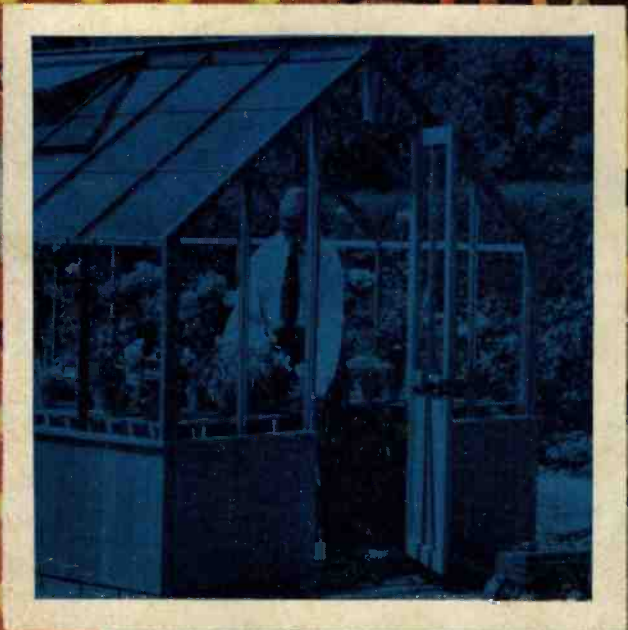
Practical Electronics

JANUARY 1967

PRICE 2/6

REMOTE TEMPERATURE MEASUREMENT



for

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AND MANY OTHER USEFUL APPLICATIONS

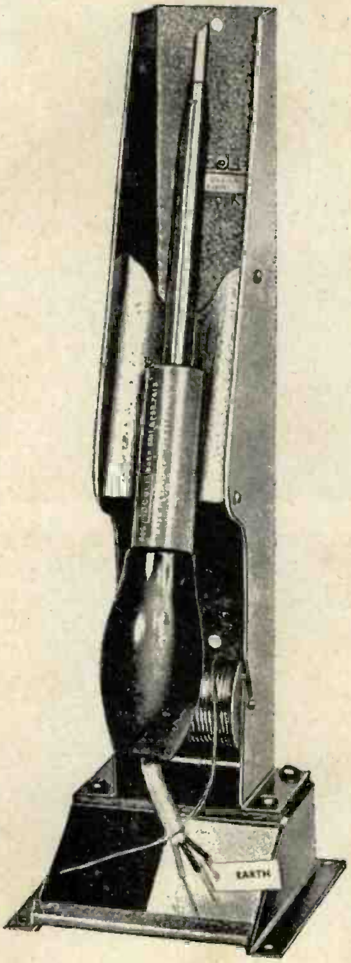
ADCOLA

PRODUCTS LIMITED
(Regd. Trade Mark)

SOLDERING EQUIPMENT

for the

DISCRIMINATING ENTHUSIAST



ILLUSTRATED:
L64 3/16" BIT INSTRUMENT IN
L700 PROTECTIVE SHIELD

APPLY DIRECT TO:

SALES & SERVICE DEPT.
ADCOLA PRODUCTS LTD.
ADCOLA HOUSE
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LONDON, S.W.4
TELEPHONE: MACAULAY 0291/3

For quick, easy faultless soldering

ERSIN Multicore 5 CORE SOLDER

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Easy to use and economical. Containing 5 cores of non-corrosive flux, instantly cleaning heavily oxidised surfaces. No extra flux required. Ersin Multicore Savbit Alloy reduces wear of copper soldering iron bits.

SIZE 5 HANDY SOLDER DISPENSER
Contains 12 ft. of coil 18 s.w.g. Ersin Multicore Savbit Alloy. Quick and easy to use.
2/6 each

NEW SIZE 15
21 ft coil of 60/40 Alloy, 22 s.w.g. in a dispenser. Ideal for small components, transistors, diodes, etc.
3/- each

SIZE 12
Ideal for home constructors. Contains 102 ft. of 18 s.w.g. Ersin Multicore Savbit Alloy on a plastic reel. 15/- each (Also available in other sizes)

BIB MODEL 3 WIRE STRIPPER AND CUTTER
Strips insulation without nicking the wire, cuts wire and splits plastic twin flex.
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From Electrical or Hardware shops. If unobtainable write to:
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OLRUS ELECTRONICS LTD.

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ECH42	9/-	UCH42	8/6
ECH81	5/2	UCH81	6/3
ECH84	8/10	UCL82	7/3
ECL80	7/-	UL41	8/6
ECL82	6/3	UL84	6/3
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EF80	5/-	U25	9/6
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EF183	6/4	5U4GB	6/6
EF184	6/4	5Y3GT	5/-
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EL41	8/6	6F23	10/-
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EM84	7/-	6SN7GTB	7/-
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EY86	6/6	6X5GT	6/-
EZ40	7/6	25L6GT	6/6
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EZ81	5/-	30FL1	10/6
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GZ32	10/-	30L15	11/-
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ACY17	8/6	NKT251	5/-	OAZ245	4/6	OC77	7/-
ACY18	5/6	NKT255	6/6	OAZ246	4/6	OC78	5/-
ACY19	6/6	NKT304	8/-	OAZ247	4/6	OC78D	5/-
ACY20	5/-	NKT403	17/6	OAZ290	9/6	OC81	5/-
ACY21	6/-	OA5	4/-	OAZ291	9/6	OC81D	5/-
AD140	16/-	OA7	4/-	OAZ292	9/6	OC81M	5/-
AD149	16/-	OA10	3/-	OC16	20/-	OC81DM	5/-
AD161	11/-	OA47	3/-	OC19	7/6	OC81Z	9/-
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AF114	6/6	OA81	2/6	OC25	9/6	OC84	6/-
AF115	6/-	OA85	3/-	OC26	7/6	OC122	15/-
AF116	6/6	OA86	4/-	OC28	12/6	OC139	7/6
AF117	5/-	OA90	2/6	OC29	15/-	OC140	9/6
AF118	12/6	OA91	2/6	OC35	12/6	OC169	5/-
AF124	9/-	OA95	3/6	OC36	12/6	OC170	5/-
AF125	8/6	OA200	3/3	OC41	6/-	OC171	6/-
AF126	8/-	OA202	4/3	OC42	5/-	OC200	7/6
AF127	8/-	OA210	7/6	OC43	9/-	OC201	11/6
AF139	15/-	OA211	9/6	OC44	5/-	OC202	13/6
AF186	19/6	OAZ200	11/-	OC44M	5/6	OC203	10/6
AFY19	22/6	OAZ201	10/-	OC45	4/-	OC204	15/-
AFZ11	17/-	OAZ202	8/6	OC45M	4/-	OC205	15/-
AFZ12	12/6	OAZ203	8/6	OC46	5/6	OC206	22/6
ASY26	6/6	OAZ204	8/6	OC47	7/6	ORP12	8/6
ASY28	6/6	OAZ205	8/6	OC57	16/-	ORP60	5/-
ASZ20	7/6	OAZ206	8/6	OC58	17/6	1S202	4/6
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P.P. 2/- in £
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METAL WORK — PANELS — CHASSIS
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CONSTRUCTIONAL PROJECTS

ENORMOUS PURCHASE GUARANTEED. APPROX. HALF PRICE. WORLD FAMOUS MAKE

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We offer you fully tensilised polyester/mylar and P.V.C. tapes of identical quality hi-fi, wide range recording characteristics as top grade tapes. Quality control manufacture. They are truly worth a few more coppers than acetate, sub-standard, joined or cheap imports. TRY ONE AND PROVE IT YOURSELF.

Standard Play			Long Play		
3in.	150ft.	2/3	3in.	225ft.	2/9
4in.	300ft.	4/6	4in.	450ft.	5/6
5in.	600ft.	7/6	5in.	900ft.	10/6
5¾in.	900ft.	10/6	5¾in.	1,200ft.	13/-
7in.	1,200ft.	12/6	7in.	1,800ft.	18/6

Double Play			Triple Play		
3in.	300ft.	4/-	4in.	900ft.	13/-
4in.	600ft.	8/-	5in.	1,800ft.	25/-
5in.	1,200ft.	15/-	5¾in.	2,400ft.	24/-
5¾in.	1,800ft.	19/6	7in.	3,600ft.	44/-
7in.	2,400ft.	27/-			

Postage 1/- net

Quadruple Play		
3in.	600ft.	8/6

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

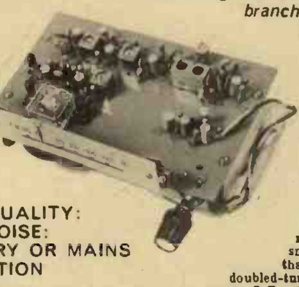
BARGAIN PARCELS

Including variable condensers, i.f. coils, loudspeaker plugs/sockets, knobs, pots, condensers, resistors, nuts, bolts, cabinet fittings, switches, transformer choke, rectifier, transistors at a small fraction of list value. Due to heavy demand we are now packing them in several sizes—TRY ONE.

3 lbs. (post 3/-) 9/-
7 lbs. (post 5/-) 17/6
14 lbs. (post 6/-) 29/-

Transistorised FM Tuner

CALLERS WELCOME *Demonstration without obligation to all branches*



HIGH QUALITY:
LOW NOISE:
BATTERY OR MAINS OPERATION

This beautifully compact 6 transistor machine (size 6 × 4 × 2½in.) will give quieter, more interference free reception. Months of use from a standard 9 volt battery or its small power requirements can be drawn from any amplifier. Low noise frequency changer with smooth 2 gang tuning feeding no less than three I.F. stages coupled to a doubled-tuned discriminator terminating in an L.F. stage giving ample output for all quality amplifiers.

avoid disappointment

ORDER NOW £8-10

15 Watt TUNER AMPLIFIER KIT

14 TRANSISTOR

consisting of FMT41 tuner and the excellent Sinclair Z12 (built) together with complete integrated control. Kit consisting complete vol. on/off treble and bass, component sets with complete connecting instructions and circuits, battery version

£13.19.0

or complete with AC mains power pack £1.18.6
STEREO VERSION with 2 Z.12 amplifiers £18.10.0
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GARRARD

All Factory Fresh. All with cartridge. EV26 Ceramic Stereo cartridge fitted to any deck for 15/- extra

SRP12	£4. 7.6
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AT60	£9.19.0
A70	£18.10.0
LAB80	£24.19.0
401	£29.19.0

B.S.R. BARGAINS

TU14	59/-
GU7	85/-
UA14	89/-
UA16	99/-
UA25 SUPERSLIM	£5.10.0

CARTRIDGES

G.C.2 Garrard Mono	16/-
EV25 Gerrard Stereo Ceramic	24/-
EUPHONIC SUPER Ceramic Stereo Diamond 100mV Output	29/-
DECCA DERAM Stereo	50/-

TRANS/CEIVERS

The very latest Silver/Black finish. They give an excellent performance with reliability, long telescopic aerial, crystal controlled. Note a licence is required to transmit. They compare with much dearer models 2/6 p. & p. **£6.19.0**
These cannot be operated in U.K.

HEAVY DUTY 14/20 WATT AMPLIFIER KITS

Famous make. Consisting integrated controls, high/low gain pre-amp stages feeding EL34 push-pull output, C core transformers complete with instructions down to the last bolt. Current model at fraction of list price. **8½ Gns.**

SP25 ON PLINTH

Latest Garrard quality single player on Garrard matching plinth. Factory fresh. Unusual value at **11½ Gns.**

NEW! STABILISED TRANSISTOR POWER PACKS

Adjustable 9V or 12V 1 amp. Ripple and voltage stabilised. 2 transistors, 2 Zener diodes. High quality, unusual value. Satisfaction guaranteed **79/-**

F.M. MICS

Dynamic microphone feeding transistor F.M. transmitter, tunable approx. 90-105Mc/s. Complete in miniature case with PP3 battery. Really excellent range and reproduction quality **£4.19.0**

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As used in expensive bookshelf units, 8 amp 8W peak. High flux. Wide full range response. Truly unusual value at **49/-**

AUTO R.P. KITS

BSR UA14 Autochanger, 2 valve mains amplifier (built), high phase speaker in modern portable 2 tone cabinet. Value built 15 gns. Special limited kit price **9½ Gns.**

MAINS TRANSFORMERS

All with 6·3V. Windings high quality 200/250V.

250V 60mA	12/6
350-0-350V 80mA	25/-
350-0-350V 120mA	37/6

Value in VALVES — GUARANTEED 3 MONTHS BY RETURN OF POST

Satisfaction or Money Back Guarantee on goods if returned unused within 14 days. ALL VALVES ARE NEW UNLESS OTHERWISE INFORMED. FREE TRANSIT INSURANCE. POSTAGE 1 valve 9d. 2-11 6d. per valve. Free over 12.

1L4	2/3	6G8GT	9/6	20P4	17/9	ECC88	9/6	GZ34	10/6	SP61	2/9
IR5	4/9	6L1	9/6	25L6GT	7/-	ECF80	7/9	KT61	12/-	TDD4	7/-
I84	4/9	5L6G	8/6	25Z4G	7/-	ECF82	7/6	KT63	5/9	U14/18	7/6
185	4/6	6L18	7/9	30F5	9/-	ECH21	10/-	KT66	19/6	U25	9/6
1T4	8/-	6LD20	8/6	30FL1	9/9	ECH35	11/-	KT88	27/6	U26	9/6
2D21	5/6	6P25	12/-	30L15	11/6	ECH42	10/6	KTW61	5/9	U35	12/6
3A5	6/-	6P28	9/6	30P4	11/6	ECH81	6/9	KTW63	5/-	U37	11/-
3Q4	5/3	6Q7G	7/-	30P12	9/-	ECH83	7/9	KTZ63	7/-	U107	12/6
5U4G	6/-	6Q7GT	8/9	30PLI	11/-	ECL80	5/9	MU14	7/-	U191	12/6
5Y3GT	6/6	6SL7GT	6/9	35A5	9/6	ECL82	7/6	N37	9/6	U281	9/6
5Z4G	6/9	6SN7GT	6/9	35L6GT	8/6	ECL83	10/6	N78	13/-	U282	15/-
5Z4GT	9/6	6U4GT	9/6	35W4	6/6	ECL86	9/6	N108	13/-	U329	8/6
6/30L2	9/6	6V6G	4/9	35Z4GT	5/9	EF36	4/9	PC86	9/6	U801	19/-
6ASG	7/6	6V6GT	6/9	30L6GT	8/6	EF39	7/-	PC97	7/6	UABC80	6/6
6AK5	4/9	6X4	4/6	80	7/6	EF40	10/-	PCC84	6/6	UAF42	7/9
6AQ5	5/-	6X5G	5/-	185BTA	19/6	EF41	9/-	PCC85	7/6	UB41	6/6
6AT6	5/-	6X5GT	6/9	807	9/6	EF50	3/3	PCC88	11/9	UBC41	8/9
6BA6	5/6	7B6	11/6	955	3/6	EF80	4/3	PCC89	11/-	UBC81	6/9
6BE6	5/6	7B7	7/6	956	3/-	EF85	6/3	PCC189	9/9	UBF80	7 6
6BH6	6/6	7C5	9/6	AZ31	8/6	EP86	7/6	PCF80	6/9	UBF89	7/6
6BJ6	7/-	7C6	7/6	CBL31	19/6	EF89	6/6	PCF82	6/9	UBL21	10/9
6BR7	9/6	7H7	7/6	DAF96	7/3	EF91	3/6	PCF86	8/3	UC92	6/9
6BW6	7/6	7S7	14/6	DF96	7/3	EF183	8/-	PCL82	7/9	UCC85	7/3
6BW7	5/-	7Y4	7/-	DK92	8/6	EF184	8/-	PCL83	9/6	UCF80	8/6
6C4	3/-	10C1	11/-	DL96	7/3	EL32	5/-	PCL84	9/-	UCH21	10/9
6C5	5/6	10C2	12/6	DL92	6/-	EL33	12/-	PCL85	9/6	UCH42	8/6
6C6	4/-	10F1	7/6	DL94	6/6	EL34	11/6	PCL86	9/6	UCH81	7/-
6C9	11/-	10LD11	14/6	DL96	7/3	EL35	8/-	PL33	8/6	UCL82	8/-
6CD6G	17/-	10P13	9/6	EABC80	6/9	EL38	15/-	PL36	11/-	UCL83	10/6
6D6	4/-	10P14	9/6	EAF42	8/-	EL41	9/9	PL38	12/6	UF41	9/-
6F1	6/6	12AT7	4/9	EB41	4/6	EL42	8/9	PL81	7/9	UF42	6/9
6F6G	5/-	12AU7	5/6	EB92	2/9	EL84	6/6	PL82	5/9	UF85	7/6
6F13	4/6	12AX7	6/-	EBC33	7/6	EM80	7/-	PL83	6/-	UF89	6/9
6F14	7/6	12J7GT	9/-	EBC41	9/6	EM81	7/6	PL84	7/-	UL41	10/-
6F15	9/6	12K7GT	5/-	EBC91	6/9	EM84	7/9	PY31	7/6	UL44	14/-
6F23	8/-	12K8GT	9/6	EBF80	7/9	EY51	7/6	PY32	9/6	UL46	10/6
6J5G	4/-	12Q7GT	6/6	EBF89	7/-	EY86	7/3	PY33	7/6	UL84	6/6
6J5GT	6/6	14S7	14/6	EBL21	11/-	EY88	8/6	PY80	5/9	UM80	9/6
6J6	3/3	19AQ5	5/6	ECC40	9/6	EZ40	7/6	PY81	5/9	UY21	8/9
6J7G	5/6	20D1	8/9	ECC81	4/9	EZ41	8/6	PY32	5/6	UY41	7/-
6J7GT	9/6	20F2	9/6	ECC82	5/6	EZ80	5/6	PY83	5/9	UY85	5/6
6K7G	2/8	20L1	16/-	ECC83	6/-	EZ81	6/-	PY88	8/6	VR105	5/-
6K7GT	5/9	20P1	9/6	ECC84	7/-	FC4	8/-	PY800	7/-	VR150	4/-
6K8G	5/9	20P3	9/6	ECC85	5/9	GZ32	9/6	PZ30	9/6	Z66	7/9

STEREO PORTABLE CABINETS

Latest black and silver metal finish. Consisting of centre cabinet size 16½in. × 13in. × 8in. deep with lift up lid together with two 10 × 6 speaker cabinets which slip on ends of main cabinet size 4½in × 13in. × 8in. making overall size of 25½in. × 13in. × 8in. High quality chrome fittings. Will take almost any autochanger or tape deck. Approx. half price at **£3.19.0**

Ditto, but less chrome, takes 7 × 4 speaker **£2.19.9**

MONO PORTABLE CABINETS. B.S.R. tape deck or single record player, new attractive finish, half price. **19/6**

AUTOCHANGE PORTABLE CABINETS. As used on 18 gns. record player. Due to fortunate purchase we offer complete with motor board and all fittings at only **49/-**

PLEASE NOTE. *A wide range of cabinets to callers at all branches.*

100 HI-STABS 9/6
1% to 5% 100 Ω to 5 mΩ

CO-AX, low loss, 6d. yd. 25 yds. 11/6; 50 yds. 22/-; 100 yds.42/6, Plugs 1/3.

100 RESISTORS 6/6
SIZES ¼-3 watt

MICROPHONE CABLE Highest quality, black, grey, white, 9d. per yard.

100 CONDENSERS 9/6
Miniature Ceramic, Silver, Mica, etc. 3pF to 5μF. LIST VALUE OVER £4.

25 ELECTROLYTICS
Assorted 2 to 500 mfd 6 to 400 volt. LIST VALUE OVER £5 **9/6**

50 TAG STRIPS 7/6
Mixed sizes 2 to 15 way

25 POTENTIOMETERS
Including with switch, long and short spindle, pre-sets, log and lin. unused. 1k-2m.Ω LIST VALUE APPROX. £4. **9/6**

CONNECTING WIRE
P.V.C. Bright Colours. Five 25ft. coils only. **4/-**

CALLERS. *A very wide range of electronic components await you at all branches. Your enquiries welcomed*

Stockist of Leak, Quad, Chapman, Goodman, Armstrong, Tripletone, Linear, Rogers, Truvox, Ferrograph, Wharfedale, etc.
Post: 1 lb. 1/5, 1½ lb. 2/6, 2 lb. 2/9, 4 lb. 3/3, 6 lb. 4/-, 14 lb. 5/6. All Mail Orders to Brighton please.

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750 mW TRANSISTOR AMP.

4 transistors including two in push-pull input for crystal or magnetic microphone or pick-up—feed back loops—sensitivity 5 m/v.

PRICE 19/6

Post and ins. 2/6.

Speakers 3in. 12/6; 5in. 13/6; 6in. × 4in. 14/6.

MAINS POWER PACK

MAINS POWER PACK designed to operate transistor sets and amplifiers. Adjustable output 6v.-9 to 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries, PP1, PP3, PP4, PP6, PP7, PP9, and others. Kit comprises: mains transformer-rectifier, smoothing and load resistor, 5,000 and 500 mfd. condensers, zener diode and instructions. Real snip at only 14/6, plus 3/6 post.

ACOS GP83 TURNOVER PICK-UP CARTRIDGE

For Stereo—L.P.—and 78 records, fitted with two Styli. Diamond for LPs, Sapphire for 78s. This is mounted and is standard replacement for most record players using Garrard, B.S.R., Collaro, etc., etc. The regular price of this cartridge is 55/-. We offer these new and perfect for 15/- (less than the price of styli), plus 2/- post and insurance.

PHOTO ELECTRIC KIT

All parts to make light operated switch/burglar alarm/counter, etc. Kit comprises printed circuit, Laminated Boards and chemicals, Latching relay, Infra-red sensitive Photocell and Hood, 2 Transistors, cond., Terminal block, Plastic case. Essential data. circuits and P.C. chassis plans of 10 photo electric devices including auto. car parking light, modulated light alarm. Simple invisible ray switch—counter—stray light alarm—warbling tone electronic alarm—projector lamp stabiliser, etc., etc. Only 39/6 plus 2/- post and insurance.

THE SQUEALER

Sleight of hand—beat the beam

A game to amuse the children and defy the others is described in the Nov. issue of *Practical Electronics*. For this circuit we can supply as a kit: the light-cell, transistors and other components (not case or hardware) price is 50/- plus 3/6 post and insurance. Kit of Components for another game "The Might Light," also described, is available. Price 20/- plus 2/6 post and insurance.

MULLARD SILICON RECTIFIERS. 350 v. 100 mA. Removed from unused equipment, perfect. Ref. BY100, 4/6 each.

REED SWITCHES. A pair of contacts sealed into a glass tube. When a magnet comes close the contacts close immediately and the circuit is switched. For burglar alarms on doors or windows, moving displays for advertising, rev. or batch counting, relay circuits. New and perfect, price is 6/6 each.

½in. MEG. POTS. By Erie, standard ¼in. spindle, 1in. long, 7d. each in doz. lots, otherwise 10d.

½in. MEG. POTS WITH D.P. SWITCH. Again by Erie. Standard size spindle 1in. length. 10d. each in doz. lots, otherwise 1/3 each.

RELAY SWITCHES. These enable micro switches, delicate thermostats or other low current devices to control up to 30 amps. Ideal to switch thermal storage heaters, motors, etc., made by the famous A.E.I. group these are listed at £25 each—you can buy it if you hurry at a very keen price of 39/6 each and we will include diagrams and data. Mounted on panel size approximately 6 × 7 × 2in. deep.

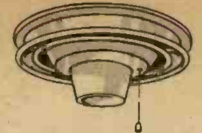
HEATER TRANSFORMERS, 6.3 v., 1½ amps., 5/6.

SEMI-CONDUCTOR BARGAINS

Type No.	Price	Type No.	Price	Type No.	Price
2N1727	15/-	MAT101	8/6	OC71	4/
2N1728	10/-	MAT120	7/9	OC72	5/-
2N1742	25/-	MAT121	8/6	OC75	6/-
2N1747	25/-	OA5	5/-	OC76	5/-
2N1748	10/-	OA10	6/-	OC77	7/-
AC107	9/-	OA47	3/-	OC78	5/-
AC127	9/-	OA70	2/-	OC78D	5/-
ACY17	8/6	OA79	2/6	OC81	5/-
ACY18	5/6	OA81	2/6	OC81D	5/-
ACY19	6/6	OA85	3/-	OC82	5/-
ACY20	5/6	OA90	2/6	OC83	5/-
ACY21	6/-	OA91	2/6	OC84	6/-
ACY22	4/6	OA200	3/3	OC139	8/6
AF114	7/-	OA202	4/3	OC140	12/6
AF115	6/6	OC22	10/-	OC170	5/-
AF116	7/-	OC23	17/6	OC171	6/-
AF117	5/-	OC24	22/6	OC200	9/-
AF118	12/6	OC26	7/6	OC201	12/6
AF139	17/6	OC28	15/-	OC202	13/6
AF186	19/6	OC29	17/6	OC203	12/6
AFZ12	15/-	OC35	12/6	OCP71	19/6
ASZ21	15/-	OC36	15/-	ORP12	8/6
BC107	14/6	OC42	6/6	ORP60	5/-
BY100	5/6	OC44	5/-	SB078	6/6
BYZ13	7/6	OC45	4/-	SB305	8/6
MAT100	7/9	OC70	4/-	SB251	10/-

The above is a list of three more popular types in stock—we can also supply almost every semi-conductor made—please send 1/6 for comprehensive list and equivalent data.

HEAT & LIGHT UNIT



Bring luxury to your bathroom—have comforting heat where you now only have light—all the parts to build a full size (16" diameter) model are now available—you will build it in an hour—12" 750 watt circular silica glass encased element, opal bowl for up to 100 watt lamp—non-rust spun reflector, white enamelled base heat shield, pull switch. Magnificent unit as sold normally at £4.5.0 only 55/- plus 5/-, post and insurance.

GOOD COMPANION Mk. V

Saves you work—it's partly built

Like its predecessors this latest Companion has full fi performance—such as only a good wooden cabinet and bi-flux speaker can give, and due to its being partly built you will have it going in an evening. Note these features:

- All Mullard Transistors including 3 × AF117.
- Two-tone Cabinet, size 11 × 8 × 3in.
- All circuit requirements, Push-Pull output, A.V.C. and feedback, etc.
- Printed circuit board all wired only connections, e.g. to Volume control—W.C. Switch and Tuning Condenser.
- Pre-aligned IF stages complete with full instructions. Price only £4/12/6 plus 6/6 post and insurance.

THIS MONTH'S SNIPS

SCOTCH 3M TAPE

Brand new, unused and guaranteed perfect and not second in any way—a connoisseur's tape on normal spools.

Standard Play	5"	600'	9/-	Long Play	5"	900'	11/6
	5¾"	900'	11/6		5¾"	1200'	16/-
	7"	1200'	16/-		7"	1800'	23/-

£3 post free, otherwise add 2/- post and ins.

CASSETTE LOADED DICTATING MACHINE

Mains operated and with all accessories. Really fantastic offer—a British made £31 outfit for only £10 brilliantly designed for speed and efficiency—cassette takes normal spools drops in and out for easy loading—all normal functions—accessories include:—stethoscopic earpiece and footswitch for typist—crystal microphone has on/off switch—telephone pick up—tape reference pad—DON'T MISS THIS UNREPEATABLE OFFER—SEND TODAY £10 plus 7/6 post and ins.

Note: If you wish to record in unusual places we have some as above but battery operated same price also spare Cassettes at 7/6 each, three for £1.

GARRARD RECORD PLAYERS

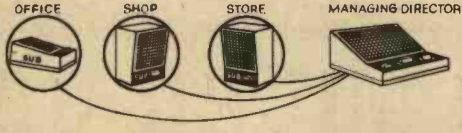
2000	£6. 9.6
3000	£7.19.6
AT60	£11.11.0
SP25	£10. 9.0
LAB80	£25. 0.0
SRP12	£3. 9.6

7/6 for post and insurance.

F.M. TUNER

F.M. tuner of exceptional quality, giving really fantastic results with virtually no noise. Suitable for mains or battery operation. 6 transistors, three I.F. stages, double tuned discriminator. Complete, new and built up all ready to work on chassis. Size 6" × 4" × 2" with tuning scale and slow motion drive, a £12.12.0 tuner for only £8.10.0.

INTERCOM BARGAIN

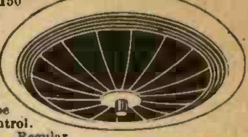


Will save time and improve efficiency. Ideal in home, office, shop, surgery, etc. Complete outfit comprises Master unit and three substations each of which can call the master and have full two-way working. No wiring problems as subs fitted with 60ft. twin flex and they plug into sockets. Also included is packet of staples and battery. Nothing else to buy—£6/9/6, plus 3/6 post and insurance.

PP3 ELIMINATOR

Play your pocket radio from the mains! Save £'s. Complete component kit comprises 4 rectifiers, mains dropper resistances, smoothing condenser and instructions. Only 6/6 plus 1/- post.

CIRCULAR FLUORESCENT



Brings sunshine into your home. 150 watts of light but uses only 40 w. Beautiful fittings with glass, non-plastic centre, fluorescent tube and choke control. Made by Philips. Regular price £4/15/-. Special Bargain price 65/-, plus 8/6 c. and ins. Please state colour of glass centre, white, pink, blue, red, black, yellow or cream. Also whether plug into lamp holder or ceiling mounting model. 80 watt model 99/6.

THERMOSTATS

Type 'A' 15 amp. for controlling room heaters, greenhouse, airing cupboard. Has spindle for pointer knob, quickly adjustable from 30°-80°F. 9/6 plus 1/- post. Suitable box for wall mounting, 5/-, P. & P. 1/-

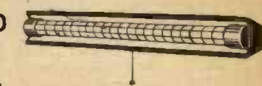
Type 'B' 15 amp. This is a 17in. long rod type made by the famous Sunvic Co. Spindle adjusts this from 50-550°F. Internal screw alters the setting so this could be adjustable over 30° to 1,000°F. Suitable for controlling furnace, oven, kiln, immersion heater or to make flamestat or fire alarm, 8/6 plus 2/9 post and insurance.

Type "C" is a small porcelain thermostat as fitted to electric blankets, etc. 1½ amp. setting adjustable by screw through side. 3/6. P. & P. 1/1.

Type 'D'. We call this the Ice-stat as it cuts in and out at around freezing point. 2/3 amps. Has many uses, one of which would be to keep the loft pipes from freezing if a length of our blanket wire (16 yds. 10/-) is wound round the pipes. 7/6, P. & P. 1/1.

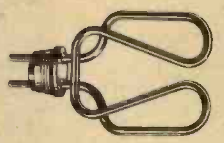
Type 'E'. This is a standard refrigerator thermostat. Spindle adjustments cover normal refrigerator temperature, 7/6 plus 1/- P. & P.

INFRA RED HEATERS



Kit to make this latest type heater. 750 watts silica enclosed element, enamelled metal casing, polished reflector and all parts, only 21/6 plus 3/6 post and ins. Pull switch 3/- extra.

SWAN KETTLE ELEMENTS



Made by famous "Best" company, suitable for most kettles. 1500 watts. 230/250 v. Normally 30/- each. Our price 17/6 each.

HALF PRICE OFFER

G.E.C. 13A SWITCHED SOCKETS

Suitable for ring mains, etc. like the modern fused plug surface or sunk (flush) mounting type. 4/9 each, 54/- doz.

TUBULAR HEATERS

New and unused made by G.E.C.—rated at 60 watts per foot—these are ideal in airing cupboards, bedrooms, offices, stores, greenhouses, etc.—curtains or papers can touch them without fear of scorching or fire. Supplied complete with fixing brackets and available in the following sizes. Prices which are about quarter of list price includes carriage by B.R.S.

8ft.—30/-, 10ft.—36/-, 12ft.—42/-

also in twin assemblies (one pipe above the other):

4ft.—40/-, 5ft.—46/-, 6ft.—52/-

FLUORESCENT LIGHT KITS. Comprising choke, lampholders, starter and two chrome tube clips 20 watt 19/6

NO SOLDERING POCKET 3

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

MOVING COIL METER BARGAIN

Panel meters are always being needed and they are jolly costly when you have to buy them in a hurry—so you should take advantage of this offer: 2in moving coil flush mounting meters only 5/6. These are actually R.F. meters and cost about £3 each but if you don't want them for R.F. then all you have to do is to remove the thermocouple and you will have a 2-3 m.a. meter which you can make into almost anything by adding shunts or series resistor. These are ex-government, of course.

Where postage is not definitely stated as an extra then orders over £3 are post free. Below £3 add 2/9.

ELECTRONICS (CROYDON) LIMITED

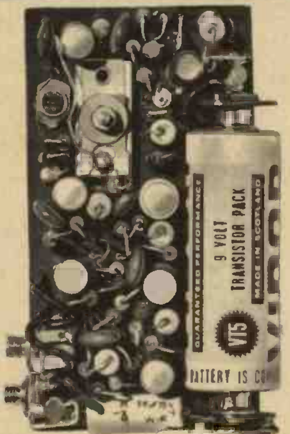
(Dept. PE) 102/3 TAMWORTH ROAD, CROYDON, SURREY *(Opp. W. Croydon Stn)*

SINCLAIR MICRO FM

POCKET SIZE COMBINED FM TUNER/RECEIVER

THE ONLY SET OF ITS KIND IN THE WORLD

- 7 TRANSISTORS 2 DIODES
- LOW I.F. ELIMINATES NEED FOR ALIGNMENT
- OPERATES FROM STANDARD SELF CONTAINED 9v BATTERY
- ONE OUTPUT FOR AMPLIFIER ONE FOR PERSONAL LISTENING



Anyone can build it!

This is a marvellous set to build and use. It has so many unique, original features that it is years ahead of any FM design ever produced for the home constructor. It is so professional in its appearance and performance too. With the Sinclair Micro FM there are simlpy no problems of alignment, so it is ready to use just as soon as you have built it. Unlike any other FM set in the world, the Micro FM is a double-purpose unit which you can use both to feed to a hi-fi system or tape recorder and as a self-contained pocket FM portable. The sensitivity of the Micro FM is such that it will operate satisfactorily using its own telescopic aerial in all but the very poorest reception areas. Quality is outstandingly good because of the system of pulse counting discrimination used, and although this set is no bigger than a packet of 10 cigarettes it uses a standard 9 volt self-contained battery. Powerful A.F.C. makes tuning simple. Backed by Sinclair service facilities and the Sinclair guarantee, anyone can go ahead and build the Micro FM straight away and with assured success.

