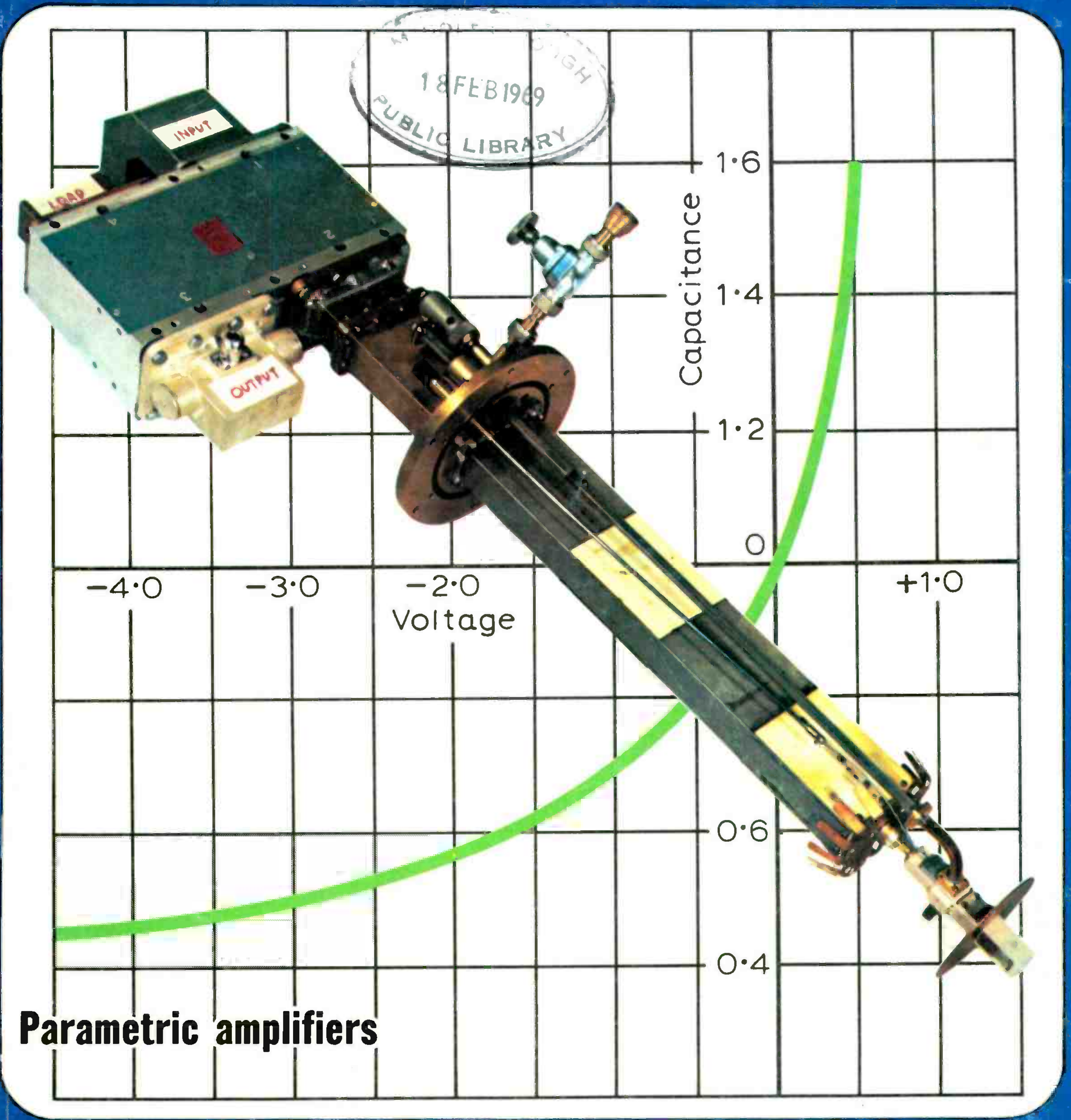
Wireless World

March 1969 Three Shillings

Improving an old loudspeaker



Parametric amplifiers

★STAR Performer

There are 20 good reasons why *STAR UHF Mobile Radiotelephone is the best radiotelephone in the world

*Standard Telephones Advanced Radiotelephones

For the Operator:
*Elegantly styled.
*Designed for safe use in vehicles.
*Excellent range and penetration of built-up areas.
*Crystal-clear speech quality.
*Noise cancelling microphone.
*No ignition noise.
*Very low battery drain.
*Simple installation and removal.
*Anti-theft catch.
*High reliability.

For the Technologist:
*Meets world-wide specifications.
*25 kHz and 50 kHz channel separation.
*Printed UHF transmitter circuitry.
*Transmission line coupling of power transistors.
*Solid-state antenna change-over switching.
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*Quartz crystal filter.
*Quartz crystal discriminator.
*Integrated circuits.
*Fully solid-state.

That's how STAR Radiotelephone brings you the outstanding advantages of UHF propagation and brilliant design.

STC Mobile Radiotelephones Ltd., Oakleigh Road, New Southgate, London N.11. Telephone: 01-368 1200. Telex: 261912.

STC Mobile Radiotelephones Ltd **STC**

69/1 EM

When is an Avo meter not an Avometer?

When it tests nuvistors, compactrons & 13-pin valves

The new Avo VCM163 Valve Characteristic Meter is one of the most versatile valve testers ever developed. With facilities for testing valves with as many as 13 pin connections (and 2 top caps), plus recently introduced types such as nuvistors and compactrons, the VCM163 provides both rapid fault diagnosis and comprehensive static/dynamic characteristics data. Nevertheless, it is even simpler to use than previous models – no backing-off is required. A separate meter displays mutual conductance values continuously during testing, and there is pushbutton monitoring of screen parameters. The full range of h.t. voltage – 12.6V to 400V – can be applied to anode and screen, heater voltage is adjustable in 0.1V steps from 0 to 119.9 and grid voltage may be varied continuously from 0 to 100V (calibrated). Get complete information about the VCM163 from your local dealer or Avo Ltd, Avocet House, Dover, Kent. Telephone Dover 2626. Telex 96283.

AVΩ MEANS BASIC MEASUREMENTS ALL OVER THE WORLD

HIGH FIDELITY MOVING COIL STEREO HEADPHONES (TYPE LS43) Now available from DAYSTROM LTD. GLOUCESTER

WW—007 FOR FURTHER DETAILS

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. (kW)	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. (kW)	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

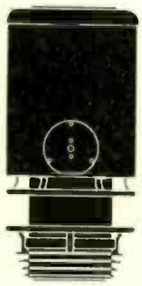
For audio or linear single sideband amplifiers. 4CX1000K has a solid disc screen contact to permit use up to 400MHz.

4CX10,000D

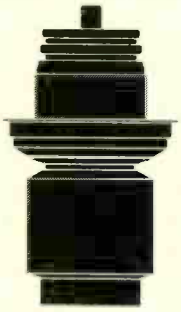
For audio, linear, single sideband or screen modulated r.f. amplifiers.

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.

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

Send for full details of EEV tetrodes

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

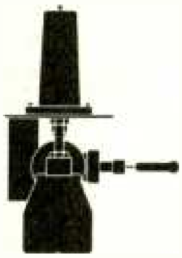
ADDRESS

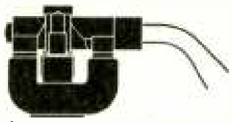
TELEPHONE NUMBER EXTENSION

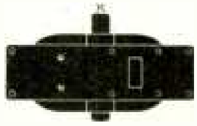
Be safe...use EEV magnetrons in your marine radar

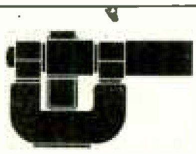
Brief data on some of the many types available. The complete range covers S-Band and X-Band types from 3-80kW.

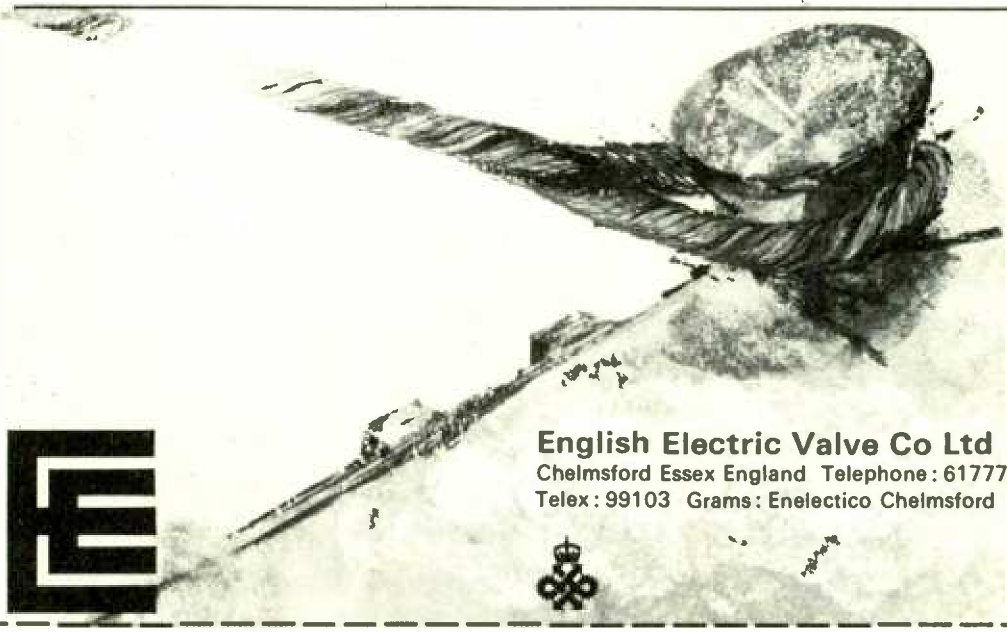
Type	Frequency Range (MHz)	Peak Output Power (kW) (Typical Operation)	Equivalents (not complete)
M5063	3025-3075	50	2J70B
2J42	9345-9475	8	ME1101, CV3676, MAG3, M526
BM1002	9415-9465	21	JP9-15B
M513B	9345-9405	22	JP9-15, YJ1110
M515	9380-9440	25	YJ1120
M597	9380-9440	10	
M598B	9380-9440	22	
599A/B	9415-9475	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



Send for full details of EEV marine magnetrons.

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

Please send me full data on your range of marine magnetrons.
I am particularly interested in using a marine magnetron with the following parameters.

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

NAME POSITION

COMPANY

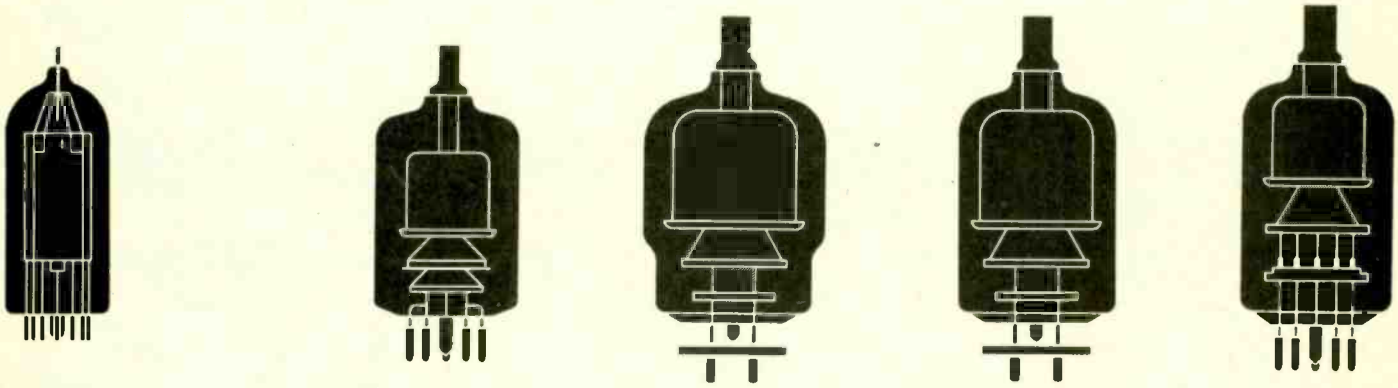
ADDRESS

TELEPHONE NUMBER EXTENSION

WW8 AP 356

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

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COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW7
AP 362

WW—014 FOR FURTHER DETAILS


it's clear to see . . .
. . . why our digital wheatstone bridge is so special. It is the only wheatstone bridge manufactured with illuminated digital readout.
No need to work out those tiresome ratios, the display gives four figures, decimal point and the correct unit (ohms, kilohms and megohms) thus permitting rapid checking.
so simple to use
The Doran range of precision instruments includes . . .
potentiometers
pH meters
bridges (of all types)
galvanometers
standard cells
micro cells
electrodes
power units
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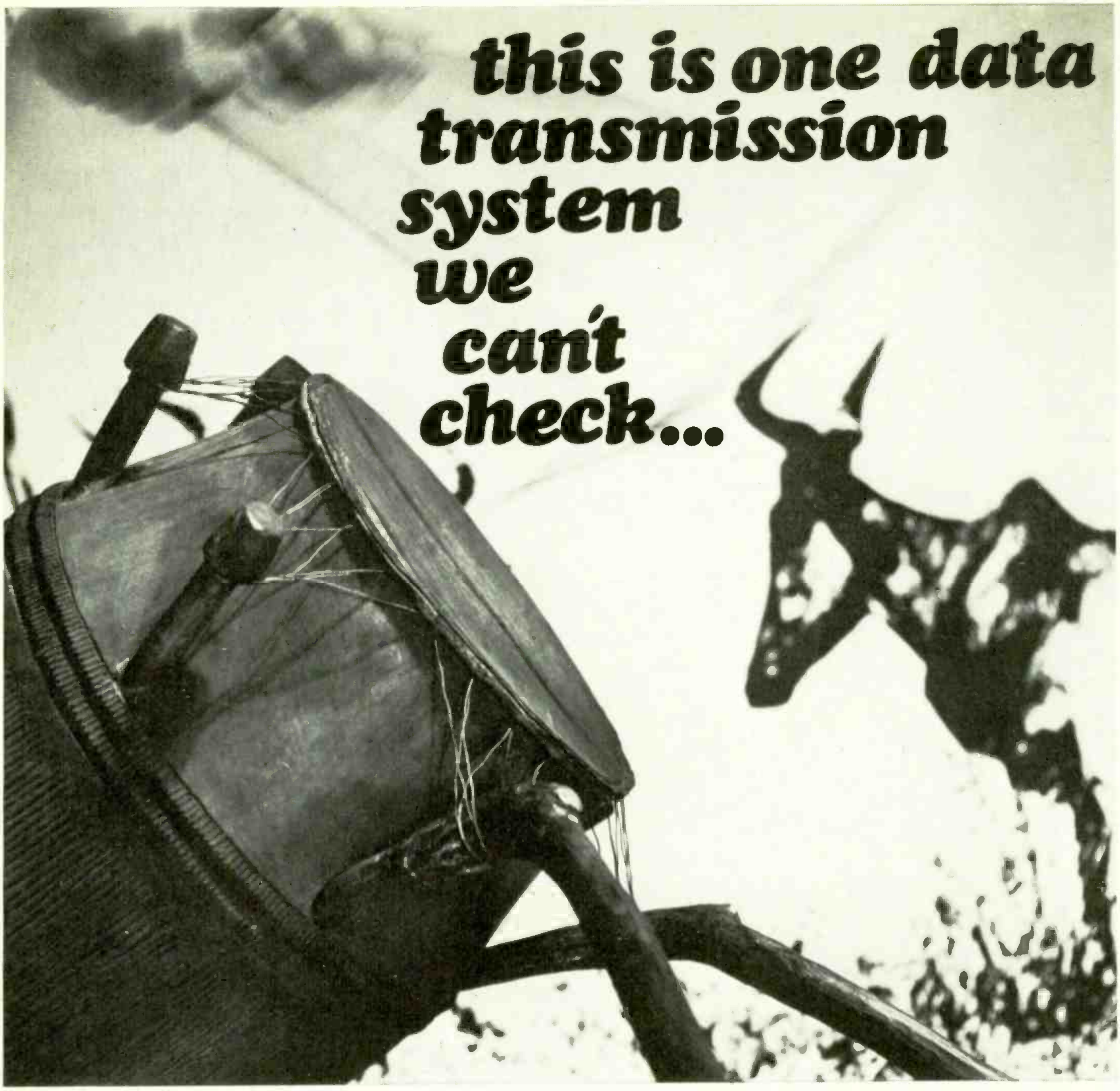
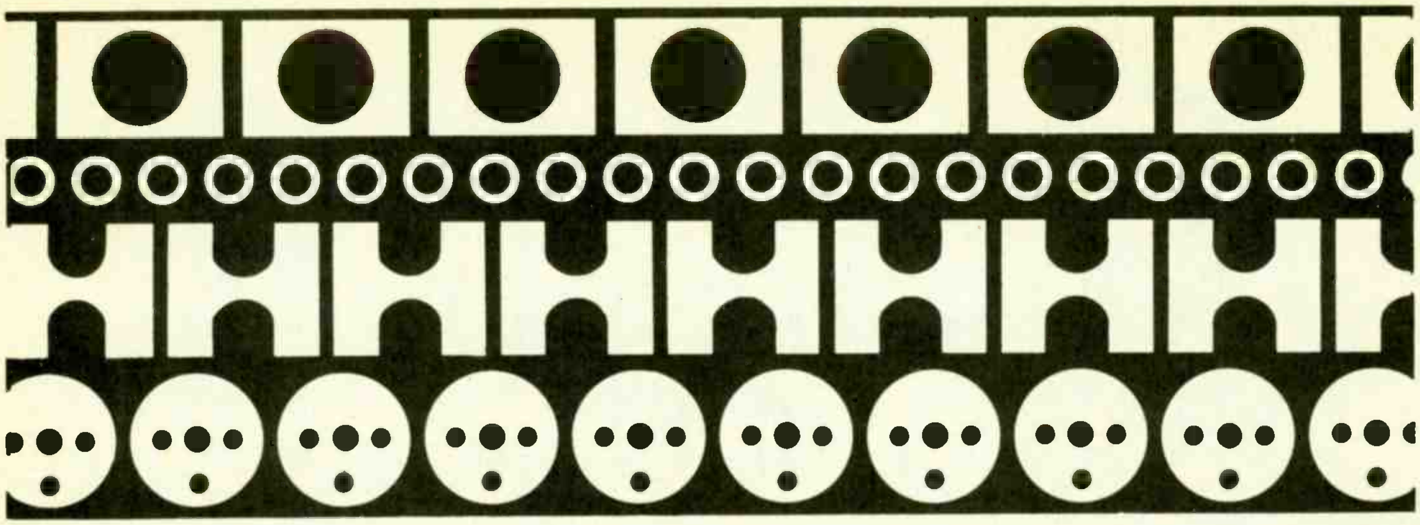
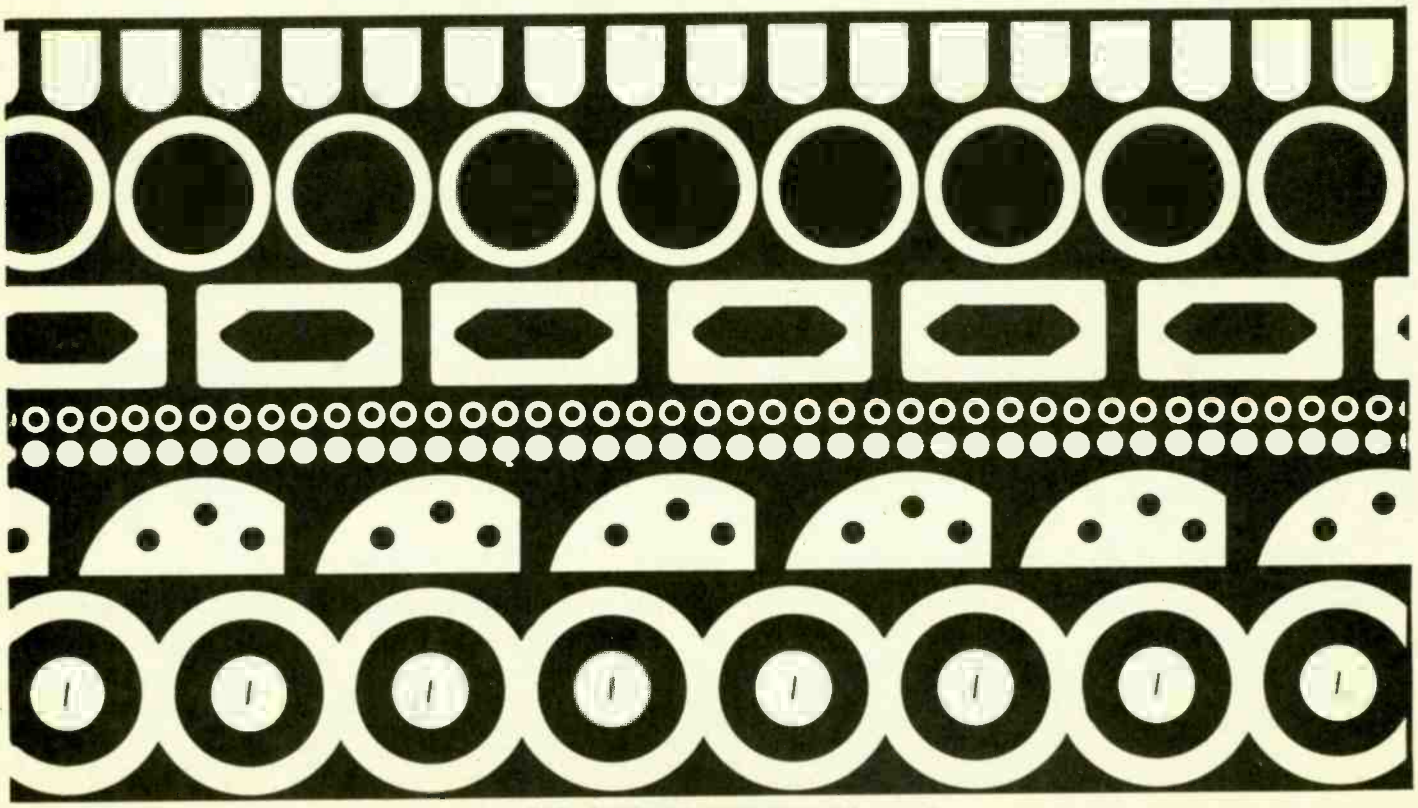
WW—018 FOR FURTHER DETAILS



Photograph of Ghanaian 'Talking Drum' by courtesy of The Commonwealth Institute, Kensington High St.





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(U.S.A.)

- ▲ High stability
- ▲ Long Life
- ▲ High Gain
- ▲ Ex-stock, London

10^D

1000–up	10^D
500–999	1/0
100–499	1/10
25–99	2/1
1–24	3/1

Collector-Emitter Voltage	V_{CEO}	25	V
Emitter-Base Voltage	V_{EBO}	5	V
Collector-Base Voltage	V_{CBO}	25	V
Collector Current	I_C	100	mA
Dissipation (free air at 25°C)	P_T	200	mW
Forward Current Transfer Ratio	h_{FE}	100-500	—
Forward Current Transfer Ratio	h_{fe}	100-750	—
Gain Bandwidth Product	f_T	120	MHz

Silicon NPN
Planar Passivated
Transistor in
Epoxy Encapsulation

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WW—022 FOR FURTHER DETAILS

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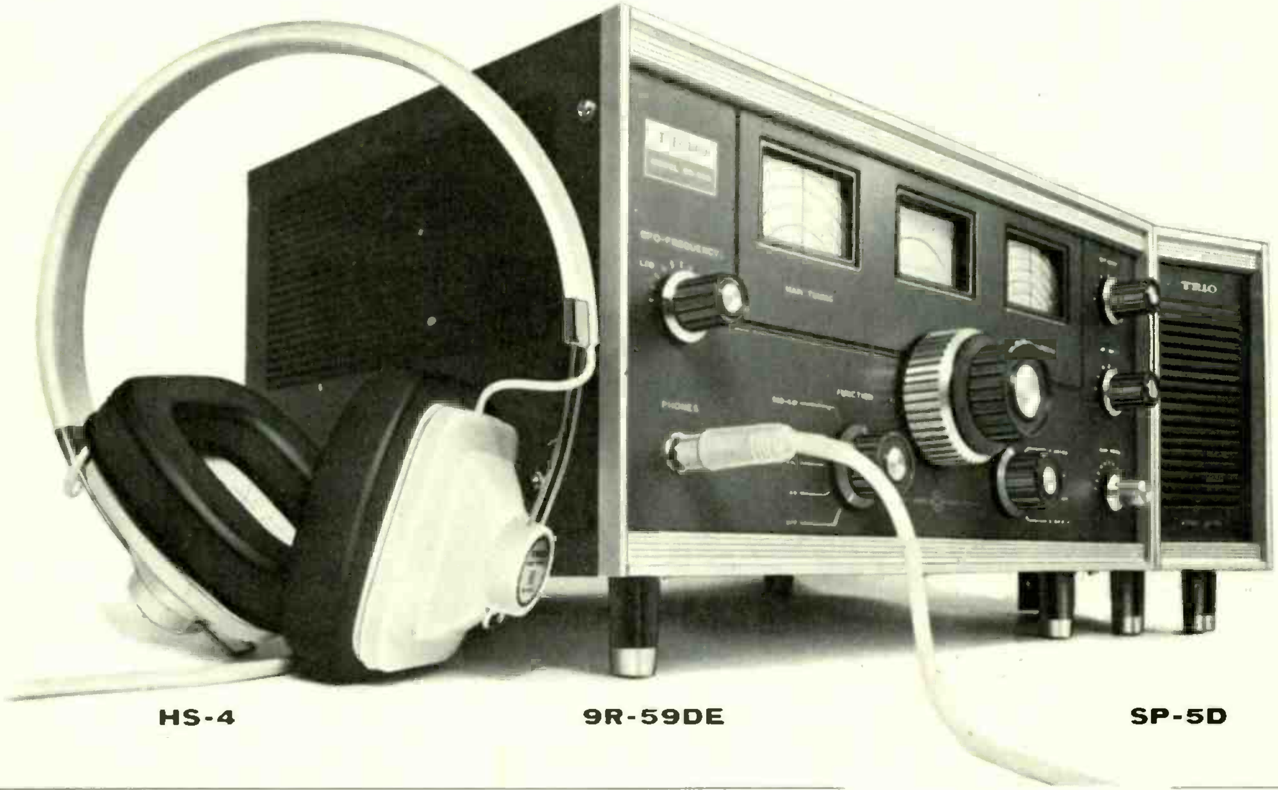


HS-4 9R-59DE SP-5D

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: ±5 KHz at −60 dB (±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.

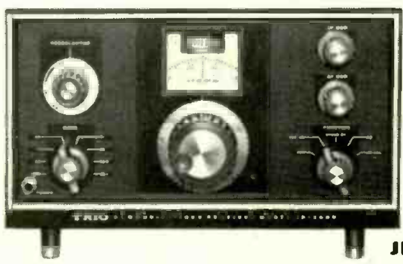
Model HS-4

- 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)
- Hi-Selectivity: ±2 KHz at −6 dB ±6 KHz at −60 dB
- Dimensions: Width 13", Height 7", Depth 10".



JR-500SE

the sound approach to quality

TRIO

TRIO ELECTRONICS, INC.
TOKYO, JAPAN

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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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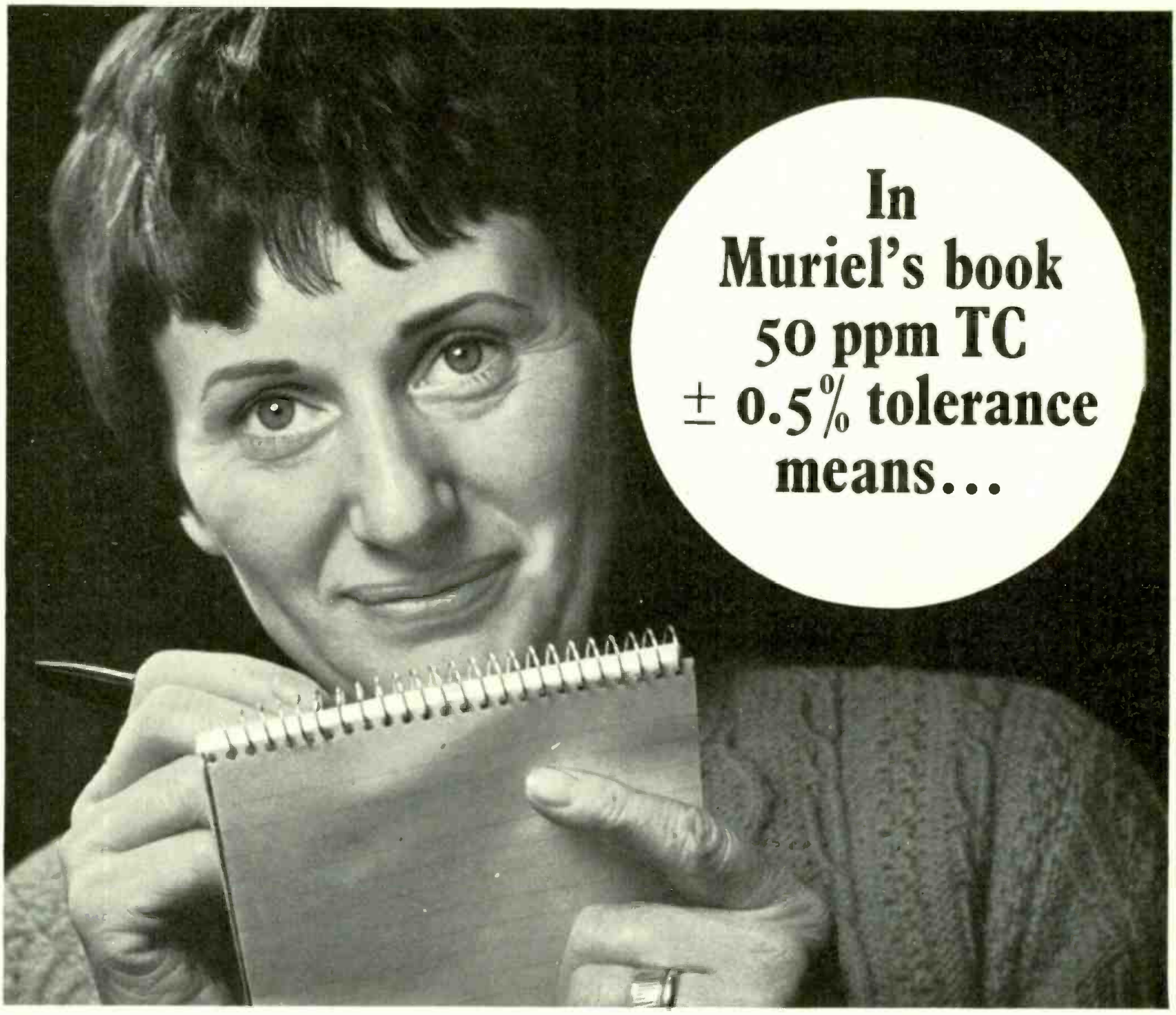

off-the-shelf-delivery for designers

Ring Muriel for off-the-shelf delivery of Filmet Resistors in development quantities. You'll get them — and fast.

The new standard Filmet range meets all the requirements of DEF 5115-1 Style RFG7 — 0.5 . . . and at a price that's *below* standard for above standard stability.

Resistance range:	100Ω to 360KΩ E24 series.
Power Rating:	$\frac{1}{8}$w, $\frac{1}{4}$w, $\frac{1}{2}$w Multi-Rating.
Temperature range:	-55°C to $+125$°C.

Ring Muriel to get yourself in the book for fast delivery.

FILMET

metal film resistors

Morgan

MORGANITE RESISTORS LIMITED,
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Telephone: Jarrow 897771. Telex: 53353.

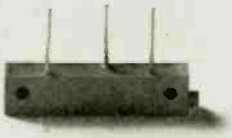
Please send me full details of the standard Filmet range.

Name:
Position:
Company:
Address:

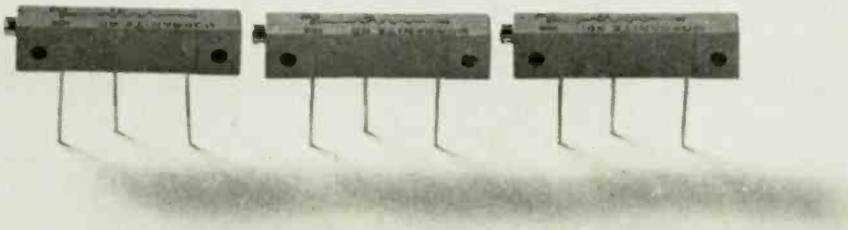
WW5

WW—024 FOR FURTHER DETAILS

This



is a dead one of these



Morganite killed it

The deceased would have become one of Morganite's Cermet Trimming Potentiometers – one, in fact, of the popular type 80 with a power rating of 0.75W at 70°C.
But it never made it. The crunch came when we examined all its tiny component parts at 500 times life size. That's quite a test. Imagine, for instance, the imperfections you might find in a 40 yard cigarette. So it's not surprising that every once in a while we detect a spanner in the ointment. And the penalty is death.
The survivors are the most reliable trimming potentiometers you can find – and finding them couldn't be easier. Samples for evaluation or for development projects are waiting in stock, ready for your 'phone call.
We are the only British company which offers ohmic values from 10 ohms to 1M ohms in the E6 range as well as the MIL-R-22097C series.
Put our Cermet trimming potentiometers through *your* test routine and watch how they stand up to it. Any that couldn't are long since dead.

MORGANITE RESISTORS LIMITED

Bede Industrial Estate, Jarrow, County Durham
Telephone: Jarrow 897771

Morgan

WW—026 FOR FURTHER DETAILS

Why have Racal stopped making specific-function instruments?

The Racal 815
Universal Counter/Timer

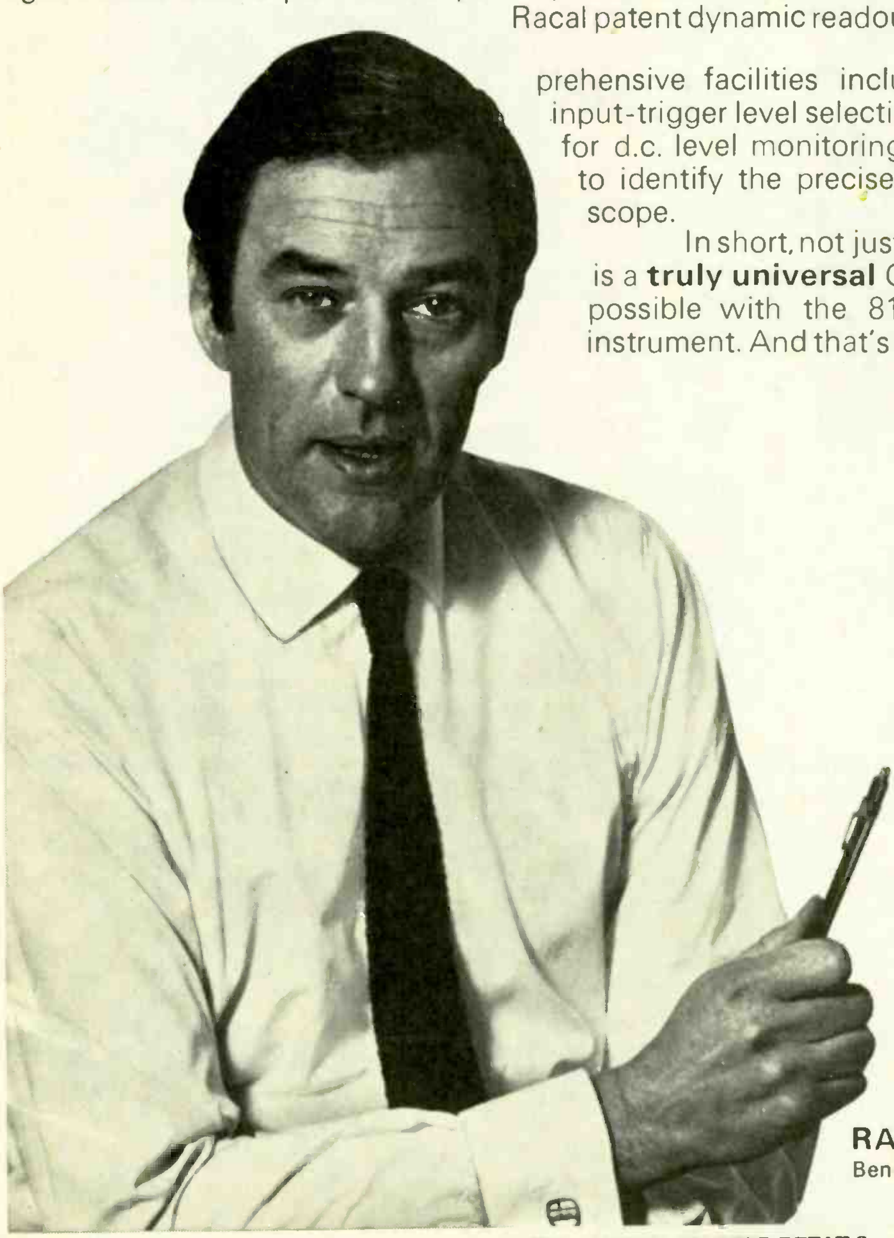
They haven't!

Racal pioneered the specific-function approach to digital instrumentation, exemplified in the successful **Racal 800 Series,** which offers high quality instruments at competitive prices – prices made possible by effective standardization.

Racal have now augmented this range with the **815, 50 MHz Universal Counter-Timer:** the last word in *versatility.* The standard features you expect in a Racal Counter are all included – high input impedance (1M Ω), excellent sensitivity (10mV), exceptional stability (fast warm-up oscillator ages at less than 2 parts in 10^8 per day and attains 1 part in 10^7 in under 3 minutes), and the fast Racal patent dynamic readout (25mS).

Additionally the very comprehensive facilities include three input channels, variable input-trigger level selection (–100V to +100V) with provision for d.c. level monitoring and an intensity modulation pulse to identify the precise measurement period on an oscilloscope.

In short, not just the usual all-rounder, this instrument is a **truly universal** Counter-Timer, any measurement not possible with the 815 will require a specific-function instrument. And that's where we came in.



Phone or write now for a demonstration at your premises or full data on the Racal 815

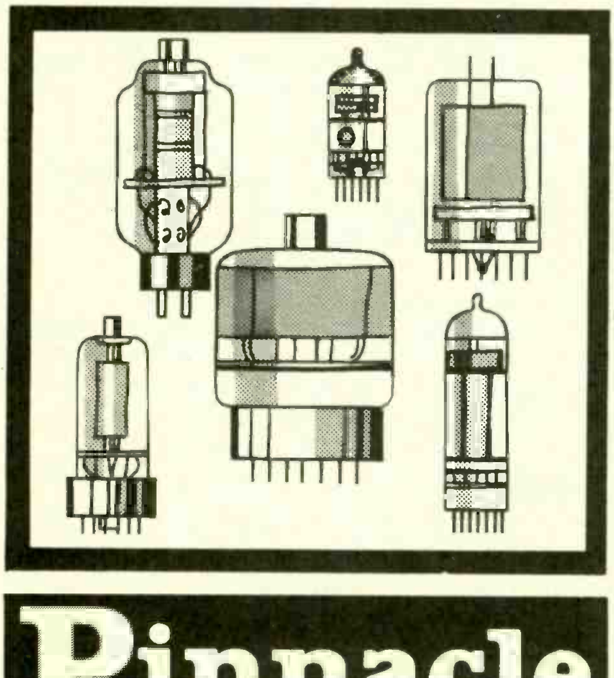
RACAL

RACAL INSTRUMENTS LIMITED,
Bennet Road, Reading, Berkshire. Reading 85571
Telex: 84166

WW—029 FOR FURTHER DETAILS

Last year we directly supplied

6 industrial giants, 89 large manufacturers, 392 smaller manufacturers, all three Armed Services, most government departments including 10 Ministries, 23 public corporations, 43 educational authorities and Universities and countless radio and television retailers in 1,162 cities, towns and villages in 38 counties.



Pinnacle the largest single valve independent

Pinnacle

PINNACLE ELECTRONICS LIMITED ACHILLES STREET · NEW CROSS · LONDON S.E.14

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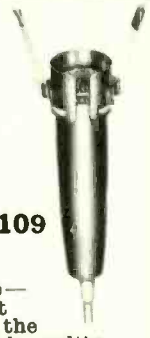
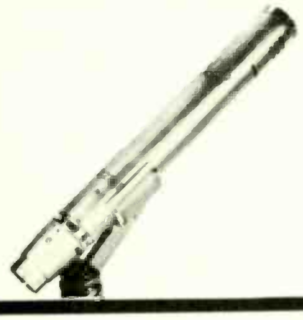
Get across loud and clear with AKG microphones!

AKG C-451
Quality condenser microphone with new CK1 capsule (interchangeable with other AKG microphones). Other capsules are available built into wind-shield with 'rifle' tube attachment. Supplied with battery power unit and/or mains unit which can feed two microphones.



AKG D-109
Dynamic miniature microphone—the smallest Lavalier on the market. High-quality reproduction compares well with others costing several times more. With 60 or 200 Ohm impedance. 3 metres cable. Use it wherever a mike is to be heard but not seen—interviewing, films, conferences, etc.



AKG D-224
Advanced studio microphone, employing two-way cardioid principle—the latest in microphone technology—in slim, elegant form. High-quality dynamic microphone ideal for all broadcasting and studio work. Incorporates bass attenuation switch and pivoted stand attachment.

Find out more about AKG mikes from

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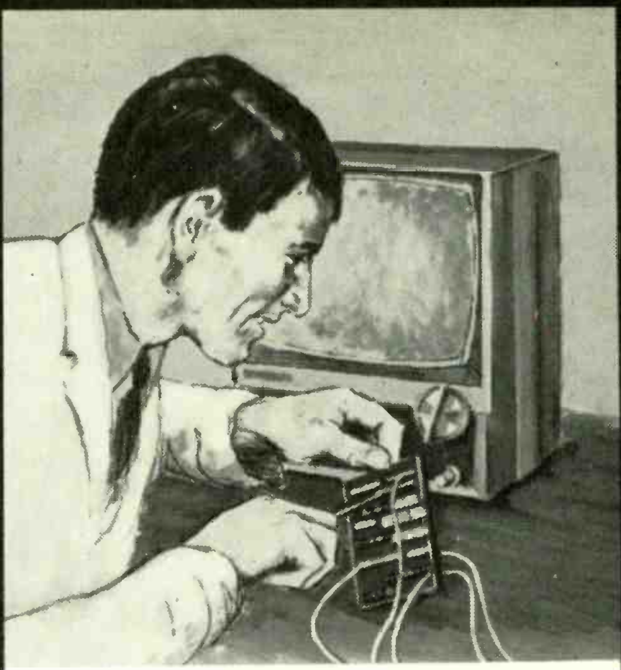
AKG microphones

WW—031 FOR FURTHER DETAILS



Train for tomorrow's world in Radio and Television at The Pembridge College of Electronics.

The next full time 16 month College Diploma Course which gives a thorough fundamental training for radio and television engineers, starts on 16th April 1969.

The Course includes theoretical and practical instruction on Colour Television receivers and is recognised by the Radio Trades Examination Board for the Radio and Television Servicing Certificate examinations. College Diplomas are awarded to successful students.

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Please send, without obligation, details of the Full-time Course in Radio and Television.

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WW—032 FOR FURTHER DETAILS

Why pay for more sophistication than you can use?

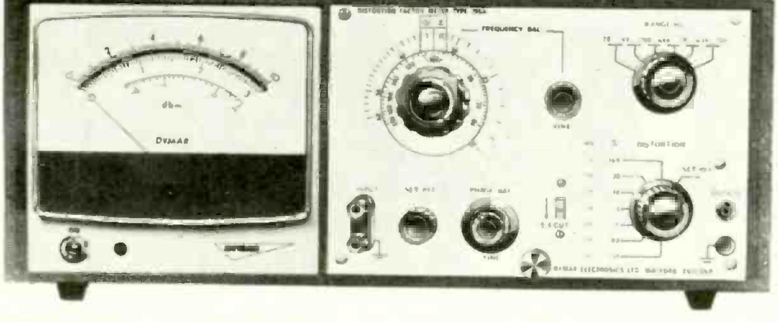
The majority of users of electronic test equipment require accuracy within a band of measurements that is common to many operators. The Dymar System of test instruments covers this need ideally. We have avoided the temptation to include more sophistication than the market wants. This means that your budget will stretch further yet cover your project development, research or quality control. Plus features are:–

(1) all instruments are energised by a master meter unit.
(2) the extreme flexibility of a proved plug-in system and
(3) the money-saving aspect.

Our explicit Short Form Catalogue will give you a run-down on our 700 Series – just complete the coupon or just pin it to your letterhead.

DYMAR

DYMAR ELECTRONICS LIMITED
Colonial Way Radlett Road Watford Herts.
Telephone: 21297/8/9.



Please send me a copy of your Short Form Instrument Catalogue.

NAME ....

POSITION ....

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ADDRESS ....

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A.C. AND D.C. VOLTMETERS – SEMICONDUCTOR TEST SETS – SIGNAL GENERATORS – NOISE FACTOR METERS – DISTORTION AND WAVEFORM ANALYSERS – 'TRUE' POWER METERS

WW—033 FOR FURTHER DETAILS

it's sensitive

but you won't hurt its feelings

In fact, it's unlikely you would hurt it in any way. Despite its acute sensitivity, diminutive size and neat appearance, the SEI Minitest, a pocket-size, multi-range test set, is really tough. It measures A.C. and D.C. volts, D.C. current and resistance over 20 ranges to D.C. sensitivity 20,000 ohms per volt and A.C. sensitivity 2,000 ohms per volt. The clear scale, knife edge pointer and layout of the controls ensure that the Minitest is really handy. The cover is of melamine, a robust, wipe-clean plastic and the movement is shielded from external magnetic fields and impact shocks by a steel case. High Voltage Probes. These extend the range of the Minitest, or any other 20,000 ohms per volt multirange test instrument, to 25 or 30KV D.C. for testing electronic equipment where source impedance is high.

For free catalogue, write to:
SALFORD ELECTRICAL INSTRUMENTS LTD
Peel Works, Barton Lane, Eccles, Manchester.
Tel: 061-789 5081 Telex: 66711
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WW—034 FOR FURTHER DETAILS

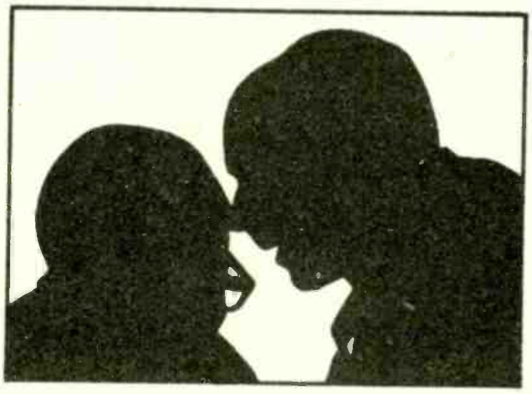
The Goldring caress... we call it transduction seduction

Smooth, breathing, open and graceful that's the sound of Goldring True Transduction. The ability of a cartridge to track properly at low forces is only the first stage of design, and from that point Goldring engineers continued development through to achieve their *True Transduction*. A micro-element of tubular permeable material lies in a 'Free-Field' generated from a fixed source away from the removable stylus assembly. It is as light as the cantilever itself – no massy magnets or coils to move! This design approach provides a texture of sound transparency previously associated with direct-coupled pickups. Excessive de-coupling techniques are rendered unnecessary and tight coupling is employed to ensure that every motion of the sensing element is identical to that of the stylus – at all frequencies.

Full technical details of these new era cartridges from Desk HF, Goldring Manufacturing Co. (Great Britain) Ltd., 486-488 High Road, Leytonstone, London, E.11, or from your nearest dealer.

WW—035 FOR FURTHER DETAILS

'Invest in Erie Blue Chips'



Erie Blue Chips are resistors. Thick film, metal glaze resistors built to satisfy the circuit designer's need for reduced physical size and increased reliability. Designed specifically for printed circuit boards, Blue Chips, with radial terminations at 0.2 in centres, make possible a packaging density up to double that of conventional cylindrical resistors.

Resistance range:

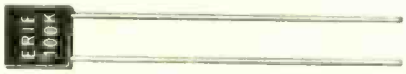
1 ohm to 1 megohm with tolerances of 1%, 2%, 5% and 10%.

Wattage ratings:

$\frac{1}{8}$ w, $\frac{1}{4}$ w, $\frac{1}{2}$ w, with maximum voltage 350V d.c.

Temperature range:

-55°C to 125°C with no derating, and an average TCR of $\pm$ 300 ppm/$^\circ$C. Closer T.C.s. available.



'And this is their average size'

With these specifications it's no surprise that Erie Blue Chips are setting the pace in resistor design and further advancing the rapid progress in circuit dependability.

WW—036 FOR FURTHER DETAILS

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Cardioid Pencil Dynamic Microphone *improved* version of the well known Reslo CPD microphone. Most suitable for:
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General Sound Reinforcement.
Loud close singing or speaking if used with an amplifier incorporating reasonable bass cut.
Frequency response is smooth over the range 70 c/s to 16 Kc/s.
Rear response better than 20dB below the front from 100 c/s to 1 Kc/s and over 14dB from 1 Kc/s to 16 Kc/s dropping to 30dB at upper presence frequencies.
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Supplied with 18' of dual impedance cable £17.15.0.
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Appropriate cable set to order.

UD1

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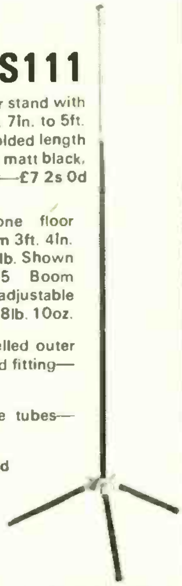
floor stands



MS111

Lightweight microphone floor stand with folding legs. Adjustable from 3ft. 7in. to 5ft. Weight 4½lb. Feet spacing 18in. Folded length 37½in. Finish: Legs and outer tube matt black, inner tube satin silver—£7 2s 0d

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MS110A

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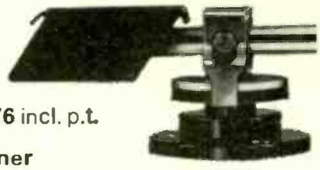

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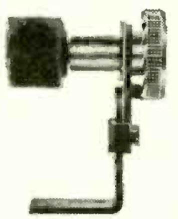

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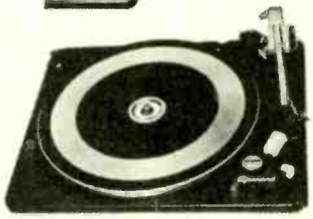

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GEC

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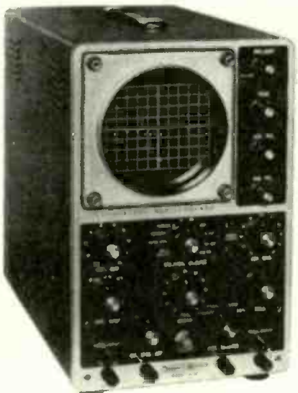
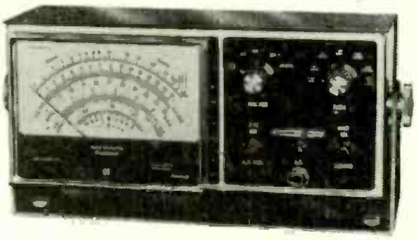


10-12U SCOPE

RF-1U GEN.



VVM IM-13U

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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.

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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.

General-Purpose RF Signal Generator RF-1u

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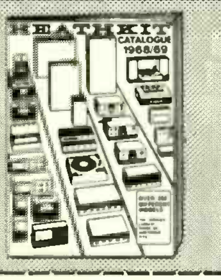

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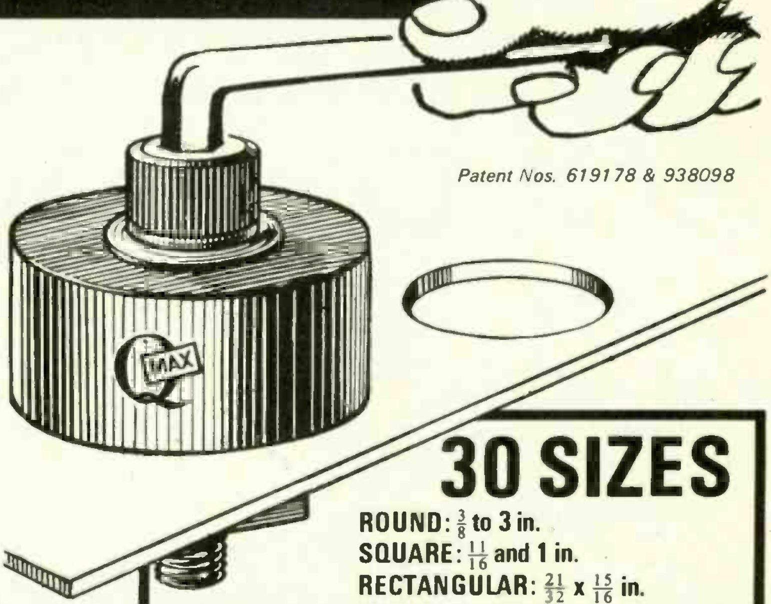
FOR QUICK AND CLEAN HOLES



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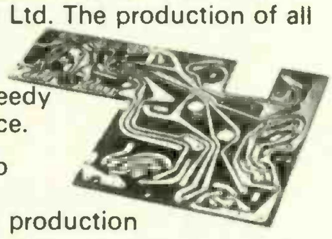

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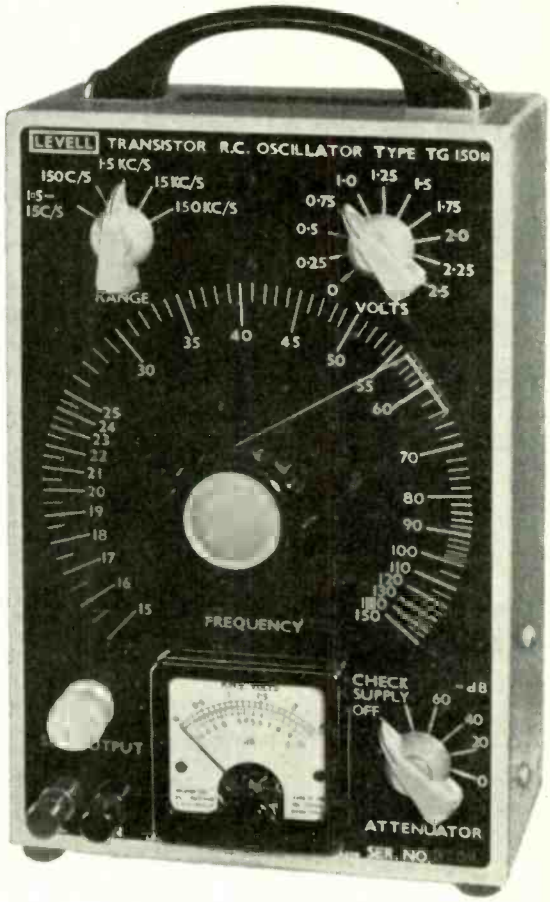

With DIGITAL or ANALOGUE frequency calibration

TYPE	TG66A	TG66B	TG150	TG150M	TG150D	TG150DM
FREQUENCY	0.2 Hz to 1.22 MHz.		1·5 Hz to 150 kHz			
ACCURACY	± 0.02 Hz below 6 Hz ± 0.3% from 6 Hz to 100 kHz ± 1% from 100 kHz to 300 kHz ± 3% above 300 kHz		± 3% ± 0.15 Hz			
DISTORTION	<0.15% from 15 Hz to 15 kHz <0.5% at 1.5 Hz and 150 kHz		<0.1% at 1 kHz, <0.3% from 50 Hz to 15 kHz, <1.5% below 50 Hz and above 15 kHz.			
SINE WAVE OUTPUT	Source voltage variable from 30μV to 5V. Output impedance 600Ω at all settings.		Source voltage variable from 250μV to 2.5V, Output impedance <250Ω above 250mV, 600Ω below 250mV. Less than 1% variation of amplitude throughout frequency range.			
SQUARE WAVE OUTPUT	None		None		Variable up to 2.5V peak. Rise time 1% of period + 0.2μS.	
OUTPUT METER	Expanded voltage scales and −2dB to + 4dB. Scale length 3.5″		None	0 to 2.5V and −10dB to +10dB	None	0 to 2.5V and −10dB to +10dB
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Output voltages 0-18 D.C. and 0-12 A.C., are continuously variable. Separate scales for D.C. and A.C., calibrated at 230 volts input.

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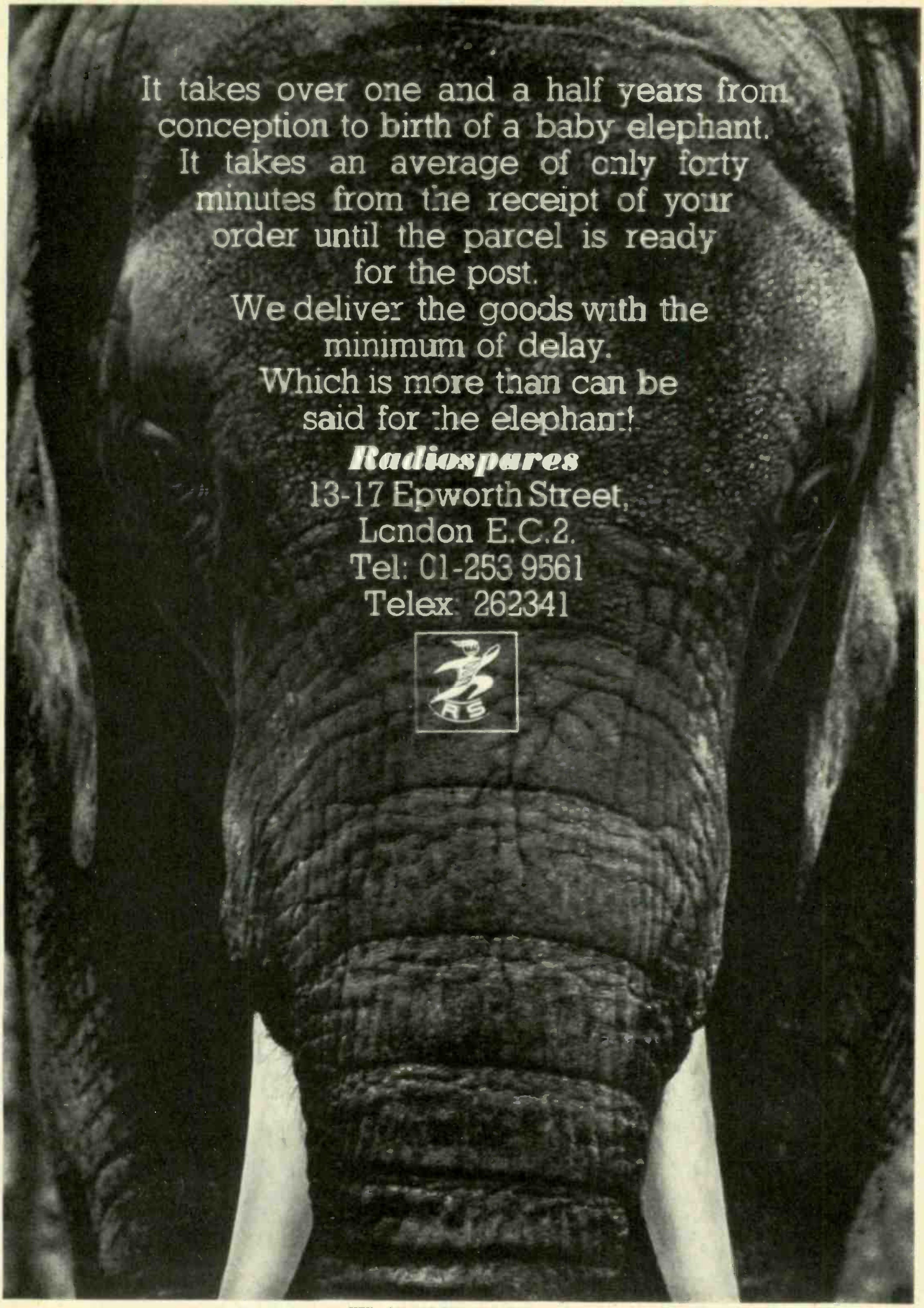
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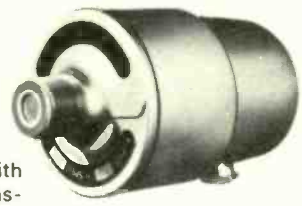

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Pressure type units are available with or without tapped 100V line transformers. The following 'built-in' features are on all models — High Sensitivity, Weatherproof, Phase Equalising Throat and Self-centring Diaphragm Assembly.

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Loudspeaker in Glass Fibre

The Celestion Glass Fibre Loudspeaker is a compact robust and watertight unit, precision built for use on open boat decks, docks, chemical plants, plating shops, etc, where protection from the weather or corrosive atmosphere is vital.

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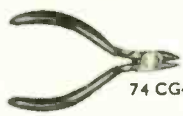
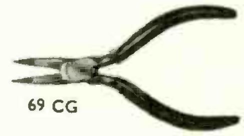

74 CG


69 CG

PLIERS

69CG Radio - TV Plier
70CG Flat Nose Pliers
71CG Round Nose Pliers
72CG Chain Nose Pliers
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74CG Diagonal Close Cutting Pliers

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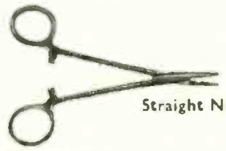
Straight Nose


Curved Nose

SEIZERS

32H 5" Staight Nose Junior 5" Seizer
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42H 6" Straight Nose Seizer
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Box joint construction, two position snap on lock. Precision machined from perfectly tempered stainless steel.
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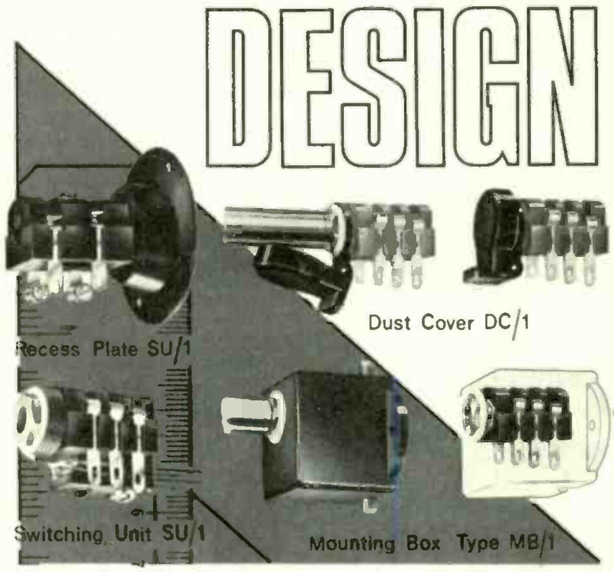
WW—062 FOR FURTHER DETAILS

Jack Socket accessories



All these products are moulded in thermoplastic. They may be used with any of the standard range of Rendar Jack Sockets.

Further information available.

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CABLES: RENDAR, BURGESS HILL

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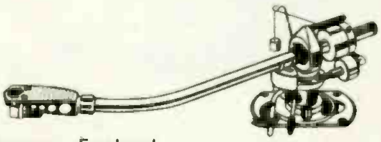
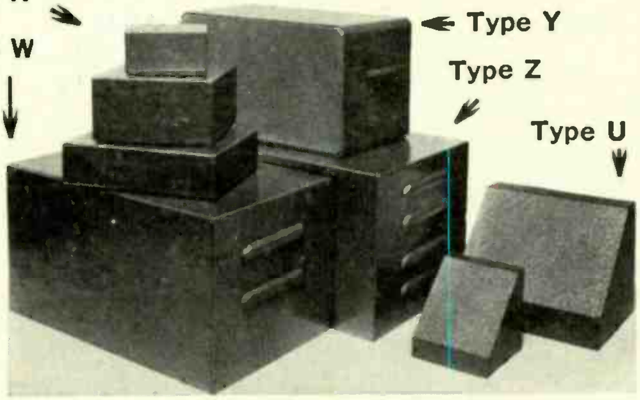
'Music when soft voices die,
Vibrates in the memory—'



CHASSIS and CASES

by Smith's of EDGWARE ROAD



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or order straight away, working out total area of material required and referring to table below, which is for four-sided chassis in 16 s.w.g. aluminium.

48 sq. in.	5/-	176 sq. in.	10/4	304 sq. in.	15/8
80 sq. in.	6/4	208 sq. in.	11/8	336 sq. in.	17/-
112 sq. in.	7/9	240 sq. in.	13/-	368 sq. in.	18/4
144 sq. in.	9/-	272 sq. in.	14/4	and pro rata.	
P. & P. 3/-.		P. & P. 3/6.		P. & P. 4/6.	

Discounts for quantities. More than 20 sizes kept in stock for callers.

FLANGES (¼in., ⅜in.), **6d.** per bend.

STRENGTHENED CORNERS 1/- each corner.

PANELS: Any size up to 3ft. at 6/- sq. ft. 16 s.w.g. (18 s.w.g. 5/3). Plus post and packing.

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N	6 × 6 × 3	17/6
N	4 × 4 × 2	11/-
U	4 × 4 × 4*	11/-
U	5½ × 4½ × 4½	17/-
U	8 × 6 × 6	23/-
U	9¼ × 7½ × 3½	24/-
U	15 × 9 × 9	49/-
W	8 × 6 × 6	23/-

Type	Size	Price
W	12 × 7 × 7	37/6
W	15 × 9 × 8	48/6
Y	8 × 6 × 6*	29/-
Y	12 × 7 × 7	45/-
Y	13 × 7 × 9	50/6
Y	15 × 9 × 7	53/6
Z	17 × 10 × 9	72/6
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Type N has a removable bottom, Type U removable bottom or back, Type W removable front, Type Y all-screwed construction, Type Z removable back and front.

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(TECHNICAL BULLETIN No. 3. HIGH EFFICIENCY SQUAREWAVE)

Transvertors of the "T" series are simple and economical.

The switching for the conversion process is actuated by an oscillator of the saturated transformer type: part of the iron core of the transformer is made adjustable so that the frequency can be varied by a few cycles. With this type of oscillator the frequency will tend to vary with changes of input voltage and load. However the frequency is sufficiently stable for operating Portable power tools, Fluorescent lighting, etc.

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Send for free information brochure giving ratings specification and application suggestions of the standard range of VALRADIO transvertors together with information giving circuit and details of emergency stand-by systems.

TYPE: B12/150T
Input: 12v.
Output: 115-230v. 150w. 50±3Hz **PRICE: £24.3.0**

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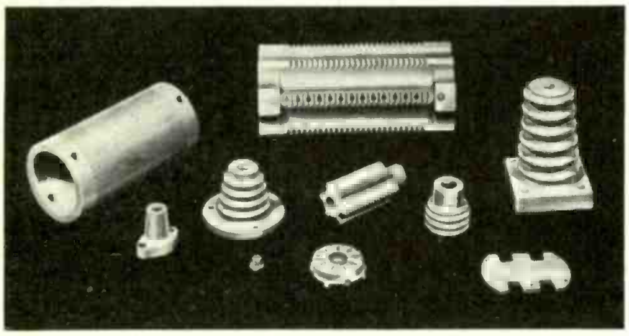
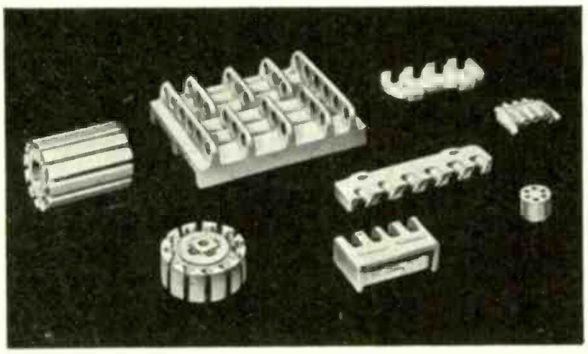
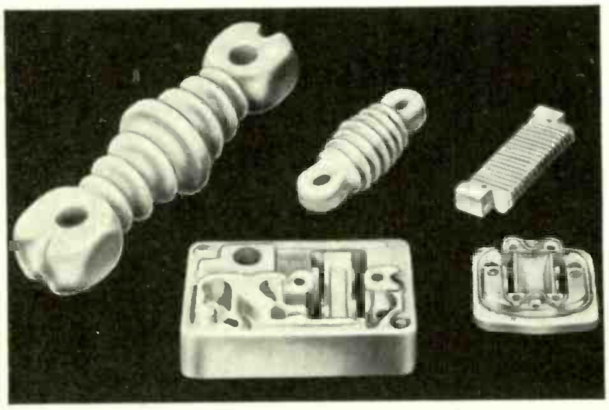
for the ELECTRONIC INDUSTRY
(and Electrical Appliance Manufacture)



Frequelex—for high-frequency insulation.



Refractories for high-temperature insulation.



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PRESTON X-MOD 135 WAVEFORM SOURCE

X-MOD 135 is a stable calibrated waveform source and, as with all X-MODs, it provides both front panel and rear patchboard connections for use either as a single test instrument or for incorporation with other X-MODs to form an automatic instrumentation system.

Range: 0.001 Hz to 10 kHz
Stability: $<0.05\%/^{\circ}C$
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Twelve calibrated outputs plus vernier control
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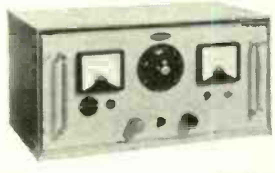
★ **TYPE: 250VRU/30/20.**



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P.A. SYSTEM

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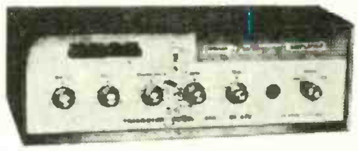
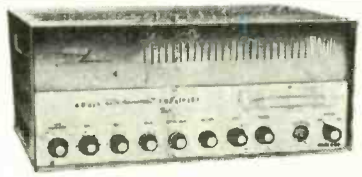


Model 50 – ATR – 50 Watts

8 Models in all Transistor A. C. Mains and Battery Operation, Power Output from 15 - Watts to 50 - Watts. Built to International Standards. Also Mixer & Pre - Amplifiers.



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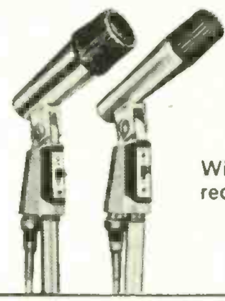
6 Models in AC operated Tube Amplifiers. Power Outputs from 20 - Watts to 100 - Watts. High Fidelity Performance. Absolute reliability in extreme working conditions.



