having first acquired some basic knowledge of the subject.

A GALVANOMETER

Our simple meter, which is in fact more accurately described as a *galvanometer*, is illustrated in Fig. 3.1. It is very easy to make and costs very little for the component parts. The items you will need are a sewing needle, an elastic band, a wooden baseboard measuring approximately 4in × 2½in × ½in, some sealing wax or glue, four ½in brass wood screws and a short length of 15 amp fuse wire.

The cylindrical former on which the coil is wound can be made of cardboard, and it should be about 2½in in diameter and 1½in wide. This former can be made by winding a piece of cardboard round a milk bottle, glueing it and tying until the glue is set. Alternatively, you could cut a piece from a postal tube, cut up an empty plastics liquid container, or an Ajax or Vim carton.

The pointer is an ordinary sewing needle around which is tightly wrapped a short piece of 15 amp fuse wire. If you have a soldering iron (and the necessary skill!) you can improve the pointer by soldering the needle and wire together—but this is by no means essential. The ends of the wire are then twisted around the centre of a piece of elastic so that the needle does not slip down. The ends of the elastic are pushed through holes in the cardboard former and fastened to it with sealing wax or glue. It may be necessary to experiment a little so as to get the position of the needle and the tension of the elastic just right.

Insert a pair of the wood screws through the former (from the inside), one on either side of the elastic anchor point. These two screws should be 1in apart.

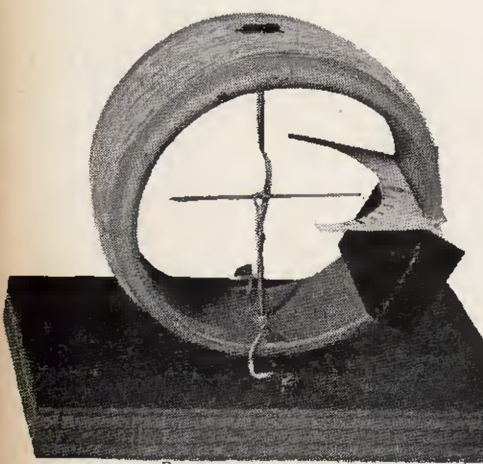
WINDING THE COIL

The only item which it is likely you will need to buy is a quantity of 36 gauge double silk covered wire. A 2oz reel will be more than adequate for the present purpose. Make a note that such wire is generally referred to in the following abbreviated form: 36 s.w.g. (standard wire gauge) d.s.c.

If any difficulty is experienced in obtaining double silk covered wire, enamelled wire will suit equally well, although it is a rather tricky operation to remove the enamel covering.

Bare the end of the wire by removing the silk covering or scraping off the enamel coating until the copper is exposed. Wrap the end of the wire tightly around one woodscrew.

Wind on a single layer of wire to cover about 1in width of the former. Bring the wire back to the start and wind a second layer immediately over the first winding. Continue in this manner with consecutive layers until the required number of turns is reached. Terminate the wire by wrapping tightly around the second screw, having first bared the wire of insulating material as before.



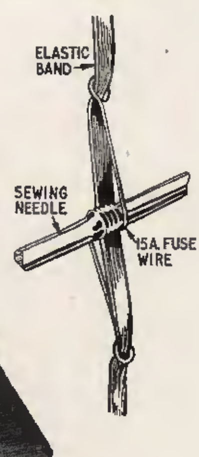


Fig. 3.1. The simple home-made galvanometer

Fig. 3.2 (right). An enlarged view of the galvanometer "movement". This shows how the needle is attached to the elastic band

If a soldering iron is available, you can make secure and permanent terminations by soldering the wire to these screws. The iron should be of the small instrument type, with a 3/16in or 1/4in bit. Use Multicore solder—this contains flux which assists the soldering operation. Ensure that the iron is fully heated and the bit well tinned, then place this on the joint and apply the solder. Remove the iron immediately the solder has flowed into the joint. Avoid an excess of solder, a thin coating is all that is necessary.

Now to return to the meter. The wood screws serve a double purpose by acting as terminals and as a means of fixing the coil former to the baseboard. If small holes are first pierced in the baseboard, the two screws can then be gently tapped into the board. Do not, of course, attempt to turn these screws for this will result in broken connections.

In the photograph you will see that we have mounted a second pair of screws on the baseboard and soldered two short wires between these and the first pair. This arrangement is not absolutely essential, but it finishes off the instrument neatly, and makes for ease of use afterwards.

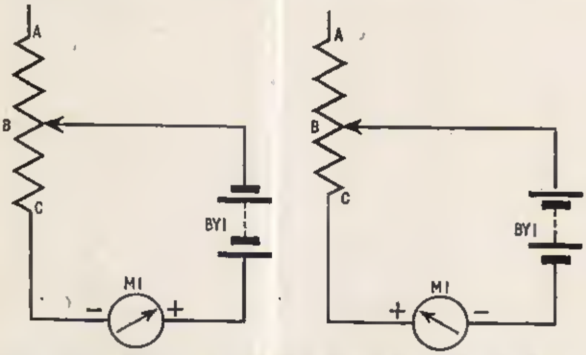


Fig. 3.3. Simple experiments can be performed using the galvanometer in conjunction with the resistance element and a small battery

THE SCALE

Next cut out a small piece of cardboard and from this fashion the scale. If you look closely at Fig. 3.1 the required shape will be clear. Attach the scale temporarily to the coil former by means of a piece of thread.

You can calibrate the scale by connecting a number of batteries of different value to the terminals and making a mark in line with the pointer setting obtained. You will notice probably that the resulting scale is not linear. This means, if you mark the point indicated for a 4½V battery then add another 4½V battery in series to give 9V, the position indicated by the needle is not twice the distance from the zero position.

You will also see that by changing round the battery connections, the needle will deflect in the opposite direction. Thus the meter can be used to indicate positive or negative values. When calibration is completed the scale can be glued to the inside of the former, or may remain simply tied to it with a piece of thread.

The amount of needle deflection obtained is decided by the voltage applied to the meter. An increase in voltage causes more electrons to flow round the circuit, more current in the coil produces an increase in the magnetic field due to the coil, and this field in turn causes a corresponding increase in deflection of the needle. As a magnetic field is produced regardless of the direction in which the current flows, the needle deflection can be in either direction—depending upon which way round the battery is connected.

USING THE METER

Those of you who have constructed the simple resistance apparatus described in the first article of this series can use it in conjunction with the meter to show the change in current as the slider is moved along the wire. Initially, you will recall, we used a bulb to indicate a change in current; now you can repeat those experiments, replacing the bulb by the meter. This is shown diagrammatically in Fig. 3.3 which you should compare with Fig. 2.1 in last month's article.

We realise that this meter is limited in the number of uses to which it can be put and for the beginner, who hopes no doubt to make electronics his hobby for many years to come, it will be simply an *indicating* device and not a *measuring* device. We are sure that those of you who are really keen will eventually invest in a good meter which, with careful use, will last many years.

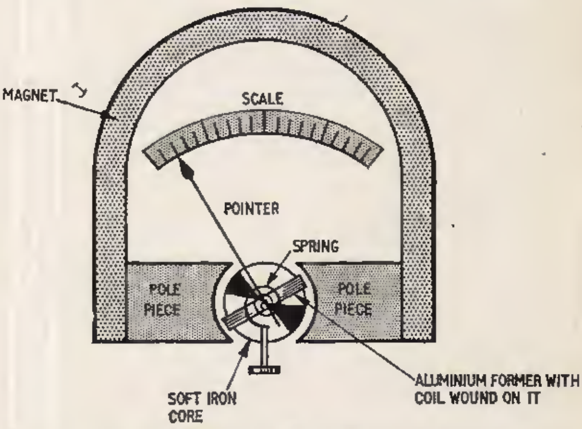


Fig. 3.4. The essential parts of a moving-coil type of current measuring instrument

THE MOVING COIL METER

It may be useful at this point to mention briefly the basic types of meter available on the market. By far the most common meter is of the "moving coil" type. As its name suggests, this is basically a coil of wire (wound on a former) which is free to rotate in a magnetic field, see Fig. 3.4. A current flows through the coil and sets up a magnetic field of its own. This field reacts with the magnetic field produced by the horseshoe permanent magnet and causes the coil to move. Attached to the coil is a pointer, the amount of movement of the pointer being governed by the current flowing in the coil.

Notice that the pointer normally rests at the left-hand end of the scale—this is the zero position. It is held in this position by a pair of hair springs which have a dual function, for they also provide the electrical connection between the meter terminals and the coil winding.

When current flows the coil rotates in opposition to the action of the springs, and the needle is thus deflected towards the right-hand end of the scale. This type of meter is very widely used. There are also centre-zero meters which respond to either negative- or positive-going currents, as in fact does our simple home-made device.

sound on tape

A SHORT SERIES FOR THE HOME RECORDING ENTHUSIAST

By H. W. HELLYER

PART THREE

It is now proposed to discuss recording level indicators. Most tape recorders incorporate some device for indicating the signal level during recording. Where there is no such device, the reason may be twofold: first, automatic recording control may be applied, and second, the simplicity of the machine may not warrant an indicator.

We need not consider the second case here, and as for the first, this is a special subject which the author hopes to return to later. Recording level indicators fitted to most machines are intended both as warning devices, to prevent overloading, and adjustment aids, to enable us to obtain the best signal-to-noise ratio under varying conditions. Two methods are used: the magic (electronic) eye, and the meter.

The magic eye, as shown in Fig. 3.1, may take a number of forms, and the display portion can be of almost any shape, provided it gives a clear indication of the peak condition, i.e. the highest modulation level, or loudest sound. For this reason, the magic eye may be referred to as a "peak-reading device". Its one great advantage is the speed of reaction: an electron beam has no inertia, whereas a meter movement must have some damping, and, however quickly it reaches the peak indication, it must take an appreciable time to fall away again.

In practice, the meter measures a varying d.c., which is the amplified and rectified signal. This charges a capacitor, the circuit constants being chosen in such a way that the meter indicates the peak slightly after it occurs, as the discharge of the capacitor begins. Successive peaks then restore the charge and the meter indicates an average level.

Without going too deeply into a.c. theory, it is necessary to explain this business of "average values". It it was only needed to measure pure sine waves, a form of meter could be used quite safely. This is because the average value of a sinusoidal waveform is always the same, being 0·707 of the peak value, and known as the root-mean-square, or r.m.s. value.

But the audio signals with which we are concerned in tape recording are far from being pure sine waves. A meter which responded to average values would give little indication of true peaks. A meter which was incorporated in a circuit that allowed it to respond to peaks of short duration would not give a true indication of the average signal level. A compromise must be found.

METER RISE-TIME

The validity of this compromise will depend on the rise-time of the meter, that is, how fast it can respond to peaks. The meters used by broadcasting stations can respond to peaks which are as short as 5 msec, the circuit being arranged so that the needle falls away at a rate of 8dB per second, which still allows adequate measurement of the average modulation level. A fall-rate of about 1½dB per second is about the limit to a useful indicating device, and a figure of about 3dB per second should be obtainable with meters of modern "constructors" quality.

FITTING A METER

Adding a meter to the normal tape recorder is not a difficult job, and may interest some readers as a useful experiment.

First, it is necessary to consider what voltages and currents are available to drive the meter, how they may be obtained, and from which points in the circuit.

One obvious source is the *high level* output or *monitor* socket of the tape recorder. But as the moving coil meter we may expect to use is a current consuming device, any attempt to use it directly will load the signal circuits of the tape recorder. A valve voltmeter is the answer to the problem.

Fortunately, we do not need to dip deeply into the purse for a convenient source of signal and a means of making a valve voltmeter based on our moving coil unit is already available. A meter of 0–1 mA f.s.d., or even 0–5 mA, should be readily procurable from several of the advertisers in PRACTICAL ELECTRONICS. But before we decide how to utilise the meter, let us take a look at the existing circuits of the magic eye.

MAGIC EYE CIRCUIT

Referring to Fig. 3.2, V1 is a magic eye of a type widely used in modern tape recorders. The audio signal is derived from the same point which feeds recording current to the recording head, the anode of the head amplifier, and applied via a blocking capacitor C1 to the magic eye circuit.

In series with this capacitor is a limiting resistor R1, whose function is to prevent the heavy loading of the signal circuits that would otherwise be offered by the rectifier D1. This resistor is also used to regulate the signal voltage, in conjunction with C2, which acts as a high frequency bypass capacitor.

The audio signal is then rectified by D1 and a varying d.c. appears across the load R2, the capacitor C3 charging up to the r.m.s. level, and thus maintaining a changing bias in proportion to the signal level, which is applied to the control grid of V1.