Complete kit including transistors, telescopic aerial, case, earpiece and instructions.

£5.19.6

TECHNICAL DESCRIPTION

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

- ★ Size: 2 11/16 x 1 11/16 x ¾in.
- ★ Pulse counting discriminator
- ★ Low I.F. completely eliminates alignment problems
- ★ Tunes from 88 to 108 Mc/s
- ★ Audio response: 10 to 20,000 c/s ± 1dB
- ★ Signal to Noise Ratio: 30dB at 30 microvolts
- ★ Plastic case with brushed and polished aluminium front and spun aluminium tuning dial

sinclair *world pace-setter in electronics*

SINCLAIR MICRO-6

The kit that builds into the world's smallest radio

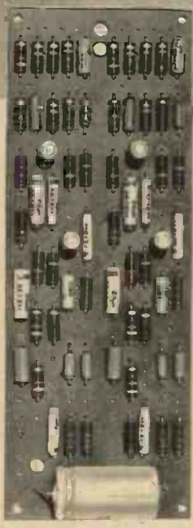
This is the kit that builds into a M.W. set against which a matchbox looks enormous. Yet it is completely self-contained, including aerial and batteries and virtually plays anywhere. Its clever six-stage circuit (2 R.F., double diode detector, 3 A.F.) ensures all you want in a radio today—power, range,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

- ● Size 1 4/5 in. x 1 3/10 in. x ½ in.
- ● Weight: One Ounce
- ● Easily built in an evening

Complete kit with earpiece, case and instructions.

59/6

ORDER FORM AND MORE SINCLAIR DESIGNS ON FOLLOWING PAGES



SINCLAIR STEREO 25

ALL-PURPOSE DE-LUXE PRE-AMP/CONTROL UNIT

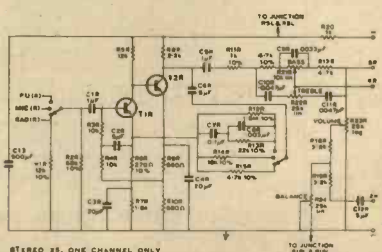
Using only the finest possible matched components in circuitry developed specially by Sinclair Radionics own research laboratories, the SINCLAIR STEREO 25 Pre-amplifier and Tone Control Unit is for use in any stereo system where it is intended to take fullest advantage of today's best amplifier and auxiliary equipment systems. When used for feeding into two Z.12s, there is even greater advantage for there is appreciable saving also in what you have to spend to get first class hi-fi. In appearance, the Stereo 25 reflects the professional elegance which characterises all Sinclair designs. The front panel is in solid aluminium brush finished and polished in horizontal sections. Solid aluminium knobs are fitted. Mounting the unit is simple and it will enhance any hi-fi furnishing scheme in which it is used. A PZ.3 is recommended for powering the Stereo 25 and two Z.12s stereo assembly. For complete hi-fi coverage a Sinclair Micro FM should be used for the radio section of your installation.

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

- **SENSITIVITY** for 10 watts into 1.5 ohms load per channel.
  Mic.—2 mV into 50K ohms.
  Pick-up—3 mV into 50K ohms.
  Radio—20 mV into 4.7K ohms.
- **FREQUENCY RESPONSE** (Mic. and Radio)—25 c/s to 30 kc/s ± 1dB extending to 100 kc/s ± 3dB.

TECHNICAL DESCRIPTION

- **EQUALISATION** — Correct to within ± 1dB on RIAA curve from 50 c/s to 20 kc/s.
- **TONE CONTROLS** Treble + 12dB to − 10dB at 10 kc/s. Bass + 15dB to − 12dB at 100 c/s.
- **SIZE**—6½in. x 2¼in. x 2¼in. overall, plus knobs.
- **FINISH**—Front panel sectioned in brushed and polished solid aluminium with solid aluminium knobs. Black figuring on front panel.



BUILT TESTED AND GUARANTEED

£9.19.6

Circuit Diagram shows one channel of the Stereo 25 Pre-amp and Control Unit.

sinclair *world pace-setter in electronics*

"Does all you claim"

So writes V.C.W. of London S.W.17 who is a keen and critical enthusiast for building unusual designs. He says:

"Micro FM assembly instructions are complete and plain, and when finished the set is truly amazing and does all you claim. Reception up and down the country proved strong, signal quality is very good and station "locking" excellent. Recording programmes through a good quality machine was all one could wish for, and I continue to be amazed at the performance the set puts up."

"I have received your Z.12 amplifier. I am extremely pleased with its performance, and it is well worth the cost. Thank you for your prompt delivery."

B.R.L., Howick, Auckland, N.Z.

"Much to my delight, the tuner (Micro FM) performs splendidly, fully justifying the modest outlay called for. The tuner picks up all the F.M. programmes. I am now anxious to purchase two Z.12 amplifiers."

P.E.R., Florida, Transvaal.

WE ARE LOOKING FOR PHOTOS showing Sinclair equipment in use in any interesting or unusual way anywhere in the world. £3.3.0 will be paid for each picture we publish. A brief story should accompany each one. All photos received will be posted back.

HA-63A COMMUNICATION RECEIVER OUTSTANDING VALUE

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

LAFAYETTE HA-55A AIRCRAFT RECEIVER

108–136 Mc/s. High selectivity and sensitivity. Incorporates 2 RF stages including 6CW4 Nuvistor, 8 tubes for 11 tube performance, solid state power supply, adjustable squelch control, slide rule dial, built in 4in. speaker and front panel phone jack. 220/240V. A.C. Supplied brand new and guaranteed. £19.7.6. Carr. 10/-. 108-176 Mc/s Ground Plane Antenna 59/6.

HA.52A. FM. RECEIVER. Covering 152-174 Mc/s. Identical in appearance to HA.55A. Built-in speaker, etc. £20. Carr. 10/-.

HAM-1. 4 BAND COMMUNICATION RECEIVER

4 wavebands covering 535 kc/s-30 Mc/s 5-valve superhet circuit. Incorporates S meter, B.F.O., BANDSPREAD TUNING, BUILT-IN 4in. SPEAKER, FERRITE AERIAL AND EXTERNAL TELESCOPIC AERIAL. Operation 220/240v. A.C. Supplied brand new with handbook. £16/16/0. Carr. 10/-.

GARRARD RECORD PLAYERS
BRAND NEW AND GUARANTEED

SRP-12 Player, mono	£4 4 0
1000 Changer, mono or stereo	£5 19 6
2000 Changer, mono or stereo	£6 6 0
A50 Changer, mono or stereo	£7 10 0
3000 Changer—Stereo	£7 7 0
AT6 Mark II	£8 19 6
SP25 Player, mono or stereo	£9 19 6
AT 60 Changer mono or stereo	£9 19 6
A70 (less cart.)	£19 19 0
LAB80	£25 0 0
401 Transcription	£27 10 0

All plus P. & P. 5/-.

MAIN LONDON AGENTS FOR CODAR EQUIPMENT

All items available as advertised

SINCLAIR TRANSISTOR AMPLIFIERS

Z12 Amplifier 89/6; Z12 Power Pack 79/6; Stereo 25 Pre-Amplifier £9.19.6; Micro FM Radio Kits £5.19.6; Micro 6 Radio Kit 59/6; Micro Amp Kit 28/6. Post Paid.

TRANSISTORISED TWO-WAY TELEPHONE INTERCOM.

Operative over amazingly long distances. Separate call and press to talk buttons. 2-wire connection. 1000's of applications. Beautifully finished in ebony. Supplied complete with batteries and wall brackets. £6.10.0. pair. P. & P. 3/6.

LAFAYETTE 2-WAY RADIOS

Superb quality. Brand new and guaranteed.
3 Transistor £7.10.0 pr.
6 Transistor £17.10.0 pr.
10 Transistor with range boost £22.10.0 pr.
Model GT50 13 transistor 500mW. 2 channel. £35 pair. Post extra.

These cannot be operated in U.K.

MAGNAVOX 363 TAPE DECKS

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

MODEL ZQM TRANSISTOR CHECKER

It has the fullest capacity for checking on A, B and Ico. Equally adaptable for checking diodes, etc. Spec.: A: 0·7-0·9967, B: 5-200, Ico: 0-50 microamps. 0-5 mA. Resistance for diode 200Ω — 1 MEG. Supplied complete with instructions, battery and leads. £6/19/6. P. & P. 2/6.

PCRI RECEIVERS

Brand new condition, fully tested and checked before despatch. 3 waveband with R.F. stage. wonderful value. 860-2080 metres, 190-570 metres, 5.6-18 Mc/s with internal speaker. £8.19.6. Carr. 10/6 with circuit. Plug in external power units 230 v.a.c. 35/- or 12 v.d.c. 19/6.

VARIABLE VOLTAGE TRANSFORMERS

Brand New—Fully Shrouded. Input 230v. 50/60 c/s. Output 0–260 Volts.

1 Amp	£4.10.0
2.5 Amp	£5.17.6
5 Amp	£9.0.0
8 Amp	£13.10.0
10 Amp	£17.0.0
12 Amp	£19.10.0
20 Amp	£32.10.0

2.5 Amp Portable—Metal Case with Meter-Fuses, etc., £9/17/6.

AMERICAN TAPE

First grade quality American tapes. Brand new. Discounts for quantities.

3in., 225ft. L.P. acetate	4/-
3¼in., 600ft. T.P. mylar	10/-
5in., 600ft. std. plastic	8/6
5in., 900ft. L.P. acetate	10/-
5in., 1,200ft. D.P. mylar	15/-
5in., 1,800ft. T.P. mylar	35/-
5¾in., 1,200ft. L.P. acetate	12/6
5¾in., 1,800ft. D.P. mylar	22/6
5¾in. 2,400ft. T.P. mylar	45/-
7in., 1,200ft. std. mylar	12/6
7in., 1,800ft. L.P. acetate	15/-
7in., 1,800ft. L.P. mylar	20/-
7in., 2,400ft. D.P. mylar	25/-
7in. 3,600ft. T.P. mylar	58/6

Postage 2/-. Over £3 post paid.

SILICON RECTIFIERS

200 v. P.I.V. 200mA.	2/6
200 v. P.I.V. 6 amp.	5/6
400 v. P.I.V. 3 amp. (S.C.R.)	10/-
400 v. P.I.V. 3 amp.	7/6
1,000 v. P.I.V. 650 mA	6/6
800 v. P.I.V. 500mA.	5/6
800 v. P.I.V. 5 amp.	7/6
400 v. P.I.V. 500mA.	3/6
70 v. P.I.V. 1 amp.	3/6
150 v. P.I.V. 165mA.	1/-
150 v. P.I.V. 25 amp.	19/6
700 v. P.I.V. 100 amp.	49/6

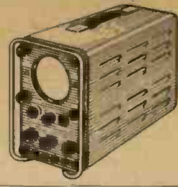
Discounts for quantities. Post extra.

CALLERS WELCOME !

Open 9 a.m. to 6 p.m. every day Monday to Saturday. Trade supplied.

TEST EQUIPMENT

PORTABLE OSCILLOSCOPE CT.52



A compact (9"×8"×16½") general purpose 'scope. T/B 10 c/s-40 kc/s. Band width 1 Mc/s. Mullard DG 7/5 2¾" CRT. For operation on 200/250 v. A.C. Supplied complete with metal transit case, strap, test leads, and visor hood. Brand new. £22.10.0. Carr. 10/-. Supplied complete with instructions.

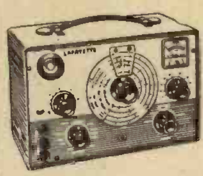
OS/8B/U OSCILLOSCOPES

High quality Portable American Oscilloscope. 3" c.r.t. T/B 3 c/s-50 kc/s X Amp: 0-500 kc/s Y Amp: 0-2 Mc/s. Power requirements 105-125v. A.C. Supplied in brand new condition, fully tested. £25. Carr. 10/-. Suitable 230/115v. Transformer 15/6.

ERSKINE TYPE 13 DOUBLE BEAM OSCILLOSCOPE

Time base 2 c/s-750 kc/s. Calibrators at 100 kc/s and 1 Mc/s. Separate Y1 and Y2 amplifiers up to 5.5 Mc/s. Operation 110/230 volt A.C. Supplied in perfect working order. £22/10/-. Carriage 20/-.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYZER



2 PF—2,000 MFD. 2 ohms—200 Megohms. Also checks impedance, turns ratio, insulation 200/250v. A.C. Brand New £15. Carr. 7/6.

TE-20 RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s.-260 Mc/s on 6 bands. Directly calibrated. Variable R.F. attenuator, Operation 200/240 v. A.C. Brand new with instructions, £12.10.0. P. & P. 7/6.

S.A.E. for details.

TE-900 20,000Ω/VOLT GIANT MULTI-METER

6 in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 V. A.C. 0/25/12.5/10/50/250/1,000/5,000 V. D.C. 0/50μA/110/100/500 mA/10 amp. D.C. 02K/200K/20 MEG. OHM. £12/19/6. P. & P. 5/-.

TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine 20 cps to 200 kc/s. on 4 bands. Square: 20 cps to 20 kc/s. Output impedance 5,000 ohms. 200/240 v. A.C. operation. Supplied Brand New and Guaranteed with instruction manual and leads. £15. Carr. 7/6.

NOMBREX EQUIPMENT

Transistorised Audio Generator 10-100,000 c/s. Sine or square wave. £16.15.0.
Transistorised Signal Generator 150 kc/s. 350 Mc/s. £10.10.0.
Transistorised resistance capacity bridge 1Ω. 100 MegΩ, 1 pf-100μF. £9.
Transistorised Induction bridge 1μN-100H. £18. Mains operated Transistor power supply unit, output 1-15v. up to 100 mA. £6.10.0.
All above post paid with battery.

CLEAR PLASTIC PANEL METERS

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

50μA	32/6	100-0-100μA	27/6	200mA.	22/6
100μA	29/6	500-0-500μA	22/6	300mA.	22/6
200μA	27/6	1-0-1mA	22/6	500mA.	22/6
500μA	25/-	1mA	22/6	750mA.	22/6
50-0-50μA	29/6	2mA	22/6	1A D.C.	22/6
		5mA	22/6	2A D.C.	22/6
		10mA	22/6	5A D.C.	22/6
		20mA	22/6	3V D.C.	22/6
		50mA	22/6	10V D.C.	22/6
		100mA	22/6	20V D.C.	22/6
		150mA	22/6	50V D.C.	22/6

100V D.C.	22/6
150V D.C.	22/6
300V D.C.	22/6
500V D.C.	22/6
750V D.C.	22/6
15V A.C.	22/6
50V A.C.	22/6
150V A.C.	22/6
300V A.C.	22/6
500V A.C.	22/6
"S" Meter 1mA	29/6

POST EXTRA. Larger sizes available—send for lists.

TE-51 NEW 20,000Ω/VOLT MULTIMETER

0 / 6 / 60 / 120 / 1,200V. A.C. 0 / 3 / 30 / 60 / 300 / 600 / 3,000V. D.C. 0 / 60μA / 12 / 300 MA. D.C. 0 / 60K / 6 Meg. Ω 85/-. P. & P. 2/6.

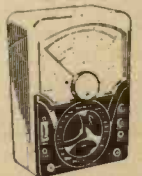
MODEL TE-12

20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 V. D.C. 0 /6/ 30 / 120 / 600 / 1,200 V. A.C. 0 / 60μA/6/60/600 MA. 0/6K/600K/6 Meg./60 Meg. Ω 50 PF. .2 MFD. £5.19.6. P. & P. 3/6.

MODEL U50D. WITH METER PROTECTION.

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

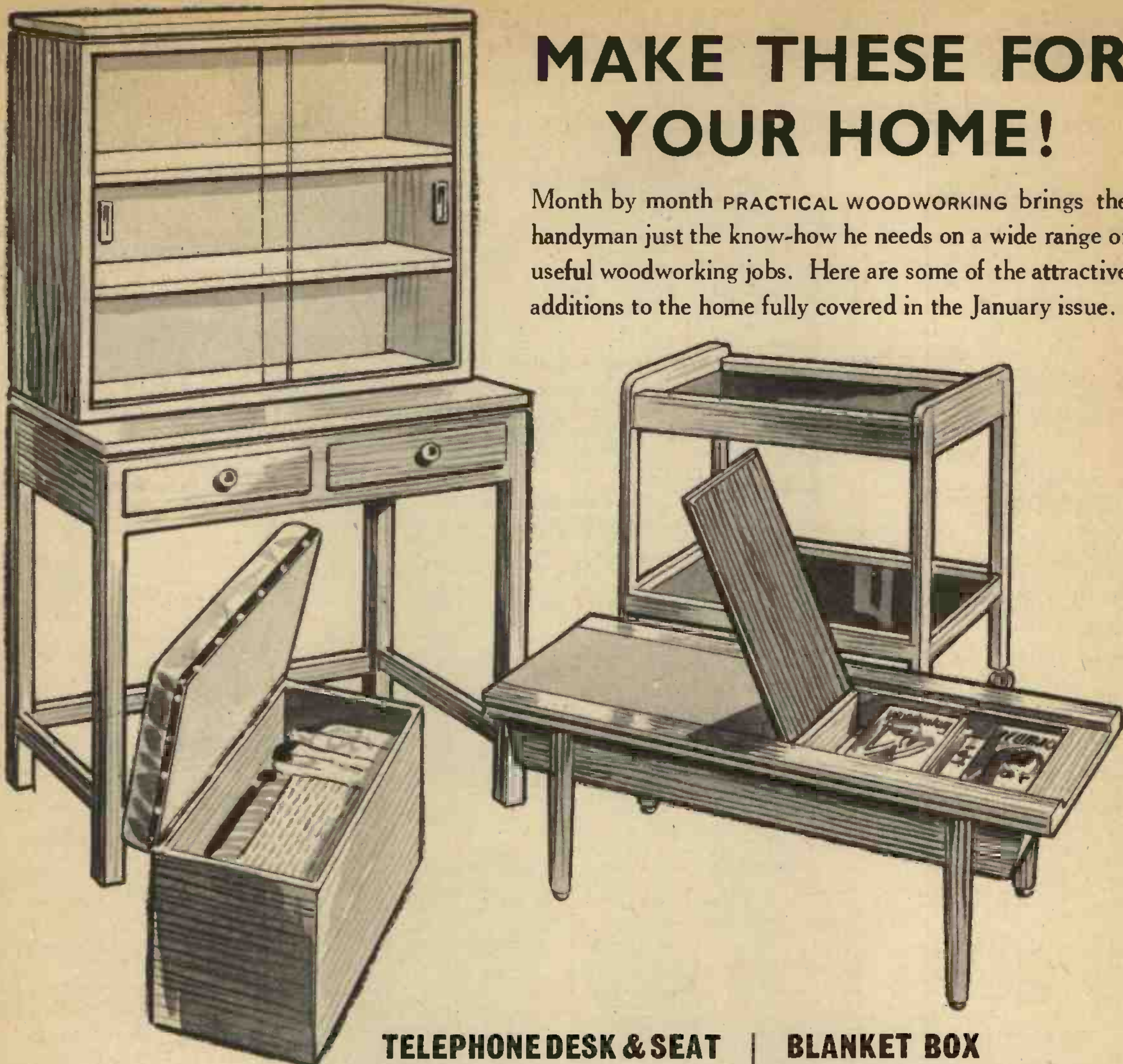
MODEL 500.



30,000 o.p.v. 0/.5/1/2.5/10/25 / 100 / 250 / 500 / 1,000v. D.C. 0 / 2.5 / 10 / 25 / 100 / 250 500 / 1,000v. A.C. 0 / 50μA / 5 / 50 / 500mA. 12 amp. D.C. 0 / 60K / 6 Meg. / 60 Meg Ω. £8/17/6 Post Paid.

G.W. SMITH & CO (RADIO) LIMITED

Phone: GERRARD 8204/9155
Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2



MAKE THESE FOR YOUR HOME!

Month by month PRACTICAL WOODWORKING brings the handyman just the know-how he needs on a wide range of useful woodworking jobs. Here are some of the attractive additions to the home fully covered in the January issue.

TELEPHONE DESK & SEAT
A handsome desk to house your telephone... a cupboard for directories... a cushioned seat for comfort... all easy to make from full constructional details.

CABINET, TABLE & TROLLEY SUITE
A space-saving 3-piecer.

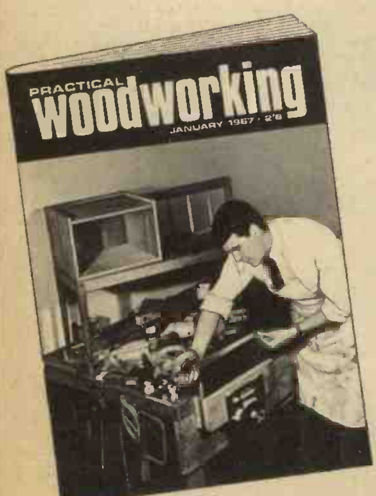
OCCASIONAL TABLE
Modern, low-line in appearance and specially designed to store books and magazines.

BLANKET BOX
To store blankets when winter's over. Also makes a handy seat.

UTILITY DISPLAY SHELVES
Simple to make for those odd corners.

CLOAKROOM MIRROR
Framed in wood, with a generous shelf for clothes-brushes.

Plus PLAN SHEET FOR SINGLE-LIGHT, FULLY-GLAZED EXTERIOR DOOR



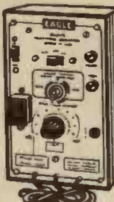
PRACTICAL
woodworking

MAKE SURE OF YOUR COPY!   JANUARY ISSUE OUT NOW - 2/6

RADIO • HI-FI • COMPONENTS • TEST EQUIPMENT

ALL ITEMS SENT POST FREE

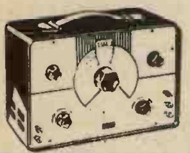
TT.144. Dynamic Transistor Tester
Tests in-circuit or out of circuit. Identifies PNP and NPN types. Indicates electrode open circuits, short circuits and current drain. Complete with instructions £4.10.0.



TT.145. De luxe Transister Diode Tester. £9.7.6.

MULTIMETERS

TK.20A 1,000 o.p.v.	£2.15.6
TK.25 1,000 o.p.v.	£2.15.6
EP.10K 10,000 o.p.v.	£4.17.6
EP.10KN 10,000 o.p.v.	£5.8.0
EP.20K 20,000 o.p.v.	£5.19.6
EP.20KS 20,000 o.p.v.	£6.8.0
EP.30K 30,000 o.p.v.	£7.19.6
EP.30KN 30,000 o.p.v.	£9.0.0
EP.50KN 50,000 o.p.v.	£11.19.6
EP.100KN 100,000 o.p.v.	£14.19.6



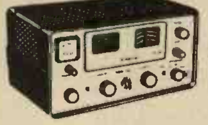
TE-188. RF SIGNAL GENERATOR
A stable wide range signal generator with a range of 120 Kc/s–260Mc/s on 6 bands. Features a large 4½in. vernier tuned, etched circular dial for easy accurate frequency adjustments. Complete with instructions. **£20.15.0**

TE190. SINE SQUARE WAVE AUDIO GENERATOR
SINE WAVE: 20–200,000 cps in four bands.
SQUARE WAVE: 60–30,000 cps. Input impedance 0–5,000 ohms. Especially designed for HI-FI Radio and TV Service men who require a dependable instrument. **£21.19.6**

LA9P. AC ELIMINATOR
with a double wound step down transformer to operate 9v Radios, etc., from AC Mains. **£1.8.6**

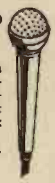
FSW1. FOOT SWITCH
Snap action foot switch with skid proof rubber base pad. Plugs into your Tape Recorder remote control system but special adaptor supplied enables this to be used with all other Tape Recorders. **24/-**

MCK.2. MORSE CODE KIT
Two station morse code kit supplied with instructions, 50ft. of connection wire and morse code charts. **£2.2.0**

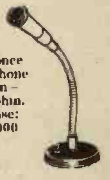


SR165. ALL BAND COMMUNICATION RECEIVER
This entirely new professional type communication receiver features frequency coverage of 535 Kc/s–30 Mc/s for complete general coverage. In particular ham bands are arranged in the same calibration scale, so that the band switching can be accomplished rapidly. **£48.0.0**

UD40H CARDOID DYNAMIC MICROPHONE
Features a pop-proof diaphragm and superior anti feed-back properties, reduces feedback and room reverberation. O/p: —42 db. Response: 60–12,000 cps; 50K ohm impedance £6.6.



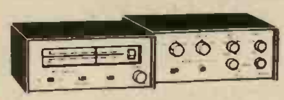
DM31C. CARDOID DYNAMIC MICROPHONE
Superb quality with ball head for distributed cardoid frontal pick-up. Output: —52db. Response: 40–13,000 cps. Impedance 50k ohm. £7.7.0.



DM24HL
A gooseneck dual impedance microphone 600 ohm – 50K ohm. Response: 50–11,000 cps. £6.6.0.

27 other microphones available.

EAGLE SA100. 10W INTEGRATED STEREO AMPLIFIER



A compact, versatile integrated unit for monaural or stereophonic reproduction from record player, tape recorder and tuner. Power output 5 watts per channel. Frequency response 40–20,000 c.p.s. **£18.0.0**

EAGLE AFM100. AM-FM TUNER
Combines a host of advanced features that easily make it the finest AM-FM tuner in its class. A tuned-RF stage on FM, AFC circuit and a heavy flywheel giving smooth but effortless tuning, built in AM Ferrite aerial. FM.88–108Mc. AM 535–1605 K/s. **£29.0.0**

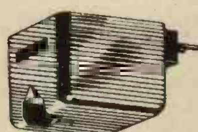
MS80. 20W ROSEWOOD SPEAKER SYSTEM
The perfect answer for the music lover who wants full range fidelity in a compact system. Features an 8in. full range high compliance speaker with an output capacity of 20 watts RMS. Frequency response: 30–20,000 c.p.s. Resonant frequency: 30–40 c.p.s. Sensitivity: 97 db/w. Flux density: Over 12,000. Impedance: 16 ohm. Size 14½in. high x 10⁵/₁₆in. wide x 8in. deep. **£14.14.0**

As well as this beautifully designed speaker there are two other models MS65. 10 watts RMS at £12.12.0 and MS40 5 watts RMS £8.10.0.
All three speakers are finished in magnificent rosewood and the entire cabinet filled with acoustic damping material.

EAGLE PRODUCTS
MAGNETIC STEREO CARTRIDGES

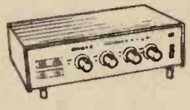
M1007G GOLD
Response: 20–20,000 cps
Output: 5MV at 1Kc/5cm/Sec.
Stylus: 0.5 Mil diamond
Tracking Pressure 1–2.5 grams.
£6.12.6

M1007F. SILVER
Response: 20–18,000 cps
Output: 10MV at 1Kc/5cm/Sec.
Stylus: 0.7 Mil diamond
Tracking Pressure 2–4 grams.
£5.14.6



Both feature singularly smooth reproduction and incisive separation of stereo channels

ALL TRANSISTOR PUBLIC ADDRESS AMPLIFIERS



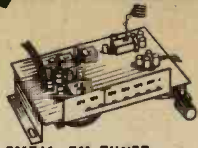
Two new models offering the last word in P.A. amplification. All transistorised circuit, negative feedback circuit reduces distortion to a minimum. Two mike inputs high and low with individual controls. Plus inputs for TAPE, TUNER and RECORD PLAYER.
PA540 35 Watts **£36.0.0**
PA541 50 Watts **£56.0.0**
Other P.A. models available.

SC10F. RECTANGULAR REFLEX HORN SPEAKER
An outstanding combination of reflex horn and driver unit for car mounting, to deliver wide angle high quality reproduction. Weatherproof, waterproof and shockproof. Output 10 watts. **£7.15.0**

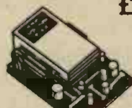
Also available SC5F: 5 watts, £4.2.6 and SC15F: 15 watts £14.12.6.

FOR FULL DETAILS OF THESE AND MANY OTHER ITEMS SEND FOR FREE COMPREHENSIVE CATALOGUE. EAGLE NEWS AND ORDER FORM. ALL ITEMS AVAILABLE POST FREE AND COVERED BY 12 MONTHS' GUARANTEE.

CALLERS WELCOME AT OUR HI-FI SHOWROOM

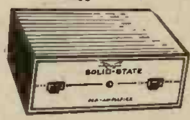


EAGLE FMT41. FM TUNER
Sub-miniature 6 transistor 3 diode F.M. Tuner. Covers 88–108 Mc. Operates from 9-volt battery, micro miniature circuit giving brilliant FM reception. Ready to use, simply connect to your Hi Fi amplifier. Instructions supplied. **£8.10.0**



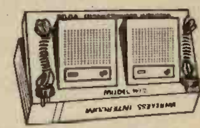
EG304
Sub-miniature 3 watt transistorised push-pull radio amplifier on printed circuit. Ideal unit for Intercoms, Baby Alarms, Radio Tuners, etc. Complete with circuit and instructions. **£3.12.6**
Also available EG104. One Watt **£3.2.6**
and EG2004 250 mW **£2.5.0**

CSK.10
Self-powered crystal set kit with private earphone. Supplied complete with instructions. **18/6**



ALL TRANSISTOR MONO & STEREO PRE AMPLIFIERS
Provide extra stage of amplification for use with magnetic cartridges, tape and microphone inputs. Both models feature wide band pass range, 20–20,000 cps.

PRE 301 MONO	£4.12.6.
PRE 302 STEREO	£5.15.0.



WI-2. TRANSISTORISED WIRELESS INTERCOM
No wires, no installation needed, simply plug them into AC power point and talk. Units have press-to-talk lock switch and on-off volume control. Ideal Intercom or Baby Alarm for home, office, factory. **£14.12.0** Complete.

DP303. DOOR PHONE INTERCOM
Ultra sensitive transistorized intercom designed so that you may answer the door from within for greater convenience and safety. **£4.12.6** Other intercoms available.

WIRELESS MICROPHONES

WM909 (as illustrated) Pocket FM Wireless transmitter complete with tie-pin microphone. Transmits clearly up to 100 yds. and is fully tunable over the entire FM band. Simply used with an FM radio or tuner. **£14.0.0**

Also available WM808 Professional stick type FM Wireless Microphone. **£21.0.0**

These cannot be operated in U.K.

RELDA RADIO LTD
(Dept. P.E.13)
87 Tottenham Court Road, London, W.1.

HI-FI AMPLIFIERS —— TUNERS —— RECORD PLAYERS

FM TUNERS FM-4U

TFM-IS

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

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

Hear the BBC stereo FM programmes on the TRANSISTOR STEREO FM TUNER. Elegantly designed to match the stereo Amplifier, AA-22U. Available in two units, sold separately, can be built for a Total Price:
Kit (STEREO) £24.18.0 incl. P.T.
Kit (MONO) £20.19.0 incl. P.T.

10W POWER AMP. MA-12

9 + 9W STEREO AMP. S-99

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

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

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

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

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

Heathkit DAYSTROM

Make the most of your leisure time . .

Here's the STEREO DECODER you have been looking for

Add Stereo RADIO to your listening pleasure at low cost. **FM DECODER SD-1.** This model will convert Heathkit valve (Mono) FM and AM/FM tuners to stereo. It can also be used with most other makes of FM tuner having facilities for multiplex output. Own buit-in power supply. Compact, 3¼" x 3¼" x 9" deep. **Kit £8.10.0. Assembled £12.5.0.** Send for full specification details.

TRANSISTOR RECEIVERS

Oxford

UXR-1

GC-1U

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

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

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

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

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

TEST INSTRUMENTS

Our wide range includes:

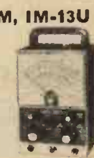
OS-2

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

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

VVM, IM-13U

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



V-7A

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

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

RF-1U

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

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

IG-82U

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

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

Prices and specifications subject to change without notice

TAPE AMPLIFIERS — TAPE DECKS — CONTROL UNITS

20 + 20W STEREO AMP. AA-22U

GARRARD PLAYER AT-60

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

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

Many other Garrard models available, ask for Lists.

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

WIDE RANGE OF HI-FI CABINETS, send for details. For example: **MALVERN Kit £18.1.0** incl. P.T.

TRUVOX DECK

AM/FM TUNER

TRUVOX D-93 TAPE DECKS. High quality stereo/mono tape decks. **D93/2,** ½ track, **£36.15.0** **D93/4,** ¼ track, **£36.15.0**

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

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

STEREO CONTROL UNIT. Model USC-1. Push-button selection, accurately matched ganged controls to ±1dB. Rumble and variable low pass filters. Printed circuit boards. Kit **£19.19.0** Assembled **£27.5.0**

Enjoy building a Heathkit model

SPEAKER SYSTEMS

SSU-1

Berkeley

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

The BERKELEY SLIM-LINE SPEAKER SYSTEM, fully finished walnut veneered cabinet for faster construction. Special 12" bass unit and 4" mid/high frequency unit. Range 30-17,000 c/s. Size 26" × 17" only 7¾" deep. Modern attractive styling. Excellent value. Kit **£19.10.0** Assembled **£24.0.0**

COTSWOLD SPEAKER SYSTEMS. Outstanding performance for price. *MFS:* Size 36" × 16½" × 14" deep. Kit **£25.12.0** Assembled **£33.17.0**

STANDARD: Size 26" × 23" × 14½" deep. Kit **£25.12.0** Assembled **£33.17.0**

Complete your motoring pleasure with this outstanding car radio. Model CR-1.

Will give you superb LW and MW entertainment wherever you drive. Tastefully styled to harmonise with any car colour scheme. Available for your convenience in two parts. Can be built for a total price **Kit** (excl. L.S.) **£12.17.0** incl. P.T. Hi-Fi Loudspeaker **£1.8.6** extra. Send for full details.