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Breakdown Proof Driver Units, Reflex Horns and Sound Column Speakers.

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Issued by Engineering Export Promotion Council Calcutta (India)

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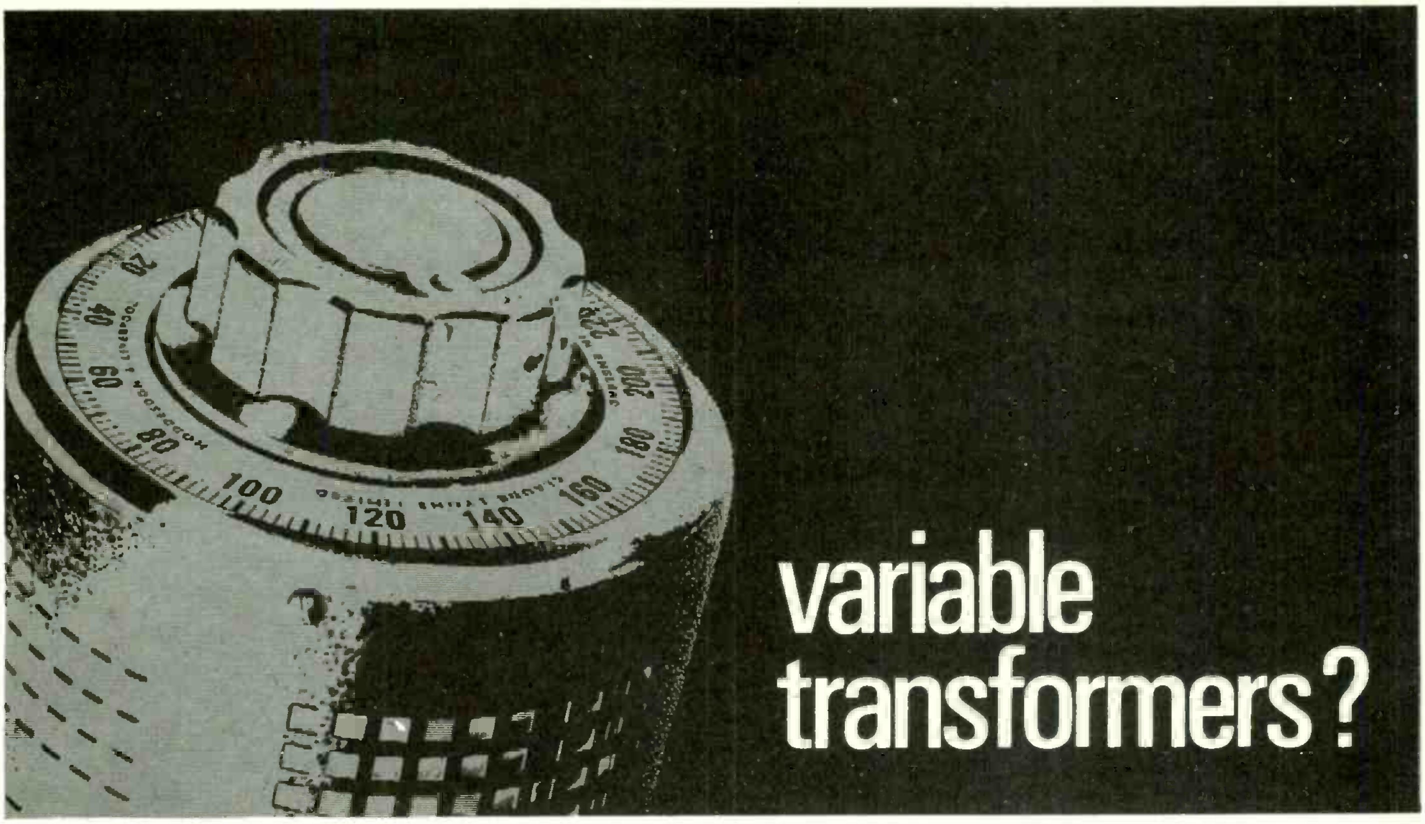

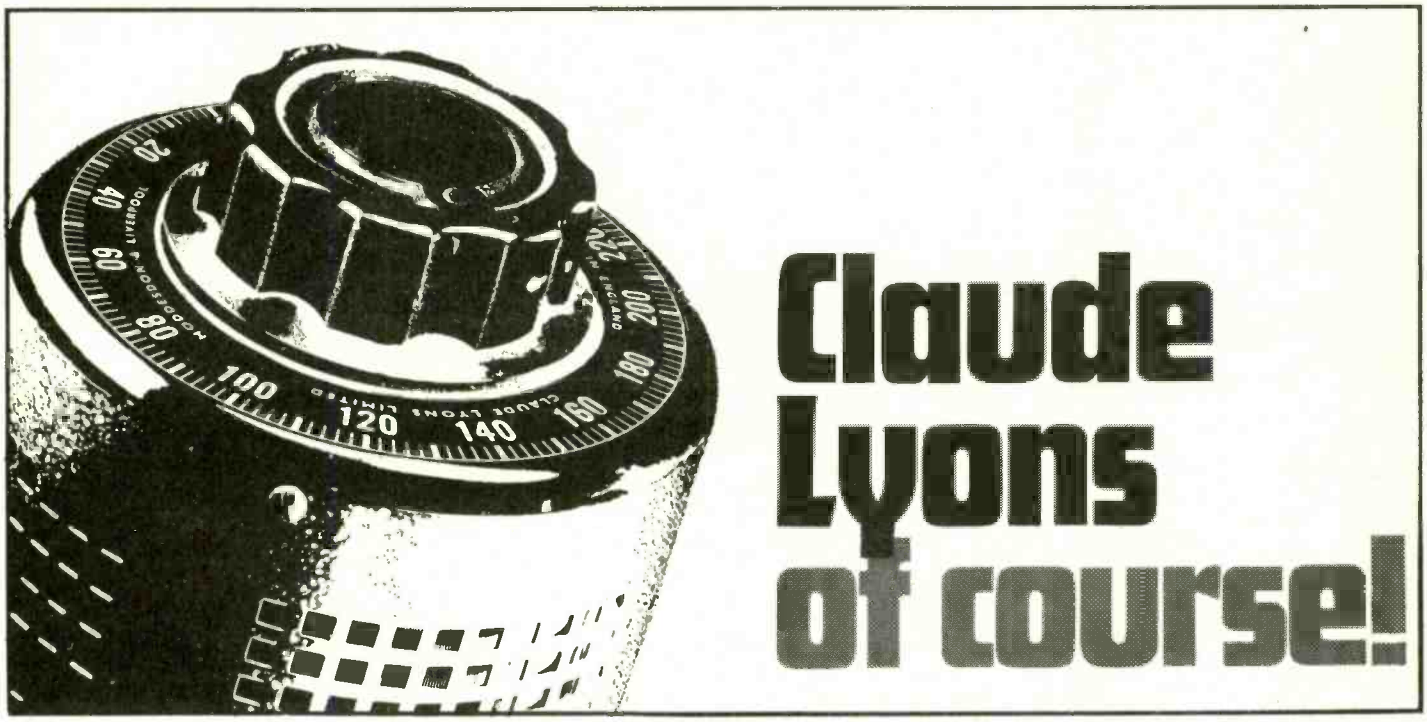

Why? Because you benefit from over 30 years' experience which Claude Lyons have accumulated in the voltage control field. In addition, you have a very wide choice from the extensive range of variable transformers available from Claude Lyons.

Variable transformers are the most useful and versatile devices ever developed for the control of AC voltage. They provide smooth, continuous adjustment of voltage output from zero to line voltage and above, either hand-operated or motor-driven.

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CL63

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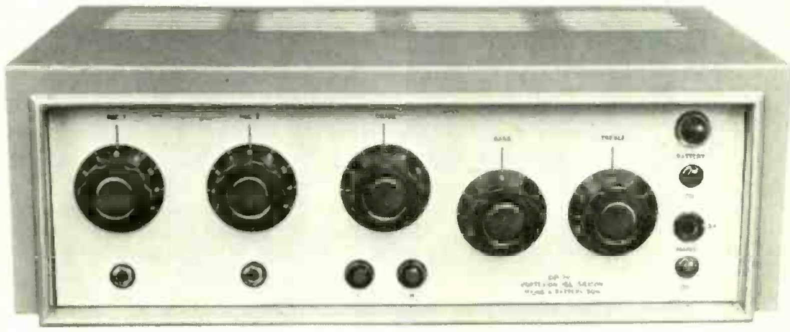
Vortexion

CP50 AMPLIFIER. An all silicon transistor 50 watt amplifier for mains and 12 volt battery operation, charging its own battery and automatically going to battery if mains fail. Protected Inputs, and overload and short circuit protected outputs for 8Ω-15Ω and 100 volt line. Bass and treble controls fitted.

Models available with 1 gram and 2 low mic. inputs. 1 gram and 3 low inputs or 4 low mic. inputs.



100 WATT ALL SILICON AMPLIFIER.

A high quality amplifier with 8 ohms-15 ohms and 100 volt line output for A.C. Mains. Protection is given for short and open circuit output over driving and over temperature. Input 0.4v on 100K ohms.

20/30 WATT MIXER/AMPLIFIER.

High fidelity all silicon model with F.E.T. input stages to reduce intermodulation distortion to a fraction of normal transistor input circuits. The response is level 20 to 20,000 cps within 2 db and over 30 times damping factor. At 20 watts output there is less than 0.2% intermodulation even over the microphone stage at full gain with the treble and bass controls set level.

Standard model 1-low mic. balanced input and Hi Z gram.

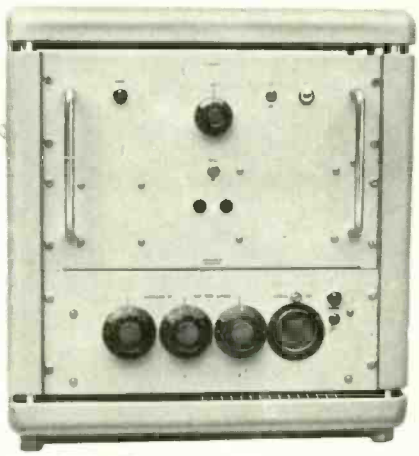
10/15 WATT ELECTRONIC MIXER/AMPLIFIER.

This high fidelity 10/15 watt Ultra Linear Amplifier has a built-in Mixer and Baxandall tone controls. The standard model has 4 inputs, two for balanced 30Ω microphones, and one for pick-up C.C.I.R. compensated and one for tape or radio input. Alternative or additional inputs are available to special order. A feed direct out from the mixer is standard and output impedance of 4, 7.5 and 15Ω or 100 volt line are to choice. Designed for continuous operation on 19" x 7" rack panel form or standard ventilated steel case.

30/50 WATT AMPLIFIER

With 4 mixed inputs, and bass and treble tone controls. Can deliver 50 watts of speech and music or over 30 watts on continuous sine wave. Main amplifier has a response of 30 c/s-20Kc/s ±1 db. 0.15% distortion. Outputs 4, 7.5, 15 ohms and 100 volt line. Models are available with two, three or four mixed inputs for low impedance balanced line microphones, pick-up or guitar.

200 WATT AMPLIFIER can deliver its full audio power at any frequency in the range of 30 c/s-20Kc/s ±1 db. Less than 0.2% distortion at 1 Kc/s. Can be used to drive mechanical devices for which power is over 120 watt on continuous sine wave. Input 1mW 600Ω. Output 100-120v or 200-240v. Additional matching transformers for other impedances are available.



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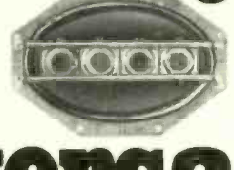

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These EMI Loudspeaker Systems, specially matched, produce every detail of the original sound over the full audio spectrum, at high and low listening levels.

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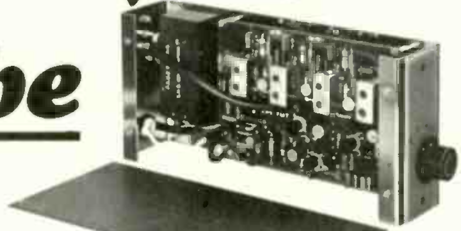
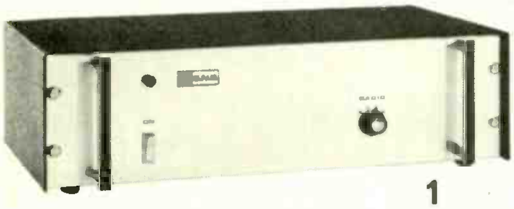
could be  **SAVED!**



1

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Service calls hit you twice—your profits and your reputation and nothing is more wasteful than service calls that could be saved by better equipment design. You know of the occasion when all a Service Engineer did was turn a volume control up (from off!), and when the complaint was "fuzzy radio" he simply put the tuner back on station (fiddled with!), and the countless dead shorts with nails through speaker cables—or open circuits when plugs mysteriously fall off, or the cable itself gets cut in half.

This new range of sound equipment counters these problems, by careful applications design to give you: 1. Tuner Amplifiers for Radio Distribution systems with switched Tuners (AM,FM, AM/FM) and all engineer controls by internal presets. 2. A range of rock steady crystal controlled Tuners, AM,FM, and AM/FM. 3. A range of fully transistorised P.A. amplifiers (12W, 40W and 100W) with the S.N.S. 'Current-Lok' short and open circuit protection.

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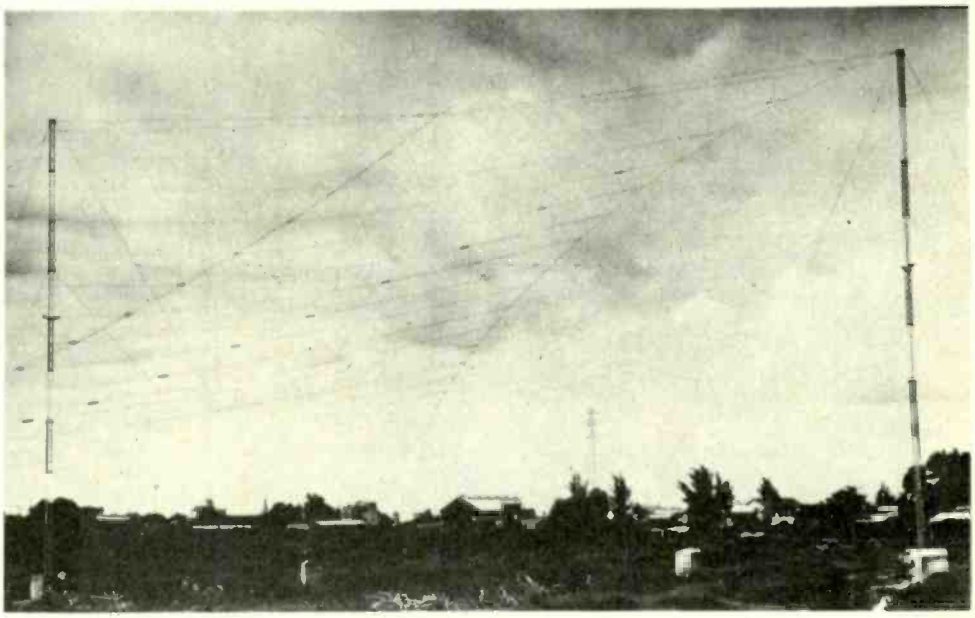
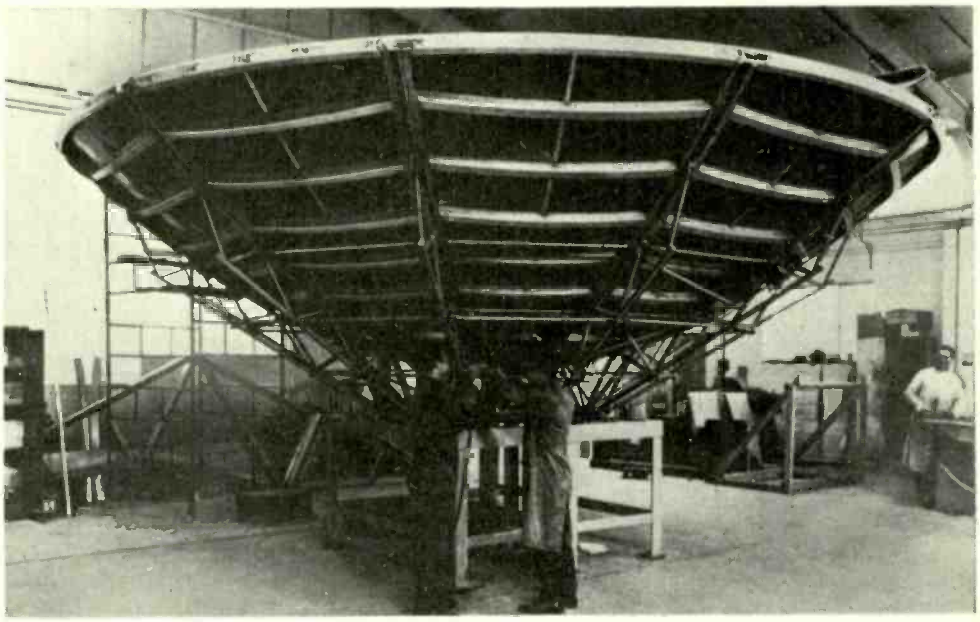
C&S Antennas Ltd





A central sales organisation has been established at Wentworth House, Ilford, to deal with overall antenna systems and projects on all frequencies—

LF TO MICROWAVES

—including initial survey and feasibility studies, design, site layout, supply, installation and final commissioning of antenna systems.

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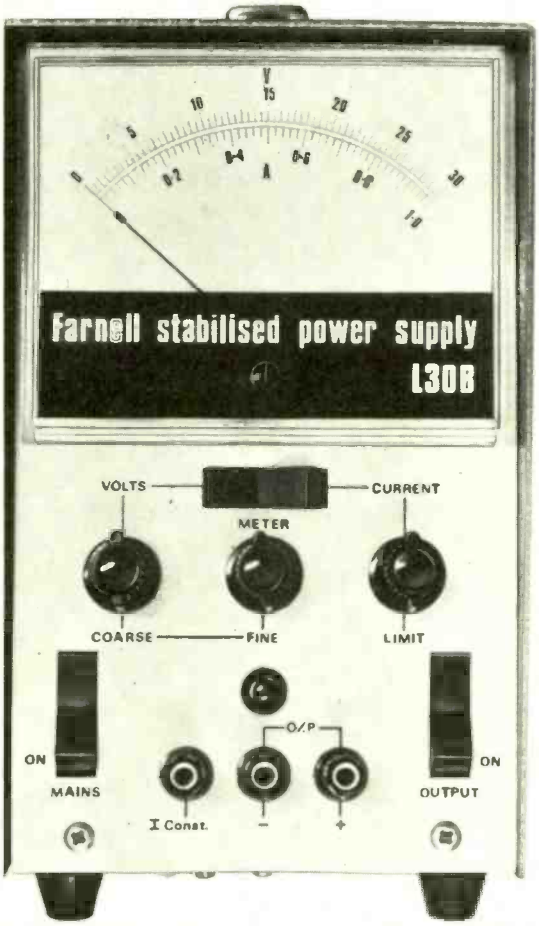
CS 15

WW—089 FOR FURTHER DETAILS

Farnell

New Constant Voltage/ Constant Current 'L' Series



Our experience in the manufacture of stabilised bench power supplies and knowledge of the latest market requirements have prompted a re-design of the well established 'L' Series. Consideration has been given to the more advanced needs of the research and development engineer, but equally the basic features of a general purpose laboratory power supply, suitable for student use, have been retained.

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* Continuous variability of voltage and current settings
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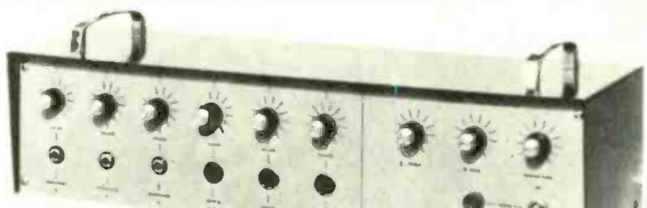

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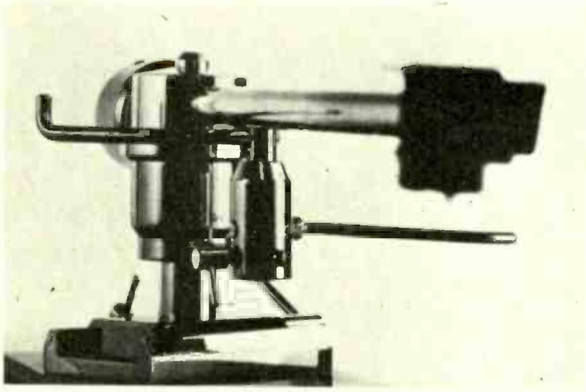

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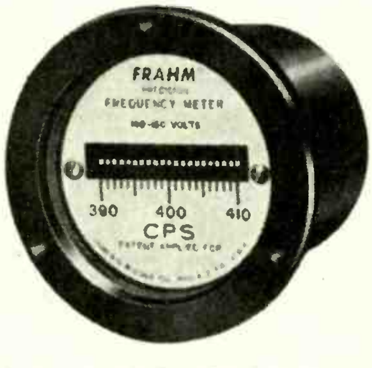

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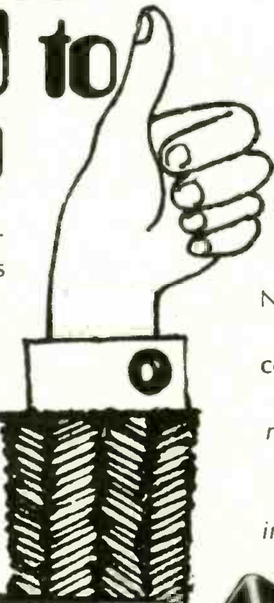

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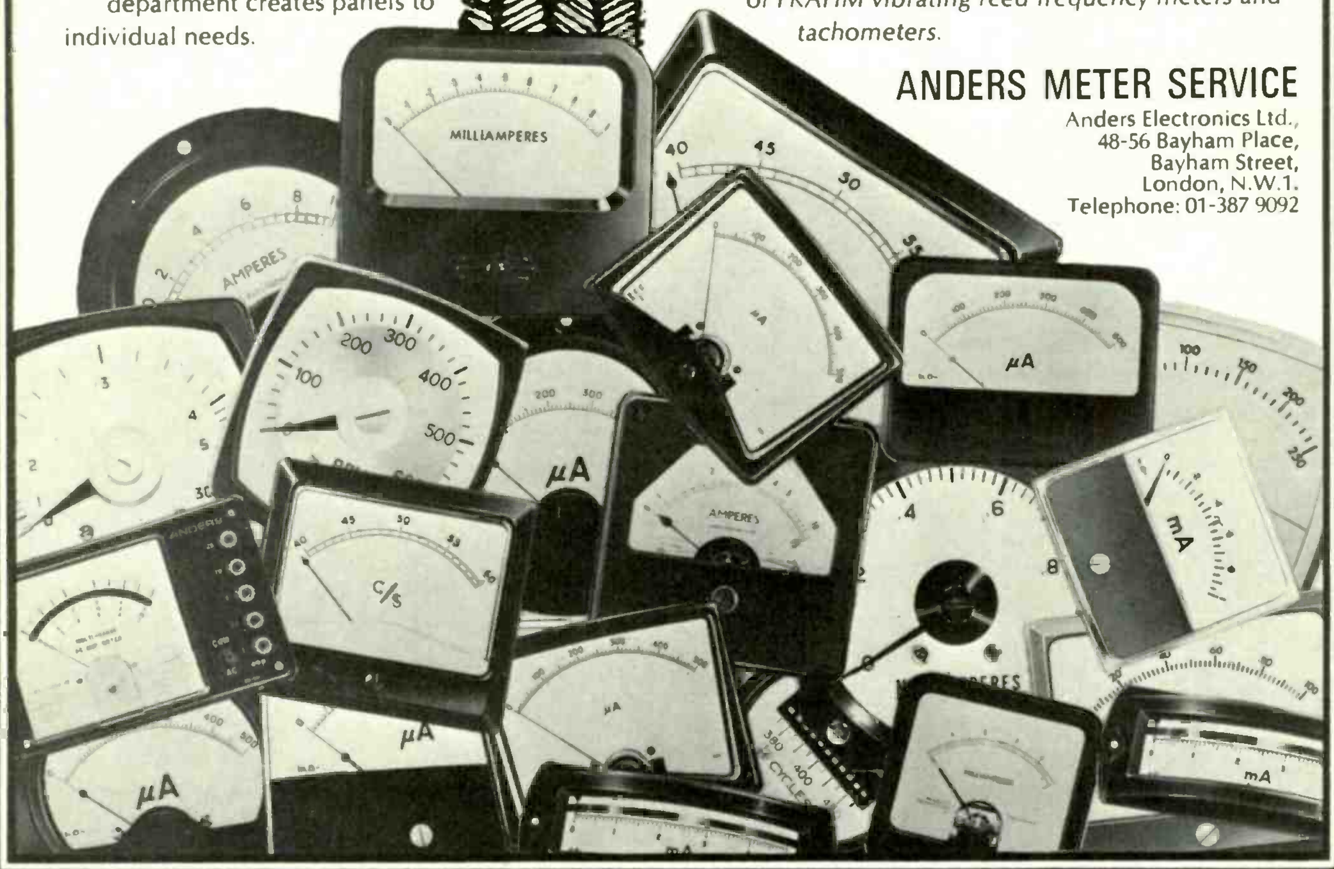

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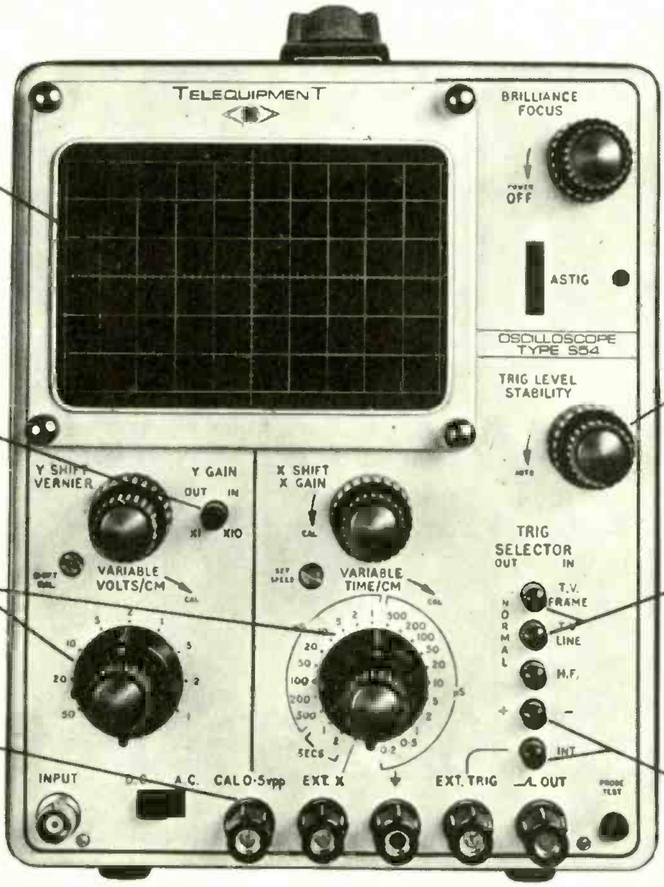

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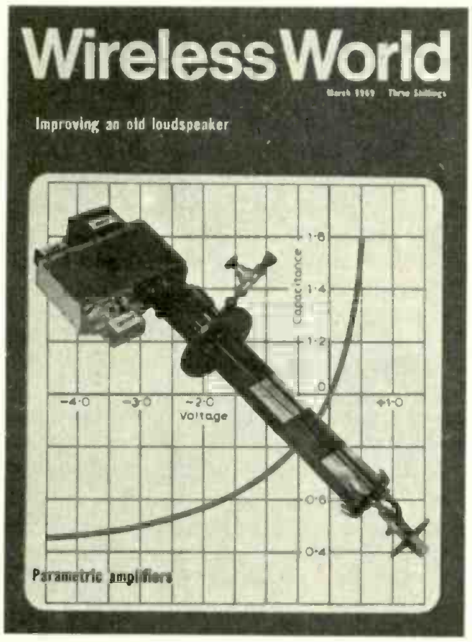

This month's cover design introduces L. Ibbotson's article on the principles of parametric amplifiers. Against a background formed by a varactor diode capacitance/voltage characteristic appears a parametric amplifier designed for operation at S-band microwave frequencies. Developed by Mullard for radio astronomy applications, the device has a pump frequency in the Q band.

Contents

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British Made?

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To what extent is British industry foreign owned, foreign dominated, foreign controlled? This is the question posed in the introduction to the book "British made?"* to be published this month. The authoress, Patricia Millard, rightly says there is no simple answer to this question either in terms of money invested from overseas or in the cost to our economy of profits sent abroad. She sets out to survey objectively various market sectors of industry—including electronics and telecommunications—in order to present the facts regarding overseas investments in the U.K. both directly in terms of subsidiary or associate companies and indirectly by minority holdings and licensing arrangements etc. Of the estimated £2,250m of overseas money directly invested in British industry 75% has come from the U.S.A. and apparently American investment accounts for some 17% of this country's manufacturing industry. At least 1,600 non-financial companies are said to be owned or controlled by American companies.

This the overall picture of this country's industry, but what of our particular industry? One sector of it, and the most rapidly developing, that of semiconductor manufacture is dominated by American money and know-how. Basil de Ferranti is quoted in "British made?" as having stated that 37% of integrated circuits sold in Britain are wholly imported from the U.S. and another 19% are imported in partly finished condition for assembly here. The import figures for semiconductors for 1968 show a total of £15.3m compared with £11.4m a year ago. Exports totalled £4.6m (£2.7m). Even the few British companies which do manufacture semiconductors on a large scale—Marconi-Elliott, Plessey, Ferranti—have licensing agreements with American companies and, of course, Associated Semiconductors Manufacturers now owned by Mullard are consequently a subsidiary of the Dutch Philips company.

In the components and instruments fields overseas influence may not be so obvious. This is probably due to the fact that many of the companies, whose names are now household words, have been established in this country for so long that we have forgotten that they are offsprings of American parents.

Miss Millard says the facts she presents may shock and startle those who are complacent about British industry. In quoting from and commenting on her facts we are seeking to do neither for we know that the large majority of our readers, whose very livelihood depends on a virile and firmly established industry, are by no means complacent; our correspondence proves this! It is, however, a useful exercise to take stock and see what is really happening.

Because electronics manufacture depends on a continuously advancing technology and necessitates the investment of vast sums of money in R & D, it is almost inevitable that the American industry, because of its financial and manpower resources, will set the pace in world electronics. If therefore we in the U.K. are to be in the running and are, for obvious reasons, unable to invest the necessary money and manpower we must take the alternative, if less gratifying, course of buying American know-how and accepting foreign investments. Does this, however, necessitate domination of the industry by overseas companies?

The alternative appears to be merging of companies into groups large enough to compete with the mammoth American corporations. However such mergers, while achieving "housekeeping" economies in R & D costs, do not necessarily mean better R & D resulting in more technically competitive products in the world market. On the other hand we must not overlook the efforts made by small independent companies in specialized sectors of industry to produce truly British made goods.

Surely the moral is for us to go it alone in a limited range of products where we are already doing well and to ensure that by accepting outside aid we do not stultify British endeavour.

*"British made?" published by Kenneth Mason Publications Ltd.

Improving Old Loudspeakers

Many old loudspeakers have excellent magnet and voice-coil assemblies but the cone suspensions and frequency response leave much to be desired. Methods of increasing the cone suspension compliance and cone rigidity are suggested

by H. C. Bennet-Clark, B.Sc., Ph.D.*

I have recently been concerned with a research project examining the courtship of fruit flies,[1] in the course of which pulses of sound where played to the flies to simulate their own courtship sounds. The fly produces, by flapping its wings, a single cycle of pressure change; it was this pulse, lasting 3 ms, that we wished to reproduce from a loudspeaker.

Early experiments used a new commercial loudspeaker of the £6-£8 class; fed with the rounded sawtooth waveform that is the analogue of the fly's wing movement, the speaker did not transduce this accurately into a cycle of pressure rise and fall but produced a jagged rising waveform and a hang-over after the cessation of the applied signal. These are typical properties of cone loudspeakers. As the experimental programme was aiming to test the sensory limits of the flies, it was clear that a better transducer was required.

An old 12in Goodmans unit, made about 1950, was lying around unused. As recent experiments elsewhere[2] have been directed to redesigning the cone and cone surround, this seemed a suitable subject for experiment. The unit, before treatment, was unsuitably rough in its response, having similar faults to the other unit. After treatment, it was capable of producing clear single sound pulses in the range from 100 to 1,000 Hz. Since then, I have modified another 12in Goodmans unit of about 1953 vintage and various other units all over 10 years old; two of these are used at home, and, subjectively, appear very much freer from transient distortion and troughs or peaks in the frequency response than they were before.

Some theoretical and practical considerations

The theory of operation of cone loudspeakers is well known and is treated elsewhere.[3] Summarizing, it appears that for a 12in unit of 10in diameter cone to operate at 40 Hz, it should have a resonant frequency below this. If the piston is truly rigid, it will be fairly flat in its response up to a frequency determined by the cone diameter; for a 12in unit this is about 800 Hz.[4] Above this frequency, the radiation resistance rises, the unit impedance rises and also the unit becomes increasingly directional.

Practical cone units are designed to cover a bandwidth up to maybe 6–15 kHz and to be omni-directional in the process. This can be achieved by designing the cone so that at high frequencies only the inner part vibrates; in a practical unit, this is encouraged by corrugating the cone in a series of annuli, each of which is separated from its neighbour by the compliance of the corrugations. As each annulus has its own resonant frequency, or range of resonant frequencies, internal damping of the cone is desirable and is achieved by use of a fluffy paper cone; even then, troughs and peaks of $\pm$ 12dB are common in the cheaper or older designs.

From this, it follows that in response to a square wave input or to any fast transient, such a speaker will produce buzzes which are caused by the various peaks in its frequency response. To perform well, a speaker must have a flat frequency response.

This all suggests that several loudspeakers each of limited bandwidth and very flat response will perform better than a single wide range unit. It also suggests that a suitable approach might be to build very rigid pistons for the various units.

A flat rigid piston is difficult to make.[5] Conical rigid pistons are also fairly difficult to make and, if very rigid, tend to become bells; a bell is essentially a disc or cone with rigid but elastic walls and can be excited at a number of different, quite sharp, resonances. Any approach to increasing the rigidity of the cone should introduce damping of bell-mode resonances if it is to be successful.

The effect of the cone suspension

The lower frequency limit of any cone unit is determined by its fundamental resonance. In many older 12in cone units having corrugated paper surrounds, the resonant frequency is 50 to 100 Hz. Thus they cannot be expected to perform to present day Hi-Fi standards, however they be enclosed.

The aim is that the cone should move axially as if constrained by a Hookean spring; symmetrically and linearly. Corrugated paper rarely meets these requirements and, by its

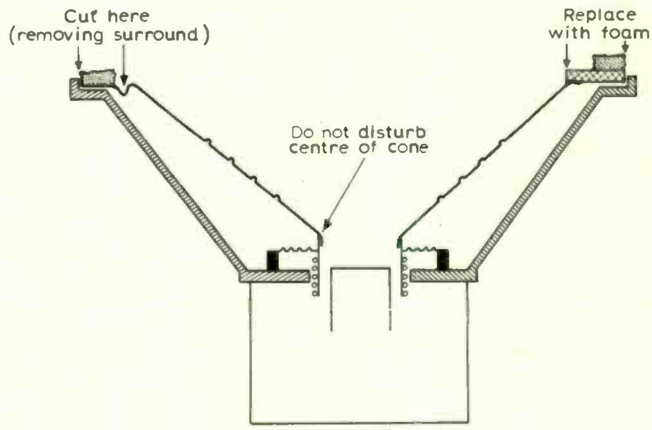


Fig. 1. Diagrammatic cross-section of a loudspeaker showing, on the left, where the cone should be cut to remove the surround and, on the right, the extent of the new foam surround.

** H. C. Bennet-Clark graduated with a B.Sc. in zoology from University College, London in 1955. During National Service he taught wireless theory at the R.A.F. Yatesbury. He then did research for a Ph.D. in Zoology at Cambridge. At the University of Edinburgh he has recently been concerned with mechanical systems in insects, including the energetics of flea jumping.*

stiffness, is not conducive to high efficiency as, at lower frequencies, the efficiency is mainly a function of cone mass and surround stiffness.

For the average living room, a power level of 0.3 acoustic watt will give an intensity level of about 100dB. At 40 Hz, this power requires an excursion of about $\frac{1}{2}$in by a 10in diameter piston.[4] This excursion must be linear.

Modifications to the cone surround

In the late 1950s, plastic polyurethane foam was used by Wharfedale as a cone surround. I modified a 12in Goodmans then, giving it a foam surround, and it has been in use ever since. The cone has not become eccentric or detached and the resonant frequency was lowered from 75 Hz to 47 Hz. I have recently modified the other Goodmans 12in unit. The resonant frequency was lowered from 54 Hz to 37 Hz. In both cases, the compliance was approximately doubled.

A suggested procedure for doing this to an existing unit is given here. On no account should the voice-coil spider be disturbed or the cone detached.

First measure the resonant frequency. By feeding directly from a signal generator, the resonance can be seen directly; this differs slightly from the infinite baffle resonance but the difference can be disregarded.

A suitable sheet of foam is obtainable at Woolworth's for 7d. and is 15in square and 5mm thick. Mark upon it concentric circles of diameter equal to that of the outside of the loudspeaker chassis mounting gasket and the base of the cone of the loudspeaker (see Fig. 1). Cut out the annulus of foam and mark it into equal sectors—4 or 8 are suggested.

Now for the point of no return! Cut out two similar opposite sectors of the cone surround, by slitting with a really sharp knife in the valley of the inner corrugation (see Fig. 1) and then lift off these sectors and the felt gasket from the chassis. Stick a sector of the foam onto the cone and the chassis using either Evo-stik or Copydex. The felt gasket can then be glued back.

Before everything sets solid, check that the cone still moves freely and does not scrape on the poles of the magnet. Then continue replacing the original surround. When finished, make sure the foam is really firmly stuck around its inner and outer edges. Leave the speaker 24 hours resting on its gasket, to ensure that this is really firmly stuck down. The final appearance can be seen from Fig. 2.

Increasing the rigidity of the cone

This is most easily done with a diaphragm that is truly conical—most are not, though, but the result can be the same. I have treated two 12in Goodmans units, an 8in Wharfedale FSAL and an anonymous 10in unit all with equal success. Basically, the cone is built up by successive layers of expanded polystyrene and then stabilized with a skin of aluminium foil.

Suitable expanded polystyrene sheeting comes in rolls like wallpaper and in a variety of thicknesses. I bought a roll 22in wide 33ft long and 2mm thick for 6s 11d and have enough left for another 10 speakers!

The main difficulty is to find a suitable adhesive as the sheeting dissolves in most organic solvents. You can use water pastes, shellac or Copydex. The last is probably the best as it sets quickly and is elastic. I have not had my speakers operating long enough to know how long it will last.

The cone is built up by glueing on sectors of expanded polystyrene. First, the cone dimensions must be measured: a 12in Goodmans speaker has a cone about 10in diameter of about 105° angle. Such a cone can be made from a circle by cutting a sector out of it. The cone angle can be measured by cutting a piece of paper to form a protractor and then measuring the angle. The table on page 101 shows the dimension required to make cones of various angles for a 10in diameter conical diaphragm.

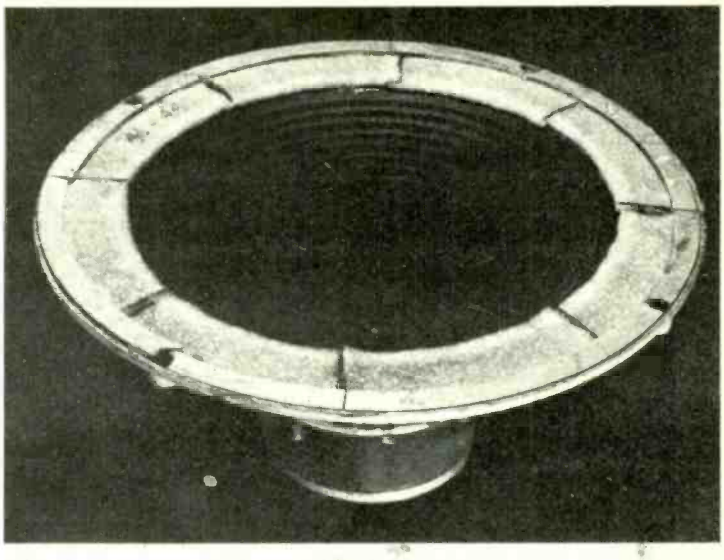


Fig. 2. Photograph of Goodmans 12in loudspeaker showing the foam surround of eight sectors, after fitting.

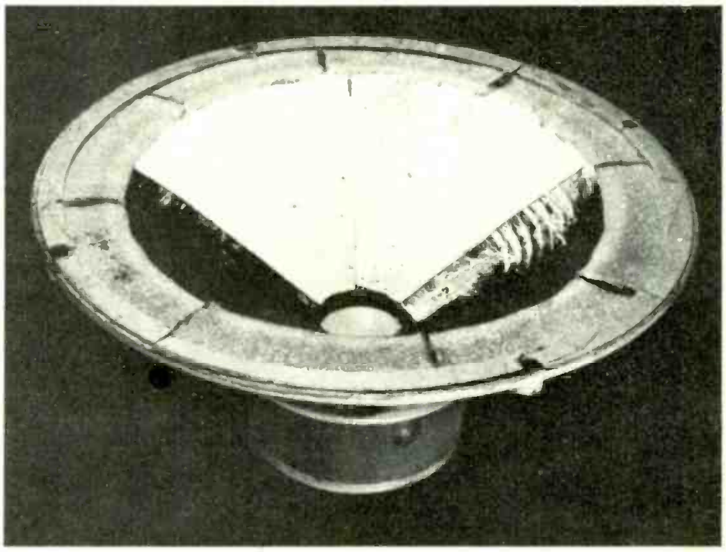
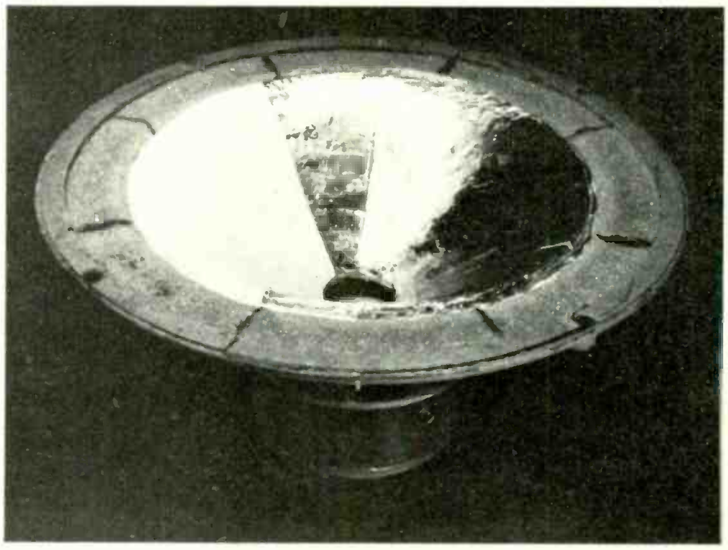


Fig. 3. Goodmans 12in loudspeaker showing the cone being built up with sectors of expanded polystyrene.

Fig. 4. Goodmans 12in loudspeaker after five layers of polystyrene have been fitted. The aluminium skin is cut and stuck down with Copydex.



In most units the angle of the diaphragm becomes more acute towards the centre. In this case, cut the sectors a little larger than the table indicates and fit them to the diaphragm.

Gluing the sectors to the diaphragm is quite quick. First, remove the dust-cover from the centre of the cone as the sectors must be attached as closely as possible to the whole of the diaphragm.

Smear an area of diaphragm rather larger than the sector with Copydex and fit the first sector snugly up to the centre and edge of the diaphragm. Press it down evenly all over and check that it is correctly fitted (Fig. 3). Fit the next 3 sectors and then, before gluing, check that the last sector fits snugly: if not, cut it to size and then fit it.

The next layer is fitted in the same way but the joins between sectors should not be above those of the first layer but should be staggered. This is necessary to reduce the extent to which "bell-mode" vibration occurs; this particular mode of vibration is probably fairly highly damped by the laminated structure. Continue adding layers. The foam sheeting is 2 mm thick, so, for a $\frac{3}{8}$in thick cone, you will need about 5 layers though I have used 4 with success. There is probably little advantage beyond this thickness in terms of gain in stiffness and you will increase the mass of the cone unduly.

After building up the cone, it must be finished with a rigid skin—this greatly increases the final rigidity of the laminate.

The skin is made of ordinary domestic cooking foil. The circular ring to make the cone should be cut about $\frac{3}{8}$in larger and smaller in radius than the original polystyrene circles to allow rolling over at the inner and outer edges. For a larger speaker, it is best to use five sectors, as before (Fig. 4).

To glue the skin with Copydex, rather more care is needed. The aluminium foil has a very shiny side and a matt side. Smear Copydex very thinly and evenly over the matt side of the foil and over the cone. Then leave it to dry for about 5 minutes and stick the foil on, overlapping both at the edge and at the centre. The skin will be most unlikely to fit really tightly but it must be made to do so.

Aluminium is fairly ductile: rub the skin all over with a smooth polished tool—a ball point pen barrel is ideal—until it is attached all over. Then proceed with the other sectors. When all are fitted, they can be rolled over the apex and edge of the cone, which should be similarly treated with Copydex. This will give a smooth finish to the inside and outside of the cone.

If the skin does not stick (and it can be awkward), you may have to try shellac. This comes, conveniently dissolved in alcohol, as button polish and French polish, and should be painted on the cone and foil as with Copydex and allowed to get tacky. The procedure is then the same.

Performance testing; efficiency and resonance

The first thing you will have done is to test the freedom of the cone. This should be tested more carefully both after fitting the foam surround and after modifying the cone.

In the case of one of my 12in Goodmans, the resonance was originally at about 55 Hz, after fitting the surround it was at 35 Hz and after fitting the polystyrene to the cone at 25 Hz. This gives quite a lot of useful information. The initial decrease of resonant frequency was to about $\sqrt{2}$ of the original, suggesting a two fold increase of compliance (a similar improvement was obtained with my other 12in unit). When the cone was modified, the resonant frequency dropped by a further $\sqrt{2}$ suggesting that the cone mass had been doubled. The first will cause an increase in speaker sensitivity and the second a similar decrease.

But, to avoid later trouble, you should check that the cone movement is adequate and free. You must produce about 5 watts at 30 Hz and feed it into the speaker (or if this is not possible, 6-10 volts of a.c. from a transformer for a 15 Ω speaker gives 2-6 watts). This should cause the diaphragm to flap through about $\frac{1}{2}$in. By picking up the speaker and turning it, it should be possible to find whether, at any point, the moving coil touches and magnet assembly—if it does, it will be only too obvious, as it will set up a scraping noise. Clearly, the speaker should not be mounted in such a position. My experience, though, is that this is one trouble that does not occur.

The speaker cone should be very rigid. A paper cone is quite easily dimpled by finger pressure, for quite small movements of the whole cone. By pressing anywhere on its surface, the cone of the 12in modified speakers can be moved over $\frac{1}{4}$in inwards before any deformation can be observed.

There are practical disadvantages in making the piston too thick and too rigid. If it is too thick, there will be serious coloration at some frequency caused by interference effects at the edge. There are also problems caused by the sharp transition from the rigid cone to the soft surround: these are to some extent reduced as the paper of the cone will protrude out from the body of the built-up cone. The effect of these two sources of non-linearity is likely to be fairly slight by comparison with those present in the original response. A serious coloration in one of the two 12in units occurred at about 1.5 kHz and examination with a microphone suggested that there was a trough of about 15 dB and a peak of 6 dB about this point. Although this was above the normal range of input frequencies, it led to serious coloration when used for pulse operation. Its source was traced to the jar-shaped hole at the centre of the thickened cone, formed by the voice coil and magnet. It was very considerably damped by fitting a central plug consisting of 4 layers of polyurethane foam alternating with 3 layers of polystyrene foam. This plug also acts as a dust cover.

Suitable h.f. units

There are many h.f. units on the British market, most of them designed to operate above 3 kHz. At this frequency, my l.f. units become rather rough and highly directional. Probably the optimal crossover point is 1 kHz but, for reasons of convenience, I have used 1.5 kHz as Whiteley Electrical make cheap units with a slope of 12 dB per octave which can be readily modified to 7.5 Ω impedance at this frequency.

For simplicity, the h.f. unit should cover the band from 1 kHz to 15 kHz smoothly. Ideally, it may be better to use 3 speakers and only expect $3\frac{1}{2}$ octaves from each, but, if a suitable h.f. unit can be found, it could be used. I had been given a Whiteley W.B.T.10 horn h.f. unit which, as delivered, responds down to its flare cut-off frequency, 2 kHz.

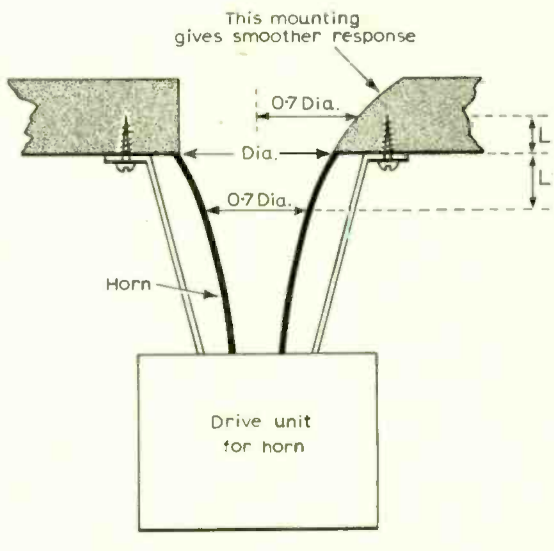


Fig. 5. Diagram of horn-loaded tweeter, showing, on the left, a parallel sided mounting hole giving rough response and, on the right, the shape of hole to continue the exponential horn for smooth low frequency response.

TABLE ONE

Dimensions of arcs of circles to generate cones of 10in basal and 2in apical diameters.

Cone angle (deg)	Outer radius (in)	Inner radius (in)	Remove sector of (deg)	Angle of each of 5 sectors (deg)
80	7.8	1.55	128.5	46
90	7.05	1.4	105.5	51
100	6.5	1.3	84	55
110	6.1	1.2	65	59
120	5.8	1.15	48	62
130	5.5	1.1	33.5	65
140	5.3	1.05	21.5	68

Dimensions are correct to ±0.05in. or ±½°.

However, by extending the flare of the horn on to the mounting board (Fig. 5), its smoothness was increased and it does provide considerable output at 1.5 kHz, and is still responding at 1 kHz, without noticeable distortion.

The situation, however, is far from ideal: horn-loaded speakers are apt to distort below the cut-off frequency[4] but this does not appear to be serious in my unit and it is fed via a 15 dB attenuator and so the power rarely exceeds 0.2 electric watt. Clearly, a better solution would be to obtain a horn unit capable of responding down to below 1 kHz. Such units are made but are apt to be expensive.

Suitable l.f. unit enclosures

This subject has been well studied and is well documented elsewhere. As the modified l.f. unit will have a resonant frequency around 30 Hz, a bass-reflex enclosure will be very large—at least 8 cu.ft—if tuned to the speaker resonance[4] One solution seems to be to use a vented enclosure of reasonable volume, say 4 cu.ft, and, by building an adjustable port, to adjust the enclosure to give a suitable bass response.

In my domestic system, I am using a pair of parallel-connected l.f. units, a 12in modified Goodmans of 25 Hz resonant frequency and an 8in modified Wharfedale FSAL of 45 Hz resonance in a closed box of 7 cu.ft. The impedance at 30 Hz is 18.5 Ω at 45 Hz, 21.5 Ω and the impedance curve is very flat, falling to a minimum of 12.5 Ω at 500 Hz, rising thereafter to 17 Ω at 1.3 kHz; these are two parallel-connected 15 Ω units. The h.f. unit is the W.B.T.10 tweeter with a suitable 1.5 kHz crossover unit and attenuator. It appears that the use of two stagger-tuned l.f. units has considerable advantages at the bottom of the response curve, but the topic does not appear to have been much examined or the technique sufficiently exploited.[3,4]

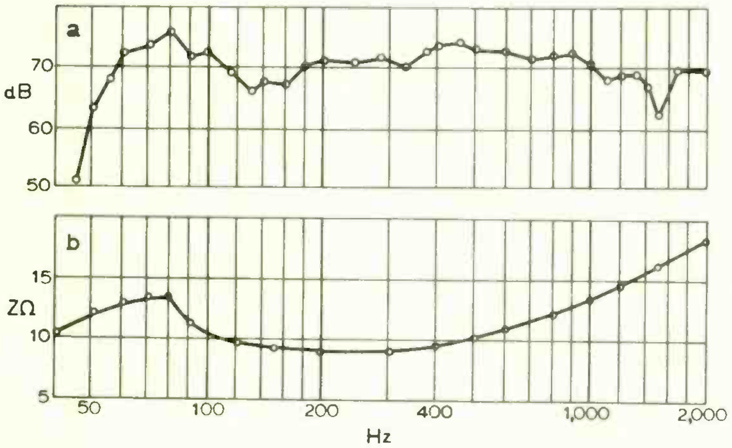


Fig. 6. (a) Graph of the axial frequency response of the two unit system measured with a constant voltage input giving a power of 0.1 watt at 500 Hz (b) Graph of the impedance of the 2 unit system against frequency. A 12in and a 10in unit are connected in parallel in a closed box of internal dimensions 29 × 14 × 11in. The impedance peak at 80 Hz corresponds with a peak in the frequency response in (a).

For producing acoustic pulses, I am currently using a damped enclosure of inside dimensions 29in × 14in × 11in with no port. This box is damped with a layer of ½in felt pinned to 1in battens away from the 1in thick walls. The rear of the box is filled with a folded length of 2in thick fibreglass roof insulation.

Early experiments used a single l.f. unit, a 12in Goodmans and, while the response was smooth, it did not extend to very low frequencies. The present version uses the 12in unit connected in parallel and in phase with a modified anonymous 10in unit (purchased with a cracked cone for 25s). These units are mounted above one another and loaded with slots to improve the h.f. radiation pattern. This arrangement gives a very flat impedance curve (Fig. 6b) and while the low frequency cut-off, at 55 Hz (Fig. 6a), is not outstandingly low, this is produced from a relatively small enclosure of about 2½ cu.ft.

Test procedures

Most of the accepted test procedures require apparatus far beyond the scope of the amateur; most of us do not have access to anechoic chambers or pulsed sine-wave generators. A certain amount can be learnt by listening tests and by using a good quality microphone. In general, care is needed to avoid placing the microphone in a standing wave reflected from a wall and this situation can be aided by hanging the microphone from a cord and swinging it while recording.

By sweeping the output from a signal generator between 20 Hz and 2 kHz, the response can be examined subjectively. It is probable that you will notice any non-linearity exceeding 6 dB, but not the overall shape of the characteristic: this does not matter as what is mostly required is freedom from coloration.[2] In this way, I was able to observe the 1.5 kHz coloration referred to earlier. The information thus obtained can be checked by use of a microphone; this suggested that the system used to produce acoustic pulses was without peaks exceeding 3 dB between 100 and 1,200 Hz and that, after suitable damping, the coloration at 1.5 kHz was of similar size. Below 100 Hz, the microphone response decreased rapidly and so no reliable information was obtained.

Later, owing to the kindness of Mr. C. S. Greeves of the National Engineering Laboratory, I was able to test the pulse-producing system in an anechoic chamber using Bruel and Kjaer measuring equipment. The results of this test are shown in Fig. 6(a). It will be seen that for a reference level of 70 dB, the axial response is 6 dB down at 50 Hz, 6 dB up at 80 Hz and that the rest of the curve is flat within ± 3 dB, except for the trough at 1.5 kHz mentioned earlier.

Although the tests were made at discrete frequencies, care was taken to locate and plot the position of troughs and peaks and it is clear that the response over the working bandwidth of 150–1,000 Hz is adequate. Indeed, when coupled to a suitable tweeter viâ a crossover unit and used as a domestic loudspeaker, the performance is very satisfactory.

Acknowledgements

I am grateful to the Director of the National Engineering Laboratory for the use of acoustical test facilities and to C. S. Greeves for his assistance with the measurements. For originally dispelling the illusion that the loudspeaker cone should not be violated, I owe grateful thanks to Dr. K. E. Machin.

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Parametric Amplifiers

Basic Principles

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

The name "parametric amplifier" is given to a circuit in which signal amplification takes place in a component having a *parameter* which varies with the applied voltage. The variable parameter normally employed in practice is the capacitance of the p-n junction in a semiconductor diode. In most types of amplifier the signal power is increased by taking energy from a d.c. supply. In a parametric amplifier, however, the signal power gained comes from an alternating source, called the "pump", which has a frequency higher than that of the signal. Despite this complication parametric amplifiers find considerable use, particularly at u.h.f. and microwave frequencies, because they can give good amplification with very low noise.

The usual text-book physical explanation of parametric amplifier action involves a capacitor with plates which are effectively moved towards and away from each other at appropriate times during the signal cycle. This explanation is not really satisfactory, and in any case relates only to a very special case—what is called a degenerate negative-resistance parametric amplifier (see later). A more acceptable general physical explanation is as follows. When a capacitor is charged and discharged by an applied sinusoidal voltage, energy is taken into the capacitor over half of a cycle and returned to the generator over the other half. If a small increment of charge δq is added when the voltage is V the increase in stored energy is $V.\delta q$. Similarly a reduction in charge stored δq results in a decrease in stored energy $V.\delta q$. The signal and "pump" oscillations are added together across the semiconductor diode referred to above. The diode has connected across it, in addition to the signal and pump circuits, a tuned circuit, known as the idler, which contains neither source nor load and which is tuned to the difference frequency between the signal and pump frequencies. Because of the non-linearity of the diode capacitance the idler circuit is coupled to the other two and it controls the relative phases of currents and voltages in such a way that the pump adds charge to the diode capacitance when the total voltage across it is high and subtracts charge when the total voltage is low. The signal source, on the other hand, adds charge when the total voltage is low and subtracts it when the total voltage is high. In this way energy is transferred from the pump to the signal circuit.

In the analysis of this process which follows an attempt has been made to keep the mathematics simple by considering the specific case of an ideal diode having a junction with a relatively simple voltage–charge relationship.

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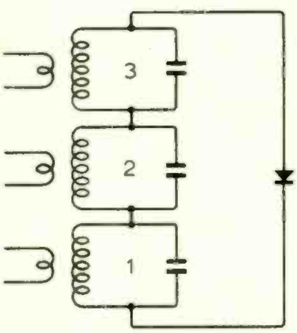


Fig. 1. Diode mixing circuit.

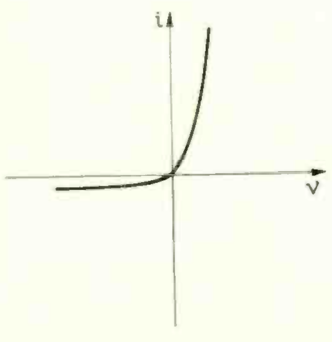


Fig. 2. Current/voltage characteristic of the diode in Fig. 1.

Diode mixing

The action of a parametric amplifier is closely related to that of a diode mixing circuit, and it is useful to consider this type of mixer first.

If two signals of frequencies f_1 and f_2 ($f_2 > f_1$) are added in a semiconductor diode then owing to the non-linearity of the diode characteristic, signals of other frequencies appear, including in particular frequencies $f_2 + f_1$ and $f_2 - f_1$. The normal circuit arrangement is shown in Fig. 1. Circuit 1 is tuned to frequency f_1 and circuit 2 to f_2, while circuit 3 is tuned to a further frequency $f_3 = f_1 + f_2$. In this arrangement $f_2 > f_1$ and, of course, $f_1 = f_3 - f_2$ and $f_2 = f_3 - f_1$. The diode is to be regarded as a non-linear resistor with a characteristic as shown in Fig. 2. In the usual application, that of heterodyning, we would feed power into circuits 2 and 3. The two voltages at f_2 and f_3 added across the diode produce a circulating current with components at $f_2, f_3, f_3 + f_2, f_3 - f_2, 2f_2, 2f_3$ and probably higher order harmonics and sum and difference terms depending on the exact nature of the diode v/i curve. The current at frequency $f_3 - f_2$ (which is f_1) develops a voltage across circuit 1 and thus power can be extracted from circuit 1 to feed a load.

The previous paragraph gives a standard explanation of mixer action, but the argument can be taken further. The voltage at f_1 developed across circuit 1 also contributes to the voltage across the diode and will thus mix with the voltage at f_2 to produce a component of current at f_3 and with the voltage at f_3 to produce a component of current at f_2. These currents will tend to feed power back through circuits 2 and 3 to the generators.

To generalize, if we take the circuit of Fig. 1 and feed power into any two of the tuned circuits, currents will circulate at all three frequencies (and at many others) and voltages will exist across all three tuned circuits. Detailed analysis shows that under all conditions the driven circuits show a net absorption of power from the generators and that the power output from the undriven circuit is smaller than either of the two power inputs (in mixer terms, conversion gain is not possible with a diode mixer).

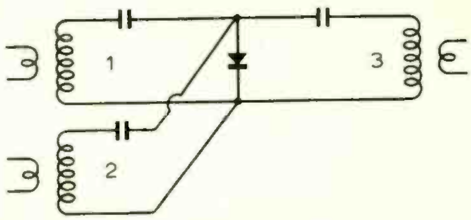


Fig. 3. A variant of the mixing circuit in Fig. 1. This is also the basic arrangement of a parametric amplifier if the diode is a varactor diode.

Assuming that we can neglect tuned circuit losses, the power lost is dissipated in the resistance of the diode.

Instead of the circuit of Fig. 1 we could use that shown in Fig. 3. In this case, assuming again that circuits 2 and 3 are driven, currents at f_2 and f_3 add in the diode and generate voltages at f_1 and various other frequencies. The voltage at f_1 can drive a current through circuit 1 so that power can be extracted from circuit 1. Again the current circulating in circuit 1 and the diode will mix with the current at f_2 to feed power back into circuit 3 and with the current at f_3 to feed power back into circuit 2. The outcome is the same as before.

The varactor diode

A junction diode has a shunt capacitance because charge which is stored near the junction varies with applied voltage. At medium frequencies and below, the reactance of this capacitance is too high to have much effect so that the impedance of the average junction diode at m.f. may be regarded as a variable resistance. At u.h.f. and above, on the other hand, this capacitance becomes dominant—particularly in a type of diode, called a varactor, designed to exploit it.

In a linear capacitor the charge stored is proportional to the applied voltage; the ratio Q/V gives the capacitance value. If the charge is not proportional to voltage then we have a non-linear capacitor. In this case the only meaning which we can give to capacitance value is that of incremental or small signal capacitance defined as dQ/dV. The capacitance of a varactor diode is non-linear. A typical incremental capacitance/voltage curve is shown in Fig. 4. At microwave frequencies, to achieve variable resistance mixing as described in the previous section a point contact diode must be used. Suppose we use instead a varactor diode. The non-linear capacitance generates sum and difference frequency signals as with the non-linear resistance, but we now find that under suitable circumstances one of the driven circuits can have more power fed back into it than it feeds out. This can be used to achieve amplification. We also find that conversion gain is possible. Here we have a parametric amplifier.

Mixing in a non-linear capacitor

In the following analysis simple ideal conditions are assumed. Consider the circuit of Fig. 3, which is the arrangement normally used in parametric amplifiers. Let the currents in circuits 1, 2 and 3 be

$$i_1 = I_1 \cos \omega_1 t$$
$$i_2 = I_2 \cos \omega_2 t$$
$$i_3 = I_3 \cos (\omega_3 t + \phi)$$

This representation is completely general provided the currents at f_1 and f_2 are harmonically unrelated so that they go in and out of phase and we can chose our zero of time at an instant when the two currents are both maximum. Having done this we must ascribe an arbitrary phase angle to the current at f_3.

The total current in the diode is given by

$$i = I_1 \cos \omega_1 t + I_2 \cos \omega_2 t + I_3 \cos (\omega_3 t + \phi) \quad \ldots (1)$$

Signs will be important in what follows. A positive current will be taken as one flowing in the forward current direction in the diode; a positive voltage as one appearing in the forward biasing direction across the diode.

Assuming that the diode impedance is purely capacitive the charge stored at any instant will be $\int i\, dt$. Hence from eqn. (1)

$$q = \frac{I_1}{\omega_1} \sin \omega_1 t + \frac{I_2}{\omega_2} \sin \omega_2 t + \frac{I_3}{\omega_3} \sin (\omega_3 t + \phi) + Q \quad \ldots (2)$$

Q, the constant of integration, represents the charge stored in the diode in the absence of signals.

An ideal abrupt p-n junction has a voltage/charge relationship of the form

$$v = a - b\, q^2 \quad \ldots (3)$$

where a and b are constants. This relationship will be assumed for the diode considered here.

> From (3) it can be shown that the incremental capacitance of the diode is
>
> $$C = \frac{1}{2b^{\frac{1}{2}}} (a - v)^{-\frac{1}{2}}$$
>
> This relationship is approximately that illustrated in Fig. 4 and is of a form with which the reader may be more familiar.

Substituting (2) in (3) the voltage appearing across the diode is given by

$$v = a - b\left(\frac{I_1}{\omega_1} \sin \omega_1 t + \frac{I_2}{\omega_2} \sin \omega_2 t + \frac{I_3}{\omega_3} \sin (\omega_3 t + \phi) + Q\right)^2 \quad \ldots (4)$$

Squaring out and rearranging the terms in a convenient order gives

$$v = a - \frac{bI_1^2}{\omega_1^2} \sin^2 \omega_1 t - \frac{bI_2^2}{\omega_2^2} \sin^2 \omega_2 t - \frac{bI_3^2}{\omega_3^2} \sin^2 (\omega_3 t + \phi) - bQ^2 - \frac{2bQI_1}{\omega_1} \sin \omega_1 t$$
$$- \frac{2bQI_2}{\omega_2} \sin \omega_2 t - \frac{2bQI_3}{\omega_3} \sin (\omega_3 t + \phi)$$
$$- \frac{2bI_1I_2}{\omega_1\omega_2} \sin \omega_1 t \sin \omega_2 t$$
$$- \frac{2b\, I_1I_3}{\omega_1\omega_3} \sin \omega_1 t \sin (\omega_3 t + \phi)$$
$$- \frac{2b\, I_2I_3}{\omega_2\omega_3} \sin \omega_2 t \sin (\omega_3 t + \phi) \quad \ldots (5)$$

To further simplify the terms of equation (5) into sinusoids and cosinusoids we must use the trigonometric relations

$$\sin^2 A = \tfrac{1}{2} (1 - \cos 2A)$$

and

$$2 \sin A \sin B = \cos (A - B) - \cos (A + B)$$

Since we are only interested in voltages at the three fundamental frequencies we can ignore the first five terms of equation (5). The last three terms expand as below

$$- \frac{2b\, I_1I_2}{\omega_1\omega_2} \sin \omega_1 t \sin \omega_2 t = \frac{b\, I_1I_2}{\omega_1\omega_2} \cos (\omega_1 + \omega_2)\, t - \frac{b\, I_1I_2}{\omega_1\omega_2} \cos (\omega_2 - \omega_1)\, t \quad \ldots (6)$$

$$- \frac{2b\, I_1I_3}{\omega_1\omega_3} \sin \omega_1 t \sin (\omega_3 t + \phi) = \frac{b\, I_1I_3}{\omega_1\omega_3} \cos [(\omega_1 + \omega_3)t + \phi] - \frac{b\, I_1I_3}{\omega_1\omega_3} \cos [(\omega_3 - \omega_1)t + \phi] \quad \ldots (7)$$

$$- \frac{2b\, I_2I_3}{\omega_2\omega_3} \sin \omega_2 t \sin (\omega_3 t + \phi) = \frac{b\, I_2I_3}{\omega_2\omega_3} \cos [(\omega_2 + \omega_3)t + \phi] - \frac{b\, I_2I_3}{\omega_2\omega_3} \cos [(\omega_3 - \omega_2)t + \phi] \quad \ldots (8)$$

Taking the three fundamental frequency terms from equation (5) and the appropriate sum and difference frequency terms from (6) (7) and (8) we find that the voltage across the diode at f_1 is

$$v_1 = - \frac{2bQI_1}{\omega_1} \sin \omega_1 t - \frac{b\, I_2I_3}{\omega_2\omega_3} \cos (\omega_1 t + \phi) \quad \ldots (9)$$

at f_2

$$v_2 = - \frac{2bQI_2}{\omega_2} \sin \omega_2 t - \frac{b\, I_1I_3}{\omega_1\omega_3} \cos (\omega_2 t + \phi) \ldots (10)$$

at f_3

$$v_3 = - \frac{2bQI_3}{\omega_3} \sin (\omega_3 t + \phi) + \frac{b\, I_1I_2}{\omega_1\omega_2} \cos \omega_3 t \ldots (11)$$

We require to find the power delivered at each frequency to the diode.

Fig. 5 is a phasor diagram showing the

relative phases of signals at the same frequency which are represented as cos ωt, cos $(\omega t + \phi)$, $-$ cos $(\omega t + \phi)$, $-$ sin ωt, $-$ sin $(\omega t + \phi)$, assuming that ϕ is less than $\pi/2$ radians. At f_1 the current is phased as cos $\omega_1 t$ and the voltage has two components, one phased as $-$ sin $\omega_1 t$ and the other as $-$ cos $(\omega_1 t + \phi)$. By reference to Fig. 3 we see that the second voltage term has a resolved part in antiphase with the current and of peak value

$$\frac{b\ I_2 I_3}{\omega_2 \omega_3} \cos \phi.$$

The fact that the in-phase component of voltage is in opposition to the current shows that power is *taken from* the diode, the amount being

$$P_1 = -\tfrac{1}{2}\left(I_1 \times \frac{b\ I_2 I_3}{\omega_2 \omega_3}\right) \cos \phi$$

$$= -\left(\frac{b\ I_1 I_2 I_3}{2\ \omega_2 \omega_3}\right) \cos \phi \quad . . . (12)$$

The minus sign is used to show power

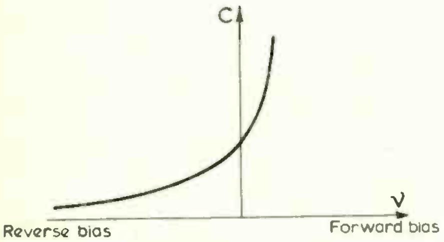


Fig. 4. Capacitance/voltage characteristic of a varactor diode.