The construction of the magic eye includes an amplifier triode so that a negative voltage of between 15 and 25 volts at the grid produces the zero shadow angle, or maximum indication, as when the columns meet on a display such as the EM84.

DIODE TRIODE

We can use the existing valve base and dispense with the rectifier by fitting a diode triode, or, more conveniently, a double triode, with grid and anode of one half strapped to operate as diode. Our signal is then applied as shown in Fig. 3.3. Again, C1 feeds the signal, via R1 to the diode. But now the diode is a strapped triode, and the feed to its cathode is via a variable resistor, VR1, to enable us to set the recording level. Note the difference in the values of the load components C3, R2. This is to increase the time constant and allow for the meter inertia discussed above.

The rectified signal is now applied to the grid of the second half of the valve V2 and the amplified anode current produces a measurable voltage across the cathode bias resistor. This is made variable to allow meter "zero-ing." An alternative method would have been to insert the meter in the anode of the valve and feed the cathode from a potentiometer across the h.t.

SCREENED LEADS

When experimenting in this way, remember to keep the leads from the existing circuit to the new circuit as short as possible, or unwanted audio feedback can occur. If any wiring is altered, it is important to avoid hum loops by keeping the screening commoned to a single point. For example, if the meter unit is more conveniently situated outside the meter, use twin-screened wire for the signal leads, and earth the screening at the tape recorder end. Take a separate lead for the h.t. negative line, and join it directly to the negative line of the head amplifier stage—not to some other, more physically convenient place.

For further experiments, it may be possible to progress at a later date to the more accurate Peak Programme Meter, which gives a better indication of peaks, while still retaining average modulation indication, as described in the earlier discussion of this subject.

The volume unit meter circuit described here measures loudness rather than peaks, and if any professional work is to be done, it is the rapid peaks that are most needful of watching. They are the signals that do the damage, overloading the tape and causing distortion.

A further refinement would be a transistorised meter circuit, allowing modification to some of the portable recorders which have no indicating devices. As a matter of interest, the reason that a meter is used on a portable rather than the popular magic eye, is simply the power demands of the latter which would quickly overtax the battery.

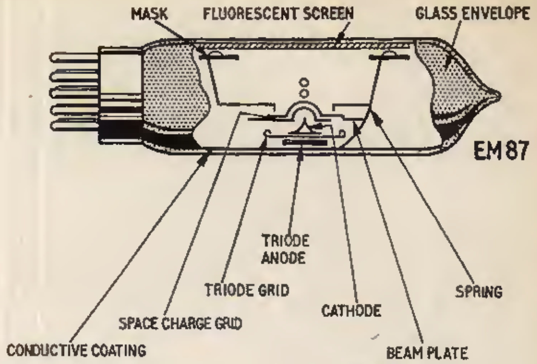


Fig. 3.1. Cross-section of Mullard EM87 magic-eye valve. The column-type beam closes with a peak input voltage of 10 volts and a 1½mm overlap; a clear bright line is produced with a 15 volt peak input

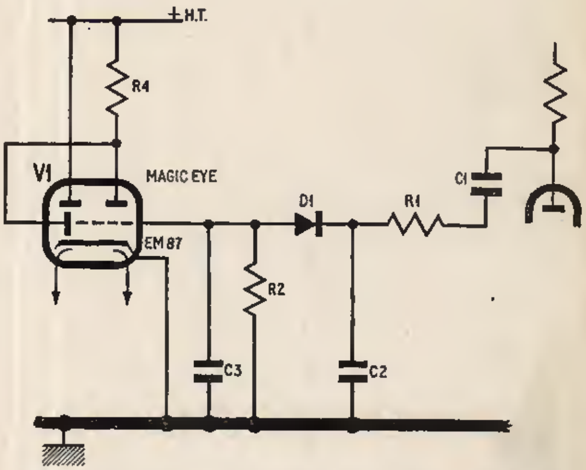


Fig. 3.2. Circuit for magic-eye recording level indicator

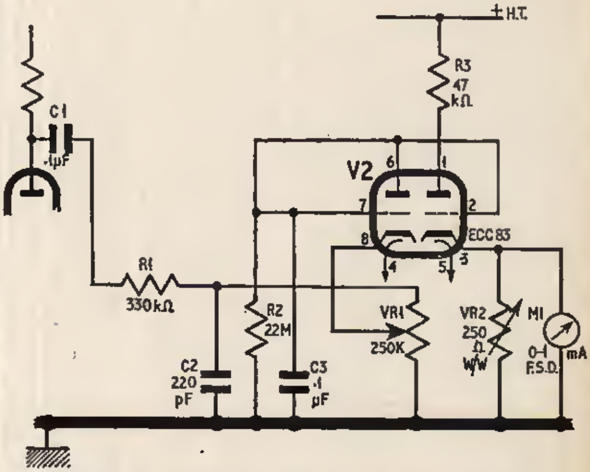
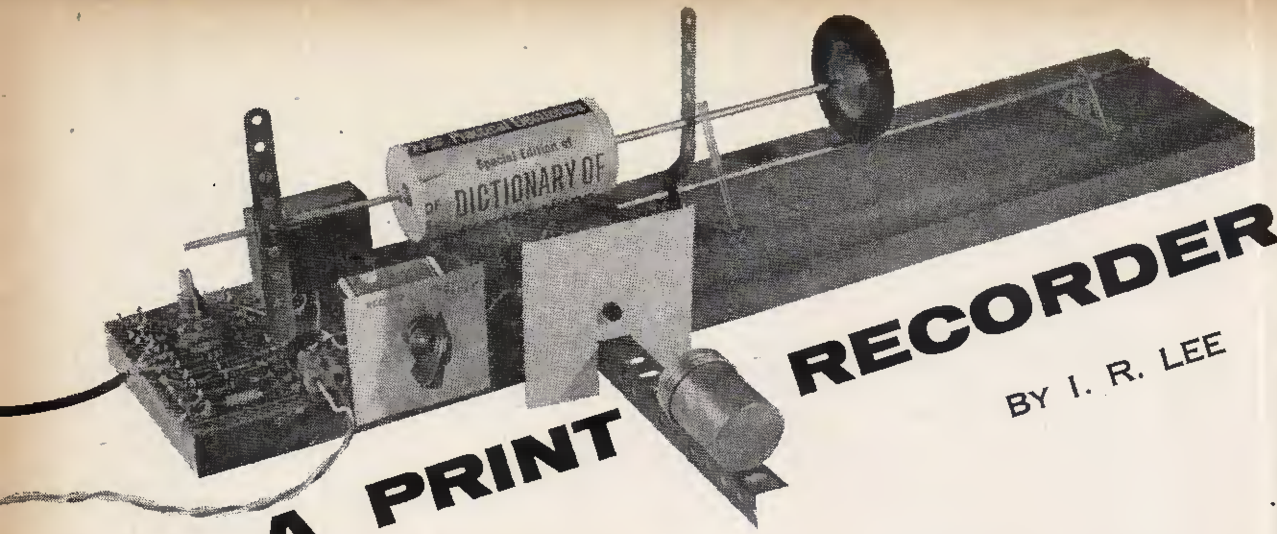


Fig. 3.3. Meter-type recording level indicator, using valve detector and amplifier



A PRINT RECORDER

BY I. R. LEE

THE machine may be called, in simple terms, a print recorder but can reproduce drawings. The drum, on which the printed matter is placed, is rotated and moved along so tracing a helical path.

A minute spot of light is focused on to the print and reflected from the print on to a photosensitive device. The output from the photo device is used to modulate a.c. for recording on magnetic tape.

When a copy of the recording is required a piece of photosensitive paper is placed on the drum, the drum is again revolved, and the recorded signal is applied to the light beam which is focused on to the paper. The picture is built up on the paper, line by line, and the paper is then developed in the normal way. The finished print is a negative copy of the original.

CIRCUIT

The photoelectric pick-up, which is placed by the drum, is an OC71 transistor with the black paint coating scraped off. This provides an adequate pick-up which is sensitive to light. The emitter and collector only of the transistor are used, the base being left unconnected.

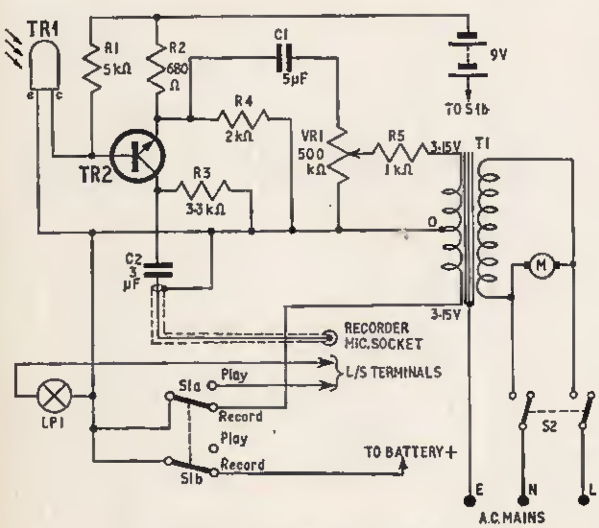


Fig. 1. Modulator circuit

The signal produced when the transistor is illuminated is used to modulate an a.c. signal from half the secondary winding of transformer T1.

The circuit shown in Fig. 1 uses any a.f. *npn* transistor. The signal from TR1 is applied to the base of the transistor TR2. The a.c. signal to be modulated is taken from half of the centre-tapped 6·3V secondary of T1 via VR1 and C1, and is applied to the emitter of the transistor TR2. The modulated signal appears across R3 and is fed to the MIC input of a tape recorder via C2.

VR1 controls the a.c. being applied to the circuit. Too much a.c. will saturate the signal and too little a.c. will cause shallow modulation so causing a very contrasting image. It may take time to obtain a reasonable setting for this control as it is very critical. R5 was put into the circuit to provide a load across T1 when the wiper of VR1 is set electrically close to the centre-tap end of T1.

The switch S1 is used to control the beam and modulation circuits. In the "record" position the beam lamp LP1 is lit continuously by half of the secondary winding of T1. Modulation takes place in the record position. In the "play" position the modulation circuit is not used and the signal from the recorder is applied direct to the beam lamp.

When the tag board is wired as shown in Fig. 2, it can be screwed to the wooden base. T1 is also screwed to the baseboard. The battery can be held in position on the baseboard by adhesive tape. S1 can be mounted on a piece of aluminium sheet 2½in square, which is screwed to the baseboard (see photograph).

Before actually fitting the pick-up to the angled strip its most sensitive surface must be found. This can be done by switching on the modulation network and monitoring the signal on a tape recorder. The pick-up is rotated in a beam of light (from a torch) until the output from the modulation network reaches its highest level. The side of the pick-up facing the beam source when the signal output is at its greatest is the most sensitive area. This surface should face the drum.

MECHANICAL CONSTRUCTION

The recorder is built on a wooden base about 2ft long, 4in wide and ½in thick. The mechanical system is mainly built up from Meccano parts.

The picture drum can be made to individual requirements. The model shown in the photograph employs

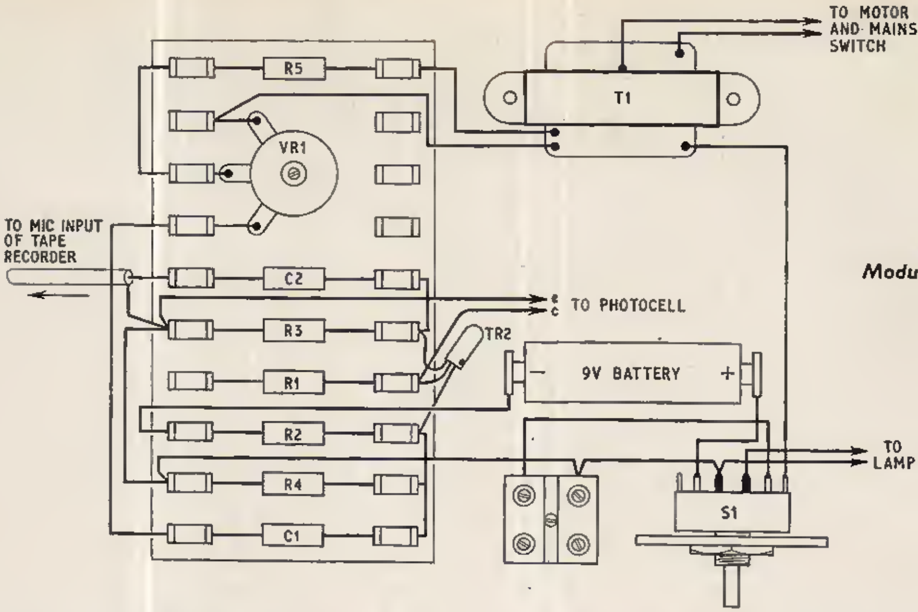


Fig. 2.
Modulator layout

a drum made from a thick cardboard tube, but a lever top can will serve just as well. A reasonable size would be about 2½ to 3½in long and 1½ to 2in diameter. An eight-hole Meccano bush is fitted centrally on one end so that the tin will revolve truly concentric (see Fig. 3).

