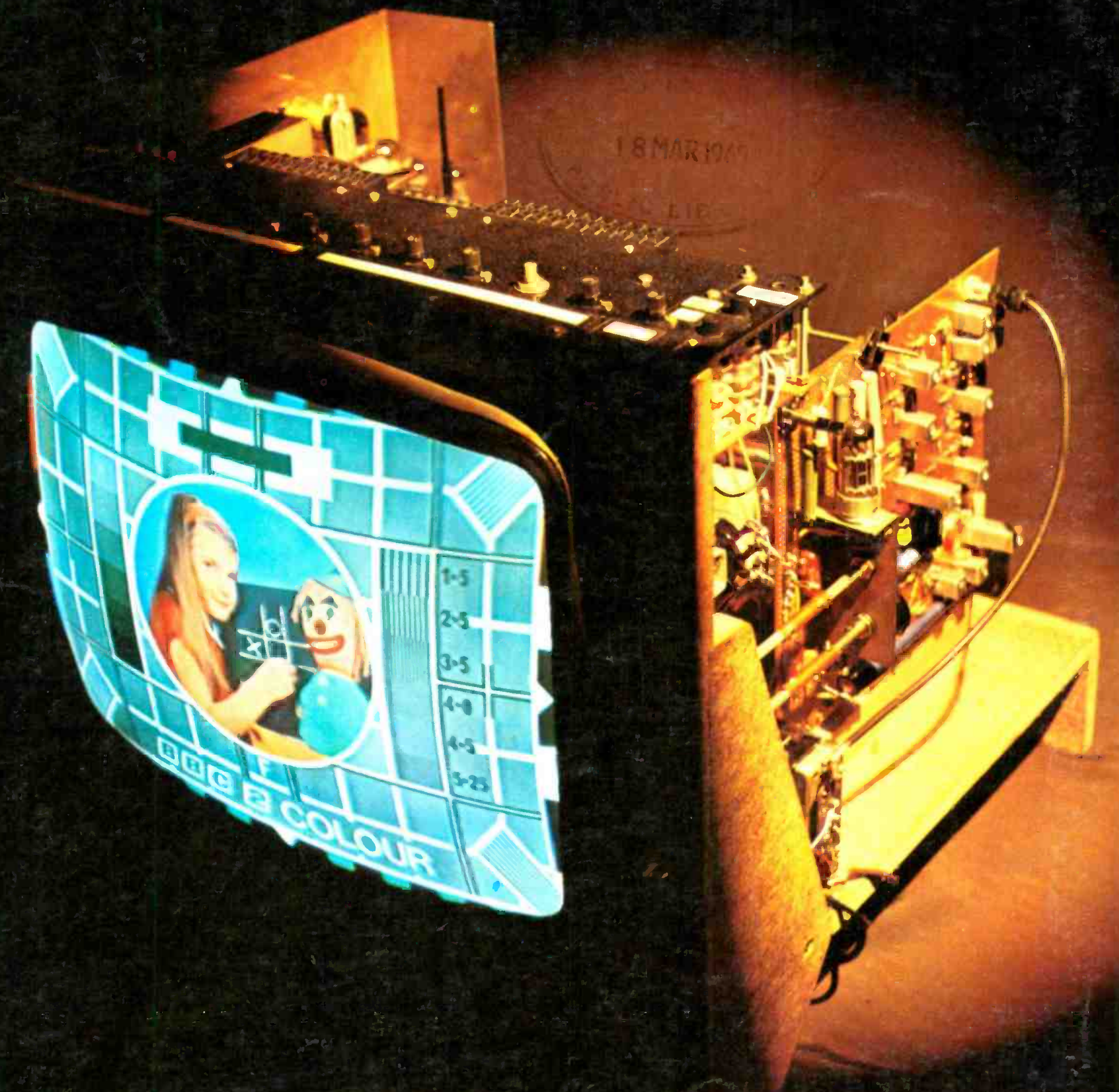
Wireless World

April 1969 Three Shillings

Class A transistor audio amplifier

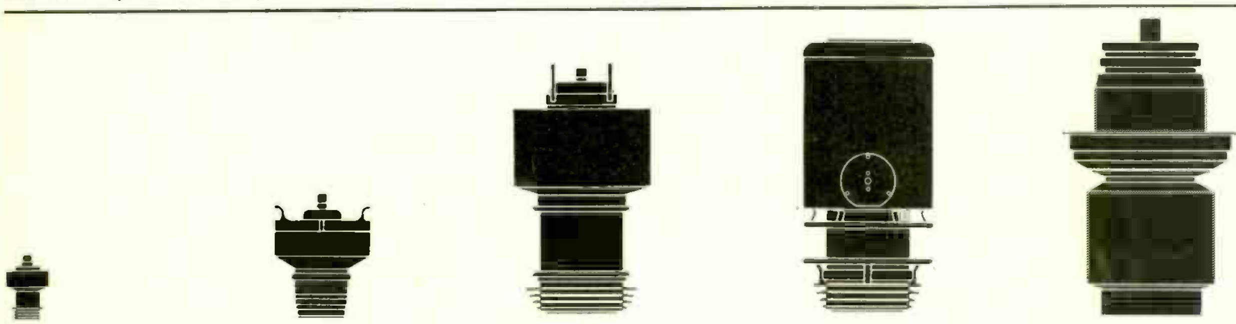


W.W. colour receiver : decoding

If you need power tetrodes at the right price look at this EEV range

Forced-air Cooled Type	Service type	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kv)	Frequency (MHz)	Filament ratings (V)	Filament ratings (A)
4CX1000A 4CX1000K	—	1.0	3.2	3.0	110	6.0	9.0
4CX1500B	—	1.5	2.7	3.0	30	6.0	9.0
4CX5000A	CV8295	5.0	16.0	7.5	30/110	7.5	75
4CX10,000D	CV6184	10.0	16.0	7.5	30/110	7.5	75
4CX35,000C	—	35.0	82.0	20.0	30	10	300
CR192A (6166A)	CV8244	10.0	9.0	6.9	60/220	5.0	175

Vapour Cooled Type	Anode dissipation max. (kW)	Output power (kW)	Anode voltage max. (kv)	Frequency (MHz)	Filament ratings (V)	Filament ratings (A)	Boiler unit
CY1170J	60	82	15	30	10	300	Integral
CY1172 (RS 2002V)	150	220	15	30	21	350	CY4120



4CX1000K — For audio or linear single sideband amplifiers. 4CX1000K has a solid disc screen contact to permit use up to 400MHz.

4CX10,000D — For audio, linear, single sideband or screen modulated r.f. amplifiers.

4CX35,000C — For audio amplifiers, r.f. linear amplifiers or Class C amplifiers or oscillators.

CY1170J **CY1172** — For audio amplifiers, r.f. linear amplifiers or Class C amplifiers or oscillators. Both types have a coaxial metal-ceramic envelope. A range of glass envelope types is also available.

Send for full details of EEV tetrodes

English Electric Valve Co Ltd
Chelmsford Essex England Telephone: 61777
Telex: 99103 Grams: Enelectico Chelmsford

Please send me full data on your range of forced-air cooled and vapour cooled tetrodes.
I am also looking for a power tetrode with the following parameters.

Output power (kW) Anode voltage max (kV) Frequency (MHz)

NAME POSITION

COMPANY

ADDRESS

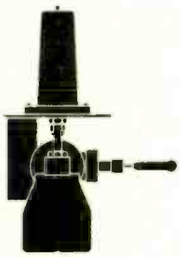
TELEPHONE NUMBER EXTENSION WW 10

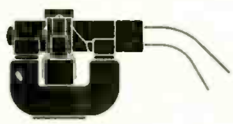
AP 358

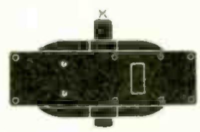
Be safe...use EEV magnetrons in your marine radar

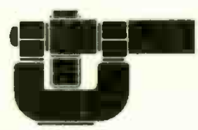
Brief data on some of the many types available. The complete range covers S-Band and X-Band types from 3-80kW.

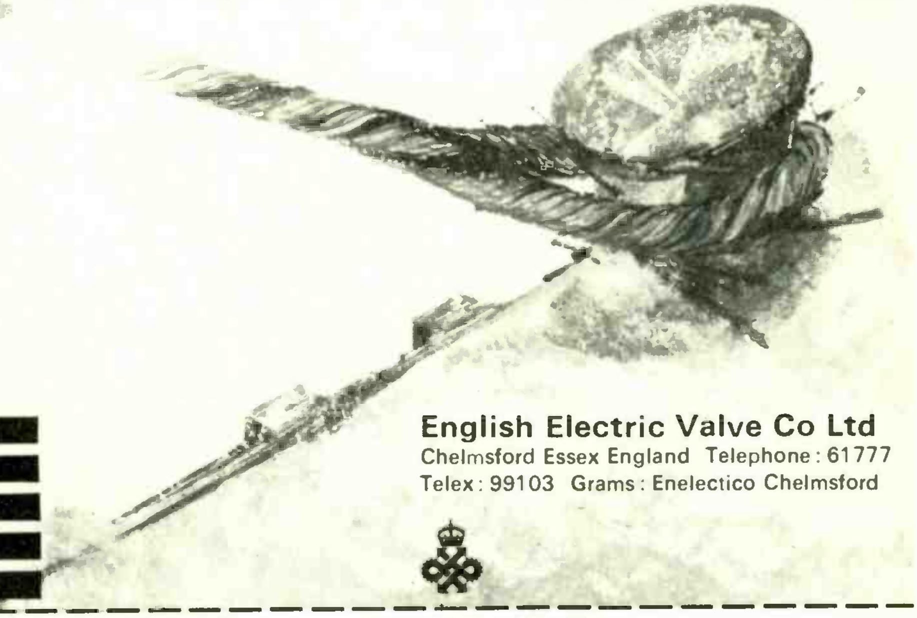
Type	Frequency Range (MHz)	Peak Output Power (kW) (Typical Operation)	Equivalents (not complete)
M5063	3025-3075	50	2J70B
2J42	9345-9475	8	ME1101, CV3676, MAG3, M526
BM1002	9415-9465	21	JP9-15B
M513B	9345-9405	22	JP9-15, YJ1110
M515	9380-9440	25	YJ1120
M597	9380-9440	10	
M598B	9380-9440	22	
599A/B	9415-9475	3	JP9-2.5D, JP9-2.5E, 7028
M5022	9415-9475	30	YJ1121
M5031	9345-9405	9	
M5043	9380-9440	5.8	
M5039	9345-9405	22.5	


M5063


M515


M599A/B


M513B



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Frequency Range (MHz)	Peak Output Power (kW)	Pulse Length (μs)	Pulse Repetition Rate (p.p.s.)

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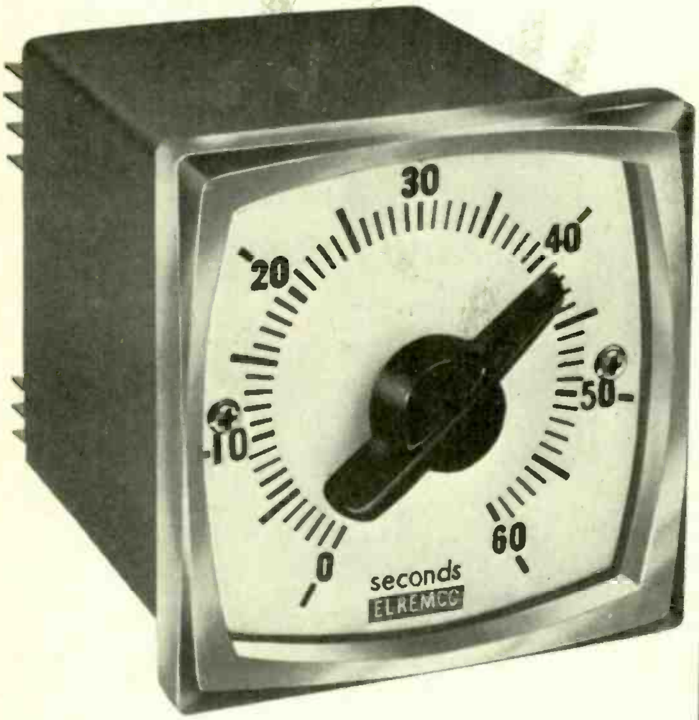
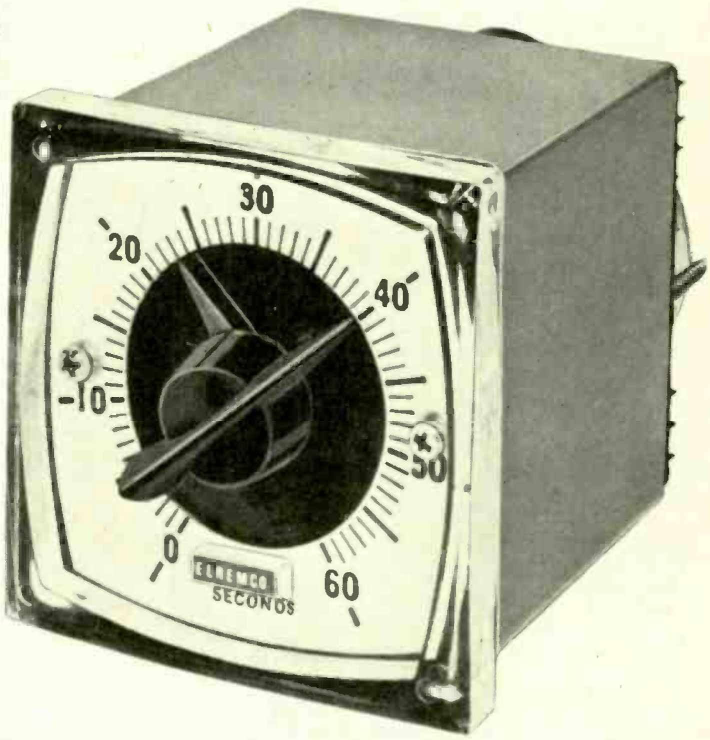
WW9
AP 355

ABOUT TIME...





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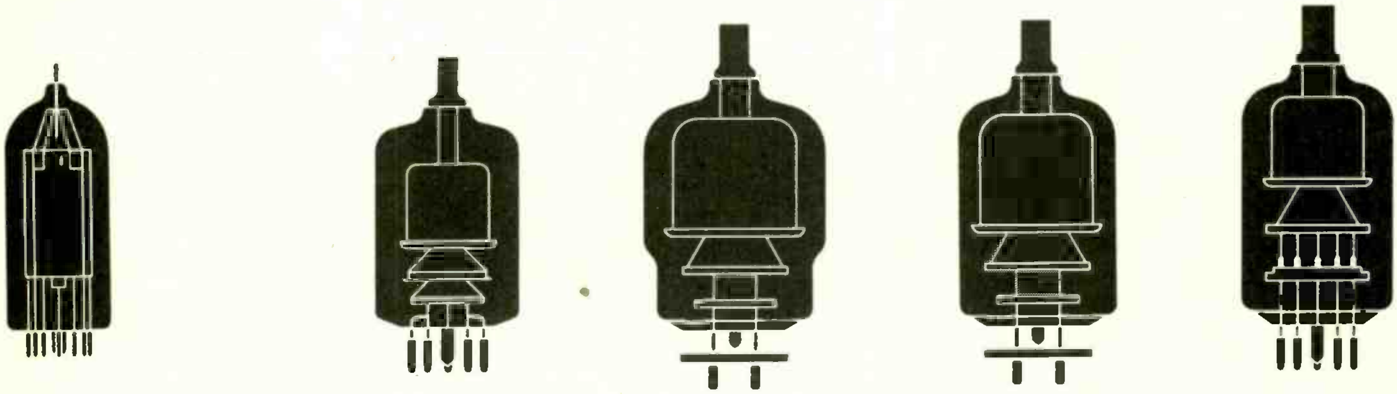
New pulse tetrode for low power radars added to EEV's range

The new C1179—a high vacuum beam tetrode designed primarily for the output stage of power amplifier pulse modulators in 5kW-10kW radars.



C1179 C1148 C1149/1 C1150/1 C1166

Type	Service type	Anode dissipation max. (W)	Pulse output power (kW)	Anode voltage max. D.C. (kV)	Pulse anode current max. (A)	Heater ratings (V)	Heater ratings (A)	Base
C1148	—	40	130	14.0	12	6.3	5.0	B5F
C1149/1	CV6131	60	330	20.0	18	26.0	2.15	B4A
C1150/1	CV427	60	205	17.5	15	26.0	2.15	B4A
C1166	—	60	205	17.5	15	6.3	9.0	B5F
C1179	—	18	65	8.0	9.0	6.3	2.8	B7A

Send for full data on the EEV range of pulse amplifier tetrodes

English Electric Valve Co Ltd
Chelmsford Essex England Telephone: 61777
Telex : 99103 Grams : Enelectico Chelmsford

Please send me full details on your range of pulse tetrodes.
I am particularly interested in using a pulse tetrode with the following parameters:

Pulse output power	Anode dissipation	Anode voltage	Pulse anode current

NAME POSITION

COMPANY

ADDRESS

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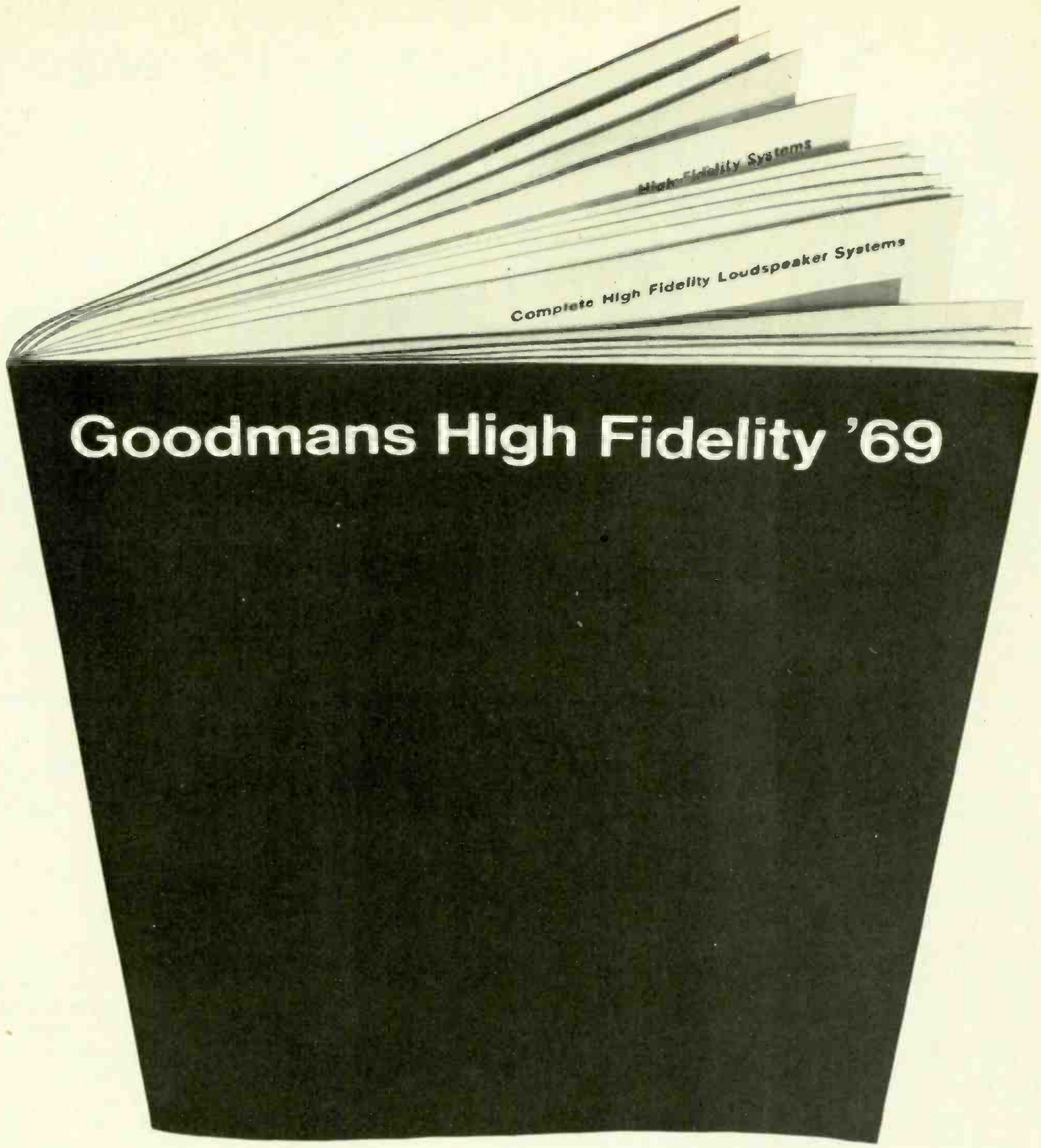
WW11
AP 362



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WW 4

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Holdings Audio Centre, *39-41 Mincing Lane*

Blackpool
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Harker & Howarth, *Churchgate*

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Tape Recorders (Bournemouth) Ltd., *874 Christchurch Road*

Bournemouth
Forrester's, National Radio Supplies Ltd., *70-72 Holdenhurst Road*

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Audio Bristol, *Park Street Avenue, Bristol 1*

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John Mitchell, *141 King street*

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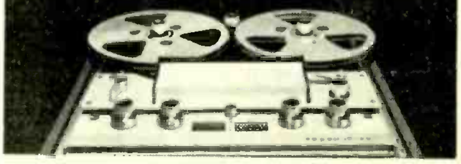

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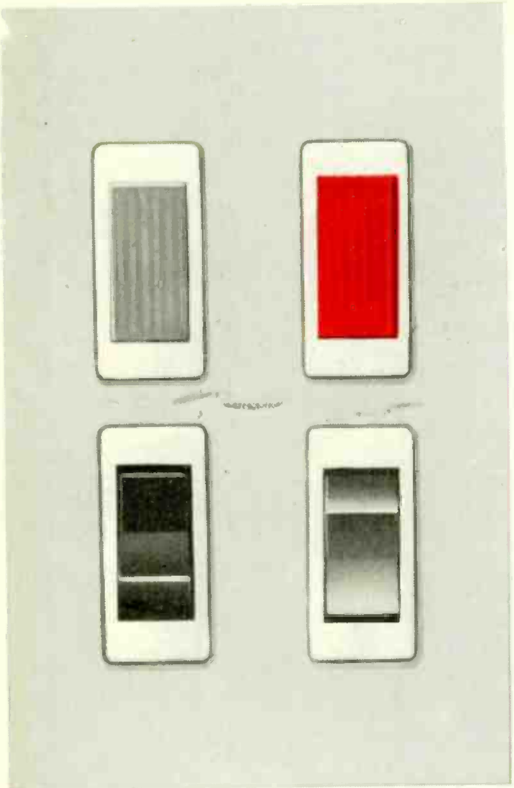

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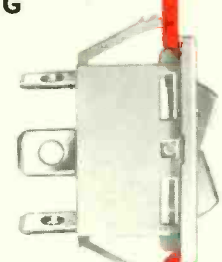

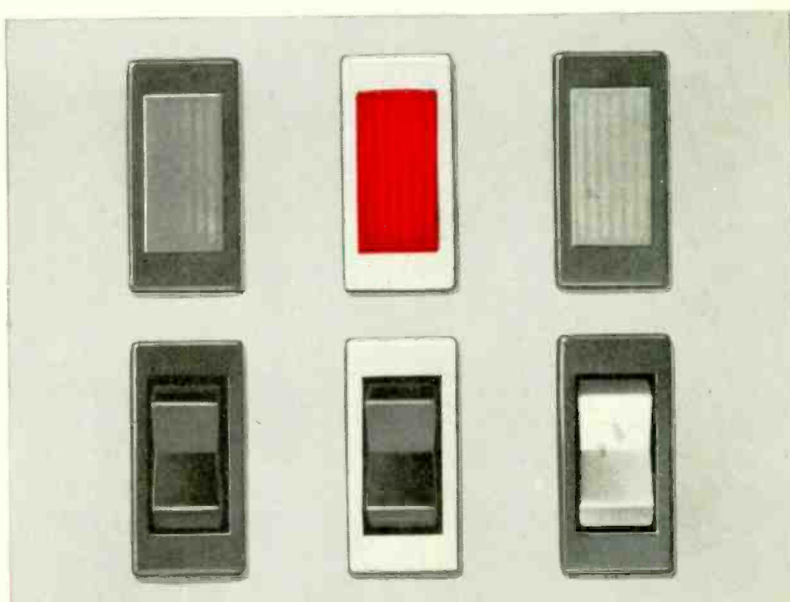

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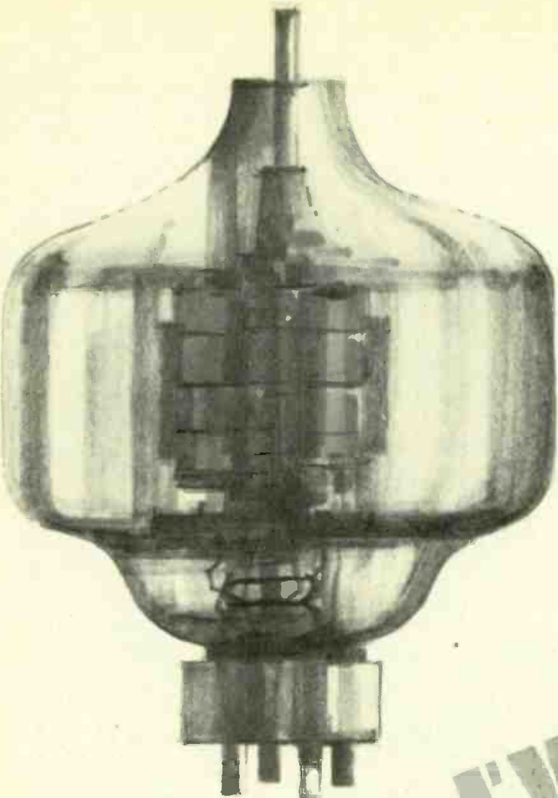

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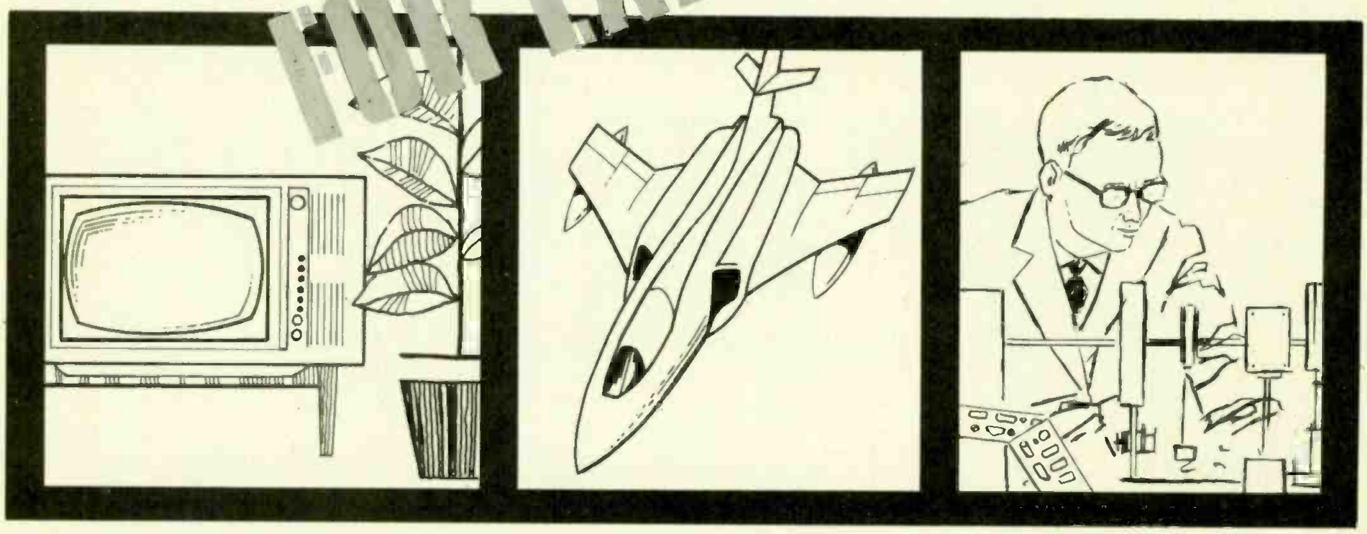

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Fully transistorised transmitter and receiver · Very high performance receiver · Crystal filter selectivity · 0·5W transmitter output · 250mW audio power · Long endurance with rechargeable or dry batteries · Can be used with external antenna to give greater range · Weatherproof.

Pye VHF Radiotelephone Fixed Station

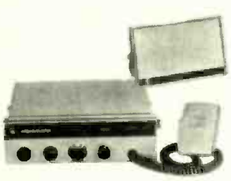
Solid-state receiver and transmitter · 10-15W R.F. output · Field-effect transistors used in receiver · Suitable for all climates · Electronic squelch · Designed to meet all relevant specifications.

Pye UHF Radiotelephone Fixed Station

Solid state receiver and transmitter · 8-10W R.F. output · Very high R.F. selectivity using field-effect transistors · Very low noise factor · Electronic squelch · A. C. or 24V d.c. operation · Suitable for all climates · Designed to meet all relevant specifications.

Pye 'Westminster' Remote Mounted Radiotelephone

Completely solid state · 5-8W R.F. output · 1-10 channels with solid state switching · Illuminated channel indicator · Suitable for all climates · Meets all relevant specifications.

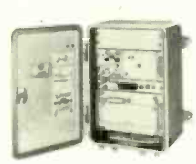


Pye 'Westminster' Front Mounted Radiotelephone

Completely solid state · 5-8W R.F. output · 1-10 channels with solid state switching · Suitable for all climates · Meets all relevant specifications.

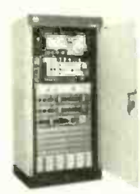
Pye Single-Sideband Radiotelephone

125W (p.e.p.) R.F. output · Fully transistorised receiver · C.W. facilities provided · Sideband selection by crystal filter · Carrier insertion for a.m. compatibility · Fixed or mobile application · Advanced transmitter design.



Pye 'Pioneer' Radiotelephone

Fully transistorised · For use with automatic, CB manual, or magneto exchanges · Weatherproof cabinet · Unattended operation over long periods · Facility for fitting privacy equipment · Optional single antenna operation.



Pye 5-Circuit UHF Radiotelephone

Compact 5-circuit radio terminal · Fully-transistorised channelling equipment · Frequency-shift signalling · Continuous unattended operation in all parts of the world · Twelve standard plans for terminals and repeaters.

PYE equipment gives you instant-contact with mobility

PYE TELECOMMUNICATIONS LTD. Cambridge England Telephone: Cambridge (0223) 61222 Telegrams: Pyetelecom Cambridge Telex: 81166


Not only beautiful, but...
✳ Lightweight
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The Astrolite headset is a unique design which brings together elegant appearance, high performance and reliability. Communications or high fidelity versions available.
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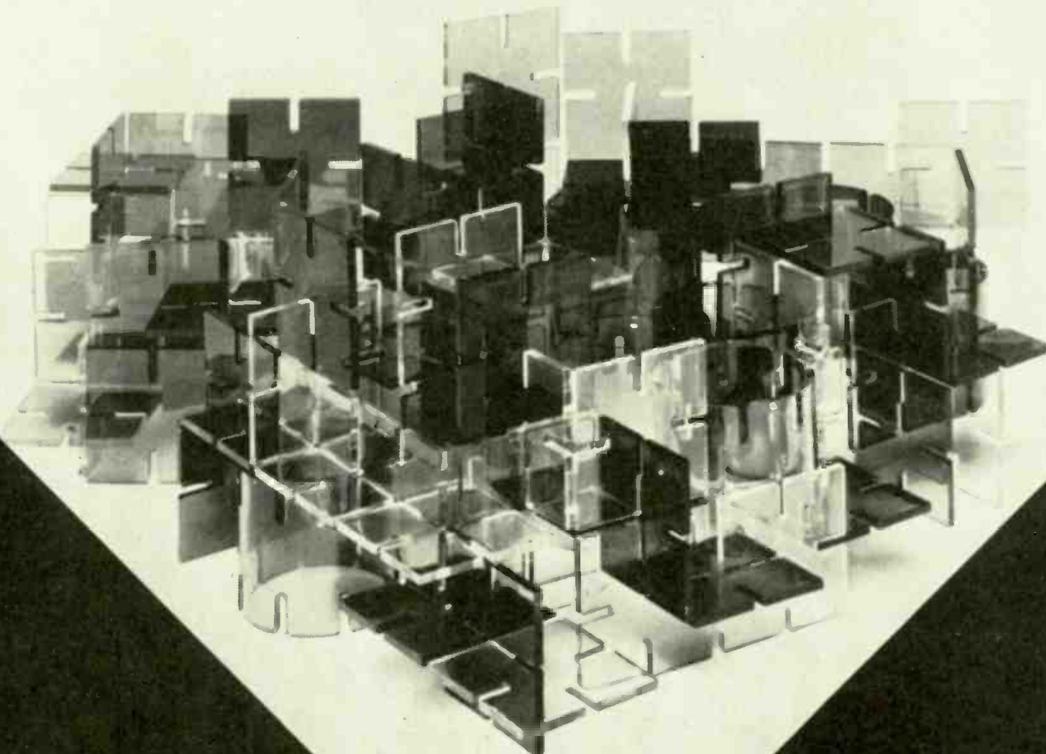

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THE MESSAGE IS PERFECTLY CLEAR: T-R-I-O

Model 9R-59DE

BUILT IN MECHANICAL FILTER 8 TUBES COMMUNICATION RECEIVER

- Continuous coverage from 550 KHz to 30 MHz and direct reading dial on amateur bands.
- A mechanical filter enabling superb selectivity with ordinary IF transformers.
- Frequency Range: 550 KHz to 30 MHz (4 Bands)
- Sensitivity: 2 μV for 10 dB S/N Ratio (at 10 MHz)
- Selectivity: $\pm$5 KHz at $-$60 dB ($\pm$1.3 KHz at $-$6 dB) When using the Mechanical Filter.
- Dimensions: Width 15", Height 7", Depth 10".

Model SP-5D

- Communications Speaker which has been designed exclusively for use with the 9R-59DE.

Model HS-4

- Communications Head Phone

Model JR-500SE

CRYSTAL CONTROL TYPE DOUBLE CONVERSION COMMUNICATION RECEIVER

- Superior stability performance is obtained by the use of a crystal controlled first local oscillator and also, a VFO type 2nd oscillator.
- Frequency Range: 3.5 MHz–29.7 MHz (7 Bands)
- Hi-Sensitivity: 1.5 μV for 10 dB S/N Ratio (at 14 MHz)
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- Dimensions: Width 13", Height 7", Depth 10".

JR-500SE

the sound approach to quality

TRIO

TRIO ELECTRONICS, INC.
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TO: B.H. Morris & Co., (Radio) Ltd. WW
Send me information on TRIO COMMUNICATION RECEIVERS & name of nearest TRIO retailer.

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TRIO KENWOOD ELECTRONICS S.A. 160 Ave., Brugmann, Bruxelles 6, Belgium

Sole Agent for the U.K. **B. H. MORRIS & CO., (RADIO) LTD.** 84/88, Nelson Street, Tower Hamlets, London E. 1, Phone: 01-790 4824.

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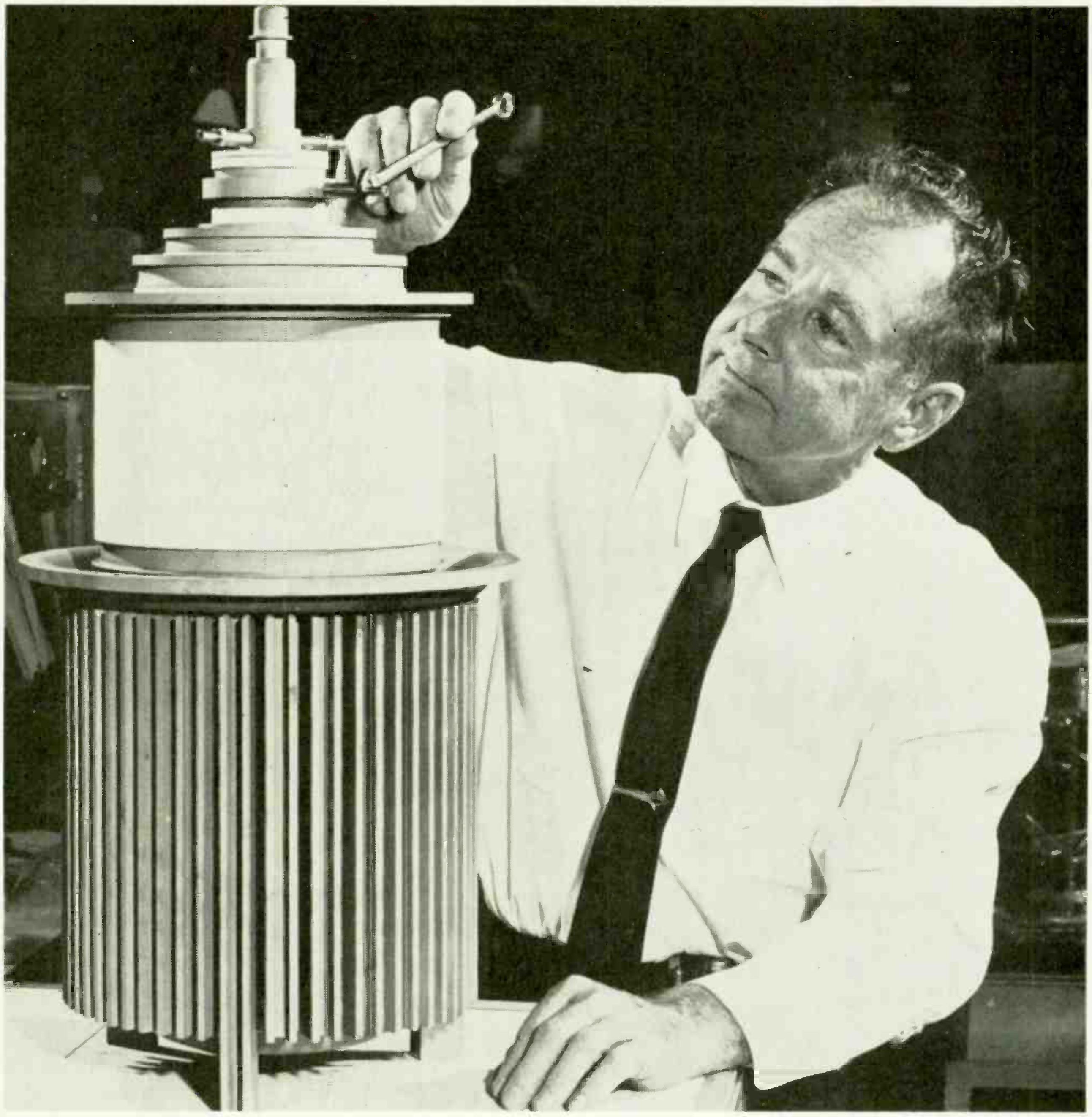

QUAD 50 is a single channel 50 Watt amplifier designed for Broadcast, Recording and other applications in the Audio industry, completely proof against misuse and giving the highest quality of reproduction.

INPUTS – 0·5 Vrms unbalanced with provision for an optional plug-in transformer for bridging 600 ohms lines.
OUTPUTS – isolated providing 50 watts into almost any impedance from 4 to 200 ohms.
DIMENSIONS – $12\frac{3}{4}'' \times 6\frac{1}{4}'' \times 4\frac{1}{2}''$

Complete the coupon and post today.

Please send me full details of the QUAD 50 Amplifier

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WW

QUAD

for the closest approach to the original sound

Your third hand

The ONTOS UNIVERSAL VICE is a new type of multi-purpose, multi-position light engineering vice and stand, fully adjustable for any angle and location in any desired plane. Applications are virtually limitless within its size capacity; i.e. holding P.C. boards for assembly or testing, building up modules, as a micrometer or gauge stand, as a light general purpose vice, in the chemical laboratory, or in fact for all those occasions when you could use a third hand!
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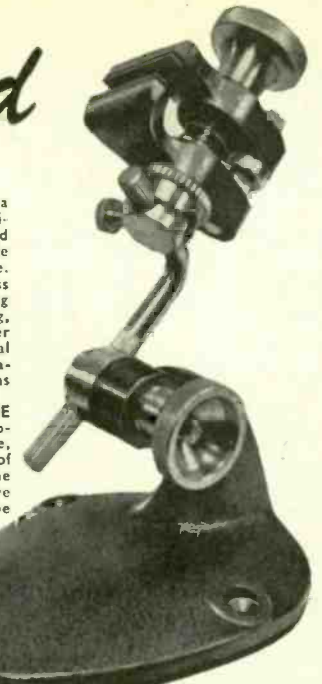
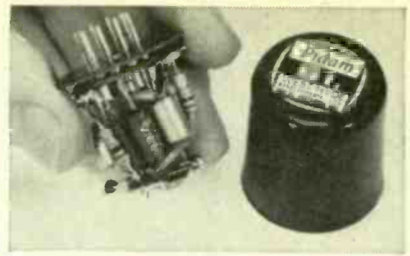
ONTOS: 67/6
plus P&P 3/6
ONTOS TWIN
£5 18 0 plus P&P 4/6



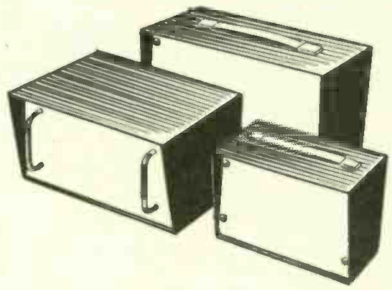


PIDAM (Plug-in Digital and Analogue Modules) perform all the usual logic functions, but, unlike other units, can be plugged in, using their B9A bases and can be quickly connected to the required configuration. To help learning, the module covers are easily removable for circuit examination and sets of components are available.
The 22 modules have an enormous range of use, from a single MONO for a tachometer, to over 300 units in a computer interface; nevertheless, their greatest asset is extreme simplicity. Design time is cut and elaborate breadboards superseded and any reader of "Wireless World" could with **PIDAM**, build up a low cost system for his own needs.
6 NEW modules—send for free information.

PIDAM PLUG-IN MODULES - PRICES

Prices range per module from 8/- to 28/- and all necessary accessories are supplied. A complete starting kit is only £20 19s. 6d. (normally £23 12s. 6d.).

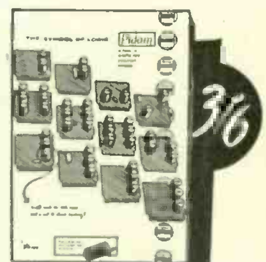
Contil Cases



Contil cases are mass-produced to give lowest prices yet. In 21-gauge steel. Finished hammer blue, with 18-gauge front panel supplied with easy-to-strip protective covering for easy marking out. For ease of ordering Contil cases are described by their dimensions, i.e. 755 is 7 × 5 × 5. Individually packed, including feet and screws.

PIDAM BROCHURE

Send for this complete explanatory booklet showing detailed examples and circuit diagrams of all modules. Examples and circuits given include voice-operated switch, alarms, flashers, tachometer, timers, batch counters, etc.



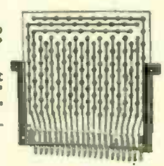
R.E.C.M.F. Exhibition

Readers of Wireless World visiting stand No. G.340 will be presented with a free model Contil instrument case.

CASE PRICES (*All supplied with protective coated steel panels*)

Nos. denote size in inches	1	5	10	25	50	100	200
755	39/6	38/-	37/-	36/-	35/-	33/-	32/-
867, 975	41/6	40/-	39/6	38/-	37/-	35/-	34/-
1277 white or black panel	45/-	43/-	42/-	41/-	39/6	39/-	38/-
1277 unboxed unpainted Zintec	37/-	36/-	35/-	33/-	32/-	29/6	28/6
1277 nylon-coated	82/6	79/-	77/6	76/-	73/6	73/6	73/6
16127	88/-	86/-	84/6	83/9	81/9	79/9	78/-
16127S	129/-	127/-	125/-	124/-	122/-	119/-	116/-
191010	119/-	116/-	114/-	112/-	111/-	110/-	109/-
191010D desk	169/-	166/-	164/-	162/-	160/-	158/-	158/-

Kit of five cases £11 19s. 0d. including postage and packing, normally £14 12s. 0d.

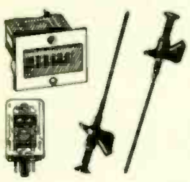


"A" board shown plugged into "M" 20-way connector with "S" board supports.
Note: Power supply rails at right angles to signal rails. "A" boards 8/6 each. 20-way "M" connector 9/-. "S" support 3/- pair. Less for quantities.

CONTIL LOW COST PRINTED CIRCUIT BOARDS

	1	10	50
Standard transistor board "A"	8/6	7/6	7/-
Half board "B"	7/-	5/6	4/6
Connectors 20-way "M"	9/-	8/6	8/-
Connectors 10-way "N"	5/-	4/6	4/-
"P" Chassis to fit 1277 case	39/6	37/6	37/-

Printed chassis kit: including case, normally £14 8s. 6d. for only £11 19s. 6d.



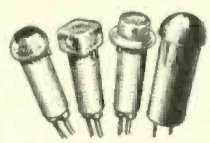
ACCESSORIES

Flexible insulated test prods, colour red or black, at 13/- each with fine steel clips at the tip, opened by button on top. High speed resetting counter including bezel and socket with speed of over 40 operations per second 165/-. Plug in octal relay, 24 volts, with two changeovers 17/6.

REED SWITCH

The West Hyde reed switch works up to 2,000 operations per second with a life of up to 50,000,000,000 operations when used in the recommended circuit. The hermetically sealed switch is protected in a brass tube and moulded into a polypropylene block giving accurate placing of the contents in relation to the mounting screws. 30" nominal leads fitted. Used for Rev. Counters, flowmeters, burglar alarms, under and over speed monitors, etc. 1 at 14/-, 10 at 10/6 each, 100 at 9/- each.

'Brightlife' NEONS



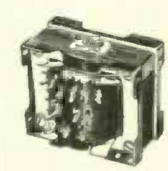
25,000 hour average life. PC type ⅜" diameter, 6" leads with resistor inside. Nine different caps available, 160–260 V, 10 at 2/6 each, 100 at 2/2 each, 1,000 at 1/10 each, 10,000 at 1/8 each. Also available with 30" leads; 110 volt resistor values. PP type ½" diameter also supplied with 30" leads and 110 volt variants. 10 at 2/6 each, 100 at 2/2 each, 1,000 at 2/- each, 10,000 at 1/11 each. Neon/resistor assemblies, 100 at 9d. each, 10,000 at 7d. each. Neons only, 100 at 7d. each, 10,000 at 5½d. each. Neons driven by neon oscillator for 6 to 24 volt input down to 50 mW input. Neons driven by transistors with or without alphanumeric caps.

SUB-MINIATURE NEONS

The smallest yet, type "Q". Overall diameter ⅛", body .7", resistor mounted externally, medium intensity. Minimum quantity 10 at 3/6 each, 100 at 3/- each, 500 at 2/10 each.

TRANSFORMERS

West Hyde have three transformers for transistorised equipment. TRA which provides low voltages at 2 Amps. and high voltages at ·1 Amp. for driving neons or number tubes. TRB which provides 2 Amps. and TRC, a 1 Amp. transformer. The low voltages on TRA, TRB are 6, 10, 15, 18, 30 which can of course be connected to give 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 24 and 30 with 12-0-12 and 15-0-15.



The 1 Amp. transformer gives 6, 10, 18 voltage outputs. The TRA also gives 150-80-0-80-150. TRA at 50/- each. TRB at 37/6 each TRC at 26/- each.

PLEASE NOTE

All products ex-stock for normal quantities. Return of post service. Minimum order £1. Fully detailed leaflets available.

WH WEST HYDE

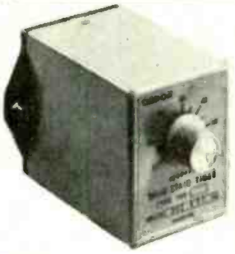
WEST HYDE DEVELOPMENTS LTD.
30 HIGH STREET NORTHWOOD MIDDX.
Telephone: Northwood 24941

WW—036 FOR FURTHER DETAILS

TIMERS MICRO SWITCHES
IMMEDIATE DESPATCH

NEW

Solid State Process Timer type TDS

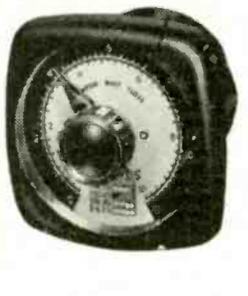


LATEST CIRCUIT PROVIDES PROLONGED ACCURACY

- 1% REPEAT ACCURACY
- OCTAL BASE PLUG-IN
- CIRCUIT CONTAINS BUILT-IN VOLTAGE STABILISER
- CONTACTS: Timed out 5 amp C/O Instantaneous 0·15 amp normally open

30 sec and 60 sec Linear dials
110 and 240 VAC operated
Approximately £10 dependent on quantity

SYS MINI-TIMER

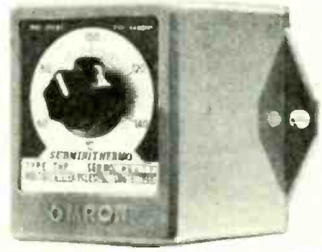


SYNCHRONOUS MOTOR & CLUTCH

★ 10 MILLION OPERATIONS
★ Instantaneous & Timed out 3 AMP contacts.
★ Repeat Accuracy $\pm\frac{1}{2}\%$. 10 secs to 28 Hrs. May also be used as impulse start and automatic reset.

£11.0.0 approx. dependent on quantity.

NEW



TEMPERATURE CONTROLLER TYPE THP

- THERMISTOR OPERATED
- OCTAL BASE PLUG IN
- COMPACT

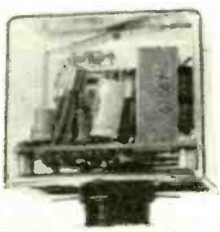
Temperature ranges up to 280°C
Output contacts .4 amp
Repeat Accuracy 3% full scale
Complete with Thermistor
Approximately £15 dependent on quantity

VV-15-1A

★ 15/10 AMPS. c/o
★ 100,000 ops.

1/11 each per 1,000
Single Throw 1/6 each

FLOATLESS LIQUID LEVEL CONTROL



★ 5 amp. OUTPUT CONTROL CONTACTS
★ Solid State
★ Octal Base plug-in

The most compact unit available, measures only $2\frac{1}{2}'' \times 2\frac{1}{2}'' \times 3''$.

Approx. **£4.0.0.**

dependent on quantity.

SINGLE AND TREBLE STAINLESS ELECTRODES AVAILABLE.

STP Sub-Mini Process Timer
SYNCHRONOUS MOTOR & CLUTCH

Matchbox size frontal area.
Automatic re-set.
★PLUG-IN OCTAL BASE
★INSTANTANEOUS AND TIMED OUT 2 AMP CONTACTS
★RANGES: 10 SECS. TO 36 MINS.

approx. **£5.0.0** each.

PROXIMITY SWITCH

YL2 GPA

★ For Batching, Conveyors, Machine Tool Control, Packaging, Sorting, etc.
★ Senses ferrous objects.
★ Needs no mechanical force or pressure to operate.
★ Solid state sensing head includes constant voltage circuit.
★ Mains operated.

approx. £12.10.0 dependent on quantity.
OTHER INDUCTIVE AND CAPACITY TYPES AVAILABLE

SLB CAPACITY PROXIMITY SWITCH

Senses any object:
PACKETS BOTTLES
CARTONS BOXES
CANS

empty or full, ferrous and non-ferrous materials.

STAINLESS PROBE

remote from 240v AC Power Pack which
Incorporates own 5 amp relay.

Suitable for
CONVEYOR SYSTEMS
PACKING MACHINERY
PRESS GUARDS

and level control of
GRANULES
POWDERS
LIQUIDS

Approximately £20.0.0 complete dependent on quantity.

S5G

★ I MILLION OPS.
5 amp. c/o Sub-miniature Micro-switch.

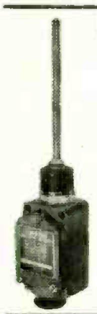
2/6 each per 1,000

VAQ

★ 10 amp. c/o PUSH BUTTON
Panel mounting.
Buttons in six colours.

4/4 each per 1,000.

LIMIT SWITCH
WL 10 FNJ

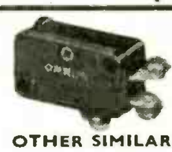


★ 10 AMP 2 CIRCUIT
★ 5 INCH FLEXIBLE ACTUATOR AS ILLUSTRATED

AS LOW AS **53/9** EACH.

FIVE OTHER STANDARD TYPES AVAILABLE

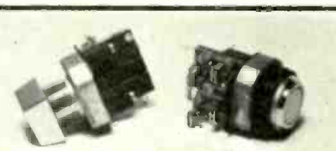
V-10-1B



★ I MILLION OPERATIONS.
★ 10 amp. c/o.
★ COMPARE OUR SPEC. & OUR PRICES WITH OTHER SIMILAR TYPES.

Screw Terms. **3/1** each per 1,000

V-10-1A Solder Tags 2/3 each per 1,000
VV-15 IC2 187 Amp Tags 2/6 each per 1,000



PUSH-BUTTON SWITCHES

Chrome rimmed flush square and flush round. Up to 4 switch blocks can be fitted. Slow break and make. 10 amps. Latest addition—Illuminated version.

U.L. APPROVED (Appr. No. 32667) - - - U.S. MILITARY SPECIFICATION

Stockists: B.P.G. Ltd., Leicester 61460; Edmundsons Electronics Ltd., London, New X 9731; A. C. Farnell Ltd., Leeds 35111; Gordon Wilson Ltd., Blackburn 59921; G.D.S. Ltd., Bucks. Slough 30211
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OMRON PRECISION CONTROLS

DIVISION OF I.M.O. PRECISION CONTROLS LTD.

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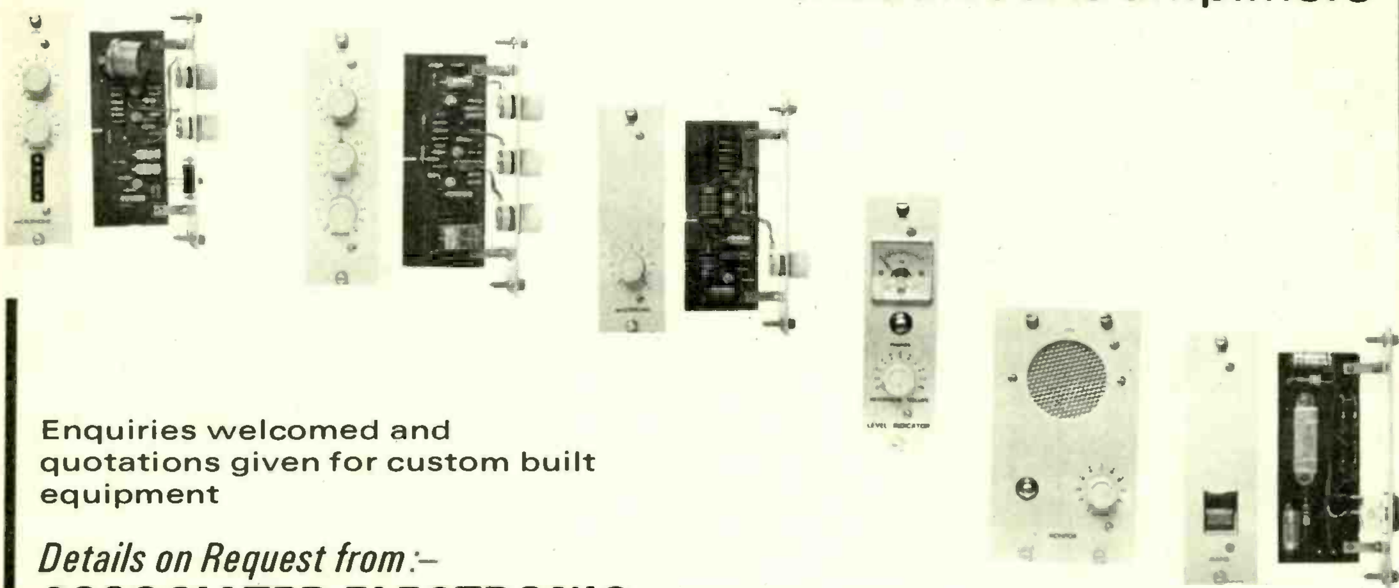
'Astronic'

series 1700

A complete range of transistorised plug-in modules and amplifiers



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Details on Request from:–

ASSOCIATED ELECTRONIC ENGINEERS LTD DALSTON GARDENS, STANMORE, MIDDLESEX
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ALL YOUR SOUND~ With the NEW LM 300 from London Microphone

Latest release in the range of LM Microphones is the most sophisticated design yet. The robust, metal construction with its good back-to-front discrimination is ideal for speech reinforcement systems and recordings.

Recommended retail price from £12 including built-in cable and quick release stand adaptor, depending on impedances.

For details of the LM300 and other superb microphones in the LM range, please ring or write to:

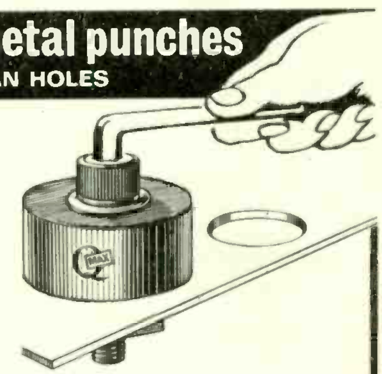
London Microphone Company Ltd

182-4 Campden Hill Road, London W.8. Telephone: 01-727 0711
(24 hour answering service) Telex 23894

WW—039 FOR FURTHER DETAILS

"Q-MAX" sheet metal punches

FOR QUICK AND CLEAN HOLES



30 SIZES:

ROUND:
$\frac{3}{8}''$ to 3″

SQUARE:
$\frac{11}{16}''$ and 1″

RECTANGULAR:
$\frac{21}{32}'' \times \frac{15}{16}''$

Full list on application

- **Simple operation**
- **Quick, clean holes (up to 16 gauge mild steel)**
- **Saves time and energy**
- **Burr-free holes—no jagged edges**
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- **Used all over the world**

Obtainable from Radio, Electrical and Tool Dealers, Wholesale and Export Enquiries to:—

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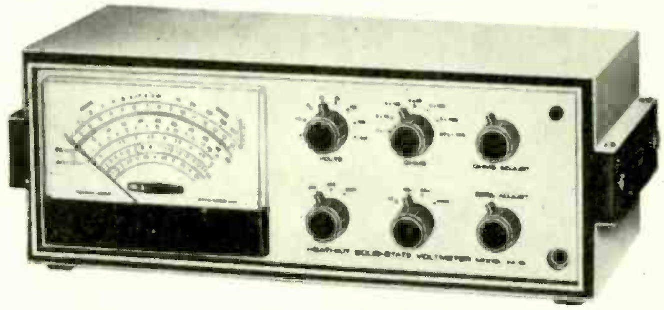
Your first step to saving on instrumentation costs...



Latest Solid - State High - Impedance Volt - Ohm Milliammeter . . . IM-25

• 9 A.C. and 9 D.C. voltage ranges from 150 millivolts to 1500 volts full scale • 7 resistance ranges, 10 ohms centre scale with multipliers ×1, ×10, ×100, ×1k, ×10k, ×100k, and ×1 meg . . . measures from one ohm to 1000 megohms • 11 current ranges from 15μA full scale to 1.5A full scale • 11 megohm input impedance on D.C. • 10 megohm input impedance on A.C. • A.C. response to 100 kHz • 6in. 200μA meter with zero-centre scales for positive and negative voltage measurements without switching • Internal battery power or 120/240 volt A.C., 50 Hz • Circuit board construction for extra-rugged durability.

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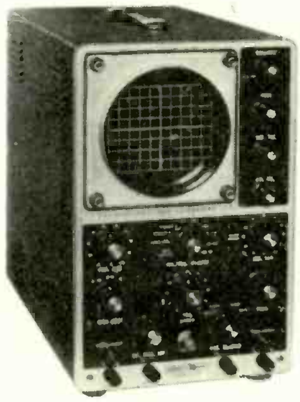
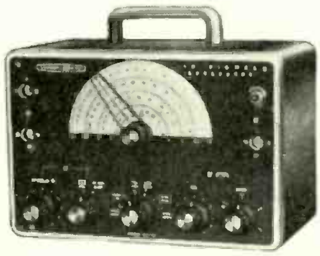
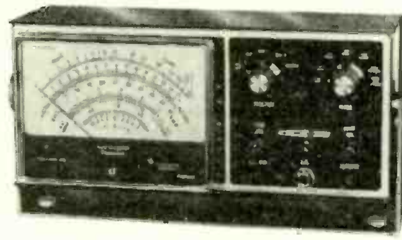


10-12U SCOPE



RF-1U GEN.



VVM IM-13U

3" Portable General-Purpose Service Oscilloscope OS-2

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Vertical amplifier: Frequency response: ± 3 dB, 2 Hz to 3 MHz. **Sensitivity:** 100 mV r.m.s. per cm. at 1 kHz. **Input impedance:** 3.3 megohm shunted by 20 pF. **Horizontal amplifier: Frequency response:** ± 3 dB, 2 Hz to 300 kHz. **Sensitivity:** 100 mV r.m.s. per cm. at 1 kHz. **Input impedance:** 10 megohm shunted by 20pF. **Time base generator:** Range 20 Hz to 200 Hz. Automatic lock-in sync; Retrace blanking **Voltage calibrator:** 1 volt, peak-to-peak, 50 Hz. **Controls:** Brilliance and on/off switch, Focus, Astigmatism, Time base range switch and Fine Frequency, Vertical and Horizontal Gain, Vertical and Horizontal Position.

5" Wide-band General-Purpose Oscilloscope 10-12u

KIT £36.18.0 Ready-to-use **£46.16.0** P.P. 10/6

Vertical sensitivity: 10 mV r.m.s. per cm at 1 kHz. **Frequency response (referred to 1 kHz):** ± 1 dB, 8 Hz to 2.5 MHz; ± 3 dB, 3 c/s to 4.5 MHz; -5 dB at 5 MHz. **Rise time:** 0.08 microseconds or less. **Input impedance:** (at 1kHz) 2.7 Megohms at X1; 3.3 Megohms at X10 and X100. **Horizontal sensitivity:** 50 mV r.m.s. per cm at 1 kHz. **Frequency response:** ± 1 dB, 1 Hz to 200 kHz; ± 3 dB, 1 Hz to 400 kHz. **Input impedance:** 30 Megohms at 1 kHz. **Time base generator:** Range, 10 Hz to 500 kHz in 5 steps, variable, plus 2 switch-selected pre-set sweep frequencies range. **Synchronising:** automatic lock-in circuit.

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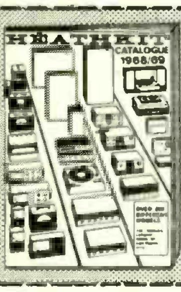

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Extract of letter from Mr. Wendell C. Ward of Texas, U.S.A. September 1968
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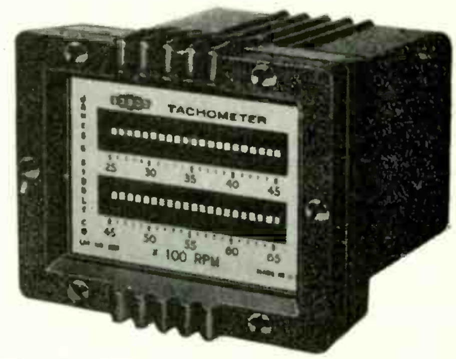

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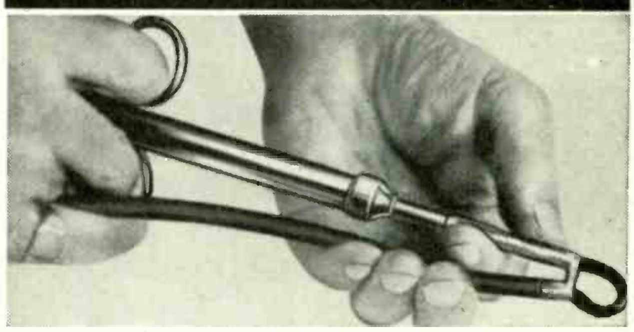

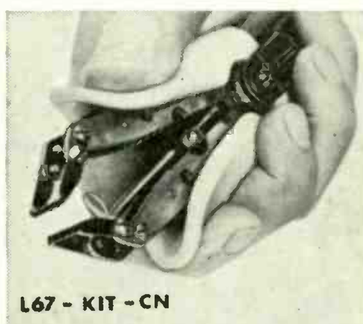

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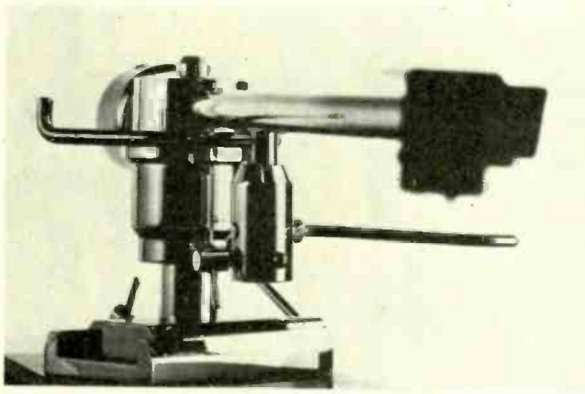

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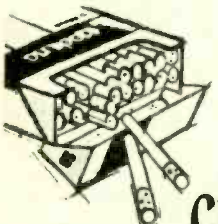

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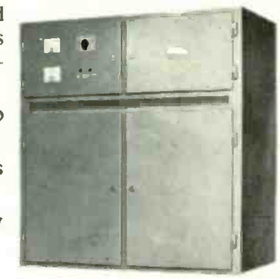

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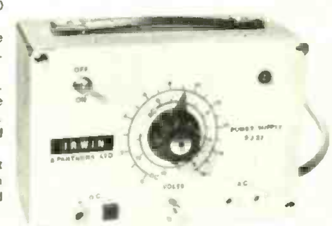

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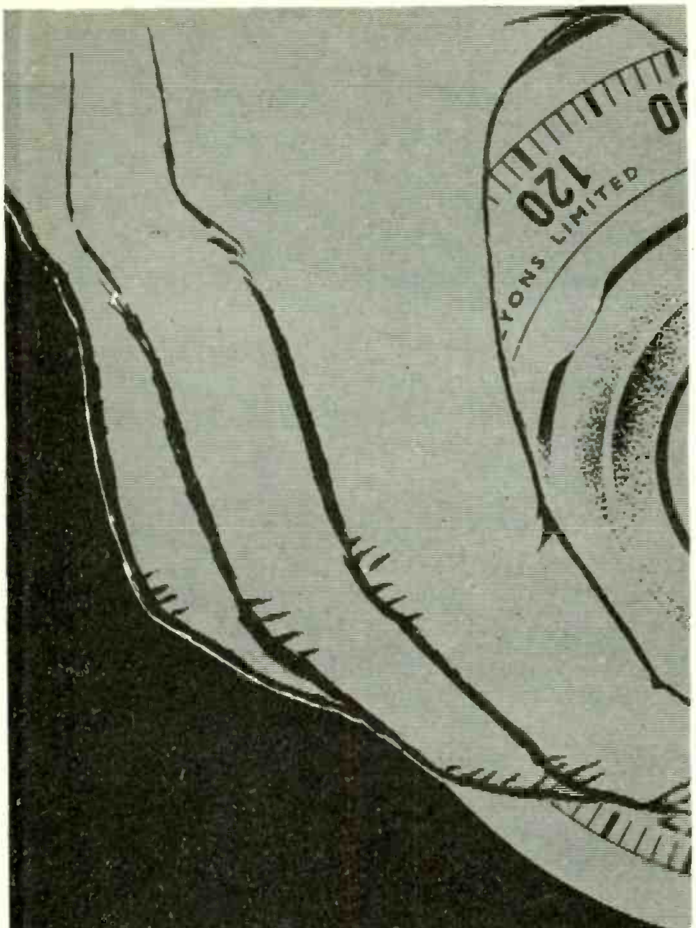
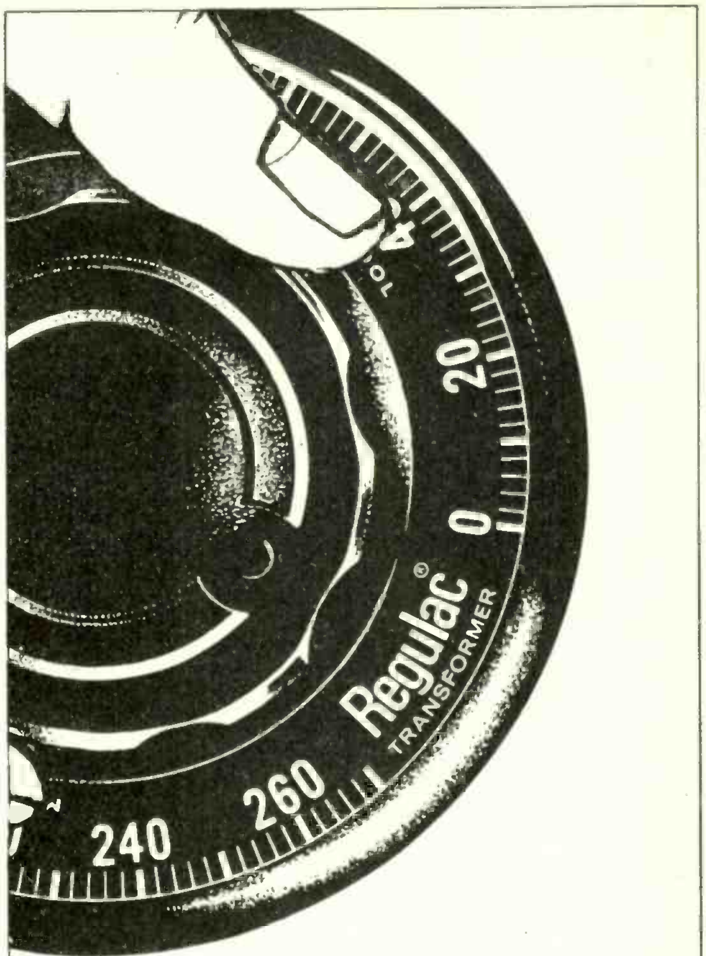


variable transformers?