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DX-40U

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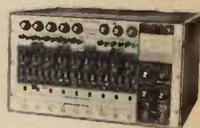

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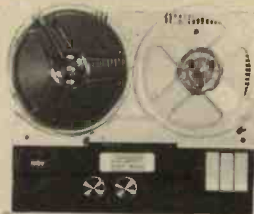

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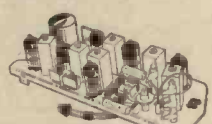

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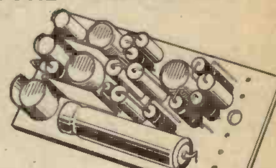

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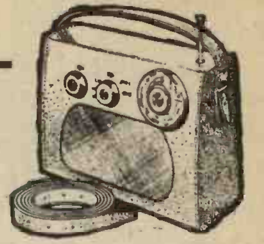

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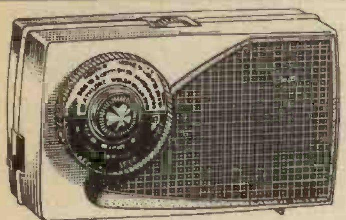

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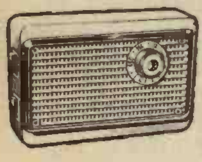

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● **6 WAVEBAND!!**

● 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 two Short Waves. Sensitive Ferrite rod aerial and telescopic aerial for short waves. Top grade transistors. 3-inch speaker, handsome case with gilt fittings. Size 7¼ × 5¼ × 1½in. (Carrying Strap 1/6 extra.)

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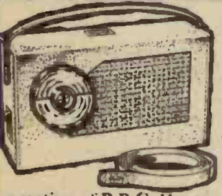

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VOL. 3 No. 1
JANUARY 1967

PRACTICAL ELECTRONICS

TOO MUCH MUSIC?

WITH an important White Paper concerning the future of broadcasting in this country in the offing, strident voices have been heard in recent months campaigning on behalf of a host of different interests. Perhaps the least bashful of these are the pop pirates with their undoubted enthusiastic followers, drawn mainly from, one supposes, the teenage section of the population. Other voices in this chorus represent local radio interests, the recording companies, The Performing Right Society, musicians, and composers.

There is violent discord in this chorus and clearly whatever the Postmaster-General decides, he will not be able to weld this motley assembly into a harmonious whole.

Is there too much music broadcast already?

This is one of the more surprising points of view to emerge from this "concert" performance. A select body of well known composers representing the whole musical scale from pop to symphony thinks there is already a sufficiency of music for all tastes available on tap from the broadcasting stations each day.

The record companies would appear to lend support to this opinion since their products are intended for private individuals to play at home as the mood takes them. The disc was never intended to provide fodder for the insatiable appetites of broadcasting stations which, incidentally, modern techniques have made relatively simple to set up and operate.

If modern electronic engineering has in this respect been kind to the pop pirates, it has been no less bounteous to land based purveyors of music in public places through wired relay and public address type systems. This kind of broadcasting is in many respects more open to objection than the radio transmission kind—the audience has no means to switch it off!

A little background music of the right type at the right time can be valuable as either a tonic or a sedative. Like all drugs its effectiveness diminishes with prolonged use; at best it becomes "musical wallpaper"—an accompaniment that can be tolerated (but this is hardly complimentary to composer and performers); at worst it degenerates to "noise" which may become a severe irritant.

An abundance of music is indeed a mixed blessing.

THIS MONTH

CONSTRUCTIONAL PROJECTS

SPECIAL SERIES

GENERAL FEATURES

NEWS AND COMMENT

Our February issue will be published on Friday, January 13

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, 36s.

LASERS

By J. B. Dance M.Sc. **PART 1**

The laser is one of the most important devices invented by physicists during the past decade. Apart from its numerous uses in pure research, the laser has many practical applications; one of the most interesting applications is the use of laser light as a carrier wave for conveying a great deal of information in a short time.

It is not possible to explain in only a few words what precisely a laser is, but basically it is a means of generating a rather special kind of light contained in a very narrow, almost parallel beam. This article sets out to explain the principles of operation and applications of lasers.

IN ORDER to understand the operation of a laser, it is first necessary to consider the various ways in which radiation can interact with matter. In the same way that matter is considered to consist of a large number of atoms, light (and also other forms of electromagnetic radiation) can be thought of as a large number of particles which are known as photons.

Indeed, individual gamma photons can be counted with Geiger counting equipment. The energy of a single photon E is equal to the frequency of the light f multiplied by a constant h (Planck's constant). Thus a photon of blue light contains more energy than a photon of red light.

We may picture the atom (after Niels Bohr) as a number of electrons travelling in orbits around a central nucleus in much the same way that the planets travel around the sun. However, only those orbits which satisfy certain conditions set by the quantum theory are stable. In general the farther an electron in a certain atom is from the central nucleus, the higher is its energy.

An atom is said to be in the ground state when it has the least possible energy. If the atom absorbs energy and this causes an electron to move further from the nucleus, the atom is then said to be in an excited state. However, an atom can absorb only an amount of energy which will cause one of its electrons to move into a stable orbit of higher energy.

PROCESSES OF ABSORPTION AND EMISSION

Absorption

- ☐ One photon + Atom in the ground state ——> Excited atom

Normal Emission

- ☐ Excited atom ——> Atom in a state of lower energy + One photon

Stimulated Emission

- ☐ Excited atom + One photon ——> Atom in a state of lower energy + Two identical photons

PHOTON ABSORPTION

One of the ways in which an atom is given extra energy involves the absorption of a photon of light. The photon disappears and an excited atom is produced. However, the photon will be absorbed only if it has almost exactly the amount of energy required to raise the electron into a stable higher orbit.

If a photon has either too much energy or too little energy, it will not be able to effect the change, although it may possibly have a suitable amount of energy to cause another change in electron energy levels. In other words, a given atom in the ground state will absorb only light of certain specified colours.

Complications occur when one considers absorption in a substance, since each atom can interact with its neighbours in such a way that many stable energy levels are created. Thus the material may absorb a band of colours rather than one specified frequency.

EMISSION

If an atom is in an excited state, it tends to lose its energy very quickly indeed. In a typical case the energy is lost in less than one hundred millionth of a second. Some forms of excited atoms lose their energy about one million times more slowly; they are known as metastable atoms.

When an atom loses its energy, a photon may be formed. The frequency of the light of which this photon forms a part is thus proportional to the difference in energy between the two states of the atom. If this difference is large, ultra-violet or violet light may be emitted, but if the atom loses a smaller amount of energy, yellow or red light may be emitted. Each energy difference causes light of one particular frequency to be emitted.

Electrons jumping between two of the energy levels in the sodium atom give rise to the characteristic yellow light emitted by street lamps filled with sodium vapour. Similarly neon filled tubes, including voltage stabiliser tubes, emit red light. Any atom will emit light (when excited) of the same colour as the light which the unexcited atom will absorb.

STIMULATED EMISSION

Let us consider the case of an atom which, when in the ground state, will absorb a photon of energy E to become an excited atom. If a photon of this same energy meets the excited atom, it will cause the atom to emit a photon virtually instantaneously. The fact that the two photons have the same frequency, the same plane of polarisation, the same phase, and the same direction of travel renders the operation of a laser possible.

The photon produced when the original photon strikes the excited atom is an exact replica of the original photon. Thus stimulated emission may be considered to be the amplification of light. If the photons meet further excited atoms, further amplification by stimulated emission will occur.

FEEDBACK

As in the case of a radio transmitter, it is necessary to convert the amplifier into an oscillator if the system is to be used to generate electromagnetic oscillations. This is accomplished by the use of a system such as that shown in Fig. 1. The two mirrors must be accurately parallel to one another and must face each other.

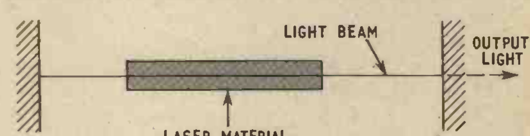
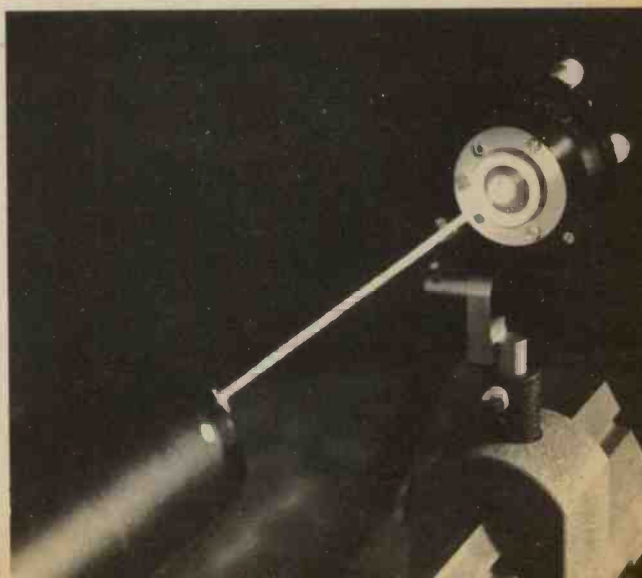


Fig. 1. A simplified diagram of a laser

Any light passing along the axis of the system is reflected back into the system so that further amplification occurs. Light which deviates from the axis by even a very small angle soon passes out of the system and is lost.

One of the mirrors of the system is only partially reflecting so that the output beam from the laser can pass through it. The divergence of this beam is extremely small. In other words the output from the laser is obtained as a beam of light which is almost exactly parallel.

This photograph and that on the opposite page show the beam from a Mullard gas laser



MASERS AND LASERS

The phenomenon of stimulated emission was first discovered at microwave frequencies in ruby crystals. The apparatus used became known as a MASER, this name being taken from the abbreviation for "*M*icrowave *A*mplification by the *S*timulated *E*mission of *R*adiation".

Masers are the best low noise amplifiers known at the present time and are used in satellite communication systems and in radio astronomy. However, they are too complicated for use as a normal electronic component and many types must be cooled in liquid helium.

A somewhat similar device, using light instead of microwaves, was developed and was called a LASER—"*L*ight *A*mplification by the *S*timulated *E*mission of *R*adiation".

PUMPING

In order for light amplification to occur in a laser material, there must be more atoms in the excited state than there are in the ground state; otherwise the probability of a photon being absorbed is greater than the probability that it will cause stimulated emission and thus be amplified. For laser action to occur, the chance that a photon travelling through the material will be absorbed must be less than the chance that it will be amplified.

In order to produce a material in which the number of excited atoms exceeds the number in the ground state, some method of supplying energy to the atoms must be incorporated in the system.

The energy supply is known as a "pump", since it pumps the atoms up from the ground state into an excited state. It supplies the energy in a somewhat similar way to that in which the power supply of a radio transmitter supplies energy to the circuits.

The energy required may be used to raise the atoms of the laser material from a level E_0 (see Fig. 2) to a level E_2. The atoms lose a part of their excess energy almost immediately and fall to the energy level marked E_1 in Fig. 2. If the energy level E_1 is a metastable one, the number of atoms with this energy may exceed the number of atoms in the ground state E_0; laser action then becomes possible.

A Ferranti gas laser in operation. The three screws on the right-hand side are for the adjustment of the mirror. The Brewster window can be seen at the end of the inner tube containing the glowing gas

Fig. 2. Energy levels in a simple laser material

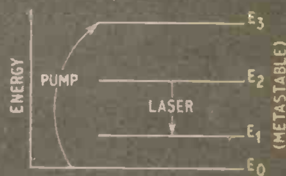


Fig. 3. Laser materials with the above type of energy level properties tend to be more satisfactory than those of the type shown in Fig. 2. It is much easier to arrange for the number of atoms in the level E_2 to exceed those in E_1 than it is for the number in any of the excited states to exceed the number in the ground state, E_0

Actual laser materials normally have a much more complicated energy level diagram than that shown in Fig. 2. In particular, the laser action is chosen so that the atoms are left in a state of slightly greater energy than the ground state (see Fig. 3). This enables an improved efficiency to be obtained.

COHERENT LIGHT

The word "cohere" means "stick together" or "reinforce". Coherent light is light in which the peaks of the waves are in phase and which stick together as the wavefront moves. Coherent light is therefore light of a single frequency.

Theoretically it is impossible for light to be of one frequency and therefore for coherent light to be obtained. However, light from the most coherent source at present known (the gas laser) has a frequency spread of less than one cycle per second; this is negligible compared with the frequency of light itself of some hundreds of millions of megacycles per second.

Coherent electromagnetic waves are needed for the efficient transmission of information. Incoherent electromagnetic waves (such as the old spark transmitters) cannot be used for the efficient transmission of information, since the various frequencies present effectively constitute "noise" signals. Incoherent waves can only be used to convey information by switching the carrier on and off.

Lasers have provided the first reasonably coherent sources of light and the possibility of using them for carrying many speech and television channels has aroused considerable interest.

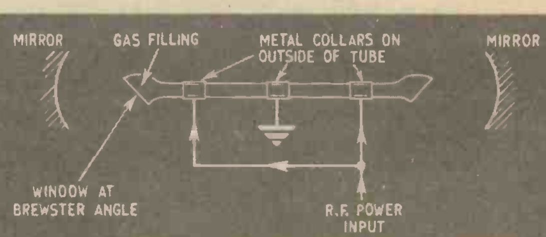
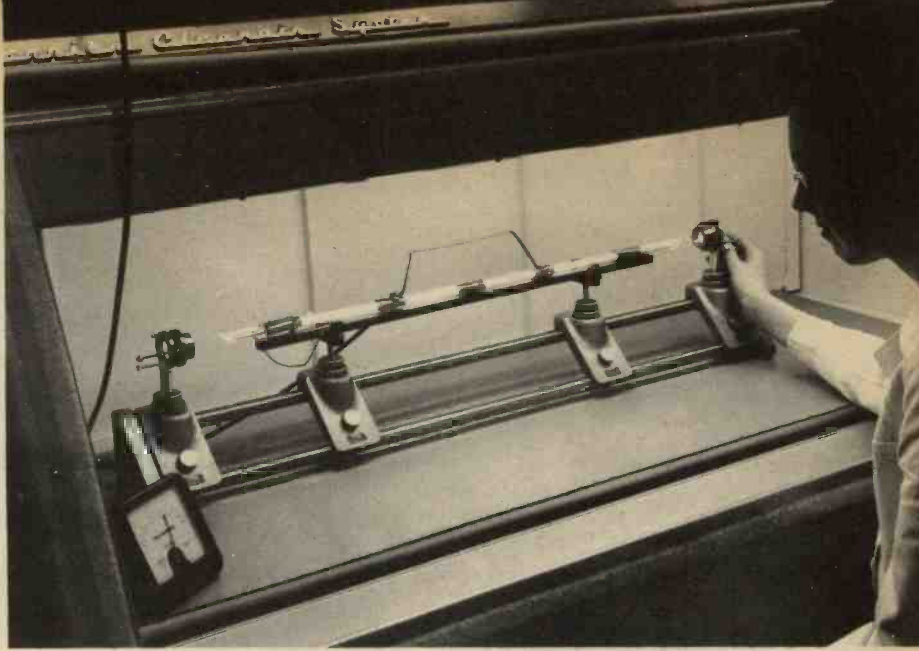


Fig. 4. A gas laser with external mirrors. The use of curved mirrors renders the alignment of the system much less critical



A gas laser tube being tested in the laboratories of the English Electric Valve Company at Chelmsford. The Brewster window can be seen at each end of the tube

THE GAS LASER

The most common form of gas laser employs a gas discharge tube filled with a mixture of helium and neon at a low pressure. The electrical discharge in the gas provides a large number of free electrons travelling at high speeds. These electrons give up their energy to helium atoms which in turn pass on the energy to the neon atoms.

The neon atoms have suitable energy levels for laser action to occur with either red light or with near infra-red light or in the far infra-red region. If the mirrors are chosen so that they reflect almost all the red light which falls on them, the output from the laser will consist of red light. Another type of mirror must be selected for the near infra-red and yet another type for the far infra-red region.

The length of the gas filled tube is normally about 100cm. The power input is often about 100 watts of radio frequency power at about 27Mc/s. Some lasers are powered by a d.c. supply, but heated cathodes must then be employed.

The amplification obtained each time the light passes through the gas filled tube is only a few per cent, therefore it is essential that little light is lost at the mirrors.

Specially designed mirrors with suitable dielectric coatings are required; they reflect about 99 per cent of the light incident upon them. The mirrors are often placed outside the gas discharge tube so that they can be aligned more easily (Fig. 4).

In this case the ends of the tube must be fitted with windows cut to the "Brewster" angle so that reflection losses are minimised. The Brewster angle is the angle whose tangent is equal to the refractive index of the material concerned—in this case the glass at each end of the tube.

Portable d.c. gas laser and drive unit developed by Scientifica & Cook Ltd.

Only light polarised in one particular plane can pass easily through the Brewster windows and hence it is only in this plane that the light is adequately amplified for laser action to occur.

The output from a helium-neon gas laser, operating in the visible region of the spectrum, appears as a bright red circle if it is allowed to fall onto a sheet of white paper. The output is typically some tens of milliwatts and this is not enough to burn the skin. However, great care should be taken to ensure that the light does not enter any person's eye, even after being reflected from a metallic object (see Part 2 next month).

It has been suggested[1] that the gas laser will be commonly used by the amateur experimenter and the transmitting "ham". The writer does not share this view.

Lasers can be used to carry information only between places which are in a direct line of sight of one another and in fog or mist cannot be employed. However, it might be possible for professional communication links using lasers linked by pipes to be established to prevent interference from fog, but amateurs will not be able to employ such methods.

Although the gas laser is probably the easiest type of laser for the amateur to construct,[2] it is nevertheless a very difficult task to make one. The gas filling is fairly critical and suitable high vacuum apparatus and gas handling equipment is essential. Filled laser tubes which have been tested can be purchased, but are not cheap by the standards of the amateur enthusiast.

Similarly the mirrors are also expensive. The total cost is not likely to be less than about £120 and in addition a unit to supply the radio frequency or other power will be required. The construction of a laser by the amateur is therefore a project which requires a considerable amount of thought before it is begun.

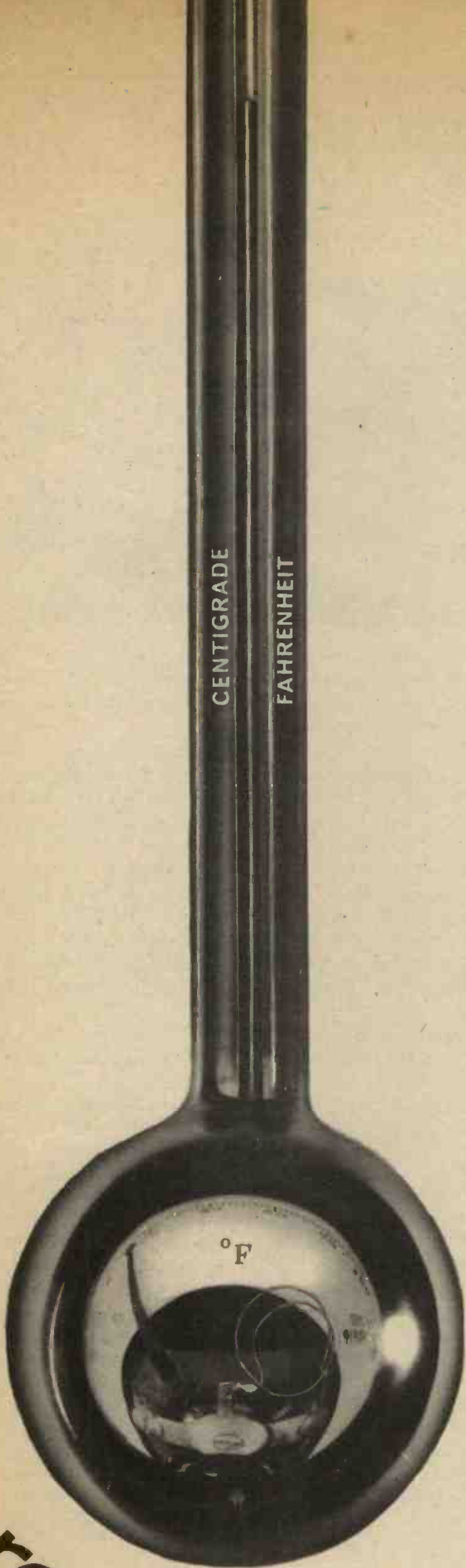
Next month we will have a look at ruby lasers, semiconductor lasers, and the safeguards necessary when working with lasers generally.

References

1. **Leinwoll, S.** Lasers. *CQ*, Vol. 20, No. 9, September 1964, page 32.

2. **Strong, C. L.** How a Persevering Amateur can build a Gas Laser at Home. *Scientific American*, Vol. 211, No. 3, September 1964, page 227.

remote temperature



KEEPING control on the temperature of a greenhouse, hot water tank, loft, or any environment where drastic temperature changes can lead to damage, is sometimes done with a thermostat. But where this is either inconvenient or non-existent, some means of monitoring environmental temperature may be necessary.

The obvious solution, on first thoughts, is the conventional thermometer, but how often does one wish to climb up into a loft, or go out in cold weather to a greenhouse, just to see if heat is being maintained?

Perhaps then some method of monitoring in a remote position is desirable. One cannot haul in a thermometer by a rope and pulley system, so the best thing is some electronic device capable of indicating temperature at almost any reasonable distance from the measuring locality.

A pair of wires are required from the place of measurement to a central point. The wires are connected to a thermistor (negative temperature coefficient resistor) whose resistance varies with temperature. This variation alters the mark/space ratio of a pulse generator; the mean voltage level output is displayed on a meter.

The main circuitry utilises a multivibrator and a monostable trigger in such a way that the current consumption is kept low, so that a battery can be used for powering the device.

FREE RUNNING

Transistors TR1 and TR2 form a free running multivibrator at a frequency of 50c/s. The cycle time of the multivibrator is determined from the formula $t = 0{\cdot}7(C_1 + C_2)(R_1 + R_2)$. See Fig. 1.

The waveform at the collector of TR2 is shown in Fig. 2a, this is fed via C3 to the base of TR3. The negative going square wave is differentiated by C3 and the input impedance at TR3 base.

As shown on the waveform the negative going wavefront is slow but the positive going wavefront is fast, therefore only the positive going wavefront will appear at TR3 base. This will switch TR3 off and by coupling from TR3 collector to TR4 base via R8 and using a common emitter resistor R9, TR4 will switch on.

TR3 will remain in the off condition and TR4 in the on condition until C4 charges towards the supply voltage via X1, VR1, and R6. TR3 then switches on and in turn switches TR4 off.

The time that TR3 is held in the off condition is determined from the formula $t = 0{\cdot}7C_4R_x$, where R_x in this instance is the combined resistance of X1, VR1, and R6.

The nominal resistance of this thermistor (type A25) at 20°C is 200 kilohms. The "A" describes the type; the "2" is the first significant digit and "5" indicates the number of noughts following this digit. The thermistor is shunted by a 1 megohm potentiometer, thus enabling the temperature range required to be preset.

The output from TR4 collector is as shown in Fig. 2. This is fed via a capacitor C5 and d.c. restoring network D1 and D2, to a 100μA meter. The circuit has been

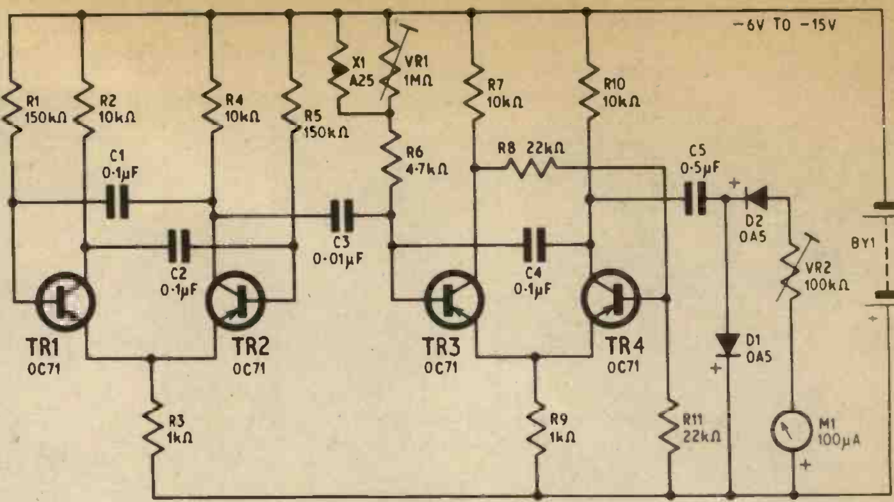


Fig. 1. Circuit diagram of the temperature monitoring instrument using a 100μA meter. An on/off switch may be inserted in series with the battery negative lead

designed to work with battery voltages between 6 and 15 volts and the consumption is only 3mA, thus giving a very long battery life as the circuit is only switched on when a reading is to be taken.

The self-heating of the thermistor due to the current flowing through it is negligible and settles down almost immediately.

Fig. 3 shows a typical resistance versus temperature curve for a thermistor and where more than one thermistor is being used it is necessary to match them as far as possible. As they are relatively cheap it may be possible to purchase more than this application requires and select one or more from them.

The transistors used in this circuit have no special requirements, the frequency of operation has been chosen low so that almost any type can be used to switch at this speed. Tests can be carried out with earphones at a frequency easily recognisable (50c/s). Transistors with a current gain in the range 30 to 150 will work suitably; these may be *pnp* or *npn* with the battery correctly connected.

If a 1mA meter is available and a larger battery drain can be tolerated, then the modification in Fig. 4 may be used. The circuit is basically the same; only component values have been altered.

CONSTRUCTION

Veroboard is a convenient method of mounting the components and a layout is shown in Fig. 5a with the underside view shown in Fig. 5b. Alternative methods may be preferred.

The thermistors are encapsulated in small glass tubes and should be suitably protected without interfering with the normal working conditions. If they are in a severe environment the leads should be protected to prevent corrosion. If they are immersed in water they should be contained in a sealed tube so that the water does not shunt the leads.

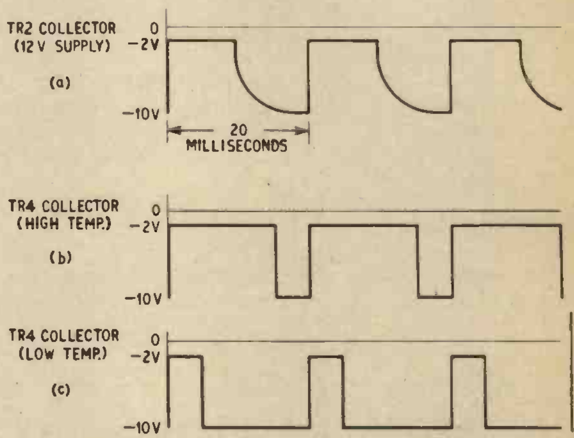


Fig. 2. Waveforms of the master pulse signal

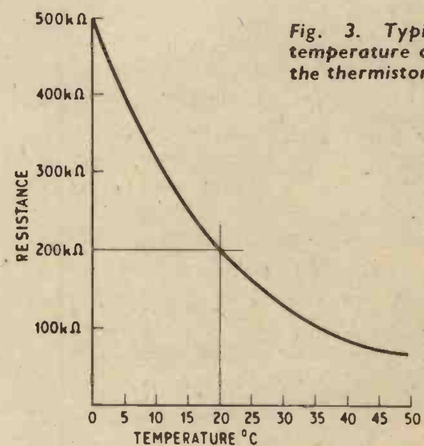


Fig. 3. Typical resistance temperature characteristic of the thermistor

measurement

By A.Thomas

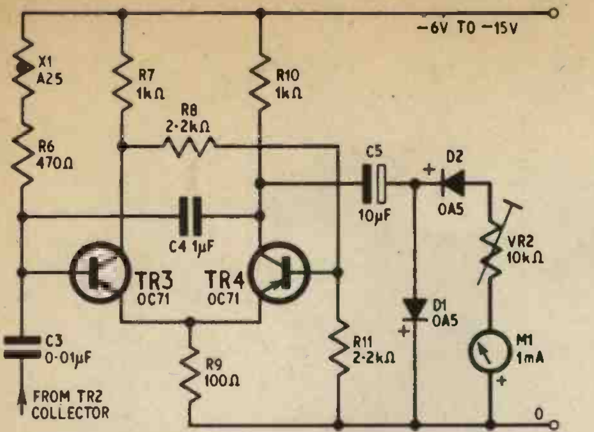


Fig. 4. Alternative circuit values of components for use with a 1mA meter

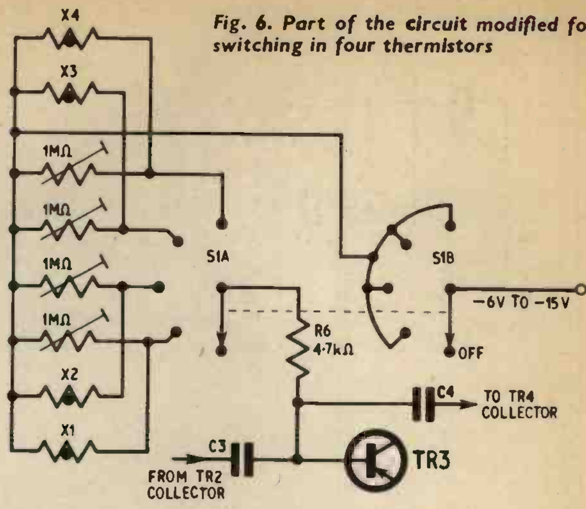


Fig. 6. Part of the circuit modified for switching in four thermistors

If more than one thermistor is used a rotary selector switch must be incorporated. The wiper would be connected to the negative supply line and each "way" tag connected to each of the thermistors used (Fig. 6).

The unit may be constructed in any small wooden or metal box, just big enough to house the component board, meter, and thermistor-selector switch if required. The front panel is shown in Fig. 8 with this selector switch mounted on it.

SETTING UP

Fig. 7 shows a bootstrap emitter-follower circuit which will enable a pair of headphones to be connected to any of the four collectors to determine if the stages are working. The emitter follower has the property of having a very high input impedance and a low output impedance; this is necessary so that the headphones do not load the circuit being tested.

A thermometer, a refrigerator, and/or a source of heat is required to calibrate the meter and thermistors depending on the ranges required. For general purposes a temperature range of 20–80°F may easily be accommodated. If selected thermistors are used, then the meter scale will be the same for each. The potentiometer VR1 provides adjustment of the temperature linearity and range, and may be replaced by a

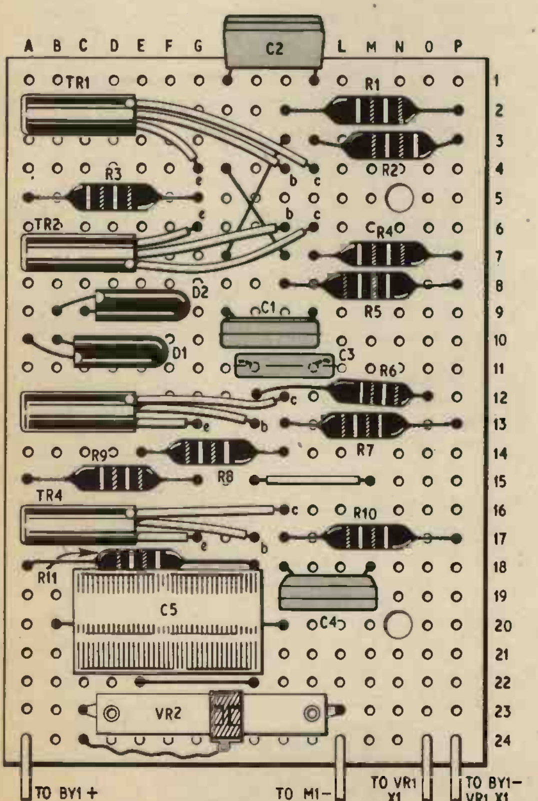


Fig. 5a. Component layout on the perforated wiring board

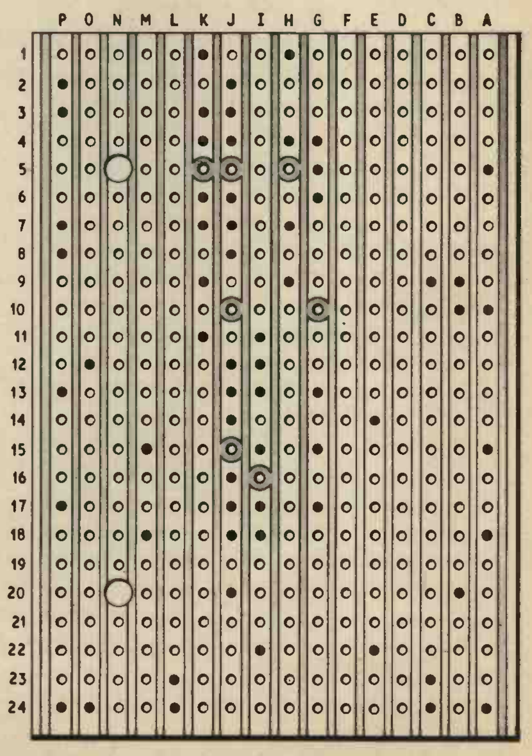


Fig. 5b. Underside of the board showing the breaks in the copper strips and connection points

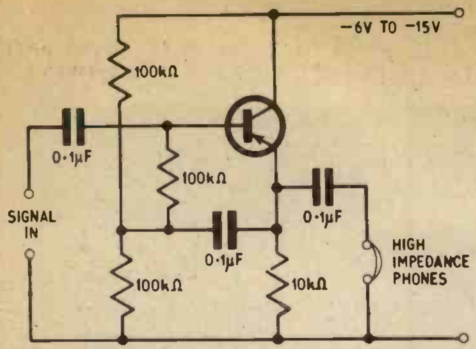
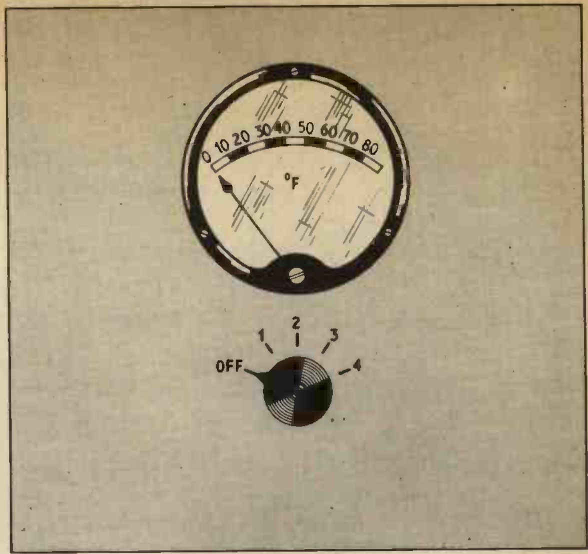


Fig. 7 (above). Suggested circuit for checking the functioning of each stage

Fig. 8 (right). Front panel layout



fixed resistor of the same value when known.