A hole is made in the *centre* of the opposite end of the drum and a long screw or a piece of studding about 4in long is threaded through the hole and fixed on both sides of the end disc (or lid of the can) with two locking nuts (see Fig. 4). This can now be fitted on to the drum. A nut, which will fit the long screw, is clamped firmly between two Meccano perforated strips bolted together. One strip is slightly longer than the other and bent at right angles so that two holes can be used to screw it down to the baseboard (see Figs. 4 and 5).

This clamp is then placed centrally on the wooden base about 6in from one end and screwed down through the holes in the bent up section of the perforated strip. (See Fig. 5.)

An angled trunnion (Meccano) is then placed centrally at the opposite end of the base from this clamp and screwed firmly home with two screws. Another angled trunnion is placed about 9in away from the one at the end and aligned parallel to it and in the centre of the baseboard, then screwed down (Fig. 3).

Next, a 3in perforated strip is bent to the shape shown in Fig. 3, part C. This strip is then bolted to the bottom hole of the second trunnion and the vacant holes aligned to take axle B.

The screw on the picture drum must now be threaded into the scanning nut which is mounted in its clamp.

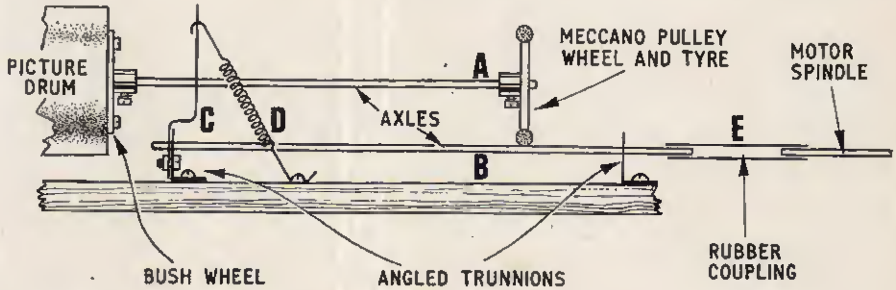
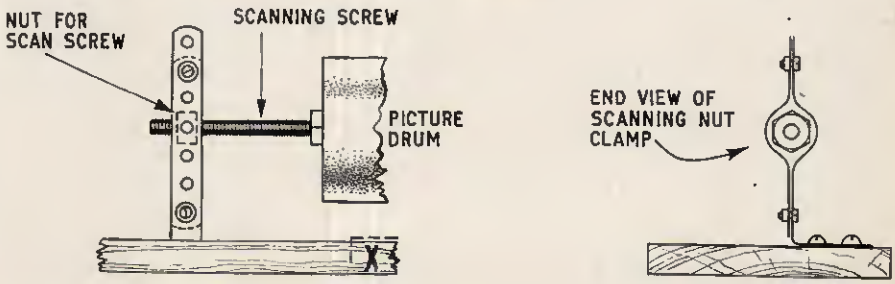


Fig. 3. Drive details



Figs. 4 and 5.
Lead screw construction

A PRINT RECORDER continued

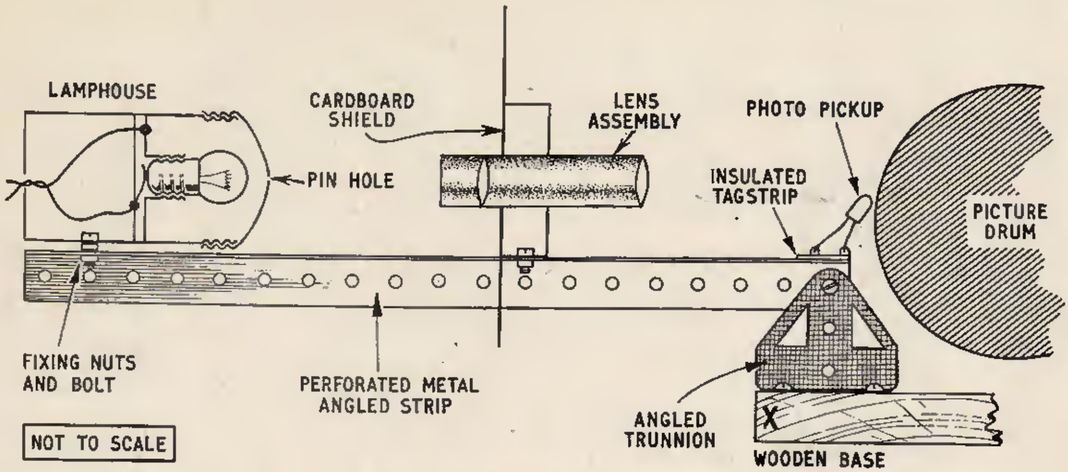


Fig. 6. Optical assembly

While holding the drum horizontally thread a 6½in Meccano axle A through the fourth hole from the bottom of strip C. Next, thread it into the bush wheel on the closed end of the picture drum and clamp it with the fixing screw provided.

Now attach a Meccano pulley with rubber tyre to the end of axle A. Loosen the clamp at the other end of the base and move the bolt up and down in the clamp until axles A and B are parallel. Tighten the clamp again. An 11½in Meccano axle B is threaded through the top holes of the two angled trunnions.

On the prototype a small spring D (removed from a gramophone brake system) was hooked into an upper hole of perforated strip C (Fig. 3) and the other end was screwed to the base. This assisted to provide good frictional contact between the wheel and axle B.

The electric motor used to drive the prototype was an old Collaro AC34 with a working speed of 78 r.p.m. (Reduction gears inside case.) The motor was attached to drive axle B by means of a small piece of rubber sleeving E. This was slipped over the end of axle B and the motor spindle providing an efficient flexible coupling.

OPTICAL ASSEMBLY

The beam lamp, spot lens and pick-up are all mounted on a 12½in Meccano angled perforated strip. The beam lamp LP1 is mounted in a tin (such as that used for storing 35mm film, see Fig. 6).

One hole, as small as possible, is drilled in the centre of the screw-on lid. Another hole, big enough to accommodate a Meccano screw, is drilled in the side and a third hole in the bottom of the tin is made adequately large, say ¼in, to accommodate two thin wires. The bulb is mounted in a standard round paxolin lampholder, which is then wired and fitted inside the tin and firmly fixed with adhesive. The lead wires are taken through the hole in the bottom of the tin.

The lamp housing is attached to the angled strip with a Meccano nut and bolt threaded through the second hole from the end of the angled strip as in Fig. 6.

In the author's model the lens was removed from an old film-strip projector and was the twin type with two lenses mounted in a small cylinder 1in long and ¾in diameter. The whole lens assembly is mounted in the lid of another film can. A large hole made in the centre of the lid accommodates the lens barrel and a smaller hole made in the threaded side takes the fixing nut and bolt. The lens should fit tightly in the holder. The whole lens unit was fixed with a Meccano nut and bolt half way between the lamp and the drum.

The distance of the lens from the lamp housing depends on its focal length and has to be found by experiment. Fine focusing may be achieved by sliding the lens back and forth in its mount. A cardboard shield was fitted to the lens mounting on the side nearest the lamp to prevent unwanted light by-passing the lens and upsetting the light image reflected from the drum. The shield is about 3in square with a hole cut in the middle to take the lens barrel. A slot should be cut in the bottom of the shield to accommodate the angled strip.

The angled strip containing the optical assembly was attached to the top hole of the trunnion using a Meccano nut and bolt (Fig. 6). One bolt was used so that the arm could be hinged up and down to obtain the best results from the pick-up. An angled trunnion is screwed to the baseboard attached in position X on the base (Fig. 6) so that it is in line with one end of the drum when the drum is at the end of its travel.

A piece of tagstrip with two tags should be bolted to the angled strip close to the drum so that the tags are insulated from the metal strip.

TR1 is soldered to the two tags with the sensitive side facing the drum. The wires of TR1 should be held with a pair of pliers to act as a heat shunt while soldering. Two wires are connected between the tags and the modulation unit.

TR1 should be repainted matt black on the surface which is *not* facing the drum, so that it will pick up light reflected from the drum and not from the optical assembly. The light beam from the optical system should strike the drum just above TR1. On no account should the beam fall directly on TR1 or the performance will be severely upset.

RECORDING A PRINT

A piece of printed paper such as newspaper can be wrapped round the drum and fixed with adhesive tape. Plug the output of the modulation network into the MIC socket of the tape recorder. Turn S1 to the "record" position, likewise the tape recorder should be switched on and set to "record". Now adjust VR1 so that when the pick-up is darkened no signal reaches the recording indicator, and when it is lit a good signal appears at the indicator. The room should be dark so that spurious light does not interfere with the instrument.

Cut a strip of bromide enlarging paper (hard) the same size as the original printed matter. Wrap it tightly round the drum and fix with adhesive tape. Switch the recorder and S1 to the "play" position and attach the appropriate wires from the machine to the external loudspeaker terminals of the recorder.

Start the machine first, then start the tape recorder and turn up the volume control until a reasonable degree of light is obtained from the lamp when the recorded signal is applied. Leave the machine until it has scanned the whole paper and then stop the recorder before stopping the machine.

Remove the bromide paper from the drum and immerse it in a developer solution specified for the paper. After the desired image has been obtained wash the paper in water and immerse it in a fixing solution (sodium thiosulphate) for 10 minutes. After "fixing" the print it may be examined in the light.

COMPONENTS . . .

MODULATOR COMPONENTS

Resistors

R1	5k	R4	2k
R2	680	R5	1k ½W
R3	3·3k		

All 10%, ¼W carbon unless otherwise stated

Potentiometer

VR1 500k log or linear

Capacitors

C1 5μF 50V elect. } Henry's Radio
C2 3μF 50V elect. }

Transistors

TR1 OC71 (see text)
TR2 Any *npn* transistor for working voltage above 9V

Miscellaneous

T1 6·3V centre-tapped heater transformer
LP1 3·5V m.e.s. bulb
S1 2-pole, 2-way rotary switch
10-way tagboard
Plugs to suit tape recorder microphone and loudspeaker sockets
9V battery; connecting wire; knob; solder
Batten lampholder (m.e.s.)

MACHINE PARTS

Meccano List

No. 2a 4½in perforated strips (2)
4 3in perforated strip
8 12½in angle girder
13 11½in axle rod
14 6½in axle rod
20a 2in diam pulley with boss
24 1⅜in diam bush wheel
126 Angled trunnions (4)
142a Motor tyre (for 2in pulley)
37 Nuts and bolts 7/32in (pkt of 24)

Miscellaneous

4in of 4 BA studding and 4 BA nuts
Wooden baseboard (see text)
35mm film can and two screw lids
Lever or screw top can (see text)
78 r.p.m. motor (e.g. Collaro AC34)
⅜in round head wood screws
Rubber tubing to fit axle and motor spindle
Small spring

A switch, connected in the mains *line* to the motor and T1, should be used to control the motor and electronics. Start the tape recorder and then start the print recorder drive motor. When the scan is completed stop the tape recorder and switch off the drive motor.

REPRINT THE RECORDED COPY

Wind the tape back to where the signal started and return the drum to its starting position. This may be done by disengaging the coupling (E in Fig. 3), and spinning the drum by hand. If a reversible motor is used it can be arranged to be switched to a reversing condition to return the drum.

The next process must be done in RED light as it involves the use of photosensitive paper.

Wash the print well in running water for about 5 minutes. The finished print will be a negative reproduction of the original.

VARIATIONS

Many readers who intend constructing this simple device will probably wish to improve its performance or modify it to their own requirements. Obviously, the finer the thread of the scanning screw, the more detailed will be the final reproduction. A larger drum may also be used provided allowance is made for adequate clearance between the drum and other nearby parts. If the drum is made larger in diameter a larger driving wheel is required. If the drum is made longer, the axles and screw should be longer. ★

Precision Decimal Step PRE-AMPLIFIER

Continued from page 115 of last month's issue

by M. L. MICHAELIS, M.A.

THE factors determining the input impedance are somewhat involved, yet their understanding is essential for making correct adjustments to the unit.

If the decimal step pre-amplifier is to be used for metric purposes between the probe and the input socket of an oscilloscope or valve voltmeter, the input impedance must be equal to that at the input socket of the oscilloscope or voltmeter, and the output impedance must be very much less; the latter condition is automatically satisfied by TR7 and therefore requires no further consideration.