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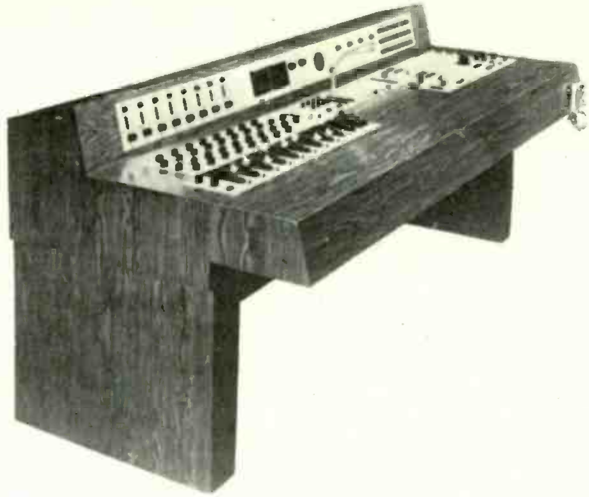

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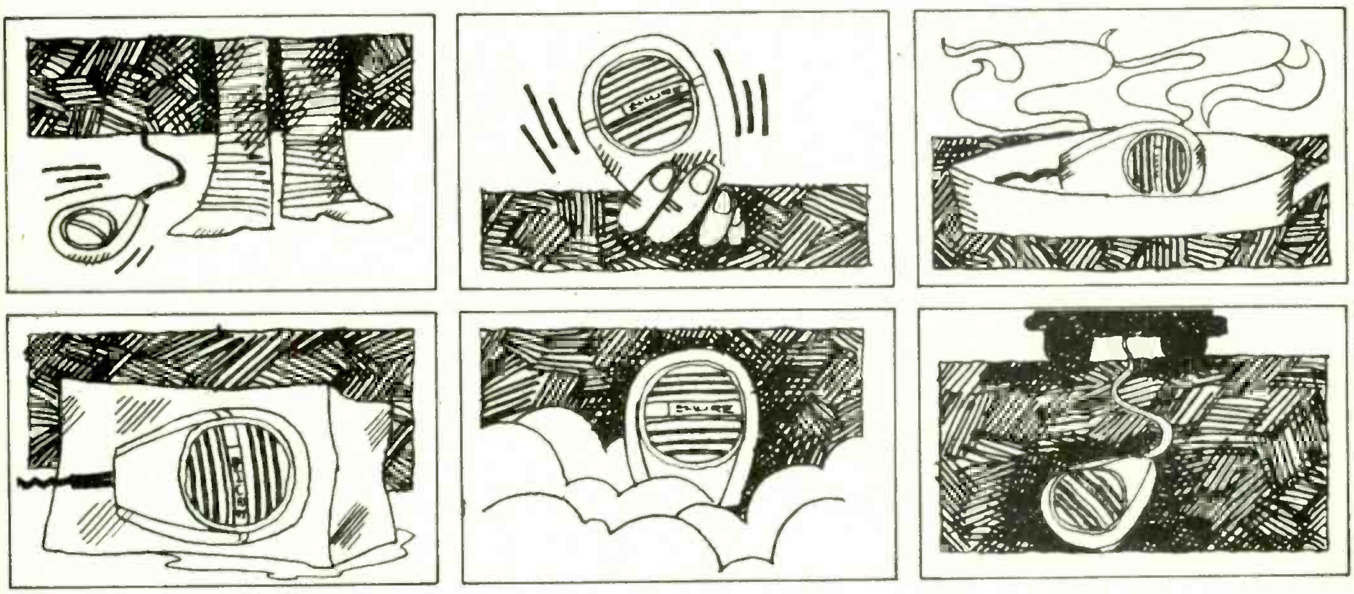

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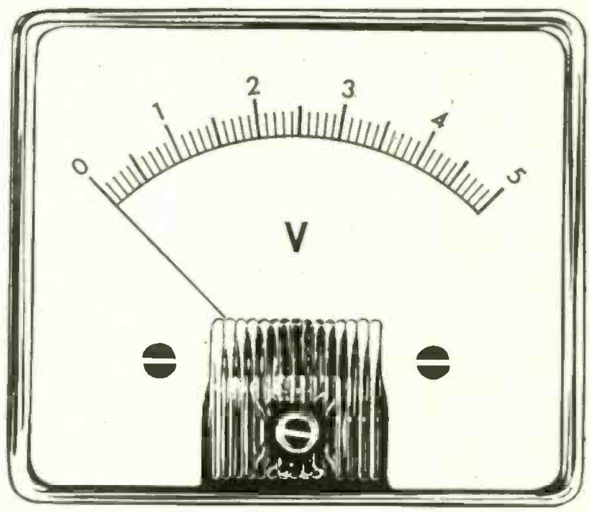

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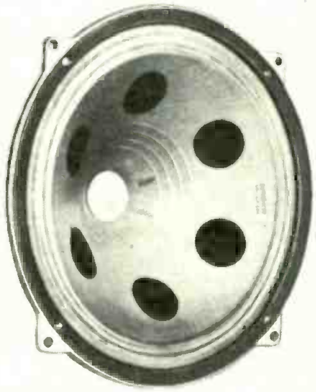
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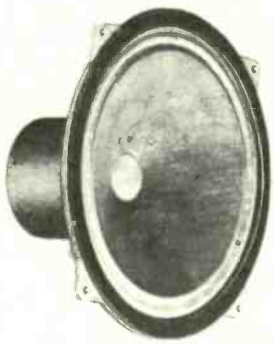

T816


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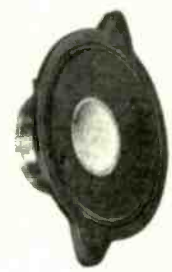

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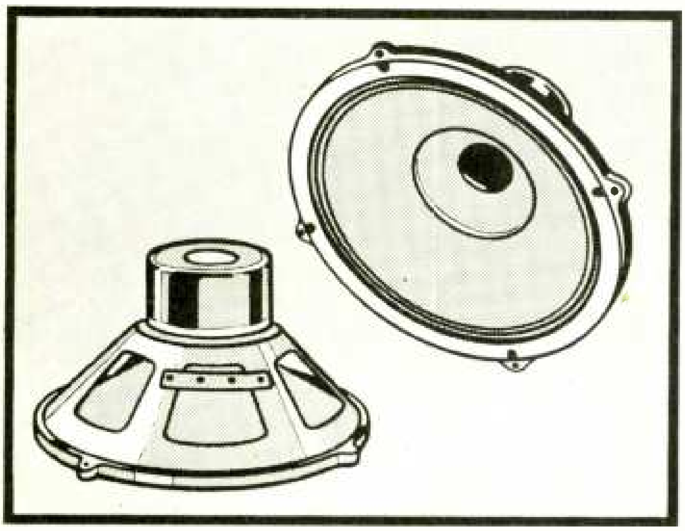

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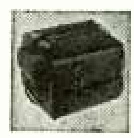

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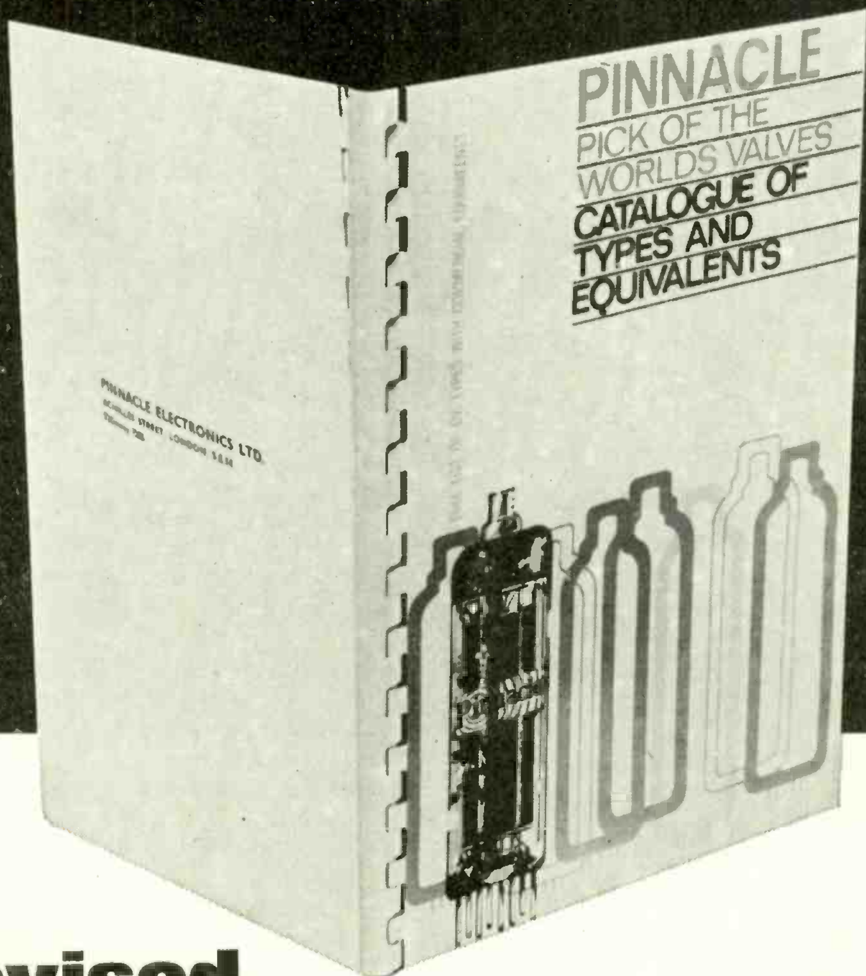

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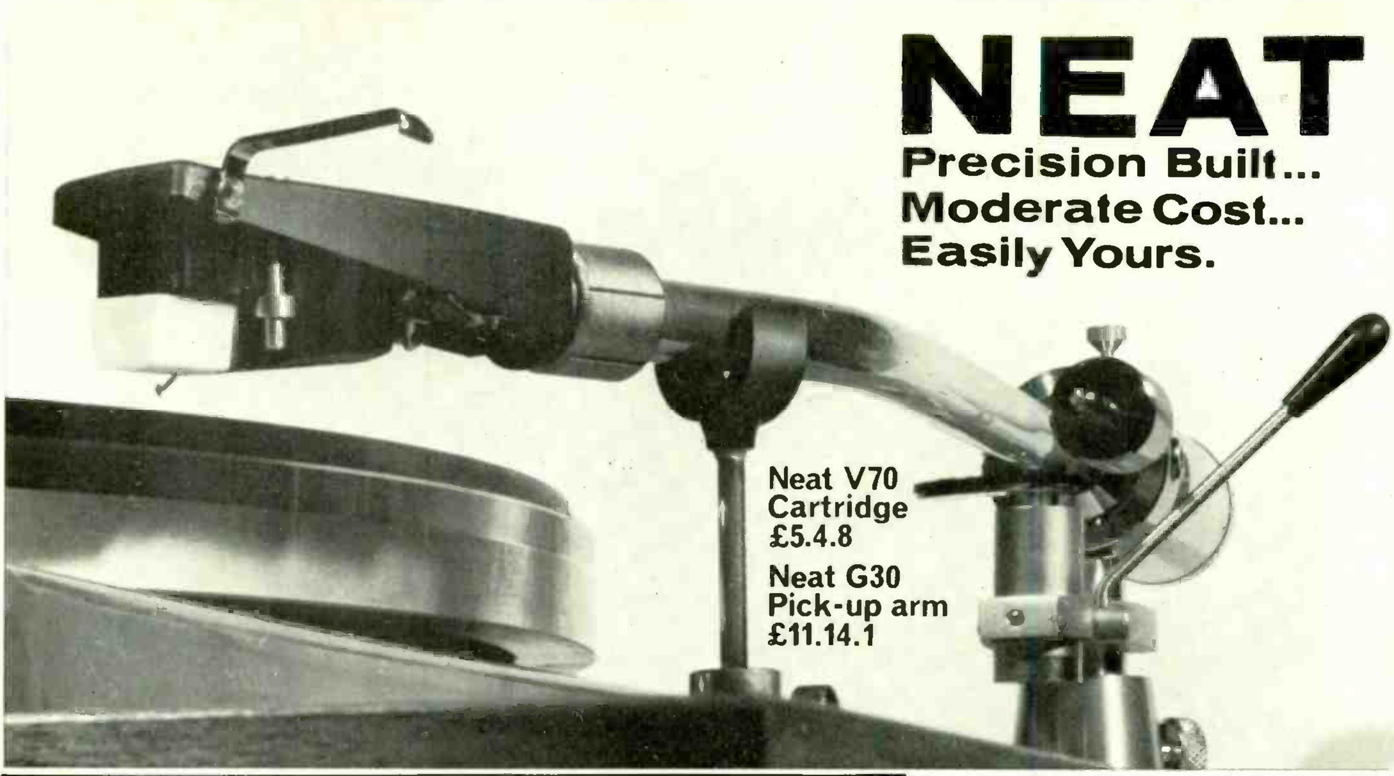

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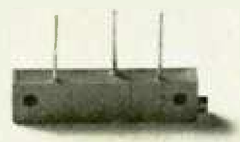
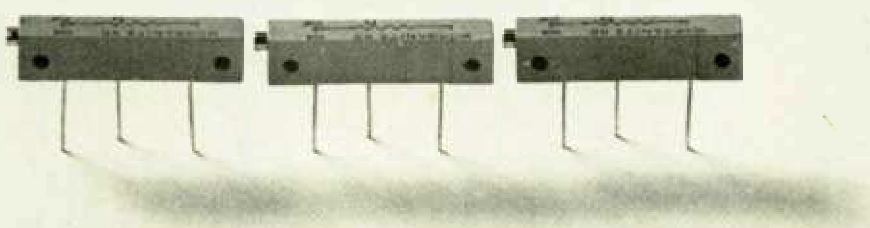


is a dead one of these



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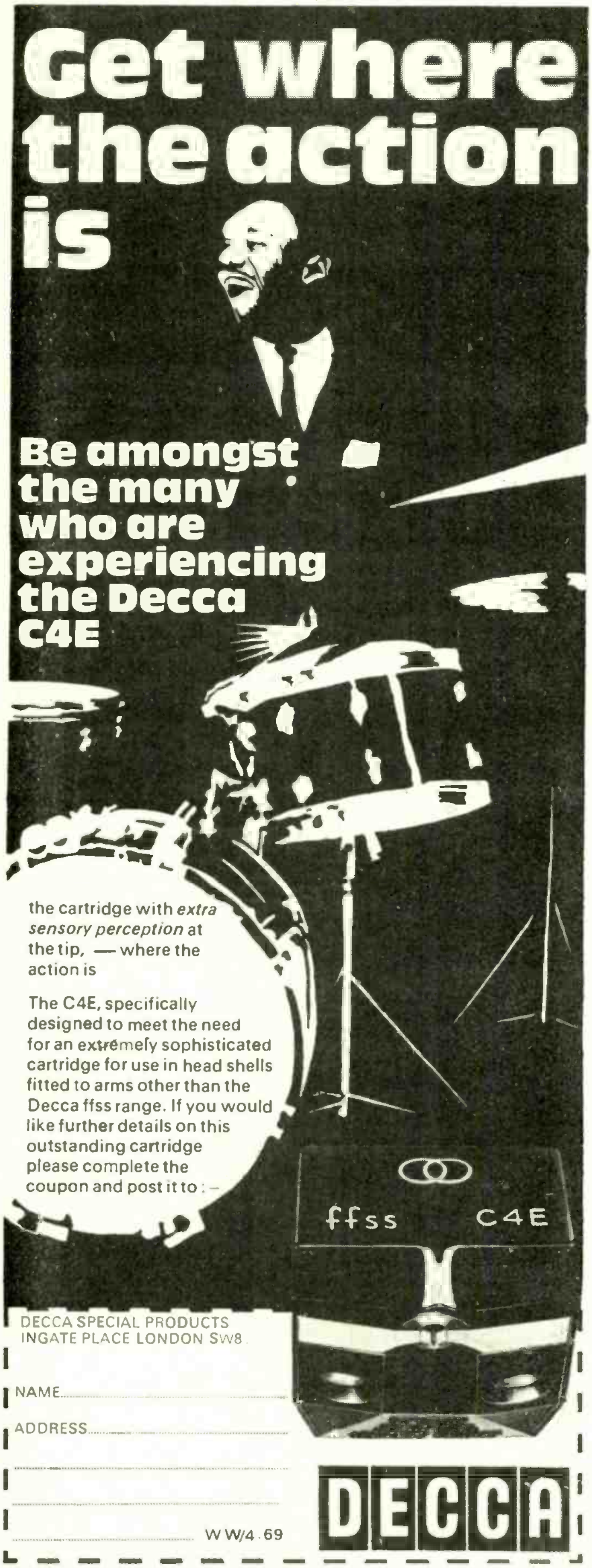

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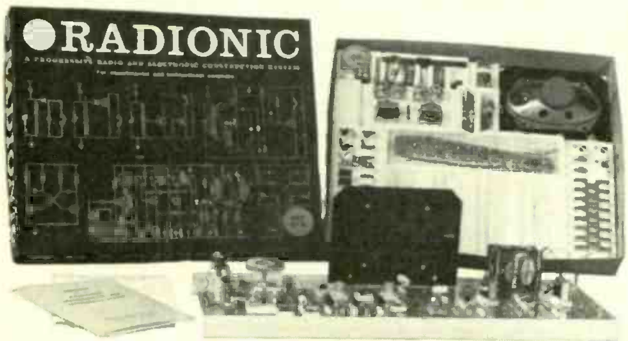

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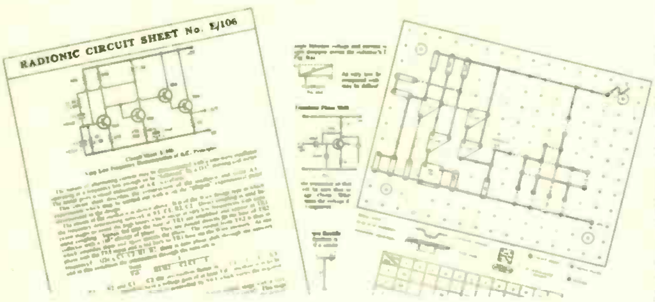

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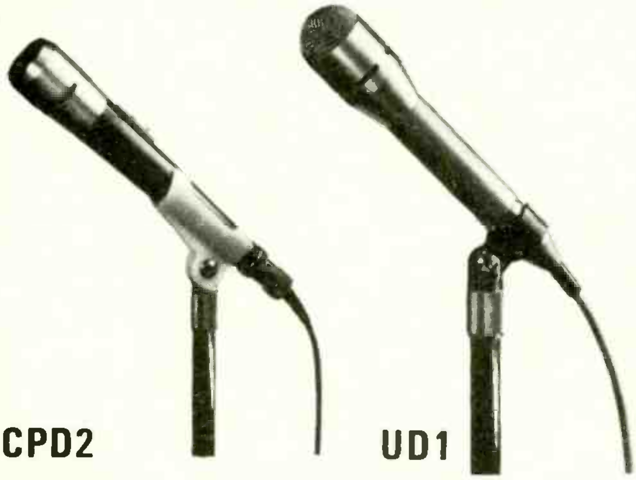

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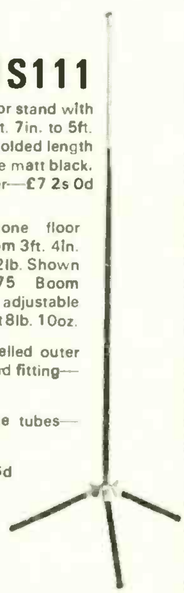

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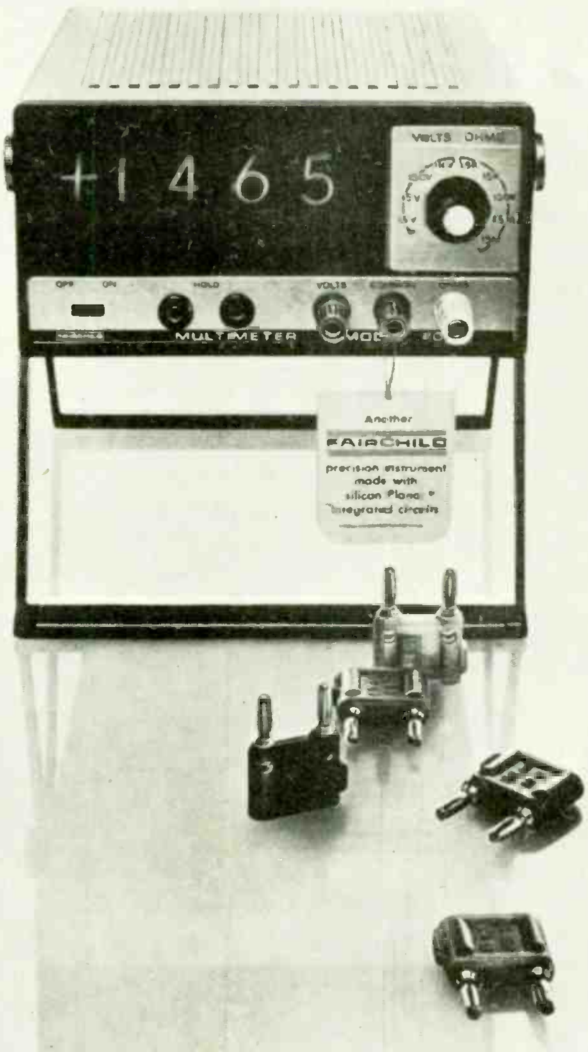

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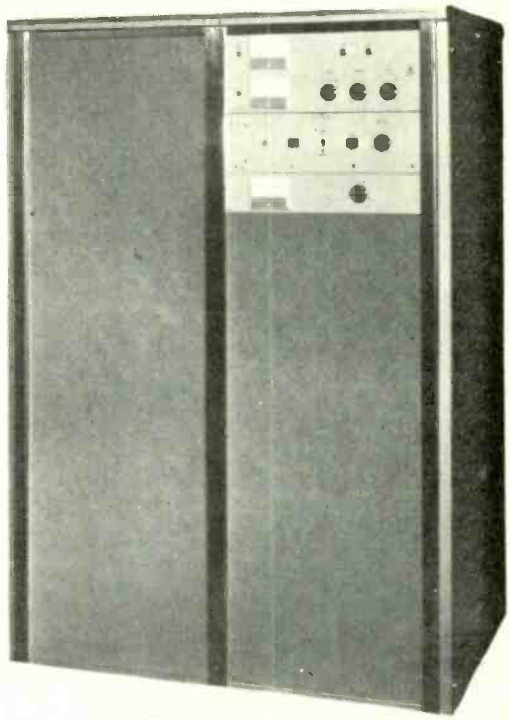

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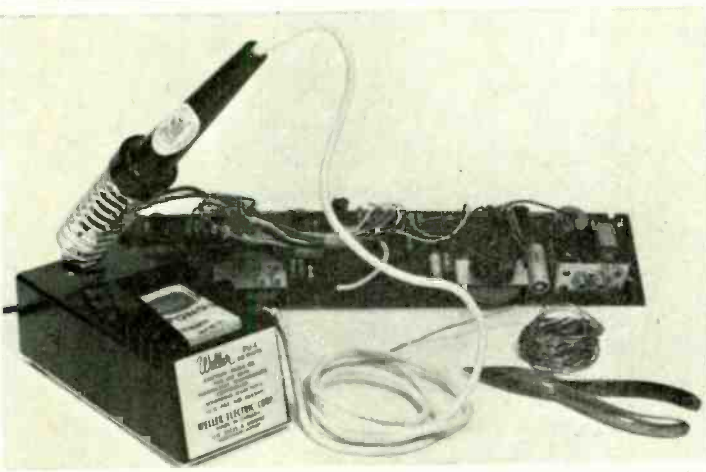

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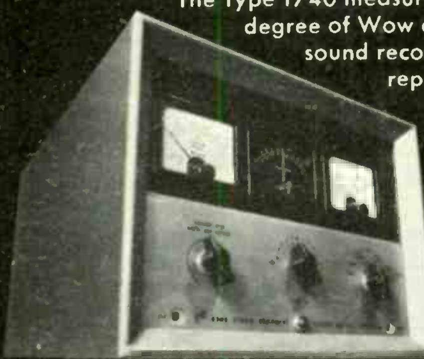

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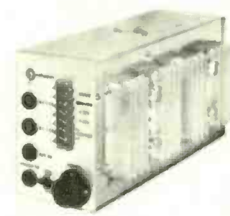

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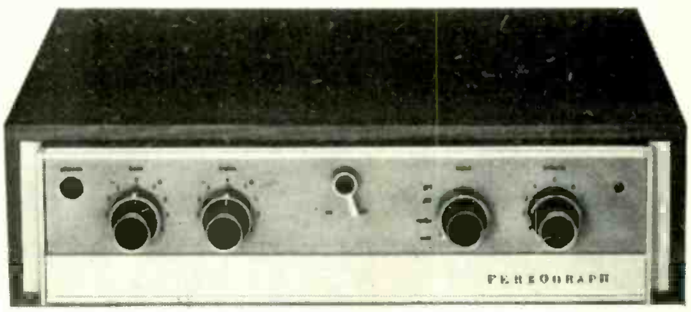

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Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication **April 1969** **Volume 75 Number 1402**

The front cover showing the *W.W.* Colour Receiver in operation symbolizes this month's instalment which deals with colour decoding.

Contents

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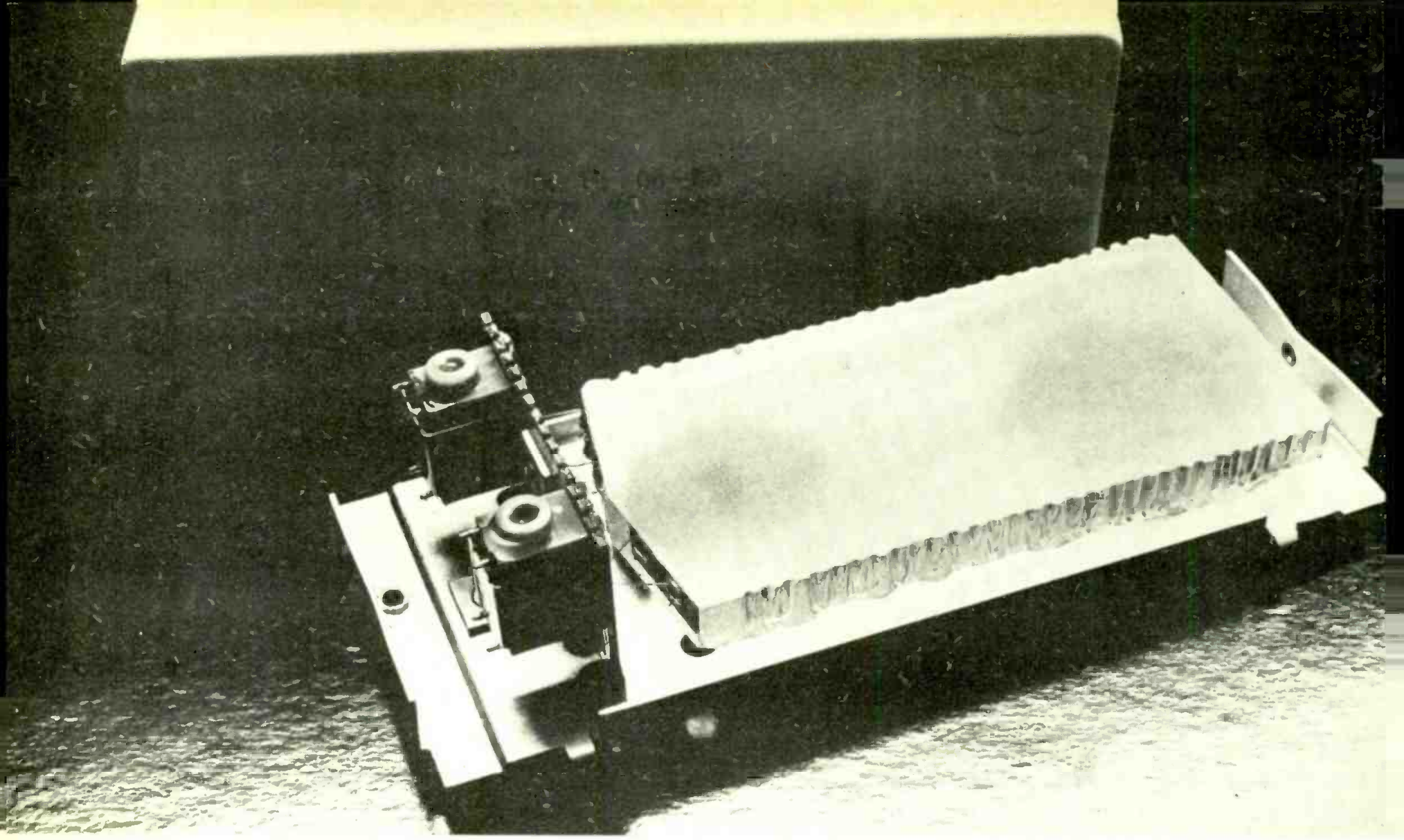


Wireless World

Our Ads

Judging from the various letters we receive, and from the replies to last year's questionnaire, it seems that many readers do not fully understand the nature and function of advertisements. For example, it is not unusual for readers to refer to items in the editorial section as "advertisements", or to advertisers' announcements as "articles". Because we are a technical journal and the advertisements often have a high content of technical information, people seem to get the impression that these advertisements are essentially different from those appearing in newspapers and general magazines. In fact they differ only in the products or services described and in the manner of presentation. Their primary purpose is the same.

In a "free enterprise" economy, advertising, whether you like it or not, has become an integral part of the machinery of mass production and distribution. In so far as it helps to reduce the price of products by increasing the size of markets and thereby lowering the cost of manufacture it is obviously a good thing. To the extent that it has to persuade people to buy goods in order to keep the already established production and distribution machinery fully loaded (and therefore economic) it is not such a good thing. But the second feature is inseparable from the first, so we just have to lump it. Journals and other media co-operate in the system by providing the means for wide dissemination of the advertisements. In return they obtain a revenue which pays for a major part of the cost of their production. Without advertisements, for example, the price of *Wireless World*—just the editorial material—would be about 7s 6d per copy.

From the reader's point of view advertisements have two aspects: (a) they are a service, in that they tell him what is available on the market, and (b) they are a commercial instrument in that they seek to make him *part of* the market, by persuading him to buy. The reader must therefore be careful to distinguish between these two functions. Probably most people would agree that, as a service, the advertisements in this journal are interesting and informative (and—dare we say it?—there are people who buy *W.W.* purely for the advertisements). But as soon as an advertiser goes into print he is starting to persuade: even a straight list of components and their prices automatically carries the implication that the products are worth buying. Any kind of print seems to have a spell-binding authority, which is sometimes justified and sometimes not by the semantic content. When, in addition, the image makers (e.g. the advertising agents) bring into play their highly developed arts of persuasion the critical thinking apparatus of the reader is almost certain to be swayed by unconscious emotional reactions to these images. "Brilliant transient response", "crystal-clear speech quality", "the secret is . . . .", "precision made", "smooth, breathing, open and graceful", "efficient", are no doubt justifiable as descriptive terms in somebody's book of values, but they are basically symbols designed to hypnotize, to stay further exploration of the meanings. Simple superlatives—"world's best", "superb quality"—also have this power.

Where factual information is presented most advertisers are, of course, aware of their legal responsibilities (e.g. the 1968 Trade Descriptions Act). But even here, in order to persuade effectively, they must emphasize the most attractive features of their goods, and this sometimes results in a certain vagueness, notably in matters of price and performance. The "frequency response" which is really only a frequency range, the "accuracy" figure which is a percentage of an unstated quantity are familiar examples.

Wireless World accepts advertisements in good faith—that is, in the belief that the statements made can be justified. But all advertisements are essentially claims; the truth is not necessarily self-evident in the words and pictures—it sometimes has to be discovered. *Caveat emptor.*

Simple Class A Amplifier

A 10-W design giving subjectively better results than class B transistor amplifiers

by J. L. Linsley Hood, M.I.E.E.

During the past few years a number of excellent designs have been published for domestic audio amplifiers. However, some of these designs are now rendered obsolescent by changes in the availability of components, and others are intended to provide levels of power output which are in excess of the requirements of a normal living room. Also, most designs have tended to be rather complex.

In the circumstances it seemed worth while to consider just how simple a design could be made which would give adequate output power together with a standard of performance which was beyond reproach, and this study has resulted in the present design.

Output power and distortion

In view of the enormous popularity of the Mullard "5-10" valve amplifier, it appeared that a 10-watt output would be adequate for normal use; indeed when two such amplifiers are used as a stereo pair, the total sound output at full power can be quite astonishing using reasonably sensitive speakers.

The original harmonic distortion standards for audio amplifiers were laid down by D. T. N. Williamson in a series of articles published in *Wireless World* in 1947 and 1949; and the standard, proposed by him, for less than 0.1% total harmonic distortion at full rated power output, has been generally accepted as the target figure for high-quality audio power amplifiers. Since the main problem in the design of valve audio amplifiers lies in the difficulty in obtaining adequate performance from the output transformer, and since modern transistor circuit techniques allow the design of power amplifiers without output transformers, it seemed feasible to aim at a somewhat higher standard, 0.05% total harmonic distortion at full output power over the range 30Hz–20kHz. This also implies that the output power will be constant over this frequency range.

Circuit design

The first amplifier circuit of which the author is aware, in which a transformerless transistor design was used to give a standard of performance approaching that of the "Williamson" amplifier, was that published in *Wireless World* in 1961 by Tobey and Dinsdale. This employed a class B output stage, with series connected transistors in quasi-complementary symmetry. Subsequent high-quality transistor power amplifiers have largely tended to follow the design principles outlined in this article.

The major advantage of amplifiers of this type is that the normal static power dissipation is very low, and the overall power-conversion efficiency is high. Unfortunately there are also some inherent disadvantages due to the intrinsic dissimilarity in the response of the two halves of the push-pull pair (if complementary transistors are used in unsymmetrical circuit arrangement) together with some cross-over distortion due to the low current non-linearity of the I_c/V_b characteristics. Much has been done, particularly by Bailey[1], to minimize the latter.

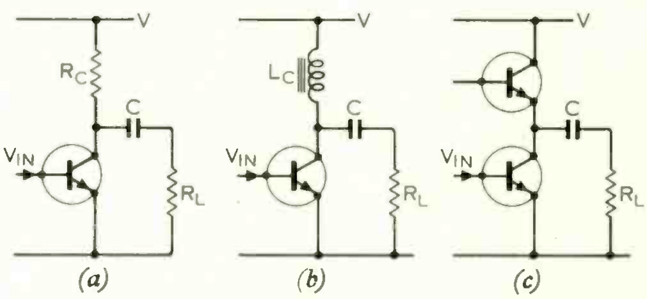


Fig. 1. Basic class A circuits using (a) load resistor R_c giving power conversion efficiency of about 12%, (b) l.f. choke giving better efficiency but being bulky and expensive, and (c) a second transistor as collector load.

An additional characteristic of the class B output stage is that the current demand of the output transistors increases with the output signal, and this may reduce the output voltage and worsen the smoothing of the power supply, unless this is well designed. Also, because of the increase in current with output power, it is possible for a transient overload to drive the output transistors into a condition of thermal runaway, particularly with reactive loads, unless suitable protective circuitry is employed. These requirements have combined to increase the complexity of the circuit arrangement, and a well designed low-distortion class B power amplifier is no longer a simple or inexpensive thing to construct.

An alternative approach to the design of a transistor power amplifier combining good performance with simple construction is to use the output transistors in a class A configuration. This avoids the problems of asymmetry in quasi-complementary circuitry, thermal runaway on transient overload, cross-over distortion and signal-dependent variations in power supply current demand. It is, however, less efficient than a class B circuit, and the output transistors must be mounted on large heat sinks.

The basic class A construction consists of a single transistor with a suitable collector load. The use of a resistor, as in Fig 1(a), would be a practical solution, but the best power-conversion efficiency would only be about 12%. An l.f. choke, as shown in Fig. 1(b), would give much better efficiency, but a properly designed component would be bulky and expensive, and remove many of the advantages of a transformerless design. The use of a second, similar, transistor as a collector load, as shown in Fig. 1(c), would be more convenient in terms of size and cost, and would allow the load to be driven effectively in push-pull if the inputs to the two transistors were of suitable magnitude and opposite in phase. This requirement can be achieved if the driver transistor is connected as shown in Fig. 2.

This method of connection also meets one of the most important requirements of a low distortion amplifier—that the basic linearity of the amplifier should be good, even in the absence of feedback. Several factors contribute to this. There is the tendency of the I_c/V_b non-linearity of the characteristics of the output transistors to cancel, because during the part of the cycle in which one transistor is approaching cut-off the other is turned full on. There is a measure of internal feedback around the loop Tr_1, Tr_2, Tr_3 because of the effect which the base impedance characteristics of Tr_1 have on the output current of Tr_3. Also, the driver transistor Tr_3, which has to deliver a large voltage swing, is operated under conditions which favour low harmonic distortion—low output load impedance, high input impedance.

A practical power amplifier circuit using this type of output stage is shown in Fig. 3.

The open loop gain of the circuit is approximately 600 with typical transistors. The closed loop gain is determined, at frequencies high enough for the impedance of C_3 to be small in comparison to R_4, by the ratio $(R_3 + R_4)/R_4$. With the values indicated in Fig. 3, this is 13. This gives a feedback factor of some 34dB, and an output impedance of about 160 milliohms.

Since the circuit has unity gain at d.c., because of the inclusion of C_3 in the feedback loop, the output voltage, V_e, is held at the same potential as the base of Tr_4 plus the base emitter potential of Tr_4 and the small potential drop along R_3 due to the emitter current of this transistor. Since the output transistor Tr_1 will turn on as much current as is necessary to pull V_e down to this value, the resistor R_2, which together with R_1 controls the collector current of Tr_2, can be used to set the static current of the amplifier output stages. It will also be apparent that V_e can be set to any desired value by small adjustments to R_5 or R_6. The optimum performance will be obtained when this is equal to half the supply voltage. (Half a volt or so either way will make only a small difference to the maximum output power obtainable, and to the other characteristics of the amplifier, so there is no need for great precision in setting this.)

Silicon planar transistors are used throughout, and this gives good thermal stability and a low noise level. Also, since there is no requirement for complementary symmetry, all the power stages can use n-p-n transistors which offer, in silicon, the best performance and lowest cost. The overall performance at an output level of 10 watts, or any lower level, more than meets the standards laid down by Williamson. The power output and gain /frequency graphs are shown in Figs. 4-6, and the relationship between output power and total harmonic distortion is shown in Fig. 7. Since the amplifier is a straightforward class A circuit, the distortion decreases linearly with output voltage. (This would not necessarily be the case in a class B system if any significant amount of cross-over distortion was present.) The analysis of distortion components at levels of the order of 0.05% is difficult, but it appears that the residual distortion below the level at which clipping begins is predominantly second harmonic.

Stability, power output and load impedance

Silicon planar n-p-n transistors have, in general, excellent high frequency characteristics, and these contribute to the very good stability of the amplifier with reactive loads. The author has not yet found any combination of L and C which makes the system unstable, although the system will readily become oscillatory with an inductive load if R_3 is shunted by a small condenser to cause roll-off at high frequencies.

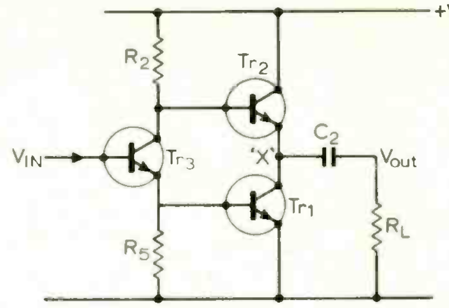


Fig.2. Arrangement for push-pull drive of class A stage.

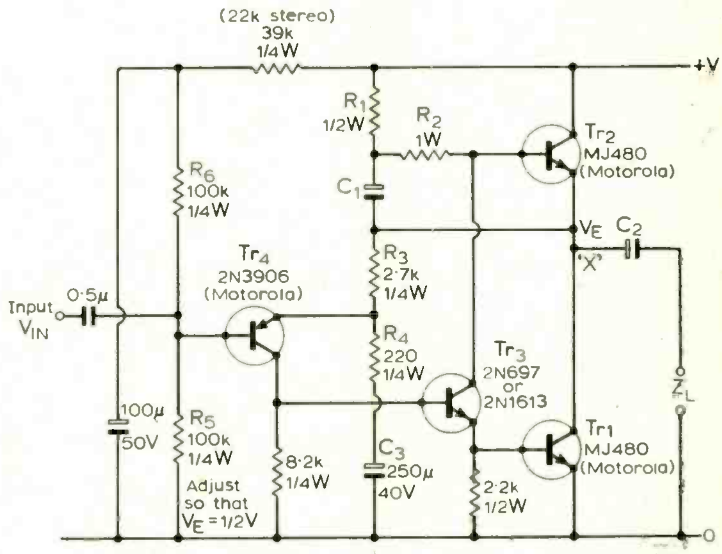


Fig.3. Practical power amplifier circuit.

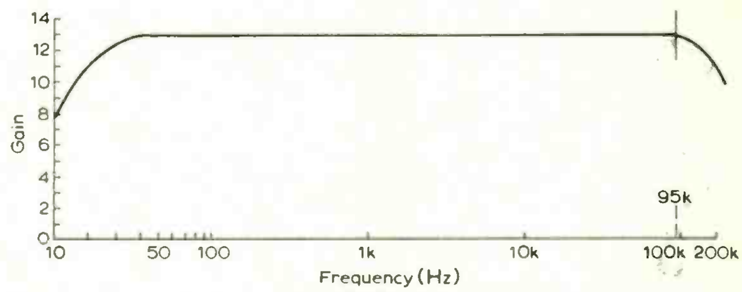


Fig.4. Gain/frequency response curve of amplifier.

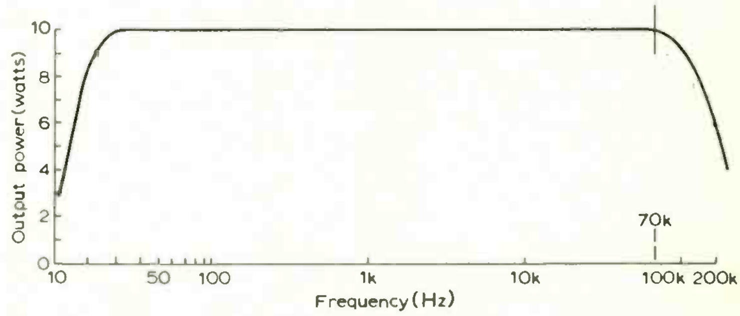


Fig.5. Output power/frequency response curve of amplifier.

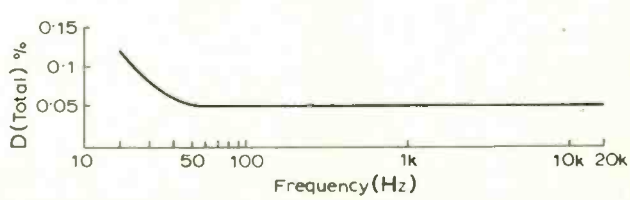


Fig.6. Distortion/frequency curve at 9W.

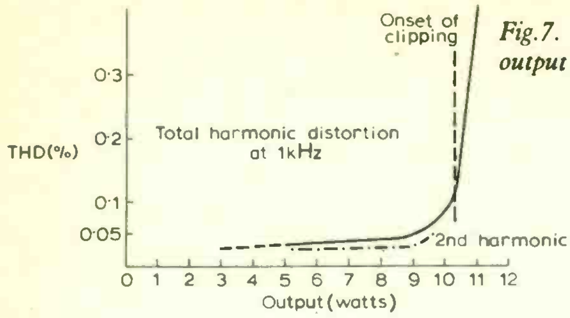


Fig.7. Distortion/output power curve.

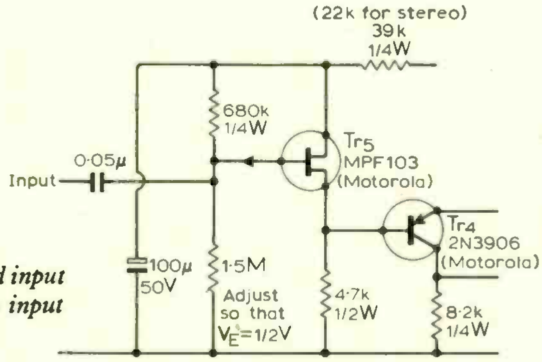
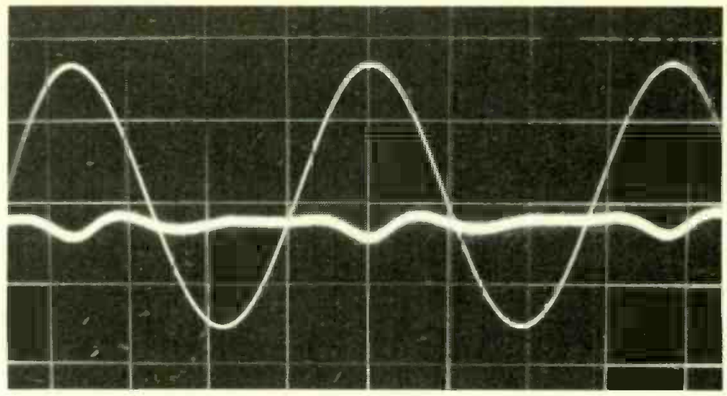
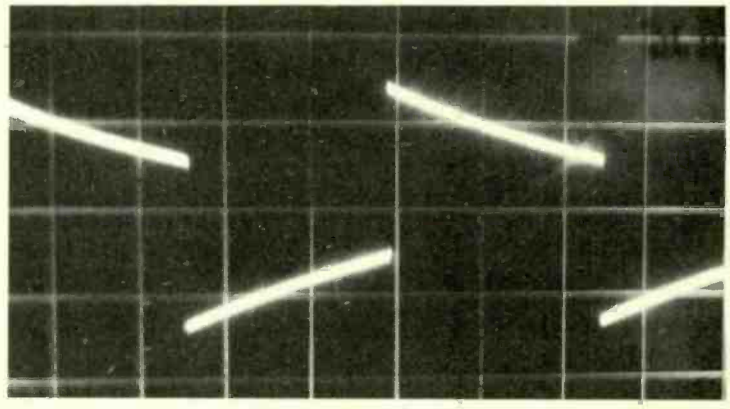


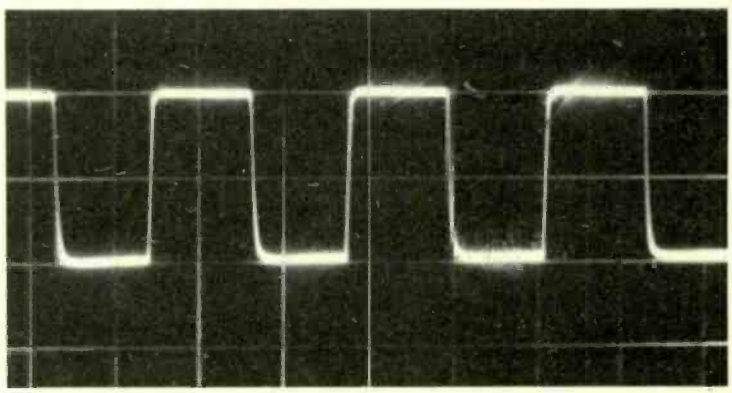
Fig.8. Modified input circuit for high input impedance.



Sine wave performance at 1kHz. 9 watts, 15 ohm resistive load. Fundamental on scale of 10V/cm. Distortion components on scale of 50mV/cm with r.m.s. value of 0.05%.



Square wave response at 50Hz.



Square wave response. Scale 10V/cm. Frequency 50kHz. 15 ohm resistive load.

The circuit shown in Fig. 3 may be used, with very little modification to the component values, to drive load impedances in the range 3-15 ohms. However, the chosen output power is represented by a different current/voltage relationship in each case, and the current through the output transistors and the output-voltage swing will therefore also be different. The peak-voltage swing and the mean output current can be calculated quite simply from the well-known relationships $W=I^2R$ and $V=IR$, where the symbols have their customary significance. (It should be remembered, however, that the calculation of output power is based on r.m.s. values of current and voltage, that these must be multiplied by 1.414 to obtain the peak values, and that the voltage swing measured is the peak-to-peak voltage, which is twice the peak value.)

When these calculations have been made, the peak-to-peak voltage swing for 10 watts power into a 15-ohm load is found to be 34.8 volts. Since the two output transistors bottom at about 0.6 volt each, the power supply must provide a minimum of 36 volts in order to allow this output. For loads of 8 and 3 ohms, the minimum h.t. line voltage must be 27V and 17 volts respectively. The necessary minimum currents are 0.9, 1.2 and 2.0 amps. Suggested component values for operation with these load impedances are shown in Table 1. C_3 and C_1 together influence the voltage and power roll-off at low audio frequencies. These can be increased in value if a better low-frequency performance is desired than that shown in Figs. 4-6.

Since the supply voltages and output currents involved lead to dissipations of the order of 17 watts in each output transistor, and since it is undesirable (for component longevity) to permit high operating temperatures, adequate heat sink area must be provided for each transistor. A pair of separately mounted 5in × 4in finned heat sinks is suggested. This is, unfortunately, the penalty which must be paid for class A operation. For supplies above 30V Tr_1 and Tr_2 should be MJ481s and Tr_3 a 2N1613.

If the output impedance of the pre-amplifier is more than a few thousand ohms, the input stage of the amplifier should be modified to include a simple f.e.t. source follower circuit, as shown in Fig. 8. This increases the harmonic distortion to about 0.12%, and is therefore (theoretically) a less attractive solution than a better pre-amplifier.

A high frequency roll-off can then be obtained, if necessary, by connecting a small capacitor between the gate of the f.e.t. and the negative (earthy) line.

Table 1. Summary of component combinations for different load impedances.

Z_L	V	I	R_1	R_2		C_1		C_2	V_{IN} (r.m.s.)
3Ω	17V	2A	47Ω	180Ω	500μ	25V	5000μ	25V	0.41V
8Ω	27V	1.2A	100Ω	560Ω	250μ	40V	2500μ	50V	0.66V
15Ω	36V	0.9	150Ω	1.2kΩ	250μ	40V	2500μ	50V	0.9V

Suitable transistors

Some experiments were made to determine the extent to which the circuit performance was influenced by the type and current gain of the transistors used. As expected the best performance was obtained when high-gain transistors were used, and when the output stage used a matched pair. No adequate substitute is known for the 2N697/2N1613 type used in the driver stage, but examples of this transistor type from three different manufacturers were used with apparently identical results. Similarly, the use of alternative types of input transistor produced no apparent performance change, and the Texas Instruments 2N4058 is fully interchangeable with the Motorola 2N3906 used in the prototype.

The most noteworthy performance changes were found in the current gain characteristics of the output transistor pair, and for the lowest possible distortion with any pair, the voltage at the point from which the loudspeaker is fed should be adjusted so that it is within 0.25 volt of half the supply line potential. The other results are summarized in Table 2.

The transistors used in these experiments were Motorola MJ480/481, with the exception of (6), in which Texas 2S034 devices were tried. The main conclusion which can be drawn from this is that the type of transistor used may not be very important, but that if there are differences in the current gains of the output transistors, it is necessary that the device with the higher gain shall be used in the position of Tr_1.

When distortion components were found prior to the onset of waveform clipping, these were almost wholly due to the presence of second harmonics.

Constructional notes

Amplifier. The components necessary for a 10 + 10 watt stereo amplifier pair can conveniently be assembled on a standard "Lektrokit" 4in × 4¾in s.r.b.p. pin board, as shown in the photographs, with the four power transistors mounted on external heat sinks. Except where noted the values of components do not appear to be particularly critical, and 10% tolerance resistors can certainly be used without ill effect. The lowest noise levels will however be obtained with good quality components, and with carbon-film, or metal-oxide, resistors.

Power supply. A suggested form of power supply unit is shown in Fig. 9 (a). Since the current demand of the amplier is substantially constant, a series transistor smoothing circuit can be used in which the power supply output voltage may be adjusted by choice of the base current input provided by the emitter follower Tr_2 and the potentiometer VR_1. With the values of reservoir capacitor shown in Table 3, the ripple level will be less than 10mV at the rated output current, provided that the current gain of the series transistors is greater than 40. For output currents up to 2.5 amps, the series transistors indicated will be adequate, provided that they are mounted on heat sinks appropriate to their loading.

However, at the current levels necessary for operation of the 3-ohm version of the amplifier as a stereo pair, a single MJ480 will no longer be adequate, and either a more suitable series transistor must be used, such as the Mullard BDY20, with for example a 2N1711 as Tr_2, or with a parallel connected arrangement as shown in Fig. 9(b).

The total resistance in the rectifier "primary" circuit, including the transformer secondary winding, must not be less than $0.25\,\Omega$. When the power supply, with or without an amplifier, is to be used with an r.f. amplifier-tuner unit, it may be necessary to add a $0.25\,\mu$F (160V.w.) capacitor across the secondary winding of T_1 to prevent transient radiation. The rectifier diodes specified are International Rectifier potted-bridge types.

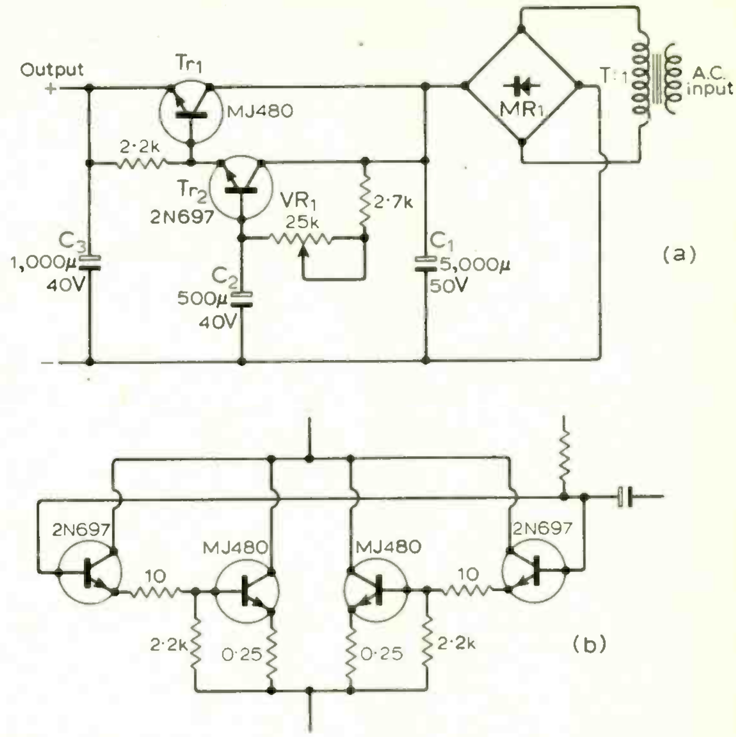


Fig.9. (a) Power supply unit, and (b) parallel connected transistors for high currents.

Table 2. Relation of distortion to gain-matching in the output stage.

	Current gain (Tr_1)	(Tr_2)	Distortion (at 9 watts)
1.	135	135	0.06%
2.	40	120	0.4%
3.	120	40	0.12% (pair 2 reversed in position)
4.	120	100	0.09%
5.	100	120	0.18% (pair 5 reversed)
6.	50	40	0.1%

Table 3. Power-supply components.

AMPZ$_L$	I$_{OUT}$	V$_{OUT}$	C$_1$	Tr$_{1/2}$	MR1	T$_1$	
15Ω	1A	37V	1000μ 50V	MJ480 2N697	5B05	40V	1A
2x 15Ω	2A	37V	5000μ 50V	MJ480 2N697	5B05	40V	2A
8Ω	1.25A	27V	2000μ 40V	MJ480 2N697	5B05	30V	1.25A
2x 8Ω	2.5A	27V	5000μ 40V	MJ480 2N697	5B05	30V	2.5A
3Ω	1.9A	18V	5000μ 30V	MJ480 2N697	5B05	20V	2A
2x 3Ω	3.8A	18V	10,000μ 30V	MJ480 2x2N697	7B05T	20V	4A

Transistor protection circuit

The current which flows in the output transistor chain (Tr_1, Tr_2) is determined by the potential across Tr_2, the values of R_1 and R_2, and the current gain and collector-base leakage current of Tr_2. Since both of these transistor characteristics are temperature dependent the output series current will increase somewhat with the temperature of Tr_2. If the amplifier is to be operated under conditions of high ambient temperature, or if for some reason it is not practicable to provide an adequate area of heat-sink for the output transistors, it will be desirable to provide some alternative means for the control of the output transistor circuit current. This can be done by means of the circuit shown in Fig. 10. In this, some proportion of the d.c. bias current to Tr_1 is shunted to the negative line through Tr_7, when the total current flowing causes the potential applied to the base of Tr_6 to exceed the turn-on value (about

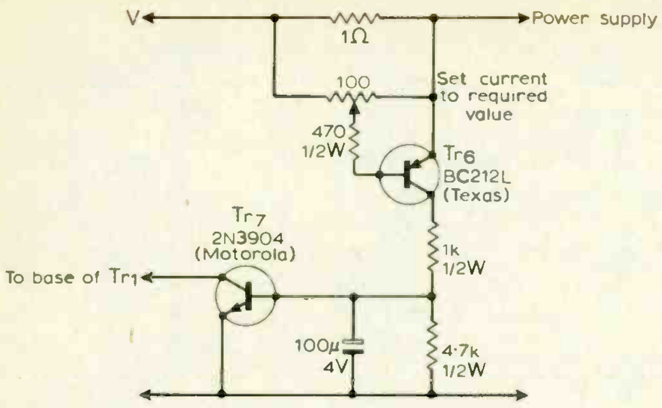
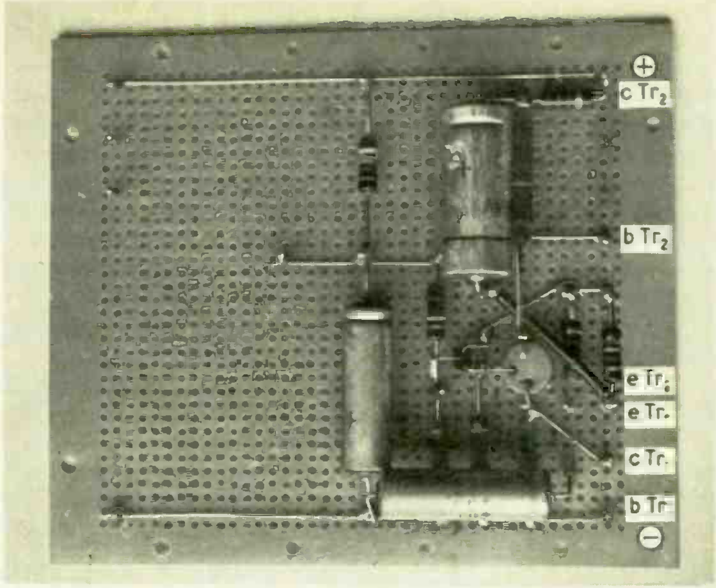


Fig. 10. Amplifier current regulation circuit.

0.5 volt). This allows very precise control of the series current without affecting the output power or distortion characteristics. The simpler arrangement whereby the current control potential for Tr_7 is obtained from a series resistor in the emitter circuit of Tr_1 leads, unfortunately, to a worsening of the distortion characteristics to about 0.15% at 8 watts, rising to about 0.3% at the onset of overload.



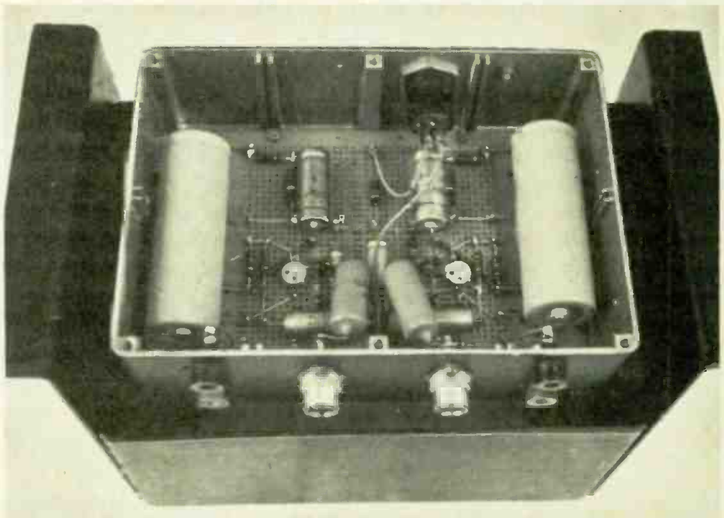
Layout of single channel of 10 + 10 watt amplifier on standard 4in × 4¼in 'Lektrokit' s.r.b.p. pin board.

Performance under listening conditions

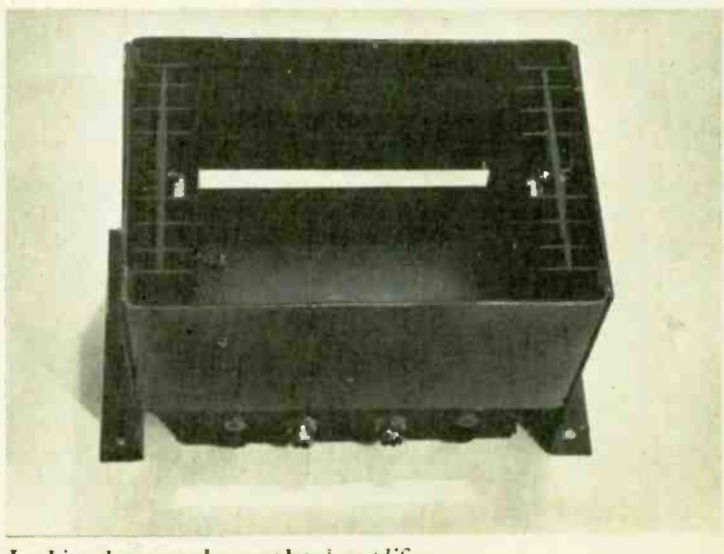
It would be convenient if the performance of an audio amplifier (or loudspeaker or any other similar piece of audio equipment) could be completely specified by frequency response and harmonic distortion characteristics. Unfortunately, it is not possible to simulate under laboratory conditions the complex loads or intricate waveform structures presented to the amplifier when a loudspeaker system is employed to reproduce the everyday sounds of speech and music; so that although the square wave and low-distortion sine wave oscillators, the oscilloscope, and the harmonic distortion analyser are valuable tools in the design of audio circuits, the ultimate test of the final design must be the critical judgment of the listener under the most carefully chosen conditions his facilities and environment allow.

The possession of a good standard of reference is a great help in comparative trials of this nature, and the author has been fortunate in the possession, for many years, of a carefully and expensively built "Williamson" amplifier, the performance of which has proved, in listening trials, to equal or exceed, by greater or lesser margins, that of any other audio amplifier with which the author has been able to make comparisons.

However, in the past, when these tests were made for personal curiosity, and some few minutes could elapse in the transfer of input and output leads from one amplifier to the other, the comparative performance of some designs has been so close that the conclusion drawn was that there was really very little to choose between them. Some of the recent transistor power amplifier circuits gave a performance which seemed fully equal to that of the "Williamson", at least so far as one could remember during the interval between one trial and the next. It was, however, appreciated that this did not really offer the best conditions for a proper appraisal of the more subtle differences in the performance of already good designs, so a changeover switch was arranged to transfer inputs and outputs between any chosen pair of amplifiers, and a total of six amplifier units was assembled, including the "Williamson", and another popular valve unit, three class B transistor designs, including one of commercial origin, and the class A circuit described above. The frequency response, and total harmonic distortion characteristics, of the four transistor amplifiers was tested in the laboratory prior to this trial, and all were found to



Underside of completed amplifier, with base cover removed, showing external box-form heat sink.



Looking down on the completed amplifier.

have a flat frequency response through the usable audio spectrum, coupled with low harmonic distortion content (the worst-case figure was 0.15%).

In view of these prior tests, it was not expected that there would be any significant difference in the audible performance of any of the transistor designs, or between them and the valve amplifiers. It was therefore surprising to discover, in the event, that there were discernible differences between the valve and the three class B transistor units. In fact, the two valve designs and the class A transistor circuit, and the three class B designs formed two tonally distinct groups, with closely similar characteristics within each group. The "Williamson" and the present class A design were both better than the other valve amplifier, and so close in performance that it was almost impossible to tell which of the two was in use without looking at the switch position. In the upper reaches of the treble spectrum the transistor amplifier has perhaps a slight advantage.

The performance differences between the class A and the class B groups were, however, much more prominent. Not only did the class A systems have a complete freedom from the slight "edginess" found on some high string notes with all the class B units, but they appeared also to give a fuller, "rounder", quality, the attractiveness of which to the author much outweighs the incidental inconvenience of the need for more substantial power supply equipment and more massive heat sinks.

Some thought, in discussions with interested friends, has been given to the implications of this unlooked-for discovery, and a tentative theory has been evolved which is offered for what it is worth. It is postulated that these tonal differences arise because the normal moving-coil loudspeaker, in its associated housing, can present a very complex reactive load at frequencies associated with structural resonances, and that this might provoke transient overshoot when used with a class B amplifier, when a point of inflection in the applied waveform chanced to coincide with the point of transistor crossover, at which point, because of the abrupt change in the input parameters of the output transistors the loop stability margins and output damping will be less good. In these circumstances, the desired function of the power-amplifier output circuit in damping out the cone-response irregularities of the speaker may be performed worse at the very places in the loudspeaker frequency-response curve where the damping is most needed.

It should be emphasized that the differences observed in these experiments are small, and unlikely to be noticed except in direct side-by-side comparison. The perfectionist may, however, prefer class A to class B in transistor circuitry if he can get adequate output power for his needs that way.

Listener fatigue

In the experience of the author, the performance of most well-designed audio power amplifiers is really very good, and the differences between one design and another are likely to be small in comparison with the differences between alternative loudspeaker systems, for example, and of the transistor designs so far encountered, not one could be considered as unpleasing to the ear. However, with the growing use of solid-state power amplifiers, puzzling tales of "listener fatigue" have been heard among the *cognoscenti,* as something which all but the most expensive transistor amplifiers will cause the listener, in contradistinction with good valve-operated amplifiers. This seemed to be worth investigation, to discover whether there was any foundation for this allegation.

In practice it was found that an amplifier with an impeccable performance on paper could be quite worrying to listen to under certain conditions. This appears to arise and be particularly associated with transistor power amplifiers because most of these are easily able to deliver large amounts of power at supersonic frequencies, which the speakers in a high quality system will endeavour to present to the listener. In this context it should be remembered that in an amplifier which has a flat power response from 30Hz to 180kHz, 90% of this power spectrum will be supersonic.

This unwanted output can arise in two ways. It can be because of wide spectrum "white noise" from a preamplifier with a significant amount of hiss—this can happen if a valve preamplifier is mismatched into the few thousand ohms input impedance of a transistor power amplifier, and will also cause the system performance to be unnaturally lacking in bass. Trouble of this type can also arise if transient instability or high frequency "ringing" occurs, for example when a reactive load is used with a class B amplifier having poor cross-over point stability.

REFERENCE

1. Bailey, A.R., "High-performance Transistor Amplifier", *Wireless World,* November 1966; "30-Watt High Fidelity Amplifier", May 1968; and "Output Transistor Protection in A.F. Amplifiers", June 1968.

Conferences and Exhibitions

LONDON

Apr. 21-25 — Savoy Place
Switching Techniques for Telecommunication Networks
(I.E.E., Savoy Pl., London W.C.2)

Apr. 22-30 — Olympia
Engineering and Marine Exhibition
(F. W. Bridges & Sons, Commonwealth House, New Oxford St., London W.C.1)

EXETER

Apr. 1 & 2 — The University
Applications of R.F. Spectroscopy to the Electronic Structure of Solids
(Dr. J. E. Cousins, The University, Exeter)

KINGSTON-ON-THAMES

Apr. 1 & 2 — Col. of Technology
Digital Storage Techniques
(Dr. R. V. Sharman, College of Technology, Penrhyn Rd., Kingston-on-Thames)

SOUTHAMPTON

Apr. 15-18 — The University
Computer Aided Design
(I.E.E., Savoy Pl., London W.C.2)

YORK

Apr. 16-18 — The University
Thin Films Conference
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

OVERSEAS

Apr. 8-10 — New York
Computer Processing in Communications
(Polytechnic Inst. of Brooklyn, 333 Jay St., Brooklyn, N.Y. 10021)

Apr. 11-14 — Munich
Semiconductor Device Research
(Dr. H. H. Burghoff, VDE Haus, Stresemann Allee 21, 6 Frankfurt am Main)

Apr. 15-18 — Amsterdam
Magnetics Conference
(Dr. Th. Holtwijk, Philips Research Laboratories, Eindhoven, Netherlands)

Apr. 16-18 — Washington
Geoscience Electronics
(I.E.E.E., 345 E.47th St., New York, N.Y. 10017)

Apr. 19 & 20 — Armentieres
Amateur Television Congress
(Club Francais de Television d'Amateur, 13 rue de Bellevue, Paris 19)

Apr. 21 & 22 — Austin
Circuit Theory Symposium
(University of Texas, Austin, Texas)

Apr. 22-24 — Washington
Telemetering Conference
(I.E.E.E., 345 E.47th St., New York, N.Y. 10017)

Apr. 23-25 — Lexington
Electronic Crime Countermeasures
(J. S. Jackson, College of Engineering, University of Kentucky, Lexington)

Apr. 30-May 2 — Washington
Electronic Components Conference
(I.E.E.E., 345 E.47th St., New York, N.Y. 10017)

Operational Amplifiers

3. Applications

by G. B. Clayton, B.Sc., A.Inst.P.*

The availability of inexpensive reliable operational amplifiers in integrated circuit and discrete component modular form makes possible a new approach to many electronic design problems. The approach involves the selection of a suitable amplifier and the connection of a few discrete components to it to form a complete subsystem. This offers a considerable simplification since it frees the system designer from amplifier design problems and in all probability it will displace discrete-component electronics in a wide variety of fields.

