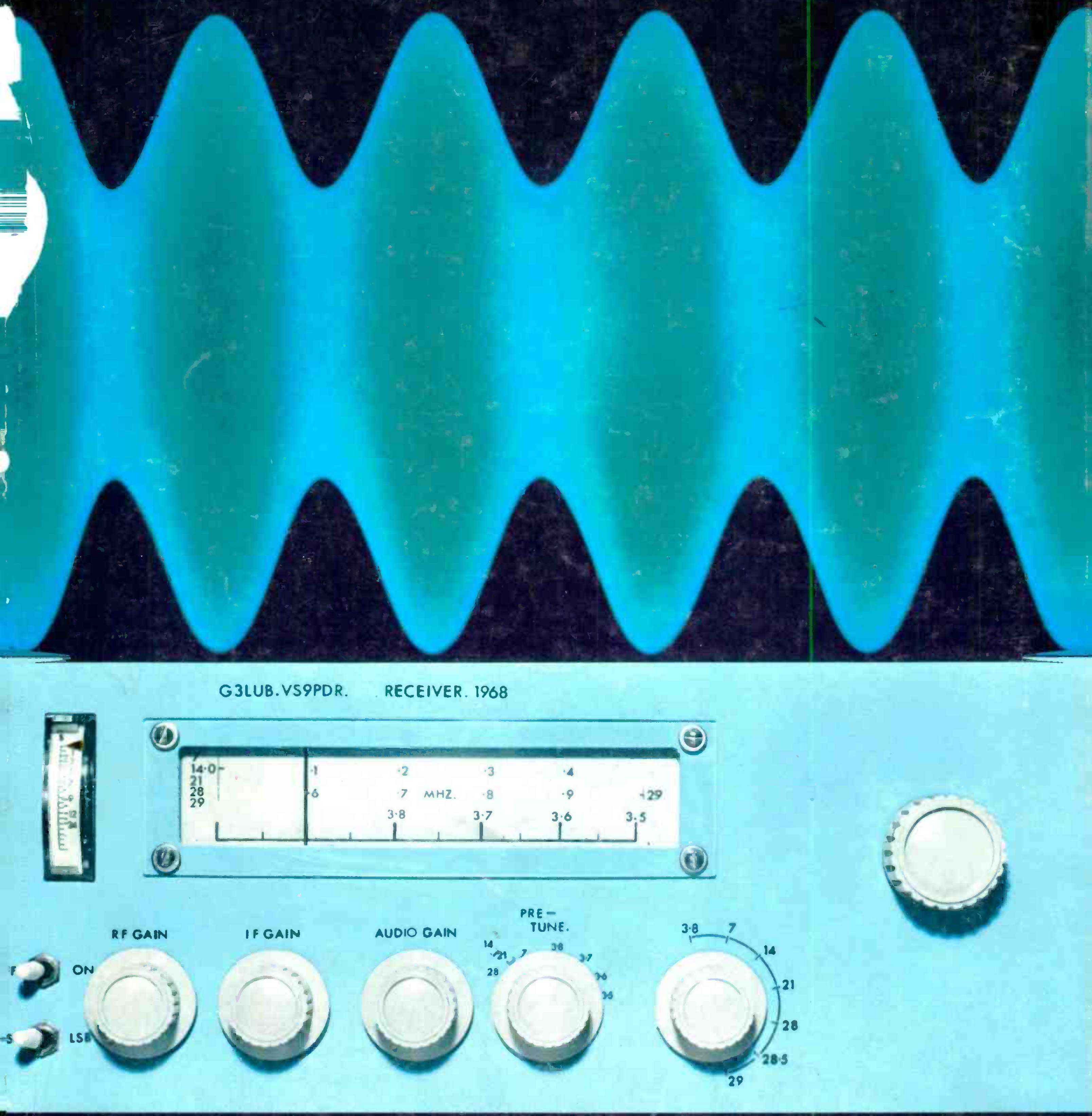
Wireless World

JULY 1969 Three Shillings

High-quality audio pre-amplifier



Amateur communications receiver

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OF YOUR MULTI-RANGE INSTRUMENTS...

BRADLEY Calibrators had this feature* back in 1964, and they still lead in design . . . look at these specifications . . .

Model 127	0-509 volts D.C. at an accuracy of 0.05%
Model 125B	0-511 volts A.C. in 100 mV steps, at an accuracy of 0.2%, with extremely low harmonic distortion. Spot frequencies 50, 60, 400 and 1000 Hz., with alternative frequencies up to 2400 Hz. available
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* BY DIRECT READING OF PERCENTAGE ERROR...

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

Forced-air Cooled

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

Vapour Cooled

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

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

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

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

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

Send for full details of EEV tetrodes

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

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

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

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW 21

AP 358

Please supply full catalogue of signal recovery instrumentation and application reports.

NAME ____________________

POSITION ____________________

COMPANY ____________________

ADDRESS ____________________

____

No grilling is too drastic for our test department. Everything is suspect until cleared. Quality Assurance is of such importance at Brookdeal that as much time goes into testing and proving as into actual manufacturing.

BROOKDEAL ELECTRONICS LIMITED,
Myron Place, London, S.E.13.
Telephone: 01-852 7433.

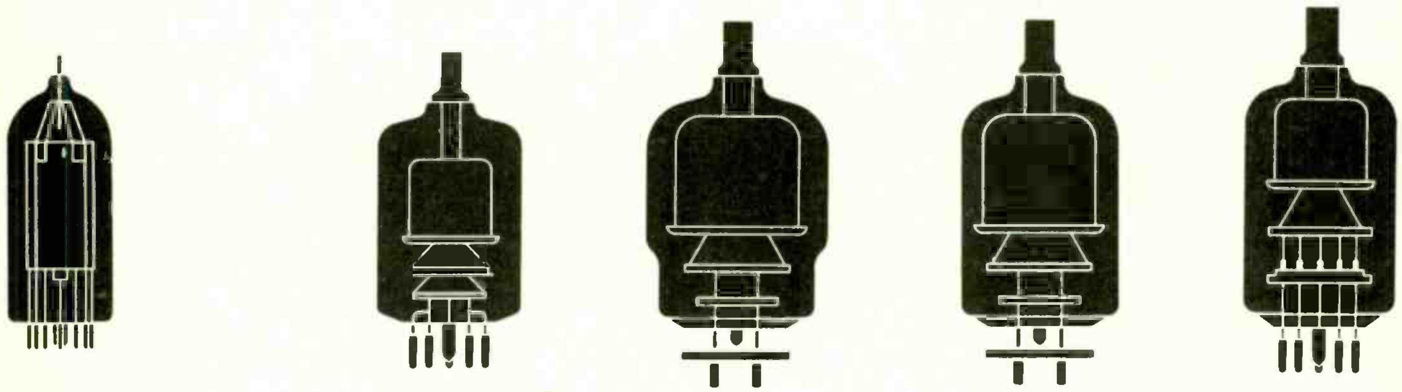
PRODUCT FEATURE: Type 432 High |Z| Preamplifier, amplifies with high cmr (120dB) and low input capacitance (0.1pF). £145 (U.K.).

Brookdeal

the preferred equipment for signal recovery

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

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



C1179 C1148 C1149/1 C1150/1 C1166

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

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

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

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

Pulse output power	Anode dissipation	Anode voltage	Pulse anode current

NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW 22
AP 362

This intercom is not unique

Except in one respect. You don't have to tear the place apart to put the system in, expand it, change it, or take it out, because it works through one 8-mm slim cable.
It has all the things a good intercom should have, because we've years of experience in solving our own intercom problems. So, we designed out all the troublesome things and left in only efficiency.
It gives instant contact with thirty people. It can be answered from across the room. It has secrecy circuits and provision for secretary intervention to leave your top men undisturbed.
Speech is delivered clearly without distortion. The call signal is pleasing but distinct. It has a "lock-out" system so that an absent executive can indicate his absence at once to any caller. This saves that vexing search for men who are simply not in the building. It can be provided with priority circuits for directors, and group calling to enable a number of men to respond simultaneously.
Have your secretary get in touch with us immediately for all the information about this unusually good intercom which is still not unique.

Electro-acoustics Division of Philips Industries, N. V. Philips' Gloeilampenfabrieken, Eindhoven, The Netherlands.

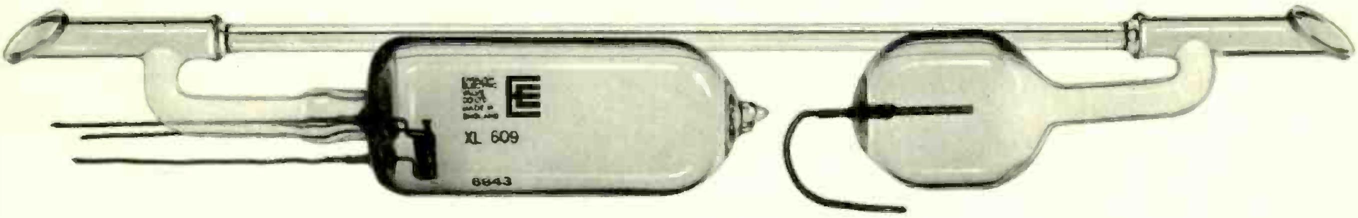
PHILIPS

intercommunication systems

WW—009 FOR FURTHER DETAILS

The secret is in the fixing of the Brewster window —the angled glass plate at each end of the tube. In many tubes the seal is made with an epoxy resin which eventually cracks and ruins efficiency by letting in air. EEV, on the other hand, use fusion sealed windows where the seal is as strong as any other part of the tube. Fusion sealing allows the tube to be heated to a very high temperature during manufacture, driving out all the gases in the tube surface which would otherwise contaminate the helium-neon filling. EEV tubes have been life tested up to 6000 hours which is two or three times the life generally expected from tubes employing epoxy sealing techniques. There is a standard range of EEV laser tubes available, full details of which can be obtained by filling in the coupon. If your laser design calls for a special tube give us brief details of what you need as we can probably meet your requirements.

Why EEV gas laser tubes



last longer

Type	Excitation	Output power at 632.8nm (mW)	Bore diameter (mm)	Active length (mm)
XL607	R.F. (27MHz)	3.0	7.0	483
XL609	D.C.	2.5	3.0	229
XL612	D.C.	6.0	7.0	457
XL614	D.C.	8.0	7.0	584

Send for full details of the complete range of EEV gas laser tubes.

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

Please send me full data on your range of gas laser tubes.
I am particularly interested in using a tube with the following parameters.

Wavelength (nm) Power Output (mW) Mode (Single or Multi?)

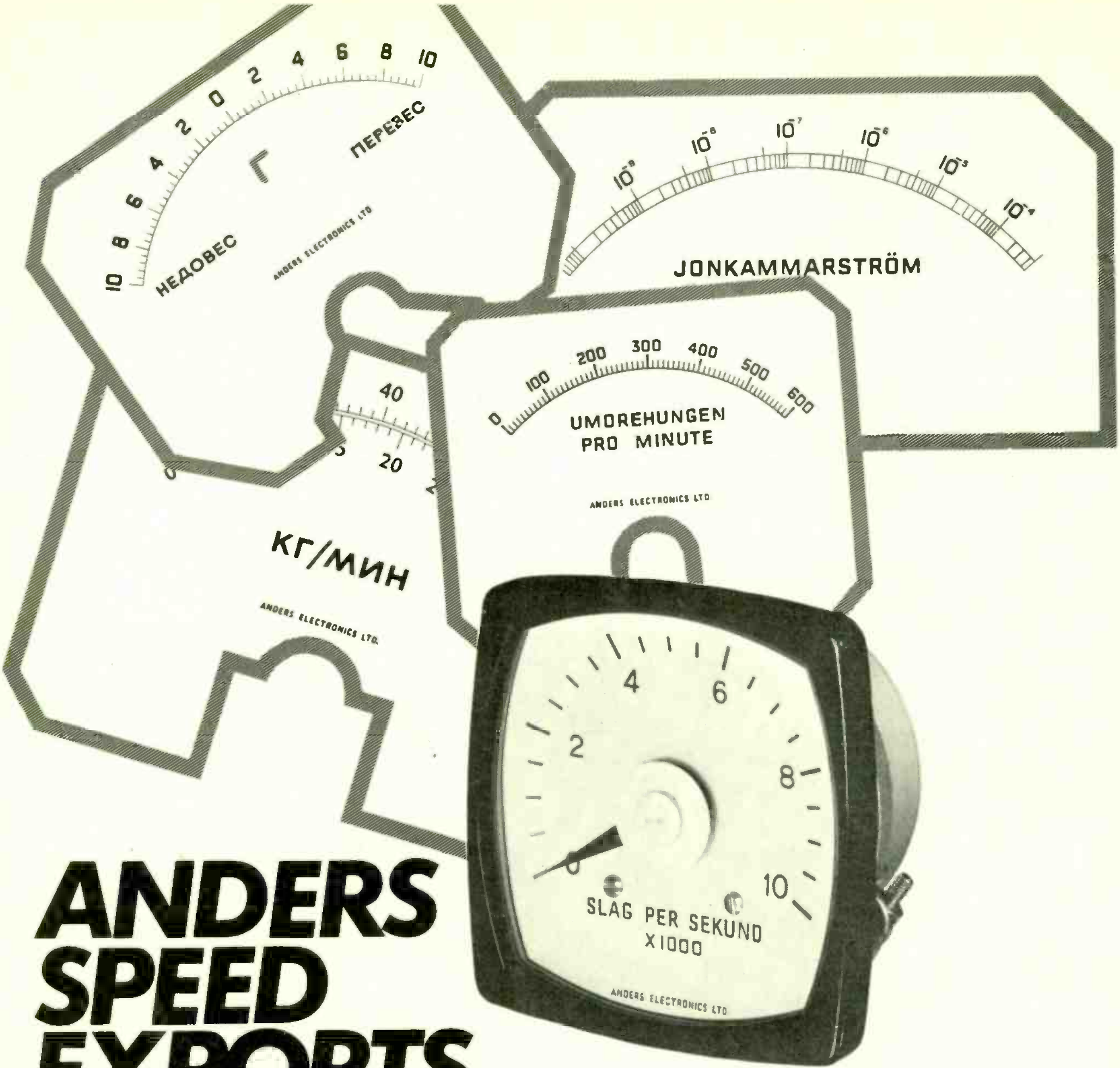
NAME POSITION

COMPANY

ADDRESS

TELEPHONE NUMBER EXTENSION

WW23
AP357



ANDERS SPEED EXPORTS

So you're doing your bit and making equipment for far-away places? And you're held up for meters? Like an 0-5mA calibrated in pulsfrekvens? Or a jonkammarström meter specially calibrated from 10^{-10} to 10^{-4}? Or a straightforward (but impossible to locate) 100mA moving-coil job reading simply 0-35 КГ/МИН? Relax. No problem at all. Anders are legending most types of meters in all sorts of languages every day of the week—and as often as not calibrating them specially into the bargain. Hand lettering specialists are standing by for the one or two off. Fast, accurate techniques are here for the quantity orders. Ring us. You'll find we are as fast at this sort of thing as we are at supplying standard meters off the shelf . . . . and, as you know (or should know), that's fast.

N.B. The variety of meters in our new catalogue is a revelation—and now we've got extensive new centralised premises for a better-than-ever service.

Manufacture and distribution of electrical measuring instruments and electronic equipment. The largest stocks in the U.K. for off-the-shelf delivery. Prompt supply of non-standard instruments and ancillaries. Sole U.K. distribution of FRAHM vibrating reed frequency meters and tachometers.

ANDERS METER SERVICE

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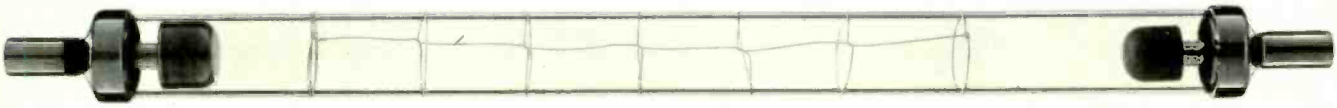
WW—011 FOR FURTHER DETAILS

Outstanding in quality, reliability and performance

Don't take our word for it—test EEV flash tubes against the equivalents you're now using and learn why other users think so highly of those made by EEV. Incorporating extra heavy duty electrodes, EEV flash tubes are renowned for their reliability, long life (up to 10^6 flashes) and high conversion efficiency. EEV liquid-cooled and air-cooled xenon flash tubes for pumping laser rods offer a wide range of input energy levels and they are capable of operation at high repetition rates.

Full details of the range are available on request—but if your application calls for a flash tube that is not in the present range, tell us your requirement because we can probably make it for you.



EEV flash tubes

				Typical operating conditions			
Type	Energy input per flash max. (J)	Arc length (mm)	Bore diameter (mm)	Voltage (kV)	Series inductance (μH)	Flash rate	Trigger voltage (kV)
XL615/7/3	600	76	7.0	2.5	400	1 per 15 sec.	12–16
XL615/9/4	1500	102	9.0	2.5	400	1 per 30 sec.	12–16
XL615/10/5.5	3500	140	10.0	2.5	400	1 per 30 sec.	16–20
XL615/10/6.5	5000	165	10.0	2.5	800	1 per 2 min.	20–25
XL615/13/6.5	10000	165	13.0	2.5	800	1 per 2 min.	25

Send for full details of the complete range of EEV flash tubes.

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

I am interested in EEV flash tubes for .... (application).
Please send me data sheets on your full range.

NAME POSITION

COMPANY

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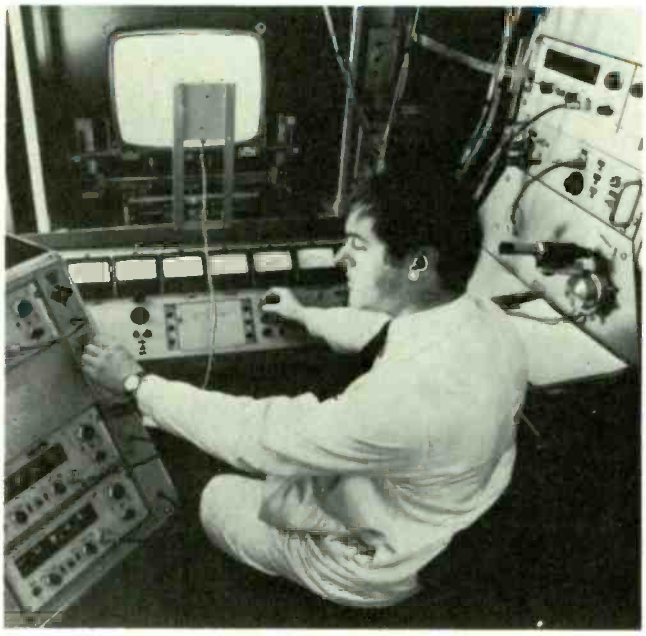
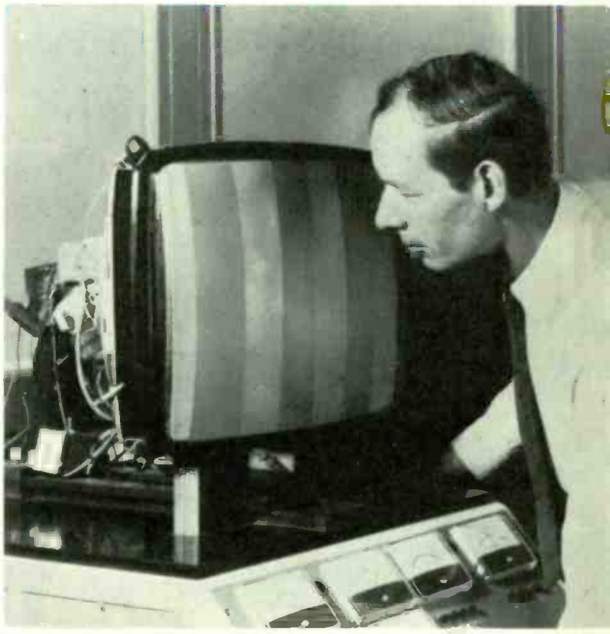
TELEPHONE NUMBER EXTENSION

WW 24
AP 356

WW—012 FOR FURTHER DETAILS

Mul
put all this...&
every pic



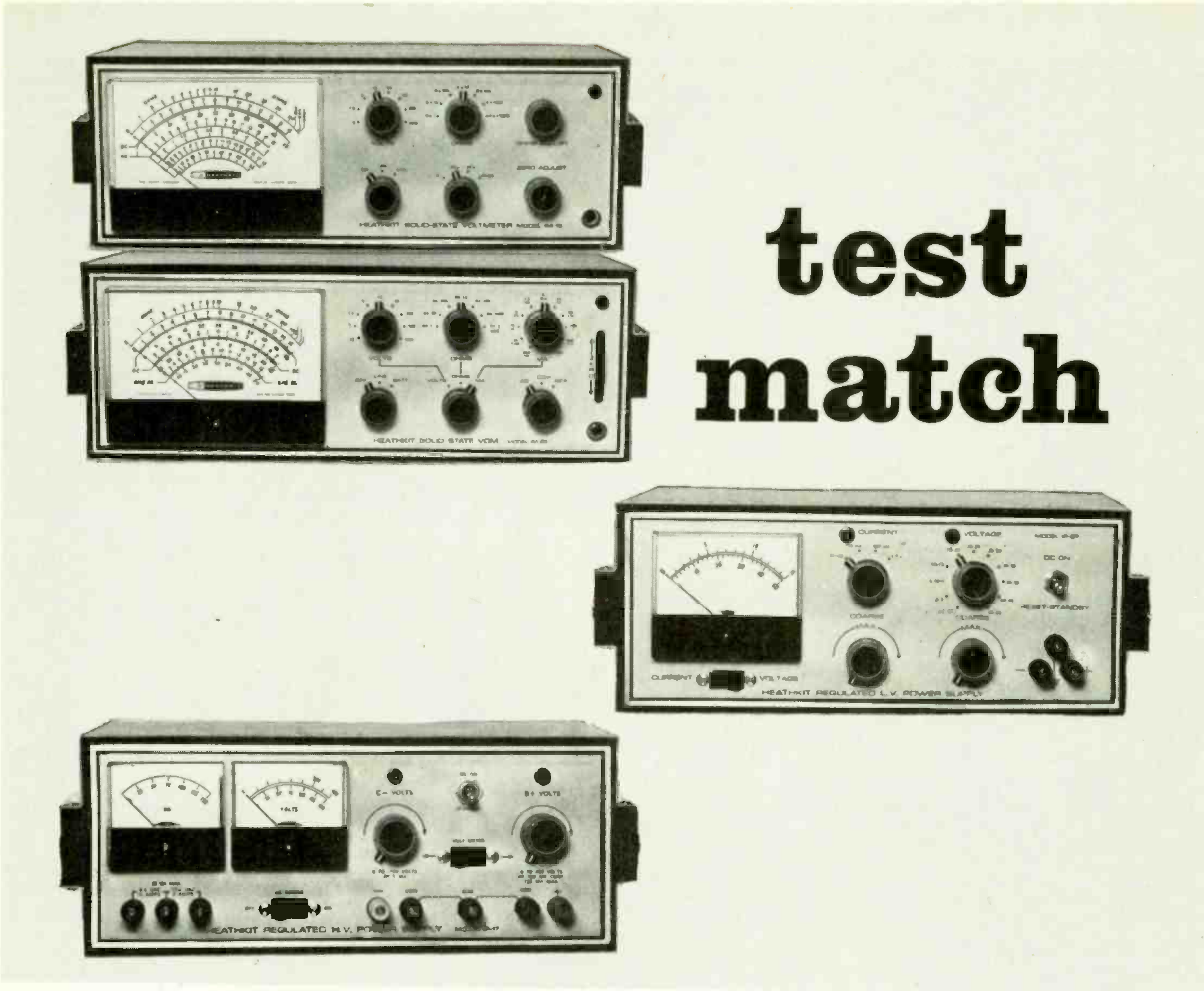


Quality in quantity
At the Mullard Simonstone tube factory, quality control procedures operate at every production stage, from raw materials to final testing. Completely independently, the Technical Department checks every facet of tube construction, operation and life. Above you see an engineer carrying out one of the 111 measurements made daily on a proportion of monochrome tube production.

Working for the industry
The Mullard Central Applications Laboratory at Mitcham, Surrey, serves the electronics industry by solving today's circuit problems and carrying out work on new techniques for the future.
The laboratory employs over forty engineers and scientists and has made many original contributions,

there's more in Mullard picture

Mullard Limited, Consumer Electronics Divisio



HEATHKIT SCORE
with their team of instruments

The opening pair, Heathkit DeLuxe Solid-State VVMs models IM-16 and IM-25, because of their excellent form and reliability, have quickly found a wide and appreciative audience. Their amazing versatility and style is always worth watching.

They are supported by the Heathkit HV and LV stabilised power supplies, models IP-17 and IP-27, which also are first class contestants in many fields throughout industry. These, backed by the excellent cover of the wide range of other Heathkit test instruments, make a team strong enough to challenge anyone.

Even when batting on a really sticky wicket, Heathkit instruments will give a good innings for your money.

Photographs, many in full colour, of all the Heathkit team of instruments as well as their performance records, can be found in our latest catalogue, which is available to all enquirers on request.

Send for your copy today.

Please send me your fully-detailed catalogue immediately
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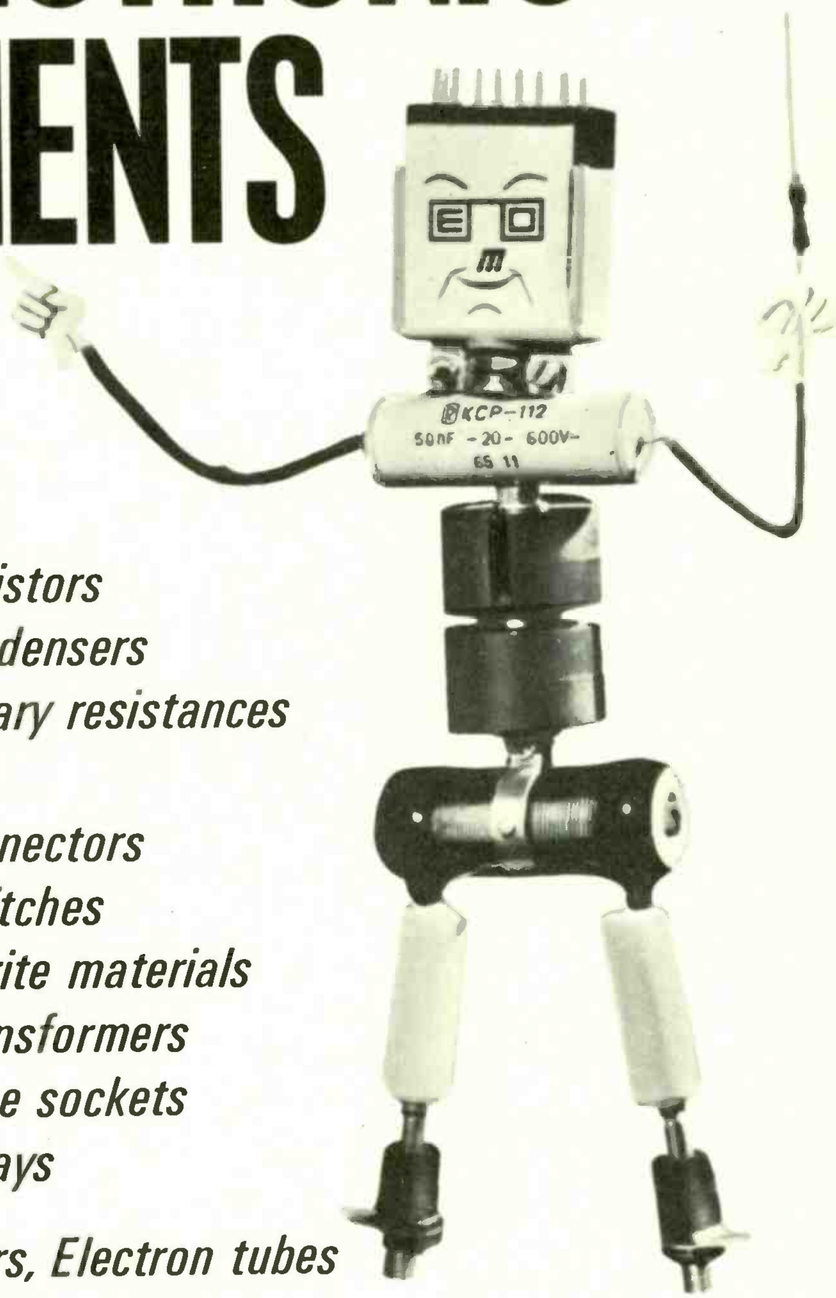

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WW—017 FOR FURTHER DETAILS

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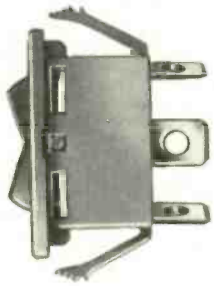
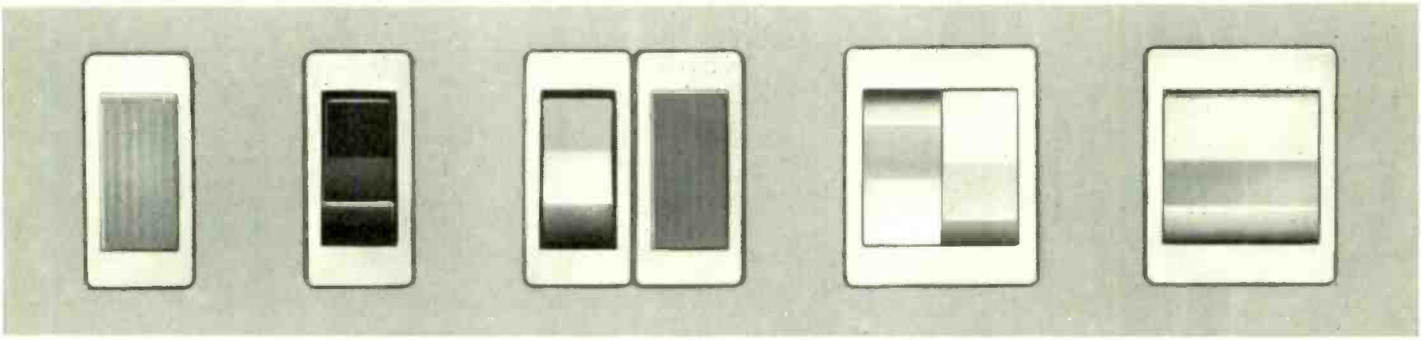
1·181"x·551"x1·213" 250V 10 AMP A.C. SINGLE POLE SNAP-IN FIXING



now meet the family



1109 | 1100 | 1100/1109 | 1100 twins | 1110

Being a snappy little 1100 rocker who is getting around fast, I am often asked about my family. Now, having managed to persuade them to have their photograph taken with me, I have much pleasure in introducing them.

1109—often seen around with me, is a most illuminating little pilot light with a variety of colour lenses. At times we are very close and can often be seen working together very harmoniously on a wide range of appliances and equipment.

The 1100 twins are going to be very popular and you can expect to see them on many companies' panels soon.

1110, the fat one, is double pole and the clever member of the family, he can operate two circuits at a time.

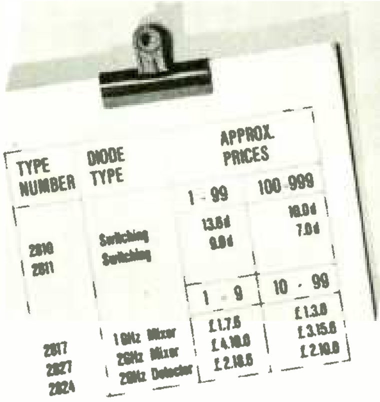
Like to know more about us? Give us a ring at 01-574 2442, we would certainly like to meet *YOU* some time. P.S. I have just been awarded my BS.3955 approval certificate.

ARROW

ARROW ELECTRIC SWITCHES LTD · BRENT ROAD · SOUTHALL · MIDDX · 01-574 2442

E 75-UK

3 It's price-cutting time for hybrid hot carrier diodes



TYPE NUMBER	DIODE TYPE	APPROX. PRICES	
		1 - 99	100 - 999
2810	Switching	13.6d	10.0d
2811	Switching	9.0d	7.0d
		1 - 9	10 - 99
2817	1 GHz Mixer	£1.7.6	£1.3.0
2827	2 GHz Mixer	£4.10.0	£3.15.0
2824	2 GHz Detector	£2.18.6	£2.10.0

A new hp manufacturing process did it: down went the prices of hybrid hot carrier diodes.

The 2800 series are epitaxial, planar passivated devices. Their unique design combines a conventional PN junction and a Schottky barrier. The benefits are fourfold.

1. The high breakdown and high temperature (200°C) operating and storage characteristics of silicon.
2. The low turn-on voltage of germanium.
3. The 100 picosecond speed of a Schottky barrier majority carrier device.
4. The inherent resistance to shocks and vibrations of a planar diode.

The latest additions to the series are two switching diodes featuring forward currents of 35 ma and 20 ma at 1 V (capacitance: 1.2 pfmax); there are also 1 GHz and 2 GHz mixers with 60 erg burnout and 6 dB noise figures; and a 2 GHz detector with -56 dBm tangential sensitivity. All are available as single units, pairs and quads. Ask for the data sheets on the 2800 series diodes.

WW202 FOR FURTHER DETAILS

4 How about measuring the time it takes light to travel 10 feet?

Measuring the 10 ns light takes to travel 10 ft. is strictly in the line of duty for the hp 5248L counter with the new 5267A time interval plug-in (resolution: 10 ns). How's this for measurements involving explosives, shock waves, laser pulses and other high-speed applications?

Then there is the hp 5256A plug-in for frequency measurement up to 18 GHz. And this is what really sets the 5248L apart: plug-ins. Twelve of them. The industry's widest choice.

Even without plug-ins, the 5248L displays a healthy capability. It measures frequencies up to 135 MHz, frequency ratios, waveform periods, and multiples of periods and ratios. It also scales frequencies and totalizes.

The 100 MHz time base of the 5248L has an aging rate of less than 3×10^{-9}/day.

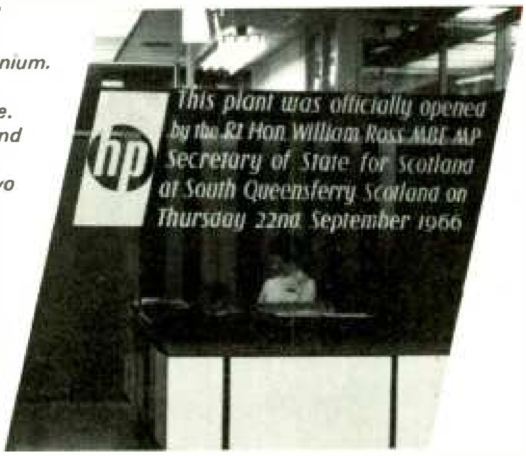
A second version (5248M) is equipped with an ultra-stable 100 MHz time base whose aging rate is less than 5×10^{-10}/day.

Your hp office has the complete story.

hp 5248L, £ 1325.
hp 5248M, £ 1507.
hp 5267A, £ 211.
hp 5256A, £ 1027.

WW203 FOR FURTHER DETAILS

5 Made in Britain



Your next hp instrument might well be British-made.

Over eighty products are today manufactured by the hp plant at South Queensferry, overlooking the Firth of Forth near Edinburgh.

In addition to communications test equipment, noise generators and related items designed in South Queensferry for world markets, the Scottish factory produces instruments which are especially popular in European and Commonwealth countries. Numerous hp customers therefore benefit from an important cost advantage.

WW204 FOR FURTHER DETAILS

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rely on PYE the vital contact

Pye 'Pocketfone' Personal Radiotelephone

New battery economy circuit · Extremely light-weight and compact · Reception free from noise and interference · Minimum of controls · Transmit button automatically extends antenna · Hearing aid socket · Easily accessible batteries.

Pye 'Bantam' Portable VHF Radiotelephone

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

Pye VHF Radiotelephone Fixed Station

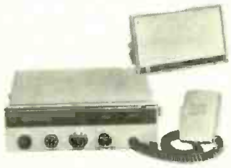
Solid-state receiver and transmitter · 10-15W R.F. output · Field-effect transistors used in receiver · Suitable for all climates · Electronic squelch · Designed to meet all relevant specifications.

Pye UHF Radiotelephone Fixed Station

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

Pye 'Westminster' Remote Mounted Radiotelephone

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

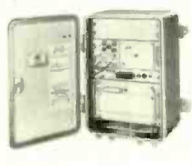


Pye 'Westminster' Front Mounted Radiotelephone

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

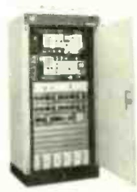
Pye Single-Sideband Radiotelephone

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



Pye 'Pioneer' Radiotelephone

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



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

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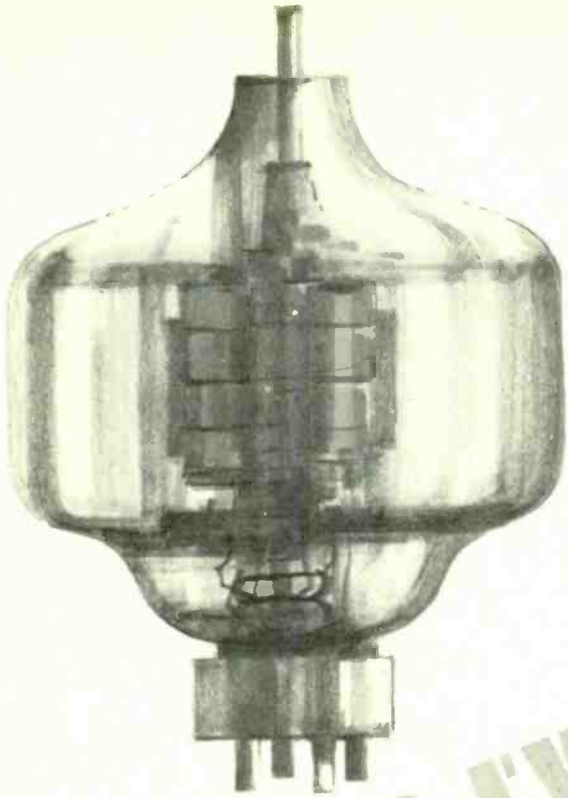

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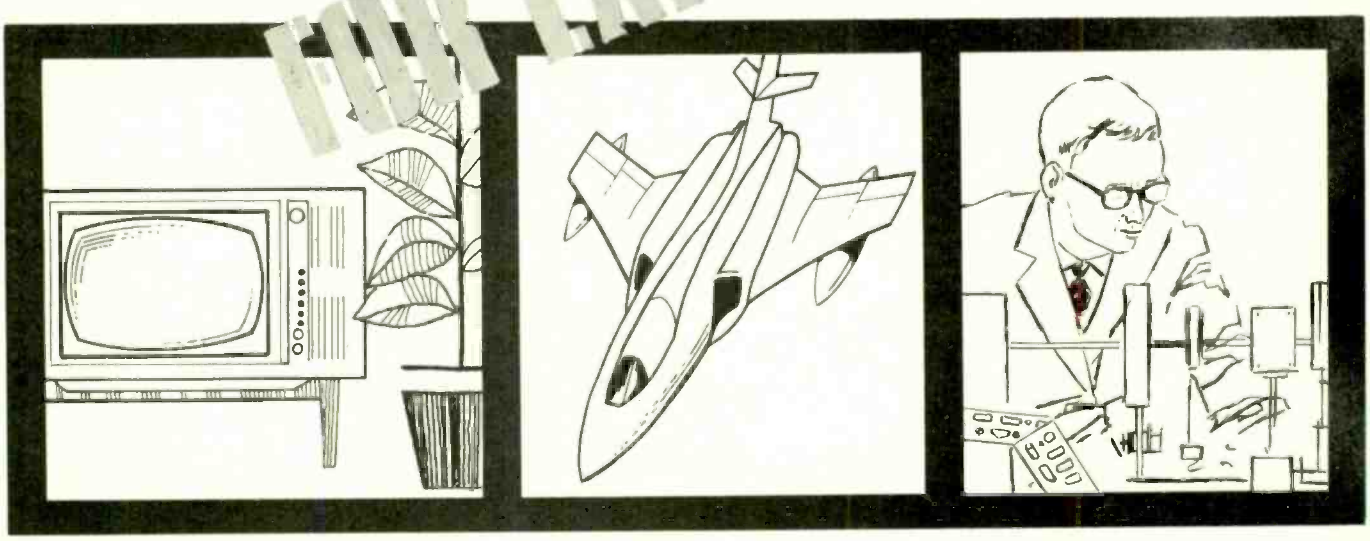

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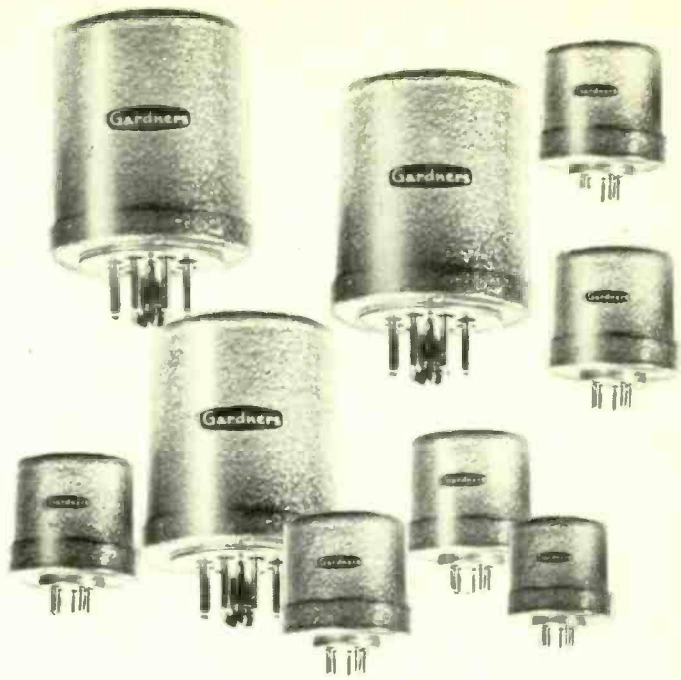
AUDIO FROM GARDNERS



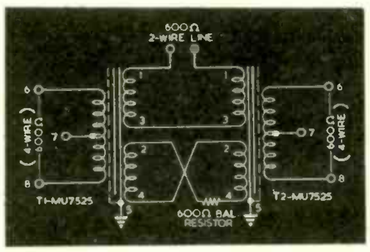
Exceptionally wide band microphone and audio line matching transformers

FREQUENCY RANGE
100 K.ohm models ±1 dB 30 c/s to 20 kc/s.
All other models ±0.5 dB 30 c/s to 20 kc/s.
MAXIMUM AUDIO LEVEL +12 dBm (16mW).
INPUT IMPEDANCE maintained to within ±10% (±20% j) at all frequencies within the range 50 c/s to 8 kc/s (to 5 kc/s only for 100 K.ohm models).
MAGNETICALLY SCREENED
—50 dB reduction in hum pick up.

For professional recording and broadcast transmission equipment, these Octal-based plug-in transformers have a frequency response extending well beyond the audio range. The design achieves dynamic performance with minimum distortion at all levels

Type No.	Input Z Ohms	Pin Nos.†	Output Z Ohms	Pin Nos.	Sec./Pri. Turns Ratio	Applications
MU.7521	3·75/15*	1-3, 2-4	600 (C.T.)	6-7-8	6·32:1/12·64:1	Low Z. Mic/Line
MU.7522	3·75/15*	1-3, 2-4	100K.	6-8	82:1/164:1	Low Z. Mic/Grid
MU.7523	75/300*	1-3, 2-4	600 (C.T.)	6-7-8	1·41:1/2·82:1	Line/Line
MU.7524	150/600*	1-3, 2-4	600 (C.T.)	6-7-8	1:1/2:1	Mixing: Bal./Unbal.
MU.7525	600 (C.T.)	6-7-8	300/1·2K*	1-3, 2-4	1+1:1·41 (C.T.)	Mixing: Hybrid‡
MU.7526	600 (C.T.)	6-7-8	2·5k/10k.*	1-3, 2-4	2·04:1/4·08:1	Line/Grid
MU.7527	150/600*	1-3, 2-4	100K.	6-8	13:1/26:1	Line/Grid
MU.7528	7·5/30*	1-3, 2-4	600 (C.T.)	6-7-8	4·47:1/8·94:1	Low Z. Mic./Line
MU.7529	50/200*	1-3, 2-4	600 (C.T.)	6-7-8	1·73:1/3·46:1	Mic. or Line/Line
MU.7530	10K. (C.T.)	6-7-8	10K.	1-4	1 (C.T.):1	600 Line Bridging
MU.7532	7·5/30*	1-3, 2-4	100K.	6-8	58:1/116:1	Low Z. Mic./Grid
MU.7534	50/200*	1-3, 2-4	100K.	6-8	22·4:1/44·8:1	Mic. or Line/Grid

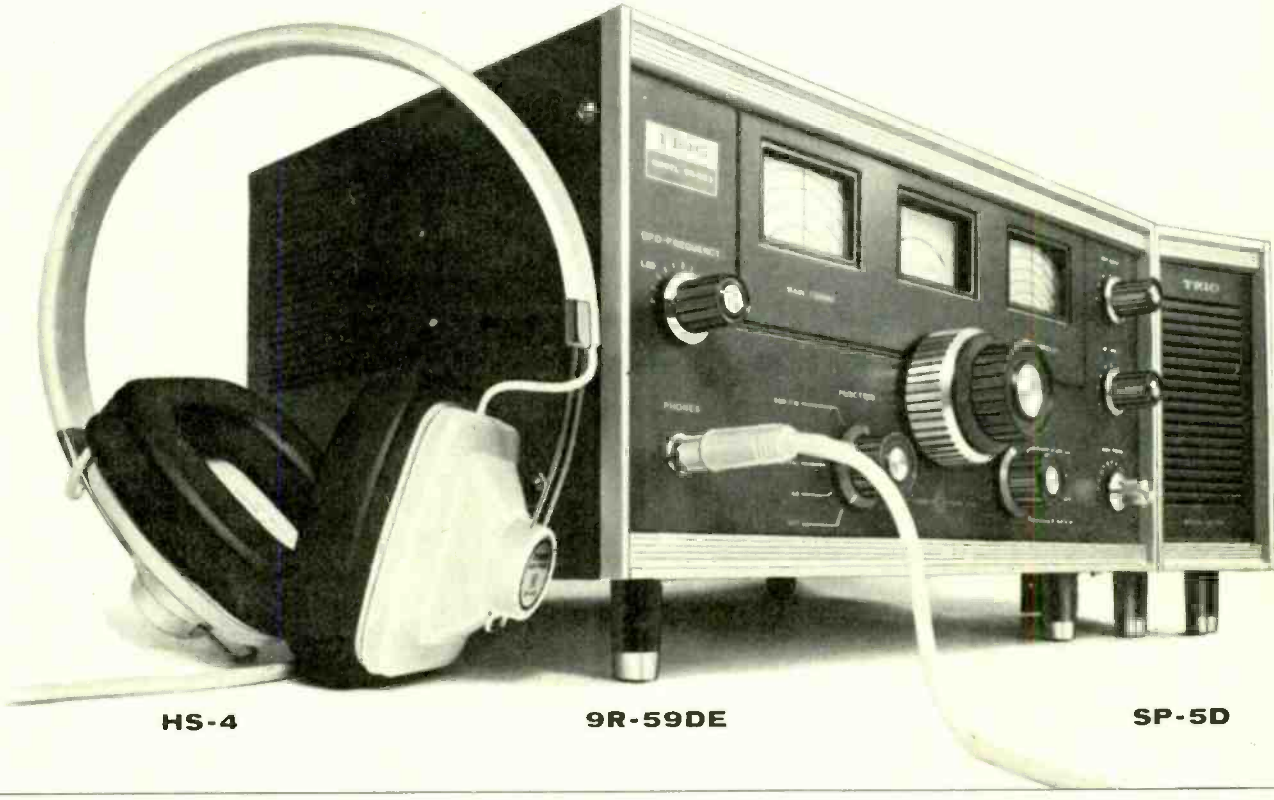
Type MU.7525 may be used in "Hybrid" circuits, as shown, to establish 2 to 4 wire operation in telephony. Accurate balancing of the windings enable guaranteed rejection of better than — 55 dB from 50 c/s to 10 kc/s. Up to — 75 dB may be expected for normal rejection levels.



Gardners WRITE FOR LEAFLET GT 22 WITH PRICE LIST

GARDNERS TRANSFORMERS LIMITED
Christchurch, Hampshire BH23 3PN. Tel. Christchurch 2284 (STD 0201 5 2284)
TELEX 41276 GARDNERS XCH

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



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.

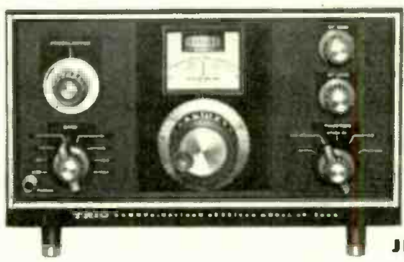
Model HS-4

- 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

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

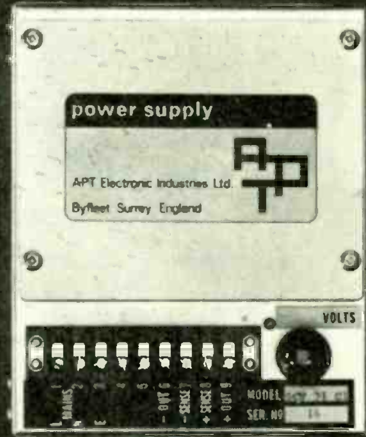
NAME: AGE:

ADDRESS:

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

A·P·T POWER PACKS



The **SERIES 30** is a range of modular, mains operated d.c. power units with output voltages from 0-500V at maximum current ratings. These all silicon units are a result of careful design, are small in size, robust in construction and give a high performance. Three standard lengths are available covering the complete output range.

For further details write for fully descriptive leaflet and free slide rule selector.

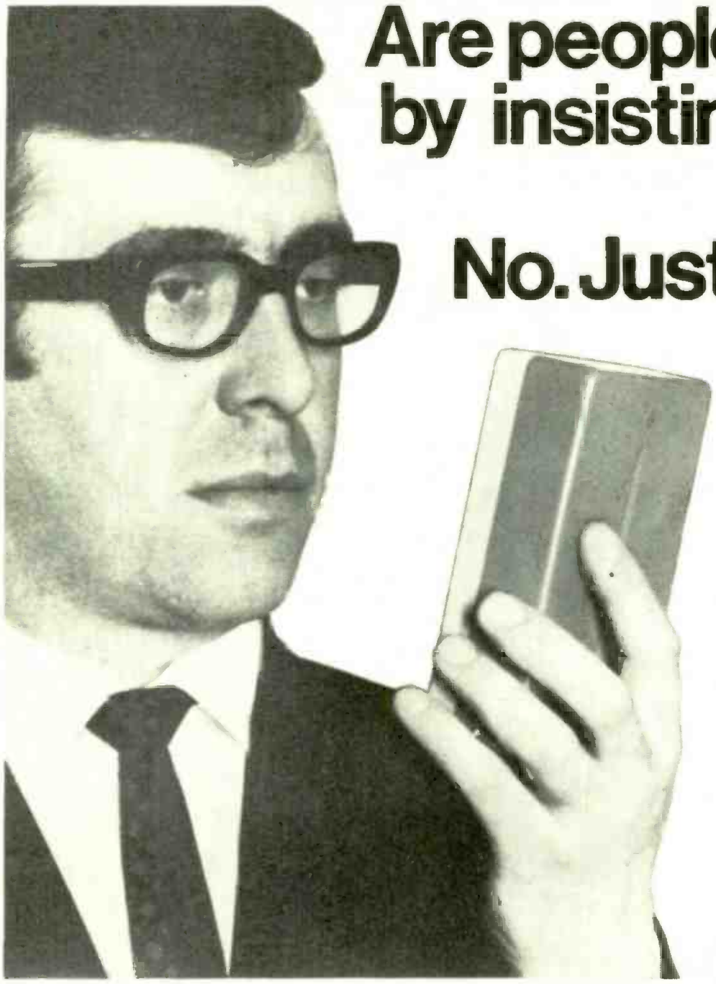
PERFORMANCE

Stabilisation ratio:	>10,000:1. Typical 20,000:1.
Temperature coefficient:	≯0.005% per °C.
Output resistance:	≯0.5m Ω + 0.05m Ω per volt of output.
Output impedance:	<0.1 Ω to 200 KHz.
	<0.5 Ω to 500 KHz.
Ripple and noise:	≯250 μV or 0.0005% p-p, whichever is greater.