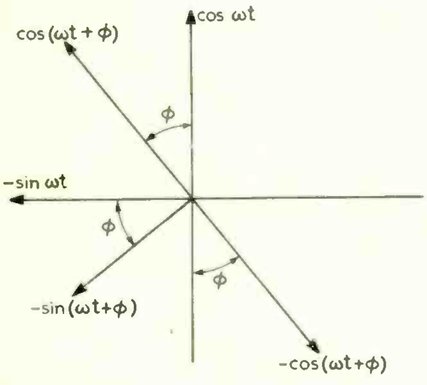


Fig. 5. Phasor diagram showing relative phases of signals at the same frequency in Fig. 3.

extracted. By exactly similar reasoning power is taken from the diode at f_2 and this is given by

$$P_2 = -\frac{bI_1 I_2 I_3}{2\ \omega_1 \omega_3} \cos \phi \quad . . . (13)$$

At f_3 the current is phased as cos $(\omega_3 t + \phi)$ and the voltage has components phased as $-$ sin $(\omega_3 t + \phi)$ and cos $\omega_3 t$. In this case we see that power is delivered to the diode and is given by

$$P_3 = +\frac{bI_1 I_2 I_3}{2\ \omega_1 \omega_2} \cos \phi \quad . . . (14)$$

If ϕ is $> \pi/2$ and $< \pi$ the directions of power flow are reversed, but we see that power must either flow into the diode at both lower frequencies or flow out of the diode at both lower frequencies.

Adding equations (12) (13) and (14) together and bearing in mind that $\omega_3 = \omega_1 + \omega_2$ we find that

$$P_1 + P_2 + P_3 = 0$$

This is as expected since a capacitor does not dissipate power.

A much more important relationship which will be seen to follow from (12) (13) and (14) is†

$$\frac{P_1}{f_1} = \frac{P_2}{f_2} = -\frac{P_3}{f_3} \quad . . . (15)$$

Sideband converters

Using the circuit of Fig. 3 with a varactor diode, we can feed an input signal at f_1 to circuit 1, a local oscillator signal at f_2 to circuit 2 and take an output at f_3 from circuit 3. Equation (15) shows that the power fed into circuit 3 from the diode is related to that fed into the diode from circuit 1 by

$$P_3 = P_1 \frac{f_3}{f_1}$$

(The minus sign is omitted because directions of power flow are specified.)

The theoretical power gain at the diode is f_3/f_1, but the actual conversion gain will be less than this. The input power must be greater than P_1 to overcome losses in the input circuit, and the output power will be less than P_3 because of losses in the output circuit. The diode, not being a perfect capacitor, will also introduce loss.

† This is a special case of the Manley-Rowe equations.

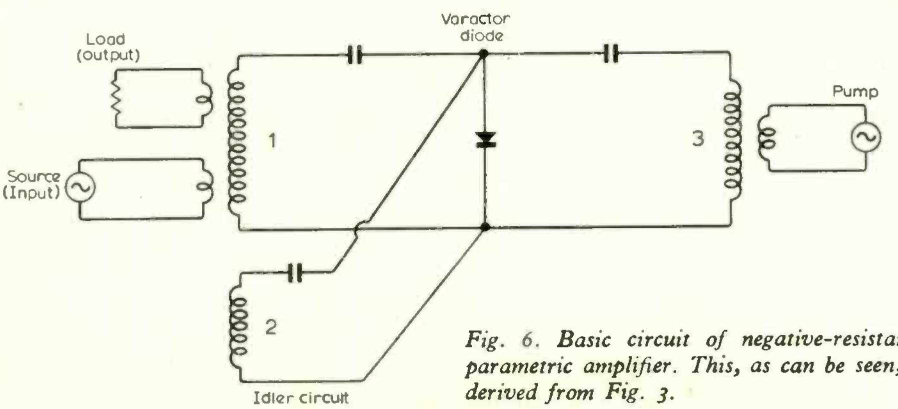


Fig. 6. Basic circuit of negative-resistance parametric amplifier. This, as can be seen, is derived from Fig. 3.

If we use the circuit as above we have an "upper sideband up-converter". By feeding the signal input to circuit 3 and taking the output from circuit 1 we achieve what is known as "parametric down conversion". Equation (15) indicates that this time we have a loss since

$$P_1 = P_3 \frac{f_1}{f_3}$$

The loss is due to the fact that power must flow in the same direction between the diode and the two lower frequency circuits. Thus the local oscillator actually absorbs power. We see that parametric down conversion is very inefficient; this is why point-contact diodes are used for microwave mixing.

Negative-resistance parametric amplifier

The most common type of parametric amplifier is what is called the negative-resistance type. For this the basic circuit of Fig. 3 is utilized as in Fig. 6. The diode is a varactor diode. A generator capable of delivering high power at f_3 is connected to circuit 3 as shown. This is the "pump". No generator is connected to circuit 2 and hence this is known as the "idler". The signal to be amplified is coupled to circuit 1 as shown, while the load into which the amplifier output signal is fed is also coupled to this circuit, as can be seen. If there is any exchange of power the direction of flow between the varactor diode and the idler must be into the idler since it has no generator. Hence power must also flow from the varactor diode into the signal circuit and not the other way.

Consider first circuit 2. It is shown in Fig. 7 with its internal losses represented by the series resistance R_2. v_2 is the voltage at f_2 appearing across the diode and has a value indicated by equation (10). Since the circuit is resonant v_2 must be in phase with i_2, hence the out-of-phase components of v_2 must cancel. Thus referring to equation (10) and Fig. 5 we see that

$$\frac{2bQI_2}{\omega_2} = \frac{b\ I_1 I_3}{\omega_1 \omega_3} \sin \phi \quad . . . (16)$$

The peak value of v_2 is then given by

$$V_2 = \frac{bI_1 I_3}{\omega_1 \omega_3} \cos \phi \quad . . . (17)$$

From Fig. 7 we see that

$$I_2 = \frac{V_2}{R_2} \quad . . . (18)$$

Combining (16), (17) and (18) together

$$\tan \phi = \frac{2bQ}{\omega_2 R_2} \quad . . . (19)$$

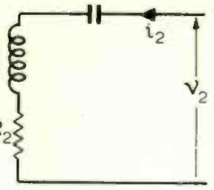


Fig. 7. Circuit 2 from Fig. 6 examined separately. R_2 represents the internal losses of the circuit.

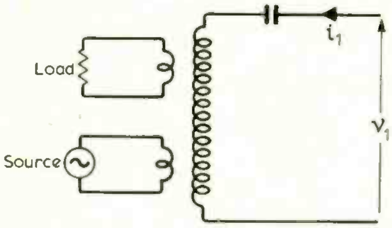


Fig. 8. Circuit 1 from Fig. 6 examined separately.

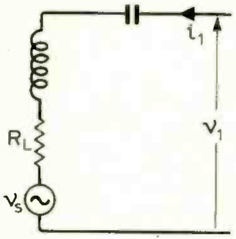


Fig. 9. Equivalent circuit of Fig. 8, including the signal source v_s and the load R_L.

Equation (19) fixes the relative phases of the three currents in the diode.

Let us now consider circuit 1. The basic arrangement shown in Fig. 8 will be seen to be equivalent to that of Fig. 9. Suppose first that $v_s = 0$. By exactly the same reasoning as that applied to circuit 2 we can arrive at the requirement

$$\tan \phi = \frac{2bQ}{\omega_1 R_L} \quad \ldots (20)$$

Now although ω_1 is less than ω_2, resistance R_L will be very much greater than R_2 (it is assumed that the losses in circuit 1, which will be of the same order as those in circuit 2, are negligible compared to the load, and their effect is included in R_L). Hence the requirements of equations (19) and (20) are incompatible and no energy will be fed into either circuit; the device does not oscillate.

The effect of introducing a voltage v_s in series and in phase with v_1 is equivalent to reducing the value of R_L by an amount sufficient to satisfy equations (19) and (20) simultaneously so that power can flow into circuits 1 and 2. The effective "resistance" of the source v_s is $-v_s/i_1$. Current i_1 will come to a value such that (from (19) and (20))

$$\omega_1 (R_L - v_s/i_1) = \omega_2 R_2$$

rearranging,

$$i_1 = \frac{v_s\, \omega_1}{\omega_1 R_L - \omega_2 R_2}$$

The power delivered to R_L is

$$i_1^2 R_L = \frac{v_s^2\, \omega_1^2\, R_L}{(\omega_1 R_L - \omega_2 R_2)^2}$$

If v_s were connected directly across the load the power delivered would be

$$\frac{v_s^2}{R_L}$$

hence we have a power gain of

$$\frac{\omega_1^2\, R_L^2}{(\omega_1 R_L - \omega_2 R_2)^2} \quad \ldots (21)$$

The effect is the same as if we connected a negative resistance in parallel with the load.

Inspection of expression (21) shows that if we increase the loading by reducing R_L the gain will go up. When $\omega_1 R_L = \omega_2 R_2$ the device will become unstable; this correlates with equations (19) and (20). To avoid any danger of this instability the gain is not generally set at greater than 20dB.

Since the currents in the signal and idler circuits grow together we could put the load in the idler circuit and extract amplified power at f_2. The analysis is essentially the same as above; the device is known as a "negative resistance up-converter". By making circuit 1 the idler circuit and 2 the signal circuit we can extract amplified power from circuit 1 and thus use the device as a "negative resistance down converter".

Practical considerations

Since parametric amplifiers are used at u.h.f. and microwave frequencies the tuned circuits are resonant lines or cavities. On casual inspection it is often difficult to decide which sections of the structure resonate at the three frequencies. It is possible to have the idler and signal frequencies the same, and to allow their currents to circulate in the same resonant structure. This type of amplifier is described as "degenerate".

The load and source are coupled to the signal cavity through waveguides or coaxial lines. Since reflections in these can cause undesirable effects, an isolator or a circulator, depending on how the energy is coupled in or out, is usually incorporated with the device.

Books Received

Logical Design of Switching Circuits, by Douglas Lewin. A lucid book describing useful methods for designing logic circuits. Much has been published on switching theory, but this book describes the best techniques that have appeared. An engineering approach has been chosen, as distinct from the more usual mathematical treatment. The book begins with an introduction to digital systems, set theory and Boolean algebra, and progresses through the design of various circuits to their actual implementation. There is a final chapter on automatic design and an appendix providing a useful introduction to computer programming. Problems with fully worked solutions appear throughout the book. The extensive references at the end of each chapter enable the reader to follow up and use current research papers. Suitable for final-year engineering students, it will also appeal to post-graduate students working in the field and to professional engineers. Pp. 368. Price 70s. Thomas Nelson & Sons Ltd., 36 Park Street, London W.1.

B.B.C. Handbook 1969. Contains facts and figures relating to the organization and services of the B.B.C. Over 20 pages are given to a section on engineering in which radio and television transmitters throughout the U.K. are described along with complete lists of the frequencies and channels used. There are hints on how to get the best reception. Pp. 280. Price 7s. 6d. B.B.C. Publications (Handbook), P.O. Box 1AR, 35 Marylebone High Street, London, W.1.

Electronics: a general introduction for the non-specialist, by G. H. Olsen, has been written for those who are not specialists in electronic engineering and who find formal or examination texts unsuitable. Two early chapters explain the function of resistors, capacitors and inductors, and the ways that they affect circuits, and there then follows a generalized treatment of thermionic and semiconductor devices. Other chapters deal with power supplies, amplifiers, oscillators, the cathode-ray oscilloscope, photoelectric devices, logic circuits, and a variety of measuring instruments and test procedures. A comprehensive index is included. Pp.493. Price 84s. Butterworth & Co. (Publishers) Ltd., 88 Kingsway, London, W.C.2.

Digital Instruments is the first of a series of books under the overall title of **Electronic Data Library.** The authors are drawn from the engineering teams of well known digital instrument manufacturers. This first issue covers the techniques and instruments in digital electronic engineering, ranging over digital voltmeters, multirange meters, analogue to digital converters, counters and frequency meters, and including a practical appraisal of digital analysers. Also given is a list of equipment suppliers and a breakdown of instrument parameters. This book of 108 pages costs 42s as an individual volume. Other volumes are titled Servo-systems, Video Techniques, AF Techniques, Modular Construction and Computer Techniques. The cost for the complete library is 9 guineas. William F. Waller, Book Division, Product Journals Ltd., Summit House, Glebe Way, W. Wickham, Kent.

Beginner's Guide to Television, by Gordon J. King, aims to give a clear, concise, and fairly non-technical explanation of the subject. Starting with a survey of basic principles, a more detailed explanation of techniques and equipment for transmitting and receiving quickly follows. Practical information is given on using test cards for setting up a receiver, and photographs are used to make this clear. Other chapters describe television relay systems, communal aerials and "pay TV", the elements of colour television, and video tape-recording. The index is well composed. Pp.205. Price 18s. Hamlyn Publishing Group Ltd., Hamlyn House, 42 The Centre, Feltham, Middx.

ITV 1969, A Guide to Independent Television, whilst in the main concerned with programme material contains three sections of technical interest titled Technical Operation, UHF and Colour, and VHF Transmitters. Pp.236. Price 10s 6d. Independent Television Authority, 70 Brompton Road, London, S.W.3.

News of the Month

Goonhilly 2—communications and the battle for bandwidth

The climax of a great deal of intensive work came in mid-January when Britain's new earth station, Goonhilly 2, locked-on to the Atlantic Intelsat 3 and added more bandwidth to our external communications capability. Goonhilly 2 is capable of handling 400 telephone channels and a television programme simultaneously.

The 27-m diameter aerial structure was built by the Marconi Company based on a design commissioned by the Post Office from their consulting engineers, Husband & Co. The electronics, also built by Marconi with some assistance from GEC-AEI, was built to a detailed Post Office specification.

As reported in "News of the Month" July, 1968, the number one aerial is being refurbished and will work the Indian Ocean Intelsat 3 later in 1969, if it is successfully launched. Some details of the Intelsat 3 network were given in our March, 1968, issue.

Goonhilly 2 has 210° freedom of movement in azimuth and may therefore be used with either of the above two satellites. Auto-track uses the conical scan method, the motive power being provided by two thyristor controlled motors which drive bogies.

Signals are relayed by a microwave link to and from the International Telephone Services Centre in London. At the central building at Goonhilly, which houses all the aerial controls for both stations, outgoing signals are assembled into blocks of 24, 60 or 132 channels at base band frequencies. The composite signals, including various control signals, then modulate 70 MHz carriers which are relayed over coaxial cables to the equipment at the aerial. Up-conversion then takes place and the various carriers are combined at low level to provide the final signal. This is fed to the transmitter which can produce 8-10kW but would not normally be used above 1.5kW to avoid intermodulation problems. For received signals a similar sequence of events takes place in reverse.

It was clear at the press conference that introduced Goonhilly 2 that the speakers were the "satellite boys" of the Post Office and there was some mention of the advantages of satellite over submarine cable systems. A talk with the "other half" of the Post Office would have probably yielded opposite results. Whatever the pros and cons of the argument it is true to say that the Post Office is carrying out intensive research in both types of system in the bid for more bandwidth and probably to ensure we don't have all our carriers in one basket; the vulnerability of satellites to jamming and military action being well known.

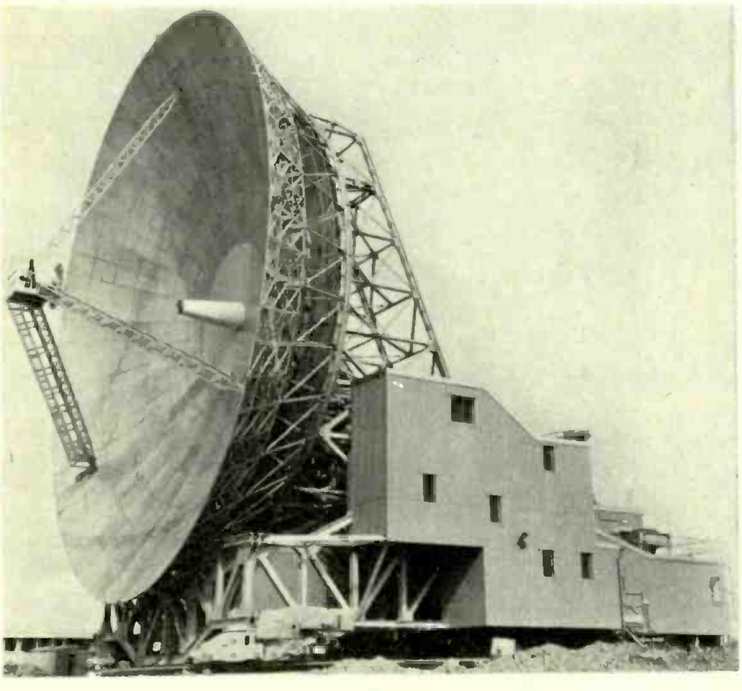
On the cable front some interesting problems are resulting from the higher and higher frequencies being used. One of these is caused by the methods used to manufacture cables and the materials used in them. A small eccentricity of a capstan or other wheel during cable manufacture could result in a slight defect being formed at regular intervals along the cable. The slight impedance mis-match caused by these defects could normally be ignored. However, because of the regularity of the defect, at one frequency the reflections from these defects all occur in phase and become additive. The resultant peaks in the overall response are very sharp and can cause serious problems.

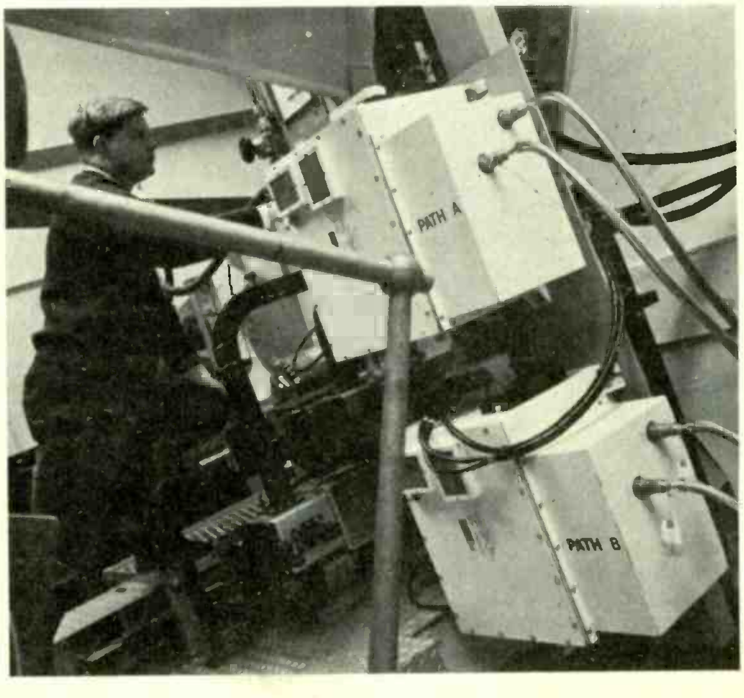
Of the future? Well apparently bandwidth isn't the most immediate problem so far as transatlantic telephone calls are concerned, although it may well be so soon. Most of the hold-ups occur, during peak periods, because of the lack of capacity of the London terminals—a matter which the Post Office says will be put right over the next few months.

When Intelsat 4 lifts-off the drawing board and into orbit an earth station will have to be provided to work it. This is the subject of talks that are in progress now. There appear to be two alternatives: a third earth station designed for the job or hire of a European station while one of the Goonhilly aerials is being modified.

Progress in the cable field will be slow and steady; higher and higher frequencies will be employed and bandwidth will be increased. Spin-off from this research will aid internal communications of the type being ex-

The 1000 ton aerial, Goonhilly 2, is shown on the left. On the right the first stages of the receiving system, which are housed in a cabin on the back of the dish, can be seen. The parametric amplifiers are cooled to a temperature of −257°C to improve noise performance





perimentally tried at Washington New Town, Durham ("News of the Month" April, 1968); incidentally this system, which uses twin cable feeders, was demonstrated for the first time recently to local radio and television trade representatives. This will eventually lead to numerous piped television channels and videophone and computer terminal facilities being available to the householder.

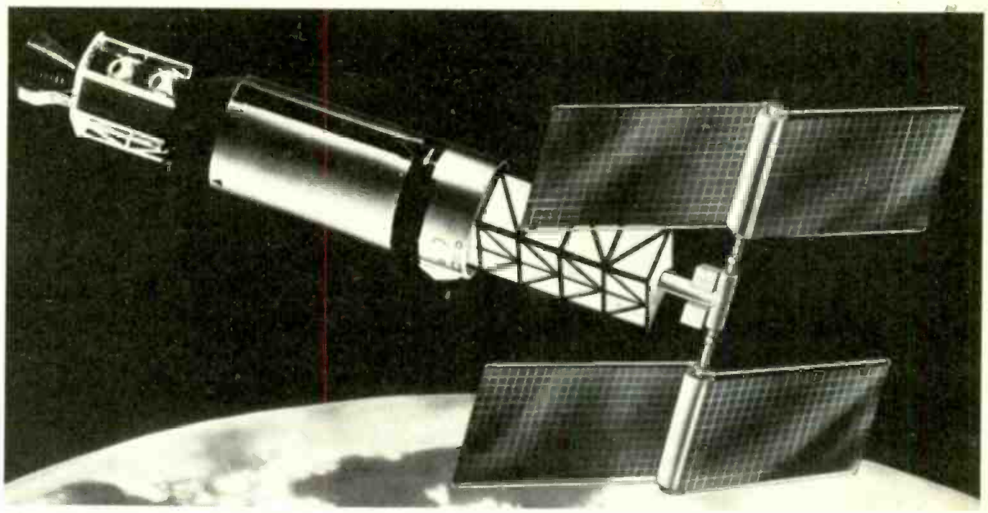
Further on still all these methods are liable to be ousted by optical communications using coherent light, optical waveguides, and suitable satellites with almost unlimited bandwidth.

3-mile "diameter" radio telescope

A new radio telescope to be built at the Mullard Radio Astronomy Observatory of the Cavendish Laboratory, Cambridge University, will have a resolving power equivalent to that of a paraboloid "dish" with a diameter as great as 5km (3 miles). The resolving power will, in fact, be 1 to 2 seconds of arc. This is required for studying the fine detail in quasi-stellar radio sources (known as Quasars) and in radio galaxies, as part of a new programme aimed at understanding the physical mechanisms occurring within these sources of e.m. energy. The effective aerial diameter of 5km will be obtained by the technique of "aperture synthesis" developed by Professor Sir Martin Ryle and his observatory team over some years. This is based on the use of several small aerials which are moved about—partly by human means on the ground and partly by the rotation of the Earth itself—so that they occupy successively the positions of the individual components of a much bigger aerial. As in earlier Cambridge radio telescopes, the system will also use interferometry to obtain extremely narrow, high-resolution aerial lobes, and correlation detection to pick out the wanted source signals from the general background noise, which is many times greater.

The 5km telescope, which will cost the Science Research Council about £2,100,000, will be built on the site of a 3-mile stretch of railway track, near Barton village, south-west of Cambridge, which became available when the Cambridge to Bedford line was closed recently. It will consist of an east-west line of eight Marconi 42-ft steerable dish aerials (modified versions of those developed by the company for satellite communications) with a control room near the middle on the site of the derelict Lords Bridge railway station. Four of the dishes, to the west, will be fixed, with 1.13km spacing, while the remaining four, to the east, will be moveable on bogies along a 1.17km track laid to an accuracy of better than 1mm on a stable concrete beam. The control room will contain a Marconi Myriad II time-sharing digital computer, which will be used both for calculating the required linear and angular positions of the movable aerials and for combining the signal values in each of 16 pairs of the possible pairs of dishes (giving simultaneously 16 interferometer spacings) to provide an output to drive an X-Y plotter. This plotter will directly draw the required "maps" of the radio sources in the form of equal-energy contours. In addition the computer will be used to control a complex cable delay network which will be necessary for equalizing the different phase delays of the signals from the various aerials (resulting, of course, from the different displacements of the aerials along the east-west line).

Initially the radio telescope will operate at 6cm wavelength but later perhaps at 3cm as well. Each 42-ft aerial will be a Cassegrain system with a horn to pick up the reflected signals, and will also carry at its hub the front end of a receiver, consisting of a parametric amplifier first stage followed by a mixer. It will therefore be the i.f. signals that will be sent to the control room for combining pairs of signals for the interferometric and correlation receiving processes.



An artist's impression of a large retractable solar array that will unfold itself in space to power satellites. It was developed by Hughes Aircraft Company for the U.S. Air Force. Each panel measures about 2 × 3m.

P.O. contracts—more flexibility

It was announced at the recent annual dinner of the Telecommunication and Manufacturing Association that the Post Office, with the assistance of industry, has set up an "Advisory Group on Telecommunications Systems Definitions" to ensure that any new systems introduced into the communications network are compatible with each other and with existing equipment. The size of problems that the new group will have to tackle will be realized when it is stated that the Post Office is currently spending between £300M and £400M annually.

The group consists of five Post Office engineers who will be advised by two or three of the senior staff of G.E.C./A.E.I., Plessey and S.T.C. Their task will be to produce specifications for equipment that will be sufficiently detailed to ensure the required compatibility and, at the same time, will allow the contractor as much flexibility and room for innovation as possible. The days of the rigid "every nut and bolt type" specification which have come from the Post Office in the past are numbered.

This situation is made possible by the ending of the bulk supply agreement next October under which several firms manufacture the same component on a "share and share alike" basis under the same contract. With this situation very detailed specifications were essential and the resulting restrictions had to be accepted by the companies concerned.

From October the Post Office will have a free hand in the placing of contracts and can therefore accept a tender providing the best, or the most competitive answer to a specification and the companies will benefit by having a free hand.

G.E.C. opt out of Associated Semiconductors

G.E.C.'s one-third holding in Associated Semiconductor Manufacturers Ltd has been sold to Mullard for an undisclosed price; Mullard now have complete ownership. The sale was predictable since G.E.C. joined Marconi and Elliott under the English Electric banner. In fact it was announced in this section last month that the microelectronics interests of Marconi and Elliott are now controlled by a new company called G.E.C. Marconi Electronics Ltd.

When Associated Semiconductors was formed in 1963 G.E.C.'s contribution amounted to £2M and, under the terms of the agreement, G.E.C. reserved the right to dissolve the partnership in the event of changing circumstances.

T.E.M.A. apprentice awards

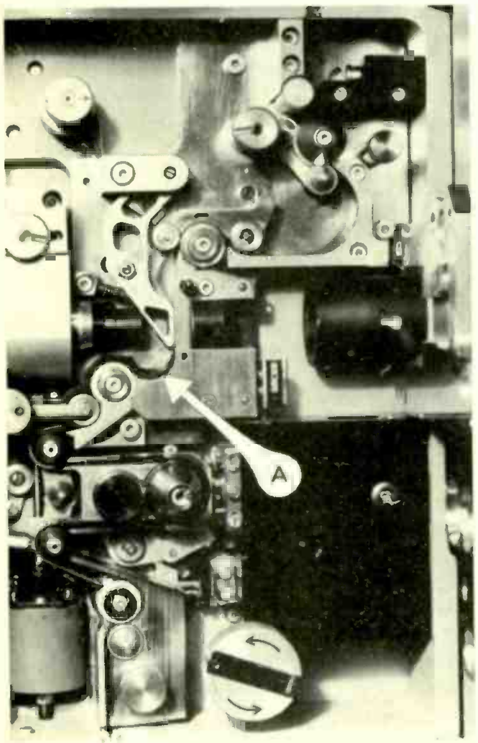
This year's awards of £50 each for the best final year technologist and technician apprentices of member-firms of the Telecommunication Engineering & Manufacturing Association were made at the annual dinner of the Association on February 4th. In the Technologist Class (previously the graduate and student classes) the recipient was B. J. Stringfellow, B.E.(Elect.), graduate of Auckland University, who came from the New Zealand Post Office two years ago to A.E.I. (now G.E.C.-A.E.I.). The Technician award went to P. L. Prince who finished his apprenticeship with the Automatic Telephone & Electric Company (part of the Plessey organization) last year. Nominees for the award have to prepare a thesis on some aspect of their work.

Pneumatic colour film scanner

At a recent exhibition in London of television studio and control equipment by Fernseh g.m.b.h., a member of the Bosch Group, a 16mm colour film scanner was demonstrated using a novel method of film transport. The conventional mechanical method of moving the film through the scanner by engaging a sprocket with holes on the edge of the film had been dispensed with and substituted by a pneumatic system which Fernseh described as a rapid pull-down mechanism. A precisely dimensioned cup shape is constructed just below the lens unit so that when the film is lying across the top of the cup it becomes an airtight chamber. This chamber is repeatedly evacuated of air through a valve in the base at 25 Hz frequency thus pulling down the film intermittently through one frame at a speed of 25 frames per second. The frame remains stationary during scanning.

The colour film scanner is otherwise similar electrically and mechanically to equipment designed for 16mm perforated film. Scanning is achieved by the flying spot principle to avoid colour registration errors but because the pneumatic pull-down takes less than 1.3ms (i.e. within 20 lines), more time is available for scanning each frame with a consequent increase in light output. Also with this type of uncoupled operation, rapid starting is possible, the run-up time until the synchronous condition of the picture is reached being less than 0.1s. A special synchronous motor is used for the drive. For mains-synchronized operation the equipment can be connected directly to the three-phase mains but for crystal-controlled or externally synchronized operation the driving motor must be connected to a synchronous inverter accessory. Although the load on the film is no greater than in a normal intermittent projector, it is understood that the pneumatic pull-down principle is suitable for 16mm film transport only, the larger 35mm being too heavy for effective operation. In reverse running, the film is not transported through the gate by vacuum action and the picture obtained is unsuitable for transmission.

Photograph of the film transport unit of the Bosch telecine equipment illustrating at "A" the cup-shaped vacuum chamber



Exhibitions at Alexandra Palace

This year's Physics Exhibition will be held in London at Alexandra Palace between the 10th and the 13th of March. For the first time the Institute of Physics and the Physical Society, who are the organizers, will be charging a 2s 6d admission fee to all visitors who are not members of the Institute or the Society to help cover rising costs.

The exhibition handbook, which contains much valuable reference material, was published in mid-February and costs 10s per copy (postage is 3s). The handbook can be obtained from the I.P.P.S., 47 Belgrave Square, London, S.W.1.

This year, and at future exhibitions, an open forum will be held. Distinguished speakers, known to hold different views, will speak briefly and then the discussion will be thrown open to any members of the audience who wish to express an opinion. This year's subject is "The Future of High Energy Physics" and there will be no restriction on attendance. The time and date? Thursday, March 13th, 3 p.m. The exhibition will be supported by a full programme of films and lectures.

While the Physics Exhibition is taking place in the Grand Hall, the Palm Court will be occupied by the Scientific Instrument Manufacturers' Exhibition.

Two-colour marine radar

Two 16-inch cathode-ray tubes are used in a new marine radar introduced by G.E.C.-A.E.I. The outputs of the two tubes, each of a different colour, are superimposed in an optical system and are viewed as a single image. One tube provides a true course conventional p.p.i. display. The second tube produces a display of auto-tracking markers that can be used to predict the future tracks of up to twelve ships.

The system, called COMPACT (Computer-Predicting and Automatic Course Tracking), has all the facilities of the Escort 650 radars for the true course display (vantage point off-centring, view ahead, and electronic bearing markers).

Early warning of an approaching radar target is provided by two guard rings placed at eleven and nine miles around own ship's position on the display. When either of these guard rings is cut by a closing target, an audible alarm is operated and a bearing indicator is displayed which identifies the target.

Collision avoidance facilities for use during coastal passages and in crowded waters are provided by the auto-tracking markers. Up to twelve of these markers can be simultaneously used and are displayed in a bright green on the orange afterglow of the p.p.i. Each marker is placed over potentially dangerous targets and the audible warning operates if any marked target passes within a predetermined distance from the ship. In addition the dangerous target is identified by the flashing of the marker ring around the target.

A track-ahead control enables the operator to determine the position of all targets for up to 45 minutes ahead.

Ground stabilization of the radar picture can be provided by one marker channel. By placing this marker over a known navigational fixed point (buoy, etc.) all track lines are shown as true courses allowing for the effects of wind, tide and drift.

Multi-font page reader

A page reader being marketed in Western Europe by a new British company, Real Time Systems Ltd., is said to represent a significant step forward in the optical character recognition field. The page reader, called the Scan-data 300, originates from America and will handle practically all typewriter, computer print out and typeset fonts. It will recognize capital and small letters in Gothic and Roman styles. It will cope with punctuation, special symbols, numerics and hand-printed matter. The input material does not have to be all in the same type style as mixtures can be handled without adjustment.

Having read a document, the page reader converts the data into a machine-language at 400 characters per second. A flying-spot scanning principle is employed.

Domestic receiver sales in America

Preliminary statistics released recently by the American Electronic Industries Association show that sales of domestic electronic equipment were higher in 1968 than 1967.

Colour television had a record year and sales exceeded those for monochrome for the first time. The actual sales of colour receivers were 5,829,150 (5,224,499) and for monochrome television receivers 5,555,339 (5,434,702).

Radio sales, including car radios, increased by 5.7% to 21,293,259. However, sales of radio receivers for home use fell by 4.7%. The overall radio receiver sales increase was due to a boom in car radio sales which were 20.1% up on last year with a total of 10,685,827.

Environmental test facilities

EMI Electronics is offering industry the use of its comprehensive environmental test facility. Originally set up to test the Company's defence products its effectiveness has inevitably led to its use in the development of many of its commercial products, particularly those destined for use in airborne or transportation environments. The company now welcomes inquiries from component and equipment manufacturers wishing to make use of the facility.

The facility comprises climatic and mechanical test laboratories that can test components and most of the equipment produced in the light and medium engineering industries. It is approved by the Ministry of Technology and the Air Registration Board with regard to the environmental test equipment and the calibration and standardization procedures and facilities available.

Test load sizes up to 2 cubic metres and 3000kg weight can be handled depending on the shape and the test environment required. A comprehensive range of individual climatic and mechanical environments can be simulated as well as combinations such as temperature cycling with vibration. Components can be tested to most national, international and N.A.T.O. specifications.

The photograph shows the very smart interior of a new mobile showroom that has been set-up by Marconi Instruments. Some of the equipment is battery operated, the rest can be powered from an internal generator or from local power sources via a variable transformer. The showroom has left on a tour of Europe that will take the rest of the year.

Tactical naval system

Under a £1M contract awarded by the Ministry of Defence Ferranti, with Decca Radar as principal sub-contractor, are to produce an equipment called Computer Assisted Action Information System.

The system was originally visualized by the Ministry of Defence and it represents a compromise between the ideal, and weight and cost.

In any particular naval force information that is available to one vessel may not be apparent to its consorts. With this system each ship in a force will be fitted with an equipment which stores information from "own ship's" sensors. This information is entered both automatically and manually and it can originate from a variety of sources including radar, sonar and other navigation equipment. The computer within the new equipment operates on this information and allows it to be superimposed, on request, on a radar p.p.i. display in alphanumeric form.

Information stored in "own ship" is transmitted by radio to all other ships in the force and vice versa, so that each ship has all the available information at the operator's disposal.

Ferranti will be supplying the computing equipment and Decca Radar the combined alpha-numeric/p.p.i. displays.

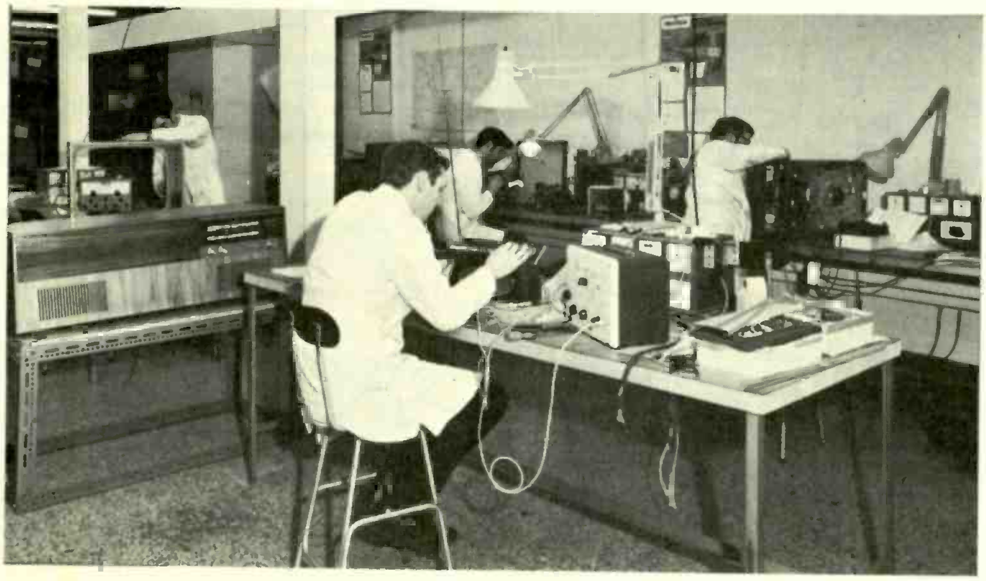
Federation of Science and Technology Institutes

It was agreed by the governing bodies of the Institutions of Biology, Chemistry, Mathematics and its applications, Metallurgists, and the Institute of Physics and the Physical Society to form a Council of Science and Technology Institutes which came into operation on February 1st.

The main objects of the Council are to speed communication between the Institutes, to aim at adopting common terminology as far as qualifications are concerned, and to collaborate on matters of educational policy and other common interests.

Initially membership will be confined to the bodies listed above. However, in the future, it is possible that applications from other organizations, who have a minimum entry requirement of a University degree or its equivalent, will be considered.

The British Radio Corporation has opened the new service depot, shown in the picture, in Manchester. Among other services the depot will provide round-the-clock repair facilities for the Thorn 2,000 series colour television chassis, as fitted to Ultra, H.M.V. and Ferguson receivers.



Radio beacon for aircraft

Two private individuals in America, a lawyer and an electrical technician, have invented a device that is causing a great deal of interest in aeronautical circles. The device consists of a crash- and water-proofed radio transmitter with a range of about 70 miles that is actuated by the breaking of a very fragile electrical conductor. This conductor can be mounted either internally or externally and is fractured by the slightest stress. The lawyer, Harold R. Hine, Q.C., and the technician, Edward Dawson, say that in the past if an aircraft crashed and there were no survivors to turn on a distress beacon search operations have been difficult.

Loran pre-amplifier

Loran (LOng-RAnge Navigation) has been in use many years and is a system of v.l.f. transmitters constituting a hyberbolic position fixing system. In some areas the signal strength, the North Atlantic being an example, is too low to be reliable.

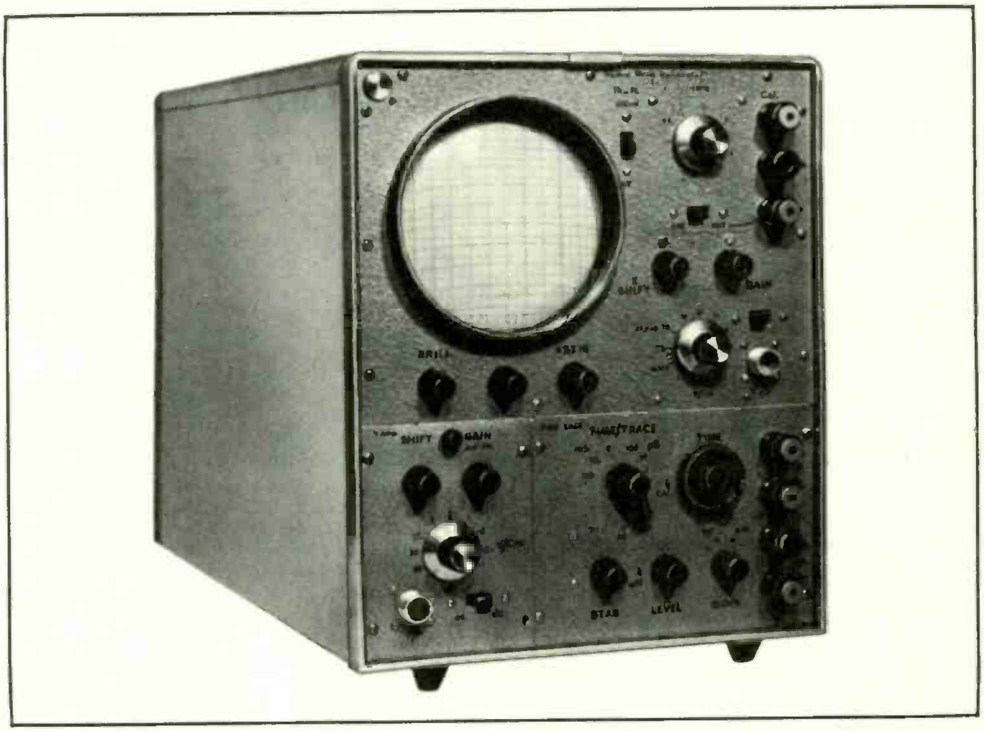
To counter this, as a result of discussions between B.O.A.C. and SGS, a low-noise tuned aerial amplifier was devised for use with Loran equipment. The pre-amplifier, which makes use of integrated circuits, has been flown by B.O.A.C. for some time now with success and will soon be going into full-scale production.

Solid-State Oscilloscope

Circuit details of a test instrument designed for work on colour TV receivers.

by Michael Phillips

To be capable of performing all the measurements needed on a colour television receiver an oscilloscope must be able to provide accurate results from d.c. up to the sub-carrier frequency of about 4.4 MHz. Experiments with a colour decoder confirmed that an elderly, low-frequency oscilloscope did not have sufficient bandwidth for such work and it was decided that the cheapest way of obtaining improved performance was to construct a new vertical amplifier as an add-on unit using the existing tube and e.h.t. supply. This was later extended to include a new timebase, *X* amplifier and square-wave calibrator.



An important requirement of this type of conversion is that the amplifiers should be designed to supply the high deflection voltages, 250 to 300 V peak-to-peak, needed by older types of oscilloscope tube. This was made easy by the availability of inexpensive silicon transistors intended for use as video amplifiers in television receivers, resulting in simple, low-power circuits giving high output voltages at bandwidths that would be difficult to achieve with valve amplifiers.

Performance figures which follow refer to a 5CP1 tube with a supply of 1.25 kV plus an additional 1.25 kV on the p.d.a. electrode and will be typical for most 13 cm. tubes of this vintage. With more modern, higher sensitivity tubes these figures can be improved upon since both amplifier gain and output voltage swing requirements are less. Possible modifications to the circuits are described later.

Michael Phillips served in minesweepers during and after the war and then went to college in 1947. For five years, 1950–55, he was engaged on radio and test-gear development with Ultra Radio. He has been with Bush Radio, more recently Rank Bush Murphy, for the last 12 years and is now project leader for monochrome television development.

Vertical amplifier

The response of the vertical amplifier is flat from d.c. to 6 MHz and is 3 dB down at 11 MHz, the maximum sensitivity being 100 mV per cm. The gain can be switched for a $\times 10$ increase with a reduction in the 3-dB bandwidth to 1.5 MHz. The circuit divides conveniently into two sections. Fig. 1 shows the pre-amplifier, which includes the input attenuator and all the controls, and Fig. 2 the output amplifier which should be situated as close to the tube base as possible. The input attenuator uses compensated potential divider sections presenting a constant input impedance of 1 MΩ in parallel with approximately 20 pF. Attenuator switching sequences tend to be a matter of personal preference so a choice should be made from the values given in Table 1. For most purposes ordinary carbon resistors with a tolerance of 10% are quite satisfactory and are much cheaper than high-stability types.

When using a high-impedance probe any difference in the input capacitance between different attenuator sections must be compensated for by adjustment of the probe trimmer. This can be avoided by connecting trimmer capacitors of about 10 pF maximum from each position of Sw_{2a} to earth. A suitable probe consists of a 9.1 MΩ resistor shunted by a 3–12 pF trimmer and mounted in a metal tube (some cigar containers are ideal). The probe should connect to the oscilloscope through about

Table 1

Sensitivity	R_a (Ω)	R_b (Ω)	C_b (F)
200 mV	510 k	510 k	20 p
300 mV	680 k	390 k	39 p
500 mV	820 k	200 k	68 p
1 V	1 M	110 k	180 p
2 V	1 M	51 k	400 p
3 V	1 M	33 k	500 p
5 V	1 M	20 k	1 n
10 V	1 M	10 k	2 n
20 V	1 M	5.1 k	4 n
30 V	1 M	3.3 k	6 n
50 V	1 M	2 k	12 n

Values for the *Y* input attenuator of Fig. 1. A choice should be made for either 1–2–5 or 1–3–10 range sequences. C_a for each section is a 30 pF max. mica compression trimmer.

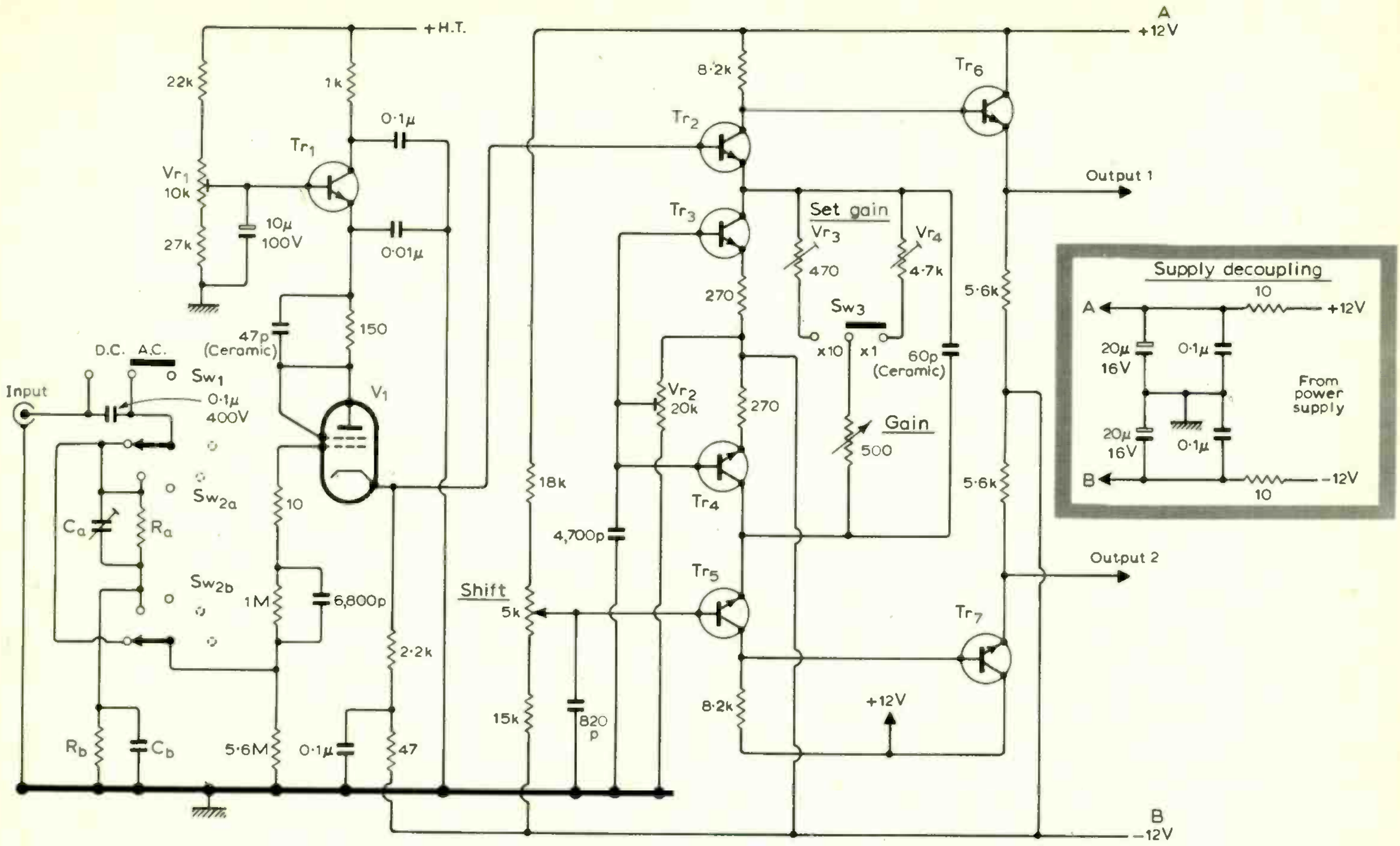
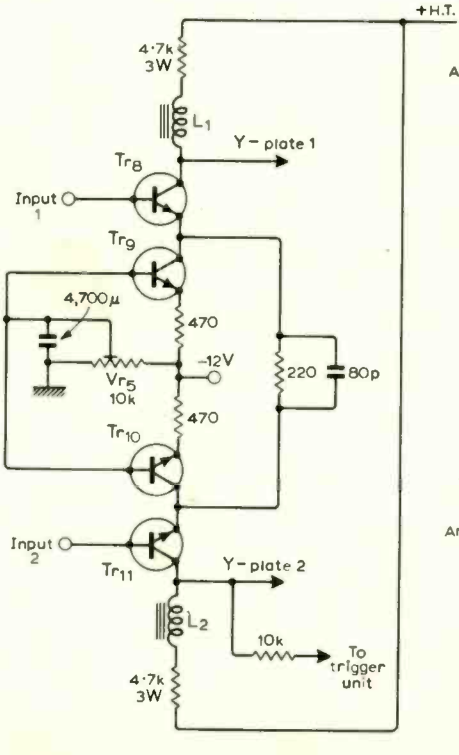


Fig. 1. Circuit diagram of the vertical preamplifier. Resistors are 1/4W carbon; capacitors are polyester type 250 V working unless otherwise marked. Preset resistors are 1/4W carbon.

1 metre of screened coaxial cable with a resistive inner conductor (Ref. 1). The input impedance increases to 10 MΩ but with an unavoidable attenuation of 10:1. Impedance matching between the input and the base of the first transistor is provided by a cathode follower valve V_1. A valve is used in this position to simplify the problem of allowing direct coupling to the input and to limit the effects of a severe voltage overload on the semiconductor devices in the amplifier. The anode voltage for V_1 is derived from the h.t.+ line via the emitter-follower Tr_1 thus giving low-impedance decoupling down to zero frequency at the anode.

Although it would probably not be as robust a buffer device, an f.e.t. could no doubt be used to replace the valve cathode-follower if one wanted completely solid-state equipment. A commonly used circuit is the source-follower with the source supply voltage and/or the source load resistor adjusted for zero drift operation. Some useful information on the subject is included in Ref. 2. The valve is followed by a long-tailed pair phase-splitting amplifier, Tr_2 and Tr_5. Constant current transistors, Tr_3 and Tr_4, are used in the common emitter impedance to reduce the gain loss which occurs with resistors. Gain control is effected by selection of the resistors bridging the two emitter loads and pre-set resistors are switched for the ×1 and ×10 gain ranges with a common variable control in series for front panel adjustment of calibration.

The vertical shift control adjusts the d.c. voltage on the base of Tr_5; this ensures that the amplifier stages are operated in a balanced condition when the trace is along the centre line of the tube face whatever the d.c. level is at the input. Capacitance loading across the 6·8 kΩ collector resistors is reduced to a low value by using emitter-followers Tr_6 and Tr_7, for coupling to the output stage and in practice the −3 dB response point due to the collector components is at about 30 MHz. Compensation for the fall-off in amplifier gain with frequency is provided by the 60 pF capacitor across the gain control resistors.



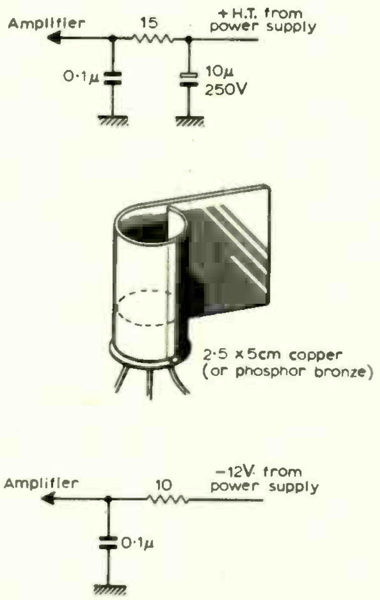


Fig. 2. Circuit diagram of vertical deflection amplifier and (right) an example of a heat sink required for Tr_8 and Tr_{11}.

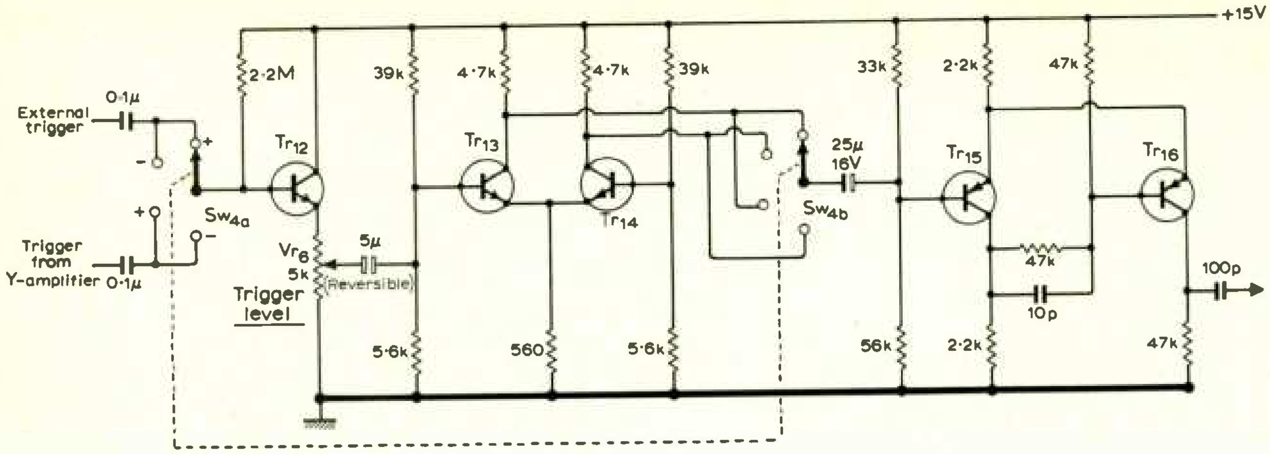


Fig. 3. Circuit diagram of time-base trigger unit.

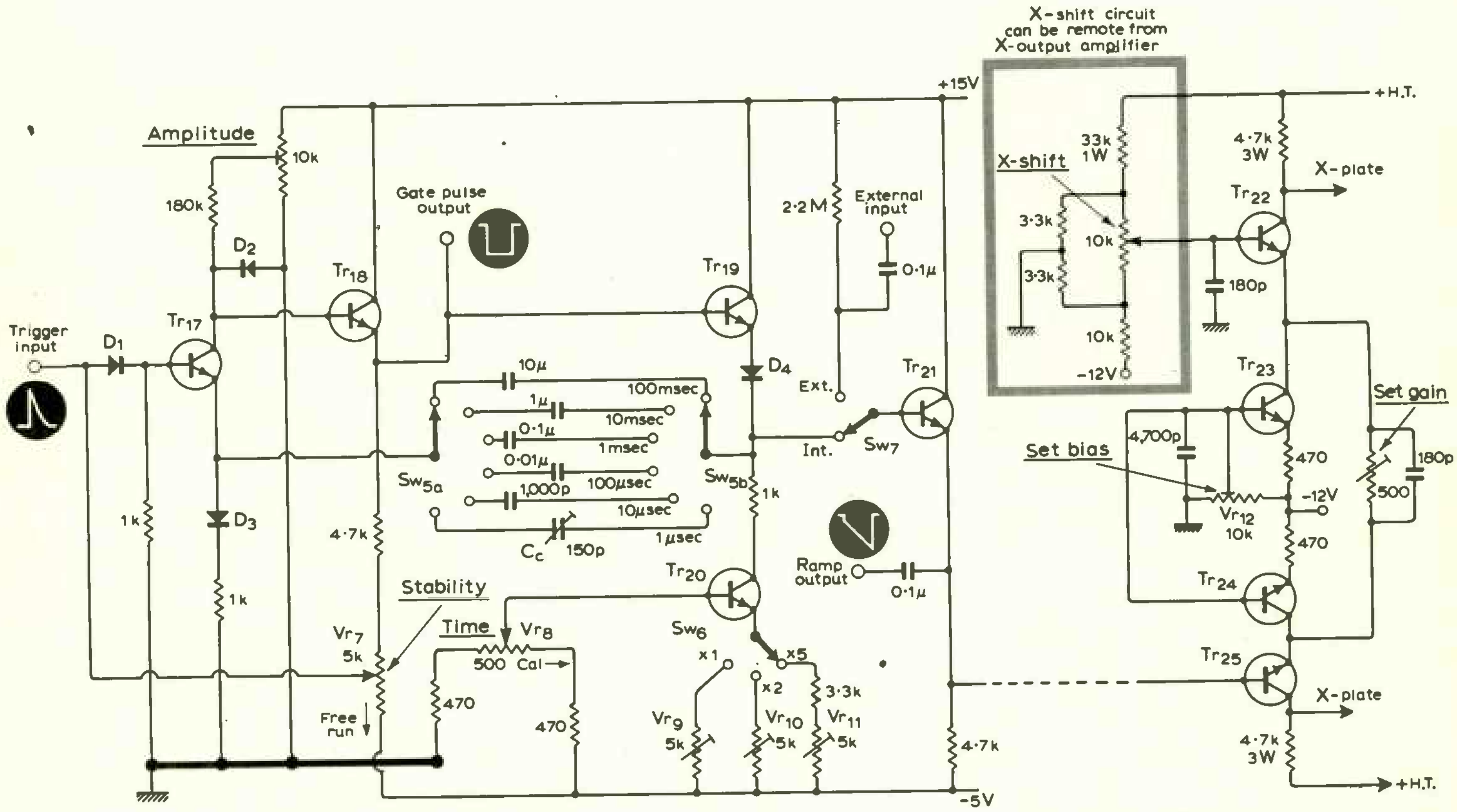


Fig. 4. Circuit diagram of ramp generator and horizontal output amplifier. Diodes are general purpose germanium types such as the OA81.

Output from the pre-amplifier is at low impedance and open wire leads of 20 cm or more in length can be used to feed the output amplifier. This again uses the long-tailed pair configuration with transistors as the common impedance. The circuit is shown in Fig. 2. With a total capacitance load due to the tube plates and the transistors of about 15 pF per collector, frequency compensation is necessary and is provided by the 80 pF capacitor linking the two emitters and by inductance in each collector load circuit. The coils need about 60 turns of 32 s.w.g. enamelled wire wound as a single layer on a former with a 4 mm core.

Turning now to the active devices used. V_1 is a small, low-consumption triode or strapped pentode such as the EF95/6AK5. The small size of Nuvistors makes them ideal and they are frequently used in commercial instruments. Transistors in the pre-amplifier are low-power silicon devices typified by the BC107 with an h_{fe} of 125–500 and an f_T of about 85 MHz. The output amplifier uses high voltage transistors, suitable types being the BF178 and the older BF109 from Mullard or the SGS-Fairchild BF157. Small clip-on heat sinks will be required and a 2.5 × 5 cm strip of thinnish copper or phosphor bronze formed to wrap round the transistor as shown in Fig. 2 will be satisfactory. A smear of silicone grease between transistor and sink assists heat conduction. Remember that the collectors are connected internally to the TO5 case, so the heat sinks will be "live". A similar transistor can be used for Tr_1 which operates with a V_{ce} of about 60 V, a small heat sink again being required.

The output amplifier works with an h.t. of 120 to 150 V depending on the rating of the transistors and the output drive required. Current drain including the cathode-follower is about 30 mA.

Horizontal deflection

The horizontal deflection section consists of a trigger unit, a calibrated time-base and an X amplifier which includes an optional pre-amplifier for external signals. A circuit diagram of the trigger unit is shown in Fig. 3. An emitter-follower Tr_{12} takes its input from either the Y amplifier or an external source and is followed by a phase-splitting amplifier Tr_{13} and Tr_{14}, for polarity selection. Two transistors, Tr_{15} and Tr_{16}, form a Schmitt trigger circuit and the differentiated output from this is used to trigger the time-base.

The time-base and amplifier, which is shown in Fig. 4, uses the emitter-coupled circuit described by Gilbert in Refs. 3 and 4 where a full account of the operation is given together with a most impressive list of advantages. Transistors Tr_{17} and Tr_{19} are coupled by the emitter-follower Tr_{18} and by the charging capacitors. A positive-pulse through the trigger hold-off diode initiates the action, resulting in a negative-going linear ramp in the emitter circuit of Tr_{19}. Tr_{20} forms a source of constant charging current. There is a small step at the start of the ramp which shows up as a bright spot at the start of the trace. This can either be cancelled by the various means described in the references or minimised by using the negative-going square pulse at the emitter of Tr_{18} as a bright-up pulse on the c.r.t. Three preset resistors in the emitter of Tr_{20} are switched to provide a $\times 1$, $\times 2$ or $\times 5$ multiplier for the decade capacitors selected by Sw_5. Adjustment of Vr_9 gives a variable interpolation. The total range is from 500 ms to 1 μs per sweep.

An emitter-follower Tr_{21} couples the sweep to the main *X* amplifier which uses the same long-tail pair circuit as is used in the *Y* amplifier. The input is single-ended so shift voltages are applied to the other amplifier base. Frequency compensation is supplied by the capacitors from the shift control to earth and across the feedback resistor. This resistor can either be pre-set or, if it is mechanically convenient, brought out as a variable sweep-width control, preferably switched as a sweep multiplier. Transistors used in this section, Tr_{12} to Tr_{25}, are of the same types as those in the *Y* amplifiers except for the Schmitt trigger circuit. Here it is recommended that OC44 or OC45 transistors are used. Although any transistor type can be used in this kind of circuit their behaviour with a large input signal is quite different. With sine-wave input the OC44/45 transistors produce a clean square-wave output with up to 60 V peak-to-peak input. Above this the tips of the sine-wave break through symmetrically. Experiments with the BC113 silicon planar and the BC107 planar epitaxial transistors show unsymmetrical break-through with a much lower input of about 12 V peak-to-peak. Alloy diffused transistors of the AF114–115–116 family are the worst tried, with break-through at about 4V input. These remarks apply to both the trigger unit and to the Schmitt trigger squaring circuit in the calibrator.

For the display of external signals, such as a wobbulator time-base, the sensitivity at the base of Tr_{21} will generally be sufficient. If extra gain is required, the a.c.-coupled circuit shown in Fig. 5 is suggested. This provides a sensitivity of about 100 mV/cm at a bandwidth of 5 MHz. The input attenua-

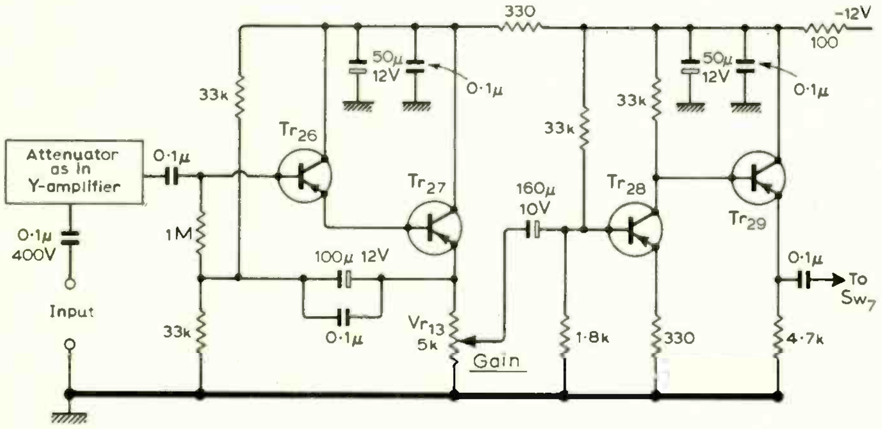


Fig. 5. Circuit diagram of optional X *pre-amplifier.*

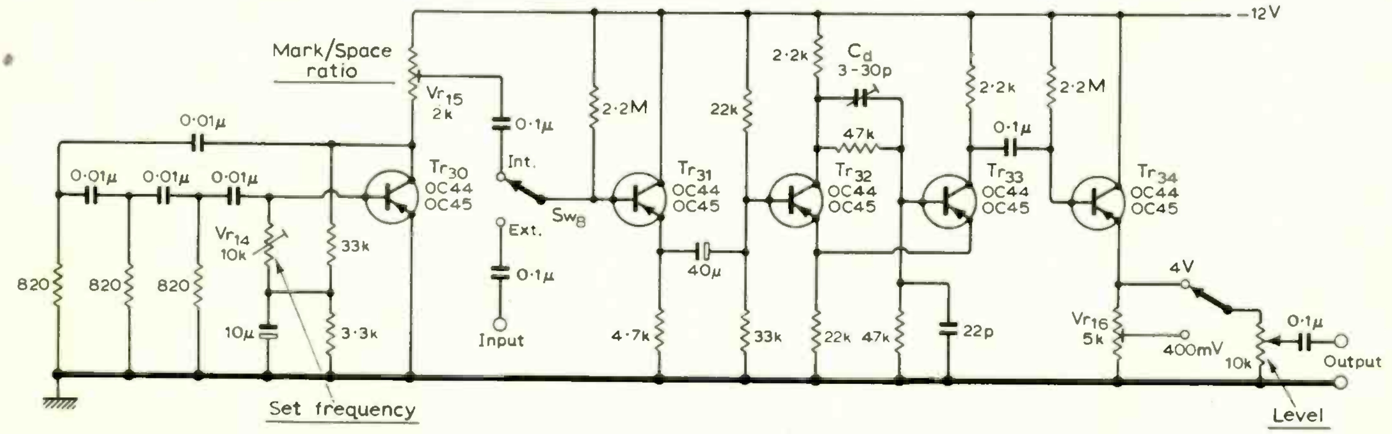
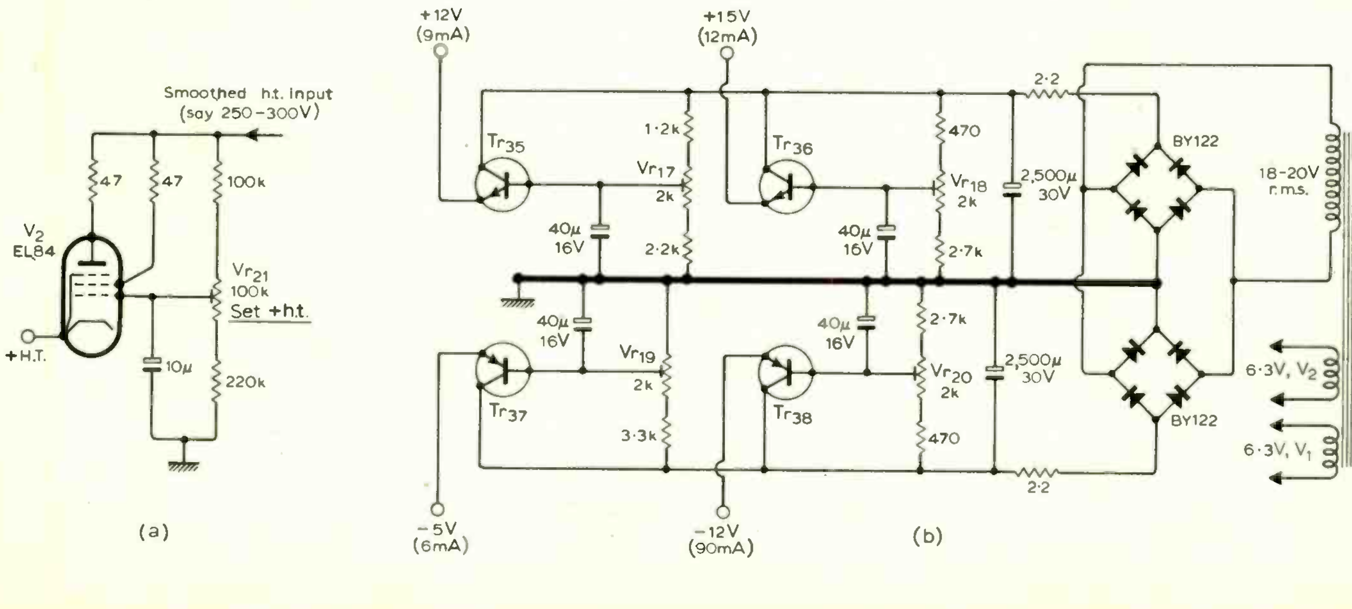


Fig. 6. Circuit diagram of square-wave generator.

Fig. 7. Circuit diagram of the h.t.+ line stabilizer (a) and power supplies for the low potential lines (b).



tor is similar to the one used in the Y pre-amplifier and is followed by the Darlington pair Tr_{26} and Tr_{27}, giving a stage gain of unity but an input impedance of several megohms. The amplifier which follows uses two transistors Tr_{28} and Tr_{29} as a common-emitter/emitter-follower pair. This last circuit, incidentally, is quite a useful one in its own right; it has a gain of ten and, with v.h.f. transistors such as those used in TV tuners and with a suitable peaking capacitor across the first emitter resistor, will maintain that gain to over 200 MHz.

For the X pre-amplifier most types of germanium h.f. transistors will be suitable or, with a reversal of all polarities, the silicon devices used in the other circuits.

Square-wave calibrator

This section generates a square wave with an output amplitude variable between 50 mV and 4 V peak-to-peak from either an internal source at 10 kHz or at any frequency from 15 Hz to 20 kHz with a sine-wave input from an external a.f. generator. The circuit diagram in Fig. 6 shows a 10 kHz sine-wave oscillator Tr_{30}, an emitter-follower buffer stage Tr_{31} into which can also be switched the external input, and a Schmitt trigger circuit Tr_{32} and Tr_{33} to generate the square-wave. The emitter-follower output Tr_{34} feeds a simple attenuator which gives two ranges of output amplitude; 50 mV to 400 mV and 500 mV to 4 V. There are pre-set trimmers for adjusting the frequency and the mark/space ratio, and the trimmer capacitor in the Schmitt trigger circuit is used for setting an exact square-wave. Besides proving very useful for gain calibration, and adjusting the attenuator and probe compensation, the calibrator can also be used as a signal source for square-wave testing.