Early op. amps. were first developed for use in analogue computation. These amplifiers were generally single-ended input and output inverting amplifiers. The modern differential-input single-ended output amplifiers are more versatile and allow a greater variety of feedback configurations. Circuits developed for use in analogue computation are equally useful in many control and instrumentation applications, largely because of the ease with which input impedance and gain values can be accurately set. The analyses of circuit behaviour presented in this article will be based on an ideal op. amp. performance; the important characteristics of practical amplifiers and the ways in which these differ from the ideal have already been considered. The ideal op. amp. concept is of sufficient importance to warrant restating: the ideal op. amp. has open-loop gain, bandwidth and input impedance tending to infinity, and an output impedance tending to zero.

The term "operational amplifier" really describes an amplifier suitable for use with a particular type of negative feedback. The basic form of the operational feedback circuit is illustrated in Fig. 1. In this circuit if a small voltage (e_ε) is assumed to exist between the differential input terminals of the amplifier, with a gain tending to infinity the output voltage fed back to the inverting terminal will force this voltage (e_ε) to be negligibly small, i.e. the ideal op. amp. with negative feedback applied to it has a negligibly small voltage between its input terminals. This is one of the assumptions that is made in all simple analyses of circuit action. The other assumption normally made is that no current flows into the input terminals of the ideal amplifier. The phase inverting terminal *X* is sometimes called the summing point and the two assumptions are called the summing

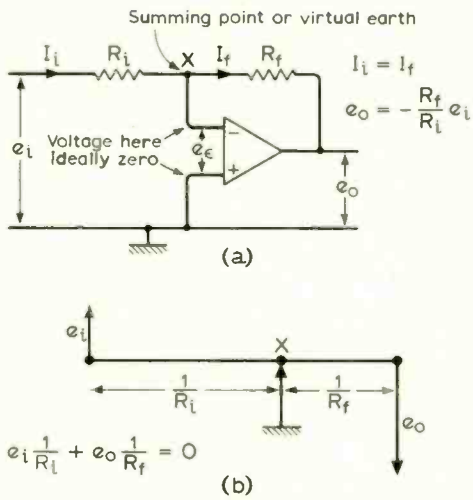


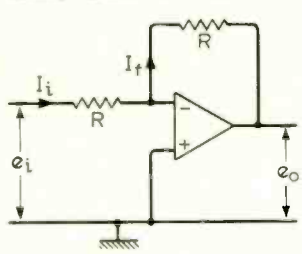
Fig. 1. (a) Inverting amplifier employing "operational feedback". (b) A voltage "lever" analogy of the inverter connection. Point X corresponds to the fulcrum, and the summation of currents at X is analogous to the summation of moments about the point of balance.

point restraints. Summation of currents at *X* must always be zero.

In the applications that follow it is assumed that the amplifiers have been frequency compensated (see March article) to achieve closed-loop stability. Amplifiers based on computing circuits will be dealt with first. All these amplifiers feature considerable isolation between input and output.

Inverting amplifier circuits

Unity Gain Inverter.



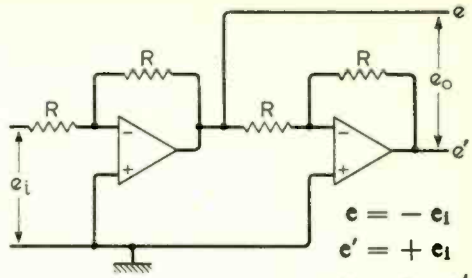
$$I_i = I_f$$

$$\frac{e_i}{R} = \frac{-e_0}{R}$$

$$e_0 = -e_i$$

Features. Input impedance equals *R*; output impedance small, usually less than 1 ohm. Used wherever sign changes are necessary or to lower the impedance level of a signal.

Balanced Output Inverter.



$$e = -e_i$$

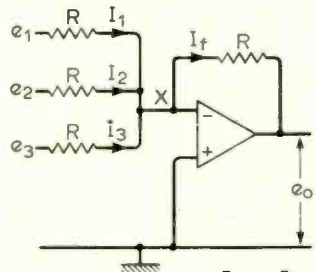
$$e' = +e_i$$

$$e_0 = e - e'$$

$$e_0 = -2e_i$$

Features. A combination of two unity gain inverters arranged to give a balanced output. Used for driving balanced loads or push-pull stages when earth reference is critical. The peak-to-peak output swing is double that of a single amplifier.

Inverting Adder.



$$I_f = I_1 + I_2 + I_n$$

$$-\frac{e_0}{R} = \frac{e_1}{R} + \frac{e_2}{R} + \frac{e_n}{R}$$

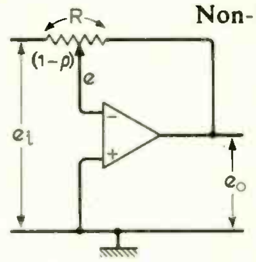
$$e_0 = -(e_1 + e_2 + e_n)$$

Features. A separate input resistor is used for each input signal to be summed. Any number of inputs may be used; the output gives the inverted sum of all inputs. The summing point *X* being a virtual earth, the inputs are effectively isolated from one another. If the individual input resistors are given values different from that of the feedback resistor the output is the sum of a series of terms each proportional to one of the input signals but each multiplied by some arbitrary coefficient, i.e.

$$e_o = -\left\{e_1 \frac{R}{R_1} + e_2 \frac{R}{R_2} + e_n \frac{R}{R_n}\right\}$$

Adjustable Coefficient Inverters.

Non-linear gain control.



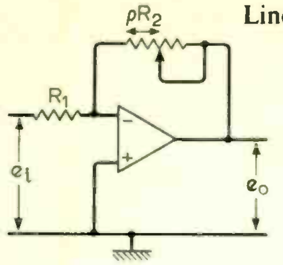
$$e_0 = -\frac{\rho R}{(1-\rho)R} \cdot e_i$$

$$e_0 = -\frac{\rho}{(1-\rho)} \cdot e_i$$

Features. A wide-range variable-gain amplifier; range from zero to very high values. Gain is not linear with respect to potentiometer rotation and the input impedance drops as the gain is increased.

*Liverpool College of Technology.

Linear gain control.



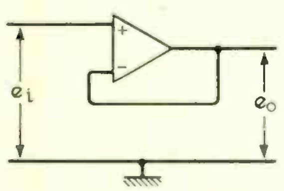
$$e_0 = -\frac{\rho R_2}{R_1} e_i$$

Features. A narrower range of gain settings than in previous circuit, 0 to R_2/R_1, but gain is linear with respect to potentiometer rotation. Input impedance equals R_1.

Non-inverting amplifier circuits

In these circuits the input signal is applied to the non-inverting input of the differential amplifier; the feedback is returned from the output to the inverting terminal as before. The feedback signal is effectively in series with the input signal and opposes the input signal; this makes for input impedances many times greater than the actual input impedance of the amplifier without feedback. Analyses are quite straightforward with the usual assumptions; the voltage between the two input terminals of the amplifier is assumed negligibly small in all cases. Non-inverting circuits are subject to a common-mode error. (Care must also be taken to ensure that the maximum common-mode voltage allowable at the input is not exceeded.) Non-inverting/inverting combinations are also included.

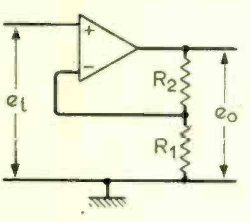
Unity Gain Follower.



$$e_0 = e_i$$

Features. All the output voltage is fed back to the inverting terminal as negative feedback. Circuit has a very high input impedance and a low output impedance. Drift is half that obtained with the same amplifier connected as a unity gain inverter.

Follower with gain.

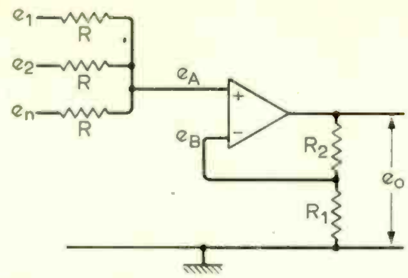


$$e_0 \cdot \frac{R_1}{R_1 + R_2} = e_i$$

$$e_0 = \left(1 + \frac{R_2}{R_1}\right) e_i$$

Features. A high input impedance and low output impedance, as before. The follower with gain is less demanding of common-mode performance, for with equal outputs the follower with gain has a smaller common-mode input signal than the unity gain follower.

Non-Inverting Adder.



With zero input current drawn by amplifier

$$\frac{e_1 - e_A}{R} + \frac{e_2 - e_A}{R} + \frac{e_n - e_A}{R} = 0$$

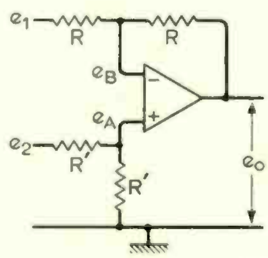
$$e_1 + e_2 + \ldots e_n = n\,e_A$$

But $\quad e_A = e_B = e_0 \dfrac{R_1}{R_1 + R_2}$

Hence $e_0 = \left(1 + \dfrac{R_2}{R_1}\right) \dfrac{1}{n} (e_1 + e_2 + \ldots e_n)$

Features. Any number of input signals may be used, a separate input resistor being used for each input. The output gives the non-inverted sum multiplied by the coefficient $(1 + R_2/R_1)\,1/n$. With two input signals and $R_2 = R_1$, $e_0 = e_1 + e_2$.

Subtractor.



$$e_A = e_2 \frac{R'}{R' + R'} = \frac{e_2}{2}$$

$$\frac{e_1 - e_B}{R} = \frac{e_B - e_0}{R}$$

$$e_B = \frac{e_1 + e_0}{2}$$

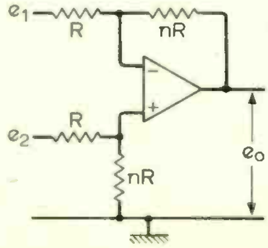
But $\quad e_A = e_B$

Hence $\quad \dfrac{e_1 + e_0}{2} = \dfrac{e_2}{2}$

$$e_0 = e_2 - e_1$$

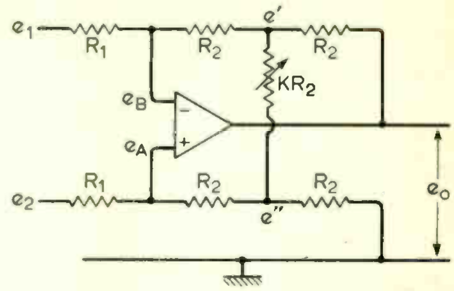
Features. The amplifier acts as a unity-gain differential-input single-ended output amplifier. A variation of this circuit is the subtractor with gain shown below.

Subtractor with Gain.



$$e_0 = n(e_2 - e_1)$$

Adjustable Gain Differential Input Amplifier.



Amplifier assumed to draw no current

$$\frac{e_1 - e_B}{R_1} = \frac{e_B - e'}{R_2}, \quad \frac{e_2 - e_A}{R_1} = \frac{e_A - e''}{R_2}$$

But $\quad e_A = e_B$ and hence

$$\frac{e_1 - e_2}{R_1} = \frac{e'' - e'}{R_2}$$

Also

$$\frac{e_B - e'}{R_2} - \frac{e' - e''}{KR_2} - \frac{e' - e_0}{R_2} = 0$$

And $\quad \dfrac{e_A - e''}{R_2} + \dfrac{e' - e''}{K R_2} - \dfrac{e''}{R_2} = 0$

Remembering that $e_A = e_B$

subtraction gives

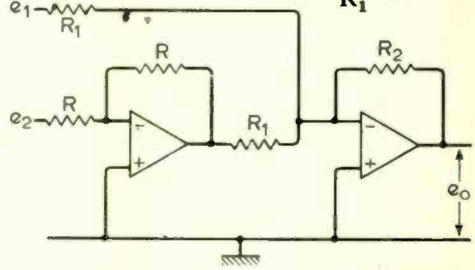
$$\frac{e_0}{R_2} = 2\frac{(e' - e'')}{R_2}\left(1 + \frac{1}{K}\right)$$

Hence $\quad e_0 = 2\dfrac{R_2}{R_1}\left(1 + \dfrac{1}{K}\right)(e_2 - e_1)$

Features. A wide range of differential gain settings is obtainable by adjustment of a single resistor $K\,R_2$. Gain does not vary linearly with K so that gain variation obtained by rotation of a linear potentiometer will be non-linear. Linearity can be improved by putting a fixed resistor in series with the potentiometer, alternatively it is sometimes convenient to select specific calibrated gains by switching in selected discrete values of $K\,R_2$.

Subtractor (Differential Input Amplifier) with common mode voltage eliminated.

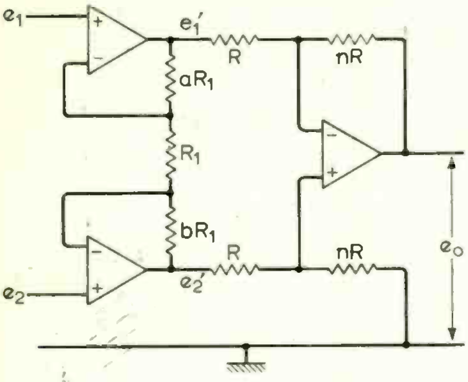
$$e_0 = \frac{R_2}{R_1}(e_2 - e_1)$$



Features. Subtraction is accomplished by a process of inversion and summation. Both amplifiers are used in the inverting configuration and common-mode voltages are effectively eliminated.

(Continued on Next Page)

High Input Impedance Differential Input Amplifier.



$$\frac{e_1' - e_1}{aR_1} = \frac{e_1 - e_2}{R_1} = \frac{e_2 - e_2'}{bR_1}$$

$$e_1' = (a + 1)\, e_1 - a\, e_2$$

$$e_2' = (b + 1)\, e_2 - b\, e_1$$

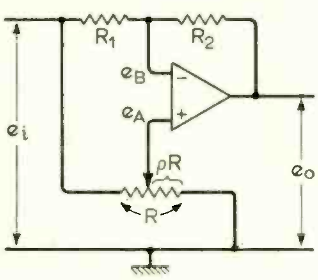
$$e_2' - e_1' = (1 + a + b)(e_2 - e_1)$$

$$e_0 = n\,(e_2' - e_1')$$

$$e_0 = n\,(1 + a + b)(e_2 - e_1)$$

Features. The input stage uses two cross-coupled followers. It passes any common-mode signal at unity gain but has a gain $(1 + a + b)$ for differential signals. An input stage consisting of two separately connected followers with gain would pass both common mode and differential signals at the same gain. The follower configurations give very high input impedances making the circuit insensitive to unbalance in source impedances. The output stage is a subtractor with gain; it is driven by the low output impedance of the differential input stage, enabling impedance levels in the feedback and divider networks to be kept low for good stability and bandwidth.

Bipolar Adjustable Coefficient Circuit.



$$e_A = \frac{\rho R}{R}\, e_i = \rho\, e_i$$

$$\frac{e_i - e_B}{R_1} = \frac{e_B - e_0}{R_2}$$

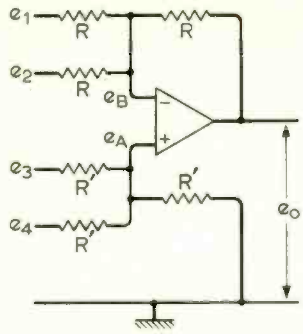
But $\quad e_A = e_B$

Substitution gives

$$e_0 = \left[\left(1 + \frac{R_2}{R_1}\right)\rho - \frac{R_2}{R_1}\right] e_i$$

Features. The circuit uses the adder subtractor technique to provide a wide and continuous range of coefficient adjustability, from a negative value R_2/R_1 through zero to a value plus one.

Adder, Subtractor.



$$\frac{e_3 - e_A}{R'} + \frac{e_4 - e_A}{R'} = \frac{e_A}{R'}$$

Therefore $\quad e_A = \dfrac{e_3 + e_4}{3}$

Also $\quad \dfrac{e_1 - e_B}{R} + \dfrac{e_2 - e_B}{R} = \dfrac{e_B - e_0}{R}$

Therefore $\quad e_0 = 3\, e_B - e_1 - e_2$

But $e_A = e_B$

Therefore $\quad e_0 = e_3 + e_4 - e_1 - e_2$

Features. There is no theoretical limit to the number of input paths that may be added to this circuit, but in order to preserve the simple form of the equation the same number of inputs has to be connected to each side and any unused inputs connected to earth. Two or more differential inputs ("floating" inputs) may be combined with this circuit by connecting them across e_1 to e_3 and e_2 to e_4.

Booster amplifiers

Some applications may require output current capabilities greater than may be obtained from a general-purpose op. amp., which is designed primarily for high voltage gain and economy of power consumption. In such cases some way must be found to "boost" the current capablities of the amplifier. The simplest way of doing this is to use a transistor having appreciable current gain and a greater current capability than the op. amp. as a simple emitter follower (See Fig. 2). The emitter follower is included in the operational feedback loop. A resistor is used in series with the collector to protect the transistor against excessive short-circuit current;

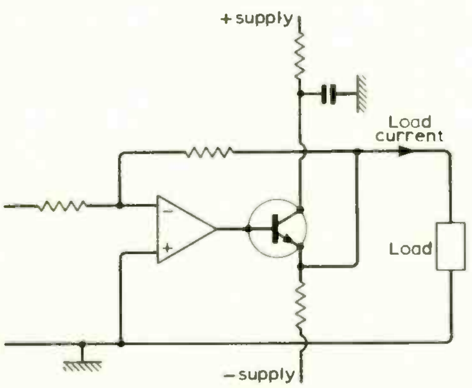


Fig. 2. Emitter follower booster.

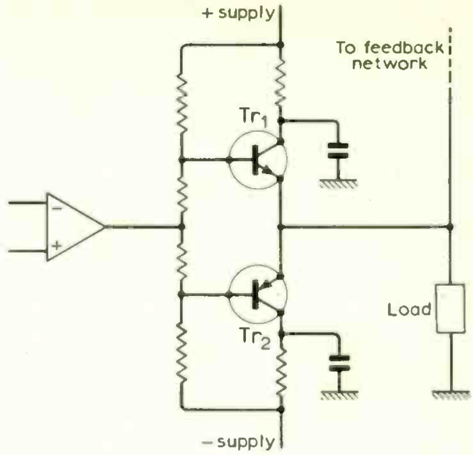


Fig. 3. Booster using complementary emitter followers.

it is bypassed by a capacitor in order that the high frequency response of the emitter follower shall not be degraded by the presence of this collector resistor. The most efficient use of a single transistor emitter follower is when output currents of only one polarity are to be supplied, n-p-n transistors for positive output currents and p-n-p types for negative output currents.

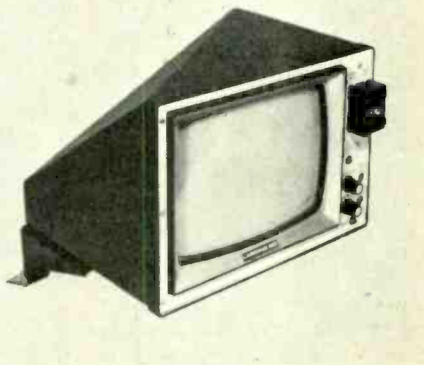
A booster using complementary emitter followers (Fig. 3) provides greater efficiency and dynamic voltage range than those of the single emitter follower for the same power supply and drive voltage. The quiescent current carried by the transistors can be made quite small without limiting the output current capability of the booster. For positive-going drive signals the output current is delivered by Tr_1, while Tr_2 takes the current for negative-going signals. Resistors in series with the collectors protect the transistors against excessive short circuit current.

Books Received

Lasers, a survey of their performance and applications, by Ronald Brown, describes the history of lasers and the principles of their functioning. Background details of quantum and solid-state theory are given allowing the reader to grasp the basis of laser theory. Different types are fully described, and differentiated into solid, glass, gas, semiconductor, liquid, chemical and x-ray lasers. The control of laser beams and the principles of non-linear optics are described. The text is complemented by 100 line drawings and over twenty photographs of laser beams in action. Pp.268. Price 95s. Business Books Ltd., Mercury House, Waterloo Road, London S.E.1.

Eurolec GB Pocket Guide 1969, Parts 1 and 2, gives an up-to-date picture of British electronics and instrument industry, taking account of all the significant changes in 1968. The first part covers over 1200 companies, giving for each the senior executive, location, products, distributors, number of employees, parent and related companies. The second part lists over 1500 foreign companies with representatives in Great Britain. Pp.256. Price 32s 6d. David Rayner Associates, Little Waltham, Essex.

News of the Month



The photographs show a television camera and monitor, produced by E.M.I., that will be used on the Concorde prototype 002 which is due to make its maiden flight from Filton, Bristol, shortly. The camera incorporates printed scan-coils and a 26mm vidicon tube. The monitor employs a 230mm (9 inch) tube and has been designed so that it may be rapidly positioned in front of the pilot should the nose of the aircraft fail to droop during the landing procedure.

Apollo-9 lunar module

The communication system in LM-3, the lunar module used in the latest Apollo programme exploit, consisted of two S-band transceivers, two v.h.f. transceivers, a u.h.f. command receiver, a signal processing unit and all the associated aerials.

Voice communication was achieved in two ways; for conversations with earth the S-band equipment was employed using a 1-m steerable parabolic aerial or two fixed, in-flight, aerials; while communication between the LM and the command service module was maintained at v.h.f.

Real-time commands for the navigation, propulsion and other systems were received at u.h.f. It is understood that for subsequent Apollo flights involving a lunar module, S-band equipment will be employed for command data.

The LM carried a four-channel voice recorder with a ten-hour recording capacity. The information so recorded, complete with time signals, cannot be transmitted back to earth, so analysis of the recording relies on the command service module's safe return to earth.

Balance of trade

Detailed analyses of last year's imports and exports of electronic and radio equipment have not been issued by the various trade associations at the time of writing but a detailed perusal of the Board of Trade "Overseas Trade Accounts for the U.K." for December gives the overall, if not so detailed, picture.

Exports rose from £130M in 1967 to £154M last year, an increase of 19%, but imports rose by 24% to £104M in 1968 against £85M the year before.

Here are some comparative figures for the various categories of equipment. Telecommunication, broadcasting and navigational equipment accounted for about 38% (£58.5M) of last year's exports—an increase of £7M over the previous year. This type of equipment also accounted for £24M worth of imports which was 20% up on the 1967 figure. Domestic radio and television receivers and parts imported rose by nearly £4M to £13.18M whereas exports rose by only £1.4M to £7.27M.

Audio equipment (amplifiers, microphones and loudspeakers) accounted for £3.33M of our imports and £3.84M of our exports; both having increased by about 30%.

As one would expect the import of semiconductor devices continues to rise—from £11M to £15M—whereas we exported only £4.6M last year although this was an increase of nearly £2M on the previous year.

Both imports and exports of computers and peripheral equipment increased by about 10%; imports rose to nearly £40M and exports to just over £43M.

The only category in which imports decreased and exports increased was scientific instruments. Equipment coming into the country fell by about £70,000 to just over £3M whereas exports went up by some £7M to nearly £30M.

I.T.A. u.h.f. transmitters

The Independent Television Authority has allocated the first 26 of its u.h.f. transmitters to programme contractors. Each of the transmitters is co-sited, which means that the B.B.C. and the I.T.A. share the same aerial masts. Because of this, and because of the difference in coverage provided by u.h.f. when compared with v.h.f. transmitters the service areas of the programme companies will not be quite the same as they are at present.

The transmitters allocated so far are as follows:

Contractor	Transmitter
London Companies	Crystal Palace
A.T.V.	Sutton Coldfield
	Waltham
	Beckley
Granada	Winter Hill
Yorkshire Television	Emley Moor
	Bilsdale
Scottish Television	Black Hill
	Craigkelly
Harlech	Wenvoe
	Mendip
Ulster Television	Divis
Southern Television	Rowridge
	Dover
	Hannington
	Heathfield
Tyne Tees Television	Pontop Pike
Grampian Television	Durris
Anglia Television	Talcolneston
	Sudbury
	Belmont
	Sandy Heath
Westward Television	Curadon Hill
	Redruth
Border Television	Caldbeck
	Selkirk

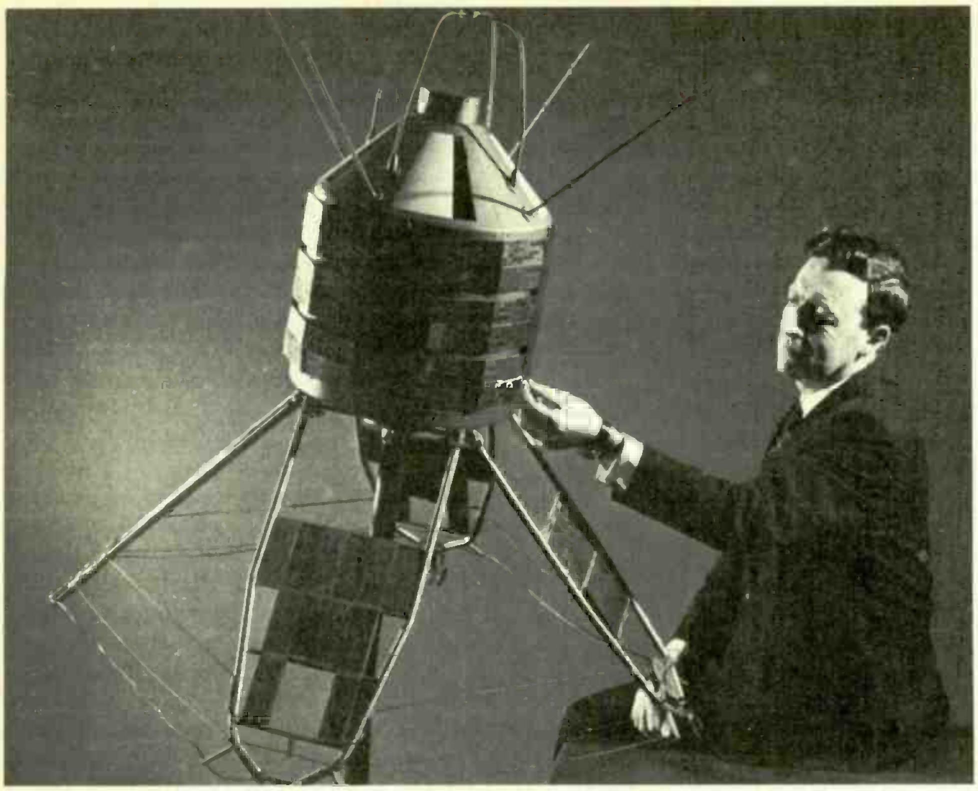
UK-4 project contracts

British Aircraft Corporation's Space and Instrumentation Group at Bristol is to be appointed prime contractor and co-ordinating design authority for the UK-4 scientific satellite project. The contract is being placed by the Ministry of Technology acting for the Science Research Council.

B.A.C. will be responsible for spacecraft design and project co-ordination and management. The Royal Aircraft Establishment, Farnborough, will be the research and development authority, and the Space Research Management Unit of the Science Research Council will be responsible for overall management.

The UK-4 satellite is due to be launched in 1971 by a National Aeronautics and Space Administration vehicle into a 550km circular orbit of the earth at 80 degrees inclination. Incidentally, another satellite in the same series, Ariel-3, recently completed 10,000 orbits of the earth.

The main body of UK-4 will be in the form of a polygonal cylinder with a conical top. Four large booms around the base of the satellite provide mountings for some of the experiment sensors well away from the main body, to reduce the risk of reflection and other interferences, and also to provide a convenient platform for mounting some of



J. B. Atkinson of G.E.C.-A.E.I. (Electronics) Ltd. seen with a half-size model of U.K.-4. G.E.C.-A.E.I. will be producing a good deal of the electronic equipment for the satellite.

the solar cells. During launch these booms are wrapped around the fourth stage motor of the Scout launch rocket. After injection into orbit, the booms are deployed to an angle of 65° relative to the spin axis of the satellite.

The satellite will be basically similar to the previous Ariel-3 satellite since this is of proven design. The prototype and development models will use certain existing UK-3 hardware, therefore the development programme will take less time than a new design. The UK-4 satellite will carry experiments from:

University of Birmingham—electron temperature experiment and electron density experiment. University of Sheffield and Radio and Space Research Station—v.l.f. experiment and lightning impulse experiment. University of Manchester (Jodrell Bank) and R.S.R.S.—radio noise experiment. Another organization (to be determined)—particle experiment.

Satellite training

Nigeria is one of the first oversea countries to take advantage of an eight-week course on satellite earth station communications organized by the External Telecommunications Executive of the British Post Office.

Two Nigerian technicians are among 16 students taking part in the current programme at the E.T.E. Training School at Leafield, near Oxford.

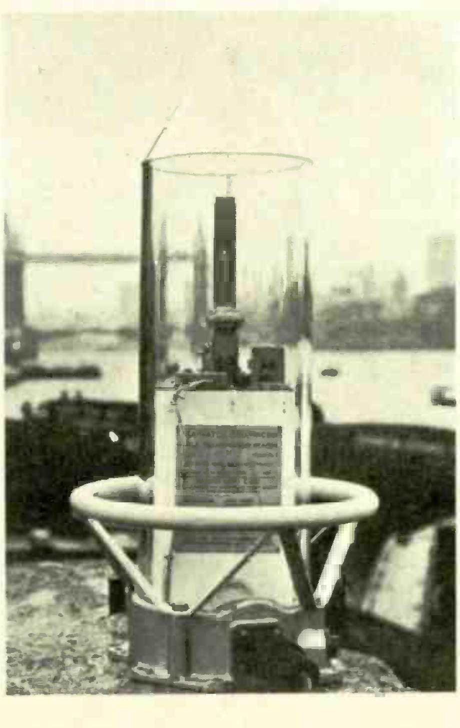
Low-power radar beacon

A radar beacon, which mounts on a buoy and transmits information on its position when triggered by a ship's radar signal, has been developed by G.E.C.-A.E.I. (Electronics) Ltd. The equipment provides a clear indication of areas to be avoided by shipping, and greatly simplifies the problem of navigating near to land or in the vicinity of underwater hazards.

Named Seawatch 300, the system is asserted to have the best range performance for its size and weight. It supplements the established Seawatch lighthouses around the coasts of Ireland and Scotland. Seawatch Major is much larger in size and has an output of 20 watts, compared with 300mW for Seawatch 300.

Both systems operate on the same principle. On receipt of transmissions from navigational radars the beacons transmit signals which appear on the ships radar display showing the range, bearing and identity of the beacon.

The new low-power (300mW) radar beacon from G.E.C.-A.E.I.



Radar beacon (Racon) responses are much stronger than the ordinary strength echoes from buoys and other small targets, even when these are fitted with radar reflectors. Detection range is increased from the normal 2 or 3 nautical miles to near the horizon ranges of 7 to 10 miles, or to a maximum of 12 miles where aerial height permits. The direct response of these systems makes buoys much easier to detect, particularly in heavy clutter.

Calibration services extended

The British Calibration Service, set-up in 1966 by the Ministry of Technology, is expanding its services to include pressure, temperature and r.f. noise measurements.

Laboratories can now seek approval for r.f. noise measurements as facilities will soon be available from the Mintech Electrical Inspection Directorate for calibrating noise standards. E.I.D. will have access to national standards for this kind of measurement at the Services Valve Test Laboratory, Haslemere, Hants, a Ministry of Defence (Navy) establishment.

Instrument standard agreement

Twenty-six national and international nuclear laboratories in Europe are to adopt a new standard, called CAMAC, for the design and manufacture of electronic instruments. Instruments designed to meet the standard will be electrically and mechanically compatible. This means that individual instruments can be interconnected via a specified data highway to form complex measuring systems. Such systems are independent of the choice of computer or other processing device. The new standard, if widely adopted throughout industry, will not only simplify the task of designing and commissioning measurement and control instrumentation systems but will also enable manufacturers to offer their products to a wider market.

The CAMAC design specification may be used free of charge, and without seeking permission, by any organization or company. Full details of the standard will soon be available in a Euratom report of which advance copies are available from the Electronics and Applied Physics Division, U.K.A.E. Harwell, Didcot, Berks.

The CAMAC standard was developed by the European Standards of Nuclear Electronics (ESONE) Committee which was set up in 1960 on the initiative of the Euratom Research Centre.

The standard anticipates and exploits, the growing use of automatic means of data acquisition and processing (especially on-line to digital computers or other equivalent equipment) and the widespread adoption of integrated circuits.

Record sales of domestic equipment in America

The Electronic Industries Association report record sales in every category for domestic electronic equipment in America during 1968. The total sales in each category are as follows: television receivers—13.2M; radio receivers—46.8M; record playing units—6.5M; and tape equipment—8.1M.

Colour television receivers accounted for 6.2M of the television total. It is interesting to note that 10M of the television receivers were home-produced and 1.2M were imported by manufacturers for sale under their own, U.S., brand name. In all, imported equipment accounted for about 11% of the total television sales; this is a steep rise over the 1967 total of 6%.

Out of the total radio receiver sales of 34.3M units (excluding car radios and radio-gramophone combinations) only 6M units were home-produced and a further 5.7M receivers of foreign manufacture with U.S. makers' labels were marketed. The 22.7M sales of radio receivers with foreign brand names accounted for 66% of the total compared with 60% in 1967. Imports, therefore, accounted for 83% of the total radio receiver sales.

New standard may make buying easier

British Standard 9000 is intended to replace the current tangle of specifications that are currently in use in this country (CV, DEF, etc.), making the task of component classification an easier one. B.S.9000 goes a little further than other specifications in that the components should be of "assessed quality", inspected to the standard scheme and accompanied on delivery by a certificate of conformity to the standard. Certified test records will be kept by all manufacturers, and from the level of performance which these indicate a prospective purchaser can confidently assess the quality of the components in question.

Nearly 150 manufacturers, stockists and test houses have applied for approval under the scheme. So far two of the 22 publications listing the standard required of components have been produced.

"You scratch my back . . ."

Hewlett Packard Ltd. have just issued a comprehensive application note entitled "Modern EMI Measurements". No doubt this courtesy will be reciprocated in the form of a booklet from EMI Electronics Ltd. called "Modern HP Measurements". (For those who don't know, EMI also stands for Electromagnetic Interference.)

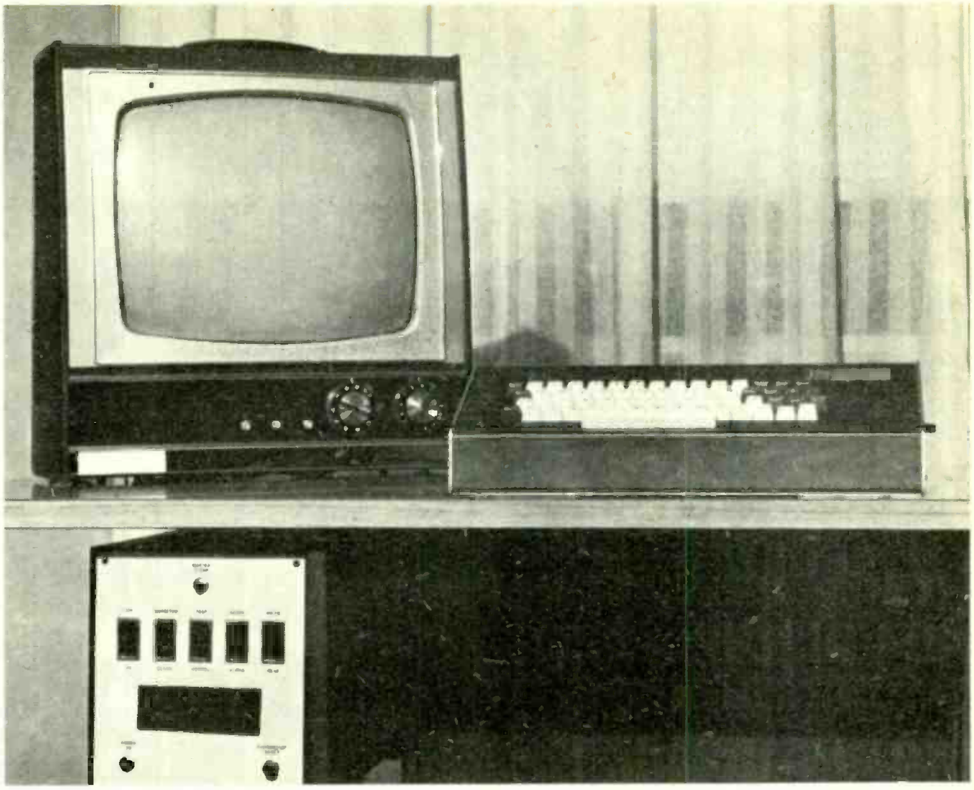
Sperry-Decca combine to produce i.n. system

An inertial platform produced by Sperry and a doppler system from Decca Navigator have been combined to produce an inertial navigation system of low cost that is suitable for both military and civil applications.

The Sperry platform, type SGP500, is based on an earlier successful design, the MRG Mk. II twin gyro platform that has seen over 300,000 flying hours.

The Decca doppler is the latest of the series 70 range which has been specified, or is already in use, in the Jaguar, Transall C160, BAC 1-11, Boeing 707, HS 125 and DC8-63.

In a complete inertial navigation system a computer would be used in conjunction with the platform and the doppler, and the performance of the system as a whole, and the number of options it offers would depend on the sophistication of the computer used. For civil applications Decca are recommending their Omnitrac 2B.



In this picture the monitor, keyboard and controller forming the CC-30 display can be clearly seen.

The new American military communications satellite dwarfs a full size model of the first synchronous communications satellite to be launched (Syncom).

Visual display terminal

A relatively new company to Britain, Intercontinental Systems Inc. (UK) Ltd which was set-up last September at Woking, recently demonstrated a range of electronic writing machines for various applications and a visual display terminal and keyboard for feeding in and retrieving information from a computer.

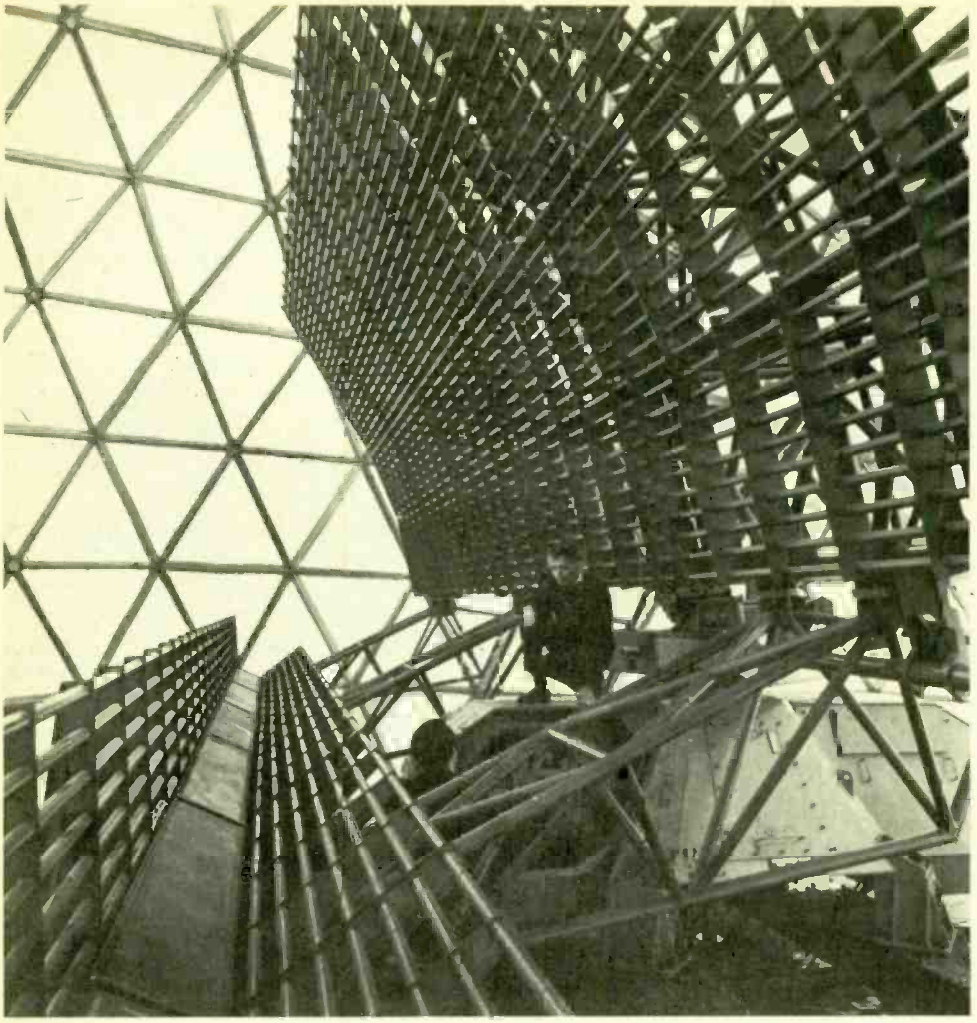
The visual display, known as the CC-30, consists of a controller, keyboard and a 625-line television receiver or monitor. Alphanumeric information is displayed in a 20- or 24-line by 40 character format. The display will communicate with a computer in a serial mode at 1,200 bits/second asynchronous or 4,800 bits/second synchronous. When the terminal is located close to the processor parallel operation can be employed at 500,000 bits/sec.

Largest communications satellite

A communications satellite as high as a two-storey building and about 3m in diameter has been launched from Cape Kennedy. It was built by the Hughes Aircraft Company, California, at a cost of $30M for the American Department of Defense and the three Services to investigate the possibilities of using a synchronous satellite for tactical communications.

A new type of stabilization system, called Gyrostat, is being employed on the satellite which makes possible the tall rod-like shape. This, if proved successful, could have a significant effect on the future design of communications satellites which have to carry large aerial systems.

The satellite, which weighs 720kg, has three aerials made up from five helical arrays and will operate in the u.h.f. and s.h.f. bands.



An unusual view of a Marconi aerial which is part of a radar installation that is nearing completion at Lowther Hill, Southern Scotland. The radar equipment employs a 500kW transmitter and will be linked directly to Prestwick Airport. In the picture part of the parabolic reflector can be seen and on the left is the linear waveguide that extends the full 52ft length of the aerial. Part of the geodetic radome can also be seen.

Baird travelling award

The Royal Television Society (166 Shaftesbury Avenue, London, W.C.2) invites applications for the 1969 John Logie Baird travelling award. The award, worth £200, is open to post-graduate students in U.K. educational establishments who are concerned with some scientific aspect of electronic engineering, television or allied technology. It is expected that the award will be made to someone in the 21- to 30-year-old age group.

The award is intended to assist the successful applicant in undertaking a period of investigation abroad of about seven weeks.

Application forms for the award are available from the above address.

G.E.C.-A.E.I. satellite centre

A satellite development and environmental testing centre at Brown's Lane, Portsmouth, previously owned and financed by the Government and managed by G.E.C.-A.E.I. (Electronics) under an agency agreement, has now been taken over completely by G.E.C.-A.E.I.

The development centre is said to have some of the most extensive testing facilities available anywhere in Europe and will enable the company to market satellites for a wide variety of uses. At the moment the company claim to have more electronic equipment in space than any other company outside the United States and have orders for more than £8M worth of earth station equipment.

Subscription TV in America

In a recent address to television dealers in America W. C. Fisher of the Zenith Radio Corporation explained some of the details of the forthcoming subscription television service. The service is made possible by the decision of the Federal Communications Commission, on December 12th last year, to allow about 80% of the American population to have subscription TV. This is in contrast to the situation in this country as, following restrictions made by the Government on the number of subscribers, subscription television was abandoned as being uneconomic under the imposed conditions.

In the American system programmes are conventionally broadcast "over-air" (the experiment in this country used wired-TV) after being "scrambled". Each subscriber hires a decoder which is interposed between the aerial and the aerial socket of any standard domestic receiver. The decoder will handle u.h.f. or v.h.f. signals in colour or monochrome and additionally records details of any programmes that are watched by the viewer on a card for future costing.

Motorola seek U.K. manufacturing site

The general manager of the semiconductor products division of Motorola recently visited Britain to inspect sites suitable for setting-up a semiconductor manufacturing plant. Sites in Cheshire, Hertfordshire, Lanarkshire and Dunbartonshire were examined. A final decision is expected shortly.

Engineering degrees

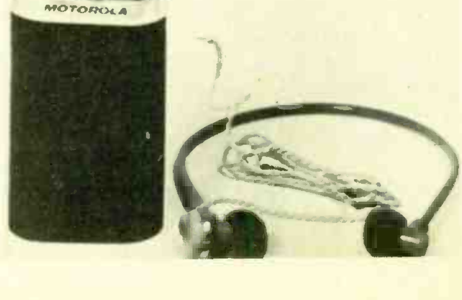
Commenting in his presidential address at the I.E.E. dinner on February 20th on "the attitude of mind that continues to persist in this country that engineering is a subject subsidiary to science" Professor J. M. Meek instanced the reluctance of nearly all universities to use the word 'engineering' in the title of their degree except, in some cases, rather shyly in brackets following the word 'science'. In drawing attention to the matter he said he did not want to be thought of as an exponent of science friction, but rather "to emphasize that, if other professions such as medicine and law merit distinct degrees, then also the profession of engineering is no less worthy to do so".

Pocket television receiver

An experimental television receiver, not intended for any commercial market at present, measuring only 90×55×28 mm, has been developed by Motorola to demonstrate just what can be done with modern semiconductor devices. Most of the volume is occupied by the electrostatically deflected 25mm c.r.t. and the four mercury pen-light cells which supply the power.

Altogether 43 transistors and diodes are employed in the receiver which at present operates on one channel only. Power consumption is about 1.5W—half of this being used by the tube heater.

Picture shows the shirt-pocket television developed by Motorola Inc., of Chicago, U.S.A. It measures 90 × 55 × 28mm.



Wireless World Colour Television Receiver

11. Decoder Circuits

Before discussing the colour-decoding circuitry, the 0.6-μsec delay line for the luminance channel will be treated. This was deferred to the colour section because it is only essential for colour in spite of being fitted to the i.f. board. The line employed during the bulk of the development work is of Mullard design but it does not appear to be available commercially. Details of the construction are given in Fig. 1. It is a difficult component to make. It is not easy to stick the copper-foil strips and patches to the polyester-foil accurately in position, nor is it easy to wind 1350 turns of No. 46 wire evenly and without breaking the wire unless a winding machine is available. Furthermore, both the Melinex sheet and the best adhesive are almost impossible to obtain in small enough quantities for making just one or two lines.

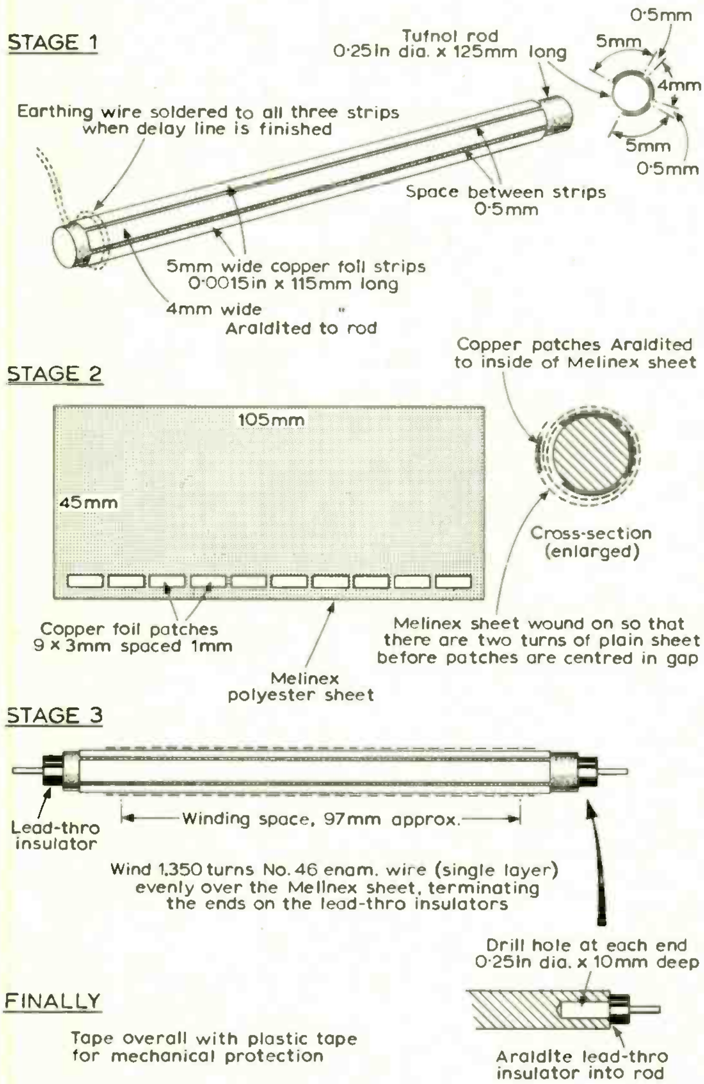


Fig. 1. Constructional details of the 0.6-μsec delay line are given here.

The merit of the design is its compactness. Where space permits the use of a physically larger component, as it does in this case, an alternative is available. This is the Delax type HH2500 flexible delay cable and this can be used with only minor changes to the circuit. The cable has a characteristic impedance of 2.9kΩ, instead of 1kΩ, and for 0.6μsec delay its length is $12\frac{1}{2}$ inches, including its terminations. It can, however, be bent to a diameter of not less than 5 inches. As it is coaxial with the outer earthed, it can be bent so that the ends come to the normal termination points on the i.f. board with the loop lying behind the board.

The cable has two pins at each end for soldered connections. The inner and outer conductors can readily be distinguished with an ohmmeter test, for the inner conductor is of noticeably higher resistance than the outer.

For impedance matching at the input, a 1.9-kΩ resistor must be connected in series with the inner conductor. If the two inner-conductor pins are soldered to the two pins in the i.f. board, shown in Parts 7 and 8 for the Mullard line, the 1.9-kΩ resistor can replace the wire connection between the input pin and the collector of Tr_4. The cable pins for the outer can be soldered directly to the printed board for their earths.

At the output end, proper matching merely requires changing R_1 of the luminance amplifier (Part 6) from 1.2kΩ to 6kΩ.

The cable is of German origin (Kabel und Metallwerke) and is available in this country from Aeon Laboratories, Beech Hill, Ridgemead Road, Englefield Green, Surrey.

A careful comparison of the performance of the two delay lines has been made. They were installed with a changeover switch so that a rapid comparison could be made and they were compared on a variety of both colour and monochrome pictures, including Test Card F. No observable difference between them was found.

We come now to the decoder circuits and here it may be helpful to refer to the block diagram in Part 10. In what follows the numbers in brackets refer to the numbered blocks in that diagram. The circuit starts in Fig. 2; we say 'starts' because there is so much of it that it is impracticable to include it all in one diagram. All told there are 359 parts involved, including 135 resistors, 73 capacitors, 15 transistors, 24 diodes and 3 double valves. With the exception of the valves and the components associated with them all the parts are assembled on two pieces of Veroboard each measuring $2\frac{9}{16}$ inches by $13\frac{1}{2}$ inches; the board is of the kind which is backed by copper strips. The component density is thus quite high.

The whole signal appearing at the emitter of Tr_4 of Fig. 1 of Part 7 is fed to the decoder at P_1 in Fig. 2 of this article. This is the complete video signal; that is, it is the luminance (Y)

signal plus line and field sync pulses plus colour burst plus the chrominance signal components around 4.43MHz. The capacitor C_1 and resistor R_1 form a simple high-pass filter (1) which removes the video signal and the sync pulses and leaves only the 4.43-MHz signals. These are attenuated quite a lot but a 3-V peak-to-peak input (burst amplitude 0.25 Vp-p) is sufficient.

The filter output is applied to an amplifier (2). This comprises transistor Tr_1 which derives its base bias from two sources. One is a positive bias through R_3 from the potential divider R_4; the other is a negative bias which comes through R_{16} from the anode of D_1. As will appear later, this diode is fed with the burst at its cathode and it rectifies the burst to produce a smoothed output increasing negatively as the signal amplitude increases. In this way a.g.c. is applied to Tr_1 and it acts to maintain the output burst and chrominance signals at a substantially constant level. The precise level is adjustable by R_4. The system is sometimes called automatic chrominance control.

The collector of Tr_1 feeds a 2:1 step-down transformer T_1. The secondary feeds a burst amplifier Tr_2 and also through P_2 a chrominance amplifier, which is located physically in another board and is not shown in Fig. 2. The burst amplifier (22) is straightforward with an output tuned circuit comprising L_1, stray capacitance, and the damping resistor R_{12}. The collector feeds a second burst amplifier and gate Tr_3 through C_7. This stage (23) is cut-off for most of the time and is conductive only for the duration of a positive pulse applied at P_3. When it is so conductive current flows into C_8 and a small positive voltage is built up across it which holds the transistor cut-off when the pulse is absent. The pulse is derived from the line flyback by components in the other board and is timed to coincide with the colour burst. Thus Tr_3 passes and amplifies only the colour burst and cuts out the chrominance signals. The burst voltage appearing across the primary of T_2 is adjustable by R_4.

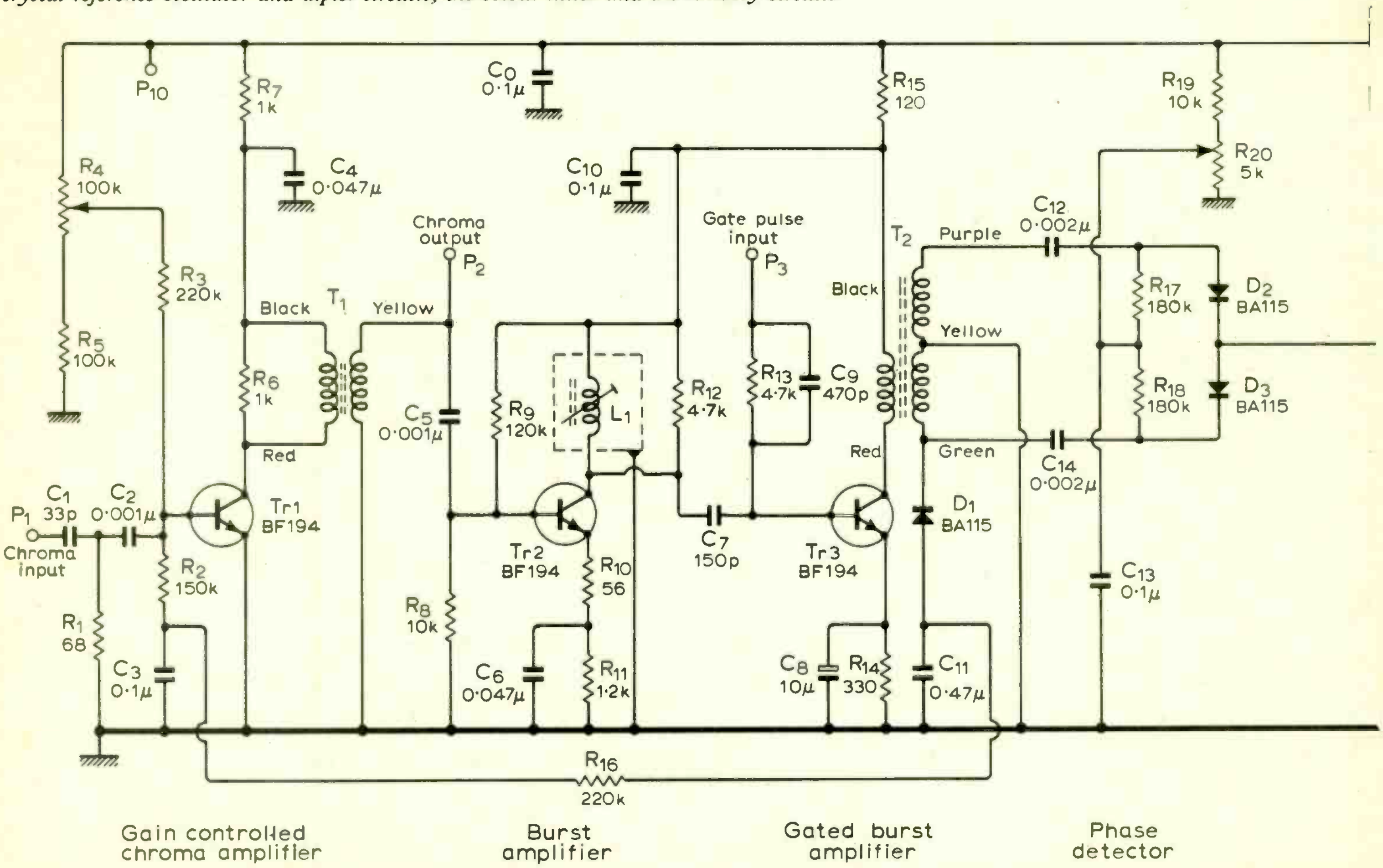
This transformer T_2 is a part of the phase discriminator (24). The secondary is centre-tapped and earthed to chassis. With respect to this point, therefore, the voltages at the two ends are equal in amplitude and opposite in phase. One side feeds D_1 and its rectified output is smoothed by C_{11}, the voltage being applied through R_{16} to Tr_1 as a.g.c.

The whole secondary output is applied through C_{12} and C_{14} to the diodes D_2 and D_3 in series. The diode loads are R_{17} and R_{18} and should be equal in value. Their exact value is unimportant and they are chosen to be 180kΩ merely because this value is in the 10% tolerance range.

A locally-generated oscillation is introduced via T_3. Starting from chassis there is one closed path through C_{15} the secondary of T_3, D_2, C_{12} and the upper half (on the diagram) of the secondary of T_2. There is a second closed path through C_{15}, the secondary of T_3, D_3, C_{14} and the lower half of the secondary of T_2. Let V_0 be the voltage across T_3 and V_b be the voltages across the two half-secondaries of T_2. Then the voltage applied to D_2 is, say, $V_0 + V_b$, whereas that applied to D_3 is $V_0 - V_b$. The two diode inputs are equal in amplitude if, and only if, the voltages are in phase quadrature. The rectified outputs of the two diodes are then equal and opposite and cancel to zero through the d.c. path which is via R_{20}, R_{19}, R_{25}, R_{24} and R_{15}. This is the ideal condition when the local oscillator is running locked precisely in frequency to the burst and at 90° in phase.

If there is a phase error V_0 will differ from one half-secondary voltage by less than 90° and will differ from the other by more than 90°. In the first case the peak voltage of the combination will increase, and in the second case it will decrease. The rectified outputs of the two diodes will no longer be equal;

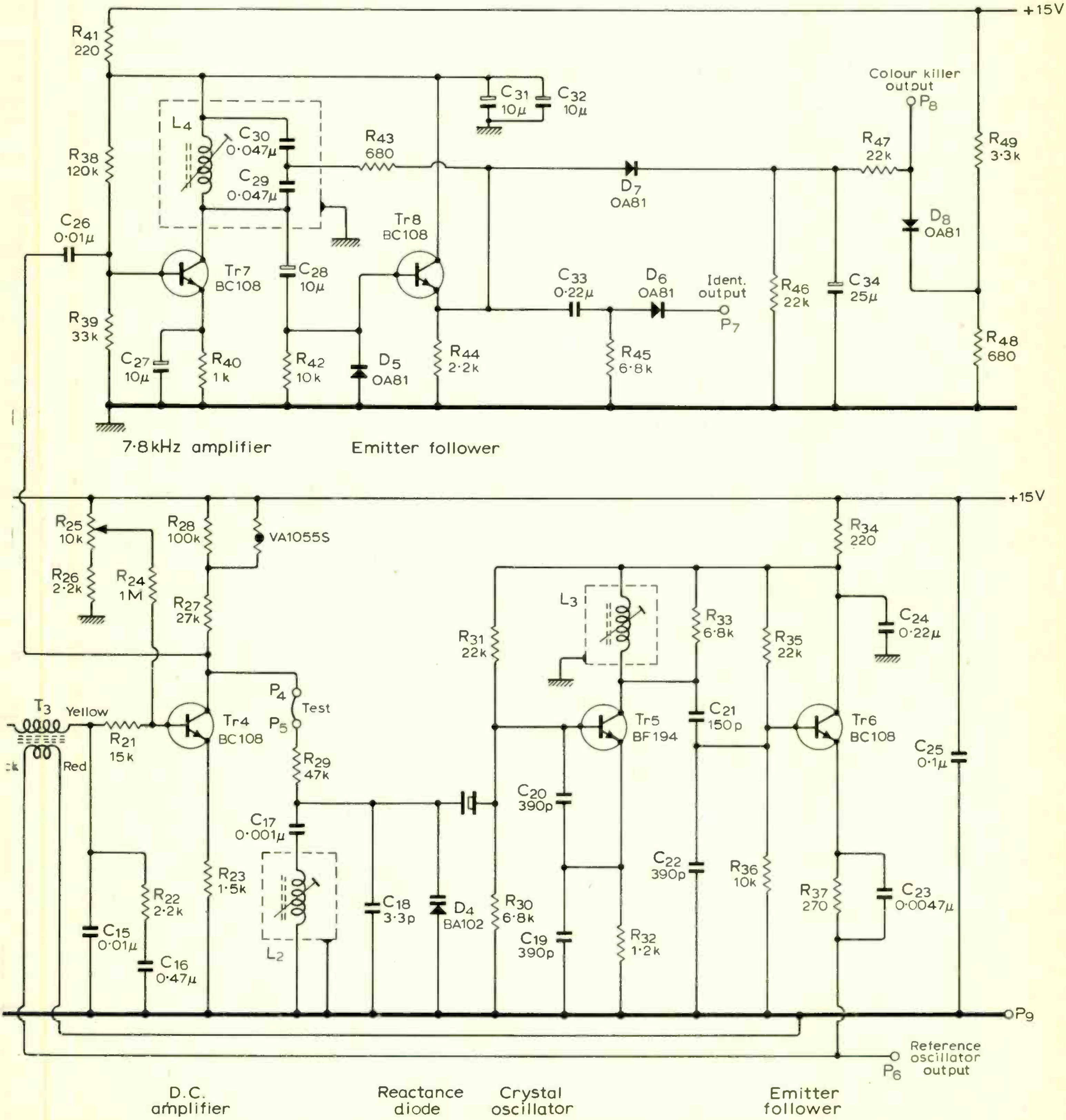
Fig. 2. Circuit diagram of one of the two main boards of the decoder. It includes the common first-stage chrominance amplifier, the crystal reference oscillator and a.p.c. circuits, the colour-killer and the identity circuits.



one will increase and the other decrease. The mean output, smoothed by C_{15}, is applied through R_{15} to the base of Tr_4, which is a d.c. amplifier (25). Thus a phase difference other than 90° between the burst and the local oscillator produces a d.c. output which increases with the magnitude of the phase error and is positive or negative depending on the direction of the error.

All this assumes that the frequency of the oscillator is exactly correct. In practice this will rarely be so when the equipment is switched on. In general terms, what happens when there is an initial frequency error is this. The output of the discriminator is varying at the difference between the two frequencies, but it is not a sinusoidal variation and it has a mean value the sign of which depends upon whether the oscillator is higher or lower in frequency than the burst. This acts through the d.c. amplifier on the oscillator to change its frequency towards that of the burst and, if all is well, it eventually brings the beat frequency to zero and the oscillator is then locked in frequency with the burst. Since a certain discriminator output is required to hold the oscillator thus locked in frequency, there is necessarily a phase error between the oscillator and the burst. This can be kept small only if the oscillator frequency is initially very close to that of the burst.

There is a limit, too, to the range over which the circuit will



act to lock the oscillator and this depends mainly upon its bandwidth. This is settled by the values of C_{15}, C_{16}, R_{22} and the other circuit resistances. The bandwidth is a compromise. If it is wide the pull-in range will be large but the lock will be affected by noise and interference. If it is narrow the pull-in range will be small but noise and interference will have little effect.

Once it is locked the oscillator will hold in lock over a greater range of variation of its parameters than it will pull in from the unlocked condition; that is, the hold-in range is greater than the pull-in range. This is a normal characteristic of automati phase control circuits (a.p.c.).

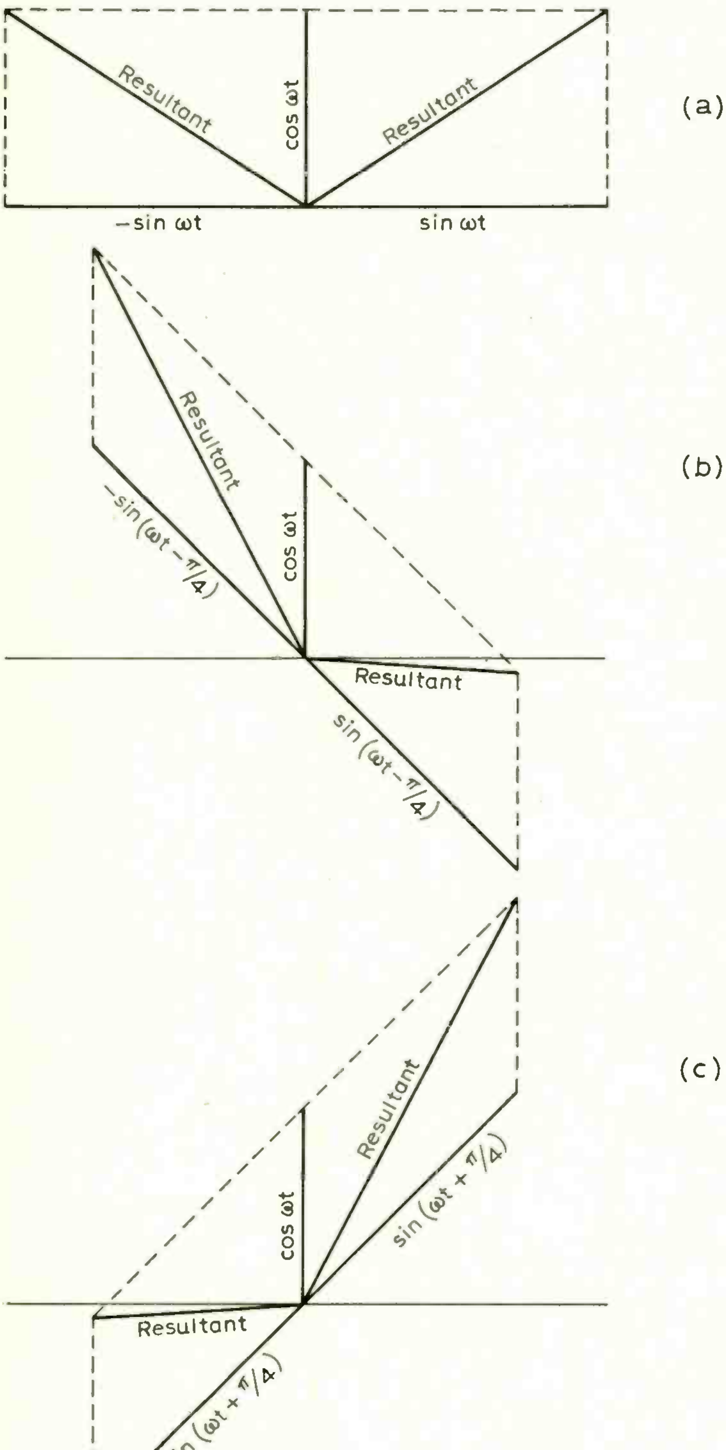


Fig. 3. The resultants of the local oscillator and the idealized swinging burst are shown at (a) and what actually happens in two successive lines at (b) and (c). The two resultants in each diagram represent the inputs to the two diodes of the phase discriminator.

Because the pull-in range is small it is necessary to have th oscillator functioning at very nearly the correct frequency in th absence of any control. This demands a crystal-controlle oscillator (27). This is Tr_5 which functions basically as a Colpitt oscillator. The crystal is connected between base and chassis, bu has in series with it the network C_{17}, L_2, C_{18} and D_4. Also betwee base and chassis are the two series-connected capacitors C_{19} an C_{20} to the junction of which the emitter is connected. Th collector, of course, is returned to chassis through variou components.

The diode D_4 is a special type and is operated with revers bias. It has a capacitance which varies with the bias by abou 30pF. It normally operates with about 6V reverse bias. Althoug all diodes give about the same range of capacitance the mea capacitance varies quite a bit between different specimens of th same type. The other components are included to allow for this

The shunt capacitance C_{18} is desirable to allow for the use of diode of unusually low capacitance and the series-tuned circui L_2C_{17} is tuned below resonance. It thus adds inductive reactanc and behaves as a variable negative capacitance.

Thus with the proper mean bias applied to D_4 and with th a.p.c. system inoperative the oscillator frequency can be brough very closely indeed to the proper value just by the adjustment o L_2. Two points P_4 and P_5, which are normally linked, are provide so that the oscillator can readily be disconnected for test purposes.

In the collector of Tr_5 there is a tuned circuit L_3 tuned by the series-connected value of C_{21} and C_{22} and damped by R_{33}. A fraction of the collector voltage developed across this circuit is applied to the base of the emitter-follower Tr_6. Emitter bias is provided by R_{37} shunted by C_{23} and the output voltage is developed across the primary of T_3 whence it is transferred to the secondary. It is also taken out through P_6 to the PAL diode switch (35) and the 90° phase shifter (36) in the other board.

The tuning of L_3 affects the oscillator output and also controls its phase to some extent. It is easily tuned for maximum output by connecting an oscilloscope to P_6 and adjusting L_3 for maximum signal. However, this is not usually the best setting for L_3 and it is usually best to tune L_3 to a slightly lower frequency.

Swinging burst

So far nothing has been said about the swinging phase of the colour burst. It has been assumed that it is $-\sin\ \omega t$ with the oscillator at $\cos\ \omega t$. In alternate lines, however, the phase of the burst is $\pm 45°$ to this. Fig. 3 shows at (a) the case previously considered looked at from the point of view of the diodes D_2 and D_3, one resultant being applied to one diode and the other to the other diode. The voltage across the secondary of T_3 is represented by $\cos\ \omega t$ and the voltages across the two halves of the secondary of T_2 by $\pm\sin\ \omega t$. Completing the parallelograms and taking the diagonals gives the diode voltages. As the diodes are peak rectifiers only the amplitudes of the resultants are important.