It is recommended that calibration of the thermistors is carried out all at the same time, the length of lead connecting the thermistors to the unit will not affect the calibration.

For calibration, the thermistors are supported in free space inside a refrigerator in close proximity to a suitable thermometer. Adjust the refrigerator control for a temperature in the middle of the range required (e.g., 50°F). On the range required VR1 is set to approximately 500 kilohms and VR2 is adjusted such that the meter reads half scale.

The refrigerator is then reduced in temperature to the lowest temperature reading required and, if this is on a suitable part of the meter scale, this may be marked. The thermistors and thermometer are then placed in cold tap water, this is then slowly heated until the highest temperature reading required is reached. This point may then be marked on the meter scale. The intermediate points can be marked as necessary.

It can be pointed out at this stage that a thermistor is not the only device that may be used to control this circuit. One can use a photo-sensitive cell, which changes resistance depending how much light falls on it, to give an indication of light intensity. ★

The greenhouse photograph on the cover is reproduced by permission of T. Bath & Co. Ltd.

COMPONENTS . . .

Resistors
- R1 150kΩ
- R2 10kΩ
- R3 1kΩ
- R4 10kΩ
- R5 150kΩ
- *R6 4·7kΩ
- *R7 10kΩ
- *R8 22kΩ
- *R9 1kΩ
- *R10 10kΩ
- *R11 22kΩ

All 5% ¼ watt carbon high stability

Potentiometers
- VR1 1MΩ linear carbon preset (see text)
- *VR2 100kΩ linear carbon preset

Capacitors
- C1 0·1μF polyester 125V
- C2 0·1μF polyester 125V
- C3 0·01μF polyester 125V
- *C4 0·1μF polyester 125V
- *C5 0·47μF or 0·5μF polyester 125V

(Lower voltage ratings can be used but should not be less than 15 volts)

Thermistor(s)
- X1 200kΩ at 20°C (S.T.C. type A25) (see text)

Transistors
- TR1 to TR4 OC71 (Mullard) (4 off)

Diodes
- D1 and D2 OA5 (Mullard) (2 off)

Meter
- *M1 100μA moving coil

Battery
- BY1 6 to 15 volts

Miscellaneous
- Veroboard 3·75in × 2·5 in, 0·15in hole matrix
- P.V.C. wire and box housing
- Rotary switch, optional (see text)

**Modifications for 1mA meter circuit*

Resistors
- R6 470Ω
- R7 1kΩ
- R8 2·2kΩ
- R9 100Ω
- R10 1kΩ
- R11 2·2kΩ

Potentiometer
- VR2 10kΩ linear carbon preset

Capacitors
- C4 1μF polyester 125V
- C5 10μF elect. 16V

Meter
- M1 1mA moving coil

MANY keen record collectors, non-technical amateurs as well as more knowledgeable enthusiasts, would gladly settle for a stereo system which, while clearly superior to the run-of-the-mill player, does not boast true hi fi facilities or performance. Compactness, relative simplicity and low cost are usually the main aims.

Unfortunately it is with this category of product that choice is so limited; to the few British made outfits there have only recently been added some isolated examples from foreign sources. They do, however, illustrate the trend in this field, particularly the use of transistors to produce very compact systems which are easy to instal, use and service.

STEREO SYSTEMS

Stereo systems by Arena and Veritone are typical. The Arena GF1225, imported by Highgate Acoustics of London, exemplifies the Scandinavian approach with its teak finish and clean styling. The lid of this neat player, as well as the base, is of wood and the overall height is only about 6in. Priced at 65 guineas, this unit incorporates the Garrard SP25 turntable and a 16-transistor amplifier with 6 watts output per channel.

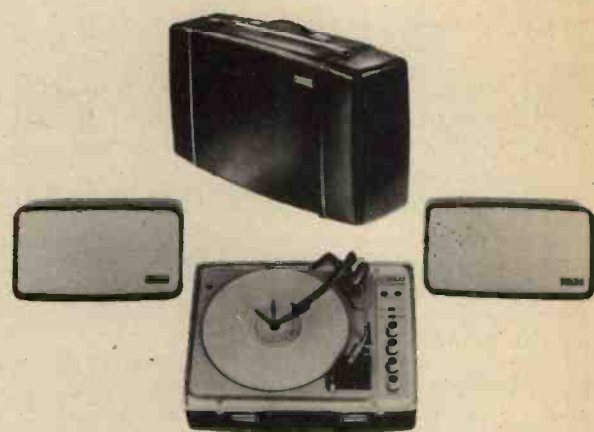
A real innovation in this class of player is the use of a magnetic cartridge—the Pickering V-15. Many small but specialised players would benefit from a pick-up of this quality, but it must be remembered that a magnetic (when compared with a ceramic) gives a low output and that consequently extra pre-amplification has to be built in. Speakers for the GF1225 are priced separately; the user can devise his own or choose from the Arena range.

The "Gemini" system by Veritone is basically similar but incorporates a record changer and is supplied with bookshelf speakers finished in rosewood. Each employs a 5in bass unit with high compliance cone plus matching tweeter. The transistor amplifier, rated at 5 watts output per channel, has the usual control complement and 200mV outlets for tape recording.

FROM THE U.S.A.

Three-piece music systems by KLH of America have been introduced here by agents P.J.N. Collaro Electronics. One of these, Model Eleven, packs away in suitcase form and weighs 28 pounds. It incorporates a Garrard auto changer, Pickering cartridge and a solid state amplifier rated, American style, at 7½ watts "music power" each channel. The speakers each house a single wide range drive unit of special type and the price of the complete system is £91 5s.

"Miniconic" semiconductor pick-up

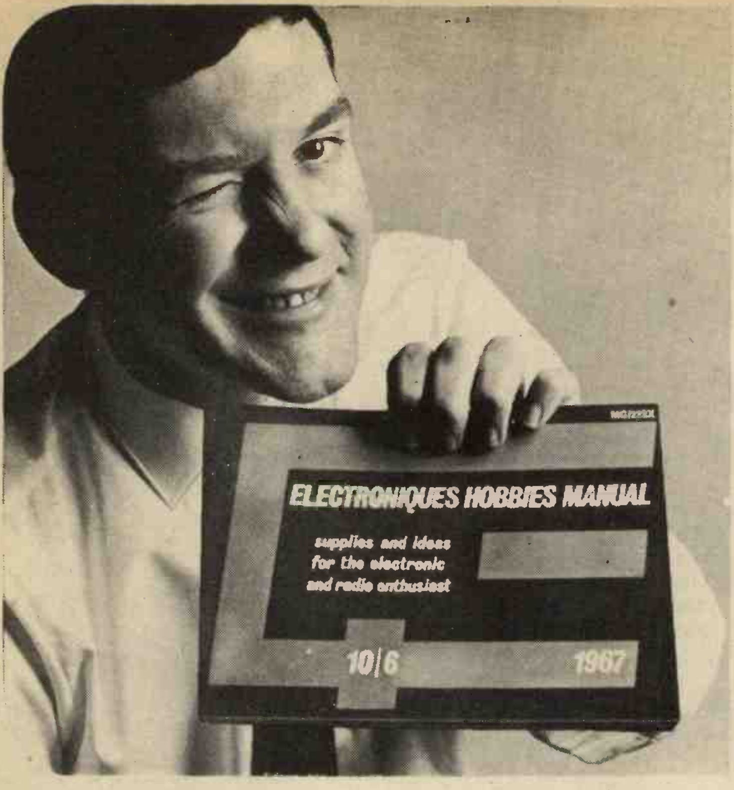


KLH Model Eleven stereo system

Other outfits from this firm are the Model Fifteen, priced at £99 19s including bookshelf speakers, and the more costly Model Twenty which, while still in compact, shelf-mounting form, includes a stereo f.m. radio tuner and connections for tape equipment and headphones. The multi-unit speakers included with this system are also available separately at £29 16s 9d.

A new version of the novel Larsen & Høedholt "Signalmaster" f.m. tuner arrived recently from Denmark via Britimpex Ltd. This small, portable and battery powered tuner (for mono only) can be used in a hi fi outfit, but is also invaluable for tape recording purposes or for connecting to the gram input of a radio set to upgrade performance. Headphones can be used with this system. The Mk2 version differs from the original "Signalmaster" in having automatic frequency control and inputs for either coaxial feeder or a telescopic aerial. Price is £21 16s 5d.

The Miniconic semiconductor pick-up, mentioned in the September *Audio Trends*, is now illustrated. This interesting device, different in principle from other pick-ups in general use, does not generate a voltage but instead produces a signal by modulating the supply from an external power source. The heads are examples of miniaturisation, featuring tiny moving mass, high compliance and wide response. Arm type TA-15 is shown in the picture.



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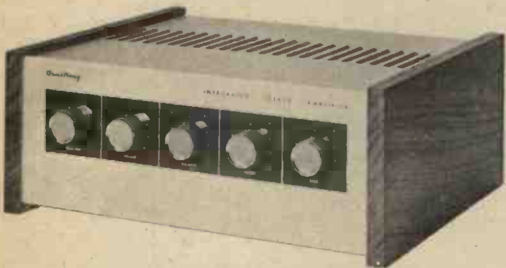

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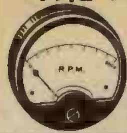

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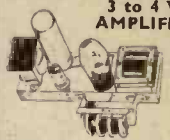

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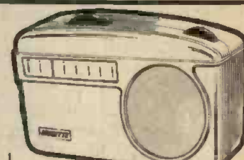

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TAPE RECORDER AUTO-SWITCH

by P. RUSH, B.A. (Cantab)

OFTEN the occasion arises when one wishes to hear a performance of a particular piece of music, or some other programme, broadcast when one is away from home.

Ideally, a request for another member of the family to record the programme is probably the best solution, but this is not always possible. An alternative method is described here whereby the tape recorder can be set to switch on at a pre-determined time and undertake the job automatically.

The circuit involved is not elaborate; although originally designed for a mains operated recorder, it is a simple task to adapt the technique to battery models.

Before contemplating the recording of any broadcast or recorded matter the reader should acquaint himself with the laws of copyright which are outlined at the end of this article.

CONTROLLED RELAY

The auto-switch circuit incorporates a means of switching on the tape recorder at the desired time and switching it off again at the end of the spool of tape. The two facilities can also be used independently. This device therefore gives even the most inexpensive of machines some of the features sometimes found on expensive recorders.

The switching of the tape recorder is done by means of a relay with heavy duty contacts mounted in the recorder itself. This relay is triggered into operation by the separate control unit, although if desired this, too, can be housed in the recorder. This arrangement means that the connecting cable will have to carry only low voltages.

A bistable circuit, designed to give a high on/off voltage ratio across the relay coil, forms the driving circuit. This is switched in one direction by a "hold" press button and a stop-foil at the end of the tape shorting an insulated bollard to earth. These two conditions switch the relay to the "on" position.

It is switched off by

(a) A "reset" press button;
(b) A watch movement closing a pair of contacts;

(c) The rise of the "start" button of the recorder caused by pressing the "stop". (The recorder used with the prototype had a spare single-pole two-way switch on the "start" button. This facility is not essential but it does mean that the recorder sets itself for normal operation on pressing the "stop" button after it has switched itself off at the end of a tape.)

CIRCUIT DETAILS

Fig. 1 shows the circuit diagram of the electronic control unit. The components specified assume that the relay used has a resistance of 165 ohms. The value of the resistor R4 is critical and may need changing slightly in individual cases.

The relay should be a 12V type but need not be exactly of the resistance quoted above. For lower values, R3 should be reduced in about the same proportion, and for higher values R3 can be raised. At the same time R4 will probably need slight alteration depending on the individual components. Correct operation is ensured when both push switches change the state of the binary circuit.

The watch movement is similar to those used in some transistor radio "alarm" clocks. At the time set on the dial a pair of contacts closes and opens again about half an hour later. This latter fact explains why the watch cannot be used directly with a power supply and the relay.

In the control unit the capacitor C1 charges up through resistor R1. When the watch contacts close C1 discharges through the base circuit of TR1, causing TR1 to switch on and TR2 to switch off. R1 is too large to prevent switching in the other direction by stop foil at the end of the tape, should this be necessary before the watch contacts have re-opened.

A watch movement suitable for use in the control unit can be obtained from Lasky's Radio who have a small quantity of these watches but, we are told, they are not all in good working order. However, they can supply three for a guinea so that the reader could probably make up a good one from them. Enquiries should be addressed to 3–15 Cavell Street, Tower Hamlets, London E.1. *before starting the project.*

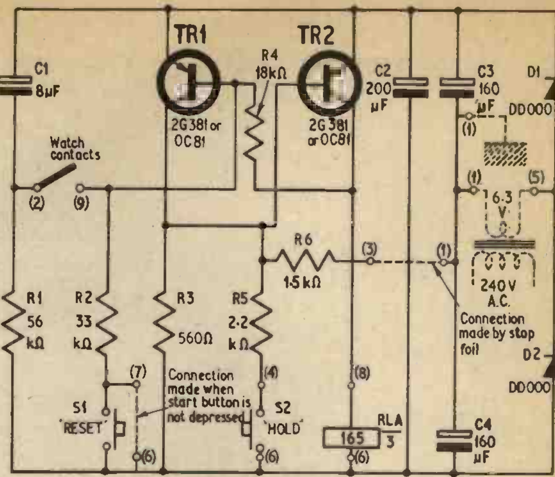

Fig. 1. Circuit diagram of the auto-switch. Parts shown dotted are connections in the tape recorder. The relay is also mounted in the recorder. Numbers in brackets refer to connections on the printed wiring board (see Fig. 4)

POWER SWITCHING

The power for the unit is conveniently obtained from the 6·3V heater line of the recorder, or a separate 6·3V heater transformer could be employed. It will be seen from the diagrams that one side of the heater supply must be connected to chassis. Centre-earth systems are unsuitable. In the former case, as in the prototype, the switching carried out by the relay has to be such that the 6·3V is still fed to the unit when the recorder as a whole is switched off.

Fig. 2a shows one way of doing this. Here switch S3 gives the option of leaving the valve heaters on while the relay is holding the h.t. and motors off by RLA1 and RLA3 respectively. Fig. 2b shows a simpler system using a separate 6·3V transformer for the control unit.

Some tape decks (in the author's case—the Collaro "Studio") have a spare uninsulated bollard or tape guide

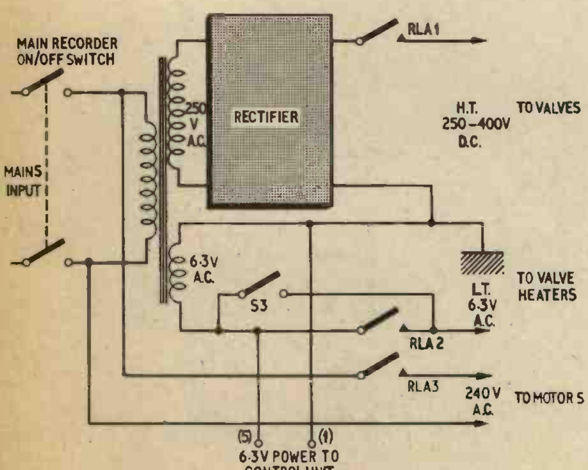

Fig. 2a. Method of obtaining power for the auto-switch using the recorder's own 6·3 volt heater supply. S3 is an extra switch. The heavy duty relay contacts are connected as shown

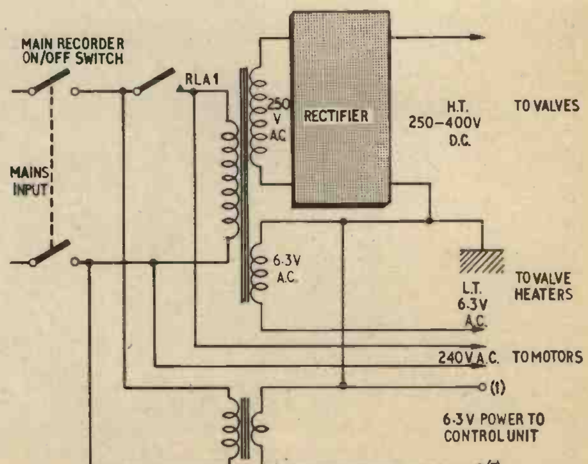

Fig. 2b. A more simple system of powering the control unit uses a separate 6·3 volt transformer. Only one set of heavy duty relay contacts are required, but in this case a time allowance must be made while the heaters warm up

WIRING AND PRINTED CIRCUIT BOARD DETAILS

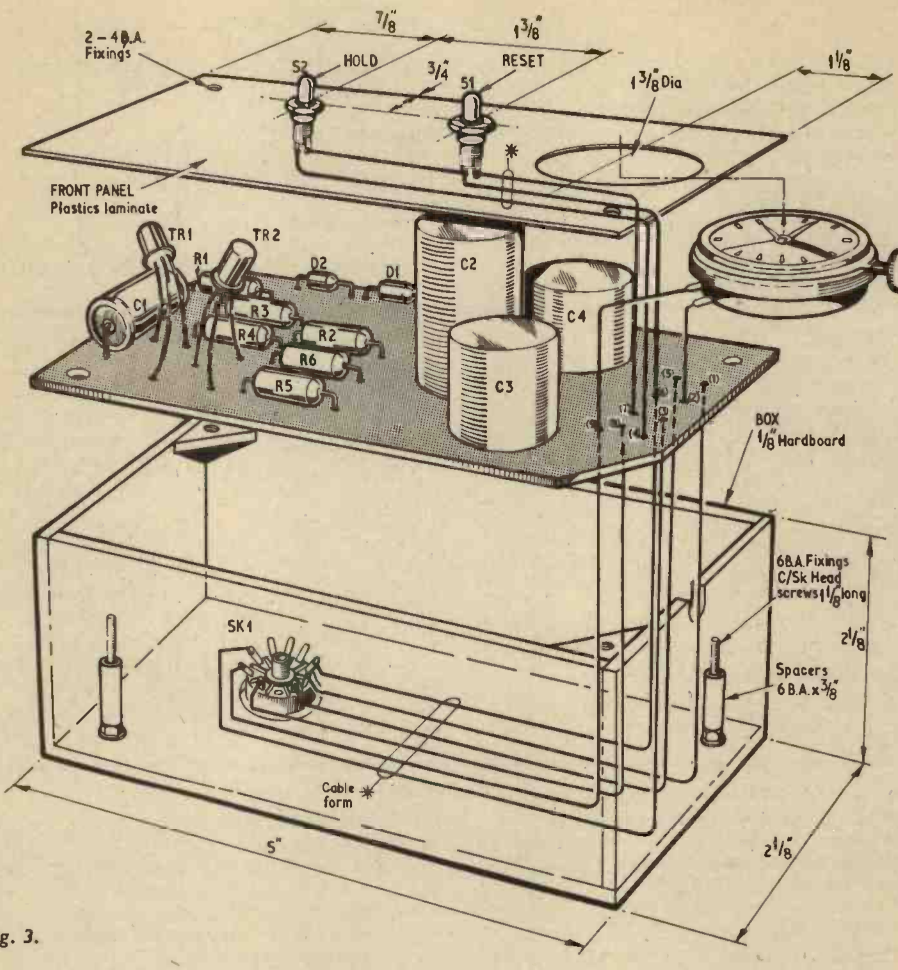

Fig. 3.

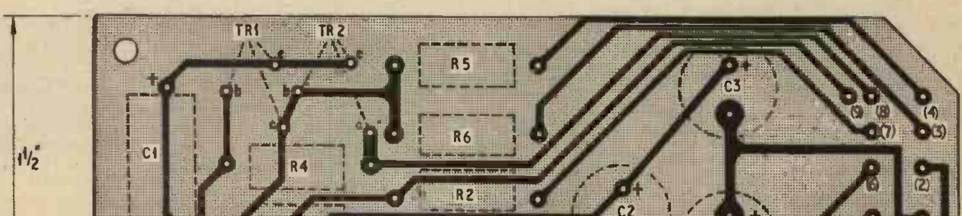

Fig. 4.

COMPONENTS . . .

Resistors
R1 56kΩ
R2 33kΩ
*R3 560Ω
*R4 18kΩ
R5 2.2kΩ
R6 1.5kΩ
All 10% ¼ watt carbon.
*See text.

Capacitors
C1 8μF elect. 15V
C2 200μF elect. 18V (or 2 × 100μF in parallel)
C3 160μF elect. 25V
C4 160μF elect. 25V

Transistors and Diodes
TR1 and TR2 2G381 *or* OC81 (2 off)
D1 and D2 DD000 (Lucas) *or* OA200 (Mullard) (2 off)

Relay
12V 150Ω (Omron type MK3) (see text) (Keyswitch Relays Ltd., 120–132 Cricklewood Lane, London N.W.2)

Switches
S1 and S2 Single-pole press on, release off push button switches (2 off)
S3 Single-pole, on/off switch mounted in tape recorder

Plug and Socket
PL1 and SK1 Multi-way (minimum 6 ways) e.g. B9A or B7G valveholder and plug

Miscellaneous
Printed circuit board 4½in × 1½in with etching chemicals. Watch movement with contacts (see text). Hardboard for box.

mounted near the heads. This should be insulated from the deck by a mica washer; the existing metal fixing screw should be replaced by a nylon screw of the same size. The bollard is now connected to a fine p.v.c. covered wire which is led through a small hole in the deck plate. This wire is connected to R6 in the control unit.

At the end of the tape about 6in of "stop" foil should be inserted. This will short-circuit the insulated bollard to chassis via another tape guide electrically connected to chassis by its metal fixing screw.

LAYOUT AND WIRING

Construction is very simple, the control circuit being made up on a printed circuit board and mounted in a small box with the push-button switches, watch and outlet socket.

Most of the layout and wiring details are shown in Fig. 3. The watch winder spindle is fitted in a slot at one end of the box, the watch itself being fitted in an aperture on the control panel. For a firm mounting it may be glued to this panel with an impact adhesive.

Fig. 4 shows the pattern of the printed circuit board with dotted shapes indicating the positions of the components. It is possible to redesign the layout to suit other kinds of wiring systems such as perforated board or Veroboard.

If printed circuit techniques are used, a special pack for the constructor can be obtained from some of our advertisers. The instructions included with the pack should be followed carefully. ★

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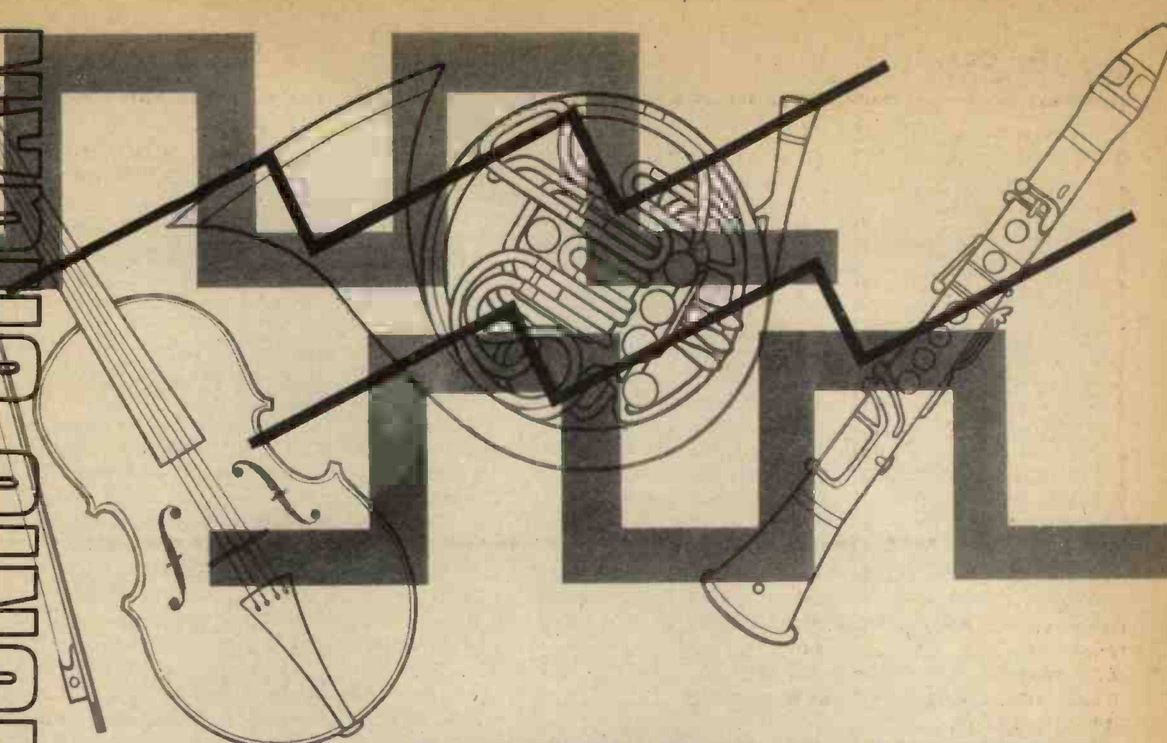
THE ELECTRONIC ORGAN



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

PART TWO

MUSICAL SOUND PATTERNS

Our opening article reviewed the historical background of the electronic organ; subsequent articles will survey the problems in a general sense, culminating in a considered design study for a romantic type instrument suitable for the small home. This organ will be featured as a constructional project shortly following the conclusion of the present series.

While these articles are essential reading for those who intend in due course to build the PRACTICAL ELECTRONICS Organ, it must be emphasised that they have been written so as to provide an introduction to the specialised techniques employed in this fascinating branch of the electronic art and are not limited solely to a discussion of one particular design.

ARTICLES about electronic organs all seem to be so anxious to get down to the circuit design that they often quite overlook the fact that we are attempting to produce a sound pattern having characteristics which can be described and identified in conventional musical terms.

But this is just where the experimenter may feel some uncertainty. Is it necessary, or even desirable, to have a 2ft piccolo or fifteenth, and what do these expressions mean? Apart from this, can we really produce the proper sound that would be heard from pipes bearing these names? So I feel that it is only right and proper that we should forget circuitry for a little and find out what we want.

DIFFICULTIES OF SIMULATION

There are several things to remember first of all. (1) If the reader wishes to make something that sounds like a church or concert organ, he will not be able to simulate the wind noise which is very prominent in this kind of organ. (2) All pipes have differing rates of speech, that is, for any stop the higher pitched pipes may sound instantly, the lower ones have some time delay. It is extremely difficult to imitate this electrically. (3) Only very small flute-like pipes and reeds of all kinds immediately sound the complete waveform; in all other cases some harmonic sounds first, and the spectrum is gradually built up, see Fig. 2.1. We cannot imitate this. Lastly, we must remember that every single pipe in an organ is its own complete harmonic generator, so that the fundamental adds to these harmonics and the builder can so proportion his pipes that any required harmonic structure can be formed. This is virtually impossible for us, since we can only generate a limited number of similar waveforms, from which by means of circuitry we can derive the sounds we want.

However, by *completely enclosing* all the pipes in soundproof boxes having adjustable louvred openings, some of the foregoing effects are reduced and this is the basis of the theatre organ. Organs have been built in which the best of both worlds have been combined, and this is what we will do when considering the design of a "popular" type of instrument; for the demands of the purist call for elaborate circuitry, whereas the romanticist is much more easily satisfied.

STANDARD ORGAN KEYBOARD

Now organs usually have more than one keyboard, which is called a manual. This is so that contrasting effects can be used together, a simple example being a melody with accompaniment. These manuals contain from 37 to 61 notes each, and the range of the notes is called the compass. There are 12 notes to each octave, but if we start on C then we end on B, so an extra note is always put in to make the compass C to C. The standard organ keyboard is 5 octaves, 61 notes.

PITCH OR FREQUENCY STANDARD

Some standard must be established for pitch, which is a subjective interpretation of frequency, and this applies in two ways: first, a standard for *tuning*.

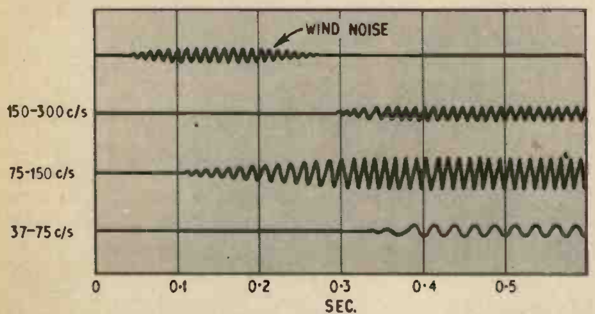


Fig. 2.1. ***This diagram shows how the sound builds up in a large organ pipe***
From Trendelburg, F.; Thienhaus, E.; Franz, E. Akust. Z, 1936, No. 50

Today this is always based on A=440c/s which is the third "A" up from the bottom of the keyboard, and you may ask why. This brings us to the second standard of pitch—that of the *basic* or *unison* pitch. For centuries this has been called 8ft pitch, because that is the speaking length of the longest open pipe which will sound bottom C on any manual, approximately 64c/s. Thus, by simple arithmetic, the octave above that would sound 4ft and the octave below, 16ft. So that if we had three pipes, one 8ft long, one 4ft and one 16ft, and sounded them all together, then provided they were all tuned to C we would hear three octaves from the one note. This variety in pitch is the very essence of organ design.

Note that these pitches do not imply any particular tonal quality; they may, and do, exist for all tonalities.

In a small organ, especially with amplifiers driving free cone loudspeakers in conventional enclosures, there is usually a tendency to emphasise the lower frequencies at the expense of the upper ones. To offset this to some extent, we introduce yet another pitch, 2⅔ft. This is the G above C 4ft, and produces sum and difference tones which, used with discretion, are of great value in a relatively simple organ. So, on the manuals we find 16, 8, 4, 2⅔ and possibly 2ft pitches, any or all of which can be sounded singly or in combination.

Normally the pedal clavier is used to provide the bass, and in small organs, always so. By popular usage, this keyboard plays one octave lower than the manuals, and it is the practice to confine it to 16ft pitch. But this is not a good thing, and we can vary this somewhat by introducing 8ft and even 4ft pitches by other means.

The other essential ingredient of the small organ is vibrato or tremulant. In a pipe organ, the mechanism used varies both the frequency and amplitude of the note. Vibrato adds character to "soulless" voices like the flute or tibia, and is really essential for romantic and popular music.

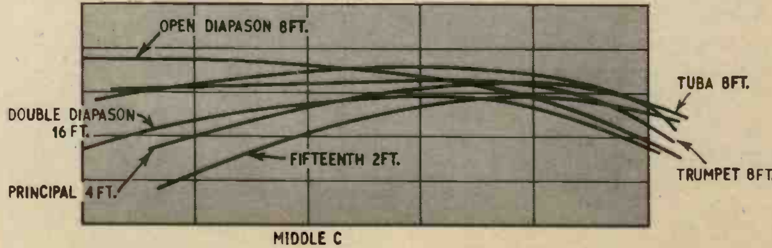
TONE COLOUR GROUPS

Of course, there are a vast number of other design features of the organ proper which could be explained, but they serve no useful purpose so far as readers of this journal are concerned. However, it seems reasonable to explain that the families of tone colour which we shall need can be divided into three—flute, string and reed. Within each category there are hundreds of possible variations in character, but we can note that the flute (essentially a small, smooth voice) can be expanded to form a tibia (which is the basis of the theatre organ) and further, to form a diapason (which is the basis of the church organ).

Strings are not susceptible to much variation except in pitch, but reeds can indeed be produced in many contrasts; oboe, clarinet, French horn, trumpet, clarion, etc. So that, bearing in mind the fact that any of these sounds can be produced in any of the pitches mentioned (except for reeds in the 2⅔ and 2ft range, where their upper harmonics would be beyond audibility), we shall not be so badly off for tone colours.

However, there must be a pattern on which to build possible combinations of "stops"; it would not do to play everything at 16ft pitch, nor would a solo at 2⅔ft accompanied at 16ft be very well received. We will attempt to explain how this is arrived at in due course, but if we look at the sound pattern of an ideal organ having the voices previously mentioned, and bearing in mind that loud sounds always mask quieter ones, then

Fig. 2.2. ***Relative loudness of well-voiced organ***
From Thienhaus-Willms, *Die Lautstarke von Orgelregistern*, Vol. 3, p. 284



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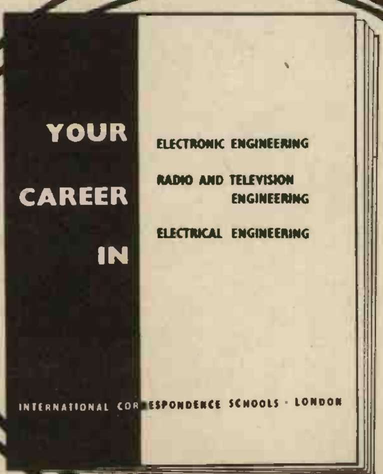

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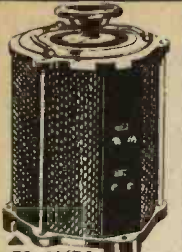

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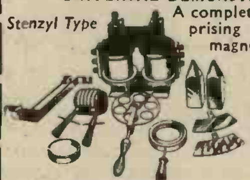

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if properly adjusted the spectrum of the organ should look like Fig. 2.2. These curves take no account of any acoustic reinforcement of the sound due to the building, this condition also applying almost certainly to the small organ for domestic use.

WAVEFORM GENERATORS

Now we said—or inferred—that in a pipe organ there was one pipe for every note of every stop. This is very largely true, though certain economies are possible. We cannot hope to do the same thing electrically, but in our ultimate design for an electronic organ we are in fact going to use a frequency dividing generator having 85 pitch sources which can be used to feed either one or two other manuals. Then there is a separate pedal generator, so that there will be square, sine and sawtooth waveforms separately available, and this will help synthesis since *all* voices are derived by subtractive methods—that is, removing unwanted harmonics from an initially complex waveform.