Power supplies

Supply for the 120–150 V h.t. line required by the output stages is most conveniently derived from a higher voltage by means of a cathode-follower valve as shown in Fig. 7. This provides an easily adjustable, low impedance source and the current, about 58 mA, is within the ratings of a small power valve such as the EL84. Four low voltages required can be obtained from a small transformer and rectifiers via transistors, Tr_{35} to Tr_{38}, connected as emitter-followers. Power dissipated in the transistors is about 110 mW, except for Tr_{38} where it is about 900 mW, and in this position it is suggested that an AC127 or similar is used. If small power transistors like the OC81 are used for Tr_{35} and Tr_{36} there will be surplus power available for connecting to external units such as a wobbulator. A BC107 is suitable for Tr_{37} and it can be mounted with the time-base assembly. The three other power supply transistors should be clipped to an aluminium plate or chassis to provide a heat sink.

Modifications

As explained at the beginning of this article the performance figures quoted throughout refer to the use of a 5CP1 tube under specified working conditions which give a deflection sensitivity of about 20 V/cm. If a more modern tube with better sensitivity is used, then high drive voltages will not be needed and the collector supply voltage to the output stages can be reduced to some 60 to 80 V. If the same basic input sensitivities of 100 mV/cm and 10 mV/cm are to be retained, then the overall gain must be reduced by increasing the values of the feedback resistors linking the bottom emitters of the long-tail pairs. Changes will also be needed to the values of the various frequency-compensating capacitors. The resulting increase in bandwidth will be most noticeable in the ×10 gain position and, as an estimate, the 10 mV bandwidth with a DN17-78 tube (7.6 V/cm) should be about 4.5 MHz at −3 dB.

There are, of course, many other facilities that can be included to make a more complete oscilloscope system and it is the purpose here to suggest a few so that switching or the necessary space can be allowed for in case such circuits are required later. If the leading edge of a pulse is used to initiate the timebase sweep then this section of the input signal will not be visible for study unless a time delay is incorporated in the path of the vertical output amplifier. Such a delay can be introduced by using a properly terminated delay line of about 400 ns, and of adequate bandwidth, between the cathode of V_1 and the base of Tr_2. It should be switched out of circuit on the ×10 gain range where the degraded rise-time does not warrant its use. The time-base trigger circuit must, of course, be fed from the cathode of V_1 and an additional trigger amplifier will be required.

For examining television waveforms, a delayed time-base sweep is needed. This can be achieved by duplicating the time-

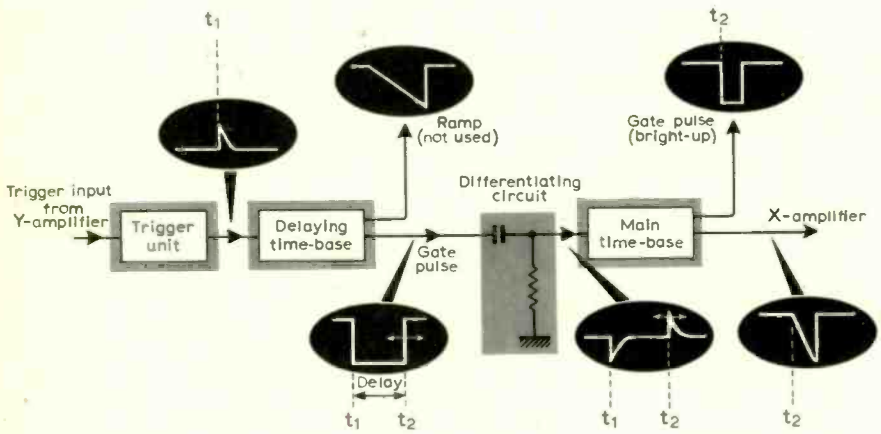


Fig. 8. Diagram showing use of additional time-base circuit to give delayed sweep for examining television video waveforms. Both time-bases are triggered by positive-going pulses only.

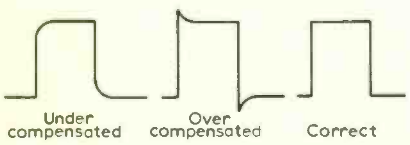
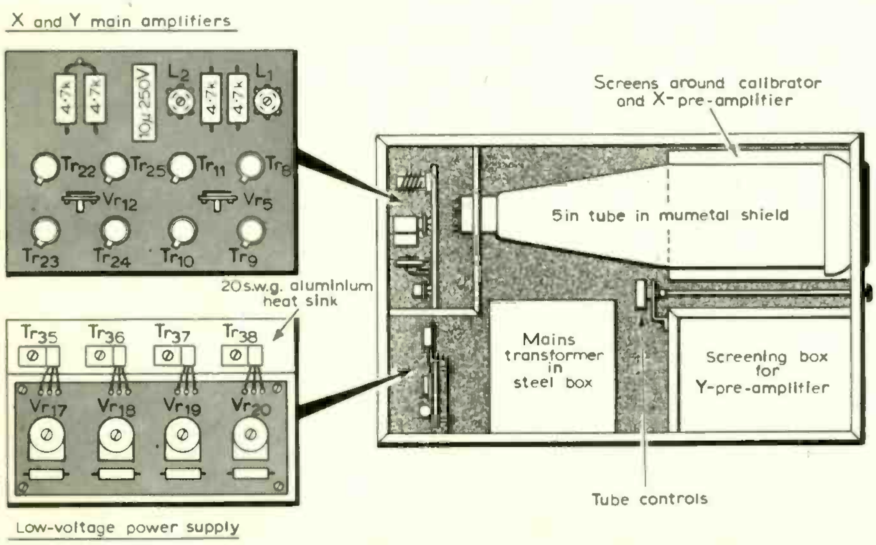
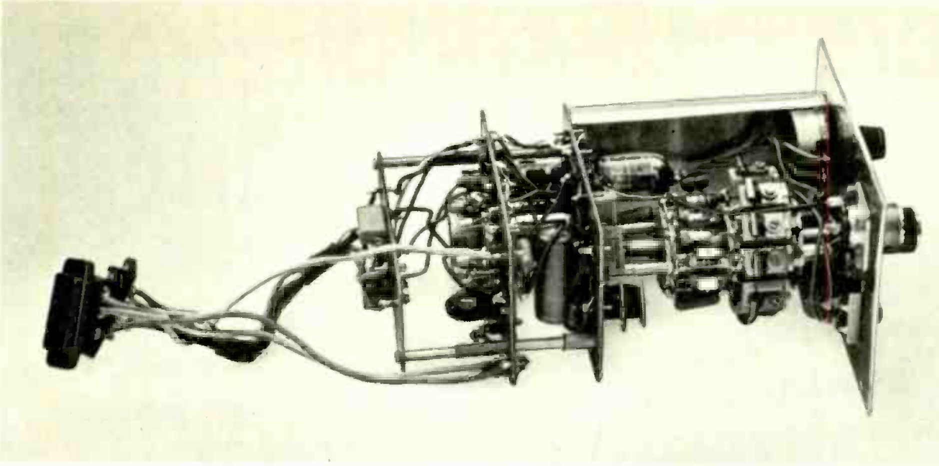


Fig. 9. Effect produced on square-wave by adjustment of compensating trimmers.

Fig. 10. General arrangement of units inside oscilloscope.





Photograph of the Y *preamplifier module.*

base circuit and driving it from the trigger unit. The differentiated gate pulse from the new unit is then used to trigger the main time-base. This description will probably be made clearer by referring to the block diagram in Fig. 8.

Setting-up and calibration

To set up the correct d.c. working conditions in the *Y* amplifier, first adjust for the following voltages: Vr_1 to give 72 V at V_1 anode, Vr_2 for 1V at Tr_3 base and Vr_5 for 8.4 V at the base of Tr_9; all voltages positive with respect to the -12 V line. Vr_2 is then finally re-adjusted for equal top and bottom limiting on a sine-wave signal of sufficient amplitude to cause overloading. During all these adjustments the *Y* shift control should be set for zero volts between the bases of Tr_2 and Tr_5. Since the amplifier is directly coupled, the preset gain controls Vr_3 and Vr_4 can be adjusted using a d.c. supply and a voltmeter as the calibration source.

Without access to a good oscilloscope the problem of adjusting the various frequency-compensating trimmers is rather like that of the chicken and the egg. Fortunately however, we can set as a starting point the $\times 1$ gain 100 mV position on the attenuator. In the absence of any instability the response of the amplifier should be as specified with no irregularities and, since there is no input compensation, this position can be used for displaying the calibrator unit output. Vr_{15} should be set for unity mark/space ratio and the trimmer in the Schmitt trigger C_d, to give a flat-topped square-wave. The effect on the waveform due to the adjustment of this and the other compensating trimmers is shown in Fig. 9. Once the output from the calibrator unit is satisfactory it can be used for setting the attenuator trimmers (C_a in Fig. 1), by adjusting each one in turn to give a flat-topped square-wave display. The 50 Hz mains supply with a period of 20 ms forms a useful standard for setting the time-base range multiplier resistors, Vr_9 to Vr_{11}, but for checking the shorter time decades and for setting the 1 μs trimmer capacitor, a generator covering the appropriate frequencies will be needed.

Construction

Since tube sizes and the type and volume of e.h.t. supplies can vary a great deal it is not the intention here to describe the construction in detail. In the title photograph is shown the oscilloscope which has evolved from a series of re-builds as circuit improvements were made, from the original add-on units mentioned in the introduction. It comprises basically a box frame-work made of 1.25 cm angle aluminium. The various circuit sections are built as separate units on s.r.b.p. perforated panels (plain Veroboard) with plug and socket connections to the power supplies. The general disposition of the units is shown in Fig. 10.

The *Y* preamplifier and the trigger/time-base unit plug-in to the front of the instrument. Construction of the pre-amplifier is illustrated in the photograph above. The attenuator switch uses three wafers, the resistors R_a and the trimmers C_a being connected in parallel between the front two wafers, while R_b and C_b connect to the last wafer which is used solely as a common earth. The first panel is used for mounting V_1, Tr_1 and their associated components, the remainder of the amplifier is wired on the second panel and the supply decoupling components on the rear one. The time-base is quite straightforward except for the choice of a time switch. The alternatives are: an eighteen way switch, separate six and three way switches or, the solution used here, two switches with concentric spindles.

Since the only real sources of heat are the tube and the two valves there are no ventilation problems, two 25 mm holes in the bottom and expanded metal mesh over half the back being all that is necessary.

REFERENCES

1. 'A Wideband Oscilloscope Probe', by L. Nelson-Jones. *Wireless World* August 1968, page 275.
2. Wescon/66 Technical Papers. Part 6. Session 11 on Field Effect Transistors.
3. 'Emitter-Timed Monostable Circuit', by B. Gilbert. *Mullard Technical Communications*, July 1961, P. 345.
4. 'Oscilloscope Timebase Generator', by B. Gilbert. *Mullard Technical Communications*, March 1964, p. 276.

The series of articles on the *Wireless World* Oscilloscope which appeared during 1963 and 1964, and which is now available in a set of five booklets, will be found generally useful for references.

Corrections

Some other Measuring Rectifiers

Owing possibly to some clod of earth still adhering to me after resurrection, or to a misguided attempt to be concise, an erroneous statement (in italics, too!) got through in "Some other Measuring Rectifiers" (Feb. issue). While it is true that the bridge rectifier type of voltmeter would correctly read r.m.s. values of square waves if it were calibrated in its natural mean values (because the mean and r.m.s.—and peak—values of square waves are all the same) it would *not* do so if the calibration incorporated the 1.11 factor converting sine-wave mean to r.m.s. My apologies.—"CATHODE RAY"

High Impedance Multimeter

The author, V. R. Krause, regrets an error that occurred in Fig. 3 of his article "High Impedance Multimeter" in the February issue. The labelling of the range switch, S_{2a}, is reversed; the 1V range switch position should be labelled 300V.

Circuit Ideas

In Fig. 2 in the contribution "A unity gain amplifier for very low-frequency filters" on p.15 in the January issue the base of the output transistor should be connected to the collector of the preceding p-n-p transistor; *not* to the junction of the complementary emitters as shown.

Negative Feedback and Hum

Economical method of reducing hum in an a.f. amplifier

*by G. W. Short**

The amplifier shown in Fig. 1 (a conventional 'single-ended push-pull' affair using a circuit familiar in battery-operated equipment) produced an irritating hum when connected to a simple power pack with a bridge rectifier and one large reservoir capacitor. Measurement at the output revealed only about 2mV of ripple voltage at the emitters of the output pair. This seemed to be much too small to account for the observed volume of hum, since the amplifier noise, which was about the same amplitude, was inaudible at normal listening distances.

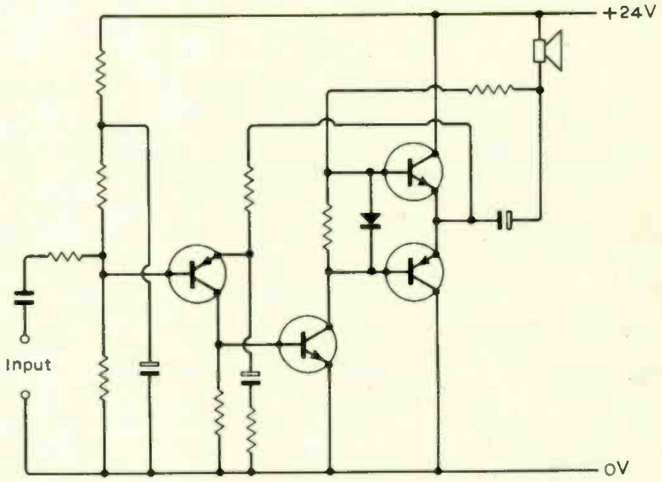


Fig. 1. The transistor amplifier circuit which emitted an abnormal volume of hum when connected to a simple mains rectifier unit. Hum-producing ripple current has a low-impedance path through the lower output transistor to the speaker coil.

The ripple on the positive line was found to be 200mV peak to peak with only the quiescent current of the (class B) amplifier flowing. After some fruitless searching for hum in the intermediate parts of the amplifier I finally realised that the cause of the trouble had been staring me in the face all along. With 200mV ripple on the power supply and only a few millivolts at the amplifier output the best part of the 200mV was across the speaker, and busily at work forcing a hum current through it.

The path for the hum current goes through the lower output transistor. This offers practically no impedance. The transistor is an emitter follower of sorts to begin with, and there is overall negative voltage feedback which further reduces the output impedance. For practical purposes, therefore, the only significant impedance in the hum path is the loudspeaker coil. In my particular circuit this was passing about 12mA of 100Hz ripple—quite enough to produce an audible hum. Rather late in the day, I then looked up an article with the same title as this note, written some 22 years ago by Cathode Ray (*W.W.*, May, 1946; reprinted in 'Second Thoughts on Radio Theory', Iliffe, 1955). Notwithstanding the fact that Cathode Ray dealt with pentodes with output transformers the article describes and illustrates with measured values exactly the same mechanism of hum production which occurred in my own transistor amplifier; i.e., a lowering of output impedance due to negative feedback providing an easy path for ripple on the supply line.

The reason why mains operated transistor amplifiers do not usually have their load slung between the output and the upper supply rail was now clear. On the other hand, this arrangement makes for higher efficiency and power output than those in which the speaker is returned to the lower supply line and extra components are included to 'bootstrap' the top end of the driver load resistance.

It seemed a pity to sacrifice power and efficiency for the sake of a little extra smoothing. Unfortunately, smoothing chokes for high currents are expensive and not all that easy to find, and smoothing resistances drop too much voltage when the amplifier is driven hard and the current consumption rises. Readers may be interested in the simple and economical solution shown in Fig. 2. Here R_1 and C_2 are selected to provide the extra 20dB or so of hum reduction needed when the amplifier is quiescent. The drop across R_1 is not sufficient to bias D_1 to conduction, so it has no effect. When the amplifier is driven, D_1 conducts, and the voltage loss due to the extra smoothing section is thus limited to the forward drop (perhaps 800mV if D_1 is a silicon diode). The ripple current through the speaker coil now increases, of course, but in practice the resulting hum is masked by the signal.

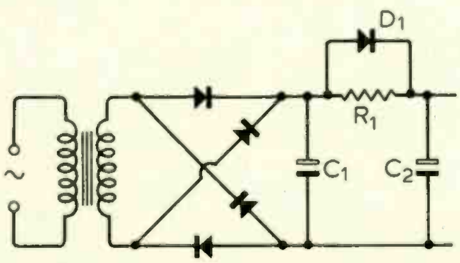


Fig. 2. "Swinging diode" smoothing system.

The arrangement is not unlike the 'swinging choke' smoothing circuits familiar in high-power class B valve amplifiers. It might be called a 'swinging diode' circuit.

In designing the extra smoothing section, the voltage at which a silicon diode starts to conduct can be taken as 500mV (600mV in high-current supplies, since the incremental resistance is then still relatively high). Since the diode has ripple voltage across it as well as the d.c. drop in R_1 it is the sum of these that has to be considered. In practice, if C_1 is big enough to provide reasonably good regulation, enough margin remains to make R_1 usefully large. In some cases, it might be worth using two diodes in series to increase the hold-off voltage.

The biasing of the amplifier is perhaps worth a comment. The output stage uses germanium transistors and there is a gold-bonded diode in the bias network. At low temperatures, however, the bias voltage is developed, not by the diode but by the current through the resistance which shunts it. If there is a rise in ambient temperature, the forward voltage of the diode falls, and the diode then becomes the dominant element in the bias circuit.

The arrangement compensates for changes in ambient temperature but not for a rise in temperature of the output transistors. To arrange this, thermal feedback is necessary. This can be introduced by using two diodes in parallel, one in thermal contact with each output transistor. The bias is then set by whichever transistor is warmer.

* Amatronix Ltd.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Digital exposure timers

Page 22 of your January issue made me feel like the small child who inadvertently leaned on the fire alarm and turned out the whole brigade. I have read *Wireless World* as an amateur since 1920, and have occasionally had letters printed in its correspondence columns, but I did not think that any casual words from me would have induced another reader to do quite so much hard work as is implied in Grahame Coates' paper. May I offer him my felicitations—especially for his appreciation that photographers are really interested in log. relative times and not arithmetic absolute times. There are things in his design I would prefer changed for my own use—the double-or-half time change given by his left-hand switch seems to me inconveniently large, for instance. And I would want a minimum dispensed time in the region of 0.3 second. But these are small details.

My trouble is that I cannot afford to make up the Coates design. My firm is not an electronics one, and though we can use soldering irons when we have to, it would take quite fifty hours to lay out a full circuit and wire it up. Since the cost of one man per hour in the firm is about 50s., the total cost of making the timer would be unacceptable. We might, of course, induce a specialist firm to make one for us, but since they would (quite reasonably) expect to make a profit for themselves, I doubt whether a one-off job would come a great deal cheaper.

But . . . is it *essential* to go to such lengths of circuit complexity? I ask the question because we lately bought for our step-and-repeat camera a "Eurotima", which dispenses arithmetic times digitally. This cost us about £20 and is warranted to have higher accuracy and better repeatability than the Coates design itself. I haven't dared to open it up and look at its "innards", but am told that an ordinary *RC* timing circuit and an operational amplifier are involved.

Now, if this kind of circuit is good enough with arithmetic time-scales, what is it about a log. time-scale that drives people away from it and into the hands of the counter-cum-decoder type of circuit? Something there must indeed be, for no sane person would consider putting a couple of thousand components—or their equivalent in microcircuitry—into an instrument when a couple of hundred can be persuaded to give as good, if not better, results. As a mere amateur, I cannot expect to know enough about electronics design to answer this question, but I wonder if some of the specialists can do so?

P. C. SMETHURST,
Bolton,
Lancs.

The author replies

I would like to thank Mr. Smethurst for his kind comments, although the design had been in my mind for some time before his letter was published!

Taking the main points in order, the circuit was designed to keep the component costs as low as possible because the home constructor would prefer it this way. If the timer were to be produced commercially, the bistables would be replaced with i.cs which would increase the component cost by about £11, but reduce the one-off construction time to 12 hours or so.

I am not conversant with the "Eurotima", and consequently I cannot comment on its accuracy. However, my article may have underestimated the accuracy, as I now understand from the C.E.G.B. that the short-term frequency variation is in the order of $\pm 0.2\%$, and does not exceed $\pm 0.4\%$ even at times of peak demand. The accuracy of repeatability depends only on the frequency stability of the mains.

As for the setting accuracy, if *R-C* timing circuits are used, this depends on how accurately an operator can set a potentiometer. Alternatively, a switch would require close-tolerance resistors, or calibration of presets; both of which would introduce difficulties for the home constructor. In my circuit there is inaccuracy only in following the logarithmic law, and this is zero for unit time values.

Finally, I must point out that there are less than 400 components in the timer, or about 100 if the bistables are replaced with J-Ks. Perhaps Mr. Smethurst could justify the expense of the timer by the increase in productivity it could achieve: test strips can be taken at full aperture, and short exposures by correspondingly manipulating the aperture and time-value switch.

The "preassembled logic units" referred to in my article are no longer available. If surplus components are used, variations in transistor parameters may be so great that all the bistables may not reset; this can be overcome by inserting a 1 kΩ resistor between the reset diode and the reset line. The positive line voltage may also have to be reduced to 5V to obtain consistent switching.

G. COATES.

"High-impedance multimeter"

The design published in the February issue is not without interest but certain features of it cast doubt on some of the claims made for its performance.

On the 'resistance' ranges, the instrument can be corrected for variations in the voltage of the 1.5V cell, but not for variations in the internal resistance of the cell. These can cause serious errors on the lower ranges. At mid-scale on the lowest range, the cell is called upon to deliver 75mA, and an internal resistance of 10 ohms will cause a measurement error of -33%. At the extreme low-resistance end of the range the cell must supply nearly 150mA, and the same internal resistance will then result in an error of -50%. On the '3V a.c.' range (incorrectly labelled '100V' on the diagram) the loading of the step attenuator by the 5MΩ input impedance of the transistor amplifier can cause an error of -4%. In view of this it is strange to read in the article that the 5MΩ impedance is 'as high as can be satisfactorily handled'.

On this '3V a.c.' range, the attenuator effectively puts 220kΩ in series with the signal source as seen by the amplifier. Unless there is some happy combination of stray capacitances in the circuit this series resistance will have a devastating effect on the upper frequency response. Without compensation, a stray capacitance of only 1pF at the attenuator output will cause an error of -30% at about 700kHz. The suggestions regarding the choice of transistors need to be taken with some reserve. It is claimed that almost any small n-p-n planar transistor will serve for use in the amplifier. This may be so in principle, but unless R_1 is selected to suit the input transistor the amplifier may not be able to deliver enough output to provide full-scale deflection.

In selecting matched pairs of f.e.ts the designer began with 12 specimens and selected three satisfactory pairs. His initial stock gave him 66 possible pairs; a stock of three f.e.ts can only provide a choice of three possible pairs, which brings the odds for finding a pair matched within 10% down rather severely. What the would-be constructor of the meter needs to know is how many f.e.ts must be bought in order to give, say, an even chance of finding a suitable matched pair. This information is absent from the article.

G. W. SHORT,
Croydon.

Helical u.h.f. aerials

In our letter which was published in the January issue of *Wireless World* we pointed out the disadvantages of circularly polarized receiving aerials for u.h.f. television. In your editorial note, you suggested that rotation of polarization can take place over long distances, but in fact, the polarization of the transmitted wave is very well maintained not only within the service area but also well beyond. As we said, it is this fact which enables two transmitters to use the same channel with minimum mutual interference, provided they radiate the opposite polarizations. It is, therefore, essential that viewers use the correct aerial with the maximum discrimination against the orthogonal polarization.

J. L. EATON,
L. F. TAGHOLM,
B.B.C. Research Dept.,
Tadworth,
Surrey.

Noise in transistor circuits

I would like to reply to Mr. Vanderkooy's comments (Feb. 1969) on my recent article on noise in transistor circuits. When I said that the use of the noise temperature concept "may be confusing to readers of the present article", I did not intend to imply that this concept is inherently more difficult than that of noise figure, but merely that, because it is a different approach from that used in the article, it might seem confusing to readers who had just assimilated the latter. I am very much aware that physics experiments are often done with very low source temperatures—indeed, I learnt quite a lot about noise by designing, in 1954, a very-low-noise valve amplifier* for the R.R.E. Low-Temperature Physics Group.

The negative feedback arrangement used in the above amplifier was essentially that shown in Mr. Vanderkooy's diagram, about 40dB of negative feedback being applied to the cathode circuit of the input valve. Because of the very high source impedance referred to the grid, and its very low Johnson noise (because of the low temperature), grid-current noise had to be allowed for and the valve noise was therefore represented by a combination of current and voltage noise generators just as used nowadays for transistors. The negative feedback had no effect on the noise performance over the small band of frequencies centred on 800Hz to which the output stage of the amplifier was tuned, except for the very slight Johnson noise introduced by the 400-ohm feedback-voltage-injecting resistor in the input cathode circuit. While it does often seem to have been "naively expected" that the use of feedback in this manner, which raises the amplifier input impedance, would also raise $R_{S_{opt}}$, it is easy to see that this cannot be so when it is appreciated that the source Johnson noise, V_N and I_N, can all be represented by voltages acting in series with R_S, and that the negative feedback reduces the gain afforded to all of these equally, thus leaving the signal-to-noise ratio, and therefore the noise figure, unaffected. Hence the value of R_S which gives best noise figure without feedback will also give it with feedback. (Of course, the application of the feedback greatly increases the bandwidth of the part of the amplifier over which it is applied, but not the bandwidth of the input transformers, and this would affect the noise figure if care were not taken to restrict the bandwidth over which the noise is measured appropriately. This consideration is taken care of, however, by the words "at any given frequency" in the first paragraph of the Negative Feedback and Noise section of my article.)

PETER J. BAXANDALL,
Royal Radar Establishment,
Malvern.

*"The Design of a Very-Low-Noise 800c/s Selective Amplifier and Input Transformers" by P. J. Baxandall, *R.R.E. Journal*, No. 37, October 1955.

Improper oscillations in transistors

In the January issue there is an interesting letter from Mr. Pitt on improper oscillations in transistors. The present letter provides some additional comments and the most likely cause of these oscillations.

(1) The oscillations never occur even if relatively small capacitors (100pF and above) are placed across the power source at the transistor terminals.

(2) If the supply line has very little inductance, or quite a large inductance, the oscillations seldom occur.

These two observations indicate that the oscillations are radio frequency in origin, quite high, and it was reassuring that I could by altering the supply leads bring the circuit into tune on a small portable v.h.f. receiver. If C is made very small, the oscillations probably become continuous, but if C is large the audible tones come through on the receiver. Since I do most of my experimenting at home, I could not study the circuit with a 100MHz oscilloscope, but I feel certain that the relaxation characteristic of the oscillations is evidence of the self-quenching of the high-frequency oscillations by the relatively high RC time constant. Hence the frequency of the audible tones is determined by the time that the capacitor C can cut off the transistor.

Thus, Mr. Pitt, although one resistor and one transistor cannot cause a transistor to oscillate, the inclusion of several unintentional inductances opens up several modes of oscillation. I suggest that the oscillations are not feasible for practical use, and am sure that the G.P.O. would agree.

JOHN VANDERKOOY,
University of Cambridge.

Quality in graduates

May an ordinary person without a degree ask Joe Tymebase, whose letter "Quality in Graduates" was published in February, just what he expects?

If there is anything at all in genetics, both extremes of intellect are recessives, which suggests that village idiots and geniuses are produced by a given population in roughly equal quantities. Many of the geniuses will be lost—however genetically capable a mind may be, it cannot think until it is filled with very great numbers of facts. This is why a medium intellect coming from understanding parents will always have the edge over a genius born into a family which is only interested in football pools, bingo and the like.

I notice a scream in the papers that more students have been put in for A-level maths yet the percentage of passes has dropped. What do they expect? The more people enter for any exam, the more does the law of diminishing returns set in. In fact, though politicians assume there is an inexhaustible supply of geniuses in the country, the real truth is that perhaps 2% of the population can appreciate science enough to comprehend it, and only a small fraction of *them* will ever have any original ideas about it.

I am exceedingly sorry for the student population. They are picked to go to university because of their ability to pass an exam at 17/18. Until they come out into the cold hard world nobody will know if any of them are intelligent, or whether they have the temperamental capacity to do hard work in employment. Yet they are cossetted by being given excellent grants on the taxpayer, and led to assume that once they have got their degrees they will know as much as Rutherford in his prime.

None of this helps Joe, I fear, but it explains why so many people these days think that the only thing about a job that matters is the salary it carries. Obviously, if they have been trained and are as good as anyone, it cannot be important what they put into the job, for it will be just what anyone else could put in.

I only hope that it will comfort Joe to know that the mere peasants, such as myself, have long known that the possession of a research degree does not mean that its owner is in the least intelligent.

P. C. SMETHURST,
Bolton,
Lancs.

Protection of engineers

Vector's two articles concerning redundancy have certainly touched a very sensitive spot. At a recent lecture I was sidetracked (with the chairman's consent) into replying to a question as to how companies wishing to economise could dismiss their senior engineers and appear to carry on just as well with juniors. My reply was that even after a man was dismissed his ideas, methods and innovations remained with his employers and could flywheel them along for a considerable period. I stated that I felt a redundancy claim should take this into account.

A solicitor in the audience took up my last point and stated that there was no common law covering a claim in this respect and that as yet no statutory provision had been made. He thought that as statutory legislation had now been undertaken there was no likelihood of a court creating new common law at present and suggested that an appointee should see his solicitor about a protective agreement under the Contracts of Employment Act, 1963. His last sentence was received with acid laughter.

I wound up by mentioning that a Trade Union had taken a full page advertisement in *The Times* devoted to protection of the senior employee, and whilst I could not go along with many of its policies and statements of its leader, I would recommend those interested to consider membership.

I. G. ABELSON,
London, N.14.

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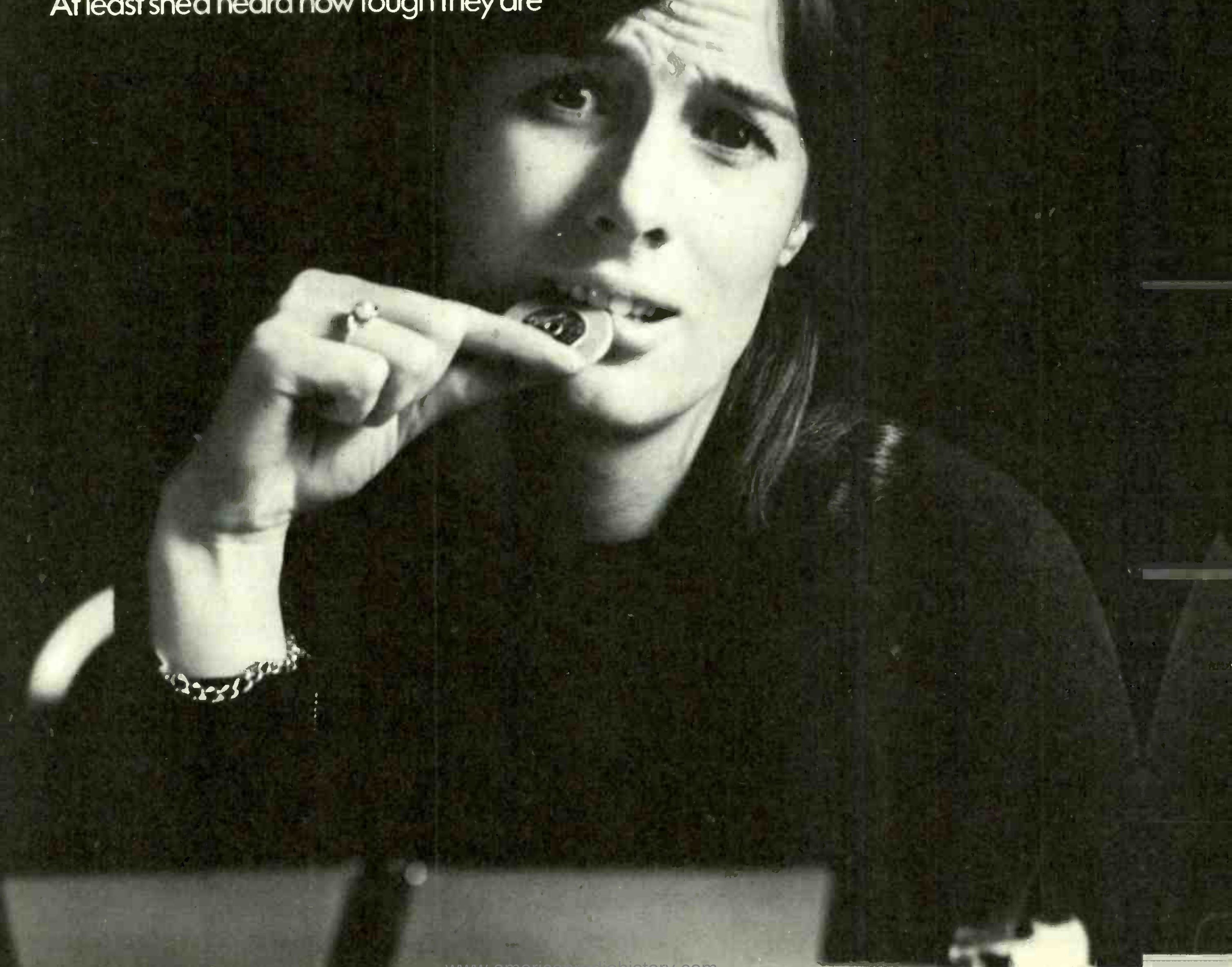

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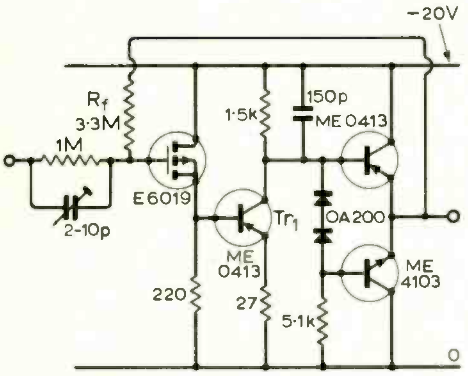
Circuit Ideas

Instrument output amplifier

The amplifier shown was designed as an output amplifier for an instrument having a response from 0.1Hz to 1MHz. Other requirements included an input resistance of 1MΩ and high stability of the standing d.c. output voltage



Instrument output amplifier.

during temperature and supply voltage changes. The gain requirement was a modest 10dB. Standard output impedances of 600Ω and 75Ω were required and the amplifier was therefore designed to provide a relatively low output impedance of 5Ω. A complementary symmetry output section and overall voltage derived shunt feedback were therefore used. The danger of instability is eliminated by the use of a 150pF phase compensation capacitor across the load resistor of Tr_1. The relatively high input impedance required was easily obtained by the use of an m.o.s. transistor.

Since the m.o.s. transistor is connected in the common drain mode and output transistors are arranged as parallel common collector stages, the open loop gain of 26dB is provided by the common emitter stage Tr_1. The 27Ω resistor may be bypassed to provide a higher open loop gain if required. With the feedback arrangements shown the amplifier has total harmonic distortion of 0.05% for a 1V r.m.s. output signal. The d.c. output voltage is held within 50mV for a temperature change of +30°C and supply voltage changes of ±40%.

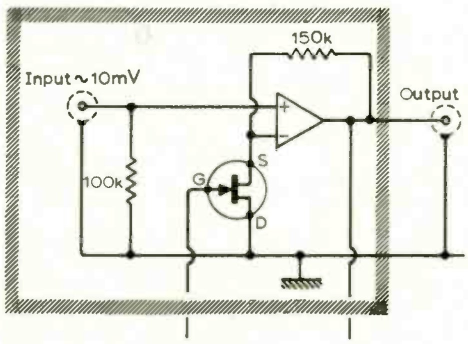
The feedback resistor R_f shown (3.3MΩ) can be increased to several hundred megohms if a very high input resistance is required. Since the feedback resistor provides the forward bias voltage for the m.o.s. transistor, care should be taken to avoid leaky input capacitors which would change the effective bias voltage supplied to the gate.

J. ROBERTS,
Marconi Microelectronics,
Witham.
H. C. DAVIES,
University College, Swansea.

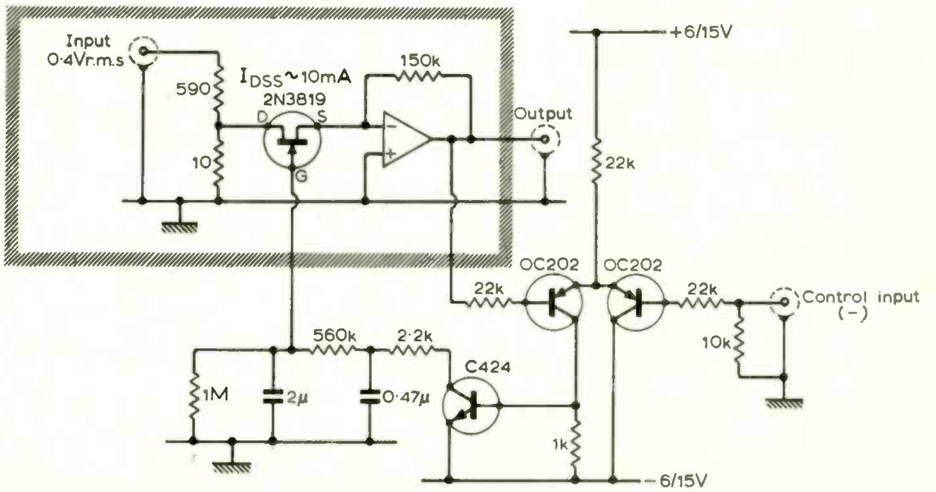
Amplitude modulator using operational amplifier

This circuit allows the amplitude of a repetitive signal to be controlled by a slowly varying voltage. The input was designed nominally for 600Ω; and a 400mV signal will be controlled with almost negligible distortion at the output. Almost any high gain (>10^4) operational amplifier can be used. The peak negative value of the output signal is very nearly equal to the value of the negative control voltage. If planar p-n-p transistors are used in place of the OC202 types the peak to peak value of the output voltage must not be allowed to exceed the base-emitter breakdown voltage of the first p-n-p device. The circuit has been used to control a 10kHz sine wave, but full frequency tests have not been done. An alternative arrangement with high input impedance is also shown.

JOHN VANDERKOOY,
Royal Society Mond Laboratory,
Cambridge.

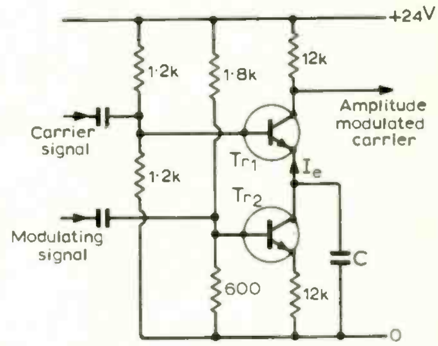


Shown below is full circuit of amplitude modulator using operational amplifier. Above is alternative input stage with high impedance.



Simple amplitude modulator

A carrier signal is applied to the voltage amplifier Tr_1, whose emitter is decoupled by C. The high collector resistor of this stage ensures that



Simple amplitude modulator.

the resistance through the emitter is high and that the gain therefore varies linearly with I_e. Tr_2 is a linear amplifier producing a signal current at the collector which is a function of the modulating signal. This varying current thus causes the gain of Tr_1 to vary. The output from the collector of Tr_1 will therefore be the carrier signal amplitude modulated by the modulating signal. The difference in frequency between the modulating and carrier inputs must be great enough for C to have a high reactance at the modulating frequency.

A. E. CRUMP,
Broadstone,
Dorset.

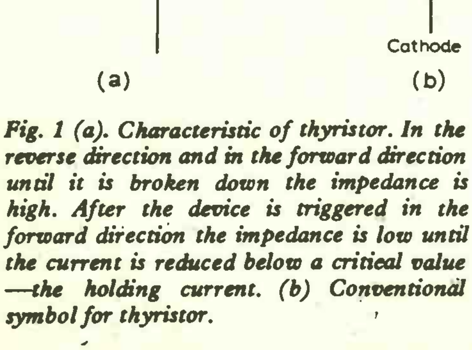
Thyristors and Associated Devices

Their characteristics and uses

by W. D. Gilmour

The thyristor is a three-terminal semiconductor switching device with properties somewhat similar to the hot-cathode thyratron. Originally the general term for the device was "silicon controlled rectifier" or s.c.r., and this term demonstrates the first important property of the device—that in the reverse direction it behaves as a normal blocking diode, and it will never conduct (until its breakdown voltage is reached) with the anode negative (Fig. 1). With the anode positive conduction will still not occur until the gate terminal has been driven sufficiently positive, when the device will break down to a low impedance, with the current flowing limited only by the external load. This current will continue to flow until it is reduced below a critical value, the holding current, either by shunting the current in a parallel path, by reducing the applied voltage, or by breaking the current with a series-connected switch; then conduction will cease and will restart only when the gate terminal is re-energized. The similarity with the operation of a thyratron will be obvious, and the relative typical parameters are compared in Table 1.

The chief advantages of the thyristor are thus a lower conducting voltage drop, much smaller size and weight, and, if operated within ratings, a very much longer life, as



(a) (b)

Fig. 1 (a). Characteristic of thyristor. In the reverse direction and in the forward direction until it is broken down the impedance is high. After the device is triggered in the forward direction the impedance is low until the current is reduced below a critical value —the holding current. (b) Conventional symbol for thyristor.

Table 1: Comparison between typical thyratron and thyristor parameters

Quantity	Thyratron	Thyristor
Peak inverse voltage (max.)	Several kV	About 800V
Peak current	Hundreds of amps	About 200A
Mean current	Tens of amps	About 100A
Conducting voltage drop	About 8V	About 1V
De-ionization time	Tens of microsecs	Microsecs
Gate conditions for breakdown	Tens of volts, tens of milliamps	Few volts, up to 100mA
Holding current	Tens of milliamps	Tens of milliamps
Weight of typical power type	Several kilograms	100g

there are no gas clean-up effects to be allowed for. On the other hand, for brief non-repetitive overloads the thyratron may be more robust, and the very low voltage drop may lead to difficulties in turning off thyristors in d.c. circuits.

A development of the thyristor is the Triac, in which the gate controls conduction in both directions, thus allowing an undistorted a.c. waveform to be switched, as by a relay. Triacs will be discussed in more detail later.

Triggering methods

The manufacturer's data for a thyristor will generally show typical characteristics of trigger voltage against trigger current, with superimposed limits showing levels at which no device will trigger, and at which all devices will trigger. From these curves it is simple to work out the required voltage and impedance of the triggering source. For the reliable triggering of all devices, it is useful to allow some 10V from an impedance of not more than 300 Ω for triggering, thus permitting a potential trigger dissipation of several hundred milliwatts, which could exceed the manufacturer's mean limits. A.C. coupling to the gate is therefore frequently used, as shown in Fig. 2 (a), (b), and (c).

Two special devices, the p-n-p-n diode and the uni-junction transistor, provide excellent sources of triggering pulses. The former has the characteristics shown in Fig. 3, where it will be seen that at some critical applied voltage a negative resistance develops, and the circuit of Fig. 2 (d) shows how the capacitor, *C*, will suddenly discharge into the load formed by the gate of the thyristor as the critical voltage is exceeded. The circuit will continue to deliver gate pulses so long as the voltage is maintained across the driving circuit.

The uni-junction is a three-terminal device, with similar characteristics to the p-n-p-n diode, in that the emitter will break down at a critical voltage, set, however, in this instance, by the voltage applied across the other two (base) terminals. Fig. 2 (e) shows a typical uni-junction triggering circuit.

The triggering pulse width and amplitude necessary to secure breakdown are to some extent related, but less so than for a thyratron, and in general triggering is independent of pulse width for lengths greater than a few microseconds. There is generally a short delay, typically one or two microseconds, between the application of the triggering pulse and the main breakdown, which is generally very rapid with modern avalanche methods of construction. In some earlier devices, however, the rate of rise of the main current had to be limited to allow time for the breakdown to spread completely across the main junction, and this limitation may still apply to devices passing more than ten amps.

D.C. applications

Complete logic systems can be built with thyristors, using the cheap plastic encapsulated or low current TO-5 can types. The thyristor is basically a two-state device with hold, similar to a conventional RS flip-flop. This type of logic has uses when a number of logical actions are required at any time during a fairly long period, with restrictions on the sequence, especially if substantial output powers are required, for external loads can be inserted in the anode leads. This use is, however, somewhat specialized and will not be discussed further here.

Combinations of relays, stepping switches, and thyristors lead to very useful circuits. For instance, consider the problem of ensuring that two uniselectors remain in step (Fig. 4 (a)). When the thyristor is fired both armatures will close, but neither can be released, thus stepping the uniselectors on, until both interrupters are broken. The current through the thyristor will then be broken and it will revert to its non-conducting state. Both uni-selectors will then have moved, in synchronism, by one step. Thyristors used with relays can give holding circuits, with pulsed unlatching (Fig. 4 (b)), without the difficulties associated with mechanical or magnetic latching.

To turn a conducting thyristor off, the

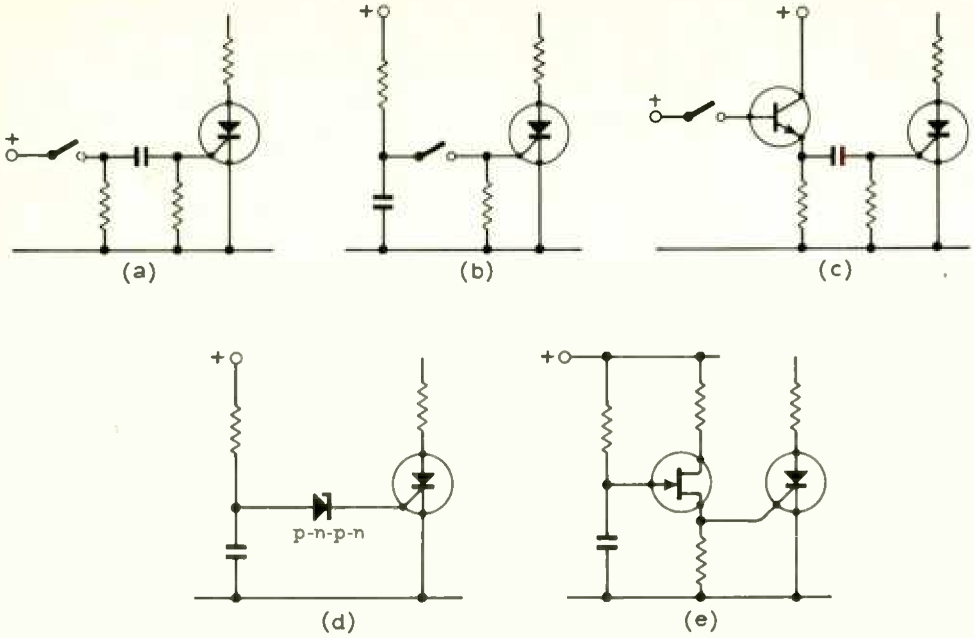


Fig. 2. Triggering methods for thyristors: (a) direct d.c. pulse; (b) discharge of already charged capacitor; (c) use of emitter follower to secure low impedance drive pulse, together with capacitor coupling to reduce mean gate dissipation; (d) use of p-n-p-n diode; and (e) use of uni-junction.

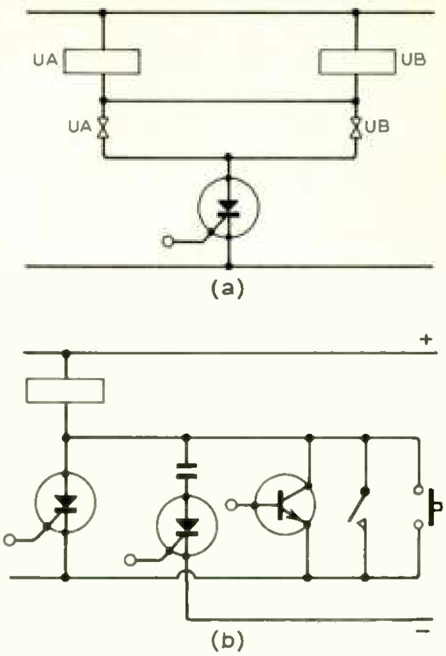


Fig. 4. Use of thyristors with electromechanical switches: (a) Synchronous drive for two uni-selectors. The current flowing through the coils of UA and UB will be interrupted only when both interrupters are open, thus resetting the thyristor; (b) Latched relay. The relay will release only when the thyristor is turned off, which may be done by four methods, shown from left to right: a second thyristor; switching transistor; second relay contact; or manual switch.

current through it must be reduced below the holding current and kept below this value for a few microseconds. In d.c. circuits this can be done by physical interruption of the circuit, as in the example of the uni-selectors given above, by shorting the thyristor by a contact or by a switching transistor, or by diverting the current into a sufficiently large capacitor (typically 50-250μF) switched into circuit by another thyristor, which in its turn ceases to conduct when its holding current falls below the critical value as the capacitor becomes fully charged.

Because thyristors can withstand very high peak currents, they form excellent devices for discharging capacitors in time-bases, and for use in "electronic crowbars" —these are short-circuiting devices deliberately placed across the output of a power supply if too high a current is drawn from it; and they are used mainly in transmitters to give instant protection against arcs in the output circuits.

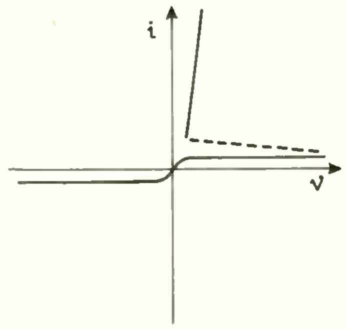


Fig. 3. Characteristic of p-n-p-n diode.

A.C. applications

With the coming of the Triac, described below, the principal application for unidirectional thyristors nowadays in a.c. circuits is as controlled rectifiers (Fig. 5a). In a typical full-wave application the rectifiers block normally in the reverse direction and will conduct in the forward direction only when triggered. By delaying the triggering point with reference to the conducting half cycle of the applied voltage waveform in the main circuit, the energy transferred into the output circuit can be controlled. Thus in the two extreme cases, if the thyristor is triggered at the start of the half cycle, the circuit will behave as a normal uncontrolled rectifier, with maximum transfer of energy, but if triggering is delayed until the end of the half cycle, no energy at all will be transferred. Intermediate triggering points will give transfers depending on the design of circuit. Thus, if a typical capacitor input circuit is used (these are quite permissible for low-power rectifiers, as thyristors can withstand higher repetitive surge currents than thyratrons of the same mean current rating), energy transfer can occur only when the instantaneous voltage of the input waveform exceeds that of the reservoir capacitor. Conduction in normal operation thus occurs only at the peaks of the input waveform and control is always exercised on the first quadrant of the input waveform between zero and the positive voltage maximum. With a resistive load, however, control is required over the entire forward half cycle. The simplest method of control is to delay the supply waveform by 90° and then compare this waveform with a d.c. level set by the quantity to be controlled, as shown in Fig. 5 (b). To secure a precise triggering instant, any of the normal pulse generating comparator circuits (Schmitt trigger, p-n-p-n diode, or uni-junction) should be used. These circuits will also give a low-impedance drive pulse suitable for direct application to the gate of the thyristor.

This type of control circuit is quite suit-

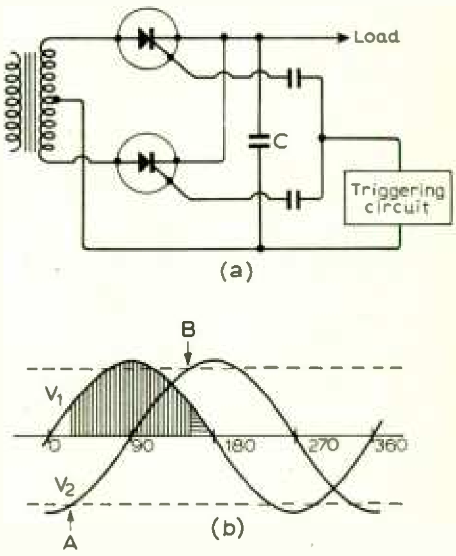


Fig. 5. Phase control of thyristors in a.c. applications: (a) Typical full-wave controlled rectifier. The capacitor C need be large enough only to give a low impedance return for the triggering pulses; (b) The main voltage waveform, V_1, is delayed by 90° to give a control waveform, V_2, not necessarily of the same amplitude. V_2 is compared with a d.c. control level, shown dotted for the two extreme values. If equality occurs at A, almost the whole half cycle, shown shaded vertically is passed in the main circuit, but at B only a very small fraction, shown horizontally shaded, is passed.

able for powers of up to about 1kW. For greater powers, the lagging power factor and the possible distortion of the waveform of the supply mains due to its finite impedance, together with the necessity for circuits to reduce the effect of interference caused by the sudden rush of current as the thyristor starts to conduct, makes this arrangement less attractive. It is recommended that, whenever possible, complete half cycles of the mains should be switched, closing the circuit at zero voltage, and controlling the power to the load by switching a controlled

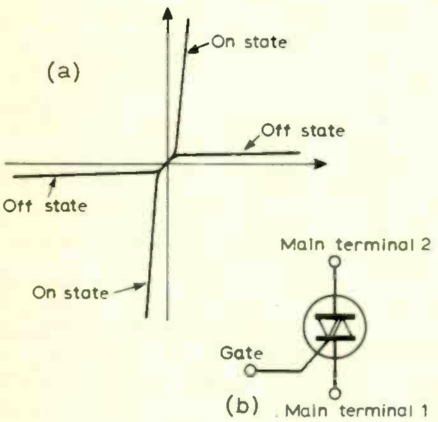


Fig. 6 (a). Triac characteristics. In comparison with Fig. 1 (a), note that breakdown can occur in both directions. (b) Conventional Triac symbol. Sometimes the triangles are moved contiguously to give a simple zig-zag, as used in Fig. 7.

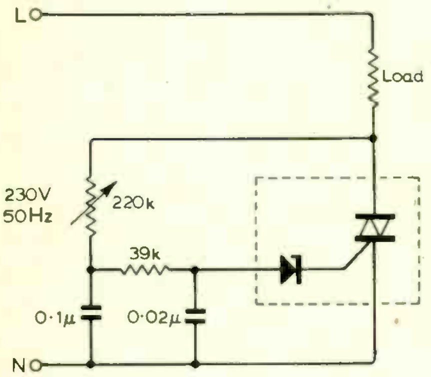


Fig. 7. Simple phase control using Triac with built-in diode.

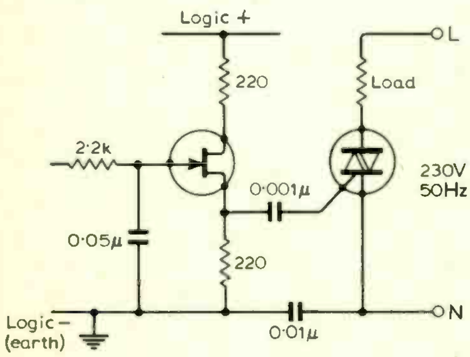


Fig. 8. Logic interface using uni-junction and Triac. Note that the logic power supply can be earthed on one side and coupled capacitatively to the Triac.

number of cycles at a time. Thus a given power level might be maintained by switching three half cycles on, two off, four on, two off, four on, two off, three on, etc., to give any desired level. This regime of control is naturally most applicable to controlled circuits of large time constants, such as heating installations and large motors; it cannot of course be used for lighting installations.

Extinction of conduction in a.c. circuits gives no trouble, as the holding current is automatically reduced to zero and then reversed at the end of each half cycle.

To secure full-wave control on a.c. rectifier circuits without a transformer, two controlled rectifiers and two normal rectifers can be used in a bridge configuration, but this type of circuit is now mainly of academic interest, having been replaced by the Triac.

Triacs

The Triac is a symmetrical device with characteristics and conventional symbol shown in Fig. 6. By applying a small control voltage to the gate terminal with respect to one of the main terminals (conventionally No. 1) the main terminals conduct, and current will remain flowing, limited by the external load, until it is reduced, as in a thyristor, below the holding limit. A high impedance state is then restored between the main terminals until the gate is fired again. The gate voltage can be unidirectional, and thus full-wave control from a d.c. or pulse source can be achieved. Some Triacs are available with a built-in p-n-p-n triggering diode, thus leading to the very simple circuit of Fig. 7, which will control the application of mains voltage to the load according to the setting of the potentiometer.

Triacs without the diode mentioned above can be triggered by low-impedance pulses of a few volts, derived for instance from a uni-junction, and this allows them to be used as interfaces between low-voltage logic devices and mains-operated devices, as shown in Fig. 8.

As we have seen, thyristors and Triacs have properties which enable them to be used in a variety of useful applications where no other active components would give the same result nearly as economically.

Announcements

The second national **symposium on logic design** is to be held at the University of Reading on March 28th. Organized by the Logic Design Group of the British Computer Society, eight papers will be given on subjects including Digital Counting Techniques, Computer Aids to Logic System Design and Implementation of a Digital Controller using Wired Logic. Further details are available from the Conference Information Office, The British Computer Society, 23 Dorset Square, London N.W.1. Fee for non-members of the B.C.S. is £6.

An international symposium on **management and economics in the electronics industry,** organized by nine institutions, including the I.E.E., I.E.R.E. and the British Computer Society, is to be held at the University of Edinburgh from March 17th to 20th 1970. Further details will be available from the secretary, D. J. T. Williams, Ferranti Ltd., Ferry Road, Edinburgh 5.

A residential symposium entitled **'Maintenance in Electronics'** will be held at Wood Norton Hall, Evesham, Worcs. The symposium, organized by the Society of Electronic and Radio Technicians, takes place from July 4th to 7th. Further details may be obtained from the Secretary, S.E.R.T., Faraday House, 8-10 Charing Cross Road, London W.C.2.

The **reliability of electronic equipment** will be the subject of a conference being organized by the I.E.E. in association with I.P. & P.S., the I.E.R.E. and the I.E.E.E. The conference will be held at Savoy Place, London W.C.2, from December 10th to 12th.

Three lectures on physiology, organized by the I.E.E./I.E.R.E. **medical and biological electronics group** committee, will be held at the Medical College, St. Bartholomew's Hospital, Charterhouse Square, London E.C.1. The lectures are entitled 'Nerve impulse' (11th March), 'Transcutaneous information' (22nd April), and 'Peripheral auditory mechanisms' (20th May). Tickets for non-members are available, price 5s each, from the I.E.E., Savoy Place, London W.C.2.

The second symposium on **field effect transistors** will be held at West Ham College of Technology, Romford Road, Stratford, London E.15, on May 6th and 7th. Details are available from the symposium organizer.

A two-day symposium on **digital storage techniques** will be held at Kingston College of Technology, Penrhyn Road, Kingston upon Thames, Surrey, on April 1st and 2nd. Details are available from R. V. Sharman, organizing secretary. Fee £10.

LECO '70. The Council of Engineering Institutions, "federal body for Britain's chartered engineers," is organizing a major engineering congress which will open at the Royal Festival Hall, London on May 4th, 1970.

A new company in the **optical character recognition** field known as Real Time Systems Ltd, of 139A New Bond Street, London W.1, has been formed by Pennsylvania Research Associates Inc., U.S.A., and a group of British data-processing specialists. The company is marketing in Western Europe the multi-font page reading systems of Scan-Data Corporation, Pennsylvania, U.S.A.

The Electronics Division of Union Carbide UK Ltd, is to manufacture **field effect and dual transistors in the** United Kingdom. The devices will be manufactured at the company's plant at Aycliffe, Co. Durham.

Cosmocord Ltd has formed a new **electronic instrument group** to be incorporated in the existing electro-acoustic division. The group will specialize in sound level test equipment, ear defending equipment, accelerometers, transducers and bearing analysers.

The marketing association between Technomark Ltd and Radford Electronics Ltd was dissolved on February 1st. All sales and service matters will be dealt with from the premises of **Radford Electronics Ltd** at Ashton Vale Road, Bristol 3.

Additional **colour equipment,** to the value of £250,000, has been ordered from Pye TVT Ltd by Associated Television for the extension of its proposed outside colour television transmissions in London and the Midlands. The order is for 8 three-tube colour cameras, equipment to convert the two existing Pye outside broadcasting units from black and white to colour and extra monitoring, vision-mixing and pulse equipments.

A £144,000 contract has been awarded to **Tellurometer (UK) Ltd,** a company in the Plessey organization, for the supply of microwave distance measuring equipment to the Italian Army.

Decca Radar Ltd, have received orders, in excess of £400,000, for radar relating to the entire building programme of 29 Esso tankers, four of which are also fitting ISIS (Integrated Ship Instrumentation Systems).

Racal Instruments Ltd has received an £82,000 contract from the British Royal Navy for the supply of **digital counters.**

Wireless World Colour Television Receiver

10. Chrominance circuit principles

The preceding articles of this series have dealt with the equipment entirely from the point of view of producing a good black-and-white picture. It has been stressed many times that such a picture is an essential prerequisite for a good colour picture and we repeat this once again in order that it shall not be overlooked. In this and following articles we shall deal with the chrominance circuits and their principles. There is nothing in these which is essentially difficult and the basic circuits of individual stages are mainly of quite familiar types.

As a whole, however, the chrominance circuitry is very unfamiliar to most people and the results of faulty components, incorrect connections or improper adjustment can be very strange indeed. There are so many parts involved that it is asking rather much to expect that the equipment will contain neither a faulty component nor a wrong connection. It is a wise precaution to check every component before connecting it into circuit, but even then carelessness in assembly and soldering can damage components.

In order to be able to find faults and to carry out the proper adjustments, it is necessary to understand the circuits. We shall accordingly devote this article to essential theory. Much of it will already be known to those who have studied the subject. There are certain important matters, however, which have either not been adequately treated or the implications of which have not been brought out previously.

At the transmitter three camera tubes are trained on the subject through red, green and blue filters and produce output signals proportional to the red, green and blue components of the colours in the scene. These are designated the R, G and B signals; they are then gamma corrected and are conventionally designated R', G' and B'. The object of all the intervening equipment is to enable these signals R', G' and B' to be developed between the three grids and cathodes of the receiving colour cathode-ray tube.

We are not concerned here with gamma correction nor with some of the subtle effects which result from it. For simplicity, therefore, we shall drop the primes to the letters and use R, G and B to refer to the gamma-corrected signals.

Because of the need to economise in bandwidth these signals are not transmitted directly in the R, G and B form. They are first processed or encoded.

First of all, the so-called luminance signal is produced, and is designated by the letter Y. This signal is obtained simply by adding together the proper proportions of the R, G and B signals according to the relation

$$Y = 0.3R + 0.59G + 0.11B$$

This is a video signal of full bandwidth which corresponds to the normal video signal of black-and-white television. If applied to a picture tube it will produce a monochrome picture. It contains all the information about the picture detail and its light and shade. Its bandwidth extends up to about 5.5MHz and it modulates the vision carrier in amplitude.

In addition to this, two chrominance signals are formed, $R - Y$ and $B - Y$ and these have their bandwidths limited to about 1.2MHz. The latter modulates in amplitude a sub-carrier of frequency 4.43361875MHz $\pm$ 1Hz, hereafter called 4.43MHz for short, whereas the $R - Y$ signal modulates in amplitude a sub-carrier of the same frequency but which differs in phase from the other sub-carrier by 90°. Furthermore, in successive scanning lines the phase of this $R - Y$ sub-carrier is changed by 180°.

After modulation the sub-carriers are suppressed and the signals remaining are added together in their proper proportions and then used to modulate the vision carrier in amplitude. Because of the precise sub-carrier frequency chosen the sidebands of the chrominance signal all fall between harmonics of the line-scanning frequency at which the energy of the Y signal is concentrated, thus minimizing mutual interference.

The complete signal as transmitted can be designated in the various ways shown by equations (1) to (4) in the Appendix. It is important to realize that the two amplitude-modulated sub-carriers do not exist as separate entities when they are added together; they form a signal in which the amplitude varies in accordance with the saturation of the colour and the phase varies in accordance with the hue.

The plus and minus signs in the equations indicate that the phase of the $R - Y$ signal is reversed in successive lines; that is, if the plus sign is taken for one line, the minus sign applies for the next. Under ideal conditions, this is also the signal obtained at the output of the detector in the receiver. In practice, of course, what is obtained is a more or less distorted version of this signal to which there are added noise and interference. We shall ignore this for the present, however. It is the purpose of the luminance and chrominance circuits of the receiver to accept the colour signal M and to convert it into three signals R, G and B between the grids and cathodes of the c.r. tube.

To enable this to be done a kind of synchronizing signal is needed for sorting out the colour components. This can be regarded as analogous to the line and field sync pulses which are always added to the vision signal for synchronizing the line and field timebases. The additional special signal for colour is known as the colour burst, or just burst for short. This comprises 10 $\pm$ 1 cycles of sub-carrier frequency inserted in the back porch of every line; that is, between the end of every line sync pulse and the start of the active portion of the line.

In the PAL system, which is all that we are concerned with here, the phase of the burst changes by $\pm$ 45° on successive lines. Taking the phase of the $B - Y$ sub-carrier as reference, on lines for which the phase of the $R - Y$ sub-carrier is 90° the burst phase is 135°, while for lines for which the $R - Y$ sub-carrier is $-90°$ the burst phase is $-135°$.

In order to decode the colour signal as received, it is necessary to generate in the receiver signals of exactly the same frequency as the sub-carrier used at the transmitter so that the

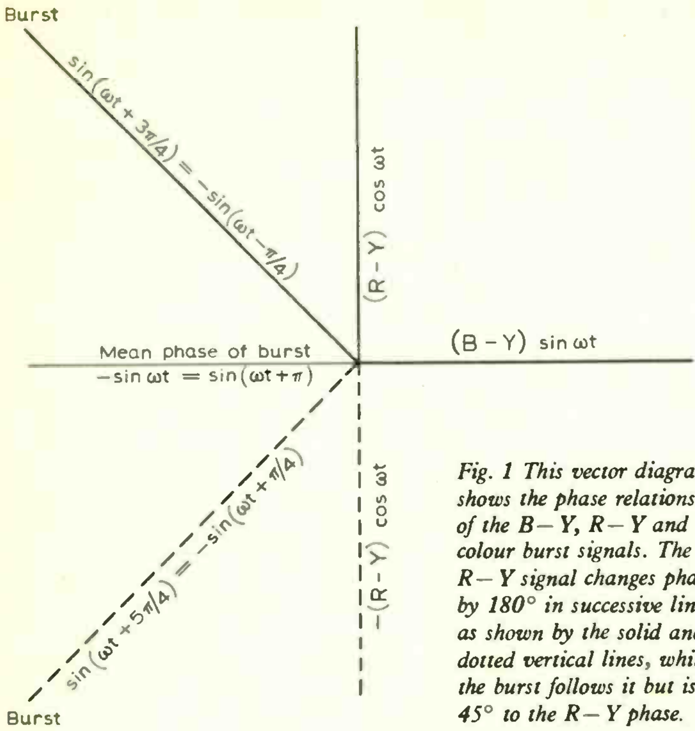


Fig. 1 This vector diagram shows the phase relations of the B – Y, R – Y and colour burst signals. The R – Y signal changes phase by 180° in successive lines as shown by the solid and dotted vertical lines, while the burst follows it but is at 45° to the R – Y phase.

sub-carriers which have been suppressed at the transmitter can be reinserted. These locally-generated signals must also be in the proper phase, although for this a small error is tolerable. Again taking the $B - Y$ component as reference, there must be one local signal in phase with this and another at 90° to it which alternates in phase in successive scanning lines.

In practice, the burst signal is used to lock a local oscillator in frequency but with some small phase error; a pulse from the line timebase is used to operate a phase-reversing switch, and the changes of phase of the burst are used to keep this switching operation in the proper phase.

It is very important to understand all these phase relations and it is a little difficult to do so at first, for most of us are inclined to get in a muddle over phase relations, especially as they do not usually assume any importance in r.f. circuits. The vector diagram of Fig. 1 helps a great deal in sorting out the relations. The $B - Y$ component is taken as the zero of reference and is shown as the horizontal line-drawn from the centre to the right. The $R - Y$ component is drawn at 90°

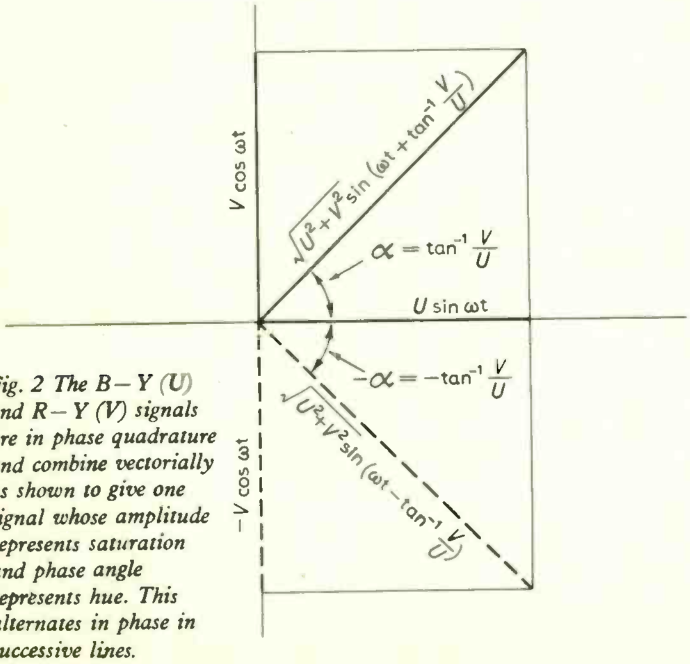


Fig. 2 The B – Y (U) and R – Y (V) signals are in phase quadrature and combine vectorially as shown to give one signal whose amplitude represents saturation and phase angle represents hue. This alternates in phase in successive lines.

($\pi/2$) to it, upwards and downwards for successive lines.

The corresponding phases of the colour burst are shown again drawn upwards and downwards for successive lines at a further 45°, 135° in all from the $B - Y$ axis. Their mean is the horizontal line drawn to the left from the centre at 180° to the $B - Y$ axis.

In Fig. 1 the $B - Y$ and $R - Y$ components are represented separately in the manner expressed in equation (1). Fig. 2 shows this again and also how they combine to form a single signal of varying amplitude and phase. Here V and U are used respectively to represent $R - Y$ and $B - Y$.

Turning now to the general form of the decoder, its block diagram appears in Fig. 3, and the complete signal represented by equations (1) to (4), plus the colour burst, is applied at its input. It will be remembered from the earlier articles that this signal is also passed through a delay line and video amplifier which provide some attenuation at 4.43MHz, to the cathodes of the colour tube. Because of this the chrominance components, which are at 4.43MHz are largely removed, and a signal $-Y$ is fed to the cathodes of the tube and is, of course, the equivalent of Y fed to the grids. In order to obtain R, G and B between grids and cathodes, therefore, we have to develop three signals $R - Y$, $G - Y$ and $B - Y$ for application of the three grids.