The actual conditions with one phase of the swinging burst are shown at (b). The two phases existing on the transformer secondary are $\pm\sin(\omega t \pm \pi/4)$ and the diagonals of the two parallelograms are of very different magnitudes.

In the burst of the following line the condition shown at (c) exists. The burst is now at $\pm\sin(\omega t + \pi/4)$. The diagram is now a mirror image of the previous one. The diode which previously had the larger input now has the smaller and vice versa. The average output over any even number of bursts is thus zero, just as in case (a). The actual output, however, is positive and finite during one burst and negative and finite during the next; this forms one cycle alternating at half the line frequency, or about 7.8kHz. This is passed by the filter circuit C_{15}, C_{16} and R_{22} and so appears at the output of the d.c. amplifier Tr_4. It is necessarily applied to the capacitance diode D_4 and varies its capacitance in sympathy. The oscillator, however, cannot change phase rapidly enough to follow it and is uninfluenced by these fluctuations. It thus behaves as if the burst phase were always the same at $-\sin\ \omega t$.

This a.c. component at half-line frequency is applied to Tr_7 which acts as an amplifier with a collector load tuned to 7.8kHz across which a large amplitude sinewave of 7.8kHz is developed (29). This is fed to an emitter-follower Tr_8 (30) with d.c. restoration by D_5 at the base. This clamps the negative half-cycle to chassis potential and so the output across R_{44} is also a sinewave which is always positive to chassis. The resistor R_{43} between the emitter of Tr_8 and the capacitance tap on the tuned circuit provides some positive feedback.

In the absence of a colour burst the 7.8kHz signal does not exist and so Tr_8 is cut-off, even if only just. Its emitter is thus at chassis potential. The anode of D_8 is then at chassis potential and this diode is cut-off, since its cathode is positive to chassis by the voltage across R_{48}. Thus the point P_8 is at chassis potential and a transistor in the chrominance channel in the other board is cut-off.

When the swinging burst is received the 7.8kHz signal appears at the cathode of Tr_8 and is rectified by D_7 and a positive potential is built up across C_{34}. This exceeds the potential across R_{48} and D_8 conducts virtually joining P_8 to R_{48} and so applying positive bias to the transistor in the other board and making it operative. This is the colour killer (31) which renders the chrominance channel inoperative when receiving a monochrome transmission.

It should be noted that the colour killer is readily put out of action. All that is needed is to short-circuit D_8. This is often needed when testing the decoder, aligning its circuits and fault finding.

The 7.8-kHz signal from the emitter-follower Tr_8 is also applied to the identity circuit (32). The output of D_6 is a positive more-or-less half cycle in alternate lines. It is applied through P_7 to the bistable in the other board. If this is operating in the right phase it has no action. If it is operating in the wrong phase, however, it suppresses its normal triggering pulse so that the bistable stays in the same state for two consecutive lines, which brings it into the proper phase.

Construction

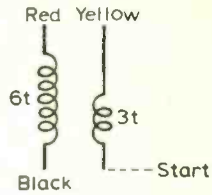
Space does not permit the treatment of the chrominance circuits in this article so that these circuits must be deferred to next month. Instead we go on to deal with constructional matters. Details are given of the windings of the transformers including those used in the chrominance channel. There are seven transformers and all are wound on Mullard Ferroxcube FX2249 cores. Each core is a block of Ferroxcube which is pierced by two holes and it is wound by poking the wire through these holes. This is quite easy since no winding has more than six turns. Rather than put each winding on separately, it is better and easier to twist together loosely as many wires as there are windings and so wind all the windings for one core together. It is better because it gives somewhat tighter coupling between the windings.

The most difficult is T_4 since it has four windings of four turns each and unless the wires are twisted quite loosely it will be difficult to get the last turn through the holes.

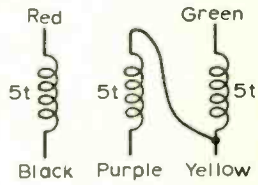
The wires are easily sorted out afterwards with an ohmmeter. It is best to leave quite long leads and to slip coloured sleeving over the wires as they are identified. The leads can be shortened as required when the mounted transformers are connected up, but it is desirable even then to leave an eighth of an inch or so of sleeving on to keep the identification unmistakable. One lead in each transformer need not be colour-coded, of course. The transformers are mounted by sticking them to the upper surface of the Veroboard with Evo-stik.

It is important that the proper connections to the transformers be made. Reversing the leads to one winding of T_3, for instance, will reverse the phase of the locked oscillator, and this will result in the final colour picture being in complementary colours!

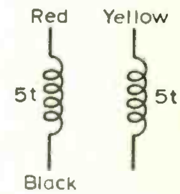
TRANSFORMER WINDING DETAILS



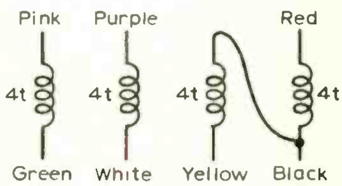
T_1 Primary 6 turns; secondary 3 turns. Twist 2 strands of wire; wind 3 turns; untwist the rest of the wire and continue with 3 more turns of one wire only.



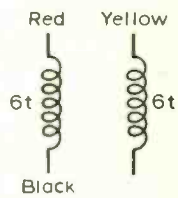
T_2 Primary 5 turns; secondary 10 turns C.T. Twist 3 strands of wire; wind 5 turns.



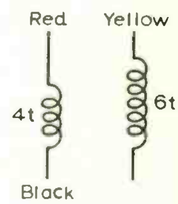
T_3 Primary 5 turns; secondary 5 turns. Twist 2 strands of wire; wind 5 turns.



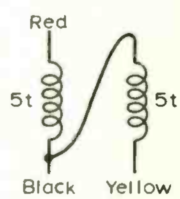
T_4 Primary 8 turns C.T.; secondary 8 turns C.T. Twist 4 strands of wire; wind 4 turns.



T_5 Primary 6 turns; secondary 6 turns. Twist 2 strands of wire; wind 6 turns.



T_6 Primary 4 turns; secondary 6 turns. Twist 2 strands; wind 4 turns; untwist the rest of the wire and continue with 2 more turns.



T_7 10 turns C.T. Twist 2 strands of wire; wind 5 turns.

All transformers are wound on Mullard Ferroxcube FX 2249 cores with No. 38 d.s.c. wire. All windings on a core are put on together by loosely twisting the appropriate number of strands together and winding the required turns of this composite wire. The core is a block of Ferroxcube which is pierced by two holes, through which the wire is readily poked. The windings are then sorted out with an ohmmeter.

The inductance (μH) is four times the square of the number of turns, but varies by about $\pm$ 12.5% with different samples of core.

An effect of this nature is actually quite trivial and can be corrected by changing the phase of the bistable, which can be done by changing over the Identity lead from one side to the other. In some cases, however, wrong connections may produce complementary colours in, say, the B−Y channel but not in the R−Y; this naturally completely upsets the G−Y channel and it becomes quite difficult to sort out what has gone wrong by looking at a most weirdly coloured picture!

Details of the coils used in both this and in the chrominance circuits will be given next month.

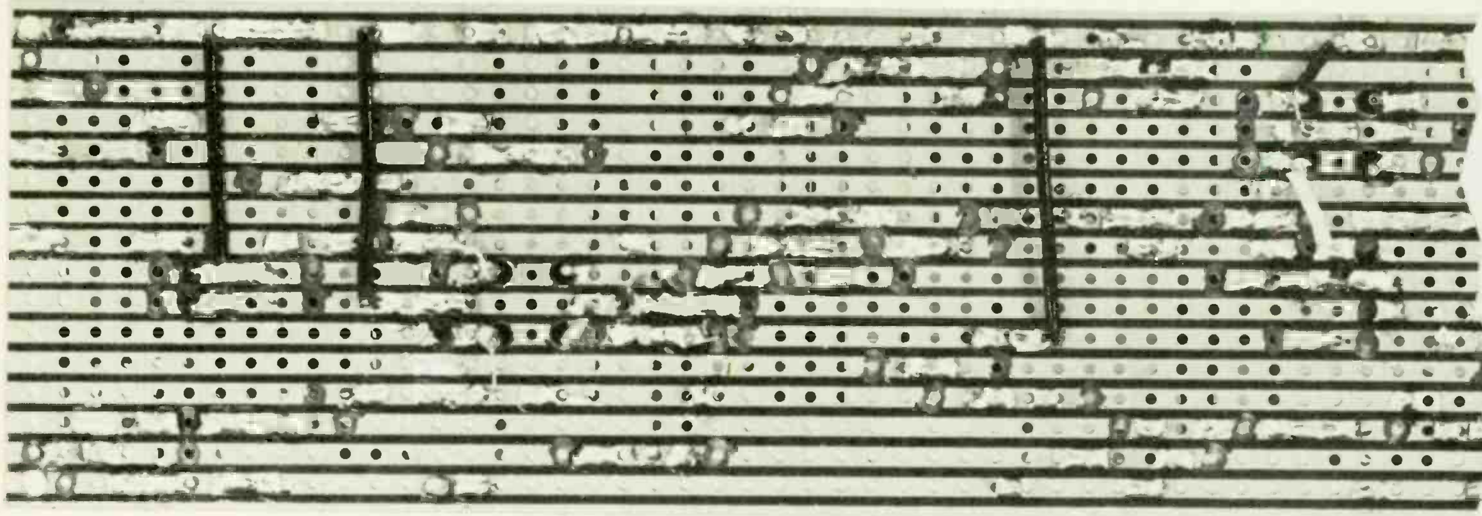
Standard size Veroboard is used. Two pieces each $2\frac{9}{16}$ inches wide by 17 inches long are needed. Each is cut to a length of $13\frac{1}{2}$ inches and one of the pieces cut off is used for the chrominance output stage. The cutting must be carried out carefully and it is wise to clamp the board between two pieces of wood very close to the cutting line and to have the copper-clad side towards one when cutting. This minimises the chance of the copper strips being pulled off the board. The board is pierced with holes 0.15 inch apart. When a hole has to be enlarged, and this occurs only rarely, do it by drilling from the copper side.

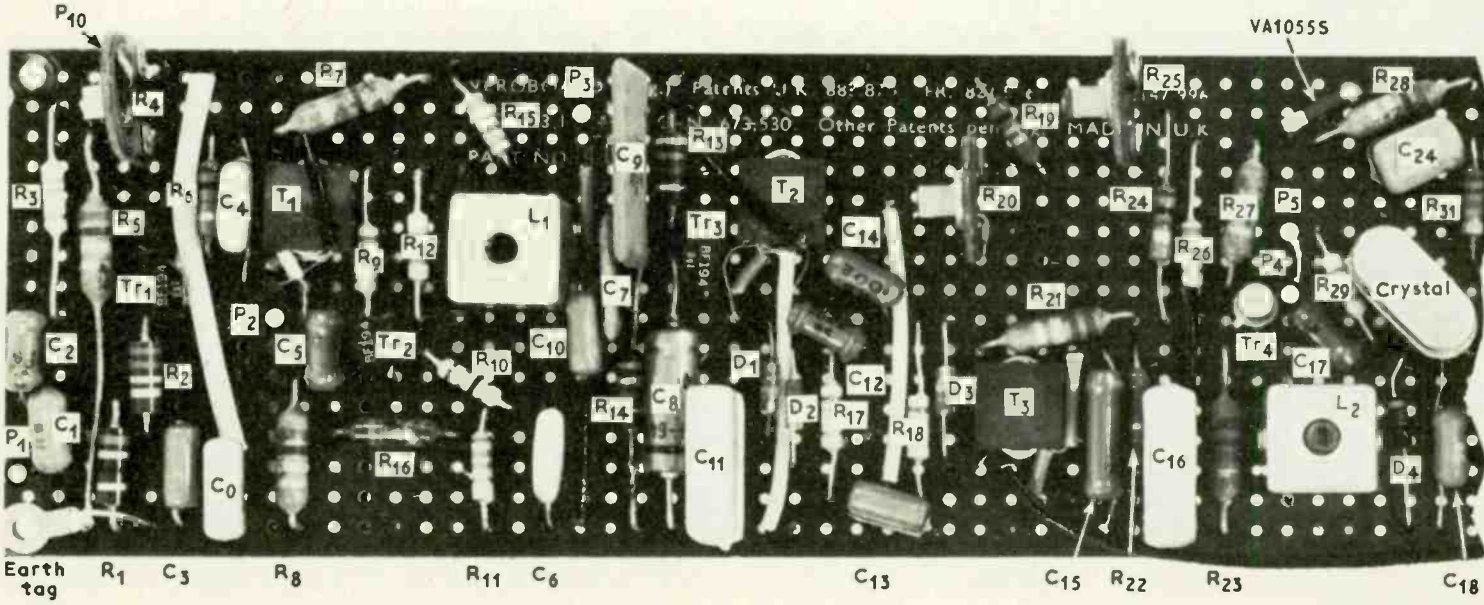
A milling tool is available for removing the copper around any hole and so providing a break in a strip. It is a satisfactory tool and carries out its function better than a drill. There are a great many breaks needed and care must be taken to make sure that they are all complete and that no whisker of copper is left t bridge the gap. Similarly when soldering, care must be taken t see that solder does not cause a short-circuit between adjacen strips. There is very little tendency to this if a small iron is use and the board is kept horizontal. When the finished board mounted it is vertical, however, and if one then has to solder to there is quite a risk of solder falling downwards and bridging t the next strip below.

Components have their leads bent at the proper points an inserted through the proper holes from the front. The board then turned over for soldering. Unless one is blessed with thre hands the component promptly falls out! The easiest way is to hol the board with one hand and press the component against th board with one finger of that hand. Then with a pair of pliers i the other hand bend over each lead at right angles at about one eighth of an inch from the back surface and so that the bent ove wires lie lengthwise along the copper strips. Cut off the surplu wire so that there is about an eighth of an inch only lying alon the strips. On removing the finger the component will drop away from the board and hang on the bent over ends and so can readily be soldered. If it does not drop of its own accord the leads ca be pushed down against the board.

It is necessary to choose physically small components especially resistors, if they are to go into the space available

Fig. 4. Photographs of the two sides of the board, showing the component layout, are given here. In order to reproduce them at a reasonable size they have had to be split, but there is sufficient overlap between them to prevent any difficulty.





Capacitors associated with tuned circuits are preferably silvered-mica types for they are both robust and quite low loss. Ceramic types are suitable elsewhere, but their losses and temperature coefficients are usually higher. The tuned circuits are mainly quite heavily damped and it is not so much the losses in themselves that are important as the fact that they seem to vary quite a lot from one specimen to another.

The photographs of Fig. 4 show the layout of components and one of them shows a *back view* of the board with the positions of the breaks in the copper together with the few wires and components which are mounted on the back of the board.

The obvious thing to do is to use this photograph to make all the breaks in the copper right at the start. This is inadvisable, however, and it is much safer to make them as one goes along. It is much too easy to make mistakes.

The best thing to do is to construct from the circuit diagram using the photographs as a guide.

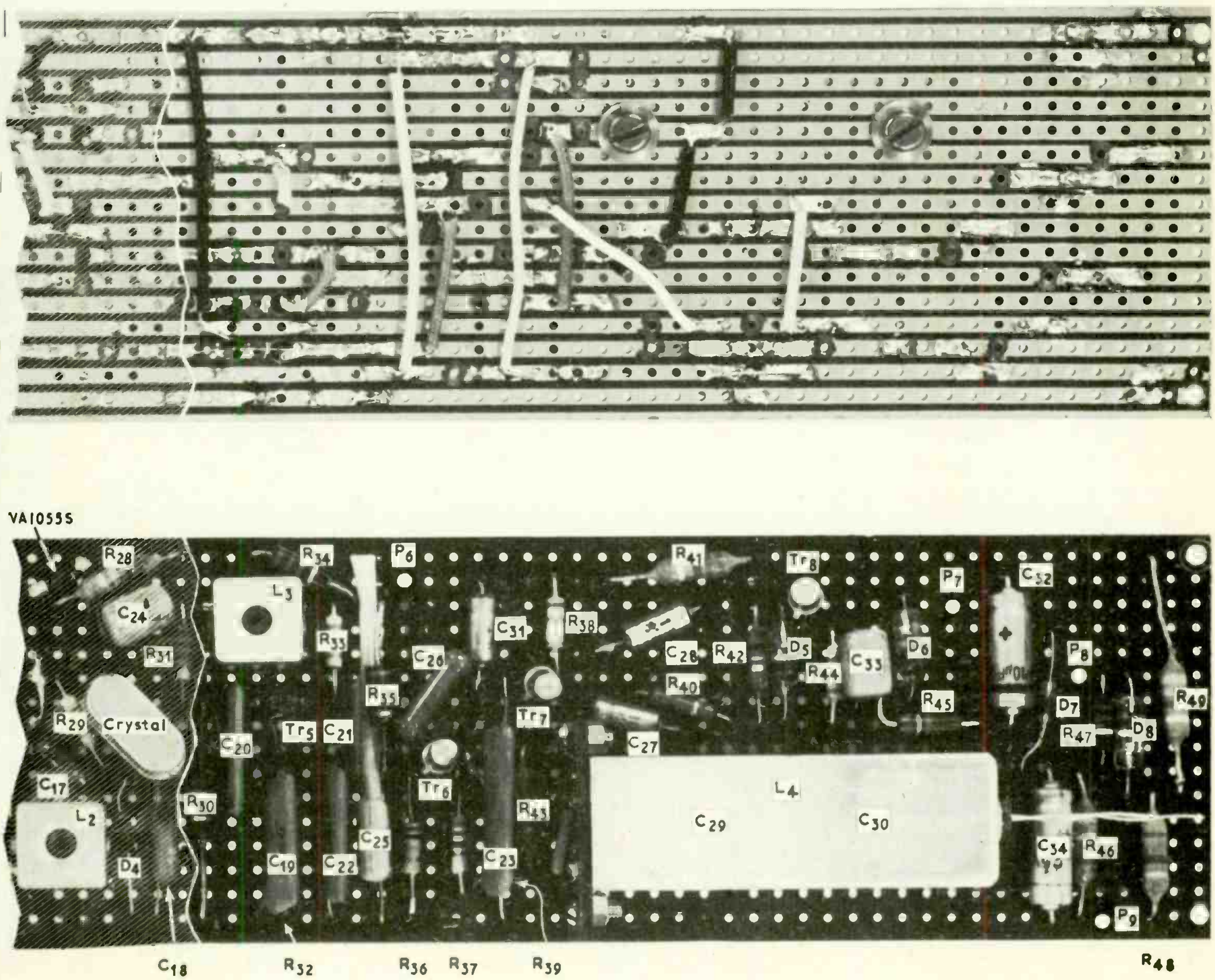
The odd unwanted break which it is almost inevitable that one will make can, of course, be bridged with a piece of wire. When the job is completed, however, it is advisable to check each little piece of strip for continuity. Not only will this reveal any wrongly made break but it will also show up any hairline break in the copper. Such a break can be invisible and can be remedied by flooding the strip with solder, fortunately, it is a rare event, but it can occur.

The transistors are normally mounted in three holes which are usually adjacent at right angles to the length of the board. The BF194 types have short lengths of copper wire soldered to them, because their tag spacing is different from the hole spacing of the board. The BC108 types, however, do not need this as they are already provided with wire ends. Do not forget that the order of leads for the BF194 is base, emitter, collector, whereas for the BC108 it is emitter, base, collector. This was referred to in the article dealing with the i.f. amplifier. Do not forget, also, that the can of the BC108 is connected to the collector.

The transistors are usually mounted as they appear in the circuit with the collector lead towards the top of the board. Sometimes, however, a different arrangement is adopted. Notably in the case of Tr_3, which has the collector towards the bottom edge.

The only unusual components are the Mullard thermistor VA1055S and capacitance diode BA102 and, of course, the quartz crystal. The one used was supplied by Cathodeon Ltd., for 4.433618 MHz, type S159/20 2M wire.

The components of the signal channel of the decoder, with the PAL switch, 90° phase shifter, synchronous demodulators, matrix and the first-stage colour video amplifiers are mounted on another board of the same size as the one used here. This will be described next month.



Wideband Linear Amplifier

1 to 30 MHz design with low intermodulation products

*by R. Hirst**

In high frequency communication equipment thermionic valves are still widely used in the design of new equipment. This is mainly due to the requirements of the transmitting side where semiconductors cannot supply sufficient power at the higher frequencies. A cursory examination of transistor manufacturers' data indicates that there are some devices capable of delivering quite considerable power at the upper frequencies; however, the problem is not simply one of delivering power but a matter of producing an output relatively free from intermodulation products. That is to say, no matter what the level of the input signal, the amplification factor of the transistor should be the same thus introducing a minimum of distortion due to the non-linearity of the transfer characteristic.

* Standard Telephones and Cables Ltd.

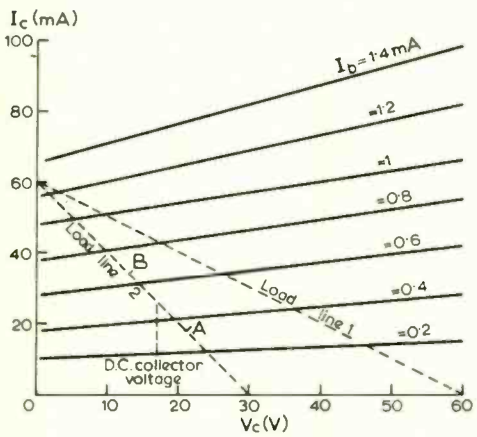


Fig. 1. Output characteristics of a common-emitter stage.

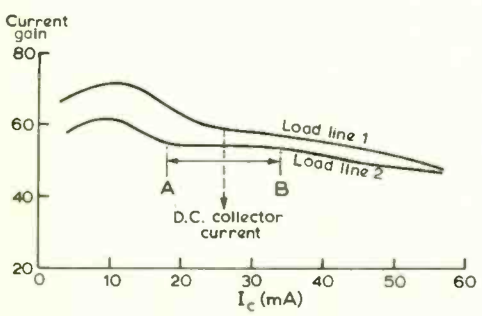


Fig. 2. Current gain versus collector current, common-emitter.

Preliminary considerations

As it is necessary to achieve relatively high performance in respect of the intermodulation products some initial investigation into the operating characteristics of semiconductors is essential.

Common-emitter: The graph in Fig. 1 is a typical output characteristic curve of a transistor connected in the common-emitter mode. Using load-line 1 it can be shown that the current gain of this particular device at collector currents of 10 mA, 30 mA and 50 mA would be 66, 58 and 50 respectively, indicating a condition of non-linearity. If a smaller portion of the load line is utilised, a greater degree of linear may be achieved provided that the mo suitable current gain and collector current selected that will cover the required swir The graph in Fig. 2 presents load lines and 2 in a manner that visually indicat the linearity of the device at two giv conditions. The portion A-B on load li 2 is reasonably linear and if plotted Fig. 1 gives a swing of 8 V, as shown. Fro the two graphs the supply voltage, th quiescent collector voltage and collect current may be readily established for th most linear point of operation. In practic though tedious, this is a simple and effecti method of determining the working par meters for linear operation in comme emitter connection.

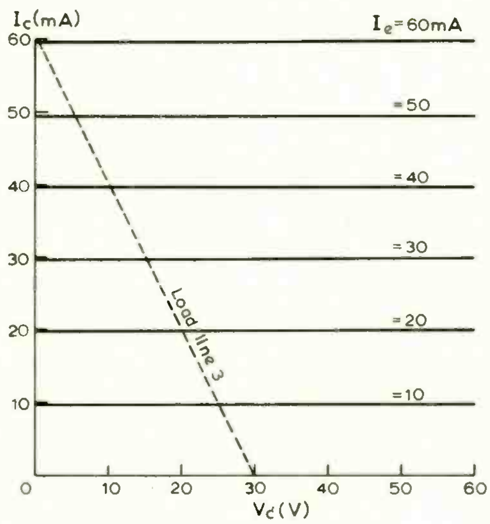


Fig. 3. Output characteristics, common-base.

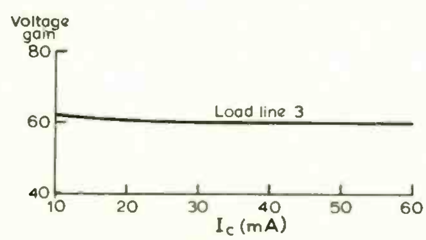


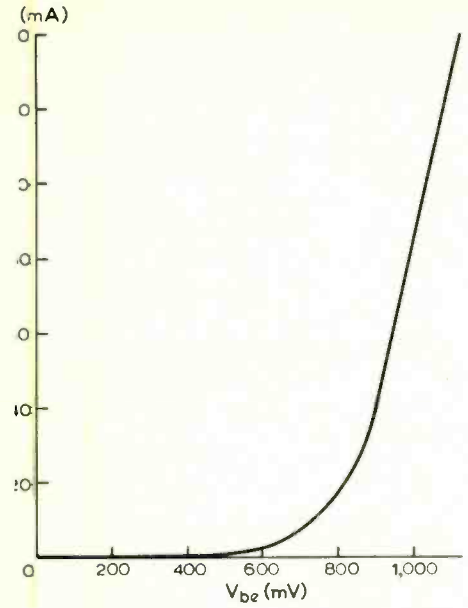
Fig. 4. Voltage gain versus collector current, common-base.

Specification

Output power	100 mW
Frequency response	1 to 30 MHz ±1 dB
Power gain	≈26 dB
Intermodulation products ..	at least 50 dB bel max. output
Second and third harmonic distortion	does not exceed 40 d
Input power	250 μW

Common-base: From an examination of manufacturers' data it is quite apparent th the most linear mode of operation may b found in the common base connection as th graph in Fig. 3 indicates. When translate into voltage gain versus collector current condition of almost perfect linearity i shown. The intermediate step of plottin current gain versus collector current ha been omitted as the linearity of the voltag gain developed across a given load is function of the linearity of the current gai of the device. For ease of compariso between the common-emitter and common base type of connection, the graph i Fig. 4 is presented. This is in units o voltage gain derived from the input curren being approximately the output current as a function of R_L/R_E where R_L is the collecto load and R_E, the emitter load.

Common-collector: This is more usuall known as the emitter-follower and differs ir one main respect from the other twc methods of connection. The device doe not give any voltage gain; however, it provides a current gain similar to that of the



'g. 5. *Typical mutual characteristic.*

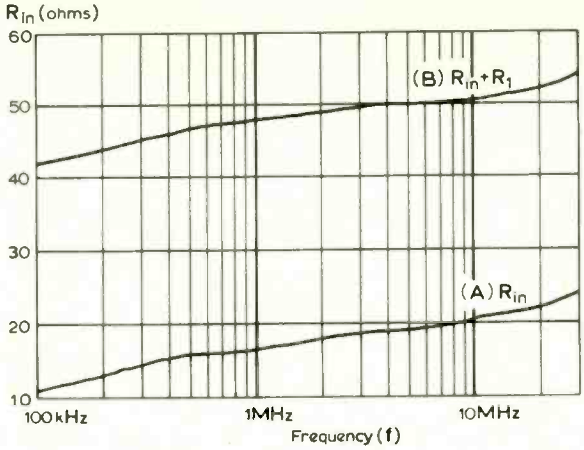


Fig. 7. Input resistance curves.

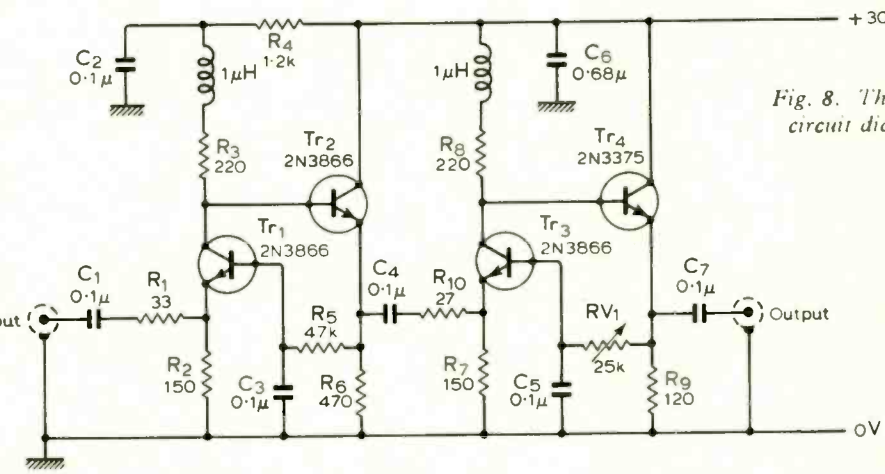
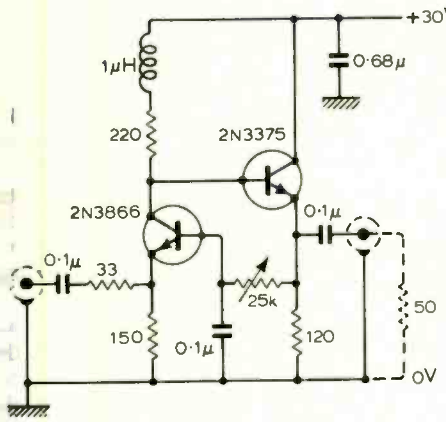


Fig. 8. The final circuit diagram.



'ig. 6. *A two stage amplifier.*

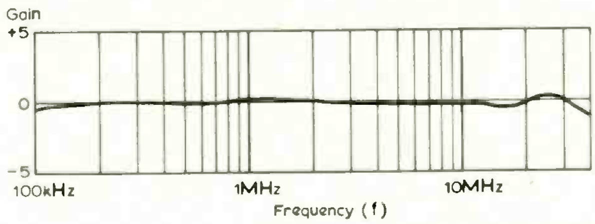


Fig. 9. Gain versus frequency performance of the amplifier.

:ommon-emitter and is therefore an :xcellent device for transferring power. It is ɔften mistakenly assumed that an emitter-follower, due to its inherent voltage feedback characteristic, reduces distortion. This is not so as the distortion that can be introduced may be just as severe as in any other method of operating a semiconductor.

It is essential, with an emitter-follower, to ensure that the input swing does not enter the non-linear portion of the mutual characteristic curve. That is, the collector current versus base-to-emitter voltage parameter indicated in the graph of Fig. 5. From this graph it can be shown that even a relatively low signal device may require a considerable quiescent current around which to swing the signal current, for linear operation.

Circuit description

In the circuit of Fig. 6 a common-base amplifier and a common-collector stage have been combined to provide a gain of 13 dB delivering an output of 100 mW into a 50 Ω load. From the published data the 2N3375 was selected for the output stage in emitter-follower connection and a 2N3866 was chosen to provide a common-base input amplifier. The most suitable operating point of the output stage was computed in a manner similar to that indicated in the graphs of Figs 1 and 2 with the result that a quiescent emitter current in the order of 120 mA was established for the 2N3375 at a supply voltage of 30 V.

The amount of gain required determined the collector load of the input stage in the following manner:

$$R_L = \frac{V_{out}\,[R_s + r_e + r_b\,(1-\alpha)]}{V_{in}\,\alpha} \quad . . (1)$$

As a 13 dB gain represents approximately a voltage gain of four and a half times and with a source resistance, R_s, in the order of 50 Ω it is possible to neglect r_e and $r_b\,(1-\alpha)$ due to two parameters being negligibly small proportions of the total. The value of the collector load can now be more simply calculated as:

$$R_L = \frac{4{\cdot}5 \times R_s}{\alpha} = 234\ \Omega$$

However this total of 234 Ω has to be considered in conjunction with the parallel input resistance of the output stage which may be calculated as follows:

$$r_{in} = r_b + \left(\beta \frac{r_e}{I_e(\text{mA})}\right) + \beta R_{L2} \quad . . . (2)$$

$$= 10 + (30 \times 0{\cdot}25) + (30 \times 50)$$

$$= 1517\ \Omega$$

where the current gain of the output stage is 30, r_b is approximately 10 Ω and R_{L2} is in the order of 50 Ω. For silicon grown transistors r_e can be considered to be 35 Ω.

A collector load of 230 Ω was calculated as the parallel combination of the results of expressions (1) and (2), but to ensure that the gain parameter was met, a final value of 220 Ω was chosen as the practical value. It was gratifying to find in practice that the gain was only 1 dB higher than calculated even though expressions (1) and (2) are approximate. As the collector load had been determined by gain considerations it was necessary to include in the collector circuit a 1 μH choke to offset the capacitive load due to strays and input capacitance of the output stage in order to maintain the gain at 30 MHz. Both the transistors used had a very high f_T and the design takes full advantage of this. The overall response, indicated in the graph of Fig. 9, was obtained without the introduction of any external feedback. The whole circuit has proved to be highly stable.

The input resistance had to be in the order of 50 Ω throughout the frequency range so a series resistor was introduced into the input circuitry. The graph in Fig. 7 indicates the input resistance of the transistor in curve A and the final input resistance, taking into account the input resistor R_1, in Curve B.

A lot of store is quite often placed in rigorous mathematical treatment of some of the parameters surrounding semiconductors; however, in the majority of instances, when dealing with devices having spreads in the order of 300% common sense should prevail and provide answers well suited to the occasion.

In the final circuit of Fig. 8, two circuits similar to that in Fig. 6 are combined to provide a total gain of 26 dB. As it is not necessary to provide more than 5 mW of power to drive the output pair, Tr_3 and Tr_4, the emitter follower stage Tr_2, in the first half of the amplifier, is provided by a lower power device, the 2N3866, biased for a suitable operating point as indicated in Fig. 5.

There tends to be a spread in the most linear point of operation of a device so a potentiometer was included in the biasing chain to ensure that the final, and most crucial, stage of the amplifier could be biased to precisely the best point. The emitter resistors of Tr_1 and Tr_3 were chosen to be as high as possible consistent with power requirements and at the same time low enough to allow for a relatively large swing across the common base stages in order to avoid the introduction of a high harmonic content.

With the supply voltage at 30 V, the emitter voltage of Tr_4 is 14·7 V and the collector voltage of Tr_3 is 15·4 V. As previously stated the quiescent condition of the output and preceding stages is set up by adjusting RV_1. Due to the d.c. feedback introduced by RV_1, the circuit automatically adjusts itself to work to the specification over the range $-5°$ to $+50°$C. The final stage, Tr_4 requires a heat sink of reasonable proportions due to the relatively high quiescent power dissipated within the device.

It must be pointed out that while the input resistance is held relatively constant over the frequency range, the output resistance may change by as much as three times due to the gain spread of the output transistor, Tr_4, and may be calculated in the following manner:

$$R_{out} = \frac{R_L\,(Tr_3)}{\beta\,(Tr_4)} \quad \ldots (3)$$

Therefore, for circuits requiring an accurate return loss characteristic some further computation will have to be made.

It is essential when laying out this amplifier that the collector to base connections are kept as short as possible so that the minimum stray capacitance is introduced into the circuit.

The supply decoupling is also very important and the appropriate capacitor should be placed directly from the collector of the output stage to the earth rail where the emitter resistor, R_9, is terminated. This ensures that the output current does not return via any of the input circuitry. The decoupling of the input stage should be between the termination points of the collector and emitter of Tr_1. The positive and negative supply tracks, if printed circuits are employed, should be as wide as possible. The positive supply lead should be taken directly from the point on the rail where the collector of Tr_4 is connected and the negative return should be taken from the junction of R_9 and the negative rail. The earthy end of the input signal lead must be taken directly to the earthy end of the emitter resistor of Tr_1.

If the points above are noted, the amplifier will prove to be extremely stable.

The amplifier is capable of delivering up to nearly half a watt of power if considerably increased intermodulation and harmonic distortion can be tolerated.

Announcements

A conference and exhibition on the subject of **electronics and education** will be held at Sheffield University from March 25th to 28th. The organizers are *Design Electronics* in conjunction with Sheffield University and Kingston College of Technology. Further details are available from D. A. R. Wallace, *Design Electronics*, 33-39 Bowling Green Lane, London E.C.1.

A **summer school on applied optics** will be held at the Imperial College of Science and Technology from 9th to 20th June. Further details may be obtained from the Registrar, Imperial College, London S.W.7. (Fee: £35.)

A new, 36-frame, 35mm, **colour filmstrip** entitled "Integrated Circuits" is now available from the Mullard Educational Service. The filmstrip (£2) may also be obtained as a set of slides (£2 10s) from the Slide Centre Ltd, Portman House, 17 Brodrick Road, London S.W.17.

Electric & Musical Industries Ltd, of London, and Varian Associates, of California, have announced the formation of two joint companies. **Varian/E.M.I.**, based at Palo Alto, California, and **E.M.I.-Varian Ltd**, at Hayes, Middlesex. The U.K. company will incorporate the power tube division of E.M.I. and will market reflex klystrons, and microwave and power tubes.

British Insulated Callender's Cables Ltd and Reliance-Clifton Cables Ltd have announced an agreement with a view to **Reliance-Clifton** becoming a member of the B.I.C.C. group.

Lennard Developments Ltd, 497 Green Lanes, London N.13, are to market the **Rainer-Walton cartridges** and replacement styli.

B.F.I. Electronics Ltd, Sinclair House, The Avenue, London W.13, have announced their appointment as **sole U.K. representatives** for the following American companies: Textool Products Inc., Irving, Texas, manufacturers of semiconductor and i.c. test sockets; Microdyne Instruments Inc., Waltham, Mass., who manufacture manual and semi-automatic i.c. tester and Film Microelectronics Inc., Burlington, Mass manufacturers of metallized substrates and chip resistor

Litton Precision Products International Inc. have bee appointed the exclusive sales and marketing organiza tion in the U.K. by the **Takeda Riken Company**, c Japan, manufacturers of electronic counters, digit voltmeters, electrometers, automatic digital integrator and data acquisition systems.

Waycom Ltd, has been appointed by A. S. Akers, th Norwegian semiconductor manufacturer, the sole U.K supplier of **hybrid i.cs** which are to be custom-built t individual requirements.

Sifam Electrical Instrument Co. Ltd, Woodland Road, Torquay, Devon, has appointed selling agents in Sweden. The agents, Teltronic AB (Eugen Eriksson), wil handle Sifam's entire range of moving-coil measurin instruments.

General Test Instruments Ltd have been appointed U.K representatives for **Non-Linear Systems Inc.**, of Cali fornia. The American company manufacture digita voltmeters, data logging systems and automatic environ mental test systems for large-scale integrated circuits.

Prosser Scientific Instruments Ltd, 1 Northamptor Street, Cambridge, have been appointed sole U.K distributors for the products of **Thermo Systems Inc** who specialize in anemometers.

Electroustic Ltd, of 73b North Street, Guildford, Surrey, have been appointed sole U.K. agents for the range of terminals, single-pole sockets, crocodile clips, miniaturized plugs and sockets etc. manufactured by Richard Hirschmann of West Germany.

The Radio Systems Division of Plessey Electronics Group has received a £500,000 order from the Ministry of Technology for its **gun sound ranging system** which incorporates radio links. All locating batteries in the British Army will be re-equipped with this system of locating hostile artillery.

Marconi **navigation and audio systems** valued at £500,000 will be fitted to the fleet of Trident III airliners due for delivery to British European Airways in 1970. Twenty-six aircraft will each use the Marconi VOR/ILS navigation system, incorporated in triplicate into the blind landing system, a radio compass in duplicate and a solid-state audio system.

Abbey Electronics & Automation Ltd., Delamare Road, Cheshunt, Herts, have been awarded contracts totalling £50,000 for **sonar test equipment** by the Admiralty.

Elliott Space and Weapon Automation Ltd, under a contract worth more than £500,000, are to supply the **radar simulation and data handling** system called Instilux to Eurocontrol's Institute of Air Navigation Services at Luxembourg.

Ekco Electronics, of Southend-on-Sea, Essex, a member of the Pye of Cambridge group, have announced a contract valued at approximately £200,000 from B.O.A.C. for the supply of **weather radar systems** for the airline's Boeing 747 fleet.

Burndept Electronics (E.R.) Ltd has received a £5,000 order for **search and rescue beacon equipment** (S.A.R.B.E.) from B.O.A.C. for use in its Boeing 747s.

The Marconi automatic direction finder, type AD370, has been selected for both **Concorde** prototypes and also the two pre-production models.

International Marine Radio Company, of Croydon, Surrey, has received an order from the Ministry of Defence (Navy) for the supply of **Solas II** portable survival transmitter-receivers.

Pye TVT Ltd has received a contract for the supply and installation of a new **television studio in Baghdad,** which will be linked with the national network and used for educational broadcasts. The equipment comprises: three 4½-in image orthicon cameras, telecine equipment, vision and sound mixing equipment, pulse equipment and ancillary items.

The new address of the **Telecommunication Engineering and Manufacturing Association** is Portland House, Stag Place, London S.W.1 (Tel: 01-828 7965).

Acoustic Absorption Materials

Their characteristics and applications

by *J. C. G. Gilbert**, M.I.E.R.E., A.T.C.L., and *R. C. Driscoll**, M.I.E.R.E.

Sound reproduction almost invariably takes place in a closed room, which may be a lecture theatre, a concert hall, or a domestic living room. The desirable acoustic properties may be different in each case, but they are of fundamental importance in the design of all of them.

This is not to say that the reflection of sound in large enclosures can always be precisely described. The science of room acoustics involves a study of the complex way in which sounds are reflected backward and forward from the boundaries of a room, and from objects contained in it, and of how to measure the effects of these reflections and the properties of different materials in absorbing or otherwise controlling the resultant sound field. Additionally, psychological factors, the listeners' personal preferences must be borne in mind in the design of listening rooms or studios, so that the measurement of the desirable properties of a listening room becomes a difficult problem, and has received much attention.

Room resonances and reverberation time

When a sound is radiated continuously in a room, the repeated reflections from its boundaries etc., mean that the resultant sound field will be of higher intensity than it would be in the open air. The initial build-up of sound pressure at any point is due first to the direct arrival of energy from the source, and then to the many indirect waves which have undergone reflection. These random reflections may have any relative phase relationship so that the energy build-up at this point may not be uniform. At certain frequencies, however, it would be found that a great many reflected waves arrive in phase, resulting in pressure or intensity maxima, due to the so-called "normal modes" of the room. These resonances, often called "Eigentones" can be calculated from the expression

$$f_n=\frac{c}{2}\sqrt{\left(\frac{n_1}{L}\right)^2+\left(\frac{n_2}{B}\right)^2+\left(\frac{n_3}{H}\right)^2},$$

where L, B, H, are the linear dimensions of the room, n_1, n_2 and n_3 integers representing the orders of the modes and c the velocity of propagation of sound (344 m/s). For example, the first axial standing wave between the two walls of a room spaced by its length of say four metres will occur at a frequency of

$$\frac{c}{2}\sqrt{\left(\frac{1}{4}\right)^2}=43\text{Hz}.$$

Axial modes, i.e., standing waves occurring between two opposite faces of the enclosure, are believed to contribute the most significantly to the "colouration" of the direct sound field. It is desirable that these resonances be as many as possible, spaced closely throughout the audible frequency range, rather than appearing over particular regions and so upsetting the broadly uniform response trend.

When the sound source in the room is turned off the reflected energy takes a certain time to decay; the effects of this reflected or reverberant energy are very dependent upon the time taken for it to decay to inaudibility.

The reverberation time, defined as the time required for the intensity of a sound at a given frequency to fall to one millionth of its initial value (60dB fall), is considered one of the most important single parameters in assessing the acoustic properties of a room. Now the acoustic intensity at a point in a closed room in which a sound is being continuously produced can be several times higher than would be the case in the open air, and this "gain" in intensity is proportional to the reverberation time for any given enclosure; a large reverberation time will therefore help to ensure that a weak sound be heard. On the other hand a large reverberation time will mask the recognition of any new source of sound, such as the next phrase from a lecturer. The choice of the most suitable value of reverberation time will therefore depend upon the nature of the sounds to be produced, sometimes being a compromise between loudness and intelligibility. The most acceptable conditions for a speaker and audience seem to correspond to a reverberation time of about 0.8 second for a small auditorium, rising to 1.5 seconds for enclosures of volume one million cubic feet or more. Enclosures designed as music rooms should be more reverberant than similar-sized lecture theatres. The optimum reverbera-

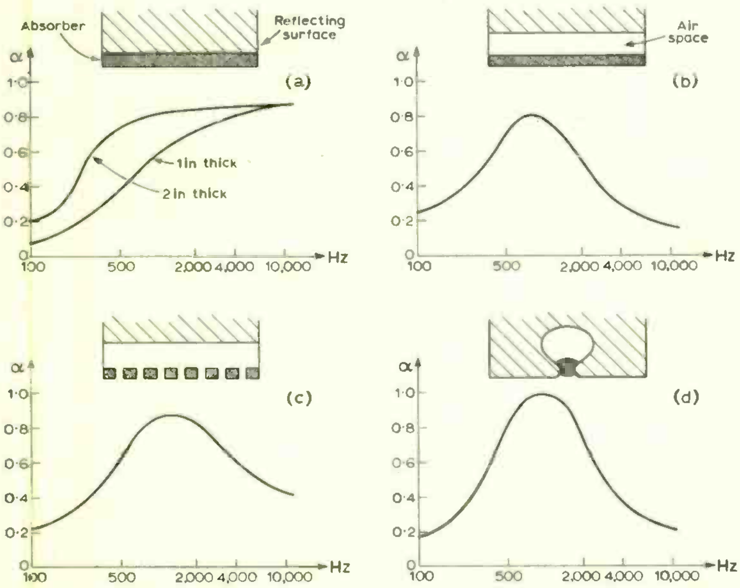


Fig. 1. Types of absorber mechanism: (a) porous absorber; (b) resonant panel; (c) perforated panel; and (d) Helmholtz resonator.

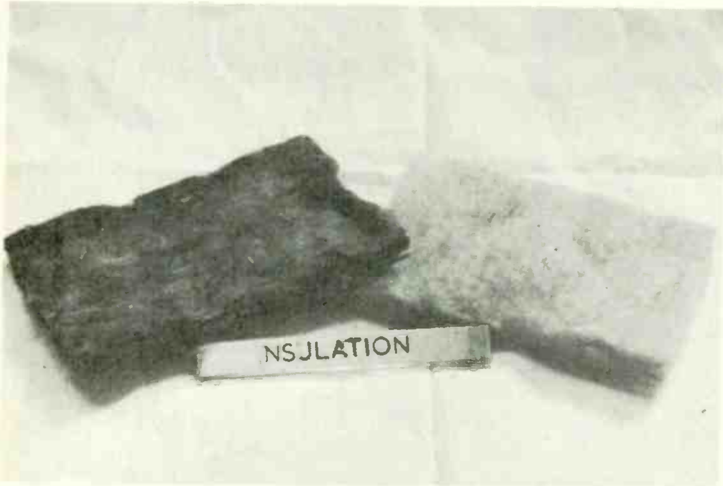
*Dept. of Electronic and Communications Engineering, Northern Polytechnic, London.

tion time ranges from 1.0 second in small rooms for soloists to 2.5 seconds for organ music in large churches.

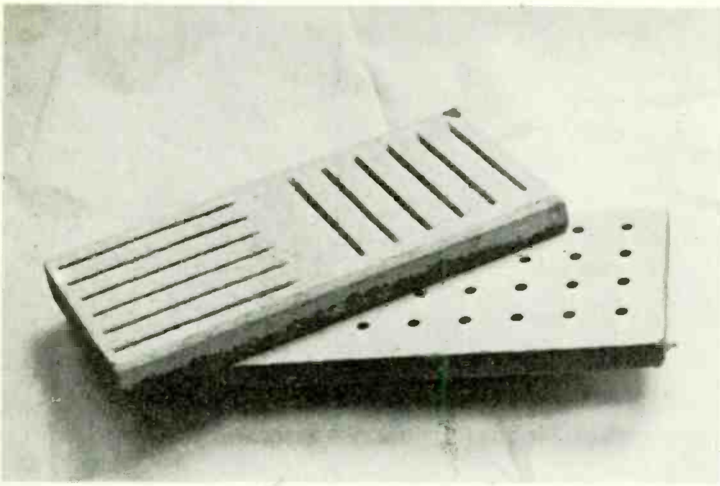
Absorption and absorption coefficient

In order to obtain good acoustical conditions in a listening room, a specification of the sound-absorbing properties of the various materials which can be used to control reverberant sound energy is required. A sound-absorbent material is one which can dissipate as frictional (heat) losses, some part of the sound energy incident on or penetrating its surface.

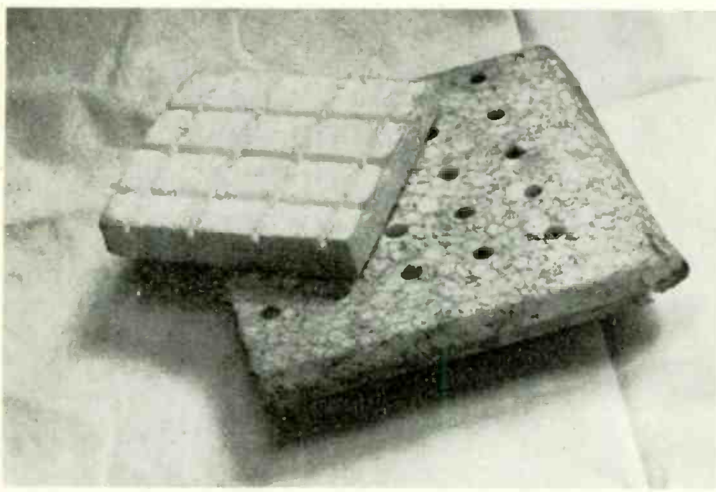
In porous materials, these losses will be due to the motion of air in small holes or passages offered by the material surface. Conduction between the air and the material fibres will take place because of temperature differences which exist due to the sound wave, and frictional losses due to relative movement—of the fibres themselves also occur. These mechanisms operate at the higher audible frequencies (above 500Hz). At low frequencies, frictional losses are due to the material vibrating as



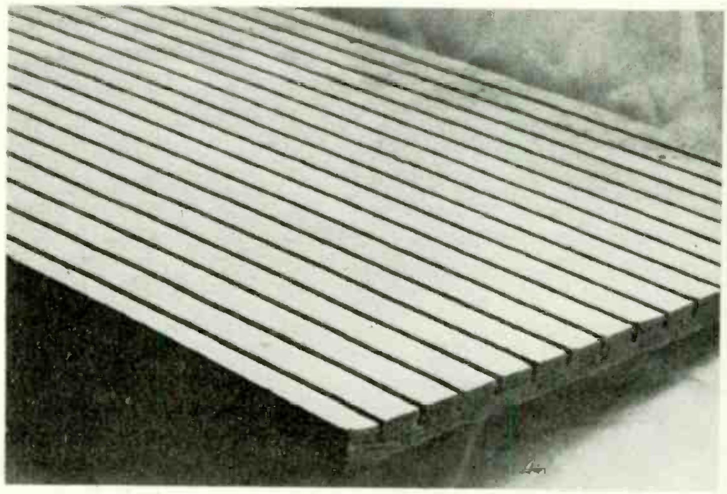
(a) Glass-fibre. Available in 20-ft rolls of various widths, 1in & 2in thick. Used in loudspeaker enclosures, and in roof insulation.



(b) Treetex Decorac (top) Perfotex acoustic tiles. Decorac available in 16-in and 24-in squares, $\frac{3}{4}$in or 1in thick. Perfotex in 16-in squares or 4ft × 8ft sheets, $\frac{1}{2}$in thick.



(c) Expanded polystyrene. Small tiles or large 8ft × 4ft sheets up to 3in thick available. Perforated sample is Jablite, in 1, 2, or 3ft squares or large sheets.



(d) Halltex acoustic fibreboard. Decorative panelling widely used on walls and ceilings.

(e) Gypklith. Building slabs of wood/wool material. Provides both thermal and sound insulation. In many sizes and thicknesses. Density 28lb per cubic foot.

Material	Mounting	Typical absorption coefficient 125	250	500	1000	2000	4000	6000	8000 (Hz)
Glass-fibre	Laid on floor or stuck to wall, or on battens	0.1	0.35	0.55	0.65	0.75	0.80	0.75	0.75
Acoustic tiles	Screwed to ceiling, floor, etc.	0.1	0.2	0.4	0.5	0.45	0.5	—	—
Acoustic tiles	Mounted on battens	0.3	0.45	0.5	0.55	0.65	0.8	0.55	0.5
Polystyrene	Mounted on frame-work of battens on wall	0.05	0.15	0.4	0.35	0.2	0.2	—	—
Acoustic fibreboard	Concealed nail fixing with grooved joints	0.1	0.2	0.4	0.5	0.45	0.5	—	—
Wood/wool materials	On heavy battens	0.1	0.25	0.6	0.75	0.6	0.75	0.8	0.8

Fig. 2. Some of the more common absorbent materials with tabulated absorption coefficients.

whole. The absorption coefficient, symbol α, for an absorbent ıaterial is a quantity defining the ratio of the energy of an ıcident sound wave transmitted through, i.e. lost to, the absorber ɔ that reflected. It is known that this ratio will vary with the ngle of incidence of the wave, so that its quoted value is the tatistical average of all the possible coefficients, i.e. for all ɔossible angles of incidence of the sound. It is easy to ensure hat this situation exists for the purposes of measurement.

Types of absorber mechanism

The most frequently encountered types of absorber mechansm are shown in Fig. 1, together with absorption/frequency characteristics. Porous absorbers form the great majority of hose in common use, including felts and fabrics, acoustic plasters and fibre tiles, and glass fibre. Increasing the thickness of a porous absorber will extend absorption to the lower frequencies, as will mounting the material an inch or so away from the reflecting surface, as in a resonant panel absorber. If the porous absorber is perforated, and mounted on battens away from the wall, then Helmholtz resonance also occurs at higher frequencies, so that high absorption over a wide frequency range is here possible. Special Helmholtz resonators are also occasionally employed. The resonant frequency can be conveniently changed by varying the mouth opening exposed to the incident wave; two practical examples are the use of these absorbers in both the Royal Festival Hall and Queen Elizabeth Hall, London. The acoustics of these halls may thus to some extent be modified to suit different performances.

Measurement of absorption coefficient

To ensure an entirely random sound field, necessary for the measurement of the absorption coefficient of an acoustic material, a special enclosure is needed. One requirement is that with no absorbers present it should have a very large reverberation time over a wide frequency range, so that high intensity reflected waves can easily be produced; the chamber should be of irregular shape if selective resonances are to be avoided. The reverberation chamber at the National Physical Laboratory has a volume of 9,700 cubic feet and a total surface area of 2,780 square feet. The surfaces are of rendered brickwork or concrete, the walls are non-parallel and the ceiling is sloping. The reverberation time at 250Hz is 17 seconds. The sound sources are loudspeakers, fed with frequency-modulated audio signals. Measurements are made at mean frequencies at octave intervals from 125 to 4,000Hz, and at higher frequencies up to 8,000Hz. The decay of intensity in the chamber is measured over a 70dB range, with the aid of a high-speed level recorder, and the reverberation time determined. The experimental result is then used in the standard formula:—

$$\text{Reverberation time} = \frac{0.049V}{-S.\log_e(1-\bar{\alpha})} \text{ (due to Eyring).}$$

V is the enclosure volume in cubic feet, S its total surface area in square feet, and $\bar{\alpha}$ the average absorption coefficient. A value is carefully determined both with and without the specimen under test being present, and the loss of reflected energy due to its insertion is then obtainable. The average absorption coefficient $\bar{\alpha}$ is related to α by $\bar{\alpha} = A\alpha/S$ where A is the surface area of the specimen absorber alone. The average coefficient therefore represents the absorption coefficient of that material which when covering the entire surface of the chamber absorbs the same energy as the specimen of area A. (At frequencies above 1kHz, corrections to this formula are required due to the absorption of sound in air.)

A few of the more common absorbent materials commercially available are illustrated in Fig. 2, together with a table of values of absorption coefficient. It will be noted that specification of the method of mounting is important to the results obtained at low frequencies. For more detailed information of price and availability the manufacturers should be consulted, particulars being given at the end of this article; the reader is also referred to the publication by H.M. Stationery Office[1], in which the results of measurement of a wide range of absorbents are listed and discussed. The heavier wood/wool materials are used in the basic construction of homes and industrial buildings, to control the level of external noise, and to provide thermal insulation. Acoustic tiles, plasters, plastics and fibreboard are now very widely used as decorative wall or ceiling surfaces in colleges and offices, to provide acoustic correction and to reduce the annoyance from airborne noise.

Glass-fibre, in addition to its wide domestic use as a thermal insulator, is a very useful absorber for the lining of loudspeaker enclosures. At the normal modes of vibration of the enclosure, the acoustic impedance due to the enclosed air becomes reactive; a high reactance presented to the loudspeaker diaphragm reduces the power radiated. The overall response curve is made smoother by lining the enclosure with an acoustic absorber having a high absorption coefficient at the first resonant (normal mode) frequency, and at all frequencies above. If the enclosure is filled with such a material, the velocity of sound in the air enclosed is reduced, i.e. the effective volume is increased. Since the reaction on the rear of the diaphragm due to the enclosed air varies inversely with its volume, it follows that the low-frequency response of the system will be extended. This permits the design of smaller enclosures, with the advantage that the electrical impedance presented to the amplifier is more uniform.

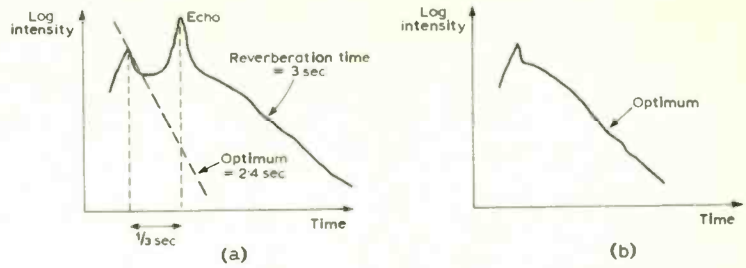


Fig. 3. Reproduction of transient sound at 500Hz in the Royal Albert Hall (a) before treatment and (b) after treatment.

Royal Albert Hall acoustics

An interesting example of acoustic treatment is the recent project undertaken at the Royal Albert Hall, by Airo Ltd.[2], in association with the B.B.C. The great character of the building has for many years been accompanied by unfortunate acoustics. This has not been troublesome to most of the audience though attempts have in the past been made to solve the problem. The latest venture, however, has shown very promising results.

The volume of the hall is approximately 3.5 million cubic feet; the presence of an echo is almost inevitable, due to the large scale of the building and to the presence of the dome, which represents about one third of the total volume. The reverberation time is 3.0 seconds at 500Hz. This figure was considered over long, but equally important, because of the concave shape of the plaster walls, and the dome, focusing of the reflected sound occurred, with the result that in certain positions the echo had a higher intensity than the direct wave. (See Fig. 3.)

This problem could not be solved simply by absorbing the incident energy; apart from being costly this would have resulted in too low a reverberation time, and would have detracted from the appearance of the hall. The aim was to reduce the intensity of the echo and to optimize the reverberation time at a value of 2.4 seconds at 500Hz. This was achieved by suspend-

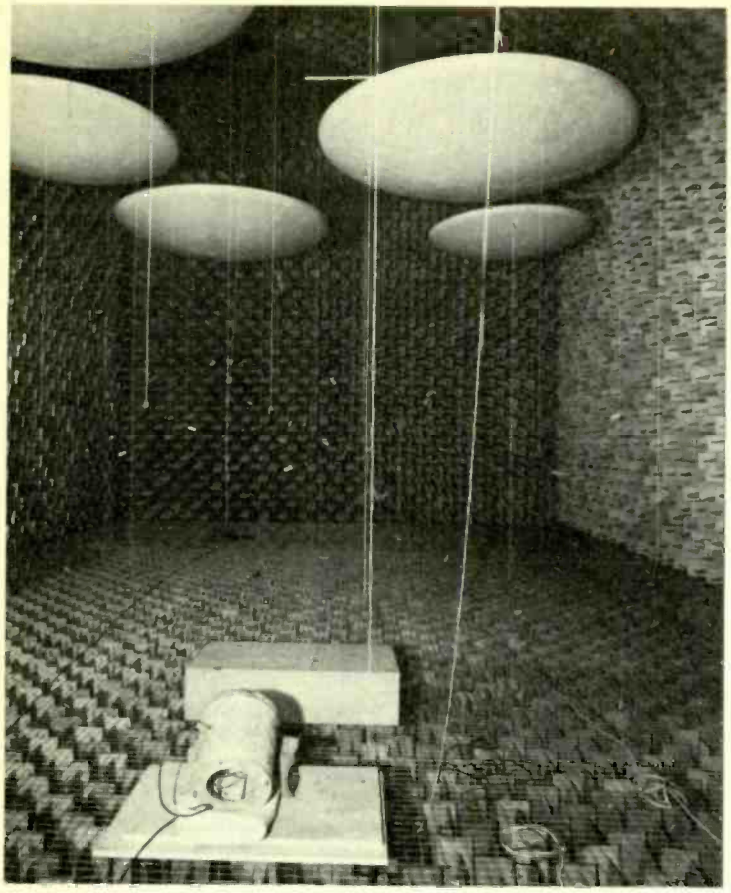


Fig. 4. Polyester/glass-fibre diffusers as used in the Royal Albert Hall undergoing tests in an anechoic chamber.

ing above the hall about one hundred polyester/glass-fibre diffusers, of various diameters ranging from 7 to 12 feet, and covering about half the roof area. The diffusers, called "flying saucers" by their designers, are shown in Fig. 4.

The lower convex surfaces provide a scattering of the incident sound, so that the intensity of the echo is reduced and a more diffuse sound field returned to the audience. In addition, the distance of travel of these reflected waves is shorter, so that the time interval between direct wave and echo is also reduced. That part of the wavefront which is not obstructed travels up to the surface of the dome, and after reflection becomes incident on the upper surfaces of the "flying saucers", where it is absorbed by impregnated glass-fibre material. The final result is that the ratio of direct to reverberant energy at low frequencies is increased and the reverberation time reduced to the desired 2.4 seconds at 500Hz. It is understood that more experiments in this hall are to be conducted.

Conclusions

The volume and geometric shape of an enclosure, as well as the sound absorbing properties of the materials used in it, are important in the design of listening rooms. Experience has shown that the energy lost to a given area of acoustic absorber varies with the sub-division of that area into smaller units, and with their positioning in the enclosure, even if this is an irregularly shaped reverberation chamber of the type discussed. The measured results thus obtained are therefore a characteristic of the particular enclosure, and not of the material alone. At the present time it is not possible to ensure exact agreement between the results obtained in different enclosures, so that the figures quoted for the materials illustrated in Fig. 2 are "rounded" to the nearest 0.05 unit.

The reverberation time is an important index of the acoustic properties of a room, and several workers such as Knudsen[3], have suggested curves giving optimum values, justified by experience, for different enclosure volumes and sound sources. When, however, the reverberation time reaches its optimum value, other factors become important, as the example considered above clearly shows. Many years ago the B.B.C.[4] erected two studios of identical linear dimensions, one with plain surfaces and the other with corrugated walls. The measured reverberation times were similar, but the subjectively assessed performances were entirely different. This was due to the wide difference between the ratio of direct to reverberent energy for the two rooms, so that the diffusion of sound is as important as absorption.

It has been suggested that for precise measurements the complex acoustic impedance (the complex ratio of pressure to air particle velocity, analogous to the ratio of voltage and current in an electric circuit) of the material be employed rather than its absorption coefficient, and this may become the more fundamental approach[5]. It is hoped that these techniques will enable a more detailed understanding of the behaviour of sound waves in closed rooms, and so permit the design of acoustic materials with accurately specified properties.

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2. "Airo", Acoustical Investigation and Research Organisation Ltd, Hemel Hempstead, Herts.
3. "Architectural Acoustics", V. O. Knudsen, published by John Wiley.
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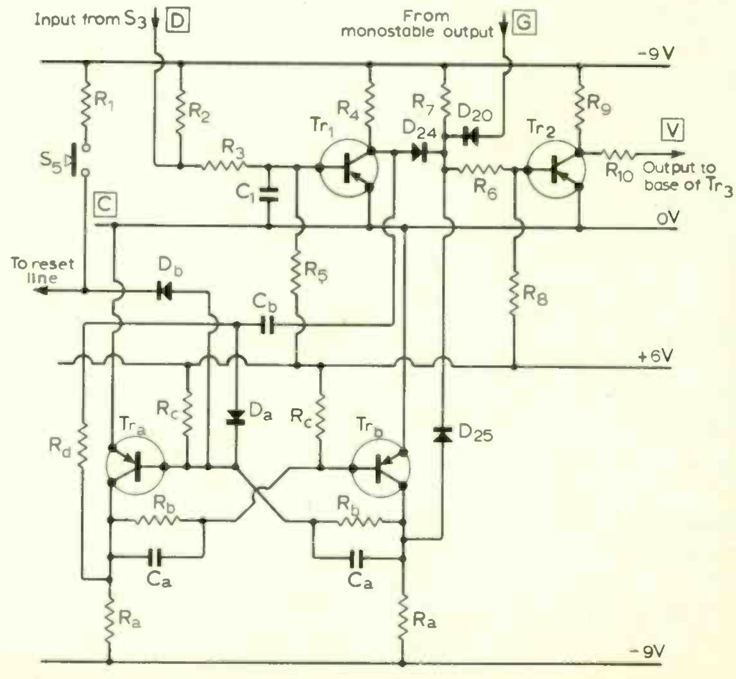
5. "Sound Absorbing Materials", Zwikker and Kosten, Elsevier Publishing Co.

Some manufacturers and distributors of the acoustic absorbing materials illustrated in Fig. 2: Fibreglass Ltd; Gyproc Products Ltd; Jablo Plastics Industries Ltd; C. Leary & Co., Ltd. (Halltex); and Treetex Acoustics Ltd.

Amendment

"Digital Exposure Timer" (Jan. 1969)

In case there is any confusion about the connections of B_{17} to the gating circuits, the author has supplied the fuller circuit diagram shown below.



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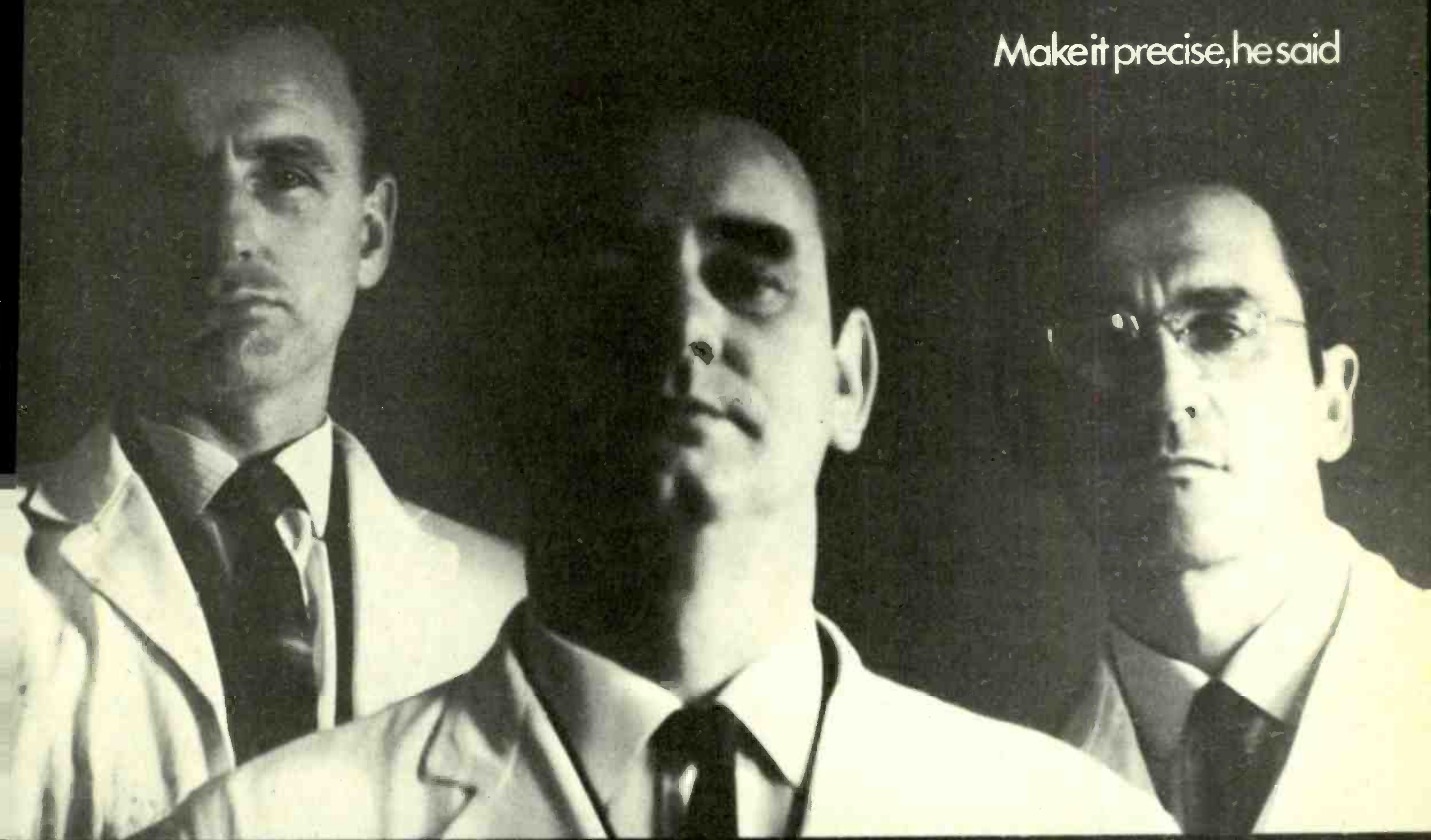

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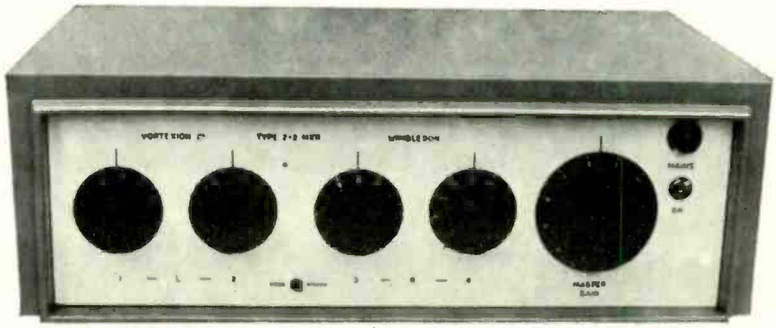

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WW—112 FOR FURTHER DETAILS

mproving the Sound Quality of ?ocket-radio Receivers

'y P. Williams*

number of types of physically small low-cost transistor ortable radio receivers have similar circuits, consisting of a ·equency changer, two i.f. stages and a detector, followed by n audio section comprising a driver stage feeding a class B ush-pull output stage, transformer—coupled to a loudspeaker. 'he a.f. stages of such a receiver purchased by the author are hown in Fig. 1. The sound output of the receiver was of poor uality and at low volume severe crossover distortion was vident. The output (from a 3-inch speaker), was almost ompletely lacking in bass—such bass as was present being ery distorted.