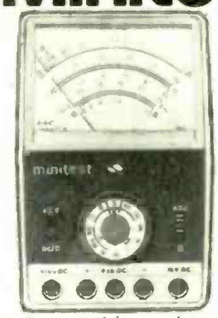
A.P.T. ELECTRONIC INDUSTRIES LTD
Chertsey Road, Byfleet, Surrey. Tel: Byfleet 41131-2-3-4 Grams: APTRAN, BYFLEET

WW—023 FOR FURTHER DETAILS

Are people being stubborn by insisting on the Minitest?



No. Just choosy!



Diminutive, sensitive, neat, tough. These are the adjectives that describe the S.E.I. Minitest. You will never be provoked into using any other for years, hence this pocket size, multi-range test set will be serving you accurately. The Minitest measures a.c. and d.c. voltages, d.c. current, and resistance over 20 ranges to a sensitivity of 20,000 and 2,000 ohms per volt d.c. and a.c. respectively. Readings are instantaneous and the minutest is clearly discernible. A steel case shields the movement from external magnetic fields and shocks. This has a robust, wipe-clean, melamine cover. All controls are handily disposed.

High voltage probes are available to extend the range of the Minitest to 25 or 30kV d.c. for testing electronic equipment with high source impedence. They can be used with any other meter of similar sensitivity. Wisdom suggests Minitest and S.E.I. probes together, right from the start. Act now: Send for the catalogue.

We manufacture a wide range of portable instruments . . . write today for full information.

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Telephone: 061-789 5081 Telex: 66711
A Member Company of G.E.C. Electrical Components Ltd.

WW—024 FOR FURTHER DETAILS

ANTEX

precision soldering

Model G—18 watts. Fitted with $\frac{3}{32}$" bit. Interchangeable spare bits $\frac{1}{8}$", $\frac{3}{16}$" and $\frac{1}{4}$". For 240, 220 or 110 volts. 32/6

Model E—20 watts. Fitted with $\frac{1}{4}$" bit. Interchangeable spare bits $\frac{3}{32}$", $\frac{1}{8}$" and $\frac{3}{16}$". For 240, 220 or 110 volts. FROM 35/-

Model ES—25 watts. Fitted with $\frac{1}{8}$" bit. Interchangeable spare bits $\frac{3}{32}$", $\frac{3}{16}$" and $\frac{1}{4}$". For 240, 220, 110, 24 and 12 volts. FROM 35/-

Model F—40 watts. Fitted with $\frac{3}{16}$" bit. Interchangeable spare bits $\frac{1}{4}$", $\frac{3}{16}$", $\frac{1}{8}$", $\frac{3}{32}$". For 240, 220, 110, 24 and 20 volts. FROM 42/6.

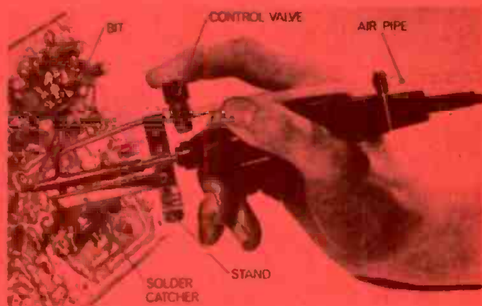
Model CN 240/2
15 watts—240 volts
with nickel plated bit ($\frac{3}{32}$") and in a handy transparent pack **31/-**

COMPLETE PRECISION SOLDERING KIT

Supplied in its own compact, rigid plastic container and *includes all of these items:*

CN 15 watts 240 volts miniature model ($\frac{3}{16}$") bit • 2 interchangeable spare bits ($\frac{5}{32}$" and $\frac{3}{32}$") • reel of resin-cored solder • heat sink for soldering transistors • felt cleaning pad • soldering iron stand • storage space for lead and plug. **49/6**

DE-SOLDERING KIT



Efficient de-soldering is assured with this high speed method from Antex. Soldered joints soon dissolve leaving a clean finish, thanks to the exclusive Antex-designed suction nozzle. Operation is by compressed air from an airline or foot-pump. No vacuum supply is needed. Two models are available, complete with 6 ft. nylon airline, 6 ft. 3 core flexible lead and $\frac{1}{8}$" BSP Male and $\frac{3}{8}$" 26 T.P.I. Male Adaptors. **84/-** (Nett Trade)

Or complete with foot-pump **99/6** (Nett Trade)

FROM **32/6**
ACTUAL SIZE

CN 15 watts, fitted $\frac{3}{32}$" Ferraclad bit. The leading iron for miniature and micro miniature assemblies: 18 interchangeable bits from .040 (1 mm) up to $\frac{3}{16}$" for 240, 220, 110, 50 or 24 volts.

If you want the best in soldering, Antex irons are for you. Pin point precision, fingertip control, interchangeable bits that slide *over* the elements and do not stick, sharp heat at the tip, reliable elements and full availability of spares. World-wide users, both enthusiasts and professionals solder with Antex. It's time you joined them.
Antex soldering irons are stocked by quality electrical dealers, or you can order direct from us. A free colour catalogue will be supplied on request.

To: Antex, Mayflower House, Plymouth, Devon.

Please send me de-soldering kit ☐ (with foot pump) ☐ (without foot pump)

Please send me the Antex colour catalogue ☐

Please send me the following irons ☐

Quantity	Model	Bit Size	Volts	Price

I enclose cheque/P.O. cash value ....

NAME ....

ADDRESS ....

.... Telephone ....

W 7

ANTEX
PRECISION MINIATURE SOLDERING IRONS
Made in England

Antex, Mayflower House, Plymouth, Devon.
Telephone: Plymouth 67377/8 Telex: 45296
Giro No. 258 1000

1's or 1,000's

are all the same to us

OUR SMALLEST ORDER
last year was for a single radio valve, value 7/6d., urgently needed for shipboard replacement and rushed by us through the Rotherhithe tunnel to the London Docks so that they could sail with the tide. . . .

OUR LARGEST ORDER
last year was for 28,546 valves worth nearly £10,000, all specially selected within special parameters for an electronics manufacturer whose name is a by-word in Industry. . . .

Between these extremes we supplied a massive number of valves of one sort or another—used in everything from domestic television sets to porpoise-tracking equipment; from experimental laboratory hook-ups in Technical Colleges to nuclear magnetic resonance spectrometers;

The largest single valve independant

Pinnacle

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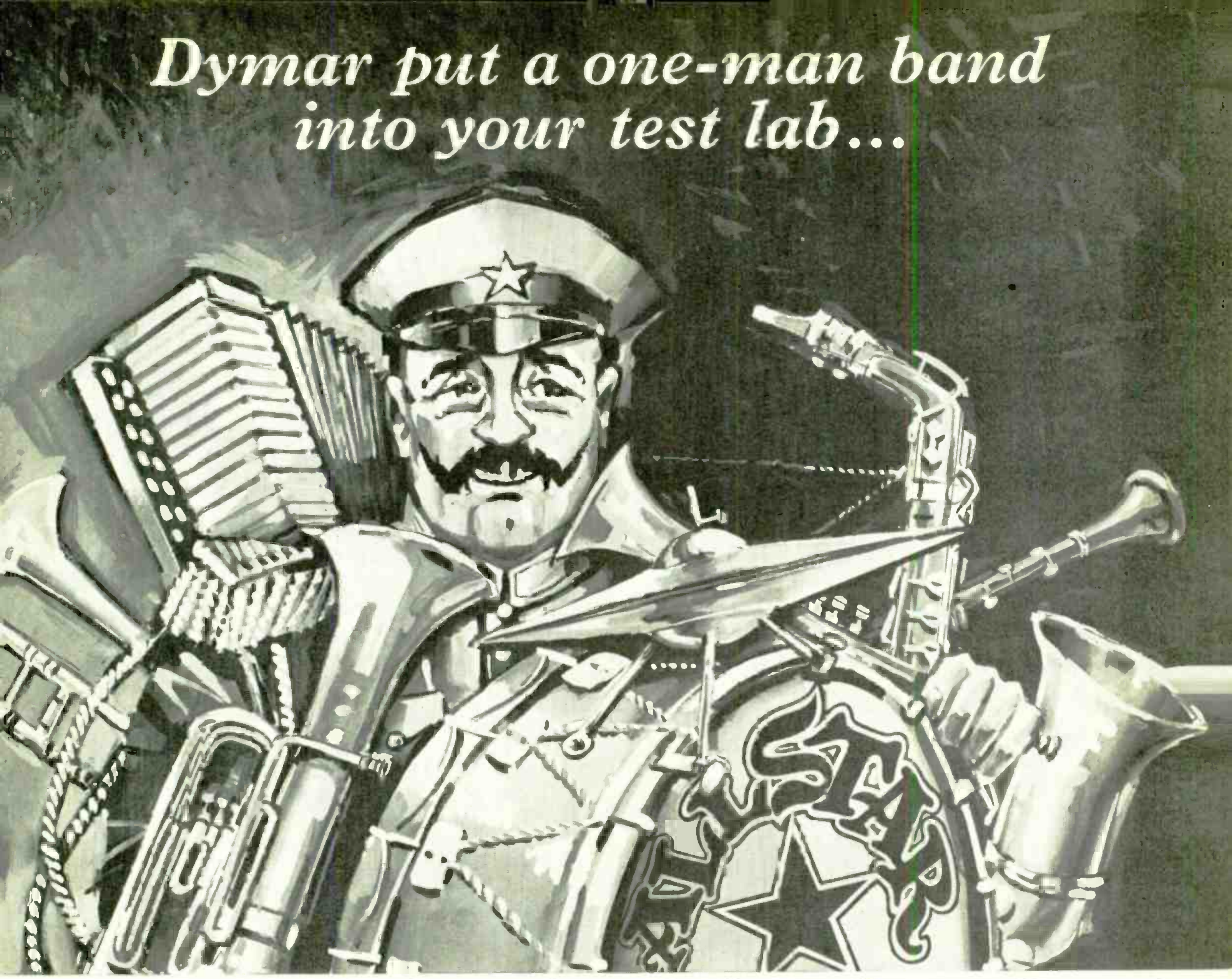
WW—028 FOR FURTHER DETAILS

WW—029 FOR FURTHER DETAILS

WW—030 FOR FURTHER DETAILS



...so why buy the whole orchestra?

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.
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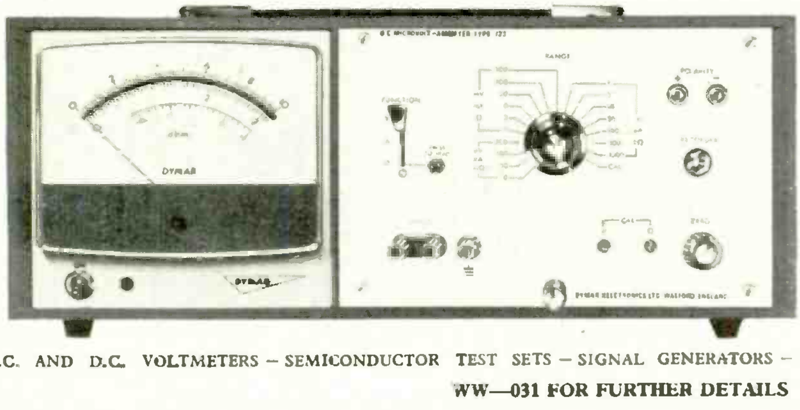

Please send me a copy of your Short Form Instrument Catalogue.

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POSITION ....

COMPANY ....

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.... TEL ....

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

WW—031 FOR FURTHER DETAILS

Farnell

CVC1 Constant Voltage Constant Current Variable Bench Supplies

With Automatic Change Over of Output Mode

*SEPARATE CONTROL AMPLIFIERS for both constant voltage and constant current operation.

*CLEAR indication of output mode, by means of front panel lights.

*HIGH DEGREE OF STABILISATION typically 0.002% in both modes.

*FEEDBACK TERMINALS are provided to compensate for voltage drop due to lead resistance.

*SEPARATE SWITCHING of mains Input and D.C. Output.

The CVC1 stabilised bench units type C500 £50 (0-50V at ½ A), C1 £75 (0-50V at 1A) and C2 £78 (0-30V at 2A) are continuously variable.

For full details, please contact us at the address below. (Please state if you require literature on our full range of power supplies, electronic instruments and digital logic equipment).

Farnell Instruments Limited,
Sandbeck Way,
Wetherby,
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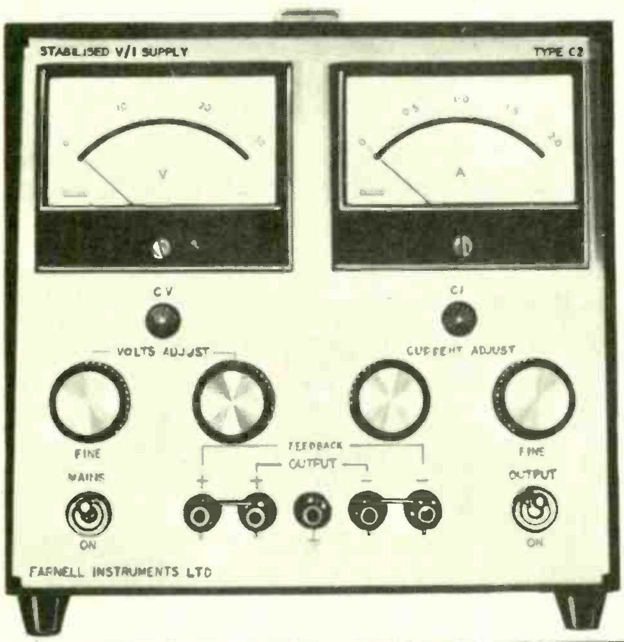
Yorkshire.
Telephone: 0937 3541/6



WW—032 FOR FURTHER DETAILS

LYNDA JENKINS

Count down. Cue light on. Tape running.
Dry throat. Switch-back stomach.
Rubber knees. Can't remember the
intro . . . Oh yes, after three.

What else can go wrong?
Not my Reslo mike, thank goodness.
Man, do I cling to *that.*

Here we go . . . loud and clear,
with any luck I'll get off before
they start throwing things.
Like golden discs.

Please send me your free brochure giving full details.

NAME ____________________

ADDRESS ____________________

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Reslo — DERRITRON GROUP

RESLO MIKES, ROMFORD, ESSEX.

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It's the finest, most comprehensive Catalogue we have ever produced —this latest edition. It has 330 pages, over 8,000 items listed, over 1,500 of them illustrated. Everything for the keen constructor —including tools and test gear. With each Catalogue we supply a 30-page Price Supplement, a bookmark giving electronic abbreviations, and an order form. All for only 8/6d plus 3/6d post, packing and insurance. Moreover, every Catalogue contains 6 vouchers, each worth 1/- when used as directed.

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The price of 12/- applies only to catalogues purchased by customers residing in U.K.

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COPENHAGEN

Bella-Centret 22nd to 31st August

ELECTRONICA '69

Electronics
Radio · TV

Open daily 10 a.m. to 10 p.m.
From 10 a.m. to 2 p.m. for trade only

WELCOME!

The electronics industry is one of the leading branches of industry in Denmark – with exports equal to that of our famous butter! You have an opportunity at ELECTRONICA '69 to see what these exports comprise, from the tiniest components to a wide range of colour TVs, stereo radios and professional electronic equipment of every type. And the Danish electronics industry is open-minded, too! We invite our foreign competitors to take part in the exhibition. ELECTRONICA '69 is thus very much an international electronics exhibition. ELECTRONICA '69 has been arranged jointly by the Danish Broadcasting Corporation and the Danish electronics industry. It is purely a display of electronics. Exhibition patron is H.R.H. Prince Henrik.

ELECTRONICA '69 consists of two sections: one for professional equipment and components, and the other for radio, TV, tape recording equipment, record players, Hi-Fi and stereo material, and with a working colour TV studio and stereo and Hi-Fi demonstrations.

ELECTRONICA 69 in its professional section will show such components and professional electronics as are on the market in Denmark, including:

Automation equipment and instrumentation
Audio and acoustic instruments
Boiler controls and instrumentation
Chemical measuring-equipment for laboratories and industry
Communication receivers
Computers, data processing and ancillary apparatus
Digital read-out- and positioning systems
Educational equipment, electronic and electrical measuring instruments
Industrial measurement, pressure, level, flow, etc.
Laboratory apparatus, equipment, furnishings
Medical electronics
Microwave and waveguide apparatus
Nuclear reactor and nucleonic instrumentation
Optical instruments, components and accessories
Radar and navigational aids
Radio test gear and equipment
Spectrographic and allied equipment
Telemetering and remote control
Television engineering equipment
Television equipment for closed circuits, black & white, and colour
Telecommunications equipment
Valves, electronic, cathode rady tubes etc.
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Secretariat and press office:
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Write for brochure.

WW—036 FOR FURTHER DETAILS

Racal and Airmec get together–

It's the Instrument event of the year!

Racal have made a big name in digital–and Airmec in analogue instruments. What better than to combine the efforts?

The brilliant new Airmec 422 VLF Digital Signal Generator is an outstanding example of the results achievable by combining analogue and digital know how–it will pay you to keep in touch with this get-together.

The highly successful Airmec range is now obtainable from the Airmec Division of Racal Instruments, with plus features of greatly improved service thinking and good solid Racal back-up.

It's going to be interesting.

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RACAL

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Take the back off any television set, radio, or stereo unit and ten to one, amid the mass of parts, you will find one of the hundreds of components made by Ariel. It makes you wonder why so many manufacturers specify our components above all others! The answer is simple. We have the very latest equipment in our five Nottingham factories giving extensive toolroom, high speed progression, pressing, injection and compression moulding, coil and transformer winding and vacuum impregnation facilites. But our progressive outlook does not end there; when we can't buy the correct plant or equipment we design and make it ourselves! If you would like any further information about our products write to Ariel Pressings Limited, Wollaton Road, Beeston, Nottingham NG9 2PB or phone Nottingham 256141 and we will send you our new catalogue.

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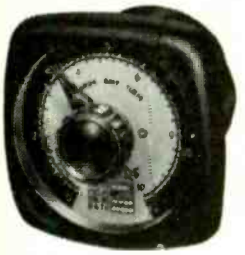
WW—038 FOR FURTHER DETAILS

TIMERS MICRO SWITCHES

IMMEDIATE DESPATCH

SYS MINI-TIMER



★ SYNCHRONOUS MOTOR & CLUTCH
★ 10 MILLION OPERATIONS
★ Instantaneous & Timed out 3 AMP contacts.
★ Repeat Accuracy ± ½%.
Dial ranges 0-10 secs up to 0-28 hrs. May also be used as impulse start and automatic reset.

£11.0.0 approx. dependent on quantity.

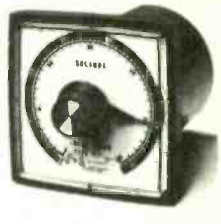
Solid State Process Timer type TDS

LATEST CIRCUIT PROVIDES PROLONGED ACCURACY

- 1% REPEAT ACCURACY
- OCTAL BASE PLUG-IN
- CIRCUIT CONTAINS BUILT-IN VOLTAGE STABILISER
- CONTACTS: Timed out 5 amp C/O

Instantaneous 0.15 amp normally open. 30 sec and 60 sec Linear dials. 240 VAC operated. Approximately £10 dependent on quantity.

NEW! ADVANCE INFORMATION LATEST NSY SYNCHRONOUS MOTOR TIMER WITH CLUTCH



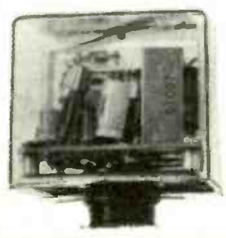
★ 2 sets 5 amp changeover output contacts
★ 10 million operations
★ Repeat accuracy ± ½%.
★ Set time can be altered whilst in operation
Dial ranges from seconds to hours
Approx. 165/- each dependent on quantity

STP Sub-Mini Process Timer SYNCHRONOUS MOTOR & CLUTCH

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

approx. **£5.0.0** each.

FLOATLESS LIQUID LEVEL CONTROL



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

The most compact unit available, measures only 2¼" × 2¼" × 3".

Approx. **£4.0.0.** dependent on quantity.

SINGLE AND TREBLE STAINLESS ELECTRODES AVAILABLE.

VV—15—1A 10 AMP C/O MICRO-SWITCH

★ 15/10 AMPS. c/o
★ 100,000 ops.

2/- each per 1,000
Single Throw 1/6 each

PROXIMITY SWITCH YL2 GPA

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

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

SLB CAPACITY PROXIMITY SWITCH

Senses any object:
PACKETS CARTONS BOXES BOTTLES CANS
empty or full, ferrous and non-ferrous materials.

STAINLESS PROBE
remote from 240v AC Power Pack which incorporates own 5 amp relay, and level control of
GRANULES POWDERS LIQUIDS

Suitable for
CONVEYOR SYSTEMS
PACKING MACHINERY
PRESS GUARDS

Approximately £20.0.0 complete dependent on quantity.

S5G

★ 1 MILLION OPS.
5 amp. c/o Sub-miniature Micro-switch.
2/6 each per 1,000

VAQ

★ 10 amp. c/o PUSH BUTTON
Panel mounting. Buttons in six colours.
4/4 each per 1,000.

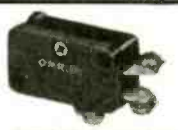
S5 GL2

Fitted Integral Roller Lever
★ 1 million ops
5 amp c/o Sub-miniature micro-switch.
5/- each per 1,000.

LIMIT SWITCH WL 10 FCA2

★ 10 amp 2 circuit
★ Roller lever actuator as illustrated.
Approx. 65/- each dependent on quantity. 5 other standard types available.

V-10-1B



★ 1 MILLION OPERATIONS.
★ 10 amp. c/o.
★ COMPARE OUR SPEC. & OUR PRICES WITH OTHER SIMILAR TYPES.
Screw Terms. **3/1** each per 1,000

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

CCR—5

New! Approx. 4/- each per 1000
Light force wire operated Micro-switch. Designed for even more economical coin operation mechanism.

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

100,000 PRODUCTS IN STOCK!
WHY WAIT?

OMRON PRECISION CONTROLS

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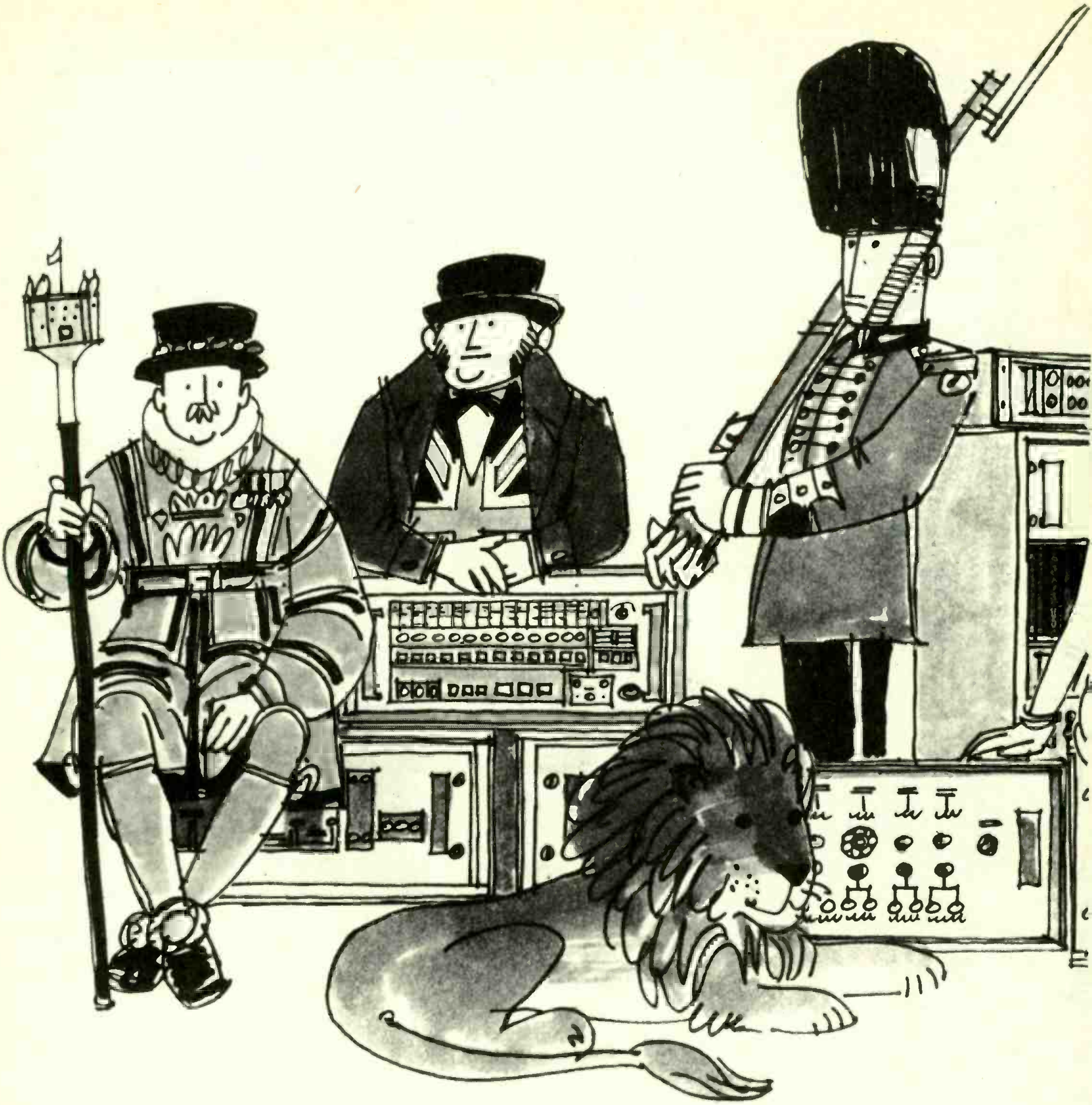
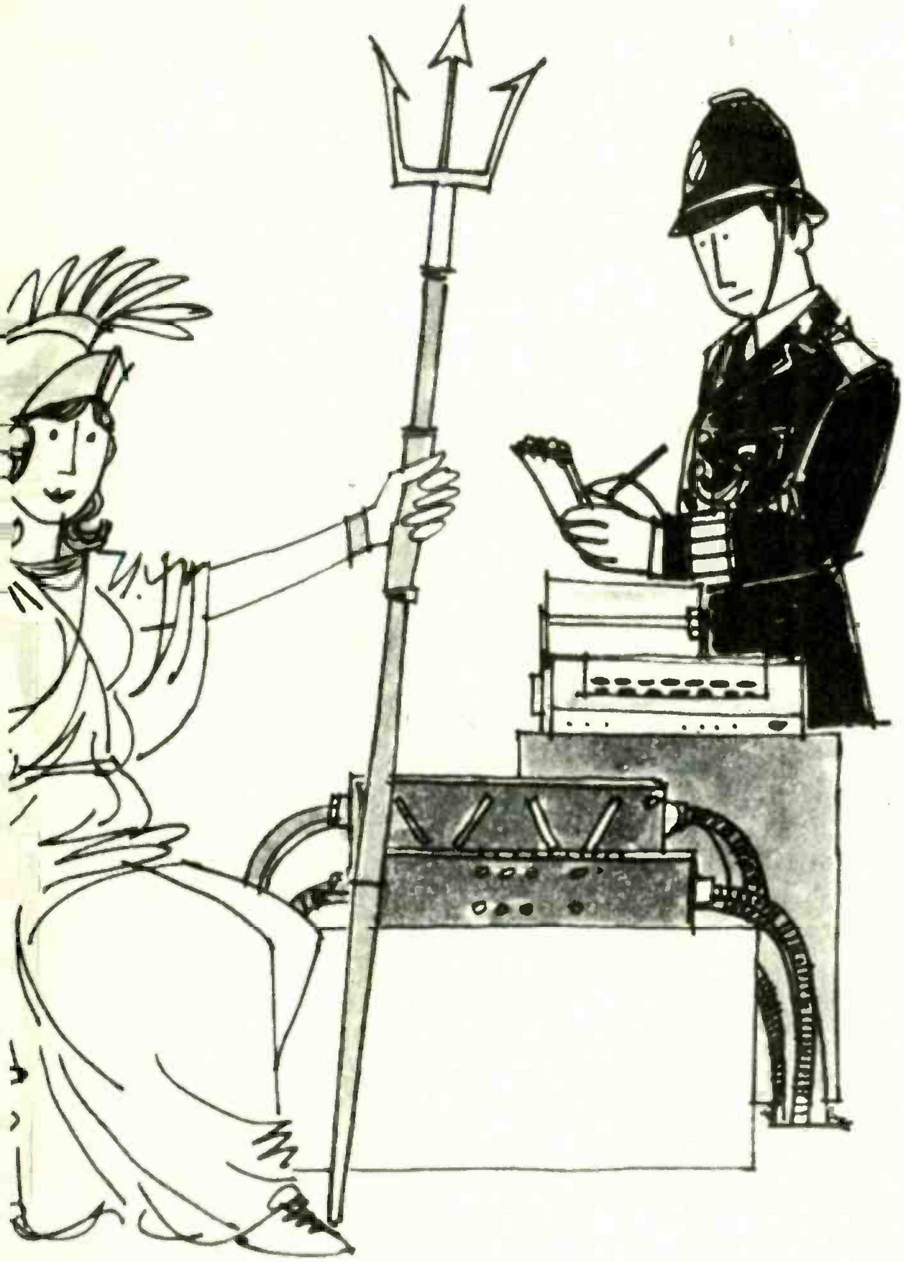


...so why not say so?

WW—040 FOR FURTHER DETAILS



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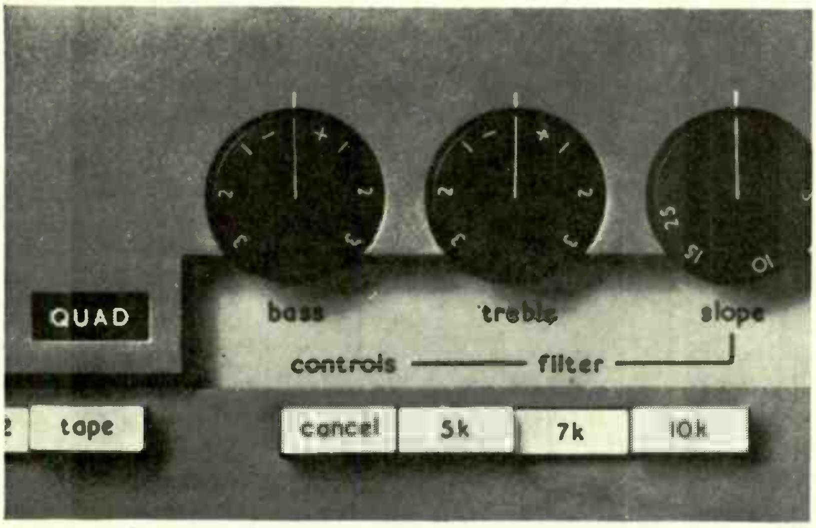

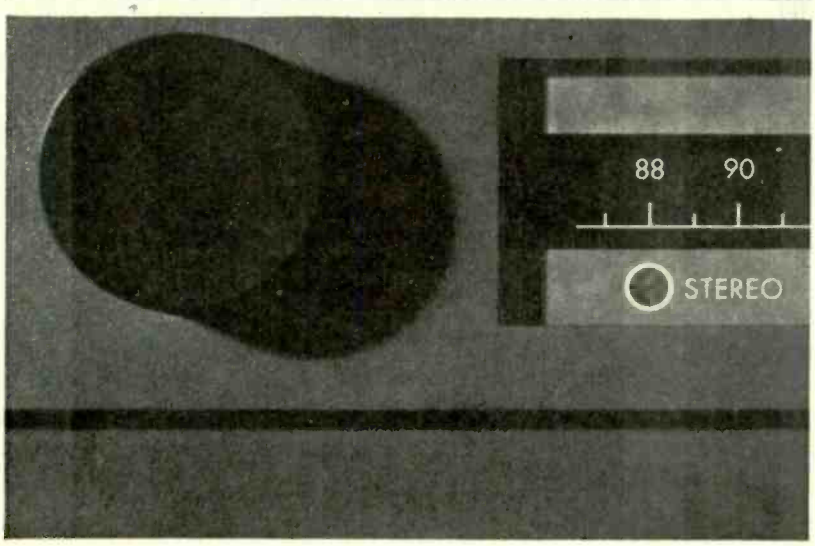

CoID
design award
1969

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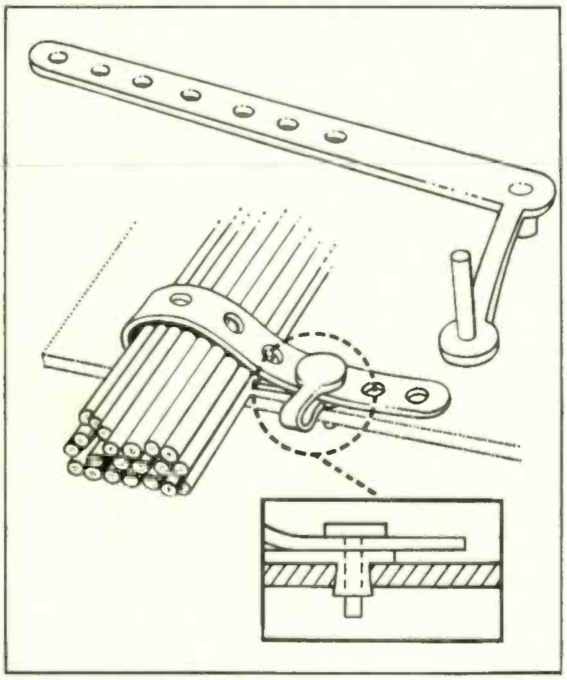
INSULOID RIVET CLIP



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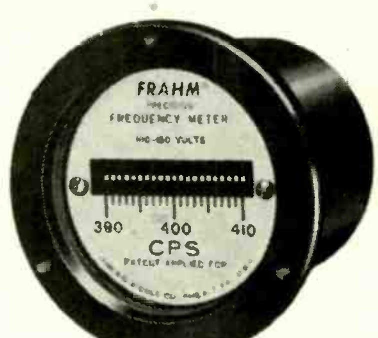

are widely used as standards in many industries because:—

1) They are accurate (to ±0.3% or ±0.1% as specified)
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5) They need only low input power
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Type
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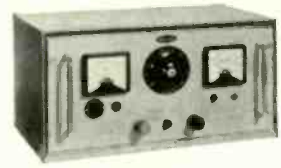

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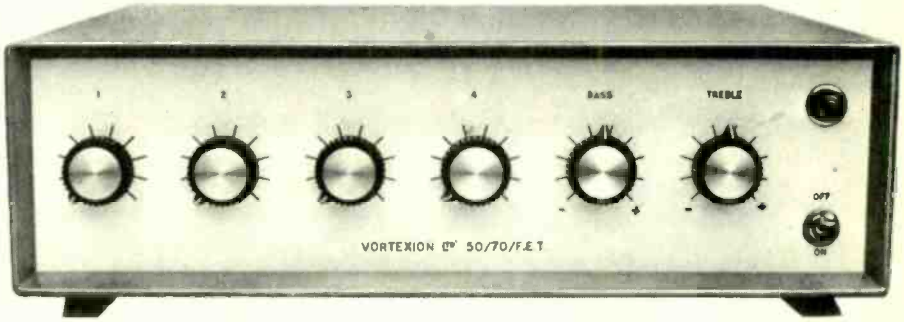
This is a high fidelity amplifier (.3% intermodulation distortion) using the circuit of our 100% reliable—100 Watt Amplifier (no failures to date) with its elaborate protection against short and overload, etc. To this is allied our latest development of F.E.T. Mixer amplifier, again fully protected against overload and completely free from radio breakthrough. The mixer is arranged for 3-30/60Ω balanced line microphones, and a high impedance line or gram. input followed by bass and treble controls. Since the unit is completely free from the input rectification distortion of ordinary transistors, this unit gives that clean high quality that has tended to be lost with most solid state amplifiers.

THE VORTEXION 50/70 WATT ALL SILICON AMPLIFIER WITH BUILT-IN 4 WAY MIXER USING F.E.T.s.



Size 14" × 11½" x 4½" Weight 20lb.
100μV on 30/60 ohm mic. input.
100mV to 100 volts on gram/auxiliary input 100K Ω.

ELECTRONIC MIXERS. Various types of mixers available. 3-channel with accuracy within 1db Peak Programme Meter. 4-6-8-10 and 12-way mixers. Twin 2,3,4 and 5 channel stereo. Tropicalised controls. Built-in screened supplies. Balanced line mic. input. Outputs: 0.5v at 20K or alternative 1mW at 600 ohms, balanced, unbalanced or floating.

200 WATT AMPLIFIER. Can deliver its full audio power at any frequency in the range of 30 c/s-20Kc/s ± 1db. 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 1 mW 600 ohms. Output 100-120v or 200-240v. Additional matching transformers for other impedances are available.

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 ± 1db. 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.

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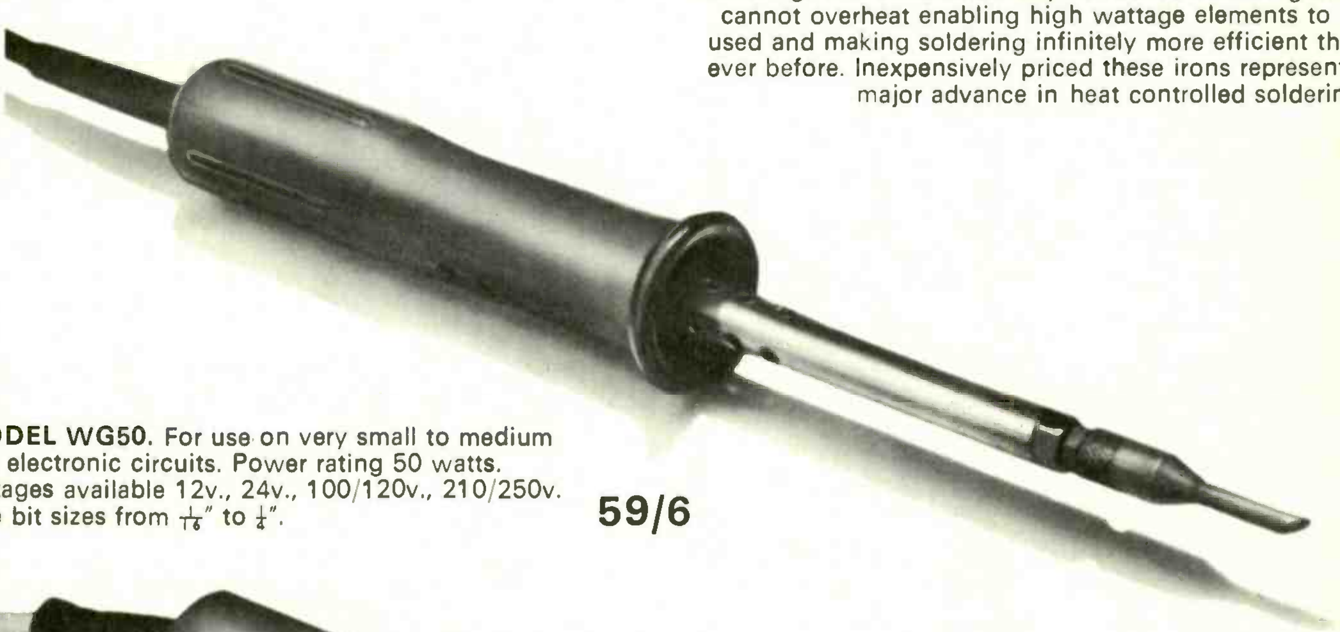
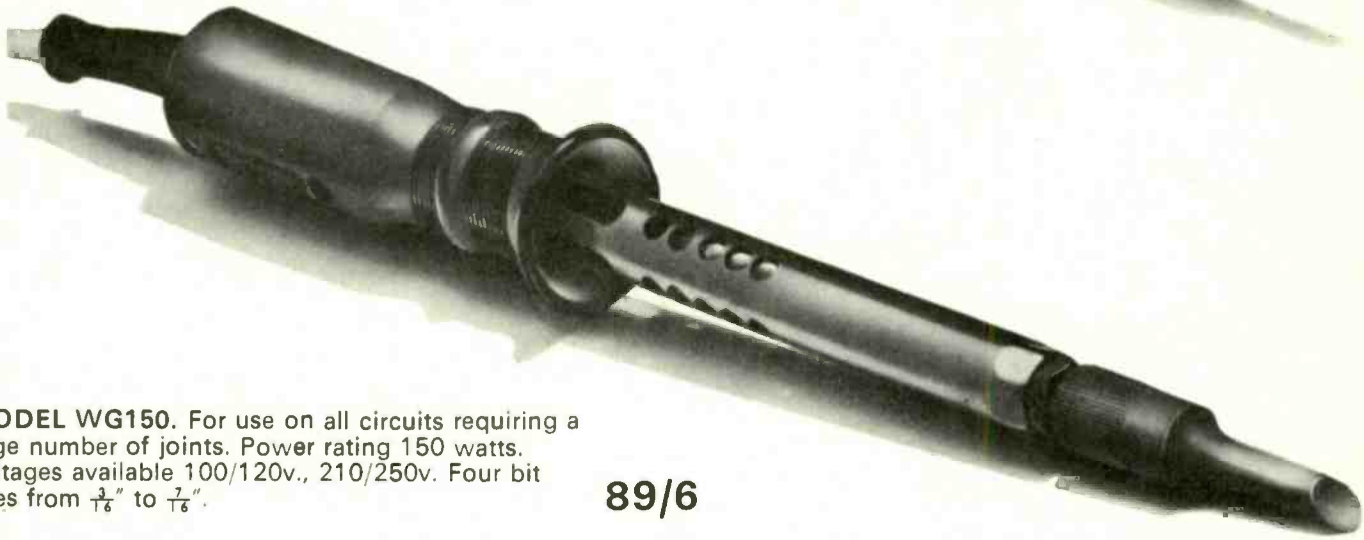


MODEL WG50. For use on very small to medium size electronic circuits. Power rating 50 watts. Voltages available 12v., 24v., 100/120v., 210/250v. Five bit sizes from $\frac{1}{16}$" to $\frac{1}{4}$".

59/6



MODEL WG150. For use on all circuits requiring a large number of joints. Power rating 150 watts. Voltages available 100/120v., 210/250v. Four bit sizes from $\frac{3}{16}$" to $\frac{7}{16}$".

89/6

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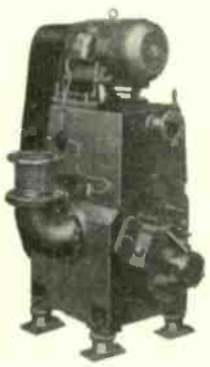

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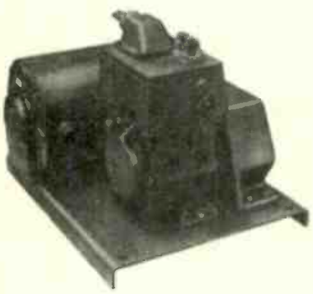

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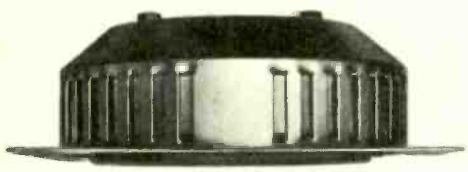

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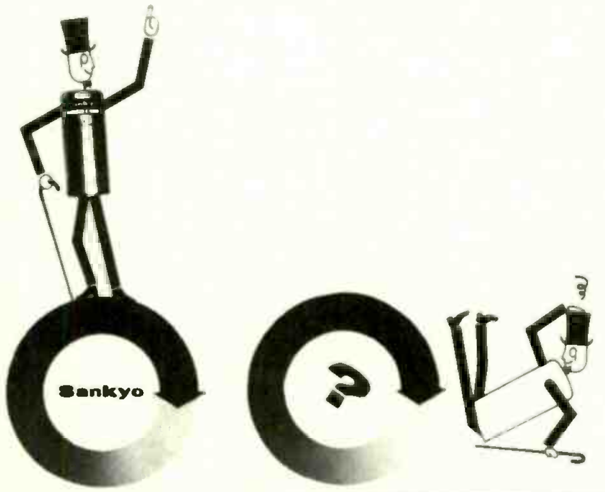

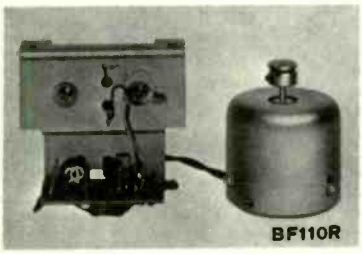

SY173L	Single speed (2000 rpm). For record players.
DMF54R-02	Single speed (2400 rpm). For tape racorders.
RK201R	Single speed (2400 rpm). For car players.
BF110R	Single speed (2000 rpm). With electrical governor motor. For tape recorders.
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Specification for Sankyo micro motors

TYPE	Dimensions ϕ (m/m)	Dimensions Length (m/m)	Rated Voltage (V)	Range of Voltage (V)	Rated Torque (gr-cm)	Rated Speed (rpm)	Load Current (mA)	Starting Torque (gr-cm)	Life (Hr)	Direction of Revolution
SY173L	40	32.4	6	4.5 ~ 6	3	2000	80	35	600	Left
DMF54R-02	38	34.8	6	4.5 ~ 6	9	2400	140	30	600	Right
RK201R	47.9	48	13.2	10 ~ 16	30	2400	210	100	1000	Right
BF110R	38	30	4.5	3.5 ~ 5.7	8	2000	160	30	1500	Right
BF200R	38	34.1	13.2	(5.5 ~) 9 ~ 16	15	2200	180	30	1500	Right
ZF200	46	50	9	6 ~ 9	20	2200	300	45	3000	Left, Right
UP550R	20	44.5	4.5	4 ~ 6 4.5 ~ 6	14	3700 5000	160	60	30	Right
VM250B	25	36.5	7	6.5 ~ 7.5	0.4	3600	45	25	500	Left, Right

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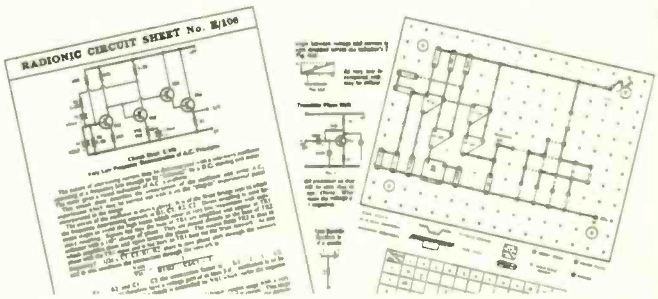

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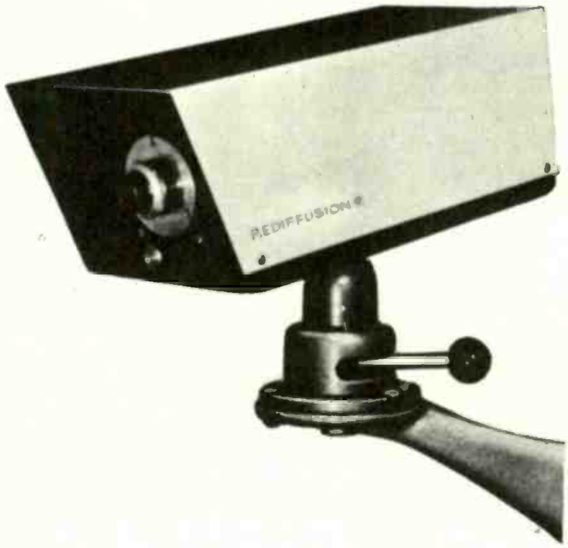

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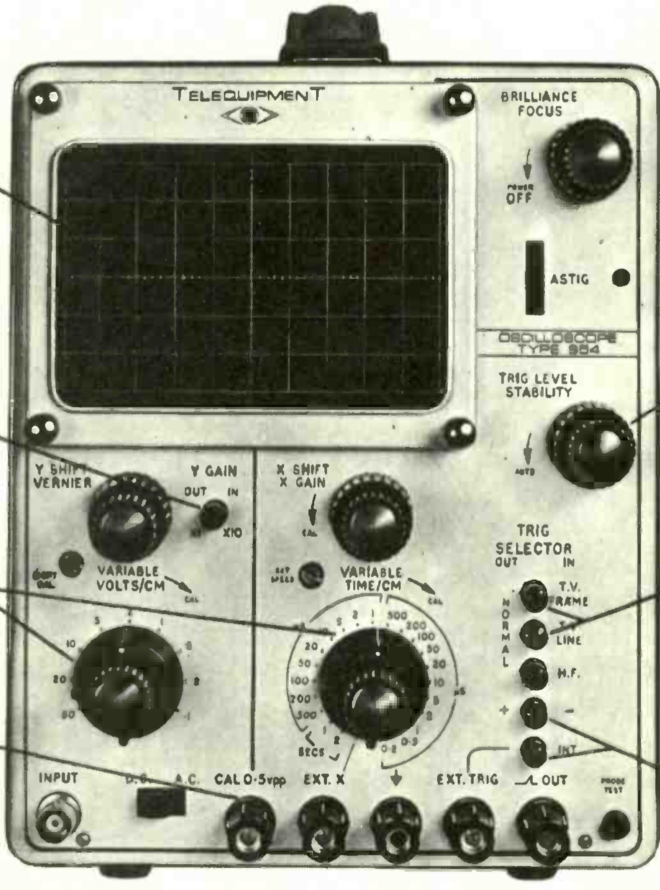

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Wireless World

Electronics, Television, Radio, Audio

Fifty-ninth year of publication **July 1969** **Volume 75 Number 1405**

This month's cover features the front panel of the amateur communications receiver to be described by D. R. Bowman in a series of articles beginning in this issue.

Contents

I.P.C. Electrical-Electronic Press Ltd
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Wireless World

Broadcasting and the v.h.f. band

"The long-term future for radio in the U.K. lies principally with v.h.f." said Mr. Curran, director general of the B.B.C., when addressing members of the Radio Industries Cub in London in May. He went on to say "It is, I suppose, a visionary thought to suggest that the industry might agree that from a given date all sets manufactured in this country should include a v.h.f. element", and reminded his audience that in the U.S.A. it needed legislation to ensure that all television receivers covered the u.h.f. band.

Mr. Curran recalled that by 1960 the B.B.C. had invested about £4M in v.h.f. radio networks and added "so far we are getting only a very partial return on that capital, because consumers are not equipped to receive the transmissions. It does not seem to make good economic or technical sense." We could not agree more.