The summing of the luminance and colour difference signals is effected in the tube, for $-Y$ applied to the red cathode and $R - Y$ to the red grid give R between grid and cathode, and similarly for the other guns. At this point the discerning reader will raise an objection. He will say that this is not true because the Y signal which is applied to the cathode is wideband, whereas the $R - Y$ signal which is applied to the grid is narrow band, and he will be quite right. The letter Y is, in fact, being used with two meanings, one for the wideband luminance signal and the other in the narrow-band colour-difference expression.

As a result, the foregoing statement is true only for frequencies up to some 1.2MHz. For frequencies above that the colour-difference signals $R - Y$, etc., disappear and the only input to the tube is the wideband $-Y$ signal applied to the cathode. This means that there is no colour in fine details. What we have, in effect, is a black-and-white picture upon which colour is superimposed in the large and moderate sized areas, but not in the fine detail. It has been determined by experiment that the eye is not very sensitive to colour in detail, and it is because of this that it is possible to restrict the bandwidth of the colour-difference signals. This arrangement is, in fact, common to all practical colour-television systems.

The decoder is fed with the complete video signal plus colour burst and sync pulses and it has to produce at its output three colour-difference signals, $R - Y$, $G - Y$ and $B - Y$. The whole signal is first applied to a high-pass filter (numbered 1 in Fig. 3), which removes the luminance signal and the sync pulses, leaving only the chrominance signal and burst which are all around 4.43MHz.

The high-pass filter is a simple affair, being nothing more elaborate than an RC coupling of small time constant. The signals are then put through a single-stage amplifier (2) with a.g.c. This stage, therefore, provides an output of substantially constant amplitude. The output feeds two separate channels. The chrominance channel starts with an attenuator (3) which forms the saturation control; it controls the amplitude of the colour-difference signals and so enables the depth of colour, or saturation, in the picture to be varied. This attenuator is a diode network controlled by a variable voltage and it has applied to it also a pulse from the line timebase which makes the attenuation very large during the line flyback and which, therefore, gates out the colour burst. The signals after the attenuator are thus the colour-difference signals in their suppressed-carrier form.

A single stage of amplification (4) follows and there are then two possibilities. In simple PAL the signals are applied directly to the two synchronous demodulators (8) and (9) shown in Fig. 4. In delay-line PAL the arrangement is different. The signal is applied to a phase-splitter (5). One output is taken from the emitter and the other is taken from the collector and passed through a delay line (6) which gives a delay of one complete line, or, more precisely, 283.5 cycles of sub-carrier frequency. The delayed and undelayed outputs are adjusted to be of the same amplitude and their sum and difference are formed (7).

Consider the $B - Y$ component. The output of a certain scanning line appears at the emitter and the output of the preceding line with the opposite r.f. phase at the output of the delay line. Subtraction of the two signals results in a double-amplitude signal which is the mean of the signals from two lines. Since the $R - Y$ signals are reversed in phase in successive lines the two outputs are in the same phase and on subtraction they cancel out. Thus the combined output is $B - Y$ only. More important than this, however, is the fact that, because the combined output is the mean of two lines, phase distortion tends to be cancelled. This is actually the whole purpose of the PAL system.

With the $R-Y$ component the phase reverses in successive lines and so the addition of the two outputs gives a double amplitude $R-Y$ signal only, the $B-Y$ components cancelling.

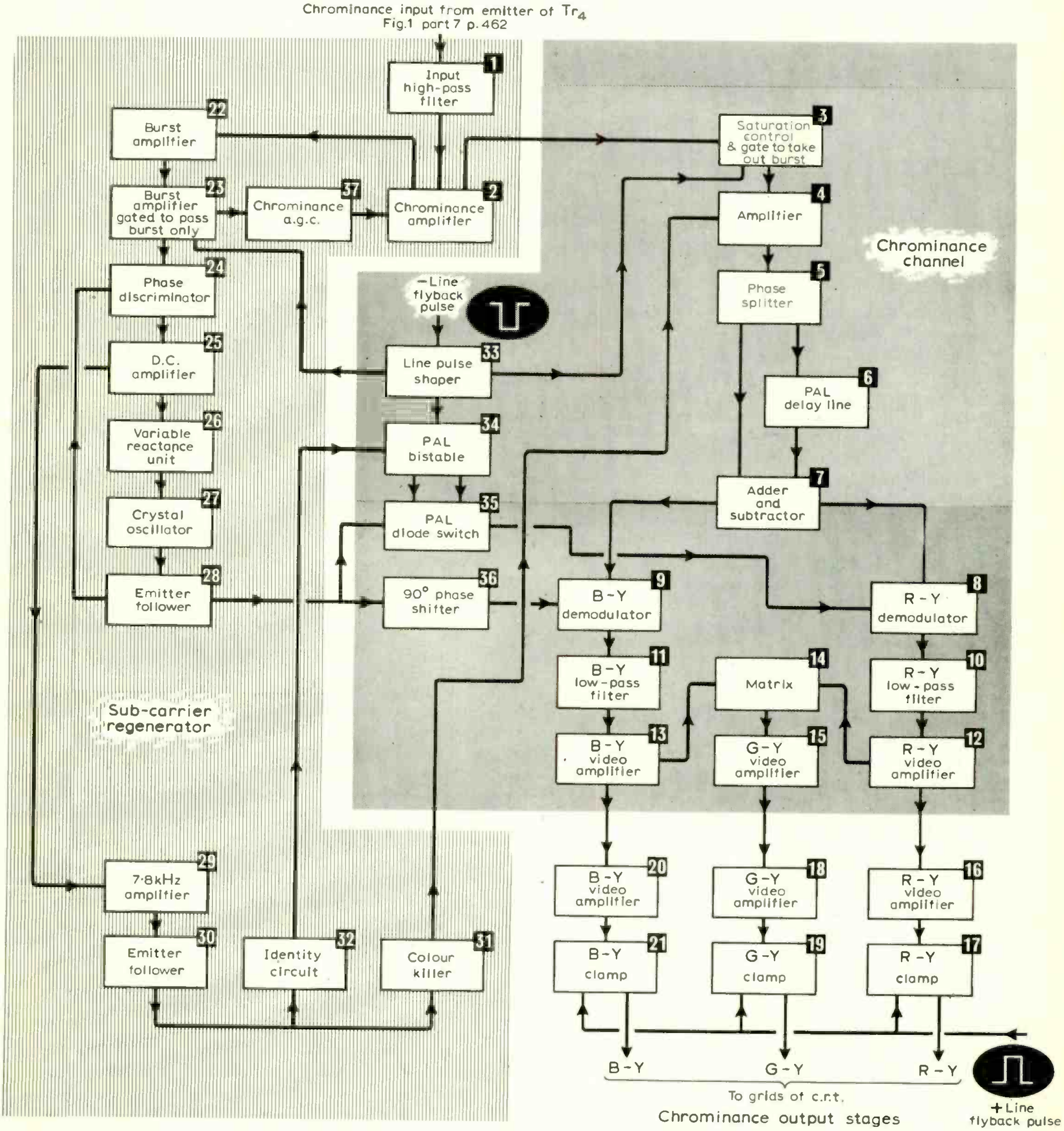


Fig. 3 Block diagram of the complete chrominance equipment which provides the $R-Y$, $G-Y$ and $B-Y$ signals on the grids of the c.r. tube. This is driven at the cathode with a $-Y$ signal from the luminance amplifier and so R, G and B signals are effective between the grids and cathodes.

The two components are then applied separately to the two synchronous detectors.

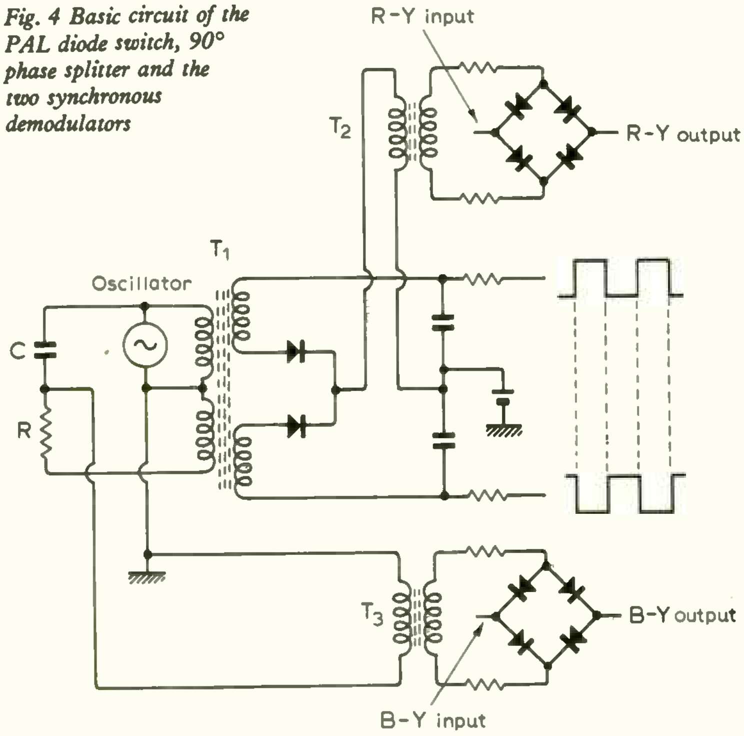
If there is a phase error between the locally generated reference oscillation and the correct reference phase, the demodulation process is affected. With simple PAL, a leading phase error causes a shift of colour in one way from the correct, whereas a lagging error causes a shift in the other way. As a result of the phase alternation in successive lines, the error is leading on one line and lagging on the other. Successive lines depart from the correct hue in opposite directions, and if the picture is viewed from far enough away, the eye averages the two and gets the impression of the proper hue. With delay-line PAL the $R-Y$ and $B-Y$ signals are separated before the demodulators, with the result that a phase error in the reference signal causes no error of hue. This is dealt with in more detail in the Appendix.

The disadvantage of simple PAL is that with close viewing the alternation of lines of different hue can be seen and they usually appear to crawl up the picture. The effect is known as the Venetian or Hanover blind effect. It can occur, but to a much lesser extent, with delay-line PAL, if the circuits are not properly balanced.

The receiver is, of course, designed for delay-line PAL but it can actually be used as simple PAL merely by removing the delay line. In fact, under good conditions simple PAL gives an exceedingly good picture.

We now turn to the other channel of the chrominance circuitry. The chrominance signal and burst are first amplified in a single stage (22) and the output of this is applied to a second amplifier (23) which is normally biased beyond cut-off so that it is inoperative. A positive-going pulse, which is derived (33) from the line timebase, is applied to the base and renders the stage operative whenever the colour burst is present. The net result is that the colour burst appears greatly amplified at the output of this second stage but no other signals. The burst is rectified (37) and the resulting smoothed output applied as a.g.c. bias to the common input stage (2). The main output, however, is applied in push-pull to a pair of diodes (24) which also have an input in parallel from the local oscillator (28). This forms a phase discriminator which gives no output if the phase of the oscillator and burst are correctly related, but gives a d.c. output for a phase difference with a polarity depending on the direction of the difference. This is amplified by a d.c. amplifier (25) and the voltage is applied to a variable capacitance diode (26) which is connected to the oscillator circuit (27).

Fig. 4 Basic circuit of the PAL diode switch, 90° phase splitter and the two synchronous demodulators



The oscillator is of a conventional Colpitt's type using a quartz crystal as the tuned circuit. The frequency is thus always very close to the correct one, and the operation of the a.p.c. loop, is gradually to reduce any initial frequency error to zero and then to hold the oscillator in lock with the burst frequency. Unless the oscillator frequency is itself precisely correct, the control circuit cannot bring it into lock without there being a phase error between the oscillator and the burst.

The oscillator is provided with an emitter-follower output stage (28) to isolate it and from this the output is fed to three things, the phase discriminator (24), the PAL switch (35), and a 90° phase shifter (36).

The phase of the burst swings at line frequency by $\pm 45°$ about a mean phase of 180° relative to $B-Y$. The oscillator cannot follow this and is locked by the mean phase, which is 180° relative to $B - Y$. In the absence of any phase error, it locks in at 90° to this mean phase. The oscillator thus locks in phase with the $(R - Y)$ signal component but whether it is the plus or minus phase depends on the design of the whole a.p.c. loop. A simple phase shifter (36) produces a 90° phase change and so a continuous oscillation in phase with the $B - Y$ component and this is correct for controlling the $B - Y$ synchronous demodulator.

The $R-Y$ demodulator requires an oscillation which reverses its phase in successive lines to keep it in step with the phase alternation of the $(R-Y)$ signal. This is carried out by the PAL switch (35). This is shown in essence in Fig. 4. The output of the oscillator emitter-follower is applied to a transformer T_1. Two secondary windings 3 and 4 are connected to a pair of diodes which are initially biased to be non-conductive. The diodes are rendered alternatively conductive by being connected to the two collectors of a bistable (34) in Fig. 3. During one line D_1 is turned on and the voltage from winding 3 drives a current through it and through the primary of T_2. During the next line D_1 is turned off and D_2 on. It is now winding 4 which is operative in driving current through D_2 and the primary of T_2 and this current is in the opposite phase to that during the previous line. The output of T_2 is thus an oscillation which reverses in phase on successive lines.

The bistable is triggered to change state every line by a pulse from the line flyback (33). Something more than this is needed, however, for as so far described it is a matter of chance whether the ouput of T_2 is in step with the phase alternations of $R-Y$ or whether it is 180° out of step.

This is highly important, for if it is 180° out of step negative, or rather complementary, colours will result.

The whole purpose of the swinging colour burst is to enable this to be sorted out rather simply. Although this does not affect the crystal oscillator, which becomes locked to the mean phase of the burst, the discriminator (24) output contains a component of half-line frequency which also appears in the output of the d.c. amplifier (25). This is applied to a circuit tuned to 7.8kHz (29) where it produces a fairly large amplitude sinewave of this frequency. This is applied through an emitter follower (30) and a diode (32) to the bistable. If it happens that this is running in the correct phase it does nothing. If it happens that the bistable is triggering in the wrong phase, the 7.8-kHz signal suppresses one of the pulses from the line timebase and prevents it from triggering the bistable. This then stays in the same state for two lines and so comes into proper phase. This so-called identity circuit functions at most once every time the set is switched on in normal operation, but it is essential.

The 7.8-kHz signal thus generated is also used for the colour killer. It is rectified and smoothed (31) to produce a d.c. bias which is applied to an amplifier (4) in the chrominance channel. This is otherwise biased beyond cut-off.

When a monochrome signal is received there is no colour burst. Therefore, no 7.8-kHz signal is generated and the chrominance channel is blocked so that noise or interference cannot be passed to the tube grids through the chrominance channel. With a colour signal, the swinging burst produces the 7.8-kHz signal which renders the chroma channel operative.

Reverting to Fig. 4, the oscillator is connected across winding 1 of T_1. Windings 1 and 2 form an auto-transformer and the voltage across the two is twice that of the oscillator. This is applied to the *CR* circuit and ideally when the reactance of *C* is equal to the resistance of *R* the voltage across the primary of T_3 equals that supplied by the oscillator but is 90° to it in phase.

The outputs of T_2 and T_3 are applied through resistors to the two diode bridges, the precise action of which is treated more fully in the Appendix. When the diodes are non-conductive the inputs are isolated from the outputs. This is during the negative half-cycles of the oscillator inputs. During the positive half-cycles all four diodes of a bridge conduct and the input is joined to the output through the forward resistances of the diodes.

In Fig. 3, the outputs of the demodulators (8) and (9) are applied to low-pass filters (10) and (11) and thence to the first video amplifiers (12) and (13). These stages feed two output stages (16) and (20), which are valve stages, and which feed the grids of the red and blue guns.

It is necessary to produce a $G - Y$ signal from the $R - Y$ and $B - Y$ signals. This is done in a matrix circuit (14). Suitable fractions of the $R - Y$ and $B - Y$ signals developed at the emitters of (12) and (13) are added together. Basically, we add 0.51 $(R - Y)$ to 0.186 $(B - Y)$, and this gives us $Y - G$. To reverse the phase the signal is applied to the emitter instead of the base of the input green channel amplifier (15) and thence to the output stage (18).

All three output stages are capacitively coupled to the tube grids and each is provided with a black-level clamp (17), (19) and (21) driven by a pulse from the line timebase.

The theoretical proportions of the $R - Y$ and $B - Y$ signals quoted above to produce $G - Y$ are not used in practice. Also the gains of the three amplifiers are not required to be identical. There are various factors which account for this. In the transmission the amplitudes of the two chroma signals are deliberately made unequal in the ratio $0.877/0.493 = 1.785$ red to blue. Instead of adding $0.51/0.186 = 2.74$ times as much $R - Y$ as $B - Y$ to get $G - Y$, we have to add $2.75/1.785 = 1.54$ times as much only. In addition to this the $B - Y$ amplifier gain must be 2.74 times that of the $R - Y$ to bring the outputs to the proper ratio.

In practice, the gain of the $R - Y$ amplifier is fixed, and adjustments for gain are provided in the $G - Y$ and $B - Y$ amplifiers. In addition, there is a matrix adjustment to control the $G - Y$ input. These adjustments enable correction to be made for variations of components and for the unequal sensitivities of the three guns of the colour tube.

When considering what happens, and especially when trying to diagnose the cause of some fault, there is one trap which must be avoided. This is the tendency to think that the $R - Y$ and $B - Y$ outputs of the synchronous detectors affect only the red and blue guns respectively. This is true after the first stages of the chrominance amplifiers. In these stages, however, the matrixing takes place and in them and before them the $R - Y$ and $B - Y$ signals each affect the inputs to all the guns.

The diagram of Fig. 5 is helpful in understanding what goes on. It illustrates the waveforms during one scanning line when the picture is a set of vertical colour bars in the order left to right, white, yellow, cyan (which is a kind of pale blue) green, magenta, red and black. The Y, $R - Y$, $G - Y$ and $B - Y$ waveforms at video frequency are shown. It is particularly to be noticed that some of the colour-difference waveforms become negative.

The envelopes of the $R - Y$ and $B - Y$ signals modulated

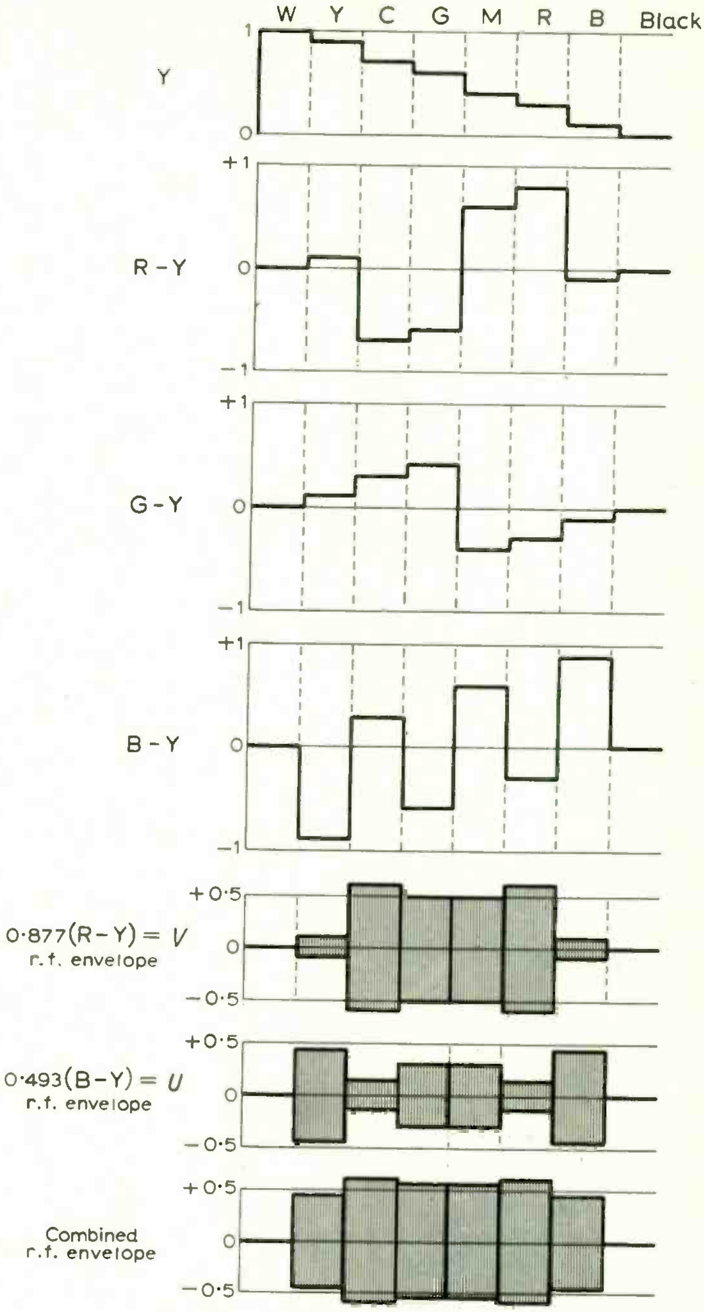


Fig. 5 Theoretical waveforms during one scanning line for a set of vertical colour bars in the order white, yellow, cyan, green, magenta, red and black.

on their sub-carriers and reduced in amplitude to the proper proportions are also shown; these are the waveforms which are designated *V* and *U* earlier in this article.

Their addition to form the composite chrominance signal must be performed vectorially, because the carriers are in phase quadrature. Their combination is shown in the diagram.

In the receiver the top waveform *Y*, but reversed in phase to be $-Y$, is the signal applied to the c.r.t. cathodes from the luminance amplifier. The next three waveforms are the ones applied to the grids, but modified somewhat in amplitude to take into account the differing sensitivities of the three guns and phosphers.

The waveforms $R - Y$ and $B - Y$ also exist at the outputs of the synchonous demodulators and at the bases and emitters of the first-stage $R - Y$ and $B - Y$ chrominance amplifiers, while $G - Y$ inverted will appear at the emitter of the $G - Y$ stage.

If delay-line PAL is used the *V* and *U* waveforms appear at the inputs to the $R - Y$ and $B - Y$ demodulators but, with simple PAL, it is the composite waveform at the bottom which is applied to both.

It may not be obvious at first how a negative colour-difference signal is conveyed in the modulation, for as they are drawn the modulation envelopes show no distinction between positive and negative video signals. There is no difference in the envelopes, but for a negative video signal the phase of the sub-carrier is at 180° to that for a positive signal.

Consider the $B - Y$ signal on green and magenta. On green the video amplitude is -0.59 while on magenta it is $+0.59$. The modulated envelopes are identical but the sub-carrier phase is the normal one quoted earlier for magenta, but is 180° out of phase with this for green.

Taking these two colours again, for green, $R - Y = -0.59$ and $Y = 0.59$, so $R = 0$, $B - Y = -0.59$ and so $B = 0$. Matrixing produces $G - Y = 0.41$, giving $G = 1$. For magenta, $R - Y = 0.59$ and $Y = 0.41$, so $R = 0.18$; $B - Y = 0.59$, so $B = 0.18$. Matrixing gives $G - Y = -0.41$ and so $G = 0$.

The point to notice particularly is that when a colour contains no component of red, green or blue, the fact that that particular gun is inoperative does not mean that there must be no signal on its grid. There is always a Y signal on the cathode and there must be an equal signal on the grid to cancel it. For magenta, for instance, which has no green component, there must be a $G - Y$ output to cancel the effect of the luminance signal on the cathode.

APPENDIX

The Colour Signal

The modulation of the vision carrier is

$$M = Y + C = Y + 0{\cdot}493\,(B - Y)\sin\omega t \pm 0{\cdot}877(R - Y)\cos\omega t \quad (1)$$

$$= Y + U\sin\omega t \pm V\cos\omega t \quad (2)$$

$$= Y + \sqrt{(U^2 + V^2)}\sin\left(\omega t \pm \tan^{-1}\frac{V}{U}\right) \quad (3)$$

$$= Y + A\sin(\omega t \pm \alpha)$$

The luminance signal Y and the colour-difference signals U and V are simple combinations of the gamma-corrected colour signals R, G and B from the camera tubes.

The combination of the two colour-difference signals U and V modulated on carriers in quadrature with suppressed carriers forms a signal

$$C = A\sin(\omega t \pm \alpha)$$

in which $A = \sqrt{U^2 + V^2}$ represents amplitude and $\alpha = \tan^{-1}(V/U)$ represents phase. Although each carrier is amplitude modulated the combination of the two is a frequency which is both amplitude and phase modulated. The amplitude A represents the saturation of the final reproduced colour and the phase α represents the hue of the colour.

Demodulators

In a diode bridge demodulator an oscillation $V\sin(\omega t + \phi)$ is generated locally and is applied through series resistors across one diagonal of a bridge of four diodes, as shown in Fig. 4. The diodes all conduct together whenever $\sin(\omega t + \phi)$ is positive, and they are all non-conductive whenever $\sin(\omega t + \phi)$ is negative. The diodes are thus conductive from $\omega t = -\phi$ to $\omega t = \pi - \phi$.

On the other diagonal of the bridge the chrominance signal is applied on one side and the output is taken from the other. For generality, we write this signal as $a\sin(\omega t + \theta)$. Then the smoothed output is the average value of this expression over the conductive periods of the diodes; that is,

$$\text{Output} = \frac{a}{\pi}\int_{-\phi}^{\pi-\phi}\sin(\omega t + \theta)\,d\omega t$$

$$= \frac{a}{\pi}\Big[-\cos(\omega t + \theta)\Big]_{-\phi}^{\pi-\phi} = \frac{2a}{\pi}\cos(\theta - \phi)$$

Simple PAL

For simple PAL, $a = A$ and $\theta = \pm\alpha$ and so

$$\text{Output} = \frac{2A}{\pi}\cos(\pm\alpha - \phi)$$

$$\text{If } \phi = 0,\quad \text{Output} = \frac{2U}{\pi} \propto B - Y$$

$$\text{If } \phi = \pm\frac{\pi}{2}\ \text{Output} = \frac{2A}{\pi}\cos\left(\pm\alpha \mp \frac{\pi}{2}\right)$$

$$= \frac{2A}{\pi}\sin\alpha = \frac{2V}{\pi} \propto R - Y$$

If there is an error ϵ in the phase of the local oscillator, then for the $B - Y$ output, $\phi = \epsilon$ and

$$\text{Output} = \frac{2A}{\pi}\cos(\pm\alpha - \epsilon)$$

$$= \frac{2}{\pi}(U\cos\epsilon \mp V\sin\epsilon)$$

The $B - Y$ signal (U) is thus reduced slightly in amplitude, but has added to and subtracted from it in successive lines a small amount of the $R - Y$ signal (V).

For the $R - Y$ output, $\phi = \pm\frac{\pi}{2} + \epsilon$ and

$$\text{Output} = \frac{2A}{\pi}\cos\left(\pm\alpha \mp \frac{\pi}{2} - \epsilon\right)$$

$$= \frac{2}{\pi}(V\cos\epsilon \mp U\sin\epsilon)$$

Thus the $R - Y$ output is reduced slightly in amplitude and has added to it and subtracted from it in successive lines a small amount of the $B - Y$ signal.

If pairs of lines are viewed from a sufficient distance for them to merge the spurious components average to zero, and only a small error of saturation exists.

Delay Line PAL

In this system, the signal $A\sin(\omega t \pm \alpha)$ is added to and subtracted from one which has been delayed by a whole line and which is, therefore, $A\sin(\omega t \mp \alpha)$.

Addition gives

$$A\,[\sin(\omega t \pm \alpha) + \sin(\omega t \mp \alpha)] = 2A\cos\alpha\sin\omega t$$

Subtraction gives

$$A\,[\sin(\omega t \pm \alpha) - \sin(\omega t \mp \alpha)] = \pm 2A\sin\alpha\cos\omega t$$

These reduce to $2U\sin\omega t$ for addition and $\pm 2V\cos\omega t$ for subtraction and complete separation of the $R - Y$ and $B - Y$ signals is effected prior to demodulation. The signals are applied to separate demodulators as before, but as they are separate a phase error in the local signal can only produce an effect on saturation and not on hue. Successive lines are reproduced with the same colour.

Personalities

G. G. Gouriet, F.I.E.E., for the past four years head of the B.B.C's Research Department, has become chief engineer, research and development, and will co-ordinate the work of the Research and Designs Departments. The greater part of Mr. Gouriet's career with the B.B.C., which he joined in 1937, has been spent in the Research Department. In 1958 he left the Corporation, where he was then head of the television group in the Research Department, to become technical director of Wayne Kerr Laboratories Ltd. He rejoined the B.B.C. in 1964. Mr. Gouriet is succeeded as head of the Research Department by **R. D. A. Maurice,** O.B.E., Dr.Ing., Ing.E.S.E., F.I.E.E., who has been head of the Designs Department since March last year. Dr. Maurice joined the B.B.C. Research Department in 1939 and after some years in the receiver and measurements section he transferred to the television group of which he became head in 1958 and assistant head of the Department in 1961.

K. O. Batsford, B.Sc., Ph.D., appointed head of the Materials Division of Standard Telecommunication Laboratories, Harlow, joined the organization in 1954 after obtaining a Ph.D. in surface chemistry at Queen Mary College, London University. Dr. Batsford was for several years concerned with X-ray crystallography, particularly in relation to the effects of crystal defects upon the performance of semiconductor devices. Two years ago he was made responsible for the physics and materials department. He now assumes responsibility also for the departments of chemistry of materials, and of ceramics and dielectrics.

John M. Spiers, B.A., recently appointed to the board of Multitone Electric Co. Ltd. as commercial director will continue to be responsible for the Communications Division which he has managed for the past two-and-a-half years. He graduated at Gonville and Caius, Cambridge, and prior to joining Multitone Electric, was with Mullard Ltd. and International Computers and Tabulators.

E. B. Stuttard, M.A., F.I.E.E., until recently technical manager of the Data Systems Group of S.T.C., has been appointed managing director of Racal-Milgo Ltd., recently formed as an equal partnership between Racal Electronics and the Milgo Corporation of Miami, U.S.A. The company will manufacture and market high-speed data modems (modulator-demodulators) and other

E. B. Stuttard

data transmission equipment. Mr. Stuttard, who read physics at Jesus College, Cambridge, spent three years in the Navy before going into industry. He was initially with Smith's Industries, then Hawker Siddeley Dynamics, and for the past four years has been technical manager of the Data Systems Group of S.T.C.

A. Lockett, who joined Aircraft Supplies Ltd. last year as deputy chief engineer, has been appointed chief designer. This Bournemouth-based company now manufactures the Midas aircraft accident data recorder. Mr. Lockett, who graduated from Manchester University with an honours degree in electrical engineering, spent eight years with the British Aircraft Corp. at Filton.

J. Maurice has retired as managing director of Lustraphone Ltd. but remains on the board in a consultative capacity. The new managing director is **Ronald L. Glaisher. George R. Pontzen,** technical manager, has also joined the board.

J. R. Brinkley, F.I.E.R.E., an executive director of S.T.C., has been appointed adviser to the International Telephone and Telegraph Corp. (the American parent company) on the worldwide development of mobile radio. Mr. Brinkley, who retains his technical and marketing responsibilities for S.T.C. mobile radiotelephones, joined the company in April 1967. Prior to this he had been managing director of Pye Telecommunications Ltd. since 1956.

W. S. Metcalf, B.Sc.(Eng.), M.A., M.I.E.E., has joined Cathodeon Crystals Ltd., a member of the Pye of Cambridge Group, as technical manager. Mr. Metcalf, who is 31, obtained his B.Sc. at Queen Mary's College, London, and his M.A. at Gonville and Caius College, Cambridge. He was until recently with the Cavendish Laboratories, Cambridge University, as technical officer responsible for providing specialized electronic design services to the various research groups. Mr. Metcalf has recently returned from the United States where he spent nearly a year with the Hewlett-Packard Company in California, working on advanced measurements, integrated circuitry and studying new management techniques.

R. T. A. Standford, B.Sc., F.I.E.E., has been appointed head of Transmission Systems Division at Standard Telecommunications Laboratories, Harlow. He was leader of the Communications Department at the Plessey Company's Electronics Research Laboratory, Havant, Hampshire. Before that he obtained considerable experience in defence oriented communications and radar problems at the SHAPE Air Defence Technical Centre in Holland and with the Mullard Research Laboratories at Salfords.

D. R. Morse, F.I.E.E., has been appointed by the B.B.C. chief engineer, capital projects, and will co-ordinate the work of the Building Department and the two Planning and Installation Departments (Studios and Transmitters). Since November 1965, Mr. Morse has been head of Studio Planning and Installation Department. He joined the B.B.C. in 1947 and has latterly been head of the film unit in the Planning and Installation Department.

Robert L. Slattery, B.Sc., M.Sc., has joined Advance Electronics of Hainault, Essex, as group quality controller. He will be responsible for all aspects of quality and reliability in the Advance Group of Companies. He started his career in 1960 as a graduate apprentice with the Marconi Company after leaving Manchester University where he read electrical engineering for a B.Sc. Tech. degree. Later he obtained an M.Sc. in quality and reliability engineering at Birmingham University. He is 29.

Donald Woods, M.I.E.E., has been appointed as the first incumbent of the Wayne Kerr Chair of Measurement Science at the University of Surrey. His first main tasks will be the setting up of research facilities for postgraduate studies, and the planning and teaching of measurement science with the emphasis on radio-frequency measurements and standards. The endowment by the Wayne Kerr Company of the Chair, which is in the Department of Chemical Physics headed by Professor V. S. Griffiths, was announced in April 1967. This Department forms part of the Faculty of Biological and Chemical Sciences. Mr. Woods, who is 61, received his engineering training with Marconi's in Chelmsford. In 1935 he joined

D. Woods

the Aeronautical Inspection Directorate's Electrical Standards Laboratory where he first became interested in precision radio-frequency measurements. After war service he returned to the A.I.D. Laboratories, Harefield, as officer-in-charge of the radio and electricity section. Since 1956 he has been responsible at the Ministry of Aviation (now the Ministry of Technology) for the administration of basic research in telecommunications.

For the first time a former R.A.F. Boy-Entrant Wireless Operator has reached Air Rank. He is **Air Commodore S.M. Davidson,** C.B.E., who recently became Director of Signals (Air) at the Ministry of Defence. He joined as a Boy Entrant in 1939 and trained at No. 1 Electrical and Wireless School at Cranwell. He was commissioned in the General Duties Branch in 1942 and completed a signal leaders' course at No. 14 Radio School in 1944. In 1950 he transferred to the Technical (Signals) Branch. After work in the Air Ministry on research and development projects involving electronic equipment for current and future fighter transport and maritime aircraft, Air Commodore Davidson, who is 46, attended the Joint Services Staff College. In 1963, he was assistant commandant at R.A.F. Locking, Somerset, and later was chairman of the Joint Signals Board in Aden and Command Electrical Engineer in the Near East.

Operational Amplifiers

2. Compensation techniques and more device characteristics

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

Last month various characteristics of integrated-circuit operational amplifiers were explained in turn. This second article starts with a discussion of methods of frequency compensation applicable to these amplifiers and concludes with further information on device characteristics.

Frequency compensation of an op. amp. consists of modifying the amplifier's open-loop frequency response in such a way that a desired closed-loop response is stable; the modification ensures that the criterion for stability (last month) is satisfied. The process is generally effected by the connection of compensating networks to points inside the i.c. made accessible by the manufacturer's provision of external connections. A particular amplifier can usually be compensated in a number of different ways; the method adopted is normally the one which will optimise other aspects of the amplifier performance which are affected by frequency compensation and which are of importance in the particular application. Slewing rate (see later) and noise performance both depend on the placing and values of the compensating networks. Compensation methods advocated by different manufacturers for their amplifiers differ in detail because of circuit differences, but the general principles involved in frequency compensation are the same for all amplifiers, and once the techniques are understood stability problems should not present too serious a difficulty.

Simple lag compensation. The simplest way of effecting frequency compensation is to shunt some signal point in the circuit with a relatively large capacitor. If the attenuation introduced by this capacitor is made to start at a low enough frequency it will ensure that the closed-loop response and modified open-loop response close at a rate of 6 dB per octave and the closed-loop response will be stable. The attenuation introduced by a single capacitor is readily evaluated from the equivalent circuit (Fig. 14) where R_i represents the effective internal resistance at the point in the circuit to which the capacitor is connected. The circuit has a first order response with break frequency $\omega_c = 1/(CR_i)$. Fig. 14 shows the method applied to an amplifier having an open-loop response similar to the amplifier

* Liverpool College of Technology

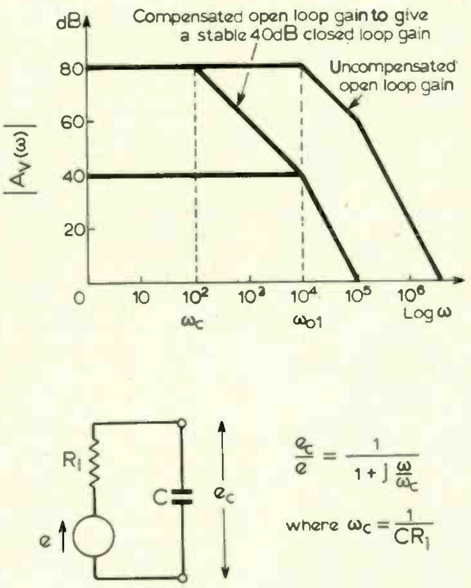


Fig. 14. Simple lag compensation.

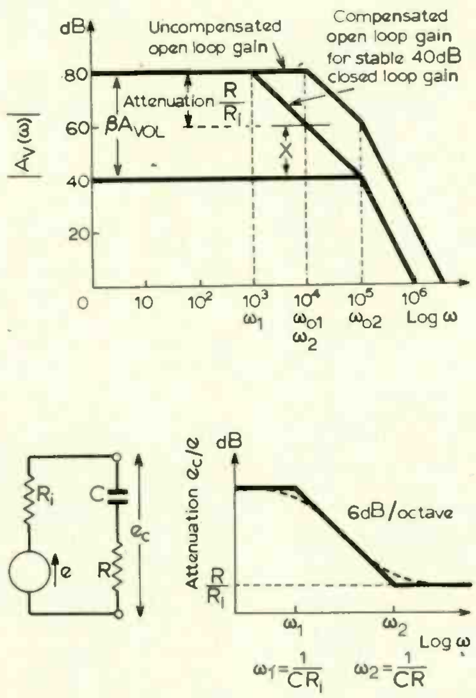


Fig. 15. Lag compensation for maximum bandwidth.

considered in Fig. 13 last month. The intersection of the modified open-loop response and the closed-loop response is arranged to take place at the first break frequency of the uncompensated open-loop response. The required value of the compensating capacitor may be calculated by using eq. (5) from last month's article. Thus

$$\frac{1}{CR_i} = \omega_c = \frac{\omega_{o1}}{1 + \beta A_{VOL}} \quad \ldots (6)$$

The equation gives the minimum value of C required to compensate for this particular closed-loop gain. For circuits having greater feedback and smaller closed-loop gains larger values of C would, of course, be required.

Lag compensation with a single capacitor is suitable for closed-loop applications not requiring wide bandwidth; an early roll-off in high frequency gain reduces broad band noise. Use of a compensating capacitor of magnitude greater than that given by eq. (6) may be advantageous in low frequency applications. It will make the circuit less susceptible to instability caused by capacitive loading or by stray capacitance in the feedback circuit. In applications requiring wider closed-loop bandwidths a method of frequency compensation which utilises part of the amplifier natural roll-off to obtain the necessary attenuation of loop gain can be used.

Compensation for maximum bandwidth with lag network. In this method of frequency compensation a series combination of a resistor R and a capacitor C is used instead of a single compensating capacitor (Fig. 15). With $R \ll R_i$ the network starts to attenuate with a break frequency $\omega_1 = 1/CR_i$ at a rate approaching 6 dB per octave and with a phase shift approaching 90°. With increasing frequency the rate of attenuation and the phase shift start to decrease. The network breaks out at a frequency $\omega_2 = 1/CR$ when the attenuation approaches its maximum value R/R_i and the phase shift returns to zero. The break out frequency ω_2 is made to coincide with the first break frequency in the amplifier natural roll-off and the resistor R is chosen so that the attenuation R/R_i enables the amplifier natural roll-off to reduce the loop gain below unity before the second amplifier break frequency. Referring to Fig. 15,

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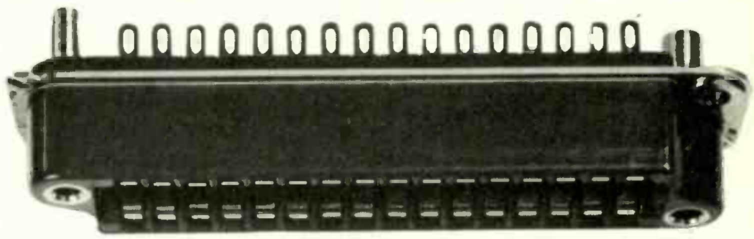

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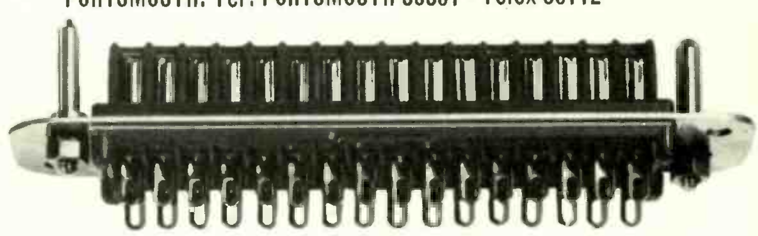

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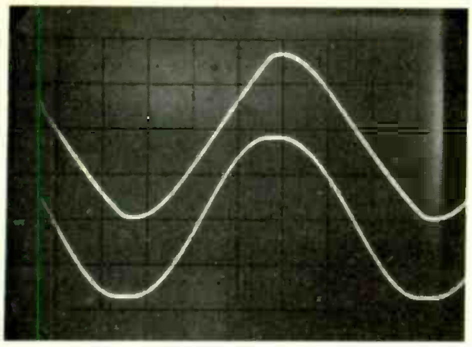


Fig. 16. Slewing rate: illustration of waveform distortion resulting from rate limiting in an MC1430P i.c. amplifier. Lower trace: input waveform; upper trace: output waveform. (Vertical scale: 2V/division. Horizontal scale 5μs/division).

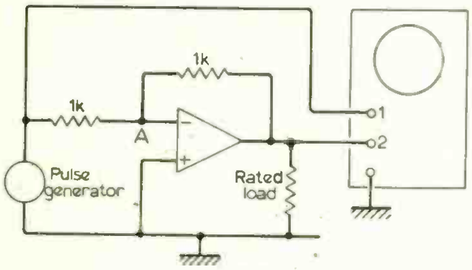
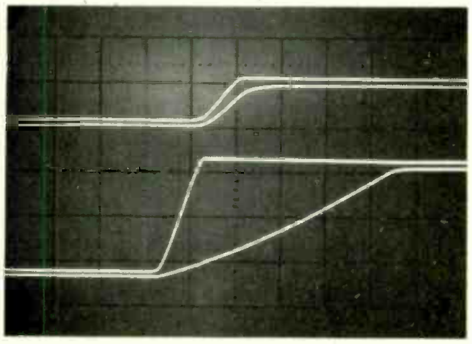


Fig. 17. (above) Test circuit for obtaining transient response. (below) Response of MC1430P amplifier obtained with the test circuit. (Vertical scale: 0·5V/division for upper pair of traces, 2V/division for lower pair. Horizontal scale 2μs/division).



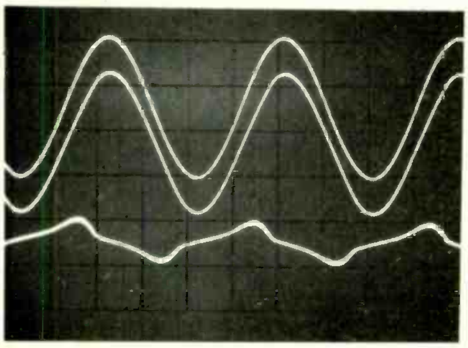


Fig. 18. Observation of error voltage as a more sensitive indication of rate limiting, using MC1430P amplifier in Fig. 17 test circuit. Upper pair of traces: input and output waveforms. Lower trace: error voltage at amplifier input

the design equation for R (is $R/R)_i$ in dB = (βA_{VOL}) in dB − (X) in dB. Once the necessary value of R has been calculated the magnitude of the required compensating capacitor is then obtained from $\omega_{01} = 1/CR$. These values give maximum closed-loop bandwidth with possibly some slight amount of peaking. If maximum bandwidth is not required additional stability margin can be obtained by reducing R and increasing C.

Lead compensation. Some i.c. op. amps are provided with compensating points whereby a small capacitor connected between them produces a leading phase shift. This moves the second break frequency in the amplifier open-loop response to a higher frequency and enables larger closed-loop bandwidths to be obtained.

Combinations of lag and lead compensation can often be used to advantage, but with wide bandwidths circuit impedance levels must always be kept low to avoid undesirable effects of stray capacitance. It is always advisable to consult the manufacturer's data sheet on an amplifier before designing frequency compensation networks; these sheets normally include a considerable amount of information on frequency compensation that is relevant to the particular type of amplifier.

Transient response, slewing rate and full output frequency. Differences exist between the large-signal and small-signal response characteristics of operational amplifiers because of dynamic non-linearities or transient saturation that can occur with large signals. Amplifiers do not generally respond to large-signal changes as fast as their small-signal bandwidth characteristics predict, for circuit and transistor capacitances can be charged only as fast as their driving circuits allow. The effect is usually specified by the **slewing rate** of the amplifier, expressed in volts per microsecond and defined as the maximum rate of change of output voltage that the amplifier can give for a large step change. This inability of an amplifier to 'slew' faster than a limiting rate can lead to distortion of sinusoidal signals with a frequency in the pass band of the amplifier, even though their amplitude is below the maximum rated output voltage of the amplifier. The type of waveform distortion produced is illustrated in Fig. 16. The lower trace shows the input waveform and the upper trace the output waveform of an amplifier connected to give unity closed-loop gain. The small signal bandwidth of this amplifier is 150kHz, but the output shows definite rate limiting and the frequency is only 25 kHz.

Manufacturers sometimes state a value of the maximum frequency for full undistorted output of their amplifiers, but care should always be taken when consulting data sheets to determine under exactly what operating conditions slewing rate and full output frequency are specified. The two quantities are closely related and both depend on the magnitude and position of the networks used to frequency compensate the amplifier and also on the particular feedback circuit in which the amplifier is used. Frequency compensating networks connected to a point in the circuit nearest to the input give the fastest slewing rates, but unfortunately here they have a minimum effect in reducing amplifier noise. A combination of compensating networks at input and output is usually found to give a reasonable compromise between fast slewing rate and low noise.

The transient response of an amplifier under particular circuit conditions can be investigated using a test circuit of the type shown in Fig. 17(top). The amplifier is connected as an inverter and is driven by a pulse or square-wave generator having adjustable rise and fall times. In the test described here the amplifier (Motorola Type MC1430P) is used with 1kΩ input and feedback resistors giving unity closed loop gain; frequency compensation (not shown) is applied to ensure closed loop stability. A double beam c.r.o. having much greater bandwidth than the amplifier under test is used to display input and output waveforms.

The following test procedure is adopted. Starting with the smallest signal that can be conveniently viewed on the c.r.o., the starting points of the signals applied to the two channels are superimposed with channel 1 inverted by the c.r.o. controls. The rise time of the input pulse is progressively decreased and the fastest rise time at which the two traces coincide is determined (upper two traces). This rise time is a measure of the closed-loop small-signal transient response of the amplifier. The oscillogram indicates a rise time of approximately 2 microseconds. The closed-loop small-signal bandwidth of this amplifier is 150 kHz. Rise time and bandwidth are related by the approximate relationship $f = 1/(0{\cdot}3T_r)$. The amplitude of the input signal is now progressively increased, the sensitivity of the oscilloscope channels being proportionately decreased. The two traces progressively diverge because of rate limiting. The slope of the channel 2 trace gives the slewing rate of the amplifier for that amplitude of output signal. The oscillogram (lower trace in Fig. 17) indicates a slewing rate of approximately 0·5 V/μs.

The same test circuit shown in Fig. 17 may be used to measure the maximum frequency for full output for the amplifier, the pulse generator being replaced by a sinusoidal signal generator. The signal amplitude is set to the rated output maximum of the amplifier at some low frequency; keeping the amplitude constant, the frequency is increased until distortion is evident. It is difficult to detect the onset of distortion if the output signal of the amplifier is viewed. A more sensitive measure of the onset of distortion is given by observation of the error signal at the amplifier input (point A). In Fig. 18 the two upper traces show input and output waveforms with little evidence of distortion; the lower trace shows the error voltage at the amplifier input with clear evidence of distortion. A value of 22 kHz is obtained for the maximum frequency for full output for the amplifier in this particular circuit.

The maximum frequency for full output without distortion and the slewing rate both measured at unity closed-loop gain are for many amplifiers related by the equation

$$\text{slewing rate,} \quad S = \frac{de_o}{dt_{max}} = 2\pi f_p E_o$$

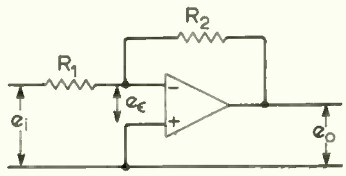
The equation is readily derived by differentiation of $e_o = E_o \sin \omega t$. The results of the measurements described, $S = 0{\cdot}5$ V/μs and $f = 22$ kHz, give an approximate agreement with this relationship.

At higher closed-loop gains with less loop gain output distortion increases and the maximum frequency for full output is generally less than when measured at unity gain.

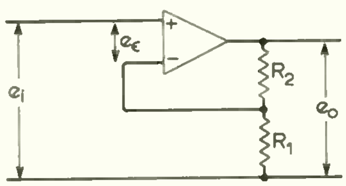
Part I Appendices

The following three diagrams were omitted from the appendices in Part I of this series (February issue, p. 58)

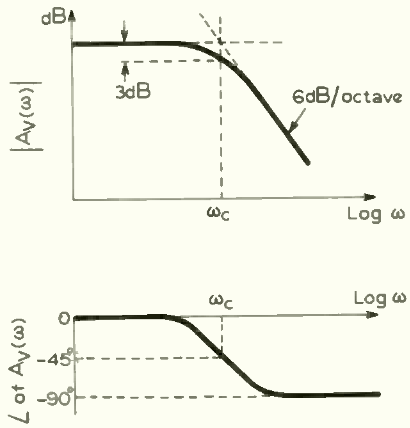
Appendix 1 Inverting amplifier



Appendix 2 Non-inverting amplifier



Appendix 3 First-order systems



Next month's article will be devoted to the applications of operational amplifiers. The availability of these devices makes possible a new approach to electronics design—the selection of a suitable op. amp. and the connection of a few discrete components to it—which offers considerable simplification since it frees the engineer from amplifier design problems.

Resilient Variable Resistor

The carbon-pile regulator brought up to date

A new mechanically variable resistance element of great versatility was on show at the recent Inventions and New Products Exhibition in London. In its simplest form, the "resilient variable resistor" is a two-terminal device whose resistance falls as pressure is applied. When the pressure is released, the device reverts to its original shape and resistance, hence the description "resilient". The r.v.r. is made from a mass of porous elastic material such as foam rubber, foamed polyurethane or foamed polystyrene. The essential criteria are that the material should be resilient and that is should have an open-cell structure. Conductive particles, such as powdered graphite, are introduced into the cells or added to the raw-material "mix" before foaming. Compressing the material increases the number of contacts between particles, and so lowers the resistance. The general form of variation is shown in Fig. 1.

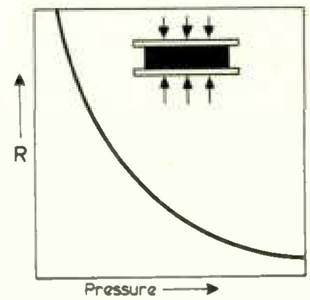


Fig. 1. Manner in which resistance varies with pressure.

The ratio of maximum to minimum resistance is more than ten when a uniform resitive body is used, but can be greatly increased by introducing nonlinearities. A possible form of wide-range variable resistor is shown in Fig. 2. A cavity is cut out of the main resistive body and partially filled with low resistance material. As pressure is applied, the initial resistance is high but eventually the upper contact plate touches the low-resistance body and the resistance falls abruptly. Resistance ratios in the region of 100,000 have been achieved using relatively crude structures. By shaping the various regions of the resistive mass the law may be changed.

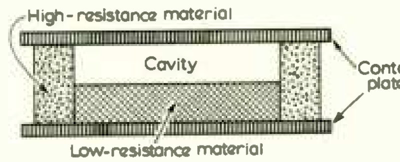


Fig. 2. Possible wide-range r.v.r.

It is claimed that laws which lend themselves well to manual speed control of small electric motors are easily obtained. This was borne out by a demonstration in which a model train was controlled by four r.v.rs in a d.c. bridge circuit (Fig. 3). This provides forward and reverse control. If desired, standby current can be reduced to zero by means of springs which lift one contact plate clear of its associated body of resistive foam when all pressure is taken off. Similarly, it is easy to arrange for the resistive mass to be short circuited by a pair of contacts which make at some desired high pressure. More complex tasks of control can be catered for by use of a joystick type of lever.

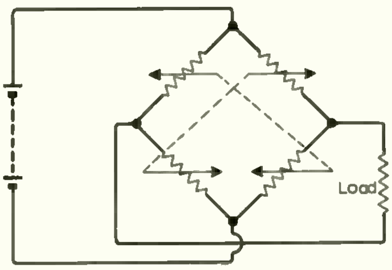


Fig. 3. Reversing motor control circuit. Opposite arms vary together.

The British patent specification 1,059,186 (15th Feb., 1957) makes proposals for a number of complex multi-electrode devices which act as potentiometers, movement sensors, pressure transducers etc. The possible applications of the r.v.r. clearly fall into "power control" and "transducer" categories. In its present form the material, so far experimental, could be put to practical use at once for low-voltage power control applications. Before serious use of the r.v.r. as a sensor can be contemplated, information about its long-term stability, repeatability, and behaviour at different temperatures will be needed. The inventor, J. H. A. Lewis of 14 Ashdown Close, Maidstone, Kent, developed the r.v.r. in his spare time.

More on Demonstrating Rectifier Action in Slow Motion

High accuracy and permanent records can be obtained by an analogue computer method

*by J. B. Swainston**

It is probably not generally appreciated how eminently suited the analogue computer is for the accurate, slow-motion demonstration of the behaviour of electronic circuitry such as the rectifier circuit discussed by Mr. T. Palmer in the February 1968 *Wireless World*†. Whilst the method outlined in the article provides a valuable, easily understood visual aid with a minimum of equipment, an analogue computer, together with an X-Y plotter, will yield more accurate results and permanent records of the circuit response.

In using the analogue computer we may take advantage of two of its most important features. The first is the ability to incorporate actual circuit hardware into the analogue program; the second is the facility for time scaling to reduce the frequencies of the phenomena being observed to a range which can be handled by the recording equipment to be used. This time-scaling is, in fact, implemented in hardware terms in Mr. Palmer's method through the use of a low frequency oscillator and a long time-constant filter following the rectifier (20-30 secs). In this account of the analogue computer approach a simulation of this low frequency circuit will be described.

Fig. 1 shows the simple rectifier circuit which is to be stimulated.

Equations describing the behaviour of the circuit are

$$I_2 = I_1 - I_3$$

$$\frac{de}{dt} = \frac{1}{C} \cdot I_2$$

$$I_3 = \frac{e}{R}$$

$I_1 = f(E_1 - e)$ (diode characteristic)

For the purposes of this exercise the following parameter values were chosen

$X = 1.6$ volts

$\omega = 0.7854$ radians/sec (7.5 cycles/min)

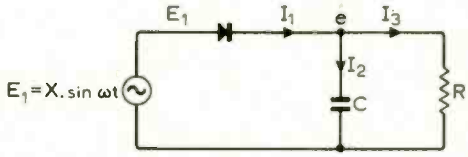
$R = 12.5\ k\Omega$

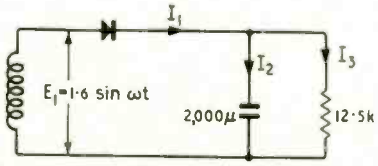
$C = 2000\ \mu F$

Fig. 2 shows the analogue computer block diagram for the simulation of this rectifier circuit in real time. A noteworthy feature of this analogue circuit is the incorporation of the rectifier in order to provide its characteristic curve. By applying across this rectifier the *actual voltage* which is applied in the real circuit (the cathode is at virtual earth) the same current will flow through it. Since this current must also pass through the feedback resistor the output voltage of this amplifier is equal to the product of this resistance and the rectifier current. It is obviously a simple matter to select the appropriate value for the feedback resistor to yield the required output scaling on the amplifier.

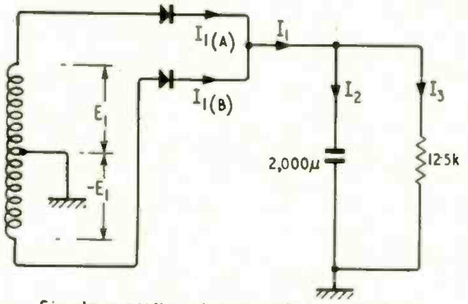
An initial condition is set on the e integrator corresponding to the "steady-state" voltage. This value is easily determined by allowing the simulation to run until the start-up transients have died away and noting the value of e at that part of the cycle at which the simulation is to be started during the demonstration.

Fig 3 shows the results obtained from this simulation. By using an X-Y recorder (or multi-channel strip recorder) we clearly demonstrate that the peak value of the rectifier current is reached before the peak value of e at that part of the cycle at which essentially exponential shapes of the current curves are obvious, something which is impossible to demonstrate using instantaneously reading meters. It is a simple matter for the student to check the current balance equation and he has a permanent record of the experimental results. Having grasped the basic principles of operation of





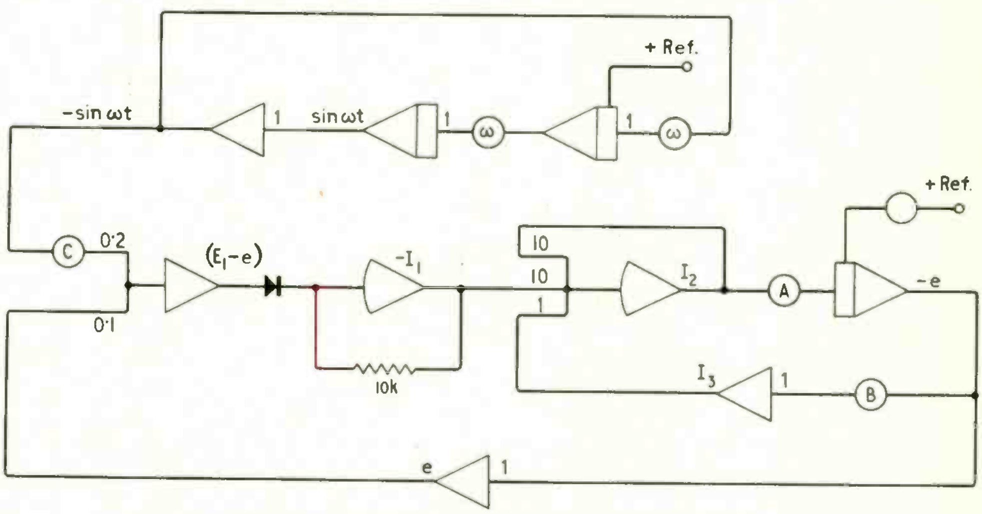
Simple rectifier circuit with single diode



Simple rectifier circuit with two diodes

Fig. 1. Simple rectifier circuit

Fig. 2. Simulation of rectifier circuit



Computer reference = 10 volts = 1 machine unit (1 M.U.)

Scaling:

Variable	1 M.U. Represents	Potentiometer	Setting
sin ωt	1		
e	1 volt	A	$\frac{1000}{C}$ (C in μF)
$E_1 - e$	10 volts		
I_1, I_2	1 milliamp	B	$\frac{1}{R}$ (R in kΩ)
I_3	0·1 milliamp	C	$\frac{X}{2}$ (X in volts)

*EAI Electronic Associates AB,
Swedish subsidiary of Electronic Associates Inc.

†Demonstrating Rectifier Action in Slow Motion, T. Palmer. *Wireless World*, February 1968, p.709.

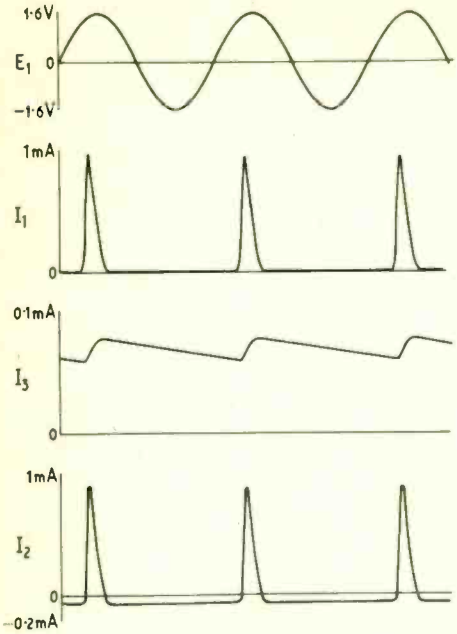


Fig. 3. Graphic results obtained from the simulated rectifier circuit

the circuit he can then experiment with different values of C and R simply by changing potentiometer settings. The start-up behaviour could also be studied. It is a simple matter to extend this method to circuits containing two or four rectifiers and to circuits with higher order filters after the rectifier.

All this can be accomplished using a modest size computer (10 amplifiers or so) such as the desk-top transistorised models at present finding wide acceptance in technical colleges and universities. Analogue computers used in this manner provide extensive facilities for the making of convincing visual aids.

"High-quality Electrostatic Headphones"

Readers of the article by Dr. Wilson, published last December, may have wondered about the safety of the phones. If one of the d.c. isolating capacitors, shown in Fig. 4, were to short itself the wearer of the phones might suffer a lethal shock. The author recommends therefore that resistors—as large as tolerable—be interposed between the output points at the amplifier and the leads. With lead capacitance in the region of 100pF, 15-kΩ resistors will result in −3dB at 20kHz. Then 25mA maximum would be available at the phones to shock the wearer. Inserting the resistors nearer to the phones would allow a higher value to be used but the remainder of the leads would be potentially dangerous. Besides the 15-kΩ resistors it is recommended that reliable 750V d.c. capacitors be used for the 0.01μF isolating capacitors.

March Meetings

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

LONDON

3rd. R.S.A.—"Educational and training technology" by Dr. R. C. G. Williams at 18.00 at John Adam St., W.C.2.

4th. I.E.E.—"Review of progress in mercantile marine radiocommunications" by C. S. Burnham and G. J. McDonald at 17.30 at Savoy Pl., W.C.2.

5th. I.E.R.E.—"The implications of educational technology" by R. A. Becker at 18.00 at 9 Bedford Sq., W.C.1.

5th. S.E.R.T.—Annual colour television lecture by D. Thompson at 19.00 at the London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

5th. I.P.R.E.—"Modern computer circuitry" by R. W. Stanton at 19.30 at Mullard House, Torrington Pl., W.C.1.

6th. I.E.R.E.—Symposium on "The possibilities of airborne detection of clear air turbulence" at 10.30 and 14.00.

6th. I.E.E.—"International collaboration in radio science" Appleton Lecture by Prof. W. J. G. Beynon at 17.30 at Savoy Pl., W.C.2.

7th. R.T.S.—"New television detector" by A. S. MacLachlan at 19.00 at the I.T.A., 70 Brompton Rd., S.W.3.

10th. I.E.E.T.E.—"Are aircraft electrics too complicated?" by H. Zeffert at 18.00 at the I.E.E., Savoy Pl., W.C.2.

11th. I.E.E. & I.E.R.E.—"Nerve impulses" by Dr. A. Richens at 17.30 at St. Bartholomew's Hospital, E.C.1.

12th. I.E.E.—"Data communications" by J. H. Rhodes at 17.30 at Savoy Pl., W.C.2.

12th. B.K.S.T.S.—"Pulse code modulation sound for TV" by C. J. Dalton at 19.30 at the Royal Overseas League, Park Pl., St. James's St., S.W.1.

13th. I.E.R.E. & I.E.E.—Discussion on "Applications of digital computer systems in medical biology" at 10.00 at Savoy Pl., W.C.2.

18th. Audio Eng. Soc. (U.K.)—"Testing by tone bursts" by S. Kelly at 19.00 at the Northern Polytechnic, Holloway Rd., N.7.

19th. R.S.A.—Trueman Wood Lecture "Society and technology" by Sir Solly Zuckerman at 18.00 at John Adam St., W.C.2.

20th. I.E.R.E. & I.E.E.—"Computers and communications in the control of train movement" by Dr. D. E. N. Davies at 18.00 at the London School of Hygiene & Tropical Medicine, Keppel St., W.C.1.

20th. R.T.S.—"Automatic production testing of colour receivers" by F. J. Wixley at 19.00 at the I.T.A., 70 Brompton Rd., S.W.3.

21st. I.E.E. & I.E.R.E.—Colloquium on "Airborne and spaceborne computers" at 10.00 at Savoy Pl., W.C.2.

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.

BASINGSTOKE

5th. I.E.E.—"Electronics and the haven finding art" by W. T. Eastwood at 18.30 at the Technical College.

BATH

3rd. I.E.E. and I.E.R.E.—"Post Office Tower" by S. G. Young at 18.00 at the Technical College.

BELFAST

11th. I.E.E. & I.E.R.E.—"Education in electronics and its problems" by Prof. G. D. Sims at the Ashby Inst., Queen's University, Stranmillis Rd.

BIRMINGHAM

13th. I.E.R.E.—"The state of the art of sound reproduction" by R. Fisher at 19.15 at the Dept. of Electronic & Electrical Engineering, the University.

25th. R.T.S. & I.P.P.S.—Symposium on "Electronic display systems" at the University.

BOURNEMOUTH

20th. I.E.R.E.—"Thyristor electronics" by R. C. Dancy at 19.00 at the College of Technology.

BRADFORD

12th. I.E.E.—Faraday Lecture "Microelectronics" by P. E. Trier at 19.00 at St. George's Hall.

BRIGHTON

25th. I.E.E.—"Integrated p.c.m. telephony bit by bit" by H. B. Law at 18.30 at the College of Technology, Moulsecoomb.

BRISTOL

13th. S.E.R.T.—"Switching logic circuits" by S. L. Hurst at 19.45 at the Royal Hotel.

26th. I.E.R.E. & B.C.S.—"Machine intelligence" by Dr. R. M. Burstall at 19.30 at the University.

CAMBORNE

11th. I.E.E. & I.E.R.E.—"Industrial applications of static logic" by G. Clarke at 19.00 at the College of Technology.

CAMBRIDGE

13th. I.E.E. & I.E.R.E.—"Closed circuit television for Education" by W. G. Beacon at 20.00 at the University Engineering Labs, Trumpington St.

CARDIFF

21st. R.T.S.—"Lenses for television" by T. P. Schofield at 19.00 at Llandaff Technical College, Western Ave.

31st. I.E.E. & I.E.R.E.—"Digital data transmission" by M. B. Williams at 18.00 at the University of Wales Inst. of Science & Technology.

CARMARTHEN

19th. I.E.E.T.E.—"Lasers" by Dr. J. A. Jones at 19.30 at Pibwrlwyd Rural Technical College.

CHELTENHAM

18th. I.E.E.T.E.—"Medical electronics" by D. H. Follett at 19.30 at the North Gloucester Technical College, The Park.

CHRISTCHURCH

5th. I.E.E.—"Computer controlled telegraph message switching" by J. A. Clark and B. Ogilvy-Morris at 18.00 at the King's Arms Hotel.

COSHAM

24th. I.E.E. Grads.—"Studio techniques in radio" by D. G. M. Stripp at 18.30 at Highbury Technical College.

COVENTRY

6th. I.E.E. & I.E.R.E.—"Pulse code modulation" by G. H. Bennett at 18.30 at the Lanchester College of Technology.

DERBY

5th. I.E.E.T.E.—"Electronic variable speed drives" by C. J. Teece at 19.30 at the Demonstration Theatre, E.M.E.B. Show rooms, Irongate.

DUMFRIES

11th. I.E.E.—"Thyristor control" by W. F. Dean at 19.30 at the Kings Arms Hotel.

EDINBURGH

12th. I.E.R.E.—"Automatic control of electricity generation in a grid control area" by F. D. Boardman at 19.00 at the Napier College of Science & Technology, Colinton Rd.

27th. I.E.E.—Faraday Lecture "Microelectronics" by P. E. Trier at 19.00 at Usher Hall.

FARNBOROUGH

6th. I.E.R.E.—"Modern methods of traffic control" by D. G. Hornby at 19.00 at the Technical College.

18th. I.E.E.—"The role of graphics in computer aided design" by J. V. Oldfield at 18.30 at the Technical College, Boundary Rd.

GLASGOW

13th. I.E.R.E.—"Automatic control of electricity generation in a grid control area" by F. D. Boardman at 19.00 at the University of Strathclyde.

19th. I.E.E.—"Electronic measurement as a guide to archaeological research" by E. T. Hall at 18.00 at the S.S.E.B., Cathcart House.

26th. I.E.E. Grads.—"Computer core stores" by R. G. Whyte at 19.30 at Strathclyde University.

GUILDFORD

26th. I.E.R.E.—"Circuit design and micro-electronics" by D. R. Hester at 19.00 at the Technical College.

HOVE

11th. I.E.E.—"Application of transistor techniques to relays and protection for power systems" by M. Legg, F. L. Hamilton and J. B. Patrickson at 18.30 at the S.E.E.B., 10 Queen's Gdns.

LEEDS

11th. I.E.E. Grads.—Silvanus P. Thompson Lecture "Colour television engineering" by C. B. B. Wood at 19.00 at the University.

20th. I.E.R.E.—"Design of a TV Studio" by P. Parker at 19.00 at the Dept. of Electrical & Electronic Engineering, the University.

LEEDS

28th. S.E.R.T.—"Multiplex stereo broadcasting" by D. Holdsworth at Kitson College of Engineering & Science, Cookridge St.

LEICESTER

24th. I.E.E. Grads.—"P.O. communications" by G. M. Wash & B. Kennedy at 19.30 at the University.

LETCHWORTH

18th. I.E.E.—"Engineering in thyristor circuits" by D. B. Corbyn at 19.30 at the College of Technology.

LIVERPOOL

12th. I.E.E. Grads.—"P.C.M. as applied to the Post Office" by G. H. Bennet at 19.00 at M.A.N.W.E.B., Industrial Development Centre.

17th. I.E.E.—"Early days in radio research" by Dr. R. L. Smith-Rose at 18.30 at the University.

19th. I.E.R.E.—"Electronics in high-vacuum measurement" by R. G. Christian at 19.00 at the Dept. of Electrical Engineering and Electronics, the University.