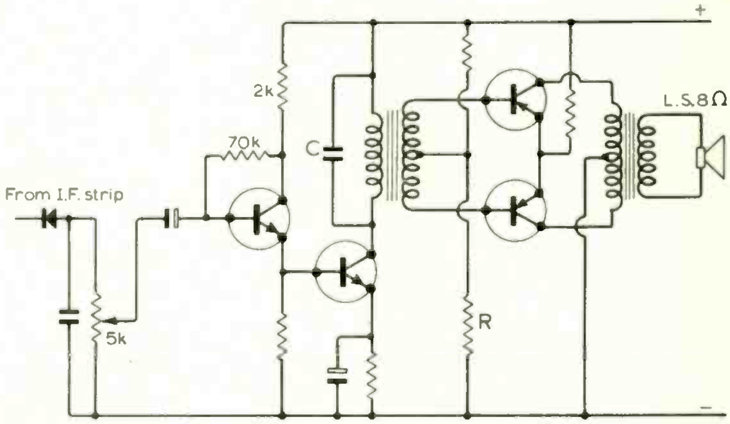

Fig. 1. Circuit diagram of the original amplifier and output stages

Modifications

The first improvement to sound quality was made by simply ncreasing the quiescent current of the output transistors very lightly. (The quiescent current of each output transistor was only about 1mA after modification.) This modification was carried out, while listening to a local station at low volume so that crossover distortion was very evident, by paralleling the bias resistor *R* with various high resistances until a value was found which gave reduced crossover distortion. The frequency response, however, was still very unsatisfactory, bass present in the output being very small and rather distorted because the "constant current" nature of the output stage did not provide loudspeaker damping, resulting in a rise in output with frequency.

Negative feedback, taken from the voltage across the loudspeaker and including the whole of the a.f. amplifying circuit, immediately suggests itself as a cure. However, there is usually not enough surplus gain available for this purpose to allow a large gain reduction. A further point is that if the feedback voltage is taken to the bottom of the volume control so as to include all a.f. stages the detector diode a.c.-to.d.c. load ratio is degraded, leading to a reduction in the modulation depth which can be handled without distortion. Both these difficulties can be avoided by using the circuit shown in Fig. 2.

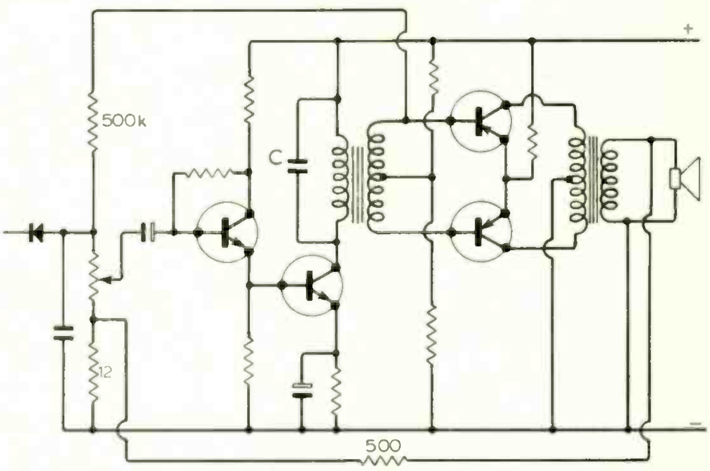

Fig. 2. Amplifier and output stages modified by the addition of positive and negative feedback. The 500k Ω resistor is connected by trial and error method to the end of the driver transformer winding which gives a slight increase in sound output

Positive feedback is taken to the top of the volume control from an early part of the a.f. circuit, where distortion is small, and negative feedback to the bottom end of the volume control. By a suitable choice of values it is possible to maintain the gain at about the same value as before the introduction of feedback while still applying a large amount of negative feedback from the output. The effect of the positive feedback is to maintain a high detector a.c.-to-d.c. load ratio. A full analysis shows that the effect of the combined positive and negative feedback is to reduce greatly the a.f. amplifier distortion which usually occurs mainly in the output stage.

Results obtained with the modified circuit were, as expected, a much improved bass response and increased loudspeaker damping factor. A further benefit of the better frequency response was an apparent increase in the signal-to-noise ratio when the receiver was tuned to a weak station.

Stability

A complete discussion of the stability of the a.f. system with feedback is beyond the scope of this short article. Instability might be expected at very-high or very-low frequencies where the phase shift of the whole amplifier without feedback reaches 180°. If the phase shift affects the response of the earlier part of the amplifier at a lower frequency than it affects the output stages, the positive feedback can improve the stability of the whole system when negative feedback is employed.

*Department of Applied Physics, University of Wales Institute of Science and Technology.

Apparent Wind-direction Indicator

A simple instrument for small boats that indicates the difference between the apparent wind direction and boat heading

*by M. I. Pope**, B.Sc., Ph.D.

It is perhaps surprising that research into the performance of sailing boats has only been carried out on a significant scale in the past two decades. In the United Kingdom, substantial advances in this field[1] are due to the work of the Department of Aeronautics and Astronautics at Southampton University.

One of the problems encountered in obtaining optimum windward performance in sailing dinghies and yachts, is to achieve a compromise between the ability of a boat to point as closely as possible to the direction of the apparent wind, and yet maintain a relatively high speed through the water. The various factors which determine a yacht's pointing ability are too numerous and complex to discuss here, but a detailed explanation will be found in a recent book by C. A. Marchaj.[2] Considerable difficulty is often experienced in assessing how small adjustments to the hull and rigging of a boat have affected the windward performance; it is here that the use of water speed and apparent wind direction indicators can be helpful.

The equipment described here is light in weight and of low cost. A simple wind vane is used to rotate the moving plates of an air-spaced variable capacitor which in turn alters the time constant in a multivibrator. This assembly is attached to the mast head of the boat and a light, 3-way lead connects it to a transistorised differential voltmeter mounted, together with the batteries, in the boat's cockpit. A circuit diagram of the two units is shown in Fig. 1. Any change in the angle between the fixed and moving plates of the capacitor alters both the frequency and the mark-space ratio of the multivibrator output signal, but has little effect on the amplitude. However, operation of the indicator depends only on the change in the mark-space ratio. The output signal from the multivibrator is not electrically integrated, but is fed directly to the differential voltmeter, which relies on the inertia of the moving coil microammeter to give a steady reading; this method has been found entirely satisfactory in practice.

*College of Technology, Portsmouth.

By a suitable choice of component values, an approximately linear relationship has been obtained between the angle of separation of the fixed and moving plates of the capacitor, over the range 10 to 100 degrees, and the indicated collector current of Tr_2, as measured by a moving coil milliammeter (Fig. 2). The voltage change at the collector of Tr_2 is measured by the centre-zero differential voltmeter directly in degrees.

The mast-head unit was built around a two-gang 500 pF air-spaced tuning capacitor, of the type used in portable transistor radios; the associated components being mounted on a printed circuit board attached to the capacitor. To reduce friction to a minimum, one of the wipers making contact with the moving plates of the capacitor should be removed and the ball races supporting the moving plates should be dismantled and degreased before being assembled and lubricated with a trace of clock oil. Take care not to over tighten the end bearings! Gooc electrical contact between the moving plates and the body of the capacitor is ensured by soldering a light, flexible coil of copper braic between the two. Also, a stop screw should be fitted to the spindle to limit rotation to 11C degrees. The capacitor, together with its associated components, is mounted vertically in a light metal case, as shown in Fig. 3.

The wind vane is formed by joining a Tufnol extension spindle to the capacitor shaft; the upper end of which is drilled to carry a horizontal 16 s.w.g. steel rod, about 10 inches long. A "Paxolin" vane was mounted at one end of the rod, which was counter-balanced by a lead weight.

To set up the apparatus, the wind vane is adjusted so that the capacitor plates are 55° open when the vane is pointing directly ahead of the boat; the microammeter can then be set to zero using the 2kΩ potentiometer VR_1. The wind vane is then moved so as to point 45° either side of the ahead position, and the gain of Tr_3 set by the 5kΩ potentiometer VR_2, to make the microammeter read to + or − 450 μA as appropriate. The meter should now give a direct reading of the angle between the heading of the boat and the direction of the apparent wind, 1° being equivalent to 10μA.

The apparatus has been tested on an *Albacore* racing dinghy and found to operate satisfactorily under conditions of steady winds and reasonably calm water. In more disturbed water, instability of the boat caused some hunting of the wind vane, with consequent

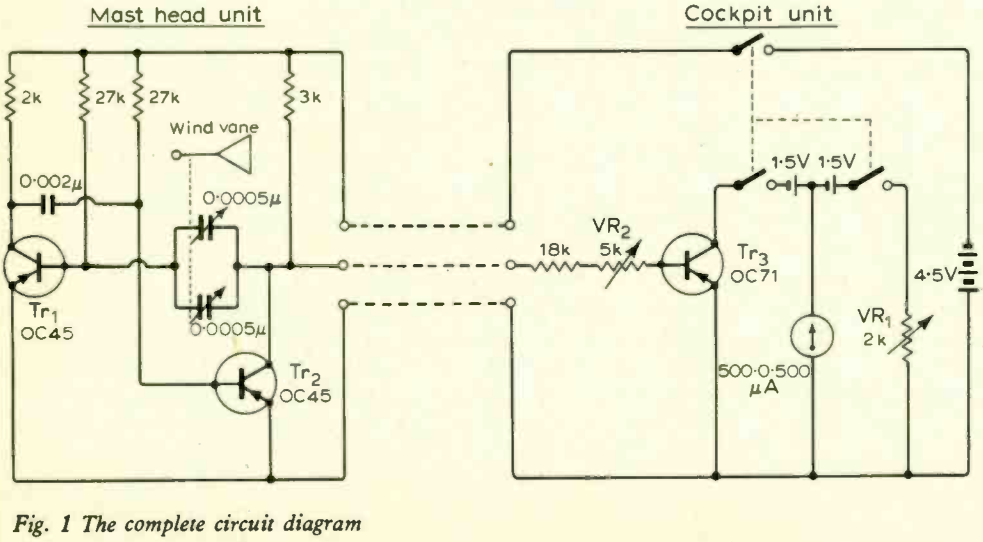

Fig. 1 The complete circuit diagram

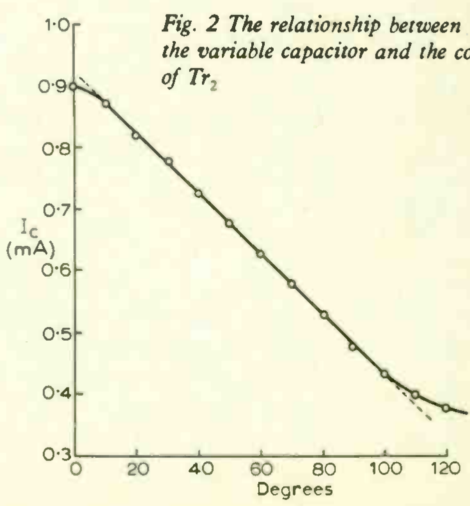

Fig. 2 The relationship between ro the variable capacitor and the coll of Tr_2

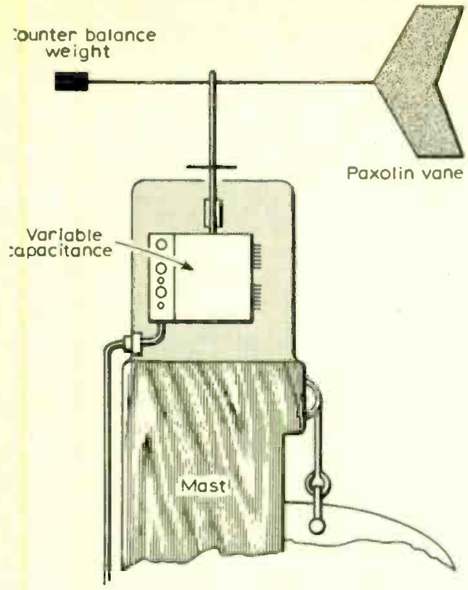

Fig. 3 *Some details of the wind-vane and capacitor unit*

fluctuation in the meter readings. However, it is reasonable to suppose that this effect could be greatly reduced by improvement in mechanical design of the mast head unit. In any event the relative stability of a keel boat should enable even the existing prototype apparatus to function satisfactorily in disturbed waters.

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2. Marchaj, C. A., "Sailing Theory and Practice" (1964) Adlard Coles, London.

Corrections

"Solid-State Oscilloscope"

The values of two resistors given in this article in the March issue were incorrect. The collector resistor of Tr_{16} (Fig. 3) and the emitter resistor of Tr_{32}(Fig. 6) should both be 2.2k, not 47k and 22k as shown. Transistor types in the power supply (Fig. 7(b)) should be as follows, and not as described in the text: Tr_{35} BC107, Tr_{36} AC127, Tr_{37} OC81, Tr_{38} AC128. The rectifier circuit submitted by the author and shown in Fig. 7 has the bridge rectifiers connected as a short-circuit across the transformer. If bridge rectifiers are used they require separate 20V windings. With a single winding, half-wave rectifiers only must be used. The description of the vertical amplifier refers to 6.8k Ω collector resistors. These should be 8.2k Ω as correctly shown in Fig. 1.

Dinsdale Amplifier Mod.

Output stage using 2N2147s

A number of readers have enquired about the modifications necessary when using 2N2147s in the output stage of the power amplifier. The reason for advocating the use of 2N2147s (or other high-frequency power transistors such as OC29s) is that the enhanced h.f. response of the power amplifier and the reduced h.f. harmonic distortion not only provide a greater degree of realism, but also reduce the onset of aural fatigue.

The 2N2147 is manufactured by RCA, and may be obtained from the company's U.K. distributors: Electronic Component Services Ltd, Roberts Electronics Ltd or Semicomps (Northern) Ltd. It is a germanium drift-field p-n-p power transistor intended for use in high-fidelity amplifiers where wide frequency range and low distortion are required. Its principal advantages are the high values of d.c. beta ($h_{FE} = 150$ at $I_c = 1A$), and gain–bandwidth product ($f_T = 4MHz$).

Its voltage breakdown, collector current and power dissipation ratings are more than adequate for this circuit, and it is constructed in a TO-3 can with a thin mounting flange which may easily be fitted on to the standard amplifier heat sinks.

When using it in the amplifier circuit, the recommended quiescent current of 10-15 mA in the output stage (20-25 mA overall) must be set up as prescribed by adjusting R_9, and it will be found that values of 56-82 ohms are necessary (cf. 22-33 ohms if conventional junction transistors are used). Experiments have been carried out using two OA5 diodes in series with a smaller resistor, but no audible improvement is noticeable. In general, R_1 must also be made slightly higher to ensure that the output d.c. level rests at half the applied line voltage, and values of 330k to 390k have been found to be suitable. It is important to ensure that this setting-up procedure is carried out: too low a quiescent current will result in high values of crossover distortion, and failure to balance the two sections of the push-pull output will cause premature squaring of one half-waveform.

Use of these transistors will increase the useful bandwidth of the amplifier to about 100kHz, but unfortunately it will also introduce the tendency for self-oscillation at supersonic frequencies to occur. This effect (which normally manifests itself only when the amplifier output is effectively open-circuit) may be reduced by connecting a 15-ohm $\frac{1}{2}$-watt resistor in series with a 0.1μF capacitor permanently across the output. Extra care must be taken to ensure that capacitive coupling between pre-amplifier input and power amplifier output does not occur, otherwise the whole system will oscillate, and it is also advisable to use non-inductive 1-ohm resistors (R_{14} and R_{15}) in the emitter leads.

A correspondent has indicated that when using 2N2147s the amplifier will drive electrostatic loudspeakers; however, I have not had the opportunity to verify this.

The audible improvement from this modification is a greater degree of clarity; snare drums and cymbals benefit especially. However, the 2N2147s appear to have a higher value of $V_{CE(sat)}$ than conventional junction transistors, and the effect of this is to limit the peak-to-peak output to about 32 volts (with a 40-volt supply). This limits the output power to some 8 watts into a 15-ohm load, and the onset of gross distortion therefore occurs at a lower listening level.

Those readers who have incorporated OC29s will find the improvement with 2N2147s very marginal; those who have used OC35s or OC36s may find the modification desirable as long as they can accept a reduction in the maximum available power. As far as audible quality is concerned, there seems little to choose between the OC29 and 2N2147.

J. DINSDALE

An invitation

If you are a newcomer to *Wireless World* you may not know that any original circuit trick or dodge, using active or passive components, can be submitted for possible inclusion in our "Circuit Ideas" feature (see page 185). If you have such an idea, send us a concise description or a series of notes. £5 is paid for each idea published.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Why not angular frequency?

I wonder if the authorities who are responsible for such matters have ever considered the following situation?

In the vast majority of cases when we make any calculation which is concerned with frequency f we have to multiply it by 2π. Would it not save a lot of trouble if instead we wrote our specifications and calibrated our instruments in terms of *angular* frequency ω? It would not of course be so convenient for use in connection with wave-motion or rotating machinery, for which the use of hertz or cycles per second has a much greater meaning, but life would be made a little easier for those who deal mainly with reactive elements. To a certain extent this practice is already with us in that the Post Office uses lining-up tone at $\omega = 5000$ (or $f = 792$) and component bridges commonly use $\omega = 10{,}000$ (or $f = 1584$).

Apart from the obvious difficulties which are associated with any such change, can you or any of your readers see any objection to this idea?

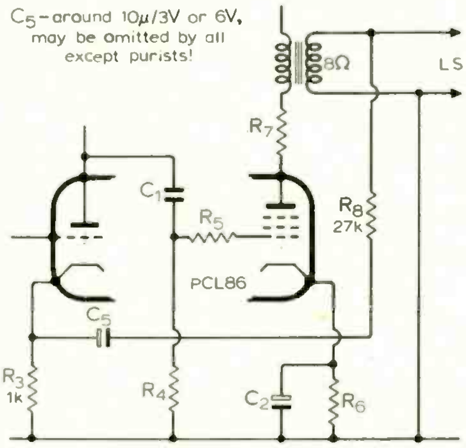
R. C. WHITEHEAD,
Northern Polytechnic,
London N.7.

Colour receiver sound output

Despite the reasonable misgivings of the designer of your colour TV receiver, there are surely constructors who will wish to get the best sound possible within the general limitations stated. They could start by modifying the suggested output stage simply as shown in my sketch, taking the negative feedback from the secondary of the output transformer. "Cathode Ray" showed, several years ago, that taking negative feedback from the primary worsens the signal-to-hum ratio.

True, this requires a respectable output transformer, but the constructor who is this interested will have that anyway. Also the loudspeaker may assume mains potential—but who touches it? Anyway, it is surely not beyond possibility that the constructor can polarize his mains connectors correctly and reliably?

Although it seems unlikely that anyone will seriously want to feed an output from the set into an external audio amplifier, some will certainly want to connect tape recorders, and one of the double-wound speaker isolating transformers marketed by Radiospares will safely feed either with at least tolerable results. The effect of such a transformer, properly used, is in my experience negligible on the great majority of programmes. Very few TV sound transmissions seem to be anything like as good as the system allows.



For the few which are, the split sound channel which your designer suggests would certainly be feasible. One needs, as I have successfully used, a pint-sized speaker of the usual kind on either side of the screen, a bass-only enclosure somewhere nearby (mine was the "plinth" on which my first small set stood, and was slung below its bigger successor), and a reasonably powerful output stage with suitable simple crossover arrangements. If the small speakers are polarized correctly there will be no trouble with the apparent source of the sound. But these speakers should not be anything special; too much treble merely tends to get messed up with that abominable whistle which most sets still radiate.

G. C. BALMAIN,
Slough,
Bucks.

I was interested to read the comments in the February instalment on the W.W. Colour Television Receiver on high-quality sound from television broadcasts. My own experience is that the human eye is the primary influence on the position of the 'image' when experiencing audio-visual stimuli, and that the relative position of the loudspeaker is therefore of secondary importance. Most people I have asked admit that, when they become psychologically 'involved' in a film or a television programme, the sound appears to come from the appropriate actor's lips; in other words the visual image creates in the brain a form of pseudo-stereophony. If one mounts an experiment to demonstrate this, the subjects must be unaware of their participation, otherwise the results are liable to be biased.

I therefore feel that there is much to be said for incorporating TV sound into a high-quality domestic sound reproducing system and I have experienced such installations where the screen of a monochromatic receiver could be positioned either between the two loudspeaker enclosures (wired of course as mono), or alternatively on top of one of the enclosures. In this latter instance it made little difference whether the distant enclosure was muted or not, provided the listener had become mentally involved in the programme.

As regards the best way of extracting the sound signal, the method used in this instance for monochromatic signals was to connect a high-quality microphone transformer at the a.f. detector. This transformer was of course capable of isolating a.c. mains. The use of a transformer need not result in a deterioration of the sound quality: many first-class microphones and magnetic pickups use them.

With regard to sound from colour receivers, although I have not carried out this work myself, I imagine that use of the special transformer mentioned above at the discriminator output, or a split i.f. strip as advocated in your article, should suffice.

It would be very interesting to hear other readers' views, first on the psychological impact of a sound source detached from the screen, and secondly on more appropriate ways of extracting the audio signal from the television receiver.

J. DINSDALE,
Cranfield,
Bedford.

"Tall oaks from little acorns grow"

The most surprising thing about 'Vector's Bandstop Ltd (a company evidently much more imaginary than real), about which he wrote in the February issue, is that it should ever have grown at all. Bandstop Ltd seems to have been founded on the belief that if you build a better mousetrap the world will beat a path to your door to buy it. The world will do no such thing. It won't know about it, for a start. Personal contacts and word-of-mouth recommendations are splendid things, as far as they go, but they don't make for a high growth rate.

Jim Bandstop's best plan would have been to find a less exacting job—he was clearly not cut out to be a group leader in a commercial research lab.—and then to have developed his amplifier business as a sideline. He might then have educated himself about marketing, an aspect of business about which he was as innocent as a new-born babe. Most probably he'd never have become rich, but then the idea *was* to escape from the rat-race, wasn't it? Technical excellence is not incompatible with profitability. I don't see Rolls-Royce going bankrupt and, nearer home,

here are some very successful instrument irms. Even manufacturers of high-grade audio amplifiers have been known to make noney out of excellence. They do not, however, urn out goods "regardless of price", nor do hey expect to sell them without advertising. The Vectors and Bandstops of this world make a fundamental error when they condemn the efficiency experts and marketing organizations as "parasitic growths". They are as necessary to a manufacturer as stomach bacteria to a cow. Failure to realise this has been a major factor in helping the Americans to penetrate so deeply into our markets.
G. W. SHORT
Croydon,
London.

'Piccolo'

In your February issue you comment in your editorial on the tardiness in certain quarters to exploit new ideas—in this case 'Piccolo'. I take it the Post Office, as the major commercial user of radiotelegraph communication in this country, is not excluded from your comments and perhaps I could make one or two observations to put the matter in the correct perspective.

The Post Office thoroughly examined the 'Piccolo' system in 1963 and came to the conclusion that it gave a highly satisfactory service under poor signal conditions, but that it did not exploit scarce frequency spectrum space adequately and required a much higher frequency stability in the bearer circuit than some competing systems.

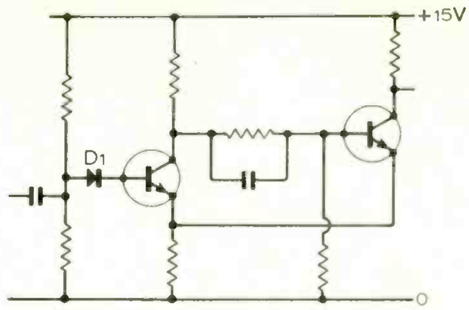
We fully appreciated the merits of the system, but also the disadvantages of using it as part of a public telegraph network, and saw no reason for departing from the currently well-established, internationally accepted, system employing narrow deviation frequency modulation and multiplex techniques backed up by error correction. The excellent all-round performance achieved by these techniques over some ten years has vindicated the soundness of this choice.

You may not be aware that a system employing these so-called 'conventional' techniques was provided by the Post Office for the transmission of press messages and newscopy to and from the Q.E.2 on her sea trials and was the system used to produce the two issues of the *Daily Telegraph* that were printed on board.
T. DAWSON,
Director of Public Relations,
G.P.O.,
London E.C.1.

"Solid-State Oscilloscope"

The signal breakthrough which Mr. Phillips observed (March issue, page 110) when using alloy-diffused and planar transistors in his Schmitt trigger circuits is caused by breakdown of the base-emitter junctions at excessive reverse bias voltages. 'Excessive' in this context can mean as little as 0.3V for alloy-diffused types, and 3V for planars.

Silicon transistors can, however, be used. In the p-n-p Schmitt triggers of Figs. 3 and 6



of the article, type 2N4285, which has a reverse breakdown rating of 35V, can be substituted directly. I do not know of any n-p-n planar transistors with such a high V_{EB} rating, but the usual cheap types such as BC168 can be used if a diode is added to protect the base-emitter junction of the first transistor (D_1 in the accompanying diagram). A diode with a reverse voltage rating above 15V would appear to be adequate for the oscilloscope circuits. Incidentally, it might be useful to insert a diode with a much higher reverse rating in the base lead of Tr_{12}, in case somebody tries to trigger the timebase directly from the mains!
G. W. SHORT,
Amatronix Ltd,
Croydon.

Protection of engineers

The view given by 'Vector' in the January issue that trade unionism is not the answer to the problem of providing protection for qualified engineers is one which is probably shared by many people.

You should, I feel, publicise as much as possible the suggestion that the learned institutions must take action to fill the void.

It may be relevant that recent moves have been made by the Engineers Guild to form a so-called union in order to counter action by established unions aimed at attracting qualified engineers to their ranks.
J. M. FAITHFULL,
Plymouth,
Devon.

The human computer

In criticising my description of the human computer, Messrs. Conway, Hunt and Liston put forward in their letter in the December issue some conventional, but by no means universally accepted, dogmas about the nature of the life process. The points they raise were carefully discussed with a number of biologists and physicists before I wrote the article and I found those whom I consulted much more constructive and encouraging than your correspondents.

The weakness of their particular school of biological teaching is that it is assertive rather than analytical and that it hides behind unexplained words. Thus it is sufficient that one gene 'dominates' another, without offering any explanation of the mechanism of 'domination'. Similarly, the life process is stated to be 'chemical' but who has ever seen a self-organizing chemical process? Atomic frequencies are held to be infinitely stable but where is the proof of this statement and is an infinitely stable oscillation feasible? Your correspondents are entitled to their views on these matters but in a subject area where ignorance greatly exceeds knowledge they are not entitled to be dogmatic nor to be purely destructive.

While a number of the points which I have raised are debatable and were intended for debate, the assertion by your correspondents that genetic and environmental information are so different that they cannot be compared is surely quite unacceptable. That human individuals are constantly comparing the relative strengths of their instinctive and intellectual response to situations and problems is a matter of everyday experience. The alternative would be to act only from 'pure reason' or 'pure instinct', with no guide as to which course to adopt.

I believe that my suggestion that the two streams of human information are compared by a process of non-linear mixing is the only one which will satisfy common experience on the one hand and the rigorous requirements of communication theory on the other.

The consequent deduction that genetic and environmental information are of precisely equal importance is, I consider, inescapable and if accepted this deduction must, I believe, be of the greatest significance in the future analysis of human behaviour.

I believe that just as Harvey identified the circulation of the blood it is essential to identify the system of information flow in the individual and I am surprised that no one, including your correspondents, has risen to the challenge of my article and proposed an alternative or a better information flow diagram than that proposed by me.
J. R. BRINKLEY,
St. Johns Wood,
London N.W.8.

C.E.I. Part II Examinations

It may be worthy of reporting in *Wireless World* that colleges are now preparing for C.E.I. Part II courses, which will replace the I.E.E. Part III.

The Leicester Regional College of Technology (soon to become the City of Leicester Polytechnic), is to launch a C.E.I. Part II course on a 38-week, full-time basis. This first course will commence on the 28th April 1969 and will end on the 16th May 1970.

Because the number of subjects is now six, compared with the three subjects required for the I.E.E. Part III examinations, it is found necessary to extend the studies over more than one session; thus, there will be nine weeks in the summer term, and the remaining 29 weeks commencing September 22nd 1969. H.N.D. students may find this a convenient course, since their studies will normally finish in April.

The Department of Electrical Engineering at this college will provide a range of subjects which, in addition to "The Engineer in Society", will give the technical coverage required for I.E.E. and I.E.R.E. membership.
A. TRANTER,
Dept. of Elec. Eng.,
Leicester Regional College of Technology.

Surface Temperature Thermometer

A simple yet accurate design using variation of diode forward voltage drop for measurement of heat sink temperatures from 0 to 100°C

by L. Nelson-Jones, M.I.E.R.E.

This article describes the design and construction of a portable instrument for the measurement of surface temperatures in electronic and other equipment. It was designed specifically for the measurement of heat sink temperatures, though many other applications spring to mind.

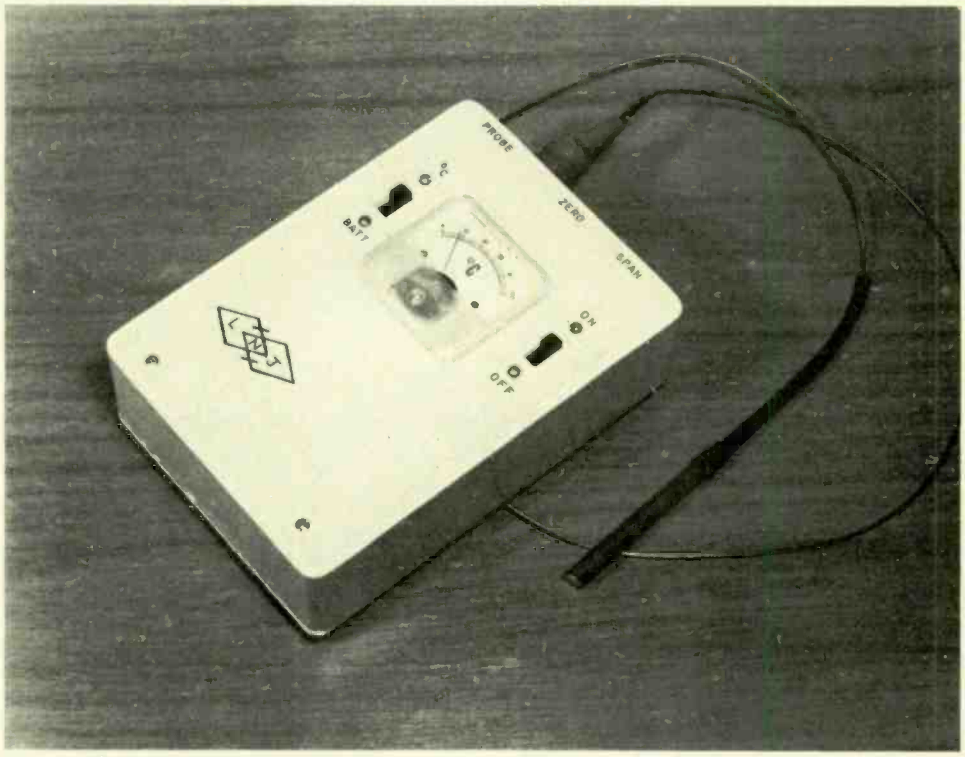
Originally when development was started a thermistor probe was considered. After a great deal of work this was dropped in favour of the diode probe to be described. This was because of the difficulty encountered in obtaining a linear scale with a thermistor without recourse to complex techniques.

Fig. 1 shows the forward characteristic of a typical high conductance planar diode similar to that used in the author's instrument. It will be seen that the temperature coefficient of the diode depends on the forward current.

The simple theory of a forward biased junction[1] suggests a temperature coefficient of 3.7mV/°C for silicon, and 2.2mV/°C for germanium at around room temperature. In practice, at current densities corresponding to 1mA of forward current in the type of diode used, the temperature coefficient is usually in the region of 2 to 2.5mV/°C. (In the author's experience there is also correlation between forward voltage at a given current, and temperature coefficient for any particular diode type.)

Fig. 2(a) is a histogram of 50 diodes BAY31 taken at random from diodes, old and new, from more than one manufacturer. These measurements were made with the object of establishing the sort of spread of forward voltage, at 1mA, that one could expect. From these 50 diodes, 16 were selected as representative and their temperature coefficient was measured over the range 20 to 100°C. Fig. 2(b) indicates the range of temperature coefficients found and the approximate correlation with forward voltage (V_f). Further measurements on the type 1N4448 diode selected for the final design indicate that a diode with a V_f between 0.55 and 0.65V at 1mA is suitable. The 1N4448 was chosen because its V_f is guaranteed within a fairly narrow spread, and because it is economically priced and very small in size.

Fig. 1 indicated that the temperature coefficient of a diode does not vary with temperature at 1mA (a conclusion in agreement with all the author's own measurements). These indicate that linearity to within ±0.25% over the range 0 to 100°C is quite possible and that the majority of diodes achieve linearity of this order.



The prototype instrument

Diode testing

The bridge circuit used for testing the diodes is shown in Fig. 3. The circuit consists of a constant current generator supplying 1mA to a decade resistance box whose reading in ohms will then be equal to the diodes V_f in mV when the bridge is balanced. The circuit may also be used with a resistance box (going up to 10kΩ) to check the constant voltage circuit used in the instrument. To this end the 18kΩ resistor used to supply the diode with 1mA of forward current may be disconnected. A stabilized supply is essential. The current source is set to 1mA using the 5kΩ resistor with a meter in place of the resistance box and with the bridge indicator disconnected.

The thermometer bridge circuit

A bridge circuit is used in the final design so that the forward voltage of the diode may be balanced out and the indicator made to read zero at 0°C (or at any other minimum temperature chosen). Having thus balanced out the diode forward voltage the meter then indicates any change in diode forward voltage due to a change of diode temperature. Two arms of the bridge circuit, shown in Fig. 4, are therefore variable: (1) the diode voltage varies with temperature, and (2) the variable resistance arm which is used to balance the bridge at 0°C. This type of bridge must be supplied from a very stable voltage source, since it is not used at null (for temperatures other than 0°C), and also because it contains a diode which has a non-linear voltage/current relationship. In addition, because of the very small changes involved, it is essential that the resistors used for the bridge arms are very stable, therefore, metal oxide, metal film, or wirewound types should be used. Carbon or carbon film resistors, although called "high-stability", should not be used because of their high and variable negative temperature coefficient. Finally the meter movement, which is wound with copper wire, must have some form of temperature compensation applied.

Meter temperature compensation

The expected temperature coefficient of the

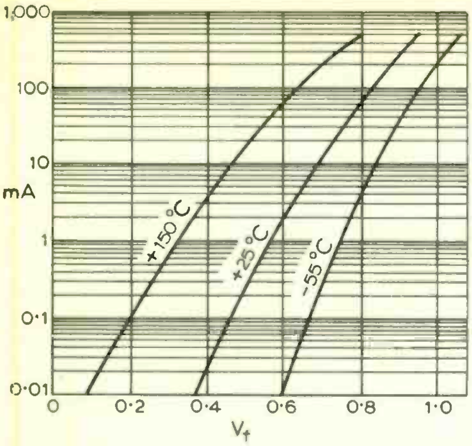


Fig. 1. Forward characteristics of a typical high-conductance diode

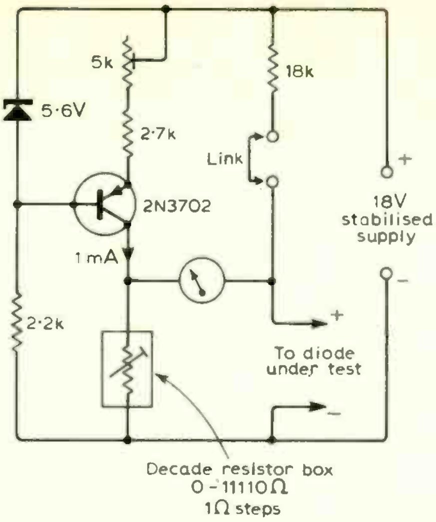


Fig. 3. Test circuit for diode and zener diode temperature coefficients.

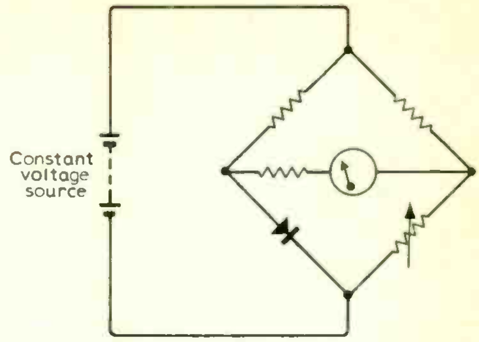
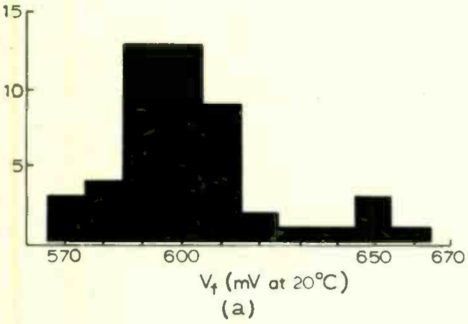


Fig. 4. Basic temperature sensing bridge.



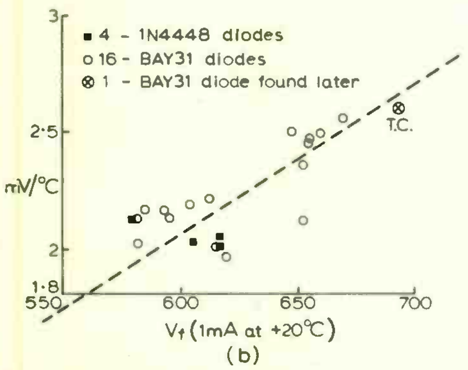
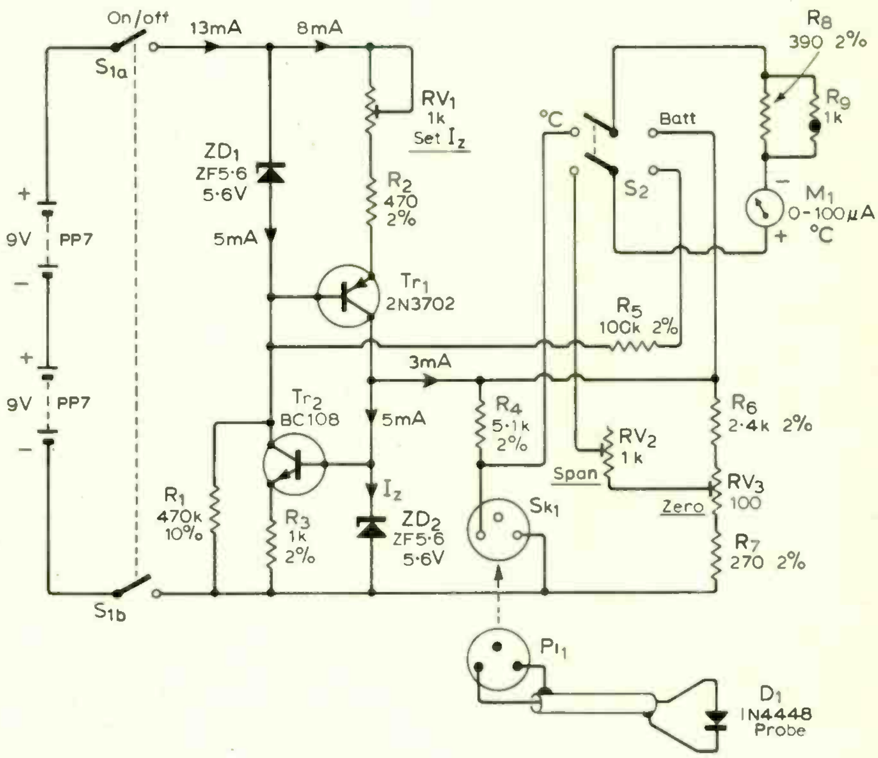


Fig. 2(a). Spread of forward voltage obtained from a random selection of 50 diodes type BAY31 when operated at a current of 1mA.

Fig. 2(b). Shows some correlation of temperature coefficient and forward voltage for the BAY31.

Fig. 5. Complete circuit of the instrument.



meter was that of copper wire namely about +0.39%/°C, and for the S.E.W., MR.45.P movement specified a value of +0.37%/°C

TABLE ONE

If a meter other than the one specified is used it will be necessary to measure its resistance and use a different value for R_8. The value of R_8 may be selected from the table below.

A	B	C
1,400	560	5.4
1,200	510	4.7
1,070	470	4.2
950	430	3.7
820	390	3.2
720	360	2.8
615	330	2.4

Where A is the meter resistance in ohms, B is the value of R_8 in ohms and C is the temperature coefficient of the R_8/R_9 combination in Ω/°C.

was measured. No other effects could be found up to 40°C, other than this resistance change. There was no shift of zero and, with a constant current feed, no change in deflection at f.s.d.

Thermistor compensation was decided upon. A suitable value of thermistor should have a temperature coefficient at 20°C, of the same order as the meter, the thermistor being shunted to obtain this. An S.T.C. type KR.102.C was selected and was measured over the range 0 to 40°C with various values of shunt resistor. The results, in Ω/°C, are given in table one. For the meter movement specified the correct value of shunt resistor is 390 Ω. With these compensating components in circuit the error in indicated reading is less than 0.3°C from 10 to 30°C ambient and less than 0.7°C from 0 to 40°C.

It will pay to measure the resistance of the meter used, as anyone having the Electroniques catalogue will notice that in this the movement used is quoted as 1050 Ω, whereas in fact the author's meter measured 880 Ω at 20°C.

Stabilized voltage source

For this part of the instrument the circuit described by Peter Williams[2], a "Ring of Two", is used (see Fig. 5). The starting problem mentioned by Mr. Williams is evident when modern low leakage transistors are used, especially at low ambient temperatures. Mr. Williams suggested the use of a resistor between the bases of the two transistors, but commented, that although this cures the starting problem it does detract from the performance of the circuit. The author has therefore used a resistor across one of the transistors to simulate leakage, and, if this is placed across the transistor feeding the diode not used to supply the temperature bridge, little effect will be noticed from its presence.

A value of 470kΩ is used (although a much higher value is sufficient to cure the problem) in order to ensure that the circuit will start even at the lowest ambient temperature.

Final design

The circuit of the final design (Fig. 5) follows the ideas outlined above, but one or two additional points are worthy of note.

With the "ring of two" circuit satisfactory operation is obtained over a wide range of battery voltages because the stabilized output is not affected until the transistors bottom; this occurs just after the collector potentials have reached equality. Therefore it is only necessary to ensure that there is a positive difference of collector voltage for the circuit to operate satisfactorily. In the final design a switch is included which connects the meter movement in series with a 100kΩ resistor to give the meter a 10V f.s.d. which is used to measure the collector voltage difference. With a new set of batteries this difference approaches 8.5V so, before zero difference is reached the batteries must fall to just over half their initial voltage. A long battery life is therefore achieved.

The temperature compensation resistors are left in circuit in the battery check position of the meter switch, S_2, purely as a matter of convenience in the layout of the printed circuit used.

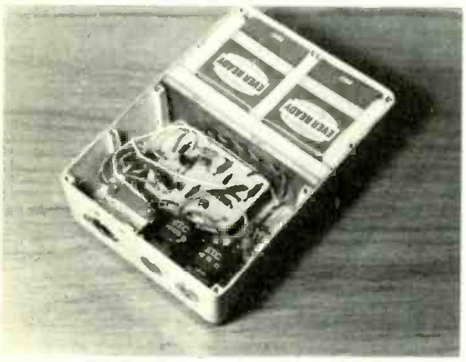


Fig. 6. The interior of the prototype instrument.

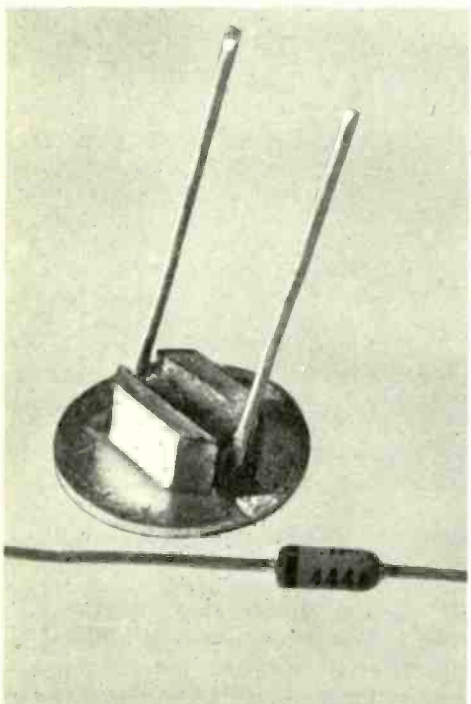


Fig. 7. The tip of the diode probe with the diode fixed in position.

Calibration

A variable resistor in the emitter of Tr_1 is included so that the current through the zener diode ZD_2 can be set to the level giving zero temperature coefficient. If this is not required a fixed value of 620Ω may be substituted for RV_1 and R_2, to give a zener current of 5mA. At this fixed current the spread in temperature coefficient of a 5.6V zener diode can cause an error in the indicated reading of the thermometer of up to ± 1°C for an ambient temperature range of ± 20°C.

The variable resistor RV_1 is initially set to give a voltage across R_2 of 3.75V (20kΩ/V meter on the 10V range), which provides a zener current of 5mA. RV_2 is then set to zero-resistance and RV_3 is set to bring the meter needle on scale (the exact reading is not important). A hot soldering iron is then held near (not touching) the diode ZD_2. If this causes a change of meter reading RV_1 should be adjusted slightly and the procedure repeated again when the diode has cooled. If now the change produced is less, continue to adjust RV_1 in the same direction until no change in meter reading is produced by gentle heating. If the change is increased alter RV_1 in the opposite direction until no change is produced on heating. It should be noted that changing RV_1 will in itself cause a change of meter reading due to the slope resistance of the zener, however, it is the change due to heating only, that should be observed.

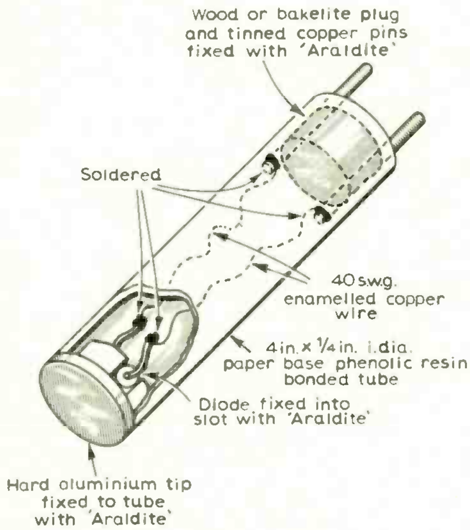


Fig. 8. Internal construction of the diode probe.

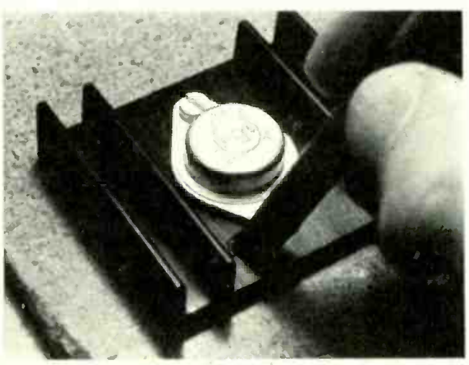


Fig. 9. The thermometer in use.

Having made the above adjustment, the following procedure should be followed.

The scale of the meter is already divided into the correct number of divisions since 0 to 100μA represents 0 to 100°C. The probe is first immersed in a mixture of cold water and ice cubes (in about equal quantities) which must be kept very well stirred. The zero set control (RV_3) is then set for a reading of 0°C. Next the probe is placed in a water bath which is raised to 100°C (if the water is already boiling the probe should be held in the steam close to the water for about 30 seconds to minimize thermal shock). With the probe in the boiling water (preferably checked with a good quality mercury-in-glass thermometer, since the boiling point is frequently not quite 100°C, the weather and altitude both affect this to an extent[3]) adjust the span control (RV_2) to make the meter read 100°C or the corrected figure if necessary.

Allow the probe to cool for a minute or so and then return it to the water/ice mixture which should be kept well stirred. The original zero reading should be obtained. If not, it should be adjusted and the process repeated until the meter reads correctly at 0°C and 100°C.

When using a mercury-in-glass thermometer, check whether it is for complete or partial immersion and act accordingly. Also note that a temporary depression of the zero of such a thermometer occurs on cooling from 100°C to 0°C.[3] There should be no need to measure the water/ice mixture providing it is well stirred at all times since this provides a very accurate source of 0°C even using tap, and not distilled, water.

Accuracy

After setting up as described the prototype was in agreement with a good mercury-in-glass thermometer within 0.75°C over the whole scale and there was no trace of hysteresis.

A check of the surface temperature of a thin metal container containing boiling water showed no difference of reading between a contact reading of the outside surface and complete immersion in the water. Silicone Grease (Midland Silicones M.S.4) was used to ensure a good surface contact, a normal precaution in surface contact thermometry.

Construction

The instrument is constructed in a die-cast aluminium case (S.T.C. type 46R.064A). The majority of the components are located on a printed circuit attached to the meter terminals. In the photograph (Fig. 6) the variable resistor RV_1 is mounted on the case but this could well be mounted on the printed circuit. The front of the instrument has a Perspex overlay, lettered on the reverse side. The lettering is covered by two coats of white cellulose paint. The overlay is held in place by the meter, the two switches and the two chrome plated 4B.A. screws in the lower half of the panel. The battery compartment is lined with a polyurethane foam sheet as shown in the photograph. A thin plywood panel is placed across the case resting against the cast ribs which is held in by the lid. The cast rib round the lid can be filed away immediately above this

COMPONENTS REQUIRED

Resistors

R_1	470k Ω*	R_5	100k Ω	R_9	1k Ω†
R_2	470 Ω	R_6	2.4k Ω	RV_1	1k Ω‡
R_3	1k Ω	R_7	270 Ω	RV_2	1k Ω§
R_4	5.1k Ω	R_8	390 Ω	RV_3	100 Ω§

*10%. 0.25W carbon composition. all other fixed resistors 2% metal oxide type TR.5. Electrosil. †Thermistor type KR.102C (5%. 20°C) Electroniques. ‡Wirewound printed circuit mounting potentiometer. §Potentiometer type T10. Electroniques.

Semiconductors

Tr_1	2N3702 (p.n.p.)	ZD_2	ZF5.6 (5.6V zener)
Tr_2	BC108 (n.p.n.)	D_1	1N4448
ZD_1	ZF5.6 (5.6V zener)		

All diodes available from Electroniques.

Miscellaneous

S_1, S_2	Radiospares slide switches	M_1	0 to 100μA*
		batteries	PP7
SK_1, P_1	3-pin audio plug and socket	case	type 46R. 064A†

*SEW. type MR.45.P †Diecast aluminium. Both from Electroniques.
Note: silicon grease type MS.4 can be obtained from Electrovalue, 6 Mansfield Place, Ascot, Berks.

panel so that the panel slots into the lid thereby locking the panel in position.

The marking "μA" on the meter is gently scraped away with a sharp razor blade. The dial is then made matt again with a typewriter eraser and the lettering "°C" is put on using Letraset, or Blick Dry-Print. Make sure that the peg of the meter zero setting screw is correctly engaged with the lever of the movement before you close the meter case up again.

Diode probe

The construction of the probe tip is shown in the photograph (Fig. 7) and an illustrated cross section of the probe is given in Fig. 8. The tip is made of aluminium sheet (10 s.w.g. —0.128in), preferably of a hard alloy. The thickness of this sheet is reduced around a central island of full thickness and of 0.25in. diameter, so that it is just small enough to fit into the end of the 0.25-inch internal diameter paper base phenolic tube. A small slot is cut across the centre and the diode is fixed into this with Araldite adhesive. (The twin-tube pack obtainable at most ironmongers.) This adhesive is also used to attach the tip to the tube and to fit the plug and terminals at the top. The tip is filed flush when the adhesive has set and the end is polished flat to ensure good thermal contact. The author found it an advantage to have the tip at a slight angle to the tube, however, this is a matter of choice. Fine coiled leads of 40s.w.g. enamelled, or enamelled single silk wire are used to connect the diode to the terminals in order to minimize the conduction of heat along the wires.

REFERENCES

1. M. V. Joyce and K. K. Clarke, *Transistor Circuit Analysis*, Addison Wesley Publications Co. Inc., world student series edition.
2. P. Williams, "Ring of Two Reference", *Wireless World*, July 1967, pp. 318-322.
3. G. W. C. Kaye and T. H. Laby, *Tables of Physical and Chemical Constants*, Longmans, Green and Co. Ltd., London.

Hot-carrier Effect Transistor

Transistor à effet porteur chaud

Since the development of the hot-carrier diode considerable research has been carried out on both sides of the Atlantic into the application of majority carrier conduction, in particular the recent achievements in France at the Centre d'Etudes en Semiconduction under Professeur Georges Bodet, have been outstanding.

The following is a résumé of the results (previously unpublished) of the research made possible by the grant of 15 million francs at the instigation of President de Gaulle, with the avowed intention of placing France in the forefront of international electronics.

That this work has been crowned with success is indicated by the entry of yet another name into technical terminology; after Schottky comes the Bodet effect.

The greater electron mobility and virtual immunity to storage of minority carriers found in the hot-carrier diode is now well known. At zero-bias the mechanism of electron flow between the electrodes in the h.c.d. consists of a constant exchange so that the net current is zero.

When the junction is forward biased the energy of the electrons is increased so that they are injected into the metal of the 'anode' with large kinetic energy or temperature, compared with the electrons at equilibrium in the metal, hence the name "hot carrier".

The real point of departure from known phenomena came as a result of attempts to increase the electron current across the junction. With high levels of forward bias the resulting high electron flow caused internal heating which in itself increased the mobility of the electrons; but with reduction of bias it was found that conduction remained at a high level until temperatures returned to almost room ambient.

During the period between reduction of bias and the eventual fall in temperature most of the electrons were found to be concentrated in the anode, so much so that an actual potential could be measured across the junction, with all bias removed. This in itself is being separately investigated with the purpose of developing a high efficiency thermal battery—possible applications being powering of satellite vehicles' equipment by solar radiation—and is likely to place French space research at a distinct advantage over those of the U.S.A. and U.S.S.R.

To exploit this otherwise enormous but uncontrolled increase in electron mobility an intrinsic layer was introduced between the electrodes. The intrinsic region has almost negligible doping, and consequently a very high resistance. This high resistance results in extremely low junction capacitance, but has the somewhat undesired effect of demanding a considerably higher forward bias to maintain the thermo-agitation of the donor electrode.

It was a logical development to increase the temperature by separate means; a small length of resistance wire buried in the electrode required quite a low potential to increase the electron energy. Even so, a further undesired but so far unsolved effect was found in that the device required several seconds pre-heating before super-energy electrons were available.

At the present time only n-type majority carrier devices have been developed; the equivalent p-type has eluded the C.E.S. team.

To return to the intrinsic layer, it should be explained that with a sufficiently increased forward bias between the original electrodes the electron energy could be increased to the extent that, despite the high resistance of the intrinsic layer, electrons could be made to pass right through.

If the intrinsic layer were reverse biased the resistance could be increased so that electron flow was reduced to virtually zero; thus the current could be controlled by varying the bias on the layer, much in the same way as the gate functions in an f.e.t.

However, many nuclear collisions occurred causing excessive current requirements in the intrinsic layer bias. The real breakthrough came with the discovery that the intrinsic layer could be replaced by a mesh electrode surrounded by a *vacuum*.

There is no doubt that the Bodet effect will come as a cold shock to a sensitive part of the U.S. semiconductor industry.

Translated from the French by a correspondent.

Personalities

Norman D. Summers, M.I.E.E., has been appointed divisional manager of Plessey Components Group's Professional Components Division at Titchfield, Hampshire. Previously he was technical manager of the Division's engineering laboratory. He joined Plessey in 1954 as a senior component engineer after six years with Siemens Bros. Company as a telephone circuit design engineer. **John R. Ashman,** who joined Plessey in 1963 as a senior engineer, takes over from Mr. Summers as technical manager of the Division's engineering laboratory. He was previously chief engineer of the engineering laboratory.

Peter Rainger, B.Sc., F.I.E.E., has become head of the B.B.C. Designs Department, in succession to **Dr. R. D. A. Maurice,** O.B.E., who was recently appointed head of the Research Department. Mr. Rainger joined the B.B.C. in 1951 after graduating at London University. He served first in the Planning and Installation Department and joined the television recording section of the Designs Department in 1953. He was appointed head of the section in 1956 and head of studio group early in 1968. Mr. Rainger is best known for his work on television standards conversion. He led the teams which developed the first all-electronic 525/625-line standards converter and the first electronic 50/60 field converter, also capable of handling colour signals. This work has been recognized by the award of the J. J. Thomson Premium of the I.E.E., the Geoffrey Parr Award of the Royal Television Society and an Emmy Award of the National Academy of Television Arts and Science of the U.S.A.

Christopher Newport, Ph.D., M.I.E.E., a graduate of Birmingham University, has been appointed engineering director for Series 16 computer systems at Honeywell's Computer Control Division in Framingham, Mass. Dr. Newport was formerly manager of the division's information systems operation, which designs and develops communications and display systems. Prior to joining the division in 1967 he had been concerned with developing systems for message switching, traffic control and display at the Marconi Company in Chelmsford.

Gordon Barrow, B.Sc., has been appointed product sales manager of the Quartz Crystal Division of ITT Components Group, Harlow, Essex. After graduating with honours in physics at Manchester University,

G. Barrow

Gordon Barrow, who is 31, joined Standard Telephones & Cables, a subsidiary of ITT, in 1962. In 1965 he went to Union Carbide as sales engineer, later becoming sales manager.

Alan Burke, F.I.E.R.E., chief engineer of British Relay, has been appointed to the board of directors. Mr. Burke originally joined British Relay in 1948 and after National Service went to the B.B.C. for two years. He rejoined British Relay in 1953 and was chief development engineer from 1962 until 1964 when he was appointed chief engineer.

P. White, B.Sc., A.C.G.I, was recently appointed chief development engineer of Link Electronics Ltd. of Ruislip, Middx. Educated at Imperial College, Mr. White was with Ferranti and then joined the B.B.C. Designs Department where he was involved in the recent award-winning design of the field store standards converter.

D. S. Campbell, D.Sc., F.Inst.P., has joined the TCC Capacitor Division of Plessey at Bathgate, Scotland, as technical manager from the Company's Allen Clark Research Centre at Towcester, Northants. He came to Plessey from S.R.D.E., Christchurch, in 1953 and since 1963 has been visiting lecturer and visiting senior lecturer in material science at Imperial College, London. Dr. Campbell, who is 40, graduated in physics at London University where he recently received his doctorate for his work in materials science at the Allen Clark Research Centre and at Imperial College, with particular reference to his work on thin films. Plessey also announce the appointment of **P. J. Harrop,** Ph.D., who is 29, as controller of research and development of the TCC Capacitor Division. He also comes from the Company's Allen Clark Research Centre, which he joined in 1966 from A.E.R.E., Harwell. Dr. Harrop studied at Brunel University.

Keith A. Riley, who is 30, has been appointed product manager of the Medical Group of S.E. Laboratories (Engineering) Limited, of Feltham, Middlesex. He will be responsible for all the company's medical products, which include transducers, defibrillators, Harco basic monitors and equipment for patient monitoring, theatre monitoring and blood flow measurement. For the past $4\frac{1}{2}$ years Mr. Riley has been with Hewlett-Packard.

John Nicholls, Grad. I.E.R.E., has become chief engineer of the newly formed Instrument Division of Coutant Electronics Ltd, of Reading. He joined the company in 1965 from Ferranti Ltd where he was concerned with integrated-circuit development. Prior to joining Ferranti he was with Specto Avionics developing aircraft "head-up" displays and before that he was at University College carrying out research into the upper atmosphere. He is 31.

Al Jenkins has been appointed manager of the Electro-Mechanical Division of ITT Components Group, Harlow, Essex. He joined ITT in 1956 at Standard Telecommunications Laboratory, where he worked in the digital systems division. Transferring to the Components Group, he first went to Magnetic Materials Division and later Rectifier Division.

Andy Thomson is appointed sales manager of the Electronics Division of Union Carbide U.K. Ltd. He has been a sales engineer with the Division for the past three years and will be responsible for U.K. sales of Union Carbide's range of Kemet solid tantalum capacitors and semiconductor devices. He takes over from **Gordon Barrow,** whose appointment with the Crystal Division of ITT Components Group is announced above.

T. D. McCrirrick, F.I.E.E., F.I.E.R.E., is now head of the B.B.C. Studio Planning and Installation Department, in succession to **D. R. Morse,** F.I.E.E., who was recently appointed chief engineer, capital projects. Mr. McCrirrick joined the B.B.C. in 1943 and after serving at several radio studio centres transferred to the Television Service in 1949. Since 1967, he has been head of engineering, television recording and is succeeded by **L. H. Griffiths,** M.A., B.Sc., M.I.E.E., who joined the B.B.C. in 1951 in the film unit of the Planning and Installation Department. Since April 1966 he has been senior television planning engineer. This position in the Studio Planning and Installation Department is being filled by **D. P. Leggatt,** B.Sc., M.I.E.E., who joined the Corporation in 1953 and served for two years in the Engineering Information Department followed by four years in the Planning and Installation Department. After three years in the Television Service, latterly as engineer-in-charge of television recording he returned to the Planning and Installation Department in 1965 as head of the film unit. Since 1966 he has been head of the television studio and outside broadcast section.

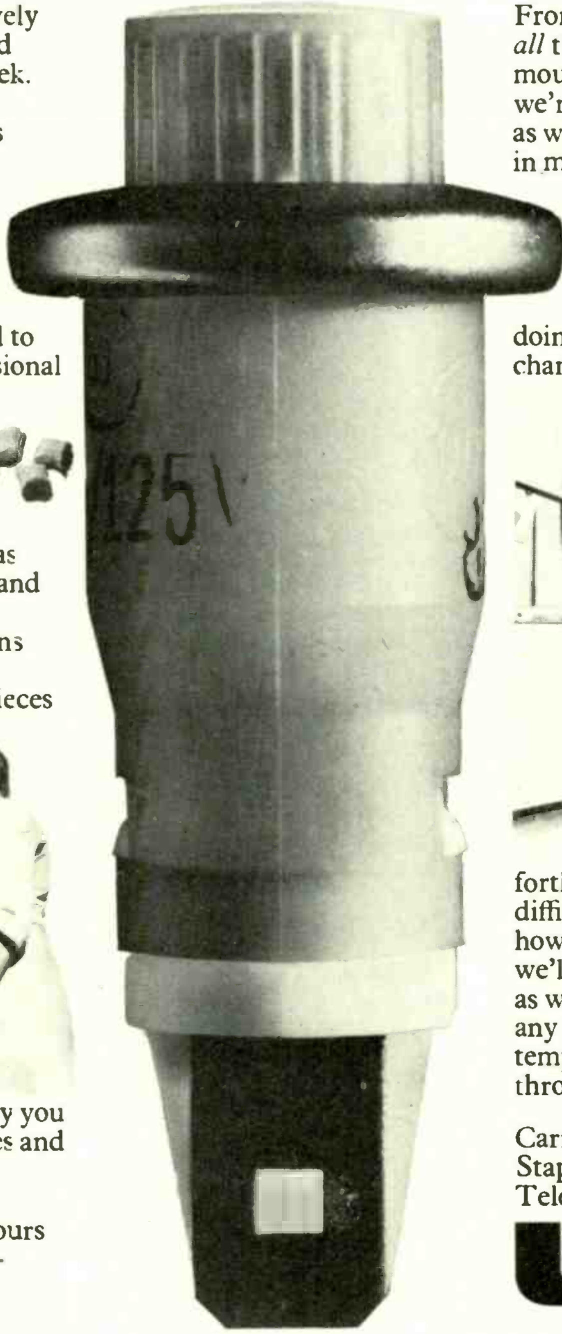
H. T. Greenfield, who has joined Grampian Reproducers Ltd as deputy managing director, has for the past nine years been sales director of Clarke & Smith Manufacturing Co. Prior to 1958 Mr. Greenfield was for 17 years with Telephone Rentals Ltd.

Dennis P. Taylor, who joined Hewlett-Packard Ltd. in 1962 and has latterly been Northern European manager, was recently appointed managing director in succession to **David Simpson** who has resigned to join George Kent Ltd as group manufacturing director. Mr. Taylor, who is 38, spent six years with Solartron Electronics Group before joining Hewlett-Packard as marketing manager.

F. K. Poulton, M.A., has been appointed managing director of the London Electrical Manufacturing Company and of associated Ceramic Products Ltd. Mr. Poulton joined the Components Group of the Plessey Company from the aircraft industry in 1959. At that time he was based at Swindon and became divisional manager of the Capacitor Division. When Plessey acquired the Telegraph Condenser Company, Mr. Poulton became commercial director of T.C.C.

W. H. Jamieson, until recently sales office manager for Abbey Electronics & Automation Ltd., of Cheshunt, has been appointed commercial manager. Prior to joining the company a year ago he was assistant sales supervisor with Marconi Instruments (Sanders Division) at Stevenage. He is 37.

We can mould your future -and even dye for you!



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accuracies of .001 in., with contact spacings as close as .050 in. And our research and development boys are constantly working to push these specifications to even finer limits.

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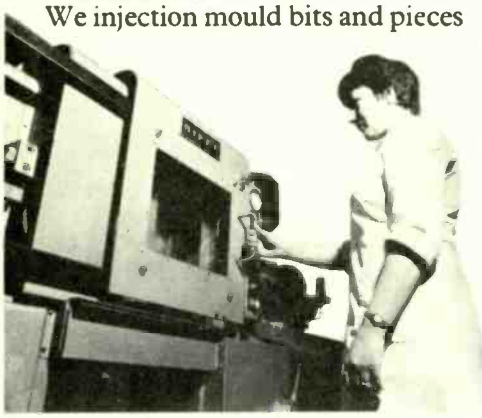

for practically every other industry you care to mention. And make the dies and moulds for these parts in our own toolroom. And if the raw material doesn't happen to come in the colours we require - and they often don't - we dye the mouldings in our own dye house.

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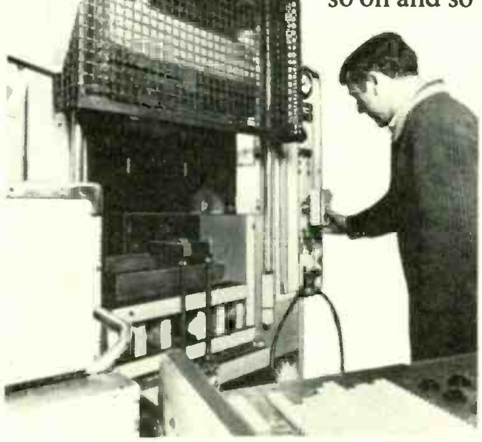

forth. Adding the metal bits can be difficult if you don't have the know-how. But we have it. Lots of it. And we'll even make the metal parts for you as well, if you like! In any metal, with any refinements such as plating, tempering, soldering, riveting etc, etc thrown in.

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CARR FASTENER

UNITED-CARR GROUP

WW—114 FOR FURTHER DETAILS

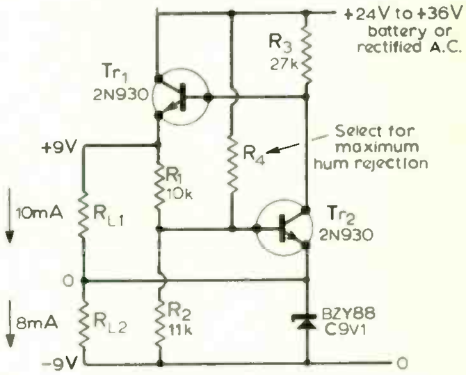
Circuit Ideas

Low-power two-rail instrument supply

This circuit, using two transistors and a single zener diode, provides two stabilized supplies of opposite polarity. The negative feedback loop, Tr_1 and Tr_2, maintains the positive rail at

$$\frac{R_1 + R_2}{R_2}(V_Z + V_{BE2}) - V_z$$

relative to 0V, provided R_{L1} draws more current than R_{L2}. This difference provides the current to operate the zener diode. Thus the circuit is most suited to operation where the load currents are constant, or the difference between them is constant. If the load current is required to vary, the zener diode should have a low dynamic resistance and the loop gain provided by Tr_1 and Tr_2 should be kept high by making R_3 large. The base current of Tr_1 should not be allowed to rise above half the collector current of Tr_2, and to this end Tr_1 may be a compound emitter follower. The voltage gain of Tr_2 is however limited to R_3/r_e where $r_e \approx \frac{25}{I_{e2}(\text{mA})}\Omega$ so that no increase in gain is obtained by raising R_3 further once r_{e2} is large compared to $\frac{R_1 R_2}{(R_1 + R_2)} h_{FE2}$.