It is commonly assumed that flutes are almost sinusoidal, but this is by no means true. So to simulate flutes and tibias, one waveform generates f, 2f, 4f and a trace of 8f. To produce string tones, it does not matter much whether a sawtooth or square wave is used, the main characteristic being a weak fundamental and strong upper harmonics. See Fig. 2.3a. Smooth "reeds" like a French horn call for a sawtooth, because they have many even harmonics as well as odd ones, Fig. 2.3b. A clarinet does in fact contain traces of even harmonics, but is well synthesised from a square wave having only odd harmonics, Fig. 2.3c. And so on. More details will be given when appropriate.

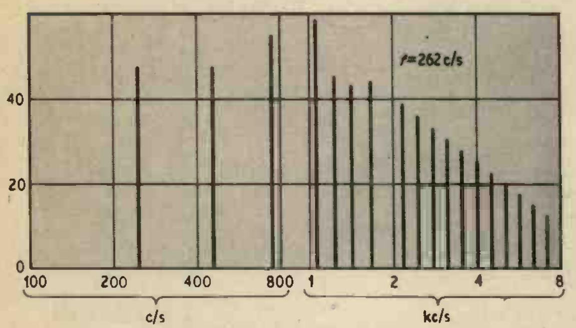


Fig. 2.3a. Harmonic content of a string tone organ pipe

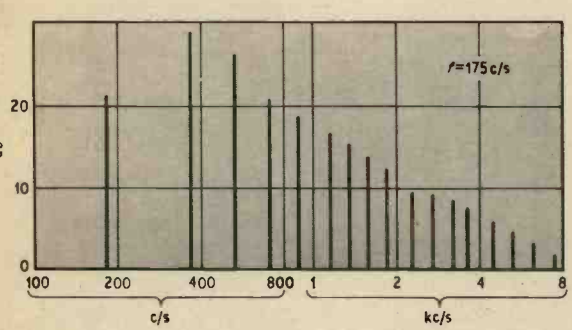


Fig. 2.3b. Spectrum of French horn

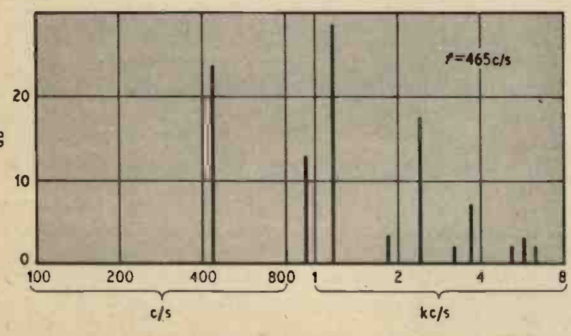


Fig. 2.3c. The organ clarinet spectrum
From Douglas, A., *The Electrical Reproduction of Music* (Published by MacDonald, London)

EXPRESSION OR LOUDNESS CONTROL

Variation of loudness in a pipe organ can only be accomplished by adding or subtracting stops, or by manipulating shutters which let more or less sound escape from a soundproof enclosure containing pipes.

The overall variation in loudness thus obtained is quite small, certainly by electrical means we can do much better and of course we can reduce the level far below that at which any pipe would speak (e.g. for headphones). To increase the range of expression on this organ we couple the lower manual and pedal stops to one expression control, the upper manual to another. We thus avoid the accompaniment "hooting" when a solo is increased in volume, a common failing with small organs.

OCTAVE COUPLER

Finally, we do not often find couplers on this kind of organ. A coupler is a device which enables the player to add notes either an octave higher, an octave lower, or from another manual to those which he is playing. For example, if we depress middle C at 8ft pitch, then drawing the octave coupler adds the C above. Any chord played sounds the same notes in the octave above. Clearly this is a way to extend the apparent pitch range of the organ without extra generators. Naturally it cannot operate above the octave below the highest note unless the generators are extended.

In our particular instrument, the generators are extended: there is an octave coupler on the main manual, and a coupler transferring any stops drawn on this manual to the pedals when required. The harmonics thus made available reinforce the simpler tones of the pedal generator.

To sum up, therefore, in this instrument we shall produce pitch ranges of 16, 8, 4, 2⅔ and 2ft—though not on both keyboards—and these will be reinforced by the couplers above. Expression is applied to each manual independently, and there are two tremulants. The manuals are of full compass, 61 notes, and the pedals of 30 notes compass. This could be reduced to 25 notes if desired. The dimensions and other mechanical details are of full scale and equivalent to pipe organ practice. This makes it far easier to play. There are no loudspeakers in the console, which is the name given to the case enclosing the playing mechanism and, in this instance, all the generators, etc.

INSTRUMENTAL AND ORGAN SOUNDS

The reader will have seen, on commercial organs, the names and pitches of the various stops and must have noticed that some are familiar, some perhaps not. We must remember that even in the finest pipe organs, there is a great difference between the names of orchestral instruments appearing on stops and the actual sounds produced. Since an organ works on fixed wind pressures, there can be no variation in the character of, say, a trumpet such as is possible by a human being changing his wind pressure and the position of his lips. Further, the compass of pipes greatly exceeds that of any orchestral instrument, so that we find 61 trumpet notes against the 30 odd of the trumpeter. Thus, higher and lower notes are an extension to the instrumental range, so there are bound to be differences in the sound.

Then the way the sound starts and stops is quite different from the way an instrumentalist controls his strings or valves, and this leads to a major difficulty with most electronic organ systems—keying. This subject requires careful examination and we will commence to deal with this in the next article. However, to conclude this part we assume that stops marked *oboe*, *clarinet*, *flute*, etc. bear sufficient resemblance to these sounds as to be self-evident, whereas the organ tones proper, which we use and which are not to be found on any other instrument are as follows:

Open diapason. Found in 8 and 16ft pitches. A rather loud flute with strong harmonic development and very pronounced wind noise. Pipes always made of metal.

Stopped diapason. 8ft pitch and, if somewhat more powerful, found in 16ft pitch and called a bourdon. Mainly odd harmonics with a pleasing "hollow" tone. Pipes made of wood.

Principal, 4ft. An octave extension of the open diapason. Metal pipes.

Fifteenth, 2ft. An octave extension of the principal. Metal pipes.

Dulciana. 8ft and occasionally 16ft. Quiet string-toned stop of great value. Metal pipes.

Vox Humana 8ft. A curious throaty sound, having a possible slight resemblance to a male singing voice. This is a reed, not of much value in itself but very useful to add to other sounds like the stopped diapason, tibia, etc. Metal pipes of ½ or ¼ normal length.

No provision has been made in this proposed design for such non-tonal effects like percussion, sustain, reverberation, etc. However some of the latest circuits for producing these adjuncts will be explained after we have tackled the keying problem; the individual constructor can then decide if any of these facilities should be incorporated in his own instrument.

NEWS BRIEFS

The Royal Television Society

It was announced on October 21 that Her Majesty The Queen has been graciously pleased to command that the Television Society shall now be known as the Royal Television Society.

This is a great honour for the first Society in the world for the furtherance of study and research in television and allied subjects. Since it was founded in 1927 it has had many eminent workers in this field amongst its members.

The Society has in more recent times broadened its scope to include the artistic side of television—programme production and direction. The various specialised applications of television are covered, as are also the servicing and retailing aspects of the receiver market.

Applications for membership are accepted from all branches of the profession. Full particulars are obtainable from the Secretary, 166, Shaftesbury Avenue, London, W.C.2.

New Postal Supply Service

A new component and equipment supply service for the radio and electronics hobbyist has just been brought into operation by Standard Telephones and Cables Ltd. The new organisation trades under the name of Electroniques, the original firm of this name now being an entirely owned subsidiary of STC. The services previously offered to the amateur by Electroniques are now reinforced by the facilities of Electronic Services Division of STC.

The aim is to provide a rapid postal supply service covering a vast selection of equipments, components, tools and accessories. Most of the STC "professional" components will be available to individual amateurs as well as many other items produced by other electronic firms.

A "Hobbies Manual" containing full details of all items offered, plus constructional tips and useful circuits for the amateur, will be published shortly.

Enquiries regarding this service should be addressed to Electroniques (proprietors STC Ltd.), Edinburgh Way, Harlow, Essex.

Electronic Control of Zinc Smelting

The largest automation project yet undertaken in the non-ferrous metals industry is to be carried out by Elliott-Automation and the Imperial Smelting Corporation.

The project involves the application of on-line computer control to the large new I.S.C. zinc-smelting plant which is under construction at Avonmouth near Bristol. In addition to the computer, the Elliott-Automation Group is providing plant instrumentation, control equipment and materials-handling systems worth almost £1M.

Thought for the Month!

How long will it be before bank services direct to the public are automated? We have already computers doing a large task in accounts ledgers, but what about the friendly bank manager to whom we look for an overdraft?

Well, this rather staggering thought occurred to us when we learned that a computer controlled money lending machine advances loans of £20 to Japanese civilians holding credit cards with the Japanese Credit Centre in Tokyo.

This *could* be the answer to those banks who wish to close on Saturday mornings, for two-thirds of the borrowers used the machine out of normal office hours. This machine also issues a note saying: "Thank you very much"—in Japanese, of course.

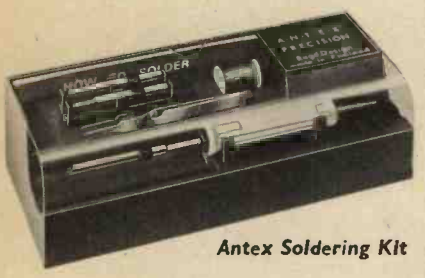
MARKET PLACE

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

LAST MINUTE GIFTS

Now that we are in the full swing of the festive season, most of us are surely joining the mad last minute rush to find a suitable present for members of the family. It seems appropriate to devote our first *Market Place* feature to a few suggestions that would make ideal gifts.

With the present day trend of technical achievements there are many good educational construction kits and these make excellent gifts to start the boys on their first steps into the science of electronics.



Antex Soldering Kit

CONSTRUCTION KITS

Typical of these construction kits are the **Philips** Young Engineer Kits. There are four basic kits, The Mechanical Engineer, The Radio Engineer, The Interphone Engineer, and The Electronic Engineer. The price ranges from £5 6s 0d to £10 0s 3d. The Electronic Engineer kit, basic version type EE8, enables eight electronic models to be made-up and with an "add-on" A20 or EE20 kit these can be extended to 21 different models. Circuits such as a direction finding two transistor radio, a gramophone amplifier and morse oscillator can be made and—with the additional kit—a one octave electronic organ.

Also available from **Philips** is the EL7500 Microphone assembly kit which is another construct-it-yourself item. This kit cost 7 guineas and contains everything needed to assemble and use the microphone, including a stand for table or desk use, and a cord and clip for wearing around the neck.

Another very good selection of construction systems are those from **Radionic Products Ltd.** Their kits range from a simple diode detector receiver (today's equivalent of the old "crystal" set) to a digital computer. Each system is marketed in the form of construction sets and each set includes a handbook, comprehensive building instructions and a series of circuit sheets. The latter includes theoretical circuit diagram, explanatory notes for each circuit and an annotated diagram of the component layout and connections.

The advantages of the Radionic system is that the circuits are, where possible, laid out in close conformity with the theoretical circuit diagram on a transparent panel, and can be followed reasonably easily. Also, the circuit sheets are designed on a progressive basis from the simplest to the most difficult circuit, which is ideal for the beginners. A price list of complete sets are available from **Radionic Products Ltd.**, Stephenson Way, Three Bridges, Crawley, Sussex.

Neither the Radionic nor Philips kits employ any soldering, eliminating precautions against damage tc components from overheating.

SOLDERING

However, soldering is one of the many techniques that have to be mastered at one time or another by anyone involved in constructing electronic circuits. Two soldering kits which would make good presents are the "Marksman" from **Weller Electric Corporation,** price 38s 0d, and the "Precision Soldering Kit" from **Antex Ltd.**, price 49s 6d.

AROUND THE HOUSE

After junior, we come to the ladies of the house; something reasonably different from the usual gift would be a cassette tape recorder. These recorders are very versatile, being battery powered, with mains units as an optional extra; they can be operated practically anywhere in the home or car. The ease of operation and the changing of cassettes is a simple process and should prove no problem to housewives, daughters or girl friends. Many large companies are now marketing cassettes of pre-recorded music by practically all the top artists. The "Musicassettes" are priced at 40s 0d each.

Now we come to the head(ache) of the house: finding something different each year is really a problem. But today we received the photograph of a collection of items which at first sight look completely unrelated to each other, but are in fact all transistor radios. Two that would make nice ornaments in the "den" are the "Old Parr Whisky Bottle" and the "Car Wheel and Tyre". A complete price list and address of the nearest stockist is available from **Denham & Morley Ltd.**, 173–5, Cleveland Street, London, W.1.

As a last resort, but surely appreciated just as much, would be a year's subscription to PRACTICAL ELECTRONICS for the small sum of 36s 0d to any part of the world.

Philips Electronic Engineer Kit

Elizabethan LZ9102T Cassette Recorder

"Musicassettes" by Philips

Novelty Radios Imported by Denham and Morley

MODEL CONTROL AMPLIFIERS

Last of a Short Series on Miniature R/C Designs

By D. Bollen

THE function of amplifiers in model radio control is to convert the low power signal from a receiver to a large d.c. current change, capable of energising a relatively insensitive relay or, in some cases, a motorised servo or escapement directly. This they must do without responding to spurious signals or background noise.

Although specifically intended for use with the receiver described in the November issue of PRACTICAL ELECTRONICS, the following units may be coupled with other receivers and with commercially manufactured equipment when additional controls are to be fitted.

AMPLIFIER "A"

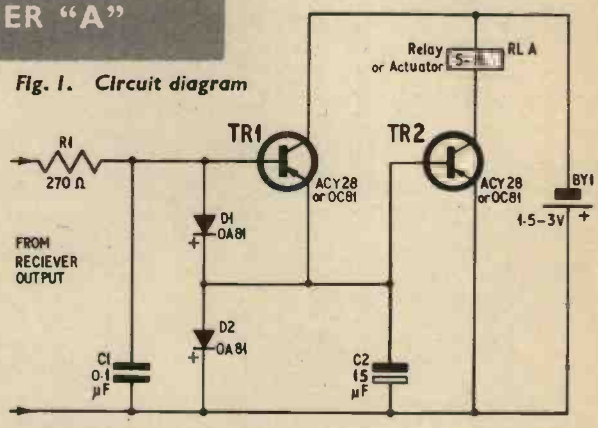
Fig. 1 shows the circuit diagram of a dual purpose amplifier designed to feed either a low resistance relay or an escapement. A photograph of this design is shown in the heading picture. It will be seen that only seven components are used and no transformer is required. An input of 50mV will cause a current change of 30mA, and the current gain is approximately 35dB.

The maximum current change is 250–300mA with the transistor specified for TR2. If small motors are to be driven by the amplifier TR2 should be replaced by a transistor of greater power handling capacity, such as OC81 or a power transistor.

With no signal on its base, TR1 remains cut off and so, therefore, does TR2, which passes a fraction of a milliamp leakage current. When an audio frequency signal is passed to TR1 base both transistors conduct—TR2 heavily—assisted by the action of diodes D1 and D2. The diodes, incidentally, also serve to stabilise the amplifier against the effects of temperature.

Inevitably the receiver will produce some noise, picked up on the base of TR1. This causes a slight bias to be applied to the amplifier, raising the stand-by consumption to approximately 6mA, well below the figure likely to cause relay chatter. This drain has a negligible effect on the life of the battery employed.

Fig. 1. Circuit diagram



BAND PASS FILTER

To reduce noise to a minimum, and to favour only the desired audio tone which activates the amplifier and relay, the overall response is tailored to give the curve shown in Fig. 2.

Capacitor C2, bypassing the emitter load of TR1, is of a small enough value to attenuate the lower audio frequencies, while still providing enough capacitance to smooth the raw d.c. pulsations resulting from a rectified a.c. signal. The input network, R1 and C1, filters out the high frequencies.

It will be seen that the peak response occurs in the region of 750 c/s and reasonable rejection of noise and interference may be expected. The low pass filter

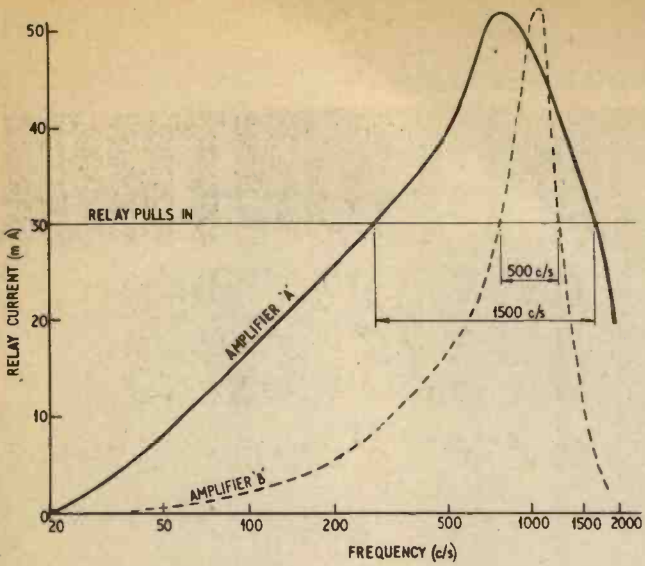


Fig. 2. Frequency response characteristic filtered to operate the relay over a narrow band

COMPONENTS . . .

Resistor
R1 270Ω 10%, $\frac{1}{10}$ watt carbon

Capacitors
C1 0·1μF ceramic 10V
C2 15μF elect. 15V

Transistors
TR1 and TR2 ACY28 *or* OC81 (Mullard) (2 off)

Diodes
D1 and D2 16P10 (Radiospares) (2 off)

Relay
RLA 5 to 15Ω (see text)
Reed switch type RS/2 (Cockrobin Controls)

Battery
BY1 1·5V *or* 3V (one or two pen-light cells)

Miscellaneous
S.R.B.P. sheet 1in × 1in
P.V.C. wire

also effectively removes the quench component of the signal. In extreme cases of interference when, for example, an old electric motor is sited close to the receiver, R1 may be replaced by a variable resistor of up to 10 kilohms. This acts as a sensitivity control and should be preset to just below the point where interference triggers the relay.

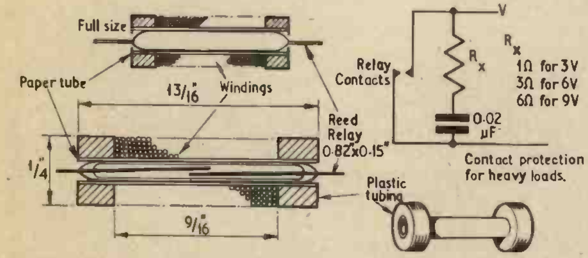


Fig. 3. Construction details of a suitable reed relay coil with suppression circuit for the contacts

DRY REED RELAY

The dry reed relay used in the original model deserves an individual mention, mainly by virtue of its simplicity and small size. Details are shown in Fig. 3. A gummed paper cylinder, fitted with plastic cheeks, acts as the bobbin on which is wound 600 turns of 40 s.w.g. enamelled wire, giving a d.c. resistance of 15 ohms. The pull-in sensitivity of the relay alone is under 20 milliwatts and the speed of operation better than 1 millisecond.

In circuit, TR2 dissipates some power giving a total of 40 milliwatts including the relay. The speed of response is limited by the decay time of C2 which works out to around 0·01 second.

The recommended long-life contact current, for the particular dry reed used, is 100mA. However, the reed is quite capable of handling heavier loads, such as small electric motors with a switch-on surge of 1 amp, in normal circumstances where the relay does not operate continuously at high repetition rates and where contact arc suppression is incorporated.

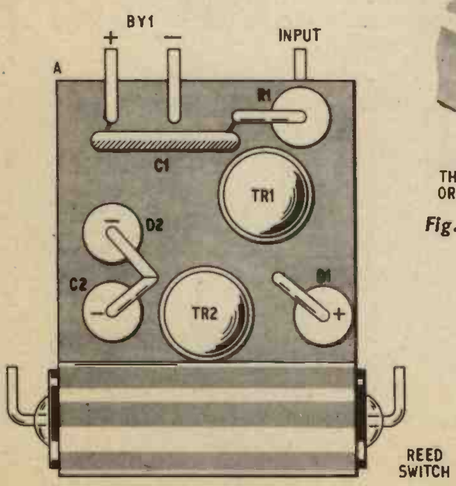


Fig. 4a. Component layout

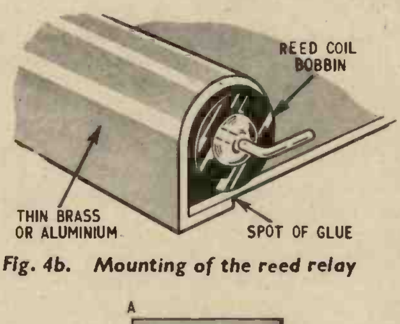


Fig. 4b. Mounting of the reed relay

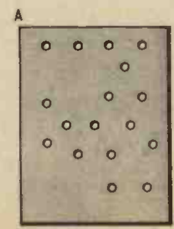


Fig. 4c. Full size drilling template

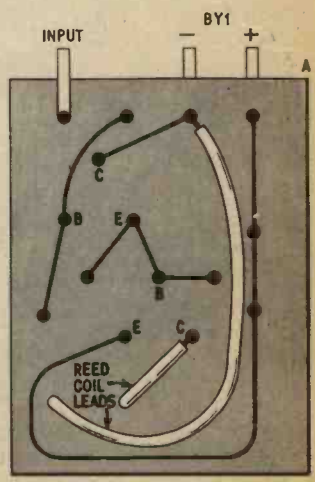


Fig. 4d. Underside wiring

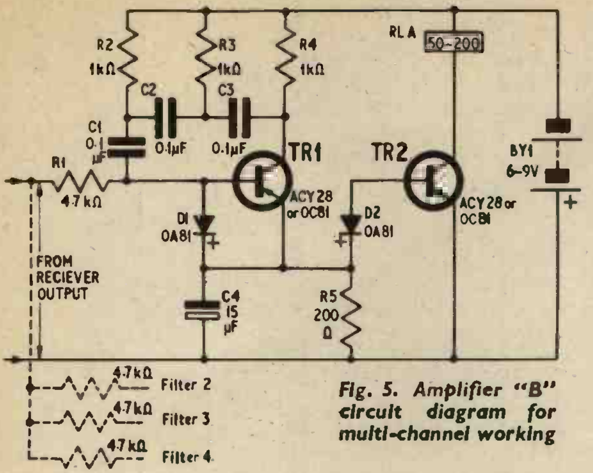


Fig. 5. Amplifier "B" circuit diagram for multi-channel working

COMPONENTS . . .

Resistors
R1 4·7kΩ R4 1kΩ
R2 1kΩ R5 200Ω
R3 1kΩ
All 10%, $\frac{1}{10}$ watt carbon

Capacitors
C1 0·1µF disc ceramic 20V
C2 0·1µF disc ceramic 20V } (Radiospares)
C3 0·1µF disc ceramic 20V
C4 15µF elect. 15V

Transistors
TR1 and TR2 ACY28 *or* OC81 (Mullard) (2 off)

Diodes
D1 and D2 16P10 (Radiospares) (2 off)

Relay
RLA 50 to 200Ω (see text)

Battery
BY1 6 *or* 9V (type PP5 or PP3)

For multi-channel working the amplifier must discriminate between different tones, responding only to the one to which it is tuned. Neglecting for the moment reed operation rather large ferrite pot-core inductances are normally employed to resonate at the selected frequency.

As a separate amplifier is needed for each channel, obviously its individual size and complexity will be multiplied by the number of channels required. It is preferable to plan for a simple, basic unit on which to build if a reasonably compact ultimate assembly is to be achieved.

The circuit of Fig. 5 provides a useful and compact alternative to the inductive filter and, with a subminiature relay, can be built on a panel less than 1in square.

PHASE SHIFT

The phase shift network composed of R2, R3, R4, C1, C2, and C3, connected between collector and base of TR1, feeds back an in-phase signal at the resonant frequency, thus increasing gain. At other frequencies the feedback is out of phase, tending to reduce gain.

The rest of the circuit is similar to that in Amplifier "A" although, in this case, D2 (Fig. 1) is replaced by a resistor R5 (Fig. 5) and a diode D2 has been added in the base circuit of TR2.

The purpose of D2 may at first sight seem obscure, but it is, in fact, a useful one. At very low input voltages the d.c. resistance of this diode is high, around 10 kilohms in the forward direction, which reduces to about 200 ohms as the voltage increases.

When low level breakthrough occurs, as from an adjacent tone, the non-linearity of D2 assists in rejecting the unwanted signal and the overall effect is to sharpen the response of the circuit.

NARROW BANDWIDTH

Returning to Fig. 2, where the output of the amplifiers "A" and "B" are presented in similar low signal terms, with their relays set to operate at the same level as a datum for comparison, it shows that "B" has the much narrower bandwidth of 500c/s, resulting from selective feedback.

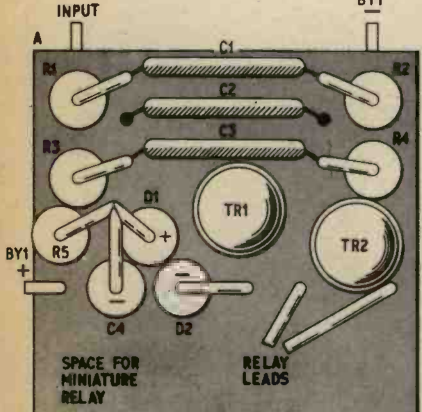
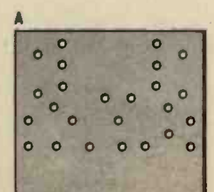
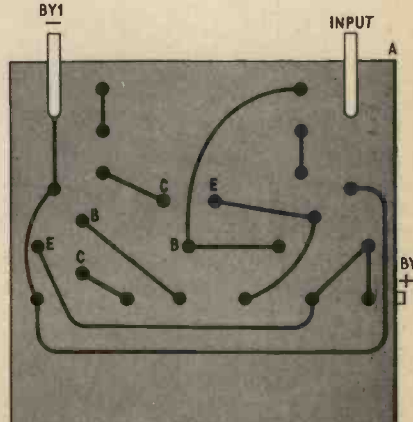


Fig. 6a (left). Component layout

Fig. 6b (below). Full size drilling template

Fig. 6c (right). Underside wiring





If amplifiers of ascending resonant frequencies are spaced at regular 1kc/s intervals, seven channels will be available up to 7kc/s, with 500c/s interval between tones. In practice it is better to make the spacing as wide as possible to prevent interaction at high signal levels, and five channels up to 7kc/s or higher would be a reasonable aim.

The tuned amplifiers may be cascaded, as indicated in the circuit diagram, each with its own feed resistor from the common source. To enhance the selectivity of the higher frequency filters, capacitors can be included in series with the 4·7 kilohm feed resistors.

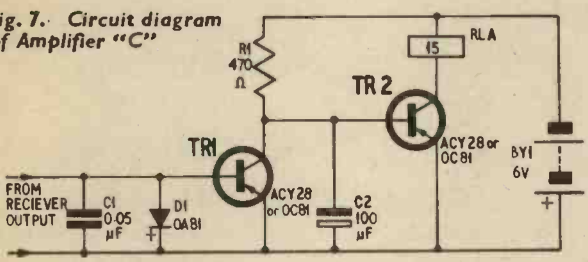
The capacitance value should be chosen to give a good current change without breakthrough from lower tones. Smaller values for C4 will also assist and should be found by experimentation.

The supply needs to be at least 6 volts to ensure sufficient regeneration from TR1, consequently a relay of 50 to 200 ohms d.c. resistance will be needed. It is possible that a dry-reed relay, wound with more turns, could be matched to the output, but a 120 ohm miniature multi-contact armature driven relay was finally employed with the prototype.

The circuit of Amplifier "B" is remarkably stable and free from any trace of self oscillation. The overall performance is largely determined by the current gain of TR1 and a minimum of 60 should be the aim. Stand-by consumption is only 0·5mA when connected to a working receiver and the total current change exceeds 50mA on signal.

AMPLIFIER "C"

Fig. 7. Circuit diagram of Amplifier "C"



Amplifier "C" adopts the principle formerly mentioned, responding to both modulated and unmodulated carrier. The circuit is given in Fig. 7.

With no signal the idling current may be set, by selection of C1, to a pre-arranged figure, say 50mA. This capacitor determines the noise bandwidth and hence the bias derived from noise. On receipt of a plain carrier the current rises to 100mA, and falls to 12mA when a tone is sent.

Tests should only be carried out while Amplifier "C" is coupled to its receiver, otherwise TR2 could be overloaded when there is no noise bias of TR1.

If a polarised relay is used, adjusted so that its armature is central at the idle current level, tone or plain carrier commands will select one of two contact positions. For example, plain carrier may represent right and tone represent left, while no signal at all would select neutral rudder providing fail-safe operation.

COMPONENTS . . .

Resistor
R1 470Ω 10%, 1/10 watt carbon

Capacitors
C1 0·05µF ceramic 30V
C2 100µF elect. 15V

Transistors
TR1 and TR2 ACY 28 *or* OC81 (Mullard) (2 off)

Diode
D1 16P10 (Radiospares)

Relay
RLA 15Ω (see text)
Reed switch type RS/2 (Cockrobin Controls)

Battery
BY1 6V (four pen-light cells)

If slowly pulsed with mark/space tone and constant carrier from the transmitter, a proportional control will result.

In the event of a fault, switching the transmitter off would automatically centralise the rudder. Similarly, this amplifier could be incorporated with existing equipment to perform a corrective function when the

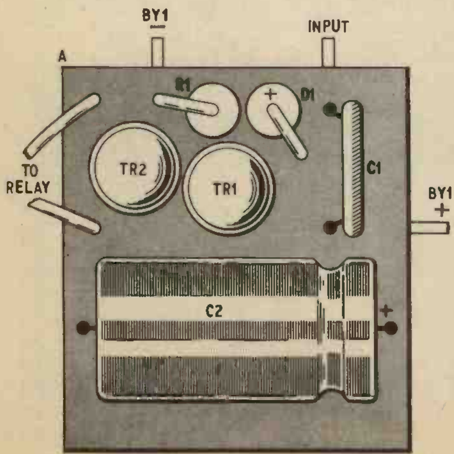
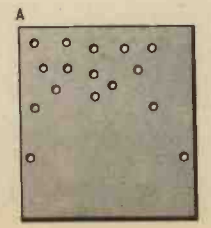
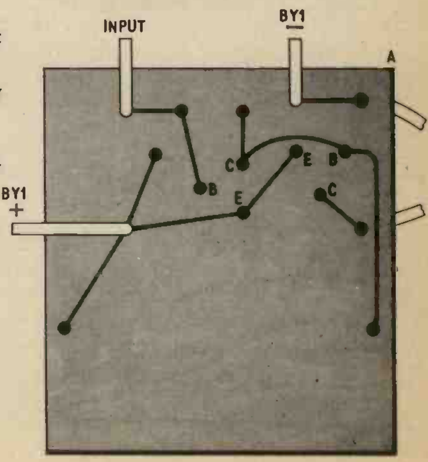


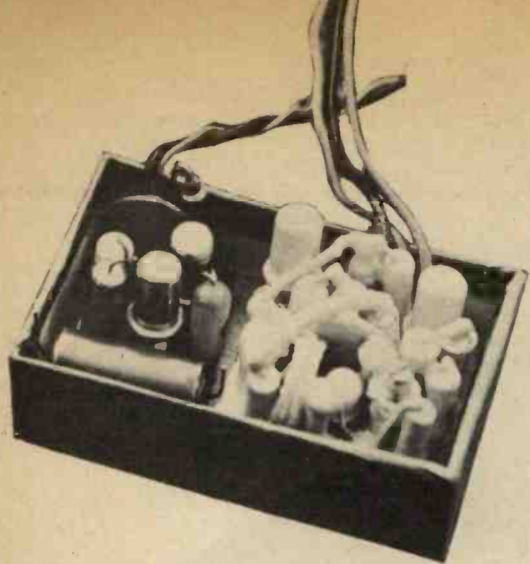
Fig. 8a (left). Component layout

Fig. 8b (below). Full size drilling template

Fig. 8c (right). Underside wiring







Amplifier "A" housed in a matchbox alongside the receiver described In Part 2

model goes beyond the range of control, triggered by the absence of carrier.

Although very simple, using few components, amplifier "C" needs careful setting up initially. Different receivers have different noise levels; the amplifier standing current can be expected to vary over quite a wide range before the right value for C1 is found.

If carrier only reception is wanted, the quiescent current may be set to a low level and the current rise resulting from a signal used to operate a relay in the normal way.

An inexplicable tendency to oscillate at a very low frequency (about 10c/s) was exhibited by the original amplifier but this in no way interfered with the correct working of the amplifier as the self-oscillation ceased with a signal, and did not interfere with the level of the standing current.

Relay details are the same as described under amplifier "A" for a 15 ohm type.

OTHER AMPLIFIERS

Considerable scope for experiment exists with the design of model control amplifiers, and the wide range of control gear now available renders each application novel in its requirements. Variants, of the amplifiers given here, may be found to suit alternative systems so no hard and fast rules of design exist.

One very promising field of investigation lies in the adoption of computer principles, the use of binary switches cascaded to give fast, positive selection of controls in sequence on one channel, with an automatic coder in the transmitter.

This could challenge the present superiority of multichannel systems as, theoretically, thousands of individual controls could be selected and set in operation within the space of a second.

Reed amplifiers have not been mentioned because they follow standard a.c. amplification principles. The reed occupies an intermediate stage in the chain of events following the receiver, needing either relays or additional amplifiers before the signal can be converted into mechanical motion. Amplifier "A" would make an ideal reed-follower if a slight bias of a fraction of a volt is switched on to the base of TR1 by the reed contacts. ★

Book reviews

OUTLINE OF RADIO AND TELEVISION

By J. P. Hawker
Published by George Newnes Limited
399 pages, 8¾in x 5¾in. Price 30s

THE AUTHOR is a well-known authority on communications techniques and has a style of writing which I find to be very clear and absorbing. In this excellent book he exhibits an art which is not often found in technical books—that is, the ability to describe his subject concisely, yet in detail, and to hold the interest of the reader.

Having read this appraisal, it will come as no surprise to most people that he has compiled, in nearly 400 pages, a great deal of readable information: from the fundamentals of electricity and atomic particles, through radio wave propagation to practical domestic systems (including colour television). Furthermore, being of allied domestic interest, tape recording principles and stereophonic sound are included.