The 1968 annual report of the British Radio Equipment Manufacturers' Association records that "growing public interest in v.h.f. broadcasts has encouraged manufacturers to equip 34% of their radio receivers [produced in 1968] with v.h.f. facilities". It is certainly significant that this is the highest output of v.h.f. receivers since 1958. During the five years to 1963 the output decreased to about 6000 (5% of the total), but there has been a gradual increase since and last year's output was about 119,000. Undoubtedly the introduction under the aegis of the B.B.C. of the series of v.h.f. local radio stations in eight cities has helped to stimulate this interest. The B.B.C. certainly wants "to be in the business of local broadcasting" and Mr. Curran said "we believe that for a full service, day and night, the only complete and long-term solution is that which depends on v.h.f."

One aspect of v.h.f. broadcasting which many feel has not been fully exploited by the B.B.C. is stereo. Had the choice of stereo programmes been wider instead of being limited mainly to classical music there might have been a much greater demand for v.h.f. equipment. The B.B.C. would, apparently, like to expand the service but there are "serious financial difficulties . . . because of the additional cost of links between transmitters" but they are "investigating ways of easing this difficulty" whatever this may mean.

The growing interference on medium-waves will doubtless continue until we have a reallocation of frequencies in Europe but it is generally admitted by those who are in a position to know that, as a country, we cannot expect to be any better off as a result of this. In fact, we may be worse off in that we may have fewer frequencies for our use. This would make the use of the v.h.f. band still more necessary. Even so Band II is not without its own problems. Private Mobile Radio base stations have been allowed by the G.P.O. to operate between 87.5 and 88MHz although this is part of the internationally allocated band for broadcasting. Due to the high field strength put down by these transmitters in their immediate vicinity the B.R.E.M.A. Report records that instances of cross-modulation or direct break-through have occurred.

One disquieting aspect of the use of v.h.f. for the national broadcasting service is that if it became the norm to produce v.h.f.-only receivers then one's listening would be limited to this country. It is to be hoped therefore that at the next European Broadcasting Conference for the allocation of frequencies in the medium- and long-wave bands each country will be allocated one or two frequencies which would be used primarily for external broadcasting. If these frequencies could be kept reasonably free from interference then those whose listening tastes extend beyond the shores of the U.K. will have the opportunity of satisfying their appetites.

Amateur Communications Receiver

Advanced design covering the 80, 40, 20, 15 and 10 metre bands
1: Design considerations

by D. R. Bowman, A.M.Inst. E., G3LUB

For many years the author's amateur radio station has included a complex home-built dual conversion valve receiver. Throughout this time a number of solid-state receivers have been constructed, though it must be admitted that none has approached the overall performance of the valve unit. The recent appearance of a number of new semiconductor devices coupled with the ever widening range of i.f. filters has prompted the author to re-appraise selected frequency band communication receiver design. A number of fundamental design requirements have been generally agreed for many years, but, in the final analysis, every receiver design is a compromise.

One of the biggest troubles is cross-modulation which can be experienced using almost all types of receiver. All one needs to do is to tune to say 7 MHz at night, listen, and then insert a 20 dB attenuator in series with the receiving aerial. The effect is most enlightening as low-power signals re-appear from under the high-power broadcast stations.

To reduce cross-modulation to the lowest level possible the selectivity must be as near to the front of the receiver as possible so as to reject the unwanted powerful signals before they can be amplified and cross-modulated in the mixer and to a lesser extent in the r.f. stages. Until recently first-rate i.f. selectivity has been unattainable above about 1 MHz and commercial filters were almost exclusively limited to frequencies in the region of 400 to 500 kHz. This limitation has forced designers either to accept poor image rejection or poor noise figures. Image rejection is a function of the r.f. circuit Q and the number of r.f. coils.

It will be shown that obtaining very high front-end selectivity and a good noise figure are conflicting requirements. It was this problem that led designers to introduce the dual conversion concept (Fig. 1). This system consists basically of a single conversion tunable receiver using a frequency band chosen to produce good image rejection, which in turn is fed from a range of h.f. converters each translating the required receiver band to the frequency of the tunable receiver. This use of a tunable i.f. also has the advantage of allowing the same basic tuning rate and dial calibration to be used on all received frequencies. The stability problems of tunable oscillators is also reduced as only one v.f.o. is required and it operates on a relatively low frequency, usually about 5 MHz. The first oscillator is invariably crystal controlled.

There are some problems in this type of system. The already mentioned need for selectivity at the front-end is not met, but by restricting the pre-i.f. gain to the minimum consistent with good noise performance and the use of low noise mixer circuits, this problem can be minimized. A good a.g.c. (automatic gain control) system controlling the r.f. gain is also essential. The other main problem, namely internally generated spurious frequencies, can be more or less overcome by the careful choice of conversion frequencies coupled with good physical screening. This said, it must be admitted that the dual conversion system is rather complex.

Recently a number of high-frequency crystal filters have become available. Although they are expensive, when it is realized that the KVG XF9B 9 MHz filter (specified in the design) consists of a double lattice using eight crystals in addition to the two carrier crystals, the author considers that it is very good value for money. The ability to achieve good selectivity (see Fig. 2) at a high intermediate frequency lends itself to the use of a single conversion system (Fig. 3). The extremely narrow bandwidth of the 9 MHz filter led to the decision to design essentially for the single sideband reception for which the filter was intended. The performance of the completed receiver on c.w. is also very good and a.m. transmissions can be resolved using the exalted carrier

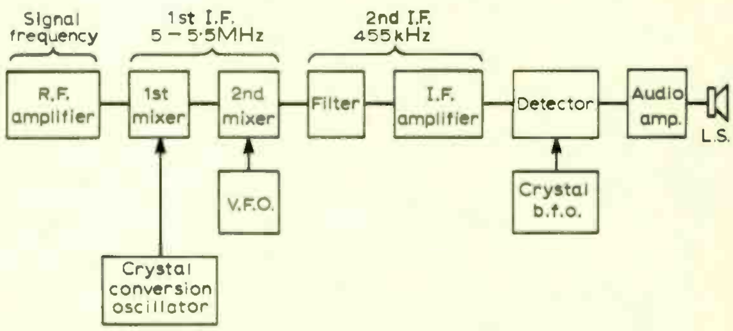


Fig. 1. The block diagram of a typical dual conversion receiver.

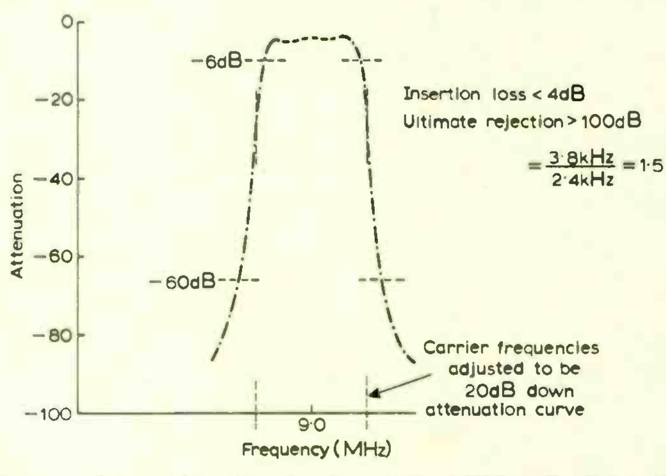


Fig. 2. Attenuation curve for the 9 MHz KVG XF-9B i.f. filter.

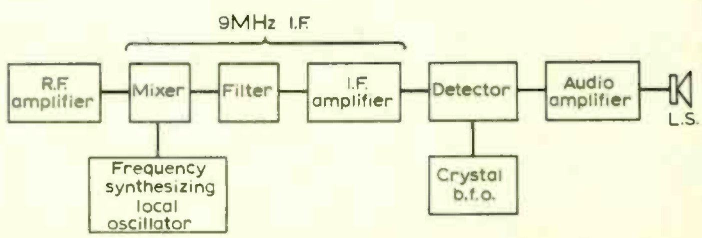


Fig. 3. The block diagram of a single conversion receiver.

method, i.e. the reception of only one sideband by zero beating the a.m. signal's carrier.

The choice of a high i.f. means that the image response to the required signal ratio is very high; remembering that the image is displaced by twice the i.f. in frequency from the required signal; in this case 18 MHz.

Although a number of first quality receivers have been designed using no r.f. amplifier preceding the mixer the author decided to include an a.g.c. controlled amplifier. The 40-dB attenuation of signals that can be achieved ahead of the mixer does reduce the quantity of blocking and cross-modulation produced in the mixer stage of the receiver. The use of an r.f. amplifier also allows adequate pre-mixer selectivity to be used.

So far the proposed system appears too good to be true, however there is a disadvantage. To tune the high-frequency amateur bands, say 10 metres, the local oscillator would have to tune either:

$$(28 \text{ to } 28{\cdot}5) + 9 \text{ MHz} = 37 \text{ to } 37{\cdot}5 \text{ MHz}$$

or

$$(28 \text{ to } 28{\cdot}5) - 9 \text{ MHz} = 19 \text{ to } 19{\cdot}5 \text{ MHz}.$$

Either band is rather high in frequency for good stability using a free running oscillator and especially when it is realised that various switched ranges are required. It would be impossible to adjust the various tuning ranges so that the dual conversion systems advantage of a constant tuning rate and dial calibration on all ranges is achieved.

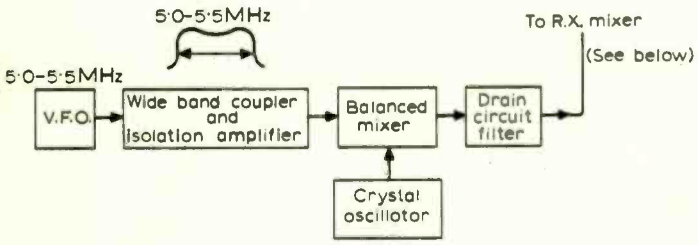
Various ideas were considered, the most promising being the heterodyne v.f.o. dating back to soon after the last war. It consists of a single range low-frequency v.f.o. fed to a mixer together with the output of an h.f. crystal oscillator; the output of the mixer circuit being tuned to the appropriate product (Figs. 4 and 5). This system was originally introduced as a means of avoiding the use of frequency multiplication with its associated output of unwanted frequencies. For receiver local oscillator use it is essential that the various frequencies are chosen carefully and that the unwanted components present in the output of the mixer circuit are not passed on to the main receiver mixer.

To avoid spurious signals within the bands the best v.f.o, frequency range is found to be 7·6 to 8·1 MHz, but this does mean that each amateur band covered requires a separate crystal (table I). If an odd one or two spurious whistles can be tolerated then, with a v.f,o. range of 5 to 5·5 MHz, two of the bands can be covered using no h.f. crystal oscillator.

Table I

range		local osc.	h.f.osc. crystal
metres	MHz	MHz	MHz
80	3·5– 4·0	5·5– 5·0*†	none
40	7·0– 7·5	16·0–16·5	11
20	14·0–14·5	5·0–5·5†	none
15	21·0–21·5	30·0–30·5	25·0
10	28·0–28·5	37·0–37·5	32·0 (3rd overtone)
	28·5–29·0	37·5–38·0	32·5 (3rd overtone)
	29·0–29·5	38·0–38·5	33·0 (3rd overtone)

* tuning direction reversed † sideband selection reversed



Synthesizer output Range:–		Crystal output Range:–	
1	5·0–5·5MHz	1	None
2	16·0–16·5MHz	2	11MHz
3	5·0–5·5MHz	3	None
4	30·0–30·5MHz	4	25MHz
5	37·0–37·5MHz	5	32MHz
6	37·5–38·0MHz	6	32·5MHz
7	38·0–38·5MHz	7	33MHz

Fig. 4. The local oscillator synthesizer.

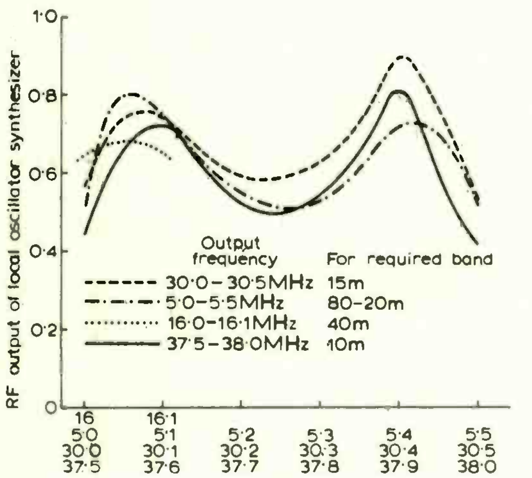


Fig. 5. Output voltage for the oscillator of Fig. 4.

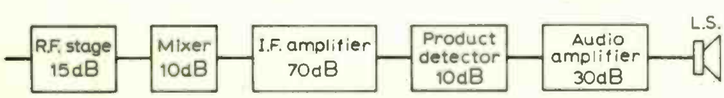


Fig. 6. Gain distribution throughout the receiver.

required band		v.f.o.		i.f.
(3·5 to 4 MHz)	+	(5 to 5·5 MHz)	=	9 MHz
(14 to 14·5 MHz)	–	(5 to 5·5 MHz)	=	9 MHz

One more slight disadvantage is that the receiver tuning direction will be reversed on one of the ranges. However, on 20 and 80 metres the receiver's performance is likely to surpass even the most advanced commercial unit.

It will be noted that one harmonic of the v.f.o. falls within the 15-metre band. The amplitude of this spurious signal can be reduced to a very low level by careful v.f.o. circuit design in conjunction with extra filtering and good mixer design. This method of local oscillator frequency generation does lend itself to a constant tuning rate and dial calibration on all ranges.

The next basic decision that a receiver designer has to make is the gain distribution throughout the receiver (Fig. 6). At first sight it would seem that the best receiver would embrace the maximum signal gain.

The random motion of free electrons in wires and resistors generates small currents, even though the average over a finite time of these currents is zero. At any one time this contributes a small noise current to the circuit. From these small currents are derived voltages which are named " white noise " because they spread more or less evenly throughout the frequency spectrum.

$e = 4\,K.T.B.R.$ Volts

$K =$ Boltzmann's constant
$1{\cdot}3 \times 10^{-23}$ Joule per °K (absolute)

$T =$ temperature of conductor in degrees Kelvin

$B =$ bandwidth of the complete system in hertz.

$R =$ resistance of conductor in ohms.

For 25°C:

aerial noise voltage $e = 1{\cdot}55 \times 10^{-20} \times BR$ volts

system bandwidth of 2×10^3 Hz

aerial resonant impedance 75Ω:

$$e = 1{\cdot}55 \times 10^{-20} \times 2 \times 10^3 \times 75 = 0{\cdot}023\ \mu V$$

As far as external noise is concerned it is generally accepted that over the frequency range 1 to 14 MHz the minimum external noise level will be at least 30 dB above the ideal figure quoted above (Fig. 7). Even from 14 to 30 MHz the level can be expected to be only about 10 dB better. This external noise is made up from various sources. Electrical storms in widely separated parts of the world contribute noise in addition to cosmic sources originating from the milky way. It is generally accepted that a signal must exceed the noise level by at least 10 dB to be readable.

This sets the minimum noise level at 30 dB above 0·023 μV or 0·7 μV, over the range 1 to 14 MHz, and 20 dB above 0·023 μV, or 0·23 μV above 14 MHz.

For a 10 dB signal ratio the minimum detectable signal levels will therefore be 2·1 μV from 1 to 14 MHz and 1 μV above 14 MHz.

Although these noise figures vary considerably from area to area they can be taken as a starting point.

In a well designed unit the vast majority of the receiver noise originates from the first r.f. stage; the succeeding mixer contributing only about 1 dB. To reduce cross-modulation to a low-level it is essential to reduce the amplitude of strong off-channel signals before they reach the mixer. To do this it would seem that a number of high-Q tuned circuits ahead of the r.f. stage could be used. It can be shown that in fact excessive pre-r.f. stage selectivity considerably worsens the overall noise figure. In general it can be said that the lowest noise figure coincides with minimum signal loss between aerial and the first r.f. amplifier device. Maximum power transfer occurs when the signal source is matched to the load. As noise performance is most important on the higher frequency ranges, 10 metres has been taken as the starting point.

Assuming stray capacitances to be of the order of 10 pF then the minimum value of C is taken as 15 pF which at 30 MHz resonates with 2 μH.

Assuming an unloaded Q of 100 then: $Q = (\omega L)/R$

therefore: $R = (\omega L)/Q$

$$= (2\pi \times 30 \times 10^6 \times 2 \times 10^{-6})/100 = 3{\cdot}8\ \Omega$$

the dynamic resistance of the parallel tuned circuit R_D is:

$$R_D = L/(CR) = (2 \times 10^{-6})/(15 \times 10^{-12} \times 3{\cdot}8) = 35{\cdot}1\ \text{k}\Omega$$

If maximum power transfer from the aerial to the tuned circuit occurs then the value of R_s is transformed up to Z_D and the effective resistance in parallel with the tuned circuit becomes

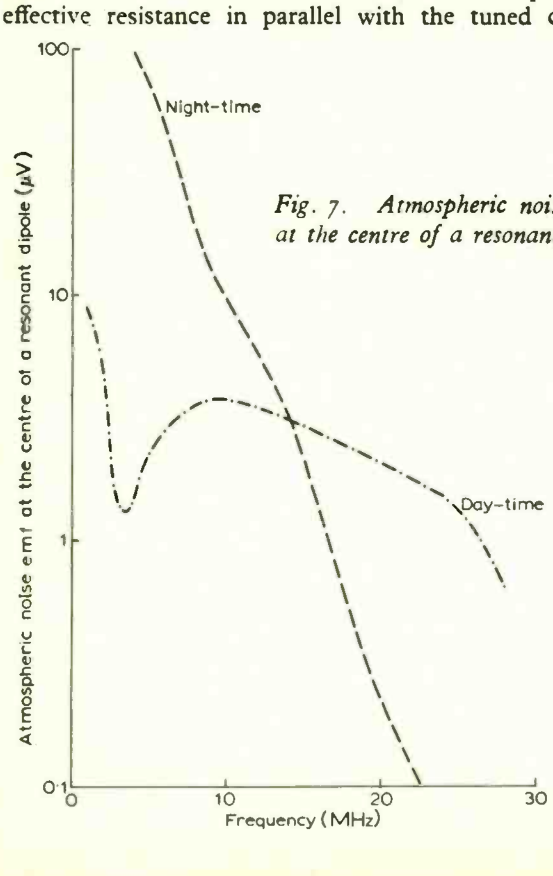


Fig. 7. Atmospheric noise. The e.m.f. at the centre of a resonant dipole.

$R_D/2 = 17$ kΩ. The tuned circuit must of course also match the input impedance of the amplifying device. The device chosen has an input impedance that varies with frequency. At 3 MHz it is very high dropping to as low as 20 kΩ at 30 MHz. It will be noted throughout this analysis that the reactive part of the devices input and output impedance is ignored. This can be justified as the reactive portion becomes part of a tuned circuit.

The total parallel resistance:

$$(17\text{ k} \times 20\text{ k})/(17\text{ k} + 20\text{ k}) = 9{\cdot}2\text{ k}$$

Therefore the circuit loaded Q is:

$$Q = R_p/(\omega L_p) = (9{\cdot}2 \times 10^3)/(2\pi \times 30 \times 10^6 \times 2 \times 10^{-6}) = 24$$

Therefore it is shown that minimum noise figure does not occur with maximum selectivity in the r.f. stage. A compromise has to be made between noise figure and selectivity. This does not mean that overall system selectivity has to suffer as this is determined by the i.f. filter. The best compromise is to trade excess r.f. gain for increased selectivity by reducing the loading on the r.f. to mixer coupling circuit. This has the extra advantage of increasing the r.f. amplifier's stability factor. Care must be taken not to reduce the gain too much. The author decided to aim for a noise figure of 12 dB on the l.f. bands and better than 8 dB on 10 metres.

R.F. amplifier

The requirements for the r.f. amplifier were as follows:

(1) Very good immunity to cross-modulation and blocking over the a.g.c. range.
(2) Low noise figure.
(3) A low reverse transfer admittance to avoid the necessity for circuit neutralization in association with high input-to-output isolation reducing resonant circuit interaction.
(4) An a.g.c. voltage range compatible with the i.f. amplifier requirements.

Cross-modulation distortion occurs when a device has a particular transfer characteristic and is fed with two differing frequency signals. As long as the transfer characteristic is linear or follows a square law then the gain applied to signal two is independent of the second signal's amplitude. If the transfer characteristic deviates from a linear or a square law the gain on signal one will be modulated by the amplitude of signal two.

An investigation into various semiconductor devices shows that only the field effect transistor has a transfer characteristic of approximately square law. Bipolar devices are particularly poor in this respect. During some earlier work the author found that even f.e.t. cross-modulation performance is determined in part by the choice of drain current operating point. Very poor performance is likely if reverse a.g.c. is applied to a single gate device. This disadvantage can be overcome by using two f.e.ts in a cascode circuit applying a.g.c. to the common base stage (Fig. 8).

R.C.A. have recently marketed an integral cascode device which has the advantage of a somewhat lower h.t. requirement than separate devices, as well as a very low reverse transfer admittance value.

These devices are marketed under an assortment of code numbers and vary in price from about 7s to 14s. The author tested the following types and at up to 30 MHz could find very little difference between them:—3N140, 3N141, TA7149 and 40500. (Since writing the MEM 564C has become available and is to be recommended since gate protection is incorporated).

The mixer and i.f. amplifier

If two signals differing in frequency are fed to a device with a square law characteristic, it is found that intermodulation will occur, i.e. addition and subtraction of the two input frequencies to produce other frequencies. Any deviation from square law will introduce cross-modulation and therefore the dual gate f.e.t. is as equally applicable to mixers as amplifiers. It has the added advantage that the two signals can be fed to separate gate electrodes to provide considerable isolation between the local oscillator and the signal voltages. The characteristics of this mixer are such that the overload performance is improved with a limited reduction in oscillator drive voltage. The mixer gain is of course also reduced and spurious signal generation suffers a very much greater reduction. The optimum value of oscillator injection for the authors' application was 0·3 V. Lower voltages than this impaired the noise performance and, above 0·5 V, the unwanted harmonic generation becomes excessive (Fig. 9).

One of the many advantages of using the 3N140, which is really intended for v.h.f. use, is the constant value of the output impedance over a range of 1 to 30 MHz.

The i.f. amplifier was designed with the following factors in mind:

(1) Maximum gain of 70 dB centred on 9 MHz.
(2) At least 80 dB of automatic gain control.
(3) Wide bandwidth, say 300 kHz, as one method of avoiding frequency shift with a.g.c. action. Note the selectivity is determined by an 8-pole, 9 MHz, crystal filter.
(4) A.G.C. voltage sense and range compatible with the amplifier.

Many circuit configurations were considered for use in the i.f. amplifier. The use of common emitter transformer coupled stages was avoided due to the high value of reverse admittance, making either circuit neutralization or low gain per-stage essential to ensure an adequate stability factor. The cascode arrangement of bipolar devices was investigated. It was decided that there was little advantage in using field effect transistors in the i.f. amplifier as the cross-modulation problem is minimal after the very narrow bandwidth filter. The cascode arrangement was found to exhibit high-gain with a very low reverse admittance. The circuit also lends itself to a.g.c. control rather in the same manner as the r.f. amplifier. The control voltage is applied to the common base connected stage. This in turn means that the r.f. and i.f. controlled sections can easily be coupled together. It was found that the cascode arrangement induced very much less de-tuning of the i.f. transformers and by using low Q single tuned circuits very little change in the overall i.f. response occurs with a.g.c. action.

Although two high-gain sections could be designed to provide the required gain, the author's previous experience suggested that to be sure of maintaining stability three stages incorporating a total of six transistors be used. The gain required is spread between the three stages. The possibility of using a capacitative potential divider across the i.f. coils to provide the consecutive base drive was investigated. It was found that the very long earth paths made a stable reproduceable design very difficult. The amplifier was very much easier to handle using low impedance coupling coils on the i.f. transformers.

During tests of the i.f. amplifier the a.g.c. gave the following performance: With a change of input signal of −50 dB below 200 mV the output dropped by −3 dB; and a change of input signal of −80 dB produced a drop of −10 dB at the output. The amplifier had a gain of 90 dB, and showed tendencies towards instability only when this figure was exceeded.

The stage from which the a.g.c. is derived is a single transistor biased so that, with no signal, it is very nearly switched off. As the signal increases so the average collector current also increases and the collector voltage change is approximately proportional to the output of the i.f. amplifier.

For the reception of a single sideband transmission the normal fast attack, fast recovery, a.g.c. characteristic is useless. Because the transmission has no steady carrier wave the fast a.g.c. system tries to follow each syllable. One method of using a.g.c. with s.s.b. is to tailor the response to fast attack, slow delay. This has the effect of reducing the receiver's gain almost instantaneously, but delaying the release for the order of a second or so.

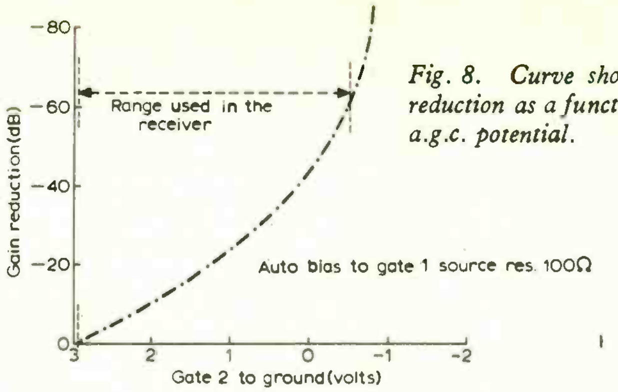


Fig. 8. Curve showing gain reduction as a function of gate a.g.c. potential.

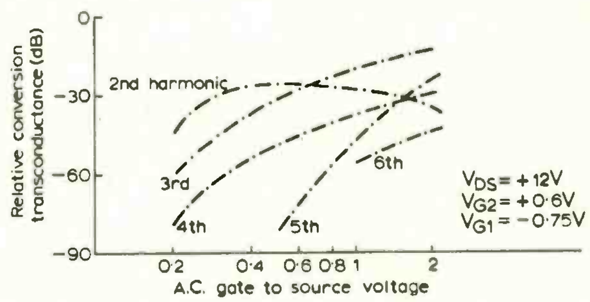


Fig. 9. Showing the relative conversion gain of several harmonics as a function of oscillator voltage (reproduced with the permission of R.C.A.).

The detector frequency oscillator

The product detect or can be considered as a mixer in which the input i.f. signal is mixed with a beat frequency oscillator to produce an output whose frequency spectrum falls in the audio range. This system of detection is used to demodulate amplitude modulated signals which are treated as if they were single sideband transmissions. In a noiseless system there is a 3 dB signal loss relative to s.s.b. but under crowded amateur band conditions it is found that the ability to select either sideband reduces the chance of a heterodyne blotting out the a.m. signal.

Remembering that the i.f. bandwidth is only 2·4 kHz wide, it was decided not to incorporate a conventional a.m. detector due to the rather restricted audio response of 0 to 1·2 kHz that would result.

A number of product detector circuits were investigated including one using an f.e.t. The author decided that the extra expense of an f.e.t. detector was not warranted. The circuit used is a balanced bipolar arrangement which requires a very low b.f.o. injection voltage of about 100 mV. This small oscillator voltage requirement helps the constructor to avoid stray b.f.o. signals getting into early stages of the i.f. amplifier. The use of a high i.f. amplifier does tend to increase this risk. The detector will operate at low distortion, with an i.f. signal no greater than 10 mV, and exhibits a gain of the order of 10 dB.

At an early stage in the design it was decided to use a crystal controlled b.f.o., whereas, when using an l.f. system the crystal frequencies have to be specified accurately, it was found that at 9 MHz the frequencies can be easily adjusted over a few kHz. This final adjustment is carried out by connecting a small trim capacitance in parallel or series with the individual crystals. If the frequency is too high then parallel C is required and if too low, series C is required. The final frequencies being set 20 dB down either side of the filter characteristic. It will be noted later that the crystal selection uses germanium diodes which allow the control switch to be positioned remote from the actual circuit.

This completes the description of the basic system and the points that have either been dealt with fleetingly or not at all will be covered in the practical description which starts next month. The receiver will show up well in comparison even with very expensive commercial units, but, it is complex and only constructors with considerable previous experience are advised to tackle its construction. The use of a valve voltmeter together with a signal generator would be very helpful, but not essential.

(to be continued)

Are We Wasting Brain-power?

A criticism of our system of "labelling"

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

I recently attended a lecture at the Royal Society of Arts concerned with scientific and technological education; the occasion served to crystalize certain uneasy feelings which I have had for some time about the training of "electronicists".

It was not so much the main themes of the discussion which jarred as a particular underlying assumption which every speaker seemed to make. The premise which offends me is roughly that any group of individuals trained or in training will always fall into two distinct and *well separated* parts, the able and successful being one, and the much less able and less successful the other.

Examples abound in life of the application of this seemingly ubiquitous principle; thus we had, and in the view of many people should still have, the "grammar school child" and the "secondary modern school child". We have the technologist and the technician, the graduate and the National Certificate man, the good honours and the pass graduate, the Ph.D. and the B.Sc.

Educationists will seemingly defend this principle to the death; thus we are told "undergraduates should be sorted out as soon as possible into potential honours graduates and potential pass graduates". It seems that the principle applies however refined the group, thus again it is a favourite dogma of the university teacher that "We do not need to decide where to make the break between upper and lower second class honours, a significant gap in the results always appears".

Now if we were to investigate the relative physical stature of all the men in London we should find that the distribution of their heights is gaussian. So is the distribution of their weights and, so far as it can be measured, of their intelligence. How odd then that their academic and scientific abilities should polarize in this peculiar manner. Could it be that our method of measurement influences the result, or are we just prejudiced (with a good lacing of special pleading for the system which appears to include *us* in the top group!)?

Please don't think that I am putting the old red line "all men are equal", not at all. Fig. 1 is a rough sketch of a gaussian distribution. A certain attribute has a measure A. The ordinate in Fig. 1 represents the number of individual dN having values of A lying within the small range dA. Suppose the attribute is aptitude in the field of electronics. Let us suppose that only people in the upper ranges of aptitude would consider pursuing a career in the field. Then it seems likely that the graph of dN/dA versus A for all people trying to make their living as electronicists will be of the form of Fig. 2. We shall expect to find small numbers of exceptional people grading down smoothly to much larger numbers of the mediocre. I certainly think that Fig. 2 will represent the spread of abilities of degree students.

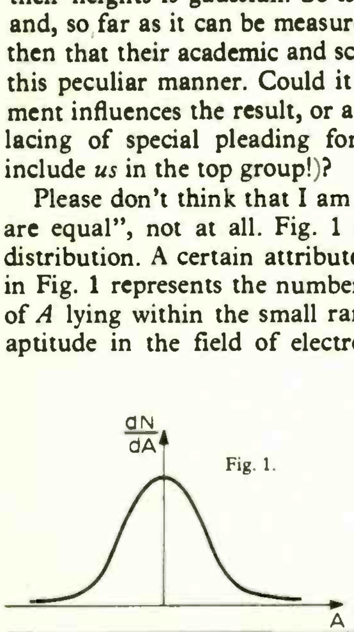


Fig. 1.

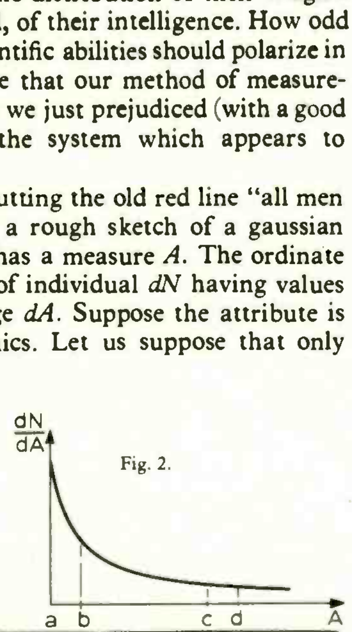


Fig. 2.

We are told that when we have grouped our students we must teach them in different ways appropriate to the ability level of their group. I think that what we are in practice doing is to select two ability ranges, say *ab* and *cd* in Fig. 2. These form the assessed ability ranges of our two groups. The large number of individuals who lie in the range *bc* must do one of two things. Either they will bluff their way into the higher group, or, being more honest or more lazy will fall into the lower group. The consequence is that the higher group must contain a large percentage of charlatans and the lower group a somewhat smaller percentage of under-achievers. In my view it is important that every electronicist should develop his skills as far as his place in Fig. 2 will allow. He should not be labelled and placed in his appropriate slot for all time because people have a tendency to be judged, *and to judge themselves* by their labels. On the other hand it is necessary that people should be graded, but the measuring instrument must be carefully designed and finely divided. Also it must be readily available for checking a person who thinks he has advanced.

I doubt the validity of the thesis that the more able man should be taught the subject in a different way to the less able man. The greater your ability the further you can progress in skill and in subtlety of understanding. Hence I should like to see a testing system consisting of a large number of grades or degrees, rather like the grades which can be achieved in piano playing. Thus the person who had reached the 5th grade or degree might be considered suitable for the work normally described as "technician level", at the 7th degree that of "technologist level". Research and development might require training assimilated to the 9th degree. This would clearly change the structure of technical education, since everyone would be required to pass through each degree. The time scale need not, however, be specified.

Anyone entering our field must be prepared for a lifetime of study (think of the rate at which the art advances) so that updating courses and degree endorsement testing should be readily available.

The professional institutions have lately closed the door on the non-graduate aspirant, and since this man is almost certainly a reformed under-achiever, I regard this as a retrograde step. In the scheme that I propose corporate membership of a professional institution would depend only on assessed achievement in the profession; this is ultimately the only valid test of status.

* Mr. Ibbotson has taught "light-current" electrical subjects at all levels including City and Guilds, H.N.C., H.N.D., B.Sc.(Eng.) and postgraduate courses.

News of the Month

ESRO space-probe to Mercury in 1975?

Several projects are being considered for inclusion in the European Space Research Organization's programme. Among them is an interplanetary probe for a Mercury fly-by mission. Mercury is the closest planet to the sun in our solar system and as yet has not been investigated by a space vehicle. What little is known about the planet has been obtained from measurements made on earth.

The projected Mercury probe, known as MESC, has been studied for ESRO by the German Messerschmitt-Bolkow Company. It would have a total weight of about 400kg. including a scientific instrument payload of about 70kg. The purpose of the trip would be to study the surface and atmosphere of the planet and it would carry a photometer, polarimeter, microwave measuring apparatus and an infra-red radiometer. Two television cameras would also be carried for short range photography of the planet's surface; a resolution of about 200m would be obtained. To study atmospheric space close to the sun a magnetometer and micro-meteorite detectors would be included in the payload.

MESO would be launched by an American Atlas-Centaur launcher into solar orbit which would pass close to Mercury after 4 months' flight. It would carry an earth-pointing high-gain telemetry aerial capable of transmitting data at 750 bits per second to be received by the American earth-stations using 65m paraboloids or the station being built at Effelsberg in Germany which has a 100m dish.

If the project is agreed upon, launch could take place in 1975.

Other projects being considered by ESRO are an Atmospheric Research Satellite (Elliott, Fokker and Dornier), dual-spin satellite for polar ionosphere research (ESTEC), scientific geostationary satellite (ESTEC), two cosmic ray satellites—cos A and cos B (ESRO)—and astronomical satellites (ESRO).

B.S. 9000, "Blatant violation of U.S. rights!"

The Americans are attacking the implementation of a tripartite agreement between West Germany, France and Britain which will enable a component manufactured in one of the countries to be accepted in the other countries without subjecting it to goods inwards and quality control inspection under B.S.9000.

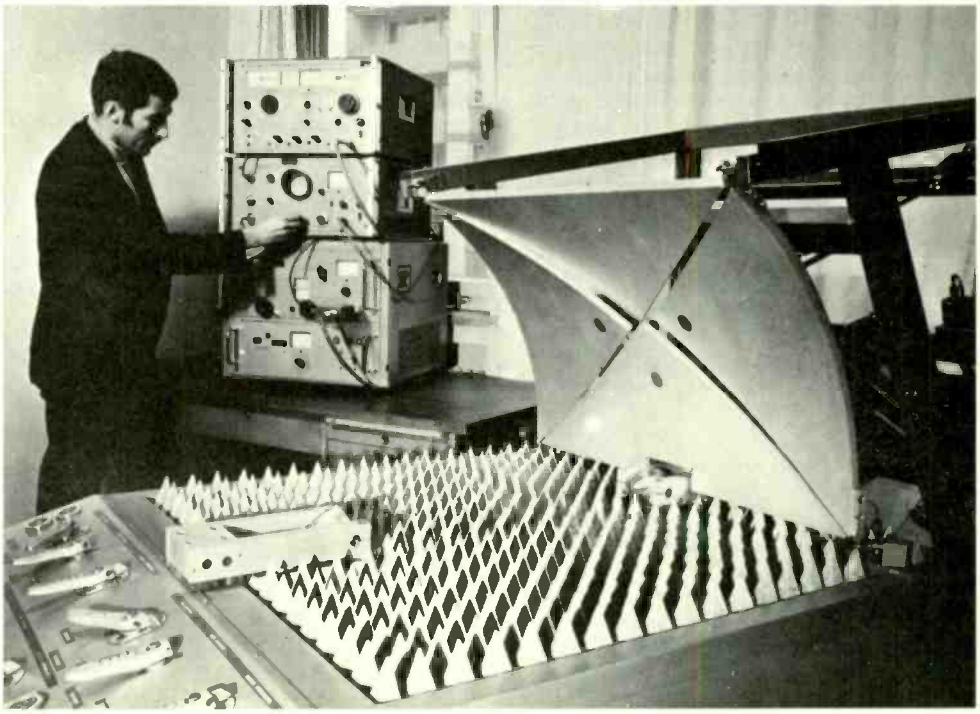
Mr. I. D. Secrest, executive vice-president of the American Electronic Industries Association, said in a letter to the American Secretary of Commerce: "The effect of the agreement is to make uneconomical for users of electronic components in those countries to purchase components from any plants other than those located within their territories which have been certified by their governments as meeting the technical standards and quality control procedures contemplated by the agreement." Mr. Secrest went on to say: "The tripartite agreement creates an absolute embargo against exports of U.S. electronic components to the United Kingdom, France and West Germany. The agreement is not yet fully implemented. There is time to prevent this blatant violation of U.S. rights under existing trade agreements from occurring if there is strong and determined action by the United States." As America shipped $88M worth of components to the three countries during 1968 they are worried, but what form this strong action might take was not mentioned.

B.S.9000, and the projected tripartite agreement was the subject of a conference held in Eastbourne recently under the auspices of the British Electrical and Allied Manufacturers' Association. The papers that were read and the discussions which followed, are available in "Conference on British Standard 9,000 series of Specifications—Proceedings", price 30s from the Industrial Control and Electronics Division of the association at: 8 Leicester St, Leicester Square, London W.C.2.

International agreement on the Mallard project

The United States, the United Kingdom, Canada and Australia have announced an agreement on continuation into Phase-2 of the advanced development of the Mallard project. This project is an unprecedented

A working demonstration of Rohde & Schwarz's "hyperbolic technique" which allows contactless measurements to be made on large curved surfaces—primarily intended for parabolic reflectors.



international undertaking in which a joint tactical communications system is being developed for the armies and associated navies and air forces of the four nations involved.

A design for the future, the long-range task is being carried out in phases as an international co-operative venture. The first phase, which was begun in April, 1967, is nearing completion, and was devoted to intensive study and system design by both government and industrial teams. Three major system studies have been completed, two in the U.S.A. and one in the U.K. These studies were augmented and complemented by 58 separate studies of the techniques involved. Principal U.S. contractors were in two teams. One, led by the Radio Corporation of America, the other, led by Sylvania. The United Kingdom team included Plessey, Standard Telephones and Cables, General Electric Company and Marconi.

Since February, an International System Selection Board has been reviewing the three system studies at Asbury Park, New Jersey. This board has selected the best elements of the three studies and recommended a single system design for further development. The Board consisted of 160 highly qualified personnel from the four nations representing 19 major fields of interest.

Project management of the Mallard project is centred in a Program Management Board located near Fort Monmouth, New Jersey. Each nation furnishes a board member. They include Major General P. A. Feyereisen, U.S.A.; Brigadier H. Roper, U.K.; Col. D. Coughtry, Canada, and Lt.-Col. D. McMillen, Australia.

The next phase of the project, which will cover a period of approximately two years, will be devoted to modelling and simulation of the selected Mallard system design, as approved by the Program Management Board.

Mintech's computer design centre in operation

The Ministry of Technology's Atlas Centre for Computer Aided Design (c.a.d.) at Cambridge is fully operational and its teams of consultants are already working on some of the engineering industry's design problems. Owned and controlled by the Ministry, the centre is managed under contract by International Computers Ltd who built the Atlas 2 computer on which the centre is based.

Mintech will co-operate with other organizations in suitable projects which are likely to contribute to the efficiency of industry by stimulating the effective use of computer-aided design. In most cases the other organizations involved in these selected projects will be running c.a.d. or developing techniques which they wish to run or develop for their own purposes. Mintech will be prepared to share the costs and, where appropriate, financial risks. In return Mintech will retain sufficient rights in the results of sponsored projects to enable those benefits that are not commercially confidential to be passed on to other users.

The Atlas 2 system being used provides a multi-access service with concurrent batch processing and is an adaptation of the Cambridge University Mathematical Laboratory operating system. Work may be initiated either through conventional peripheral equipment or from teletype or graphics terminals, some on a dial-in basis, using the s.t.d. system. Up to 100 jobs can be handled at one time. Each job is run intermittently for periods that depend on the resources required and on the resources available so that the central processor is used as efficiently as possible. A magnetic disc filing system with back-up magnetic tapes provides a centrally organized mechanism for the safe custody and efficient retrieval of information. Other software is provided to operate associated computers, their display systems and their interfaces with Atlas 2. The address for enquiries is:—Mintech Atlas Centre for Computer Aided Design, Madingley Rd., Cambridge, CB3 OHB.

Stolen; can you help?

The following equipment was stolen from a laboratory in Oxford:

S.E. Laboratories u.v. recorder type 3006 'DL' serial number 0346/1.

Telequipment Oscilloscopes type D.43R, serial number 6623, and type D.43, serial number unknown.

If you have any information on the whereabouts of these instruments please contact: The Superintendent, Thames Valley Constabulary, Cowley Police Station, Oxford Road, Cowley, Oxford.

Ultrasonic probe evaluation Any suggestions?

Many of the aids to quality control used by industry make use of some form of ultrasonic testing method in which an ultrasonic probe, or probes, is employed. These probes form an essential part of the inspection system, and many different types exist, each being adapted to particular test requirements. The resulting probes have usually performed their intended task, but when probes developed for one purpose are used for another purpose, or when comparison of results between equipment from different manufacturers is required, it is sometimes found that results are inconsistent because of the ill-understood characteristics of the probes. Since the functioning of ultrasonic probes is a complex matter it has been found difficult, on the basis of current knowledge, to define the probe characteristics that are important or which may be relevant to any specific application.

In an attempt to resolve this problem, the Nondestructive Testing Centre at Harwell has been asked to undertake a programme to define important probe characteristics, and, where possible, to develop methods of measuring them. The two classes of probe characteristics which will be investigated initially are those concerned with the shapes of beams emitted and with the frequency spectra which the probes are capable of producing. These two factors are interrelated, since the frequency characteristics in part determine beam shapes.

The programme has been set up with the approval of the N.D.T. Centre Advisory Committee and, after consultation with industrial users of ultrasonic probes, representatives of interested Research Associations and the British Standards Institution. Further user experience and practical suggestions regarding the problems of probe characterization and the definition and measurement of characteristics will be welcomed. Please write to A. D. McEachern at The Nondestructive Testing Centre, A.E.R.E., Harwell, Didcot, Berks.

Eurocontrol radar inaugurated at Shannon

An Anglo-French secondary radar system, SECAR, developed and supplied jointly by the Marconi Company and Thomson-CSF for Eurocontrol at the upper area control centre at Shannon, Eire, was inaugurated on 9th May.

SECAR will not only give air traffic controllers in Shannon their first radar contact with many of the airliners flying across the Atlantic, but it will also provide a positive identification of the aircraft. SECAR, a form of air-to-ground data link, is designed to provide a radar controller with the identity, height and the "plan position" of any aircraft. The system caters for all four civil modes of interrogation.

Tunnelling memories

The Guidance and Control Systems Division of Litton Industries claims to be more advanced than anyone else in producing a non-volatile semiconductor store (a store which retains information after power has been disconnected). Their claim cannot be substantiated because no one else has published information on the subject although other firms are known to be working on the same lines.

Non-volatile semiconductor stores are made using m.o.s. field effect transistors in which a layer of silicon nitride is deposited on top of the silicon oxide gate dielectric. It is the layer of nitride that acts as the storage medium.

The silicon nitride has roughly the same electronic structure as semiconductor except that the conduction and valence bands are further apart. Between the two bands are discrete "centres" or "traps" that can store one or two electrons. The trapped electrons will stay where they are for years depending on the exact construction employed.

If an electric field of about 3×10^6V/cm (between about 20 and 40 volts in this case) is applied to the nitride the majority of the trapped electrons will leave the trap by tunnelling through the bulk silicon. Data is therefore written into the memory by applying either a negative or a positive field of 3×10^6 V/cm. Whether a 1 or 0 is stored depends on the presence or absence of electrons in the traps.

The amount of charge held in the nitride region traps determines the transistor threshold voltage (the voltage at which the transistor starts to turn on). A transistor in the 0 state has a threshold of about -3V and about -10V in the 1 state. Interrogating the transistor is accomplished by applying a voltage of −6 to −7 volts. If the transistor contains 0 it will switch on, if it contains a 1 it will not.

The design of the device is a trade off between the storage, read, and write times required. Litton expect to produce a memory operating at standard m.o.s. logic levels and with standard m.o.s. power supplies with a read and write time of 1 sec and a capacity of up to 40,000 bits per cubic inch. After this extension to a million bits in the same area will follow, say Litton.

European airlines communication network

The Sociète Internationale de Telecommunications Aeronautiques (S.I.T.A.), Paris, has awarded Raytheon Company a $3.3 million contract to supply a real-time communications network to serve more than 100 airlines in Europe and the Middle East

S.I.T.A., an association of international airlines, has ordered 18 computer-based message processing systems from Raytheon. The systems will provide real-time message interchange between the widely scattered offices of the airlines that comprise S.I.T.A.

The centres will be able to control and process messages received through Telex, Teletype or various types of existing agents' terminals currently used by the airlines in their communications and reservation systems.

S.I.T.A. currently operates a network of high-speed communications processors in Amsterdam, Paris, Brussels, London, Madrid, Frankfurt, Rome and New York.

The Raytheon systems will extend the network to many new locations including Lisbon, Las Palmas, Milan, Geneva, Hamburg, Istanbul, Stockholm, Prague, Vienna and other locations. Installation in these cities is scheduled from July 1970 through June 1971.

Weather data routing system

Much faster and more efficient handling of weather information for the United Kingdom is promised with the installation of a computer-based, message switching system, valued at nearly £750,000, in Britain's Meteorological Centre, at Bracknell within the World Weather Watch network.

The system is capable of handling a million weather bulletins a day and is to implement Bracknell in its role as a regional telecommunications hub on a World Trunk. The World Trunk is a medium/high speed data circuit for transmitting weather data around the globe.

The Automatic Relay System will also link key meteorological stations in the U.K. with Bracknell using the existing low-speed telecommunications network. The system will automatically edit the reports from the World Trunk and route the weather information to these meteorological stations without the need for any manual intervention.

The system will also provide automatic facilities for transmitting facsimile chart information in an analogue form, or digital data information on the same channels, between the Regional Telecommunication Hubs.

The Congress of the World Meteorological Organisation, held in April 1967, agreed to set up World Weather Watch to provide an international weather sharing network. The network is to link Regional Telecommunications Hubs which are to be sited at major meteorological centres in Paris, Offenbach, Prague, Moscow, Cairo, New Delhi, Melbourne, Tokyo, Washington and Bracknell. Each Hub will have responsibility for collecting and collating the weather information over its own area and relaying it to the other Hubs. Bracknell is responsible for the United Kingdom, Ireland, Iceland, Greenland, Gibralter, The Netherlands, and four ocean weather stations, as well as merchant shipping in the Eastern Atlantic. The Marconi Automatic Relay System to be installed at Bracknell will handle this mass of weather data both from these outlying meteorological stations and the World Trunk.

Sounding of the lower atmosphere

The Australian Weapons Research Establishment, Salisbury, South Australia, has developed a technique for the acoustic sounding of the lower atmosphere which may be brought into use by the Australian Bureau of Metereology.

A 50ft diameter acoustic dish is used in a radar system which enables measurements to be made of air turbulence and temperature inversions up to an altitude of 5,500 ft.

One possible use of the technique could be for profiling atmosphere contamination, particularly fog conditions at airports. The new system is based on the fact that the velocity of sound waves is very sensitive to air temperature.

Australian radio telescope for lunar landing transmissions

At the American National Aeronautics and Space Administration's request the Commonwealth Scientific and Industrial Research Organisation's (C.S.I.R.O.) radio telescope at the Austrailian National Radio Astronomy Observatory at Parkes, New South Wales, will be made available for N.A.S.A's first manned lunar landing. It will relay TV signals from the moon to the U.S. during the Apollo XI mission scheduled for July.

Under present plans for the landing a TV camera will be erected on the moon's surface by the astronauts to record their activities. It is expected that signals from the 2ft lunar module aerial will be received by N.A.S.A's 210ft diameter aerial at Goldstone, California, or by the C.S.I.R.O. 210ft aerial at Parkes, N.S.W. Soon after arrival on the moon, the astronauts will set up a 10ft diameter high-gain aerial on the lunar surface. Transmissions from this aerial will be received by tracking stations round the world.

The signals picked up at Parkes will be transmitted to Sydney by microwave through links provided by the Australian Post Office.

The converted picture will then be relayed from Sydney to a station at Moree, thence via the Pacific Intelsat III to Jamesburg, California, and to Houston. The prime function of the TV link is for monitoring and controlling the lunar operations. It is understood that Australian TV stations are considering the possibility of a direct release of the lunar transmission through Australian networks.

Marriage begets new airborne weapons system

Elliott Flight Automation have combined a number of their avionic products with products from their sister company Marconi, to form a comprehensive airborne weapons, navigation and control system called SWORD (Strike and Weapons Ordnance Delivery), announced at the Paris air show.

The complete system consists of a miniature Elliott inertial platform with an associated digital computer; a 920M digital computer for central flight management, and as a navigation and weapons aiming processor; head-up display with digital electronics as the main flight instrument system; projection map display, control/indicator panel, head-down electronic display, and horizontal situation indicator together forming the tactical display, navigation and flight instrument system; automatic pilot and stabilizer system with a high-speed low-level flight fail operative option; air data computer; radar or laser range finder for line-of-sight operation; high-definition radar for terrain following and target acquisition; ranging low-light television for passive target acquisition; and doppler radar as an alternative navigation sensor. Also available as part of SWORD are the Marconi AD1410 v.h.f./h.f. communications and homing radio and the Marconi v.o.r./i.l.s. navigation receiver.

The equipment can be fitted in part as a number of the sub-systems are self supporting. The complete system is complemented by the Elliott C.700 computer-controlled automatic test equipment and by the Retriever air control system, a mobile computer-controlled miniature operations centre capable of being installed in a field car to provide forward control of low-level tactical strike and reconnaissance operations.