If the input impedance differs from that of the oscilloscope Y-amplifier input, then the attenuation factor of the probe is correspondingly abnormal and it delivers a different signal voltage to the pre-amplifier than it would, under exactly the same conditions, deliver to the oscilloscope Y-amplifier input. Although, of course, the decimal step gain of the pre-amplifier with respect to the signal input voltage it *actually receives* is not affected, the oscilloscope voltage calibration is then, nevertheless, disturbed if the probe is incorrectly matched to the pre-amplifier input.

The primary determinative component for the input impedance at PL1 is R9 (470 ohms). This reflects an impedance β times as great in parallel with R8, where β (approximately 20) is the current gain of TR3. The combined impedance at the emitter of TR2 is thus about 3 kilohms. This reflects in the same way, multiplied by the current gain of TR2 (again about 20) in parallel with R6, i.e. about 60 kilohms reflect in parallel with R6 as emitter impedance of TR1, which is equivalent to about 20 kilohms. This 20 kilohm net impedance at TR1 emitter reflects once again in the same manner at about 20 times this value, i.e. about 800 kilohms, in parallel with R3.

As far as a.c. signals are concerned, the series combination R4 and VR1 also acts in parallel with R3 (via C2). Finally, the series combination of these three parallel impedances on the one hand and R1 on the other hand is the ultimate input impedance presented to PL1. As already mentioned in last month's article, this is equal to 135 kilohms in the prototype, to match the Y-amplifier input of the author's oscilloscope.

If the pre-amplifier is to be used with any other oscilloscope, the resistors on VB1 and, if necessary, TR3 must be suitably modified to match the input impedance to that of the oscilloscope Y-amplifier.

As a typical example, we will discuss the modifications for 1 megohm input impedance, a quite common figure for many commercial oscilloscopes. Modification to any other impedance figure will be along similar lines, though it will be difficult to get above 1 megohm (which should not normally be required anyway).

Since the ratio of R9 to VR2 determines the ultimate gain, it is not possible to increase the value of R9 indiscriminately in order to reflect correspondingly higher impedances back to PL1, without having to increase VR2 correspondingly in order to maintain gain. But increase of VR2 increases the high-frequency shunting effects of stray capacities at S1 and associated wiring to VB2. Another method of increasing impedance is to replace TR3 with a different type of transistor having higher current gain. Yet two further methods of increasing impedance are to increase the ratios of R3 and R6 in relation to the respective parallel reflected impedances.

We thus have a total of four ways of increasing impedance and it can be shown that optimum results are obtained if the required change of impedance is distributed equally between all four.

With respect to TR1 base, we require an impedance increase of about 10 times in our example, to reach an impedance of 1 megohm at PL1. Each of the four methods of impedance increase must therefore be applied, ideally, to a factor equal to the fourth root of 10, i.e. about 1·8. Accordingly, increase R9 by a factor of 1·8, making it 820 ohms (nearest preferred value). Increase VR2 by the same factor, i.e. replace by a 20 kilohm linear preset potentiometer. Replace TR3 by a different transistor with nominally 1·8 times the current gain of the OC303; this is, near enough, the OC304.

By the same calculation as previously, these changes now lead to about 30 kilohm reflected impedance in parallel with R8. The simplest way of calculating the necessary modification to R8 is to consider that the new net emitter

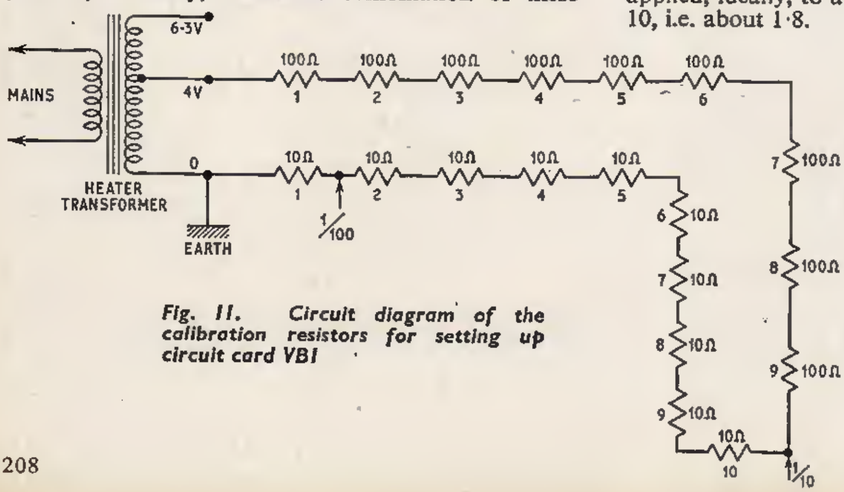


Fig. 11. Circuit diagram of the calibration resistors for setting up circuit card VB1

impedance for TR2 must be greater by three factors of 1·8 compared to the former value (3 kilohms), i.e. it must now be about 17 kilohms. The new value required for R8 must thus be such as to give 17 kilohms when taken in parallel with the reflected virtual 30 kilohms. The nearest preferred value is 33 kilohms, for satisfying this condition. Accordingly, replace R8 by a 33 kilohm resistor.

The resulting 17 kilohm net impedance at TR2 emitter reflects some 20 times as large, i.e. about 340 kilohms, in parallel with R6. These reflected 340 kilohms, in parallel with the required new value for R6, must now lead to 10 times the former emitter impedance for TR1, because all four changes have therewith been completed. The former impedance at TR1 emitter was 20 kilohms, so that R6 must now be chosen to make it 200 kilohms. In other words, R6 in parallel with 340 kilohms is to be equal to 200 kilohms, making the nearest preferred value for R6 equal to 470 kilohms. The 200 kilohm net impedance at TR1 emitter now reflects as usual some 20 times as large (current gain factor of TR1) to the base of TR1, in parallel with R3.

If R3 is now replaced by a 3·3 megohm resistor, R4 by a 1·5 megohm resistor and VR1 by a 1 megohm linear preset potentiometer, the combined parallel impedance will be just about the required 1 megohm. Any slight final correction can be made subsequently by altering the value of R6 alone, after adjusting VR1 for correct d.c. operating point (350mV d.c. voltage drop across R10 in this case).

SETTING UP CIRCUIT CARD VB1

The first step is to set the d.c. operating point. Connect across R10 a high impedance multimeter or valve voltmeter (sensitivity at least 20 kilohms per volt) set to a range of about 1 or 2 volts d.c. f.s.d. Adjust VR1 until the meter reading is 600mV (for the given case with component values as in Fig. 1 (of last month's blueprint) and 135 kilohm input impedance at PL1; otherwise reading to be *less* by the same factor as used in each of the four steps to change to a different input impedance as described).

Now connect ten 10 ohm resistors and nine 100 ohm resistors all in series across a 4 volt heater winding on a mains transformer (Fig. 11), earthing the end of the winding at which the 10 ohm resistors are situated. Connect the voltage across all ten 10 ohm resistors straight to the Y-amplifier input of the oscilloscope with which the pre-amplifier is to be used and adjust the height of the c.r.t. display to a convenient size.

Having previously adjusted the input impedance of VB1 to near the required value (equal to the oscilloscope input impedance) as described above, connect the input of VB1 across *only one* of the 10 ohm calibration resistors. Connect the output from PL2, with the pre-amplifier set to gain 10, to the oscilloscope Y-amplifier input, having disconnected the latter from the ten 10 ohm calibration resistors without disturbing the settings of the oscilloscope controls. Now adjust VR2 with a screwdriver until exactly the same height of trace as previously is obtained. The gain of VB1 between connections 16 and 8 is then exactly 10.

Now connect the probe of the particular oscilloscope (so far not used in these adjustments) to the Y-amplifier input, and the prod of the probe to the full 4 volts applied to the calibration resistor chain. Again adjust the trace to a convenient height. Then move the probe connection to the input PL1 of the pre-amplifier set to gain 10, taking the output from PL2 to the oscilloscope Y-input directly. Connect the prod of the probe and the earth clip across all ten 10 ohm calibration resistors. Adjust the value of R6 until the display on the c.r.t. is of the same height as previously.

Now return right back to the beginning of this sequence of adjustments, re-adjusting VR1 to obtain the stipulated d.c. reading across R10, followed by repeating all subsequent adjustments in the same order.

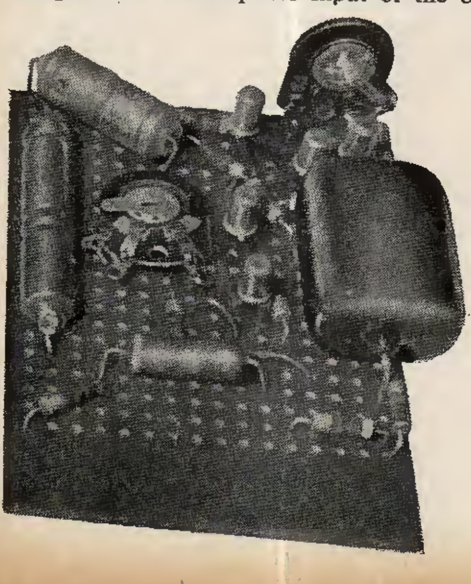
Repeat the entire sequence until mutually correct settings are observed to have been achieved, i.e. until nothing needs altering any more on an entire run-through. VB1 is therefore properly adjusted to have a gain of exactly 10 between connections 16 and 8, and its input impedance exactly matches that of the oscilloscope Y-amplifier input.

ADJUSTMENTS TO CIRCUIT CARD VB2

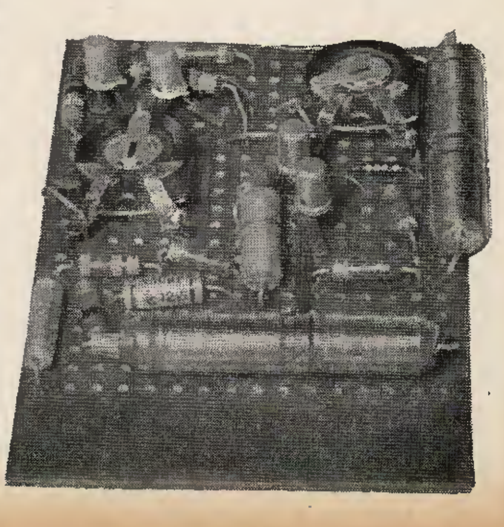
It is absolutely essential to have completed adjustments to VB1 before proceeding to adjust VB2.

The actual adjustment of VB2 is very much simpler than that of VB1, because this can be built with the component values as shown in Fig. 1 under all circumstances, whatever the input impedance actually required at PL1. The exact values of input and output impedance of VB2 are relatively unimportant.

continued on page 214



Photograph of VB1 showing component layout and positioning of VR1 and VR2



Photograph of VB2 showing component layout and positioning of VR3 and VR4

DETACHED PARTICLES
By John Valence

POWER WITHOUT WIRES

THE other day I was enjoying a quiet interlude strolling around the National Gallery in central London. Coming face to face again with the works of those great landscape artists Constable and Turner, I was reminded of the fierce controversy that arises whenever the Electricity Board proposes to build a generating station or wishes to run a new high voltage grid line over some part of the countryside.

Why should modern structures such as these be considered an intolerable intrusion upon the natural scene, when Constable was happy to paint man-made structures such as mills and lock-gates. Indeed, buildings like these are prominent features of some of his most admired landscapes. Why does an old broken-down mill have charm to our eyes, and why does a contemporary engineering work offend?

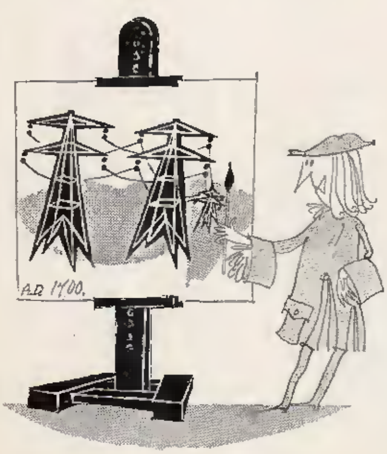
Consider the nuclear power stations. Each of these shows thought and consideration for the local amenities. Well designed outlines and the use of local stone wherever possible for cladding the outer surfaces have produced quite aesthetically pleasing results.

But it is mainly the transmission system that offends. It is a question of scale. In the vast mountainous regions of North Wales or Scotland even the super grid cannot predominate over nature. However, when these networks reach the flatter (and more heavily populated) parts of the country the gargantuan towers and the aerial fence strung between them overwhelm the surrounding scene for miles.