The important point in a book of this nature is to be topical, and this Pat Hawker has done within the limitations of printing time. Let me hasten to add that the most recent of semiconductors (for example, thyristor, f.e.t., and unijunction transistors) are not explained because their applications are not usually to be found in domestic systems at present.

To anyone embarking on radio or television (or even electronics) as a career or hobby, this book is to be thoroughly recommended, and will always be used in later years as a valuable reference. Good value for money; ideal as a Christmas gift.

M.A.C.

HANDBOOK OF RELAY SWITCHING TECHNIQUES

By Appels and Geels
Published by Philips Technical Library
321 pages, 9½in × 6in. Price 72s

THIS book sets out to review the relay both as an isolated individual and as an active circuit element. Taken overall it does this very well and there are numerous examples and diagrams showing relays in almost every conceivable application, usually with detailed descriptions of each circuit.

There are chapters devoted to coding, decoding and checking circuits which convert data from one form to another, counting and storage systems, and certain types of computing, translating and identification arrangements, all using relays. Another chapter deals with switching algebra. Semiconductors appear in some circuits, these are mainly diodes but transistors occasionally appear.

Each chapter contains worked problems as well as extra questions at the end, the answers being given elsewhere. Some aspects seem rather over-emphasised, for example there is a fair amount of information on the design of relays which is useful to a manufacturer rather than a user. The mathematics tends to be slightly overwhelming, for example in the coding chapter, but most circuits can be understood without difficulty.

A very wide range of relay switching applications is studied here although it must be remembered that the modern trend in automation uses solid-state, rather than mechanical, switches. At 72s this book is expensive but it does provide a very fair introduction to relay circuits in general.

G.D.H.

BUYING SECONDHAND

Ed. by E. Rudinger
Published by the Consumers' Association
144 pages, 8in x 5in. Price 8s

A LITTLE out of the ordinary to find a book of this sort to be mentioned on this page, but it is suggested that readers contemplating buying secondhand radios, television sets, tape recorders, or record players should have some idea of what snags to look for. This is only one section in a book devoted to numerous consumer (or domestic) products.

The Consumers' Association was set up in the interests of the general public. The service provided in the publication of this book goes a long way to helping potential buyers.

Meetings . . .

THE INSTITUTION OF ELECTRICAL ENGINEERS

LONDON

Date: December 16
Title: Colloquium on "Properties and the Possible Application of Hard Superconductors"
Time: 9.30 a.m.
Address: I.E.E. Savoy Place, London, W.C.2. (Sponsored by the I.E.E. and the Institute of Metals)

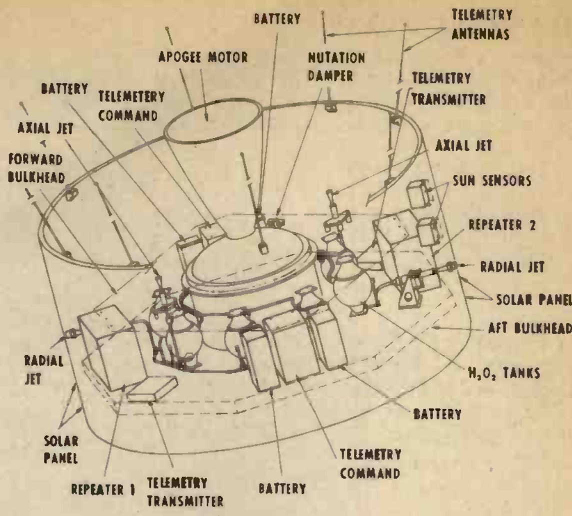
Date: December 29 and 30
Title: Waves, Waveguides and Radar
Prof. P. J. B. Clarricoates and Dr. J. R. Richardson
Time: 2.30 p.m.
Address: I.E.E. Lecture Theatre, Savoy Place, London, W.C.2.

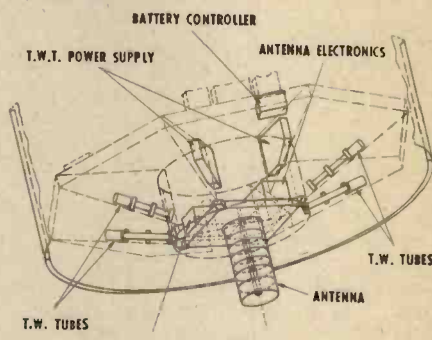
This lecture is intended for boys and girls of the fifth and sixth forms. Admission is free.
Applications for tickets should be made to the Secretary, Institution of Electrical Engineers, Savoy Place, London, W.C.2. *Note: state which day is required.*

SOCIETY OF ELECTRONIC AND RADIO TECHNICIANS

BRISTOL

Date: December 20
Title: Oscilloscopes and Their Practical Applications
R. A. Watson (Telequipment)
Time: 7.15 p.m.
Address: Royal Hotel, Bristol.



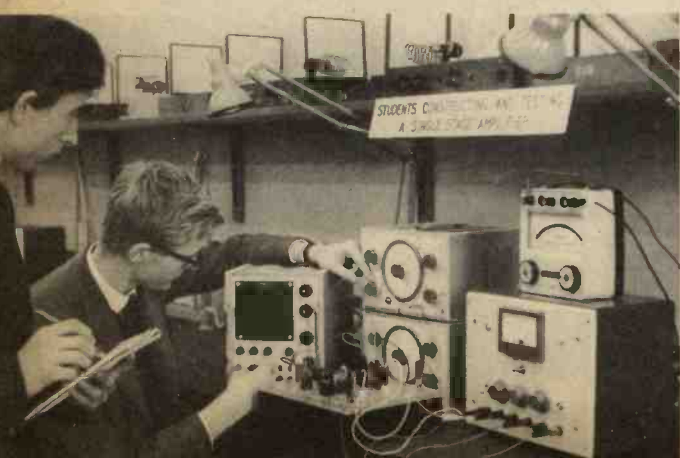


Later Birds are Up

Two new communications satellites, were launched recently with the aim of extending the range available for global communication links, and to support the Project Apollo. The first, *Lani Bird*, failed to kick into the correct orbit over the Pacific Ocean, but its equipment is functioning.

On the left we show the biconical horn antenna which picks up radio and television signals. Above is a diagram of the layout of equipment in the satellites. Notice the antenna on the underside. Both satellites were launched by N.A.S.A. for the Communications Satellite Corporation.

ELECTRONORAMA



Trainees for New Radio Station

PART of the function of the new Leafield G.P.O. Radio Station, in addition to being a central automated transmitter for overseas broadcasting, is to train technician apprentices in radio engineering. Two of them are seen (left) testing a single stage amplifier by feeding in a signal from a signal generator and examining the output on an oscilloscope. Both instruments are supplied by Advance Electronics.

Colour for Copenhagen

DENMARK'S first u.h.f. television transmitter to be used for colour and u.h.f. propagation tests will be installed at Gladsaxe, near Copenhagen, where black and white technical test transmissions are due to begin early next year. In the foreground of the photograph below, work is shown in progress on the equipment section containing one of two 10 kilowatt klystron output tubes used in the transmitter. The equipment is being built and tested at Marconi's Chelmsford factory. ▼

Mock Attack with Sonar ▲

NAVY ship crewmen at the Fleet Antisubmarine Warfare School, San Diego, California, are practising a simulated, but realistic attack on an "enemy" submarine. The mock attack is being carried out in the Underwater Battery Plot Room of a new surface ship ASW attack trainer built by Honeywell's California Ordnance Center. Sailors at the two "attack" consoles (foreground), using information from sonar echo sounding equipment (background), are able to simulate the firing of an ASROC missile at their target with deadly accuracy.

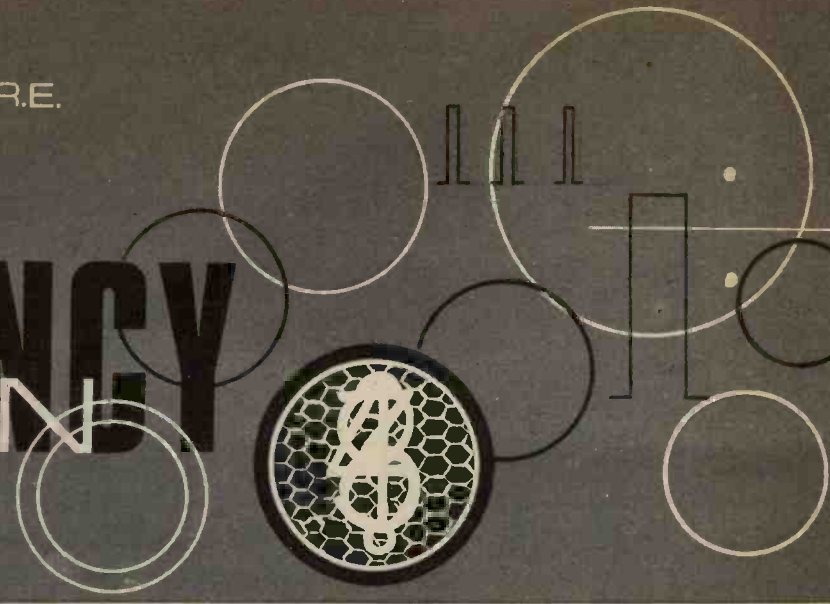
Tuning in to Hong Kong ▶

MUCH has been seen and heard about transistor radios from Hong Kong, but let us not forget that there is also a thriving potential in electronic components for computers and satellites there.

In the more "domestic" role high standards are maintained. This operator is making adjustments to an assembled tuner for television.

J. D. LOCKE A.M.I.E.R.E.

FREQUENCY DIVISION



The article *An Electric Clock with Digital Presentation* (March 1965 issue of PRACTICAL ELECTRONICS) mentioned several methods of producing a clock with all electronic working but these were not discussed in detail. Here we present a discussion of some of these methods, placing special emphasis on frequency division techniques.

THE problem of designing electronic clocks is, very briefly, one of frequency division. That is, you start with the mains frequency of 50c/s and divide this until you get one cycle per minute for operating the minutes display, one cycle per hour for operating the hours display and one or two cycles per day according to whether the 12-hour or 24-hour system is to be used.

There are various ways of obtaining frequency division:

(1) Binary circuits to give division by two for each circuit used;
(2) Diode pump circuits to give division by up to 10;
(3) Tunnel diode circuits to give division by up to 100;
(4) Gas filled counting tubes (e.g. Dekatrons to give frequency division of up to 12.

Having mentioned the kinds of circuit elements which may be used, let us consider what we require exactly from the circuits. Firstly, the frequency division factor must be constant or the clock will run fast or slow. Secondly, the circuits must be capable of operating at very low frequencies—at least one cycle per hour. Thirdly, the circuit must use components of practical size.

The implications of these requirements are that frequency division must not vary with changes of voltage, temperature, humidity, or aging of components. At very low frequencies, circuits relying on capacitors retaining their charge cannot be used because capacitors always have a certain amount of leakage resistance. This leakage resistance may be hundreds of megohms but will nevertheless discharge the capacitor over a long period.

Low frequency circuits demand the use of high value capacitors; these would probably be electrolytic, but are the least ideal because of their very low leakage resistance. What is really required is a circuit with a "memory" of the condition it was in one hour previous and, in fact, of those listed, only the binary divider and Dekatron meet this requirement. However, a brief explanation of the other circuits will be discussed as a matter of interest.

BINARY DIVIDER

The circuit, often referred to as a "flip-flop", Eccles-Jordan, or bistable circuit, is shown in Fig. 1. In the present context it can be considered as a ÷ 2 circuit, that is the output will be half of the frequency of the input.

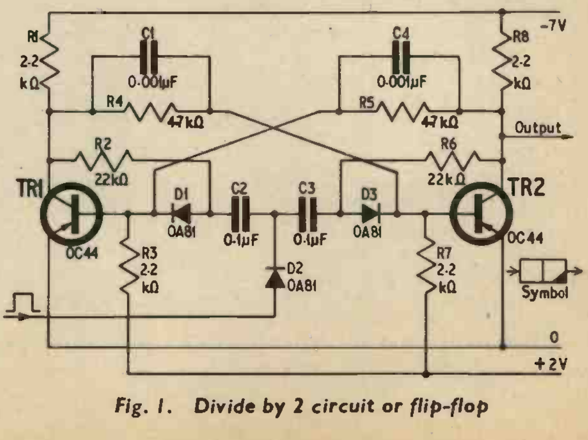


Fig. 1. Divide by 2 circuit or flip-flop

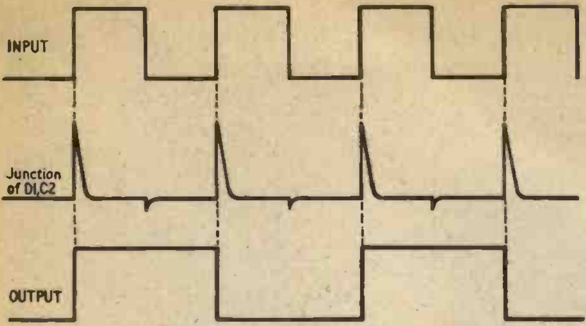


Fig. 2. Waveforms of the flip-flop circuit showing the input, the differentiated trigger pulse, and the output

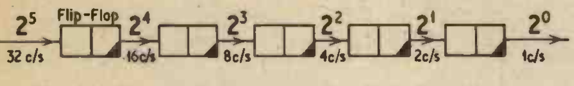


Fig. 3. Simple divide by 2 series from 32c/s to 1c/s

By connecting several of these circuits in series, the input frequency can be divided by any power of 2; for example, if the input is 32c/s, the output after four series connected flip-flops will be 2c/s (as illustrated by Fig. 3) and after five will be 1c/s.

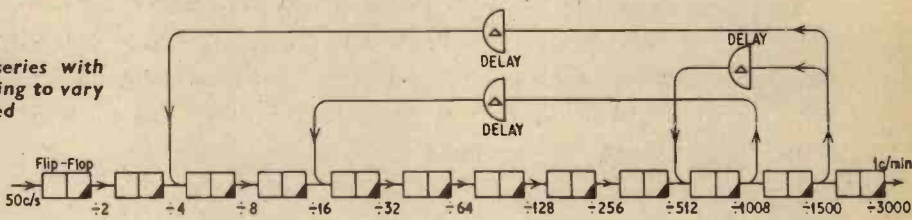
In order to count down from 50c/s to one cycle per minute, a frequency division factor of 3,000 is required, The nearest greater power of 2 is $2^{12} = 4{,}096$. This system will have to be modified to give division by 3,000. The modification involves feedback of pulses to reduce the count from 4,096 to 3,000. This is illustrated in block form in Fig. 4.

Delays are necessary in the feedback lines so that a feedback pulse does not coincide with an input pulse. Also shown are the dividing factors of the original frequency after each flip-flop, assuming that they all start from the zero condition simultaneously.

After dividing down to one cycle per minute the signal is fed into display circuits to drive a numerical indicator. These circuits will be dealt with later.

This particular method of frequency division fulfils all of the requirements but is expensive in components—at least 24 transistors, 100 resistors, 36 diodes and 36 capacitors.

Fig. 4. More complex series with added delay networks including to vary the division factor as required



On first switching on the supply, one transistor will conduct fractionally more than the other due to slight unbalance in the voltages around the circuit (don't forget that component values are not spot on but often are within say ±10 per cent tolerance).

If TR1 conducts more than TR2 then its collector voltage will be less negative than that of TR2. Therefore, the base of TR2 will be less negative than the base of TR1. As emitters are held at "earth" potential TR1 will conduct more heavily and TR2 will conduct even less. This effect is cumulative until TR1 is conducting heavily and TR2 reaches cut-off.

This action occurs very rapidly and is assisted by the capacitors C1 and C4. The transistors remain in this condition provided that no input pulses are applied to the bases. The steady state condition will be that the collector of the conducting transistor will be at about −0·5 volts and its base −0·2 volts. The non-conducting transistor will have a collector voltage around −5·5V and a base voltage of +1V.

When a square wave input is applied as shown it will be differentiated by C2 and R2, C3 and R6, and clipped by D2 giving the waveform at the junction of D1 and C2, and at D3 and C3, as shown in Fig. 2. The resulting positive pulses will not affect the "off" transistor but will reduce current through the "on" transistor.

This initiates a switching action so that the transistor formerly "on" will be switched "off" and that formerly "off" will be switched "on". The result of this is that one pulse will be obtained from the output for every two pulses at the input. The waveform at the output of the circuit will be as shown in Fig. 2.

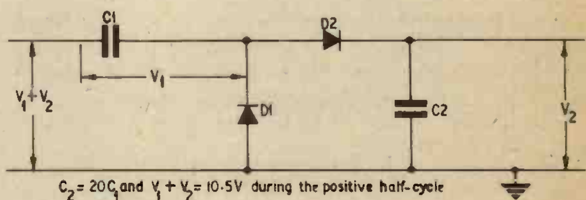


Fig. 5. Basic diode pump circuit

DIODE PUMP

The next method of frequency division to be considered is the diode pump circuit, shown in basic form in Fig. 5. In order to understand the operation of the circuit, let us assume that both capacitors are fully discharged. A square wave input is now fed to the circuit. On the arrival of the first positive half-cycle, D2 conducts and both capacitors are charged. The voltages to which they are charged are V_1 and V_2; the sum of these must add up to the total input (10·5 volts in this case). Let us assume that the capacitance of C2 is equal to 20 times that of C1. Since the reactance $X_c = 1/2\pi\sqrt{(fC)}$, the voltage across a capacitor is inversely proportional to the capacitance.

Therefore it can be said that

$$\frac{C_1}{C_2} = \frac{V_2}{V_1}$$

where the frequency f is the same for both capacitors.

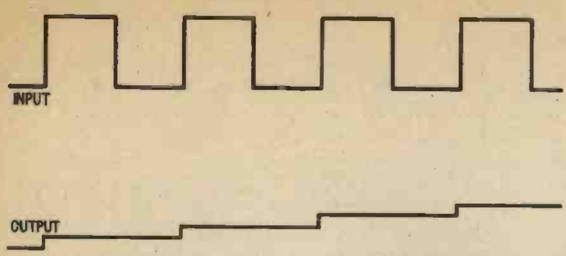


Fig. 6. Waveforms of the diode pump input and output

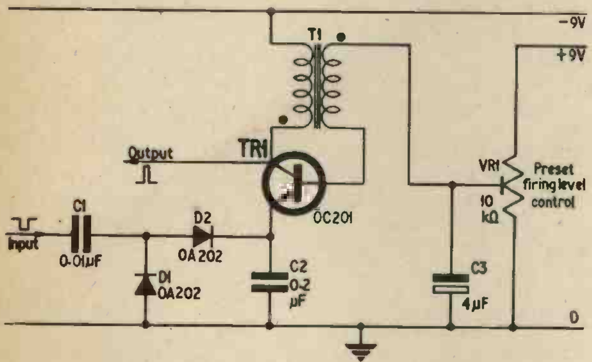


Fig. 7. Diode pump used with a blocking oscillator to govern the frequency division factor

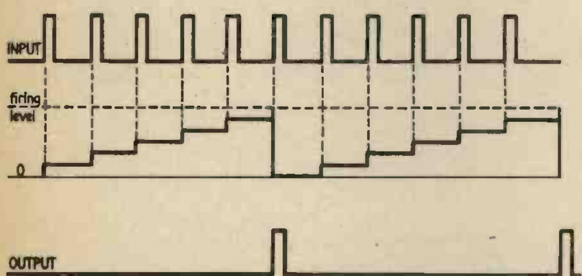


Fig. 8. Waveforms showing the staircase and output pulse in synchronism

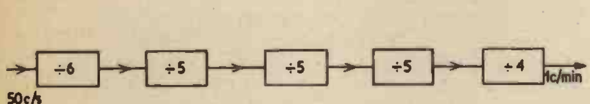


Fig. 9. Complex series of dividers for ÷ 3000

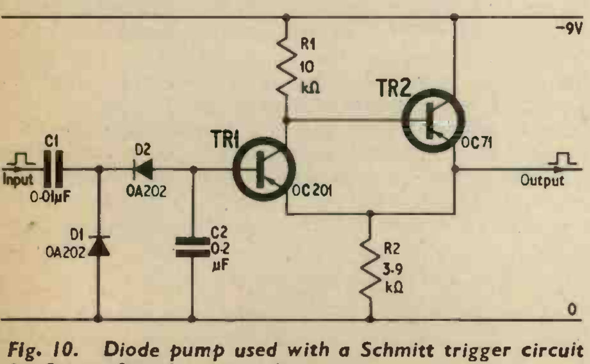


Fig. 10. Diode pump used with a Schmitt trigger circuit for firing after the required count

If the ratio of the capacitors is 20 : 1 then the ratio of their voltages is 1 : 20, or 0·5V across C2 for 10V across C1. During the following negative half-cycle, D1 conducts and discharges C1. On the following positive half-cycle, C2 once more gets 0·5V charge. The resultant input and output waveforms are shown in Fig. 6. This output is called a "staircase" waveform, for obvious reasons.

When the voltage across C2 reaches a certain level, it should be arranged to trigger another circuit to discharge C2 and produce an output pulse at the same time. This voltage will determine how many pulses are to be let through before resetting the circuit to "zero". Hence the division factor is determined. One way of doing this is to use a blocking oscillator, see Fig. 7.

In this circuit, the positive bias on the base, set by VR1, keeps the transistor cut off until the "staircase" level on the emitter rises above this bias. The transistor then conducts and is rapidly driven to saturation by positive feedback from collector to base via T1. When this occurs, C2 is very rapidly discharged and would charge in the opposite direction were it not for diodes D1 and D2 conducting and clamping the voltage on C2 to zero.

When the transistor saturates it ceases to amplify so that positive feedback ceases. The current then drops and the transistor rapidly cuts off (feedback through T1 again). It remains cut off until the staircase voltage once again becomes more positive than the bias. This is shown in graph form in Fig. 8.

ACCURACY

This circuit has the disadvantage that C2 slowly discharges through transistor leakage current. This necessitates the use of a silicon transistor such as OC201. Needless to say the capacitors used must have a very high leakage resistance and polystyrene dielectric capacitors are recommended for C1 and C2. D1 and D2 are silicon diodes to reduce leakage current effects.

Another disadvantage of this circuit is that its frequency division depends so much on supply voltage, temperature and stability of component values. Thus it cannot always be relied upon to give the correct count. It is quite good for a count of up to 6. If it drifts and counts 5 instead of 6, your clock will probably gain 4 hours a day overall. The rate can of course be set by VR1, which is thus the fast/slow control.

To divide by 3,000, several of the circuits will be required in succession with division ratios set as shown in Fig. 9. For those who wish to experiment, an

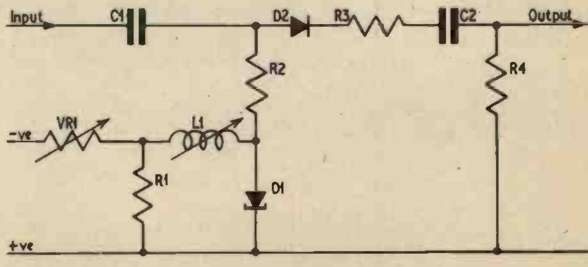


Fig. 11. The tunnel diode D1 can be used for frequency division but can be an expensive way of achieving the required result

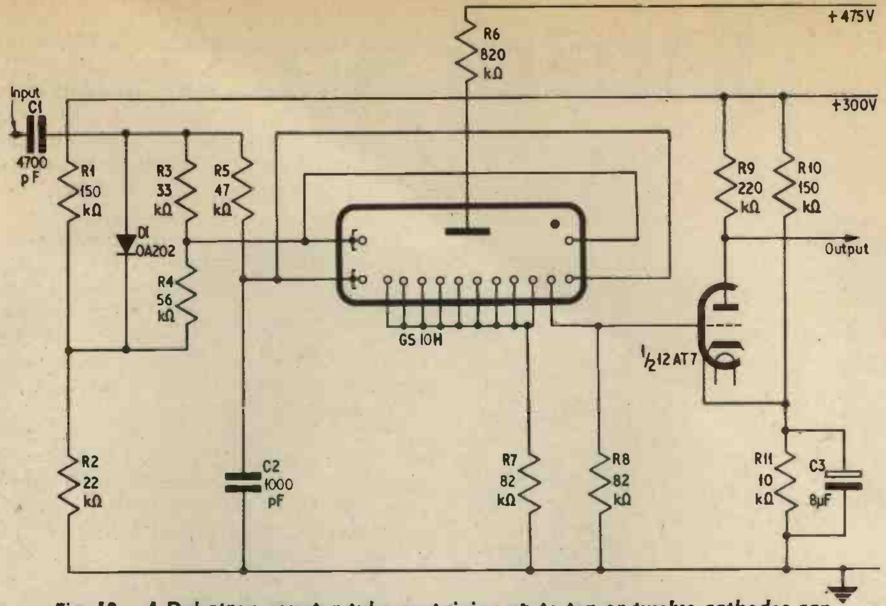


Fig. 12. A Dekatron counter tube containing up to ten or twelve cathodes can be very efficient for frequency division in clocks

Fig. 13. Complex series of Dekatron counters can be used to divide by 3,000

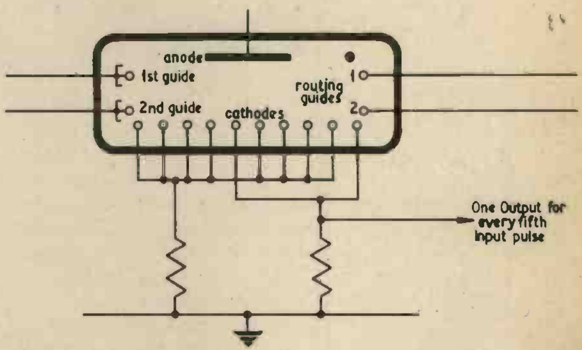


Fig. 14. Key to Dekatron electrodes and wiring for division by five

alternative circuit arrangement of the diode pump is shown using a Schmitt trigger circuit for firing after the required count. With the suggested values shown in Fig. 10, the circuit will fire when the base of the OC201 goes more negative than about −7·8V, and when fired discharges C2 to about −2·5V. This means that the range of voltage across C2 is 5·3V. If the voltage on this capacitor builds up in 1V steps then the circuit will divide by 6. To divide by 6 the input voltage should be about 20V peak-to-peak. Above 21·2V p–p the circuit will first divide by 5, and below 15·5V p–p, it will first divide by 7.

Only brief mention will be made of tunnel diode countdown circuits. The basic circuit is shown in Fig. 11.

To get the circuit to work at low frequencies, the inductance L1 has to be very large—perhaps hundreds of henrys and of high Q. This factor alone would put it out of the running from a practical point of view. Tunnel diodes are also very expensive.

GAS-FILLED DEKATRONS

The last method of frequency division to be dealt with (and the most attractive from the cost point of view) uses Dekatron tubes. These tubes will give a count of 10 or 12 depending on the number of electrodes in the tube. Intermediate counts of 2 and 5 for the 10 counter and 2, 3, 4, and 6 for the 12 counter may be obtained with some tubes. To couple one stage to the next, coupling amplifiers are required.

The Dekatron requires two negative pulses is succession to step the glow from one cathode to the next (see Fig. 12). The first negative pulse is applied to the first "guide" and transfers the glow from one cathode to the first guide. The second pulse is applied to the second guide and transfers the glow from first guide to second guide. On completion of the second pulse, the glow transfers from the second guide to the next cathode.

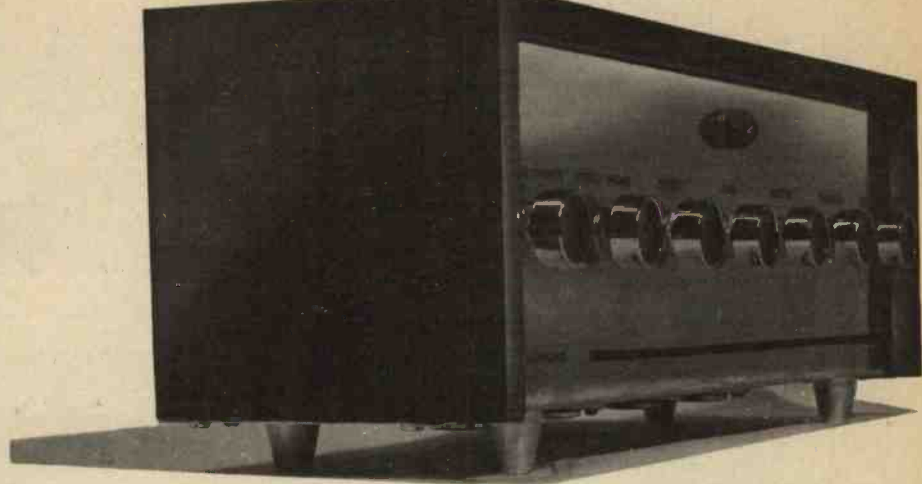
The guides and cathodes are pins arranged in succession around the tube. At the end of a count of 10, the glow is on the last cathode and about 25 volts appears at the cathode end of R8. This is amplified by the triode to drive the next stage. The input circuit forms this drive into two pulses which are required as described above. The routing guides, which are not in all tubes, determine the direction of glow transfer.

In order to get a countdown of 3,000, four tubes are required, three of them decade counters and one a duo-decal counter (count to 12).

One possible arrangement of Dekatrons is shown in Fig. 13. The intermediate counts of 5 or 6 are obtained by strapping the fifth and tenth cathodes together or the sixth and twelfth cathodes together respectively; for example, to divide by 5 the connections would be as shown in Fig. 14.

Next month: The second and final part will describe methods of display and give some basic circuits incorporating the design principles outlined here for experimental electronic clocks

Integrated Stereo Amplifier



PART TWO

By. R. Hirst

In last month's issue, the first part of this article described the features of the circuit that provide a high performance compatible with the neat and clean appearance, both externally and internally. Component assembly and wiring of the two main channel amplifiers (except the output transistors) were shown on perforated board.

In Fig. 2 (last month) the wiper leads of VR3a and VR3b should be screened, and screens connected to C'11 and C11 on the board. The junctions of C19a and VR3a, and C19b and VR3b, should be connected to these screens. This is shown in Fig. 9. Also in Fig. 2, C29b (between VR1b and VR2b) should read R29b. Diodes D1 and D2 (a and b) should be OA95.

It is intended in this part to show how the two channels are combined with the tone controls, interchannel circuitry, and power supply unit.

One particularly important point to remember is that "earth return" wiring is carried out in thick wire, 12 s.w.g., to avoid mismatching impedances (see last month's article). Good mechanical joints are essential prior to soldering. The constructor should follow all the diagrams given to ensure the best results.

MECHANICAL CONSTRUCTION

As previously indicated the mechanical structure has been fabricated from two main component parts, in order to ease the problem of having to make difficult bends that would stem from the use of one piece of material (Figs. 6 and 7).

Prior to the assembly of sections 1 and 2 (Figs. 6 to 9) it would be advisable to mount upon Section 1 the mains transformer T1, the output transistors TR8a, TR8b, TR9a and TR9b, the controls, the rectifier and the electrolytic capacitors, as shown in Fig. 9. These should then be wired up as far as possible.

Tackled in this manner it will prove a comparatively easy assembly. However should the two sections be married together before any wiring procedure takes place then it will be difficult to delve into the interior of the U-shaped chassis.

Once this initial operation has been completed then all the components should be mounted on Section 2 (Fig. 9) including the completed amplifier board (Fig. 5). Sections 1 and 2 should now be bolted together and the final wiring operations completed as shown.

When mounting the output transistors it will be necessary to smear both sides of the mica insulating washers with silicon grease before fitting them between the transistors and the metal chassis. This will ensure that the best possible heat transference will be effected between transistor and heatsink.

It is also essential to fit the isolating bushes or nylon screws so that the transistors are electrically insulated from the heatsink otherwise all the transistors in the output configuration could be irrepairably damaged because their collectors are connected to the case. At best the amplifier will just refuse to function.

You will notice from the final assembly photograph that small feet have been fitted on the underside of the chassis. This is necessary to allow a free passage of air over the output transistors, thus helping to maintain the temperature stability of the amplifier as well as to obviate the damage that might occur if stood on a polished surface.

The small pillars that hold the component board away from the chassis of Section 2 were made from a length of tubing cut to the required size. When finally wiring the board to the output transistors care must be taken to ensure that the bottom of the board is clear of the main chassis so that no short circuit can take place.

The fixing holes for the smoothing capacitors have been deliberately omitted so that the constructor can use capacitors of his own choice, but the voltage and capacitance values must be adhered to.