CORRECTIONS

"Modified Treble Filter for Bailey Preamplifier" (June). The two response curves in Fig. 2 p. 275 are shown with the switch positions and capacitor values transposed. Maximum roll off is given by C_3.

"Labelling Components" (Letters, June, p. 272). We regret that an error occurred in Mr. Müller's letter. For "1000μF" read "10000μF".

Modular Pre-amplifier Design

Optimally designed stages that may be used separately or in several different combinations

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

The type of distortion introduced by a class A transistor amplifier operating at low signal level will be predominantly second harmonic and inoffensive to the ear. Although harmonic distortion is a convenient thing to measure, and makes a reasonable yardstick for comparative purposes, at low levels its presence is less important than that of the intermodulation effects which it causes. When a complex signal is transmitted through a non-linear element, intermodulation products between the separate components of the signal are formed, and these are readily apparent in the final audible result as a 'blurring', and loss of separate identity, of the individual components which make up the whole. A measure of this is the ease (or difficulty) in distinguishing the words of a choral performance in the presence of an orchestral background, or in identifying the presence and nature of individual instruments in a large orchestra.

Measurements by a number of workers[1] have indicated that the magnitude of intermodulation products can be much greater than that of the total harmonic distortion level, and the non-linearities which are likely to be of most importance in this respect are those at the low- and high-frequency ends of the audible range.

At the moment, the performance of audio amplifiers is much superior in this respect to that of f.m. transmissions, tape recordings, disc replay systems or loudspeakers. However, advances in the manufacturing techniques of gramophone records, pickup cartridges and loudspeakers have allowed a continuing improvement in the performance of these in harmonic and i.m. distortion, and it is clear that any amplifier

John Laurence Linsley Hood, born in 1925, was educated at Reading School, Acton Polytechnic, the Royal Technical College (Glasgow) and, after the war, at Reading University. In 1942 he joined the G.E.C. Research Laboratories at Wembley, working on magnetron development as junior member of a team. In 1943 he joined the R.A.F. in aircrew but was transferred to work on radar. He subsequently worked with T.R.E. (Malvern) overseas. After a return to university he joined the Windscale Research Laboratories of the Atomic Energy Authority. He has been in charge of the electronics team in the research laboratories of British Cellophane Ltd. since 1954.

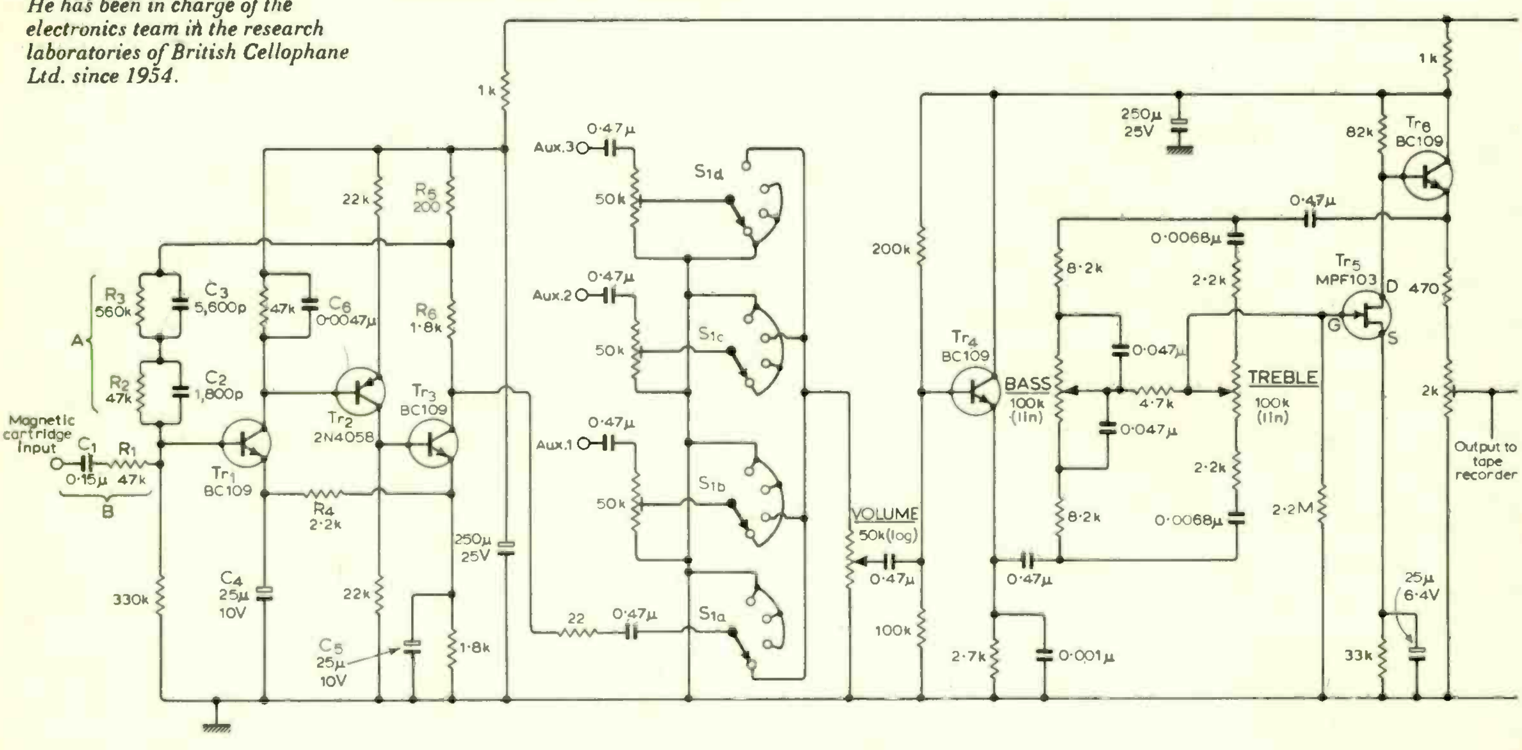


Fig. 1. A likely combination of stages.

design offered at this time should have a very high standard of performance if it is to remain of continuing value over the next decade.

The author has designed a range of high-quality pre-amplifier stages. Each stage performs its required operation with negligible noise and distortion. When joined together, as for example in Fig. 1, the total harmonic distortion level is below 0.1% over the frequency range 20Hz-20kHz, at any tone-control setting, and for up to 2V r.m.s. output. Each stage is capable of operating on its own and has an output impedance low enough for screened cable inter-connections to be made without high frequency loss.

Magnetic pickup equalization circuit

The required R.I.A.A. replay characteristic can be approximated by several different circuit arrangements. The most straightforward from the point of view of performance calculation is that shown in Fig. 2, employing a simple phase-inverting amplifier stage. If the gain of amplifier M is high enough, point Z becomes a virtual earth (see Appendix I), and the input impedance of the circuit equivalent to that of the input network B. The load resistance required by the pickup cartridge, usually 47-50kΩ, is provided by a suitable choice of R_1. With resistor R_2 equal to R_1, stage gain is given by $\frac{R_4 + R_5}{R_5}$ at the mid-point frequency (usually 1kHz) if the impedance of C_2 is large, and that of C_3 small, in relation to R_2. Since the voltage output to be expected from most good quality magnetic pickup cartridges is in the range 4-10mV for a 5cm/sec recorded velocity, a gain of 10 is adequate for this stage. The required replay frequency-response curve shown in Fig. 3 can be obtained by a suitable choice of C_2 and C_3. Since the two networks A and B determine the frequency response of this circuit, it is apparent that substitution of these can be made to provide a wide range of different performance characteristics without alteration to the circuit of the amplifier unit M.

The final circuit can be seen at the front of Fig. 1. Because phase inversion between input and output is required, and because the necessary gain is higher than can be obtained from any single transistor arrangement, a triplet circuit has been used.

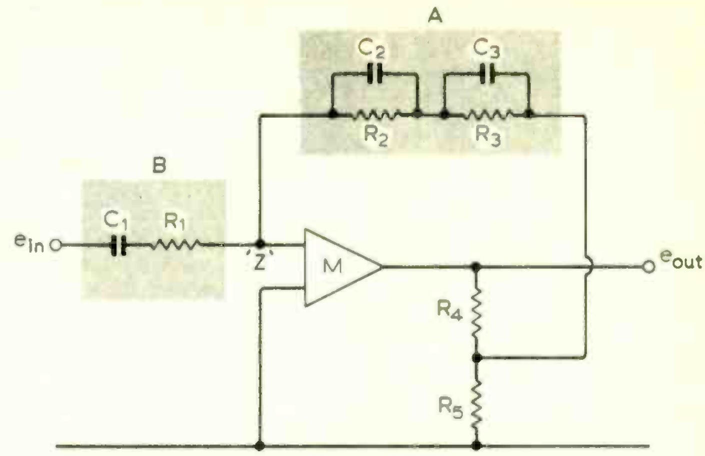


Fig. 2. Phase-inverting amplifier stage used to obtain R.I.A.A. replay characteristic.

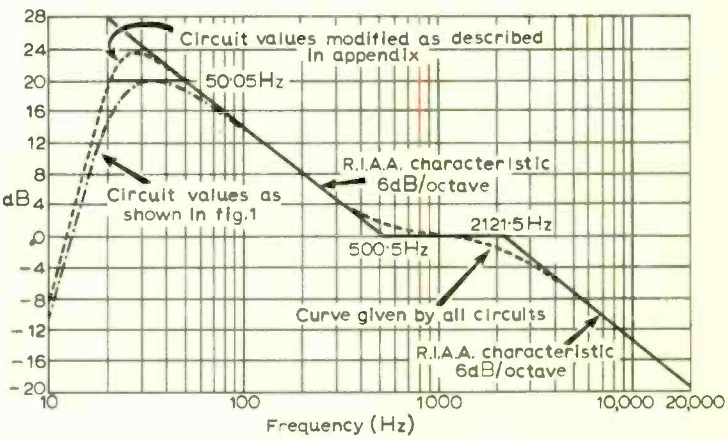
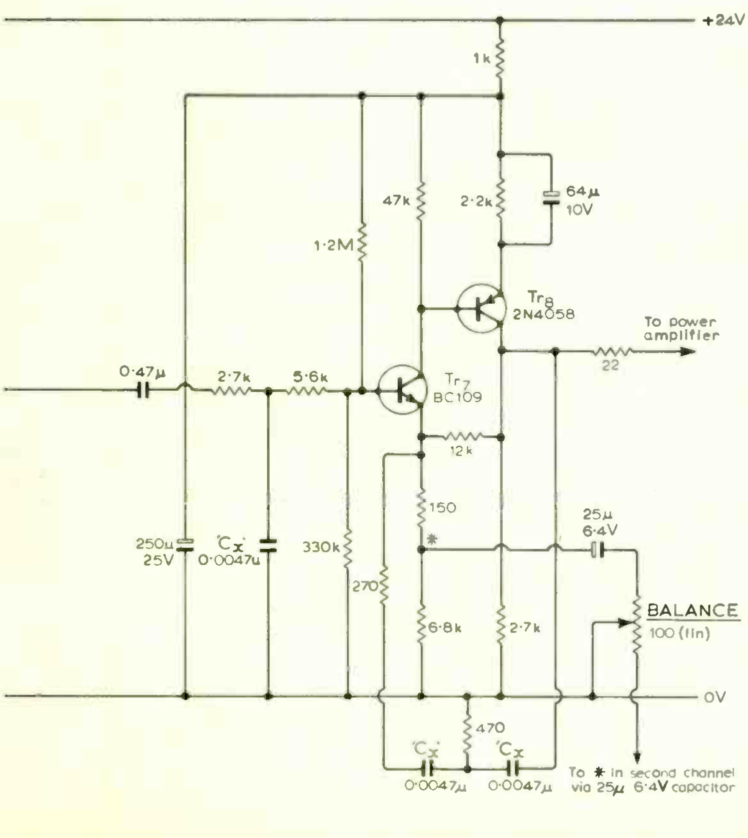


Fig. 3. Required R.I.A.A. frequency-response curve and circuit approximation to this.



Tr_1 and Tr_3 are high-gain, low-noise voltage-amplifying stages, and Tr_2 is a phase and voltage transformation stage allowing the input transistor to be used in its most linear region. The output transistor has a low collector load resistance, to reduce distortion to the lowest possible level.

D.c. working-point stability is ensured by d.c. negative feedback through R_3 and R_2 to the base of Tr_1, and through R_4 to the emitter circuit of the same transistor. The circuit R_4, C_4 and C_5 also provides the feedback path necessary, in conjunction with the input capacitor C_1, to provide an 18dB/octave steep-cut rumble filter, with a turn-over frequency of 25Hz (see Appendix II), and an ultimate attenuation of more than 40dB at 8Hz.

Capacitor C_6 provides phase correction, and is essential for a clean square-wave response, and freedom from transient ringing, when used with a capacitive load.

The response of this circuit is particularly good, and it can deliver up to 1 volt output with distortion less than 0.02% from 100Hz to 10kHz.

Stages for ceramic cartridge equalization

Fig. 4 is an impedance conversion stage contributing less than 0.05% distortion at 1kHz and having a flat response from 35Hz to greater than 200kHz, with 18dB/octave roll-off below 35Hz. This simple stage may be directly substituted for the magnetic cartridge stage of Fig. 1.

Alternatively, should it be required that the pre-amplifier be able to cope with inputs from both magnetic and ceramic cartridges, then switchable equalization networks for A and B can be provided. These are shown in Fig. 5. When used with a ceramic cartridge the output voltage is from 50 to 200mV. To preserve the required shape of the rumble filter characteristic it is necessary to alter the values of C_4 and C_5 from 25μF to 12.5μF. The pre-amp response is then as shown in Fig. 5, curve 1.

The performance of many ceramic pickup/amplifier combinations is disappointing in comparison with that obtainable from a good magnetic cartridge with a similar amplifier. This is sometimes due to the mismatching between cartridge and amplifier, or through inadequate input impedance provision (in the modification shown in Fig. 5 this is 4.4MΩ), or due to the failure of the piezoelectric element within the cartridge to provide the required equalization for the 12dB fall in voltage output anticipated when a recording having R.I.A.A. velocity characteristics is replayed on a displacement sensitive device. In the latter case, a very considerable improvement in the relative performance of the ceramic cartridge may be obtained by shunting part of the input resistor in the input network B by a small capacitor. Curves 2 and 3 in Fig. 5 show partial and complete correction respectively.

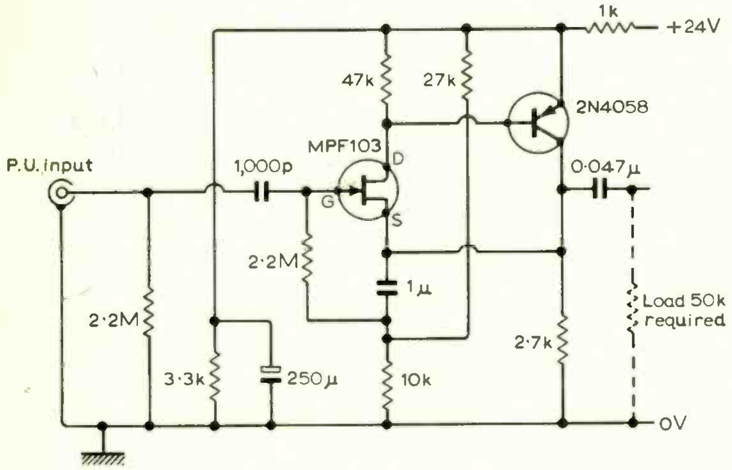


Fig. 4. Impedance conversion stage for use with ceramic cartridge. This may be directly substituted for the magnetic cartridge stage at the front of Fig. 1.

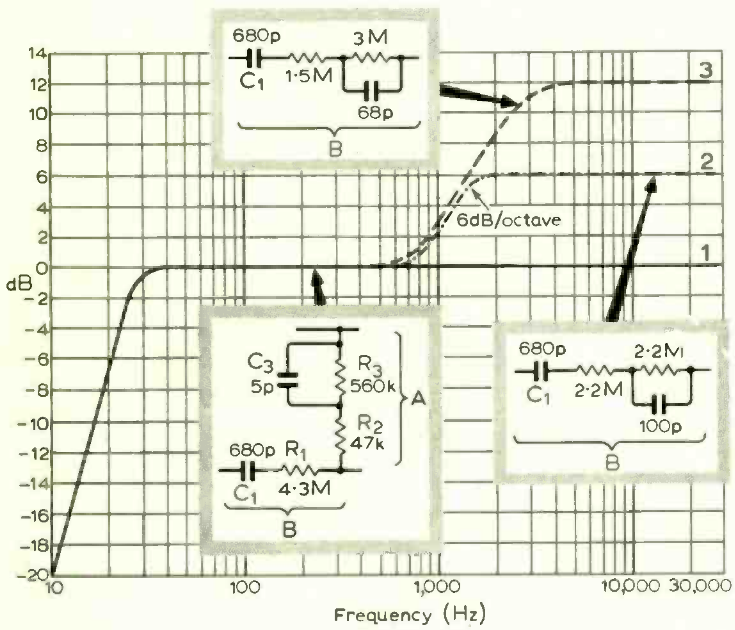


Fig. 5. Changes in equalization networks A and B of the magnetic cartridge input stage allowing direct use of ceramic cartridge. Components for network A are the same for the three curves show.

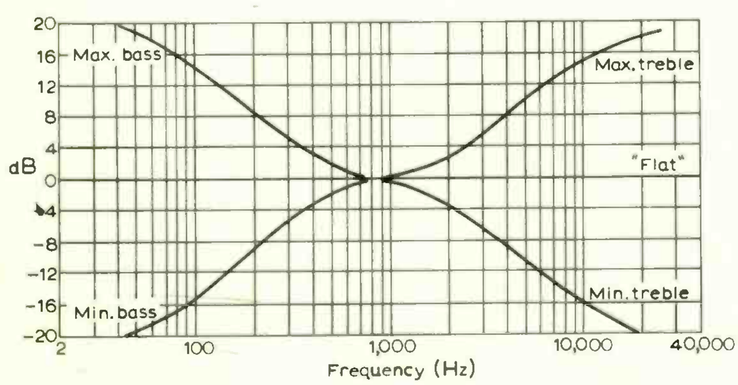


Fig. 6. Gain/frequency characteristics of the tone control stage.

Tone-control stage

The tone-control stage is of conventional type, and uses a negative feedback system derived from the design due to Baxandall[2]. However, it differs from normal practice in that a junction field-effect transistor is used as the active element. Field-effect transistors have both lower noise levels and better linearity than bipolar transistors, and in this type of circuit the high input impedance results in negligible loading of the tone-control network. The stage gain needed in this circuit requires a high value drain load resistor, and the f.e.t. must therefore be followed by an emitter-follower to provide the low output impedance desired for easy interconnection of the separate units.

If the feedback tone-control network is to perform satisfactorily, both the input and output impedances seen by the network at its ends must be low in relation to the network input impedance when the sliders of the potentiometers are at the position nearest to the point being measured. Some form of impedance conversion circuit is therefore also needed between the volume control and the tone-control circuit. An emitter follower is also used at this point. The 0.001 F capacitor in the emitter circuit of Tr_4 is to avoid the possibility of high frequency parasitic oscillation occurring if long screened leads are used to connect the base of Tr_4 to the volume control.

The input to this section is taken through a switch from the gramophone pre-amplifier section, and other inputs provided with preset gain-equalization potentiometers. The switch is arranged to earth the inputs not in use, to minimize breakthrough between programme channels.

The gain/frequency characteristics of the stage are shown in Fig. 6.

Low-pass filter circuit

The voltage amplifying stage preceding the main amplifier should include a steep-cut low-pass filter that can be set to remove unwanted high frequencies. This can be done either by a suitable *LCR* filter arrangement, or by an active filter giving an equivalent performance without the use of inductors. The circuit arrangements available for low-pass active filters are shown in Fig. 7. (b) is the well known circuit arrangement first employed in an audio amplifier design by P. J. Baxandall[3], and (d) is the unity gain rearrangement of this circuit introduced by Sallen and Key[4]. The frequency response of all of these circuit arrangements is similar, *mutatis mutandis*, to that shown in Fig. 8, and the circuit should be preceded or followed by a simple *RC* filter if the type of response shown in the dotted line is required.

For a given overall stage gain, type (b) gives a much better distortion factor near the region of cut-off than (a), and (c) is marginally better than (b) when used with non-linear amplifier elements. The particular advantage of (c) however, is that it can be used conveniently with a very low-distortion two-transistor circuit.

The final stage, with the filter circuitry, is shown in Fig. 1. As a matter of practical convenience, the component values of this circuit have been chosen so that the required low-pass response is obtained when all of the capacitors 'C_x' are of equal value to each other. The frequency response obtained with a given value of 'C_x' can be found from Fig. 9. The user can interpolate between these to obtain turn-over frequencies at any points to suit his own requirements. If a ganged selector switch is employed to give a range of turn-over frequencies, the switch arms (moving contacts) should be connected to the junction of the resistors in the *RC* filter and to the 470Ω resistor in the main filter network. In Fig. 1 the 0.0047µF capacitor for 'C_x' results in response being 3dB down at about 18kHz. With good quality programme sources this is a recommended capacitor value.

With capacitors of zero value, the response of the circuit is flat to about 100kHz. The user should however arrange for the response to fall off above 25kHz. (It is unlikely that the listener will find anything to gain from the parts of the sonic spectrum beyond this point.)

The optimum performance of this particular type of circuit arrangement is obtained when the overall gain is about 50 with feedback. A 20-40mV input is therefore adequate for this stage for the output voltages required.

The distortion level of this circuit is less than 0.03% at 2 volts r.m.s. output or less, at any frequency within the pass band. The output impedance is less than 150 ohms over the range from 20Hz to the cut-off frequency selected.

It is convenient, for several reasons, to operate at the 50-100mV level through the tone-control stages. At this output voltage level the distortion introduced by an *RC* coupled f.e.t. stage is less than 0.1% even without feedback, so that the maximum 'lift' settings of either 'bass' or 'treble' controls cannot give rise to unacceptable levels of distortion. It is also large enough for the noise and inevitable 50Hz pickup to be unobtrusive. Some attenuation is therefore desirable between the tone control unit and the steep-cut filter circuit. This is obtained by the preset 2kΩ potentiometer in the tone control circuit, which provides a convenient means for setting the overall gain of the amplifier system, and also as a coarse 'balance control' in a stereo system. Fine balance between channels is obtained by adjusting the 100Ω balance potentiometer in the output stage. This alters the stage gain over the ratio 6 : 10.

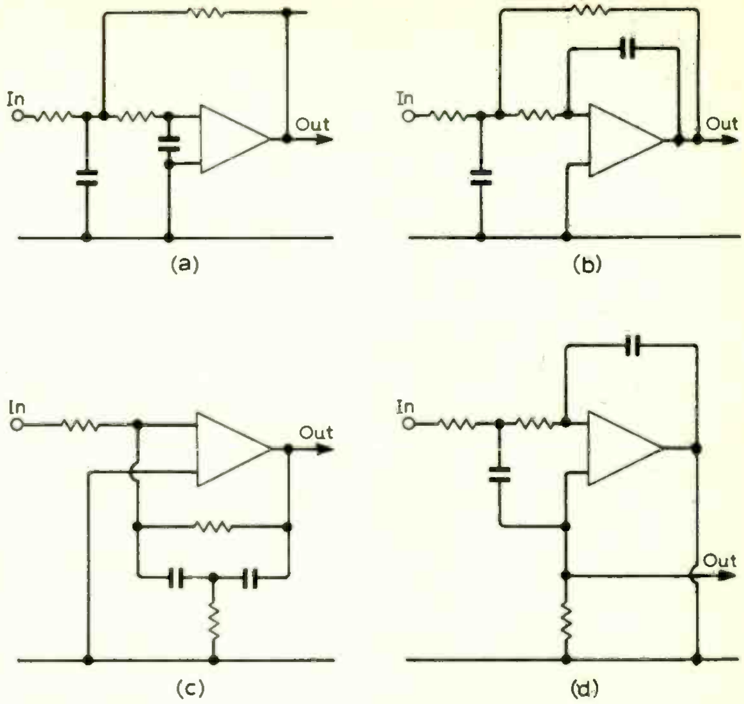


Fig. 7. Circuit arrangements for active low-pass filter design.

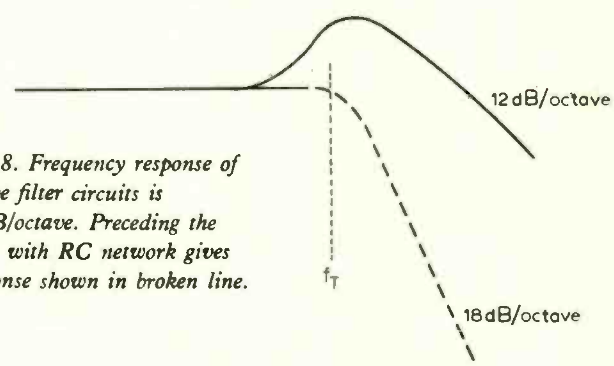


Fig. 8. Frequency response of active filter circuits is 12dB/octave. Preceding the filter with RC network gives response shown in broken line.

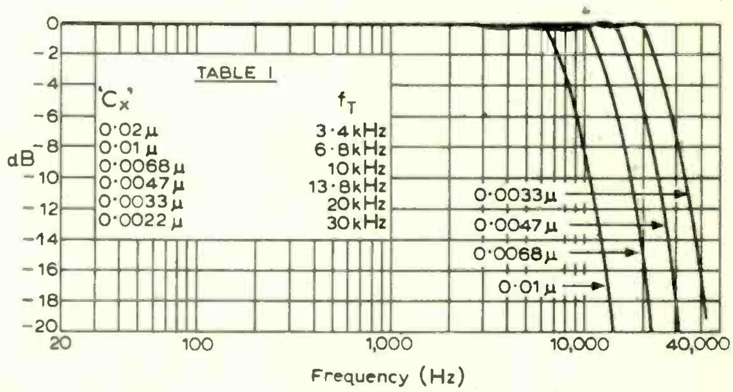


TABLE I

'Cx'	f_T
0·02µ	3·4kHz
0·01µ	6·8kHz
0·0068µ	10kHz
0·0047µ	13·8kHz
0·0033µ	20kHz
0·0022µ	30kHz

Fig. 9. Graph and table of turn-over frequencies for different value of 'Cx'.

Constructional notes

The constructional technique used by the author in building the prototype of this amplifier is similar to that used in the 10-watt class A design described in *Wireless World* in April 1969, with the separate units laid out in mirror image form, as a stereo pair on a single 4in × 4¾in s.r.b.p. pin board. Two units of each type can be accommodated on each board, laid out more or less in the form of the circuit diagram (or its mirror image).

In general, reasonable care should be taken to separate input from output leads, and where the boards are to be mounted as a group within the same box, it would be wise to interpose a sheet metal screen between them.

The units are separately decoupled by 250µF capacitors from a common 24-volt line, derived from a zener diode stabilized *RC* filter power supply. This supply is separate from the main amplifier, and a 30mA output is ample. Details of a suitable power supply are given in Fig. 10. The expected working voltage on each of the unit sub-rails is about 15 volts.

Apart from the input transistor in the gramophone pre-amp unit (Tr_1) for which the BC109 is to be preferred, there is no particular reason why any modern silicon planar types should not give an indistinguishable performance. For example, the n-p-n types could be 2N3904, BC107/8/9, 2N3707 or BC184Ls. Similarly, the p-n-p types could be 2N4058, 2N3906 or BC214Ls.

Although, in many cases, the use of ¼ watt resistors is sufficient,

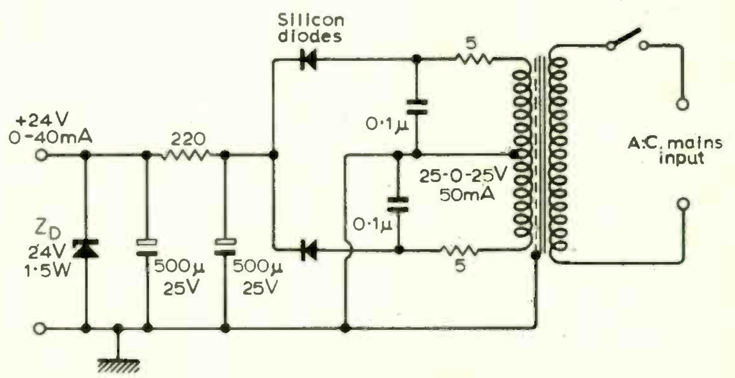


Fig. 10. Suitable power supply for any combination of stages.

it will probably be found simpler to use $\frac{1}{2}$ watt units throughout. 5% tolerance carbon film resistors are to be preferred.

The author has mounted the gramophone pickup equalization circuit in a separate small diecast box, immediately under the gramophone turntable unit, so that the leads from the gramophone are taken at a low impedance from the output of this unit. This has been very effective in reducing the hum picked up on the output leads to an imperceptible level.

Appendix I

The use of 'virtual earth' (null seeking) amplifier circuit arrangements is superficially ill-advised with input elements such as pickup cartridges, because it appears that as the operating frequency is increased, the input half of the balancing limbs will also change, with a resultant change in the gain of the circuit. In particular, a magnetic pickup cartridge may have an inductance of some 300-800mH and the impedance of this will exceed that of the input circuit in the range 12-20kHz. This should clearly reduce the gain of the system by reducing the ratio of A to B.

However, on reflection, it can be seen that the amplifier operates as a null generating device, sensitive only to the current flowing in the input circuit to the 'virtual earth'. As the operating frequency increases, so the current flow through R_1 will decrease, but so it would in any case, regardless of the amplifier, were the element simply connected across network B as the load recommended by the cartridge manufacturers (at these frequencies the impedance of C_1 can be ignored), and the voltage across R_1 measured by a perfect voltage amplifier. The decrease of current input into a given resistive load from a source having series inductance is simply an unfortunate fact of life, from which one cannot escape, whatever one's technique of measurement, and high impedance voltage amplifiers connected across the load, or low impedance current amplifiers connected in series with it, are alike in this respect, except that with transistors, the latter are a bit easier to contrive. The same argument is also applicable, in the appropriate context, to high impedance capacitative elements such as piezo-electric pickup cartridges. Once again, the voltage amplifier and current amplifier see the same phenomena in identical form. The necessary, and inevitable, corrections can be accomplished simply by the tone-control settings.

Appendix II

Although the R.I.A.A. replay characteristic suggests an approximately flat velocity response from 20Hz-50Hz, this would effectively imply recording bass lift in this region, and the author suspects that this is not done, a constant modulation characteristic being used instead. The author has therefore, for his own use, modified the values of the feedback elements as follows: R_5-470 ohms; R_6-1.5k ohms; C_1-0.47μF; C_3-6800pF; and C_6-6800pF. These changes maintain the velocity response flat down to 25Hz, with a rapid rumble attenuation below this frequency. Unfortunately the mid point gain of the circuit is reduced to 5, and some additional amplification is therefore needed if it is desired to avoid working with the tone control circuit at the 20mV level. the simple floating emitter collector-follower circuit of Fig. 11 is therefore interposed, without coupling capacitors, between the output series resistor and the collector of Tr_3. The distortion contributed by this is less than 0.05%.

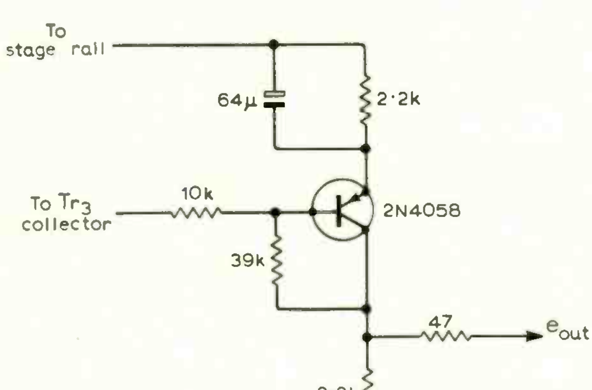


Fig. 11. Floating emitter collector-follower circuit referred to in Appendix II.

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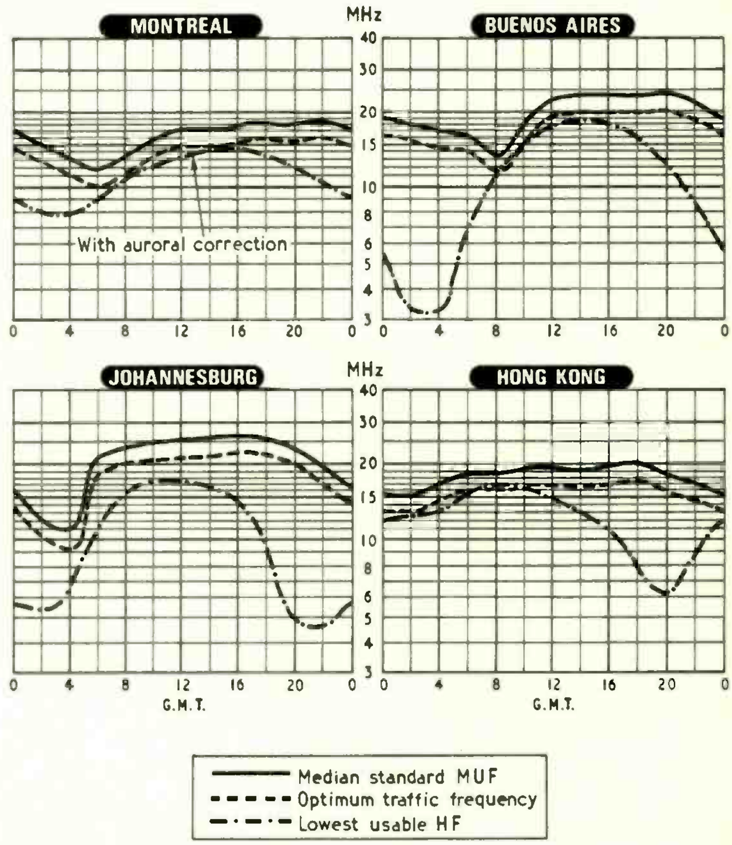
2. Baxandall, P. J., "Negative-Feedback Tone Control", *Wireless World*, October 1952.
3. Baxandall, P. J., "Gramophone and Microphone Pre-amplifier", *Wireless World*, January 1955.
4. Sallen, R. P. and Key, E. L., *I.R.E. Trans. Circuit Theory*, March 1955, p.74-85.

H. F. Predictions—July



The charts show median standard MUF, optimum traffic frequency (FOT) and lowest usable frequency for reception in this country. LUFs were calculated by Cable and Wireless Ltd for individual point-to-point telegraph circuits. Those for high-power broadcasting will be similar, whilst those for amateur service, where e.r.ps are much lower, will be several MHz higher.

To make allowance for day-to-day variations of solar activity and seasonal trend over the month, commercial working frequencies are kept below FOT. Amateur 'openings' can be expected on bands up to 15% above MUF.

Observed solar activity for March was much higher than forecast, consequently predictions since then have been rather pessimistic as regards MUF.

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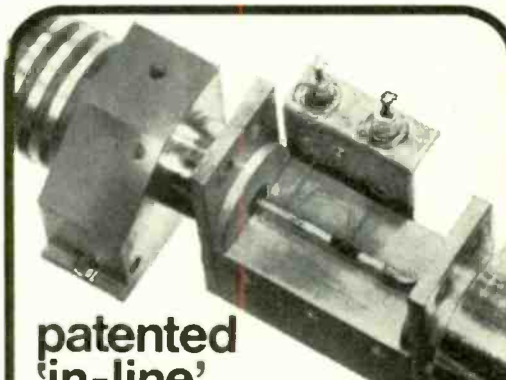

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Wireless World Logic Display Aid

3: Clock generator, counter, code converter and character generators

*designed by B. S. Crank**

The clock generator multivibrator is built around a single integrated circuit type ZN330E which is mounted in position six (see Figs. 25 and 26) on board two. It will be seen from Fig. 29 that this integrated circuit is described as a dual four-input NAND gate although each gate is drawn with five input connections. The fifth connection, the one terminating in a dot on the periphery of the circle representing the gate, is connected to the internal resistor R_1 (Fig. 28) and has direct access to the base of Tr_1 via D_5. This means that a conventional multivibrator can be constructed merely by connecting two external capacitors to the integrated circuit as shown in Fig. 33.

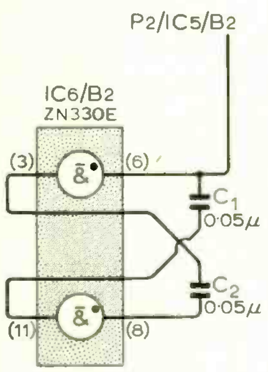


Fig. 33

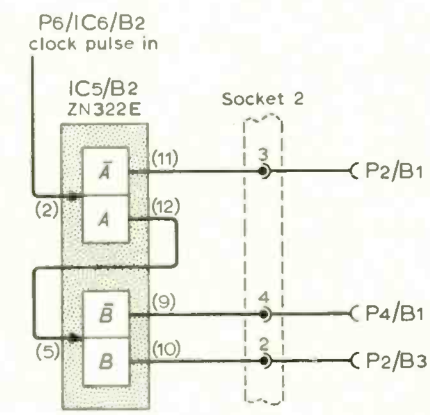


Fig. 34

Fig. 33. Clock pulse generator circuit

Fig. 34. First two stages of the Y counter

Counter

The counter is a straight conventional binary counter in which the J and K terminals of the bistables are not used. In order to accommodate the code converter, to be described later, the counter is spread-out over three boards (2, 3 and 4). The counter consists of eight bistables (four ZN322E) with the output of one bistable driving the trigger input of the following bistable. The logic diagram and the position of the various integrated circuits on the boards is shown in Figs. 34, 35 and 36.

The bistable outputs $\overline{A}, \overline{B}, \overline{C}, \overline{D}, E, F, G, H$ are taken to board output connections where they will be fed to the inputs of the buffer amplifiers which will in turn drive the two dians. Notice that these variables have been printed in italics. Variables printed in italics are the direct outputs of the counter and must not be confused with ABCDEFGH which will be introduced later as the outputs of the code converter. Italic variables are used only for certain counter internal connections, to drive the dian buffer amplifiers and to drive the code converter. The Y buffers are connected to the "not" outputs of the bistables to produce a negative going staircase and the X buffers to the "true" outputs of the bistables to produce a positive going staircase.

When the counter boards are built, not forgetting the input from the clock generator shown on Fig. 34, the board socket wiring can be started. This is simple at this stage and consists of interconnecting the various stages of the counter and connecting the counter to the buffer amplifiers on board one. This is shown on Figs. 34, 35 and 36.

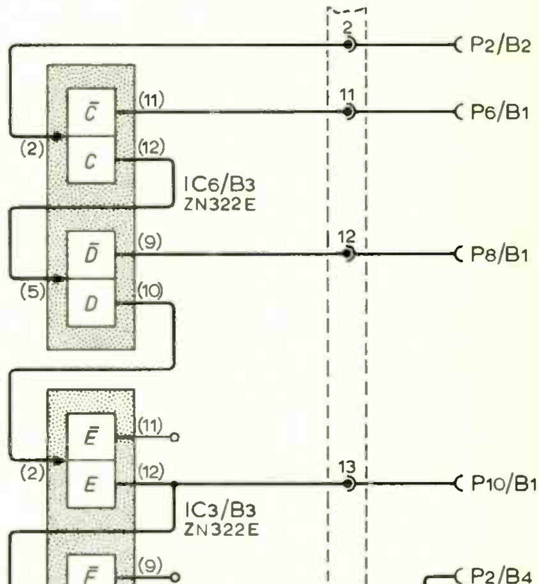


Fig. 35. Sections of the counter that are on board three

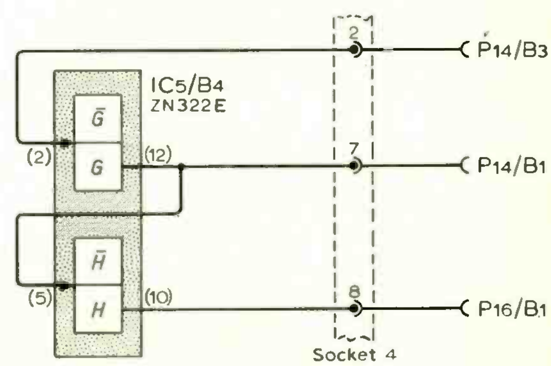


Fig. 36. Final counter stages

*Assistant Editor, *Wireless World*.

Testing the counter, buffer amplifier and dian assembly

When one is satisfied that all the previously described wiring has been carried out correctly the test circuit of Fig. 37 can be built. This test circuit will be used through-

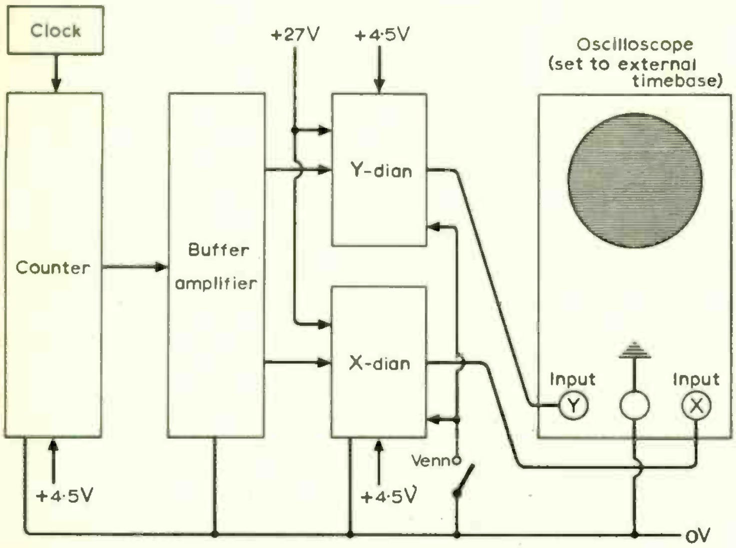


Fig. 37. Test circuit interconnection diagram

out the construction of the rest of the logic circuits of the display aid and as such it should be set-up on a semi-permanent basis, preferably on a bench where it does not have to be dismantled at the end of each session. Not only does the circuit test all the work done so far but it is a most valuable piece of test equipment for the rest of the equipment.

Switch everything on and adjust the oscilloscope (which should be set to external timebase) to produce one of the rasters shown in Figs. 3 or 13. It is possible that the standing d.c. potential at the output of the dians will be more than the oscilloscope X and Y shift controls can cope with. In this case it is permissible to block the d.c. by connecting capacitors, say about 0.22μF, in series with the output of the dians. If trapezium distortion is evident increase the value of the series capacitor.

Should the required pattern not be produced check the following points. With an oscilloscope a square wave should be observed at the output of the clock generator multivibrator; if there is no square wave the fault lies in the multivibrator. Look at the output waveform of each stage of the counter starting with stage A and finishing with stage H. Each waveform should be exactly half the frequency of the preceding one. A fault in the counter will easily be detected in this way. Check the output of each dian for a staircase waveform. If no waveform exists, or a waveform other than a staircase is produced, check all connections to the dians and buffer amplifiers.

When all is well the effect of operating the Venn switch will clearly be seen.

Code converter

The code converter, as mentioned earlier, it used to make the task of decoding the various functions of the display aid an easier one. It does once what would have had to be done several times if it were not included.

The code converter is divided into four sections, each section operating on a pair of outputs of the counter. It has a natural binary input and gives an output similar to that used along the edges of the Karnaugh map shown in Fig. 11.

The output of the code converter has a unit distance property (each successive output differs by only one variable) over each pair of digits.

Consider the two tables set out below:

	natural binary input *B A*	output of code converter B A
0	0 0	0 0
1	0 1	0 1
2	1 0	1 1
3	1 1	1 0

The aim is to design a logic circuit that with a natural binary input will produce the output shown. An examination shows that the variable B remains unaltered at both the input and the output, only A alters. A truth table for the required function is shown below:

B	*A*	A
0	0	0
0	1	1
1	0	1
1	1	0

From this:

$$\mathrm{A} = A\overline{B} + \overline{A}B$$

which is the exclusive OR function. It was seen earlier that this function can be performed with either the circuit of Fig. 30 or 32.

An additional complication arises from the fact that it is the output of the code converter that drives the rest of the logic circuits of the display aid and that more than eight gates have to be connected to some of the code converter outputs. Because of this power gates, which can drive up to 25 other gates, have to be used in some places.

The logic diagram of the code converter, and the positions of the various integrated circuits on the boards are shown in Figs. 38, 39 and 40.

Fig. 38 shows the code converter required to produce the variables A and B. In an earlier section it was pointed out that if the wired OR connection was used the exclusive OR function could be performed with only two gates, one gate being fed with $\overline{A}\ \overline{B}$ and the other with A B. However, at the output of the code converter we require the complement of the output variable as well as the variable itself.

In Fig. 38 then the input to P12/IC4 is given by:

$$\overline{\overline{A}B + A\overline{B}} = \overline{\mathrm{A}}$$

This is inverted to give at P11/IC4:

$$\overline{A}B + A\overline{B} = \mathrm{A}$$

Notice that the B and $\overline{\mathrm{B}}$ outputs have a single NAND gate acting as an inverter to buffer the counter from the rest of the circuits.

Fig. 39 shows the code converter for the C and D, and E and F stages of the counter. This follows the same general rules as for the A and B stage with the exception of the introduction of some power gates. IC5/B3 for instance allows the C and E output variables to drive up to 25 other gates each. IC4/B3 and ICI/B3 are power AND gates. As only one input terminal is used they serve as amplifiers only to increase the drive on the D, $\overline{D}$, F and $\overline{F}$ outputs.

Fig. 40 shows the last of the code converters which operates on the G and H outputs. This follows the same general principle as the other converters with a minor variation. IC1/B4 is a dual power NAND gate and is effective on the G and $\overline{G}$ outputs. As before the unmodified outputs, H and $\overline{H}$ in this case, are given the necessary drive in a dual power AND gate (IC2/B4) with only one input used.

To summarize, the complete output of the code converter can be written as:

$A = \overline{A}\,B + A\,\overline{B}$	$\overline{A} = \overline{\overline{A}\,B + A\,\overline{B}}$
$B = B$	$\overline{B} = \overline{B}$
$C = \overline{C}\,D + C\,\overline{D}$	$\overline{C} = \overline{\overline{C}\,D + C\,\overline{D}}$
$D = D$	$\overline{D} = \overline{D}$
$E = \overline{E}\,F + E\,\overline{F}$	$\overline{E} = \overline{\overline{E}\,F + E\,\overline{F}}$
$F = F$	$F = \overline{F}$
$G = \overline{G}\,H + G\,\overline{H}$	$G = \overline{\overline{G}\,H + G\,\overline{H}}$
$H = H$	$\overline{H} = \overline{H}$

And the output sequence, or code, of the converter, taking the Y side as an example, is:

D	C	B	A
0	0	0	0
0	0	0	1
0	0	1	1
0	0	1	0
0	1	0	0
0	1	0	1
0	1	1	1
0	1	1	0
1	1	0	0
1	1	0	1
1	1	1	1
1	1	1	0
1	0	0	0
1	0	0	1
1	0	1	1
1	0	1	0

For the sake of completeness a list of the pins at which the various variables are available is given below.

Y		X	
A.	P 5/B2	E.	P 8/B3
$\overline{A}$.	P 6/B2	$\overline{E}$.	P 7/B3
B.	P 7/B2	F.	P 10/B3
$\overline{B}$.	P 8/B2	$\overline{F}$.	P 9/B3
C.	P 4/B3	G.	P 4/B4
$\overline{C}$.	P 3/B3	$\overline{G}$.	P 3/B4
D.	P 6/B3	H.	P 6/B4
$\overline{D}$.	P 5/B3	$\overline{H}$.	P 5/B4

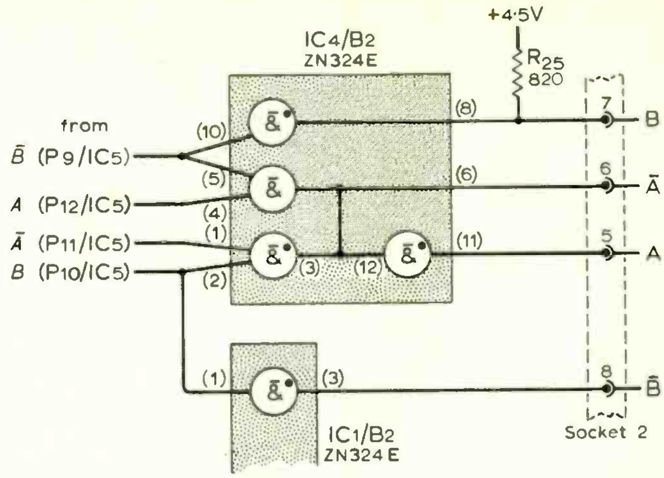


Fig. 38. Part code converter

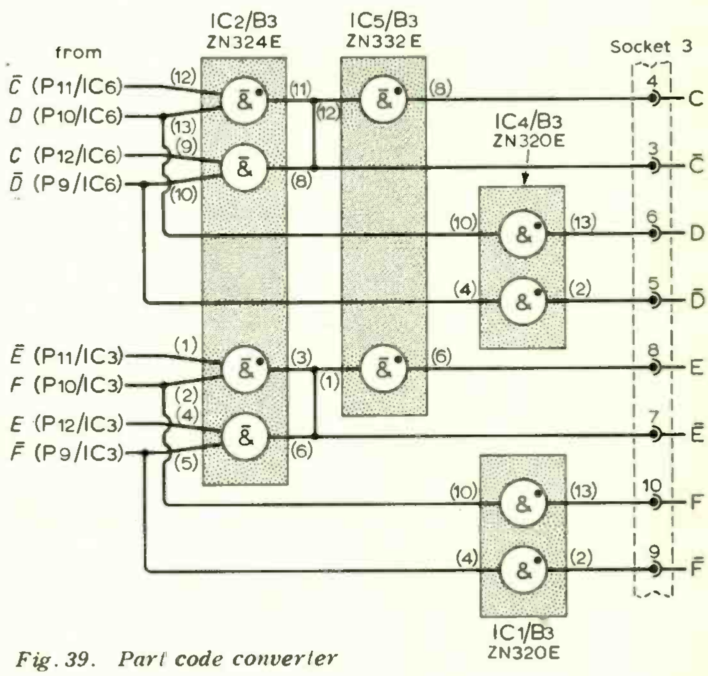


Fig. 39. Part code converter

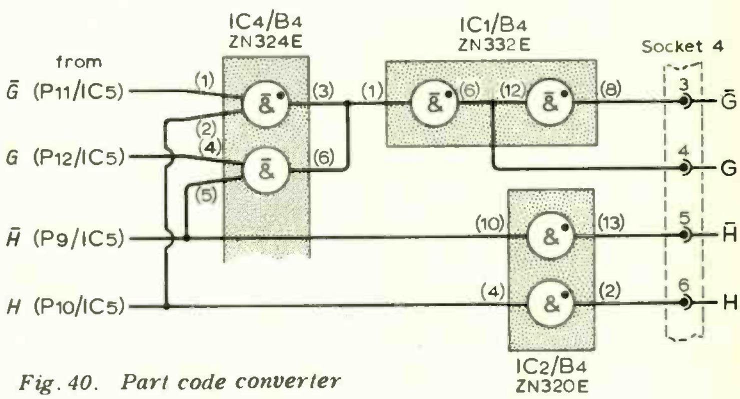
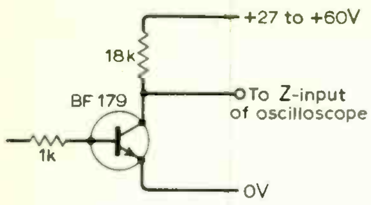
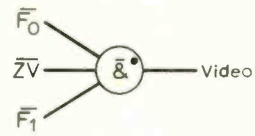


Fig. 40. Part code converter

Testing the code converter

In order to test the code converter it is necessary to build the video amplifier as shown in Fig. 41. The amplifier can be built on any small piece of Veroboard or an old tag board or something similar. The input of the





(left) Fig. 41. Make-shift video amplifier

(right) Fig. 43. Forming the video equation

amplifier is connected to a probe and the output of the amplifier is connected to the Z input terminal of the oscilloscope connected as in Fig. 37.