The national grid system is the country's life-line and demands for electrical power are ever increasing. But is there no real alternative? We are told that the cost per mile of an underground cable is very nearly ·15 times that of an overhead system. It is apparent that overhead cables there must be—at any rate until the transmission of power by radio or light waves becomes a practical proposition.

Power by "wireless" has been talked about for years past. I believe many of the early pioneers considered this the next logical development following successful attempts to communicate over long distances by radio waves.

Will this remain just a pipe dream for another ·50 years or more? Or will visitors to the National Gallery in 2064 stand enthralled in front of landscapes painted by their contemporaries that owe much of their "old world" charm to the long disused pylons standing sentinel on the distant hill tops?



Actually . . . it's an abstract

NON-CONDUCTOR

IS the familiar cry "all fares please" soon to become extinct—soon to be numbered among the street cries of bygone days?

I started musing on this subject after reading reports of electronic ticket reading machines now being brought into service on conductor-less buses in Manchester.

The scheme operates apparently like this. The intending passenger buys a special ticket with a metallic inset from a vending machine at the bus stop. When boarding the vehicle the ticket is pushed into a slot and is examined by the ticket reading machine which then cuts off the metal portion, thus preventing its further use. If a phoney ticket is offered to the machine a bell rings and the culprit stands exposed (blushing furiously, I hope) and the driver is thus alerted to repell this particular boarder.

Electronic means for ejecting passengers who try to stay on beyond their proper fare stage have yet to be invented. In the meanwhile, this part of the operation remains exclusively in human hands (well, let's be quite fair about this—inspectors *are* human you know).

In case Mancunians think this is one more example of what Manchester Does Today etc., may I mention that in the greatest conurbation of all, London Transport has been trying out a number of electronic devices all with the intent of speeding the flow of its million per day commuters.

CONTROLLED ENTRY

IN fact, an electronic ticket inspector has been on duty at one of London's Underground Railway Stations for several months now—but he is still only on probation.

The passenger places his ticket into a slot by the entrance gate, the ticket is scanned by an electronic device and, if in order, the gate is released and the passenger picks up his ticket as it emerges from another slot adjacent to a second gate which admits him to the platform.

What exactly happens should one attempt to pass off an out-of-date or phoney ticket, I have not had the courage to find out! The thought of being trapped between locked gates to the possible accompaniment of ringing bells and flashing lights is a sufficient deterrent to yours truly!

This ticket barrier heralds the arrival of automation on the London Underground Railway System. Let us hope no fuses are blown during rush hour.

Incidentally, further applications of this kind of device intrigue me. How about an electronically operated letter box for the home? This could be programmed so that bills, soap powder vouchers and other undesirable communications are promptly rejected from the front door. Well, it's a thought anyhow.

HIGH IMPEDANCE VOLTMETER

continued from page 177

S1 AND THE MULTIPLIERS

First wire into circuit R9 and BY1. The latter should preferably be a slightly used D23 battery (use one to feed a torch bulb for a minute or two) so that the open-circuit voltage is near to 1·5—a new cell will have an open-circuit voltage greater than 1·5. R9 should be quite accurate, say 5 per cent or closer, and can be a 10 per cent type with a suitable series or parallel resistor to bring the value closer to 15 kilohms.

Resistor R1 can be wired into circuit and should be a 5 per cent or 10 per cent type suitably adjusted with other resistors. The meter is then switched on with S2, brought to zero with VR2 (S3 may need opening or closing), and then switched with S1 to "Cal.". VR1 should then be adjusted to obtain f.s.d. on the meter.

If the scheme in Fig. 1a is being used, S1 is turned to position 2 (1V) and the resistor to be used for R2 is then temporarily connected in series with the negative test lead. The test leads are then connected to a source of which the potential is known (a used, but not exhausted, dry battery, for example) and the value of R2 adjusted, with the aid of series or parallel resistors, to give the correct deflection on the meter M. This procedure is then used to determine the other multipliers, each being soldered into position when the correct value has to be obtained. Note that the resistors must be determined in the order R2 to R8.

If the scheme in Fig. 1b is being used, each multiplier is adjusted individually and it is not essential to proceed from position 2 of S1 to position 9 in that order.

Reference potentials for ranges over, say, 50V can normally be found in the h.t. circuits of amplifiers and radio receivers. Calibration should be carried out by measuring the potentials with an ordinary multimeter connected in parallel with this instrument.

USING THE INSTRUMENT

First, the unit is switched on with S2 and set to one of its eight ranges. The meter will probably not read zero, so VR2 should be adjusted until zero reading is obtained (it may be necessary to open or close S3 which is used to compensate for the variations in standing current through TR1 due to alterations in the ambient temperature). Having obtained a zero reading, S1 is now switched to "Cal." and VR1 turned to obtain f.s.d. on the meter. The instrument is now set up ready for use, but the adjustments may need to be repeated if it is used for long periods, particularly if the ambient temperature changes.

The meter will be found particularly useful for measuring a.g.c. potentials, limiter-grid potentials in f.m. receivers, and anode voltages where anode loads are high in value. If instability results from connection of the unit to the circuit under test, a 4·7 kilohm or 10 kilohm resistor can be used in series with the "live" test lead, right at the end, and will give rise in most cases to negligible error. ★

P.E. DATA BOOKLETS

THE pull-out supplement in the centre of this issue forms the middle section of Data Booklet 2, pages 5 to 12 inclusive. The outer section was included in last month's PRACTICAL ELECTRONICS.

Remove these supplements by pulling smartly from the magazine. Fold each supplement in half and cut along the top edges of the pages.

Data Booklet 1

Attention is drawn to certain amendments that should be made to Data Booklet 1 presented with our first issue.

This booklet contains formulae of fundamental importance and it is much regretted that a few inaccuracies crept in during its compilation and printing. In order to avoid any confusion arising from its use at a later date, it is suggested that the following points be recorded immediately on the appropriate pages of your copy of Data Booklet 1.

page 2

Resistance is inversely proportional to area $\frac{1}{a}$

$$\text{thus } R \propto \frac{1}{a} \times l \text{ and } R = \rho\frac{l}{a}$$

Note: $\frac{1}{a}$ (*figure* 1 *not l in first two cases*)

page 3

Multi-plate Capacitor formula *should read:*

$$C = \frac{EoEr(n-1)a}{d} \text{ Farads}$$

n = number of plates

pages 4 *and* 5

w should read ω

page 5

Second formula should read:

or using j notation Z ohms $= R - j/\omega C$

Third formula should read:

$$= \cos^{-1}\frac{R}{Z} = \cos^{-1}\frac{R}{\sqrt{R^2 + \left(\frac{1}{2\pi fC}\right)^2}}$$

page 6

Basic Magnetic Formula. *Equation* (1) *should read:*

$$\therefore \quad \frac{\phi}{a} = \mu_0\mu r\frac{I.N}{l}$$

Note: l not figure 1
and *μo should read* μ_0

page 10

First formula should read:

$$\text{power factor } \phi = \cos^{-1}\frac{R}{Z} = \cos^{-1}\frac{R}{\sqrt{R^2 + (2\pi fL)^2}}$$

page 11

Geometrical Progression. *Add under formula:* for $r = <1$ multiply top and bottom of right-hand side of equation only by -1.

Also add note: r = common ratio

page 12

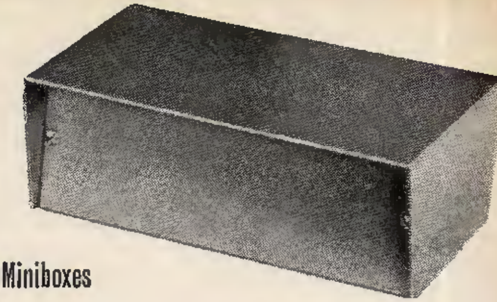
Trigonometrical Identities. *Last line but one should read:*

$$\cos 2A = \cos^2 A - \sin^2 A$$

Sine and Cosine Laws (for any triangle). *Second line should read:*

$$a^2 = b^2 + c^2 - 2bc \cos A \text{ Cosine Law}$$

NEW PRODUCTS



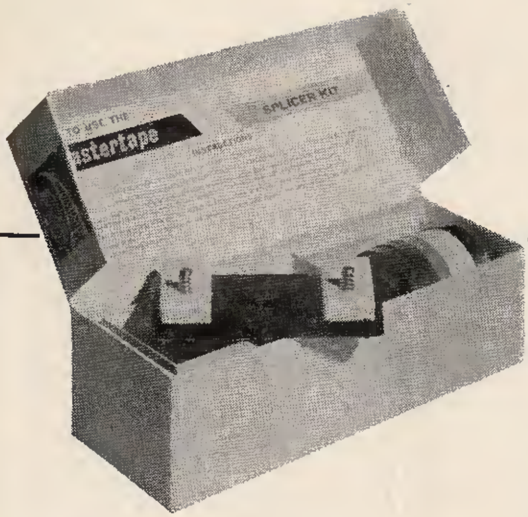
Visor Miniboxes

Alfred Imhof Ltd., Ashley Works, Cowley Mill Road, Uxbridge, Middx.

One of the blueprints in last month's issue contains details of a home or office intercom.

Readers desirous of obtaining a truly professional finish will be glad to learn that a suitable cabinet finished in stove enamel either blue, silver or dark grey hammer tone on all internal and external surfaces is available from Imhofs.

The cabinet is made from 20 s.w.g. aluminium and is of two-piece design allowing maximum space for installing components. Our photograph shows type VM 4060 which costs £1 2s 6d.



Good Recording

Vidor Ltd., West Street, Erith, Kent.

Ideal for tape enthusiasts are two recently announced products by Vidor Ltd., and manufactured by M.S.S. Recording Ltd. These are a "Mastertape Splicer Kit" and a low cost triple play tape called "Mastertape."

The kit contains five different coloured rolls of leader tape and one roll of metallic strip and jointing tape—as well as a newly designed splicer. The complete kit which retails at 21s is shown on the left.

The new tape is available on standard spools containing 600ft to 3,600ft, price ranging from £1 1s 0d to £4 19s 0d. A polyester film 0·0005in thick is used for the base material and is covered by a new oxide with low friction finish which reduces recording head wear.

Contact Cleaner

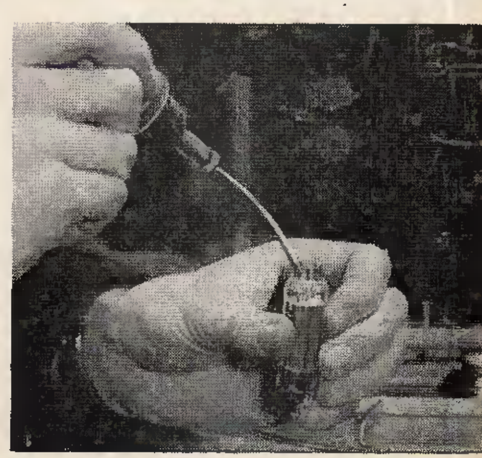
Electrolube Ltd., Oxford Avenue, Slough, Bucks.

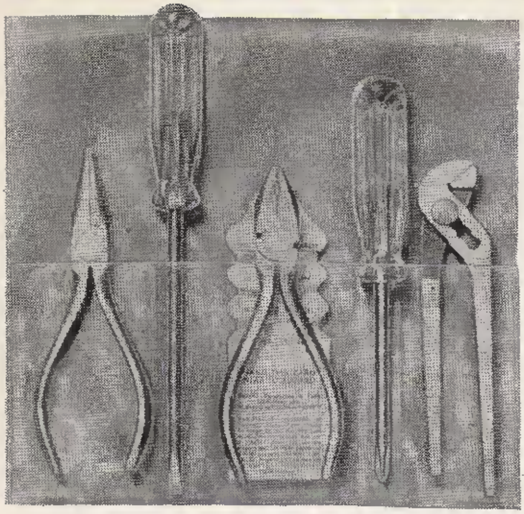
The efficient functioning of electrical and electronic equipment is often impaired by the effects of corrosion and tarnish on contacts.

Electrolube Ltd. produce a range of solvents especially to deal with the above mentioned problems. The most commonly used is Electrolube Nos. 1 and 2, which are available in handy 2oz "snorkel" bottles or pen dispensers.

Electrolube No. 1 is recommended for dirty or worn contacts on potentiometers (wire or carbon track), valve or plug pins and sockets, and push-button or wafer switches. Since the solvent does not evaporate quickly it may carbonise if used on contacts where sparking can occur. For treating and lubricating all clean arcing and non-arcing contacts, surfaces and mechanisms free from mineral or other lubricants and grease, No. 2 is recommended.

Our photograph shows the solvent being applied to valve pins to improve sensitivity and signal to noise ratio.





Tool Pack

W. K. & C. Peace Ltd., Templeborough Works, Sheffield 9.

A new kit of small hand tools, suitable for electronic enthusiasts, model makers, radio repairers etc., is now being marketed by the above firm.