LOUGHBOROUGH

13th. I.E.E. Grads.—"Performance of brushless synchronised motors" by R. Grigg and "Electronics in severe environments" by S. Bradley at 19.00 at the University of Technology.

MALVERN

26th. I.E.R.E.—"Reducing the cost of good reproduction" by P. J. Baxandall at 19.00 at the Abbey Hotel.

MANCHESTER

27th. R.T.S., I.E.E. & I.E.R.E.—"The E.M.I. Colour camera" by J. P. James at 19.00 at Granada Studios.

NEWARK

26th. I.E.R.E.—"Colour television" by H. V. Sims at 18.30 at the Technical College.

NEWCASTLE-UPON-TYNE

3rd. I.E.R.E. & I.E.E.—"Colour television" by B. J. Rogers at 18.30 at Rutherford College of Technology.

5th. S.E.R.T.—"Closed circuit television" by J. B. Kitching at 19.00 at the Charles Trevelyan College, Maple Terrace.

25th. I.E.E.—Faraday Lecture "Microelectronics" by P. E. Trier at 19.15 at the City Hall.

NEWPORT

28th. I.E.E.—"Stereophonic broadcasting" by G. J. Phillips at 18.30 at the Isle of Wight Technical College, Hunnyhill.

PAISLEY

18th. I.E.E.—"Computer aided instruction" by Capt. G. Huggett at 18.00 at the College of Technology.

PLYMOUTH

5th. R.T.S.—Fleming Memorial Lecture "Digital methods in television" by A. V. Lord at 19.30 at the studios of Westward Television Ltd.

21st. R.T.S. & R.T.R.A.—"Colour television—convergence and purity" by Ian Nicholson at 19.45 at the Continental Hotel.

PONTYPRIDD

28th. S.E.R.T.—"Automatic control systems" by W. J. Lambert at 19.30 at the Glamorgan College of Technology, Llantwit Rd., Treforest.

PORTSMOUTH

19th. I.E.E. Grads.—"Flexible modular data handling system for satellite use with particular reference to the Black Arrow programme" by E. K. Crompton at 18.30 at the College of Technology.

PORT TALBOT

20th. I.E.E.—"Colour television receiver design and maintenance" by G. D. Barnes at 18.00 at the Steel Co. of Wales.

READING

17th. I.E.E.—"Automatic landing of aircraft" at 19.30 at the Great Western Hotel.

27th. I.E.R.E.—"Electronic components, past, present and future" by G. W. A. Dummer at 19.30 at the J. J. Thomson Physical Lab, the University.

ST. HELENS

27th. I.E.E. Grads.—"Critical path analysis and P.E.R.T." by A. B. Hodgkiss at 19.00 at the Technical College, Water St.

SEASCALE

13th. I.E.E.—"Concorde electronics" by H. Hill at 19.30 at the Windscale Club.

SOUTHAMPTON

12th. I.E.E. & I.E.R.E.—"V.L.F. radio communication" by R. D. Holland at 18.30 at the Lanchester Theatre, the University.

SWANSEA

13th. I.E.E.—"The engineering of thyristor circuits" by D. B. Corbyn at 18.15 at University College.

Conferences and Exhibitions

Further details are obtainable from the addresses in parentheses

LONDON

Mar. 10-13 — Alexandra Palace
Physics Exhibition
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

Mar. 10-13 — Alexandra Palace
Scientific Instruments Exhibition
(Scientific Inst. Mftrs. Assoc., 20 Peel St., London W.8)

Mar. 10-14 — Earls Court
Medical Engineering and Automation Exhib.
(Industrial Exhibitions, 9 Argyll St., London W.1)

Mar. 11-13 — Kings Head, Harrow
Public Address Show
(Assoc. of Public Address Engrs, 394 Northolt Rd., Harrow, Middx.)

Mar. 25-29 — Earls Court
Laboratory Apparatus & Materials Exhib.
(U.T.P. Exhibitions, Racquet Court, London E.C.4)

CAMBRIDGE

Mar. 26-28 — Selwyn College
Elementary Particles
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

CRANFIELD

Mar. 23-26 — College of Aeronautics
Aerospace Instrumentation Symposium
(N. O. Matthews, Department of Flight, College of Aeronautics, Cranfield, Beds.)

MANCHESTER

Mar. 31-Apr. 3 — The University
Atomic and Molecular Physics
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

NOTTINGHAM

Mar. 25-27 — The University
Interactions among Elementary Excitations in Solids and Liquids
(I.P.P.S., 47 Belgrave Sq., London S.W.1)

SOUTHAMPTON

Mar. 25-27 — The University
Lasers and Opto-Electronics
(I.E.R.E., 9 Bedford sq., London W.C.1)

OVERSEAS

Mar. 2-11 — Leipzig
Spring Fair
(Messehaus am Markt, DDR-701 Leipzig)

Mar. 4-8 — Basel
Industrial Electronics Exhibition
(Sekretariat INEL 69, CH-4000, Basel 21)

Mar. 5-7 — Washington
Accelerator Engineering & Technology
(E. H. Eisenhower, Center for Radiation Research, National Bureau of Standards, Washington, D.C. 20234)

Mar. 5-16 — Sao Paulo
British Industrial Exhibition
(Industrial & Trade Fairs, Commonwealth House, New Oxford St., London W.C.1.)

Mar. 6-7 — Huntington Beach
Acoustical Holography Symposium
(Douglas Advanced Res. Lab., McDonnel Douglas Corp., 5251 Bolsa Ave., Huntington Beach, Cal.)

Mar. 6-11 — Paris
Festival du Son
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15e)

Mar. 12-14 — Cologne
Microwave Techniques
(H. H. Burghoff, Stresemann Allee 21, 6 Frankfurt/Main 70)

Mar. 18-30 — Rome
Electronics, Radio & TV Show
(Rassena Int. Elettronica, Via Crescenzio 9, 00193 Rome)

Mar. 24-27
Scientific Congress on Electronics
(Rassena Int. Elettronica, Via Crescenzio 9, 00193 Rome)

Mar. 24-27 — New York
I.E.E.E. Convention & Exhibition
(I.E.E.E., 345 E. 47th St., New York, N.Y. 10017)

Mar. 24-27 — Munich
Semiconductor Device Research
(H. H. Burghoff, Stresemann Allee 21, 6 Frankfurt/Main 70)

Mar. 24-28 — Paris
Remote Data Processing
(Soc. Francaise des Electroniciens et des Radio-electriciens, 10 av. Pierre-Larousse, Malakoff)

Mar. 25-27 — Mannheim
Data Transmission
(H. H. Burghoff, Stresemann Allee 21, 6 Frankfurt/Main 70)

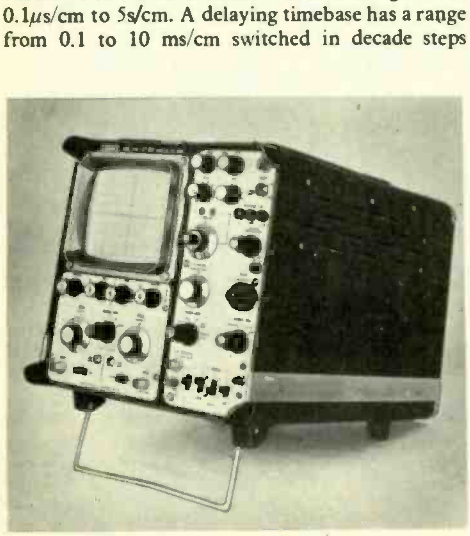
Mar. 28-Apr. 2 — Paris
Components & Electro-acoustics Show
(Fed. Nat. des Ind. Electroniques, 16 rue de Presles, Paris 15e)

Mar. 31-Apr. 2 — Cambridge
Electrohydrodynamics
(Prof. J. Melcher, c/o Dept. of Elec. Eng., Massachusetts Inst. of Tech., Cambridge, Mass. 02139)

New Products

Two Cossor Oscilloscopes

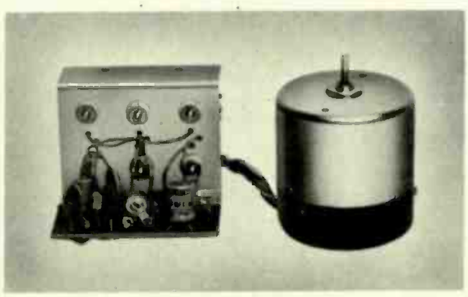
The CDU.150 is the commercial version of the military CT.531 oscilloscope from Cossor which has been chosen by the Government's Joint Departmental Radio and Electronics Measurements Committee to be the general purpose oscilloscope for the armed forces. This double-beam 'scope has a d.c. to 35MHz bandwidth at 5mV/cm sensitivity and a 1-M Ω input impedance shunted by 25pF. The measuring accuracy is $\pm 3\%$. Operating modes are: channel one only; channel two only; alternate sweep; chopped (25kHz); and added (channel one $\pm$ channel two). The Y amplifiers can be cascaded to give a 1mV/cm sensitivity with a 3Hz to 1MHz bandwidth. The two timebases (A and B) can be operated in the following modes: A only, A intensified by B, A delayed by B, and A delayed by B gated. The 22-step control and a variable control allows the A timebase to operate from 0.1μs/cm to 2.5s/cm. The decade switched B timebase, which has a ten-turn variable control, operates between 1μ/cm to 10ms/cm. A five-times magnification switch increases all sweep speeds on both timebases by five (A, 20ns/cm; B, 0.2μs/cm etc.). The X amplifier can be switched from 100mV/cm to 5V/cm with a bandwidth of d.c. to 3MHz. The rectangular flat-faced 8 $\times$ 10cm single-gun mesh tube operates at 12kV. Price is £470. The second 'scope from the same stable is the CDU.120. This double-beam instrument has a d.c. to 60MHz bandwidth at 50mV/cm; increasing the gain to 1mV/cm lowers the upper limit to 25MHz. The Y input impedance is 1M Ω shunted by 20pF and the gain can be set to within 3% using the calibrated controls. Operating modes are: channel one only; channel two only; alternate sweep; chopped (1MHz); and added (channel one $\pm$ channel two). If desired channel two can be switched as a calibrated X amplifier with 1mV/cm sensitivity and a d.c. to 6MHz bandwidth. The main timebase has a range from 0.1μs/cm to 5s/cm. A delaying timebase has a range from 0.1 to 10 ms/cm switched in decade steps with interpolation by a ten-turn multiplier. A multiplication facility is available which increases the speed of both timebases by a factor of ten (10ns/cm). The timebase offers a large number of switched facilities. The c.r.t. is a single-gun mesh p.d.a. tube with an 8 $\times$ 10cm display area. The X amplifier has a 500mV/cm sensitivity and a 6MHz bandwidth. The price is £590. Cossor Electronics Ltd., The Pinnacles, Elizabeth Way, Harlow, Essex.



WW304 for further details

Micro-motor

A d.c. micro-motor with transistor regulator equipment is announced by Sankyo of Japan. It has no slipping parts, such as brushes and commutator, and variable speed is obtained via an electronic control circuit. Clockwise or anti-clockwise revolution is possible by means of a switch, the motor characteristics being the same in either direction. The motor is designated model



ZF 200 and it is available in 9 or 12 V d.c. versions. The rated torque is respectively 1960 and 4940 μNm, and the current 280 and 350mA. Speed can be regulated within the range 1000-3000 r.p.m. Starting torque is greater than 9800 μNm and starting time less than 0.5s. Eight transistors and four diodes are employed. The motor measures 46 $\times$ 50mm. Sankyo Seiki Manufacturing Co. Ltd., 17-2, 1-Chome Shinbashi, Minato-Ku, Tokyo, Japan.

WW 305 for further details

I.C. Range for Communications

Six integrated circuits from Plessey comprising a new family, the SL600 series, are designed for professional communications and are all fully compatible. They are claimed to offer benefits to transceiver equipment designers in terms of size and performance. Devices in the range are the SL610 (r.f. amplifier), 612 (i.f. amplifier), 621 (s.s.b. a.g.c. generator), 620 (VOGAD), 630 (audio amplifier) and 640 (double balanced modulator). All are priced at £6 6s 6d for quantities of 100 or more. The SL610 wideband r.f. voltage amplifier is intended for use in the 2-76 MHz communications band and offers a signal handling capability of 250mV r.m.s. The SL612 i.f. amplifier has a voltage gain of 50 times and a bandwidth of 0.1-15MHz. Designed for use in s.s.b. receivers, the SL621 s.s.b. a.g.c. generator will follow fading signals but hold a fixed a.g.c. level during pauses in speech. The SL620 VOGAD (voice operated gain adjusting device) is claimed to be the only commercially available i.c. capable of this function. It is designed to control the gain of the SL630 when this device is used as a microphone amplifier, and will hold the amplifier output level between 70mV and 78mV r.m.s. for a 35dB range of audio input. Having a gain of 40dB, the SL630 audio amplifier will operate from any supply in the range -6V to -12V and features a wide range logarithmic a.g.c. facility. The SL640 replaces the diode ring at frequencies up to 76MHz. It eliminates transformers and requires no external adjustment for balance. Plessey Microelectronics, Cheney Manor, Swindon, Wiltshire.

WW322 for further details

Temperature Measuring Instrument

Surface temperatures in refrigeration systems through to heating systems, or temperatures of metal and plastics mouldings, can be monitored by the Mini-T range of temperature measuring instruments by Polkinghorne Industries. Three basic models, priced at about £10 each, cover respectively -50 to 100°F (-46 to 38°C), 100 to 250°F (38 to 121°C) and 250 to 400°F (121 to 204°C). Features include an accuracy of ± 2°F with a linearity of 0.2%. Response time is 5 to 10 seconds. A 1m probe houses a thermistor sensor. Operating power is obtained from an internal stabilized power supply. The unit case measures 76 $\times$ 70 $\times$ 65mm and is constructed of polystyrene. Polkinghorne Industries Ltd., Lillyhall Industrial Estate, Winscales, Workington, Cumberland.

WW 320 for further details

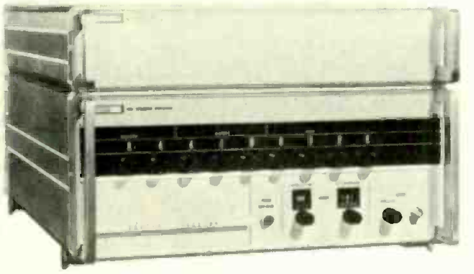
MF/HF Communications Receiver

A new general-purpose communications receiver by Redifon, model R550 "Altair", provides continuous frequency coverage from 200kHz to 30MHz. In the basic receiver, frequency synthesizer controls are used to set MHz $\times$ 10, MHz $\times$ 1 and kHz $\times$ 100 with a direct reading digital display, the rest of the tuning process being carried out on a v.f.o. dial. The v.f.o. has a 100kHz sweep with digital read-out in steps of 0.1kHz. Further subdivisions of the final digit give a resolution down to 10Hz and a frequency accuracy of the order of 20Hz. Frequency synthesis of the tuning process can be completed down to 0.1kHz steps with an optional add-on adaptor. The receiver is solid-state and operates in c.w., m.c.w., d.s.b. and s.s.b. modes. A second add-on adaptor is available for i.s.b. reception. Front-end protection is provided against very strong aerial e.m.fs of up to 30V with additional fuse protection for e.m.fs in excess of 30V. Interlinked front-end and intermediate frequency a.g.c. systems are employed. The a.g.c. has a 130dB range; a change of 110dB in input signal results in an output change of less than 1dB. Double conversion is employed with intermediate frequencies of 38MHz and 1.4MHz. Intermediate frequency bandwidths can be selected at 0.2, 1 or 3kHz for c.w; 1 or 3kHz for m.c.w; 3, 6 or 12kHz for d.s.b; and 3kHz for upper or lower sideband on s.s.b. or i.s.b. (or 6kHz to order). The squelch level is adjustable and to guard against incorrect setting the squelch does not completely cut-off the output but reduces it by 26dB to indicate that the receiver is still operative and to allow wanted signals to be heard. Sensitivity can be as high as 0.5μV for 0.5W a.f. output. Outputs

include an internal loudspeaker and two earphone sockets with separate provision for an external loudspeaker. Also provided are a 600-Ω line output and a 1.4-MHz i.f. (90mV across 50 Ω) output. The receiver is normally operated from mains supplies of 100/125V, 200/250V 47—63Hz and in emergency it can be operated from a 24V d.c. supply. Redifon Ltd., Communications Division, Broomhill Road, London S.W.18.
WW 306 for further details

Frequency Synthesizers

Coming in three basic models, 622A, 633A and 644A, a range of solid-state frequency synthesizers covering respectively 0-2MHz, 0-11MHz and 0-40MHz is announced by Fluke International. The frequency increments on each are 1Hz with 0.1Hz as an optional extra, and non-harmonically related signals are at least 90dB below the fundamental over the greater part of the frequency range of each type. Phase noise is also low, the signal-to-noise ratio varying from 56dB on the 644A to 64dB on the 622A. All models include a

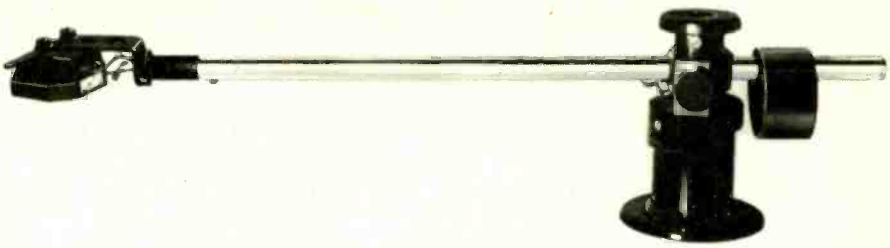


sweep/search oscilllator operating symmetrically about the chosen frequency. In the sweep mode, the triangular waveform employed obviates hysteresis effects during the return sweep. The provision of special configurations for particular purposes is afforded by the modular design. Basic prices including duty are: 622A £3567, 633A £3338 and 644A £5749. Fluke International Corporation, Greycaines House, Greycaine Road, Watford, Herts.
WW 321 for further details

Pickup Arm and Remote Cueing Unit

Decca have recently released for home market distribution their International pickup arm and the Deccalift remote pickup control. The International p.u. arm employs magnetic bias compensation with three magnets arranged in repulsion to provide accurate neutralization of the forces which draw the pickup head towards the centre of the record. This is adjustable to suit different playing weights. The only bearing surface in the arm is an inverted jewelled universal pivot which enables the arm to move both laterally and vertically with negligible resistance to motion. Where lateral and vertical damping is reqnired, a damping fluid, supplied in a container with the arm, can be poured into a depression at the top of the pickup barrel and allowed to trickle through into a small chamber below, where it serves to retard movement of the arm in all directions. Magnetism is also used as the method of support for the p.u. arm, thus reducing rumble and shocks to the assembly. A novel way of checking the counter-balance for correct playing weight makes use of a length of solder, inserted in a slot behind the counter-weight and cut to the length indicated on a chart to simulate the required playing weight. Adjustment is made for correct balance, after which the solder is removed.

Deccalift is a motorized raising, lowering and cueing device which can be controlled remotely or from a switch on the motor-board. A 6V a.c. supply is required for the motor which can be



obtained from a valve amplifier heater supply or via a mains voltage step-down transformer (a 6V bell transformer would be suitable). The Deccalift is not recommended for use with autochangers. Prices: International pickup arm 25gn, Deccalift 8gn. Decca Special Products, Ingate Place, Queenstown Road, London, S.W.8.
WW 334 for further details

R.F. Heating Triode

The second of a series of industrial ceramic triodes from E.E.V. is a forced-air cooled type (BR1183) for industrial induction and dielectric r.f. heating. In construction, the filament/grid terminal is coaxial and the air-cooled radiator is integral with the anode. Ceramics replace glass. The BR1183 can operate at full ratings up to 50MHz, giving an output of 70kW under class C unmodulated conditions. Overall nominal length of the triode is 406mm and overall nominal diameter is 254mm. Weight is 18kg English Electric Valve Co. Ltd., Chelmsford, Essex.
WW 309 for further details

Gunn-effect Devices

Three new Gunn-effect devices announced by Mullard operate over the frequency range 12 to 18GHz. The three devices have the development type number 803CXY followed by a suffix to indicate the power output. Devices with the suffix A have an output of 5mW; suffix B, 10mW; and suffix C, 15mW. They are encapsulated in miniature pill packages which are suitable for coaxial or waveguide cavities. The devices require a supply of only 6V d.c. and are suitable for use as local oscillators in J-band (12—18GHz) radar systems, test signal sources and transmitters and local oscillators in miniature doppler radar equipment. Mullard Ltd., Torrington Place, London, W.C.1.
WW 307 for further details

Video Test Equipment

Three companion video signal generators announced by E.I.L. of Haslemere are the TVT/1/PB sine-squared pulse and bar generator, the TVT/1/S sawtooth generator and the TVT/1/LF 50Hz squarewave generator. All are designed as transportable equipment and use semiconductors throughout. Model /PB provides an output signal of 1V at 75Ω comprising a positive-going sine-squared pulse of 100ns or 200ns period for 10 and 5MHz bandwidth systems, a 25 μs duration bar and a negative-going sync pulse of 4.7μ s duration, with a repetitive time of 64 μ s (625-line TV waveform). Model /S also has a 1V 75Ω output comprising a sawtooth, superimposed with a crystal-controlled colour sub-carrier waveform at 4.43MHz. It allows non-linear distortion and differential phase/gain measurements to be made on amplifiers and transmission systems. Preset controls allow adjustment of line frequency, sawtooth amplitude and sawtooth level. Model /LF is a 50Hz squarewave generator superimposed with line suppression and sync waveforms enabling low frequency response measurements to be made of wideband systems. A 1V 75 Ω output is again provided, comprising a 20ms positive-going squarewave complete with 11ms blanking pulses and 4.7 μ s negative-going sync pulses with a repetitive time of 64 μ s. The sync waveform can be switched off while the unit is locked to external line and field sources. All of the units operate from 200-250V 40-60Hz a.c. and their prices are: TVT/1/PB £120, TVT/1/S £140 and TVT/1/LF £95. Electrocraft Instruments Ltd., Coombeswell, Farnham Lane, Haslemere, Surrey.
WW 329 for further details

Service Aids

Two hand-held pressurized container spray products by Kontakt-Chemie of West Germany with applications in the radio and television field, have recently become available in this country. One is a colloidal graphite product which can be sprayed to any thickness to provide a conductive coating. It adheres firmly to glass, plastics and other smooth surfaces where it acts as an effective screen. The other is a soldering varnish for printed circuits where it functions as a soldering agent and a protective coating preventing the oxidization of platinums. It is equally suitable for production work or service. Each container holds 450g of fluid. The Graphit-Spray 33, as it is called, costs 21s, and the soldering lacquer SK10, 12s 6d. Special Products Distributors Ltd., 81 Piccadilly, London W.1.
WW 308 for further details

Microwave Signal Sources

Continuous tuning over the frequency range 850 to 2150MHz is a feature of a new microwave signal source, type 6055, by Marconi Instruments Sanders Division. Of solid-state construction this instrument includes internal amplitude modulation, digital readout of operating frequency and low residual f.m. of the order of 1 p.p.m. The transistor oscillator, tuned by a resonant line terminated in a variable capacitance, operates at fundamental frequency. This frequency is indicated by a four-digit mechanical counter. Maximum output is typically 100mW into a 50 Ω load: the square-wave modulation is at a nominal frequency of 1kHz, variable over a 200Hz range. The instrument contains its own power unit and a wide range of coaxial components is available as accessories. Dimensions of the 6055 are: 100 × 286 × 204mm and weight is 5kg. Two further microwave signal sources, types 6457 and 6458 are similar in design and complement each other, the 6457 covering the range 1.5 to 5GHz and the 6458 the range 4 to 12GHz. The instruments are highly stable and feature a direct reading 1% frequency dial, internal sawtooth f.m.

and square-wave a.m., and provision for external modulation by sine or sawtooth waveforms. The r.f. signal is klystron driven, a non-contacting piston tuning the coaxial resonator. A high resolution potentiometer, ganged to the tuning shaft, forms part of an automatic tracking network, which maintains optimum reflector potential conditions as the tuning is varied. Output from the oscillator is drawn via a capacitive probe, which is integral with the coaxial socket. The output level is controlled by the probe's penetration into the resonant cavity. Both f.m. and a.m. can be applied to the signal internally or externally. The internal square-wave a.m. generator can be varied from 1 to 4kHz by a panel control. The sawtooth f.m. generator operates at 1.2kHz. Marconi Instruments Ltd., Sanders Division, Gunnels Wood Road, Stevenage, Hertfordshire.
WW301 for further details

Clock Waveform Modules

A stable 1:1 mark-space ratio clock waveform over a wide range of frequencies is offered in a new series of digital clock modules (series 420) from Arcturus Electronics. These are claimed to be capable of driving most major types of i.c. logic directly. Frequency stability is governed by an external crystal providing an a.c. voltage which is divided down to give a dual-phase square-wave output. A single 5-V power supply is required. Connecting pins are spaced at multiples of 0.1in. for use with standard circuit boards. Output frequencies are available in two ranges of 50-500kHz and 500-5000kHz and output "high" state voltage is 2.4V; "low" state 0.4V. Epoxy resin encapsulation is used. Oscillator crystals should be cut for parallel resonance at twice the required frequency and a 32pF capacitive load specified. Arcturus Electronics Ltd., 6 Cadogan Lane, Belgravia, London S.W.1.
WW302 for further details

R.F. Signal Generator

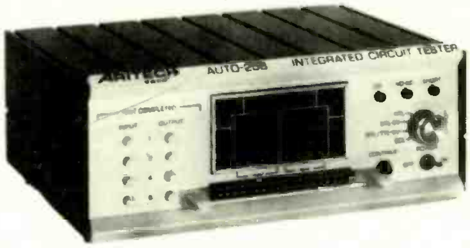
Details of two versions of an r.f. signal generator covering the frequency range 150kHz-220MHz have been released by Nombrex Ltd. Standard model 29-S operates on fundamentals with eight bandspread scales and a scale frequency accuracy within ±1.5%. Output impedance is 600Ω and the average maximum output is 100mV. The attenuator is calibrated 0-10 and is continuously variable. Modulation depth is 0-100% variable, and the modulation frequency is adjustable from 400 to 1000Hz. The instrument is powered by a 9V dry battery and there is stabilization against battery voltage variation. Model 29-X is covered by the same general specification as the 29-S but in addition it incorporates a crystal oscillator module providing harmonic calibration check points on all ranges. Using the scale calibrator panel control, which is common to both versions, a check-point accuracy of ±0.02% can be achieved. Spin-wheel tuning is available as an optional extra on both models. Dimensions of the generator are 190 × 146 × 95mm and the price is £20 (model 29-S); £27 10s (model 29-X). Nombrex Ltd., Exmouth, Devon.
WW303 for further details

Stereo Tape Recorder

A successor to the Tandberg Series 12 tape recorder is announced by Elstone Electronics. Called Series 12X, it is a self-contained stereo record and playback system using a new type of bias head which the makers claim provides exceptional frequency response at all speeds. The equipment comprises two 10W transistor amplifiers and twin internal loudspeakers, with a separate volume control for each channel and bass and treble controls. Available in 2- or 4-track three-speed versions, signal-to-noise ratio is 58dB (4-track) and 60dB (2-track). Multiple track synchronized recordings are possible. Two moving coil meters indicate recording levels. The recorder is designed for vertical or horizontal operation and costs 134gn. Elstone Electronics Ltd., Hereford House, North Court, off Vicar Lane, Leeds 2, Yorkshire.
WW330 for further details

Integrated-circuit Tester

A simple go/no-go tester which performs functional operation tests on logic i.cs has been produced by the Aritech Corporation and is being marketed by Litton Precision Products. No programming is needed since the tester will circulate any initial conditions required by the device under test. Each device is put through a se-



quence of tests, with each test taking 5ms, and a rotary switch on the front panel enables the selection of conditions of r.t.l., d.t.l., t.t.l. and e.c.l. logic. A range of adaptors is available for any i.c. family having up to 16 pins. Litton Precision Products, 95 High Street, Slough, Bucks.
WW327 for further details

Microwave Power Meter with Easy Zero Set

A microwave power meter which, with associated thermistor mounts, covers the range 10MHz to 40GHz, features what is described as automatic zero set. This means that instead of manually adjusting a control to zero the meter before making a measurement, the operator merely depresses a toggle switch momentarily. Once zero has been set on the most sensitive range, it remains accurate within 0.25% when switching from range to range. The meter (type 432A) has an accuracy of 1% of full scale on all ranges over temperatures of 0-55°C. Full-scale measurement ranges are from 10μW to 10mW. The temperature-compensated thermistor mounts are the same as those supplied with the existing 431 series power meters. These cover a frequency of 10MHz to 18 GHz in coax and 2.6 to 40GHz in waveguide. Performance improvement over previous power meters results from the use of d.c. to drive the meter's thermistor bridge circuits rather than the conventional a.f. bias current. Thermoelectric voltages from a.c. bias in the thermistors no longer affect measurement accuracy, thus enabling the 1% accuracy to be specified. Model 432A is manufactured in the U.K. and is priced at £227.

A built-in rechargeable battery pack (up to 24 hours' operation on one charge), is available for an additional £42. Hewlett Packard Ltd., 224 Bath Road, Slough, Bucks.
WW304 for further details

Amateur Band Mobile Aerial

A 2-metre-band (144-146MHz) aerial for the radio amateur has been developed by Bantex from the construction design employed in their existing half-wave aerial in use with v.h.f. commercial mobile equipment. The aerial can be trimmed for best performance at operating frequency and a special base allows easy mounting on a car roof or wing. Bantex whip aerials are embedded in a glass fibre sheath, thus providing protection against corrosion. Price including carriage: £5 2s. Bantex Ltd., Truro House, Mark Road, Hemel Hempstead, Hertfordshire.
WW328 for further details

Photo-electric Lighting Control

A lighting control unit for controlling lighting loads up to 10A at 250V a.c. without the need for separate contactors is offered by Photain Controls. It is suitable for the control of street lighting, loading bays, neon signs and all types of outdoor lighting. The new unit, type 250-10, comprises two main parts: a base with socket and mounting bracket, and a translucent plastics domed housing with plug, and containing the electronic circuitry, photoconductive cell and switching relay. A 60-second time delay prevents operation of the unit during short-term variations in ambient lighting intensity, and protection is provided against damage caused by mains voltage surges or lightning. Price: £12 19s 6d. Photain Controls Ltd., Randalls Road, Leatherhead, Surrey.
WW331 for further details

Moisture-removing Chemical Spray

Wet electrical equipment can be recovered from corrosion by timely use of their water displacing fluid say the makers of Rocket WD-40, which is supplied in an aerosol container and which removes moisture from contact with metal, rubber and plastics surfaces. Electric motors and other moisture-sensitive machinery suffering water damage in a fire can be quickly returned to working order if they are "de-watered" within 36 hours. The fluid can also be sprayed on ignition components where ignition failure is caused by moisture due to flood or damp conditions, or in any position where rust prevention is required. Two

sizes of WD-40 are available at 9s 9d and 16s 9d. U.K. distributors: Cadulac Chemicals Ltd., The Bridge, Radcliffe, Lancashire.
WW 318 for further details

Low-cost Reed Switch

A dry reed switch which can cost as little as 6d each in bulk quantities is being offered by the M-O Valve Company. Its hermetically sealed contacts provide fast switching and long life. Known as type RCX, the reed is rated to switch 5W resistive loading and the contact resistance is not greater than 150m Ω. Suitable application is where reliable low-level fast switching is required. Overall length of the glass encapsulation is 27mm. The M-O Valve Co. Ltd., Brook Green Works, Hammersmith, London W.6.
WW 319 for further details

P.C. Board Assembly Unit

An adjustable unit into which printed circuit boards of various sizes can be inserted for the purpose of assembling components has been announced by Kingham Electronics. It will accept boards up to 255 × 255mm, or numbers of smaller sizes up to 3.2mm thick. A hinged mechanism allows the board to be turned over ready for cropping and soldering and an adjustable rubber pad retains components of varying heights. A turntable is fitted to allow the board to swivel. The unit, type KAPCBU, measures 305 × 330 × 130mm high. Kingham Electronics Ltd., 17 Briary Wood Lane, Welwyn Heath, Herts.
WW 317 for further details

Bipolar L.S.I. Array

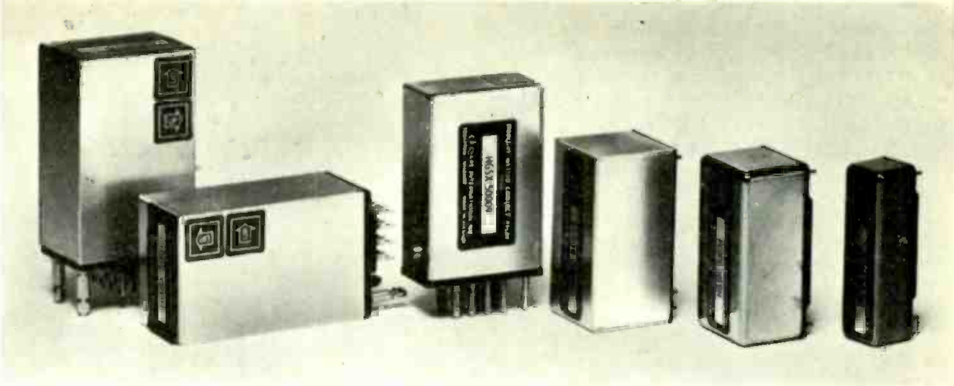
Custom designed l.s.i. circuits in which standard wafers diffused with groups of functions can be interconnected to suit a user's particular requirements are made possible by the 4500 Micromatrix system introduced by SGS Ltd. A series of cellular arrays complete except for metal interconnection layers are produced in volume and stocked at their factory. The interconnection pattern of cell functions is determined by the customer and interconnections are carried out at the factory. The 4500 array comprises eight cells, each containing four 4-input NAND gates, and it can be used to perform any function that can be carried out with 32 NAND gates and 28 bonding pads. Chip size is 80 × 100mm with an active area of 600kmm^2. The Micromatrix can be packaged in a variety of ways depending on the number of pins and the form factor required. SGS (United Kingdom) Ltd., Planar House, Walton Street, Aylesbury, Bucks.
WW 336 for further details

Lower-power F.E.T. Operational Amplifier

A quiescent current of only 500 μA characterizes the microcircuit f.e.t. operational amplifier model 1402 from Philbrick Nexus Research Ltd. Power supply voltages can be from ± 4V to ± 24V. The unit is housed in a TO-8 case. The input impedance of the amplifier is 10^{12} Ω. Bias currents of 10 pA and low wideband noise for both voltage and current are also f.e.t. characteristics. Philbrick-Nexus Research, 81a North Street, Chichester, Sussex.
WW 348 for further details

Data Communication Modules

For use in high-speed data transmission systems, requiring a square-wave pulse with fast rise and fall times, a range of modules are available from C.P. Clare Electronics Ltd. Operating speeds are up to 350 bauds with bias distortion down to 1% for specified drive conditions. The square-wave output is bounce-free, and has a rise time in the nanosecond region. Contact efficiency is high, and



transfer time is of the order of 0.5 ms. Complete isolation of 1000 MΩ is typical and the sealed contacts are capable of switching 100 W. Using solid-state single-or double-current drive gives an interface where drive power can be as low as 10 mW. To give minimum distortion at a specified frequency for transmission control, the module is adjusted on square-wave drive. For reception control, the module is adjusted on sine-wave drive. C.P. Clare Electronics Ltd., 43 Clarendon Road, Watford, Herts.
WW 347 for further details

Variable Counter/Timer

A new addition to Plessey's range of devices based on r.t.l. logic is a variable counter/divider, type SP260, comprising four binary counter elements arranged as a parallel clock counter. Any division ratio from 2 to 16 can be set by means of external connections, and control inputs are provided for selection between the full count of 16 or any other set division. Encapsulation is 14-lead flat-pack. Plessey Microelectronics, Cheney Manor, Swindon, Wiltshire.
WW 324 for further details

Tunable Pulse Magnetron

For use in linear accelerators, where a long pulse is required, English Electric have produced a mechanically tuned 1300kW S-band pulse magnetron, type M5058. Operation is possible with a pulse length up to 5 μs, giving a peak output power of 1300kW and a mean output power of 2kW. This new model has the same mechanical outline as M5015 which is for use in short pulse accelerators. Both magnetrons are tunable over the range 2994 to 3002MHz. The tuner mechanism is of low torque and is suitable for remote control by servo units via a flexible drive. Efficient cooling is ensured by an integral water-jacket. The cathode construction is sturdy: to minimize both frequency and power variations when the magnetron is orbited about a horizontal axis. English Electric Valve Company Ltd., Chelmsford, Essex, England.
WW 346 for further details

2 Watt I.C. Audio Amplifier

Two watts maximum output, 8mV sensitivity and a wide range of possible supply voltages (9V to 27V) are attractive features of the integrated circuit amplifier PA 237 made by General Electric (U.S.A.). The package is dual-in-line with 8 leads and a heat transfer tab. It is offered from stock at 28s by Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
WW 344 for further details

High-voltage Logic

Complementing their existing 9109 and 9112 high-level logic/c.c.s.l. interface elements, SGS Ltd. have introduced type 9110 d.i.l. device comprising six high-level DT μL gates without input diodes to enable more complex functions such as flip-flops or shift registers to be constructed. Main areas of application are those where the use of c.c.s.l. is not possible due to either high voltage supply or high noise. The 9110 has a V_{CC} operating range of 12-20V, minimum d.c. noise immunity of 6.5V and a.c. noise immunity of 10V at 150 ns. Output swings can be up to 18V and it will operate with high capacitance loads. SGS (United Kingdom) Ltd., Planar House, Walton Street, Aylesbury, Bucks.
WW 332 for further details

Dual Transistors

Two low-cost n-p-n silicon planar dual transistors are available froom Texas Instruments Ltd. They are packaged in 6-lead TO-5 cases and are especially suitable for low cost a.c. and d.c. amplifiers and applications where good thermal tracking between stages is required. Both devices have 50 volt BV_{CEO} leakages below 100na and minimum h_{FE} of 25 at 100μA and 40 at 10mA collector current. Typical fT is 50MHz. The component transistors of type BCW25 are matched to better than 0.7h_{FE} ratio, with V_{BE} differential of 20mV which varies less than 20mV per °C. Type BCW26 is an un-matched dual pair. Texas Instruments Ltd., Manton Lane, Bedford.
WW 345 for further details

Transcription Unit and Preamplifier

Two audio items from the Goldring company, shown for the first time at the Hi-Fi '68 Exhibition in Dusseldorf, were a transistor preamplifier unit, and the GL75 transcription unit mounted in a teak cabinet with a hinged Perspex cover and designated GL75/P. The GL75 transcription unit employs a mains-operated 4-pole constant velocity motor and a 4kg non-magnetic turntable. Wow,

flutter and rumble measurements accord to DIN specifications. The pickup arm is fitted with counterbalance weight and bias compensation and has a tracking error claimed to be ±0.8%. A removable pickup headshell can accommodate any cartridge. Model VV7 stereo preamplifier is designed for coupling high quality magnetic cartridges to less sensitive amplifiers and it is small enough to be mounted under the turntable. It has its own mains power unit and provides a gain of approximately 40dB at 1kHz. Two silicon transistor stages are employed in each channel. The VV7 measures 120 × 50 × 40mm and weighs 170g. Unit prices: GL75 /P £44 2s 8d, VV7 £8 10s. Goldring Manufacturing Co. (Gt. Britain) Ltd., 486-488 High Road, Leytonstone, London, E.11.
WW 335 for further details

Miniature Thyristors

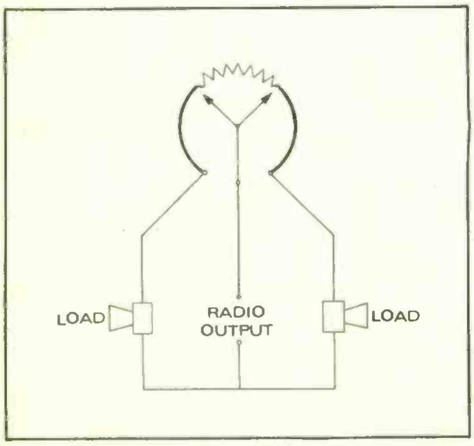
Cole Electronics of Croydon have announced that they are marketing a range of Siemens miniature thyristors in plastics housings. Four p.i.v. ratings are available between 100 and 700V, the higher rating permitting operation at normal mains voltage. Maximum d.c. current ranges from 0.85A in a half-wave circuit to 2.4A in a three-phase bridge using six thyristors with unsupported wiring (T_u = 45°C). Equivalent current ratings when the devices are chassis mounted are 3—6.6A. The minimum trigger voltage at T_u = 25°C, at which all devices will fire, is 3V and the maximum continuous gate voltage which will not initiate turn-on is 0.2V. Cole Electronics Ltd., Lansdowne Road, Croydon, Surrey, CR9 2HB.
WW 342 for further details

Single-digit Indicator Tube

A numerical indicator tube type XNS1 by Hivac contains only the digit "1" and measures 6.4mm diameter by 38mm. The makers claim that it effectively doubles an instrument's display range, e.g. 999 becomes 1999. The XNS1 provides the same character height of 16mm and glow characteristics as other side-viewing tubes in the Hivac range and is available with a clear bulb or with red or amber lacquer filters. Hivac Ltd., Stonefield Way, South Ruislip, Middx.
WW 340 for further details

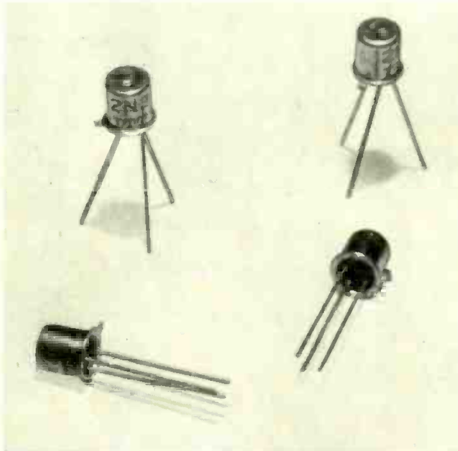
Differential Volume Control

Now available for use as a balance control for low-impedance twin speakers is Reliance Controls' type MWD wirewound potentiometer, a variation of existing type MW. Type MWD is less than 26mm in diameter and is supplied with resistances to suit customer requirements. Using a double wiper technique, a reasonably constant impedance is maintained in a circuit while giving control of volume between two outputs. Reliance Controls Ltd., Drakes Way, Swindon, Wilts.
WW 338 for further details



V.H.F. Transistor

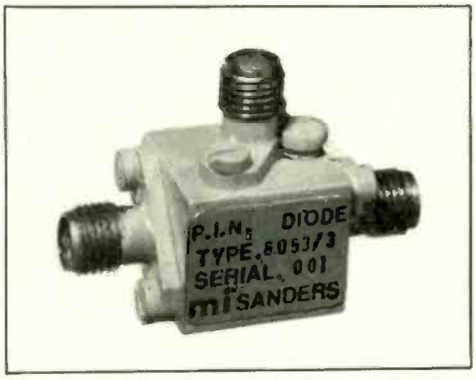
Transistor type 2N3209 by S.T.C. is a 400 MHz p-n-p epitaxial device packaged in a TO-18 case. It is designed for saturated and non-saturated switching at collector currents of up to 200mA



and for r.f. and i.f. amplifier and oscillator circuits up to 100MHz. It has a low saturation voltage and a V_{CEO} rating of 20V. S.T.C. Semiconductors Ltd., Footscray, Sidcup, Kent.
WW 333 for further details

Miniature Diode Modulator

Weighing only 0.05kg and measuring 35.6mm long, p.i.n. diode modulator type 6053/3 has been introduced by Marconi Instruments for use where cable length or available space is critical. It covers the frequency range 7.5 to 12.4GHz, and applications include amplitude modulation, r.f. switching and signal source levelling. Insertion loss is 0.75dB unbiased, and a



forward bias current of approximately 10mA applied the attenuation obtained is greater than 20dB. The frequency range can be extended for applications where an increase in insertion loss can be tolerated. The modulator uses o.s.m. connectors and the r.f. centre conductor is d.c. earthed, requiring no d.c. blocking capacitors. Marconi Instruments Sanders Division, Gunnels Wood Road, Stevenage, Hertfordshire.
WW325 for further details

TO-8 Photocells

Adding to their existing range of TO-18 and TO-5 size photocells, Teknis are now marketing a series of larger photocells in TO-8 style. The new range is designated VT500 and is available in cadmium sulphide and cadmium selenide materials with peak spectral responses ranging from 515nm to 675nm. Power dissipation is 0.5W at 25°C, but up to 2W can be dissipated with an adequate heat sink. Maximum voltage is 300V and the resistance tolerance is 33⅓% at 21.5 lx. Teknis Ltd., 31 Stoke Road, Guildford, Surrey.
WW 339 for further details

Low-cost diodes

The Fagor 'KSK' range of 1A, 200 to 1500V (p.i.v.), silicon diodes can withstand non-recurrent surge peaks of 40A and repetitive peak currents of 5A. They are suitable for direct printed circuit board mounting, and available from the C.G.S. Resistance Co. Ltd., Marsh Lane, Gosport Street, Lymington, Hampshire, SO4 9YQ.
WW 310 for further details

I.C. Op. amp

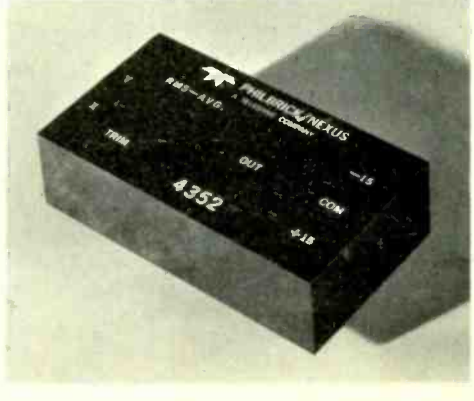
Analog Devices' model 801 i.c. operational amplifier has 4 × 10^{-9}A maximum bias current, making it especially useful in circuits for active filters, integrators, and current-to-voltage converters. This model supersedes the 709, but is mechanically compatible, allowing direct substitution in existing layouts. The differential input impedance of the 801 is a minimum of 25MΩ while the common mode impedance is a minimum of 500MΩ. Analog Devices Ltd., 38/40 Fife Road, Kingston upon Thames, Surrey.
WW 311 for further details

X-Y Recorder

A d.c. servo-system, self-lubricating potentiometers and a sapphire-tip pen to reduce wear and eliminate clogging—these are features of the X-Y recorder model 530 from Honeywell. A low-impedance motor drive allows 2% maximum overshoot while the servo system allows a 20in/s slewing speed (at 240V/50Hz). The differential input is floating and guarded on each axis. There are five ranges from 1mV/in to 10V/in, plus × 10 vernier to 100V/in. There is also an optional timebase with ±1% short term accuracy at room temperature. Price: £641. Test Instruments Division, Special Products Group, Honeywell Controls Ltd., Eaton Road, Hemel Hempstead, Herts.
WW 312 for further details

Vector Function Module

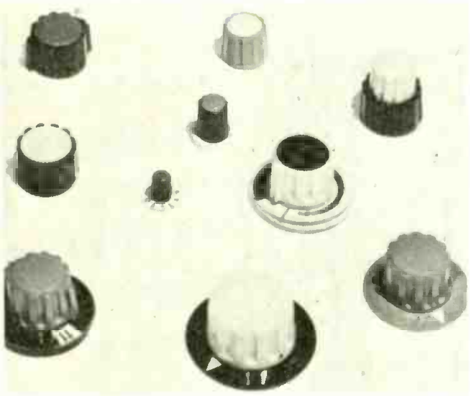
Average or r.m.s. values of a signal, or the square root of the sum of the squares of two signals can be calculated by a vector function module, type 4352, introduced by Philbrick-Nexus. It is an encapsulated unit measuring 70 × 40 × 22mm and it can be used where average, r.m.s. or $\sqrt{X^2 + Y^2}$ functions must be provided. It replaces servo mechanisms for $\sqrt{X^2 + Y^2}$ computations delivering an output into a 5-kΩ load without external circuitry. Accuracy is said to be ±3% over a wide range of temperatures. The module can be applied as a data-processing tool, as a data-monitoring system to combine quadrature inputs for presenta-



tion as a single variable, and as a component in manufactured equipment. Averaging and r.m.s. operations are based on filtered values of one input signal with the output appearing as a positive voltage. The operation $\sqrt{X^2 + Y^2}$ is based on instantaneous value of the function. Price £106. Philbrick-Nexus Research, 81a North Street, Chichester, Sussex.
WW 313 for further details

Control Knobs

A family of collet-fixing control knobs in four styles and in grey, black and red has been announced by Radiatron Ltd. The knobs are designed to accept a wide range of push-on com-



ponents such as pointers and figure dials, skirts, caps, etc. Knob diameters are 9, 10, 14.5, 21, 28 and 36mm, and spindle sizes 3, 4, 6, 8, 10mm, $\frac{1}{4}$in., and $\frac{1}{8}$in. Radiatron Ltd., 7 Sheen Park, Richmond, Surrey.
WW 337 for further details

Monolithic Crystal Filters

A standard range of 10.7MHz monolithic crystal filters, manufactured by Collins Radio of Newport Beach, California, can now be obtained from G. A. Stanley Palmer Ltd. Bandwidths range from 3 to 30kHz at 6dB, with a maximum of 100dB

rejection and a 3 to 1 shape factor. Operation is possible from 40° to 85°C. The complete range is supplied in flat pack cases. G. A. Stanley Palmer Ltd., Island Farm Avenue, West Molesey Trading Estate, Surrey.
WW 314 for further details

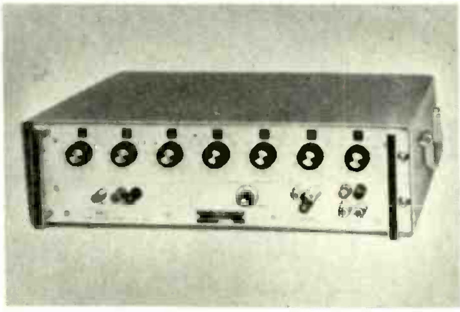
Digital dB Meter

A commercial equivalent of a digital dB meter originally designed for the Post Office is now available from Advance Electronics and is designated type DBM2. This is a portable instrument providing measurement and display of level over an 80dB range (+20 to −60dBm ref. 1mW in 600 Ω), and employing i.cs. Display is by three end-view neon indicators with polarity symbol. Range selection is automatic in 5dB steps with an overriding "lock-on range" facility to hold any existing range between measurements for rapid point-to-point readings of similar values. Calibration accuracy of 0.1dB ±1 digit is quoted for the frequency range 100Hz to

10kHz, but the instrument may be used outside these limits for level comparison in the range 50Hz to 30kHz. Advance Electronics Ltd., Roebuck Road, Hainault, Essex.
WW 315 for further details

Synchro/Resolver Bridges

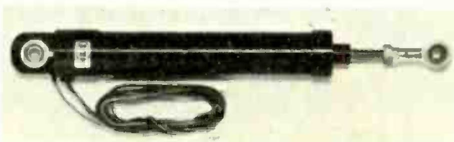
Intended for synchro, resolver and servo system testing, Astrosystems Inc. of America has introduced a range of bridges featuring 1 to 0.0001 deg resolution with arc accuracy of 2s. These units are direct readout inductive instruments which combine the function of a decade synchro bridge and a decade resolver bridge. They are entirely passive, being constructed from precision toroidal transformers which are wound to accuracies of better



than one part per million. A full 360° range is provided and, due to the low output impedance, the output is insensitive to pick-up and loading errors. When there is a difference in angular position between the bridge setting and the input synchro-resolver angle, the bridge produces an error signal proportional to the angular difference. When the input synchro-resolver signal is equal to the bridge setting, the error signal is zero volts, or nulled. U.K. agents: Litton Precision Products, 95 High Street, Slough, Bucks.
WW 316 for further details

Contactless Potentiometer

In applications where a contactless type of potentiometric device is desirable, such as in coal mines and other underground installations, Salford Electrical Instruments have introduced an infinite resolution linear potentiometer based on the variable capacitor principle. To avoid making contact to a moving capacitor plate the unit is constructed of two capacitors effectively connected in series. One plate of each capacitor is varied and contact is made to the two fixed



plates. When used with suitable electronic circuitry, this capacitor provides a d.c. output voltage which varies in magnitude in direct proportion to the sensing shaft position. The ratio of output voltage to shaft position can be maintained linear to better than 1%. The associated electronic circuit is constructed on a printed board inside the potentiometer body. Salford Electrical Instruments Ltd., Barton Lane, Eccles, Lancashire.
WW 323 for further details

Transistor Tester

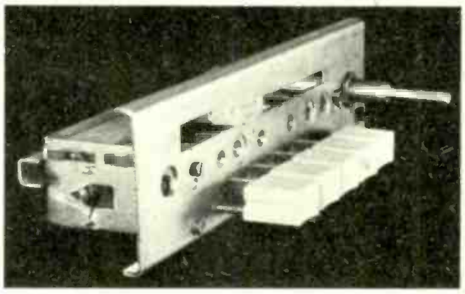
The latest portable tester for checking the leakage current and current gain of bi-polar transistors comes from R. M. S. Instruments of Chertsey. The instrument, type TT1, will measure current gain anywhere in the region of 5μA to 100mA, thus enabling circuit operating conditions to be reproduced. It is powered by an internal 9-V battery which provides the collector voltage. Indication is given on a 76mm moving-coil meter and a calibrated dial. The TT1 measures 230 × 150 × 75mm and weighs 1.36kg. R. M. S. Instruments Ltd., 24 Guildford Street, Chertsey, Surrey.
WW 326 for further details

New Resistor and Capacitor Range

Two new products added to the Dubilier range are metal glaze resistors and tantalum capacitors. The resistors are 6.5mm long and will carry up to $\frac{1}{2}$W at 70°C. Load life stability at $\frac{1}{2}$W rating is typically ±0.65%. Available in 1, 2 and 5% tolerance. The tantalum capacitors are plain foil versions featuring wide temperature and long shelf life characteristics with a claim for high reliability. They will also withstand high ripple currents and have good thermal stability. Capacitance range is in the E 12 series (0.33μF to 220μF) of preferred values with peak working voltages between 6.3V and 160V. Dubilier Condenser Co (1925) Ltd., Ducon Works, Victoria Road, North Acton, London W.3.
WW 341 for further details

Small Car-radio Tuner

What the makers believe to be the world's smallest press-to-lock car-radio tuner unit is now in production at the factory of Sydney Bird & Sons. Known as the Cyldon type AS50 it was developed to meet the trend by car designers of allocating less space for the radio unit (frontal presentation and particularly recess depth). Although the radio circuitry presents no problems the provision of a mechanical



press-button tuner is a limiting factor. The AS50 tuner dimensions fall within requirements specified by an international study group for a 177.8 × 50.8mm aperture, and it is not more than 50.8mm deep. Five press-buttons can be fitted and up to six coils if a.m./f.m. operation is required. Permeability tuning is used and button travel does not exceed 96mm. Reset accuracy is better than 2kHz. Sydney Bird & Sons Ltd., Cyldon Works, Fleets Lane, Poole, Dorset.
WW 343 for further details

Test Your Knowledge

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

10. Telecommunications Fundamentals

1. The rate at which information can be passed through a telecommunication channel depends on
(a) the carrier frequency
(b) the bandwidth
(c) the transmission loss
(d) the transmitter power.

2. The bandwidth required for television transmission is of the order of
(a) 100Hz
(b) 15kHz
(c) 470kHz
(d) 4MHz.

3. If music is to be transmitted over a carrier telephone system, three speech channels are normally used for one music programme. This is necessary
(a) to reduce the risk of interference from adjacent channels
(b) to provide sufficient bandwidth to accommodate all the important sound frequencies
(c) to reduce phase distortion
(d) because of the greater dynamic range of music compared to speech.

4. Two trains of rectangular pulses of voltage, each with a pulse repetition frequency of 1000 pulses per second, have pulse lengths of 1 microsecond and 10 microseconds respectively. If each pulse train were applied in turn to the input of an ideal low-pass filter with a cut-off frequency of 100kHz the output would be
(a) a 1kHz sine wave in each case
(b) similar to the input for the shorter pulses; a train of non-rectangular pulses in the case of the longer pulses
(c) similar to the input for the longer pulses; a train of non-rectangular pulses in the case of the shorter pulses
(d) a train of non-rectangular pulses in both cases.

5. Any two-port network having a 6dB loss will give
(a) an output power which is one-quarter of the input power
(b) an output voltage which is one-half of the input voltage
(c) an output voltage which is 0.707 of the input voltage
(d) an output power which is 0.707 of the input power.

6. One of the following forms of distortion cannot be produced by a transmission line
(a) attenuation distortion
(b) phase distortion
(c) group delay distortion
(d) harmonic distortion.

7. Two sinusoidal voltages of different frequencies are applied in series to a diode. The current which flows will contain sinusoidal components
(a) at the two applied frequencies only
(b) at the two applied frequencies and harmonics of them only
(c) at the two applied frequencies and their sum and difference frequencies only
(d) at the two applied frequencies and harmonics of them, and at sum and difference frequencies of all these.

8. The method of dividing a signal circuit into channels by "time division multiplex" can only be used for the transmission of
(a) speech and music
(b) single - sideband suppressed - carrier amplitude modulated signals
(c) frequency modulated signals
(d) pulse modulated signals.

9. The amplitude of a signal of which the highest frequency component is F hertz is to be sampled at intervals of time with the purpose of generating a pulse modulated signal. For the pulse modulated signal to specify the original signal completely
(a) is impossible
(b) the sampling rate must be greater than F samples per second
(c) the sampling rate must be greater than $2F$ samples per second
(d) the time duration over which a sample is taken must be greater than $1/F$ seconds.

10. An audio frequency amplifier cannot employ valves or transistors working in
(a) Class A conditions
(b) Class AB conditions
(c) Class B conditions
(d) Class C conditions.

11. The application of negative feedback to an aperiodic amplifier generally results in
(a) an increase in bandwidth and a decrease in distortion
(b) a decrease in bandwidth and an increase in distortion
(c) an increase in bandwidth and an increase in distortion
(d) a decrease in bandwidth and a decrease in distortion.

12. With reference to a radio frequency power amplifier the disadvantage of Class C operation compared to Class B is that
(a) it is less efficient
(b) it cannot be used when the signal to be amplified is amplitude modulated
(c) Class C amplifiers are prone to oscillation
(d) Class C amplifiers cannot be used in push-pull.

13. A transmission line having a characteristic impedance $R + jX$ is fed by a generator with an internal impedance which is also $R + jX$. Maximum power will be delivered to a load connected to the line if the load impedance is
(a) $R + jX$
(b) $R - jX$
(c) R
(d) jX.

14. The signals from a teleprinter operating at a speed of 50 bauds are amplitude modulated on to a carrier. The minimum theoretical bandwidth required for transmission is
(a) 50Hz
(b) 500Hz
(c) 4,000Hz
(d) 10,000Hz

15. Above 100MHz twin wire transmission line is rarely used, coaxial cable being preferred. The main reason for this is that at these frequencies
(a) twin line becomes lossy due to the increasing resistance of the wires
(b) suitable coaxial cable is easier to make than suitable twin line
(c) twin line radiates away a lot of energy
(d) the fact that the outer of coaxial cable is at earth potential is advantageous.

16. Telephone lines are sometimes "lump loaded" with inductance at uniform intervals. The purpose of this is
(a) to reduce attenuation
(b) to make the line non-dispersive
(c) to reduce cross-talk
(d) to eliminate high frequencies.

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

World of Amateur Radio

Amateur Television

An international amateur television conference is to be held in Armentières, France, during the week-end April 19-20, 1969, when it is expected that enthusiasts from several European countries will join the increasing number of French amateurs who are interested in television transmitting. Mr Cassanhiol (F3DD), 13 rue de Bellevue, Paris, will furnish full details of the programme which will commence at 0900 hours on Saturday, April 19. Cars will be available at Calais to drive overseas visitors direct to the conference, to which ladies are cordially invited.

Considerable interest in amateur television is reported from different parts of Belgium. Among the most active stations are ON4TG/T (Mons) and ON4HV/T (Antwerp) both of whom continue to arrange excellent local demonstrations. ON4GG, ON4HC and ON4ZZ have all constructed equipment for the reception of transmissions from ON4HV/T and all report the clarity of vision is equal to that offered by the local Channel 10 commercial station. Signals have also been received from ON4ZK/T. All vision transmissions take place on frequencies around 434.75 MHz while sound is transmitted around 144.54 MHz. ON4HV/T uses a QQEO3/20 valve for transmitting which produces a mean carrier level of about 8 watts. A 40-element collinear is used as the aerial array.

I.A.R.U. Region I Conference—1969

With less than three months to go before the Seventh Triennial Conference of I.A.R.U. Region I Societies opens in the Hotel Metropole, Brussels, on May 5th, more than half the subscribing member societies in the division have intimated their intention to be represented. Conference proposals and contributions have been received from a dozen societies and these are now being issued as Brussels Conference (B.C.) documents. Subjects to be discussed range from a German proposal to establish a system of world beacon stations, to a number of Russian proposals designed to give greater prominence to the treatment of amateur radio as a sport with the annual award of gold, silver and bronze medals to the leading "radio sportsmen". Proposals to limit the number of contests and certificates will be discussed, together with a range of v.h.f. subjects put forward by the R.S.G.B., including one for wider use of the s.s.b. mode of transmission in the v.h.f. bands. The R.S.G.B. will also propose that more consideration be given to plans for reporting to official sources the persistent presence of non-amateur stations in "exclusive" amateur bands. The R.S.G.B. was the first society to set-up an "Intruder Watch" and its methods of reporting "intruders" are to be reported upon fully to the conference. The conference is being organized locally by the Belgian national society (U.B.A.) and the conference secretary is your contributor.

Canadian Licence Fees

Representatives of the A.R.R.L. Canadian Division, the Canadian Amateur Radio Federation, the Radio Amateurs of Quebec, the Saskatchewan Amateur Radio League and the Nova Scotia Amateur Radio Association recently met the director of the telecommunications bureau of the Canadian Post Office Department to discuss the proposal to increase by 400% the annual licence fee charged to Canadian radio amateurs. Among the interesting facts disclosed at the meeting was that approximately 75% of all Canadian licensed amateurs hold an advanced amateur certificate and that the number of cancellations during the past year (414) had been four times normal. There were 11,000 licensees in force on August 31, 1968. No final decision has yet been reached by the telecommunications bureau but the representatives of Canadian amateur radio hope the arguments put forward, particularly their case for a three- or five-year licence, will lead to a less penal increase in licence fees.

Fox-Hunting Championships

On the continent of Europe, fox hunting (D/F) competitions are a regular summertime activity of many radio societies and clubs. Among the activities arranged by the executive committee of I.A.R.U. Region I Division are triennial European Fox-Hunting Championships. At the conference held in Yugoslavia in 1966 it was agreed to set-up a fox-hunt group under the chairmanship of Col. Carl-Eric Tottie (SM5AZO), of Stockholm, to produce a new set of international rules based on experience gained during past competitions. The proposed new rules have been prepared and are at present being studied by Region I societies prior to the Brussels conference in May.

The rules have been published as a conference document (B.C.29) a copy of which can be obtained (price 1s. 6d. post free) from the Conference Secretary, G6CL.

'Aeronautical Mobile' contact

After calling CQ on two metres one Saturday afternoon recently F. J. Willshire (G8BKW), of South London, was surprised to hear a strong signal replying and signing WA1JZB/Aeronautical Mobile. Suspecting that the caller was a "joker", G8BKW was delighted to discover that his CQ call had been answered by the navigator of a U.S. Boeing 707 military jet aircraft which at that moment was cruising at a height of 34,000 ft over Cornwall, having just crossed the Atlantic. The operator, who gave his name as Mo, made contacts with several other U.K. stations before finally signing off.

Top Band DX

The first section of the 1968-1969 series of Transatlantic Top Band (160m) DX tests organized by Stewart Perry (W1BB), Winthrop, Mass., U.S.A., was very successful, with KV4FZ (Virgin Islands) providing many Europeans with their first KV4 contact. Top Band signals were also reported for the first time from ZB2BY (Gibraltar) and 6W8CW (Senegal) by many participants in the tests. During the first part of the Transpacific Top Band tests many U.S.A. and Japanese stations were worked by KH6GLU (Hawaii). Two Japanese stations (JA2CLI and JA1RQR) succeeded in making numerous contacts with U.S. West Coast stations.

African Safari

David Dunn (GW3XRM), 25-year-old design draughtsman from Cardiff heads a team of four which left in early February on a trans-Africa expedition. During an eight-month journey through North, East and South Africa, the team will make daily radio contact with Cardiff University and study the reliability of low-power short-wave communications.

N.R.S.A. Convention 1969

The Northern Radio Societies Association convention and exhibition is to be held this year in the Cumberland Suite, Belle Vue Gardens, Manchester, on Sunday, April 27. Details from R. M. Clarke (G8AYD), Hillside, Quickedge Road, Mossley, Ashton under Lyne, Lancs.

Maidstone Rally

Maidstone Y.M.C.A. Amateur Radio Society will hold a mobile rally and fete on Sunday, June 1, to celebrate the Y.M.C.A's golden jubilee.

JOHN CLARRICOATS G6CL

Literature Received

"The Use of Semiconductor Devices" Pt. 1 is the first of a series to be published by The British Standards Institution, British Standards House, 2 Park St., London W.1. Pt. 1 is called General Considerations and costs 12s.

"Catalogue of Radio, Television and Electronic Books" from The Modern Book Co., 19-21 Praed St., London W.2, lists a wide range of books from a variety of publishing houses. The catalogue costs 2s.

We have received a great deal of literature from the Du Pont Company, Du Pont House, 18 Breams Buildings, London E.C.4, which is concerned with **chemicals for the electronics industry. (1)** Plastics: consists of a folder containing two brochures and an article concerned with Teflon, p.t.f.e. and f.e.p. resins. **(2)** Film: a folder giving information on polyester, polymide and p.v.f. films (Mylar, Kapton and Tedlar). **(3)**: a folder containing information on chemicals for thick films and thick-film techniques. **(4)** Freon: again a folder, containing information on chemicals and solvents for cleaning electronic assemblies. **(5)** Is concerned with the production of printed circuits.

(1) WW 401 for further details **(2) WW 402 for further details**
(3) WW 403 for further details **(4) WW 404 for further details**
(5) WW 405 for further details

Electronic Services (S.T.C.), Edinburgh Way, Harlow, Essex, have produced a supplement for their industrial catalogue. This lists integrated circuits and low-cost epitaxial planar transistors.
WW 406 for further details

(1) "Computer Careers for School Leavers" and **(2) "Computer Careers for Graduates"** are two booklets produced by International Computers Ltd, ICL House, Putney, London S.W.15. They cover a full range of employment in design, manufacture, programming and selling.
(1) WW 407 for further details **(2) WW 408 for further details**

Details of the **laminates and services** offered by Tufnol Ltd, Perry Barr, Birmingham 22B, are contained in a new catalogue. Materials from Tufnol include paper- and fabric-based phenolic and epoxide laminates and plain and copper-clad glass fabric epoxide laminates.
WW 409 for further details

A useful article on **noise measurement** techniques is contained in a brochure from Dawe Instruments Ltd, Concord Rd., Western Avenue, London, W.3. The brochure also gives details of the range of noise measuring instruments produced by the company.
WW 410 for further details

A **stereo amplifier** with a frequency response that is −1dB at 30Hz and 20kHz and with a typical harmonic distortion of 0.1% is described in a leaflet from Welbrook Engineering & Electronics Ltd, Brook St., Stockport, Cheshire.
WW 411 for further details

Anybody concerned with **using resin** will find the latest edition of "Resinotes" published by Cray Valley Products Ltd, St. Mary Cray, Kent, of interest.
WW 412 for further details

(1) "Measuring Instruments" and **(2) "Communications Equipment"** are the titles of the latest catalogues from Rohde & Schwarz which are available from Aveley Electric Ltd, South Ockendon, Essex. Each catalogue describes a wide range of equipment.
(1) WW 413 for further details **(2) WW 414 for further details**

A **Digital Integrated Circuit Training Aid** for home construction is described in a booklet produced by Mullard Ltd, Mullard House, Torrington Place, London W.C.1. Basically it shows how a patch-board can be made up containing four JK-bistables and four dual NAND gates with lamp read-outs and how this set-up can be used to patch-up numerous types of binary counters.
WW 415 for further details

High-speed pen recorders manufactured by Watnabe Instruments, of Tokyo, Japan, are described in a leaflet received from Environmental Equipments Ltd, Denton Rd., Wokingham, Berks. The frequency response is flat from d.c. to 30Hz with a recording amplitude of 80mm, or up to 80Hz using a 40mm recording amplitude.
WW 417 for further details

"D Subminiature Rectangular Connectors" is the title of the catalogue of Cannon Electric (GB) Ltd, Lister Rd., Basingstoke, Hants. It lists a wide range of connectors and accessories for connectors.
WW 418 for further details

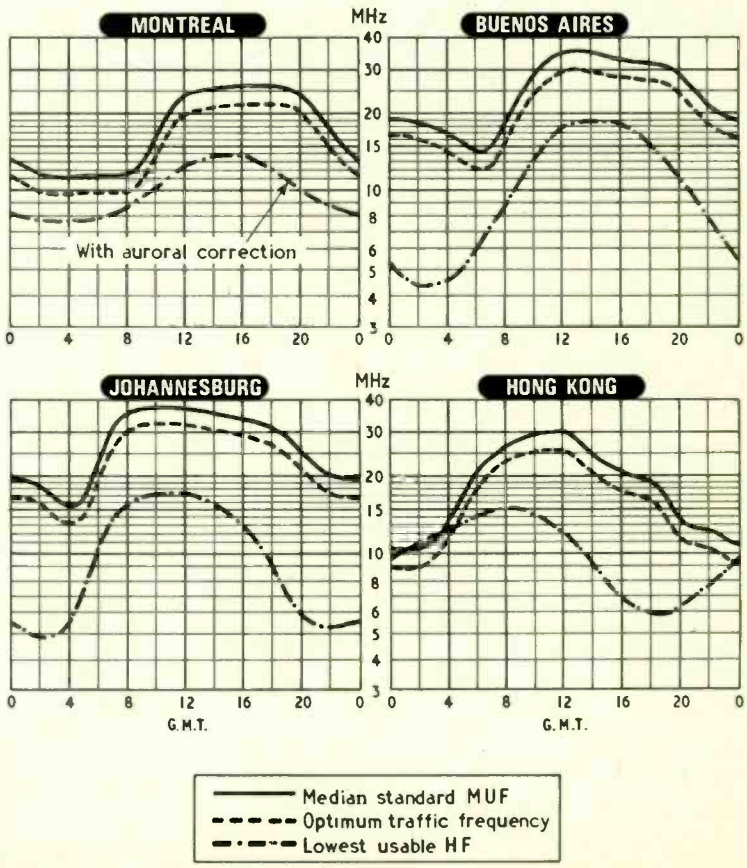
Thyristors, triacs, diodes, fuse links, voltage surge protectors and other components are included in a new short-form catalogue from International Rectifier, Hurst Green, Oxted, Surrey. The catalogue, which is well presented, gives technical data and device outline drawings.
WW 419 for further details

Socket assemblies for crystals manufactured by the American company Augat Inc. are described in a catalogue (No. CS 868) available from Electrosil Ltd, Pallion, Sunderland, Co. Durham. Crystals may be fitted in the holders without adjusting latches or screws and it is stated that the crystals will not shake loose even under the most severe vibration.
WW 420 for further details

H. F. Predictions—March

MUFs are based on a predicted value for the ionospheric index (IF2) of 104. This gives curves almost identical to those of March 1968 for which the IF2 value was 111. Daytime MUFs on northern hemisphere routes are beginning to drop whilst trans-equatorial routes continue to be workable above 25MHz.