Some oscilloscopes do not have a Z input terminal; however, one can usually be provided by making a connection to the cathode of the c.r.t. via a small capacitor, say 0.05μF. It is important to note that the cathode of the c.r.t., in an oscilloscope, is usually at minus e.h.t. and may be several kilovolts below earth potential. The capacitor used should be new and should have a working voltage of at least one-and-a-half times the oscilloscope's e.h.t. voltage. If, for instance, the 'scope's working e.h.t. is 1kV the capacitor should be rated at 1.5kV.

When the wiring of the code converters has been completed and visually checked for accuracy plug the boards into their correct positions and switch-on the oscilloscope and the +4.5 and +27V supplies; at some stage the 4.5V supply will have to be obtained from a bench power supply to handle the load. Adjust the oscilloscope controls to display a nice square matrix of dots; it is best to use the Venn mode (Fig. 3). Adjust the brightness control so that the dots are only just visible.

Place the amplifier probe on P5/B2, some of the dots should glow brighter. A little thought will show that the dots which increase in brightness must be in the areas which are true for the variable A as P5/B2 is the pin at which the variable A is available as was seen in the table.

Examine Fig. 42. This shows the matrix-raster and how the outputs of the code converters each correspond

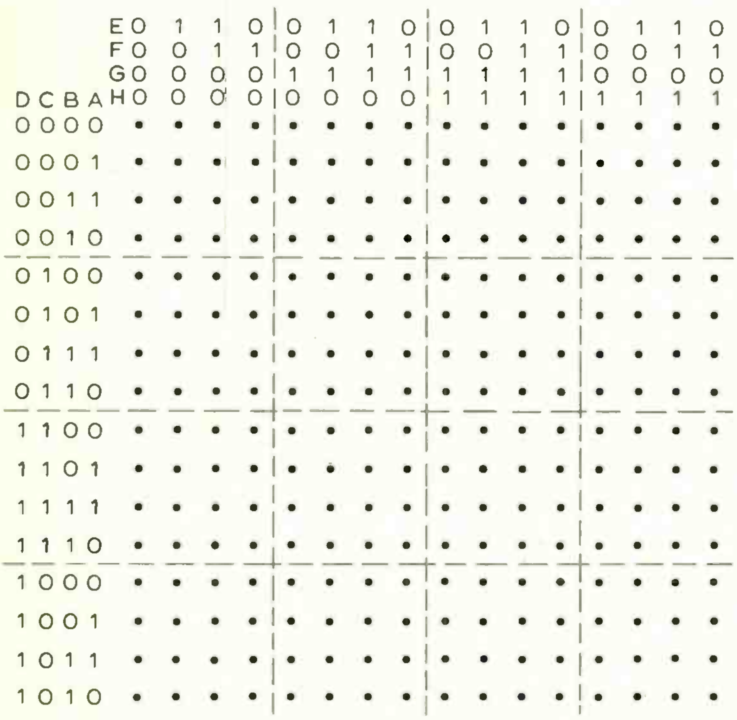


Fig. 42. Addresses within the matrix-raster

to a particular column or row of the matrix. In the example above we placed the probe on A. Now A originates from the Y counter and so "addresses" horizontal rows of the matrix (as do B, C and D). E, F, G and H address the vertical columns of the matrix. With the probe on A the horizontal rows that will glow brighter will be those rows with a 1 under A in the list of code converter outputs at the left-hand side of Fig. 42. So, counting from the top, rows 2, 3, 6, 7, 10, 11 etc will be brighter.

If the probe is placed on $\overline{A}$, which is at P6/B2, the rows that will be the brightest will be those with 0 under the A column of converter outputs (Fig. 42).

Using the same reasoning it is possible to test all the outputs of the code converter. For instance if the probe is placed on P6/B4, the variable H, the whole right-hand half of the matrix will be brighter because this is the area where a 1 appears under the H column.

Proceed to test all the sixteen outputs of the code converter that were listed with pin numbers earlier.

It is possible, due to differences in oscilloscopes, that the results will be the exact opposite to those required. When the probe is placed on A for instance all the rows corresponding to $\overline{A}$ are brighter. If this occurs in every test the simple remedy is to build another video amplifier stage to carry out another inversion.

Another point that may worry constructors is that the brighter areas in some cases will not be of even brightness. This is nothing to worry about as it is caused by the small size of the Z input coupling capacitor and can be ignored at this stage. If the constructor wishes to do something about it increasing the size of this capacitor will put things right.

If at any stage the desired pattern is not obtained check the connections in the appropriate section of the code converter using the circuit diagrams.

When the correct pattern has been obtained for each output of the code converter then the constructor can rest assured that all the circuits built so far are functioning perfectly.

These tests serve also to illustrate very clearly the whole concept of the display aid. They show how the various areas of the matrix correspond to the code converter output variables and how these variables can be used as a video signal to intensity modulate the c.r.t.

Composite video signal

The instrument has three modes of operation. When displaying Truth tables or Karnaugh maps the screen will be filled with a pattern of 0s and 1s. It would be reasonable to suppose, therefore, that the video signal would come from a circuit for generating 0s and from a circuit for generating 1s. This is the case. The signal that will produce an 0 on the screen face is designated F_0 (Form 0) and, using the same argument, the form 1 signal is F_1.

As was seen in the introduction the Venn display is made up from a pattern of dots. Another signal will be introduced at this stage that will be called Z. At the moment there is no point in complicating the issue by saying where this signal, Z, comes from, suffice to say that when Z exists, in the Venn mode, a bright dot is required on the tube face and when $\overline{Z}$ exists no dot is required. If we represent the Venn mode by V, the equation for a video signal can be written as:

$$\text{Video} = F_0 + F_1 + VZ \qquad (1)$$

Fig. 43 gives a circuit that will produce this function. Notice that because we are employing NAND gates the negative form of each term is required to produce OR.

Character generators

The circuit that produces the F_0 signal is such as to write an 0 in each of the 16 sub-matrices. Later on it will be discovered that another control signal decides in which sub-matrix an 0 is required.

An examination of Fig. 42 will show that the first row in each sub-matrix is addressed by $\bar{A}\,\bar{B}$ the second by $A\,\bar{B}$ and so on. In the other direction the variables E and F repeat themselves over each sub-matrix. In Fig. 42

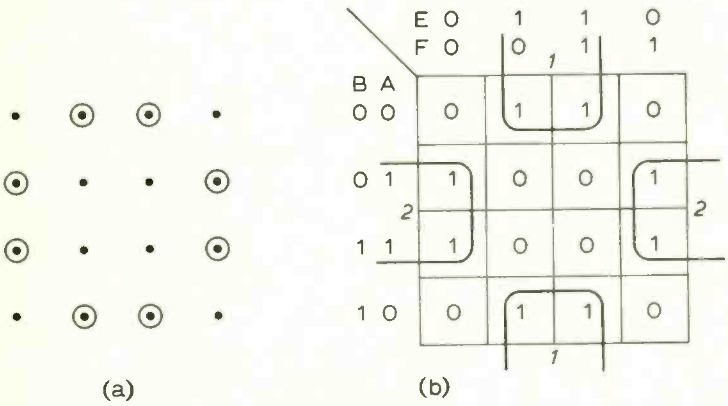


Fig. 44. Deriving the expression for F_0

each sub-matrix is bordered by a dashed line. It follows that if we select the dots necessary to form the character 0 in one sub-matrix using only the variables A, B, E and F an 0 will be written in each sub-matrix because the variables employed repeat themselves over each sub-matrix in an identical fashion.

The dots to be selected to form 0s are ringed in Fig. 44(a). The code converter gave the address code a unit distance property over each pair of digits, thereby turning each sub-matrix into a Karnaugh map. Fig. 44(b) shows the Karnaugh map for the character 0. Each square represents a dot and each dot to be selected is shown as a 1.

The top of the Karnaugh map is adjacent to the bottom and the left-side is adjacent to the right-side for simplification purposes. Two loops will therefore enclose all the 1s on the Map. The map is solved as follows:

Loop 1 consists of the terms:

$\bar{A}\ \bar{B}\ E\ \bar{F}$

$\bar{A}\ \bar{B}\ E\ F$

$\bar{A}\ B\ E\ \bar{F}$

$\bar{A}\ B\ E\ F$

Selecting only common variables gives $\bar{A}E$

Loop 2 consists of the terms:

$A\ \bar{B}\ \bar{E}\ \bar{F}$

$A\ B\ \bar{E}\ \bar{F}$

$A\ \bar{B}\ \bar{E}\ F$

$A\ B\ \bar{E}\ F$

taking only common variables gives $A\bar{E}$ therefore:

$$F_0 = \bar{A}\,E + A\,\bar{E} \qquad (2)$$

Fig. 45(a) shows the dots within a sub-matrix necessary to form the character 1 and Fig. 45(b) shows the appropriate Karnaugh map. All 1s are adjacent and can be ringed with a single loop. One could apply the same simplification procedure as was used for F_0, however this is not necessary as by inspection it can be seen that:

$$F_1 = \bar{E}\,F \qquad (3)$$

It was mentioned earlier that the F_0 and F_1 circuits operate under the control of other signals. These signals are called W_0 (Write 0) and W_1. The way in which these signals are derived will be discussed later. Incorporating these control signals in equations (2) and (3) gives:

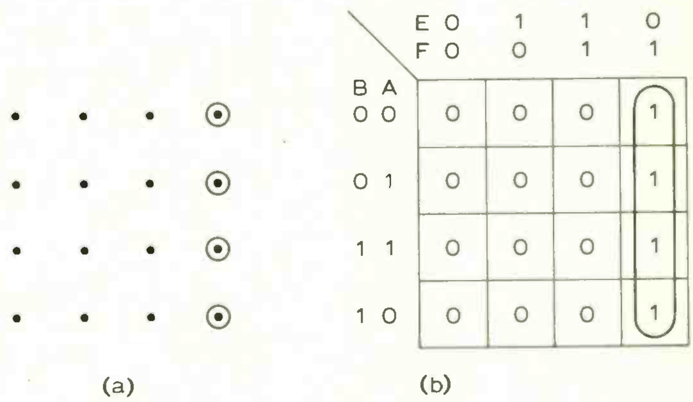
$$F_0 = W_0\,(\bar{A}\,E + A\,\bar{E}) \qquad (4)$$

$$F_1 = W_1\,\bar{E}\,F \qquad (5)$$

Now that the terms for the F_0 and F_1 signals have been precisely defined they can be substituted in equation (1) to give the complete video equation:

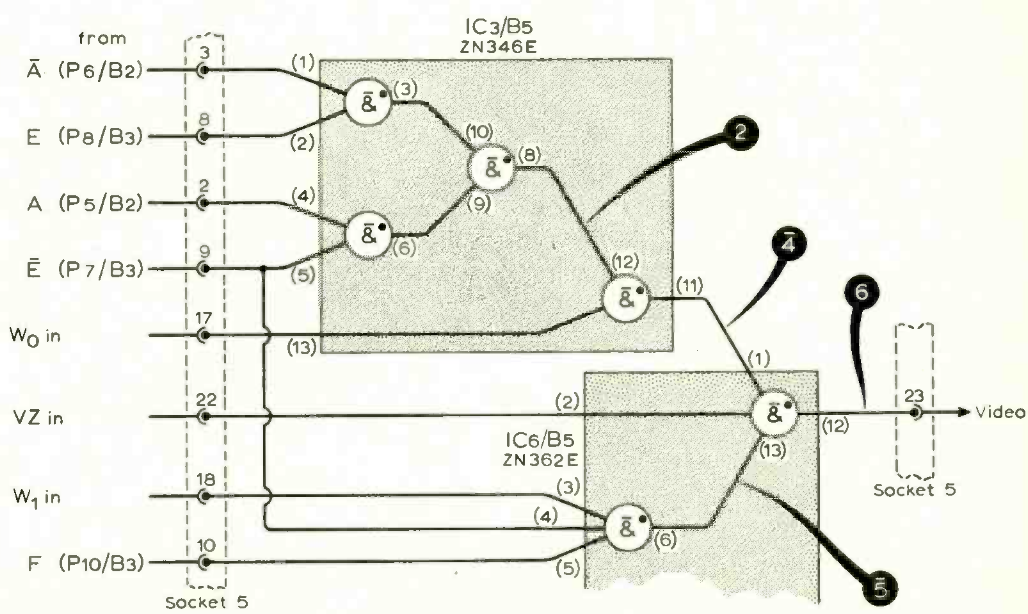
$$\text{Video} = W_0\,(\bar{A}\,E + A\,\bar{E}) + W_1\,\bar{E}\,F + VZ \qquad (6)$$

The logic diagram that performs this function and the position of the various integrated circuits is shown in Fig. 46. In this drawing the white letters in black circles



(above) Fig. 45. Forming the expression for F_1.

(below) Fig. 46. The 1 and 0 character generators



refer to the equations above. For convenience the board socket has been drawn in two halves. This circuit can now be built on board five.

When satisfied with the board wiring the inter-socket wiring can be carried out. Notice that for the time being P17/B5, P18/B5 and P22/B5 are not connected to anything.

Testing the character generators

When the wiring has been completed the satisfaction of the reader tests can be commenced. For these tests it is necessary to simulate the W_0 and W_1 signals. To this end temporarily connect socket pin 18/B5 to the 0V line, this will disable the 1 character generator.

Place the Venn switch in the Karnaugh map/Truth table position, connect the video amplifier probe to P23/B5 and switch-on the 'scope and other power supplies. A total of sixteen 0s should be displayed on the screen.

Switch-off, disconnect the earth from P18/B5 and reconnect to P17/B5 to disable the 0 character generator. Switch-on and sixteen 1s should appear. On the satisfactory completion of these tests disconnect the earth from P17/B5, the probe can be left connected as it will be required in this position later on.

If trouble is experienced the probe can be used at earlier points in the circuit to locate the fault. If this is done intelligently the exact cause of the fault can be located within minutes. It is necessary to relate the logical quantity that should be present on a particular wire with the pattern on the screen. A full understanding of how the instrument functions is essential if this is to be done satisfactorily.

It is felt that the constructor has been given enough to occupy his time until our next issue is published. At this time details of the logic design and construction will be continued.

Announcements

A High-Fidelity Exhibition is being planned for next year by the Federation of British Audio, which has some 30 member companies and has its headquarters at 49 Russell Square, London W.C.1. The exhibition will be held at the Skyway Hotel, near London Airport, from April 23rd to 26th.

The 2nd United Kingdom Symposium on **Electronics for Civil Aviation** organized by the Electronic Engineering Association in conjunction with the Ministry of Technology and the Board of Trade will be held at the Festival Hall, London, from 15th to 19th September.

Bendix Vacuum (CVC) is co-operating a symposium on **"The Deposition of Thin Films by Sputtering"** in the United States 9th and 10th September and in Europe 23rd and 24th October. Further details may be obtained from Bendix Vacuum Ltd., Eastheath Avenue, Wokingham, Berks.

An I.E.E. vacation school on **"Systems engineering"**, co-sponsored by the I.E.R.E., will be held at the University of Lancaster from 8th to 12th September. Further information from the Secretary, Control & Automation Division, I.E.E., Savoy Place, London W.C.2.

Thorn Electrical Industries and RCA of the United States have announced an agreement whereby the two companies will form a joint operation for the manufacture of **colour television tubes** in the United Kingdom. The new company will be named Thorn Colour Tubes Ltd. in which Thorn will own 51% of the shares and R.C.A. Ltd. 49%. The new company will bring together the Thorn manufacturing facilities at Brimsdown, Enfield, and those of R.C.A. Colour Tubes at Skelmersdale, Lancs.

Thorn Electrical Industries has acquired from AEI their 50% participation in Thorn-AEI Radio Valves and Tubes so that this company will be wholly owned by Thorn. It has been re-named **Thorn Radio Valves and Tubes Ltd.**

As part of a new five-year development plan that is expected to involve an investment of £1M in one specific project, Emihus Microcomponents Ltd is extending its plant at Glenrothes, Fife. The investment is concerned with the manufacture of a completely new range of **MOSFET** integrated circuits and discrete devices.

Communication satellites. An agreement has been signed between the Philco-Ford Corporation and G.E.C.-Marconi Electronics to co-operate in developing and marketing spacecraft and equipment.

Ates Componenti Elettronici S.p.A., of Milan, manufacturers of semiconductors, have opened a **U.K. Sales Office** at Prospect House, Boston Manor Road, Brentford, Middx. (Tel: 01-560-8337).

Erie Technological Products Ltd, South Denes, Great Yarmouth, Norfolk, have acquired control of **Davall Electronics Ltd**, of Northampton.

Racal Research Ltd, Newtown, Tewkesbury, Glos, now offer **thick film circuits** in batches ranging from 10 to 10,000, tested and packaged to individual requirements.

Fibre Light, Teknis House, Stoke Road, Guildford, Surrey, is a new company which has been formed to distribute **"Teknis"** continuous lengths of glass fibre optic non-coherent light guides.

Celdis Italiana S.p.A. is a new company, with headquarters in Milan and a sales office in Turin. It has been formed as the first step in a five-year plan by Celdis Ltd, of Reading, Berks, to establish a wide distribution organization throughout Europe.

Brookdeal Electronics Ltd, 2 Myron Place, Lewisham, London S.E.13, have announced a **marketing agreement** with Keithley Instruments Inc. of Cleveland, Ohio, U.S.A. Keithley are to market the Brookdeal "400" series of lock-in amplifier systems.

Carston Electronics Ltd, 71 Oakley Road, Chinnor, Oxfordshire, have been appointed sole U.K. agents for the **Sharpe Instruments Division** of Scintrex Inc., of Buffalo, New York. Sharpe manufacture headphones and microphone/headphone combination units.

The Modular Electronics Division of STC at Cefndy Road, Rhyl, will in future be known as the **ITT Manufacturing Services Division.**

Newmark Instruments Ltd, Control Engineering Division, has received orders amounting to £20,000 for electronic **motor speed control** systems from Fukuhara Industrial & Trading Company of Japan.

The Marconi Company has received orders totalling over £½M for high-power 50cm radars and radar link equipment from the Board of Trade.

Emihus Microcomponents Ltd have received an order worth more than £40,000 for the supply of **wet tantalum capacitors** for use in the West German built Leopard tanks for Nato forces.

Honeywell Ltd have been awarded a contract worth more than £1M from the Ministry of Technology, to supply **radar altimeters** for a number of R.A.F. and R.N. aircraft.

Pye Telecommunications Ltd has received orders for **mobile radio equipment** totalling £75,000 from Abu Dhabi, one of the Trucial States in the Arabian Gulf. The system includes full radio telephony for the Abu Dhabi Police.

Standard Telephones and Cables Ltd of London have received a follow-up order worth approximately £160,000 for STAN. 37/38/39 **instrument landing systems** to be installed at Australian airports.

Decca has been awarded a contract by the Australian Government valued at $1.5A million for the supply of a **Decca Navigator chain** to be located at Port Hedland, Western Australia.

Teleng Ltd, manufacturers of u.h.f. and v.h.f. television distribution systems equipment, has moved to Arisdale Avenue, South Ockendon, Essex, RM15 5TR.

Distortion Factor Meter

Five-range instrument covering 0.1% to 100% full-scale

by L. Haigh

While high fidelity reproduction cannot be described as an exact science, since it is to some extent a subjective matter, it is an undoubted advantage to be able to measure the amount by which an audio amplifier and other components fall short of technical perfection. In the case of an audio amplifier, two main factors are frequency response and non-linearity. The first is comparatively easy to measure, requiring only an audio generator covering the required frequencies and a suitable output measuring meter.

Non-linearity, which means that the degree of amplification varies with the amplitude of the signal, requires more refined measuring equipment to determine its extent. Non-linearity has at least two effects, in that alien frequencies (harmonics) are introduced and when, as is almost always the case in practice, more than one frequency is being handled by the amplifier, further alien frequencies (intermodulation) are produced. The extent of non-linearity, can be readily expressed by the percentage of harmonics introduced by the amplifier compared with the fundamental frequency of the test signal.

British Standard 3860:1965, Part 3, sets out the position clearly as follows:—

Paragraph 9(a) "*Measurement of harmonic distortion.* To ascertain the output power at which the distortion becomes a specified value, it is convenient to use a distortion factor meter, which automatically sums the power in all the harmonics and gives the result as a percentage of the output voltage."

A block schematic diagram of equipment to measure total harmonic distortion is shown in Fig. 1. In addition to the amplifier under test, there are required,

(a) an audio generator, the total harmonic distortion of which should be lower than that of the amplifier being tested, or if not, a filter must be used to reduce harmonics. B.S.3860: 1965, paragraph 7, specifies that the audio generator's total harmonic distortion should not exceed one-fifth of that of the amplifier being tested.

(b) some form of output measuring device and

(c) a distortion factor meter.

Fig. 2(a) is a copy of a trace obtained on a Cossor model 1035 oscilloscope, using a sine wave directly from a low-distortion audio generator, the measured total harmonic distortion of which is less than 0.1%. This same signal source was then applied to a voltage amplifier, in this case a single triode valve, at sufficient strength to overload it and to produce a measured total harmonic distortion of 10%. The considerable flattening in Fig. 2(b) of the lower peaks shows the distortion to be mainly second harmonic. These waveforms were taken at a middle frequency where there was no phase shift of harmonic frequencies as compared with the fundamental. If oscillograms were taken at either very low or very high audio frequencies where phase shift does occur, the wave form of Fig.2(b) would slightly different, depending on the degree of phase shift.

While this trace is interesting, as showing the effect of one kind of harmonic distortion on waveform, it also reveals that a high degree of distortion is needed to make a noticeable difference to it. An oscilloscope can, of course, be used in another way to reveal amplifier distortion, as well as phase shift, by connecting one set of deflector plates to the amplifier input, and the other plates to its output. Distortion will then be indicated by the departure of the trace from a straight line. To measure the total harmonic distortion of a high-fidelity amplifier, which can probably be regarded as one which, among other things, has a total harmonic content of 1% or less, a distortion factor meter is needed.

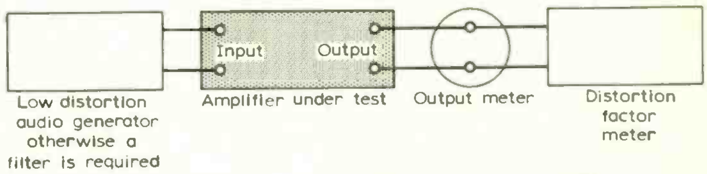


Fig.1. Block diagram of the set-up for measuring amplifier distortion.

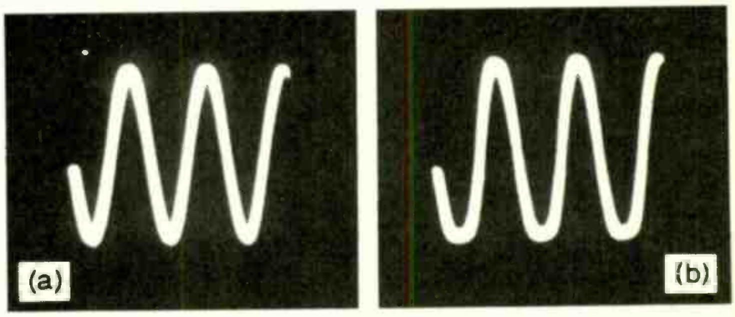


Fig.2. Oscilloscope trace of an 800-Hz wave having less than 0.1% distortion (a) and 10% distortion (b).

For certain purposes it may be more useful to be able to measure the percentage of the individual harmonics, but this needs relatively elaborate and expensive equipment, as well as taking much longer.

While B.S. 3860:1965 specifies a test frequency of 1000Hz ±2%, as a standard for comparing one amplifier with another, it is useful to apply other test frequencies also. It is well known that some amplifiers show a considerable increase in harmonic distortion at very low and high frequencies compared with 1000Hz. For this reason, this distortion factor meter has been made capable of measurement not only over the full range of audible frequencies, but beyond them at each end.

The principle of operation is simple, in that the fundamental-frequency signal introduced into the amplifier is removed (and only that frequency), and the remaining signals, which mainly represents harmonics introduced by the amplifier, are compared with the fundamental before its rejection.

The instrument to be described uses 6 transistors and two diodes and is powered by a 12-volt battery, the current consump-

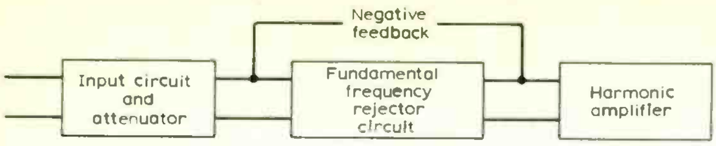


Fig.3. Block schematic of distortion factor meter. The rejector is cut out in position D of switch 2 in Fig.4.

tion being 6 mA. It has proved simple and reliable in use and as the percentage of distortion is indicated directly on the meter, readings can be taken quickly. It may be divided into three sections:—

(a) Input circuit
(b) Fundamental-frequency rejection
(c) Harmonic measurement.

Design of the distortion factor meter

Figs. 3 and 4 show respectively a block diagram of the instrument and the complete circuit. Taking each of the three sections in turn:—

(a) The input circuit comprises a simple attenuator and an emitter-follower transistor Tr_1. To give the full range of readings, the prototype requires an input of not less than 0.6 volt r.m.s., and for signals of this amplitude up to about 6 volts r.m.s. the switch S_1 is closed. By opening S_1 the maximum input which can be handled is about 250 volts. Tr_1 has an input impedance of 100,000 ohms, which has little effect on the input attenuator, while its output impedance, being low is not affected by the rejector circuits which follow.

(b) The success or otherwise of these distortion-measuring equipments depends mainly on the circuit for rejecting the fundamental test frequency. To measure adequately distortion as low as 0.1%, an attenuation of at least 70dB at the test frequency is needed. At the same time the second harmonic should be unchanged in value, or as nearly so as possible, or the accuracy of total distortion measurement will be impaired.

An attenuation of 70dB corresponds to a voltage reduction, the load resistance remaining constant, to approximately 0.032% of its original value. Using this distortion-factor meter connected directly to the output from a really low distortion audio generator, it is readily possible to obtain a distortion reading of 0.03% or less, showing that sufficient rejection of the fundamental-frequency is attained by means of the filter circuit used.

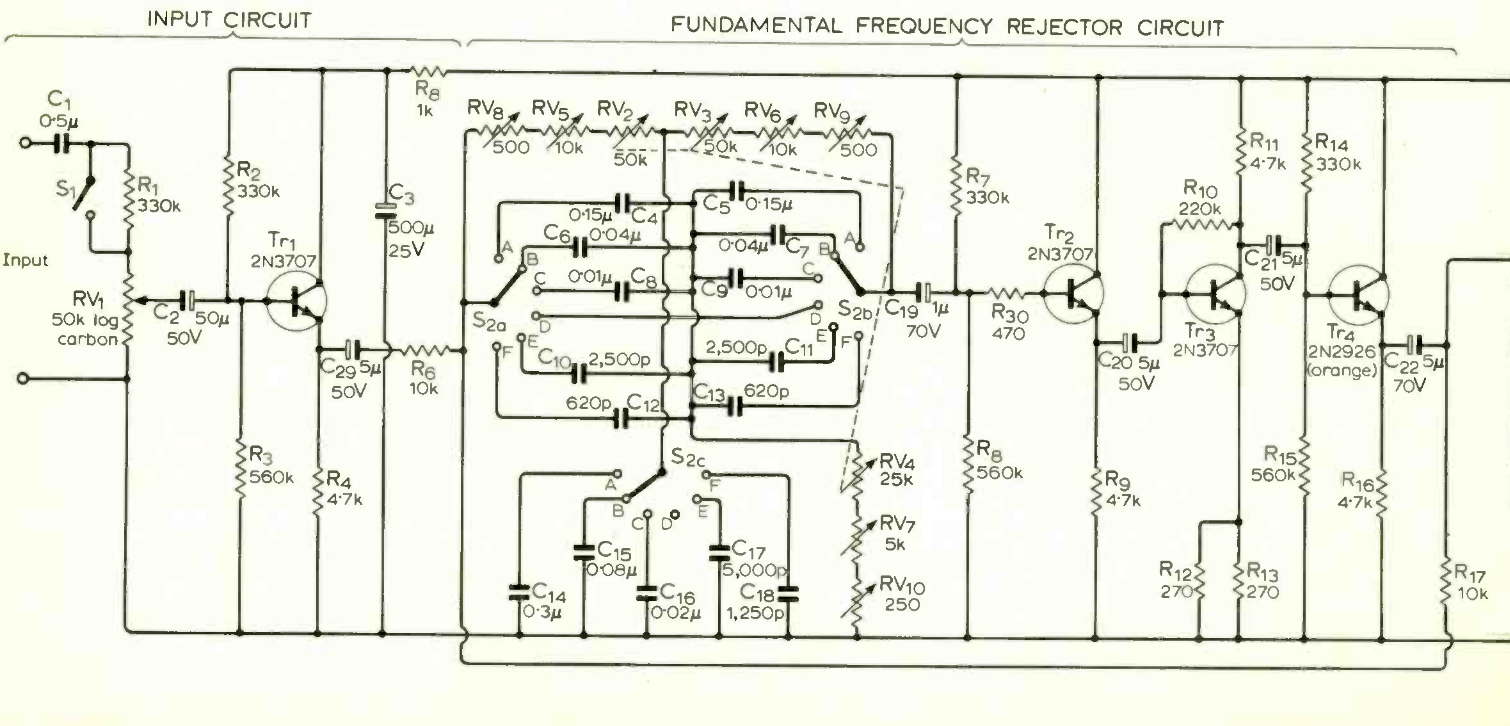
While it is possible to use a Wien bridge circuit for rejection of the fundamental, and this has the advantage of needing fewer components than the twin-T filter, the latter was chosen, since the full output is available from it, compared with only one-third from the Wien bridge. In addition, both the input and output circuits can be earthed. The filter is variable and will reject frequencies from 20Hz to 20kHz. The basic circuit and principle is shown in Fig. 5 in which $R_1 = R_2 = 2\,R_3$ and $C_1 = C_2 = C_3/2$ and the rejection frequency is $1/(2\ R_1C_1)$ with R_1 in ohms and C_1 in farads.

To cover the entire audio frequencies of 20Hz to 20kHz 5 switched ranges are used, each range having a ratio of about 4 to 1. While it is possible to cover this band in three ranges with a 10-1 ratio, this would result in rather too great a variation in the input impedance of the filter.

Each range is covered by variable resistors or potentiometers, the coarse control being a 3-gang potentiometer, RV_2 and RV_3 of 50,000 ohms each and RV_4 of 25,000 ohms. To cover the slight mismatching of the capacitors C_4 to C_{18} and the ganged potentiometer, medium matching controls RV_5, RV_6 and RV_7 are used, together with fine adjustments from RV_8, RV_9 and RV_{10}. These last need not generally be used, except to measure total distortion of less than 1%.

While the twin-T filter gives very high attenuation of the fundamental frequency it also reduces to a quite unacceptable extent the second and third harmonics. To improve its selectivity, negative feedback is arranged over the filter. This is provided by transistors Tr_2, Tr_3 and Tr_4 and associated components. Tr_2 and Tr_4 are emitter-followers to provide a high input impedance (approximately 100,000 ohms) and low output impedance. Tr_3 is adjusted, by means of the unbypassed emitter to earth resistors R_{12} and R_{13} to give a voltage gain of about 30. By taking the output from Tr_4 via C_{22} and R_{17} to the input of the filter, sufficient negative feedback is applied to render the filter's attenuation of harmonics very small. Without negative feedback, the second harmonic is reduced by about two-thirds and the third harmonic by about 40%. With the degree of feedback used, the second harmonic is reduced by less than 10%, which allows reasonable accuracy of measurement of distortion.

Fig.4. Complete circuit diagram of distortion factor meter.



Of the six contacts in each arm of S_2, one (indicated by D) is used to disconnect the filter, so that by setting the switch S_3 of the measuring amplifier at 100%, the input signal can be adjusted by RV_1, and if necessary S_1, to give a full-scale reading of 100 on the meter M, and this is the reference level.

When the filter, by means of the required capacitance range and adjustment of the variable resistors RV_2 to RV_{10} has been set to reduce the fundamental frequency as much as possible, any alternating voltage across R_{16} represents distortion, noise or other spurious signals. The noise and distortion introduced by this distortion factor meter are of the order of 0.02%, so that for most purposes, alternating voltages read on the meter can be regarded as representing distortion.

Tr_5 and Tr_6 with associated components and the meter M comprise a sensitive a.c. millivoltmeter, or it could be regarded as a millivoltmeter if it were calibrated. It is, of course, used for comparison, in conjunction with the potentiometer S_3 and resistors R_{18} to R_{23}, of the harmonics, left after the rejection of the fundamental, with the fundamental. By returning the lower ends of C_{27} and C_{28} to the emitter of Tr_5, some negative feedback is provided, which is useful in adjusting the amplifier gain to some extent. The potentiometer made up of S_3 and resistors R_{18} to R_{23} form the distortion range control. When S_3 is in the position shown in the diagram (f) the meter indicates between 10% and 100% distortion, as well as being used to adjust the input signal to give a reading of 100 when the filter is switched out of use.

Lower degrees than 10% of distortion require the switch S_3 to be moved towards R_{18} and in the position for full gain the meter gives a maximum reading of 0.1% distortion. The switch S_3 gives the following maximum distortion ranges: (a) 0.1%, (b) 0.3%, (c) 1%, (d) 3%, (e) 10% and (f) 100%.

Construction

The layout of the components is not critical, but if low levels of distortion are to be measured, it is essential to enclose the equipment in a metal case, which is connected, of course, to the earth line of the circuit. In radio workshops and laboratories there is considerable pick up of 50-Hz voltages from the mains unless reasonable screening is used.

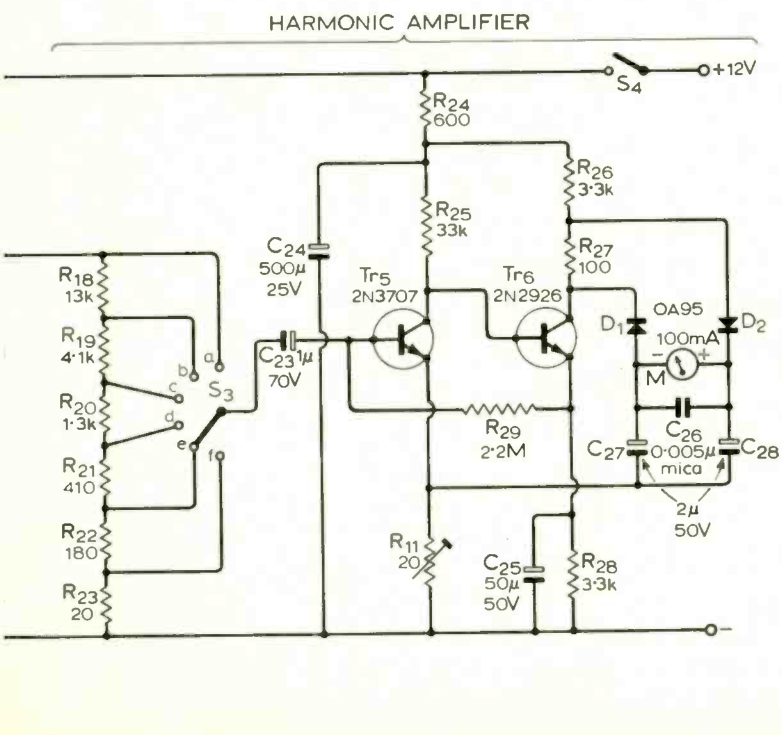


TABLE 1

Range	Frequency	Capacitance
A	20-80 Hz	$C_4=C_5=0.15\mu F$, $C_{14}=0.3\mu F$
B	80-320 Hz	$C_6=C_7=0.04\mu F$, $C_{15}=0.08\mu F$
C	320-1280 Hz	$C_8=C_9=0.01\mu F$, $C_{16}=0.02\mu F$
D	filter disconnected	
E	1.25-5 kHz	$C_{10}=C_{11}=2{,}500pF$, $C_{17}=5{,}000pF$
F	5-20 kHz	$C_{12}=C_{13}=620pF$, $C_{18}=1{,}250pF$

As the harmonic amplifier Tr_5 and Tr_6 gives high gain, it is advisable to keep its input leads away from the output. Apart from these two points the layout of components is a matter of convenience of construction and operation.

As there are a fairly large number of controls a front panel area of not less than 12 in. × 10 in. is advisable and 16 gauge aluminium is suitable, if a vertical flange is provided to stiffen it. In the prototype, a chassis of $3\frac{1}{2}$ in. deep is used and the capacitors C_4 to C_{18} are mounted underneath with the switch S_2. High-stability resistors have been used throughout to reduce noise and for the same reason capacitors with higher working voltages than are necessary for safety have been used.

The values of the capacitors, C_4 to C_{18}, form, of course, the capacitance elements of each of the five ranges and their values are shown in Table 1.

To obtain some of these values of capacitance it will probably be necessary to connect more than one in parallel (or in series), and in any event a capacitance bridge should be used to measure them. The exact values are not of vital importance, except that too great a divergence will affect the range of frequencies covered. What is important is that C_4 and C_5 are within, say 5% of each other and that C_{14} is within 5% of double the value of C_4 and C_5. The same consideration applies to the other four ranges.

A 12-volt battery is used and as the current consumption is only 6mA, any transistor receiver type of battery may be used. As the collector current of T_6 is low, there is no risk of damage to the meter through overloading.

While it is not strictly necessary for the operation of the instrument, some form of scale with five ranges marked A, B, C, E and F and with the approximate frequencies, increase the convenience and speed of operation, if it is attached to the control knob of the three-gauge coarse rejection control RV_2, RV_3 and RV_4.

The transistors used have rather short connecting leads, and so it is important to use a pair of pliers or similar device to form a heat sink when soldering them into position. Most of the components and the transistors are mounted on tag boards above the chassis in the prototype, as this form of construction lent itself well to the numerous changes and experiments which have been needed in developing this instrument.

Adjustment

When the wiring has been completed, the only adjustment required is the setting of the preset variable wire-wound resistor RV_{11}, which is in the emitter circuit of Tr_5. Increasing its value reduces the gain of the measuring amplifier by increasing the negative feedback applied from the collector of TR_6 to the emitter of Tr_5. It is suggested that it should be adjusted by:—

(a) Setting S_3 to the 100% position.
(b) Closing S_1
(c) Adjusting RV_1 to maximum
(d) Setting S_2 to position D (filter out)
(e) Applying an audio voltage of approximately 0.5 to 0.7 volt r.m.s.
(f) Adjusting RV_{11} to obtain a full-scale reading on the meter.

This setting determines the sensitivity of the instrument; that is, the minimum input signal to allow the full range of distortion measurements to be made. Constructors may have their own ideas as to its setting and the sensitivity required, but with the prototype a sensitivity of 0.5 to 0.7 volt r.m.s. has proved satisfactory in use.

Operation

As shown in Fig. 1 the amplifier under test is supplied with a low-distortion sinewave of the required frequency, either from a low-distortion oscillator or the more usual type of oscillator with a filter. An output meter and the distortion-factor meter are connected, in parallel, to the amplifier output.

If a voltage amplifier is under test the output meter will probably be a valve voltmeter or a transistor a.c. millivoltmeter with voltage ranges as required. When the required output has been obtained from the amplifier, as measured, the distortion meter is brought into operation, and the following sequence is advised.

1. Set S_3 to 100%
2. Set S_2 to position D (filter disconnected)
3. Switch distortion meter on:
4. Adjust RV_1, and if input to meter is high enough, open S_1, to obtain the full-scale reading, 100 on the meter.
5. Switch S_2 to the required frequency band.
6. Set the medium frequency controls RV_5, RV_6 and RV_7, and, fine frequency controls RV_8, RV_9 and RV_{10} to approximately their middle positions.
7. Adjust RV_5, RV_6 and RV_7, (three gang) to obtain the minimum meter reading. If this is below 10% of full scale, move S_3 to the 10% position.
8. Adjust RV_5, RV_6 and RV_7 in turn, and repeat adjustments until the minimum meter reading is obtained.
9. With each reduction of the meter reading below 30% of full scale move S_3 to the next lower distortion setting. It will usually be found that for working below 1%, that is, when the meter shows a reading of 100 on the 1% distortion setting of S_3, that the fine frequency controls RV_8, RV_9 and RV_{10} will be required.
10. The general principle, of course, is to reject the fundamental frequency introduced into the amplifier, by means of repeated adjustments of the frequency controls RV_5 to RV_{10}, to obtain the lowest meter reading. That meter reading, when related to the setting of S_3, indicates the total harmonic distortion of the amplifier under test.

With a little practice the above adjustments can be made quickly. While the meter will not be damaged by overload on account of the small collector current of T_6, there is no point in overloading it unnecessarily. A few simple precautions will obviate this, such as:—

(a) If it is required to move the main frequency control RV_2, RV_3 and RV_4, set S_3 to 100%.

(b) Set S_3 to 100% before making any adjustments to the signal generator or the amplifier.

If the input signal to the meter is too small to give a full-scale reading in (4) above, the meter can still be used but it will be necessary to multiply the final setting by a fraction, as follows:—

Final distortion reading, say, 0.25% x 100÷(input reading on setting up).

For example, if a reading of 50 can be obtained, the final meter reading of distortion should be multiplied by 2. RV_1 can be adjusted to give a meter reading which allows a convenient multiplier to be used, such as 2, 3 or 4.

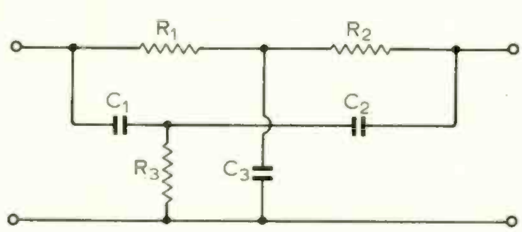


Fig.5. Basic circuit of twin-T filter used to reject the fundamental frequency.

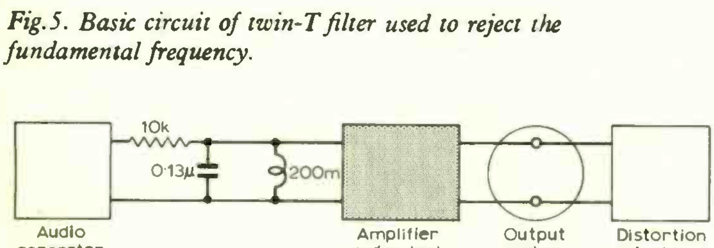


Fig.6. Simple tuned filter for 1kHz to reduce the harmonic content of an audio signal generator.

Acknowledgements

It is suggested that readers and constructors of this meter may find it helpful, if they wish to make standard tests of amplifiers for harmonic distortion, to obtain B.S.3860:1965. This can be obtained for 6s, plus postage, from British Standards Institution, Sales Branch, 101 Pentonville Road, London, N.1.

The author wishes to thank Dr. Arthur R. Bailey, for his article in *Electronic Technology*, Febuary 1960 on "Low distortion Sine Wave Generator". This instrument uses a Twin-T filter for producing sine waves and a brief reference in the article to using this filter for measuring distortion suggested this instrument.

Acknowledgement and thanks are also due to Mr D. E. O'N. Waddington, for his article on a "Silicon Transistor Millivoltmeter" in March 1966 *Wireless World*. The writer built one of these instruments and it is most useful for audio-frequency measurements. The circuit of its output stage and meter-rectifier arrangement has been used in the distortion-factor meter.

Appendix

A filter circuit for use at a frequency of approximately 1kHz to enable the usual type of Wien bridge audio generator to be used is shown in Fig. 6.

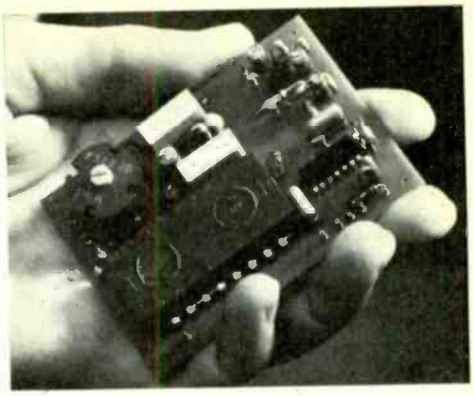
Provided that the generator's frequency is stable, its distortion can, by means of a simple tuned circuit interposed between the generator and the amplifier under test, be reduced to about one-fifth. If it is desired to operate at other frequencies, it is necessary, of course, to use different values of inductance and capacitance. It must be emphasised that this arrangement is less convenient than using a low-distortion (say less than 0.05% distortion) oscillator, but it makes possible measurements with a much less expensive generator.

To operate such an arrangement, it is necessary to vary the frequency of the generator until maximum output is obtained from the filter, and this can be done by setting S_2 to position D and S_3 to 100%. The remaining operations are the same, of course, as without the filter. For a filter of 1kHz an air-core inductance of 200mH with a parallel capacitance of 0.13μF are needed. It is essential not to use an iron core, as this itself introduces considerable distortion. The inductance consists of 4200 turns of No. 34 s.w.g. enamelled-copper wound on a former ½in. in diameter and 1in. wide. No insulation between the layers of the wire is needed, but they should be wound on the wooden or paxolin former reasonably tidily.

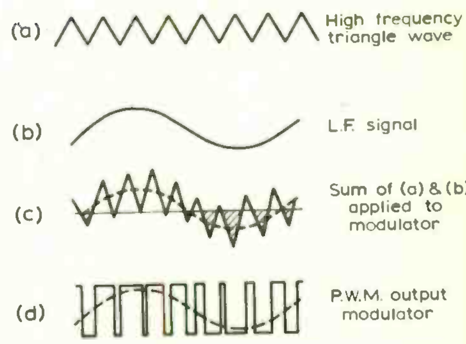
The usual type of Wien Bridge oscillator produces distortion in the region of 0.2% to 0.5%, and such a filter by reducing this distortion to less than 0.1% makes it possible to measure lower levels of distortion with a comparatively inexpensive generator.

Components on Show

A selection of items seen at the London Electronic Components Show



Complete p.w.m. amplifier.



Generation of a p.w.m. carrier.

The title of the show held at Olympia from May 20-23 and the above heading focus on components, but on reflecting on what we saw and on the information sent to us by exhibitors we feel bound to put the question "What is a component?" Visitors to the biennial Components Show sponsored by the Radio & Electronic Component Manufacturers' Federation and the intervening Instruments, Electronics & Automation Exhibition promoted by five industrial organizations including the R.E.C.M.F. must ask "What is the difference?" Each seems to present the products of a fairly representative cross-section of the electronics industry—whether it be components, instruments, systems, processes or equipments.

It will be realized that it is impracticable, even if we utilized every editorial page to give a comprehensive review of a show offering such diverse "components". We have, therefore, selected a few of the many interesting products on show and give a brief description of each in the following few pages.

This was the 21st Components Show and for the first time overseas exhibitors were permitted and 75 foreign firms were represented. The total number of exhibitors increased by 40% compared with the last R.E.C.M.F. Show reaching a record of 436. During the four days of the show the overall attendance totalled 62,600—an increase of nearly 3,500 on the previous show—and of this number 3,800 were from overseas—some 50% more than in 1967.

Experimental 30W pulse-width-modulated amplifier

Mullard have developed a highly efficient power amplifier with 0.25% total harmonic distortion at 30W output. Pulse-width modulation is a technique that enables linear signals to be amplified in a digital manner.

The active devices, in the high current stages of the design, operate purely as switches and thus have two states—the saturated "on" condition and the "off" condition. Provided fast-switching transistors are used, the main dissipation is due only to the saturation losses of the transistors, which are small. Such a system allows collector efficiencies of 90 to 95% to be obtained—only 5 to 10% of the power taken from the supply appears as heat in the active devices.

The generation of a p.w.m. carrier is shown above. After power amplification the pulse train is applied to a low-pass filter, the output of which is the original l.f. signal. This signal is fed to the load in a conventional manner.

Raising the p.r.f. from the usual 100kHz or so (used in previous closed loop and open loop designs) to about 2MHz has the following advantages: (1) small cheap filters can be used to reduce radiation to a level adequately meeting BS.800: 1954; (2) the inter-modulation products between the pulse and l.f. analogue frequencies are very small; (3) wide-bandwidth signals up to 0.5MHz may be amplified; and (4) the ratio between switching frequency and the modulation frequency is so large that more than 30dB of feedback can be applied without instability.

The high speed modulator is built around an experimental integrated circuit, incorporating a triangular-wave generator, modulator, level changer and driver unit.

The performance of the modulator is such that a modulation index of 0.95 can be obtained at 1MHz and 0.9 at 2MHz, for a total analogue harmonic distortion less than 0.5% and 1% respectively. The switching power output circuit, which can also operate up to 2MHz has been encapsulated in a block 50 × 22 × 14mm. Mullard Ltd, Mullard House, Torrington Place, London W.C.1.
WW511 for further details

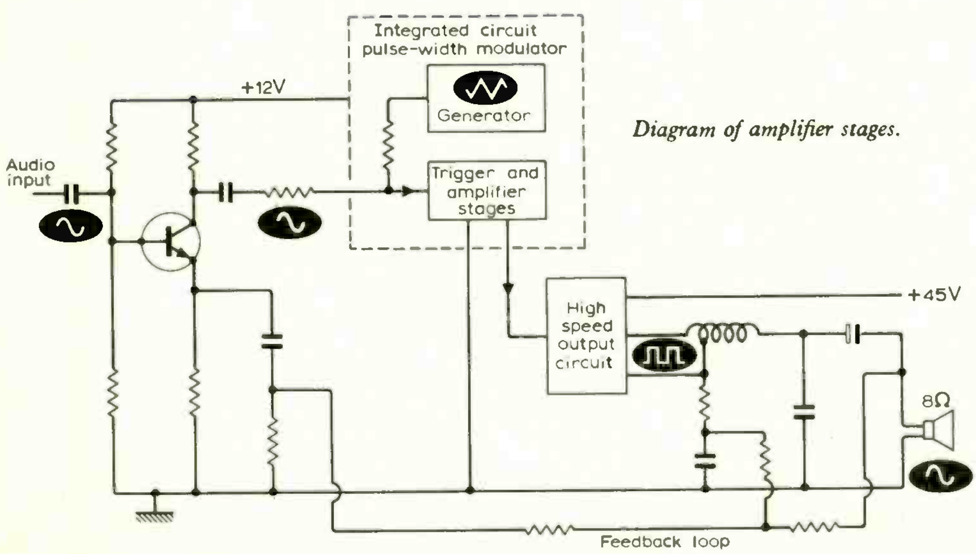


Diagram of amplifier stages.

Nickel cadmium cells

The Special Battery Division of Ever Ready is manufacturing a range of rechargeable fully sealed maintenance-free nickel cadmium cells. The range comprises six button cells, nine cylindrical and two rectangular cells.