The kit consists of three of the most commonly used pliers (combination, radio and multi-grip), two screwdrivers (one conventional and one Phillips recessed head type), and a card of 5, 10 and 15 amp fuse wire completes the pack. The kit is housed in a roll-pack wallet and retails at 28s 6d.

This new kit should prove to be a handy addition to the tool box, but we feel we must point out that the pliers do not have insulated handles and should never be used in "live" circuits.

Transformer Design Kits

The Belclere Co. Ltd., 385-387, Cowley Road, Oxford.

Readers who find it necessary to wind their own transformers for prototype electronic circuits should find the transformer kits of the above firm helpful. They now supply 51 different kits which offer a wide selection of bobbins and clamps, if needed, together with the required amount of laminations in a choice of materials.

PRECISION DECIMAL STEP PRE-AMPLIFIER—*continued from page 209*

The factors governing internal impedance relationships within VB2 are the same as for VB1.

Having completed adjustments to VB1, switch the pre-amplifier to "gain 100" with S1. Connect the oscilloscope probe directly to the oscilloscope and the prod and earth clip thereof across the entire chain of calibration resistors in the same arrangement as previously. Adjust for convenient height of display on the c.r.t. (Y-amplifier gain). Disconnect probe from the oscilloscope and connect to input PL1 of the pre-amplifier, having first adjusted VR3 for 600mV reading on a high impedance voltmeter across R20. Connect prod and earth clip of probe across one single 10 ohm calibration resistor at the extreme earth end of the chain. Adjust VR4 to bring the height of the trace on the c.r.t. to the same value as previously.

Adjustment of VB2 is now complete, as is that of the entire pre-amplifier.

SIGNAL-TO-NOISE RELATIONSHIP

With the oscilloscope probe connected to the input of the pre-amplifier, conditions are virtually those of an open circuit. In the author's set-up about 25 microvolts of noise were observed to be developed at the base of TR1, leading to 2·5 millivolts of noise at the output terminal PL2. The resulting "grass" on the trace of the c.r.t. when everything is set to full gain is well under one millimetre wide.

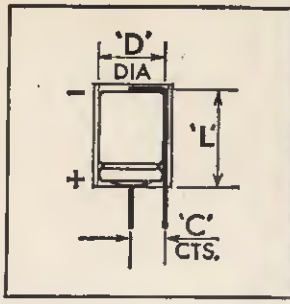
If the pre-amplifier is connected to the Y-input, again with Y-gain full up and pre-amplifier gain set to 100, and input signals to the pre-amplifier are fed in directly without a probe, then the noise level will be less than the normal trace width on the c.r.t. as long as the input signal source impedance is less than 10 kilohms. In other words, noise will be quite unnoticeable on the c.r.t. under these conditions.

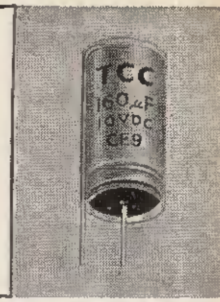
If the signal source impedance is even less still, as will mostly be the case for electroacoustic applications where the effects of residual hiss would be most serious, it is advisable to remove R1, connecting PL1 straight through to C1. The impedance presented to the base of TR1 by most gramophone pick-ups or microphone arrangements, with or without transformers, is then so small that the hiss level is hardly audible in the final loudspeakers following a subsequent main amplifier of any normal design. It is, however, essential to retain R1 if there is any danger of d.c. surges being applied to PL1 under any working conditions, though the value of R1 may be reduced to 10 kilohms to strike a compromise.

If the pre-amplifier is intended to be used equally frequently for electroacoustic and for metric purposes, with great importance attached to optimum signal-to-noise ratio in the former case, it is advisable to build VB1 without R1, taking PL1 straight to C1. R1 must then be built into the coaxial connecting cable reserved for metric applications, always taking care to use this cable and no other one when making quantitative measurements and/or when high d.c. components may be present in the signal source. R1, of course, has some influence on the effective gain of VB1, so that the exact adjustments should then be made *including* the metric cable with built-in R1.

The gain without the metric cable, for low-noise electroacoustic work, will then be very slightly higher, but this is unimportant in such cases. ★

Sub-miniature Electrolytics for Transistor Circuits





This range of shorter capacitors has been introduced to meet the ever increasing demand for smaller electrolytics to be used in miniaturised transistor circuits in both industrial and commercial electronic applications. Each type is available for either horizontal or vertical mounting and preference should be indicated when ordering by inserting V or H after the T.C.C. type number.

T.C.C. TYPE NO.	Case Size in inches			Maximum D.C. Wkg. Voltages and Cap. (μF)							
	D	L	C	3V	6V	9V	10V	12V	15V	25V	50V
CE.2VorH	$\frac{1}{8}$	$\frac{1}{2}$	0.07	8	6	4	–	3	2	–	–
CE.3VorH	$\frac{3}{16}$	$\frac{7}{16}$	0.1	25	20	15	–	10	6	4	–
CE.4VorH	$\frac{3}{16}$	$\frac{1}{2}$	0.1	40	30	20	–	15	8	6	–
CE.5VorH	$\frac{1}{4}$	$\frac{7}{16}$	0.14	50	40	25	–	20	10	8	–
CE.6VorH	$\frac{1}{4}$	$\frac{1}{2}$	0.14	80	60	40	–	30	15	12	–
CE.7VorH	$\frac{5}{16}$	$\frac{1}{2}$	0.18	100	75	50	–	40	20	15	–
CE.8VorH	$\frac{1}{4}$	$\frac{3}{4}$	0.14	100	80	–	60	–	40	25	8
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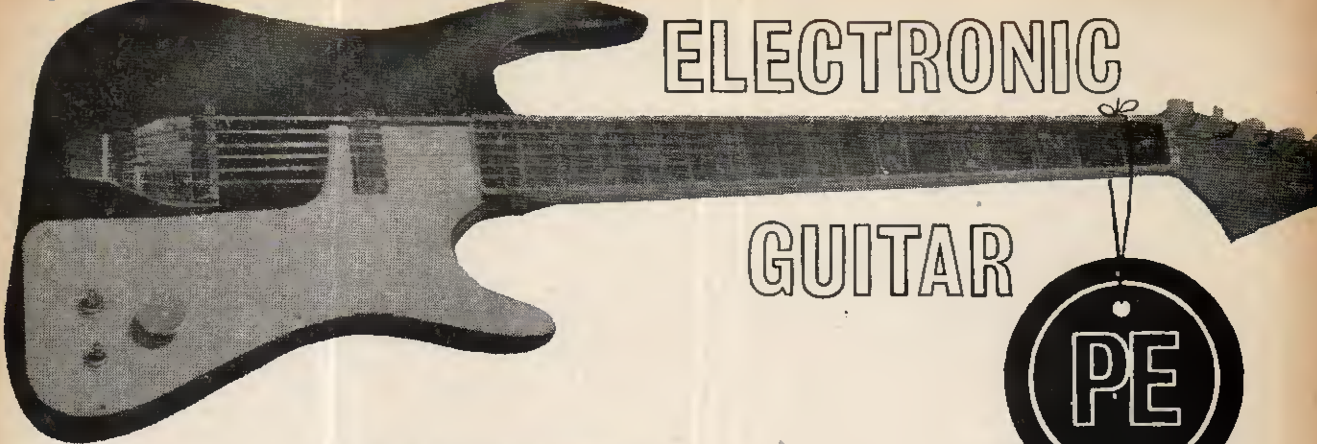

ELECTRONIC GUITAR

PE BLUEPRINT

By S. Chisholm

THE tenor guitar described in this article is intended for use with the electronic guitar amplifier, details of which will be published in the February issue of PRACTICAL ELECTRONICS. The guitar includes the following controls:

(1) Continuously variable volume control.
(2) Preset tone control giving bass boost, normal response or treble boost, all conditions being volume compensated.
(3) Optional preset two-speed vibrato selection.

Tremolo is not provided but can be included by a changed design of bridge assembly and the addition of a lever mechanism.

GENERAL CONSTRUCTION

The body of the guitar (see Fig. 1 on blueprint for overall view) is formed of two close-grained hardwood plates, channelled to hold the pick-up, controls, sockets and internal wiring. The stem is also of a sound close-grained hardwood (preferably oak) with no grain curvature in any direction and well seasoned so that the stem will not bend under string tension. The fretboard on the stem is of softer material (fine mahogany) and screwed firmly to the stem. The frets are made from standard commercial fret wire.

The head is also of oak, dowelled and glued to the stem. A steel plate holds the head at the correct angle for string tensioning and prevents the head from rising under tension. The string winders are commercial items. The bridge is made from hardwood and set on the tailplate (of heavy gauge brass) secured to the face of the body. Two pressure screws provide adjustment at the tailplate to set the strings at the optimum height above the pick-up.

The pick-up cover is of thin sheet brass, clamped into position when the pick-up adjustment has been carried out. The pick-up uses Eclipse button magnets and is designed for easy construction, simple adjustment, and for ample sensitivity. If correctly made it cannot burn out, or go open-circuit. The low impedance output is passed to a transformer housed within the guitar body, then through a volume control to the output socket for connection to the amplifier.

The controls are mounted on a removable fingerboard cut from a sheet of Formica, under which the transformer is housed, making it easily accessible.

BODY

The body should be tackled first. Obtain two pieces of hardwood approximately 18in × 13in × $\frac{3}{4}$in thick. Mark out the surface of one piece (A) in accordance with Fig. 1 to take the matching transformer (e), the recess for the pick-up (b), and the recess for the volume control and two switches (c). (Note that dimensions for the transformer recess are not given as these will depend on the size of the component used.) Cut out these areas completely, then cut shallow channels on the underside to link (b), (e) and (c) as shown.

Place the second piece (B) under A. Mark **B** through the apertures in A. Remove A, then chisel out sufficient of B to provide the required depth of recess to take the toggle switches, volume control, and transformer (the measurement will, of course, allow for the thickness of A). Note that the switches must be of shallow construction in order to clear the control socket beneath them.

Drill a $\frac{1}{16}$in diameter pilot hole in the centre of circle (d) within the volume control recess in B. Turn B over and, using this pilot hole, cut out the 1in diameter hole (d) to accommodate the control socket.

The shape of the body may now be marked out on A, then clamp A and B together, ensuring that the holes in A align with the recesses in B. Using a fine padsaw or similar tool, cut around the body outline. Round off the edges of the two pieces to provide a pleasing contour and smooth off with fine garnet paper any roughness on the front and back of the body which might spoil the enamelling process. The finished job should be rounded off smoothly to meet the outline of the pattern for the fingerboard.

The two pieces may now be glued together taking great care to secure accurate alignment. After glueing, hold the parts in position with clamps. It is worthwhile to cover the jaws of the clamps with scrap wood or thick rag to protect the workpiece.

PICK-UP

The materials required are three $\frac{1}{2}$in diameter Eclipse button magnets, three $\frac{1}{2}$in 8 BA countersunk head screws with nuts and washers, an aluminium strip approximately $3\frac{1}{2}$in × $\frac{3}{4}$in × $\frac{1}{16}$in thick, about 30ft of 30 s.w.g. enamelled wire, a piece of sponge rubber approximately 2in × ¾in × ¼in, two brass woodscrews 2in No. 4, some adhesive tape (see later), and about 12in thin plastics coated flexible wire.

Bend the aluminium strip to the shape shown in Fig. 2, then drill as shown. Check that the pick-up mount is a nice sliding fit in the pick-up aperture on the body, then fit all three magnets to the pick-up mount so that the channel in each magnet will be along the length of the body when the mount is fitted.

Around each magnet limb wind one turn of the adhesive tape making sure the ends overlap.. Polyester thermosetting or electrical tapes (Sellotape Products Ltd.) should be used. Ordinary packaging tapes are not recommended as the adhesive may remove the enamel from the wire and impair insulation. The pick-up is now ready for winding.

Cut the plastics coated flex into two lengths (6in each); bare one end of each length for about ⅜in. Bare the end of the enamelled wire for about ⅜in. Twist these bared ends together as shown in Fig. 2, then neatly solder the connection. Carefully pass the free end of the flex through the mount as shown, then lay the connection on the outer limb of the first magnet. It is worthwhile insulating the soldered joint with tape or sleeving. Wind on 30 turns of 30 s.w.g. enamelled wire as neatly as possible so that the coils will not slip off the magnet limb; take care not to scrape the wire on the tips of the limb.

Having reached the 30th turn, carry the wire diagonally across the channel as shown in Fig. 2, then wind 30 turns on the remaining limb. Note that the direction of winding is S-shaped round the two limbs.