Low-power two-rail supply.

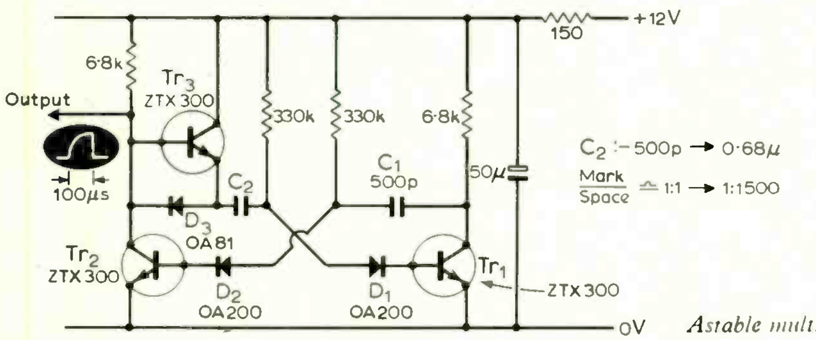
D. I. H. May,
Plymouth, Devon

Large space-mark ratio multivibrator

The addition of a transistor and a diode to the basic astable multivibrator allows a large space-mark ratio to be attained without requiring the power supply to provide vastly different currents during the mark and space periods. The limitation in the basic astable is that the larger timing capacitor must charge through a collector load resistor during the shorter time interval. The circuit operates as follows:—When Tr_2 goes "off", D_3 is reverse biased and Tr_3 acts as an emitter follower to charge C_2. This results in the waveform at the collector of Tr_2 rising much more rapidly and C_2 charging in a shorter time.

The circuit was constructed first with D_3 and Tr_3 omitted. The maximum space-mark ratio obtained was 20:1, the pulse at the collector of Tr_2 then being 100μs in base width but with a rise time of 95μs. With the inclusion of D_3 and Tr_3 the same pulse was obtained at the collector of Tr_2 when the mark space ratio was 1500:1, whereas with a space-mark ratio of 99:1, i.e. at the collector of Tr_2 a 100μs pulse every 10ms, the rise time of the pulse at the collector of Tr_2 was 5μs. A similar circuit configuration may be used to improve the recovery time of a monostable multivibrator.

K. D. Cliff,
Sutton,
Surrey.



Astable multivibrator circuit.

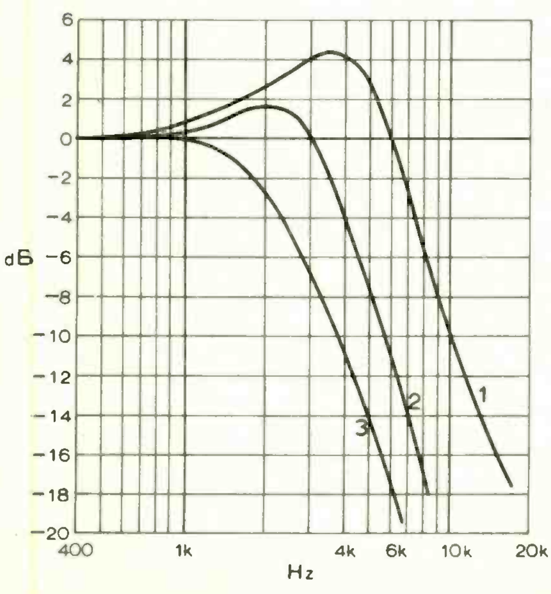
Simple second-order active filter

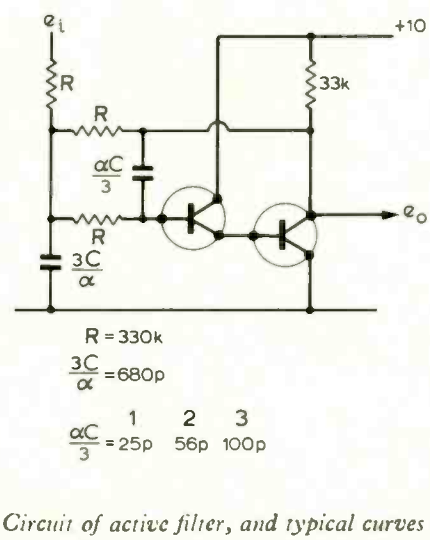
The circuit is used with an operational amplifier for various applications requiring a low-pass filter. The transfer function is

$$e_o = \frac{-1}{1 + \alpha(sT) + (\alpha sT)^2}\text{(where } T = RC\text{)}$$

The version shown uses only two transistors. It will be seen that various degrees of underdamping may be obtained by variation of α. Only C_s has been varied here to illustrate the responses more clearly, and hence curves do not have the same cut-off frequency. Tr_1 should be a low-current type ($h_{FE} > 50$ at $I_c = 10\mu$A). The cut off slope is 12dB/octave.

J. M. Firth,
Ottawa, Canada.





Circuit of active filter, and typical curves obtained.

New Products

Return Loss Bridge

To specify sending and terminating impedances of television equipment in terms of return loss over a band of frequencies, a method which is gaining preference, requires the use of a measuring bridge. A simple reasonably-priced instrument developed specially for this purpose is the return loss bridge type 131 by Michael Cox Electronics. This is of Wheatstone type, with modifications to allow for single-ended source and detector. The source can be any television test signal generator, such as pulse and bar, or augmented pulse and bar, multi-burst, or frequency sweep generators. The source feeds the ratio arms which are high precision 75-ohm resistors, with a third resistor to complete a delta section, and making the arms appear as a 6dB loss splitter pad. This is done because in most cases, the unknown impedance has to be connected to the bridge via a short length of cable. In order to balance out the copper loss in the cable, the reference impedance should also be connected via a similar length of cable. By adding the third 75-ohm resistor, the bridge presents a 75-ohm source impedance to the two cables. The detector has to be connected across the two reference and unknown connectors and should therefore be a balanced device. As most available oscilloscopes or waveform monitors are unbalanced devices, with inadequate gain for the amplitude of error signal produced by the bridge, the use of a high gain wideband differential amplifier in an integrated circuit, solves this problem. To allow the bridge to be balanced over the band of frequencies (10MHz) adjustment for stray capacitance is provided. Two further refinements are provided. In cases where the return loss is less than 28dB, the error signal may exceed the "window" of the differential amplifier. To allow for this, a built-in -10dB pad may be switched in to attenuate the source signal. To calibrate the error signal displayed on the oscilloscope, a 2% reduction in impedance can be switched into one side of the bridge. This represents 40dB return loss. For accurate measurement of the loss, the oscilloscope amplitude is noted at frequencies of interest, and the unknown impedance disconnected; an attenuator inserted in the source feed is then set to give the same oscilloscope deflection as before. The attenuator setting in dB is the return loss of the unknown impedance. The bridge measures $18.5 \times 117 \times 56$mm and is available in battery- or mains-operated version. Price: £45 (battery), £50 (mains). Michael Cox Electronics, 56 Upper Grotto Road, Twickenham, Middlesex.
WW 301 for further details

Precision Crystal Oscillator

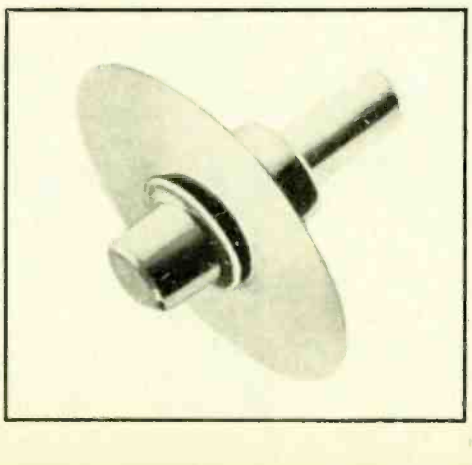
Extremely high stability is claimed by the manufacturers, Ebauches S.A., of Switzerland, for oscillator type B-1322, which is available in the frequency range 8kHz to 5MHz. A choice of sinewave or squarewave output is provided. The parameters of the squarewave make the oscillator suitable for feeding directly into i.cs without the need for intermediate buffer stages. Both the oscillator circuit and quartz crystal are contained within a proportionally controlled oven as protection against changes in ambient temperature and all connections are made via solder terminals on the base of the unit. A hermetically sealed version is produced. To compensate for crystal ageing the oscillator frequency can be adjusted by 5 parts in 10^6. Typical performance features for a 1-MHz oscillator include an ageing rate of 1 part in 10^9 per day after 30 days, and a frequency variation with temperature of less than 5 parts in 10^8 over the range $-40°$ to $+75°$C. Output voltage is 1V r.m.s. (sinewave) and the supply required is 12 or 24V d.c. U.K. agents: Newmark Instruments Ltd., 143-149 Great Portland Street, London W.1.
WW 302 for further details

Ten-way Delay Line

A wide choice of close tolerance delay times from 2.5ns to 500ns, all from one size module, are provided by a tapped delay line named Silver Star by the Johnson Matthey Group. The module comprises ten tapped equal delay sections encapsulated in epoxy resin and measuring $66 \times 12.7 \times 8.1$mm. Maximum working voltage is 125V d.c. and terminal wires are spaced to suit p.c. boards' 2.54mm matrix. Full technical information is available from: Matthey Printed Products Ltd., William Clowes Street, Burslem, Stoke-on-Trent, Staffordshire ST6 3AT.
WW 303 for further details

Microwave Oscillator Transistor

A special arrangement of the base and emitter terminals of RCA's transistor TA7403 makes for possible increased efficiencies in microwave equipment operating in the L and S bands. Th is a new silicon overlay transistor intended primari for power oscillator applications in receivers ar power sources, and it features a low-loss ceramic metal coaxial package with low inductance ar low parasitic capacitances. The TA7403 is simil to the 2N5470 except that the external feedbac required by the 2N5470 to sustain oscillations not required. A typical unit operated at 21V ca provide 600mW of power at 2GHz with 25% efficiency, and 100mW at 3GHz. RCA Grea Britain Ltd., Lincoln Way, Windmill Road, Sun bury-on-Thames, Middlesex.
WW 304 for further details



Dynamically Balanced Thyristors

By adjusting the parameters of thyristors to opti mum values, Mullard has produced a new range c dynamically balanced types which do not requir compensation networks often necessary with con ventional thyristors. Five devices in the new serie are labelled type BTX92 followed by suffix 800, 900, 1000, 1100 or 1200 as a direct indication o the crest working reverse voltage. Average on-stat current is 16A and maximum junction temperatur is 125°C. These thyristors have shorted gate-to cathode structures and use field-assisted turn-o techniques. They can tolerate rapid increases i voltage and current and will operate under arduou conditions. The dV/dt and dI/dt ratings are 200V/μs and 100A/μs respectively, coupled with an I^2t rating of 400A^2/S. Encapsulation used is SO-36 Mullard Ltd., Torrington Place, London W.C.1.
WW 305 for further details

Crystal Oscillator for Printed Circuits

A thick-film oscillator which can be preset to any frequency in the range 5 to 75 MHz, and is designed for mounting on a 2.54mm printed circuit matrix, has been added to the Salford crystal oscillator range. The new oscillator, type QC1260 is hermetically sealed and operates from a 9V d.c. supply. Output is 500mV sinewave into a 50-Ω load. Initial tolerance is quoted as ± 10 p.p.m. at 25°C and frequency variation over the temperature range $-30°$ to $+80°$C is 30 p.p.m. Salford Electrical Instruments Ltd., Peel Works, Barton Lane, Eccles, Manchester.
WW 306 for further details

Television Aerial Tester

A Siemens signal level meter (so called by the manufacturer although it does not operate on the m/c meter principle) for measuring TV receiving aerial signals of any transmission standard is introduced to the U.K. by Cole Electronics. An oscilloscope display is incorporated and the amplitudes of the signal under test are displayed on the screen as a function of time. Time deflection is at field or line frequency selected by a switch. Facilities are provided for control of the vision channel frequency response enabling the related sound signal to be measured thus obtaining the two principal measurement points in any one TV channel. The measurement method used is specially adapted for television signals. A test pulse added to the signal during deflection, is adjusted in amplitude to the desired test level, the amplitude control being linked to the front scale. (The test level of interest will normally be the peak white level, or the sync pulse level, depending on the direction of modulation.) When the r.m.s. voltage corresponding to the highest amplitudes of modulation V_k is related to the reference voltage V_o the ratio is presented as a dB figure. The channel level N_k (20 log V_k/V_o) can be read off the scale in decibels above 1μV, since the scale calibration

$V_0 = 1\mu V$. A blanking pulse added to the signal place of the test pulse enables aerial orientation be optimized. Frequency coverage is continuously riable over the three bands 40 - 100, 160 - 230 ıd 470 - 860MHz. Inputs at r.f. have an impedance ˙ 60 Ω (nominal) and measurements can be made om approximately 26 to 129dB, corresponding ı 20 μV to 3V. Operating power can be obtained om 220V 50Hz mains or 12V d.c. Dimensions of ıe instrument, type SAM390, are 410 × 110 ; 400mm. U.K. agents: Cole Electronics Ltd., -15 Lansdown Road, Croydon, Surrey, CR9 2HB.
VW 307 for further details

)ual Output Pulse Generator

łodel PG-23 by Lyons Instruments is a silicon ansistor pulse generator providing rise and fall mes better than 5ns, repetition rates from 1Hz ı 10MHz, single or double pulse (20MHz effective ngle pulse rate) or square wave, plus wide range ɔntrol of pulse width (20ns to 200ms) and of elay (−10ns to +200ms). Simultaneous positive ıd negative outputs are available which are vari-ɔle independently over a 40dB range up to 10V ıto 50 Ω. A normal/complement facility is pro-

vided independently on each output. Outputs are fully protected against short-circuit. Other facilities include manual one-shot operation, synchronous gating and variable width sync output pulse. Dimensions are 60 × 380 × 355mm and the price £235. Lyons Instruments Ltd., Hoddesdon, Hertfordshire.
WW 308 for further details

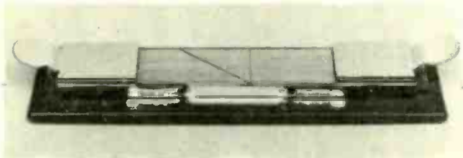
Digital Universal Testmeter

Model X-3A by N.L.S. of California is a multi-function meter with digital readout. It is of i.c. construction using logic techniques avoiding the use of separate plug-in function modules. All functions are selected by a front panel mode switch. Measurements are: d.c. volts from 10μV to 1kV in six ranges; a.c. volts from 0.5 to 300V in three ranges; ohms from 10m Ω to 2000M Ω in nine ranges; and current from 10pA to 200mA in eight ranges (2A with external shunt). A "HI-MED-

LO" switch simplifies operation in production line testing, and an analogue output, scaled zero to ±6V at 1mA, can be used to drive an alarm monitor or recorder. A fourth digit 100% over-range virtually doubles the measurement capability. U.K. agents: General Test Instruments Ltd., Gloucester Trading Estate, Hucclecote, Gloucestershire GL3 4AA.
WW 309 for further details

25mm Tape Splicer

A one-inch (25mm) magnetic recording tape splicer is announced by Multicore, based on their ¼-in and ½-in models. It enables diagonal or butt joins to be made in the wider tape used for video recording and computer work. Two swinging



clamps grip the tape in the channel of the splicer block which is chrome finished and mounted on a plastics base. Price of the splicer, type 22, complete with tape cleaning accessories is £7 18s. (£7.90). Multicore Solders Ltd., Hemel Hempstead, Hertfordshire.
WW 310 for further details

I.F. Receiver

Micro-Tel Corporation, of America, has announced that their new i.f. receiver, model IF240, is available in the U.K. from B & K Instruments. This receiver is designed for aerial pattern measurements, attenuator calibration and measurement, and as a general purpose laboratory receiver. Commonly available signal sources can be used as local oscillators and an internal a.f.c. system minimizes the need for a.f.c. to be applied to the local oscillator, although a d.c. output voltage is available for

this purpose if required. An internal step attenuator permits i.f. substitution measurements up to 103dB and a sample of the swept output of the amplifier is displayed on a c.r.t. to provide a tuning aid for microwave signals. A bolometer output is available at the front panel. Source level compensation, crystal current, a.f.c. and normal or expanded reference levels are indicated on a panel meter. Input is at 75MHz c.w. or a.m. with i.f. bandwidths of 0.3, 5 or 100kHz. U.K. agent: B & K Instrument Ltd., 59 Union Street, London S.E.1.
WW 311 for further details

Control Knobs

Four new models, K4–7, have been introduced to the Rendar range of control knobs. The K4 model is designed with a built-in pointer and it can be supplied in many colours in phenolic or thermoplastic materials. Designed to fit spindle sizes from 0.125in to 0.281in (and comparable metric sizes), the K4 pointer knob measures 0.8in in diameter,

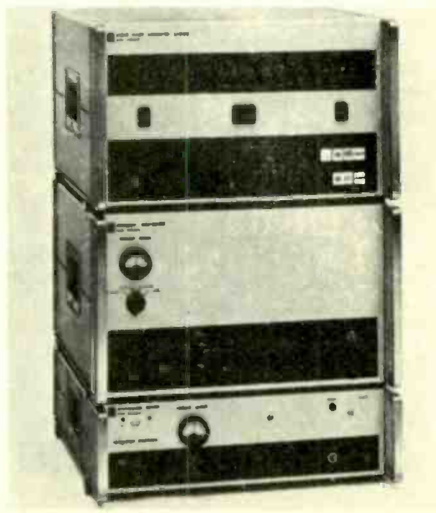
1.5in from handle end to pointer tip and 0.6in in depth. A similar but smaller pointer knob is also available, designated as the K7 model. Where faster positioning is required, a crank handle knob is available with a 1.25in diameter (K5 model) or 1.5in (K6). The knob fits on a 0.250in or 0.281in spindle and is moulded in a.b.s. plastics in various colours. New accessories include interchangeable figure dials and stators which permit easy change of knob function. Control knobs can be supplied in several finishes, including bright metal, polished brass and aluminium-turned. Rendar Instruments Ltd., Victoria Road, Burgess Hill, Sussex.
WW 312 for further details

Encapsulated Differential Amplifier

Differential amplifier type 15B-2 will accept direct signal injection, without an extra resistive input network, making it suitable for high impedance applications in bridge amplification, null detectors, voltage comparators and measurement of electrical potentials in biological research. Maximum supply and input voltage is ±18V; output voltage ±10V. Frequency response bandwidth is 1000kHz. Other details include input offset voltage 10μV/°C, input offset current 0.01nA, and input impedance 100,000M Ω. Operating temperature range is −30° to +80°C. The 15B-2 is totally encapsulated in a case measuring 51 × 30 × 15mm. Ancom Ltd., Devonshire Street, Cheltenham, Glos.
WW 313 for further details

Linear Sweep Generator

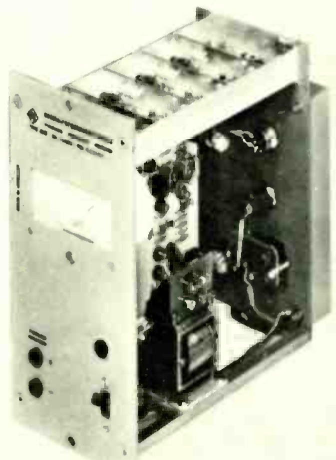
Barry Research model LSG-6 is a linear sweep generator providing highly accurate fixed or sweep-frequency signals in the range 0–50MHz. The sweep end-points are digitally selectable and the output frequency is an absolutely linear function of time. The design, based on the Hewlett Packard 5100 B frequency synthesizer, avoids the use of phase-locked loops and yet obtains phase- and amplitude-continuous frequency switching (except across the four, integer 10MHz transitions). The



spectrum of the output signal is said to be exceptionally pure and permits signal arrival-time measurements to an accuracy of 100ns. The generator is entirely solid state with plug-in digital circuit boards. Digital frequency readout is provided. Barry Research, 934 East Meadow Drive, Palo Alto, California, 94303, U.S.A.
WW314 for further details

Comparison Frequency Standard

Rapid monitoring of secondary frequency standards and electronic counters using the highly stable Droitwich long-wave transmitter as a frequency reference is made possible by type XKD standard frequency receiver by Rohde & Schwarz. This unit receives the 200-kHz signal emitted by the Droitwich transmitter and compares it with the 100kHz output of the equipment under test. If the two frequencies are not in synchronism, the recurrence



frequency and rise tendency of the sawtooth signal delivered by the XKD gives information about the magnitude and direction of the phase and frequency deviation. A built-in meter has an error ($\Delta f/f$) of less than 3×10^{-8}. If a recorder is connected to the set, the measurement error is smaller than the error of the Droitwich frequency standard ($\Delta f/f < \pm 5 \times 10^{-10}$). This instrument was first shown at the 1968 Hanover Fair. Rohde & Schwarz, Mühldorfstrasse 15, Munich 80, Germany.
WW315 for further details

A.F. Filters

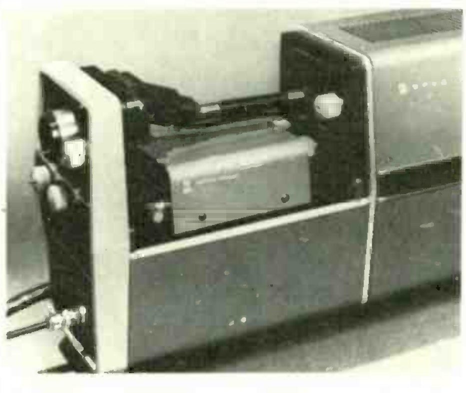
Audio active filters announced by M.C.P. Electronics have applications in tone squelch systems in mobile radio telephones and in radio remote control systems employing multi-tone switching. The filters come in three separate families. First are the BPF1500 bandpass series offering a choice of centre frequency between 5Hz and 10kHz with a stability of $\pm 0.3\%$, over an operating temperature range $-30°$ to $+70°$C. A Q of $50 \pm 10\%$ is achieved with 20dB rejection $\pm 5\%$ of centre frequency. Next come type LPF1101 thick film low-pass active speech filters with a specified 18dB per octave cut-off. Cut-off frequencies between 20Hz and 20kHz can be provided. Operating voltage can be from 6 to 15V and power consumption is 5mW. Lastly there is a series of active filters designed as substitutes for mechanical reeds and may be used in the same circuitry. It employs a Wein bridge in conjunction with a low-voltage monolithic amplifier and has a frequency stability of better than $\pm 0.3\%$ over the temperature range $-30°$ to $+70°$C. Centre frequencies range from 5Hz to 10kHz and the Q is $40 \pm 20\%$. Prices of these items are from £10 to £20 depending on requirement specifications and quantity. M.C.P. Electronics Ltd., Alperton, Wembley, Middlesex.
WW316 for further details

Microwave Oscillator Transistor

A microwave transistor, featuring a coaxial package with a special arrangement of the base and emitter terminal connections that makes possible increased efficiencies in self-excited power oscillators used in microwave equipment, is announced by RCA of America. This new silicon overlay transistor, type TA7403, is intended primarily for power oscillator applications in receivers and power sources that operate in the L- and S-band ranges. It features a low-loss, ceramic-metal, coaxial package with low inductance and low parasitic capacitances and it can be mounted in coaxial, stripline, and lumped constant oscillator circuits. The emitter is connected to the flange for increased internal feedback to provide higher efficiency at S-band frequencies in Colpitts oscillator circuits. The TA7403 is similar to the 2N5470 except that the internal base-to-emitter connections have been reversed, thus dispensing with external feedback between collector and emitter to sustain oscillations. A typical unit operated at 21 volts can provide 0.6 watt of power at 2GHz with 25% efficiency; and provide 100mW at 3GHz. RCA/Electronic Components, 415 South Fifth Street, Harrison, N.J.07029, U.S.A.
WW317 for further details

Laser Accessory

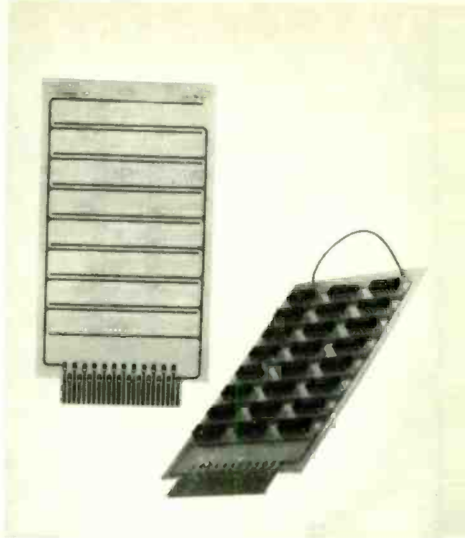
Mode locking accessory, model 360 by Spectra-Physics, is able to convert the output of their model 125 helium-neon laser into a narrow pulse-width generator. The 125/360 combination generates a precise train of extremely narrow pulses with peak power greater than 1W. The 360 is used as the controlling element in an oscillating servo-loop. Pulse spacing is approximately 13ns. Narrow band frequency modulation of the 125/360 system at a frequency rate of 75MHz



$\pm \Delta f$ is possible by disconnecting the feedback circuit and inserting an external modulator into the element. Spectra-Physics Ltd., Queensway Estate, Glenrothes, Fife, Scotland.
WW 318 for further details

24-package I.C. Card

Cardic 24 is a copper clad, epoxy glass laminate card by A.P.T. for mounting up to 24 i.cs, dual in line, 14 or 16 leads. Printed power supply leads run to each i.c. and a 24-way edge connector provides plug-in facilities at 2.54mm pitch. The cards are designed to allow easy insertion and withdrawal of i.cs without damage to the device or wiring. They measure 165 × 89mm and cost



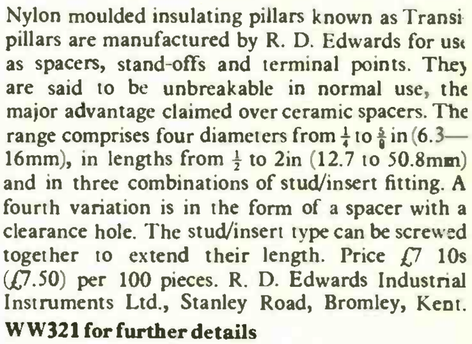
£1 2s (£1.10). These cards also form part Lektrokit assembly number 10 which incluc components for a complete rack mounting fram work with 12 sockets, guides and Cardic 24 car for £23 10s (£23.50). A.P.T. Electronic Industri Ltd., Chertsey Road, Byfleet, Surrey.
WW 319 for further details

Impedance Meter

The ability to measure quickly and witho calculation, any complex impedance, such those met with in aerials, transmission line filters, capacitors, inductance coils etc., is pr vided by the Metrix impedance meter ty IX704A. The instrument comprises two unit a measuring unit, made up of a 50-Ω rigid coaxi line fitted into a standard chassis with detecto fixed along the length of the coaxial element t measure the r.f. voltages taken at different poin of this line; and a computing unit which consis of three printed discs designed around the Smit chart. The magnitude of the various r.f. voltag are displayed on three independent meters. Th IX704A has a bandwidth of 50-1000MHz. IT Metrix, Chemin de la Croix-Rouge, Boite Postal 30-74, Annecy, France.
WW 320 for further details

Pillars and Spacers

Nylon moulded insulating pillars known as Transi pillars are manufactured by R. D. Edwards for us as spacers, stand-offs and terminal points. They are said to be unbreakable in normal use, the major advantage claimed over ceramic spacers. The range comprises four diameters from ¼ to ⅝ in (6.3—16mm), in lengths from ½ to 2in (12.7 to 50.8mm) and in three combinations of stud/insert fitting. A fourth variation is in the form of a spacer with a clearance hole. The stud/insert type can be screwed together to extend their length. Price £7 10s (£7.50) per 100 pieces. R. D. Edwards Industrial Instruments Ltd., Stanley Road, Bromley, Kent.
WW321 for further details



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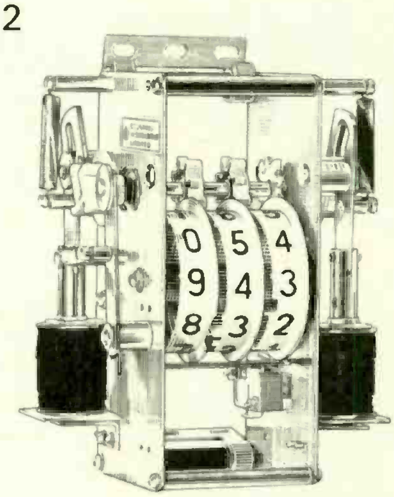
WW—116 FOR FURTHER DETAILS

Know the latest from C.I.

No. 2



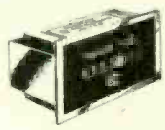
Count up, count down counter SERIES 943

Now in quantity production, this new C.I. counter has been produced with the needs of the Gaming and Amusement Machine manufacturers in mind. Nevertheless, it will have many other outlets where a robust unit of uncomplicated design is needed.

The three drum wheel bank can be indexed by solenoid actuators in either direction. The wheel bank registers from 000 to 999 where a stop prevents an additional pulse zeroing the wheels. Similarly the counter cannot subtract from 000 to 999. When readout is 001, a subtract pulse will find 000 and a change-over micro-switch will operate. Approximately $6\frac{1}{2}''$ high, $4\frac{1}{2}''$ wide, $3\frac{1}{2}''$ deep. 230 volts. AC 50 cycle supply. Other operating voltages available.

ELAPSED TIME METER SERIES 36

Records time in hours and tenths of hours an electric circuit or machine has been in use: provides data on servicing and plant maintenance.



COUNTING INSTRUMENTS LIMITED
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Please send details of Series 943 Counter
Series 36 Elapsed Time Meter

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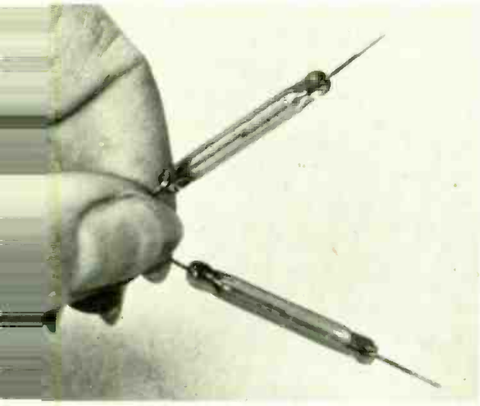
WW—117 FOR FURTHER DETAILS

eed Switch

ong-life reed switch, type RL 12, meeting G.P.O. cification T4547, is available from Mullard. force equivalent to 58 ampere-turns ensures sure of the contacts, and 27 ampere-turns will



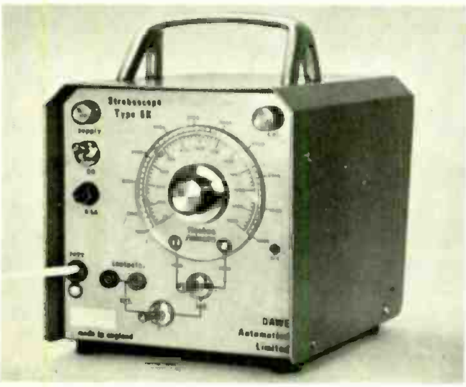
ld them closed. Closure time is 1ms and release ne 50μs. Current of 100mA can be switched t 1A can be carried by the closed contacts. Inlation resistance between the reeds exceeds)^{5}M Ω and minimum breakdown voltage is 1000V. esonant frequency is approximately 1650Hz. mbient operating temperature range extends om $-55°$ to $+100°$C. Mullard Ltd., Mullard ouse, Torrington Place, London W.C.1.
W 322 for further details

.C. Connectors

escribed as microminiature connectors for use ith standard 1.6mm circuit boards, series 1064 announced by Ultra Electronics. The contact itch is only 1.27mm between centres which is id to adequately meet the demand for a high ensity package. Diallyl phthalate is used for e body and the contacts are gold-plated. Connecors are supplied with double-sided contacts in izes ranging from 10+10 to 64+64 contacts. Contacts are designed to grip the surface area of he board over the effective length of the contact rea thereby eliminating local high-spots and educing contact resistance. It also enables low ontact pressure to be used permitting easier inertion and withdrawal. The two- or four-row erminals can be selected for solder or spot weld onnection. Ultra Electronics (Components) Ltd., 419 Bridport Road, Greenford, Middlesex.
WW 323 for further details

Versatile Stroboscope

Observation of cams, gears, motors and vibrating parts is provided by a white light stroboscope, type 6K, manufactured by Dawe Automation. The instrument covers the rate 300-6000 flashes per minute in two ranges and is sufficiently powerful for photography. Triggering



is by means of an internal oscillator or contact closure and accuracy is 2%. A high-intensity flash tube with an output of 10W is incorporated. The instrument measures 165 × 215 × 165mm and weighs 3kg. Price: £45. Dawe Automation Ltd., South Hill Lodge, South Hill Avenue, Harrow, Middx.
WW 324 for further details

Metal Oxide Resistors

High-voltage probes for digital voltmeters, meter multipliers, deflection circuits etc, are specific applications for an extended range of metal oxide glaze resistors by Victoreen with values up to 2500M Ω. The MOX3, MOX4 and MOX5 series employ thick-film techniques and are based on the standard $\frac{1}{4}$-in (6.3-mm) overall diameter size and are respectively 76, 102 and 127mm long. They can withstand 7.5kV per 25mm of the length for resistance values above critical and can dissipate 2.5W per 25mm of length below critical resistance values at 70°C. Temperature coefficients range from 200 to 600 p.p.m. Tolerances available are down to $\pm 0.5\%$ and stability is less than 1% full-load drift in 2000 hours. U.K. agents: Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, London W.C.2.
WW 325 for further details

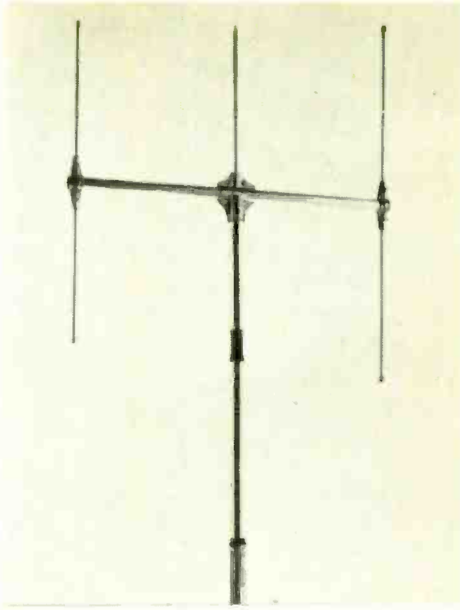
Radio "Bug" Detector

Radio "bugging" equipment used for industrial espionage is the target of a new detection device by Leonard Wadsworth & Co. This counter-espionage tool is a sweep unit which will detect the presence of a.m. or f.m. radio transmitters operating between 10 and 250MHz, at a distance of 8 metres. The frequency range is swept in sequence through four bands and when a note

is heard the instrument locks on to the signal which, say the makers, enables the operator to determine if the signal is from a legitimate local transmitter or from a clandestine unit. Having established that the room contains hidden illegal equipment, a probe enables the offending equipment to be located. Leonard Wadsworth & Co. Ltd., Broadway House, Broadway, London S.W.19.
WW 326 for further details

V.H.F. and U.H.F. Communications Aerials

Telecommunications aerials introduced by J Beam comprise a double 8-element slot-fed Yagi array and a 12-element heavy-duty array, both for u.h.f., and an end-fed Yagi and an end-fed single dipole for v.h.f. A feature of the v.h.f. Yagi, which is designed for operation in the frequency range 50–250MHz and is shown in the photograph, is the dual use of a coaxial air-spaced matching stub which also forms the aerial mounting. This does not interfere with the radiating portion of the aerial and does not introduce any distortion or coupling. No insulator is required at the centre of the dipole so that a rigid mechanical structure is possible.



Similarly, on the standard dipole model a socket on the base of the aerial enables the lower end of the dipole and feeder to be fitted inside a scaffold mast. J Beam Engineering Ltd., Rothersthorpe Crescent, Northampton.
WW 327 for further details

Photoelectric Keyboard

Disadvantages associated with mechanical switches in data entry keyboards have been eliminated in the PK 200 series keyboard, announced by the Digitronics Corp., of New York, which features photoelectric encoding. Depressing a key causes shutters to move which interrupt light beams, the resultant light pattern being detected by photocells. The photocells' resistance value is changed from 3000 Ω (logic 0) to 200k Ω (logic 1) and a data strobe is generated with each key operation to ensure proper sampling of data. Layouts can contain from 10 to 75 keys; the basic unit includes all the characters and functions normally required for data input operations. Digital code output can be any selected code containing up to 14 bits. U.K. agents: BFI Electronics Ltd., Sinclair House, The Avenue, London W.13.
WW 328 for further details

Stable F.M. Tuner

A new crystal-controlled f.m. tuner unit by S.N.S. Communications comes in two versions: type FMT/1C single channel; and type FMT/4C four-channel switched unit. The unit comprises an r.f. amplifier, mixer with separate crystal oscillator, four stages at i.f., detector and audio amplifier. Power requirement is 9V d.c. 15mA, and an optional power unit, type PSU 2, is available. Sensitivity is given as 10μV for 30dB signal-to-noise ratio, reception being within the frequency range 88-100MHz. Output via an unbalanced screened lead is 5k Ω impedance, the level continuously variable 0-500mV at 22.5kHz deviation. The screen can be connected to the positive or negative line (positive common line is fitted as standard). Bandwidth of the i.f. channel is 350kHz and i.f. rejection is 50dB. Image rejection 55dB. Model FMT/4C is switchable over 6MHz, but for optimum performance over the four channels, the sensitivity figures become slightly impaired. The unit size is 51 × 102 × 152mm deep. S.N.S. Communications Ltd., 851 Ringwood Road, West Howe, Bournemouth, Hants.
WW 329 for further details

World of Amateur Radio

Amateur Radio in Czechoslovakia

Notwithstanding the political difficulties currently existing in Czechoslovakia amateur radio continues to prosper under the new Federal Republic which came into existence on January 1st. The new Republic consists of two separate republics—Czech and Slovak. The Czech republic comprises the historic territories of Bohemia (amateur prefixes OK1, OL1-5) and Moravia and Silesia (OK2, OL6 and 7), while the Slovak republic consists of the eastern part of the country (OK3, OL8-0). Thus in spite of internal changes, amateur prefixes have not been changed. The position regarding the amateur radio organizations in the country is, however, undergoing change. In the Czech republic, a Czech-Moravian union of radio amateurs—Ceskomoravsky Avaz Radioamatero (C.R.A.)—has been established as successors to the earlier organizations C.A.V. and C.R.A. The new C.R.A. is quite distinct from the previous semi-military organization Svazarm (formed by the State in 1952) but in the Slovak republic Svazarm continues to hold sway (having the support of the State) and thus retains control over OK3 amateurs. However, amateurs in the eastern part of the country have formed an independent organization (Slovak Union of Radio Amateurs) which operates in partnership with C.R.A. The State authorities have not yet recognized the existence of S.R.A. but as both C.R.A. and S.R.A. are national-level societies within the Federal Republic they intend to form a common representative committee under the title Czechoslovakian Radio Amateurs (C.S.R.A.) for international purposes and to co-ordinate internal affairs between C.R.A. and S.R.A. Members of the committee of C.S.R.A. may thus, in due course become the supreme representatives of Czechoslovakian amateur radio at the international level. The only amateur radio magazine published in the country is issued by an official military authority. As no facilities exist for the transfer of money abroad Czechoslovak amateurs find difficulty in obtaining English or American technical publications.

Scientific Studies Bulletin

Prepared for the Scientific Studies Group of the Radio Society of Great Britain by Ray Flavell, G3LTP, of Wokingham, Berkshire, the "R.S.G.B. Scientific Studies Bulletin" is the successor of a series of Newsletters entitled "Project Lerwick" produced by Mr. Flavell for the Society during the International Quiet Sun Year (1965). The new publication begins just in time to take up the continuing story of scientific study at a period of sunspot maximum. The first issue (dated November-December 1968) was devoted in the main to summaries of what had been happening during the previous three years and included dates of solar rotations, Zurich sunspot numbers and Lerwick geomagnetic storm data all for the period 1966-1968. Of particular interest in that issue was an account by Alec Low, GM3GUI, of Friockhein, Angus, Scotland, of the auroral opening which occurred on October 31st–November 1st, 1968. The second issue (January 1969) recorded day-by-day coverage of solar and geophysical events, made possible, first, through the co-operation of the director of the Radio and Space Research Station, Slough (Dr. John Saxton) who provided copies of the daily "ursigramme" messages sent to Slough by teleprinter from Meuden, and second, through the assistance of Dr. W. F. Stewart of the Institute of Geological Sciences, Edinburgh, who provided geomagnetic data originating from Lerwick Observatory.

The I.A.R.U.

The current calendar of the International Amateur Radio Union records that with the recent admission of societies in Monaco, Mauritius and Surinam, Union membership has reached the all-time high of 80, of which total 33 are subscribing member societies in I.A.R.U. Region I Division (Europe, Africa and parts of Asia). During 1968 the world population of radio amateurs showed an average increase of 6.4% and of 6.1% in the case of licensed amateurs. The need for a strong international body was emphasized during the year when the International Telecommunication Union announced plans to hold a World Administrative Radio Conference on space communication during the late months of 1970. Because the World Conference is expected to discuss frequencies at present allocated to amateurs, I.A.R.U. member societies are being urged to ascertain the position being taken by their respective governments prior to the conference.

Applications for the I.A.R.U. Worked All Continents Award (W.A.C.) resulted in the issue during 1968 of 2000 certificates to amateurs in more than 20 countries. These awards included special endorsements for single sideband (837), teleprinting (3), Top Band (3) and 3.5 MHz (1) operation.

The calendar records that the Germ society (D.A.R.C.) has the largest number members (18,717) with the R.S.G.B. in seco place with 14,500. But, whereas, in Germa out of a total of 13,485 licensed transmitte 10,408 (75%) are members of D.A.R.C., t U.K. position reveals that out of a total 12,300 licensees only 7,500 (61%) are memb of R.S.G.B. As R.S.F. of the U.S.S.R. ha provided no statistical information since 196 their figures cannot be included. Th Yugoslav society (S.R.J.) reported a tot membership of 30,000 but only 4,800 (16% hold a transmitting licence.

International V.H.F. Convention

The Annual International V.H.F. Conve tion arranged by the V.H.F. Committee the R.S.G.B. will be held at the Winnin Post Hotel, Whitton, Twickenham, Middx., o Saturday, April 26th, when the guest honour at the dinner will be Col. St. Q. Severi O.B.E., a well known figure at postwar I.T.U Administrative Radio Conferences. Fu details of the programme can be obtaine from F. E. A. Green, G3GMY, 48 Boroug Way, Potters Bar, Hertfordshire.

S.S.B. 2-metre Contest

Tom Douglas, G3BA, of Coventry, wa the winner of the first 2-metre s.s.b. contes organized by the R.S.G.B. or any othe national organization. His score of 212 wa 17 points higher than that achieved b "Mike" Dormer, G3DAH.

"U.K.W. Beriche"

An English edition, of this well-known anc unquestionably the most up-to-date of al v.h.f. amateur radio publications, is now available. Originally printed in German the English version (published quarterly) can be obtained from D. Hayter (G3JHM), 4 Newling Way, High Salvington, Worthing, Sussex, who is the U.K. representative. The title of the English edition is *V.H.F. Communications.*

Vale O.M.

Harold Walker, who died recently at the age of 70, was one of the best-known amateurs in the early days. Operator of WBX prior to World War 1 and of 20M in the early '20s he helped to form the Radio Transmitters' Society in 1923. He became Treasurer under the chairmanship of Ian Fraser (now Lord Fraser of Lonsdale, C.H.) when his colleague, P. P. Eckersley, was president. Harold Walker joined the B.B.C. in December 1923 and became a member of the development (later research) department.

U.K. Licensing Authority

The new address of the Radio and Broadcasting Department of the Post Office—the licensing authority for amateur radio in the United Kingdom—is Waterloo Bridge House, Waterloo Road, London, S.E.1 (Tel. 01-928 7878).

JOHN CLARRICOATS (G6CL)

·est Your Knowledge

1. Transistor common emitter amplifier ındamentals

eries devised by L. Ibbotson,* B.Sc., A.Inst.P., M.I.E.E., M.I.E.R.E.

The small-signal a.c. input resistance of ıe transistor in the amplifier of Fig. 1 is 85k Ω The amplifier is fed from a small-ʒnal voltage source of low internal impe-ınce, and the amplifier output is open circuit. he mid-band voltage gain will be of the ·der of
(a) unity
(b) 70
(c) 140
(d) 210.

. Two exactly similar circuits as shown in ig. 1 are connected in cascade. The resulting ʌwo-stage amplifier is fed from a small signal oltage source of low internal impedance and ts output is open circuit. The mid-band voltage ˌain (expressed as a ratio) will be
(a) twice that of a single stage measured under similar conditions
(b) about $1\frac{1}{2}$ times that of a single stage measured under similar conditions
(c) the square of that of a single stage measured under similar conditions
(d) about half of the square of that of a single stage measured under similar conditions.

3. The voltage waveform shown in Fig. 2 is applied to the input of the amplifier shown in Fig. 1. The voltage waveform appearing at the output will be (apart from the amplification)
(a) the same as the input
(b) the same as the input, but delayed by $2\frac{1}{2}$ milliseconds
(c) the input inverted
(d) the input inverted and delayed by $2\frac{1}{2}$ milliseconds.

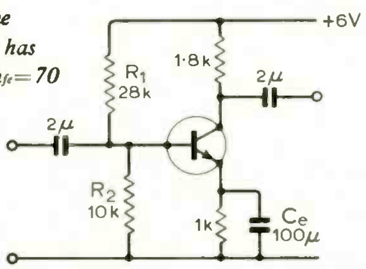
4. If the amplifier of Fig. 1 has the resistor R_2 removed
(a) the small-signal gain of the amplifier will increase, but the temperature stabilization will be lost
(b) the small-signal gain of the amplifier will fall to zero
(c) the amplifier properties will be unchanged so long as the temperature does not rise
(d) the transistor will be destroyed.

5. With no input signal the current in the base lead of the transistor in the circuit of Fig. 1
(a) has a conventional direction of flow into the transistor
(b) has a conventional direction of flow out of the transistor
(c) may flow in either direction
(d) is zero.

6. A tuned radio-frequency amplifier is shown in Fig. 3. The collector connection is made at the point P rather than Q
(a) to give an adequate bandwidth
(b) to prevent oscillation
(c) to improve the temperature stabilization of the stage
(d) to increase the gain.

7. Some radio frequency amplifiers have a circuit consisting of a resistor in series with a capacitor connected between X and Y in Fig. 3. The purpose of this is
(a) to reduce distortion
(b) to increase the bandwidth
(c) to provide automatic gain control
(d) to counteract the effects of internal feedback in the transistor.

Fig. 1. The transistor has α, β or h_{fe}= 70



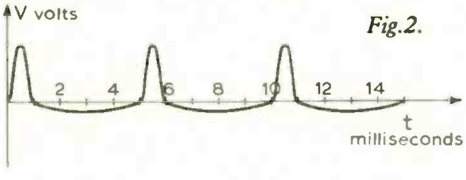
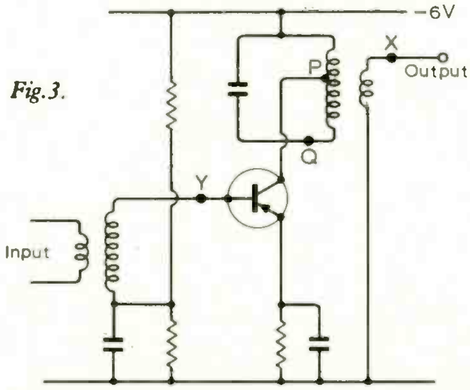


Fig.2.

Fig.3.



8. Fig. 4(a) represents an audio frequency power amplifier; 4(b) shows the collector characteristics of the transistor together with an a.c. load line and a maximum collector dissipation curve. The output transformer has a 1 : 1 turns ratio. The impedance of the loudspeaker (assumed resistive) is
(a) 3 Ω (b) 6 Ω
(c) 9 Ω (d) 12 Ω

9. The common emitter current amplification factor (α′, β or h_{FE}) of the transistor in the circuit of Fig. 4 has a value in the region of the operating point of about
(a) 20. (b) 40. (c) 50. (d) 70.

10. The maximum power output obtainable without gross distortion from the amplifier of Fig. 4 is about
(a) 250 milliwatts. (b) 2.5 watts.
(c) 5 watts. (d) 10 watts.

11. If in the circuit of Fig. 4 the output transformer were removed and the loudspeaker connected directly in the collector circuit, the maximum undistorted power output would
(a) remain the same
(b) increase
(c) decrease
(d) drop to zero.

12. The significance of the maximum collector dissipation curve shown on the characteristics in Fig. 4(b) is
(a) the load line must not cross it
(b) the load line may cross it at the low voltage end, but not at the high voltage end
(c) the load line may cross it at the high voltage end, but not at the low voltage end
(d) the load line may cross it at any point, but the operating point must not lie above it.

Answers and comments, page 193.

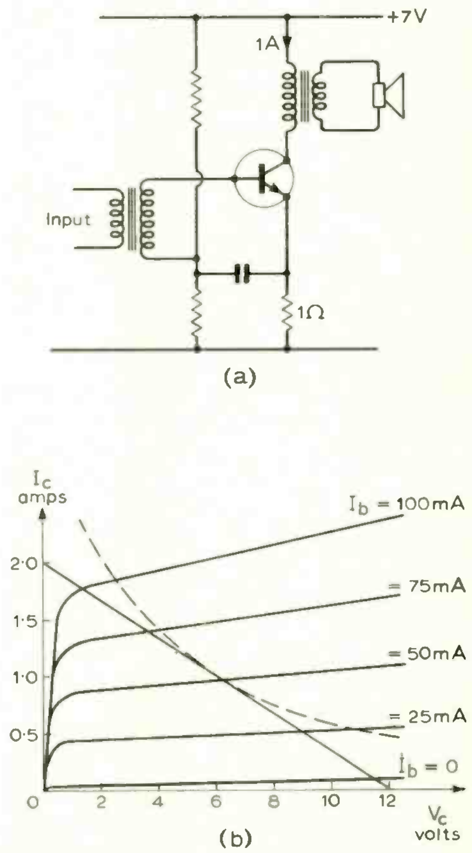


Fig.4.

*West Ham College of Technology, London, E.15.

April Meetings

Tickets are required for some meetings: readers are advised, therefore to communicate with the society concerned

LONDON

2nd. I.E.E.—"Low-noise travelling-wave tubes" by J. G. Armstrong, B. Dunford and J. Willard at 17.30 at Savoy Pl., W.C.2.

10th. I.E.R.E. & I.E.E.—Colloquium on "Modern trends in magnetic disc storage" at 15.00 at 9 Bedford Sq., W.C.1.

10th. Instn of Electronics—"Opto-electric semiconductor devices" by D. F. Dunster at 18.45 in the Manson Theatre, London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

11th. R.T.S.—"Recent developments in camera tubes" by A. C. Dawe at 19.00 at the I.T.A., 70 Brompton Rd., S.W.3.

14th. I.E.E. Grads.—"Robots" by Prof. M. W. Thring at 18.30 at Savoy Pl., W.C.2.

15th. I.E.R.E.—Symposium on "Communications and navigational satellites for ships and aircraft" at 14.30 at 9 Bedford Sq., W.C.1.

16th. I.E.E.—"Information display techniques" by D. W. G. Byatt at 17.30 at Savoy Pl., W.C.2.

16th. B.K.S.T.S.—"Recent research in the development of high-quality loudspeakers" by R. E. Cooke & L. R. Fincham at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

17th. I.E.E.—Discussion on "Electromagnetic and other flow measurements" at 17.30 at Savoy Pl., W.C.2.

17th. R.T.S.—Fleming Memorial Lecture "The open university" by Prof. Walter Perry at 19.00 at the Royal Institution, Albemarle St., W.1.

18th. I.E.E.—"Image orthicon targets" by Prof. R. L. Beurle and W. E. Turk at 17.30 at Savoy Pl., W.C.2.

21st. I.E.E.T.E.—"Tomorrow's Europe—the role of the electrical and electronic engineering industries" at 18.00 at I.E.E., Savoy Pl., W.C.2.

22nd. I.E.E. & I.E.R.E.—"Transcutaneous information" by Dr. T. A. Quilliam at 17.30 at St. Bartholomew's Hospital, E.C.1.

22nd. I.E.R.E.—"Hill-climbing self-optimization for industrial process control" by Z. J. Jelonek at 18.00 at 9 Bedford Sq., W.C.1.

23rd. I.E.R.E.—"The future of thin and thick films in micro-electronics" by Dr. P. L. Kirby at 18.00 at 9 Bedford Sq., W.C.1.

23rd. B.K.S.T.S.—"Some transistor amplifier problems and their practical solutions" by P. J. Baxondall at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

24th. I.E.E.—60th Kelvin Lecture on "Pursuit of measurement" by Prof. R. V. Jones at 17.30 at Savoy Pl., W.C.2.

24th. I.E.R.E.—"The marketing concept" by M. W. Lauerman at 18.00 at 9 Bedford Sq., W.C.1.

25th. I.E.E. Grads. — "Telemetry and remote control" by S. H. Woodham at 18.30 at the Assembly Hall, Westminster Technical College, Vincent Sq., S.W.1.

28th. I.E.E.—"Educational television" by W. Kemp at 17.30 at Savoy Pl., W.C.2.

30th. I.E.E.—Discussion on "Transistor microwave power amplifiers" at 17.30 at Savoy Pl., W.C.2.

BATH

17th. I.E.E.—"Electronics and the automobile" by W. F. Hill at 18.00 at the Technical College.

BELFAST

16th. I.E.E. Grads.—"Thyristors and their applications" by J. H. Parker at 18.30 at the Ashby Inst., Queen's University, Stranmillis Rd.

22nd. I.E.R.E.—"Modern methods of traffic control" by D. G. Hornby at 18.30 at the Ashby Inst., Queen's University, Stranmillis Rd.

BIRMINGHAM

24th. I.E.E.—"Teaching methods employed on the training of B.B.C. technical staff" by H. Henderson at 18.15 at the University of Aston, Gosta Green.

28th. I.E.E.—"Computers and design" by G. A. Montgomerie at 18.00 at M.E.B. Offices, Summer Lane.

BRIGHTON

22nd. I.E.E. Grads.—"The thyristor cycloconverter" by D. R. Aubrey at 18.30 at the College of Technology.

CAMBRIDGE

1st. I.E.E.—"The Cambridge one-mile telescope" at 19.30 at the College of Art & Technology.

CARSHALTON

22nd. S.E.R.T.—"Video tape recorders" by P. Leggatt at 19.30 at the College of Further Education, Nightingale Rd.

CARDIFF

1st. I.E.E. Grads.—"Amateur radio" by L. D. Watts at 19.00 at Llandaff Technical College.

CHELMSFORD

8th. I.E.R.E.—"Receivers for satellite ground stations" by P. J. Cott at 19.00 at the Civic Centre, Duke St.

14th. I.E.E.—"The management of major electronic projects" by J. W. Sutherland at 18.30 at the Lion & Lamb Hotel.

COLCHESTER

22nd. I.E.R.E.—"Man-machine systems engineering" by B. R. Gaines & Dr. J. L. Gedye at 19.00 at the University of Essex, Wivenhoe Park.

DUNDEE

29th. I.E.E. Grads.—"Information storage and retrieval systems for the engineer" by D. Anderson at 19.30 at the University.

DURHAM

23rd. I.E.E.T.E.—"The electron microscope, its development and application" by Dr. B. E. P. Beeston at 19.30 at the University Science Laboratories, South Rd.

EASTBOURNE

29th. I.E.E.—"Colour television" by B. J. Rogers at 18.30 at S.E.E.B., Westlords, Willingdon Rd.

EDINBURGH

1st. I.E.E.—"A model superconducting motor" by A. D. Appleton at 18.00 at the Carleton Hotel.

16th. I.E.E.T.E.—"Decca navigation" by A. Brooker-Carey at 19.00 at Heriot Watt University.

EVESHAM

22nd. I.E.R.E. & I.E.E.—"Interesting aerials" by M. Maclese at 19.00 at the B.B.C. Club.

FARNBOROUGH

22nd. I.E.E.—Lecture by Prof. E. R. Laithwaite at 18.30 at the Technical College, Boundary Rd.

LEEDS

15th. I.E.E. Grads.—"Aircraft equipment" by G. B. Sugden at 19.00 at the University.

MANCHESTER

1st. I.E.E.—"Government future policy with rega to technology" by I. Maddock at 18.15 at U.M.I.S.T.

17th. I.E.R.E.—"Trends in supervisory telemet ing systems" by G. S. Kermack at 19.15 at the Ren Bldg, U.M.I.S.T., Altrincham St.

23rd. I.E.E.—"Low-noise microwave amplifiers" D. Lynes at 18.15 at U.M.I.S.T.

MIDDLESBROUGH

2nd. I.E.E.—"Application of transistor techniques relays and protection of power systems" by F. Hamilton at 18.30 at the Cleveland Scientific Inst.

23rd. I.E.E. Grads.—"Radio control systems appli to models" by A. Pearson at 18.30 at the Clevela Scientific Inst.

NEWCASTLE-UPON-TYNE

9th. I.E.R.E.—"Satellite communications—state the art" by J. K. F. Jowett at 18.00 at the Inst. Mining and Mechanical Engrs., Neville Hall, Westga Rd.

NOTTINGHAM

22nd. I.E.E.—"Holography" by W. R. Bradford 18.30 at the University.

PARKSTONE

17th. I.E.E. Grads.—"Experimental speech recogn tion system" by A. Witts and "Principles and applic tions of data logging" by J. A. Whitfield at 18.30 at th Central Hotel, Ashley Cross.

PLYMOUTH

15th. I.E.E.T.E.—"Colour TV—principles an applications" by M. Cosgrove and I. M. Waters at 19.3 at the College of Technology, Tavistock Rd.

PRESTON

16th. I.E.E.—"The Institution—today and in th future" by Dr. G. F. Gainsborough at 19.30 at Harri College.

READING

24th. I.E.R.E.—"Computer graphics" by B. S Walker at 19.30 at the J. J. Thomson Physical Labora tory at the University.

SHEFFIELD

9th. I.E.E. Grads.—"Concorde" by H. Hill at 18.3(at the University.

SOUTHAMPTON

24th. I.E.E.—"The place of the technician in the engineering industry" by H. L. Haslegrave at 18.30 at the University.

29th. I.E.E. Grads.—"Thyristor controllers" by P. Bowler at 18.30 at the University.

SWANSEA

10th. I.E.E.—"The design and application of M.O.S. linear integrated circuits" by J. Roberts at 18.15 at University College.

29th. U.C. Radio Soc.—"Stereophony and high-fidelity audio" by J. Hamm at 19.30 at Faculty of Applied Sciences, University College.

TORQUAY

17th. I.E.E.—"Holography" by W. R. Bradford at 14.30 at Electric Hall.

WOLVERHAMPTON

24th. I.E.R.E.—"Television studio equipment and operations" by C. R. Longman at 19.00 at the College of Technology.

Late March meetings in London

26th. B.K.S.T.S.—"Paul Voigt's contributions to audio" (various speakers) at 19.30 at the Royal Institution, 21 Albemarle St., W.1.

27th. R.T.S.—"Television and data display techniques in civil aviation" by J. O. Clark and L. E. Hardy at 19.00 at the I.T.A., 70 Brompton Rd., S.W.3.

31st. I.E.E.—"Array thinning" by Dr. P. Matthews at 17.30 at Savoy Pl., W.C.2.

Answers to "Test Your Knowledge"–11

Questions on page 191

1. (*b*). Since the collector load (R_L) can be assumed to be much smaller than the output impedance of the transistor the current gain of the stage is approximately h_{fe}. Hence the voltage gain will be $h_{fe} R_L/r_{in}$ and $R_L \simeq r_{in}$.

2. (*d*). The second stage loads the first, and, since $R_L \simeq r_{in}$, approximately halves its open-circuit gain.

3. (*c*). It is a common fallacy that an amplifier of this sort produces a mid-band phase shift of 180°. It in fact produces a signal inversion which is the same as a 180° phase shift for a sinusoidal input signal only.

4. (*b*). The base current will be so large that the transistor will be driven into saturation.

5. (*c*). The current $(1 - \alpha)\ I_e$ flows into the base, the leakage current I_{CBO} flows out (the symbols have their usual meanings). This circuit tends to maintain I_e almost constant so that at high temperatures I_{CBO} may be greater than $(1 - \alpha)\ I_e$ and hence the net current flow is outwards; at lower temperatures the net flow is inwards.

6. (*a*). The effect is to decrease by auto-transformer action the L/C ratio presented to the transistor, thus reducing the loaded Q. This allows convenient values of L and C to be used in the tuned circuit (their product, of course, determines the frequency) without a damping resistor which would waste power and reduce the gain.

7. (*d*). This is one form of "unilateralization" which may be required if the internal feedback is large as it often is in germanium alloyed transistors.

8 (*b*). This can be deduced from the slope of the load line.

9 (*a*). It can be seen from the characteristics that a change of base current of 50mA at constant collector voltage corresponds to a change of collector current of about 1 amp.

10 (*b*). The maximum peak to peak swing of collector potential is about 11V, of current about 1.8A, for no gross distortion. This corresponds to a power output of $1.8 \times 11/8 \simeq 2.5$W.

11. (*d*). The base potential is effectively fixed, hence the emitter current cannot fall very far. With 1 amp of current the voltage drop across 6 Ω is 6V; the transistor will therefore be in saturation somewhere near the point on the current axis of the characteristics $I_C = 1$ amp.

12. (*d*). For a class A amplifier the operating point determines the maximum mean power dissipated in the transistor.

Literature Received

"Integrated Circuit Data Book" is a substantial 960-page volume listing all the digital and linear integrated circuits manufactured by Motorola and it forms a useful companion to the "Semiconductor Data Book" published earlier. The book gives performance data, test circuits and application notes, and, unusually, it includes an integrated circuit equivalents list. The book is available from The Modern Book Company, 19-21 Praed St, London W.2, at £2 10s plus 5s postage.

"Bulletin of Special Courses in Higher Technology, Management Studies and Commerce" is compiled by the London and Home Counties Regional Advisory Council for Technological Education, Tavistock House South, Tavistock Square, London W.C.1. It gives details of special advanced courses held in London and the Home Counties which do not regularly appear in college calendars or prospectuses. The bulletin, which consists of 117 pages, is available from the above address, price 9s.

We have received a copy of a booklet; **"Sound System Equipment"** Part 1, General; which sets out the decisions of the International Electrotechnical Commission regarding standardization. Copies may be obtained from the British Standards Institution, British Standards House, 2 Park St, London W.1, price 23s plus 2s postage.

A large wallchart giving information on **communications satellites** in general and Intelsat 3 in particular is available from: Marketing Services, E2/9043, TRW Systems Group, One Space Park, Redondo Beach, California 90278, U.S.A.; price $3.95.

Circuit details of a crystal clock employing plastic encapsulated transistors are given in application note number 34 from Ferranti Ltd., Gem Mill, Chadderton, Oldham, Lancs. The clock uses a 100kHz crystal oscillator driving monostable dividing circuits and will operate from an HP2 cell for about a year.
WW 401 for further details

"Noise at work" from Hewlett-Packard, 224 Bath Rd, Slough, Bucks, is a booklet which shows how the Hewlett-Packard noise generator can be used in a cross correlation technique in the design of process control systems.
WW 402 for further details

The latest edition of the **Radiospares catalogue,** Jan/March, 1969, is now available from Radiospares, P.O. Box 427, 13-17 Epworth St, London E.C.2.
WW 403 for further details

A new catalogue concerned with **coaxial connectors** of various shapes and sizes is available from Precision Connectors Ltd., 56/58 Green St, Forest Gate, London E.7.
WW 404 for further details

A guide to the structure of the British Electronic Valve Industry is given in a booklet published by B.V.A. and V.A.S.C.A. Copies of the booklet which is called "British Valve and Semiconductor Industry" are available from the General Secretary, B.V.A./V.A.S.C.A., Mappin House, 4 Winsley St, Oxford St, London W1N ODT.
WW 405 for further details

"Platinum" is the title of a booklet produced by International Nickel, Thames House, Millbank, London S.W.1. It gives details of the metal's properties, its alloys, composites and compounds and reviews its applications.
WW 406 for further details

A **teleprinter terminal unit** which forms a compact interface between a teleprinter and a radio receiver system is described in a leaflet from Redifon Ltd., Broomhill Rd, Wandsworth, London S.W.18.
WW 411 for further details

Details of the **materials and services** offered by Metals Research Ltd., Mє bourn, Royston, Herts, are given in a booklet received from the compan Most of the metals and metallic single crystals used in the electronics industı are listed; aluminium, cadmium, copper, indium, nickel, niobium, silver, tant lum, tungsten, etc.
WW 407 for further details

Logic design is the subject of three nicely produced technical papers publish by the Sprague Electric Company, North Adams, Massachusetts 01247. Tl titles are as follows **(1)** "Power Considerations in High-speed t.t.l. Logic **(2)** "A Comprehensive Look at Microcircuit Flip-flops and their Operatior **(3)** "Series 5400/7400 Integrated Circuit Application Guide".
(1) WW 408 for further details **(3) WW 410 for further detai**
(2) WW 409 for further details

Information on a range of **medium- and high-power thyristors** suitable fc invertor and other forced commutation applications is given in Technica Publication T/WEF from Westinghouse Brake and Signal Company Ltd., 8 York Way, Kings Cross, London N.1.
WW 419 for further details

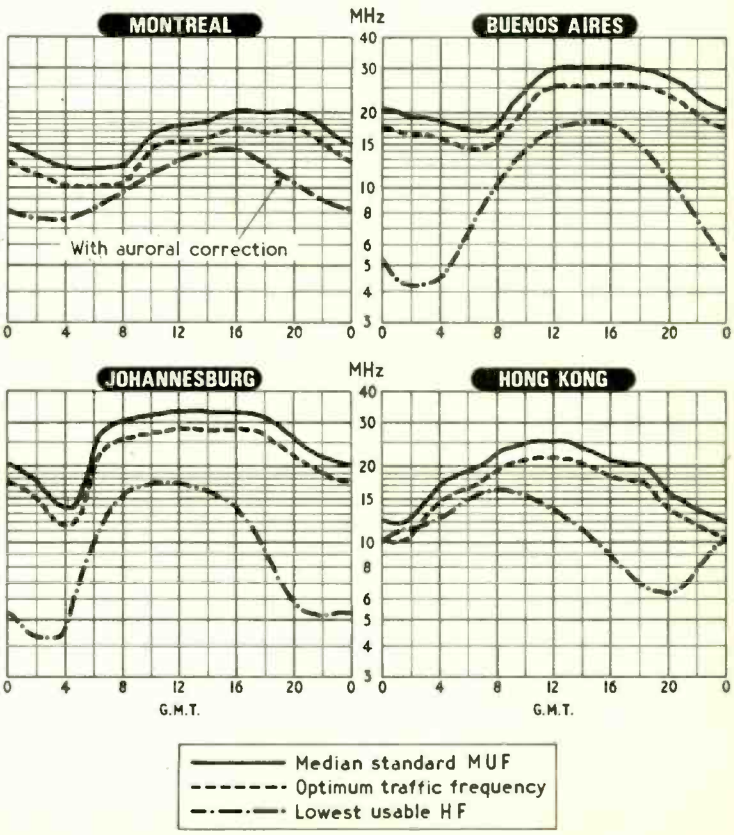
The model 5102 integrated circuit **operational amplifier tester** is describe in a leaflet **(1)** from Philbrick/Nexus Research, 81a North St, Chichester Sussex. The instrument will carry out a range of both static and dynamic tests From the same source we have received a brochure **(2)** giving details of 2 products concerned with analogue computing in general.
(1) WW 420 for further details **(2) WW 421 for further detail**

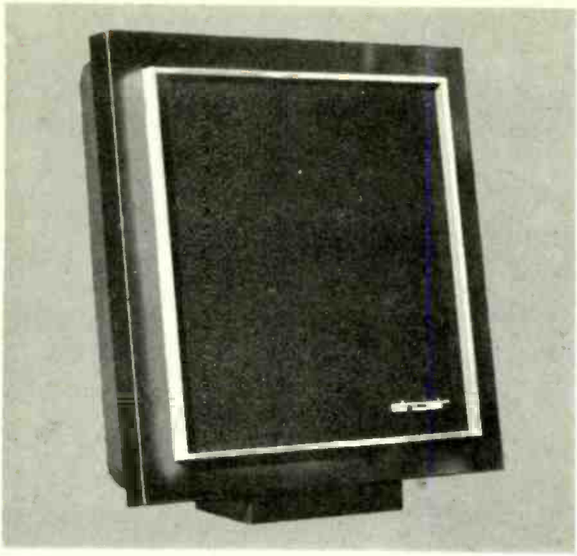
The range of **condenser microphones** handled by Ficord International Charlwoods Road, East Grinstead, Sussex, is described in a leaflet. In all sevei types are covered.
WW 425 for further details

H. F. Predictions—April

MUFs are based on predicted values of 104 and 94 for the ionospheric inde: IF2 and sunspot number respectively. By comparison with April 1968, which had values of 110 and 70, this means that the range of available frequencie: between FOT and LUF will be reduced about 10%.

LUFs depend partly on geographic variation of noise level and therefore unlike MUFs do not apply to both directions of the route. Those shown are prepared by Cable and Wireless Ltd. for reception in the United Kingdom of point-to-point telegraph services using medium-power transmitters and directional aerials.