In small quantities the prices are from 3s 10d for the smallest (90mAh) button cell to 97s for the larger 10.0Ah rectangular cell. Some of the chief characteristics of the nickel cadmium electrochemical system are: (1) almost flat voltage curve throughout discharge; (2) specially suited to continuous high rates of discharge (very low internal resistance); (3) operation over temperature range −40°C to +60°C; (4) can be charged and discharged again and again depending on conditions of use; (5) indefinite shelf life between −60°C and +60°C; and (6) good charge retention characteristics especially at low temperature. Two solid-state constant current chargers are available. Model CH12 will charge up to 12 cells in series and costs £20. Model CH20 will charge up to twenty cells in series and costs £28. The Ever Ready Company (Great Britain) Ltd, Hockley, Essex.

WW507 for further details

Digital volt/ohmmeter

This is a low-cost Russian instrument of the electro-mechanical type; all control and switching functions are accomplished by relays. The meter has automatic range and polarity selection and automatic positioning of the decimal point in the four-digit display. Significant figures from the performance data are: voltage measurement range 0.01 to 1,000V d.c. with an accuracy of ±0.2% ±1 digit; the input resistance is 1MΩ. Resistance measurements can be made between 100Ω and 1999kΩ with an accuracy of ± 0.3% ±1 digit. The measurement cycle takes three seconds. Power supply requirements are as follows:—220V±10% at 50Hz or 220V ±5% at 400Hz or 115V ±5% at 400Hz. The instrument weighs 66lb and measures 325×220×415mm. It costs £128 complete with a full complement of spares. Agents in this country are Z & I Aero Services Ltd., 44a, Westbourne Grove, London W.2.

WW 505 for further details

Solid-state communication Receiver

Frequency coverage from 10kHz to 30MHz in ten overlapping ranges is provided by the Eddystone EC 958 communication receiver introduced at the Components Show. Basic circuit configuration is governed by the tuning range in use, single or double conversion being employed at frequencies up to

1.6MHz. At higher frequencies triple conversion is used, the additional i.f. providing an incremental tuning facility which is absent on the lower frequencies. Circuit arrangements permit continuous tuning over any selected range in the high-frequency band, or high-stability operation with incremental coverage in steps of 100kHz. In the latter mode, frequencies are readable to within 200Hz and the first oscillator is locked to harmonics derived from an over-controlled master oscillator having a long-term stability of the order 1 part in 10^7. High stability working at frequencies below 1.6MHz is possible by using an external synthesizer.

Reception facilities cover c.w., a.m. and s.s.b. and (with the addition of an optional module) f.s.k.

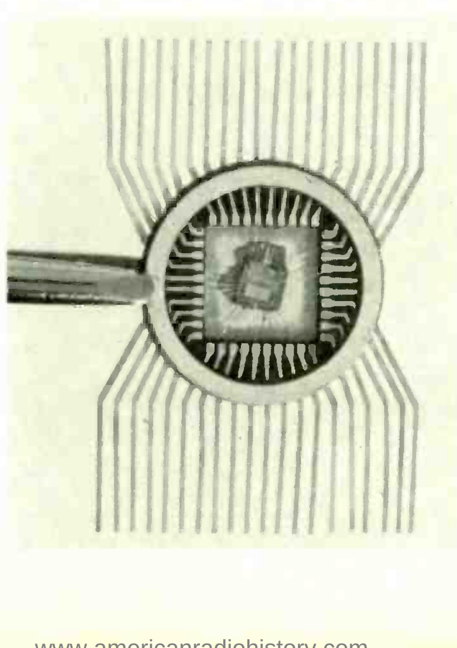
The set, the front panel of which measures 426 × 134mm, can be supplied with a matching panoramic display unit (upper unit in accompanying photograph) for applications where visual signal analysis is required. This unit (EP961) covers 50kHz to 60MHz using three plug-in r.f. tuners. All three tuners employ double conversion.

Eddystone Radio Ltd., Alvechurch Rd, Birmingham 31.

WW 514 for further details

Mosaic multiplexers for Concorde

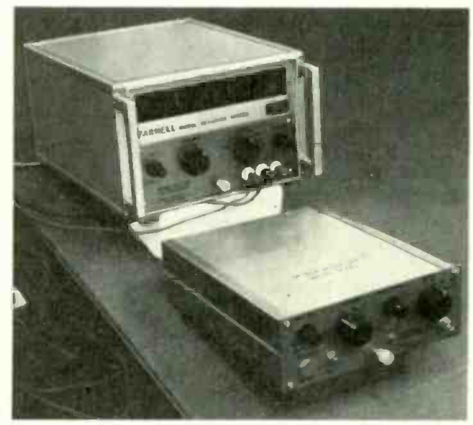
Plessey have developed a mosaic chip, consisting of eight balanced-channel multiplexers, for use in Concorde's data handling system. Small analogue signals are fed continuously from the aircraft's monitoring transducers to the switch inputs. Any one of the eight signals may be switched through the multiplexer, by feeding in an appropriate address, which is then stored and decoded to select a switch. The switch output is then fed to the magnetic flight-test recording system. The single chip replaces an array of discrete f.e.t. switches and t.t.l. currently being used in Concorde 001 and 002. Its incorporation will enable the installation to be reduced from nine racks to only one. The whole multiplexer chip is set in a 40 lead pack. The Plessey Co. Ltd, Ilford, Essex.



WW509 for further details

Modular digital measuring system

The basic structure of this modular instrument shown by Farnell is a display unit (incorporating the power supplies for the main frame and the various modules) below which is an access port to accommodate the plug-in units. This main frame, which measures 245 × 175 × 350mm, includes a non-blinking digital display which incorporates a polarity display and a wrong-polarity warning indicator. It also has a printer output socket at the rear. It operates from a.c. supplies from 110 to 250 volts, 47-400Hz, and has a 5MHz counter response.



Four plug-in modules are at present available converting the display unit into either a digital d.c. voltmeter, 1MHz counter-timer, capacitance meter or an ohmmeter.

The voltmeter module (DCV 100) is an integrating type utilizing a photo-chopper stabilized voltage-to-frequency converter and precision gate, providing true integration for best noise rejection with no drift or zero offset. It maintains a high input impedance throughout its range and its a.c. rejection characteristics ensure maximum accuracy. It measures 0.1mV to 1000V in five ranges.

The counter/timer (DFM 100) displays frequencies from 0.1Hz to 1MHz and periods from 0.1ms to 999 sec. Over-range capability provides up to 7 digit resolution with accuracy of ±0.0005% of reading ± 1 digit. Where a six-digit readout is required the first three figures are read on the kHz range and the last three on the Hz range. Its internal crystal-controlled timebase checks frequency at 1Hz, 1kHz and 100kHz. Gate times are 1ms to 10 s in five ranges.

A Wheatstone bridge circuit with automatic null-point is incorporated in the ohmmeter module (DOM 100) which enables impedances from 0.001Ω to 1000MΩ to be displayed with an accuracy of ± 0.1% of reading ± 1 digit for seven of the ten ranges.

Capacitances from 1p...F to 10^4 M F are displayed in eight ranges without manual balancing or nulling using the DCM 100 module.

Farnell Instruments Ltd, Sandbeck Way, Wetherby LS22 4DH.

WW 513 for further details

Ceramic power triode

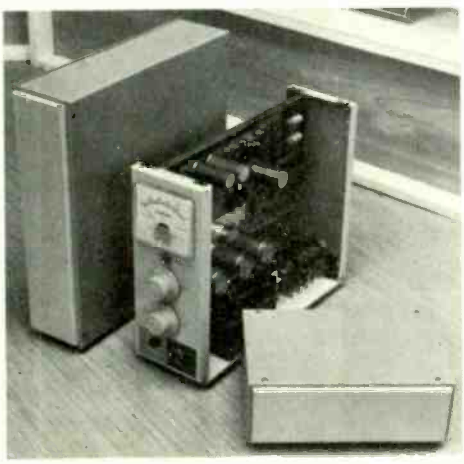
A further r.f. power valve (BR1182) has been added to the series of industrial ceramic triodes being developed by English Electric Valve company for both induction and dielectric radio-frequency heating. Of coaxial filament/grid terminal construction, this tube is forced-air cooled and has a ceramic /metal envelope. It can operate at full ratings up to 50MHz, and under class C unmodulated conditions will give an output at the valve anode of 50kW. The valve, which is 371mm high and 254mm in diameter, has a maximum continous anode dissipation rating of 15kW. The net weight is approximately 35lb (16kg).

English Electric Valve Co., Chelmsford, Essex.

WW 516 for further details

P.V.C. clad instrument cases

A range of instrument cases was announced by West Hyde at the exhibition that employs p.v.c. coated steel side panels and p.v.c. coated aluminium front and back panels in 24 different sizes. The cases arrive packed flat for assembly by the customer to minimize storage and handling problems. Main advantages claimed for the p.v.c. finish are ease of cleaning, no paint to be scratched, ease of marking out, resistance to scuff marks and attractive appearance. The cases

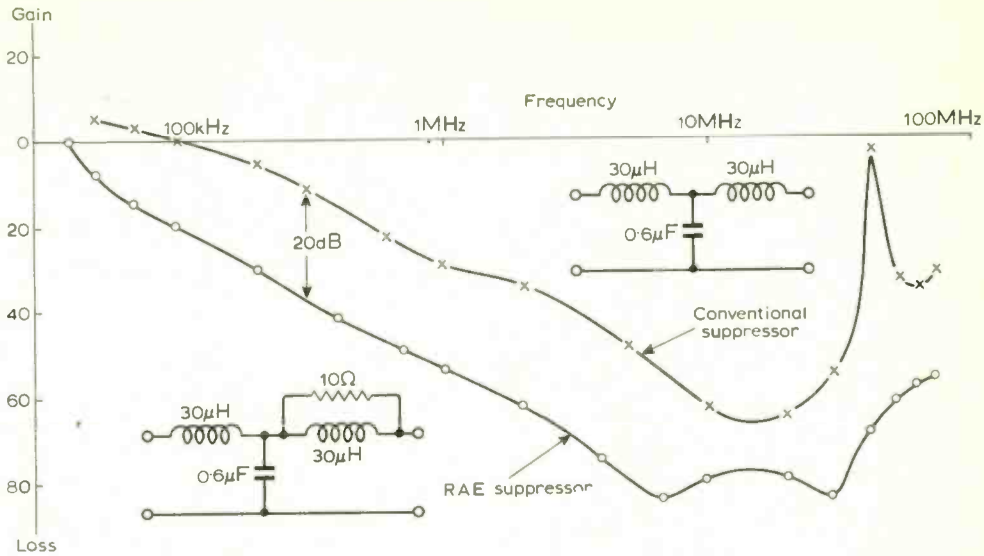


are called the Mod-2 range, and as an example, one measuring 9 × 10 × 6.5in. costs 58s 6d. complete with chassis. West Hyde Developments Ltd., 30 High St., Northwood, Middlesex.

WW 503 for further details

Radio interference suppressor

It is well known that the performance of a suppressor depends on the load connected to it. It can be shown theoretically that there is always a critical load, for a given frequency,



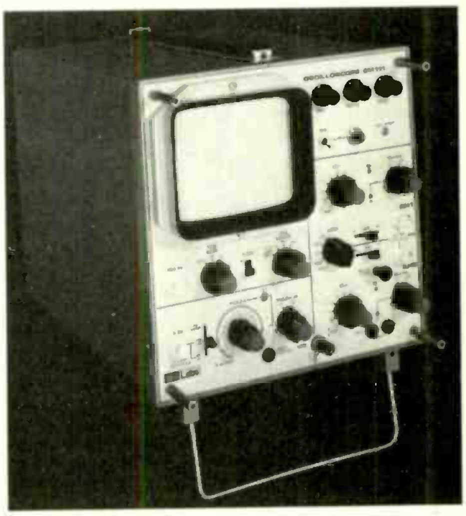
which results in the worst performance of the suppressor even to the extent of there being an actual voltage gain rather than a loss. The 'critical' loads are those which form a series resonant circuit with Thévenin's impedance of the suppressor. Consequently the transmission gain condition can be avoided by introducing damping components in the suppressor circuit. Such damping is the subject of Royal Aircraft Establishment Patents JR 2351/01 and JX 2491/01. The curves in the above diagram show that by the simple procedure of adding a resistor to a conventional suppressor a general improvement of 20dB is obtained. Royal Aircraft Establishment, Farnborough, Hants.

WW510 for further details

Double-beam oscilloscope

One of the main features of this new oscilloscope is the large useful screen area (10 × 8cm) in a case that is only 35.5 cm long. The short-necked tube responsible for this has been developed for this 'scope and it employs a p.d.a. and an e.h.t. of 4kV. In order that the complete leading edge of waveforms can be viewed a 170ns delay-line has been incorporated in the Y amplifiers. Y bandwidth (rise-time 19ns) extends to 18MHz (−3dB) at 20mV/cm or to 5MHz (−3dB) at 2mV/cm. An 11-position Y attenuator (20mV/cm to 50V/cm) operates in conjunction with an ×1/×10 switch; max. allowable input is ±500V peak. Provided measurements are made within ±20°C of the setting-up temperature accuracy is ±5%. Input impedance is 1M shunted by 35pF on all ranges. The following Y channel functions are provided by a five-position switch (CH = channel): (1) CH1 only; (2) CH2 normal or inverted; (3) alternate between CH1 and CH2; (4) chopped CH1 and CH2 (at 100 kHz); (5) CH1 and CH2 added algebraically. The built-in calibrator provides a 1kHz (±2%) square wave with less than a 1Ω s rise time at 100mV or 1V (±1%). The timebase has 21 ranges in a 1-2-5 sequence from 200ns/cm to 1s/cm with a switched expansion of × 1 or × 5. The triggering facilities provided are fairly comprehensive and synchronization can be obtained from either channel, an external source or from the line frequency. The timebase can be triggered from negative or positive waveforms and will free-run. The normal polarity and slope controls are incorporated. S E Laboratories (Engineering) Ltd., North Feltham Trading Estate, Feltham, Middlesex.

WW500 for further details



Kit volt/ohmmeter

Available ready to use or in "Heath Kit" form a new instrument features a single 12-position function selector switch and is capable of measuring a.c. or d.c. volts, or ohms. Indication is by a 114mm (4½in) meter which employs colour coded scales that match up with coloured lettering on the range switch for convenience. The test leads are permanently connected to the instrument and a storage space is provided for them in the meter's polypropylene case; however, a jack socket is provided for connecting accessory probes, should these be required.

The specification is as follows:—d.c. volts—1, 10, 100, 1000, f.s.d., ± 3% accuracy, input impedance = 11MΩ; a.c. volts—1.2, 10, 100, 1000 f.s.d., ± 5% accuracy, input impedance = 1MΩ, frequency response ± 1dB from 10Hz to 1MHz; ohmeter—centre scale reading 10Ω, ranges × 1, × 10^2, × 10^4, × 10^6 (measures 0.2Ω to 1GΩ).

The instrument, which is type 1M—17, costs £12.18s in kit form or £17.18s ready to use, and is available from Daystrom Ltd., Gloucester, GL2 6EE.

WW506 for further details

Circuit Ideas

Frequency divider with variable tuning

Frequency division by means of bistable stages is a well established technique. Division by any integer can be achieved by means of feedback or gated forward feed. The output waveform is rectangular, and if a sinusoidal output is required it is necessary to use a narrow-band filter which will transmit the fundamental frequency, or some selected harmonic, and reject the other harmonics. The most popular audio-frequency narrow-band filter is the parallel *T* feedback amplifier, but tuning of this type of circuit has until fairly recently been inconvenient because it involved the simultaneous variation of 2 or 3 components with fairly accurate ganging. However, a modification of the parallel *T* circuit which allows tuning by means of a single variable resistance has been published by Douce and Edwards[1]. By connecting this network in the feedback path of an amplifier, a narrow-pass amplifier of variable frequency is produced.

Since the rectangular waveform form the bistable stages is rich in odd harmonics, it is possible to tune the selective amplifier to the 3rd, 5th, etc., harmonic of the divided frequency. The overall effect is therefore to multiply the frequency of any sinewave by a factor $\frac{m}{n}$ where $m = 1, 3, 5 \ldots$ and $n = 1, 2, 3 \ldots$

A greater degree of frequency discrimination is required to separate a higher harmonic, so that it is difficult to achieve a reasonably pure sinewave output for values of *m* greater than about 7 with a single tuned amplifier. Fig. 1 shows a circuit designed to divide an input frequency by 2, with sinewave output, over a range of input frequency from about 5 to 20 kHz. Fig. 2 shows examples of input and output oscilloscope traces.

F. C. EVANS,
University of St. Andrews.

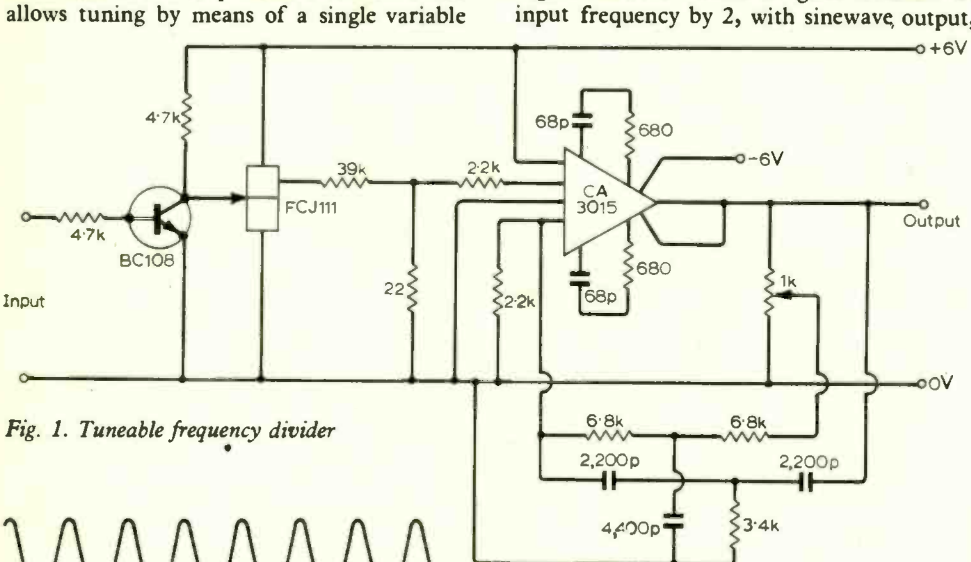


Fig. 1. Tuneable frequency divider

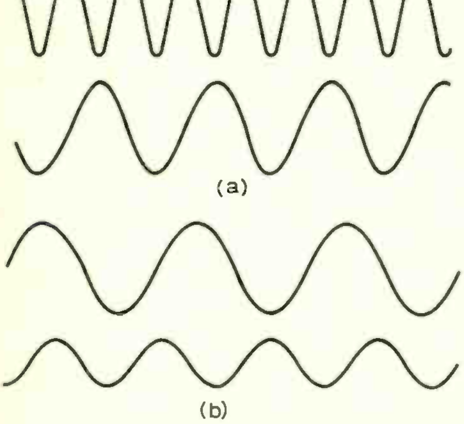


Fig. 2. Input and output waveforms for the circuit of Fig. 1. The input is the upper trace in each case. (a) 5kHz input, $\frac{m}{n} = \frac{1}{2}$. (b) 1.7kHz input, $\frac{m}{n} = \frac{3}{2}$.

1. J. L. Douce and K. H. Edwards, "A simple null filter with variable notch frequency", *Electronic Engineering*, July 1964, p. 478.

Shunt stabilizer with hum cancellation

The voltage stabilized power supply for a constant load, such as a pre-amplifier or a tuner unit, is often obtained by using a zener diode as a shunt stabilizer. However, greater flexibility of operating voltage is available if the "amplified diode" (see Peter Williams' letter in the February 1969 issue) is used. Moreover, with an active shunt component now in place of the zener diode, there arises the possibility of reducing, by cancellation, the mains ripple in the output (often desirable in the above low signal-level units).

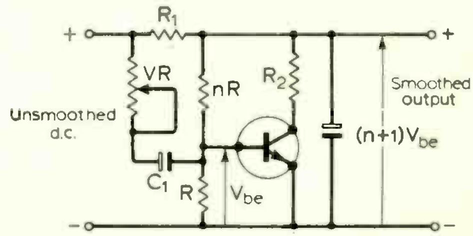


Fig. 1. Shunt stabilizer with hum cancellation.

If *VR* and C_1 are added to the standard supply circuit (see Fig. 1), then by adjustment of *VR* the ripple at the output can be reduced by at least an order of magnitude. This improvement will be maintained throughout input voltage changes of about ±10%, and load current fluctuations of about ±25%. For optimum ripple attenuation R_2 should be somewhat larger than R_1 (R_2 is present to reduce the power dissipation in the transistor), and C_1 should be large enough that no appreciable phase advance in the correction signal occurs. A typical suitable value of *VR* is 25kΩ.

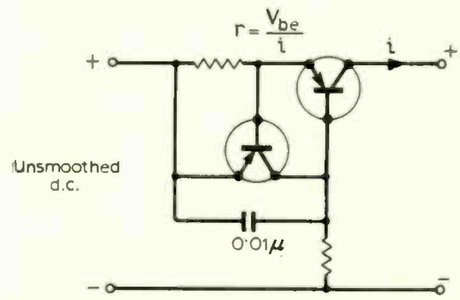


Fig. 2. Constant current source for stabilizer.

However, if further attenuation of ripple is required, or if large variations in supply voltage and load current are expected, then the circuit of Fig. 1 should be driven by the constant current source shown in Fig. 2.

R. D. L. MACKIE,
Edinburgh 9.

Correction. "Sunchronized oscilloscope time-base generator" (June). The bistable, Tr_2 and Tr_3, was incorrectly drawn. The connection between the collector of Tr_2 and the base of Tr_3 should not be tied to the positive rail.

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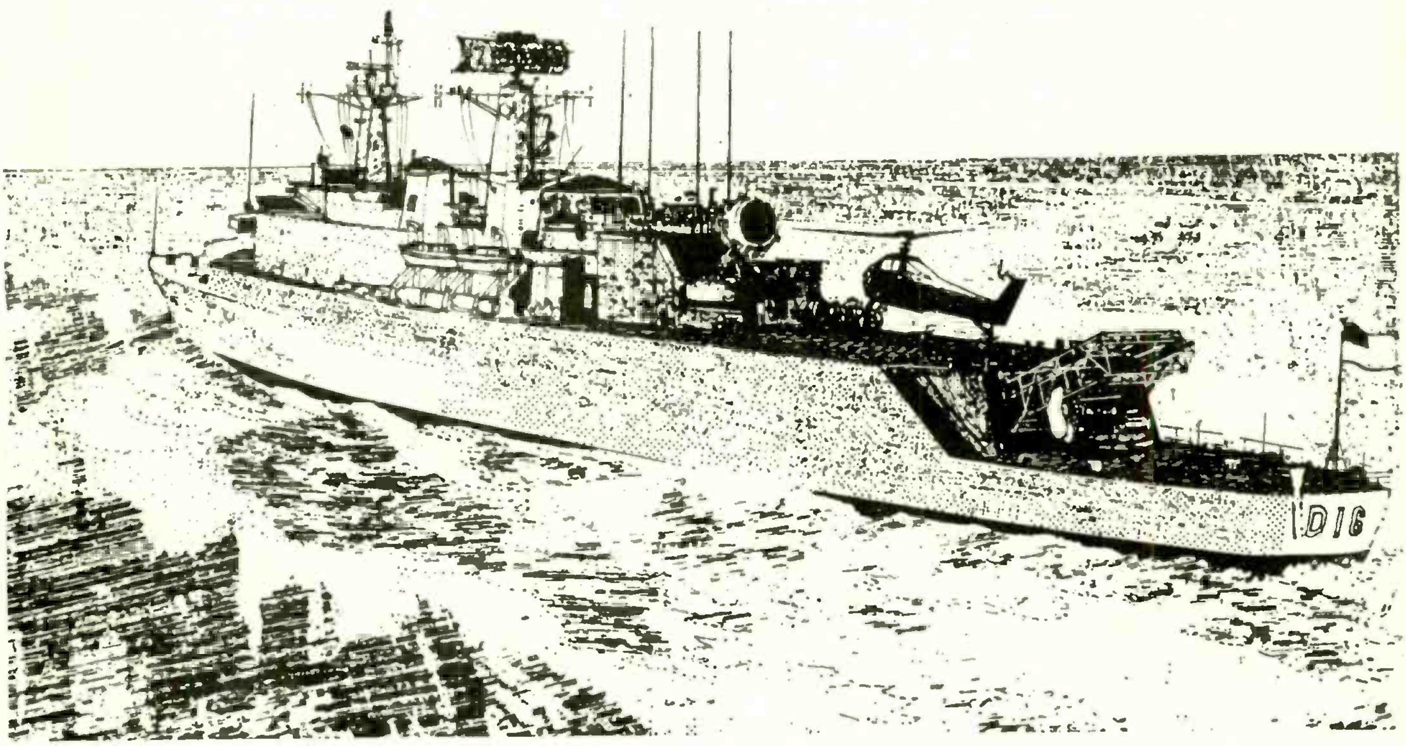

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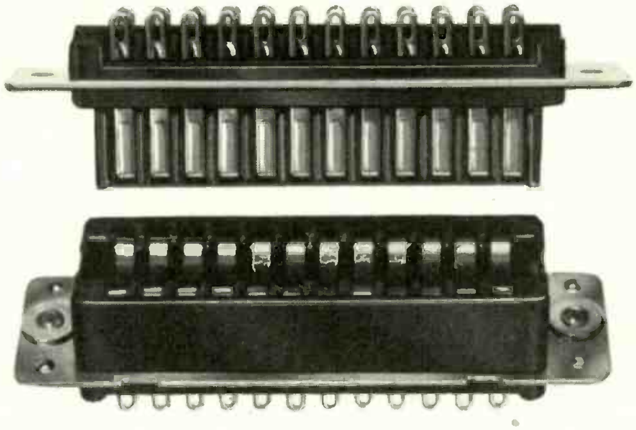

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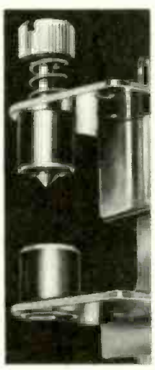

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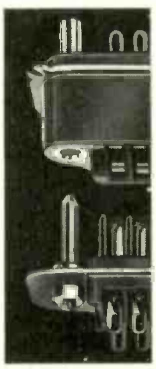

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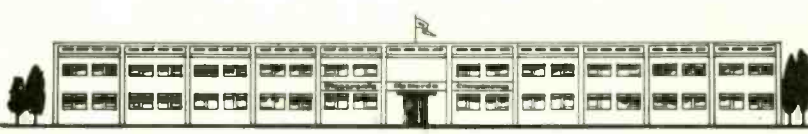

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WW—072 FOR FURTHER DETAILS

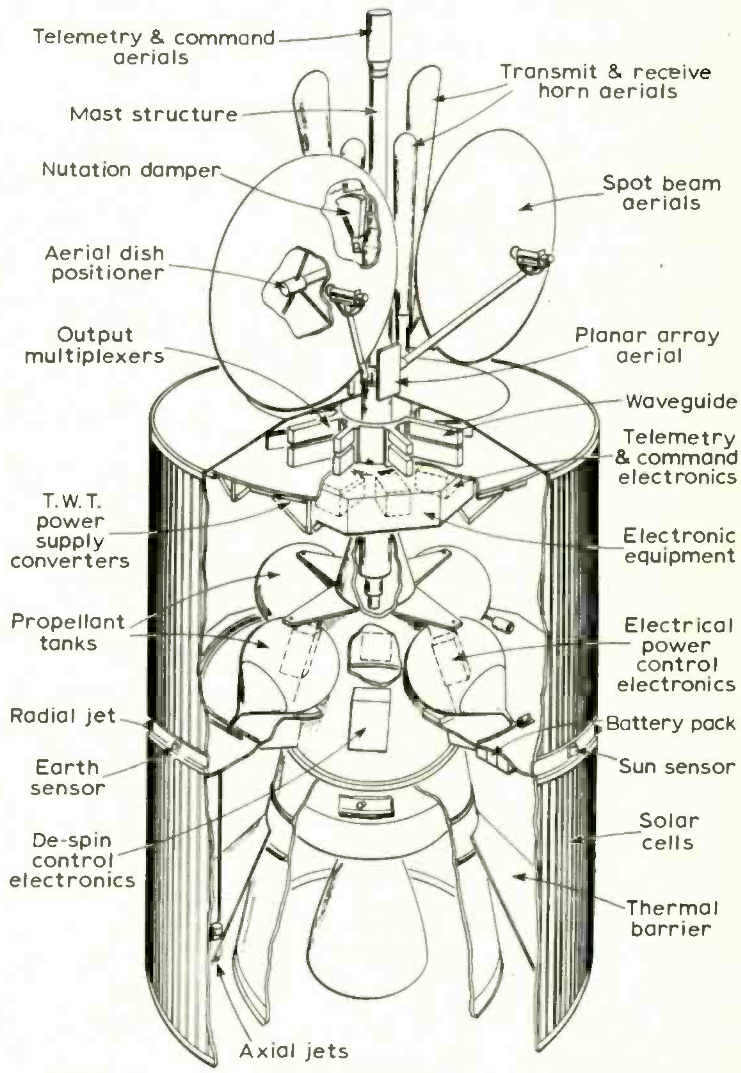
Satellite or Terrestrial Broadcasting?

Future possibilities and current projects disclosed at Montreux television symposium

Broadcasting engineers—whose livelihoods depend on our apparent willingness to go on absorbing more and more audio-visual information—are now applying themselves to the task of providing additional services for the world. In areas where broadcasting is already highly developed, such as Europe, it is a matter of finding new technical means to transmit extra programmes (produced in some cases by private or specialist organizations). In other areas, like India, Mongolia and Africa, the task is to bring services to people who at present have none at all or are very restricted (e.g. some sound but no television). In all this the emphasis is on television, which is demanded automatically, as a right, by the programme producers of Europe and as the latest modern medium by the broadcasters just starting in Africa and Asia.

It was in fact at a recent television conference that the various technical means now being considered by the engineers were brought together and examined—the 6th International Television Symposium and Technical Exhibition at Montreux, Switzerland (19th-23rd May). At a "round table conference" on world broadcasting which was one of the high points of the proceedings, the picture presented was that there are three main systems available—direct broadcasting from satellites, terrestrial broadcasting using new frequency bands where necessary, and cable distribution systems. This line-up could be simplified into a contest between terrestrial and extra-terrestrial transmissions, or between radio and cable, but, of course, whether one technique is better than another depends largely on local factors such as population density, coverage required, economic conditions and languages used. For example, small countries, or large countries containing many different language areas, might well find the selective technique of cable distribution more suitable than the "blanket" coverage of satellite broadcasting.

In conventional terrestrial broadcasting the situation doesn't look very expansive, at least in Europe. Now that Band V has been largely occupied, European attention is focused on Band VI (11.7 to 12.7GHz). J. Feldmann and G. Heinzelmann from W. Germany—where there is considerable interest in developing private television broadcasting systems—gave an account of propagation tests in this centimetric-wave region of the spectrum. It was envisaged that 75 channels of 8MHz each might be obtained in this band (600MHz altogether), but this would depend on satellite frequency allocations and in fact the total spectrum space available might turn out to be only 300MHz. A trial network of several 12-GHz omni-directional transmitters had been set up and these were modulated with signals conforming to the television standards used in W. Germany (625 lines, 5MHz vision bandwidth, negative modulation). The signals were intended to be picked up "line of sight" by parabolic aerials and fed to converters attached to standard television sets providing reception in Bands I, III, IV and V. Results showed that gaps in coverage were produced by



Intelsat IV communications satellite, a full-size model of which was displayed at Montreux. Measuring 17ft 6in high, it has five times the communications capacity of Intelsat III satellites now in service, being capable of relaying 12 television programmes simultaneously or up to 6000 two-way telephone calls. Reception is at 6GHz over a 500MHz band using two of the horn aerials; transmission is at 4GHz over 500MHz, using two horn aerials (17° beamwidth) or the two dish aerials (4.5° width) to give steerable "spotlight" beams. The cylindrical structure, covered with 50,000 solar cells, will rotate at 60 r.p.m., but the aerial assembly is mechanically de-spun so that the aerials will be continuously pointed towards the earth. Companies from 10 countries are assisting the main contractors, Hughes Aircraft. The third and fourth satellites will be assembled by the British Aircraft Corporation.

zones of total "shadow" behind obstacles, so that transmission to all houses in a town could not be ensured at reasonable cost. Consequently individual reception—one receiver per household—would not be practicable, and the best solution would be to transmit with low or medium e.r.ps to a limited number of good receiving sites at which community cable distribution systems would be set up. It might be possible to provide eight programmes in densely populated areas.

The characteristics of cable distribution systems were discussed by J. J. Geluk of the Netherlands and L. Richard of Belgium, and statistics were given to illustrate the growth of this form of broadcasting, which was largely based on the use of communal receiving aerials (c.a.t.v. systems) except in the U.K. For example there were now about 2,250 c.a.t.v. systems operating in the U.S.A. and in the near future the figure was expected to rise to about 5,000. There were about one million relay subscribers in the U.K. Advantages were quality of reception and elimination of aerials, but installation costs were high (estimated at 4,500 dollars per kilometre of system). Speakers from Asia (H. Matsuura, Japan) and Africa (A. H. Antar, Mali) felt that c.a.t.v. systems had particular advantages in their own areas where there were many different languages and religions. It was envisaged by all speakers that c.a.t.v. systems could, if required, receive their signals from direct broadcasting satellites.

R. P. Gabriel (Rediffusion International, U.K.) described an interesting new cable system that gave even greater selectiveness by allowing the subscriber to dial any one of a large number of programmes (typically 36) provided at a programme exchange. Each subscriber had a standard television set plus a unit containing a frequency converter and a telephone-type dial, and this installation was connected by a two-pair cable through a junction box (bringing in neighbouring subscribers) to a local programme exchange, which served a 0.1 square mile area and up to 5,000 subscribers. The system has been tried out in Rediffusion television studios at Teddington, Middx, and has recently been demonstrated to the F.C.C. in the U.S.A. for consideration.

Systems for India

The satellite-borne transmitter is, of course, the most advanced and exciting prospect for television broadcasting and has been the subject of speculation ever since it was first suggested by Arthur Clarke in his classic article in *Wireless World**. India is one country particularly interested in this technique—as a means of bringing social and economic enlightenment to its millions of people spread over huge areas—and F. P. Adler (Hughes Aircraft Company, U.S.A.) revealed in an invited lecture that a large team of Indian engineers had been working with his company on the design of suitable satellites and receiving systems. One satellite broadcasting station being considered was a u.h.f. transmitter producing 80 watts of r.f. power and using a 20-ft dish aerial that would give a 4 degrees beam covering the whole of India. Details of this and other designs being studied are shown in the table. Some 5,000 receiving stations were being planned, 3,000 of these being communal stations for direct reception in remote villages while 2,000 were for re-broadcasting in more densely populated areas.

In general Dr. Adler envisaged the use of u.h.f. amplitude-modulated vestigial-sideband signals for direct broadcasting (e.g. with 24dB-gain, 3-metre diameter parabolic, or 12dB-gain, corner-reflector, receiving aerials) and u.h.f. or microwave frequency-modulated signals for community distribution (3-10 metre receiving aerials). With distribution systems there would be one-channel reception for small towns and multi-channel reception for large metropolitan areas. There were economic problems in choosing for a given area between direct broadcasting and distribution, the main factors being the number of receiving sets needed in the area and the initial cost of the satellite receiving equipment. Dr. Adler said that the Intelsat IV class of communication satellites now being built (see illustration) was also suitable for a variety of broadcasting applications, but in general the purpose-built direct broadcasting satellites he described were somewhat different in structure—a central transmitting equipment dwarfed by huge, flat rectangular "wings" covered with solar cells to generate the necessarily large electrical power. He predicted that by 1975 it would be possible to generate powers of 12kW-25kW from such solar batteries.

*"Extra-terrestrial Relays", October 1945, p. 305.

Satellite designs for use in India

Band	u.h.f. only	microwave only	u.h.f. & microwave combined	u.h.f. only
Frequency	860MHz	4GHz	860MHz/4GHz	860MHz
Aerial size	20ft	4ft	20ft/4ft	30ft
R.F. power	80W	114W	160W/64W	80W
Effective radiated power	51.5dBW	52.4dBW	54.5dBW/51dBW	52dBW
Video channel capacity for TV	one	two	two	one
Telephone channel capacity	none	1800 two-way (3 carrier)	2400 two-way (4 carrier)	none
Launch vehicle	Thor Delta	Thor Delta	Atlas Centaur	ATS-F
Orbit weight	500lb	500lb	1340lb	—

In Europe, according to G. Hansen (European Broadcasting Union, Brussels), most countries are in favour of a satellite direct-broadcasting scheme using beam widths of about 1 degree. Such a beam would cover, say, the whole of the U.K. but would be too wide for smaller countries like Belgium and Holland. He foresaw that additional broadcasting services, perhaps in the 1980s, might well be a combination of 1-degree beam satellite transmissions and cable distribution. G. J. Phillips (B.B.C., London) discussed the technical possibilities in more detail, and the picture that emerged was of a number of geo-stationary satellites (perhaps 30 launched over a period of 10 years) producing a series of just overlapping 1-degree coverage areas, and providing two extra programmes in all countries of Western Europe. He thought it might be possible for coverage to be measured in units of half-a-degree beam width and that individual countries could be allocated as many of these units as they required. Beam cross-section need not necessarily be circular but could be elliptical (as might be desirable with satellites positioned over the Equator).

Transmission frequencies would be in the 11.7 to 12.7GHz band and it would be necessary to use frequency modulation or some other system such as "hybrid-p.c.m." which improved signal/noise ratio at the expense of a large bandwidth requirement. Amplitude modulation, even with the narrow 1-degree beam, would not give a good enough picture at the receiver if the transmitter were restricted to the few kilowatts of supply power that could be expected from solar batteries in the next decade. With f.m., however, it would be possible to operate satisfactorily with a few hundred watts of r.f. power. A deviation of 15MHz would be desirable and with this it would be possible to provide one television programme per 100MHz of available spectrum. An advantage of centimetric-wave over u.h.f. transmissions was that quite small "dishes" could be used for reception—a 1-metre diameter aerial would have a 2-degree beam width—so that good discrimination between transmissions could be obtained. Costs for Western Europe were estimated as 1,200 million dollars for constructing and launching 30 satellite stations, and, assuming the cost of a single receiver and aerial to be 80-100 dollars, a total of 10,000 million dollars for reception.

Among various comments, H. Juskevicius (Organisation Internationale de Radiodiffusion et Télévision, Prague) remarked that required coverage areas in Eastern Europe were similar to those in Western Europe but pointed out that there were considerable differences in time across the O.I.R.T. region.

He felt that there were possibilities for all three systems of broadcasting discussed but that there was still much work to be done in developing established methods of terrestrial broadcasting in places like Mongolia before any advanced projects were started. G. Bartlett (National Association of Broadcasters, U.S.A.) gave the impression that America was very satisfied with its already highly developed system of broadcasting and he could not see any radical changes taking place during his lifetime. He was somewhat scornful of present and future European schemes which involved costs to the viewer—the lucky Americans having everything paid for by the advertisers—and remarked that "satellite direct broadcasting violates all the principles on which our system is based".

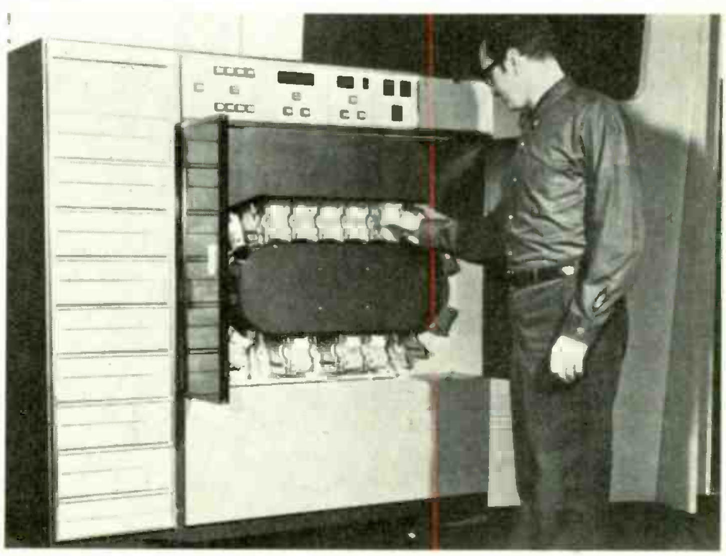
The exhibition running concurrently with the symposium provided a valuable shop-window for European broadcasting engineers and contained a fair proportion of recently introduced equipments. The most interesting of these—RCA v.t.r. cartridge recorder/player, RCA one-tube colour camera, Philips digitally controlled colour camera, Ampex v.t.r. random access programmer—have already been described in our report on the American N.A.B. Show in Washington (May issue, p. 230). Other new items at Montreux were a 3-tube separate-luminance colour camera from Fernseh; a Marconi studio vision mixer using a solid-state matrix, digital control logic and integrated circuits; a colour and monochrome video test pattern generator with a digitally constructed circle in the pattern, from Philips; an English Electric 3-inch image orthicon camera tube with a modified electron optical system giving improved signal/noise ratio; a PAL encoder from Rank Cintel; and from E.M.I. a simplified 4-tube colour camera, based on an existing design and intended for colour telecine and slide and caption scanning.

During the exhibition Ampex announced that they now have available adaptors to enable their standard 3.4MHz bandwidth helical-scan video tape recorders to record good quality PAL or SECAM colour video signals as well as N.T.S.C. colour signals. They gave an impressive demonstration using their standard VR-7003 recorder. The adaptor is based on the FAM (Frequency and Amplitude Modulation) technique, invented some years ago by the German Institut für Rundfunktechnik, which overcomes the picture degradation caused by the effect of a v.t.r's poor timebase stability on the colour subcarrier in the composite signal. In this technique a luminance signal and a 2.65MHz subcarrier are recorded, and the subcarrier is frequency modulated by a colour difference signal $R-Y$ and amplitude modulated by a colour difference signal $-(B-Y)$, these having been derived from the original composite signal. During replay the subcarrier is frequency and amplitude demodulated to recover the colour-difference signals. Inputs and outputs of the adaptor are R, G, B signals or colour-difference signals. The demonstration was warmly applauded when the audience saw the excellent quality of the displayed recording.

A new service, for recording colour television programmes on film, was presented by its originators, Colour Video Services Ltd. (London). The red, green and blue components of the colour signal are separately displayed on three 7-inch high-resolution cathode-ray tubes, each having the correspondingly coloured phosphor. The three colour-component pictures are then spectrally filtered, and the rasters are brought into registration by a dichroic mirror optical system to form a real image which is photographed on to 16mm colour motion-picture film. A feature of the system is that the camera uses a continuous-motion mechanism for pulling the film. The process is claimed to produce better quality film recordings than are possible by photographing a conventional colour television display tube.

EMI simplified 4-tube colour camera working as a slide scanner operated from a remote control panel.

Ampex v.t.r. controller allowing randam access to material on on or more video tape recorders. Television frames are individually addressed to allow automatic searching.



RCA video tape cartridge recorder/player with 18 cartridges, each providing 1-3 minutes' playing time.

M.O.S.-Bipolar Amplifiers

A discussion of wideband amplifiers, with high input impedance, built by coupling a metal-oxide-silicon field-effect transistor directly to a bipolar transistor

by J. A. Roberts and K. Rowlands†*

Although there are a number of circuit techniques open to the circuit designer who requires a high input impedance amplifier, the m.o.s.-bipolar approach is particularly attractive when a wideband amplifier is required. Advances in m.o.s. technology have appreciably improved the stability and noise properties of the m.o.s. transistor, and its use in linear circuits is therefore likely to increase considerably.

A large number of m.o.s.-bipolar amplifier configurations are possible, and Fig. 1 illustrates some practical forms. Of particular value are circuits that permit d.c. coupling between input and output; for such circuits may be conveniently cascaded, and if phase inversion occurs d.c. coupling between input and output will alleviate the stability problem.

The common drain to common emitter connection has the characteristically high input impedance of the field effect transistor and the useful voltage gain of the bipolar transistors.[1] The circuit shown in Fig. 1(a) will be examined in detail since it can easily be arranged to provide the qualities outlined above. The method of analysis can, however, be extended to the other forms. Since the gate takes no significant bias current it takes up the terminal voltage of the bias resistor. The bias voltage must be sufficient to ensure that the gate and source voltage is well above the transition voltage (turn-on voltage) of the p-channel enhancement m.o.s. (2·5–4·5 volts) without being so large as to turn the device hard on, or limit the dynamic range of the amplifier. Where possible in the circuit outlines shown in Fig. 1, the gate bias resistor is terminated at the drain as this is often a satisfactory bias condition. In some cases a better bias condition is possible as shown for the common drain to common emitter (p-n-p) case.

The circuit arrangement shown in Fig. 2(a) provides a stable connection system. The resistor R_f provides the voltage bias for the enhancement m.o.s.t. Tr_1. The overall d.c. negative feedback stabilizes the working point of the amplifier. The resistor R_f may be split and by-passed with a capacitor to prevent a.c. negative feedback. The input resistance then becomes simply the value of the resistor that is employed between the by-pass capacitor and the gate. The resistor may be made as large as 500 MΩ. It should be noted, however, that the gate capacitance, and any coupling capacitor used to connect the signal source to the amplifier, will have to be charged via the feedback resistors. The amplifier will not reach its correct operating condition until these capacitors have been fully charged.

The circuit of Fig. 2(a) has limited bandwidth due to the effects of Miller capacitance ($g_m R_L C_{b'c}$), capacitance $C_{b'e}$ and the relatively high driving impedance provided by the m.o.s.t. The bandwidth of this simple circuit may be considerably improved by the addition of a resistor R_1 as shown in Fig. 2(b). The bandwidth of the amplifier is determined by the resistor R_1 and the combined effects of Miller capacitance and the hybrid-pi capacitance $C_{b'e}$. Consequently the bandwidth may be improved at the cost of lower gain by reducing R_1. The circuit Fig. 2(b) has a bandwidth of 3·5 MHz as shown in Fig. 3. The d.c. feedback provided by R_b stabilizes the supply current to within 7% for a temperature rise above ambient of 50°C. A good substitute for the ME0413 is type 2N4289.

The amplifier requires a 12 V supply from which it draws about 14 mA at 25°C. The maximum peak-to-peak output voltage before signal compression can be observed is 2 V.*

Circuit analysis

The output characteristics of the E6018 m.o.s.t. are shown in Fig. 4.

The operating point of the m.o.s.t. may be found from

$$I_D = \frac{V_{BE}}{R_1}$$

and

$$V_{DS} = V_{DD} - V_{BE}$$

where

$V_{BE} \approx 0{\cdot}6\text{V}$, $V_{DD} = 12\text{V}$

and

$$R_1 = 68\Omega$$

The gate/source voltage V_{GS} corresponding to the bias point may be found from Fig. 4. The collector to emitter voltage, V_{CE} is

$$V_{CE} = V_{BE} + V_{GS}$$

The voltage across R_L is

$$V_{RL} = V_{DD} - V_{CE}$$

which gives the current through R_L, i.e. the collector current as

$$I_C = \frac{V_{DD} - V_{CE}}{R_L}$$

We can now obtain the approximate mutual conductance (at 25°C) of the bipolar device from

$$g_m = 39\, I_C \text{ mA/V} \quad \ldots (1)$$

when I_C is given in milliamperes.

The input resistance (neglecting $r_{bb'}$) can now be obtained from

$$r_{b'e} = \frac{\beta}{g_m}$$

where β is the low frequency current gain. Neglecting $r_{bb'}$ does not lead to serious errors at the relatively low currents employed. The output resistance of the bipolar transistors can also be neglected as it is large compared with load resistor R_L. An expression for the low-frequency gain can be easily derived using the component transfer matrices. The transfer matrices shown below the equivalent circuit Fig. 5 are multiplied to obtain the transfer characteristics of the amplifier.[2,3] From the final matrix the voltage gain is

$$G_V = \frac{1}{A} = -\frac{R_L g_{m1} g_{m2}}{\dfrac{1}{r_{ds}} + \dfrac{1}{R_1} + \dfrac{1}{r_{b'e}} + g_{m1}}$$

The output resistance is

$$R_o = \frac{B}{A} = R_L$$

The gain relation gives a value which is 15% (1·2 dB) above that measured due to the optimistic value of mutual conductance provided by equation (1). A rough estimate of the bandwidth can be obtained if the total capacitance across X-Y can be found (Fig. 5). The hybrid-pi capacitance $C_{b'e}$ may be obtained from the relation

$$C_{b'e} = \frac{g_m}{2\pi f_T}$$

Continued on page 330

* In order to preserve the highest possible input impedance the E6018 is not gate protected. Care should be taken to earth all mains operated test equipment. In very dry environments static charges may be large enough to break down the gate oxide. The gate should therefore be connected to the drain until the transistor is ready for use.

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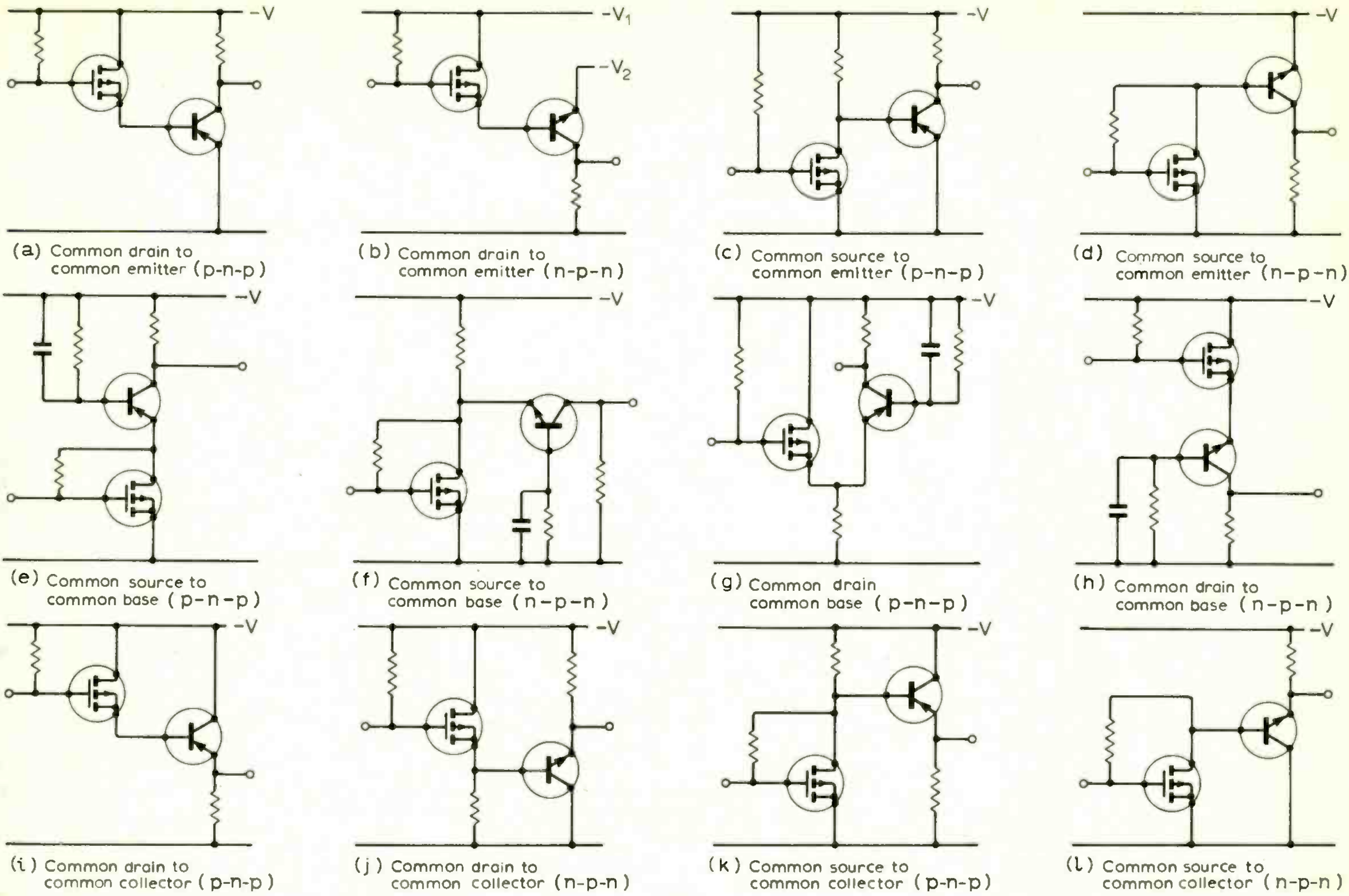
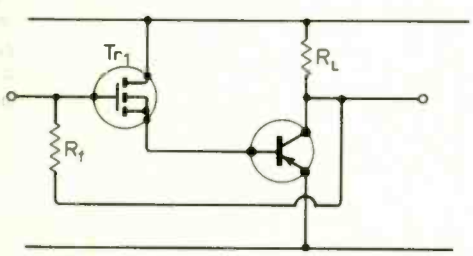


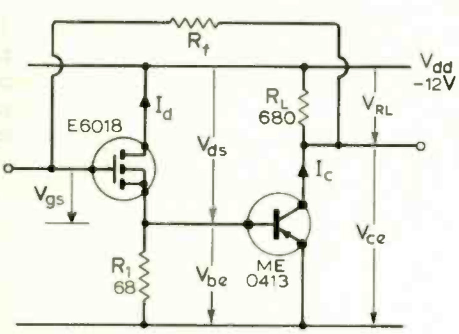
Fig. 1. Basic practical arrangements for high input impedance p-channel enhancement m.o.s.-bipolar amplifiers.