LUF curves were drawn by Cable and Wireless Ltd. for particular point-to-point telegraph circuits and serve to indicate when reception on the various broadcast and amateur bands should be possible.



Answers to "Test Your Knowledge"—10

Questions on page 142

1. *(b)*. For an ideal system the maximum rate at which information can be transmitted is $W \log_2 (1 + S/N)$ bits per second, where W is the bandwidth in hertz and S/N the signal-to-noise power ratio.

2. *(d)*.

3. *(b)*. The base bandwidth of a carrier telephone channel is standardized at 4kHz. This is sufficient for the transmission of intelligible speech, but music restricted to this bandwidth would be very "low fidelity"!

4. *(c)*. The spectrum of a train of rectangular pulses consists of an infinite series of harmonics of the pulse repetition frequency. The pulses suffer little degradation, however, if the components of frequencies greater than the reciprocal of the pulse length are removed. Removal of components of lower frequencies than this distorts the shape and reduces the amplitude of the pulses.

5. *(a)*. Solution *(b)* is correct only if the impedance is the same at the input and output.

6. *(d)*. A transmission line is a linear circuit. Harmonic distortion can be produced only by a non-linear component.

7. *(d)*. This is the basis of diode mixing. An appropriate tuned circuit, included in series, will develop a voltage at the desired difference frequency.

8. *(d)*. The pulses representing the signals to be transmitted are interposed so that each signal in turn occupies the whole available bandwidth.

9. *(c)*. This is the "sampling theorem".

10. *(d)*. For class AB or class B working the devices must be in push-pull.

11. *(a)*. The gain of the amplifier is, of course, reduced.

12. *(b)*. The amplitude of the output of a class C amplifier is not proportional to the amplitude of the grid input.

13. *(b)*. This follows from the maximum power transfer theorem. Notice that the load does not correctly terminate the line.

14. *(a)*. The minimum theoretical base-bandwidth in hertz is half the signalling speed in bauds. The modulated carrier will require twice this bandwidth.

15. *(c)*.

16. *(a)*. For a normal telephone line adding inductance reduces the attenuation and also makes the line less dispersive. The amount of extra inductance which would be required to make the line non-dispersive, however, is generally far greater than can practically be added.

Real and Imaginary

By "Vector"

"Tall oaks from little acorns grow"

Let us consider the dossier of Jim Bandstop, electronics engineer and ex-group leader of Gargantuan Laboratories Inc. We'll start from the day when Jim, sitting moodily in his glass cage, sees the light. He is but a tooth on a small cog in a mighty machine. He is a goldfish in a highly expensive bowl. He is a hapless buffer between the chief of research who wants the impossible done yesterday and his junior minions whose taste and fancy run more towards the curves in the typing pool than on the square waves displayed on the £5000 analyser (which is at the moment earning its keep by supporting two card-board cups of *chateau automatique* coffee).

It is at this point that a megajoule laser beam hits Jim Bandstop between the eyes. He has had enough. He wants out. The simple life; that's it. Down in the country, running his own small business. Better to be a big frog in a tiny pool—and all that jazz.

Going it alone

A year passes and his dream has come true. A small workshop in an olde-worlde village stands monument to Jim's resolve. And in other ways the year has borne fruit. Something of a level-response genius himself, Jim initiated one or two rather special hi-fi amplifier circuits and has supervised their development, skilfully hidden within the legitimate jobs in the lab. Now he is in the custom-built hi-fi market as a one-man manufacturer.

At first the going is sticky, for Jim is horning in on a limited market. But his designs are good and he has astutely established contacts beforehand, so it is not long before he is working all the hours there are to keep up with the demand. Mrs. Jim deals with the paper work while Jim does the assembly and test work. True, the idyll of life in the country has vanished, because neither has time to stand and stare; but apart from that (and some interference from H.M. Inspector of Taxes) all goes as merrily as a marriage bell. (H.M. Inspector, who spends his weekends wringing blood out of stones for practice, resolutely refuses to accept Jim's figures and insists on receiving them via a chartered accountant. The first extraneous overhead has arrived.)

Orders pile up and Jim decides to take on some help. He engages an experienced wireman, and a youth to do the odd jobs. This, he decides, makes things much more efficient. It leaves him free to do the design work—the thing he is best at—and at the same time to keep a close eye on everything else. He can now diversify from hi-fi amplifiers into rather more ambitious enterprises.

Naturally, there are snags. Overheads begin to mount. Inspectors of this and that arrive at the workshop and insist on highly expensive alterations to the structure. In brief, the expansion exercise, which looked so profitable on paper, does not pay off to the same extent in reality. Nevertheless, the turnover increases considerably and things are looking up.

The trend continues; Mrs. Jim retires to go into production on her own account and her place is filled by a secretary and a typist. Jim changes from sweater and slacks to a neat business suit and is less preoccupied by design than by the machinations of the Income Tax Inquisitors. Both the plant and the number of employees swell visibly every year.

The time arrives when a further large expansion is desirable; a move to an establishment which might be properly described as a factory is clearly indicated. Jim gets out his neglected slide rule and does some quick sums. The simple life idyll is long since past. He must now move nearer to civilization, which means a far more expensive site; to get the kind of chassis he wants a machine shop is necessary, with a servicing workshop to keep the machines going. White-collar staff must also be imported to deal with the paper-work. All of them essential to the scale of the enterprise but parasitic in terms of actual production.

Ruefully Jim realises that a move into manufacture (as distinct from assembly) is going to take far more cash than he can provide. The solution obviously is to float a public company, and, surprisingly, this proves to be far easier than he would have expected.

In due course Bandstop Limited comes into production, with Jim (but now James) as managing director. An executive-type car is now essential, of course, and this is the precursor to other "essentials". The capacity of the factory is such that advertising becomes a permanent fixture on the debit side. Bandstop must take space at exhibitions; not so much that the firm can afford to do so as that it cannot afford not to be among those present.

The first few years leaves the shareholders dissatisfied with the pickings. James, who (as Jim) had achieved his success with first-class design and first-class components, now finds himself under considerable pressure to bring up the profits by using cheaper materials and components. Not to put too fine a point on it, he receives an ultimatum—do it or get out. He does it. A company can never stand still. It must either go forward or back. By ruthless pruning on materials, James pushes this forward, trading on his past reputation for quality regardless of price. Now, however, he finds himself out of the limited quality market and engulfed in the run-of-the-mill, mass produced, squawk-box rat-race. Efficiency consultants appear upon the scene followed by time-and-motion study and those other ideologies that many of us know so well; all perfectly justifiable on paper, but all specialist little empires. Human nature being what it is, the first concern of the empire builders is to devote much effort towards justifying the further expansion of their domains (Who was it who said 'Lies, damned lies and statistics'?).

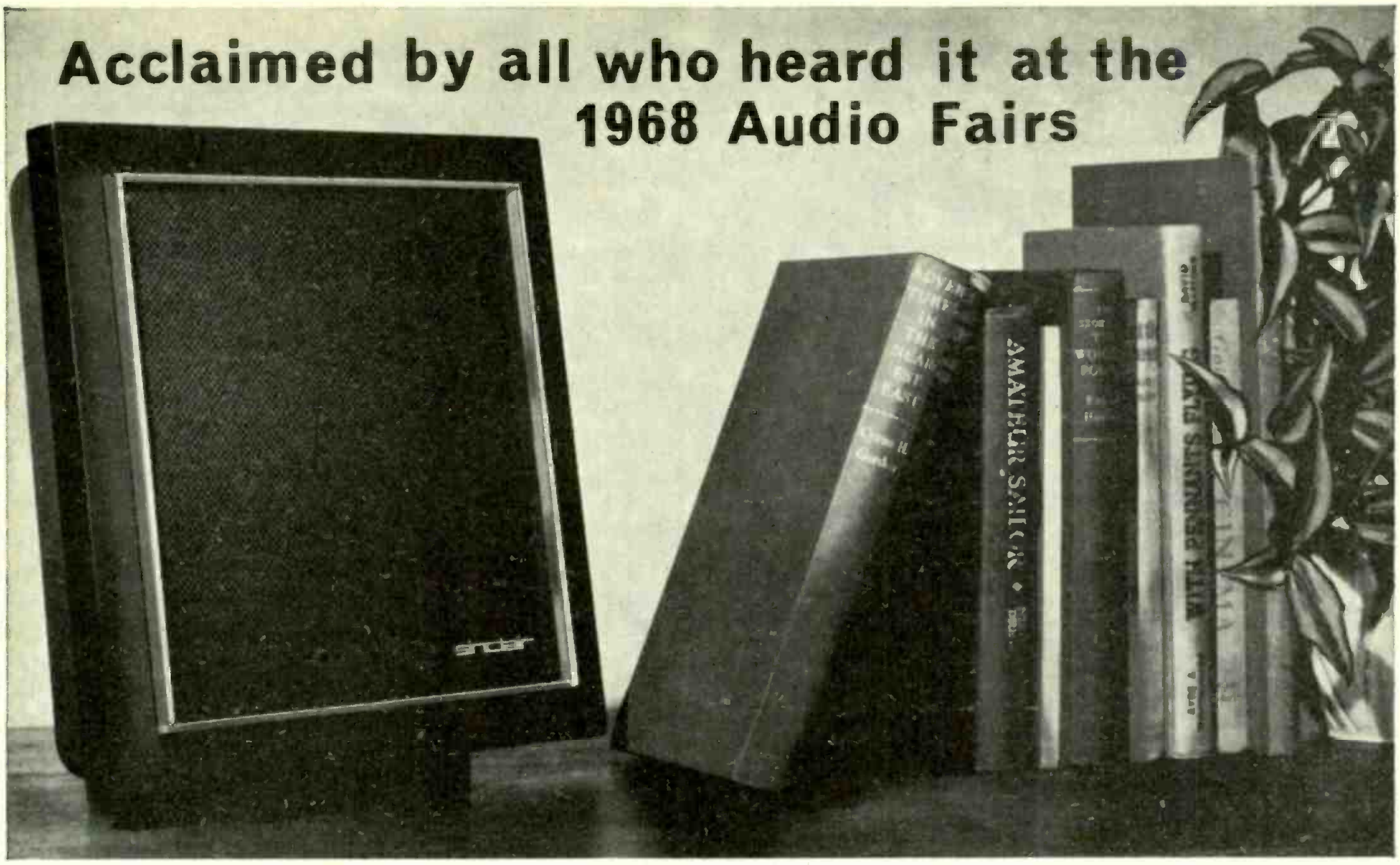
Parasitical growths

At the beginning of this yarn, Jim could control his business quite efficiently using only his brain and a simple filing system. James, managing director of Bandstop Ltd, is absolutely incapable of doing so in detail. Now his mass-production plant has to bear the burden of an ever-growing battalion of control departments, plus supporting services of all kinds. All essential to the size of the organization, all beneficial in some degree or other, but all, in the final analysis, parasitical growths drawing sustenance from the production area.

The final phase in the Bandstop saga is the company's take-over by a mammoth group. Either Bandstop Ltd's profits and assets will now be milked to feed a sagging member company or its structure will be "rationalized" to prevent over-capacity within the group as a whole. James, who has for a long time been the biggest frog in a fair-sized pool, can now resign himself to taking orders from the Lord High Executioner Bullfrog, or resign. It is at this juncture we will leave him, making his decision.

The "One-Man-Bandstop" firm can, if it is on its toes, make rings around the mammoth group in terms of quality-for-price, and also in terms of deliveries. Concerning this last, I once traced the history of an order for an in-stock capacitor through the system of a large firm. The outcome shook me. By sticking to the established paper-work procedure the time-lapse between receipt of order and its posting to the customer could not possibly be less than 46 days. And that assumed that everyone concerned dealt with his piece of paper immediately it arrived on his desk. The resistors probably cost fourpence to make; taking everyone's time into account they were probably accounting for about £15 worth of the firm's money before they left the works. At, say, a shilling apiece to the customer.

Isn't it time there was some re-thinking about company structure?



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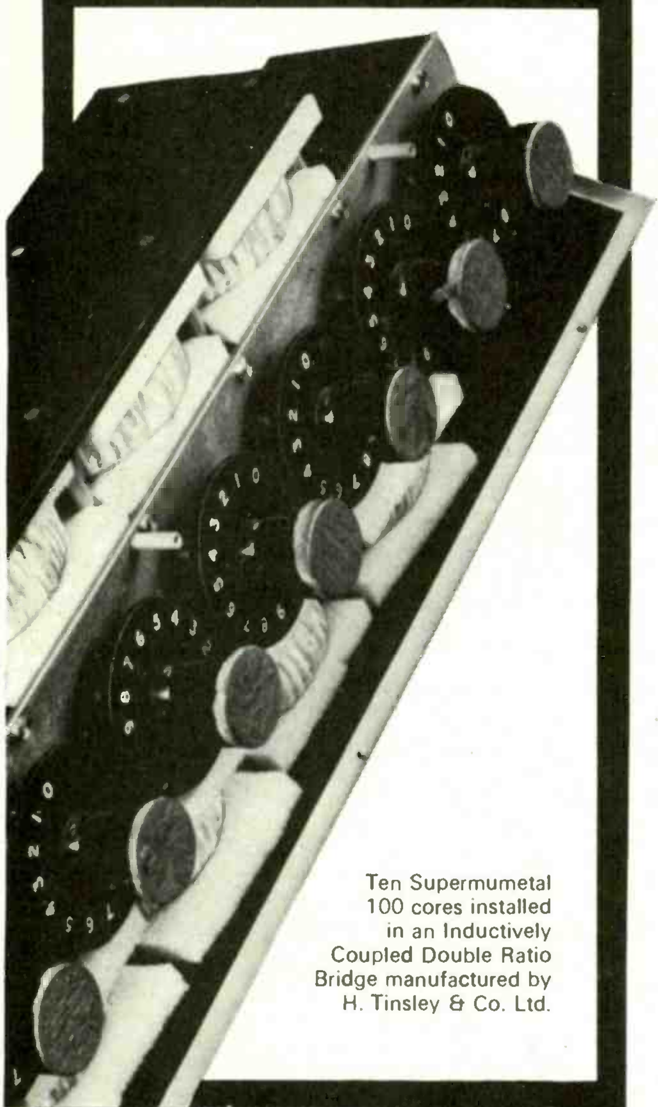

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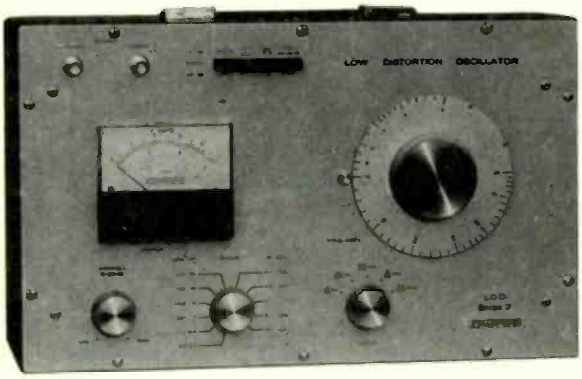
In an article in the Journal of the Audio Engineering Society for July 1967, Bart N. Locanthi, Vice-President, J. B. Lansing Sound Inc. describes the development of an ultra low distortion direct current audio amplifier. In it he says "... to get the highest accuracy possible, an English made RADFORD Low Distortion Oscillator was used which has less than 0.01% harmonic distortion at 20kHz."



LOW DISTORTION OSCILLATOR (Series 2)

An instrument of high stability providing very pure sine waves, and square waves, in the range of 5 Hz to 500 kHz. Hybrid design using valves and semiconductors.

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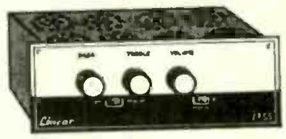

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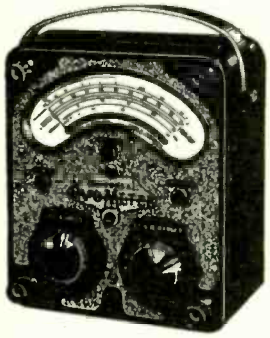

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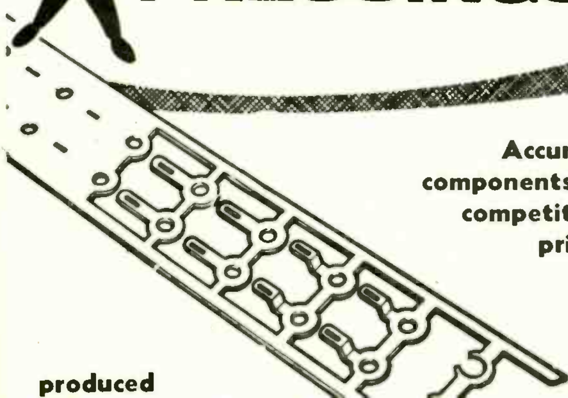

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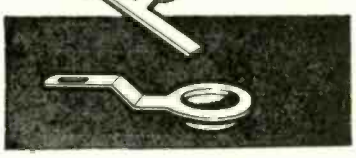

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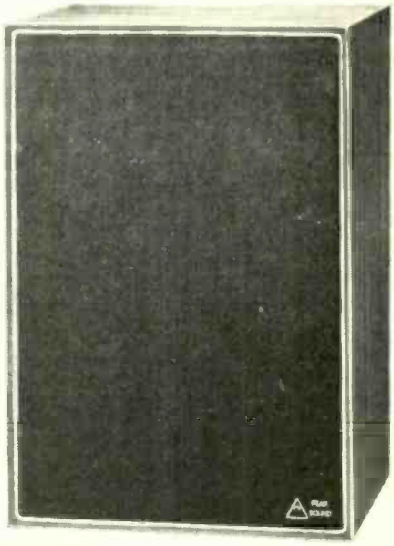

ES/10-15 BAXANDALL SPEAKER

AS DESCRIBED IN *WIRELESS WORLD*

"Rolls-Royce standards"
SAYS RALPH WEST,
Hi-Fi News
OCTOBER, 1968

"The immediate impression was of a thoroughbred speaker, smooth and effortless . . . voices both speaking and singing were uncannily real . . . Once again we see the possibility of Rolls-Royce standards from comparatively cheap components . . . when you know how." *Hi-Fi News* Test Report, Oct. 1968.

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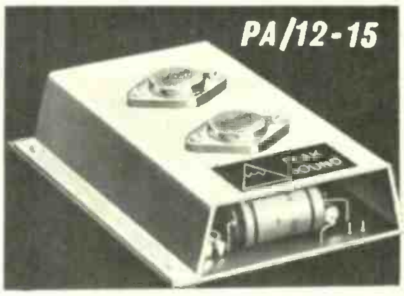
a new Peak Sound hi-fi power amplifier



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GIANT SELENIUM PHOTO-CELLS. OUTPUT UPWARDS OF 5ma AT ·6V
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2½in. × 1in 0·15in matrix	1/1	17in × 2½in. 0·15in. matrix	11/-
3¾in × 2½in 0·15in. matrix	3/3	17in × 3¾in 0·15in. matrix	14/8
3¾in × 3¾in 0·15in. matrix	3/11	3¾in × 2½in 0·1in matrix	4/2
5in × 2½in 0·15in matrix	3/11	3¾in × 3¾in 0·1in matrix	4/9
5in × 3¾in 0·15in matrix	5/6	5in × 2½in 0·1in matrix	4/7
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Spot Face Cutter 7/6 Pin Insert Tool 9/6. Terminal Pins 3/6 for 36.
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MULTIMETERS. 20,000 ohms per volt.
Ranges: a.c. 1,000V, 500V, 100V, 50V, 10V.
d.c. 250mA, 2·5mA, 50µA.
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Resistance: 0/60kΩ and 0/6MΩ.
Special price £4/-/- only.

ELECTROLYTIC CONDENSERS

0·25µF	3 volt	4µF	12 volt	25µF	6 volt	320µF 10 volt
1µF	6 volt	4µF	25 volt	25µF	12 volt	400µF 6·4 volt
1µF	20 volt	5µF	6 volt	25µF	25 volt	
1·25µF	16 volt	6µF	6 volt	30µF	6 volt	
2µF	3 volt	8µF	3 volt	30µF	10 volt	
2µF	350 volt	8µF	12 volt	50µF	6 volt	All at 1/- each.
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3µF	25 volt	10µF	6 volt	64µF	9 volt	20 assorted
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SKELETON PRE-SET POTENTIOMETERS 100Ω, 100KΩ, 200KΩ, 500KΩ 6d. each.
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CRYSTAL OR MAGNETIC LAPEL MIKES. 10/- each.
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STANDARD RANGE OR DESIGNED TO YOUR SPECIFICATION.
0-50KVA, "C" CORE, PULSE, 3 PHASE, 6 PHASE, TOROIDS, ETC.
Transformers for 20W Transistor Amplifier (W.W., Nov. 1966).
Driver 22/6 Carr. 2/-
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Fitted with terminal panel, taps at 0.5, 2, 4 and 8W into 15 ohms 17/-. Carr. 2/-
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Specialist Switches make **Rotary and Lever switches, types H, DH, HC, and LO, to specification.** There is one limitation (standard 2 in. long spindles), but this is not important when you are getting the **fastest switch service in the world.**

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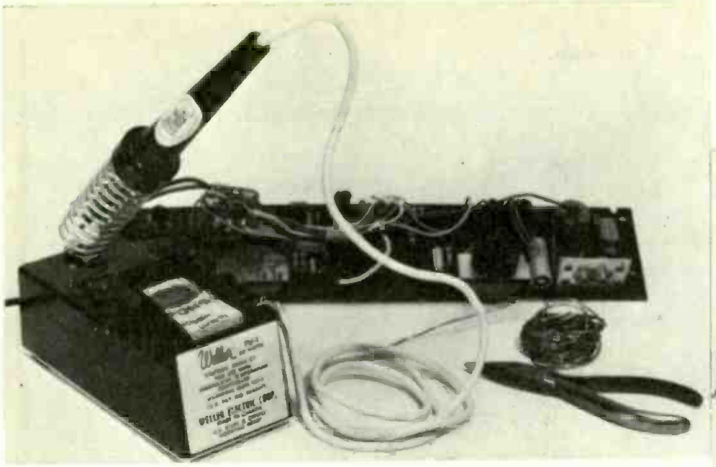

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LARGE RANGE OF STANDARD MODELS from £10. Also
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LOW COST • TOP QUALITY • QUICK DELIVERY
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WW—122 FOR FURTHER DETAILS

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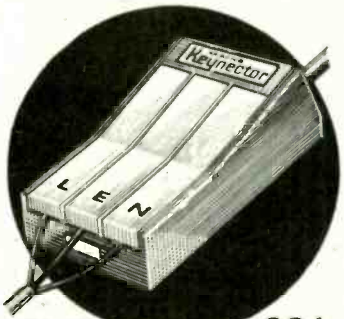

The safest, quick and handy connector for electrical appliances is now available ex-stock

Only 5" x 3" x 1¾" the MAINS KEYNECTOR is designed in modern style and attractive two-tone colour. The unit eliminates the need of terminating the mains input lead of any electrical instrument or appliance with a plug. Also enables more than one appliance to be connected in parallel and used simultaneously. Rating 13 amp.

British and Foreign Patents applied for

Send cash with order

39/6
P.P. extra

CYBERNAUT CONTROLS LTD. (ref. W.W.14). 28-30 Rivington Street. London. E.C.2

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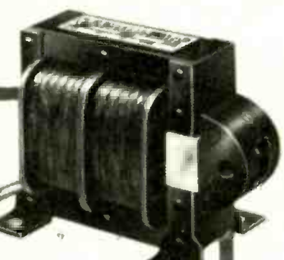
A.C. SOLENOID TYPE SBM



Continuous Rating $3\frac{3}{4}$lb. at 1in Instantaneous up to 16lb.

Fitted with stainless steel guides—6 times the life. Larger and smaller sizes available—also transformers to 8kVA 3-phase.

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KNAPPS LANE, CLAY HILL, BRISTOL 5. TELEPHONE 65-7228/9

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WW—125 FOR FURTHER DETAILS

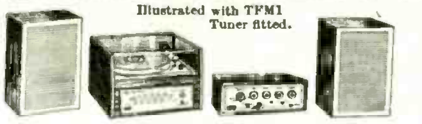
SENSATIONAL R.S.C. HIGH FIDELITY STEREO PACKAGE OFFERS

Matched for optimum performance. Compare prices with equipment and cabinets purchased individually.

'Package 3' 30 Watt System

- ★ Goldring Transcription Turntable on Plinth.
- ★ Shure Magnetic Pick-up Cartridge.
- ★ Super 30 Amplifier in cabinet.
- ★ Pair of Stanton Loudspeaker Units.

Special inclusive price. Fully wired units ready to "plug-in". **85 Gns.** Really superb performance. *Plus small P.T surcharge* Send S.A.E. for leaflet. Carr. 25/-



Illustrated with TFM1 Tuner fitted.

'Package 2' 30 Watt System

- ★ Garrard SP25 Mk. II Turntable on Plinth.
- ★ Goldring CS90 Ceramic P.U. Cartridge.
- ★ Super 30 Amplifier in cabinet.
- ★ Pair of Stanton Loudspeaker Units.

Special inclusive price. Fully wired units ready to "plug-in." **75 Gns.** Carr. 25/- *Plus small P.T. surcharge*

Extremely Attractive and Versatile Plinths finished in Teak or Afrormosia veneer. Tinted Perspex "hinged" cover with satin chrome handle.

'Package 1' 13 Watt System

- ★ Garrard SP25 Mk. II 4-speed Player Unit, on plinth.
- ★ Goldring CS90 Ceramic P.U. Cartridge.
- ★ TA12 Amplifier in cabinet.
- ★ Pair of Dorset Loudspeaker Units.

Special inclusive price. **49½ Gns.** Perspex cover **3 gns** extra. Or Dep. £10. and 9 mthly. pmts. £5.4.0. (Total £56.16.0.) Carr. 25/- *Plus small P.T. surcharge*

BLACKPOOL AGENT APPOINTED See addresses

AUDIOTRINE HIGH FIDELITY LOUDSPEAKERS

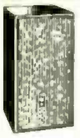
Heavy construction. Latest high efficiency ceramic magnets. Treated Cone surround giving low fundamental resonance. "D" indicates Tweeter Cone providing extended frequency range 40-15,000 c.p.s. Impedance 3 or 15 ohms. Exceptional performance at low cost.

Please state impedance. Prices include carriage.

HF 510L	5"	10W	57/9	HF 120	12"	15W	69/9
HF 801D	8"	8W	57/9	HF 120D	12"	15W	79/9
HF 811D	8"	10W	£4/4/0	HF 126	12"	15W	89/9
HF 102D	10"	8W	59/9				
HF 100D	10"	15W	£5/15/0	HF 126D	12"	15W	5 Gns.

HIGH FIDELITY LOUDSPEAKER UNITS

Cabinets of latest styling Satin Teak or Afrormosia veneer. Acoustically lined or filled with woollen damping material. Ported where appropriate. Credit terms available.



DORSET Size 16 × 11 × 9in. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 8" Dual cone speaker. Impedance 3 or 15 ohms. **£8.19.9** inc. carr.

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.**

GLOUCESTER Size 25 × 16 × 10in. 12in. High flux 12,000 line speaker. Cross-over unit and Tweeter. Rating 10 watts. Frequency range 40-20,000 c.p.s. Impedance 15 ohms. **12½ Gns.**

AUDIOTRINE HI-FI SPEAKER SYSTEMS

Consisting of matched 12in. 12,000 line 10 watt 15 ohm high quality speaker, cross-over unit and tweeter. Smooth response and extended frequency range ensure surprisingly realistic reproduction. **5 Gns.** Or Senior 15 watt inc. HF 126 15,000 line Speaker 6 Gns. Carr. 6/6. Carr. 5/9

HI-FI 'SPEAKER ENCLOSURES

Teak or Afrormosia veneer finish. Modern design. Acoustically lined and ported. Prices inc. carr.

JE8 Size 16 × 11 × 9in. Pressurised. Gives pleasing results with any 8in. Hi-Fi speaker. **4 Gns.**

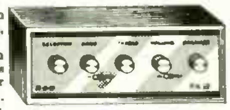
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. Size 22 × 15 × 9in. **5 Gns.**

SE10 For outstanding results with 10in. Hi-Fi speaker. Size 24 × 15 × 10in. **£5.10**

SE12 For high performance with 12in. Hi-Fi speaker and Tweeter. Size 25 × 16 × 10½in. pressurised. **6 Gns.**

R·S·C·TA12 13 WATT STEREO AMPLIFIER

FULLY TRANSISTORISED, SOLID STATE CONSTRUCTION HIGH FIDELITY OUTPUT OF 6.5 WATTS PER CHANNEL



Designed for optimum performance with any crystal or ceramic Gram P.U. cartridge, Radio tuner, Tape recorder, 'Mike' etc. ★ 3 separate switched input sockets on each channel ★ Separate Bass and Treble controls ★ Slide Switch for mono use ★ Speaker Output 3-15 ohms ★ For 200-250 v. A.C. mains ★ Frequency Response 30-20,000 c.p.s. —2dB ★ Harmonic Distortion 0.3% at 1000 c.p.s. Hum and Noise —70dB ★ Sensitivities (1) 300 mV (2) 50 mV (3) 100 mV (4) 2 mV ★ Handsome brushed silver finish Facia and Knobs. Output rating I.H.F.M. Complete kit of parts with full wiring diagrams and instructions. 12½ GNS. Carr. 7/9. Factory built with 12 mth. gntee. 16 GNS. Or Dep. £4/16/- and 9 mthly. pymts. 29/- (Total 17 Gns.) Or in Teak or Afrormosia veneer housing 19 GNS. or Dep. £4/19/- and 9 mthly. pymts. 39/- (Total £22/10/-.)

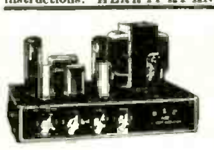
THE 'YORK' HIGH FIDELITY 3 'SPEAKER SYSTEM

• Moderate size approx. 25 × 14 × 10 in. • Range 30-20,000 c.p.s. Impedance 15 ohms. • Performance comparable with units costing considerably more. Complete kit. **19 Gns.** Consists of (1) 12 in. 15 watt Bass unit with cast chassis, Roll rubber cone surround for ultra low resonance, and ceramic magnet. (2) 3-way quarter section series cross-over system. (3) 8 × 5in. high flux middle range speaker (4) High efficiency tweeter. (5) Measured weight of woollen acoustic damping material. (6) Teak veneered cabinet. (7) Circuit and full instructions. HEAR IT AT ANY BRANCH.

R.S.C. BATTERY/MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5½ × 4½ × 2in. approx. Completely replaces batteries supplying 1.5 v. and 90 v. where A.C. mains 200/250 v. 50 c/s. is available. Complete kit with diagram 49/11 or, Ready for use, 59/11.

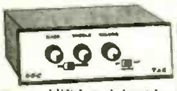
R.S.C. A10 30 WATT ULTRA LINEAR HI-FI AMPLIFIER



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.

INTEREST CHARGES REFUNDED On Credit Sales settled in 3 months.

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. In fully enclosed enamelled case, 9½ × 2¾ × 5½in. Attractive brushed silver finish facia plate 10½ × 3½in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. **6 Gns.** Or factory built with 12 months' guarantee. 8 Gns. Carr. 7/6.

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 C488, 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 of 52/6 (Total £28/5/-). Carr. 15/-

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. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250 v. 50 c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2½ × 2½in.

250 v., 60 mA, 6.3 v. 2 a.	15/11
250-0-250v., 60mA. 6.3v. 2a.	16/11

FULLY SHROUDED UPRIGHT MOUNTING

250-0-250v. 60mA., 6.3v. 2a., 0-5-6.3v. 2a.	21/9
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., 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
425-0-425v. 200mA, 6.3v. 4a., 6.3v. 3a, 5v. 3a	75/-
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. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams & instructions. **14 Gns.** Inc. Carr. 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

SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

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%
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 £18/3/9). 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/- **19½ 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. **6 Gns.** 59/9

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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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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60 P.I.V. 290 MA	2/-	400 P.I.V. 8 AMP	7/6
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150 P.I.V. 25 AMP	10/-	800 P.I.V. 5 AMP	7/6
200 P.I.V. 6 AMP	5/6	1000 P.I.V. 6 AMP	7/6
400 P.I.V. 500MA	3/6	1000 P.I.V. 650MA	6/6
400 P.I.V. 6 AMP	5/6		

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400 P.I.V. 3 AMP	7/6	400 P.I.V. 7 AMP	15/6
100 P.I.V. 7 AMP	13/6	500 P.I.V. 100 AMP	79/6
200 P.I.V. 7 AMP	15/6		

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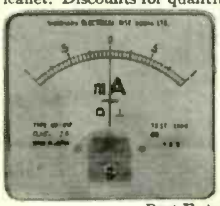
STC. 1 WATT SERIES 5% 2.4/2.7/3/3.9/4.3/13/16/18/20/30/33 volt, 5/- each.
Z series. All voltages from 3.9-50 volt. 250 mW, 2/6 ea. 1.5 w. 4/- ea. 7 w. 5/- each.

PLEASE ADD POSTAGE

CLEAR PLASTIC PANEL METERS

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



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

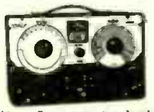
Post Extra. Larger sizes available—send for lists.

TE-20RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kc/s-260 Mc/s. on 6 bands. Directly calibrated. Variable R.F. attenuator. Operation 200/240 v. A.C. Brand new with instructions. £15.

P. & P. 7/6. S.A.E. for details.

ARF-100 COMBINED AF-RF SIGNAL GENERATOR



AF. SINE WAVE 20-200,000 cps. Square wave 20-30,000 cps. O/P HIGH IMP. 21 v. P/P 600 Ω 3.8 v. P/P. R.F. 100 kc/s-300 Mc/s. Variable R.F. attenuation. Int./Ext. Modulation. Incorporates dual purpose meter to monitor. AF output and % mod. on R.F. 220/240 v. A.C. £30. Carr. 7/6.

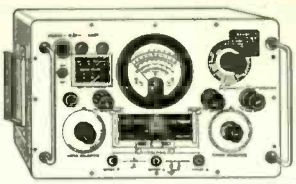
TE22 SINE SQUARE WAVE AUDIO GENERATORS

Sine: 20 cps to 200 kc/s. on 4 bands. Square 20 cps to 30 kc/s. Output impedance 5,000 ohms. 200/250 v. A.C. operation. Supplied brand new and guaranteed with instruction manual and leads. £16.10.0. Carr. 7/6.

LAFAYETTE TE-46 RESISTANCE CAPACITY ANALYSER

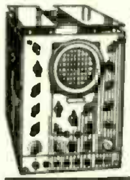
2 pf-2,000 mfd. 2 ohms-200 megohms. Also checks impedance turns ratio insulation. 200/250 v. A.C. Brand New. £17.10 Carr. 7/6.

AVO CT.38 ELECTRONIC MULTIMETERS



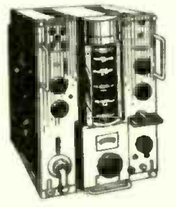
High quality 97 range instrument which measures A.C. and D.C. Voltage. Current, Resistance and Power output. Ranges D.C. volts 250mV-10,000 v. (10 megΩ-110megΩ input). D.C. current 10μA 25 amps. Ohms: 0-1,000 megΩ. A.C. volt 100 mV-250 v. (with R.F. measuring head up to 250 Mc/s). A.C. current 10μA-25 amps. Power output 50 microwatts-5 watts. Operation 0/110/200/250 v. A.C Supplied in perfect condition, complete with circuit lead and R.F. probe, £25. Carr. 15/-.

TYPE 13A DOUBLE BEAM OSCILLOSCOPES BARGAIN



An excellent general purpose D/B oscilloscope. T.B. 2 cps-750 Kc/s. Bandwidth 5.5 Mc/s Sensitivity 33 Mv/cm. Operating voltage 0/110/200/250 v. A.C. Supplied in excellent working condition, £22/10/-. Or complete with all accessories, probe, leads, lid. etc. £25. Carriage 30/-.

ADMIRALTY B.40 RECEIVERS

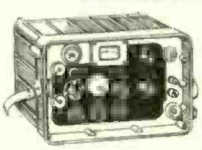


Just released by the Ministry. High quality 10 valve receiver manufactured by Murphy. Coverage in 5 bands 650 Kc/s-30 Mc/s. I.F. 500/Kc/s. Incorporates 2 R.F. and 3 I.F. stages, bandpass filter, noise limiter, crystal controlled B.F.O. calibrator I.F. output, etc. Built-in speaker, output for phones. Operation 150/230 volt A.C. Size 19½ × 13½ × 16in. Weight 114lb. Offered in good working condition. £22/10/0. carr. 30/-. A few brand new, £35. Carr. 30/-. With circuit diagrams. Also available B41 L.F. version of above. 15 Kc/s-700 Kc/s. £17/10/-. Carr. 30/-.

CLASS D. WAVEMETERS

A crystal controlled heterodyne frequency meter covering 1.7-8 Mc/s. Operation on 6 v. D.C. Ideal for amateur use. Available in good used condition £5.19.6 Carr. 7/6. Or brand new with accessories £7.19.6 Carr. 7/6.

AM/FM SIGNAL GENERATORS



Oscillator Test No. 2. A high quality precision instrument made for the Ministry by Airmec. Frequency coverage 20-80 Mc/s. AM/CW/FM. Incorporates precision dial, level meter, precision attenuator 1μV-100Mv. Operation from 12 volt D.C. or 0/110/200/250 v. A.C. Size 12 x 8½ x 9in. Supplied in brand new condition complete with all connectors, fully tested, £45. Carr. 20/-.

MARCONI CT44 TF956 AF ABSORPTION WATTMETER

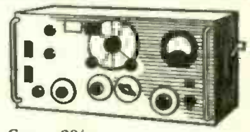
1 u/watt to 6 watts. £20. Carr. 20/-.

TE-16A TRANSISTORISED SIGNAL GENERATOR

5 Ranges 400 KHZ-30 MHZ. An inexpensive instrument for the handyman. Operates on 9v. battery. Wide easy to read scale. 800 KHZ modulation. 5½: × 5½: × 3½:. Complete with instructions and leads. £7/19/6. P/P 4/-.

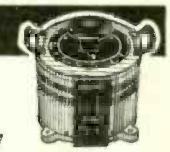
FIELD TELEPHONES TYPE L. Generator ringing, metal cases. Operate on 2 1.5 v. batteries (not supplied.) Excellent condition. £4.10.0 per pair. Carr. 10/-.

MARCONI TEST EQUIPMENT



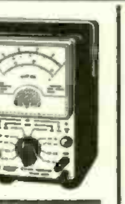
EX-MILITARY RECONDITIONED.
TF 144G STANDARD SIGNAL GENERATORS, 85 Kc/s-25 Mc/s, £25. Carr. 30/-.
TF 885 VIDEO OSCILLATOR 0-5 m/cs £45 Carr 30/-.
T.F.195M. BEAT FREQUENCY OSCILLATOR. 0-40 kc/s, 200/250 v. A.C. £20. Carr. 30/-.
TF 142E DISTORTION FACTOR METER £20. Carr. 20/-
All above offered in excellent condition, fully tested and checked.
TF 1100 VALVE VOLTMETER, Brand New, £50. TF 1267 TRANSMISSION TEST SET, Brand New, £75. TF1371 WIDE BAND MILLIVOLT METER, Brand New, £50.

Variable Voltage TRANSFORMERS



Brand new, guaranteed and carriage paid.
High quality construction. Input 230 v. 50-60 cycles.
Output full variable from 0-260 volts. Bulk quantities available.
1 amp.—£5/10/-; 2.5 amp.—£6/15/-; 5 amp.—£9/15/-;
8 amp.—£14/10/-; 10 amp.—£18/10/-; 12 amp.—£21; 20 amp.—£37

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



10 meg. input 10 ranges: .01/.03/.1/.3/1/3/10/30/100/300 v. R.M.S. 4 cps.-1.2 Mc/s. Decibels −40 to +50 dB. Supplied brand new complete with leads and instructions. Operation 230 v. A.C. £17/10/-. Carr. 5/-.

ADVANCE TEST EQUIPMENT

Brand new & boxed in original sealed cartons.
VM.76. VALVE VOLTMETER. R.F. measurements in excess of 100 Mc/s & D.C. measurements up to 1000 v. with accuracy of ±2%. D.C. range 300 MV to 1 KV. A.C. range 300 MV to 300 V RMS. Resistance 0.02—500 M. Price £72.
VM.78. A.C. MILLIVOLT METER. Transistorised. 1 Mv—300V. Frequence 1 c/s to 1 Mc/s. Price £55.
VM.79. UHF MILLIVOLT METER. Transistorised. A.C. range 10 Mv—3V. D.C. current range 0.01/A—0.3 Ma. Resistance 1 ohm—10 megohms. £125.
H1B. AUDIO SIGNAL GENERATOR. 15 c/s—50 Kc/s, sine or square wave. Price £30.
J1B. AUDIO SIGNAL GENERATOR. 15 c/s—50 Kc/s. Price £30.
J2B. AUDIO SIGNAL GENERATOR. As per J1B except fitted with output meter £35.
TT1S. TRANSISTOR TESTER. £37/10/-.
Carriage 10/- per item.

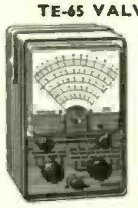
LELAND MODEL 27 BEAT FREQUENCY OSCILLATORS

0-20 Kc/s. Output 5K or 500 ohms. 200/250 v. A.C. Offered in excellent condition. £12/10/- Carriage 10/-.

★ TRANSISTOR FM TUNER ★

6 TRANSISTOR HIGH QUALITY TUNER SIZE ONLY 6in. x 4in. x 2½in. 3 I.F. stages. Double tuned discriminator, ample output to feed most amplifiers. Operates on 9 volt battery. Coverage 88-108 Mc/s. Ready built ready for use. Fantastic value for money, £6/7/6. P. & P. 2/6.
STEREO MULTIPLEX ADAPTORS. 5 Gns.

TE-65 VALVE VOLTMETER

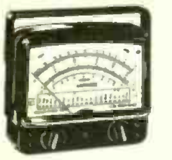


High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions £17/10/0. P & P. 6/-. Additional Probes available: R.F. 35/- H.V. 42/6.

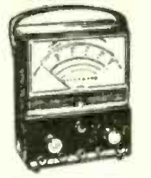
G. W. SMITH
& Co. (Radio) Ltd.
3-34 Lisle St., W.C.2.

ALSO SEE OPPOSITE PAGE

MULTIMETERS for EVERY purpose!

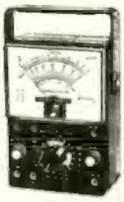


LAFAYETTE DE-LUXE 100 KΩ/VOLT "LAB TESTER." Giant 6½in. scale. Built in meter protection, 0/.5/2.5/10/50/250/500/1,000 v. D.C. 0/3/10/50/250/500/1,000 v. A.C. 0/10/100μA/10/100/500 MA/2.5/10 Amp. 0/1K/10K/100K/10M/100MΩ. —10 to 49.4dB. **£18/18/-.** P. & P. 5/-.



TE-900 20,000Ω/VOLT GIANT MULTIMETER Mirror scale and overload protection. 6in. full view meter. 2 colour scale. 0/2.5/10/250/1,000/5,000 v. A.C. 0 / 25 / 12.5 / 10 / 50 / 250/1.000/5.000 v. D.C. 0/50μA/110/100/500mA/10 amp. D.C. 02K/200K/20 MEG. OHM. **£15/-/-.** P. & P. 5/-.

LAFAYETTE 57 Range Super 50KΩ/V. Multimeter. D.C. volts 125mv—1000v. A.C. volts 1.5v—1000v. D.C. Current 25μA—10 Amp. Ohms 0—10 MegΩ. D.B.—20 to +81 db. Overload protection. **£12/10/-.** P. & P. 3/6.

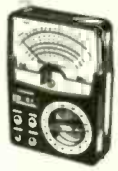


MODEL AS-100D. 100KΩ/Volt. 5in., mirror scale. Built-in meter protection 0/3/12/60/120/300/600/1,200 v. D.C. 0/6/30/120/300/600 v. A.C. 0/10μA/6/60/300MA/12 Amp. 0/2K/200K/2M/200MΩ. —20 to +17dB. **£12/10/-.** P. & P. 3/6.

NEW MODEL 500 30,000 O.P.V. with overload protection, mirror scale. 0/.5/2.5/10/25/100/250/500/1,000 v. D.C. 0/2.5/10/25/100/250/500/1,000 v. A.C. 0/50μA/5/50/500 mA. 12 amp. D.C. 0/60K/6 meg/60 megΩ. **£8/17/6.** Post paid.

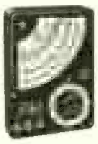
MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30μA/3/30/300mA. 0/16K/160K/1.6M/16 MegΩ. **£5/10/-.** P. & P. 3/-.

MODEL TE-90 50,000 O.P.V. Mirror scale overload protection. 0/3/12/60/300/600/1,200 v. D.C. 0/6/30/120/300/1,200. v D.C. .03/6/60/600 MA. D.C. 16K/160K/1.6/16 MEG Ω. —20 — + 63db. **£7/10/0.** P. & P. 3/-.



TE-51. NEW 20,000Ω/VOLT MULTIMETER, with overload protection and mirror scale, 0/6/60/120, 1,200 v. A.C. 0/3/30/60/300/600/3,000v. D.C. 0/60μA/12/300m A.D.C. 0/60K/6 meg. ohm. 92/6. P. & P. 2/6.

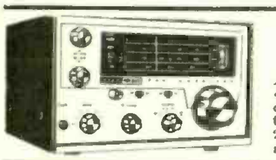
MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60μA/6/60/600 mA. 0/6K/600K/6 Meg./60 Meg.Ω. 50 PF. .2 MFD **£5/19/6.** P. & P. 3/6.



MODEL TE-10A. 200kΩ/Volt 5/25/50/250/500/2,500 v. D.C. 10/50/100/500/1,000 v. A.C.
0/50μA/2.5 mA/250 mA D.C. 0/6K/6 meg. ohm. —20 to +22 dB.
10-0, 100 mfd. 0.100-0.1 mfd. 69/6. P. & P. 2/6.

MODEL TE-80. 20,000 O.P.V. 0/10/50/100/500/1,000 v. A.C. 0/5/25/50/250/500/1,000 v. D.C. 0-50μA. 5/50/500mA. 0/6K/60K/600K/6 meg. **£4/17/6.** P. & P. 3/-.

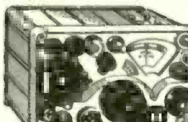
PROFESSIONAL 20,000 O.P.V. LAB TYPE MULTITESTER. Automatic overload protection, mirror scale. Ranges 1/10/50/250/500/1,000 v. D.C. and A.C. 0-500μA, 10mA, 250mA, Current: 0/20K, 200K, 2megohm, Decibels:—20 to + 22db. **£5/19/6.** P. & P. 2/6.



NEW STAR SR-200 SSB AMATEUR RECEIVER

An exciting new receiver covering 6 amateur bands 160/80/40/20/15/10 metres. Illuminated slide rule dial. S meter. Crystal calibrator. Product detector. Automatic noise limiter. RF tuning and gain controls. Speaker or phone outputs. 8 valves, 2 transistors, 2 diodes. 220/240 V. A.C. Supplied brand new and guaranteed. **£40/-/-.** Carr. 10/-.

R209 Mk. II COMMUNICATION RECEIVER

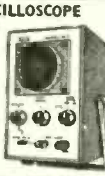


11 valve high grade communication receiver suitable for tropical use. 1-20 Mc/s. on 4 bands. AM/CW/FM operation. Incorporates precision vernier drive, B.F.O. Aerial trimmer, internal speaker and 12v. D.C. internal power supply. Supplied in excellent condition, fully tested and checked, **£15** Carr. 20/-.

TO-3 PORTABLE OSCILLOSCOPE. 3" TUBE

Y amp. Sensitivity. .1v p-p/CM. Bandwidth 1.5 cps—1.5 MHZ. Input imp. 2 meg Ω. 25 PF. X amp sensitivity. ·9v p-p/CM. bandwidth 1.5 cps—800 KHZ. Input imp. 2 meg Ω 20 PF. Time base. 5 ranges 10 cps—300 KHZ. Synchronization. Internal/external. Illuminated scale. 140 × 215 × 330 MM. Weight 15½lbs. 220/240 V. A.C. Supplied brand new with handbook. **£35/-/-.** Carr. 10/-.

TO-2 PORTABLE OSCILLOSCOPE



A general purpose low cost economy oscilloscope for every-day use. Y amp. Bandwidth 2 CPS—1 MHZ. Input imp. 2 meg Ω. 25 PF. Illuminated scale. 2" tube. 115 × 180 × 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22/10/-.** Carr. 10/-.

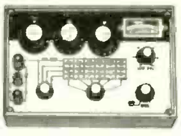
AVOMETERS

Supplied in excellent condition fully tested and checked. Complete with prods, leads and instructions.

Model 7 £13/10/0

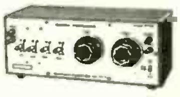
P. & P. 7/6.

TRANSISTORISED L.C.R. A.C MEASURING BRIDGE.



A new portable bridge offering excellent range and accuracy at low cost. Ranges: R. 1Ω—11.1 MEG Ω 6 Ranges ± 1%. L. 1μH—111 HENRIES. 6 Ranges — 2%. C. 10PF ± 1110MFD. 6 Ranges ± 2%. TURNS RATIO 1:1/1000—1:11100. 6 Ranges ± 1%. Bridge voltage at 1,000 CPS. Operated from 9 volts. 100μA. Meter indication. Attractive 2 tone metal case. Size 7¾" × 5" × 2". **£20.** P. & P. 5/-.

TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db × 10) + (1 db × 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db × 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brw enan d **£27/10/-.** P. & P. 5/-.

NEW CATALOGUE

Nearly 200 pages giving full details of a comprehensive range of COMPONENTS, TEST EQUIPMENT, COMMUNICATION EQUIPMENT and HI-FI EQUIPMENT. Each section greatly enlarged and fully illustrated. Thousands of items, many at bargain prices. FREE DISCOUNT COUPONS VALUE 10/-.

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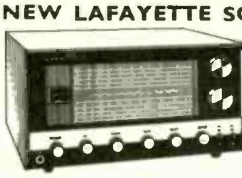
UNR-30 4 BAND COMMUNICATION RECEIVER

Covering 550 Kc/s-30 Mc/s. Incorporates variable BFO for CW/SSB reception. Built-in speaker and phone jack. Metal cabinet. Operation 220/240 v. A.C. Supplied brand new, guaranteed with instructions. **13gns.** Carr. 7/6.

TRIO COMMUNICATION RECEIVER MODEL 9R-59DE

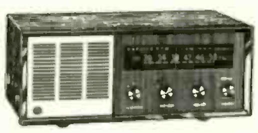
4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 × 15 × 10in. With instruction manual and service data. **£39.15.0.** Carriage paid Trio Communication Type Headphones. Normally £5.19.6. Our price **£3.15.0** if purchased with above receiver.

NEW LAFAYETTE SOLID STATE HA600 RECEIVER



5 BAND AM/CW/SSB AMATEUR AND SHORT WAVE. 150 kc/s-400 Kc/s AND 550 Kc/s-30 Mc/s. F.E.T. front end ● 2 mechanical filters ● Huge dial ● Product detector ● Variable BFO ● Noiselimiter ● S Meter ● 24½in. Bandspread ● 230 v. A.C./12 v. D.C. neg earth operation ● RF gain control. Size 15in. × 9½in. × 8½in. Wt. 18 lbs. EXCEPTIONAL VALUE **£45.** CARR. 10/-. S.A.E. FOR FULL DETAILS.

LAFAYETTE PF-60 SOLID STATE VHF FM RECEIVER



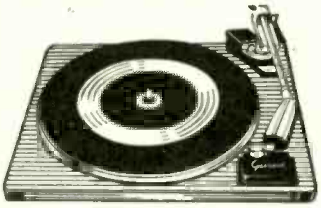
A completely new transistorised receiver covering 152-174 Mc/s. Fully tuneable or crystal controlled (not supplied) for fixed frequency operation. Incorporates 4 INTEGRATED CIRCUITS. Built-in speaker and illuminated dial. Squelch and volume controls. Tape recorder output. 75Ω aerial input. Headphone jack. Operation 230 v. A.C./12 v. D.C. Neg. earth. **£37/10/-.** Carr. 10/-.

LAFAYETTE LA-224T TRANSISTOR STEREO AMPLIFIER

19 transistors, 8 diodes, IHF music power 30 watts at 8 ohms. Res. 30-20,000 ±2 dB at 1 w. Distortion 1% or less. Inputs 3 mV and 250 mV. Output 3-16 ohms. Separate L and R volume controls. Treble and bass controls. Stereo phone jack. Brushed aluminium, gold anodised extruded front panel with metal case. Size 10½in. × 3 $\frac{5}{8}$ in. × 7 $\frac{11}{16}$ in. Operation 115/230 volt A.C. **£28.** Carr. 7/6

GARRARD

GARRARD RECORD DECKS. FULL CURRENT RANGE OFFERED BRAND NEW AND GUARANTEED AT FANTASTIC SAVINGS.



SRP22 Mono	£6.10.0	*SP25 MKII	£11.19.6
SRP22 Stereo	£6.19.6	*SL55	£11.19.6
*1025 Mono	£7.10.0	A70 MKII	£12.10.0
*1025 Stereo	£7.19.6	*AT60 MKII	£13.10.0
*2025 Stereo	£8. 8.0	*SL65	£14.14.6
*2025T/C Mono/Stereo	£8.17.6	AP75	£19. 0.0
		401	£28. 7.6
*3000 Stereo	£9.19.6	SL75	£29. 0.0
		SL95	£35. 0.0

Carriage/insurance 7/6 extra any model.

*Special offer base and cover available for these models at £4.15.0. Carr. 5/-.

Full range of Garrard accessories available

E.M.I. SINGLE PLAYERS

4 speed with separate arm and cartridge **52/6** 3/6. Carr.

COMPUTER TAPE

3,600 ft. × ¼ in. on 10½ in. NAB SPOOLS. Used but good condition. 25/- reel. P & P 5/-.

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Cables: SMITHEX LESQUARE
3-34 LISLE STREET, LONDON, W.C.2

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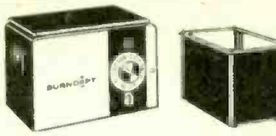


1. ULTRASONIC CLEANERS

(Burndept B.E.352) 60 watt model. Supplied Brand New complete with stainless steel tank 9¾ × 6¼ × 4½ in. **£60.** Carr. 20/-.

2. **FAST NEUTRON MONITORS** (Burndept 1407C) for measuring neutrons in the energy range 0.15-15 meV. **£100.**

3. **Radiation Monitors** (Burndept BN 110 MK. V) 0-5/50/500/5k. c.p.s. Brand new. **£100.** Alpha and Beta Gamma probes available at extra cost.

4. **PORTABLE RADIATION MONITORS** (Burndept BN 132) 0-5/50/500/5k c.p.s. With built-in Gamma probe. Brand new. **£50** complete with carrying harness.

S.A.E. for literature. 10% discount for Educational Authorities.

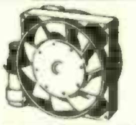
LARGE CAPACITY ELECTROLYTICS. 2,000 μF. 30v.; 2,500 μF. 25v.; 2,500 μF. 50v.; 4,000 μF. 90v.; 5,000 μF. 25v.; **7/6** ea. 5,000 μF. 50v.; 10,000 μF. 30v.; 16,000 μF. 10v. **10/-** ea. p.p. 1/-.

SPEAKER BARGAINS. E.M.I. 13×8 in. with double Tweeters 15 ohm, **65/-**, P.P. 5/-. As above less tweeters 3 or 15 ohm, **45/-** ea., P.P. 5/-.

FANE 12 in. 20 watt (Dual Cone), **95/-**. P.P. 5/-.

CAR RADIO SPEAKER 7×4 in. 3/5 ohm. **15/-** ea. P.P. 2/6

EXTRACTOR/BLOWER FANS (Papst)



100 c.f.m. 4½ ×4½ ×2 in. 2800 r.p.m. Wonderful buy at **50/-** ea. 240v. A.C.

SPEAKER SYSTEM (20×10×10 in.). Made to spec. from ¾ in. board. Finished in black leathercloth. 13×8 in. speaker with twin tweeters complete with cross-over. 50c/s-20k/c. **£7.10.** P.P. 10/-.

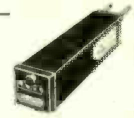
PHOTOMULTIPLIERS 6262 and 6262b. **£15** ea.

RELAYS H.D. 2 pole 3 way 10 amp. contacts. 12v.w. **7/6** ea.

LIGHTWEIGHT RELAYS (with dust-proof covers) 4 c/o contacts. 12v. 100 ohm. or 24v. 500 ohm **7/6** ea.

RE-SETTABLE HIGH SPEED COUNTER (3×1×¾ in.) 3 digit. 12/24/48v. (state which), **32/6** ea. P.P. 2/6.

HIGH SPEED MAGNETIC COUNTERS (4×1×1 in.) 4 digit. 6/12v. 24/48v. (state which), **6/6** ea. P.P. 1/-.



MINIATURE KEY SWITCHES. (P.O. Lever Type 1000), centre off. 2 c/o each way. **7/6** ea.

DEAC BATTERY PACKS (5×4½×1½ in.) containing 3 cells giving 4 volts at 5a.h. **35/-.** P.P. 5/-.

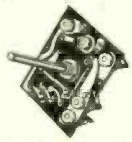
SOLARTRON PULSE GENERATORS (OPS 100C) 50c/s-1m/c. **£60** each. Carriage 50/-.

WOBBULATORS TYPE 210 (Metrix) 0-220 M/c. Sweep width 1/2/5/10/20 m/c. **£40.** Carriage 30/-.

THYRISTOR LIGHT DIMMERS

500 watt Module **45/-**
1000 watt Module **60/-**

These modules may be fitted into standard socket boxes and made up into banks as required.



5 kW **DIMMERS** in metal cabinet **£20** ea.

TRANSFORMERS

H.T. TRANSFORMER (Parmeko 'Neptune') Prim. 200/250v. Sec. 350-0-350v. 150 m.a. 6.3v. @ 1/2/6 amp. **35/-.** P.P. 5/-. Matching Choke 10h 180 m.a. **12/6.**

E.H.T. TRANSFORMER (Parmeko 'Neptune') 3,000v. 280 m.a. **£12/10/0.** P.P. 50/-.

L.T. TRANSFORMERS Prim. 200/250v. Sec. 0-1/0-3/0-9/0-27v. 30 amp. **£7.10.** 15 amp. **£5.** P.P. 15/-.

L.T. TRANSFORMER Prim. 200/250v. Sec. 0/25/35v 30 amp. **£7.10.** P.P. 20/-.

STEP-DOWN TRANSFORMERS Prim. 200/250v. Sec. 115v. 1.25 amps. **25/-** ea. P.P. 5/.

L.T. TRANSFORMERS Prim. 240v. Sec. 8/12/20/25v. 3.5 amp models **20/-**; 5 amp model **25/-.** P.P. 5/6.

L.T. TRANSFORMERS Prim. 240v. Sec. 14v. 1 amp **10/-** ea. P.P. 2/6.

ELECTRIC SLOTMETERS (1/-) 25 amp. L.R. 240v. A.C. 85/- ea. P.P. 5/-.

QUARTERLY ELECTRIC CHECK METERS, 40 amp 240v. A.C., **20/-** ea. P.P. 5/-.

COPPER LAMINATE PRINTED CIRCUIT BOARD (8½×5½×$\frac{1}{16}$ in.), **2/6** sheet, 5 for **10/-**. Also 11×9 in., 4/- ea., 3 for **10/-**.

BULK COMPONENT OFFERS

100 Capacitors (latest types) 50pF to .5μF
250 Resistors ⅛ and ¼ watt.
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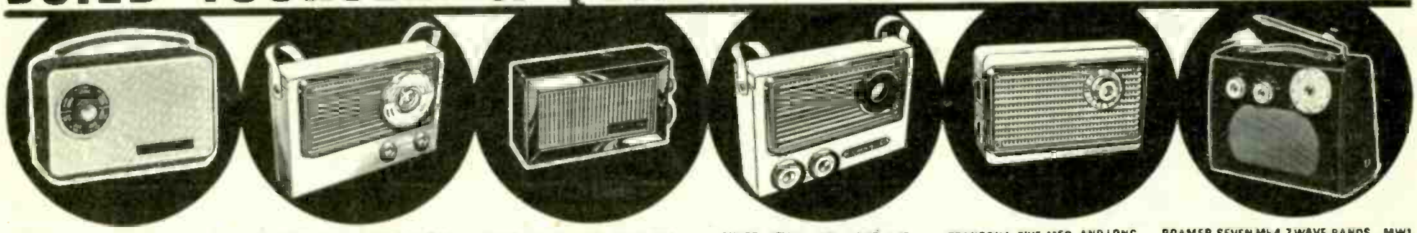

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12BH7 3/6
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12H6 3/-
12J7GT 6/6
12K7GT 7/6
12K8M 8/-
12Q7GT 5/-
12SC7 4/-
12SG7 4/6
12SH7 3/-
12SJ7 4/-
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12SL7GT 7/-
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13D1 4/-
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50 micro amp 2 in. square panel	32/-
300mA 2½ in. square panel	22/6
20-20mA 2 in. Round panel	17/6
30-0-30mA 2½ in. round panel	20/-
70-150v 2 in. square, black dial luminous hand and figures	12/6
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200µA. 2in. round panel, sealed calibro-30	22/6
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500µA. 2½in. round proj.	20/-
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75 mA. 2½in. plug in	14/-
100 mA. 1½in. proj.	17/6
100 mA. 1½in. round panel	17/6
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100 V 4in. round panel	25/-
150 VDC 4in. round panel	25/-
150-0-1500 mA. 3½in. round panel	25/-
1.5 KV with res. 2in. round panel	27/6

R.F. METERS

120 mA. 2½ in. round panel	32/-
1 amp. 2½ in. square panel	30/-
4 amp. 2 in. round panel	22/6

MOVING IRON METERS

15 VAC 2½in. round panel	27/6
500 VAC 2½in. round clip fix	25/-
50 amp 2½ in. round panel	19/-

MINIATURE METERS. General Electric 1½in. round flush, clip mounted:
1 mA D.C., 22/6
25 mA D.C., 20/-.
75 mA. D.C., 18/-. P. & P. 3/-.
150 mA. D.C., 15/-.

"S" METER FOR H.R.O. RECEIVERS. Brand new, £2/10/-. Carriage paid U.K.

SUB - MINIATURE "PENNY SIZE" METERS. 1in. round, flush ring nut mounted 500µA FSD, calibrated 0-1 mA. 20/-. P. & P. 3/-.

NULL METER (unscaled 25-0-25 micro-amps) 3½in. square panel. 45/-.

NAGARD OSCILLOSCOPE TYPE DE 103, £85. Carriage 10/-.

PORTABLE SONTRANIC OSCILLOSCOPE 2½in. tube 220/250v. A.C., £22 10s. Carriage 30/-.

HEWLETT-PACKARD VTVM MODEL 410B. A compact instrument for A.C., D.C. and resistance measurements with A.C. meas. in excess of 100 mc/s; D.C. polarity reverse facility and 7 resistance ranges. Large easily readable meter. A.C. range 1-300V in 6 ranges. D.C. range 1-1,000V in 7 ranges. Resistant 0-50 Mohms. £22/10/-. Carriage 15/-.

RF WATT METER PM16. Frequency 0.2-500 mc/s, 3 ranges 0-150, 0-600, 0-1,500w. Impedance 51.5 ohms. "N" type connector. £75. Carriage 40/-.

PHASE MONITOR ME-63/U. Manufactured recently by Control Electronics Inc. Measures directly and displays on a panel meter the phase angle between two applied audio frequency signals within the range from 20-20,000 c.p.s. to an accuracy of ±1.0°. Input signals can be sinusoidal or non-sinusoidal between 2 and 30 v. peak. In excellent condition together with handbook and necessary connector. £45. Carriage 30/-.

SPARES FOR AR.88D. RECEIVERS. Ask for your needs from our huge selection.

INSET MICROPHONE for telephone handset, 2/6. P. & P. 2/-.

FIELD TELEPHONES TYPE "F" Housed in portable wooden cases. Excellent for communication in- and out-doors for up to 10 miles. For pair including batteries and 1/6th mile field cable on drum. Completely new, £6/10/-. Slightly used, £5/10/-. Carriage 10/-.

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HARNESS "A" & "B" control units, junction boxes, headphones, microphones, etc.

29/41FT. AERIALS each consisting of ten 3ft., ⅝in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag, £3/9/6. P. & P. 10/6.

300W 15V JAP Petrol Generator (Charging set). £35. Carriage 15/-.

1260W 35V CHARGING SET. Complete with switchboard. New £45. Carriage 40/-.

L.T. SUPPLY UNIT RECTIFIER No. 19. Consists of two separate 12V DC circuits each rated at 3 amp, which may be used independently, giving two separate outputs of 12V at 3 amps, connected in parallel giving 12V 6 amps or connected in series giving 24V at 3 amps. Ideal for battery charging, DC power supply, etc. 100/250V AC input. Brand new, complete with connectors. £6/19/-. Carriage 9/-.

SMALL 28V MOTORS. 150/200mA approx. 4,000 r.p.m. Ideal for small fans, running models, miniature drills, grinders, etc. 12/-. P. & P. 2/-.

MECHANICAL TIMED DELAY RELAYS. Coil resistance 150 ohms, working from 12-40v D.C. Adjustable delay within range of few seconds. 17/-. P. & P. 3/-.

HIGH SPEED ULTRA SENSITIVE PLUG IN RELAYS with two separate windings each of 1685 ohms. 12/-. P. & P. 2/-.

LOW INERTIA 24V D.C. MOTOR, complete with gears. 15/-. P. & P. 3/-.

UNIVERSAL GALVANOMETER SHUNTS. 25/-. P. & P. 3/-.

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COLLINS TCS. Complete installations and spare parts.

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BC 610E & BC 6101 TRANSMITTERS. Complete with speech amplifier BC 614E. Aerial tuning unit BC 939A, exciter units, tank coils, etc. Fully tested and guaranteed. All spares available.

No. 19 HIGH POWER SETS. By introducing RF Amplifier the output increased to 25 watts. Complete installations supplied.

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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.

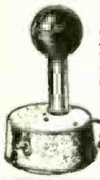
220/240 A.C. MAINS MODEL incorporates mains transformer rectifier and special relay with 3 × 5 amp. mains c/o contacts. Price inc. circuit 47/6, plus 2/6 P. & P.

PHOTO ELECTRONIC COUNTER

Can be set for counts of up to 500 per minute. 210-250 v. A.C. powered. Kit of Components, including photo cell, high speed non-resettable counter, transformer, relay, etc., together with clear circuit diagram, £3/2/6, plus 3/6 P. & P. With resettable counter, £4/2/6, P. & P. 3/6.

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$\frac{1}{16}$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. × ½in. New. Price 8/6 per pair. Post Paid.
6 of the above mentioned units (12 Reeds) fitted in metal box. Size 4in. × 3½in. × 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. × 5½in. 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.

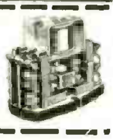
MOVING COIL HEADPHONE AND MIKE

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.

A.C. CONTACTOR



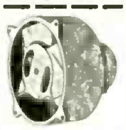
2 make and 2 break (or 2 c/o) 15 amp. contacts. 230/240 v. A.C. operation. Brand new. 22/6 plus 1/- P. & P.

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 ⅜in. dia. $\frac{5}{16}$in., 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.
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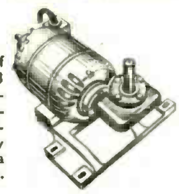
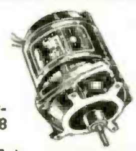
6½ INCH POLISHED REFLECTOR. Ideally suited for above Strobe Kits. Price 8/6 post paid.
Regret not sold separately.

PARVALUX TYPE SD19 230/250 VOLT AC REVERSIBLE GEARED MOTORS



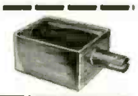
30 r.p.m. 40 lb. ins. Position of drive spindle adjustable to 3 different angles. Mounted on substantial cast aluminium base. Ex-equipment. Tested and in first-class running order. A really powerful motor offered at a fraction of maker's price. 6 gns. P. & P. 10/-.

BODINE TYPE N.C.1 GEARED MOTOR



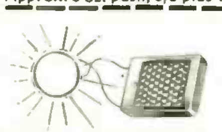
(Type 1) 71 r.p.m. torque 10 lb. inches Reversible 1/70th h.p. 50 cycle ·38 amp.
(Type 2) 28 r.p.m. torque 20 lb. in reversible 1/80th h.p. 50 cycle ·28 amp.
The above two precision made U.S.A. motors are offered in 'as new' condition. Input voltage of motor 115v A.C. Supplied complete with transformer 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.

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.

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.

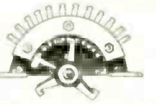
PRECISION INTERVAL TIMER

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



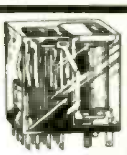
3 banks of 11 positions, plus homing bank. 40 ohm coil. 24-36 v. D.C. operation. Carefully removed from equipment and tested. 22/6, plus 2/6 P. & P.