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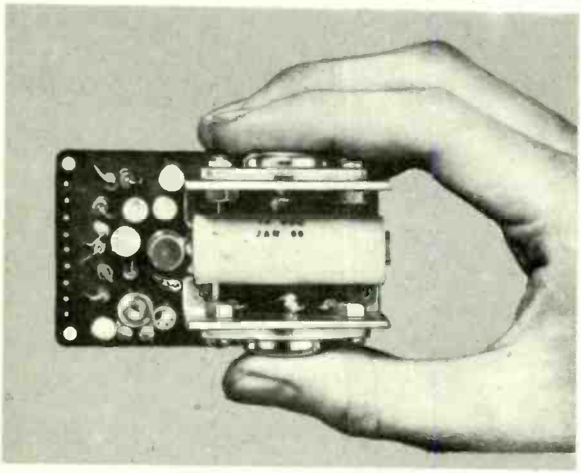

SINCLAIR Z.12

12 watt hi-fi amplifier/pre-amp

This eight transistor amplifier is the most successful of its kind ever designed and is easily adapted to a wide variety of applications. The Z.12 is supplied ready built, tested and guaranteed together with useful manual of circuits and instructions for matching the Z.12 to your precise requirements. Two may be used for stereo. Size—3in x $1\frac{3}{4}$in x $1\frac{1}{4}$in. Class B Ultralinear Output: Frequency response from 15 to 50,000Hz ± 1dB: Suitable for 3 to 15 ohm loudspeakers. Two 3 ohm speakers may be used in parallel: Input 2mV into 2k Ω Output 12 watts R.M.S. continuous sine wave (24 watts peak); 15 watts music power (30 watts peak). Power requirements 6—20V d.c. from battery or PZ.4 Mains Supply Unit.

89/6

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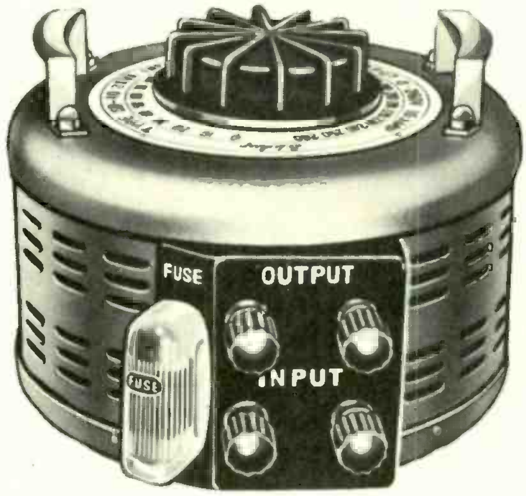

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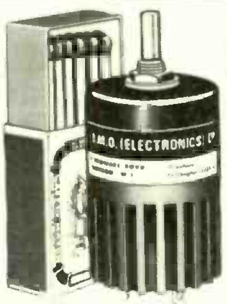

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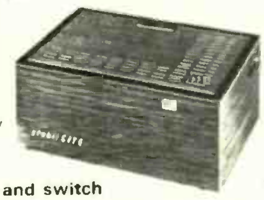

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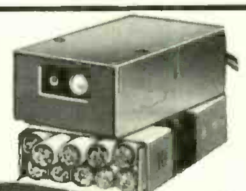

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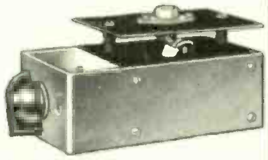

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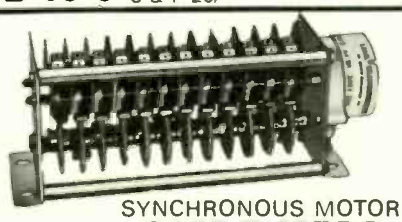

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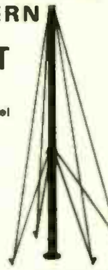

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2N711A	7/6	2G382	6/-	ASY29	4/4	GET102	6/-	OC28	12/-	SX636	10/8
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2N1302	5/-	2S018	8/6	AUY10	39/6	GET114	4/-	OC35	9/6	SVC1	17/4
2N1303	5/-	2S024	25/-	BA115	2/8	GET115	9/-	OC36	13/-	C426	8/3
2N1304	5/-	2S034	15/-	BAY38	3/-	GET573	7/6	OC41	3/6	P346A	6/-
2N1305	5/-	2S702	15/-	BCY30	7/-	GM378B	6/-	OC42	4/-	V405A	9/3
2N1306	8/-	AAY11	2/-	BCY31	9/-	OA5	3/8	OC43	5/-	EC401	5/-
2N1307	6/-	AAY30	2/-	BCY32	18/-	OA47	1/6	OC44	3/-	EC402	4/8
2N1308	10/6	AC107	14/6	BCY33	4/8	OA70	1/6	OC45	3/-	C111E	18/-
2N1309	10/6	AC126	6/6	BCY34	8/4	OA73	1/6	OC71	3/-	C400	9/-
2N2369	5/6	AC127	6/-	BCY38	8/-	OA79	1/6	OC72	4/6	2C111	45/9
2N2369A	7/6	AC128	4/-	BCY39	27/4	2xOA79M	4/6	OC73	3/-	2C425	32/-
2N2646	10/-	AC176	7/6	BCY40	13/4	OA81	1/6	OC75	5/-	EA403	3/6
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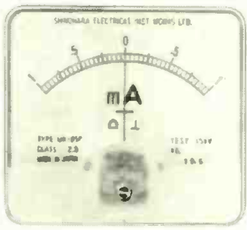

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Total dissipation (in free air, T_{amb} = 25°C.)........100mW. Derating Factor........2mW/°C. Output Current Intensity........100mA. Voltage........25V. Operating Temperature........from —30° to +125°C.
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Forward current I_F max. D.C.........400mA. Forward peak current I_F max.* (pk)........6A*
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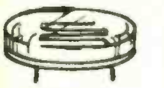
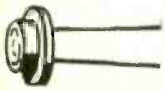


MKY251
Epoxy sealed 1¼ in. diam. x ¼ in. thick. Resistance at 100 Lux – 700 to 3,000 ohms. Maximum voltage 200 A.C. or D.C. Maximum current 500 mW. **12/6** *post free*



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MKY71
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These have a higher dark resistance in a given period than Cadmium Sulphide Cells, indicating much faster response. Suitable for all Cds applications plus applications in chopper, electronic musical instruments, computer and other sophisticated circuitry. Time response shown in megohms is dark resistance measured 10 secs. after 400 Lux light intensity is intercepted.

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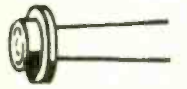

MKB12H
Hermetically metal sealed ⅜ in. diam. x $\frac{3}{16}$ in. thick. Time response 100 megohms. Resistance at 1,000 Lux – 100 ohms to 1,000 ohms. Resistance at 10 Lux – 1 Kohm to 10 Kohms. Maximum voltage 50 A.C. or D.C. Maximum current 80 mW. Continuous 30 mW. **16/6** *post free*

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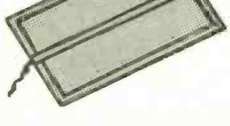

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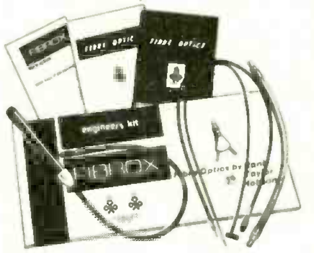

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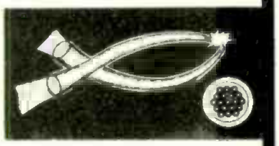

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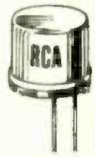

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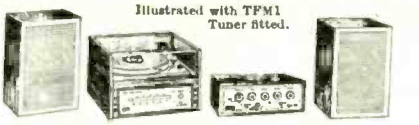

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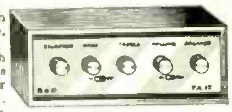
R·S·C· TA12 13 WATT STEREO AMPLIFIER



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STANTON IIIS Size 18 × 11 × 10in. Rating 10 watts. Incorporating Fane 803b speaker with roll rubber cone surround and 15,000 line magnet. High flux tweeter. Handsome Scandinavian design cabinet. Range 30-20,000 c.p.s. Impdnce. 3 or 15 ohms. Gives smooth realistic sound o'pt. **16 Gns.**

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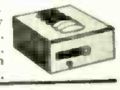

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300-0-300v. 100mA. 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 130mA, 6.3v. 4a., c.t., 6.3v. 1a. For Mullard 510 Amplifier	45/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	37/9
350-0-350v. 150mA, 6.3v. 4a., 0-5-6.3v. 3a.	47/9
425-0-425v. 200mA, 6.3v. 4a. c.t., 5v. 3a	69/9
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450-0-450v. 250mA. 6.3v. 4a., ct., 5v. 3a.	87/9
TOP SHROUDED DROP-THROUGH TYPE	
250-0-250v. 70mA, 6.3v. 2a., 0-5-6.3v. 2a.	21/9
250-0-250v. 100mA, 6.3v. 3.5a.	25/9
250-0-250v. 100mA, 6.3v. 2a., 6.3v. 1a.	26/9
350-0-350v. 80mA, 6.3v. 2a., 0-5-6.3v. 2a	27/9
250-0-250v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 100mA, 6.3v. 4a., 0-5-6.3v. 3a.	37/9
300-0-300v. 130mA, 6.3v. 4a., 0-5-6.3v. 1a. Suitable for Mullard 510 Amplifier	44/9
350-0-350v. 100mA., 6.3v. 4a., 0-5-6.3v. 3a.	37/9
350-0-350v. 150mA., 6.3v. 4a., 0-5-6.3v. 3a.	45/11

FILAMENT or TRANSISTOR POWER PACK Types 6.3 v. 1.5a. **7/9**; 6.3v. 2a. **8/9**; 6.3v. 3a. **10/9**; 6.3v. 6a. **21/9**; 12v. 1a. **8/9**; 12v. 3a. or 24v. 1.5a. **21/9**; 0-9-18v. 1½a. **17/9**; 0-12-25-42v. 2a. **29/9**.

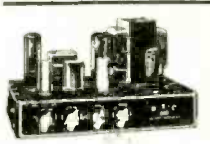
CHARGER TRANSFORMERS 0-9-15v. 1½a. **14/11**; 2½a. **17/9**; 3a. **19/11**; 5a. **23/9**; 6a. **27/9**; 8a. **33/9**.

AUTO (Step UP/Step DOWN) TRANSFORMERS

0-110/120v.-200-230-250v. 50-80 watts	15/9
150 watts. 29/11; 250 watts 49/9; 500 watts	99/9
OUTPUT TRANSFORMERS	
Standard Pentode 5,000Ω or 7,000Ω to 3Ω	8/9
Push-Pull 8 watts EL84 to 3Ω or 15Ω	12/9
Push-Pull 10 watts 6V6 ECL86 to 3, 5, 8 or 15Ω	22/9
Push-Pull EL84 to 3 or 15Ω 10-12 watts	21/9
Push-Pull Ultra Linear for Mullard 510, etc.	39/9
Push-Pull 15-18 watts, sectionally wound 6L6 KT66, etc., for 3 or 15Ω	35/9
Push-Pull 20 watt high quality sectionally wound EL34, 6L6, KT66, etc. to 3 or 15Ω	59/9

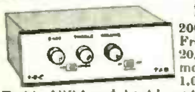
SMOOTHING CHOKES 150mA, 7-10H. 250Ω **12/9**; 100mA, 10H. 200Ω **10/9**; 80mA, 10H, 350Ω. **8/9**; 60mA. 10H, 400Ω **4/11.**

R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



Highly sensitive. Push-Pull high output, with Pre-amp./Tone Control Stages. Performance figures: Hum level —70dB. Frequency response ±3dB 30-20,000c/s. Sectionally wound output transformer. All high grade components. Valves EF86, EF86, ECC83, 807, 807, GZ34. Separate Bass and Treble Controls. Sensitivity 36 millivolts so that any kind of Microphone or Pick-up is suitable. Designed for Clubs, Schools, Theatres, Dance Halls or Outdoor Functions, etc. For use with Electronic Organ, Guitar, String Bass, etc. Gram. Radio or Tape. Reserve L.T. and H.T. for Radio Tuner. Two inputs with associated volume controls so that two separate inputs such as Gram and "Mike" can be mixed. 200-250 v., 50 c/s. A.C. mains. For 3 and 15 ohm speakers. Complete Kit parts wiring diags., instructions. Twin-handled perforated cover **27/6.** Supplied factory built with EL34 output valves. 12 months' guarantee for **17** gns. Tech. figs. apply to factory built units. Carr. 12/6 **14 Gns.** **TERMS:** Deposit **£5/14/-** and 9 monthly payments of **31/3** (Total **£19/15/3**). Send S.A.E. for leaflet.

R.S.C. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER



200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, 9½ × 2½ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Carr. 7/6 **6 Gns.** Or factory built with 12 months' guarantee. **8 Gns.**

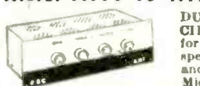
INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months.

R.S.C. COLUMN SPEAKERS

Covered in two-tone Rexine/Vynair. Ideal for vocalists and Public Address. 15 ohm matching. Type C57 15 watts inc. 5 × 7 × 4in. spkrs. **£7/19/11.** Type C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. **16 Gns.** Or deposit **65/-** and 9 mthly pmts. **34/9** (Total **£18/17/9**). Carr. 10/-

Type C412s, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. **24Gns.** Or Deposit **£4/13/6** and 9 monthly payments Carr. 15/- of **52/6** (Total **£28/5/-**).

R.S.C. A11T 15 WATT HIGH FIDELITY AMPLIFIER



DUAL PURPOSE P.A. or HI-FI SOLID STATE CIRCUITRY. ★ 3 input sockets. ★ 2 vol. controls for mixing purposes. ★ Input Selector. ★ Output for speakers between 3 and 15 ohms. ★ Separate Bass and Treble Controls. Suitable for Gram. Radio, Tape, Microphone, or Guitar P.U. For Vocal and Instrumental groups. Frequency Response 20-40,000 c.p.s.—3dB. Hum level —80dB. Harmonic Distortion 0.2% at 10 watts R.M.S. Operation on 200-250v. A.C. mains. Size 9½ × 2½ × 5½in. Complete Kit of parts with comprehensive wiring diagrams and instructions. **9 Gns.** Carr. 9/6

Or Factory built with 12 mths. guarantee **13** gns. Carr. 9/6. Terms: Deposit **£4** and 9 monthly payments **25/6** (Total **£15/9/6**).

R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams & instructions. Inc. Carr. **14 Gns.** Or factory built **16½** gns. Or in Teak finished cabinet as illustrated **19½** gns. Terms: Deposit **£5** and 9 monthly payments **£2.** Total **£23.**

★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Simple alignment instructions. ★ Output available for feeding tuning meter. ★ Output for feeding Stereo Multiplexer. ★ Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version. All parts **20** gns. Inc. Carr. Assembled **22½** gns. Inc. Carr.

12in. High Quality LOUDSPEAKERS

In teak veneered cabinets. 15 Watt Model. Gauss 11,000 lines. 3 or 15 ohms. **£5/15/-** Carr. 7/6

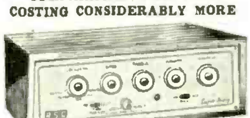
20 Watt Model. 15 ohm. Size 18 × 18 × 10in. Gauss 10,000 lines. Rexine covered **10/-** extra. **£8/19/9** Carr. 8/9

TWO-WAY 'PHONE AMPLIFIER

Listen and speak with both hands free. Handsome black case. Battery operated. **59/9**

R.S.C. SUPER 15 HI-FI AMPLIFIER

SOLID STATE



FULLY TRANSISTORISED 200/250v. A.C. Mains.
OUTPUT 10 WATTS R.M.S. continuous into 15 ohms.
15 WATTS R.M.S. continuous into 3-4 ohms.
TRANSISTORS. 9 current types of high quality by leading manufacturers.
5 POSITION INPUT SELECTOR SWITCH EQUALISATION to Standard R.I.A.A. and C.C.I.R. Characteristics for Gram and Tape Heads.
FULL TAPE MONITORING FACILITIES
SENSITIVITIES: Magnetic P.U. 4 mV. Crystal or Ceramic P.U. 400 mV. Microphone 4.5 mV. Tape Head 2.5 mV. Radio/Aux. or Ceramic P.U. 110 mV.
FREQUENCY RESPONSE: ±2 dB 20-20,000 c.p.s.
TREBLE CONTROL: +15dB to —14dB at 10 Kc/s. **NEG. FEEDBACK:** 52dB.
BASS CONTROL: +17dB to —15dB at 50 c/s. **HUM LEVEL:** —75dB.
HARMONIC DISTORTION at 10 watts 1.000 c.p.s. 0.2%

SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

Complete Kit of parts with full constructional details and point to point wiring diagrams. Carr. 12/6. **11½ Gns.** Supplied factory built. **15½** Gns. Carr. 12/6. Terms: Deposit **4** Gns. and 9 monthly payments **31/1** (Total **£18/8/9**). Or in Teak or Afrormosia veneer housing as illustrated. **19** Gns. COMPONENTS ETC. ARE OF A HIGH STANDARD AND SUPPLIED BY LEADING MANUFACTURERS.

R.S.C. SUPER 30 STEREO AMPLIFIER

A DUAL CHANNEL VERSION OF THE SUPER 15. Employing Twin Printed Circuits. High quality Ganged Pots. Matched Components. **CROSS TALK:**—52dB at 1,000 c.p.s.

CONTROL: 5 position Input Selector, Bass Control, Treble Control, Volume Control, Balance Control, Stereo/Mono Switch, Tape Monitor Switch, Mains Switch. **INPUT SOCKETS** (Matched Pairs). (1) Magnetic P.U. (2) Ceramic or Crystal P.U. (3) Radio/Aux. (4) Tape Head/Microphone. Operation of the Input Selector Switch assures appropriate equalisation. Rigid 18 s.w.g. Chassis. Size approx. 12in. wide, 3in. high and 8in. deep. Neon Panel indicator. Attractive Facia Plate and Spun Silver Matching Knobs. Above facilities, etc., except for Ganging and Balance control, apply also to Super 15.

THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Moving Coil, Ribbon) **CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USING WITH FIRST RATE ANCILLARY EQUIPMENT.** All required parts, point to point wiring diagrams and detailed instructions. Carr. 15/- **21 Gns.** Unit factory built **28** Gns. or deposit **£7/5/-** and 9 monthly payments **56/3** (Total **£32/13/3**). Or in Teak or Afrormosia Veneered housing. **31** Gns. Carr. 15/- or Deposit **£7/3/6** and 9 monthly paymts. **64/-** (Total £35/19/6). Send S.A.E. for leaflet

SELENIUM RECTIFIERS

F.W. Bridged 6/12v D.C. O/P Input Max. 18v. A.C. 1a., **3/11.** 2a. **6/11**; 3a., **9/9**; 4a., **12/9**; 6a., **15/9.**

Record Playing Units

MONEY SAVING UNITS Ready to plug into Amplifier

RP2 Consisting of Garrard SP25 Mk. II (with heavy turntable) fitted Goldring CS90 high compliance ceramic Stereo/Mono cartridge with diamond stylus. Mounted on plinth. Perspex Cover included. Carr. 15/-. **22**Gns. Plus 8/7 P.T. surcharge.

RP3 As above but with Goldring Lenco GL68 Transcription unit and CS90 Cartridge. Cover included. Inc. P.T. surcharge. Carr. 21/-. ONLY **£28**

R.S.C. PLINTHS

for Record Playing units. Teak finish cut for Garrard 1000, 2000, 3000, AT6, AT60, SP25 or Goldring GL68. Available with clear Perspex cover as illustrated. Inc. carr. **59/9** **6 Gns.**

Perspex cover sold separately at 3 Gns. Limited number of covers slightly damaged but repaired by Manufacturer. **39/9** to clear.

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R·S·C HI-FI CENTRES LTD.

MAIL ORDERS to: 102-106 Henconner Lane, Bramley, Leeds 13. No C.O.D. under £1. Terms C.W.O. or C.O.D. Postage 4/6 extra under £2. 5/9 extra under £5. Trade supplied S.A.E. with enquiries please. Hi-Fi Catalogue 4/6. **Open all day Sats. except High Holborn.**

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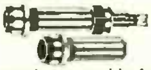
Postage and Carriage shown below are inland only. For Overseas please ask for quotation. We do not issue a catalogue or list.

LIGHT SENSITIVE SWITCHES

Kit and parts including ORP.12 Cadmium Sulphide Photocell. Relay Transistor and Circuit. Now supplied with new Siemens High Speed Relay for 6 or 12 volt operations. Price 25/-, plus 2/6 P. & P. **ORP 12 and Circuit 10/- post paid.**

220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 3 × 5 amp. mains c/o contacts. Price inc. circuit **47/6**, plus 2/6 P. & P.

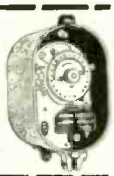
LIGHT SOURCE AND PHOTO CELL MOUNTING



Precision engineered light source with adjustable lens assembly and ventilated lamp housing to take MBC bulb. Separate photo cell mounting assembly for ORP.12 or similar cell with optic window. Both units are single hole fixing. Price per pair £2/15/0 plus 3/6 P. & P.

VAN DE GRAAF ELECTROSTATIC GENERATOR, fitted with motor drive for 230 v. A.C. giving a potential of approx. 50,000 volts. Supplied absolutely complete including accessories for carrying out a number of interesting experiments, and full instructions. This instrument is completely safe, and ideally suited for School demonstrations. Price £7/7/-, plus 4/- P. & P. *L't. on req.*

200/250 v. AC HORSTMAN 20AMP TIME SWITCH



2 on/off every 24 hrs. at any pre-set time. Fitted in metal case 36 hr. spring reserve. Used but fully tested. Fraction of maker's price. **£3.19.6** plus 4/6d. post and pack. Available with solar dial on request.

LATEST TYPE SELENIUM BRIDGE RECTIFIERS
30 volt 3 amp., 11/-, plus 2/6 P. & P.
30 volt 5 amp., 16/-, plus 2/6 P. & P.

NICKEL CADMIUM BATTERY
Sintered Cadmium Type 1.2 v. 7AH. Size: height 3¼in., width 2⅛in. × 1$\frac{3}{16}$in. Weight: approx. 13 ozs. Ex-R.A.F. Tested 12/6. P. & P. 2/6.

DRY REED SWITCHES

2 × lamp Dry Reeds (makes contacts) mounted in 870 ohm 9-18v coil. Size 3in. × 3¼in. × ¾in. New. Price **8/6** per pair. Post Paid.
6 of the above mentioned units (12 Reeds) fitted in metal box. Size 4in. × 3¼in. × 1½in. Mfg. by Elliott Bros. New 45/- each. Post Paid.

Telephone Dials (New) 14/6d. Post Paid.

SOLAR OIL-FILLED CONDENSER. 240 mfd. for 230 V.A.C. 600 volt D.C. Overall size 14in. × 9in. × 5¼in. plus feet. Weight 46 lb. Guaranteed perfect. Manufacturer's packing. Price £7/10/-. Carriage 15/-.

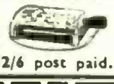
AUTO TRANSFORMERS. Step up, step down. 110-200-220-240 v. Fully shrouded. New. 300 watt type, **£3** each. P. & P. 4/6. 500 watt type, £4/2/6 each. P. & P. 6/6. 1,000 watt type, £5/5/- each. P. & P. 7/6.

LEVER MICRO SWITCH

Brand new lever operated micro switch. 20 amp. A.C. Price 4/6 each plus 1/6 P. & P. 5 for £1 post paid.

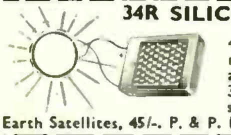
MOVING COIL HEADPHONE AND MIKE
Soft rubber ear-pieces with M/C Mike fitted 5-way plug as on No. 19 set. New, in maker's packing, 16/6, plus 3/6 C. & P.

SEMI-AUTOMATIC "BUG" SUPER SPEED MORSE KEY
7 adjustments, precision tooled, speed adjustable 10 w.p.m. to as high as desired. Weight 2½lb. £4/12/6 post paid.



***NEW MODEL* HIGH FREQUENCY TRANSISTORISED MORSE OSCILLATOR**
Adjustable tone control. Fitted with moving coil speaker, also earpiece for personal monitoring. Complete with morse key. 45/- plus 3/6d. p. & p.

34R SILICON SOLAR CELL



4 × .5 volt unit series connected, output up to 2 v. at 20 mA. In sunlight, 30 times the efficiency of selenium. As used in power Earth Satellites, 45/-. P. & P. 1/6d.

CONDENSERS

New at a fraction of maker's price.
2,500 mfd. 100 v... 12/6 — 4,000 mfd. 25 v... 10/–
10,000 mfd. 35 v... 15/– — 4,000 mfd. 50 v... 15/–

220/240v. A.C. COOLING UNIT

2,300 r.p.m. 6in. blade size. Smooth powerful motor. All metal construction. Continuously rated. Individually tested. Offered at fraction of maker's price, £2/15/-. P. & P. 7/6.

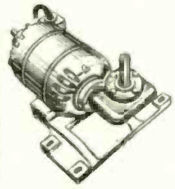
100 WATT POWER RHEOSTATS

(NEW) Ceramic construction, winding embedded in Vitreous Enamel, heavy duty brush assembly designed for continuous duty.
AVAILABLE FROM STOCK IN THE FOLLOWING 11 VALUES:
1 ohm 10a., 5 ohm 4.7a., 10 ohm 3a., 25 ohm 2a., 50 ohm 1.4a., 100 ohm 1a., 250 ohm 7a., 500 ohm 45a., 1,000 ohm 280mA., 1,500 ohm 230mA., 2,500 ohm .2a. Diameter 3½in. Shaft length ⅝in. dia. ⅜in., **27/6**. P. & P. 1/6.
50 WATT 1/5/10/25/50/100/250/500/1,000/1,500/2,500 ohm, **21/-**, P. & P. 1/6.
25 WATT 10/25/50/100/250/500/1,000/1,500/2,500 ohm, **14/6**, P. & P. 1/6.
Black Silver Skirted knob calibrated in Nos. 1-9. 1½ in. dia. brass bush. Ideal for above Rheostats, 3/6 each.

STROBE! STROBE! STROBE!

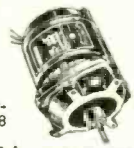
TWO EASY TO BUILD KITS USING XENON WHITE LIGHT FLASH TUBES. SOLID STATE TIMING + TRIGGERING CIRCUITS. PROVISION FOR EXTERNAL TRIGGERING. 230-250v. A.C. OPERATION.
The Strobe is one of the most useful and interesting instruments in the laboratory or workshop. It is invaluable for the study of movement and checking of speeds. Many uses can be found in the psychiatric and photographic fields, also in the entertainment business. It is used a great deal in the motor industry and is a real tool as well as an interesting scientific device.
EXPERIMENTERS "ECONOMY" KIT. 1 to 36 Flash per sec. All electronic components including Veroboard S.C.R. Unijunction Xenon Tube + Instructions £5.5.0 plus 5/- P. & P.
INDUSTRIAL "ADVANCED" KIT. 1 to 80 Flash per sec. IDEAL FOR LABORATORY OR SCHOOL USE. Fully isolated from the mains supply by specially wound transformer. 500v. FLASH CIRCUIT and stabilised timing circuit. Higher output flash tube. Price £8.8.0 plus 7/6 P. & P.
6½ INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 8/6 post paid.
Regret not sold separately.

PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on substantial cast aluminium base. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. **6 gns.** P. & P. 10/-.

BODINE TYPE N.C.1 GEARED MOTOR



(Type 1) 71 r.p.m. torque 10 lb. inches Reversible 1/70th h.p. 50 cycle ·38 amp.
(Type 2) 28 r.p.m. torque 20 lb. in reversible 1/80th h.p. 50 cycle ·28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer for **230/240v A.C. input**
Price, either type £2.17.6 plus 6/6 P. & P. or less transformer £2.2.6 plus 4/6d. P. & P.
These motors are ideal for rotating aerials, drawing curtains, display stands, vending machines etc.

230/250 v. A.C. SOLENOID
Heavy duty type. Approx. 3lb. pull. 17/6 plus 2/6 P. & P.
12/24 v. D.C. SOLENOID
Approx. 8 oz. push, 8/6 plus 1/6 P. & P.

A.C. CONTACTOR

2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. 22/6 plus 1/- P. & P.

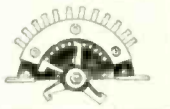
PRECISION INTERVAL TIMER

From 0-30 seconds (repetitive). Jewelled balanced movement. Lever re-set. Operates 230 v. A.C. 5 amp. c/o micro-switch. Brand New 17/6 plus 2/6 P. & P.

Latest American. New. Plastic THYRISTOR 400 P.I.V. 8 amp. Data sheet. 19/6 post paid.

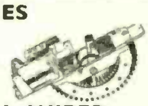
COPPER LAMINATE PRINTED CIRCUIT BOARD. Large sheet 15½ × 5½in. Price 3/9, 3 for **10/-** post paid.

MINIATURE UNISELECTOR



3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

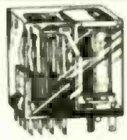
UNISELECTOR SWITCHES
NEW 4 BANK 25 WAY



25 ohm coil, 24 v. D.C. operation. **£5/17/6**, plus 2/6. P. & P.

8-BANK 25-WAY FULL WIPER
24 v. D.C. operation, **£7/12/6**, Plus 4/- P. & P.

RELAYS



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1250	20—40	2 c/o Heavy Duty	12/6
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Dual range voltmeter. 0-5 and 0-100 v. D.C. FSD 1 mA. In carrying case with tests prods and leads. 32/6. P. & P. 3/6.

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¼W: 10 × 4·3
Leads: 35mm
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		each	10 off	25 off	100 off
⅛W	10%	2d	1/6	3/3	10/4
⅛W	5%	2½d	1/9	3/8	11/8
¼W	10%	2½d	1/9	3/8	11/7
¼W	5%	2½d	2/-	4/-	12/10

(10% ranges available in E12 renard series. 5% ranges available in E24 renard series.)

ELECTROLYTIC CAPACITORS (Mullard). —10% to +50%.
Subminiature (all values in µF)

4V	8	32	64	125	250	400
6·4V	6·4	25	50	100	200	320
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25V	1·6	6·4	12·5	25	50	80
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64V	0·64	2·5	5	10	20	32
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Tubular, 10%, 160V: 0·01, 0·015, 0·022ΩF, 7d. 0·033, 0·047µF, 8d. 0·068, 0·1µF, 9d. 0·15µF, 11d. 0·22µF, 1/-. 0·33µF, 1/3. 0·47µF, 1/6. 0·68µF, 2/3. 1µF, 2/8.
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Modular, Subminiature, Epoxy encapsulation, Polyester film, P.C. mounting. 10%, 100V: 0·001, 0·002, 0·005, 0·01, 0·02µF, 6d, 0·05µF, 8d, 0·1µF, 10d, 0·2µF, 1/1, 0·5µF, 2/-.

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

JACK PLUGS (Screened): Heavily chromed, ¼in. Standard: 2/9 each Side-entry: 3/3 each.
Standard (Unscreened): 2/3 each.

JACK SOCKETS (¼in. Plug): With chrome insert, 2/9 each. Available with: Break/Break, Make/Break, Break/Make, Make/Make contacts.

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

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Miniature: 0·3W at 70°C. ±20% ≦½M, ±30%>½M. Horizontal (0·7in. × 0·4in. P.C.M.) or Vertical (0·4in. × 0·2in. P.C.M.) mounting, 1/- each.
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12K7GT	7/6
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12SG7	4/6
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12SK7	5/6
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6AK6	12/6
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6AK8	6/-
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6BW7	13/-
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6K6GT	8/-
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AF125	6/6
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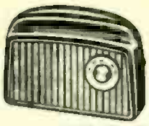

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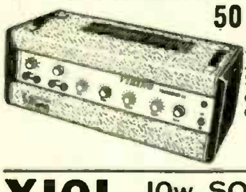

An extremely reliable general purpose valve Amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organs etc. Separate bass and treble controls. Output Impedance 3, 8 and 15 ohms.

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Sensitivity (for rated output): 1mV into 3 Kohms (0.33 microamp). Total Distortion (at 1 KHz): At 5 watts 0.35%; At rated output 1.5%. Frequency Response: Minus 3 db points 20 Hz and 40 Khz. Speaker: 3-4 ohms. (3-15 ohms may be used). Supply voltage: 24v D.C. at 800 mA. (6-24V. may be used).

Price **49/6** plus 2/6 p. & p.

CONTROL ASSEMBLY: (including resistors and capacitors). 1. Volume: Price 5/-. 2. Treble: Price 5/-. 3. Comprehensive bass and treble: Price 10/-. The above 3 items can be purchased for use with the X101. **POWER SUPPLIES FOR X101:** P101 M (mono) 35/- p. & p. 4/6: P101 (stereo) 42/6 p. & p. 4/6.

The CLASSIC

CONTROLS: Selector Switch. Tape Speed Equalisation Switch (3¾ and 7½ i.p.s.). Volume. Treble. Bass. 2 position scratch filter and 2 position rumble filter.

SPECIFICATION: Sensitivities for 10 watt output at 1 KHz. Tape Head: 3mV (at 3¾ i.p.s.). Mag. P.U.: 2 mV. Cer.P.U.: 80 mV. Radio: 100mV. Aux. 100 mV. Tape/Rec. Output: 100 mV. Equalisation for each Input is correct to within ± 2dB (R.I.A.A.) from 20 Hz to 20KHz. Tone Control Range: Bass ± 13 dB at 60 Hz. Treble ± 14 dB at 15 KHz. Total Distortion: (for 10 watt output) < 1.5%. Signal Noise: < −60dB. AC Mains 200-250v. Size 12½" long, 4½" deep, 2¾" high.
Teak finished case. Built and tested. Price **8½ gns.** plus 7/6 p. & p.

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Specifications: Output: 10 watts. Output Impedance: 3 to 4 ohms. Inputs: 1. xtal mic 10mV. 2. gram/radio 250mV. Tone Controls: Treble control range ± 12dB at 10KHz; Bass control range ± 13dB at 100Hz. Frequency response: Minus 3dB points are 20Hz and 40KHz. Signal to Noise Ratio: better than —60dB. Transistors: 4 silicon Planar type and 3 Germanium type. Mains input: 220-250V. A.C. Size of chassis: 10½" × 4¾" × 2½". A.C. Mains, 200-250V. For use with Std. or L.P. records, musical instruments, all makes of pick-ups and mikes. Two inputs with control for gram. and mike. Built and tested. 8" × 5" speaker to suit. **Price 14/6 plus 1/6 p. & p. Crystal mike to suit 12/6 plus 1/6 p. & p.**

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THE VISCOUNT

Integrated High Fidelity Transistor Stereo Amplifier
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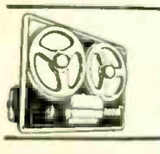
MOTEK



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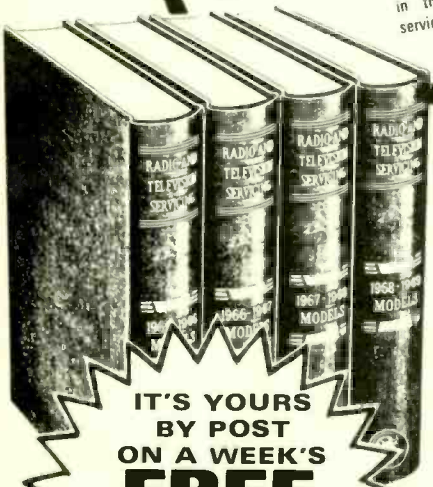

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2N3704β = 90 to 330 3/9.
2N3705β = 45 to 165 3/5.
25V 200ma pnp
2N3702β = 60 to 3000 3/6.
2N3703β = 30 to 150 3/3.
Small Signal npn
2N3707 low noise 4/-.
2N3711β = 180 to 660 3/11.
Small signal pnp
2N4058 low noise 4/9.
2N4026β = 180 to 660 4/3.

BC107 series
300mW 300MHzfT, T018
BC107 45Vβ = 125 to 500 2/9.
BC108 20Vβ = 125 to 900 2/6.
BC109 20Vβ = 125 to 900 2/9.
BC167 series
180mW 300NHzfT. T092
BC167 45Vβ = 125 to 500 2/3.
BC168 20Vβ = 125 to 900 2/-.
BC169 20Vβ = 240 to 900 2/3.
BC109 and BC169 are low noise.
BC167, BC168 and BC 169 are plastic.

★ FETS. *PRICES REDUCED!*

A brand new FET. 2N5163 1·8mA/V min. 5/- only. MPF105 25V max., gm = 2 to 6mA/V low noise 7/6. 2N3819 25V max. gm 2 to 6mA/V, low noise 9/-.

★ MINI TRANSISTORS. *PRICES REDUCED!*

2N4285 pnp hFE 35 to 150 at 10mA fT 7 MHz min. Veb 35V max.
2N4286 npn 30V hFE over 100 at 10μA fT 280 MHz typ.
2N4289 pnp 60V hFE over 100 at 100μA to 1mA fT 170MHz typ.
2N4291 pnp 40V hFE over 100 at 100mA.
2N3794 pnp 40V hFE over 100 at 100mA complementary driver/output.
2N4292 npn 30V UHF N.F. 6dB max at 100MHz fT 570MHz typ.
B5041 Power 14·3W at 100°C base temp. 35V, hFE over 100 at 0·5A.
Insulated T066 size mounting surface.
Prices: 2N4285 to 2N4292, 2N3794 2/11; B5041 13/6.

1000 volt 1·5A GENERAL PURPOSE RECTIFIER type 1N5054 3/6 only.
100V 0·75A miniature rectifier type TSI 1/9.
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ZENER DIODES
3V to 27V 5% 400mW all preferred voltages 4/6 each.

★ NEW TRANSISTOR BARGAINS

All power types supplied with free insulating sets

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2N697	6/-	2N1711	7/4	40250	15/-	BC148	3/6
2N706	3/5	2N2147	16/9	40406	16/3	BC149	4/3
2N1132	13/-	2N2218	11/6	40408	14/6	BD123	24/3
2N1302	4/-	2N2369A	6/9	AC126	6/6	BF194	7/-
2N1303	4/-	2N2646	9/6	AC128	6/-	BFX29	12/3
2N1304	4/-	2N2924	5/-	AC176	11/-	BFX84	7/5
2N1305	4/-	2N2925	5/9	ACY17	8/-	BFX85	8/3
2N1306	6/9	2N3053	5/6	AD161	7/-	BFX88	7/9
2N1307	6/9	2N3054	15/6	AD162	7/-	BFY51	4/-
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Transistor complement £7/8/- per channel PC boards for main amp. 12/6 each *or free with channel of transistors.*
November 1968 WW reprint giving amplifier and power supply circuit 1/- post free.
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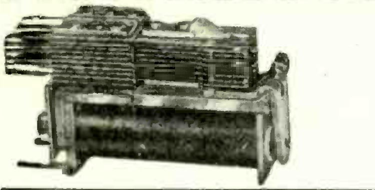
Wilkinsons FOR RELAYS



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BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY
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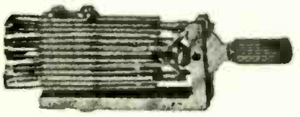

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KEY SWITCHES ONE HOLE FIXING with knobs. Stop/2 change over locking 2 position **7/6.** Stop/4 C.O. non-locking 2 position **10/6.** 6 C.O. lock/2 C.O. lock 3 position **17/6.**

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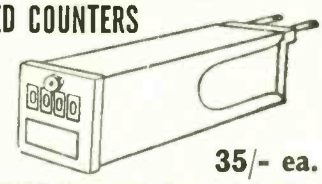

3½ × 1in., 10 counts per second with 4 figures. The following D.C. voltages are available, 6 v., 12 v., 24 v., 50 v. or 100 v.

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STABILIZED POWER UNITS RACAL Inst. type PU 156C, A.C. input 200/250 v. D.C. output positive HT 200/300 v. stabilized Load current 250 mA negative HT 150 v. stabilized 15 mA. NEW **£45.**
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METERS GUARANTEED. Complete list available.

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SINGLE POLE. Double Throw, 3 amp. 250 v. A.C. can be used as on/OFF or CHANGE-OVER switch. **18/-** per dozen, post 2/-. **130/-** per 100, post 5/-.

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RESISTORS, wire wound or carbon, potentiometers, condensers, quantities ex-stock at low prices.
BRIDGE MEGGERS SERIES I. With resistance box and leads, 1,000 v., 0-100 megohms. **£60** ea.

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MINIATURE TRANSISTORISED B.F.O. UNIT
This is a miniature transistorised B.F.O. unit (tunable) that will enable your set to receive C.W. or S.S.B. reception. Compact. Single hole fixing. This small unit will fit anywhere. Ideal for all Ex-Govt. Communication Receivers and most Commercial Types. Complete with fitting instructions. **49/6**, post free.
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We make a plug in Power Supply unit, input 200/250 volts 50 c/s AC mains, Output to run any of the sets listed below. The units are brand new and contained in an attractive louvered steel case, with full connecting leads, plugs & sockets.

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Enquiries invited for Power Supply units to run any type of equipment not listed.

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Mains input power supply unit to run this popular transmitter and receiver, complete brand new and ready to plug in. Only **£6.10.0**, carriage 10/-.

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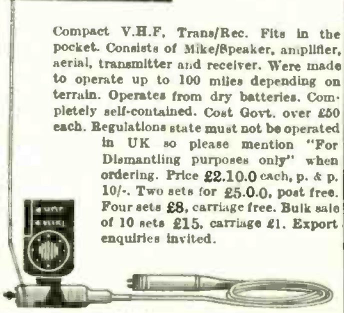

Compact V.H.F. Trans/Rec. Fits in the pocket. Consists of Mike/Speaker, amplifier, aerial, transmitter and receiver. Were made to operate up to 100 miles depending on terrain. Operates from dry batteries. Completely self-contained. Cost Govt. over £50 each. Regulations state must not be operated in UK so please mention "For Dismantling purposes only" when ordering. Price **£2.10.0** each, p. & p. 10/-. Two sets for **£5.0.0**, post free. Four sets **£8**, carriage free. Bulk sale of 10 sets **£15**, carriage £1. Export enquiries invited.

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Input 240 volts AC. Output 250 volts 80 m.a. DC. 6.3V. at 2 amps plus 12 volts at 2 amps. Built on a robust compact chassis. Containing double isolated transformers, smoothing chokes, capacitors and Silicon rectifiers. In semi kit form with full instructions for completion. ONLY **25/-** plus 5/- carriage.

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Our Price Only **£7/15/0**

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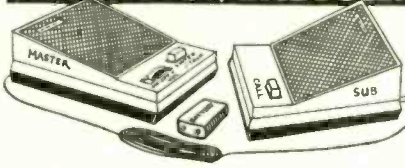

OUR PRICE ONLY **65/-**

Same as 4-Station Intercom for two-way instant conversation from MASTER to SUB and SUB to MASTER. Ideal as Baby Alarm and Door Phone. Complete with 66ft. connecting wire. Battery **2/6.** P. & P. 4/6.

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(1 MASTER & 6 SUB-STATIONS) in strong metal cabinets. Fully transistorised. 3½in. Speakers. Call on Master identified by tone and Pilot lamp. Ideally suitable for Office, Hotel, Hospital and Factory. Price **27 gns.** P. & P. 14/6 in U.K.

Transistor TELEPHONE AMPLIFIER

59/6

Why not increase efficiency of Office, Shop and Warehouse with this incredible De-Luxe Portable Transistor **TELEPHONE AMPLIFIER** which enables you to take down long telephone messages or converse without holding the handset. A useful office aid. A must for every telephone user. Useful for hard of hearing persons. On/off switch. Volume Control. Operates on one 9 v. battery which lasts for months. Ready to operate. P. & P. 3/6 in U.K. Add 2/6 for Battery.

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AF115	3/6	2N711	10/-
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AF117	3/6	2N1304-5	5/-
AF118	3/6	2N1306-7	6/-
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BFY50	4/-	Transistors	
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P/P 2/6 PER PACK (U.K.)

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TRANSISTORS ONLY 1/- EACH

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All these types available

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BC108	2N3011	2S102	2N2220	2N1507	2N1893	2N2484	2S732

All tested and guaranteed for gain and leakage—unmarked. Manufacturers' fall outs from the new PRE-PAK range.

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25	BC107-8-9 NPN Silicon	TRANSISTORS 10/-
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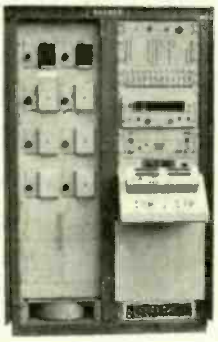
TRANSISTOR AND COMPONENT TESTER by Texas



Utilizing digital programming and the functional block approach to perform a wide range of component testing. The design theory used in the transistor and component test incorporates a universal programming system, a socket control unit, and a readout system, usable with a number of functional modules.
The system can test any two or three terminal components within the physical and electrical limits of the tester. The system is capable of performing D.C. 1000 cycle pulse tests.
The programming facility is carried out by a rigid plastic card with holes punched out to indicate a bit of information. Up to 24 card readers may be used in the system.

THE TESTER CONSISTS OF THE FOLLOWING UNITS:

- Control unit—158906—2
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- Intermediate storage unit
- Standard socket control unit (Nerve centre of the system)
- Standard relay service panel (16 columns × 12 indicators)
- Digital voltmeter indicator
- Analogue to Digital converter and indicator
- Three digit digital comparator and punch drive
- Three digit trip system
- Relay power supplies (contains three independent voltages)
- Test bias supplies and current regulators
- h Parameter attachment
- h Fe attachment
- Test programme panel
- Sequence unit
- 1000 cycle Oscillator
- Two bay ETC enclosure size 80in. high by 30in. deep, 49in. wide.

This unit cost in the region of £12,000 and is offered in very good condition, complete with all circuit diagrams, instructional manual, and test procedures. Also, a number of pre-punched programmes. **£1,250**

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100/100		Beckman	A	160/-
100	0.5	Beckman	A.8	60/-
200	0.5	Beckman	A	60/-
500	0.1	Beckman	8	70/-
500		Colvern	2501	45/-
500		Foxes	PX4	40/-
500		Colvern	2610	50/-
1K		Colvern	2501	45/-
1K		Colvern	2610	50/-
1K	0.1	Reliance		40/-
1K		Foxes	GPM/15	40/-
2K	0.5	Beckman	8A1101	60/-
2K		Beckman	7216	60/-
2K		Reliance	GPM15	40/-
5K	0.5	Beckman	A	60/-
5K	0.25	Beckman	A	65/-
10K	0.5	Beckman	A	60/-
10K	0.1	Beckman X	A	70/-
10K	0.05	Beckman	A	95/-
15K		Foxes	GPM15	50/-
18K		Beckman	A	60/-
20K	0.5	Beckman	A	60/-
20K	0.05	Beckman	8A1244	95/-
30K		Colvern	2402	30/-
30K		Beckman	8A 95C	60/-
30K	0.1	Beckman	A.88	70/-
30K	0.5	Beckman	8A 1692	60/-
30K	0.25	Beckman	8A 1692	65/-
50K		Reliance	07.10	45/-
50K			07.5	45/-
50K		Colvern	2503	45/-
50K	X	Foxes	PX 4	45/-
50K	0.5	Beckman	A	60/-
50K	0.1	Beckman	A	70/-
100K/100K		Ford	A	100/-
100K	0.1	Beckman	A	70/-
100K	0.5	Beckman	A	60/-
100K		Colvern	2501	45/-
100K		Colvern	2610	50/-
298K	0.1	Beckman	8A 3902	70/-
300K	0.1	Beckman		70/-

THREE TURN 780° ROTATION

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100	0.5	Beckman	A	80/-
300		Beckman	9303	45/-
1K		General Controls		40/-
10K	0.5	Beckman	A	45/-
10K	0.5	Beckman	C.88	45/-
10K	0.1	Beckman	C	55/-
20K/20K	0.1	Beckman	C.8	100/-
10K/10K	0.1	Beckman	C	100/-
50K	0.5	Beckman	C.8	45/-

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£9.10s.
46/K/46K	Beckman B	10 watts	£9.10s.

TWENTY TURN 7200° ROTATION

250 ohms	General Controls	PXM130	80/-
1 Meg	General Controls	PXM130	80/-

156 TURN 56,160° ROTATION

460 ohms .. Kelvin Hughes .... KTP0701 £9.10s.

FIVE TURN 1800° ROTATION

500 ohms	Colvern	CLR 2505	40/-
1.5K	Colvern	CLR 2605	40/-

SINE COSINE

Colvern 8601	10K	£12.10s.
Colvern 8601	15K	£12.10s.
Colvern 8601	20K	£12.10s.
Colvern 9501	11K C.T.	£16.10s.

CLR 9604—Cam Corrected High Precision. Sine Cosine Outputs 25K. £20.

PRECISION BECKMAN 40 TURN 14,400° ROTATION

Wirewound Precision Potentiometer. SE 107A 20 watts at 40°C. 3 1/16" Diameter. Servo Mounting. 200K. Brand New £12.10s. List Price £30.

TRIMPOTS

990 GB — Wirewound Micropot Potentiometer. Low noise. Brand new, by well known manufacturer. 1 watt @ 70°C. 100 ohms and above ±5%. Available in the following values: Ohms: 5, 15, 25, 50, 100, 250, 400; 1K, 2K, 2.5K, 10K, 25K. Price, 1-9 = 20/- each, 10-25 = 15/- each, 25-50 = 12/6 each, 50 and over 10/- each.

FERRANTI PRECISION CONTINUOUS WIRE-WOUND POTENTIOMETER, TYPE P4A

Size 15, Seven Sections. Ganged, giving seven different predetermined values, £9.10.0.

COLVERN 10-TURN INSTRUMENT DIALS 10/6

RECORDING INSTRUMENTS AND MOTORS

FOUR CHANNEL HIGH SPEED PEN RECORDER

by Kelvin Hughes, with four channel amplifier, giving a frequency range of 0-100c/s.
The Recorder consists basically of a magnet carrying in its poles four stiffly suspended moving coil units, each with a stylis arm attached. The stiffness of the coil unit suspension enables the instrument to withstand the effects of vibration and acceleration.
Mains operated. Pen deflection ± 7.5 m.m.
6 chart speeds—o, 5; 1; 2; 4; 8; and 16 cm/sec.
Excellent condition. £195
N.B. Two channel version available, giving ± 16.5 m.m. deflection.

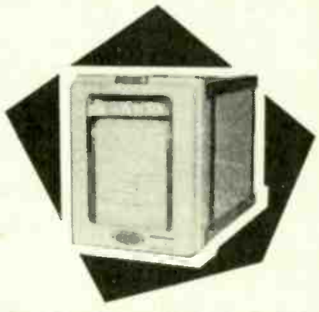
FIVE CHANNEL PEN RECORDER

complete with five channel amplifier.
Chart width 9in.
Maximum trace width of ± 2 c.m. per channel.
Frequency response flat to 60 c/s.
Mains operated, complete in free standing consul.
Fully overhauled Cost £1200+ Our price £450

HYSTERESIS CLUTCH MOTOR

with integral clutch allowing the motor to drop out of engagement with the gear train, thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v., 50 c/s. L = left, R = right. 15 r.p.m. L, 8 r.p.m. R & L, 6 r.p.m. L. 4 r.p.m., ½, ⅓, ¼ r.p.m. L, 1/5 r.p.m., 1/6 r.p.m., R & L, 1/10 r.p.m., 1/12, 1/15 r.p.m. L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/-.

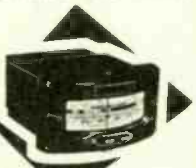
PORTABLE SINGLE PEN RECORDER BY RECORD ELECTRICAL



(Illus.). 3 in. chart, sensitivity 500 micro amps. Coil res. 1.53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250v. Size: 8 × 11 × 6 in. Brand new—complete with chart and ink. List over £100. Our price £49.10.0.

TRANSITROL 2 POSITION INDICATING TEMPERATURE CONTROLLER BY ETHER

TYPE 990

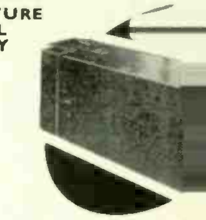


Completely transistorised self-contained direct deflecting units for indicating and controlling temperature accurately over a wide range. Suitable where a signal can be converted into D.C. Sensitivity 10 ohms per M.V. Minimum F.S.D. 8 M.V. Cold junction compensation, thermocouple break protection. Coppe compensation. Calibrated scale length, 6.5 in., 0-800 degrees centigrade accuracy ±1%. Front panel size 10 × 5½ in., weight 11 lb. Mains supply 100-260 v. Control switching and Thermocouple connections all at back of case. Our price £22.10.0. List price £49. New condition.

MAGNETIC FLUX MEASURING SET TS 13A

Range 1,200-9,600. Gauss—Bold. Pole face diameter of magnets ¾ in.-¼ in. Air gap 550 in.-1.51 in. Powered by U2 1.5V cell. Our price £18.10.0.

MINIATURE DIGITAL DISPLAY



Operates on a rear projection 6.3 pilot lamp projects the corresponding digit densing lens through a projector lens viewing screen at the front of the unit. 3 1/16 in. deep. 1 1/16 in. high. Weight 3½ o size ½ in. high. 0-9 with 8 right hand de and degree. Available to special order, other characters or colour, at cost of plates. List price 6 gns. Our price 49/

DIFFERENTIAL PRESSURE DUCERS

by Sifam Ltd. G.B. Type Range ± 900MB Resistance Our Price £19.10.0

HOLLERITH 80 COLUMN READER.

Complete with Verifier By No. H 129/2489. Good condition £185.

FERRANTI HIGH SPEED 5 H CHARACTERS per second reader.

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives, extremely quiet; useful in areas where ambient noise levels are low. Having a high starting torque a relatively high inertia load can be driven at 1 r.p.m. 240 volts 50 cycles. 10 r.p.m. R & L, ½ r.p.m. L, ¼ r.p.m. R, 1/5 r.p.m. r.p.m. R, 1/12 r.p.m., 1/20 r.p.m., 1/4 1/60 r.p.m., 1/180 r.p.m., 1/360 r.p.m.; 1/6 1/12 r.p.h.; 1 r.p.m., 1½ r.p.m. 25/-.

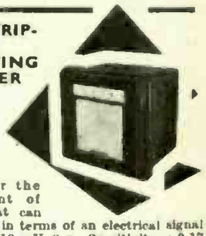
HYSTERESIS REVERSIBLE M

Incorporating two coils. Each coil when will produce opposite rotation of the outp 240 volt 50 cycle, ⅓ r.p.m., ¼ r.p.m., 1/ 1/10 r.p.m., 120 volt 60 cycles 1/10 r.p. reduced to 30/-.

POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRA

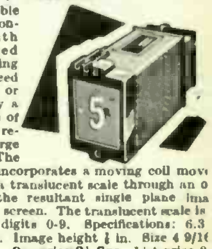
For use with thermocouplers, pyrometers a e.m.f. sources. 6 point. Range (—100)—0 mV; 0—1,600 deg. C. 6½ in. chart width; p 8 secs. Accuracy ±0.5%; 10 chart sp 720mm/hr. Tropicalised. Including tools an Listed at over £200 Our price £79.10.0. version available £99.10.0.

KENT STRIP-CHART INDICATING RECORDER



Suitable for the measurement of anything that can be measured in terms of an electrical signal width 9¾ in. 10 mV.-2 v. Sensitivity ±0.17 scale. Speed of operation 33 sec. for full-scale Chart speeds ¼ in., 3 in., 6 in. per hour. Singl £49.10.0.

EAC DIGIVISOR Mk. II DIG READ-OUT DISPLAY



Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to charge the digits. The DIGIVISOR incorporates a moving coil move which moves a translucent scale through an o system and the resultant single plane ima projected on a screen. The translucent scale is to represent digits 0-9. Specifications: 6.3 250 microamp. Image height ¾ in. Size 4 9/16 39/64 × 1½ in. Our price 3½ Gns. List price 8

NOTE OUR NEW ADDRESS

LOW COST ELECTRONIC AND SCIENTIFIC EQUIPMENT AND COMPONENTS

D NEW S.E. LABORATORIES SDUCER complete with encapsulated /demodulator S.E. 441/2
y D.C.—60 c.p.s.
in the following ranges:

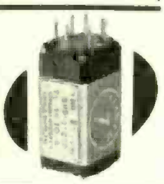
s.i.	0 - 100 p.s.i.	0 - 1000 p.s.i.
s.i.	0 - 250 p.s.i.	0 - 1500 p.s.i.
s.i.	0 - 500 p.s.i.	0 - 4000 p.s.i.
s.i.	0 - 750 p.s.i.	

llable deferential types ± 5 p.s.i.
e £70+ Our price **£15**

T HIGH SPEED CARD READER
/32 80 column.
e 7¼ in. × 3¼ in.
e 400 cards per minute.
t condition Our price **£120**

GRAMME BOARDS BY ECTRO. These boards are basically a le multi throw switch device consisting of a trix with two contact decks in the Z Plane at 90 degrees to each other. Contact is made er, shorting or plugging in pins. Ideal for pe work, etc. Boards available in 16 × 16 **£4.5.0.**
2 plane **£12.10.0.** Pins available 1/3 each.

ATURE ING COIL Y S115

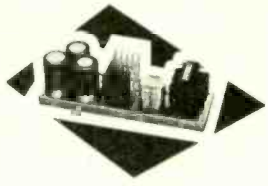


gama Weston, suit- D.C. circuit. A high ity relay more sen- than the electro- ic type. Single Coil nce 2K. 50 - 0 - 50 Amp. List price Our price **20/-**

VACTRIC 144-WAY HIGH SPEED MINIATURE SAMPLING SWITCHES, consisting of 24 segments in six bank. 8000 samples per second can be obtained from these switches. Ideally suitable for data logging application. Low inherent noise and contact resistance permitting high speed sampling of the most difficult transducers.
Pulse generator for digital counting.
Brand new. **£25**

SAFETY OHM METER BY EVERSHED AND VIGNOLES Suitable for testing contact and resistance of circuits where current must never exceed specific amount.
Range: 0 - 5 ohms 12 m.a.
List price £31 10s. Our price **£8 10s.**
Carrying case available 20/- extra.

ADVANCE TRANSISTORISED DC STABILISED POWER UNITS

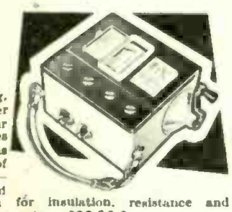


	Input Volts	Output Volts	Amps	Price
DC 4	200-245 ± 15%	12	4	£17/10/-
DC 3	200-245 ± 15%	12	1.25	£10/10/-

SPEECH INVERTER MI-7181-A'
The R.C.A. Speech Inverter is a device intended for use in radio-telephone installations where privacy is a prime consideration. The equipment when used in conjunction with the R.C.A. MI-7182 Hybrid Transformers enables parallel two-way conversations on a single telephone pair line at each terminal of the communications system. With inversion, speech fed into the transmitting inverter circuit will feed the radio transmitter with unintelligible signals. These signals will remain unintelligible until they pass through a receiving inverter circuit at the other end of the communication channel. (Used only under Licence in U.K. P.O.A.) **£12.10.0.**

BRID UNIT MI-7182 The Hybrid Unit is designed for use with the Speech Inverter where esirable to operate the output of a receiving circuit and the input of a transmitting circuit from a pair of telephone wires whose electrical characteristics are essentially constant. When the Hybrid s properly connected and balanced to the line, high attenuation will be provided between the receiver t circuit and the transmitter input circuit. **£10.10.0.**

RSHED DGE GGER



olt, 50 meg. ation tester built-in four le bridges ratio arms g ratios of 10 — 1 — + 0.01 and tor switch for insulation, resistance and ty measurements. **£29.10.0.**
volt 0-100 meg. with Varley Loop. **£69.10.0.**

CONSTANT VOLTAGE TRANSFORMERS by Sola 210-250-600 watts. Our price £25.

TORQUEMOTOR 225 BY ELLIOTT
Originally designed to operate hydraulic valves or hydraulic motor under extreme conditions of temperature, altitude and vibration. The torquemotor is practically unaffected by vibration or sudden shock i.e. Consists of a moving iron rotor with a travel of 7 degrees either side of centre. MIN TORQUE (gm-cm) 500 at Zero at 6 degree. 70 gm cm. Total hysteresis at 0°C. 0-58 degree current 45 M/A. **£9.10.0.**

PHOTOMULTIPLIER VMP11/44 (CV 2317) by 20th Century Electronics
Cathode sensitivity 40 μ A/L. Operating volts for 10 A/L 1100 volts. DARK current 0.004μA. **£8.10.0.**

GITAL MAGNETIC DATA ORAGE DECK
ven track record replay heads
se machines originally ex-computers, lend ideally for use as audio stereo ti-track recording units or data storage. ord and Playback Heads encased in common unit. This unique close spacing Record and Playback Head will enable operator to monitor instantly while rding, crosstalk between tracks abso- minimum. Head Resistance 40 ohms l 7 ohms. Freq. Response approx. c.p.s.—30 Kc/s with a good response to Kc/s. Deck driven by one synchronous stan motor and two variable-speed ind motors. Wow and flutter—detect it you can. Electro-pneumatic capstan te-up mechanism. Speed 37½ i.p.sec. ote: Capstan Head can be easily re- oved and any diameter Capstan Head rresponding to any speed can be fitted.) l deck function push buttons are illumin- ed and are brought out to separate ulti-core leads which can be wired to y deck function or auxiliary equipment. Finished in brush-aluminium and matt-black. Size: 27 × 26 × 8 in. eight 90 lb. 230v-380v. A.C. Capstan motor speed 1.500 r.p.m. Must have cost £1,000. Our price **£65.**
ew condition but ex-equipment. **VACUUM ASSEMBLY** required for computer and data use. **£7.10** extra.
ven Track record replay head, ex-computer, complete with guides, little used. **£12.10.0.**
in. Tape. 2,400 ft. **£8.10.** new. Empty reels **25/-**. in cassettes **45/-**.
MPEX FR300 Tape Deck in free standing 6ft. cabinet less heads. **£99.10.0.**

URROUGHS 101 DESK SIZE lectronic Digital computor with flexo-riter FPC-8 and E101 Tape reader for electronic omputations of small complex or repetitive alculating problems. Little used. **£495.0.0.**

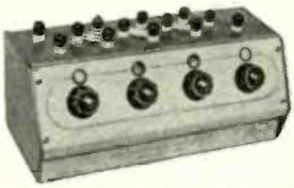
SCANNER MODULES TYPE LP 1132
50/100 channel scanner with added sub units samples from 1-1,000. Sampling is carried out by relays.

"V" SCAN DIGITAL SHAFT ENCODER BY MOORE REED TYPE 18 DV-19-EP 116 3 discs. Size 18. Counts 524288 in 1024 revolutions of shaft in V Scan. Brand new in maker's original sealed tins. List price £75 approx. Our price **£22.10.**

Carriage extra on all equipment.

★ BRAND NEW
LABORATORY TEST EQUIPMENT
PURCHASED DIRECT FROM LEADING MANUFACTURERS & DISTRIBUTORS

HIGH VALUE RESISTANCE BOX TYPE R.7003



Specification. Range: 0.01-11.10 Megohm in 0.01 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hammer finished stove enamel.
List price £60. Our price **£22/10/-.**

DECADE CAPACITANCE BOX TYPE R.7004

Specification. Range: 0.00002uF-1uF in 0.00002uF steps. Accuracy 0.05%. Frequency Range: 40 c/s-10 Kc/s for all decades except X1 = 40 c/s-5 Kc/s. Case: Hammer finished stove enamel.
List price £60. Our price **£22/10/-.**

MUTUAL INDUCTANCE BOX TYPE R.7005

Specification.
Range: 0-11.110 mH in 0.002 mH divisions. Accuracy: $\pm(0.3 \times \frac{0.012}{M})\%$ where M = value of mutual inductance in mH set on the box. Frequency range: 0-2.5 K/cs for all decades except X1 = 0-15 K/cs. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary windings). Case: Polished teak. List price £65. Our price **£26/10/-**

MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.01 H. 0.001 H. Accuracy: ± 0.3%. Operating Frequency: 5 Kc/s, 10 Kc/s. Maximum current: 1A, 8A. Resistance of coils: 4 ohm, 1 ohm. Case: Moulded plastic. List price 8 gns. Our price **50/-.**

★ A Special price of £45 is offered if the following equipment is ordered together: High Value Resistance Box, Decade Capacitance Box, Mutual Inductance Box, Mutual Inductance Coil.

PORTABLE WHEATSTONE BRIDGE

Specification. Type: Moving Coil Galanometer. Ranges: 1. 0.05 to 5 ohms. 2. 0.5 to 50 ohms. 3. 5 to 500 ohms. 4. 50 to 5,000 ohms. 5. 500 to 50,000 ohms. Scales: Switched. Slidewire: 0.5 to 50. Galvanometer Scale: 10-0-10. Case: Moulded plastic. Internal Source: 4V. Dry battery. Operating Temperature: +10 to +35 deg. C. Operating Humidity: Up to 80% R.H. Dimensions: 200 × 110 × 65mm. Weight: 0.9 kg.
List price £25. Our price **£9/19/6.**

PORTABLE MULTIRANGE METER

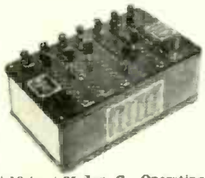
Specification.
Ranges: 0-60 & 0-300uA, D.C. 0-3, 0-30 & 0-120mA, D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30 mA, A.C. 24-120 mA, A.C. 0.24-12A. A.C. 3-12-30-300-600-1,200 & 6,000 V, D.C. 0.6-3, 2.4-12, 6-30, 60-300, 120-600, 240-1,200 & 1,200- 6,000 V. A.C. 3-333 ohms, 0.3-30 Kohms, 0.03-3 megohms D.C. Resistance —12 to +78 Decibels. Frequency: 50 cps. Input Resistance D.C.: 20,000 ohms/volt. Input Resistance A.C.: 2,000 ohms/volt. Temperature Range: —10 to +50 deg. C. Dimensions: 254 × 215 × 170mm. Weight: 8 kg. Supplied with 2 voltage dividers, H.V. leads, spare rectifiers, 1.5 & 22.5 V. battery.
List price £25. Our price **£12/19/6.**

SET OF MEASURING INSTRUMENTS

Specification Type: Moving Coil D.C. Ranges: 0-75mV, 0-3V, 3-15-150V, 3-150-450V, 0.3-0.75A, 1.5-7.5A, 15-30A. Scale Length: 82mm. Accuracy: 1.0%. Shunts: 1. 0.3-0.75 amps. 2. 1.5-7.5 amps. 3. 15-30 amps. Case: Moulded plastic. Carrying Case: Stove enamelled metal.
List price £30. Our price **£12/19/6.**

PLUG TYPE RESISTANCE BOX

Specification: Range: 0.1 to 114, 111.0 oh 114, 11.0 ohms. Steps: 0.1 ohm. Accuracy: 0.1%. Rated Power Per Step. 0.5W Coils: Manganin. Opening Temperature: +10 to +35 deg. C. Operating Humidity: Up to 80% R.H. Dimensions: 320 × 190 × 165mm. Weight: 4 kg.
List price £20. Our price **£8/17/6.**



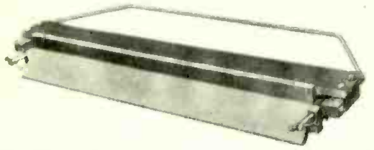
PORTABLE RECORDING MILLIAMMETER

Specification. Type: Moving Coil, D.C. Range: 0-500 milliamps. Chart Width: 100mm. Scale Length: 127mm. Chart Speeds: 20, 60, 180, 600, 1800 and 5400 mm/hr. Precision: 1.5%. Shunts: 75mV (Internal). Operating Temperature: + 5 to +50°C. Dimensions: 180h × 163 w × 245mm. Weight: 5.5kg. Complete with: 10 chart rolls, gears, inks, pipette, scale template and component case. List price £65. Our price **£35.**

Illustrated leaflets available.

ELECTRONIC BROKERS LTD., 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2 Cables: SELELECTRO

NEW 48" FOLDING MACHINES
SHEET METAL BENCH MODEL BY PARKER



Forms channels and angles down to 45 degrees which can be flattened to give safe edge. Depth of fold according to height of bench.

48" × 18 gauge capacity	£40 0 0
36" × 18 gauge capacity	£27 10 0
24" × 16 gauge capacity	£26 10 0

Carriage Free

Also the well-known vice models of

36" × 18 gauge capacity	£14 0 0
24" × 18 gauge capacity	£8 0 0
18" × 16 gauge capacity	£8 0 0

Carriage Free

One year's guarantee.
Money back if not satisfied.

Send for details:

A. B. PARKER

FOLDING MACHINE WORKS,
UPPER GEORGE STREET,
HECKMONDWIKE, YORKS.

Telephone 3997

WW—139 FOR FURTHER DETAILS

M.O.S.T. INTEGRATED CIRCUIT D.C. LOGIC

Ideal for EDUCATIONAL PURPOSES • INDUSTRIAL LOGIC • LOGIC EXPERIMENTS

Each unit consists of two separate 3-input NOR gates in a 10-lead TO-5 can, and is new and guaranteed.

Specification: Supply, —24 ± 1V; logic levels, 0 to —3V and —12 to —24V; power dissipation, approx. 20mW per gate when on; noise immunity, typically 2V with ½V guaranteed; speed, up to 200 KHz depending on load conditions.

Prices per circuit: 1-3, 15/-; 4-9, 13/6; 10-24, 12/-; 25-99, 11/-; 100 and over, 10/-. Terms, cash with order.

Guarantee: The circuits are guaranteed against a data sheet for one year

ACACIA HOUSE ELECTRICAL LTD., 1 Shortlands Close, Helmdon, Brackley, Northants.

INVERTERS

R GILFILLAN AND CO LTD
SOUTHDOWN VIEW ROAD
WORTHING SUSSEX
WORTHING 31587/8

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a unique and indispensable guide to prominent people in the electrical industry

1968-1969 electrical WHO'S WHO

Recognised as the standard guide to leading men and women in the electrical and electronics industries, the ELECTRICAL WHO'S WHO now contains some 8,500 biographies. Over 1,000 new names are included so that, taking into account those who have died or who have left the industries, the number of entries has increased by 250. Inclusion in this section is at the Editor's invitation and no charge is made for entries.
To add to the value of the directory we have again produced an index to the personnel of companies, boards, associations, etc., compiled from lists provided by the organisations themselves.