Fig. 2(a). Common drain to common emitter amplifier with feedback.

Fig. 2(b). Wideband common drain to common emitter amplifier.



(a)



(b)

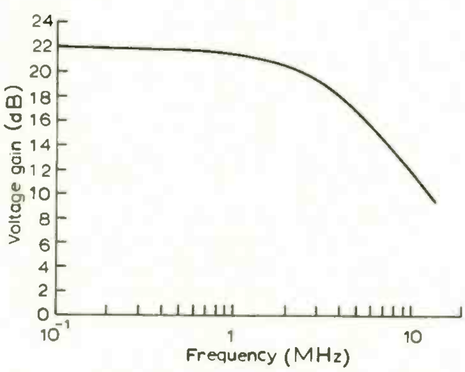


Fig. 3. Frequency response of amplifier shown in 2(b).

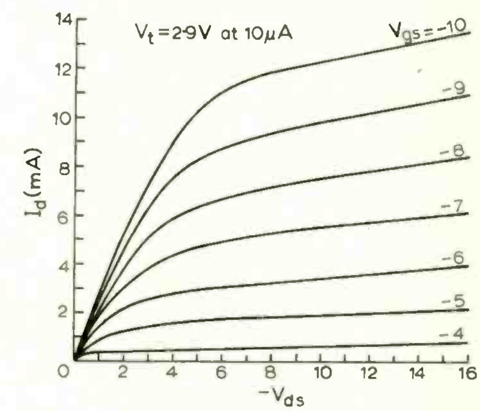
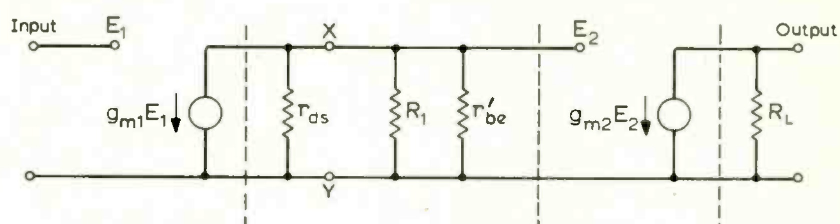


Fig. 4. Characteristics of the E6018.



$$M = \begin{vmatrix} 1 & \frac{1}{g_{m1}} \\ 0 & 0 \end{vmatrix} \begin{vmatrix} 1 & 0 \\ \frac{1}{r_{ds}}+\frac{1}{R_1}+\frac{1}{r'_{be}} & 1 \end{vmatrix} \begin{vmatrix} 0 & -\frac{1}{g_{m2}} \\ 0 & 0 \end{vmatrix} \begin{vmatrix} 1 & 0 \\ \frac{1}{R_L} & 1 \end{vmatrix}$$

after multiplication,

$$\begin{vmatrix} -\dfrac{\frac{1}{r_{ds}}+\frac{1}{R_1}+\frac{1}{r'_{be}}+g_{m1}}{R_1\, g_{m1}\, g_{m2}} & -\dfrac{\frac{1}{r_{ds}}+\frac{1}{R_1}+\frac{1}{r'_{be}}+g_{m1}}{g_{m1}\, g_{m2}} \\ 0 & 0 \end{vmatrix} = \begin{vmatrix} A & B \\ C & D \end{vmatrix}$$

Fig. 5. The l.f. equivalent circuit and transfer matrices.

where f_T is the gain bandwidth product. The Miller capacitance can be found from the gain of the bipolar stage ($Gv_1' = g_{m2}R_L$) and a knowledge of the internal feedback capacitance of the transistor $C_{b'c}$. Since $C_{b'c}$ is not usually given and in any case stray capacitances will add to the total effect, it is not unreasonable to use the value of C_{ob} commonly provided on data sheets. The total capacitance across X-Y is now

$$C_T = g_m R_L C_{ob} + C_{b'e}$$

again neglecting the effect of $r_{bb'}$. Since the resistance across X-Y is approximately the resistance R_1 for the example given in Fig. 2(b) the radian half-power bandwidth is

$$\omega_B = \frac{1}{R_1(g_m R_L C_{ob} + C_{b'e})}$$

This relation gives a value which is 30% below the measured results if the value of C_{ob} max. given by the data sheet is used. When a higher order of accuracy is required the y parameters of the device at frequency of interest and at the appropriate current and voltage levels should be measured. The admittance matrices can then be converted to the required transfer matrices. If a higher gain is required without loss of bandwidth the simplest approach is to use a m.o.s.t. with a higher mutual conductance. The Marconi E6019 with a g_m of 6–8 mA/V increases the gain of the amplifier to 32 dB without any component changes being required.

H.F. amplifiers

Amplifiers employing a common emitter stage suffer from bandwidth limitations for the reasons given above. The circuits of Fig. 1 that employ a grounded base stage offer a much greater bandwidth at the cost of reduced voltage gain. The gain reduction arises from the difficulty of driving the low input impedance of the grounded base stage. It becomes essential to use a high g_m m.o.s.t. such as the E6019 in order to obtain useful voltage gain. The nominal bandwidth of the circuits having a grounded base stage is given by

$$\omega_B = \frac{1}{R_L C_{ob}}$$

In practice wiring inductances raise the bandwidth and bandwidths greater than 100 MHz have been observed. The circuit shown in Fig. 6 provides a voltage gain of 10 dB at 40 MHz.

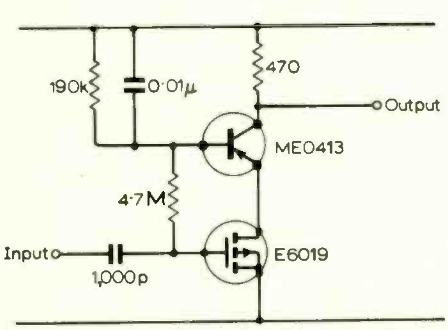


Fig. 6. Common source to common base wide-band amplifier.

Impedance transformation

The common drain to common collector circuits provide a high order of impedance transformation with a voltage gain of less than unity. The common source to common collector circuits can be arranged to provide a useful voltage gain whilst achieving an output impedance sufficiently low for most applications. The bipolar transistor should obviously be chosen and biased so that β is maximized.

Input capacitance

The input capacitance of the amplifiers is frequency dependent since C_{iss} is frequency dependent. The input capacitance will also, of course, depend on the amplifier configuration and layout. Where Miller effect is absent or negligible (due to low first stage gain) the value of C_{iss} at the frequency of interest may be taken as an initial estimate of the amplifier input capacitance. For the E6018 and E6019 devices at 1 kHz, C_{iss} can be taken as 3·5 pF and 13 pF respectively. These values are largely independent of gate voltage.

ACKNOWLEDGEMENTS

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Appendix

Circuit analysis by matrix methods

The general network equations for the two-port network shown in Fig. 7(a) are

$$V_1 = V_2 + ZI_2$$
$$I_1 = I_2$$

The above relations can be rewritten in transfer matrix form as

$$\begin{vmatrix} V_1 \\ I_1 \end{vmatrix} = \begin{vmatrix} A & B \\ C & D \end{vmatrix} \begin{vmatrix} V_2 \\ I_2 \end{vmatrix}$$

where

$$A = \frac{V_1}{V_2}\bigg|_{I_2 = 0} = 1$$
$$B = \frac{V_1}{I_2}\bigg|_{V_2 = 0} = Z$$
$$C = \frac{I_1}{V_2}\bigg|_{I_2 = 0} = 0$$
$$D = \frac{I_1}{I_2}\bigg|_{V_2 = 0} = 1$$

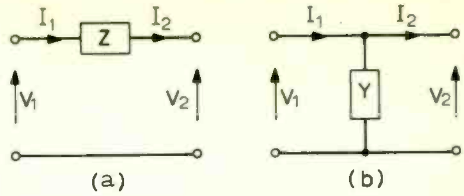


Fig. 7(a). Two port network—series impedance. (b). Shunt admittance.

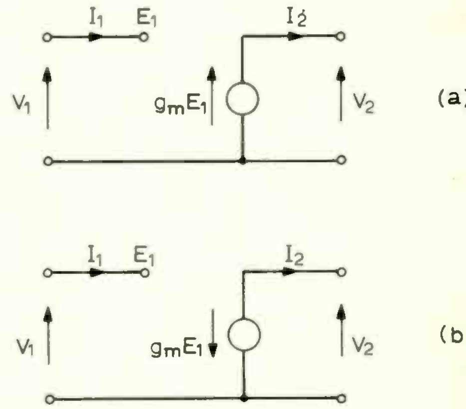


Fig. 8(a). Current generator corresponding to non-inverting connections.

Fig. 8(b). Current generator corresponding to inverting connections.

so that

$$\begin{vmatrix} V_1 \\ I_1 \end{vmatrix} = \begin{vmatrix} 1 & Z \\ 0 & 1 \end{vmatrix} \begin{vmatrix} V_2 \\ I_2 \end{vmatrix}$$

The transfer matrix (TM) for a series impedance (Fig. 7(a)) is therefore

$$TM = \begin{vmatrix} 1 & Z \\ 0 & 1 \end{vmatrix}$$

The shunt admittance shown in Fig. 7(b) can similarly be shown to correspond to the matrix

$$TM = \begin{vmatrix} 1 & 0 \\ Y & 1 \end{vmatrix}$$

Active devices

The idealized equivalent circuits of an active device are shown in Fig. 8. The input impedance, feedback impedance and output impedance are infinite in these representations. The polarity of the current of the current generator shown in Fig. 8(a) corresponds to the non-inverting connections such as common collector, common drain etc. The elements of the transfer matrix of Fig. 8(a) are

$$A = \frac{V_1}{V_2}\bigg|_{I_2 = 0} = \frac{V_1}{V_1} = 1$$
$$B = \frac{V_1}{I_2}\bigg|_{V_2 = 0} = \frac{V_1}{g_m V_1} = \frac{1}{g_m}$$
$$C = \frac{I_1}{V_2}\bigg|_{I_2 = 0} = \frac{0}{g_m V \infty} = 0$$
$$D = \frac{I_1}{I_2}\bigg|_{V_2 = 0} = \frac{0}{g_m V_1} = 0$$

The transfer matrix of Fig. 8(a) is therefore

$$\mathrm{TM} = \begin{vmatrix} 1 & \dfrac{1}{g_m} \\ 0 & 0 \end{vmatrix}$$

The polarity of the current generator shown in Fig. 8(b) corresponds to inverting connections such as common emitter and common source. The transfer matrix of Fig. 8(b) is

$$\mathrm{TM} = \begin{vmatrix} 0 & -\dfrac{1}{g_m} \\ 0 & 0 \end{vmatrix}$$

The transfer matrix of an ideal grounded base or grounded gate circuit is

$$\mathrm{TM} = \begin{vmatrix} 0 & \dfrac{1}{g_m} \\ 0 & -1 \end{vmatrix}$$

The inevitable departure from the ideal active device (such as finite output impedance etc.) are easily handled by considering the finite values as series or shunt components requiring an additional matrix (as demonstrated in Fig. 5).

Multiplication

The transfer matrix of a cascade of two-port networks is obtained by multiplying the individual transfer matrices, i.e. where

$$\mathrm{TM}_1 = \begin{vmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{vmatrix}$$

and

$$\mathrm{TM}_2 = \begin{vmatrix} b_{11} & b_{12} \\ b_{21} & b_{22} \end{vmatrix}$$

$$(\mathrm{TM}_1)(\mathrm{TM}_2) = \begin{vmatrix} (a_{11}b_{11} + a_{12}b_{21}) & (a_{11}b_{12} + a_{12}b_{22}) \\ (a_{21}b_{11} + a_{22}b_{21}) & (a_{21}b_{12} + a_{22}b_{22}) \end{vmatrix}$$

(i.e. row 1 by column 2 etc.)

$$= \begin{vmatrix} A & B \\ C & D \end{vmatrix}$$

It is important to note that

$$(\mathrm{TM}_1)(\mathrm{TM}_2) \neq (\mathrm{TM}_2)(\mathrm{TM}_1)$$

The final matrix elements ($A\ B\ C\ D$) contain the required amplifier (or network) transfer characteristic since

$$A = \frac{1}{\text{voltage gain}}$$

$$\frac{B}{A} = \text{output impedance}$$

$$D = \frac{1}{\text{current gain}}$$

$$\frac{A}{C} = \text{input impedance}$$

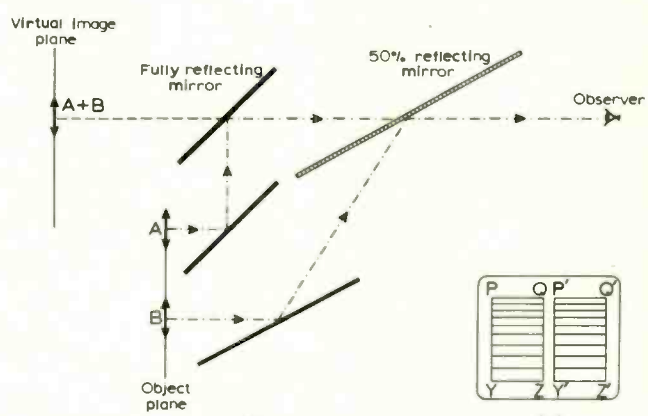
$$\frac{1}{AD} = \text{power gain}$$

Two-Colour Optical Combiner

An optical system that will combine two coplanar images—for example two patterns displayed side by side on the same cathode-ray tube screen—has been devised by A. V. Krause of 20th Century Electronics Ltd (see diagram (a)). The value of the system lies in the fact that the two images can be in different colours, and there are potential applications in colour television monitoring, "head-up" displays in aircraft, oscillographic presentation of phenomena, and industrial inspection. A familiar system of optical combining is that used in the "trinoscope" for colour television picture monitoring; but here the images to be combined (on red, green and blue cathode-ray tubes) are arranged at right angles to each other. The feature of Krause's system is that the images are in the same plane and can in fact be very close together.

A practical difficulty in setting up the conventional trinoscope is that the rasters on the three c.r. tubes must be accurately superimposed, and this demands extremely delicate mechanical and electrical adjustments. If the Krause system is used for combining two television-type pictures this problem can be avoided because the two images can be displayed on two halves of a common scanning raster as shown in diagram (b); it is then only necessary to make one linear mechanical adjustment to the mirror system in order to make points P' and Q' coincide with points P and Q in the combined image. Furthermore, there is no registration problem if the vertical scan is non-linear as shown in (b): points Y' and Z' will automatically coincide with points Y and Z. Of course, the accuracy of registration in (b) depends on the linearity of the horizontal scan, but Krause says that if the middle points of the two rasters are made exactly coincident by adjustment the rest of the scan can progressively depart from linearity up to about 1%. Three-colour combining should also be possible.

The system was demonstrated to *Wireless World* in two experimental forms. The first was oscillographic: two Lissajous figures (made different colours by filters in front of the c.r.ts) were superimposed for comparison by a small version of the system designed for viewing though an eyepiece or for projection on to a ground glass screen. The second form was in a closed-circuit colour television system using the two colour-components red and cyan. The original scene was analysed into the two colour components by the system in (a) working in reverse, in conjunction with two filters, and the two adjacent images were focused on to a vidicon pick-up tube and transmitted to the display system electrically as one picture. At the receiving end the two images were presented side by side on a single monochrome cathode-ray tube, and again with two filters and a larger model of the optical combiner they were re-assembled into a complete colour picture.



The optical principle of the combiner is shown at (a). Diagram (b) represents two halves of a common scanning raster on a cathode-ray tube (non-linear in the vertical direction).

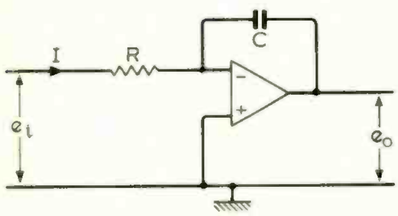
Operational Amplifiers

6. Integrators and differentiators

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

One of the most widely used "building bricks" in electronics is the integrator, in which the output voltage is proportional to the integral with respect to time of the input voltage. The following circuits are various types of integrators based on operational amplifiers.

Single Input Integrator.



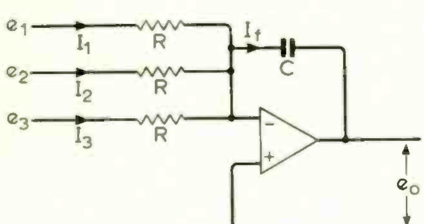
With the usual summing point restraints,

$$I = \frac{e_i}{R} = -C\cdot\frac{de_0}{dt}$$

Thus $$e_0 = -\frac{1}{CR}\int_0^t e_i\cdot dt$$

Features. The time $T = CR$ is called the "characteristic time" of the integrator. It is sometimes useful to think of $1/T$ as the integrator "gain" in terms of volts-per-second output per volt input.

Summing Integrator.



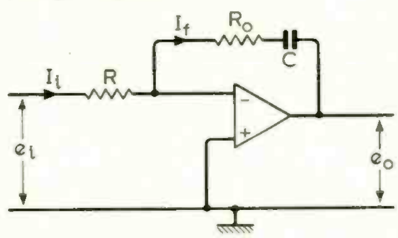
$$I_f = I_1 + I_2 + I_3 = -C\frac{de_0}{dt}$$

$$\frac{e_1}{R} + \frac{e_2}{R} + \frac{e_3}{R} = -C\frac{de_0}{dt}$$

Thus $$e_0 = -\frac{1}{CR}\int_0^t (e_1 + e_2 + e_3)\,dt$$

Features. The output gives the integral of the sum of the input voltages with its sign changed. Any number of inputs may be used. The single amplifier performs the function of both adder and integrator. By using unequal input resistor values the contributions to the output of the several inputs may be weighted in inverse proportion to the resistor values.

Augmenting Integrator.



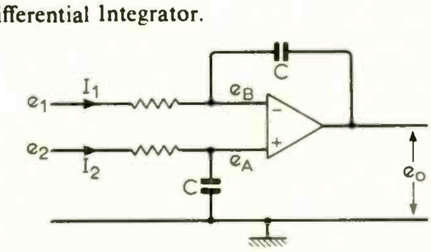
$$I_i = I_f = \frac{e_i}{R}$$

$$e_0 = -(I_f R_0 + v_c)$$

$$e_0 = -\left(\frac{e_i}{R}R_0 + \frac{1}{CR}\int_0^t e_i\,dt\right)$$

Features. The output is a composite signal made up of two components, one component proportional to the input signal added to another component proportional to the time integral of the input signal. Like the simple integrator, the circuit may be adapted to the summation of several input signals by the addition of appropriate input resistors.

Differential Integrator.



$$I_2 = \frac{e_2 - e_A}{R} = C\frac{de_A}{dt}$$

$$I_1 = \frac{e_1 - e_B}{R} = C\left(\frac{de_B}{dt} - \frac{de_0}{dt}\right)$$

But $e_A = e_B$

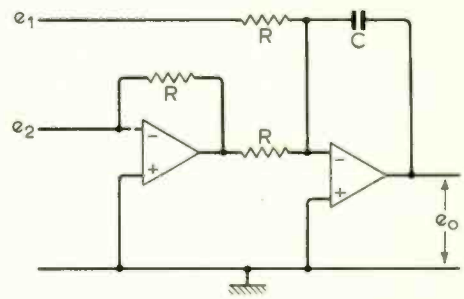
Subtraction gives

$$\frac{e_2 - e_1}{R} = C\frac{de_0}{dt}$$

Thus $$e_0 = \frac{1}{CR}\int_0^t (e_2 - e_1)\,dt$$

Features. Reset and hold problems (see later) are increased with this circuit because of the two capacitors and it may be found more convenient to perform the differential integrator operation using a combination of an inverter and simple integrator (see below).

Differential Integrator using two amplifiers.



$$e_0 = \frac{1}{CR}\int_0^t (e_2 - e_1)\,dt$$

Integrator drift, integrator reset

In the case of practical integrator circuits, amplifier input offset voltage and bias current cause a continuous charging of the feedback capacitor when the applied input voltage is zero; this means that the output voltage of a free running integrator drifts until the amplifier eventually saturates. The drift rate at the output of a free-running simple integrator due to amplifier offsets is given by the relationship:

$$\frac{de_o}{dt} = \frac{V_{io}}{CR} + \frac{I_b}{C}$$

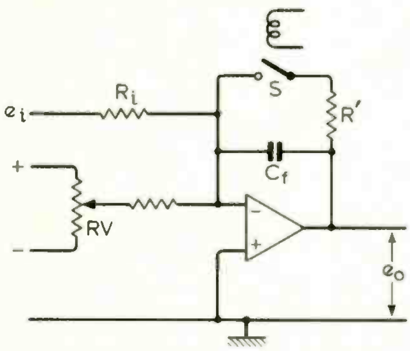
Integrator drift may be adjusted to zero under a particular set of conditions and at a particular time by cancelling the effects of the amplifier offsets with a suitable balancing control; however, amplifier offsets are temperature dependent and also show some long-term time dependence. This means that the zero drift condition established with a balance control is not maintained and a free-running integrator always eventually drifts to one of its saturated states. Practical integrators have to be provided with some means of setting their output voltage at some required value at the start of the integrating time.

Examination of the integrator drift relationship shows that drift due to voltage offset is a function of the integrator "gain" ($1/RC$), while the drift due to bias current is determined by the value of the feedback capacitor alone. For a particular integrator "gain" the relationship suggests that minimum drift can be obtained by using a value of C large enough to make the bias current contribution to drift negligibly small compared to the voltage offset contribution. In fact it may not always be practicable with a particular amplifier to use the value of C dictated by the relationship, for the required value of C may be so large and consequently expensive (and perhaps leaky) that it may be better to choose a different amplifier with a lower bias current to achieve a small required value of drift rate. Another factor that has to be borne in mind is that the larger C the smaller R for a

* Liverpool College of Technology.

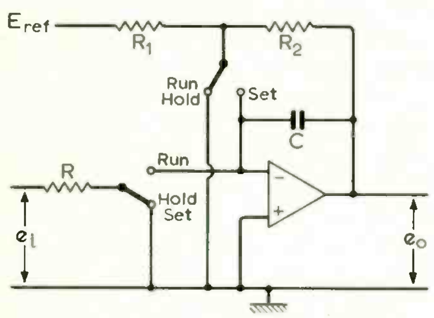
particular characteristic time and consequently the smaller the resultant input impedance of the integrator.

Integrator with Balance Control and Reset.



Features. With the relay reset switch open and e_i zero RV is adjusted for zero drift. With S closed the feedback capacitor is discharged and the initial output of the integrator is set to zero. A small series resistor R' is included to limit the capacitor discharge current and so protect the relay contacts and capacitor. The start of the integrating time is initiated by the opening of S.

Integrator Run, Set, Hold, Modes.



Features. With the switch in the "set" position the initial value of e_o may be set to any desired value within the capability of the amplifier;

$$\underset{t=0}{e_o} = -\frac{R_2}{R_1} E_{ref}$$

When switched to the "run" position the circuit integrates the input voltage and

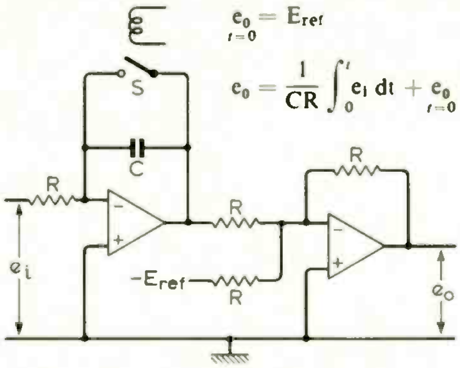
$$e_o = -\left(\frac{1}{CR}\int_0^t e_i\, dt + \underset{t=0}{e_o}\right)$$

If the integrator is switched to "hold" the integration is stopped and ideally the output then remains constant at any value it may have reached. In practice leakage currents and amplifier bias current cause drift in the "hold" mode. In the "run" mode, amplifier input offset voltage causes an additional error current and consequent increase in drift as explained in the previous section. For integrators to be operated with long "run" and "hold" times it is essential that the temperature coefficients of bias current and offset voltage be very small, and this normally involves the use of a chopper-stabilized type of amplifier. The demand for low drift with temperature performance of the amplifier is less strict for shorter "run" and "hold" times.

Initial Conditions Reset with Separate Amplifier.

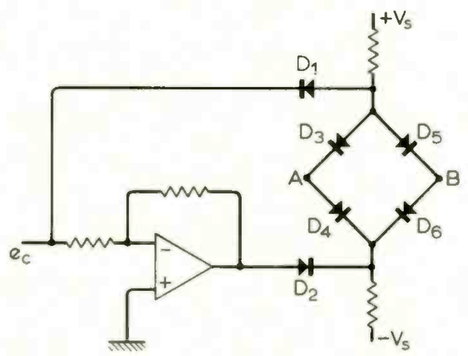
$$\underset{t=0}{e_o} = E_{ref}$$

$$e_o = \frac{1}{CR}\int_0^t e_i\, dt + \underset{t=0}{e_o}$$



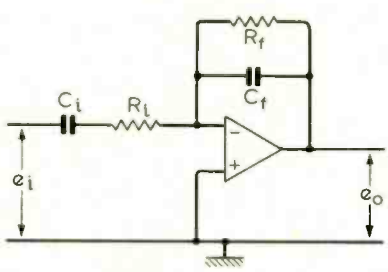
Features. With this circuit arrangement the integrator initial output is set by adding the initial conditions using a separate adder The integrator itself is set to zero with a single switch.

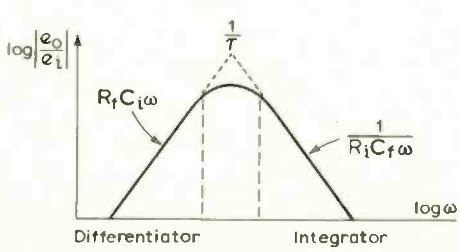
Electronic Switch (suitable for resetting integrators).



Features. Diode D_1 is reverse biased by a value of the control voltage (e_c) greater than 2 volts and the output from the unity gain inverter causes D_2 also to be reverse biased. Under these conditions the diode bridge D_3, D_4, D_5 and D_6 is conducting, and a conducting path exists between points A and B. With a negative value of control voltage D_1 and D_2 become conducting and the bridge diodes are reverse biased, opening the path between points A and B. When the switch is to be used as an integrator, reset points A and B are connected across the integrator feedback capacitor.

Integrator with A.C. Coupling.





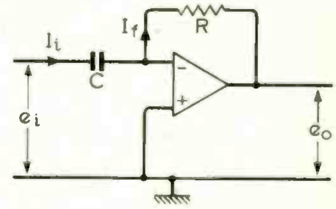
With $C_i R_f = C_f R_i = \tau$

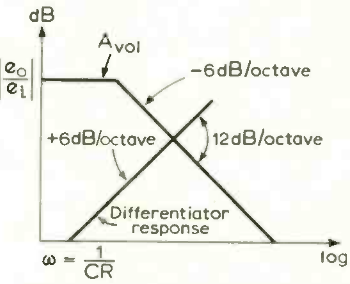
$$\frac{e_o}{e_i} = -\left(\frac{j\omega\tau}{1 + j\omega\tau}\right)^2 \frac{1}{R_iC_fj\omega}$$

Features. For integrator applications not requiring a response down to d.c., relay resetting may be dispensed with and integrator drift leading to amplifier saturation can be prevented with a circuit of this type. The circuit acts as an integrator for frequencies $\omega > 1/\tau$; for frequencies below this value it acts as a differentiator.

Differentiators

Simple Differentiator.





Bode plot for simple differentiator

$$I_i = C\frac{de_i}{dt}$$

But $$I_i = I_f = -\frac{e_o}{R}$$

Thus $$e_o = -CR\frac{de_i}{dt}$$

Alternatively we write

$$\frac{e_o}{e_i} = -\frac{Z_f}{Z_i}$$

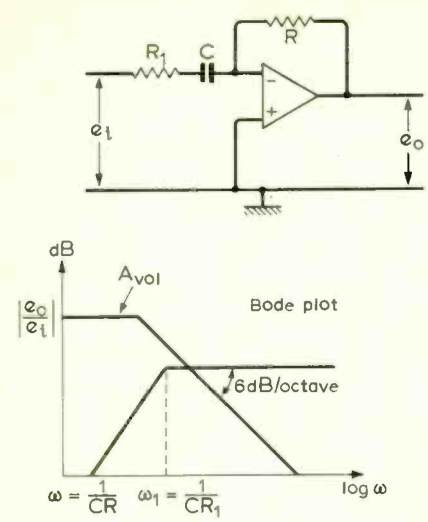
$$\frac{e_o}{e_i} = -j\omega CR$$

The simple differentiator circuit shown above is not realisable in practice. The Bode plot for a simple differentiator response ($e_o/e_i = -j\omega CR$) cuts the unity gain axis at a frequency $\omega = 1/CR$; the gain then increases with frequency at a rate approaching 6 dB/octave. The rate of closure between this curve and the open loop response curve for an amplifier having a 6 dB/octave roll off is thus 12 dB/octave, making the simple differentiator circuit inherently unstable. Also since the gain of the circuit increases with frequency it is very susceptible to random noise.

Achieving differentiator stability

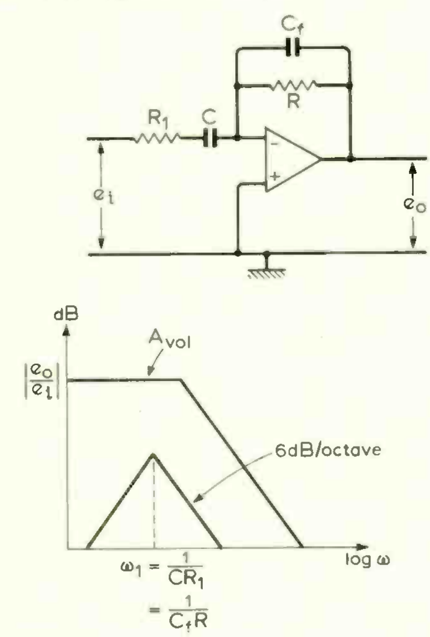
A resistor R_1 (see next page) placed in series with the input capacitor prevents instability and helps to reduce high frequency noise. Further it reduces the effective magnitude of the capacitive loading

Achieving Differentiator Stability.



on the signal source driving the amplifier. At frequencies above $\omega_1 = 1/CR_1$ the amplifier acts as an inverter with gain $-R/R_1$ and the rate of closure between the open loop and closed loop response becomes 6 dB/octave thus ensuring closed loop stability. The frequency ω_1 is arranged to be greater than the signal frequencies of interest.

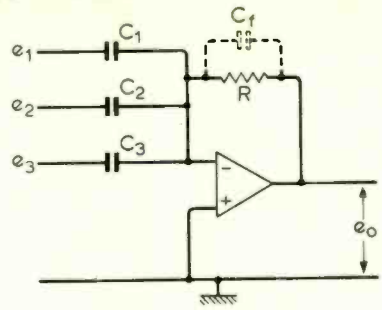
Reduction of Differentiator Noise.



Improved rejection of high frequency noise may be obtained by the connection of a capacitor C_f in parallel with the feedback resistor R. If CR_1 is made equal to C_fR the two networks have the same break frequency and combine to attenuate frequencies above $\omega_1 = 1/CR_1$. The circuit is now in fact identical in form to the a.c. integrator considered earlier.

Like the operational integrator the differentiator circuit can be adapted to summation by the addition of appropriate input paths; also by making use of the non-inverting input terminal of the amplifier a difference differentiator can be achieved.

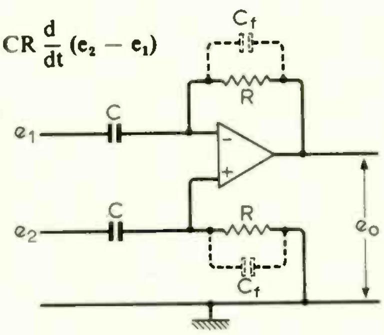
Summing Differentiator.



$$e_0 = -\left[C_1R\frac{de_1}{dt} + C_2R\frac{de_2}{dt} + C_3R\frac{de_3}{dt}\right]$$

Difference Differentiator.

$$e_0 = CR\frac{d}{dt}(e_2 - e_1)$$



Book Review

Intended primarily, but by no means exclusively, as a text for university electronic engineering students, who are expected to have the necessary theoretical background but who may be rather "green" as far as practical knowledge is concerned, "Amplifying Devices and Low-Pass Amplifier Design" by E. M. Cherry and D. E. Hooper is an outstandingly good book.* This explains certain features which may seem, at first sight, to be rather unbalanced—for example, in Chapter 1, appear the words "a knowledge of manipulation in the complex frequency plane is assumed in this book", whereas, in Chapter 17, the resistor colour code is given and explained.

The two Australian authors, already well-known for their valuable published papers,† have both spent a good deal of time in industry as well as in the teaching profession, and while theoretical matters are presented in an exceptionally sound, and sometimes novel, manner, there is a commendable emphasis throughout the book on the non-ideal, or engineering, aspects of design.

Though most of the discussion is, of course, concerned with transistor circuits, valve circuits are also considered, and a very well thought out treatment of the charge-control concept provides a unifying approach embracing ordinary transistors, f.e.ts and valves. The inclusion of a good deal of valve material is defended partly because valve equipment is still in widespread use, but also because it helps to emphasise the continuing tradition in good electronic circuit design, which goes back for more than thirty years. It is argued that this should be valuable to the increasing number of young engineers who seem unaware of the significant developments of the valve era and make "new" discoveries of well-established techniques.

It is very refreshing, for once, to see great emphasis laid on the importance of mutual conductance as a transistor parameter, and a debunking of the widely held notion that a transistor must be regarded as a current-operated device, quite different in nature from a valve. It is therefore not surprising to find that the authors have a preference for the hybrid-π equivalent circuit.

The great advantages of minimising interaction between amplifier stages by intentional mismatching are clearly presented, and it is shown how this technique leads to simple and predictable designs.

The discussion of transistor parameters and their dependence on type, working conditions and temperature is particularly good, and the authors are not afraid to say "If the general nature of a transistor is known, an intelligent guess is often the best way for arriving at its parameters".

While statistical ideas about reliability are well presented, it is emphasised that significant improvements come more from careful investigations of the physical reasons for failures than from the mere use of more impressive statistical techniques.

There is a short, but very good, summary of transistor physics, an extensive treatment of negative feedback principles and practice, and a good deal of sound information on non-linearity distortion, transformers, l.f. and h.f. compensation of amplifier stages, d.c. amplifiers, class B amplifier, secondary breakdown, overload effects, distributed amplifiers, integrated circuits, and a very down-to-earth chapter on "Components, Construction and Reliability". This last chapter contains the comment "If pen-and-paper design is an art, then completion of the job to the hard-ware stage is an art of a higher order".

The sections on noise were found a little disappointing, seeming to make some topics appear rather more difficult than necessary. Indeed, if any adverse criticism of the book as a whole is possible, it is that, out of a praiseworthy enthusiasm to be very thorough and accurate, the authors occasionally make it difficult for the reader to see the wood for the trees.

A few rather unconventional terms and symbols are used, but they have been carefully chosen and add character to the exposition. The term "dynamic response" is used to mean either frequency response or time response, according to the context. "Spot noise" means noise at a particular frequency. And a pear-shaped symbol is used for the active device, when it is not desired to be specific as to whether it is an ordinary transistor, an f.e.t. or a valve.

Another good feature is the inclusion of 65 pages of practice examples at the end. Many of these are of a type very different from those usually given in examinations. There is quite a lot of explanatory text in some of the exercises, which thus constitute a valuable appendix to the main text. The associated questions are sometimes of a design type, not having a unique correct answer, and they are often very thought-provoking. The authors say that such problems do not result in an increased load on the teacher, for the circuits designed can be built and tested experimentally.

The style of writing is consistently excellent, as also are the printing and diagram drawing. Almost no errors have been spotted, and it is evident that the book, which took five years to write, has been prepared with very great care.

It seems most unfortunate that the publishers have decided to set the price as high as £14, which will surely prevent most private individuals from buying it, though it is to be hoped that all technical libraries will do so. However, it would be money well spent for anyone who is prepared to study the book thoroughly and derive the full educational benefit from so doing.

P. J. Baxandall

* John Wiley & Sons (1968), 1036 pages, price £14.

† e.g. E. M. Cherry, "An engineering approach to the design of transistor feedback amplifiers", *J. Brit. I.R.E.*, Vol. 27, No. 127, Feb. 1963; and E. M. Cherry and D. E. Hooper, "The design of ide-band transistor feedback amplifiers", *Proc. I.E.E.*, Vol. 110, No. 375, Feb. 1963.

Letters to the Editor

The Editor does not necessarily endorse opinions expressed by his correspondents

Who's to blame?

I have been investigating a number of commercial transistor amplifiers in order to select one to work in combination with a popular "bookshelf" loudspeaker for use as a monitor loudspeaker in the very confined space of mobile sound-control rooms.

Included in the specification to be met by these amplifiers was that they should provide 10 watts r.m.s. into 15Ω, distortion products at this or any lower power not to exceed 0.1% at 1kHz, or 0.2% at 100Hz.

Although some amplifiers met this specification, even they produced noticeable distortion on programme when driving the bookshelf speaker.

The manufacturers of the commercial loudspeaker quote a value of 8 to 15Ω as the speaker impedance. Inspection of the combined impedance and phase angle curves obtained for this unit (Fig. 1) however reveals a resistive impedance of 45Ω at 70Hz, 25Ω at 2kHz and about 8Ω elsewhere. Thus, when driving the speaker, the power capability of an amplifier which will supply 10 watts r.m.s. in 15Ω will be halved at 2kHz.

But this is not all; the above figures refer to r.m.s. sine-wave power. What happens when the amplifier handles programme?

The impression of loudness gained by the listener is a subjective effect based upon the integration of sound energy over some unspecified time. Since the ear determines loudness by the energy in the waveform and not by the amplitude alone, it seemed a good idea to examine the relationship between the peak and r.m.s. values of programme waveforms. For a sine wave peak value equals $\sqrt{2}$ times the r.m.s. value, but for a miscellany of live programmes, the peak value was found to be, on average, $2.86\sqrt{2}$ times the r.m.s. value.

Consider the effect of this on say an amplifier with a 50 volt rail. Maximum r.m.s. (programme) voltage across load

$$= \frac{50}{2.86 \times 2\sqrt{2}} = 6.2\text{V r.m.s. prog.}$$

But resistive impedance of the loudspeaker is 45Ω at 70Hz, therefore maximum r.m.s. (programme) power which can be supplied to the loudspeaker *without clipping*

$$= \frac{6.2^2}{45}\text{W} = 0.85\text{W}$$

This means that using a low efficiency loudspeaker of the type described, there will almost always be some clipping distortion at a reasonable listening level, particularly when, as is likely, some bass lift is used. The effect of the clipping will depend on the time clipping actually takes place. Tests published by the B.B.C.[1] indicate that distortion due to such clipping is inaudible if the period is shorter than 2.5ms. As the length of the period increases, the sound becomes brighter until perceptible distortion occurs.

W. R. SEYMOUR,
New Malden,
Surrey.

[1] B.B.C. Engineering Training Supplement No.6. "Programme Meters"

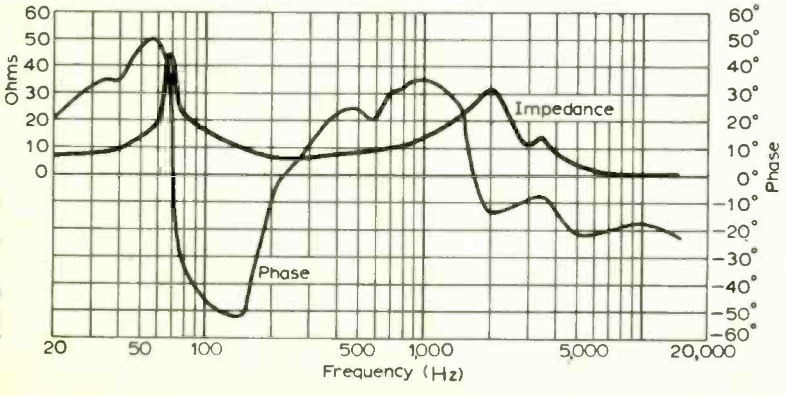
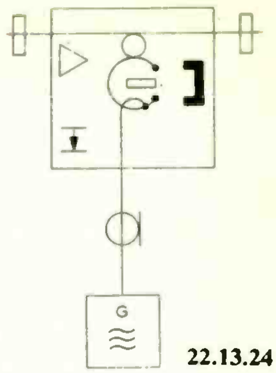


Fig. 1 (W. R. Seymour)

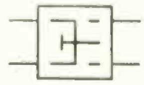
Sterile symbology

It has been said that a camel is a horse designed by a committee and indeed, the recent publication by the British Standards Institution of Section 22 to BS.3939: "Block symbols for telecommunications transmission and general applications", must rank as the outstanding night*mare* of the season.

22.6.8



22.13.24



22.7.6

The essence of block diagrams is the removal of all extraneous detail so that the reader is able to see what the device achieves. There is not, or should not be, any need to show how that end is achieved; this is the proper purpose of the circuit diagram. Thus Section 22 is something of an enigma merely because of its existence.

The very first symbol, an open square, is the only one which is relevant to a block diagram; inside it should be written the function of the equipment that it represents. Oddly the second symbol is an alternative to the square namely an oblong. This basic pure simplicity becomes suspect however when the rectangle appears again as symbol no. 22.12.1 where it represents exchange equipment and yet again as symbol no. 22.13.2 where it represents an unspecified material in lasers and masers.

The third symbol is equally pleasing to the simple mind; a straight line represents a signal path and also, no. 22.9.11, tape printing (a qualifying symbol).

In 22.2.1 a square with a capital *G* printed inside it, represents a non-rotating generator (the user of this symbol must be careful not to confuse the reader with a different *G* which represents conductance); and in 22.6.18 where, with a capital *B* printed inside it (nothing to do with susceptance) it represents a phase-changing network. In case of confusion the *B* may be replaced by φ ; I wonder Y? I am slightly startled by the symbols for a non-rotating sawtooth generator (dentist's drill?) and a non-rotating noise generator.

Attenuator symbols nos. 22.6.1 and 22.6.2, consisting of squares with the letters *dB* inside, might be mistaken by the simple-minded for amplifiers, but maybe *dB* uses less ink than *att*.

In the same section the distinction between an attenuation equalizer and a pre-emphasis device is too fine for me but it does help with the impression that the following symbols, for expander and compressor, relate to bandwidth changing devices.

My favourite (22.6.8) is the interference suppressor which can only be interpreted as an all-stop filter; and very effective too. Symbol no. 22.7.6—equipment for connecting a 4-wire input to either a 2-wire output or a 4-wire output depending on the receipt of a control signal—has two inputs and two outputs and appears to consist of a terminating set, a balancing network and a perforated tape; presumably the tape stores all the possible control signals.

The Section closes in style. Symbol 22.13.24 represents a maser used as an amplifier with external permanent magnet and with crystal in cavity resonator window-coupled to rectangular waveguide and loop-coupled via a coaxial cable to a pump generator; it is probably coincidence that it closely resembles a flushing toilet even though the generator is non-rotating.

Will this madness ever cease? Were I to translate a German document into French and send it along to a Kurdistan reader with a French dictionary I might well be certified but apparently it is acceptable to present technical information in code and tell the reader to buy an expensive copy of BS.XYZ if he wishes to untangle it. If BS stands for *British* standard why cannot we use English instead of hieroglyphics?

K. H. GREEN,
Slough, Bucks.

Television v.h.f. bands

With regard to J.H.W's article "Is there a future for the television v.h.f. bands?" in the May issue, it would seem that he fears that some or all v.h.f. television transmissions will be closed down seven years after duplication of BBC-1 and I.T.A. commences. This is not at all the case. It is true that the ultimate objective of duplication of 405-line services in the u.h.f. bands on 625 lines and in colour is the closing down of the former, thus leaving the v.h.f. bands free for re-engineering to 625-line standards. But no 405-line service will be closed down until an adequate 625-line service is available to replace it.

It may be that J.H.W's seven-year period has come from the fact that this duration is considered to be the average life of a television receiver but we are all aware that, assuming the average life to be close in value to the median life, 50% of receivers will last longer than seven years; in fact appreciable numbers may last very much longer. The life of television receivers is one important factor, but another is the need to ensure the existence of adequate field strengths of 625-line television services before the shutting down of the 405-line ones.

H. T. GREATOREX,
Engineering Information Department,
B.B.C., London W.1.

We were surprised to read the comment by J.H.W., that the receiver industry seems wary of offering single-standard u.h.f.-only sets *in advance* in those areas where all three existing programmes will be available on u.h.f. 625 lines.

Since the earliest forecast date for the BBC-1 and I.T.A. 625-line programmes (in the first four major regions only) is still some months away, it should be obvious that there is no demand for these receivers as yet and any supplies delivered to dealers would, therefore, remain in their stock until nearer the opening date. Designs of single-standard sets are, of course, ready, and some manufacturers have started production, to be held in stock for the time being.

His other comments regarding the continued manufacture of dual-standard receivers are also rather misleading; the facts are that a little under half the population will still have to depend on v.h.f. for their 405-line BBC-1 and I.T.A. pictures at the end of this year, and although this number will steadily decrease over the following few years there will still be a significant proportion unserved by u.h.f. in the mid-'70s. Naturally therefore, manufacturers will continue the production of dual-standard sets for some years to come to serve these viewers.

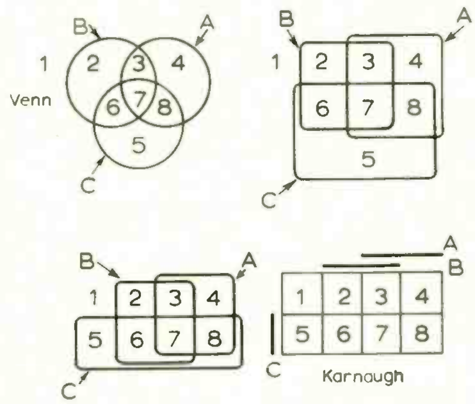
The receiver manufacturers are once again faced with the difficult problem of planning their advance production without knowing all the facts.

R. L. BOOTH,
British Radio Equipment
Manufacturers' Association
London W.C.1.

Logic display aid

In the design of the *Wireless World* Logic Display Aid described by B.S. Crank (May 1969), it is hard to justify the effort in displaying a Venn diagram at the same time as a Karnaugh map. It is a fact when three variables are involved, each device is a topographical transform of the other and both convey the same information. The figure demonstrates this point far better than any words can.

Although the Venn diagram is excellent for presenting the idea of overlapping sets, and this was its original purpose, the Karnaugh map is far more useful particularly in switching theory. It can be extended to cover any number of variables, while the Venn diagram is restricted to three. Furthermore, the arrangement on a regular matrix makes visualization of the functions represented much easier.



It would probably be worthwhile to redeploy the components so that the size of the map could be varied. Then it would be possible to show a three variable map on 2 × 4 matrix and the Venn diagram would be superfluous.

F. E. SANVILLE,
Bath University of Technology.

The author replies

Mr. Sanville's letter is most interesting and he is of course quite right in pointing out that the Karnaugh map and the Venn diagram both convey the same information; this is to be expected as they both consist of a number of overlapping areas.

It is difficult to understand why Mr. Sanville suggests omitting the facility for showing the Venn diagram when he himself points out that the Venn diagram and Karnaugh map have different purposes. The Venn diagram is excellent for presenting the idea of overlapping sets and is, therefore, particularly suitable for the beginner. The Karnaugh map, on the other hand, has a larger number of other uses and may be employed in more advanced instruction and circuit design. In any case, there is no reason why they should both be displayed at the same time; in fact the basic instrument cannot do this. The extra circuitry for multiple displays, added as modifications, is minimal.

It would be possible quite easily to vary the size of the map. However, this would require extra front panel controls and was rejected for this reason. With the display as it stands, and if only three variables are employed, the Karnaugh map appears twice in the same matrix.

Finally, if the user was prepared to let each dot represent a particular combination then up to ten variables could be accommodated. (1024 dots).

B. S. CRANK.

Negative feedback & hum

I am afraid Mr. G. W. Short (March issue p.116) has fallen into a trap with his suggested "swinging diode" arrangement. He has been unwise enough to assume that music is invariably scored throughout the sound spectrum and that signals occasioning sufficient current drain to cause the diode to be biased into conduction will contain enough bass information to mask the hum.

A particularly unpleasant case that comes to mind is of high woodwinds playing loudly resulting in heavy current drain whilst nothing is playing in the bass.

Mr. Short is, however, not alone in his mistake. Many commercial amplifier designers rely on the fact that at low currents a simple single capacitor power supply is relatively smooth and they too rely on the music masking the hum that arises when the current drain increases. Mr. J. Dinsdale has found an example where the hum from such an arrangement has beat with an organ pedal note giving especially unpleasant sound, so the arrangement appears vulnerable from both treble and bass signals.

The heater winding of a mains transformer from discarded valve equipment makes an effective, if rather bulky, choke, or a low-grade power transistor may be used as an active filter for similar cost to the power diode Mr. Short suggests.

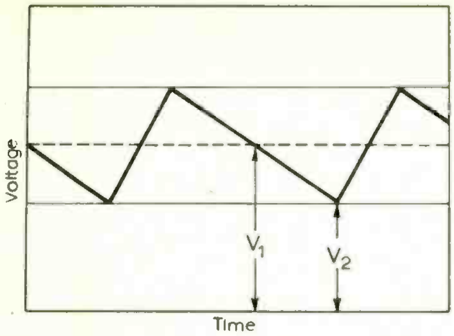
I. G. ABELSON,
London N.14.