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



BULK PURCHASE ENABLES US TO OFFER THE FOLLOWING NEW **SIEMENS PLESSEY**, etc. MINIATURE PLUG IN RELAYS COMPLETE WITH BASE, AT A FRACTION OF MAKER'S PRICE

COIL Ω	WORKING VOLTAGE	CONTACTS	PRICE
280	6—12	2 c/o	14/6
280	9—18	4 c/o	15/6
700	12—24	2 c/o	12/6
700	16—24	4 c/o	15/6
700	16—24	4M 2B	12/6
1250	20—40	2 c/o Heavy Duty	12/6
2500	30—50	2 c/o Heavy Duty	12/6
5800	50—70	4 c/o	10/-
9000	40—70	2 c/o	10/-

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230 VOLT AC COIL
Two c/o 5 amp contacts. Plug-in I.O. Base. Price 14/6d. incl. base. Post Paid.
Three c/o 5 amp contacts. 17/6. incl. base. Post Paid.

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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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300-0-300 microamp. Calibrated 30-0-30. Mounted in sloping front case £2/10/-. P. & P. 3/6 **D.C. Voltmeter** 0-3 V and 0-15. V £2 plus 3/6 P. & P. **D.C. Ammeter.** 0-6 amp. and 0-3 amp. £2, 3/6 P. & P. The set of 3 matching instruments £6, P. & P. 6/6.

A.C. AMMETERS 0-1, 0-5, 0-10, 0-15, 0-20 amp. F.R. 2½in. dia. All at 21/- each.
A.C. VOLTMETERS 0-25 v., 0-50 v., 0-150 v. M.I 2½in. Flush round all at 21/- each. P. & P. extra.
0-300 v. A.C. Rect. M-Coil 2½in. 29/–
0-300 v. A.C. Rect. M-Coil 3½in. Type W23 ...... 55/–

'AVO' METER MODEL 7

Supplied fully checked and tested on all ranges and in excellent condition. Complete with batteries and leads. Price £13/10/-. P. & P. 7/6d.
Avo Leather Carrying Case 3/-.

'AVO' POWER AND DECIBEL EXTENSION UNIT

For Model 7 and 7X "AVO" Meters. This resistance box will permit values from 500 to 1,500 ohms to be obtained. Supplied complete with leads. 42/6 p. & p. 4/6.

"AVO" 25,000 VOLT D.C. MULTIPLIER
For E.T.M. Complete with leads. New and boxed, 21/- P. & P. 6/6.

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All primaries 220-240 volts.

Type No.	Sec. Taps	Price	Carr.
1	30, 32, 34, 36 v. at 5 amps.	£4 5 0	6/-
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3	10, 17, 18 v. at 10 amps.	£4 10 0	4/6
4	6, 12 v. at 20 amps.	£5 17 6	6/6
5	17, 18, 20 v. at 20 amps.	£6 12 6	6/6
6	6, 12, 20 v. at 20 amps.	£6 5 0	7/6
7	24 v. at 10 amps.	£4 15 0	5/6
8	4, 6, 24, 32 v. at 12 amps.	£6 10 0	6/6

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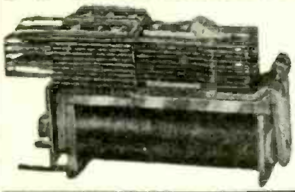


P.O. TYPE 3000 AND 600

BUILT TO YOUR REQUIREMENTS—QUICK DELIVERY
COMPETITIVE PRICES — VARIOUS CONTACTS
DUST COVERS — QUOTATIONS BY RETURN
LARGE STOCKS HELD OF MINIATURE SEALED RELAYS

CONNECTING WIRE 1/024; 7/0076; or 14/0048 PVC covered in various colours 100 & 200 yard reels. £4 per 1,000 yds. post 6/-

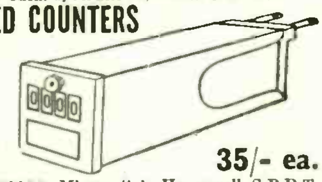
MINIATURE SILVER ZINC ACCUMULATOR. 1·5 volt. 1·5 ampere. Size 2" × 1·13" × 0·63". Weight 1¼ oz. Ideal for model work. **12/6** each. **120/-** doz., post 1/6.
STROBOSCOPE FORK. 125 cycles. P.O. No. 5, **30/-** each, post 2/6.
LEDEX SOLENOID DRIVENWAFER SWITCHES SIZE 5S. From **90/-**. 11 Way and off. 3 to 24 Pole: also 4 Pole 12 Way and 54 Pole on/off.
SOLENOIDS type 3E in stock at 17/6 each.
CERAMIC AND PAXOLIN WAFER SWITCHES available from stock at keen prices, send for list. 24 way Double Pole Pax Wafer Switches **12/6** each, post 2/6.
P.O. STANDARD RACKS 6ft U channel sides drilled for 19in. panels heavy angle base. **150/-**, cge 20/-. Desk Units for Racks **30/-**, cge 7/6.
BANKS OF 5 SWITCHES flush mounting in strong bakelite case made for Aircraft use **12/6**.
MINIATURE BUZZERS. 12v. with tone adjuster, **7/6**.

SPECIAL OFFER
43.500 Condensers 0.1 mfd 150 volts T.M.C. wire ended £15 per 1,000 or offer to clear lot.

PLASTIC-FILM CONDENSERS TMC S125017LM 0·9 + 0·1 mfd 500V also 1 mfd. 1%. 150V. TCC **20/-** each.
AIR BLOWERS. 200/250 volt. A.C. cylindrical 7in. — 7in. suitable for intake or extraction, 1/50th h.p. **£10.** 1/15th h.p. **£11.** 1/10th h.p. **£14.**
ELCOM STUD SWITCHES. 12 pole 2 way or 3 way types on 3 Banks, break before make action 50/- ea.
GEARED MOTORS. 3 r.p.m. or 1 r.p.m. 4 watts very powerful, reversible 24 v. AC **35/-**, post 2/6, can be operated from 230v with our **20/-** Transformer.
SUB-MINIATURE LAMPS. Flying leads 0.75 volts 50/- 100.
DOUBLE HEADPHONES. Balanced armature. Sound powered type DHR, **17/6**. Post 3/-.
MICRO SWITCH. Burgess MK4BR, robust die cast casing. **8/6** each. Post 1/-. Others available.
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**.
BATTERIES Portable 6 volt 125 amp hour in metal case uncharged **110/-**.

PHOTOGRAPHIC EQUIPMENT
Dallmeyer Projection Lens F = 65 mm, 35 mm mount **70/-** each, post 2/6. Condenser Lenses. Plano-Convex optically ground and polished 1¾" dia. 2¼" focus **7/6** each, post 2/-. 2¼" dia 3" focus **10/-** each, post 2/6. 6" dia. 10" focus **35/6**, post 4/6.
Photofloods G.E.S. 230 volts 1,000 watts **10/-** ea., post 7/6.
LAMP HOUSES with pair of 6" lenses mounted in a 9" square case. Ideal spotlight **70/-** each, post 10/-.

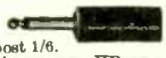
HIGH SPEED COUNTERS



3¼ × 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.

35/- ea.

SUB-MINIATURE Microswitch Honeywell S.P.D.T. type 11 SM1 TN 13 size ¾" × ½" × ¼" **6/6** ea. or mounted in fives for **22/6** post free.
DIGITAL INDICATOR. KGM M5 28 vt. 0 to 9. **50/-** ea.
SPEAKERS ELAC 5in. ROUND. 9700 Gauss. 3Ω **12/6**. Post 2/6.
JACK PLUGS. 2 Point with screw-on cover, **2/6**, post 9d.



PO 201 on headphone cord **3/-**, post 1/6.
PLUG-IN RELAYS. Londex 4 change-over HD contacts 28 v. D.C. or 240 v. A.C. with base and cover, **35/-** ea.
RELAYS. 24 volt DC, 4 make, 4 break heavy duty contacts with dust cover, **12/6** each, quantities available.
UNISELECTOR DIGIT SWITCHES 8 level 12 outlets 3 bridging 5 non-bridging 50 volts. NEW **£8/10/-** each.
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.**

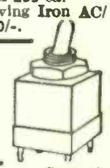
ROBUST AIRCRAFT PUSH 5C/898 of bakelite barrel type construction, with 1¾" square 4 hole fixing top with actual push below the level of a 1" bakelite circle to prevent it being used accidentally. Samples **5/6** each large quantities available.

MAGNETIC COUNTERS Veeder Root with zero reset. 800 counts per minute, counting to 999,999. 110 or 125 volts AC or 110 volts DC. **65/-** each, post 3/-.
METERS GUARANTEED. Complete list available.

Microamps 0/100 2½in. MC	40/-
Microamps 0/500 2in. MC	25/-
Microamps 0/500 2½in. MC	37/6
Milliamps 0/50 2½in. MC..	35/-
Milliamps 0/500 3½in. MC	54/-
Amps 50-0-50 2in. MC....	17/6
Amps 0/5 2in. MC........	37/6
Volts 5/0/5 2½in. MC......	25/-
Volts 0/20 2in. MC........	37/6
Volts 0/10 A.C. 3½in. MCR	70/-

MICROAMPS 0/50 scaled in Rontgens 2½in. MC **45/-**.
LEAK DETECTOR A.E.I. mains powered **£35** ea.
PORTABLE VOLTMETERS 0/250 Moving Iron AC/DC, 6in. scale, in polished wood case, **£7/10/-**.

ONE HOLE FIXING SWITCHES



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/-.

MASTER CONTACTOR. Precision made. Contacts making and breaking twice per second in soundproof case with thermostat controlled heating. 12 or 24v. **18/6** post 6/-.
"VISCONOL-CATHODRAY" CONDENSERS. .001 mfd. 10 kV, **5/-**; .002 mf. 15 kV, **9/-**; .02 mf. 10 kV, **10/-**; .025 mf. 2.5 kV, **5/-**; .05 mf. 5 kV, **9/-**; 0.1 mf 4 kV, **9/-**; 6kV, **17/6**; 0.5 mf. 2.5 kV, **17/6**; 1 mfd. 2 kV. **17/6**.
RESISTORS. wire wound or carbon, potentiometers, condensers, quantities ex-stock at low prices.
BRIDGE MEGGERS SERIES 1. With resistance box and leads, 1,000 v., 0-100 megohms. **£60** ea.

L. WILKINSON (CROYDON) LTD.
LONGLEY HOUSE LONGLEY RD. CROYDON SURREY
Phone: THO 0236 Grams: WILCO CROYDON

LATEST RELEASE OF

RCA COMMUNICATION RECEIVERS AR88

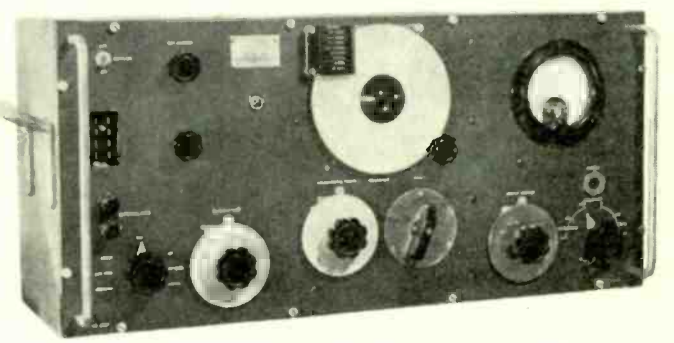
BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price **£87/10/-** each, carr. £2.

Same model as above in secondhand cond. (guaranteed working order), from £45 to £60, carr. £2.

***SET OF VALVES:** new, £3/10/- a set, post 7/6; **SPEAKERS:** new, £3 each, post 10/-. ***HEADPHONES:** new, £1/5/- a pair, 600 ohms impedance. Post 5/-.

AR88 SPARES. Antenna Coils L5 and 6 and L7 and 8. Oscillator coil L55. Price 10/- each, post 2/6. RF Coils 13 & 14; 17 & 18; 23 & 24; and 27 and 28. Price 12/6 each. 2/6 post. By-pass Capacitor K.98034-1, 3 × 0.05 mfd. and M.980344, 3 × 0.1 mfd., 3 for 10/-, post 2/6. Trimmers 95534-502, 2-20 p.f. Box of 3, 10/-, post 2/6. Block Condenser, 3 × 4 mfd., 600 v., £2 each, 4/- post. Output transformers 901666-501 **27/6** each, 4/- post.

** Available with Receiver only.*



MARCONI SIGNAL GENERATORS

TYPE TF-144G

Freq. 85Kc/s-25Mc/s in 8 ranges. Incremental: +/— 1% at 1Mc/s. Output: continuously variable 1 microvolt to 1 volt. Output Impedance: 1 microvolt to 100 millivolts, 10 ohms 100mV-1 volt-52.5 ohms. Internal Modulation: 400 c/s sinewave 75% depth. External Modulation: Direct or via internal amplifier. A.C. mains 200/250V, 40-100 c/s. Consumption approx. 40 watts. Measurements: 19¼ × 12¼ × 10 in. The above come complete with Mains Leads, Dummy Aerial with screened lead, and plugs. As New, in Manufacturer's cases, £40 each. Carr. 30/-. DISCOUNT OF 10% FOR SCHOOLS, TECHNICAL COLLEGES, etc.

S.A.E. for all enquiries. If wishing to call at Stores, please telephone for appointment.

W. MILLS 3-B TRULOCK ROAD, TOTTENHAM, N.17
Phone: Tottenham 9213

HRO RECEIVER. Model 5T. This is a famous American High Frequency superhet, suitable for CW, and MCW, reception crystal filter, with phasing control. AVC and signal strength meter. Freq. range 50 kc/s. to 30 mc/s., with set of nine coils. Complete HRO 5T SET (Receiver, Coils and Power Unit) for £30, plus 30/- carr.

COMMAND RECEIVERS; Model 6-9 Mc/s., as new, price £5/10/- each, post 5/-.

COMMAND TRANSMITTERS, BC-458: 5.3-7 Mc/s., approx. 25W output, directly calibrated. Valves 2 × 1625 PA; 1 × 1626 osc.; 1 × 1629 Tuning Indicator; Crystal 6,200 Kc/s. New condition—£3/10/- each, 10/- post.
(Conversion as per "Surplus Radio Conversion Manual, Vol. No. 2," by R. C. Evenson and O. R. Beach.)

BC-433G COMPASS RECEIVER; Freq. 200-1,750 Kc/s. in 3 bands, suitable for aircraft, boats, etc. Complete with 15 valves, power supply input 24 v. D.C. at 2 amps. Receiver only £5 each, carr. 15/-.

ROTARY CONVERTERS: Type 8a, 24 v D.C., 115 v A.C. @ 1.8 amps, 400 c/s 3 phase, £6/10/- each, 8/- post. Converter 12 v D.C. input, 110 v A.C., 60 c/s @ 2.73 amps. 0.300 Kva, £15 each, carr. £1. 24 v D.C. input, 175 v D.C. @ 40mA output, 25/- each, post 2/-.

CONDENSERS: 150 mfd, 300 v A.C., £7/10/- each, carr. 15/-. 40 mfd, 440 v A.C. wkg., £5 each, 10/- post. 30 mfd, 600 v wkg. D.C., £3/10/- each, post 10/-. 15 mfd, 330 v A.C. wkg., 15/- each, post 5/-. 10 mfd, 1000 v, 12/6 each, post 2/6. 10 mfd, 600 v, 8/6 each, post 5/-. 8 mfd, 1200 v, 12/6 each, post 3/-. 8 mfd, 600 v, 8/6 each, post 2/6. 4 mfd, 3000 v wkg., £3 each, post 7/6. 2 mfd, 3000 v wkg., £2 each, post 7/6. 0.25 mfd, 32,000 v, £7/10/- each, carr. 15/-. 0.25 mfd, 2Kv, 4/- each, 1/6 post. 0.01 Mfd. MICA 2.5Kv. Price £1 for 5. Post 2/6.

RACK CABINETS: 6 ft. by 19 in., and 16 in. depth, with rear door and safety switch, £5, carr. £2.

AVO MULTIRANGE No. 1 ELECTRONIC TEST SET: £25 each, carr. £1.

AVOMETERS: Model 47A, £9/19/6 each, 10/- post. Model 7x, £13/10/- each, 10/- post. Excellent secondhand cond. (Meters only). (Batteries and Leads extra—at cost).

OSCILLOSCOPE Type 13A, 100/250 v. A.C. Time base 2 c/s.-750 Kc/s. Bandwidth up to 5 Mc/s. Calibration markers 100 Kc/s. and 1 Mc/s. Double Beam tube. Reliable general purpose scope, £22/10/- each, 30/- carr.
COSSAR 1035 OSCILLOSCOPE, £30 each, 30/- carr.

RELAYS: Relay Unit (with 9 American relays) 24 v. D.C., 250 ohm coils, heavy duty, M. & B. 30/- each, 4/- post. GPO Type 600, 10 relays @ 300 ohms with 2M and 10 relays @ 50 ohms with 1M., £2 each, 6/- post.
12 Small American Relays, mixed types £2, post 4/-.

CALIBRATION TACHOMETER Mk. II: Maxwell Bridge Type 6C/869 £25 each, £2 carr.

ROTAX VARIAC & METER UNIT: Type 5G.3281. Reading 0-40 v., 0-40 mA and 0.5 amps., all on 275 deg. scales, £30 each, £2 carr.

HEWLETT PACKARD TYPE 400C: 115 v./230 v. input 50/60 c/s. Freq. range 20 c/s-2 Mc/s. Voltage range: 1mV-300 v. in 12 ranges. Input impedance 10 megohms. Designed for rack mounting, £30 each, carr. 15/-.

TCS MODULATION TRANSFORMERS, 20 watts, pr. 6,000 C.T., sec. 6,000 ohms. Price 25/-, post 5/-.

AUTOMATIC PILOT UNIT Mk. 2. This complex unit of diodes and valves, relays, magnetic clutches, motors and plug-in amplifiers, with many other items, price £7/10/-, £1 carriage.

FOR EXPORT ONLY: B.44 Trans-ceiver Mk. III. Crystal control, 60-95 Mc/s. **AMERICAN EQUIPMENT:** 5C-640 Transmitter, 100-156 Mc/s., 50 watt output. For 110 or 230 v. operation. ARC 27 trans-ceivers, 28 v. D.C. input. Also have associated equipment. BC-375 Transmitter. BC-778 Dinghy transmitter. SCR-522 trans-ceiver. Power supply, PP893/GRC 32A; Filter D.C. Power Supply F-170/GRC 32A: Cabinet Electrical CY 1288/GRC 32A; Antenna Box Base and Cables CY 728/GRC; Mast Erection Kits, 1186/GRC; Directional Antenna CRD.6; Comparator Unit, CM.23; Directional Control CRD.6, 567/CRD and 568/CRD; Azimuth Control Units, 260/CRD. Test Set URM.44, complete with Signal Generator TS.622/U.

VARIABLE POWER UNIT: complete with Zenith variac 0-230 v., 9 amps.; 2½in. scale meter reading 0-250 v. Unit is mounted in 19in. rack, £16/10/- each, 30/- carr.

SOLENOID UNIT: 230 v. A.C. input, 2 pole, 15 amp contacts, £2/10/- each post 6/-.

CONTROL PANEL: 230 v. A.C., 24 v. D.C. @ 2 amps., £2/10/- each, carr. 12/6.

AUTO TRANSFORMER: 230-115 v.; 1,000 w. £5 each, carr. 12/6. 230-115 v.; 300VA, £3 each, carr. 10/-.

OHMITE VARIABLE RESISTOR: 5 ohms, 5½ amps; or 2.6 ohms at 4 amps. Price (either type) £2 each, 4/6 post each.

POWER SUPPLY UNIT PN-12B: 230 v. A.C. input, 395-0-395 v. output @ 300 mA. Complete with two × 9H chokes and 10 mfd. oil filled capacitors. Mounted in 19in. panel, £6/10/- each, £1 carr.

TX DRIVER UNIT: Freq. 100-156 Mc/s. Valves 3 × 3C24's; complete wit filament transformer 230 v. A.C. Mounted in 19in. panel, £4/10/- each, 15/- carr

POWER UNIT: 110 v. or 230 v. input switched; 28 v. @ 45 amps. D.C. output. Wt. approx. 100 lbs., £17/10/- each, 30/- carr. SMOOTHING UNITS suitable for above £7/10/- each, 15/- carr.

ADVANCE TEST EQUIPMENT: VM76 Valve Voltmeter, £78 each; VM78 A.C. Millivoltmeter (transistorised) £55 each; VM79 UHF Millivoltmeter (transistorised) £125 each; J1B Audio Signal Generator £30 each; TT1S Transistor Tester (CT472) £37.10 each. 10 per cent Discount for schools, colleges, etc. on the above items. Carr. 10/- extra per item.

INDICATOR UNIT TYPE CRT.26: complete with CV1526 Cathode Ray Tube (3EG1). (3 × CV138; 3 × CV329; 1 × CV858; 2 × CV261; 6 × Crystals). Complete with brilliance and focus controls. Suitable for converting into a small oscilloscope (10 × 8 × 6 in., wt. 15 lb.) £5 each. Post 10/-.

NIFE BATTERIES: 6 v. 75 amps., new, in cases, £15 each, £1 carr.; 4 v. 160 amps, new, in cases, £20 each, £1 10/- carr. **L.R.7 Cells,** only 1.2 v. 75 amps., new, £3 each, 12/- carr. The above batteries are low resistance designed to give a heavy surge for starting and can be stored for long periods without any effect to their performance.

FUEL INDICATOR Type 113R: 24 v. complete with 2 magnetic counters 0-9999, with locking and reset controls mounted in a 3in. diameter case. Price 30/- each, postage 5/-.

UNISELECTORS (ex equipment): 5 Bank, 50 Way, 75 ohm Coil, alternate wipe, £2/5/- each, post 4/-

FREQUENCY METERS: LM13 or BC-221; 125-20,000 Kc/s., £25 each., carr. 15/-. TS.175/U, £75 each, carr. £1. TS323/UR, 20-450 Mc/s., £75 each, carr. 15/-. FR-67/U: This instrument is direct reading and the results are presented directly in digital form. Counting rate: 20-100,000 events per sec. Time Base Crystal Freq.: 100 Kc/s. per sec. Power supply: 115 v., 50/60 c/s., £100 each, carr. £1.

CT.49 ABSORPTION AUDIO FREQUENCY METER: freq. range 450 c/s-22 Kc/s., directly calibrated. Power supply 1.5 v.-22 v. D.C. £12/10/- each, carr. 15/-.

CATHODE RAY TUBE UNIT: With 3in. tube, colour green, medium persistence complete with nu-metal screen, £3/10/- each, post 7/6.

APNI ALTIMETER TRANS./REC., suitable for conversion 420 Mc/s., complete with all valves 28 v. D.C. 3 relays, 11 valves, price £3 each, carr. 10/-.

GEARED MOTORS: 24 v. D.C., current 150 mA, output 1 r.p.m., 30/- each, 4/- post. Assembly unit with Letcherbar Tuning Mechanism and potentiometer, 3 r.p.m., £2 each, 5/- post.

MOTORISED ACTUATOR: 115 v. A.C. 400 c/s. single phase, reversible, thrust approx. 3 inches complete with limit switches, etc. Price £2/10/- each, postage 5/- (ex equipment).

Actuator Type SR-43: 28 v. D.C. 2,000 r.p.m., output 26 watts, 5 inch screw thrust, reversible, torque approx. 25 lbs., rating intermittent, price £3 each, post 5/-.

SYNCHROS: and other special purpose motors available. British and American ex stock. List available 6d.

Model PM-4: 28 v. D.C. @ 2 amps., 4,500 r.p.m., output 40 watts continuous duty complete with magnetic brake. Price £2 each, postage 4/-.

Model SR-2: 28 v. D.C. 7,000 r.p.m., duty intermittent, output 75 watts, price 25/- each, postage 4/-.
A.C. Motor 115 v. 50 c/s. 1/300 H.P., 3,000 r.p.m. Capacitor 1mfd., 25/- post 3/-. Dalmotor SC5, 28 v. D.C. at 45 amps; 12,000 r.p.m. output 750 W. (approx. 1 h.p.), brand new, £2/10/- each, post 7/6.

MARCONI NOISE GENERATOR TF-987/1; Used to determine noise factor of a.m. and f.m. receivers. Designed for 230 v. a.c. operation. In used condition, £20 each, carr. £1.

MARCONI TF-956 (CT.44) AUDIO FREQUENCY ABSORPTION WATTMETER; Large clear 6in. scale. 1 microW. to 6W. £25 each. Carr. 15/-.

MARCONI DIVERSITY RECEIVERS; Consisting of 2 x CR.150's and associated equipment. £175 each. Carr. £5.

MARCONI DEVIATION TEST SET TF-934: Freq. 2.5-100Mc/s. Can be extended to 500Mc/s. Deviation range 0-5, 0-25 and 0-65 Kc/s. £35 each, carr. £1.

CANADIAN C52 TRANS/REC.: Freq. 1.75-16 Mc/s on 3 bands. R.T., M.C.W. and C.W. Crystal calibrator etc., power input 12V. D.C., new cond., complete set £50. Used condition working order £25. Carr. on both types £2/10/-. Transmitter only £7/10/- (few only) Carr. 15/-. Power Unit for Rec., new £3/5/-. Used power units in working order £2/5/-. Carr 10/-.

COAXIAL TEST EQUIPMENT: COAXWITCH—Mnftrs. Bird Electronic Corp. Model 72RS; two-circuit reversing switch, 75 ohms, type "N" female connectors fitted to receive UG-21/U series plugs. New in ctns., £6/10/- each, post 7/6. CO-AXIAL SWITCH—Mnftrs. Transco Products Inc., Type M1460-22, 2 pole, 2 throw. (New) £6/10/- each, 4/6 post. 1 pole, 4 throw, Type M1460-4. (New) £6/10/- each, 4/6 post.

TERMALINE RESISTOR UNITS: type 82A/U, 5000W, freq. 0-3.3 KMC Max VSWR 1.2 Type "N" female connectors, etc. Brand new, £30 each, carr. 15/-.

PRD Electronic Inc. Equipment: STANDING WAVE DETECTOR: Type 219, 100-1,000 Mc/s. (New) £65 each, post 12/6. FREQUENCY METER: Type 587-A, 0.250-1.0 KMC/SEC. (New) £75 each, post 12/6. FIXED ATTENUATOR: Type 130c, 2.0-10.0 KMC/SEC. (New) £5 each, post 4/-. FIXED ATTENUATOR: Type 1157S-1, (new) £6 each, post 5/-.

ALL GOODS OFFERED WHILST STOCKS LAST IN "AS IS" CONDITION UNLESS OTHERWISE STATED

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MINIMUM ORDER VALUE 5/-

C.W.O. Post and Packing 1/6

DISCOUNT 10% over £3
15% over £10

CERAMIC DISC CAPACITORS (Hunts.). 500V ±20%; 100, 220, 330pF. —20%, +80%; 470, 680, 1,000pF. 5d. each.

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
10V	4	16	32	64	125	200
16V	2·5	10	20	40	80	125
25V	1·6	6·4	12·5	25	50	80
40V	1	4	8	16	32	50
64V	0·64	2·5	5	10	20	32
Price	1/6	1/3	1/2	1/-	1/1	1/2

Small (all values in μF)

4V	800	1,250	2,000	3,200
6·4V	640	1,000	1,600	2,500
10V	400	640	1,000	1,600
16V	250	400	640	1,000
25V	160	250	400	640
40V	100	160	250	400
64V	64	100	160	250
Price	1/6	2/-	2/6	3/-

POLYESTER CAPACITORS (Mullard)
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.
400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, **6d.** 6,800pF, 0·01, 0·015, 0·022μF, **7d.** 0·033μF, **8d.** 0·047μF, **9d.** 0·068, 0·1μF, **11d.** 0·15μF, **1/2.** 0·22μF, **1/6.** 0·33μF, 2/3. 0·47μF, 2/8.
Modular, metallised, P.C. mounting, 20%, 250V: 0·01, 0·015, 0·022μF, **7d.** 0·033, 0·047μF, **8d.** 0·068, 0·1μF, **9d.** 0·15μF, **11d.** 0·22μF, **1/-.** 0·33μF, **1/5.** 0·47μF, 1/8. 0·68μF, 2/3. 1μF, 2/9.

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, 560, 680, 820pF, 1/-. 1,000, 1,200, 1,500, 1,800, 2,200, 2,700, 3,300, 3,900pF, **1/3.** 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, 1/9. 0·047, 5,000, 0·056μF, 2/-. 0·068, 0·082, 0·1μF, **2/3.** 0·12μF, **2/9.** 0·15, 0·18μF, 3/-. 0·22μF, **4/-.** 0·27, 0·33μF, **5/-.** 0·39μF, **5/9.** 0·47, 0·5μF, 6/3.

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, ¼W 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.

SKELETON PRE-SET POTENTIOMETERS (Carbon): Linear: 100, 250, 500 ohms, etc., per decade to 5M.
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.
Submin. 0·1W at 70°C. ±20% ≤ 1M, ±30% > 1M. Horizontal (0·4in. × 0·2in. P.C.M.) or Vertical (0·2in. × 0·1in. P.C.M.) mounting, **10d.** each.

RESISTORS (Carbon film), very low noise. Range: 5%, 4·7Ω to 1MΩ (E24 Series); 10%, 10Ω to 10MΩ (E12 Series).
¼W (10%), **1½d.** 100 off per value **12/-.** ¼W (5%), **2d.** 100 off per value **13/9.**
½W (10%), **2d.** 100 off per value **13/9.** ½W (5%), **2½d.** 100 off per value, **15/6.**

SEMICONDUCTORS: OA5, OA81, 1/9. OC44, OC45, OC71, OC81, OC81D, OC82D, 2/-. OC70, OC72, 2/3. AC107, OC75, OC170, OC171, **2/6.** AF115, AF116, AF117, ACY19, ACY21, 3/3. OC140, 4/3. OC200, 5/-. OC139, 5/3. OC25, 7/-. OC35, 8/-. OC23, OC28, 8/3.

SILICON RECTIFIERS (0·5A): 170 P.I.V., 2/9. 400 P.I.V., 3/-. 800 P.I.V., 3/3. 1,250 P.I.V., 3/9. 1,500 P.I.V., 4/-. (0·75A): 200 P.I.V., 1/6. 400 P.I.V., 2/-. 800 P.I.V., 3/3. (6A): 200 P.I.V., 3/-. 400 P.I.V., 4/-. 600 P.I.V., 5/-. 800 P.I.V., 6/-.
THYRISTORS (5A): 100 P.I.V., 8/-. 200 P.I.V., 10/-. 400 P.I.V., 15/-.

SWITCHES (Chrome finish, Silver contacts: 3A 250V, 6A 125V., Push Buttons: Push-on or Push-off 5/-. Toggle Switches: SP/ST, **3/6.** SP/DT, **3/9.** SP/DT (with centre position) 4/-. DP/ST, 4/6. DP/DT, 5/-.

PRINTED CIRCUIT BOARD (Vero).
0·15in. Matrix: 3¾in. × 2½in., **3/3.** 5in. × 2½in., **3/11.** 3¾in. × 3¾in., **3/11.** 5in. × 3¾in., 5/6.
0·1 Matrix: 3¾in. × 2½in., 4/-. 5in. × 2½in., 4/6. 3¾in. × 3¾in., 4/6. 5in. × 3¾in., 5/3.

RECORDING TAPE (Finest quality MYLAR—almost unbreakable).
Standard Play: 5in., 600ft., 7/6. 5¾in., 850ft., 10/6. 7in., 1,200ft., 12/6.
Long Play: 3in., 225ft., 4/-. 5in., 900ft., 10/6. 5¾in., 1,200ft., 13/-. 7in., 1,800ft., 18/-. (Add 9d. postage and packing per reel).

Send S.A.E. for January, 1969 Catalogue

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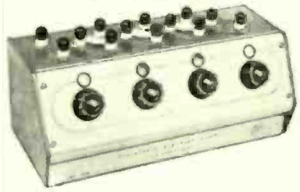
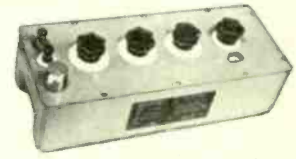
LABORATORY TEST EQUIPMENT
Purchased direct from leading manufacturers & distributors

HIGH VALUE RESISTANCE BOX TYPE R.7003



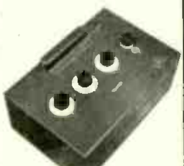
Specification. Range: 0.01-11.10 Megohm in 0.01 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hemmer finished stove enamel.
List price £60. Our price £22.10.0.

DECADE CAPACITANCE BOX TYPE R.7004



Specification. Range: 0.00002uF-1uF in 0.00002uF steps Accuracy: 0.05%. Frequency Range: 40c/s–10 K/cs for all decades except X1 =40c/s–5 K/cs. Case: Hammer finished stove enamel.
List price £60. Our price £22.10.0

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 = 0–1.5 K/cs. Maximum current: 0.5A for decades 1A for variometer (both primary and secondary windings).
Case: Polished teak.
List price £65. Our price £26.10.0.

MUTUAL INDUCTANCE COIL TYPE R.7006

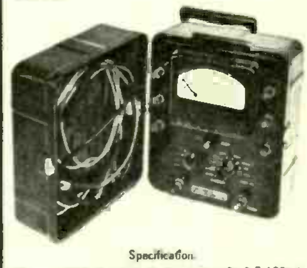
Specification. Value: 0.01 H, 0.001 H. Accuracy: ±0.3%. Operating Frequency: 5 K/cs. 10 K/cs. Maximum current: 1A. 3A. Resistance of coils: 4 ohm. 1 ohm. Case: Moulded plastic.
List price 8 gns.
Our price 50/-.

★ A Special price of £65 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

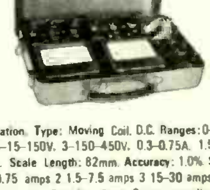
Specification. Type: Moving Coil Galvanometer. Ranges: 1 0.05 to 5 ohms 2 0.5 to 50 ohms 3 5 to 500 ohms 4 50 to 5,000 ohms 5 500 to 50,000 ohms. Scales: Switched Slidewire: 0.5 to 50. Galvanometer Scale: 10–0–10. Case: Moulded plastic. Internal Source: 4V, Dry battery. Operating Temperature: +10 to +35°C. Operating Humidity: Up to 80% R.H. Dimensions: 200 x 110 x 65mm. Weight: 0.9 kg.
List price £25. Our price £9.19.6

PORTABLE MULTIRANGE METER



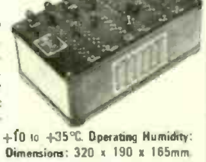
Specification.
Ranges: 0-60 & 0-300uA. D.C. 0-3. 0-30 & 0-120mA. D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30mA. A.C. 24-120mA. A.C. 0.24-1.2A. A.C. 3-12-30-300-600-1,200 & 6,000 V. D.C. 0.6-3. 2.4-12. 6-30. 60-300. 120-600. 240-1,200 & 1,200-6,000 V. A.C. 3-333 ohms. 0.3-30 Kohms. 0.03-3 megohms D.C. Resistance -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 x 215 x 170mm. Weight: 8kg. Supplied with: 2 voltage dividers. H.V. leads. spare rectifiers. 1.5 & 22.5V 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

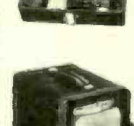


Specification.
Range: 0.1 to 111, 111.0 ohms. Steps: 0.1 ohm. Accuracy: 0.1%. Rated Power Per Step: 0.5W. Coils: Manganin. Operating Temperature: +10 to +35°C. Operating Humidity: Up to 80% R.H. Dimensions: 320 x 190 x 165mm. Weight: 4 kg.
List price £20. Our price £8.17.6.

POTENTIOMETRIC 6 POINT STRIP CHART RECORDER

For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (–100)–0–(+100) mV; 0–1,600°C; 6½" chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20–720mm/hr. Tropicalised. Including tools & spares. Listed at over £200. Our price £79.10.0. 12 point version available at £99.10.0.

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 & 5400 mm/hr. Precision: 1.5%. Shunts: 75mV (Internal). Operating Temperature: +5 to +50°C. Dimensions: 180h x 163w x 245mm. Weight: 5.5 kg. Complete with: 10 chart rolls, gears, inks, pipette, scale template and component case.
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A42	5 CT41/45 Germ. Trans. PNP = OC71, AC151, AC125, AC122, 2N280	8/-
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A56	2 2N708 Sil. Trans. 300 M/cs NPN = BSY63 = BSY19	8/-
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A67	4 AC126 Germ. Trans. PNP = AC163, NKT229	8/-
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Sil. Germ & Zeners Identification Chart free
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150 TRANS. Mixed AF/RF XA100 10/-

100 SIL. DIODES DO-7 SIM 10/-

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THE ABOVE DEVICES ARE UNTESTED

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400	2/-	2/6	4/-	5/6	7/6	25/-
500	—	3/-	—	6/-	8/6	30/-
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1,000	—	5/-	6/-	9/3	12/6	50/-
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200	12/6	15/-	20/-	55/-
300	15/-	20/-	25/-	—
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100 PIV 10/- 400 PIV 25/- FULLY
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1½ AMP SCR's TO-5

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AD161 NPN **AD162** PNP

MATCHED COMPLEMENTARY PAIRS OF GERM. POWER TRANSISTORS. For mains driven output stages of Amplifiers and Radio receivers.
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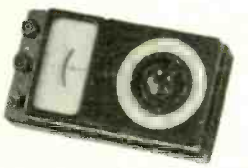

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Special quotations for quantities of 100 or more.

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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 Gutput 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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Low current

Blue spot; 200 piv 5 amps. Gate Voltage 3.25V at 120mA	12/6

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CR 100-351A, 100 Amps. 350 piv	50/-
CR 100-401A, 100 Amps. 400 piv	60/-
CR 100-501A, 100 Amps. 500 piv	70/-

For all CR series Minimum gate firing voltage is 3V at 150mA

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Glass dry reed inserts approx. ⅛in. dia. × 1in. long with axial leads. One "make" contact of 100mA. capacity at 50V. Can be operated by permanent magnet or 30-50 Amp-turns relay coils. PRICE 18/- per doz., post free.

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24-range precision portable meter. 5,000 o.p.v. D.C. Volts 2.5-10-50-250-500-2500V. A.C. Volts: 10-50-100-250-500-2500 V. D.C. current 0.5-5-50-500 mA. Resistance: 2.000-20,000 ohms-2-20 megohms. Power output calibration for 600 ohms line, £6/5/-. P.P. 7/6. Dimensions: 7⅝in. × 6in. + 3⅛in. Weight 3½lb.

TYPE MF16

D.C. Voltage range 0-0.5-10-50-250-500V.
A.C. Voltage range 0-10-50-250-500V
D.C. current ranges: 500µA-10-100mA.
Resistance ranges: 100MΩ-1MΩ The meter is also calibrated for capacity and output level measurements. Sensitivity 2000Ω V. Accuracy ±2.5% for D.C. and ±4% for A.C. measurements. Dimensions: 4⅝in. × 3⅛in. × 1⅜in. Price £4/5/-.

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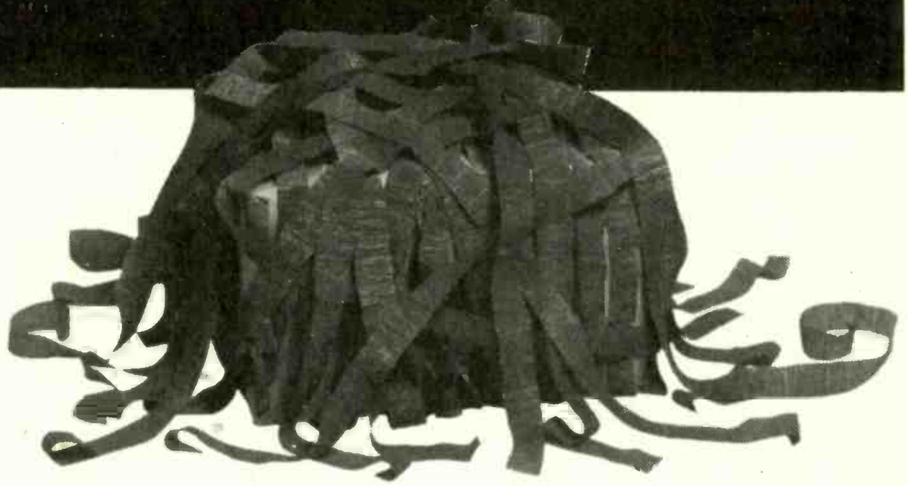

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SERIES DISCOUNT: 15% is allowed on orders for twelve monthly insertions provided a contract is placed in advance.
BOX NUMBERS: Replies should be addressed to the Box number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London, S.E.1.
No responsibility accepted for errors.

Advertisements accepted up to MARCH 6 for the APRIL issue, subject to space being available.

JUNIOR TEST ENGINEER

Duties include the responsibility for routine measurements in connection with the manufacture of Tape Recorders and Record Players and assistance in the technical control of the factory. Previous experience of Radio or Television desirable but knowledge of other electronic products could be a suitable qualification. Good salary and promotion prospects for the right man. Applications in writing please to:—

Personnel Manager,
British Radio Corporation,
Denton Island, Newhaven, Sussex.

Independent Television News Limited
requires a

SUPERVISORY ENGINEER

with detailed knowledge and practical experience of Colour Television Engineering including semiconductor and integrated circuitry techniques. Applicants should have an ability to impart this knowledge formally or informally. The successful candidate will be responsible to the Chief Engineer for Vision Maintenance Services. He will work the hours required by the post but it is envisaged that these will be on a five day week basis. Current ACTT Salary £2,458 per annum (revised rates under negotiation). Permanent post. Pension Scheme and Free Life Insurance.
Candidates should telephone or write to the Personnel Manager, Independent Television News Limited, Television House, Kingsway, London, W.C.2. Telephone 01-405-7690.

BERMUDA VACANCY—ELECTRONICS ENGINEER

A qualified technician is required for workshop and field maintenance work in Bermuda. The majority of the work is in TV and Radio, but there is also a requirement for work on specialist equipment for transmitting stations, hospitals, ship-to-shore radio, marine radar, etc. A single man is preferred.

Remuneration by way of basic salary and incentive bonus. A good man can expect to earn in the region of £1,750 per annum.

The appointment will be initially for a minimum of one year and passage to Bermuda will be paid by the Company. Completion of 3 consecutive years service with the Company will qualify for payment of return passage.

Application in own handwriting should give full personal details, with age, education, academic qualifications, experience and previous appointments, with references, and should be accompanied by a recent photograph. Forward to:—

General Manager,
BELL SERVICES LIMITED,
P.O. Box 98, Paget, Bermuda.

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

V.H.F. TELEVISION RELAY & COMMUNAL AERIAL SYSTEMS

We are planning a considerable expansion of our activities and have the following vacancies:

I. A SENIOR ENGINEER

to have control of all aspects of systems design, planning, estimating, installation and commissioning.

II. ENGINEERS

capable of undertaking either:
(*a*) System planning and estimating.
(*b*) control of installation work.
or (*c*) test and commissioning duties.

Candidates for these appointments must have a good background of practical experience in this field of work, and an up-to-date knowledge of techniques and equipment.

Applications, which will be treated in strict confidence, should be sent to:

BRITISH RELAY

The General Manager,
Special Services Division,
British Relay House,
41, Streatham High Road, S.W.16

GOVERNMENT of HONG KONG

REQUIRES

CONTROLLER

(Police Telecommunications)

on contract for one tour of 36 months in the first instance. Salary in scale rising from $3730 a month (£ Stg. 3077 p.a.) to $4430 a month (£ Stg. 3654 p.a.). Low Income Tax. Terminal Gratuity of 17% of total salary drawn. Free Passages. Furnished accommodation at moderate rentals. Generous leave. Contributory pension scheme available in certain circumstances.

Candidates, preferably 45 years of age, should be corporate Members of the Institute of Electrical Engineers, should have at least ten years experience in Telecommunications Engineering in an executive capacity with an expert knowledge of maintaining and installing V.H.F. and H.F. radio equipment and ship-borne radar. Candidates possessing equivalent alternative qualifications and suitable experience may be considered for appointment.

The officer will be required to detail the planning and processing of technical requirements and supervise the Communications Section including Radar Workshops.

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 M2R/680607/WF.

Dictum Meum Pactum

The Stock Exchange require two

Television Service Engineers

Later this year, as the Stock Exchange continues its programme of modernisation, a closed circuit television system is being installed for the display of market prices.

To maintain this system, two experienced Television Service Engineers are required. Appropriate Television and Radio servicing certificates are essential, and applicants must be able to prove their ability as competent Service Engineers by suitable trade test.

Attractive salaries are offered in the region of £1,500–£1,600 p.a. with these positions and fringe benefits include a non-contributory pension scheme.

Applications giving brief details of qualifications and experience should be sent to: The Personnel Officer, Council of the Stock Exchange, 61 Threadneedle Street, EC2.

TEST ENGINEER

We require a keen young Audio Test Engineer to work on high quality professional transistorised mixing desks for use in television and sound broadcasting and recording studios.
Experience in this or a similar field is desirable, although a man with the basic knowledge of semi-conductor circuitry would be considered.
Above all the person we are looking for should be reliable and accurate in his work. Apply to:

W. Tory, General Manager,
Neve Electronic Laboratories Ltd.,
Cambridge House, High Street,
Melbourn, Nr. Royston, Herts.

OPPORTUNITIES WITH

Marconi

WEMBLEY

Test methods development/liaison engineer

To assist in planning the provision of test facilities and devising test methods for use in Production Test Department dealing with wide range of communications transmitters and receivers, data-handling equipment, radar, and various electronic aids. Liaison with development engineers to solve technical problems encountered during production. Wide production test experience, or relevant technical experience in the Regular Forces. HNC would be an advantage.

Test engineers

With knowledge of Circuitry and able to undertake testing and fault finding of a wide range of communications transmitters and receivers, data-handling equipment, radar, and a variety of electronic aids. Should have previous production test experience or similar experience as ex-regular Forces' Technicians.

Salaries will be negotiated according to experience and are reviewed regularly. Excellent Contributory Pension Fund and Life Assurance Scheme, 37-hour week.

Please apply by letter quoting REF/WW/2, giving age, education, experience and present salary to:

THE QUEEN'S AWARD TO INDUSTRY 1966 1967 1968

D. M. McPhail, Personnel Officer
The Marconi Company Limited
Lancelot Road, Wembley, Middx.

ASSISTANT PRODUCTION MANAGER

Assistant Production Manager required for factory in West Africa assembling radio and television receivers. Practical experience of all aspects of line assembly and testing required, with ability to plan assembly line and control staff. Excellent opportunity for young man to assume early responsibility and earn good salary.

Tours of 15 to 18 months with generous paid leave. Furnished accommodation provided.

Details of experience to Box 5053 c/o Paper.

SIGNALS ENGINEERING LABORATORIES

R.A.F. Northolt
RUISLIP, Middlesex
Ministry of Defence (Air Force Department)

ELECTRONICS ENGINEERS (graded Experimental Officer) for work on
(i) Radar and Navigation Aids, Air Traffic Control and Blind landing. Experience of Microwave measurements and pulse techniques essential; knowledge of display systems desirable.
(ii) Telecommunications, Navigational Aids, Telemetry and Data Processing. Experience of HF, VHF, UHF and line communications and knowledge of digital techniques essential; familiarity with integrated circuits desirable.

The work involves circuit design, laboratory measurements and field investigations. Some outside duty at R.A.F. Stations at home and abroad will be involved, and an ability to maintain good relations with service personnel at all levels is necessary.

QUALIFICATIONS: Degree, H.N.C., or equivalent in appropriate subject.

SALARY (Outer London) (minimum age 26): £1,589-£1,985.

Prospects of permanent pensionable appointments.

APPLICATION FORMS from the Head of Laboratories at the above address. *Closing date 6th March, 1969.*

City of Liverpool Education Committee

LIVERPOOL REGIONAL COLLEGE OF TECHNOLOGY

Byrom Street, Liverpool, L3 3AF

Dept. of Navigation

LABORATORY TECHNICIAN

(Grade T3—£895-£1,055 per annum)

Applications are invited for a full-time appointment as Laboratory Technician in the above department. Candidates should have O.N.C. in Electrical Engineering, or an equivalent qualification, a good electronics background and preferably experienced in radar.

The department is equipped with 4 line radar sets, 2 radar simulators and other electronic navigational aids.

Application forms (obtainable from the Director of Education, Education Offices, 14 Sir Thomas Street, Liverpool, L1 6BJ) should be returned to the Vice-Principal by 24 February, 1969.

RACECOURSE TECHNICAL SERVICES LIMITED

Require an

AUDIO ENGINEER

at their Headquarters at Raynes Park, S.W.20. Must have good theoretical knowledge and wide practical experience of maintaining all types of Public Address and Sound Distribution equipment. Some construction of special units involved. Occasional visits to racecourses throughout the country required. Clean driving licence therefore an advantage. Preferred age 25-45. Salary £25 to £27 per week. Good working conditions. Canteen facilities available. Contributory pension scheme after qualifying period.

Applications in writing with full details to Secretary.

RACECOURSE TECHNICAL SERVICES LTD.
88 Bushey Road, Raynes Park, London, S.W.20.
01-947 3333

MEDICAL RESEARCH COUNCIL CYCLOTRON UNIT,

Hammersmith Hospital. London, W.12. invite applications for the following posts.

GRADUATE ELECTRICAL ENGINEER

Age 21-23, with a good honours degree, required to assist in accelerator development. Initially the work would entail development of Ion Sources for the M.R.C. cyclotron with opportunities in design and construction of special magnets, beam transport systems and data handling techniques. An interest in gaseous discharges, electromagnetism or electronics would be an advantage. Starting salary (under review) £1,110-£1,240 according to age. 30 days leave.

ELECTRONICS ENGINEER

Age 25 minimum. Pass degree, H.N.C. or equivalent. Several years practical experience, used to modern Semiconductor techniques. To join small group concerned with the design and construction of equipment of high engineering standard for use on and around the M.R.C. cyclotron, varying from integrated circuits to high current power supplies. Technical Officer category. Starting salary £1,109-£1,468 according to age and experience.

JUNIOR TECHNICAL OFFICER (Electronics)

Age 20-25. Two 'A' levels or H.N.C. depending on age. To help with development and construction of electronic equipment of widely varying type for use on M.R.C. cyclotron. Starting salary £838-£1,109.

Initial application, giving career particulars, should be sent to the Director, M.R.C. Cyclotron Unit, Hammersmith Hospital, Ducane Road, London, W.12.

Radio Technicians

enjoy exciting new scope now in

Air Traffic Control

There are opportunities in the National Air Traffic Control Service, a Department of the Board of Trade, for you to play a vital part in the safety of Civil Aviation. You'll work on the latest equipment including Computers, Radar and Data Extraction, Automatic Landing Systems and Closed-Circuit Television, at Civil Airports, Air Traffic Control Centres, Radar Stations and other engineering establishments, including Heathrow, Gatwick and Stansted.

If you are 19 or over, with practical experience in at least one of the main branches of telecommunications, fill in the coupon now. Your starting salary would be £869 (at 19) to £1,130 (at 25 or over); scale maximum £1,304 (rates are higher at Heathrow). Non-contributory pensions for established staff.

Career Prospects. Your prospects are excellent, with opportunities to study for higher qualifications in this expanding field.

Apply today, for full details and application form.

Write for details to: Mr. T. H. Mallett, B.Sc. (Eng.), C.Eng., M.I.E.E., Room 705, The Adelphi, John Adam Street, London W.C.2, marking your envelope 'Recruitment'.

Name ______________________

Address ______________________

____

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Not applicable to residents outside the United Kingdom.

RWW 9

NATCS National Air Traffic Control Service

ASSISTANT SIGNALS OFFICER
METEOROLOGICAL OFFICE
MINISTRY OF DEFENCE (AIR FORCE DEPARTMENT)

ELECTRONIC ENGINEER (man or woman, aged at least 23) for a post of Assistant Signals Officer at the Meteorological Office Headquarters in Bracknell, Berks.

Duties relate to the planning, provision and installation of meteorological landline and radio telecommunication systems embracing transmission by both low/medium/high speed data and analogue/digital facsimile, and including facilities for reception from satellites. A particular objective will be to automate the U.K. system making optimum use of computers.

Qualifications: Either (a) Corporate Membership of the Institution of Electrical Engineers, the Institution of Electronic and Radio Engineers or the Royal Aeronautical Society, or exemption from their examinations, *or* (b) 1st or 2nd class honours degree in Electrical Engineering, Physics or Applied Physics, together with at least 2 years' training and experience in Telecommunications or Electronic Engineering. Wide knowledge of telecommunications and aptitude for planning, including some experience of planning for automation in telecommunications essential.

Salary (national): £1,087 at age 23—£1,761 at 34 or over (possibly higher if at least 35). Scale maximum £2,065. 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/6960/68*. Closing date 25th March 1969. Candidates who have already applied should not do so again.

The 5 GeV Electron Synchroton NINA, housed at Daresbury Laboratory in north-west Cheshire, is being used for research into high energy physics by university and resident groups. It is, however, being continuously modified both to increase its efficiency, reliability and operation and to improve its performance, particularly in respect of accelerated beam intensity.

RADIO FREQUENCY SYSTEMS

A Senior Scientific Officer
is required to investigate various aspects of the acceleration process of NINA, particularly the effects of beam loading on the RF accelerating system and also injection into the synchroton. Applicants must be familiar with radio frequency techniques at UHF and with systems involving waveguides and cavities. They must also possess at least a second class honours degree in physics or electrical engineering and must have a good mathematical background and the ability to programme computers in Fortran. At least three years' post graduate experience is required.

A Senior Experimental Officer
is required to initiate and be responsible for developments of the existing RF accelerating systems. These include very high power amplifiers at 408 and 2856 MHz, waveguides and resonant cavities, together with complex electronic programme and feedback circuits. The work will include special component development and improving diagnostic equipment and the flexibility of the systems. It will also entail some responsibility for the day to day running of the plant, particularly dealing with faults beyond the scope of the regular crews. Applicants must be fully conversant with and have wide experience in modern techniques in radio engineering at UHF and in electronics. They must also possess at least a pass degree or HNC or equivalent in physics or electrical engineering.

Starting salary will be assessed according to age, qualifications and experience on the following scales:

Senior Scientific Officer	£1,925 - £2,372
Senior Experimental Officer	£2,220 - £2,720

The superannuation scheme is non-contributory. Advice and assistance to obtain house loans is available. Write for application form quoting reference number DL/275/M to:

Science Research Council

DARESBURY NUCLEAR PHYSICS LABORATORY

Personnel Officer,
Science Research Council,
Daresbury Nuclear Physics Laboratory,
Daresbury,
Nr. Warrington.

GRUNDY & PARTNERS LTD.
require
ELECTRONICS INSPECTOR

The man required must be fully experienced and capable of working from circuit diagrams. Mainly semi-conductor equipment. Excellent rates of pay. Knowledge of E.I.D. procedure an advantage but not essential. Apply to:

Mrs. Lloyd,
GRUNDY & PARTNERS LIMITED,
3 The Causeway,
Teddington, Middx.
Telephone: 01-977-3402

UNIVERSITY OF SHEFFIELD

Senior Technician required for Electronics Section of Department of Physics. Duties of Section are designing, maintenance and production of electronics equipment for teaching and research. Previous experience essential. Salary £987-£1,225 per annum with basic qualification. Supplement for approved higher qualification. Write to the Bursar (B.130), The University, Sheffield S10 2TN.

Electro-Medical Service Department requires

ENGINEERS

for testing and servicing electronic apparatus. Applicants should be aged 23-30, and should be of H.N.C. standard.

Apply in first instance in writing to:

SIEREX LTD.,
Electro-Medical Dept., Heron House, Wembley Hill Road, Wembley, Middx.

DERRITRON
have a vacancy for a
TELECOMMUNICATIONS ENGINEER

Experience in the design and development of MF and VHF Marine Radio or similar equipment, and S.S.B. Transmitter Receivers, using modern semiconductor valve circuits.
Excellent prospects in this rapidly expanding Division. Personnel with appropriate qualifications and experience apply to:

The Chief Engineer,
Derritron Electronics Ltd.,
Sedlescombe Road North,
Hastings, Sussex.

RADIO OPERATORS

PREFERABLY WITH PMG2 CERTIFICATE, REQUIRED IMMEDIATELY FOR DUTY ON METEOROLOGICAL OFFICE OCEAN WEATHER SHIPS.

Salary Scale £871—£1309 per annum (revised rates under negotiation) according to age, plus £157 overtime allowance. Free food and accommodation provided on board ship. Applicants must be natural born British Subjects. Full details from Shore Captain, Ocean Weather Ship Base, Great Harbour, Greenock. Telephone: Greenock 24291.

INSTRUMENT SYSTEMS ENGINEER

The Job

Designing and commissioning electronic aircraft simulator instrument systems in association with analogue and digital computer equipment.

The Man

Qualified and/or experienced engineer who has a knowledge of aircraft instrument design theory and a sound understanding of servo and synchro techniques. Applicant should also have a knowledge of analogue and digital computing techniques.

The Rewards

Long term career. High job interest in association with the airline industry. Good working conditions. Contributory pension scheme coupled with free Life Assurance. Good welfare benefits. Excellent salary.

Apply giving brief details of experience and qualifications, quoting reference W.W.2369, to:
H. C. Hall,
REDIFON LIMITED
FLIGHT SIMULATOR DIVISION
Gatwick Road, Crawley, Sussex.
Telephone: Crawley 28811

THE QUEEN'S AWARD TO INDUSTRY

REDIFON

A Member Company of the Rediffusion Organisation

Government of ZAMBIA

REQUIRES

POSTAL ENGINEERS

TELECOMMUNICATIONS, PLANNING and EVALUATION

Professional Engineers required for telecommunications by the GOVERNMENT OF ZAMBIA, General Post Office on contract for one tour of 36 months in the first instance. Commencing salary according to experience in scale. Kwacha 2784 rising to Kwacha 4464 a year (£Stg.1624–£Stg.2605) plus inducement allowance of £Stg.348–£Stg.429 a year. Gratuity 25% of total salary drawn. A direct payment of £Stg.233–£Stg.350 is also payable direct to an officer's home bank account. Both gratuity and supplement are normally TAX FREE. Free passages. Quarters at low rental. Children's education allowances. Liberal leave on full salary or terminal payment in lieu. Special terms of service apply to serving civil servants including employees of the General Post Office.

Candidates should have a recognised degree in telecommunications or electrical engineering or equivalent qualification. This should be followed by several years of experience with a telecommunications organisation. The duties of the posts are varied. They include planning of trunk and telegraph multiplex systems and radio systems, also the technical and economic evaluation of local and trunk line development policy in the field of underground cables and open wire lines.

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/61610/WF.

LEC

RADIO & TELEVISION SERVICING
RADAR THEORY & MAINTENANCE

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.

ELECTRONICS INSTRUCTOR

Due to our expanding interests in electronic calculating machines and small computers, we have a vacancy for an additional instructor to join our team based in Central London. After a comprehensive training period, he will assist in the progressive training of service engineers, both from the U.K. and overseas, on the digital techniques used in our equipment. He must also be prepared to carry out training courses abroad at a later date.

The successful applicant will not necessarily have had experience with electronic calculating machines, but he will have a sound knowledge of basic electronic principles and practical experience in electronics, radio, television, radar, or similar fields.

Previous experience as an instructor is not considered to be absolutely essential, but might well be an advantage. We are most anxious to find someone who has the ability and a real desire to teach fellow technicians.

Anyone interested in this vacancy is invited to send full details of his qualifications and relevant experience to Mr. D. D. Davies, Sumlock Comptometer Ltd., The Island, Uxbridge, Middlesex.

Test Engineers Electro Mechanical Inspectors

Due to continued expansion there are excellent opportunities for experienced Test Engineers and Electro-mechanical Inspectors, covering a wide range of advanced electronic equipments.

Vacancies exist at:

Research Laboratories, Hersham, Surrey

Radar Development Laboratories, Chessington, Surrey

Production Division, New Malden, Surrey,

These appointments offer attractive salaries, career development and the usual fringe benefits associated with a progressive organisation.

DECCA

1966 1967 1968

Apply in first instance quoting Ref INSP/163 to
Senior Personnel Officer,
Decca Radar Limited,
Burlington House,
Burlington Road,
New Malden, Surrey.

ELECTRONIC SERVICE ENGINEER

required with knowledge of cinematograph projection and sound equipment. Training will be given to applicant with limited experience. Pension scheme. Five-day week. Apply in writing, briefly stating age and experience to Personnel Manager, Rank Film Processing Ltd., North Orbital Road, Denham, Nr. Uxbridge, Middlesex.

Freelance Electronic Designer

required. Experienced in Photo-electric and Audio techniques. To design in liaison with Technical Department of established company.

Small well-equipped lab. available if necessary. Time to suit applicant.

Write in first instance to:

Dubreq Studios Ltd.,
15 Cricklewood Broadway,
London, N.W.2

UNIVERSITY OF BRISTOL
Dept. of Extra-Mural Studies

Weekend Courses in Colour Television—Spring 1969

Feb. 28th, Mar. 1st, 2nd
Lecturer: H. V. Sims (B.B.C.)
Mar. 28th, 29th, 30th
Lecturers: Dr. G. B. Townsend (Thames Television)
M. H. Cox (M. H. Cox Electronics Ltd.)
Both courses will be held in Bristol.
Full details from D. S. Wilde, 20A Berkeley Square, Bristol BS8 1HR

ELECTRONIC TECHNICIAN

to assist with maintenance and operation of a 2MeV linear accelerator and associated equipment in connection with cancer research. Keen practical interest in electronics essential. Salary in accordance with MRC technical scale according to age, qualifications and experience, all grades considered

Apply to:
Director B.E.C.C.,
Research Unit in Radiobiology,
Mount Vernon Hospital,
Northwood, Middx.

THE GENERAL POST OFFICE
has vacancies for

RADIO OPERATORS II

at its

COAST RADIO STATIONS

Applications are invited from men between 21 and 35 years of age who must hold either the Postmaster General's First or Second Class Certificate of Competence in Radiotelegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

The posts which will be temporary in the first instance, carry a salary scale of £765-£1,129, depending on age at entry, but successful applicants will be eligible to enter the open competitive selection for permanent appointment to be held in the spring and autumn of 1969.

Applicants should write to: The Inspector of Wireless Telegraphy, Union House, St. Martin's-le-Grand, London, E.C.1, or telephone 01-432 5628 for further information.

AVELEY ELECTRIC LTD

AVELEY ELECTRIC LTD

AVELEY ELECTRIC LTD

we require

CALIBRATION and SERVICE ENGINEERS

have you

- 3 to 5 years calibration or service experience
- O.N.C./H.N.C.

are you

- between 25-40 years of age

do you have

- self drive and initiative
- ability to work with minimum supervision

do you want

- a well paid interesting post

you do then contact

Personnel Manager
Aveley Electric Ltd., South Ockendon Essex
Tel: South Ockendon 3444

AVELEY ELECTRIC LTD

SOUTHERN
INDEPENDENT TELEVISION

require

ENGINEERS, ASSISTANT ENGINEERS
and
TECHNICAL ASSISTANTS

for the operation and maintenance of television equipment at their Southampton Studios. The successful applicants would be required to live in the Southampton area and would be employed on shift duty. The Company is expanding and later this year will occupy a new studio centre fully equipped for colour television. The following qualifications should be held:

Engineers	Higher National Certificate in electrical engineering or equivalent, preferably with experience with a Broadcasting Company or Broadcast Equipment Manufacturer.
Assistant Engineers & Tech. Assistants	Ordinary National Certificate in electrical engineering or equivalent.

Before appointment applicants will be required to undertake a colour blindness test.

Rates of Pay:

Engineers	A.C.T.T. Grade 'D' £1876 p.a.
Assistant Engineers	A.C.T.T. Grade 'E' £1582 p.a.
Technical Assistants	A.C.T.T. Grade 'H' £1295 p.a.

Canteen facilities and an excellent Pension Scheme available.

Please apply in writing to:

The Personnel Officer,
Southern Television, Ltd.,
Northam,
Southampton,
SO9 4YQ

CHALLENGING OPPORTUNITIES in CANADA

Radio and Electronic Technicians with a desire to see more of the world can find rich rewards by joining Canadian Marconi Company. Technicians are required for maintenance duties on Northern installations.

Successful applicants will enjoy minimum salaries of $8,479 plus first-class prospects for rapid advancement and further substantial rises during the first year. There are also genuine opportunities for promotion to supervisory grades with salary ranges of over $13,500 per annum.

Food and accommodation is provided free for the employee (no family accommodation), in addition to heavy duty clothing. Assistance with air passage is available.

A chance of a lifetime is offered to accrue substantial savings.

CAN YOU QUALIFY?

Formal training and experience in maintenance of communications type equipment is required with special emphasis on:

Microwave
Tropospheric Scatter
Communications Systems
Telephone and Carrier (Multiplex)

If you have three or more years' experience in installation or maintenance on this type of equipment together with recognized qualifications, i.e. City and Guilds, Higher National or equivalent, the answer is Yes! Interviews will shortly be held in London and possibly in the provinces. Please send brief career details, quoting WW 2988H, to Mr. D. S. Howell, **Canadian Marconi Company, P.O. Box 540, Station "O", Montreal 379, Quebec, Canada.**

CMC CANADIAN MARCONI

CANADIAN MARCONI COMPANY

Computer Engineering

NCR requires additional ELECTRONIC, ELECTRO-MECHANICAL ENGINEERS and TECHNICIANS to maintain medium to large scale digital computing systems in London and provincial towns.
Training courses will be arranged for successful applicants, 21 years of age and over, who have a good technical background to ONC/HNC level, City and Guilds or radio/radar experience in the Forces.
Starting salary will be in the range of £900/£1150 per annum, plus bonus. Shift allowances are payable, after training, where applicable. Opportunities also exist for Trainees, not less than 19 years of age, with a good standard of education, an aptitude towards and an interest in, mechanics, electronics and computers.
Excellent holiday, pension and sick pay arrangements. Please write for Application Form to Assistant Personnel Officer NCR, 1,000 North Circular Road, London, N.W.2, quoting publication and month of issue.

Plan your future with NCR

ARE YOU EXPERIENCED..... in

Circuit Design or Systems Development—earning £1,200 to £2,500 and considering relocation?

Are you a *Technical Sales Engineer, Test Engineer or Production Engineer* perhaps unrecognised or poorly rewarded in your present position?

Have you special skills which are not fully utilised on your present job?

Then do you know that *Electronics Appointments* is constantly in touch with almost 800 companies in the electronics field, covering all aspects of electronic engineering at all levels.

Unique opportunities exist for you to obtain the best available job, with excellent prospects, in the area of your choice.

The service is free and confidential, you need only telephone or write for full details.

EAL LTD

ELECTRONICS APPOINTMENTS LTD.

NORMAN HOUSE · 105/109 STRAND · LONDON · W.C.2
TEL · 01-836 5557

PYE

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 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

GOVERNMENT OF ZAMBIA

REQUIRES

ASSISTANT TELECOMMUNICATIONS ENGINEER

for the General Post Office, Ministry of Transport, Power and Communications, on contract for one tour of 36 months in the first instance. Total gross salary in scale up to £2654 maximum comprising basic salary in scale Kwacha 3408 (£STG.1988) rising to Kwacha 3516 (£STG.2051) a year, entry point depending on experience, plus Inducement Allowance of £STG.584–£STG.603 a year. Gratuity 25% of total salary drawn. A direct payment of £STG.291 is also payable to an officer's bank account in the U.K. Both Gratuity and direct payment are normally TAX FREE. Free passages. Quarters at low rental. Children's education allowances. Liberal leave on full salary or terminal payment in lieu. Contributory Pension Scheme available in certain circumstances.
Candidates, preferably between 30 and 50 years of age, must have not less than ten years' training and experience, with a recognised Telecommunications administration and currently considerable experience on the operation and maintenance of ISB HF Radio Transmitters and/or Receivers and ancillary equipment employed on international circuits; a City and Guilds Intermediate Certificate, with a pass in Radio Grade II, or the equivalent is also essential. Preference will be given to candidates with experience as a Controlling Officer at an International HF Radio Station.
The officer will be in charge of, and responsible for the International HF Radio Transmitting or Receiving Station in Zambia which will be operated on a 24 hour basis. In addition to his technical control duties, he will be required to undertake various administrative functions and to train Zambian staff on technical watch-keeping duties.

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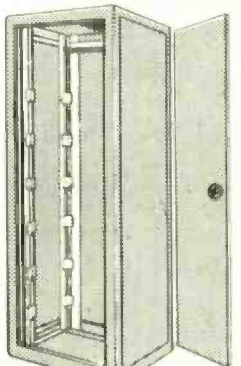

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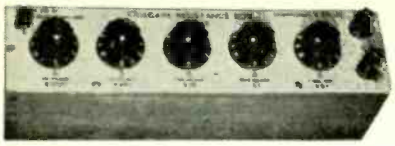

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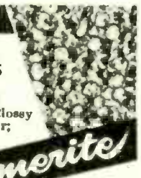

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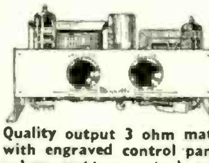

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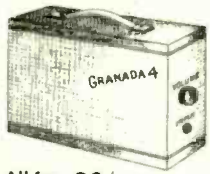

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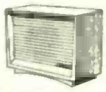

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INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 111-124

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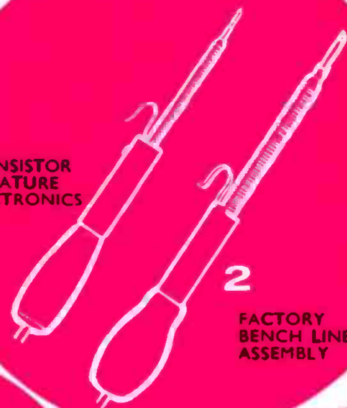

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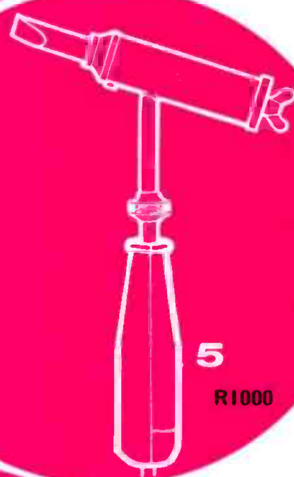

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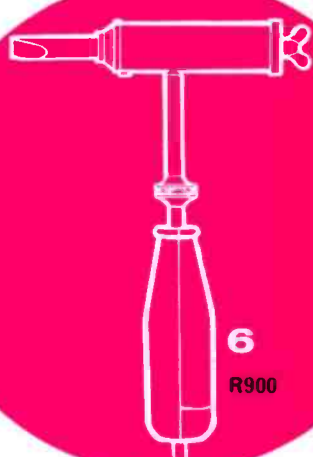

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