9" x 6" 567 pp **65s. net** 69s. 6d. by post

Published for ELECTRICAL REVIEW by
ILIFFE BOOKS LTD 42 Russell Square, London, WC1

Multi Purpose Neon Test Unit. Robust, useful and instructive, tests insulation, capacity, continuity, resistor, volume controls, also acts as signal injector and L.T. fault finder, kit comprises neon indicator, 4-way wafer switch, ebonite tubes, resistors-condensers, terminals etc., with diagram, only 9/6, plus 2/- post and insurance.

Tuning Condenser, solid di-electric .0005mfd. variable 2/6 each, 24/- dozen.

A.E.I. Fractional H.P. Motor. 200/250 v. 50/60 c.p.s. enclosed. continuous rating 1/40 h.p., ex. equip. Perfect order, 19/6, plus 4/6.

Experimenting with ultra violet? Philips U.V. lamp, 16/6; holder and control gear 19/6.

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Neon Mains Tester, 1/3 each, 12/- doz.

Flood Lamp Control. Our dim and full switch is ideal for controlling photo flood lamps; it gives two lamps in series, two lamps full brilliance and lamps off. Similar control of other appliances can be arranged where used in pair or where circuit can be split exactly in half. Technically the switch is known as a double-pole change over with off. Our price 4/6.

Sub-Miniature Silicon Diodes. General purpose type with gold-plated leads, 1/- each or 7/6 per dozen.

Message Tapes. 225ft. Tape on 3in. spools, normally 4/6 each, we offer 4 tapes for 12/6.

White Circular Flex. Ideal for lighting drops, twin made by BICC. Usually 8d. yd., 100yd. coil for 30/-, plus 6/- postage.

Edgewise Control. Morganite, as fitted many transistor radios, 2K or 5K with switch, 2/6 each or 24/- per dozen.

12 v. Inverter. Full transistorised for operating a 20-watt fluorescent tube, size 6in. long × 1¼ × 1¼. £3.10.0. Post and insurance 3/-.

Silicon Rectifier. Equiv. BY100 75mA 400 v., 10 for 20/-.

Miniature Pickup for 7in. records made by Cosmocode, crystal cartridge with sapphire stylus only 3/9 or 36/- dozen.

Headphones. Ex-WD unused and perfect, low resistance. Single with headband 4/6. Double with headband 8/6.

Midget Neons for mains indicators, etc., 1/3 each or 12/- dozen.

Compression Trimmers. Twin 100pF, 1/- each; 9/- per dozen.

3in. PM Loudspeaker. 3 ohm. 12/6; 80 ohm. 13/6.

Rotary Cam Operated Switch. 12 positions each of which close a separate pair of contacts except the last which leaves them all open. Contacts rated at 250 v. 16 amps. 15/- each.

Rotary Cam Operated Switch. 4 positions: 1st position all contacts open; 2nd, contact 1 closed; 3rd, contacts 1 and 2 closed; 4th, contacts 1, 2 and 3 closed. Contact rated 250 v. 16 amps. 8/6 each.

Pocket Test Meter, measures AC volts (3 ranges), DC volts (3 ranges), ohms, milli amps, ideal to carry around. Complete with instructions and test prods. 39/6 plus 2/6 p. & p

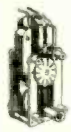
Breast Microphone. Fine American-made dynamic type, adjustable on breast plate with neck straps, 7/6, post 4/6.

Circular Fluorescent. 22 watt, 9in. diam. tube complete with choke, starter, holders and chrome clips. 29/6, post, etc., 4/6.

Midget Relay twin 250 ohm coils, size approx. 1¼in. × 1in. × 1in. 4 pairs changeover contacts, 7/6 each.

Printed Circuit Board, Edge Connector, solder terminations. 32 contacts, standard spacing for veroboard, etc. 6 in. long but easily cut, 7/6 each, 80/- doz.

1,000W Fire Spiral, replacement for most fires, 1/3 each, 12/- doz.

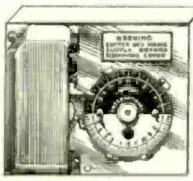


Rotisserie Motor

Very powerful 7 r.p.m. operates from standard AC mains. 29/6 plus 3/6 p. & p.

230 VOLT SOLENOID

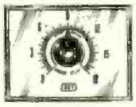
¾in. stroke. Size 2¼in. × 2in. × 1¼in., 14/6 postage 2/9.



ELECTRIC TIME SWITCH

Made by Smiths these are AC mains operated, NOT CLOCKWORK ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours, 5A changeover contacts will switch circuit on or off during these periods. 59/6, post and ins. 4/6. Additional time contacts, 10/- pair.

THIS MONTH'S SNIP



Process Time Controller

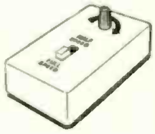
Made by Smiths, motorised and mains driven, enables 15A circuit to be started up to 18 hours in advance and to stay on for a period from 15 minutes to 3 hours. Totally enclosed in metal box with glass front and chrome surround. 49/6 plus 4/6 post and ins.

Electric clock with 20 amp switch

Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set—also on the left is another time or alarm—this may be set in minutes up to 1 hour. At the end of the period a bell will sound. Offered at only a fraction of the regular price—new and unused only 45/-, less than the value of the clock alone—post and ins. 2/9.

DRILL CONTROLLER

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions 19/6, plus 2/6 post and insurance. Or available made up 29/6. Plus 2/6 post.

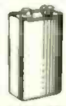


VARYLITE

Will dim incandescent lighting up to 600 watt from full brilliance to out. Fitted on M.K. flush plate, same size and fixing as standard wall switch so may be fitted in place of this, or mount on surface. Price complete in heavy plastic box with control knob £3.19.6.

MAINS TRANSISTOR POWER PACK

Designed to operate transistor sets and amplifiers. Adjustable output 6v., 9v., 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, condensers and instructions. Real snip at only **16/6**, plus 3/6 postage.



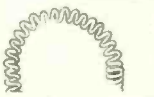
PP3 ELIMINATOR. Play your pocket radio from the mains! save £s. Complete component kit comprises 4 rectifiers—mains dropper resistances, smoothing condenser and instructions, only **6/6** plus 1/- post.

MINIATURE WAFER SWITCHES

4 pole, 2 way—3 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way—1 pole, 12 way. All at 3/6 each, 36/- dozen, your assortment.

WATERPROOF HEATING ELEMENT
26 yards length 70W. Self-regulating temperature control. 10/- post free.

Soil Warming Element
30yds. heavy P.V.C. covering 12/6



SPRING COIL LEADS

as fitted to telephones. 4 core **2/6** each, 3 core **2/-** each.

50 ohm 50 watt Wire-Wound Pot-meters, 8/6 each.

1 Meg Miniature. Pot-meter Morganite standatd ¼in. spindle, 1/- each; 9/- per dozen.

1 Meg Miniature. Pot-meter Morganite preset screwdriver control. 9d. each; 8/- per dozen.

Pre-Set 100K by Welwyn with intrical bakelite knob, 1/- each; 9/- per dozen.

100K Pot-Meter. Miniature type with double pole switch and standatd ¼in. spindle, by Morganite. 2/- each; 18/- per dozen.

Battery Motor 1¼in. long. 7in. dia., operates from 3 v. upwards, reversible, speed variable by changing voltage or resistance, 4/6 each; 50/- dozen.

Thermal Relay. Can be used to delay the supply of HT while heaters warm up, or will enable 15A loads to be controlled by miniature switches or relays. Regular list price over £2, price 7/6 each.

Siemens High Speed Relay. Twin 1,000 ohm coils. Platinum points changeover contacts—Ex-equipment, 8/6 each.

Toggle Switch Bargain. 10A 250 v. normal one hole fitting, 2/9 each; or 30/- per dozen.

Electric Lock. 24 v. coil, but rewindable to other voltages, 4/6 each.

Where postage is not stated then orders over £3 are post free. Below £3 add 2/9. Semi-conductors add 1/- post. Over £1 post free. S.A.E. with enquiries please.

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PRECISION IMPEDANCE BRIDGES

Marconi TF868/1 good used condition.... £65
Marconi TF2700 as new................ £55
Marconi TF373D reconditioned.......... £35
Bradley Model 131 little used.......... £45
B.P.L. Model UB202 good used condition.. £45
The above instruments are in guaranteed serviceable condition.

SPECIAL OFFER AVO LTD. TRANSISTOR ANALYSER MODEL TA

These extremely versatile instruments are offered in first class and serviceable condition incorporates all facilities for transistor testing. List price £115 .... only £40

HIGH QUALITY RF SIGNAL GENERATORS

Marconi 801/D1 Range 10-470 mc/s this model is in as new condition and guaranteed for three months........................ £150
Marconi TF1066A/2 FM/AM 10-470 mc/s. as new condition guaranteed three months £225
Rhode & Schwarz Model SDR-41022 300-1,000 mc/s little used condition.............. £125
Advance B4A2 100kc/s—70 mc/s as new.. £18
Advance Q1 7.5-250 mc/s.............. £20
Advance E1 100Kc/s-60 mc/s £15
General Radio U.S.A. 605B 500 kc/s 30 mc/s. £35
General Radio 804B 7-330 Mc/s.......... £22
AVO Ltd. CT378 2-225 Mc/s as new...... £40
All the above generators have internal mains power supply units.

LEVELL TRANSISTOR AND MULTI-TESTER MODEL TM.1

Small portable battery powered instrument in first class condition. Price only........ £12

AUDIO FREQUENCY GENERATORS

Levell Transistor Oscillator RC Type TG 150.............................. £16/10/0
Marconi TF195L 0-40 kc/s sine wave...... £15
BSR LO50A 2 c/s-16 Kc/s sine wave.... £12
Advance H1 O-50 kc/s sine square...... £25
Advance H1B 0-50 kc/s sine square...... £22
Cintel Model 1873 Square wave and pulse generator 0-250 kc/s.................. £35

REFLECTOMETERS BY A.T.E.

This equipment consists of reflectometer suitable for VSWR measurements at frequencies from 5 to 500 Mc/s and as a power output meter incorporating a non inductive dummy load for RF measurements up to 200 watts impedance 50 ohms all stages are interconnected by "N" type connectors these units are mounted on a 19 inch rack fully equipped and no extra fixings are necessary, offered at a fraction of original cost, brand new boxed. Price only £17

COMMUNICATIONS RECEIVERS

Redifon R50 13.5 Kc/s-32 Mc/s.
Hammerlund SP600 550 kc/s-54 Mc/s.
CR150/2 10-60 Mc/s.
Murphy B40 640 Kc/s-30 Mc/s.
Marconi Electra 260 Kc/s, 25 Mc/s.
Hallicraters SX28 550 Kc/s, 42 Mc/s.
All receivers in first class condition.

AUDIO GENERATORS

Listed below are a selection of first class instruments at much reduced prices.

Advance H1B, sine square wave. Range up to 50 Kc/s. As new. Price.... £22/10/0.

Advance H1. Sine square 5 c/s-50 Kc/s. Price £25

H & H. Sine square range 1.5 c/s to 150 Kc/s, fully transistorised as new. Our price £40

Hewlett Packard (Sine Wave). Range 190 c/s to 64 Kc/s. Brand new £45
Muirhead 695A Decade Osc'. Muirhead 638A Decade Osc. Both excellent condition. Price each.............. £55

Levell Transistor RC OSC' type TG 150. Range 1.5 c/s to 150 Kc/s. Our price. £17/10/0

B.S.R. LO50A. Range 2 c/s, 16 Kc/s. Price £15

Marconi TF195L 0-40 Kc/s outputmeter, etc. Price £15

TS 382 F/U (U.S.A.) Range 0-200 Kc/s. with calibrator, etc. New. Price...... £45

SQUARE WAVE GENERATOR

Range 100 Kc/s-1 mc/s (uncalibrated). Price £12/10/0

Cintel 1873 square wave and pulse generator. Range 0-250 Kc/s........ £35

DIGITAL VOLTMETERS

Hewlett Packard type 405CR cost £375. Our price £125

Weir Electronics Type DV500 Mk2, as new list £115. Our price £55

Gloster BIE 2113. See previous W/W. Cost price £198. Measures A.C., D.C. volts £90

DIGITAL FREQUENCY METERS

Racal model SA520. this current series DVM is portable, light and accurate. List £99. Our price as new.......... £60

DIGITAL FREQUENCY METER

0-100 Kc/s. Beckman (U.S.A.).
Racal Model SA520 portable transistorised. Range 0-500 Kc/s. As new List £98. Our Price £60

ADVANCE MODEL TC2A COUNTERTIMER

Range 0-1 mc/s. Time greater than 3 micro secs. to approx 28 hrs. this instrument is in first class, little used condition. Portable, fully transistorised. Price with manual £95
List over £240.

PORTABLE MULTIRANGE METER CATALOGUE NO.: R.7020

SPECIFICATION
Type: Magnetoelectric.
Ranges: 0-60 & 0-300 uA, D.C. 0-3, 0-30 & 0-120 mA, D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30 mA, A.C. 24-120 mA, A.C. 0.24-1.2A, A.C. 3-12-30-300-600 1,200 & 6,000 V, D.C. 0.6-3; 2.4-12; 6-30; 60-300; 120-600; 240-1.200 & 1,200-6,000 V, A.C. 3-333 ohms; 0.3-30 K ohms 0.03-3 megohms D.C. Resistance —12 to +78 Decibels. **Frequency:** 50 c.p.s. **Input Resistance D.C.:** 20,000 ohms/volt. **Input Resistance A.C.:** 2,000 ohms/volt. **Temperature Range:** —10 to +50° C. **Dimensions:** 255 × 215 × 170 mm. **Weight:** 8 kg. **Supplied with:** 2 voltage dividers, H.V. leads, spare rectifiers, 1.5 & 22.5 V battery. **Only £12/19/6**

CINEMA ENGINEERING ROTARY STUD SWITCHES

1 pole, 40 way, 3 banks............ 20/-
4 pole, 3 way BB & M, 3 bank 30/-
1 pole, 33 way, 2 bank.............. 20/-
2 pole, 5 way, 2 bank.............. 25/-
2 pole, 3W. BBM, 2 bank 20/-
1 pole, 7W. BBM, 1 bank 25/-
2 pole, 5W. BBM, 1 bank 25/-
All the above are new with heavy duty Ratings. P.P.2/6.

DALE PRODUCTS INC. HEAT SINK RESISTORS

These Resistors are non inductive and make excellent dummy loads.
15 ohms, 250 watts.............. 35/-
800 ohms, 250 watts.............. 35/-
200 ohms, 75 watts................ 10/-

0-2 amp AEI HIGHLY STABILISED P.S.U. R2240

This fully transistorised unit is variable between 3-30 Volts D.C. with a maximum load of 2 amps. Supplied brand new at only £22/10/0, carriage 20/-. List price £73.

0-1 amp. AEI TRANSISTORISED STABILISED P.S.U. R2414

3-53 Volts, fully variable by coarse and fine controls. These P.S.U. are continuously rated. The D.C. output is completely isolated from earth. A voltmeter and ampmeter are provided on front panel. Offered brand new at £22/10/0. P.P. 20/-.

0-600 V 0-500 MA A.E.I. STABILISED P.S.U. R2130

Outputs D.C. 0-600 V. Adjustable in one continuous range + Unstabilised D.C. Voltage of VO + 120 to VO + 220 Volts + two independent 6.3 V. A.C., centre tapped outputs 5 amp. each. Brand new boxed £45

DIRECT CURRENT AMPLIFIER

Contains "Brown Convertor", for continuous balance system and associated circuit. Complete less valves (5) Brand new .... 50/- P.P. 4/6

OSCILLOSCOPES AVAILABLE THIS MONTH

Tektronix 541B. With type "L" plug in mint condition. Fully demonstration. Guarantee 3 months, half manufacturers list price.
Solartron CD711S/2.............. £85
Solartron CD643/2 .... £125
Solartron CD316 .... £25
Solartron CD 523 .... £50

BURNDEPT RF PLUGS

These difficult to obtain plugs suitable for the Londex aerial c/o relay and many other types of equipment are offered. New, ex. equipment at 4/6 each. P.P. 6d.

COSSOR 1049 Mk3 DB.

D.C. coupled, a few available in first class condition. Complete, less graticule.. £35

COSSOR, PORTABLE 1052

Double beam general purpose. Scope ideal TV and radio service £35

BRADLEY 148A

General purpose miniature scope. Battery or mains. Fully transistorised band width D.C., 6 mc/s. Price £55

TELEQUIPMENT SERVICE SCOPE

TPYPE S31. DC-8 Mc/s. List price £78. Our price. Excellent condition.......... £35
We have many types in stock from £12/10/0, the above scopes are in fully serviceable condition. We also repair and overhaul and recalibrate any type of scope. Write or phone for quotation.

HARTLEY TYPE 13A DB

We still have some available. Band width 2 c/s-5.5 Mc/s, fully overhauled, the best buy in scopes for TV and radio service. Complete with all leads, etc. Price £22/10/0 With circuit diagram and instructions.

EDDYSTONE DIE CAST BOXES

Contains sensitive amplifier originally intended for amplification of P.E. Cells C/W input socket, fuse, signal lamp. P.S.U. (Mains) Amplifier, fully transistorised. Brand new........ 32/6 P.P. 2/6

Lasky's Radio

LASKY'S RADIO ESTABLISHED OVER 36 YEARS

TEST EQUIPMENT

THREE NEW METERS BY TMK

These meters by the famous TMK Co. of Japan incorporate the very latest developments in design and set a new standard in quality and accuracy. The new shape permits a more compact cabinet yet the meter size is actually increased! All have strong impact resistant cabinets with carrying handles and are complete with test leads, batteries and full instructions.

Model PL-436

20,000 O.P.V. Multi-tester for the amateur or professional. Features mirror scale and wood grain finish front panel. SPEC.: DC/V ranges: 0.6, 3, 12, 30, 120, 600V at 20K/O.P.V. AC/V ranges: 3, 30, 120, 600V at 8K/O.P.V. DC current: 50μA, 0.6, 60, 600mA. Resistance: 10K, 100K, 1M and 10M ohms end scale (65, 650, 6.5K and 65K ohms centre scale). Decibels: −20 to +57dB in four ranges. Operates on 2 x 1.5V U7 type batts. Size: 5⅞ x 4⅜ x 2⅞in.

£7.19.6 Post 6/–

Model 5025

50,000 O.P.V. Multi-tester suitable for all professional and educational uses. Features a fantastic 57 measurement range cover (±2% accuracy on full scale DC), high-speed range selection, polarity reversal switch and overload meter protection circuit. SPEC.: DC/V ranges: 0.125 to 1000V in 12 ranges (0.25 to 500V at 50K/O.P.V.). AC/V ranges: 1.5V to 1000V in 10 ranges (1.5 to 500V at 5K/O.P.V.). DC current: 25μA to 10Amp. Ohms: 0 to 10M ohms. Decibels: −20 to +81.5dB in 10 ranges. Operates on 2 x 1.5V U7 type batts. Size 6⅞ x 5¼ x 2⅜in.

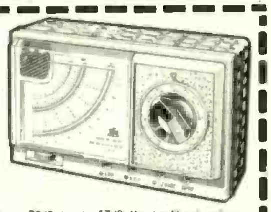
£13.10.0 Post 6/–

100,000 O.P.V. "LAB" Model

A highly accurate yet rugged Multi-tester using a 10μA meter hand calibrated to a DC accuracy of ±3% of full scale. Special features—ultra large meter scale 6⅛ x 3⅛in. incorporating an entirely new type of range selection panel which gives instant identification without taking your eyes from the meter. An audible buzzer is provided for easy short testing. SPEC.: DC/V ranges: 0.5, 2.5, 10, 50, 250, 500, 1000V at 100K/O.P.V. AC/V ranges: 3, 10, 50, 250, 500, 1000V at 5K/O.P.V. DC current: 0-10, 100 A, 0-10, 100mA, 0-2.5, 10Amp. Resistance: 0-1K, 10K, 100K, 10M, 100M/ohms. Decibels: −10 to +49.4dB. Continuity test: Audible buzzer. Operates on 1 x 1.5V U2 and 1 x 15V B.154 type batts. Cabinet size 7⅞ x 6⅞ x 3⅛in. Weight 4lb.

LASKY'S PRICE £19.10.0 Post 6/–

TTC Model C-1051



A completely new design 20,000 O.P.V. pocket multimeter with mirror scale and built-in thermal protection circuit. Exceptionally large easy-to-read meter with D'Arsonval movement. Colour coded scales. Single positive click-in, recessed selection switch for all ranges. Ohms zero adjustment. Range spec. AC Volts: 0-6-30-300-1200V at 10K/ohms/V. DC volts: 0-3-15-150-300-1.2KV at 20K/ohms/V. Resistance: 0-60K-6megs. DC current: 0-60 A-300mA. Decibels: −20dB to + 17dB. Hand calibration gives extremely high standard of accuracy on all ranges. Uses one 1½V penlight battery. Strong impact resistant plastic cabinet—size only 4⅜ x 3⅛ x 1⅛in. Two-colour buff/green finish. Complete with test leads and battery. Original list price £5.5.

LASKY'S PRICE ONLY 75/– Post 2/6

NEW! WIEN FMX-1917 AM/FM STEREO TUNER AMPLIFIER

A new solid-state AM/FM Multiplex tuner Amplifier offering excellent quality and pleasing design at a price you can afford. Brief spec: 18 transistors, 9 germanium diodes, 1 variable diode and 1 silicon rectifier. Single ended push pull amplifier—output 5W, RMS per channel into 8 ohms. Frequency response 30 c/s to 12 Kc/s. Frequency range: FM-88 to 108Mc/s, AM-535 to 1605Kc/s. Stereo separation 15dB at 100uV input. External FM aerial; built-in ferrite rod antenna for AM. Controls: Balance, Mode, Tone, Vol/on-off, tuning. Input for ceramic phono pick-up. Powered by 220/250V, A.C. 50/60c/s. Extremely well made oiled walnut finish cabinet with large clear tuning dial (black/grey/silver trim). Size: 14 x 8½ x 5½in.

LASKY'S PRICE £29.0.0 Post Free

Garrard

SPECIAL OFFER

AP.75 (illustrated) 4 speed single player offered with **AD.73K** stereo Moving Magnet Cartridge.

LASKY'S PRICE £21 Post 6/–

AUTOCHANGERS

1025 less cartridge	£6	19	6
1025 with Mono cartridge	£7	15	0
2025TC with Stereo cartridge	£8	19	6
2025TC less cartridge	£8	10	0
SL.55 with Stereo cartridge	£12	9	6
SL.65 with Stereo cartridge	£15	19	6
SL.75 less cartridge	£32	0	0
SL.95 less cartridge	£39	10	0
AT.60 Mark II less cartridge	£14	10	0

SINGLE PLAYERS

AP.75 less cartridge	£19	10	0
SRP.22 with mono cartridge	£6	10	0
Deccadec de luxe, with Deram cartridge	£17	17	0

TRANSCRIPTION DECKS

Lab.80 Mk II on base	£30	9	0
401	£27	15	0

GARRARD BASES

WB1 £3.6.11 WB4 MK II £5.8.11 WB5 £5.8.11

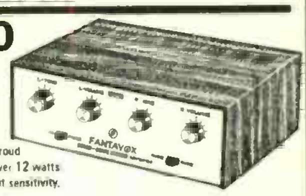
CLEARVIEW PERSPEX COVERS

SPC1 £3.5.0 SPC4 MK II £4.6.6

Postage on all above 5/- extra

FANTAVOX 500

12 WATT STEREO AMPLIFIER



This outstanding amplifier incorporates all the features expected of an expensive unit but at a budget price. The amplifier has separate tone and volume controls for both channels plus stereo mono switch and tuner output socket. Finished in an attractive walnut grained metal cabinet this amplifier would be a proud addition to any budget stereo system. Brief Spec: Output, Peak power 12 watts. Freq. Response: 40-20,000 Hz. Output impedance 4-16 ohms. Input sensitivity. Phono/Tuner 250mV. Size: 9½ x 2⅞ x 5½in.

LASKY'S PRICE £12.10.0 Post 6/–

FM TUNER Model A 1008

For size, quality and price we feel sure the A1008 FM Tuner is unbeatable. Probably the world's most compact FM Tuner with 6 transistor and 3 diode printed circuit, self powered—operating from any 9V DC source. Slow motion tuning drive. Housed in beautifully finished walnut cabinet with classic silver trim. Clear horizontal tuning scale covering the entire FM band from .88-108 Mc/s. Complete with FM aerial. Brief Spec: aerial imp. 75 ohms. Sensitivity better than 10μV (at 100% modulation for 20dB S/N). Size 7½ x 5 x 3⅛in.

LASKY'S PRICE £9.19.6 Post 3/6

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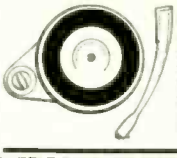
WW—143 FOR FURTHER DETAILS

HARVERSON'S SUPER MONO AMPLIFIER.
A super quality gram amplifier using a double wound mains transformer, EZ80 rectifier and ECL82 triode pentode valve as audio amplifier and power output stage. Impedance 3 ohms. Output approx. 3.5 watts. Volume and tone controls. Chassis size only 7in. wide × 3in. deep × 6in. height overall. A.C. mains 200/240v. Supplied absolutely Brand New, completely wired and tested with valves and good quality output transformer. LIMITED NUMBER ONLY. OUR ROCK BOTTOM BARGAIN PRICE **49/6** P. & P. 6/-.

TRANSISTOR STEREO 8 + 8 Mk. II

Now using Silicon Transistors in first five stages on each channel resulting in even lower noise level with improved sensitivity. A really first-class Hi-Fi Stereo Amplifier Kit. Uses 14 transistors giving 8 watts push pull output per channel (16W. mono), Integrated pre-amp. with Bass, Treble and Volume controls.* Suitable for use with Ceramic or Crystal cartridges. Output stage for any speakers from 3 to 15 ohms. Compact design, all parts supplied including drilled metal work. Cir-Kit board, attractive front panel knobs, wire, solder, nuts, bolts—no extras to buy. Simple step by step instructions enable any constructor to build an amplifier to be proud of. Brief Specification: Freq. response ±3dB, 20-20,000 c/s. Bass boost approx. to +12dB. Treble cut approx. to −16dB. Negative feedback 18dB. over main amp. Power requirements 25V. at .6 amp.

PRICES: Amplifier Kit £10/10/0; Power Pack Kit £3/0/0; Cabinet £3/0/0. ALL POST FREE.
Circuit diagram, construction details and parts list (free with kit) 1/6 (S.A.E.).



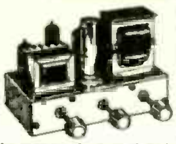
HUGE PURCHASE!
E.M.I. 4-SPEED PLAYER.
Heavy 8½in. metal turntable. Low flutter performance 200/250 v. shaded motor (90 v. tap). Complete with latest type lightweight pick-up arm and mono cartridge with t/o styli for LP/78
LIMITED NUMBER ONLY 63/-. P. & P 6/6

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

QUALITY RECORD PLAYER AMPLIFIER MK. II
A top-quality record player amplifier employing heavy duty double wound mains transformer. ECC83, EL84, EZ80 valves. Separate bass, treble and volume controls. Complete with output transformer matched for 3 ohm speaker. Size 7in. w. × 3in. d. × 6in. h. Ready built and tested. PRICE 75/-. P. & P. 6/-. ALSO AVAILABLE mounted on board with output transformer and speaker ready to fit into cabinet below. PRICE 97/6. P. & P. 7/6.

DE LUXE QUALITY PORTABLE R-PLAYER CABINET MK.2
Uncut motor board size 14½ × 12in., clearance 2in. below 5½in. above. Will take amplifier above and any B.S.R. or GARRARD Autochanger or single Player Unit (except AT60 or SP25). Size 18 × 15 × 8in. PRICE 79/6. Carr. 9/6.

3-VALVE AUDIO AMPLIFIER MODEL HA34



Designed for Hi-Fi reproduction of records. A.C. mains operation. Ready built on plated heavy gauge metal chassis, size 7½in. w. × 4in. d. × 4½in. h. Incorporates ECC83, EL84, EZ80 valves. Heavy duty, double wound mains transformer and output transformer matched for 3 ohm speaker, separate bass, treble and volume controls. Negative feedback line. Output 4½ watts. Front panel can be detached and leads extended for remote mounting of controls. The HA34 has been specially designed for us and our quantity order enables us to offer them complete with knobs, valves, etc., wired and tested for only £4/5/-. P. & P. 6/-.

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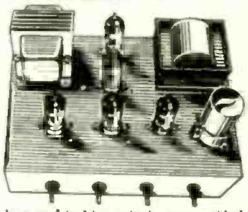
Similar in appearance to HA 34 above but employs entirely different and advanced circuitry. Complete set of parts etc. 79/6 P. & P. 6/-.

HIGH GAIN 4-TRANSISTOR PRINTED CIRCUIT AMPLIFIER KIT TYPE TA1
● Peak output in excess of 1½ watts. ● All standard British components. ● Built on printed circuit panel, size 6 × 3in. ● Generous size driver and output transformers. ● Output transformer tapped for 3 ohm and 15 ohm speakers. ● Transistors (GET 114 or 81 Mullard OC81D and matched pair of OC81, o/p). ● 9 volt operation. ● Everything supplied, wire, battery clips, solder, etc. ● Comprehensive easy to follow instructions and circuit diagram 2/6 (Free with Kit). All parts sold separately. SPECIAL PRICE 45/-. P. & P. 3/-. Also ready built and tested 52/6. P. & P. 3/-.

10/14 WATT HI-FI AMPLIFIER KIT



A stylishly finished monaural amplifier with an output of 14 watts from 2 EL84s in push-pull Super reproduction of both music and speech, with negligible hum. Separate inputs for mike and gram allow records and announcements to follow each other. Fully shrouded section wound output transformer to match 3-15Ω speaker and 2 independent volume controls, and separate bass and treble controls are provided giving good lift and cut. Valve line-up: 2 EL84s, ECC83, EF86, and EZ80 rectifier. Simple instruction booklet 1/6 (Free with parts). All parts sold separately. ONLY £7/9/6. P. & P. 8/6. Also available ready built and tested complete with standard input sockets. £9/5/-. P. & P. 8/6.

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Mains models. All brand new in maker's original packing.
E.M.I. Model 999 Single Player with unit mounted pick-up arm and mono cartridge £5.5.0.
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1/- TESTED TRANSISTORS 1/- each
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BC109	2N697	2N1613	2N3707	2N3391
BFY50	2N706	2N1711	2N3711	TI544
BFY51	2N708	2N2904	2S102	2N2906
BFX84	2N929	2N2905	2S103	2N2907
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Type No.	PIV	Amp	Each
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2N1596	100	1	8/-
2N1597	200	1	10/6
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TO-48 CASE (STUD)

Type No.	PIV	Amp	Each
2N682	50	16	12/-
2N683	100	16	15/-
2N685	200	16	19/6
2N687	300	16	25/6
2N688	400	16	32/6
2N689	500	16	47/6
2N690	600	16	50/-
2N691	700	16	56/-
2N692	800	16	62/-

TO-46 CASE (STUD)

Type No.	PIV	Amp	Each
2N1771	50	4·7	9/-
2N1772	100	4·7	9/6
2N1774	200	4·7	12/6
2N1776	300	4·7	16/6
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AC125	ACY22	ACY36	NKT677	OC81
AC126	ACY27	NKT141	NKT713	OC82
AC127	ACY28	NKT142	NKT773	2G301
AC128	ACY29	NKT212	OC44	2G302
AC130	ACY30	NKT213	OC45	2G303
ACY19	ACY31	NKT214	OC71	2G308
ACY20	ACY34	NKT215	OC72	2G371
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OA202 Silicon Diode. Fully Coded.
150 PIV 250mA Qty. Price £30 per 1,000 pieces.
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Sub-Min. Plastic 1 Amp Sil. Rect.

Type No.	PIV	Each
1N4001	50	1/3
1N4002	100	1/6
1N4003	200	2/-
1N4004	400	2/9
1N4005	600	3/3
1N4006	800	3/9
1N4007	1,000	4/9

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2,500 cross references of transistors—British, European, American and Japanese. A must for every transistor user. Exclusively distributed by DIOTRAN SALES. 15/- EACH.

Vast mixed lot of subminiature glass diodes. Comprising of Silicon, Germ, Point Contact and Gold Bonded types plus some Zeners. 500,000 available at Lowest of Low Price.
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Battery Powered Portable Resistance Bridge. Range 0.5 to 50 ohms with multiplier settings of 0.1-1-100-1000, providing a measuring range of 0.05 to 50,000 ohms. Accuracy in the middle 3 ranges—0.5% approx. PRICE £15 15 0

TRIACS TYPE 40432

Gated bi-directional Silicon Thyristors with integral trigger. The triac will control up to 1440 watts at 240V mains frequency. Supplied complete with heat sink, data sheet and application sheets for motor control and dimmer circuits 37/6 each.

UNIJUNCTION TRANSISTORS 2N2646

Power dissipation 300mW R.M.S. Base-to-Base voltage 35V max. Peak emitter current 2·0A. Suitable for triggering of thyristors. 12/6.

INTEGRATED CIRCUIT AMPLIFIERS

R.C.A. TYPE CA 3020 TO-5 encapsulated 12 lead Audio Amplifier equivalent to seven N-P-N Transistors, three diodes and eleven resistors. Maximum Power Output 550mW. Bandwidth 6 mc/s. Total harmonic distortion 1% Sensitivity 3.5mW. Max. peak signal input ±3V. Max. signal current drain 47mA. Voltage required 3 to 9V. PRICE 30/-, P. and P. 2/-.

GENERAL ELECTRIC TYPE PA222 Epoxy moulded four-in-line 8 pin package plus heat sink lead, equivalent to six N-P-N transistors, one diode and six resistors. Max. power output 1 watt into 15 ohms. No transformer required. Full signal current drain 155mA from a 22V source. PRICE 40/- P. and P. 2/-. Supplied complete with application data.

GENERAL ELECTRIC TYPE PA234—Epoxy moulded four-in-line 8-pin package plus heat sink lead equivalent to seven transistors, three diodes and three resistors. The circuit is a complete 1-watt A.F. Amplifier and requires only three resistors and three capacitors. Power supplies 9 to 25V. Load impedance 8, 16 and 22 ohms. 1 watt output for 600mV input. PRICE 27/6 p.p. 2/-.

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Blue spot; 200 piv 5 amps. Gate Voltage 3.25V at 120mA	12/6

High current

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HIGH POWER STUD MOUNTED 15% ZENER DIODES

SERIES D815, 8 watts dissipation: 4.7, 5.6, 6.8, 8.2, 10.0, 12.0, 15.0 18.0V.
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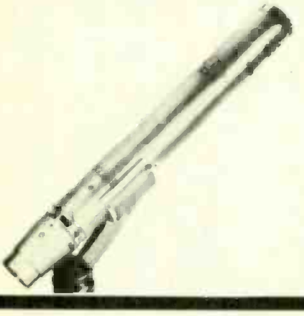

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Candidates, 30-45 years, must possess City and Guilds Intermediate or equivalent, or practical experience preferably in the Police or Armed Forces giving comparable ability. Proven administrative ability and service in a position of authority in Police or Armed Forces is essential. The officer selected will undertake installation, operation and maintenance of the Police Radio Network comprising H.F., S.S.B. and V.H.F./F.M. stations up to 500 watts and will have control of and responsibility for the Police Communications Section.

Apply to CROWN AGENTS, M. Dept., 4 Millbank, London, S.W.1.

for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference, M2K/680842/WF.

ASSISTANT INSTRUCTOR— H.F. RADIO COMMUNICATIONS

Due to the expansion of our customer training facilities we require the services of an ASSISTANT INSTRUCTOR—H.F. RADIO COMMUNICATIONS.

Responsibilities will include lecturing, organising, syllabus planning and dealing with the extramural requirements of Trainees.

The Company provides a high level of training to customers, engineers and technicians (the school is situate in Reading but the position may require some overseas travel) and it is essential that applicants are fully conversant with modern H.F. Communications systems.

The position may well suit an ex-member of the regular Forces who has previous lecturing experience.

Applications in writing please, to:—

RACAL
THE RACAL GROUP

**The Group Personnel Manager,
Racal Communications Limited,
Western Road,
Bracknell, Berkshire.**

This Company is one of the largest simulator manufacturers in the world and exports over 50% of its products. The ever-increasing demand for sophisticated training aids to match the complexity of modern aircraft has given rise to vacancies for engineers.

SYSTEMS DESIGN ENGINEERS

B.Sc./H.N.C. Elect. or Aeronautical Analogue/ Digital Systems experience with preferably Aeronautical or Avionic background. Willing to travel, etc.

We would welcome people with the following backgrounds:—

Systems design; Servo Mechanisms design; Real Time Programming; Flight Testing; Auto pilots; Aircraft Performance; Stability and Control, Avionics.

They will be employed in:

The analysis of aircraft systems and the preparations of systems for use with analogue and digital computers to simulate aircraft behaviour; investigation of customers' requirements, preparation of schemes using logic and digital computer techniques, detail design of systems and to manage project from inception to completion.

We will be happy to show you the factory on either 14th or 15th March, or to hold an interview in London. Or if these arrangements are inconvenient, you name the date; we want to meet you. (1969 holidays will be discussed at interview.)

Applications, with details of experience, should be sent to:—

The Personnel Manager,
REDIFON AIR TRAINERS LIMITED
**Bicester Road, Aylesbury, Bucks.
Telephone: Aylesbury 4611**

REDIFON

A Member Company of the Rediffusion Organisation

RADIO & TELEVISION SERVICING RADAR THEORY & MAINTENANCE

LEC

This private College provides efficient theoretical and practical training in the above subjects. One-year day courses are available for beginners and shortened courses for men who have had previous training.

Write for details to: The Secretary, London Electronics College, 20 Penywern Road, Earls Court, London, S.W.5. Tel.: 01-373 8721.

GRANADA TELEVISION

Electronic Engineers for Operational Television

We have a number of vacancies at the TV Centre in Manchester for men with a good knowledge of television engineering to work in all aspects of Granada's production and transmission operations. These cover studio sound and vision, videotape, telecine, transmission switching and maintenance of equipment. Entry points and salaries depend on experience and qualifications. Salaries will range between £1,295 and £1,876 p.a.
Housing prospects in the Manchester area are excellent and we will give assistance with housing and removal expenses. Generous Granada Group Pension and Life Assurance Scheme.
Write full details age experience and qualifications, quoting Reference EE/WW to Kevin Crumplin, Granada Television, Manchester 3.

Communications Officer

BOAC has a vacancy for a Communications Officer at Heathrow Airport—London.

His duties will be to assist in ensuring the efficient functioning of ground communications facilities at Heathrow Airport which will include telephone, telegraph, facsimile and public address services.

Candidates for this appointment must have a good knowledge of telephony and in particular of the operation of PABX's No. 4, PAX's both step by step and cross-bar, intercommunication and public address systems. Experience in telephone traffic studies and a knowledge of GPO practices and services and telegraph and facsimile systems would be an advantage.

Salary according to experience will be in the range of £1,558 per annum to £1,819 per annum.

There is an excellent pension scheme and opportunities exist for holiday air travel.

Write to:

Manager Selection Services (100WW), BOAC PO Box 10, HOUNSLOW, Middlesex.

BOAC

ROYAL HOLLOWAY COLLEGE

(University of London)
Englefield Green, Surrey

PHYSICS DEPARTMENT SENIOR ELECTRONICS TECHNICIAN

Required to assist with the design and construction of equipment used in Teaching and Research in Physics. This is interesting and non-repetitive work on designing, building, and servicing a wide range of electronic instruments. E.T. certificate, O.N.C. or experience of development or servicing electronic equipment would be an advantage. Salary on the scale £987-£1,125, with London Weighting and qualifications allowance. 4 weeks Holiday, Superannuation. Applications to the Secretary.

KENT COUNTY COUNCIL

KENT EDUCATION COMMITTEE

Closed Circuit Television in Schools

TECHNICIAN/PRODUCTION ASSISTANT required for 1st July 1969 for Closed Circuit Television scheme for schools to be introduced in the Dover and Deal area. Salary scale Technician 4 (£1,055 to £1,265 a year). Applicants will be based on a studio in Dover and should have a sound practical knowledge of the use of cameras, control and recording equipment involved in closed circuit television and be capable of taking charge of the equipment in a studio. The person appointed will also be expected to assist with production.

Applications by letter, giving the names and addresses of two referees, to County Education Officer (T1), Springfield, Maidstone, by 31st March 1969.

COLLEGE OF I.M.R. COMMNS., Brooks' Bar, Manchester 16, invite applications from suitably qualified persons for the following:

ASSISTANT LECTURER IN MARINE RADIO. P.M.G. Cert., and up-to-date knowledge of the technical syllabus essential. Radar and other qualifications and/or teaching experience an advantage, taken into account when fixing salary, based on the Burnham Scale.

ASSISTANT LECTURER IN MARINE RADAR. Applicants must hold the B.O.T. Radar Maintenance Certificate, and should also have had Radar experience as a marine Radio Officer and/or service engineer.
Both positions available April or September 1969.

Write Principal, giving in confidence full details of experience, education, present salary, etc.

CITY AND COUNTY OF BRISTOL EDUCATION COMMITTEE

BRISTOL TECHNICAL COLLEGE

DEPARTMENT OF ELECTRICAL ENGINEERING

Applications invited for posts of:
(a) SENIOR TECHNICIANS (Grade T3).
(b) TECHNICIAN (Grade T2).
for following laboratories:

(a1) ELECTRIC CIRCUITS & ELECTRONICS. Ref. T693/2/2 (T3)
(a2) ELECTRICAL MACHINES. Ref. T693/21/1 (T3).
(b1) ELECTRICAL INSTALLATION WORKSHOPS Ref. T693/3/2 (T2).

Post (a1) Experience required in Radio and TV, or Electronic Servicing.
Post (a2) Experience required in maintenance of Electrical Power Equipment.
Post (b1) Experience required in Electrical Contracting Industry or Electrical maintenance.

Duties include maintenance and construction of equipment, and servicing of laboratory and workshop classes.

Salary Scales: Grade T3 £895-£1,055.
Grade T2 £765-£895.
Starting salary in accordance with age, qualifications and experience. £50 or £30 per annum extra for appropriate City and Guilds qualifications or equivalent.

38-hour, 5-day week with usual holiday and sick pay schemes. Posts superannuable.

Application forms (to be returned within fourteen days of this advertisement) from Registrar, Bristol Technical College, Ashley Down Bristol BS7 9BU. Please quote appropriate Reference Number in all communications.

PYE

We have vacancies for

EXPERIENCED TEST ENGINEERS

in our Production Test Department. Applicants are preferred who have experience of Fault Finding and Testing of VHF and UHF Mobile Equipment. Excellent opportunities for promotion due to expansion programme.

Please apply to Personnel Manager

PYE TELECOMMUNICATIONS LTD., Cambridge Works, Haig Rd., Cambridge. Tel: Cambridge 51351, ext. 355

Telecommunications Technical Officers

BOARD OF TRADE (CIVIL AVIATION DEPARTMENT)

Posts for men aged at least 23 for work on Radar, Data Processing Equipment, Navigational Aids and Communications Equipment at Civil Aerodromes and other stations in the United Kingdom.

QUALIFICATIONS: O.N.C. in Engineering (including a pass in Electrical Engineering A), *or* City and Guilds Intermediate Certificate in Telecommunications Engineering (old syllabus i.e. subject No. 50) plus Radio II, or Intermediate Telecommunications Certificate (new syllabus i.e. subject 49) plus Certificate in Mathematics B, Telecommunications Principles B, and Radio and Line Transmission B, *or* equivalent standard of technical education. At least 5 years' appropriate experience essential.

SALARY (national): from £1,119 (at age 23) to £1,347 (at 28 or over on entry); scale maximum £1,521 (somewhat higher in London). Salaries under review. Promotion prospects. Non-contributory pension.

WRITE to Civil Service Commission, Savile Row, London, W1X 2AA, or TELEPHONE 01-734 6010 Ext. 229 (after 5.30 p.m. 01-734 6464 "Ansafone" Service), for application form, quoting *S*/207/68. Closing date 1st April 1969.

REDIFFUSION

COLOUR TELEVISION FAULTFINDERS & TESTERS

We have a number of vacancies in our Production Test Departments for experienced faultfinders and testers.

Knowledge of transistor circuitry and experience with Colour Receivers together with R.T.E.B. Final Certificate or equivalent qualifications required.

These will be staff appointments with all the expected benefits.

Applications to:

**Works Manager,
Rediffusion Vision Service Ltd.,
Fullers Way South,
Chessington, Surrey (near Ace of Spades).
Phone: 01-397 5411**

Bench engineer fully experienced in all sections, also improver wanted. Five day week, excellent prospects.

**KINGS RADIO, 151 Sloane St., S.W.1
Tel: Sloane 1797**

INSTRUMENTS FOR SALE

SIGNAL GENERATORS. R.F.T.—10-240 MHz in 10 ranges with coarse and fine output controls. Output impedance 60Ω. Output level 0.5μV to 50 mV. **£120**

AIRMEC MODEL 365—20-300 MHz. Output level 100 mV. Output impedance 53Ω. **£165**

WAVEMETER. Type R.F.T.—30 KHz-30 MHz with built-in crystal calibrator and coarse and fine tuning. **£30**

PHASE METER. Airmec Type 206—20Hz-100 KHz. **£45**

**ALL IN GOOD WORKING ORDER
BOX NO. 5054**

UNIVERSITY OF SOUTHAMPTON

Department of Chemistry
Electronics Engineer

The post calls for the development and servicing of instruments in a large chemistry department with a strong interest in spectroscopy. Facilities are excellent and a wide range of instrumentation is employed including 100 m/c N.M.R., Raman, I.R., U.V., E.S.R., spectrometers, lasers, etc. Candidates should have a degree or appropriate professional qualifications and considerable ability in electronics, including design, together with an interest in optics and instrument design and be able to run a small team of technicians. The position is permanent. Salary on scale for Experimental Officers £1,240 to £1,930 per annum. Please write stating age, qualifications, experience and giving the names of two referees, preferably previous employers, to the Deputy Secretary, The University, Highfield, Southampton SO9 5NH, quoting reference WW.

**C.S.E. (AIRCRAFT SERVICES) LTD.
OXFORD AIRPORT • KIDLINGTON**

Electrician
Electronic Wireman
Radio Technician

It you are one of these, a job awaits you at C.S.E. (Aircraft Services), Kidlington. The work covers the preparation of Wiring and Components and the Installation into modern aircraft (including the Jetstream), of Radio and Electronic Systems Equipment.

Weekly Staff Status, Pension Scheme, Free Life Assurance, Sickness Allowance.

Apply in first instance to:—

**THE ADMINISTRATION SUPERVISOR
C.S.E. (AIRCRAFT SERVICES) LTD.
OXFORD AIRPORT
KIDLINGTON
OXFORD**

Telephone: Kidlington 3931

AIRBORNE ELECTRONICS SERVICE TECHNICIANS

RCA is an international electronics company with diverse interests in the field of electronic engineering. Part of our Service Division is operating in the South of England and is engaged on servicing and maintaining airborne electronic equipment, particularly AIRBORNE RADARS, ELECTRONIC NAVIGATIONAL AIDS and HF, VHF and UHF COMMUNICATIONS.

A number of interesting vacancies have arisen which offer excellent opportunities for developing the initiative and furthering the career of young men between 22 and 35. They must have relevant experience preferably on the specific equipment mentioned above.

These positions carry monthly paid staff status with excellent fringe benefits, including three weeks paid holiday each year. A competitive salary will be paid and there are excellent promotion prospects.

Please write or 'phone for an application form to:—

Mr. R. G. Hancock, RCA Limited,
Sunbury-on-Thames, Middlesex.
Telephone: Sunbury 85511.

RCA

ABERDEEN

SENIOR TECHNICIAN IN ELECTRONICS

School of Electrical Engineering
Robert Gordon's Institute of Technology

Applications are invited for the above post. Candidates should preferably have at least an Ordinary National Certificate or equivalent and have had a wide experience in the construction and maintenance of electronic equipment. The Senior Technician will be assisted by two technicians and be responsible to the Chief Technician. The post is superannuable and the salary scale is £987-£1225 per annum.

Forms of application and further details may be obtained from the undersigned to whom they should be returned on or before 18th April 1969.

Charles Birnie,
Secretary

The Company is one of the largest simulator manufacturers in the world and exports over 50% of its products. The ever-increasing demand for sophisticated training aids to match the complexity of modern aircraft has given rise to vacancies for engineers.

DESIGN ENGINEERS

(Mechanical)

We need experienced men with the following backgrounds:

Apprentice trained mechanical engineer with experience in industrial and/or aircraft hydraulic design. Academic standard H.N.C.

Mechanical engineer with aircraft structures and fuselage experience as well as control systems. H.N.C. or H.N.D. Degree.

They will be employed in:

The design of motion platforms and structures;

The design of optical and mechanical assemblies;

Design of flight instruments to simulate those used in the aircraft;

The design of high performance hydraulic servo systems.

DRAUGHTSMAN

(Mechanical)

Applicants should have mechanical detail and/or aircraft structures experience.

We will be happy to show you the factory on either 14th or 15th March, or to hold an interview in London. Or if these arrangements are inconvenient, you name the date; we want to meet you. (1969 holidays will be discussed at interview.)

Applications, with details of experience, should be sent to:—

The Personnel Manager,
REDIFON AIR TRAINERS LIMITED,
Bicester Road, Aylesbury, Bucks.
Telephone: Aylesbury 4611

REDIFON

A Member Company of the Rediffusion Organisation

SERVICE TECHNICIANS

Experienced electro engineers, minimum qualifications O.N.C./City and Guilds, to service and repair a wide range of electro-acoustic instruments. Driving experience essential.
Excellent salary and opportunities for advancement. Write or telephone for immediate interviews.

Personnel Department,
Amplivox Limited,
Beresford Avenue, Wembley, Telephone 902-8991.

TECHNICAL SALES MANAGER

Manufacturers of Laminates for Printed Circuits and technical products

based in North West, under British and American direction, wish to appoint a TECHNICAL SALES MANAGER to cover a wide range of LAMINATED PRODUCTS for

COMPUTER, ELECTRONICS & AUTOMOTIVE

industries and other technical applications.

Essentials: Previous experience in the industry.
Well proven Sales performance.
Drive and initiative in respect of new products.
Electrical, mechanical or chemical background favoured.

Excellent prospects in fast growing newly established Company. Attractive conditions. Salary will be negotiated. Please write with essential details in confidence to Box **5055**.

Pye Telecommunications Ltd.
OF CAMBRIDGE

The largest exporters of VHF/UHF radiotelephone equipment in the world require:

ENGINEERS AND DESIGN DRAUGHTSMEN

Type of work and experience: We require electronic engineers and design draughtsmen to join teams engaged in the design and development of fixed mobile and portable UHF and VHF transmitters and receivers. These teams are responsible for all aspects of designing and development through to the production line.

Applicants should have experience in economic design for quantity production in the same or similar field of activity.

Education. Appropriate degree or diplomas preferred or proven experience of comparable level will be considered.

Age: 20-40 years.

Company contribution Pension Scheme.

Applications should be submitted to PERSONNEL MANAGER

Pye Telecommunications Ltd
Newmarket Road, Cambridge Tel: 0223 61222
Telex 81166

Chief Electronics Technician required for the maintenance, commissioning and development of electronic equipment for cardio-respiratory investigation and research at the Brompton Hospital, Fulham Road, London S.W.3. This is a new and responsible position requiring considerable experience, preferably in the bio-medical electronics field. H.N.C. standard is expected. Salary £1,419-£1,600 p.a., but an exceptional candidate may be offered a higher salary.
Further information and application form from the Laboratory Superintendent (CT.BH), Department of Electronics, Chelsea College of Science and Technology, Manresa Road, London S.W.3.

DEVELOPMENT GROUP
providing
ADVANCED ELECTRONICS TECHNOLOGY
for **RESEARCH**

requires additional member. Day release if working for suitable qualification. Salary in range £847-£1,182. Applications to Professor G. R. Hall, Department of Chemical Engineering & Chemical Technology, Imperial College, London, S.W.7.

THE UNIVERSITY OF ASTON IN BIRMINGHAM
ELECTRICAL ENGINEERING DEPT.
M.Sc. COURSES
October 1969 to September 1970

Graduate courses, of one year duration, leading to a Master's Degree are offered in Electrical Engineering and in Precision Measurement and Instrumentation.

M.Sc. in ELECTRICAL ENGINEERING (Ref. M.Sc.8)

One-third of the lecture work will cover mathematics and electrical engineering materials. The remaining time will be devoted to one specialist option selected from the following:
(*a*) Communication Systems
(*b*) Control Systems
(c) Design and Pulse and Digital Circuits and Systems
(*d*) Electrical Machines.
(*e*) Power Systems
The Science. Research Council has accepted this course as suitable for tenure of its advanced course studentships.

M.Sc. in PRECISION MEASUREMENT AND INSTRUMENTATION (Ref. M.Sc.27)

This course is run by an interdepartmental group comprising Electrical Engineering, Mathematics, Mechanical Engineering, Physics and Production Engineering departments.
Both courses are open to applicants who have graduated in science or engineering or who hold equivalent professional qualifications.
Suitably qualified persons who wish to attend for part of either course (without examination) may do so by arrangement.
Application forms and further particulars (quoting ref. no.) may be obtained from:

THE HEAD OF THE DEPARTMENT OF ELECTRICAL ENGINEERING,

THE UNIVERSITY OF ASTON IN BIRMINGHAM,
GOSTA GREEN
BIRMINGHAM 4.

TELECOMMUNICATIONS OFFICER

(CIVIL AVIATION)

Required by the GOVERNMENT OF MALAWI to serve on contract for one tour of 24-36 months in the first instance. Salary in scale £955-1905 a year (inclusive of Overseas Addition), point of entry according to experience. In addition, a supplement of £100 is payable by the British Government direct into officer's bank in U.K. Gratuity at rate of 25% provided officer completes 30 month tour. Generous paid leave. Furnished accommodation. Education and outfit allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates, 25-45, should possess City and Guilds Telecommunications Technician's Certificate (Intermediate) plus at least two 'B' year certificates and in addition not less than four years' experience in radio/radar maintenance after serving a recognised apprenticeship or similar training. Applicants lacking formal educational qualifications but with extensive experience can be considered.

The officer will be responsible for the installation and maintenance of telecommunications and radio navigational equipment at airports throughout Malawi.

Apply to CROWN AGENTS, M. Dept., 4 Millbank, London, S.W.1., for application form and further particulars, stating name, age, brief details of qualifications and experience and quoting reference M2K/681117/WF.

KODE LTD.

DATA PROCESSING EQUIPMENT

ELECTRONIC SERVICE TECHNICIANS

and

SITE TECHNICIANS

for the Greater London Area

Required to join a service team of a progressive Data Processing Co. The successful candidates will have Electro-Mechanical experience, but preference will be given to those with some basic semi-conductor knowledge.
The ability to work without supervision will be rewarded with a good salary and a company vehicle. Full training on the company's equipment will be given.

Apply with summary of career to:—

The Service Manager
Kode Limited, Calne, Wiltshire.
Tel. Calne 3771

Maintenance Engineers

You can do better for yourself in computers

ICL, Britain's biggest computer manufacturer, needs service engineers in the London area and Surrey. The job—keeping customer installations at peak efficiency—demands dedication: and offers special rewards. A thorough training in computers will be given.

Career development

In the UK alone there are well over 1,000 ICL computer installations now and every week numbers increase. Overseas there are ICL installations in 70 countries. So the scope for Field Service Engineers is enormous.

Qualifications

You should:

- Be aged 21-35
- Have City and Guilds Electronics Technicians Certificates, or HNC Electronics or equivalents
- Have experience in electronics (perhaps in HM Forces)
- Actively want responsibility, and the chance to get on.

Write: giving brief details of your career and quoting reference WW. 929 to A. E. Turner, International Computers Limited, 85-91 Upper Richmond Road, Putney, London, S.W.15.

The Computer Industry

ICL
International Computers Limited

SITUATIONS VACANT

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

EXPERIENCED TV Engineer required. Permanent position, good salary. Transport available if required. This is an addition to staff to cope with expanding TV service. REM RADIO, 79 Church Road, Ashford. Tel. Ashford 5336 (Middlesex). [79

ELECTRONICS TECHNICIAN required by University Department for servicing and development. Opportunity to gain wide experience combined with possibility of further study. Salary on scale rising to £995 or £1,200 according to qualifications and experience. Apply in writing to The Superintendent. University Chemical Laboratory, Lensfield Road, Cambridge. [2151

ELECTRONICS: man required to be responsible for development and manufacture of electronic apparatus for the Department, either as Departmental Research Assistant "A" (Graduate, in scale £1,450 to £2,425), "B" (technical qualification, scale £850 to £1,900) or Principal Technician (H.N.C. or equivalent skill) in scale £1,180 to £1,494. Written applications stating age, experience and qualifications by 9th March to: Administrator, University Laboratory of Physiology, Oxford. [2152

ELECTRONICS TECHNICIAN required for Department of Physiology to assist in electronic workshop, both in maintenance and development of electronic apparatus. Salary on scale £722 to £1,007 p.a. Apply: Personnel Adviser. University of Birmingham. P.O. Box 363, Birmingham 15, quoting reference 429/T/272.1. [2153

GLAMORGAN COUNTY COUNCIL EDUCATION COMMITTEE. COUNTY SCIENTIFIC INSTRUMENT REPAIR SERVICE, INSTRUMENT REPAIRER for the repair and maintenance of scientific laboratory equipment, projectors, record players and radio and television sets from schools throughout the County area. Workshop centre established in CWMAMAN, ABERDARE. Applicants must have had previous experience in this type of work. Salary in accordance with Grade 3 of the Technicians and Technical Staffs Division £895 by annual increments of £1,055 per annum. Additions (varying from £30 to £50 per annum) will be made to the scale for approved qualifications. Commencing salary may be above the minimum of the scale. Age limit 55 years. Application forms (to be returned by 14th April) and further particulars are obtainable from Director of Education, County Hall, Cardiff. Richard John, Clerk of the County Council. [2149

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26

THE UNIVERSITY OF LEEDS: PHYSICS DEPARTMENT. Required immediately, electronics technician to join the British National Cosmic Ray Research project at Haverah Park, near Leeds. The work involves construction and maintenance of electronic apparatus. Minimum qualifications; ONC or equivalent. Salary dependent upon qualifications and experience, on a scale £722-£1,007. Applications in writing giving age and experience, should be sent to the Administrative Assistant, Physics Department, The University, Leeds LS2 9JT. [2150

TV RETAIL BUSINESS of the highest standing, established over 40 years N.W. London. Owner requires PERSONAL ASSISTANT with servicing experience. Good position and prospects for keen and capable man. State age and details of experience. Box W.W. 2156 Wireless World.

URGENTLY required by R. Barden Ltd., BRANCH MANAGERS for N.E. London area. Good basic plus comm. Apply MR. GROBER. CLISSOLD 8811. [2155

VACANCIES occur for two additional Instructors to commence in April 1969 at the Wireless College, Colwyn Bay, North Wales, to assist in preparing students for P.M.G. examinations. Both are junior posts but with the prospects of advancement. Applicants should hold a P.M.G. certificate. Recent marine operating and/or teaching experience is desirable but not absolutely essential. Write in the first instance to the Principal. [2160

WE HAVE VACANCIES for Four Experienced Test Engineers in our Production Test Department. Applicants are preferred who have Experience of Fault Finding and Testing of Mobile VHF and UHF Mobil Equipment. Excellent Opportunities for promotion due to Expansion Programme. Please apply to Personnel Manager, Pye Telecommunications Ltd., Cambridge Works, Haig Road, Cambridge. Tel. Cambridge 51351. Extn. 327 [77

WEST London Aero Club invite "A" and "B" licensed engineers with capital and/or necessary equipment to commence Radio Workshop. Alternative propositions may be considered. Write full details to—White Waltham Airfield, near Maidenhead, Berks. [68

YOUNG MAN with good working knowledge of tape recorders and other associated professional equipment, required as Maintenance Engineer in recording studio. Please write to: R.T., 30 Old Compton Street, W.1., giving details of age and experience. [2161

YOUNG (ca 20) technical assistant required by Sound Recording Studio maintenance department. Some relevant experience useful, but must have practical aptitude. Apply: Mr. King, IBC STUDIOS LTD., 35 Portland Place, W.1. 01-580 2000. [2154

SITUATIONS WANTED

WIDELY experienced electrical engineer/technical college lecturer, bored with watching television, will undertake technical writing for manufacturers or magazines. Box W.W. 340 Wireless World.

ARTICLES FOR SALE

BBC2 KITS and T.V. SERVICE SPARES. Suitable for Colour:—Leading British makers dual 405/625 six position push button transistorised tuners £5.5.0, 405/625 transistorised sound & vision IF panels £2.15.0, incl. circuits and data, P/P 4/6. Basic dual purpose 405/625 transistorised tuners incl. circuit £2.10.0, P/P 4/6. New UHF tuners incl. valves, slow motion drive assy, knobs, leads, fittings £5.12.6 P/P 4/6. Sobell/GEC 405/625 IF & output chassis incl circuit 45/- P/P 4/6. Ferguson 625 IF amplifier chassis incl. circuit 19/6, Ultra 625 IF amplifier plus 405/625 switch assy incl circuit 25/- P/P 4/6. New VHF turret tuners:—Cyldon C 20/-, Pye CTM 13 ch. incremental 27/6, P/P 4/6. Many others available incl. large selection channel coils. New fireball tuners 56/6, used good condition 30/-, salvaged 15/-. P/P 4/6. LOPTs, Scan coils, Frame output transformers, Mains droppers etc. available for most popular makes. TV signal boosters transistorised Pye/Labgear B1/B3, or UHF battery operated 75/-, UHF mains operated 97/6, UHF masthead 95/- post free. Enquiries invited, COD despatch available.
MANOR SUPPLIES, 64 GOLDERS MANOR DRIVE, LONDON N.W.11. CALLERS 589B HIGH RD., N. FINCHLEY N.12. (near GRANVILLE RD.) TEL. 01-445 9118. [60

BRAND new miniature Electrolytics with long wires, 15 volt, 1, 2, 5, 6, 8, 10, 15, 20, 30, 40, 50, 100 mfds. 7s. 6d. per dozen, postage 1s. The C.R. Supply Co., 127 Chesterfield Road, Sheffield S8. [342

BUILD IT in a DEWBOX quality plastics cabinet. 2 in. x 2½ in. x any length. D.E.W. Ltd. (W), Ringwood Rd., FERNDOWN, Dorset. S.A.E. for leaflet. Write now—Right now. [76

ELEKON Star Bargain Offers. Assorted Wire-Wound Resistors, 100 for only 12/6. Subminiature Plug-in Crystals, type 3 26.985 MHz, 12/6; type 6 27.025 MHz, 12/6. RM4 Metal Rectifiers, 5/.—Elekon Enterprises, 30 Baker Street, London, WIM 2DS. Telephone 01-486 5353. [343

JOURNALS I.E.R.E./Brit.I.R.E., 93 issues Apr. 60 to Dec. 67. Offers to Box W.W. 337 Wireless World.

LAB. CLEARANCE, X-TAL controlled pulse gen's., Cambridge/Elliott recorders, microwave spectrum Analysers, E.M.I. Studio tape recorders, P.S.U.'s, selective amps/VTVM's, test equipment, etc. Lower Beeding 236. [338

"RADIO-MIKE" (Lustraphone). Used maybe only half a dozen times. Cost £120. A genuine bargain at £60. Horntons Electronics Ltd., 18/19 Freeman Street, Birmingham 5. 021-643-0972. [2158

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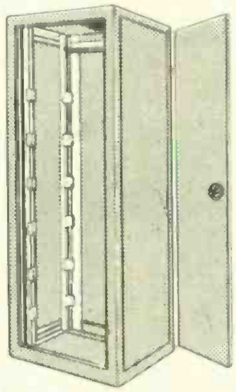

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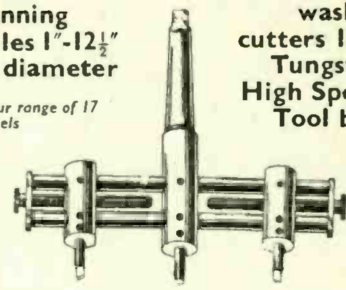

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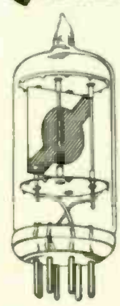

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for electronic components - by return

WW—156 FOR FURTHER DETAILS

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, S.E.1

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- **Rate: 7/- PER LINE.** Average seven words per line.
- Name and address to be included in charge if used in advertisement.
- Box No. Allow two words plus 1/-.
- Charges etc., payable to "Wireless World" and crossed "& Co."
- Press Day 10th April for May 1969 issue.

NAME ....

ADDRESS ....

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			REMITTANCE VALUE..............................ENCLOSED		

Please write in block letters with ball pen or pencil.

NUMBER OF INSERTIONS....................

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 117-131

Printed in Great Britain by Southwark Offset, 25 Lavington Street, London. S.E.1, and Published by the Proprietors, Iliffe Technical Publications Ltd., Dorset House, Stamford St., London, S.E.1, telephone 01-928 3333. *Wireless World* can be obtained abroad from the following: Australia and New Zealand: Gordon & Gotch, Ltd. India: A. H. Wheeler & Co. Canada: The Wm. Dawson Subscription Service, Ltd.: Gordon & Gotch Ltd. South Africa: Central News Agency, Ltd.: William Dawson & Sons (S.A.) Ltd. United States: Eastern News Co., 306 West 11th Street, New York 14. CONDITIONS OF SALE AND SUPPLY: This periodical is sold subject to the following conditions, namely that it shall not, without the written consent of the publishers first given, be lent, re-sold, hired out or otherwise disposed of by way of Trade at a price in excess of the recommended maximum price shown on the cover; and that it shall not be lent, re-sold, hired out or otherwise disposed of in a mutilated condition or in any unauthorised cover by way of Trade or affixed to or as part of any publication or advertising, literary or pictorial matter whatsoever.

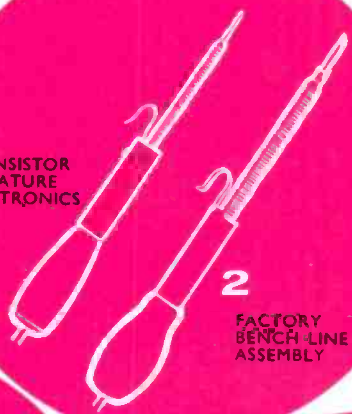
SOLDERING INSTRUMENTATION

ADCOLA PRODUCTS LIMITED (Regd Trade Mark)

HIGH EFFICIENCY INSTRUMENTS

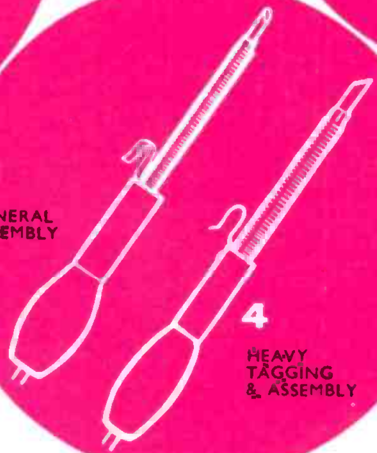
1 TRANSISTOR MINIATURE ELECTRONICS

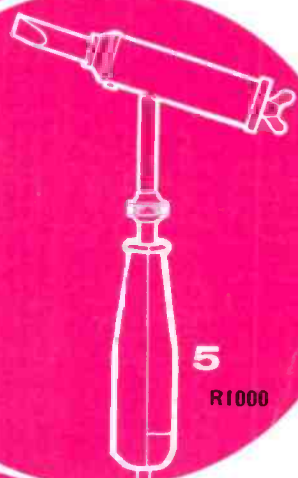
2 FACTORY BENCH LINE ASSEMBLY



3 GENERAL ASSEMBLY

4 HEAVY TAGGING & ASSEMBLY

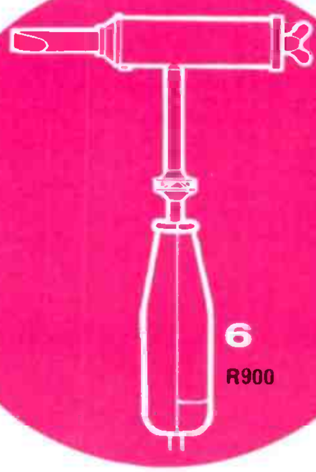




5 R1000

1. 1/8" DIA.—3.2 mm. dia. detachable bit. Standard temp. 340 c at 19 watts. Special temps. from 250 c–400 c. Weight 4.5 ozs. 127 grms.
2. 3/16"—4.75 mm. dia. detachable bit. Standard temp. 360°c at 23 watts. Special temps. from 250 c–410°c. Weight 6 ozs. 170 grms.
3. 1/4"—6.34 mm. dia. detachable bit. Standard temp. 360 c at 27 watts. Special temps. from 250 c 410°c. Weight 6.5 ozs. 184 grms.
4. 5/16"—7.9 mm. dia. detachable bit. Standard temp. 360 c at 30 watts. Special temps. from 250 c–410 c. Weight 7 ozs. 198 grms.
5. OFFSET BIT SIZE 1/2" 12.7 mm. diameter.
6. RIGHT ANGLE BIT SIZE 1/2" 12.7 mm. diameter.

BOTH AVAILABLE IN THE FOLLOWING TEMPERATURES 250 c—27 watts, 360 c—50 watts, 410 c—60 watts, 500 c—90 watts. Supplied in all voltages from 6 volts to 250 volts.



6 R900

WE HAVE, FOR YOUR CONVENIENCE, A HIGHLY SPECIALISED SERVICE SECTION, SO ORGANISED AS TO MAINTAIN A PROMPT EXECUTION OF ALL REPAIRS OF EQUIPMENT OF OUR MANUFACTURE.

ADCOLA PRODUCTS LIMITED (Regd Trade Mark)

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WW—002 FOR FURTHER DETAILS