When 30 turns have been wound on the second limb, carry the wire, without a break and without tension, diagonally across the space between the first and second magnet, then wind 30 turns on the nearest limb. The winding direction is now the same as that on the first limb of the first magnet. Proceed as with the first magnet, then wind the third magnet similarly. When 30 turns have been wound on the last limb, cut off the surplus and bare the ends of the wire and the plastics coated flex, as described earlier, and make a connection which will lie on the outside of the last limb wound. Insulate this soldered joint with another piece of tape or sleeving. Pass the free end of flex, together with the original flex, through a larger piece of sleeving and feed the wires and sleeve through the mounting for external connections later.

Bare the free ends of the lead-in wires and if an ohmmeter is available, check continuity to ensure the connections are still quite sound. The pick-up can be tested audibly if an amplifier is available. To do so, connect the pick-up leads to the low impedance terminals of the matching transformer and the high impedance terminals of the transformer to the input of the amplifier. Switch on the amplifier, turn up the volume control (the amplifier will probably hum because the pick-up is being handled) and gently tap the pick-up limbs with a steel object. A definite click should be heard from the amplifier as each pick-up limb is tapped. Judgement may be difficult, but if one limb sounds *much* weaker than another, the turns on that limb may be short-circuited; it is advisable to rewind, using new wire.

When satisfied that the pick-up is in good order, carefully smear each limb with Scotch glue to secure the winding; it may then be fitted into the pick-up housing as follows. File around the edge of the countersunk heads of both brass screws to be used to secure the pick-up, until the head diameter is little more than that of the holes through which they will pass. The heads will then clear the windings on the pick-up. Insert the sponge rubber into the pick-up housing to provide a resilient seat for the pick-up, then fit the pick-up mount to straddle the rubber seat, first guiding the pick-up wires into the channel provided.

Drill through the mount, and the sponge rubber, until the drill bites into the wooden body to provide a starting hole for the fixing screw. Screw down the pick-up but do not over compress the sponge rubber, as adjustment of pick-up height has to be made later. Solder the two pick-up leads to the low impedance terminals of the microphone transformer. Fit the transformer into its housing, leaving the free terminals accessible. Pieces of sponge rubber should be packed into the receptacle to absorb any vibration that may occur, as some transformers themselves act as microphones and will transmit the sound of mechanical shock. The fingerboard will eventually hold the transformer and rubber protection in place.

STEM

The stem is cut from a length of fine grained oak 19in × 2½in × ¾in. Dimensions of the finished piece are given in Fig. 3. Rounding off the back of the stem should be carefully done to give a pleasing final appearance and comfortable handling while playing. The finish must be very smooth. If correctly done, the polyurethane coating will present an appearance indistinguishable from french polish.

FRETBOARD

This is a piece of mahogany of dimensions as shown in Fig. 3. It may now be prepared up to the point where the frets are required, fitted for size on the stem, then removed for the present.

HEAD

Dimensions and drilling marks for the head appear in Fig. 4. The material must be very sound hardwood as there is a considerable and continuous strain exerted on the winders attached to it. Thus the material must not yield under the tension of the strings.

Having cut out the piece and drilled for the winders, drill the butt as shown, to accept two ¼in dowels with at least ¾in insertion. Note the shallow angle at the butt of the head where it will meet the stem; the dowels are fitted at right angles to the butt, and not parallel to the face of the material as one might expect. Groove the dowels along their length to allow surplus glue to escape, then glue them in position. Allow ample time for the glue to set firmly, then cut the dowels so that they protrude by ¾in.

HEAD STIFFENER

The stiffener is preferably a piece of mild steel of the dimensions shown in Fig. 5. Cut a recess in the head at the area shown in Fig. 4 so that the stiffener fits firmly into it. Drill the stiffener (this is best done *after* bending the stiffener, otherwise the metal tends to bend slightly near the holes) and assemble it to the head. Mark the head through the holes in the stiffener, then drill the head to accept ⅜in No. 8 countersunk head wood screws. The winders should now be fitted; one will have to be shaped slightly to allow room for the stiffener plate.

FITTING THE HEAD TO THE STEM

Offer up the head to the stem and mark the position where the dowels will fit into the stem. Drill the stem and ensure that the dowels fit snugly. While the head is still in position, turn over the stem and head, fit the stiffener into the head as far as it will go, then mark the outline of the stiffener and fixing holes where it lies on the stem. Remove the stiffener and the head, then cut out a recess in the stem to take the stiffener. This *must* be an accurate and flush fit, otherwise the stiffener will be a permanent nuisance when playing. Drill the stiffener holes for ⅜in No. 8 countersunk head screws.

As the string separator will be part of the stem assembly when glueing, it should be prepared now from the details shown in Fig. 3.

Warm the mating surfaces of the head and stem, apply glue to the dowels and mating surfaces, then fit the head to the stem.

Carefully fit the stiffener plate before the glue has set, then drive home the wood screws in the head and stem. The string separator is also glued into position at the head of the stem.

FITTING THE STEM TO THE BODY

On most guitars, there is a critical angle between the upper surface of the fretboard, and that of the body. This angle determines the sensitivity of the electro-magnetic pick-up and the clearance between the pick-up and strings when pressing the strings on frets low down on the stem. In this particular instrument three adjustments are provided in order to minimise the need for high accuracy. These are:

(a) adjustable pick-up assembly,
(b) adjustable tailplate,
(c) adjustable angle of stem.

This adjustable stem, once set, is left as a permanent fixture. It is fitted as follows.

On the face of the body (Fig. 1) cut away the area (a) ⅝in deep. Drill three holes in the stem for 1½in No. 6 countersunk head wood screws. Provide one or two pieces of $\frac{1}{16}$in plywood or similar material shaped to the recess, for use later. Lay the stem snugly into the recess and mark through for entry of the wood screws. Drill on these marks and assemble the stem to the body, but *do not tighten fully* yet. The fretboard is fitted later.

BRIDGE

The bridge tailplate is formed from $\frac{1}{16}$in sheet brass. Bending may require the assistance of a tinsmith with the necessary equipment.

Mark out the material as shown in Fig. 5. Shape and drill accordingly, remembering to cut keyholes to catch the beads on the strings. Prepare the bridge block from hardwood; the shape is shown in Fig. 5. Slotting of the block will be done later.

On the underside of the tailplate solder a 4 BA nut at both pressure screw holes. (Hold the nuts with a pair of pliers; brass gets *very* hot, *very* quickly.) Allow the tailplate to cool, then position it on the guitar body below the pick-up (see Fig. 1). Lay the bridge block on the tailplate so that one long side lies flush with the edge of the tailplate nearest the pick-up.

The next step is critical and assistance should be obtained. Lay a tape measure with its zero end lying exactly on the junction of the head and stem, then mark the body exactly 25in from this junction. Set the assembled plate and bridge so that the hump of the bridge lies over the 25in mark. If this is not accurately done, the instrument cannot produce the correct notes at the frets. Mark the guitar body around the edge of the tailplate below the bridge block and a little way down both sides. Remove the tape measure and the bridge block.

At the tailplate, mark through the holes for the securing screws and pressure screws, then remove the tailplate. At the pressure screw marks, channel out an area 2½in × ⅜in to a depth to accommodate a similarly dimensioned slip of $\frac{1}{16}$in brass. The depth is not critical. Fit the tailplate in its marked position, and fit the securing screws so that the plate is just held without free movement. Fit a 4 BA round head screw in each of the pressure holes and check that, when they bear on the pressure plate, the front of the tailplate tilts upward, with the assembly pivoting on the securing screws. The bridge block is fitted later. If upward movement is difficult, the securing screw holes should be elongated on the pick-up side.

FRETWIRES

The fret wires may now be fitted to the fretboard. Mark off the positions of the frets as shown in Fig. 3, then make a fine sawcut at each one, using a fretsaw blade or a junior hacksaw to accept the fretwire. When marking off, measure down *both* edges of the fretboard to ensure accuracy, otherwise the tuning of the instrument will not be correct. Use Araldite to glue the frets into position, then place a weighted board on top of the assembly and leave overnight in a warm atmosphere to harden. When set, fit the fretboard to the stem and tighten firmly. Use ½in *not* ⅜in screws.

SLOTTING THE BRIDGE BLOCK

This task is combined with positioning of the wires above the limbs of the pick-up. To do both, fit the two outer strings by passing the wires through the tailplate and over the bridge block (placed on the extremity of the tailplate), then into the outer grooves of the string separator at the head of the stem. Attach the wires to the relevant winders and tighten until just taut. Set the bridge block accurately in position, hold it firmly, then move one wire outward until it lies along the centre of the outer limb of the outer magnet. It is advisable to seek assistance to mark on the bridge the point where the wire crosses. Ease off the wire, move it into the next inner groove of the separator, tighten the wire and position it over the inner limb of the same magnet, ensuring the bridge does not drift. Mark the block bar where the wire crosses. Proceed in this way for the remaining four positions, remembering to change to a more convenient wire as necessary. When all six positions have been marked on the bar, slacken the wires, remove the bridge, and cut notches to accept the wires. The depth of cut for wrapped strings should be slightly less than for the others.

SETTING THE PICK-UP

The horizontal balance of the pick-up is made at its securing screws, as follows. Tighten the two outer strings to approximately their correct notes. Note that the bridge block should remain in the correct position if the strings are each tightened a little at a time. Adjust the tailplate pressure screws to lift the bridge block about $\frac{1}{16}$in. Depress the No. 1 string halfway down the fretboard and check the string lies approximately parallel to the pick-up. If the angle between string and pick-up is excessive, unscrew the brass screw on the affected side of the pick-up assembly and tighten the other. Check the No. 6 string similarly, and re-

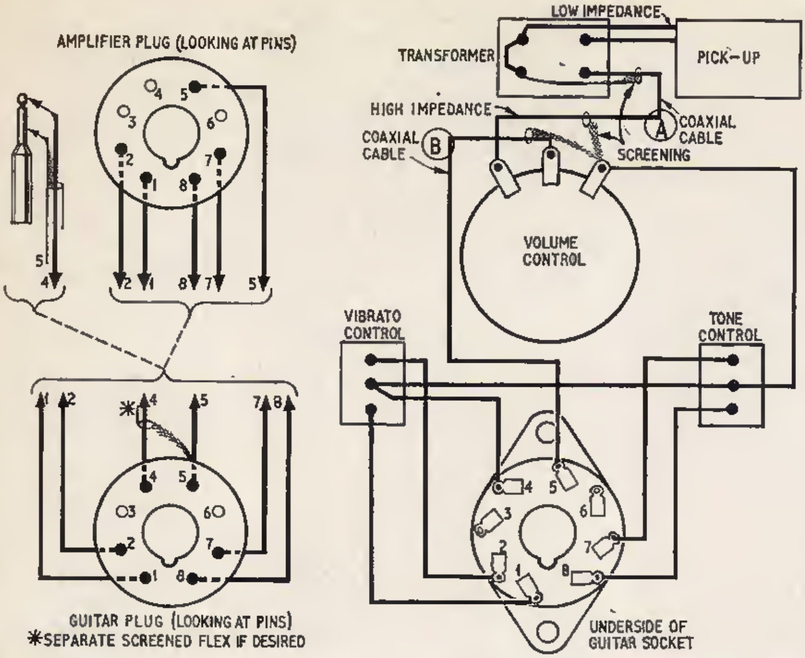

Fig. 6. Wiring details of the guitar components and connecting cable for the amplifier. Note the pin connections of the plugs and socket from underneath

adjust the pick-up as necessary. If clearance is unobtainable, see "String assembly and stem adjustment" later. When the pick-up angle is satisfactory, check that the bridge pressure screws provide adjustment to decrease and increase the gap.

PICK-UP COVER

The pick-up cover is made up from thin sheet brass cut as shown in Fig. 2, and with the inside of all four corners held by solder. When assembled, remove the strings from the guitar and fit the cover in position securing it by small countersunk head brass screws. (Complete measurements of the cover cannot be quoted here as the height of the cover will depend on the projection of the pick-up above the body.)

FINGERBOARD

The fingerboard plate may now be prepared to the pattern shown in Fig. 5, and the components assembled. The switches must be quite shallow in order to clear wiring to the connection socket.

Temporarily fit the plate, noting that the top edge slides under the end of the fretboard and that the cutaway surrounds the pick-up cover. When assured that the plate fits neatly, remove it and connect the volume control and both switches as shown in Fig. 6; connect wires about 4in long on the switches and control for connection to the socket. The screened lead to the transformer should be long enough to follow the channel to the transformer. Connect the pick-up and transformer as shown (the choice of pick-up lead and transformer terminal is immaterial so long as the low impedance terminals are used). If one transformer terminal is connected to the case, this must also be the terminal connected to the screen of the lead from the volume control.