Although it was not necessary on the prototype to screen the input circuitry, it may be advisable in

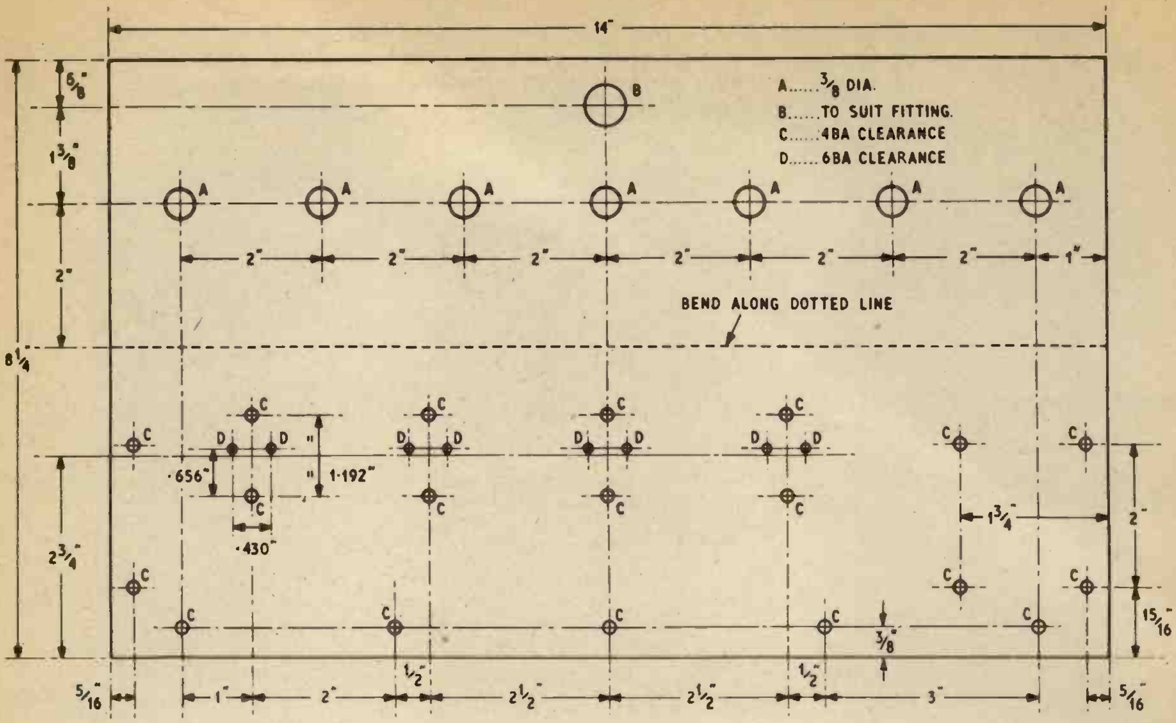
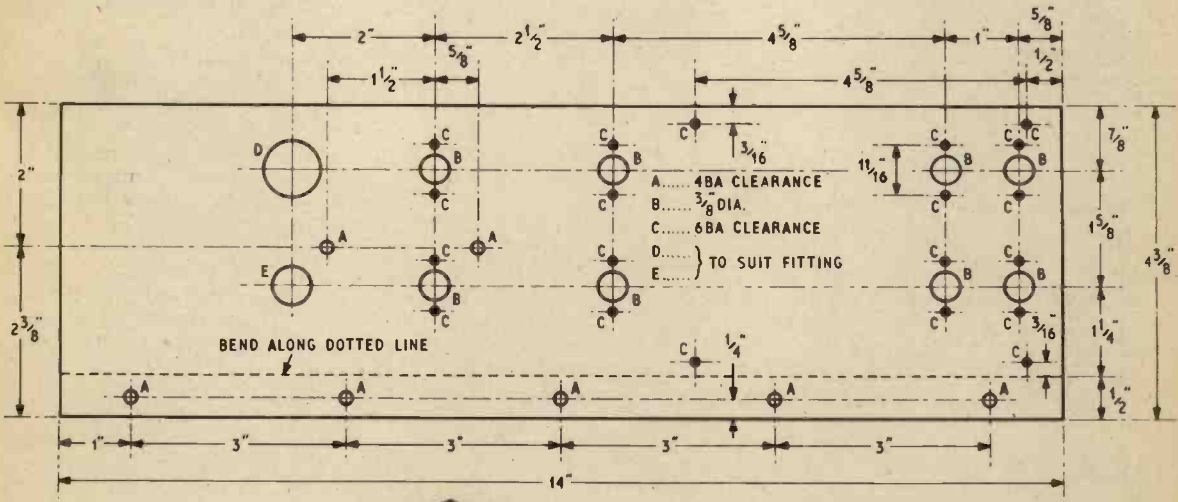


Fig. 6. Drilling details of Section 1, the base and front panel. Bend away on the dotted line to look like the model shown in photograph below. Material 18 s.w.g. aluminium



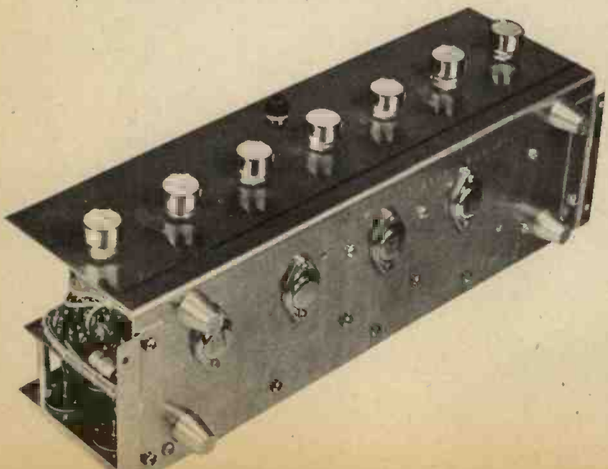


Fig. 7. Rear panel drilling details. Bend away on the dotted line (see photograph on next page). Material 18 s.w.g. aluminium

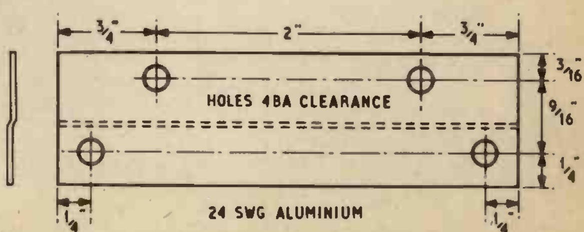
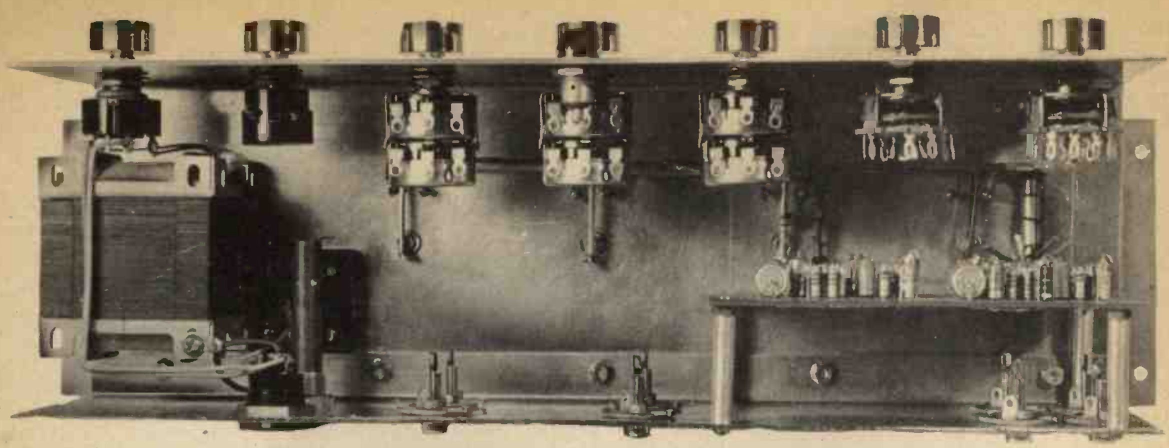


Fig. 8. The fixing brackets to hold the wooden case (see photograph on left)



The half-way stage. Most of the chassis mounted components are assembled. Before adding the capacitors wire up the output transistors in a cable form as shown, ready for connection to the board

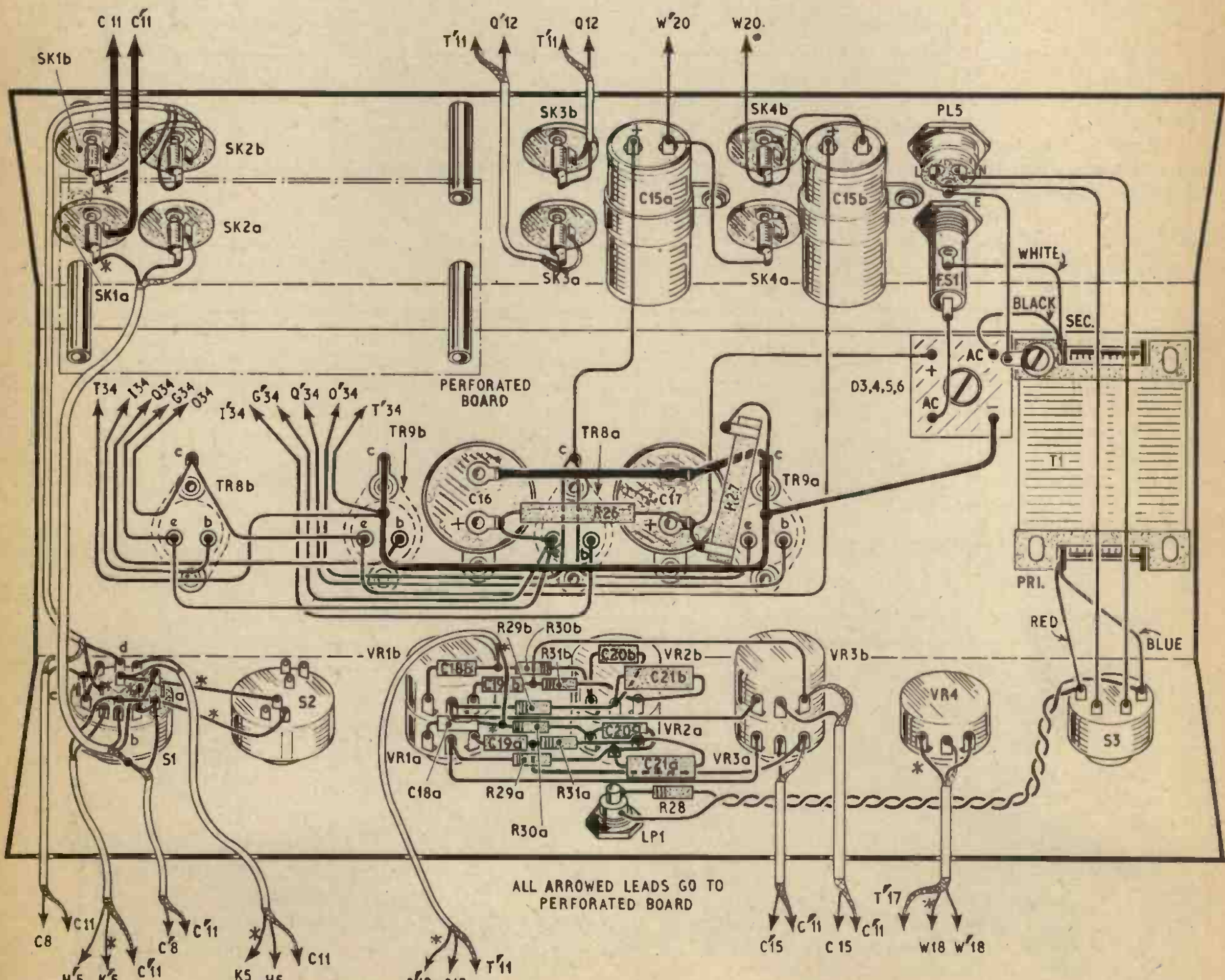


Fig. 9. The wiring of the base and front panel piece (Section 1) and that of the rear panel (Section 2), and assembled into one unit. Asterisks are shown to identify twin leads. Arrowed code numbers relate to perforated board locations (see Fig. 5 last month). For exact position of board see photographs. Observe thick 12 s.w.g. wires

certain instances to provide a simple screen to cover the appropriate part of the component board and the input sockets.

The cabinet was made from ordinary softwood and then finally finished with veneer. The cabinet just rests on the fixing brackets (Fig. 8) and then screwed in position from the underside. The front panel was satin finished by rubbing the surface of the material with steel wool coated with a silicon furniture polish.

Afterwards the surface was polished quite vigorously with a soft duster until all the polish was completely removed and the surface was reasonably shiny. The lettering was taken from a Letraset pack of electronic data and then sprayed or brushed with a clear varnish.

SETTING UP PROCEDURE

Having thoroughly checked out the wiring of the amplifier and set VR6a and VR6b at *zero* resistance, then VR5a and VR5b should be adjusted to about the mid-way point. IT IS IMPERATIVE THAT THESE LATTER TWO INSTRUCTIONS BE CARRIED OUT PRIOR TO SWITCHING ON.

The unit may now be switched on at the mains. At this stage it may be better not to connect in the speakers or any input while the d.c. conditions are set up. In the quiescent condition, that is to say when no input signal is being applied to the amplifier, the centre voltage measured at the emitter of TR9a or TR9b will not be half the rail voltage as expected. This is due to the reduction in the main rail voltage when the amplifier is functioning at full power output. When this happens then the centre voltage is indeed half of the rail voltage.

The voltage at this point should be set in the quiescent state by varying VR5a and VR5b until it reads exactly 35 volts on a 20 kilohm-per-volt meter. This should ensure that the amplifier should clip evenly when under full drive conditions.

Once this voltage has been set up it will be necessary to disconnect one of the amplifiers by breaking the positive supply to each amplifier in turn. It is essential to make sure that the whole of the amplifier section has been disconnected otherwise the current reading that follows from the setting of VR6a and VR6b will not be a true reading.

Having disconnected one of the positive supplies the volume control should be reduced to zero and an

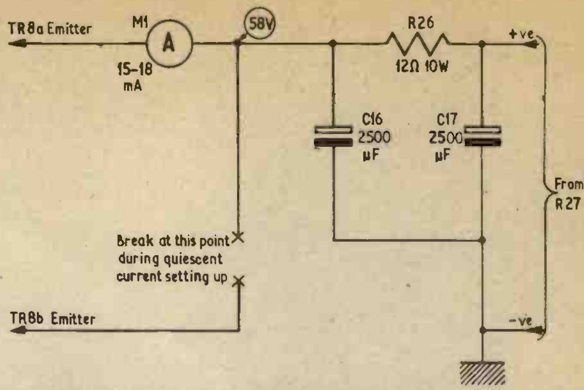


Fig. 10. Measure the supply quiescent current while adjusting VR6a and b. Break each channel h.t. line in turn while the other is being set up

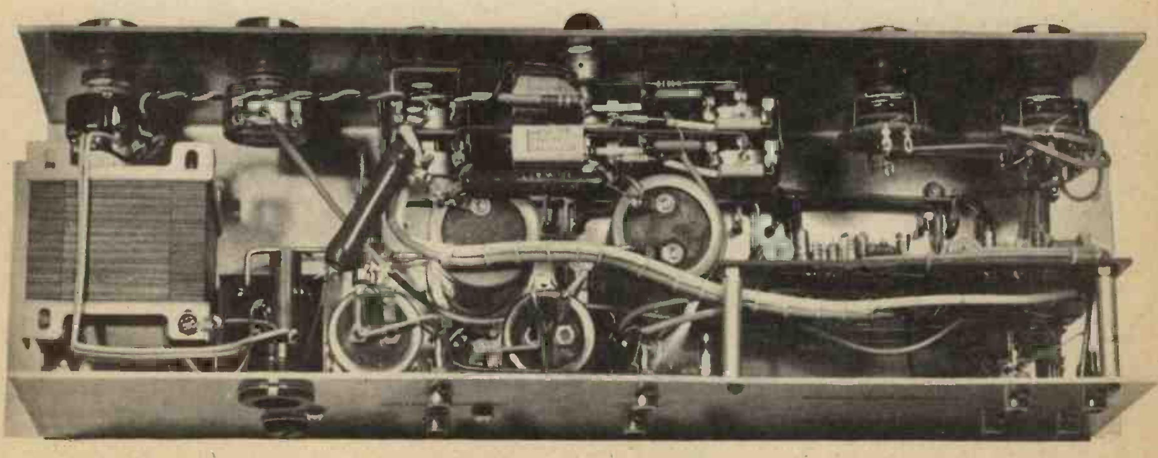
ammeter introduced into the positive rail between the junction of R26 and C16 and the amplifier positive rail as shown in Fig. 10. VR6a should now be advanced very slowly until the current measured lies between 15 and 18mA. Reversing the operation VR6b should be set up in the same manner.

If an oscilloscope is available then the setting up of VR5a and VR5b is much more of a simple matter. The oscilloscope should be connected across the terminals of the output socket and a 15 ohm resistor should be inserted in place of the loudspeaker.

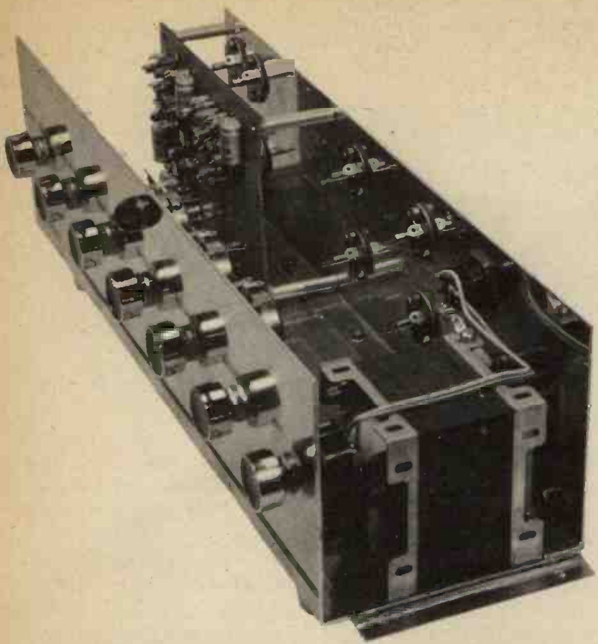
The volume control should then be advanced to about a half-way position and a signal of 1kc/s introduced into any one of the input sockets of the same channel. The signal should be increased until one side of the waveform shown on the oscilloscope starts to flatten off.

VR5a should now be varied until both halves of the waveform start to clip at the same time. The peak-to-peak voltage measured should be somewhere in the order of 43 volts. The voltage representing an output power of 10 watts is 35 volts peak-to-peak.

After the setting up of these four potentiometers there is no further setting up procedure required but it is advisable to check the input sensitivity and balancing operation to ensure that there is no great discrepancy between the channels.



The finished amplifier wired up and ready for testing and setting up



Half-way stage in construction of the amplifier

A.C. TEST PROCEDURE

The volume controls should be advanced to their maximum output condition and the tone and balance controls set to the mid-position. The stereo/mono switch should be set to MONO and the input selector set to TUNER. A 1kc/s signal should be introduced into the appropriate input socket and should not exceed 250mV r.m.s. (measured on an a.c. millivoltmeter) for an output of 35 volts peak-to-peak as indicated by an oscilloscope or 12·5 volts r.m.s. measured on an a.c. millivoltmeter.

Now the input signal should be reduced to zero and the "function" switch set to the MIC position. The input level may now be advanced once more until the output across the load reads 35 volts peak-to-peak; the input signal required to promote this output should not be more than 5mV r.m.s. After transferring the input to the "phono" socket the input signal should not exceed 250mV r.m.s.

By checking the performance of the amplifier in the MONO condition it is possible to transfer the output measuring instrument from one output socket to the other so that a quick comparison can be made between the opposite channels.

Having ascertained the input characteristics the balance control may then be checked by reducing the volume control until the output is below 4 volts peak-to-peak, then turning the balance control in the appropriate direction. The output signal should now increase by approximately two and a half times, in other words the output voltage should now read about 10 volts peak-to-peak.

The tone control characteristics may be easily confirmed by referring to the curves shown in Fig. 4 (last month). There is also an output provided to feed a tape recorder giving 300mV r.m.s.

Note: The mains transformer T1 delivers 58V at a load of 50mA. At full load the secondary winding is rated 43V at 2·5A. ★

NEWS BRIEFS

Baird Travelling Scholarship

As the outstanding scholar involved in the study of the science of television, Mr J. D. Penney, B.Sc.(Eng.) has been awarded the 1966 Baird Travelling Scholarship awarded through the Royal Television Society. Mr Penney is using his scholarship to further his investigation into tunnel diode amplifiers and superconducting tunnel diode amplifiers (tunneltrons). He visited several companies in the U.S.A. during November and has also been doing research work in this field with the aid of a Science Research Council grant.

Telemetry Monitoring of Waterways

A NETWORK of newly-developed electronic "sentinels" soon will be monitoring and recording quality data of many key waterways throughout the U.S.A. By the end of 1967, over 100 of these water quality data collection systems will be providing basic information for the United States Geological Survey on the behaviour of water resources, yielding data useful to agencies concerned with pollution control and other water management problems. The telemetry and computer systems are developed by Honeywell.

The Engineers' Day

BRITAIN'S urgent need for professional engineers prompted the Government to stage The Engineers' Day Exhibition at the Science Museum, London.

Opened by The Queen on November, 18, 1966, this exhibition will run until January 14, 1967. Girls and boys between the ages of 13 and 18 are the target. Large parties from schools in southern England have already visited this exhibition; it is also open to individual visitors and is likely to be a major attraction during the Christmas holiday period.

All young people who are trying to formulate ideas for a career would be well advised to seize this opportunity of learning about the exciting and rewarding future that is assured for the qualified engineer. Fathers should make a point of attending too, for much bias against engineering and technology as a career stems from out-moded ideas and prejudices about the subject held by parents.

The great variety of paths open to the practicing engineer is vividly demonstrated by the individual exhibits of national industries and Government departments—all manned by qualified engineers ready and eager to talk about the work of "their day."

Charge Storage in TRANSISTORS

Two unusual circuits using this effect

By K. T. Wilson

While a transistor is conducting, charge is flowing between emitter and collector through the base region. The sign and direction of this charge will, of course, depend on whether the transistor is a *pnp* or a *npn* type. Some of this charge will flow to the base circuit and the ratio of the amounts of charge flowing in the two circuits is the current gain or amplification factor, commonly represented by the symbol h_{fe}.

When forward bias is removed from the transistor, a certain amount of charge will still exist in the base region, and consequently the transistor will continue to conduct until this charge has been dissipated. If the base is sharply reverse-biased, base current will flow in the opposite direction to normal and will help to dissipate some of this excess charge.

This characteristic is used in several high-quality audio amplifiers to obtain an extended frequency response from power transistors. In such a case, using power transistors which would normally show a response 3dB down at 4kc/s, reverse base currents of 20 to 30mA may be flowing into the base of each power transistor in order to sustain a level response at 10kc/s.

STORAGE TIME

If the base is not reverse biased, however, the stored charge supports an undiminished collector current for some time until the charge is exhausted. This delay time is called the *storage time* of the transistor, and depends mainly on the current which the transistor was passing before base cut-off. Conversely, when forward bias is applied, current does not flow in the collector circuit immediately. In this case the odd phenomenon of *base-following* can occur—the collector voltage moves in phase with the base voltage until normal transistor action comes into effect.

Normally, both these effects cause considerable trouble in transistor switching circuits, and combined efforts had to be made by transistor designers and by circuit designers to give us the very fast switching arrangements which exist today.

It is possible, however, to design circuits which make deliberate use of these two charge storage effects.

A PULSE SHARPENER

Fig. 1a shows a pulse-sharpener which makes use of the switch-on time. With no input, the transistor is held cut-off by the positive bias developed by the current flow through the diode, D1 via R2 and R3. If a negative pulse is now applied to the input, the output will follow the input potential until the transistor switches on. When this happens, the output potential goes very sharply positive, cutting off the diode. In this way, a sharp spike very suitable for triggering purposes can be produced from a rather poor square wave or any other waveform with a reasonable rise time over a limited voltage. The waveforms are shown in Fig. 1b.

A DELAY CIRCUIT

The second circuit shown in Fig. 2a depends on the switch-off time and the *base-following* effect. The bias on TR1 is adjusted until roughly half the battery volts are dropped across R1. In this condition, both diodes are back-biased by about 4½ volts each and if the input pulses are less than this, they will not change the state of the transistor. If a negative pulse of greater amplitude is applied, it will appear unchanged at the output of the transistor without causing any switching action, as the diode D2 is back-biased.

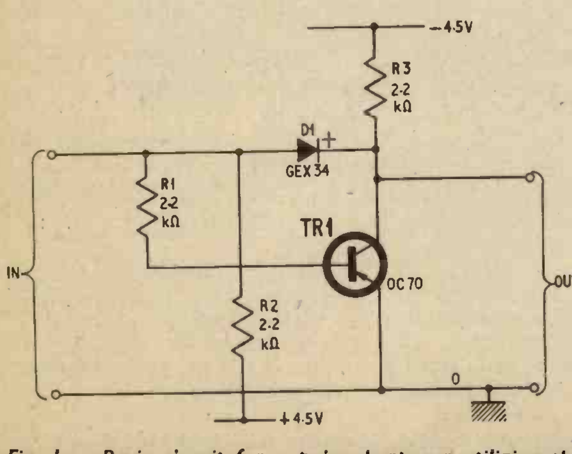


Fig. 1a. Basic circuit for a pulse-sharpener utilizing the "switch-on time" effect. The transistor and diode specified are suitable for pulses not narrower than 1µs

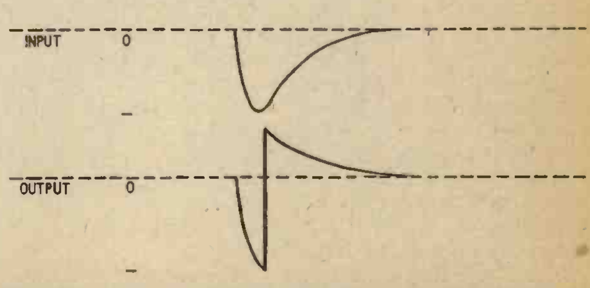


Fig. 1b. These waveforms show how the output initially follows the input, but swings very sharply positive when the transistor switches on

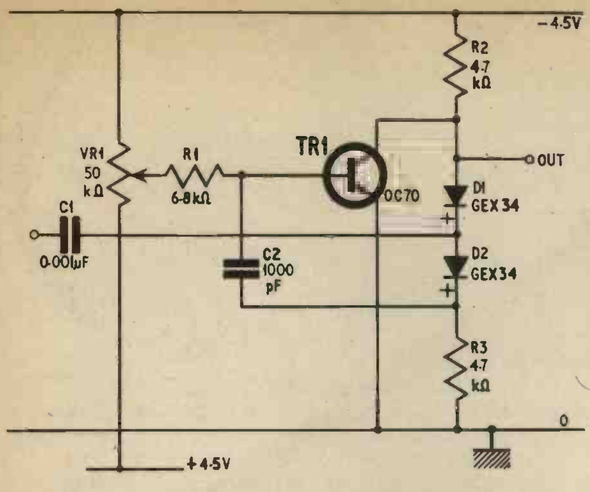


Fig. 2a. Basic circuit using the base-following effect

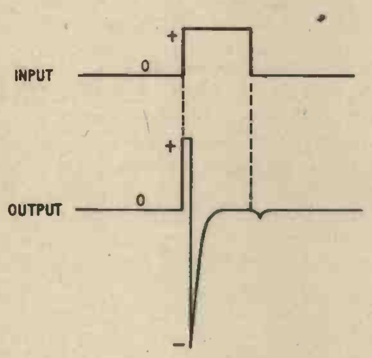


Fig. 2b. These waveforms show how sharp positive and negative pulses are obtained from a positive input pulse

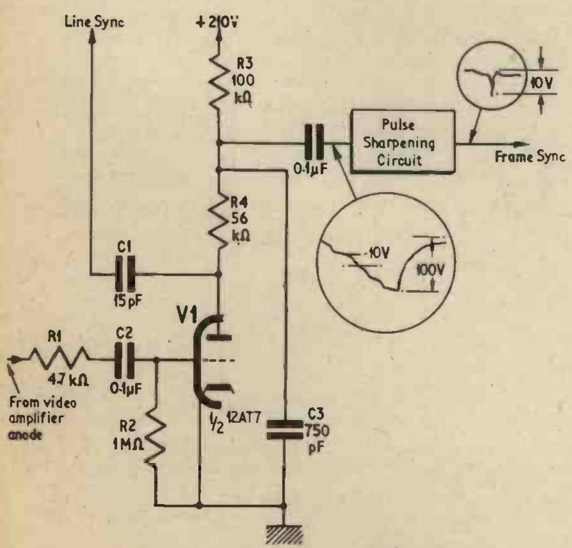


Fig. 3. A practical application of the pulse-sharpener is this arrangement to produce a sharp pulse for frame sync in a TV receiver

If a positive pulse is applied, however, D2 conducts, the pulse appears at the base of TR1 and, since the transistor does not switch off instantly, the positive pulse also appears at the collector. Both diodes D1 and D2 are now in a conducting state and the pulse at the collector serves to sharpen that at the base in *bootstrap* fashion until the transistor switches on.

This circuit can be used to discriminate between positive and negative pulses, to obtain sharp positive and negative pulses from a single positive pulse or from the leading edge of a square wave, or to obtain a pulse delay of a fixed amount. It should be noted that the values of the coupling capacitors have very little effect on the waveforms.

Some examples will now be given of practical applications of the two effects illustrated in Fig. 1 and Fig. 2.

FRAME SYNC PULSE

One use of the pulse sharpening circuit is shown in Fig. 3. On most television receivers, the frame sync pulse is obtained by integration, and the resulting waveform consists of a series of steps superimposed on a slowly rising waveform. The frame time base requires a sharp pulse for really good synchronisation, however, and the usual circuit does not provide it, so faulty interlace and even frame jitter are common faults. The use of the pulse sharpening circuit greatly improves this. Only one of the steps is sharpened, the others occurring either while the transistor is too far beyond cutoff to respond, or when the transistor is fully on. Thus one, and only one, sharp pulse is delivered to the frame time base, and perfect synchronisation is the result.

IMPROVING A SQUARE WAVE

Another use for the pulse sharpening circuit is shown in Fig. 4. In this case, the problem is a square wave generator whose output has an insufficiently sharp edge. With older type valve operated square wave generators, this usually occurred with the positive going leading edge of a positive square pulse.

This problem is tackled in a slightly different way, as the output pulse must be very considerably sharpened. The leading edge of the pulse is picked off at an earlier stage of the generator, where it is negative-going and still fairly sharp. This is differentiated and applied to the sharpening circuit which produces a negative pulse followed at once by a very sharp positive pulse. This positive pulse is picked off by a diode and added to the square wave whose positive leading edge is defective. The excess is then clipped off by a Zener diode, and the result is an excellent square wave.

OSCILLOSCOPE TRIGGERING

Fig. 5 shows how the circuit of Fig. 2 can be used to provide the facility for oscilloscope triggering in a pulse generator.

Unless the oscilloscope is triggered before the arrival of the pulse being observed, the front edge of the pulse will not be seen due to the time needed to start the time base. If the trigger for the pulse generator (whether internal or external) is sent through a delay circuit so that the original trigger is used for the oscilloscope and the delayed trigger is used for the pulse generator, then the whole of the pulse will be visible on the c.r.t. This is a useful facility which is often missing on home-made pulse generators.

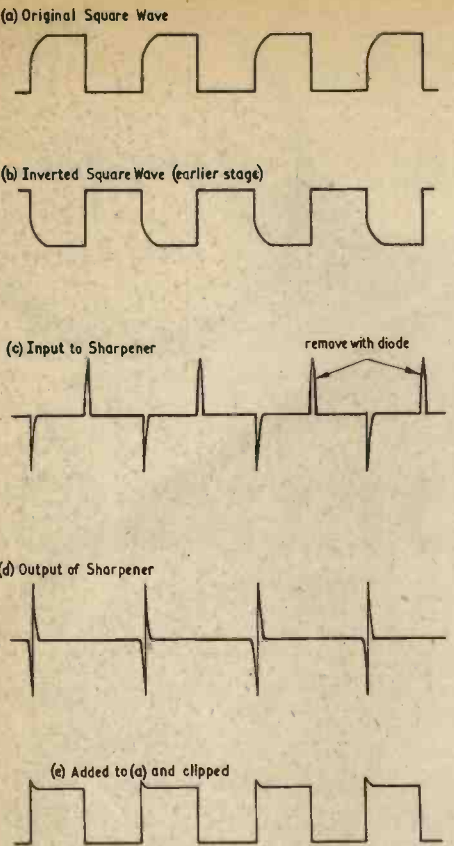


Fig. 4. Deficiency in the leading edge of a square wave can be restored by the process depicted in the waveforms (a), (b), (c), (d) and (e).

Finally, as shown in Fig. 6, the circuit of Fig. 2 can be used to generate square waves of variable width. The output of the circuit is applied to a Schmitt trigger so that a pulse applied at the input of the circuit produces a square wave whose width can be altered within limits by varying the bias on the base of the transistor TR1.

PRACTICAL NOTES

Since, in each of these circuits, the properties of the transistor rather than the external components determine the action of the circuit, almost any transistor will work.

Small a.f. transistors, with a cut-off (common-base) of a few hundred kilocycles, will give output pulses of one microsecond or better; r.f. transistors can produce pulses with extremely rapid rise and fall times and widths of down to 50 nanoseconds. The author's prototype circuits were built on "Veroboard", but any construction is suitable as long as it is remembered that stray capacitance must be kept to a minimum round the collector circuit. A rather straggly layout is often better for the purpose of reducing strays than a very neat "everything-close-to-the-baseboard" form of construction.

Some variation in performance may be noted using different diodes. The same type of switch-off problems exist for diodes as for transistors. The point contact diodes specified are suitable for use with the transistors specified, but those who aspire to very fast-rising waveforms will have to use faster diodes such as those used in computing. For most purposes, however, it is not necessary to use the ultra-fast gold-bonded type of diode; in fact the virtue of these circuits is that they enable sharp pulses to be produced with the minimum of expenditure in components. ★

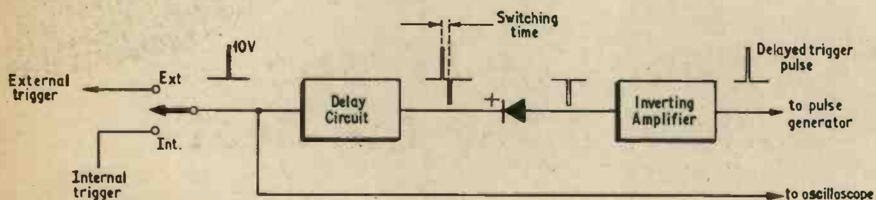


Fig. 5. An arrangement for using the base-following effect to provide a delayed triggering facility for an oscilloscope

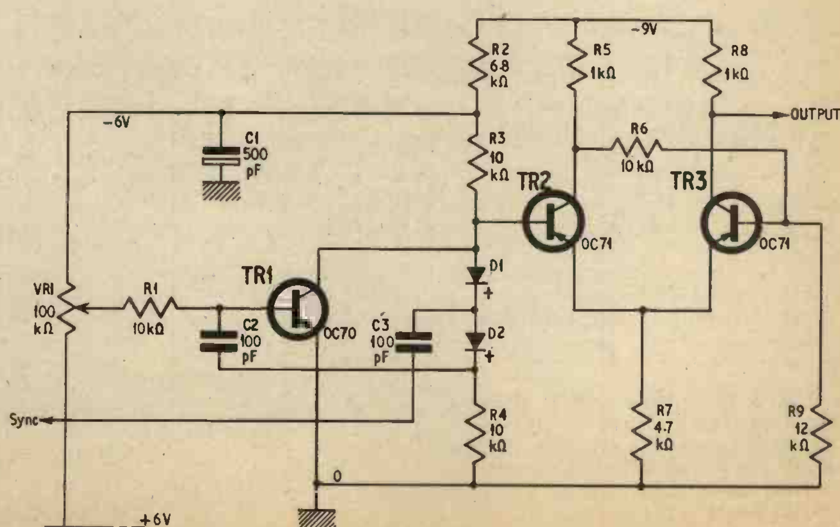


Fig. 6. This circuit provides square waves of variable width and is derived from Fig. 2

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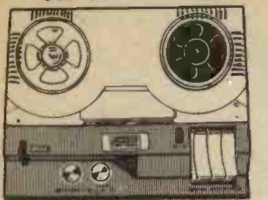

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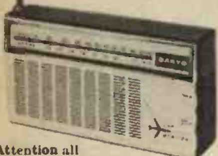

Attention all enthusiasts, this is history! Lind-Air first in the field once again with this wonderful SANYO Portable transistor radio with medium and Aircraft wave bands. Transmitting from 107 to 135 Mc/s. Limited quantity available, so send at once.