Connect the remaining leads from the volume control and switches to the connector socket, ensuring that the wiring will coil down when the fingerboard plate is fitted.

Fit the plate and check that the wiring lays in the channels. When satisfactory, the plate may be screwed down using ⅜in No. 2 plated screws.

STRING ASSEMBLY AND STEM ADJUSTMENT

Stringing may now be completed as described earlier. Check that the strings just clear the pick-up when depressed at the highest fret and plucked. If this is not so, slacken all strings and stem securing screws. Insert a shim of single plywood into the junction of stem and body, and on the body side of the two securing screws at the extremity of the stem; tighten up and check again for string clearance. Alternatively, if the clearance was found to be excessive, the shim should be positioned on the head side of the single securing screw. The shim will set up an angle to correct the string height, whereupon the securing screws are finally tightened. Any error consequent on final tightening is taken up by the tailplate pressure screws.

The guitar may now be tuned and will then be ready for use as an acoustic instrument.

FINISH

The prototype was finished in black gloss enamel on an undercoat of matt black. The stem was stained to deepen the natural colour of the oak, then treated with polyurethane varnish. The fretboard was stained, but not treated further. White Formica was used for the fingerboard, this providing a pleasing contrast to the glossy black body. The tailpiece is of polished brass, treated with polyurethane to provide a lacquered finish. The pick-up cover was similarly treated, but the bridge was simply polished after smoothing with the finest silicon abrasive paper obtainable. A leather support strap is attached to the body by domed mirror screws. Users will possibly have other ideas on finish.

CABLE ASSEMBLY

The connector plug is of the type which will fit an international octal valveholder (see Fig. 6). The required leads are bared to the full length of the pin, lightly tinned, then inserted and soldered at the tip. Excess wire is snipped off. Do not allow surplus solder to set round the outside of the pins.

Grip the plug between two pieces of thick rag set in the jaws of a vice. Suspend the cables so that they are in a straight line with the plug. Melt some beeswax in a tin and fill the interior of the plug. Leave the assembly to harden and similarly treat the other end of the cable. If using a completely enclosed cable, remember to separate the signal input leads for connection to the input plug.

Next month: a description of a guitar amplifier with special tone and vibrato controls.

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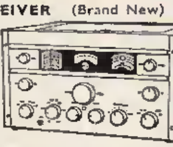

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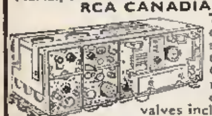

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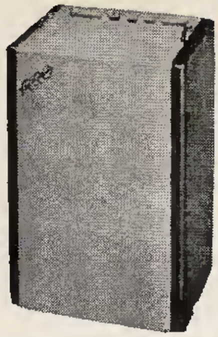

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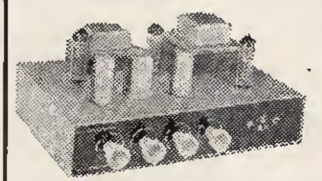

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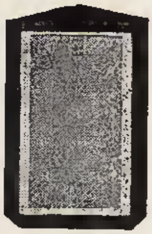

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AUDIOTRINE HI-FI SPEAKER SYSTEMS. Consisting of matched 12in. 12,000 line, 15 ohm high quality speaker, crossover unit (consisting of choke, condenser, etc.) and Tweeter. The smooth response and extended frequency range ensure surprisingly realistic reproduction. Standard 10 watt rating **£4.19.9.** Carr. 5/-. Or Senior 15 watt, **£6.19.9.** Carr. 7/6.

HEAVY DUTY LOUDSPEAKERS IN SUBSTANTIAL REXINE COVERED CABINETS. Type BG1. Suitable for Bass Guitar. Speaker Unit 15in., High Flux, 15 ohms, 30 watts. Cabinet size approx. 24 x 21 x 13in. Only **19½ gns.** Or Deposit **43/-** and 12 monthly payments of **34/-.**

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A highly sensitive Push-Pull high output unit with self-contained Pre-amp. Tone Control Stages. Certified performance figures compare equally with most expensive amplifiers available. Hum level 70 dB down. Frequency response ±3 dB 30-20,000 c/s. A specially designed sectionally wound ultra linear output transformer is used with 807 output valves. All components are chosen for reliability. Six valves are used EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls are provided. Minimum input required for full output is only 12 millivolts so that **ANY KIND OF MICROPHONE OR PICK-UP IS SUITABLE.** The unit is designed for **CLUBS, SCHOOLS, THEATRES, DANCE HALLS or OUTDOOR FUNCTIONS,** etc. For use with Electronic **ORGAN, GUITAR, STRING BASS,** etc. For standard or long-playing records. **OUTPUT SOCKET PROVIDES** L.T. and H.T. for **RADIO FEEDER UNIT.** An extra input with associated vol. control is provided so that two separate inputs such as Gram and "Mike" can be mixed. Amplifier operates on 200-250 v. 50 c/s. A.C. mains and has output for 3 and 15 ohm speakers. Complete Kit of parts with fully punched chassis and point-to-point wiring diagrams and instructions. If required perforated cover with carrying handles can be supplied for **19/9.** The amplifier can be supplied, factory built with EL34 output valves and 12 months' guarantee, for **14 gns.** Send S.A.E. for leaflet.

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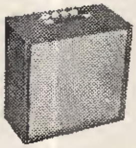

A highly efficient unit incorporating a massive 15in. high flux loudspeaker specially constructed to withstand heaviest load conditions. Rating 25 watts. Individual bass and treble controls give ample "boost" and "cut". Two high impedance jack socket inputs are separately controlled. All controls are conveniently positioned in a recess on top of the cabinet. Cabinet is of substantial construction and attractively finished in two contrasting tones of Rexine and Vynair. Size approx. 24 x 21 x 13in. Operation from 200-250 v. 50 c.p.s. A.C. mains.

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122/12 20 watt, 7 gns.	122/12A 20 watt, 8 gns.	152/14 27 watt, 14 gns.	152/14A 27 watt, 15 gns.
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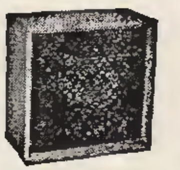

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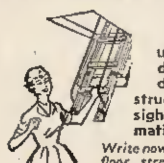

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It fully covers the medium-wave band and that part of the long-wave band to bring in B.B.C. Light. The circuit includes a highly efficient slab aerial and 2¼" P.M. speaker. Overall size approximately 4½ × 2½ × 1¼in. Supplied complete with carrying case.

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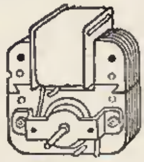

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3	3/11	4/6	5/2	6/9	8/-	9/6	9/6	10/3
4	4/6	5/4	6/2	7/10	10/-	12/-	12/-	13/-
6	5/9	7/-	8/3	10/9	15/-	17/-	17/-	18/6
8	8/-	8/8	10/4	13/8	18/-	22/-	22/-	25/-
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12in. High fidelity loudspeaker. High flux permanent magnet type with 3 ohm or 15 ohm speech coil. Will handle up to 10 watts. Brand new, by famous maker. Price **27/6**, plus 3/6 post and insurance.

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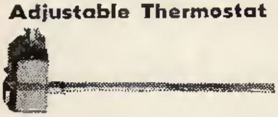

Suitable for Industrial or domestic purposes such as controlling furnace oven, immersion heater, etc. Can also be used as a flamestat or fire alarm. Made by Sunvic these are approximately 17in. long and adjustable over a range 0 to 550°F. The contacts are rated at 15 amps. 230 volts, and the adjustment spindle, which comes to the top, can be fitted with a flexible drive for remote control or just a pointer knob for local control. Listed at **£3** or **£4** each, these are offered at only **8/6**, plus 2/6 postage and insurance.

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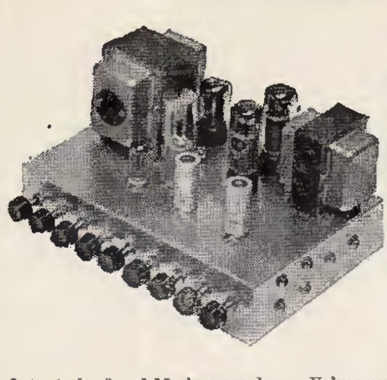

Five jack socket inputs, four with separate mixing volume controls, and one input "straight through". All inputs are of very high sensitivity only 10 millivolts input is required for full output, making them suitable for all types of guitars and microphones. Separate Bass and Treble controls, giving a wide range of lift and cut. Separate master gain control. Tremolo speed and depth controls. Jack socket for remote tremolo switching.

Outputs for 3 and 15 ohms speakers. Valves used in the 30 watt and 50 watt amplifier ECC83, ECC83, EL34, EL34, GZ34. In the 15 watt amplifier ECC83, ECC83, EL84, EL84, EZ81. An extra valve ECC83 is used in the tremolo circuit. The chassis is complete with baseplate and is solidly made of 18 gauge steel, finished silver grey hammer. Size 12 × 8 × 6½ inches high.

PRICES—

50 watt with tremolo	**£20.10.0**
50 watt less tremolo	**£19.10.0**
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15 watt with tremolo	**£12.10.0**
15 watt less tremolo	**£11.10.0**

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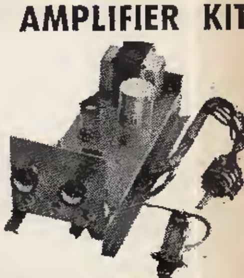

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122/10A	Dual	10-15000	15	32 or 75	20	10,000	100,000	Aluminium	12in.	11in.	6lbs.	6 gns.
122/12	Single	25-5000	15	32 or 75	20	12,000	160,000	Copper	12in.	11in.	6lbs.	7 gns.
122/12A	Dual	30-15000	15	32 or 75	20	12,000	160,000	Aluminium	12in.	11in.	6lbs.	8 gns.
122/14	Single	25-5000	15	32 or 75	22	14,000	186,000	Copper	12in.	11in.	7lbs.	9 gns.
122/14A	Dual	30-15000	15	32 or 75	22	14,000	186,000	Aluminium	12in.	11in.	7lbs.	10 gns.
122/17	Single	25-6000	15	32 or 75	25	17,000	226,000	Copper	12in.	11in.	10½lbs.	£11/17/6
122/17A	Dual	30-17000	15	32 or 75	25	17,000	226,000	Aluminium	12in.	11in.	10½lbs.	£12/17,6
152/12	Single	25-3500	15	30 or 75	20	12,000	160,000	Copper	15in.	13½in.	8lbs.	12 gns.
152/12A	Dual	30-15000	15	30 or 75	20	12,000	160,000	Aluminium	15in.	13½in.	8lbs.	13 gns.
152/14	Single	25-3500	15	30 or 75	22	14,000	186,000	Copper	15in.	13½in.	9lbs.	14 gns.
152/14A	Dual	30-15000	15	30 or 75	22	14,000	186,000	Aluminium	15in.	13½in.	9lbs.	15 gns.
152/17	Single	25-4000	15	30 or 75	25	17,000	226,000	Copper	15in.	13½in.	12½lbs.	16 gns.
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JOY'FUL NEWS No. 3

"CQ", the Radio Amateur's Journal, reviewed the "JOYSTICK" V.F.A. in their July, 1964 issue. The following extracts are quoted:—

I tried the JOYSTICK out with HB9ACN's help and found that it performed remarkably well. FOUR DIFFERENT RECEIVERS SHOWED IMPROVED PERFORMANCE OVER A DIPOLE when the JOYSTICK was mounted high on the outside of an apartment house. A little drop-off in signal was noted when the antenna was laid against the wall on the inside. For transmitting, the antenna will take a KW.

When you write to the manufacturer for full information he will send you testimonials from many hams who have nothing but praise for the JOYSTICK, among these will be a number from U.S. hams especially WoCJW and K5GDH.

I recommend that if you buy a JOYSTICK you also buy a tuner Actually the antenna could be used for mobile work* too without much trouble.

COMPLETE SYSTEM FOR RECEIVING, comprising Standard **JOYSTICK** and **Type 3 JOYMATCH** for complete coverage of the Short Wave bands—will suit **ANY** Short Wave Receiver—**£5.11.0d.** including carriage and packing.

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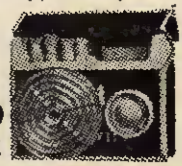

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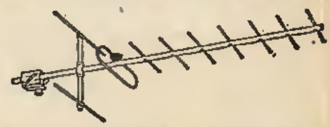

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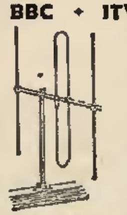

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