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THE LUMOSTAT

PART THREE by M.L. MICHAELIS M.A.

In this final article, the automatic function is discussed in some detail and the general operating procedure explained. Constructional details of the photocell sensing unit are also included.

AUTOMATIC EXPOSURE FUNCTION

The range of capacitor values to be wired to the contacts of S9b in relation to the range of photographic speeds we desire to work with is determined by the following expression.

$$C = \frac{1}{500\,S}\ \mu F \text{ (S in ASA units).}$$

Let us now look at the range of photographic speeds which come into question in the average darkroom. We will do this in the form of a small table, listing major groups of photographic materials in the first column, approximate ASA speed ratings in the next column, resulting values of C in the third column and the corresponding settings of S9 with specified component values in the final column. Note that the settings of S9 in "seconds" are given merely as time-function scale positions. These times have no direct meaning here for the automatic function, since there the exposure time is computed and varied automatically.

The camera film speeds are quoted just for comparison and orientation in the above tabulation. If such films were to be used under the enlarger instead of in the camera, the integrating capacitor values would need to be unmanageably small in order to obtain fast enough shut-down of the exposure. In such cases it is essential to weaken the lamp intensity of the enlarger (insertion of high-density reduction filters) and then to switch over to the time-function of the Lumostat. As far as the automatic function is concerned, it is evident that there are no immediate problems in exposing materials of low sensitivity in this manner, whilst high-sensitivity materials become increasingly problematic on account of the very small values of C then required.

Let us now look at this problem more closely, in order to determine the smallest value of C which is usable in practice, and thus the maximum permissible speed of a photographic material for automatic exposure. If on occasion materials of *greater speed* than this determined limit are used in the darkroom, they will have to be exposed on the *time* setting of the Lumostat, set to exposure times as determined by a conventional exposure meter, estimated, or found out by trial exposures. The so-called *dark current* of the photocell and the question of insulation impose a lower limit on C before stray capacitances would set an ultimate limit.

THE DARK CURRENT

Every photocell passes a minute current even in total darkness, due to thermal emission at room temperatures, cosmic radiation, etc. Thus V7 will fire after a certain elapse of time even in total darkness, because the capacitor selected by S9b will gradually charge up on the minute dark current. The smaller C, the sooner will this process be completed.

It is quite essential to use only the very best materials in the entire integrating grid circuit of V7. Thus use a ceramic switch for S9, a ceramic base for V7 and best quality capacitors for the integrator banks on S9.

Also pay particular attention to the insulation of switches, relay contacts, plugs and sockets, photocell cable and photocell mounting. The weakest point of the whole chain is V7 itself, since the guaranteed leakage resistance between grid and other electrodes of most small ECC-range double triodes is only in the region of 100 to 500 megohms. This is not sufficient here. The ECC82 is an exception, being specially specified for unusually high grid insulation among valves of its class. Make sure to use a new and guaranteed ECC82.

Check the entire insulation of the circuit as follows. Set S9 to "½ sec." and VR2 to minimum (× ¼), i.e. to the fastest available timing setting. Switch to "AUTO" and have the photocell plug, cable, socket and housing connected, but the photocell removed from its socket. Start an exposure.

If there is an elapse of at least one minute before the exposure is terminated automatically through insulation leakage, the latter is satisfactory as far as leakage between positive voltages and V7 pin 2 is concerned. However, if the exposure does not terminate within 5 minutes, insulation leakage between V7 pin 2 and chassis points is excessive. The offending component (switches, relays, etc.) can be determined by disconnecting these one by one and taking the wiring direct. If none of these components are at fault, then the capacitor itself may be poor. Note that we here require insulation efficiencies of thousands of megohms, since the photocell operates with usable photoelectric currents down to as low as one hundredth of a microamp at nearly 90V anode voltage, i.e. with a photoelectrically controllable impedance of up to nine thousand megohms.

Assuming that the insulation is satisfactory, we are left solely with the inevitable dark current of the photocell as limiting factor. This behaves as an insulation leakage to a positive voltage, thus making all computed exposures too short. We may consider the tolerable limit to lie at 25 per cent error introduced due to this cause, since otherwise correctly exposed black-and-white photographic materials have this exposure tolerance under virtually all circumstances and slight correction with VR2 is possible anyway and valid over long sequences of exposures.

Tests with the prototype showed operation being stable and as ideally predicted up to very much longer times of exposure covering normally required values. This must mean that the actual dark current of the photocell is very much smaller indeed than the makers guaranteed maximum of 0·05μA. It was found that V7 fires on dark current after about 120 seconds, not 1·5 seconds, under the above-mentioned conditions.

TABLE I

Type of Photographic Material	Approximate Speed Factor	Value of C	Setting of S9 ("seconds")
FOR THE CAMERA			
Special high-speed films	up to 20 thousand ASA commonly marketed	—	—
Normal films	20 to 80 ASA	—	—
DARKROOM MATERIALS			
Diapositive plates Diapositive copy film (e.g. Perutz Positive) Documentation enlarging paper (e.g. Agfa AGEPE)	2 ASA	0·001μF	1/2
Ordinary bromide enlarging papers	0·3 to 1·0 ASA	0·002μF to 0·0068μF	1, 1·5, 2, 3, 5
Direct-reversal copy films (e.g. Ferrania CONTRATIPPO DIRETTO ORTO)	about 0·05 ASA	about 0·04μF	10 or 15
Reserve in hand on Lumostat for still more insensitive special materials	down to 0·015 ASA	up to 0·1μF	20 or 30

This permits automatically computed exposures of up to 30 seconds in the settings for bromide enlarging papers before the tolerable limit of 25 per cent dark current error is approached.

Practical tests with several hundred enlargements of the most varying densities have shown that if VR2 is judiciously adjusted, automatic exposures up to 60 seconds duration are adequately accurate on normal bromide paper. Most exposure times with a 75W lamp in an enlarger with a lens opening up to about f/4, with f/5·6 or f/8 as working setting, and enlargement up to half or full postcard size from 35mm negatives, come out at 1·5 to 10 seconds on bromide paper. This is a full order of magnitude below the dark-run time, so that dark current errors are normally negligible in practice.

The dark current is thus some 80 times smaller than the maximum value which the makers guarantee as never being exceeded. The maximum value applies when the photocell is run near the maximum permissible ambient temperature, which is 70°C.

The dark current is strongly temperature dependent, as is any thermal electron emission process, so that it is very much less at room temperatures. However, in order not to aggravate other factors which might cause the dark current to rise, the photocell should not be subjected to intense illumination with anode voltage applied. Thus switch back to the time function and preferably cover the photocell up before switching on the main white ceiling light after the conclusion of a working session.

In principle, R23 gives adequate protection even if intense illumination should inadvertently reach the photocell, since at the maximum safe photo-current of 5μA it gives a voltage drop making the anode voltage collapse down to a small residual value. Under normal working conditions, R23 has no effect since its value, although high as far as carbon resistors go, is quite negligible in comparison with the photocell impedance. R23 thus need not be of high accuracy, but it should be of good stability since it is an appreciable part of the time-determining resistor chain on the time function.

In view of small dark current errors, it would be pedantic to specify close tolerance capacitors for the automatic function bank on S9b, yet these capacitors must possess meticulous insulation, calling for types such as Siemens "Styroflex" which happen to have tolerances of 1 or 2 per cent. For the time function bank on S9a, modern metallised plastic film capacitors of any make, especially if selected from the ranges marketed for "slow time-bases", are most suitable.

BEHAVIOUR AROUND 2 ASA SETTING

Referring back to the table of speed ratings of darkroom materials and corresponding capacitance settings of S9 (derived from theoretical considerations well confirmed by practical tests with the prototype) we see that C must be about 1,000pF for exposing diapositive plates and sheet films as well as high-speed documentation enlarging papers, all of which are some two to six times faster than ordinary bromide papers. In the mid-way setting of VR2, dark current will shut down the exposure after some 40 seconds with this value of capacitance, dropping to some 10 seconds when VR2 approaches minimum setting on various picture size corrections described below. This brings the maximum usable automatic exposure down to somewhere between 2·5 and 10 seconds, which is beginning to cut things rather fine.

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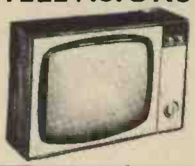

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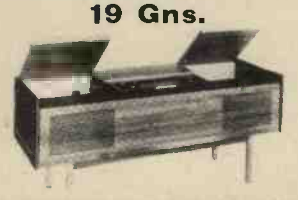

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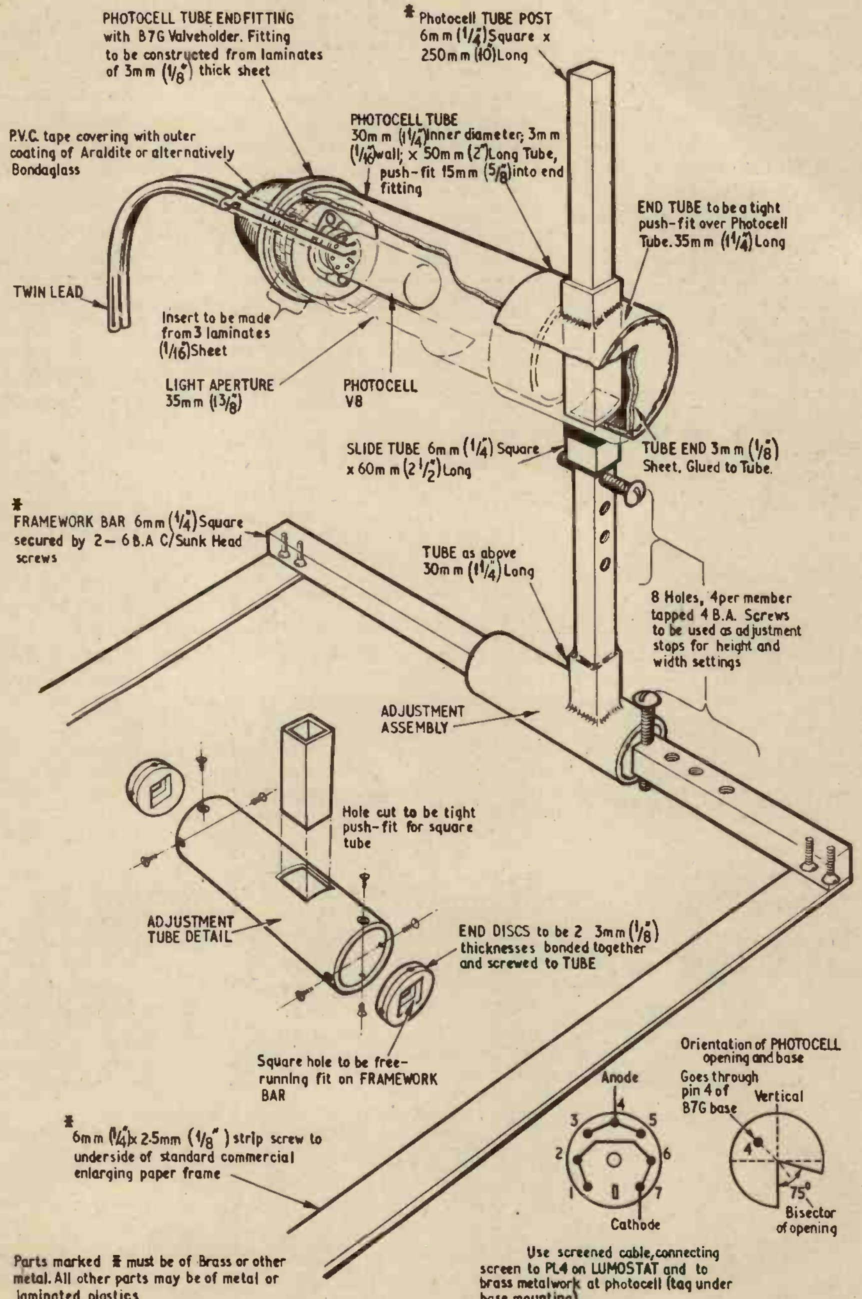
However, under proper conditions the required exposures of the documentation paper do not exceed 2·5 seconds, so that automatic exposure would work *in principle*, but it is here undesirable for another reason. It exposes the papers such that the mean of highlights and shade, weighted according to area, is a medium grey, as it should be for normal pictures. But this may not be true for documentation copies! Suppose the last page of a manuscript has just one line of text and the rest blank. The copy must come out virtually blank white. The automatic would try to make it run grey, if full pages are adjusted to come right!

The time function of the Lumostat is thus normally more appropriate for all documentation purposes; *fortunately* so, since the scope of automatic exposure is beginning to be severely limited at 2 ASA with a 90AV

Fig. 7. Constructional details of the photocell sensing unit



Drill and tap the holes for the vertical and horizontal stop bolts so that the line from the centre of the photo-cell opening to the centre of the picture is square to the picture edge and at 45 degrees to vertical

Drill corresponding pairs of holes for common picture sizes: 6 × 9cm; 7 × 10cm (half postcard); 9 × 12cm; 10 × 14cm (postcard); 13 × 18cm photocell in the published arrangement, which is clearly really comfortable only for ordinary bromide papers or anything slower.

OTHER TYPES OF PHOTOCELLS

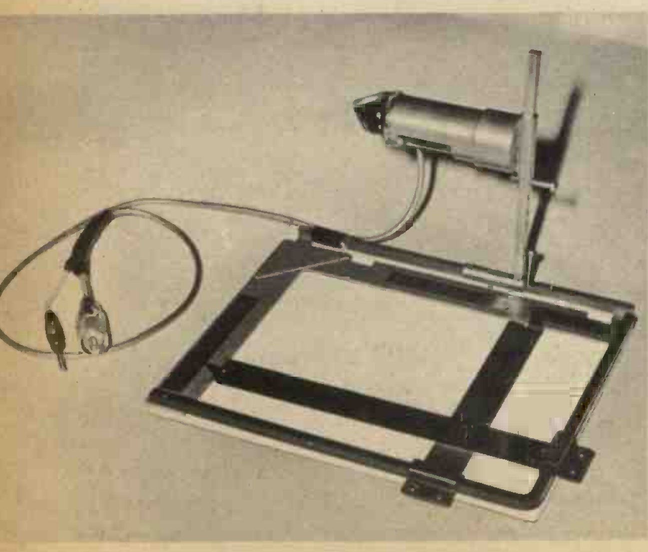
Professional automatic exposure systems for the darkroom have combated this limitation by resorting to secondary emission photomultiplier tubes, e.g. to the RCA 931 A tube which has already appeared in amateur CCTV designs for flying spot scanners. Cadmium sulphide photoresistors are of the same order of sensitivity, but of much lower impedance and different spectral response as well as lack of inherent constant current operation, thus less suitable. In principle, a photomultiplier probe using the RCA 931 A could be devised for connection to the Lumostat as it stands. It would have to be provided with its own high voltage power supply. The expense and complications were, however, not considered worthwhile in the present case, since the simple 90AV vacuum photocell adequately covers copy films and bromide papers, whilst the 2 ASA group of documentation materials is best exposed to time for other reasons.

However, these considerations considerably influenced the decision to provide optional time and automatic functions, instead of either alone as more common in electronic exposure control equipment for the darkroom.

Colour enlarging papers are of roughly the same speed as bromide papers, or effectively slower due to colour balance filter effects in relation to the spectral response of the 90AV photocell. Thus there is no difficulty in obtaining accurate automatic colour exposures.

PROVISION FOR PHOTO-DOCUMENTATION

It will be seen upon perusal of Fig. 1 (full circuit diagram of the Lumostat), that circuit provisions have been made for operating a photocopy film unit. To the left of the Auto/Time switch S8 on the front panel is situated the selector switch S6 with the settings "Photocopy Unit" and "Enlarger". In the former setting, a.c. is switched straight through to the output socket SK1 for the photocopy unit. The loading of 400 watts



of the photocopy lamps would not be possible to obtain from the stabilised supply, and lamp stabilisation is quite unnecessary when taking microfilms with the photocopy unit. However, the 400 watts a.c. supply goes via RLA and is controlled in the same manner as for enlarger operation, via the exposure control circuit of V7. The stabilised d.c. supply is hereby idling, apart from supplying V7 with the necessary stabilised supplies. The function of S7 is identical to that for the enlarger.

The shortest exposure times on the time function, reaching down to $\frac{1}{8}$ of a second, have been provided mainly with the requirements of the photocopy unit in mind. If on occasion special fast films are used, such short exposures are here required, although practically never with the enlarger. An exposure of $\frac{1}{8}$ second is the shortest practicable while still allowing the lamps to reach operating brilliance in a time short.

COPYING FROM FILM TO FILM

With the commonly used arrangement for copying from film to film with an enlarger, it is clear that the time function of the Lumostat must be used, since there is no logical position for applying the photocell for an automatic exposure.

Since the optical system is fully enclosed on the film-to-film operation, subdued white light may be used for convenient working. The switch S5 is provided on the Lumostat for this purpose.

THE OPERATION OF VR2

The control VR2 should be set largely empirically, to correct all manner of subsidiary effects and influences affecting the automatic exposure. On the time function, it is a straightforward multiplication factor control for the time settings of S9 and may be set unambiguously as required.

If the details for the photocell mount given in Fig. 7 are followed exactly, there will be only small variations necessary in relation to picture size, which must be determined by experiment.

Special picture compositions, where the average tone is deliberately not to be a medium grey, can also be corrected by adjusting VR2. For example, consider a shot of uncle George coming in at the garden gate late at night, taken by flash. This picture is required to be almost entirely black, with just uncle George lit up. The automatic exposure, without appropriate special instructions, would under expose this shot because of the large clear areas of the negative. Thus VR2 must be temporarily advanced. The converse would be true of high-key compositions such as a group of eggs in a white dish on a white tablecloth. However, such subjective corrections with VR2 are virtually never critical, and one soon gets the knack of knowing how far to move VR2 for that odd non-standard picture within a film strip of otherwise average pictures.

Of course, VR2 may also be turned up or down to change the basic speed setting in interpolation of the step settings of S9. However, it is quite pointless to attempt to improve the signal-to-noise ratio in this manner, i.e. to reduce the dark current error when operating near the upper speed limit, for any change of setting of VR2 changes the voltage swing through which the integrating capacitor has to charge and thus changes the dark run time in direct proportion. The maximum usable exposure for a given setting of S9 in relation to a given photographic speed is thus not changed. ★

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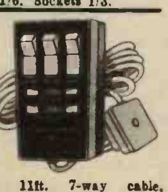

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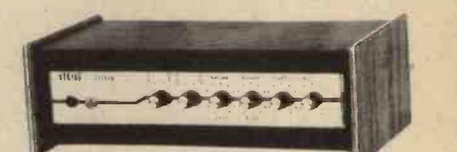

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Few of our readers will need convincing that you can't get a good stereo effect from a one-piece stereogram. The set manufacturers produce large quantities of these lowboy type cabinets with loudspeakers placed rarely more than 3ft apart—and they sell quite well. One can only assume that these instruments are not bought primarily for their reproduction qualities, but rather as items of furniture that will fit into the domestic scene without any major upheaval to existing arrangements.

The Consumers' Association has been having a look at these stereograms, and their findings are reported in the November issue of *Which?*

In this report the closeness of the loudspeakers is commented upon, with the statement that the best stereo effect is obtained in one rather small area immediately in front of the instrument. (The idea of sharing one chair may of course have its attraction to some couples. . . . I would suggest to the Consumers' Association that they investigate how many of these stereograms are bought by newlyweds. All in the interests of sociology, of course.)

The *Which?* report concludes with an emphatic note that if you want good quality sound, separate (hi fi) units are essential. Hi fi equipment makers and dealers are delighted and are, I expect, already stocking up in anticipation of the rush of new converts to the cult.

MODERN TIMES

According to the latest reports, Bevercotes will soon start working.

Good news certainly, but it is only a partial victory for the National Coal Board, since the miners have agreed to work the automated pit for only five days a week. The NCB wanted the mine worked for the full seven days in order to reap the maximum advantage of automation.

One of the major difficulties to be overcome is the miners' objection to the disruption of normal social life.

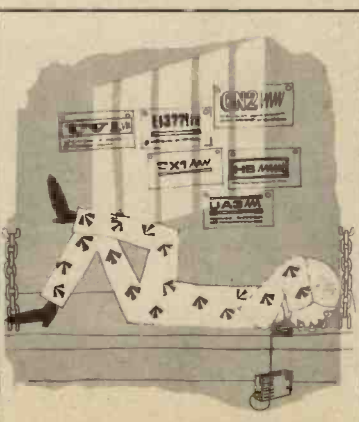
Perhaps this all seems remote to most of us—but is this not a problem that countless workers in diverse fields will have to face in the future? The introduction of costly automation systems in industry will be a viable proposition only if the plant is operated continuously. Thus greater, and more economic, production with (we hope) improved standards of living can only be obtained by accepting some revolutionary changes affecting our social lives.

Some bank computer centres are operated 24 hours per day. Did they have difficulty in getting clerks to work these shifts I once asked a bank official, "Oh no," he said, "in fact many volunteered." There are obviously *some* compensatory advantages for those working "unconventional" hours.

BREACH OF SECURITY

It would seem a shrewd choice to select Lord Mountbatten to lead the investigation into prison security. A past President of the I.E.R.E. and chairman of the National Electronics Research Council, Lord Mountbatten is well at home in the field of electronics. We can be sure that the lamentable absence of electronic surveillance systems will not go unheeded in the report which is expected very soon now.

But there remains the said spectacle of bolting the stable door. . . .



. . . nor iron bars a cage

Why, oh why, one can only ask, has this security been allowed to deteriorate while there is an abundance of electronic devices on the market capable of reinforcing the sorely pressed prison staff?

With installations of closed circuit television, proximity detectors (infrared, radio or ultrasonic), and a comprehensive communications system it should be possible to achieve almost 100 per cent inviolability of an outer perimeter wall, while allowing the limited amount of freedom of movement to the inmates that modern ideas on this subject require.

COLD COMFORT

The Electricity Council are making ambitious plans for the "all electric" new town of the future, as was indicated during a recent conference.

The heating of homes by cheap off-peak current is becoming increasingly popular. With a little more attention to heat insulation in house design heating costs can be reduced by as much as 50 per cent it is claimed. But this is not all. The "waste" heat from lamps and the multitude of electrical equipment which will be used even more extensively in future will contribute significantly towards heating up the cocooned homestead, it was suggested.

But just a moment: is not the Electricity Council's peep into the future somewhat unimaginative, and does it not indicate a lack of appreciation of the potentialities of that closely related and up and coming younger branch of technology?

When electronics really comes into its own there will be no waste heat. Cold cathode fluorescent tubes and electroluminescent wall and ceiling panels will oust the incandescent filament lamp, while transistors will drive out the last remaining thermionic valves from receivers and amplifiers thus denying the household those few additional watts of thermal energy "on the side."

Sorry, but in this respect it would appear that the electrical people can expect only cold comfort from the advance of electronics.

Readout—
A SELECTION FROM OUR POSTBAG

Anchors aweigh!

Sir—I was most interested to read the descriptive article by S. Simpson, entitled *Ship to Shore Radio*, which appeared in the November 1966 issue. Having heard these stations operating in contact with coastal shipping on many occasions, it was pleasant to have information concerning the equipment installed at the GPO Radio Stations and also to learn of the very full coverage of services provided by these stations.

Perhaps at some later date, it would be possible to include a similar article, dealing with the radio communication, radar and direction-finding equipment installed on the larger type of merchant ship. I feel this would be an equally interesting subject and a fitting sequel to the feature on coastal radio stations.

A. G. Coker,
Guildford,
Surrey.

Foiled

Sir—Having received some excellent information from your magazine I am hoping you can help with my present problem.

I am a keen fencer. Our club is at the moment trying very hard to obtain electrical equipment for fencing, and in order to reduce costs, I offered to try and obtain a circuit diagram for an electronic counter. This is, as you probably know, a piece of equipment that counts the number of hits.

I was wondering if your magazine had any such circuit, or if not, whether any of your readers have access to a circuit diagram.

A. C. Farrow,
Cardiff,
S. Wales.

Sir—Being a member of the Worcester Fencing Club, I am interested in foil fencing with the electric foil and wondered if you have any information on the equipment and circuitry concerned.

R. Kenwrick,
Worcester.

Sound definition?

Sir—In re-reading the article by M. Scibor-Rylski describing how to make a *Fuzz Box* (July 1966), I noticed in the introduction a mistake which I hope he will not mind me correcting. It said "Vibrato, sometimes mistakenly called tremolo—is produced by mixing a fixed low frequency oscillation with the guitar signal."

The first point to be corrected is that the low frequency, usually 2 to 4c/s, is used to modulate the guitar signal and is not merely mixed with it. If it was, no change in the sound would be produced, as all such low frequencies are inaudible.

The second, more debatable point, is that of the name given to this effect. Both the Oxford and Nuttall's dictionaries suggest that the names tremolo and vibrato are interchangeable, whereas others are vague enough to be of no help.

The answer seems to be that vibrato is a regular variation in the frequency of a note, whereas tremolo is a regular variation in the volume of a note.

Tremolo is, therefore, the name correctly given by amplifier manufacturers to the effect described above, and vibrato is the effect produced by what is commonly called the tremolo arm on a guitar, but should, as the guitar manufacturers name it, be called a vibrato arm, or vibro-arm for short.

Malcolm P. Hamer,
Bath.

There is much confusion over the loose use of the words tremolo and vibrato. Strictly speaking, Mr. Hamer is correct. The word vibrato is of recent origin and is thus not well defined. Some organ makers use this for amplitude modulation, some for frequency modulation. If the pitch changes, it is vibrato, but in an organ it should be called tremulant since this is the expression used for pipe organs. It is derived from the French word "tremblant"; they were the originators of the effect and no pipe organ has ever had the name vibrato on a stop.

Tremolo is an Italian word first associated with the singing voice and is quite definitely an amplitude modulation. Incidentally, the frequency of 2 to 4c/s seems suspect to me although it might be used for a special effect; the normal organ vibrato or tremulant runs at 6 to 7c/s.—A.D.

CAN YOU HELP?

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

Sir—I wish to acquire copies from November 1964 to August 1965 inclusive, complete with blueprints.
C. Farrall, 34, Wellfield Road, Stockpost, Cheshire.

Sir—I wish to obtain copies of Volume 1, November 1964 to September 1965 inclusive, and Volume 2, February 1966, complete with blueprints.
H. A. Newell, 41, Old Palace Road, Guildford, Surrey.

Sir—I am anxious to obtain the August 1966 issue and wondered if any of your readers could help?
D. S. Gradziuk, 41, Hawthorne Avenue, Gillway Estate, Tamworth, Staffs.

Sir—I wish to obtain the July and August 1965 back numbers, if possible complete with blueprints.
E. J. Darby, Jnr., Nettleslack Farm, Broughton Beck, nr. Ulverston, N. Lancs.

Sir—I wish to obtain the blueprint or circuit diagram with details of parts of the guitar amplifier which was described in the February and March 1965 issues.
I. M. Edward, Manuel Industries, Ernakulam-6, Kerala, India.

Sir—Can any reader supply me with the March and April 1965 issues, complete with blueprints, if any?
A. M. Riddle, Glendore, Church Road, Wembury, Plymouth, Devon.

Sir—I wish to purchase from any reader the October 1965 issue, *without* blueprints.
L. C. Galitz, 103, Sheaveshill Avenue, Colindale, N.W.9.

Sir—I require a handbook or any other data for the R109 Reception Set, and the January and February 1966 issues of PRACTICAL ELECTRONICS.
H. Delia, 37, Avon Road, Burnage, Manchester, 19.

Sir—I would be most grateful if any reader could supply me with the February and May 1966 issues of PRACTICAL ELECTRONICS.
G. H. A. Hardwick, 24, Westwood, RAF Bawtry, Doncaster, Yorks.

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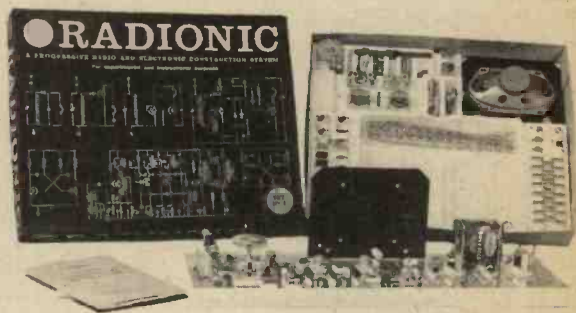

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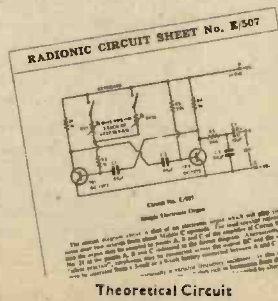

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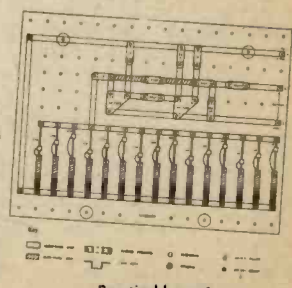

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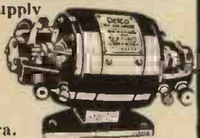

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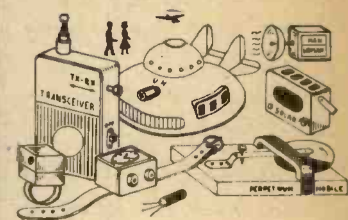

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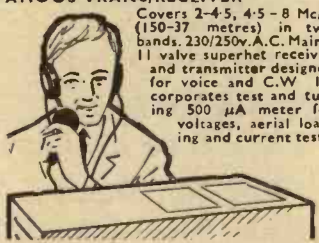

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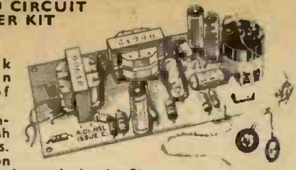

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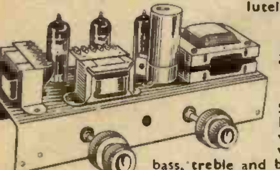

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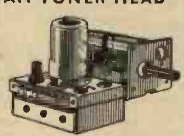

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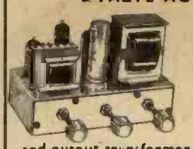

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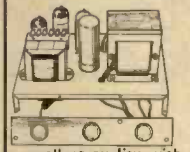

★ Heavy duty double-wound mains transformer with electrostatic screen. ★ Separate Bass, Treble and volume controls, giving fully variable boost and cut with minimum insertion loss. ★ Heavy negative feedback loop over 2 stages ensures high output at excellent quality with very low distortion factor. ★ Suitable for use with guitar, microphone or record player. ★ Provision for remote mounting of controls or direct on chassis' ★ Chassis size only 7½ in. wide x 4 in. deep. Overhaul height 4½ in. ★ All components and valves are brand new. ★ Very clear and concise instructions enable even the inexperienced amateur to costruct with 100% success. ★ Supplied complete with valves, output transformer (3 ohms only), screened lead, wire, nuts, bolts, solder, etc. (No extras to buy.) PRICE 79/6. P. & P. 6/-.

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This kit although similar in appearance to HA34 employs entirely different and advanced circuitry.

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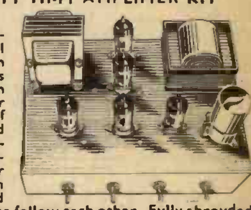

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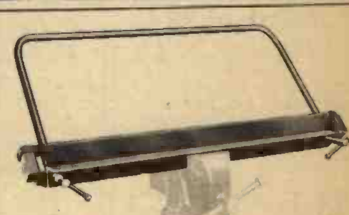

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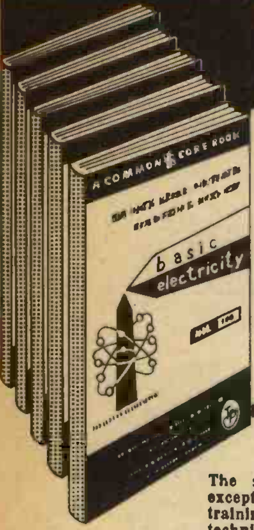

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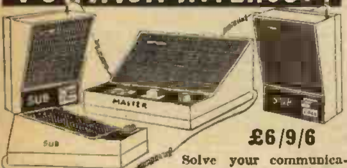

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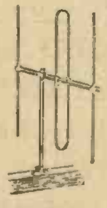

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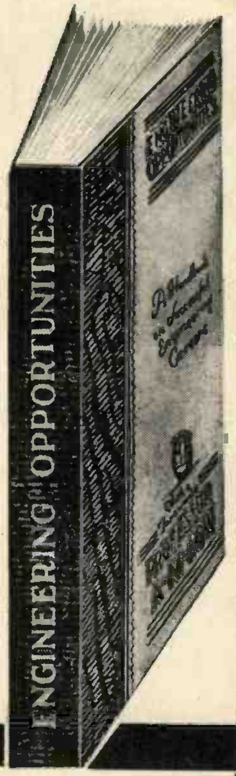

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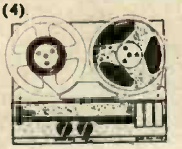

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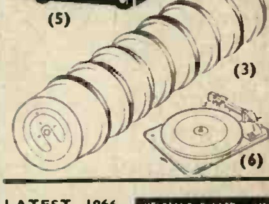

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