The author replies:

I suppose it is possible to find some kind of input signal that will show up the defects of any design. If Mr. Abelson is trying to make the point that a well smoothed power supply is better than a badly smoothed one then it goes without saying, but I suggest that there is another way of avoiding his particular difficulty, namely to turn down the volume!

My own amplifier design was a cheap and cheerful medium-fidelity job. In the case of the commercial designs which he criticises (which are presumably hi-fi amplifiers) I think it is as well to remember that there are two distinctly different ways in which ripple on the supply line can impair the performance.

The first is straightforward entry of the hum into the amplifier circuit, where it gets mixed up with the input signal and appears



at the output. This is avoided in good commercial designs. The other is that with large signals the ripple causes intermodulation without ever finding its way into the signal path as usually understood. The mechanism can be seen with reference to Fig. 1, which shows the output of a rather badly smoothed mains supply unit. The mean voltage is V_1, but the troughs of the ripple take the voltage down to V_2. As signals of increasing amplitude are applied a point is reached where the amplifier is overloaded at V_2. The tips of the signal wave are thus modulated by a 100Hz sawtooth, and the result is a nasty buzz or rattle. If the signal frequency is nearly harmonically related to 100Hz beats will be heard as well.

It will be obvious that this effect occurs only when the amplifier is driven so hard that it would be almost at the point of overload even if the supply were perfectly smooth. Improving the smoothing, even in a supply with peak-to-peak ripple of 20% of the mean d.c. voltage will produce less than 3dB more distortionless output. The improvement may well be worth having, especially if you have an old mains transformer going begging, but it is not spectacular. In a commercial design, it would be cheaper to raise the supply voltage in the first instance, and hope the purchasers will not try to get a quart out of a pint pot.

The use of a transistor in an active smoothing circuit will usually reduce the available power output still further. The transistor must have enough collector-emitter voltage even during the troughs of the ripple. At the sort of currents involved this knocks about 1V off the available supply voltage.

G. W. SHORT

Audio amplifier performance

I have read with great interest the excellent "state of the art" review, of high-quality audio amplifier design, given by Mr. R. Williamson in the June issue and I applaud the common sense and lucidity of his appraisal. However, in the section dealing with the design of the output stages, Mr. Williamson suggests that the problems associated with class B designs are either non-existent or are of a temporary nature, and I am left with the unhappy feeling that this may be an over-simplification of the problems involved.

It is clearly desirable to devise techniques or instrumental measurements to quantify the performance of audio amplifiers, in order that progress in this field can be put on a proper basis, but we are, unhappily, still in the state in which there is not general agreement on the correct measurements to make to predict the acceptability of the result to the listener. In these circumstances, we still have to rely on the evidence of our ears to tell us whether the performance of a given design is good or bad, and some of this evidence suggests that class B transistor output stages are sometimes less pleasing to listen to than the performance on paper would suggest.

Because the most noteworthy outward and visible difference between class B transistor amplifiers, which may sound unpleasing, and the traditional thermionic valve class A power amplifiers, which usually do not cause auditory offence, is the kink in the curve of an output sinewave as the voltage waveform intersects the axis, the audible malfunction is usually categorized as "crossover distortion", and assumed to be due to dissimilarities in the two halves of the output stage, to be minimized by symmetry and made negligible by negative feedback. However, when these steps have been taken, and the purity of the sinewave performance is such that the measured harmonic distortion is of the order of 0.02%, the difference in performance is still audible. I believe that this is due to three separate things.

(1). The reduction in harmonic distortion due to crossover phenomena is normally accomplished by the use of substantial amounts of loop negative feedback, taken around a loop containing, of necessity, a large number of phase shifting elements. The provision of an adequate gain and phase margin of stability increases in difficulty as the number of elements within the loop and the feedback factor is increased, so that beyond a certain point the reduction in the nominal distortion content is offset by a worsening in transient performance. However, this is only part of the problem, in that when a transistor which is conducting is driven into cut-off the input impedance abruptly changes from a large capacitance in parallel with a low non-linear resistance into a very high resistance in parallel with a much smaller voltage-dependent capacitance. At this transition the loop feedback stability margin may be much impaired, but this may not be visible except on an arrested transient which stops short somewhere near the crossover point. Such waveforms do occur in speech and music.

(2). Although it may be desirable to construct systems in which the two halves of the output stage are symmetrical, this is not possible because p-n-p and n-p-n transistors rely for their action on different types of current carriers. This leads to differences in the transfer characteristics, especially at the higher frequencies, and can cause a "point of inflexion" distortion on transfer from one to the other, which is indistinguishable on a distortion meter from crossover distortion.

(3). Hole storage. When a transistor which has been conducting heavily is abruptly turned off—as can readily happen in a class B audio output stage—the presence of uncollected minority carriers within the base region prevents the current flow from ceasing as rapidly as would be expected, and for a brief period the transistor behaves as a resistor (or even as an electrical delay line) giving a current output uncontrolled by the potential on its base. P-n-p transistors suffer more from this problem than n-p-n ones because of the nature of the carriers, and although this problem can be minimized by the use of transistors with a high transition frequency, and by using low resistance base-emitter return paths, this is a source of transient distortion which may be worsened rather than improved by the use of full complementary symmetry in the output stage.

Although transistor and circuit developments are likely to minimize the importance of these effects, some of these are quite fundamental in their nature, and liable always to be a potential source of difficulty in class B designs, unless elaborate measures have been taken to circumvent them. The recognition of this fact and the adoption of alternative class A circuitry may, in fact, be good economic sense in high-quality systems, and not a "sweeping of problems under the R. & D. carpet" as was implied.

However, if the economies of class B operation are really so necessary, and the shortcomings of this system are, on balance, more conspicuous at low volume levels, surely the answer is to use a system which operates in class A up to a watt or two, and retreats into class B on the transients where the higher powers are momentarily demanded.

J. L. LINSLEY HOOD,
Taunton,
Som.

The Emley Moor saga

I enjoyed reading the little piece in your June issue (p.256) about the remarkable achievements of the I.T.A. at Emley Moor following the collapse of their 1250-foot mast. But I expected to see some reference to the restoration of the BBC-2 service, because our u.h.f. aerials were also on this mast.

BBC-2 was, in fact, back on the air at Emley Moor after only 44 hours, using a temporary 60-foot mast. True, this provided only a limited service but this was considerably extended (to more than 2 million people) when we brought into use a 300-foot mast on Easter Monday. This mast, made up from two 200-foot masts stored at Skelton in Cumberland was brought to the site and erected in four days. This must be some sort of record!*

H. T. GREATOREX,
Engineering Information Dept.,
B.B.C., London W.1.

*It is indeed. We apologise for the oversight. ED.

Motor using piezo-electric effect

In the description of the above motor given in the May issue, page 227, there is an error in the first paragraph which can be corrected by interchanging the two phrases in line 12. This would then read 'clamping the first magnet, de-energizing the other magnet.'

This error is important in that it would prevent the motor from resisting an applied load since it implies that at one stage in the stepping cycle both clamps are off. In the sequence actually used this condition can never occur and at least one clamp is energized at all times.

GORDON C. JOYCE,
Royal Radar Establishment,
Gt. Malvern,
Worcs.

Personalities

Group Captain E. Fennessy, C.B.E., B.Sc., F.I.E.E., managing director of the Electronics Group of the Plessey Company, has accepted the invitation to become managing director, telecommunications, of the Post Office. Gp. Captain Fennessy joined the Plessey Group in 1965 when they acquired the ground radar and data-handling divisions of Decca Radar of which he was managing director. Gp. Capt. Fennessy, who is 57 and a graduate of London University, served on the staff of No. 60 (Radar) Group, R.A.F., for the major part of the war having previously been with the original Air Ministry radar research team at Bawdsey Manor from 1938. He joined the board of the Decca Navigator Company in 1945.

Group Captain E. Fennessy

E. A. W. Spreadbury, F.I.E.R.E., for the past two and a half years editor of our associate journal *Electrical & Electronic Trader*, has retired. He joined the *Trader* laboratory staff in 1937 and was technical editor for 25 years until his appointment as editor in 1966. Prior to joining the *Trader* Mr. Spreadbury spent 14 years in the radio industry. Mr. Spreadbury has also retired from the chairmanship of the Society of Electronic and Radio Technicians which he has held since the inauguration of the society in 1964. The new chairman of S.E.R.T. is **Kenneth Tempest,** head of the Electrical Engineering Department, Carshalton College of Further Education.

Professor Kurt Hoselitz, Ph.D., F.Inst.P., F.I.E.E., has been appointed director of the Mullard Research Laboratories. Dr. Hoselitz, who is

Prof. K. Hoselitz

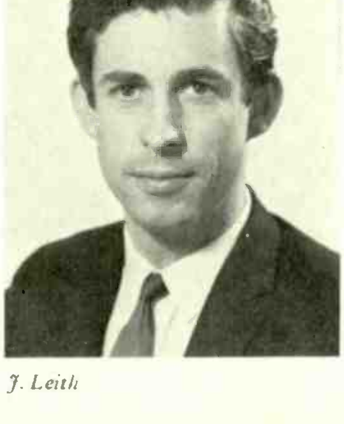
52, was educated at the Universities of Vienna and Bristol. He gained his Ph.D. at Bristol in 1942 and subsequently joined the Permanent Magnet Association as a research scientist. In 1952 he joined Mullard Research Laboratories to establish the Solid State Physics Division and for the past five years has been deputy director of the Laboratories. He is a visiting professor in physics at the University of Surrey.

Appointments designed to strengthen the development of electronic and space systems activities of the Guided Weapons Division of British Aircraft Corporation outside the guided weapons field are announced. **D. Rowley,** M.A., F.R.Ae.S., is appointed executive director responsible for the overall management of the electronic and space systems activities comprising the Space and Instrumentation Group at Bristol and the Precision Products, Industrial Products and Plastic Products Groups at Stevenage. Mr. Rowley was previously general manager at Bristol. **A. T. Slater,** M.B.E., M.A., is appointed general manager of the G. W. Division and **S. A. Smith,** M.A., A.F.R.Ae.S., is appointed general manager Bristol Works. Mr. Slater was previously general manager, Stevenage, and Mr. Smith, deputy general manager, Bristol.

Three new appointments are announced by the Weapon Systems Division of Ferranti Ltd., Wythenshawe, Manchester. **A. M. Bell,** B.Sc., will in future be responsible for promoting and co-ordinating the sales of all military electronic equipment. He has been associated with the Ferranti systems for Bloodhound ground-to-air missiles for 15 years, including four years as resident engineer in Australia. **F. W. Gee** now has special responsibility for technical liaison on future radar, sonar and visual training simulators. Until recently he was a Flight Lieutenant at the R.A.F's Radio Introduction Unit. **P. W. Smith,** B.Sc., is to lead a new group which will be responsible for the preparation of engineering proposals and for product planning within the Weapon Systems Division. Mr. Smith has been closely involved with the development of Ferranti computers and display systems.

John V. N. Granger, A.B., M.S., Ph.D., chairman of the board of Granger Associates, Palo Alto, California, has been nominated for president of the Institute of Electrical and Electronics Engineers in 1970. At Harvard, Dr. Granger became a teaching fellow in physics and communications engineering, instructing in the pre-radar school for Army and Navy officers. During World War II he joined the Anglo-American team working on radar at T.R.E., Great Malvern. Dr. Granger entered Harvard again in 1946. A year later he became a research fellow in electronics and group leader in the Electronics Research Laboratory. He earned his Ph.D. in 1948 with a thesis on low-frequency aircraft aerials. In 1949, Dr. Granger joined Stanford Research Institute to organize and supervise the aerial research programme. He resigned in 1956 when he formed Granger Associates.

John Leith, who joined what is now SGS (United Kingdom) Ltd. three years ago from Rank Bush Murphy, where he was engaged on development work on radio receivers and record players, has become sales manager of the Consumer



J. Leith

P. Hubble

Dept. During the early part of his career he spent two years in the United States working in the Development Lab. of Radiation Incorporated, Florida, and prior to joining Rank Bush Murphy was with Multitone. SGS also announce the appointment of **Paul Hubble** as distributor co-ordinator. Mr. Hubble, who is 37, joined SGS two and a half years ago. He was at one time Midlands representative for the Sub Assemblies Division of the Mullard Equipment Co. Ltd. (now MEL Equipment) and before that spent three years on digital control equipment sales with the Instrument Division of Ericsson Telephones Ltd. (now Thorn Bendix).

Geoffrey Laycock, M.Sc., F.Inst.P., United Kingdom marketing and sales manager for Honeywell's Computer Control Division, has been appointed director of marketing for the Northern Europe region. Based at the Watford sales headquarters, Mr. Laycock will control all marketing and sales activities in Great Britain and Scandinavia, as well as export activities to some other countries. He has been with the Computer Control Division since its formation in 1966. Prior to that he was manager of the special systems division within the Industrial Products Group. Mr. Laycock is a graduate of St. Andrews University. Honeywell also announce the appointment, within the Northern Europe region, of **Richard Killick,** M.A. (Cantab.), as director of engineering. He will be based at the divisional systems engineering headquarters at Hemel Hempstead. Previously chief engineer of the division's systems development team, Mr. Killick has been with Honeywell since early 1967. Prior to joining the company he was manager of technical support activities within G.E.C's computers and automation group.

G. R. Gamble, an honours graduate in physics from the University of Surrey, has joined Brookdeal Electronics Ltd. as applications engineer. After leaving university, Mr. Gamble, who is 25, joined the Plessey Company as a communications development engineer in the Electronics Design Development Unit, where he stayed until taking up his present position.

More and more the demand is for the consistently high quality and reliability of Electrosil glass-tin-oxide resistors in instruments, telephone exchanges, computers, automation, missiles and, in fact, in every type of electronic equipment. Over and over again glass-tin-oxide proves its superiority. For example, recent independent tests by a major equipment manufacturer showed that Electrosil 100 p.p.m. C5 resistors gave a more consistent performance on load and temperature stability than metal film resistors by six competing suppliers.

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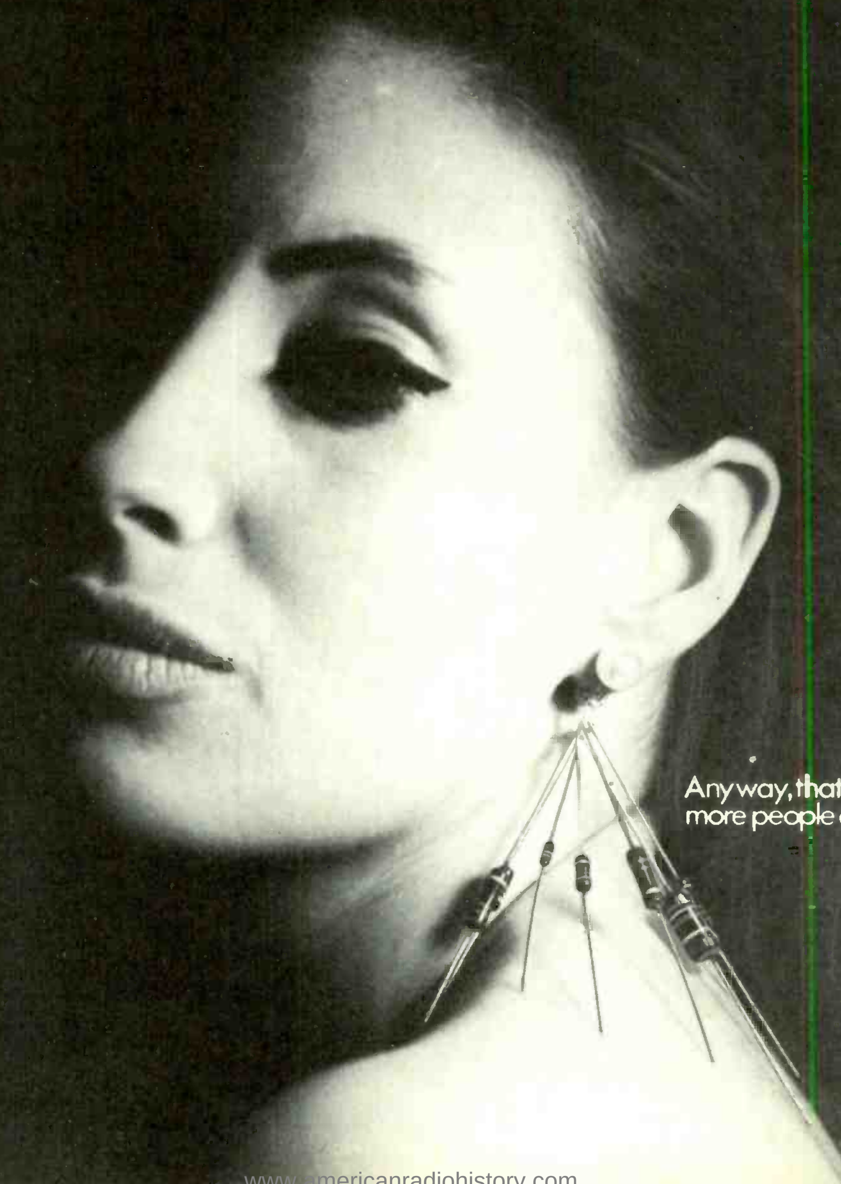
The one that keeps on resisting is the one you can't resist



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MST SUCCESS

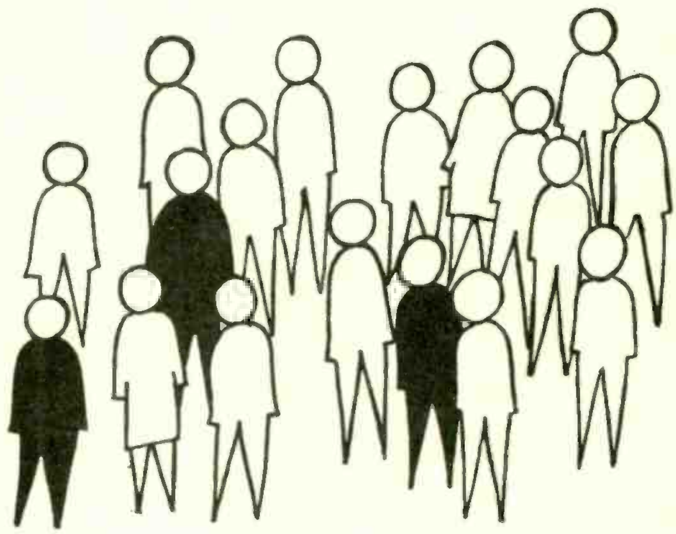
SALES NOW EXCEED £12,000,000

More and more countries are buying Marconi Self-Tuning h.f systems . . .

and one good reason is:

ECONOMY IN SKILLED MANPOWER

- Centralized station control by one man who need not be technically skilled.
- Full remote control of transmitting and receiving complex extends this concept to allow complete stations to be unmanned on a routine basis.
- Built-in MST reliability means that only a nucleus of high grade technicians required to service a full h.f complex.
- **Reduction of manpower requirements can be of the order of 5 to 1.**



and other good reasons are:

Reduced capital outlay

MST designs reduce demands for space, and need for standby equipment. Installation costs are decreased.

Increased reliability

Maximum use of solid state techniques plus the use of wideband amplifiers reduces number of moving parts, gives higher reliability and longer equipment life.

Traffic interruption reduced

Frequency changes and retuning accomplished in less than one minute without loss of traffic.

World-wide acceptance

30 countries throughout the world have ordered more than £12,000,000 worth of MST equipment to improve their communications services.

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The Marconi Company Limited, Radio Communications Division, Chelmsford, Essex, England

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WW—073 FOR FURTHER DETAILS

New Products

B.C.D. Programmer

A clever idea is a new b.c.d. programmer manu-actured by Ghielmetti, AG, of Switzerland, and narketed in this country by Data Precision Equipment) Ltd. The programmer is based on a mall plastics block which contains four switches hat are operated by a plastics plug engraved with he decimal number it is desired to programme. Each plug has raised surfaces that actuate the witches in such a way as to form the desired inary code. The blocks containing the switches nay be plugged into 3mm matrix boards or fitted o printed circuits. The blocks and the plugs are vailable in a variety of colours and any four-bit .c.d. code can be accommodated. Complete rogrammes can be stored by fitting the plugs into sheet which holds them captive, in this way ntire programmes can be changed in a single peration. Data Precision (Equipment) Ltd, ondon House, Duke St., Woking, Surrey.
VW 305 for further details

Miniature Mains Transformers

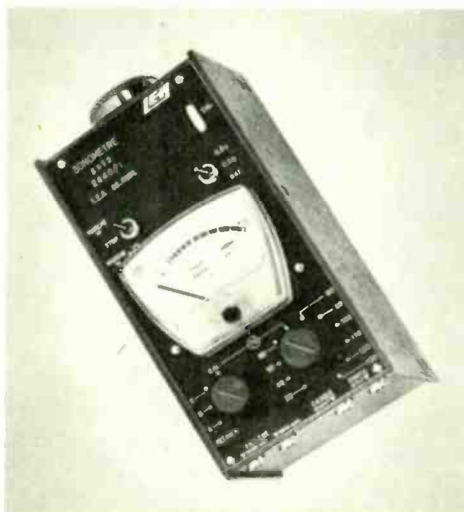
range of miniature power transformers is avail-ble from Belclere. Using 240V 50Hz primary the llowing outputs are provided: 3-0-3V at 200 mA ype ES3876), 6-0-6V at 100mA (type ES4147), -0-9V at 66mA (type ES4148), 12-0-12V at 50mA ype ES3874) and 20-0-20V at 30mA (type S3875). If the centre-tap is not required the fol-wing outputs can be obtained respectively: V at 100mA, 12V at 50mA, 18V at 33mA, 24V at 5mA and 40V at 15mA. Standard transformers are r printed circuit mounting. They measure 5.4 × 25.4 × 19mm, are varnish impregnated and st 15s 6d (77½p) plus postage and packing. A amped version is slightly larger and has 38mm xing centres. Clamps are 6d (2½p) extra and an terwinding screen, if required, is 9d (4p) extra. he Belclere Co. Ltd, 385/387 Cowley Road, xford.
'W 327 for further details

Microwave Impatt Oscillators

ew Impatt oscillators in the X and J bands nounced by Varian Associates, provide powers 400mW at 10-12.4GHz, 200mW at 12.4-15GHz, d 100mW at 15-17.5GHz. Improved thermal nding between the semiconductor mesa and the ode package permits more rapid dissipation of at developed at the junction and thermal co-ficients of 10°C/W are now available. Because the cillators operate in a relatively low Q circuit of 0-150 they are suitable for operation in an jection locked mode giving improvements in an m. and f.m. noise and frequency stability. plications include parametric pumps, drivers for Q-Band multipliers and Doppler transmitters. Varian Associates Ltd, Russell House, Molesey Road, Walton-on-Thames, Surrey.
WW 312 for further details

Sound Level Meter

K.S.M. Electronics are now marketing a sound level meter designed to simulate a human ear and provide objective measurements of sound levels within a range extending from near audibility to above the pain threshold. Using an internal moving-coil microphone, sensitivity is 24 to 140dB. There



is a built-in calibrator. The sound level meter is battery-operated and its dimensions are 102 × 102 × 226 mm. K.S.M. Electronics Ltd, Bardmore Works, Bradmore Green, Brookmans Park, Hatfield, Herts.
WW307 for further details

Gas Laser

Scientifica and Cook Electronics Ltd, have developed a small gas laser—model B.15. Power output is 0.5mW uniphase and 1.0mW multiphase at a wavelength of 6,328Å. The beam diameter is 2.5m approximately at the exit aperture. Weighing about 4kg and measuring 9×9×37cm the laser runs off the mains, is guaranteed for 6 months, and costs £96. Scientifica and Cook Electronics Ltd, 40-48 High Street, Acton, London, W.3.
WW 311 for further details

Memory Voltmeter

Model 5203 from Sintrom Electronics Ltd, is a portable broad-band (d.c. to 20MHz) instrument capable of measuring, storing and displaying pulses and transients as short as 50ns in the range 0-1000V. The range can be extended to 30kV using an external probe. Accuracy is 1% of full scale for wide-band readings and 0.25% (±2 bits) for narrow band. The peak value on the digital display remains indefinitely until reset or until a pulse of greater amplitude is applied. (Alternative display versions are available giving an analogue on a panel meter, or multi-channel measurements of transient voltages.) Other features of the instrument include: provision for remote programming of mode, range and reset; analogue output signals, which may be used to drive a low-frequency

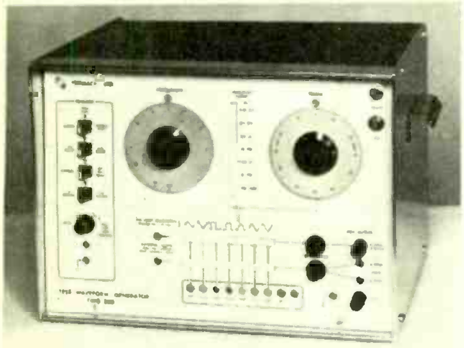
strip chart recorder; BCD output for simplified interfacing with printers, card punches, and data loggers; and off-scale and off-zero indicators to ensure readout accuracy and sample and hold capability. The dual-shielded cabinet prevents radiated transient pick-up or common-mode errors. Operation can be from battery or mains. Prices from £480 for the analogue version. Sintrom Electronics Ltd, 2 Castle Hill Terrace, Maidenhead, Berks.
WW 304 for further details

"Chip" Capacitors

Multi-layer capacitor chips for incorporation into integrated circuits are available from the Radio Resistor Co. in a wide range of capacitance values, with or without tin-plated electrodes. The range is also available as complete components with radial terminations and synthetic coated finish in a capacitance range of 470 — 47,000pF. Dimensions of the complete component are approximately 7 × 5 × 0.06mm thick. Available tolerances on both types are either ±20% or ±10% and working voltage is 63V d.c. These capacitors are manufactured by Rosenthal Isolatoren G.m.b.H. U.K. agents: The Radio Resistor Co. Ltd, 9-11 Palmerston Road, Wealdstone, Harrow, Middlesex.
WW 303 for further details

Test Waveform Generator

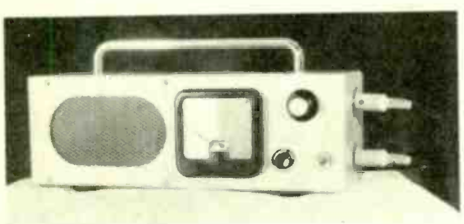
Feedback Ltd, announce the release of a solid-state waveform generator, the TWG500. The instrument provides simultaneously sine, square and triangular waveforms over the frequency range 1.01Hz to 100kHz. Also incorporated is a calibrated phase-shift control for the generation of variable-phase sinewaves. Two main output channels may be connected, via push-button switches and attenuators, to any of the seven waveforms available. One channel provides a level up to 20V peak, the other provides normal or inverted outputs (or both) at levels up to 10V peak. Both output amplifiers are accessible to external input for the processing of external signals. All waveforms are available at 2V peak-to-peak for monitoring purposes. Comprehensive triggering and gating facilities are provided. Initiated manually or by external signal with independent trigger-level and polarity controls, the instrument is capable of operating in a variety of modes ranging from single cycle to gated bursts of integral numbers of cycles. The application of a voltage from 0 to 10 fully sweeps the decade range selected, with the output frequency directly proportional to the applied voltage. When used with a suitable oscilloscope the generator provides all the neces-



sary facilities for frequency and transient response testing, giving direct null balance readings. Using an additional generator to sweep a particular frequency range, it is possible to generate gain or loss against frequency displays on the oscilloscope. Price £334. Feedback Ltd., Park Road, Crowborough, Sussex.
WW 302 for further details

Meter-checking Alarm

The MA21C alarm system, from J. D. Jackson Electronics, provides a method of keeping critical meter readings under constant surveillance. Warning of deviation from the correct reading is given by a loud tone calling the attention of the operator to the offending instrument. The basic alarm is battery operated and portable. It employs integrated circuitry and has facilities for plugging in two photo-electric sensor heads. The heads are stuck to the front glass of the instrument under observation, after which, passage of the pointer past either head will trigger the alarm. A single head may be used to detect either a high or low reading, while two heads are needed to cover both high and low readings. Alternatively a single head may be set up over the pointer after which deviation of the pointer in either direction will trigger the alarm. The alarm will be actuated regardless of the speed at which the pointer passes the head and will continue to sound until manually re-set by push button. The MA21C may be applied to all kinds of pointer type instru-



ments including meters, thermometers and pressure gauges and will function equally well when used with either conventionally marked instruments or instruments with black scales and white pointers. Effects of ambient illumination and temperature variation are minimized by built-in compensation whilst sensitivity is such that the knife type pointer of an Avo model 8 test meter may be readily detected. The instrument is 'fail safe' in that the alarm will sound if drift occurs under extreme environmental conditions. Battery deterioration and bulb failure will also trigger the alarm. J. D. Jackson Electronics, Egglestone Works, Limbard Street, Newark, Notts.
WW 331 for further details

Metal Film Resistors

Morganite Resistors Ltd have increased their range of "Filmet" metal film resistors by the introduction of the FC55. A $\frac{1}{8}$ watt resistor conforming to DEF 5115, pattern RFG7-0.125, it is available over the range 6 Ω to 270 kΩ with a temperature coefficient from ± 15 p.p.m./°C and tolerances from $\pm 0.1\%$. E24 ohmic values are standard, but other values can be supplied to customer requirements. Morganite Resistors Ltd, Bede Industrial Estate, Jarrow, Co. Durham.
WW 321 for further details

Miniature Digital Panel Meter

The Instrument Division of Coutant Electronics has announced the latest addition to their line of digital instruments. This is a range of ten miniature low-cost digital panel meters, with a basic type number CDM.100, which have been designed to replace conventional analogue meters for d.c. voltage and current measurements. For minimum size and maximum reliability these meters have been designed with integrated circuits and silicon planar transistors. A particular feature of the range, for data-logging and measuring systems, is a built-in 1248 binary coded decimal (BCD) output facility. Five separate models are available for d.c. voltage measurement and five for direct current measurement. Accuracy is 0.1% of actual reading ($\pm$ 1 digit) for voltage, and 0.5% of reading for current. The five voltage meters have a full-scale reading of 100mV, 1V, 10V, 100V and 1000V, respectively. The five current meters have full-scale readings of 10 μA, 100 μA, 1mA,

10mA and 100mA, respectively. Input impedance for the voltage meters is 100 megohms for the two lowest ranges and 10 megohms for the three highest: the resolution of all meters is one-thousandth of full scale. The individual model numbers specify the range, e.g., the 100V meter is known as CDM.100/100V and the 1mA meter is given the number CDM.100/1mA. All models, except the CDM.100/1000V, have an overrange of 60% giving a maximum reading of 1599. Up to 1000V may be applied to any voltage meter and all current meters will safely withstand over 100mA. Each CDM.100 is fitted with three separate numeral tubes (each capable of displaying any number from 0 to 9) and an indicator tube which, when energized, displays only the digit one; the three numeral tubes together display numbers up to 999 and the indicator tube operates as the digit one on a 1000 reading and also as the highest digit on overrange. (No agreed standard nomenclature yet exists to describe this arrangement, but some American companies refer to this type of instrument as a '3½-digit meter'.) Common mode rejection is 70dB and the assessing period is 10 milliseconds; the operating temperature range is +10°C to +50°C. The meter measures only 114mm wide by 70mm high and 190mm deep. The cost is £95. Coutant Electronics Ltd, Instrument Division, 5 Loverock Road, Reading, Berks.
WW 333 for further details

M.O.S.Ts

Single m.o.s. f.e.ts, types 3N163 and 3N164, and dual m.o.s. f.e.ts, types 3N165 and 3N166, do not require gate protective diodes. The input impedance of these Union Carbide devices is very high and leakage of T_{DSS} is 200pA maximum for the 3N163. The transient gate-to-source voltage for both duals and singles is guaranteed at ± 125V. In switching operations the range exhibits a delay time $t_{d(on)}$ of 12ns max., and a rise time t_r of 24ns max. for singles, and 30ns max. for duals. The dual devices are matched within a 100mV gate-source threshold voltage differential. Union Carbide U.K. Ltd., P.O. Box 2LR8, Grafton Street, London, W.1.
WW 313 for further details

Decade Box

J. J. Lloyd Instruments Ltd have introduced a new heavy-duty decade resistance box HD1/L. The lowest decade of this unit is in the form of a high dissipation potentiometer calibrated from 0 to 10 ohms with a resolution of approximately

0.2 ohm and will pass a maximum current of 5 amps. The remaining decades utilize precision vitreous enamel resistors and are rated at 160 watts per decade, except for the upper decade where the rating is limited by voltage and not current. The whole instrument is housed in a screened steel case and is double insulated, so that it may be used safely at voltages up to 1kV. Accuracy at 20°C is $\pm 1\%$ throughout the switched range. The range is 0 to 111,110 ohms, in steps of 0.2 ohm. J. J. Lloyd Instruments Ltd, Brook Avenue, Warsash, Southampton, SO3 6HP.
WW 318 for further details

Integrated Circuit Modules

A range of low-cost logic modules is available from Honeywell Ltd. Called the μ-Pac series 320, the range is compatible with other Honeywell ×-Pac integrated circuit modules and is designed for systems operating at 2MHz. Initially included in the new range are gated flip-flop, counter, NAND, multi-input NAND, transfer gate, buffer register, power amplifier, decimal/octal decoder and selection gate modules. The range will be expanded in the near future. Honeywell Ltd, Great West Road, Brentford, Middlesex.
WW 319 for further details

Plastic Potentiometers

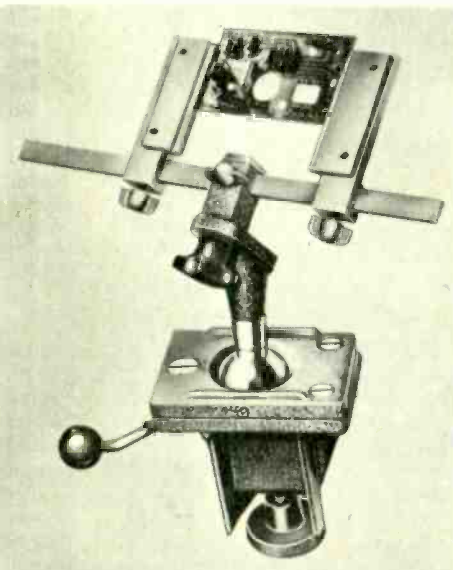
The recently formed Rotating Components Group of Ferranti Ltd, has announced the introduction of a new product line—conductive plastic potentiometers. These have been developed over

the past few years to provide a range of environmentally proven components of high stability and virtually infinite resolution. The new potentiometers are continuously rotatable through 36(

degrees and provide an electrical output through 340 degrees (standard) or any angle up to 350 degrees (special). The resistance tolerance is 10% (standard) or 5% (special), and life expectancy is better than ten million sweeps. Operating temperature range is −55° to +100°C. The first types introduced in the new range are the type 20 and the type 11HL. The type 20 provides a resistance range of 1kΩ to 10kΩ. Up to eight sections can be ganged together, with as many as eighteen :aps per section. Standard linearity is ±0.25%. The type 11HL has a resistance range of 500Ω :o 5kΩ, and is available in two configurations: :he type 11HL1, a single gang model without iide terminals; and the type 11HL2 which is availible in units up to six gangs and is fitted with side :erminals. Standard linearity is 0.25%. Rotating Components Group, Ferranti Ltd, Crewe Toll, Ferry Road, Edinburgh.
WW 329 for further details

ʼersatile Vice

\ multi-position vice, the Spannfix-Vario, has been lesigned specifically for the assembly of electronic :omponents and printed circuits. The standard ›ase is fitted with clamps for bench fixing and :omprises a universal toggle joint which can be



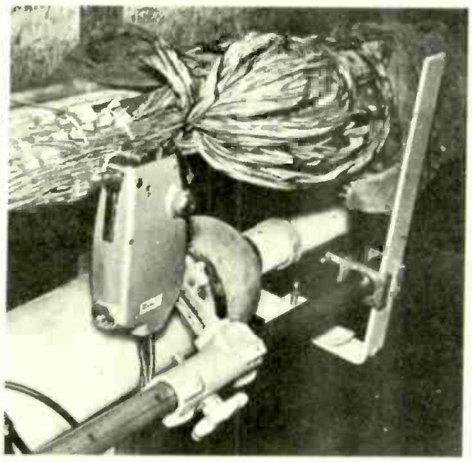
ɩcked by a lever. The working attachments are tted to this joint enabling the workpiece to be :cured at any angle. Vice jaws are 42mm wide ith a maximum capacity of 45mm. The p.c. ɔard holder is available in two sizes. The smaller ze will take boards from 25 to 220mm wide and ıe larger size will take boards from 30 to 240mm ide. Construction is of light alloy with hardened :eel for parts which are subject to wear. Henri icard & Frere Ltd, 34/35 Furnival Street, London .C.4.
ʼW324 for further details

ːadiation Tolerant ʻransistors

ew from Texas Instruments Ltd are two radiaɔn-tolerant silicon small-signal transistors :signed for general purpose switching and nplifier applications. They are said to be the ost radiation-tolerant complementary-paired :vices currently available. Both have f_T ratings om 800-1500MHz, and both use the TO46 ıckage. 2N5332 is a p-n-p transistor with a orst-case static forward current transfer ratio $_{FE}$) of 10 at I_C = 20mA after exposure to a :utron fluence (time-integrated neutron flux :nsity) of 10^{15} neutrons/cm^2. The 2N5399 is an :p-n device with a worst-case h_{FE} of 12 after :posure to the same neutron fluence and at the same collector-current level. These transistors are noteworthy because of their low (less than 3 to 1) h_{FE} degradation following exposure to neutron fluence of 10^{15}/cm^2. The pre-radiation h_{FE} for the 2N5399 ranges between 30 and 90 (typically 50) at I_C = 20mA. Pre-radiation h_{FE} for the p-n-p version 2N5332 is 20 to 80 (typically 40) at the same I_C level. BV_{CBO} for the p-n-p unit is 20V, and 25V for the n-p-n device. V_{CE} ratings are 12 and 15V, respectively. Both radiation-tolerant transistors are made with a processing technique that utilizes very shallow diffusion profiles, high concentration of impurity dopants, and minimum area. Texas Instruments Ltd, Manton Lane, Bedford.
WW 332 for further details

Cable Jointing Machine

A machine which has been designed by the G.P.O. and by the Plessey Company produces more reliable joints in shorter time, when compared



to earlier methods, and is intended for use on telephone cables although many other applications are possible. There is no need to strip the wires before jointing. The wires are laid in the jaws of the electro-hydraulic machine and a button is pressed, the insulation is penetrated, the wires are cold welded together and the joint is protected by a wrap around insulating sleeve, all in a single operation and in less than three seconds. The insulating sleeves are held in an easily replaceable magazine. Plessey Company, Kembrey Street, Swindon, Wilts.
WW 306 for further details

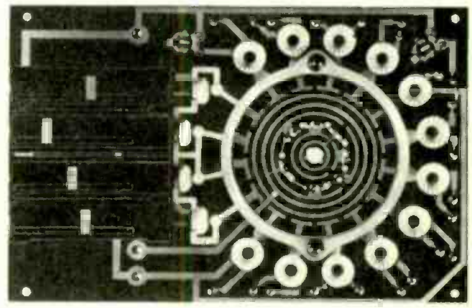
Variable-frequency Power Source

A variable-frequency power supply rated at 120W continuous output has been added to the range marketed by LTV Ling Altec Ltd. The new model

PPA120VA, complete in its own free-standing cabinet, can be used as a general purpose laboratory power supply to provide any frequency between 40Hz and 10kHz. The output voltage is continuously variable between zero and 100%. Fixed or variable frequency sources can be used. The low distortion allows the amplifier to be used in high-power audio systems. LTV Ling Altec Ltd, Baldock Road, Royston, Herts.
WW 308 for further details

Programme Selector for Varicap Tuners

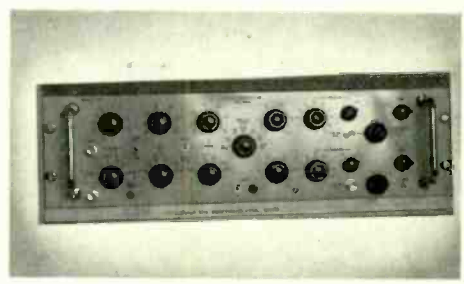
A tuning assembly by ITT is designed to store the tuning positions of 12 v.h.f. and four medium-wave band programmes in receivers with



Varactor diode tuning. The 16 carbon resistance films for the potentiometer and the switch contacts are printed on a single substrate. Connection of the 12 v.h.f. tuning potentiometers is such as to provide an overlap of 2MHz between adjacent switch positions. A large knob, which operates the switch for programme changing, contains a smaller knob which engages with the selected potentiometer when it is depressed thus allowing retuning to be carried out by the user. ITT, Edinburgh Way, Harlow, Essex.
WW 334 for further details

Pulse Generator

Pulse generator model T15-S by K.S.M. Electronics is a solid-state instrument with an internal oscillator range of 15Hz to 15MHz. A delay circuit and pulse-width circuit each have a range of 30ns to 30ms. Rise and fall times can be controlled independently in the range 10ns to 30ms thus



allowing waveforms of different shapes to be produced. An independently controlled positive and negative output pulse up to 10V in amplitude is provided with d.c. levels variable from −3V through to +3V allowing a variable offset voltage about earth. Single, double or groups of pulses can be obtained. K.S.M. Electronics Ltd, Bradmore Works, Bradmore Green, Brookmans Park, Hatfield Herts.
WW317 for further details

Programmable Voltage Source

A voltage source announced by Oltronix gives a remotely programmable output voltage range from 1mV to 200V in increments of 1mV. Other programmable functions include output polarity, floating or chassis earth and internal or external sensing of output voltage. Line regulation is 2 parts in 10^5 and load regulation 1mV + 5 parts in 10^5 output voltage. Recovery time is 200mA with automatic current limiting at 230mA. The unit,

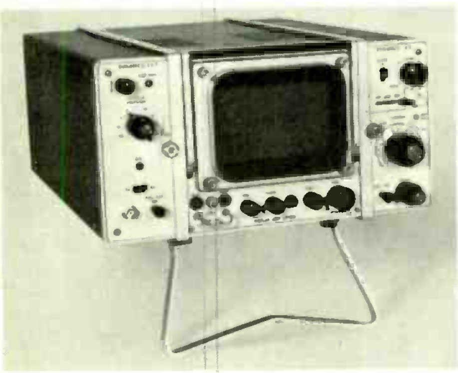
type A200, is protected against short-circuit and overload. Programming is by contact closure in an 8421 b.c.d. format at a maximum current of 25mA. Supply voltage is 240V ±10%, 0.5A, 50Hz ±6%. Dimensions are 480 × 90 × 254mm and weight 7kg. Oltronix UK Ltd, 99 Bancroft, Hitchin, Hertfordshire.
WW 320 for further details

Fast Power Switches

Eight n-p-n silicon power transistors for high-voltage, fast-switching, and high-current applications are announced by Motorola. At 2A collector current the maximum saturation voltage ($V_{CE\ sat}$) is only 0.7V and maximum rise time 100nsec. Types 2N5336-39 are devices in TO39 cases (up to 6W dissipation) and types 2N5427-30 are 7A devices in TO66 cases (up to 35W dissipation). Sustained V_{CEO} is 80V for the first two of each series and 100V for the second two. Motorola Semiconductors Ltd, York House, Empire Way, Wembley, Middx.
WW 314 for further details

Lightweight Oscilloscope

A new oscilloscope announced recently by Dynamco is a solid-state lightweight model with 15MHz bandwidth and costing £355. It is fitted with a general purpose single-channel Y amplifier



with a basic deflection factor of 50mV/division and a switched × 10 a.c.-coupled pre-amplifier. The timebase module provides calibrated sweep rates of 0.5μs to 0.2s/division. A switched ×10 magnifier gives a maximum sweep speed of 50ns/division. Dynamco Ltd, Hanworth Lane, Chertsey, Surrey.
WW 336 for further details

Digital Volt/Ohm Meter

Model 9000 Volt/Ohm meter marks the debut in the digital voltmeter field of Systron-Donner, of Concord, Colorado. This instrument can be panel-mounted, used on the bench top or fixed on a swivel

mount above the bench area. The makers say a quick response input amplifier eliminates hunting and enables the d.v.m. to track varying inputs. Noise rejection is 80dB and reading accuracy is 0.1% of reading on d.c. and ohms. Measurement ranges selected by front panel control are: 1, 10, 100V and 1kV, and 1k Ω to 10M Ω in five steps. U.K. agents: Aveley Electric Ltd, South Ockendon, Essex.
WW 335 for further details

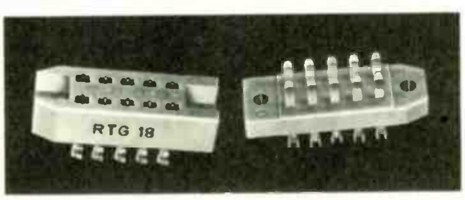
Tunable TR Limiter

A new X-band TR limiter (BS908) introduced by English Electric Valve Co. Ltd, combines a high Q cell with a varactor limiter stage. The addition

of the limiter stage gives added protection against spike leakage, which in turn reduces noise deterioration and limits crystal burn-out. For use in marine radar applications the BS908 is tunable over the frequency range 9250 to 9550MHz, and will work in duplexers with up to 75kW transmitted power. Overall dimensions are height 96.85mm, width across mounting flange 41.28mm and depth 39.5mm. Net weight is approximately 250g. English Electric Valve Co. Ltd, Chelmsford, Essex.
WW 301 for further details

Rack and Panel Connector

Cannon connector type RTG-18 is for rack and panel mounting and features a shell-less design with crimp removable contacts. The contacts are in numbers of 39, 26, 20, 16 and 10 (DIN specification 41618) and contact cavities can be left empty to



provide additional arrangements. The blade-type pin contact and knife-edge socket contact are said to require low insertion and removal forces. Contact finish is silver. The RTG-18 insulator features a monobloc construction giving high mechanical strength and good electrical characteristics. Cannon Electric (Great Britain) Ltd, Lister Road, Winchester Road, Basingstoke, Hants.
WW 323 for further details

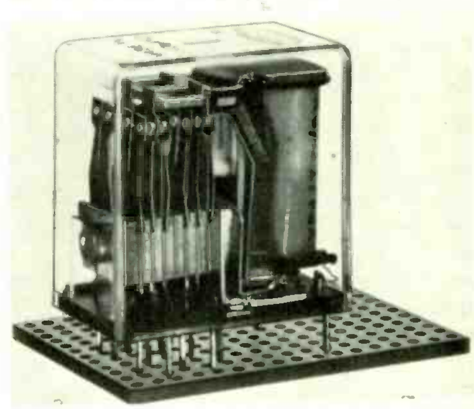
Instrumentation Tape Recorder

The Philips ANA-LOG 7, is an advanced IRIG compatible transportable instrumentation tape recorder providing up to seven data channels

and one voice channel on a half-inch tape. The dual-capstan crystal-controlled tape transport has four speeds with an overall ratio of 1:32. The tape is protected by a closed cassette and is threaded into the machine automatically. The complete electronics for record and replay, in either f.m. or direct record modes, is contained in a single plug-in module for each channel. Equalization for each tape speed is selected automatically. Frequency response is 0-10 kHz f.m. and 250Hz-100kHz direct recording. Power requirement is 110-250V at 50 or 60Hz, or 24V d.c. Pye T.V.T. Ltd, Cambridge.
WW 326 for further details

Relay for P.C. Board

A relay, for direct mounting on 0.1in (2.54mm) grid centre printed-circuit board, is available from Oliver Pell Controls Ltd. Contact arrangements are 2, 4 and 6 changeover and 6 or 8 make



or break, at 1A or 5A ratings. The relay stands 30.1mm above the board and widths vary from 24.4mm to 36mm. Depths are all constant at 18.5mm. Oliver Pell Controls Ltd, Cambridge Row, Woolwich, London, S.E.18.
WW 310 for further details

Transistor Test-set

Labgear Ltd announce a transistor test-set which combines the functions of a dynamic transistor-tester and that of a test-signal generator. Essentially a serviceman's fault-finding unit, the set provides direct reading of important transistor characteristics and particularly gives indication of the current gain and also of the collector leakage current of transistors in common emitter connection. A plug-in signal injector probe is supplied with the set, permitting "in-circuit" fault localization. There is a built-in a.c. mains operated power supply although, to maintain absolute portability, the set can be battery powered. Equipment under test can be powered from the external d.c. output available from two spring terminals on the top of the unit. Labgear Ltd, Cromwell Road, Cambridge.
WW 328 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.

4. Two-port networks

Of the four networks referred to below lect the one which asymmetrical
(a) Fig.1 (c) Fig.3
(b) Fig.2 (d) Fig.4

. Of the four networks referred to below elect the one which is balanced
(a) Fig.1 (c) Fig.3
(b) Fig.2 (d) Fig.4

Three of the networks referred to below e electrically equivalent at all frequencies rovided there is no external connection etween input and output). Select the "odd an out".
(a) Fig.1 (c) Fig.5
(b) Fig.2 (d) Fig.7

At a particular frequency it is found that hen an impedance of value Z is connected to e output terminals of the network shown in g.9 the input impedance is also Z. Z is
(a) an image impedance
(b) an iterative impedance
(c) the characteristic impedance
(d) the design impedance.

With the output terminals of the network own in Fig.9 short-circuited the input imedance, Z_{S1}, is measured. The output terinals are now open-circuited and the input npedance, Z_{01}, is measured. Both these easurements are made at the same freiency. The square root of the product of $_{1}$ and Z_{01} gives at that frequency
(a) the image impedance
(b) the iterative impedance
(c) the characteristic impedance
(d) the design impedance.

The network of Fig.10 is related to those Figs.1 and 5 in that
(a) its two image impedances have the same values as their characteristic impedances
(b) its two iterative impedances have the same values as their characteristic impedances
(c) the phase shift which it produces at any frequency is the same as that of both in series
(d) the attenuation which it produces (under matched conditions) is the same as that produced by the two in series.

Fig.8 shows an attenuator network with haracteristic resistance of 600 Ω and a rated enuation of 6dB. Its insertion loss is 6dB
(a) under all conditions
(b) only if the load impedance is 600 Ω resistive
(c) only if both the load impedance and the generator internal impedance are 600 Ω resistive
(d) if either the generator internal impedance or the load impedance or both are 600 Ω resistive.

7est Ham College of Technology, London, E.15

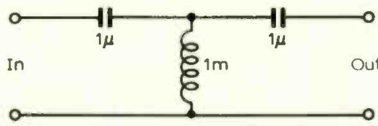


Fig. 1

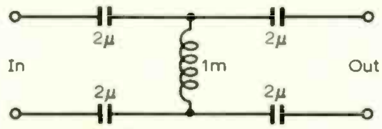


Fig. 2

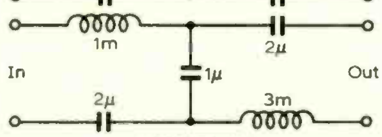


Fig. 3

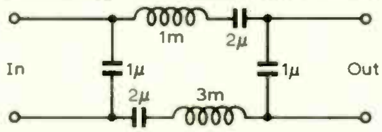


Fig. 4

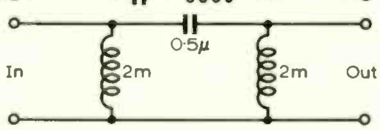


Fig. 5

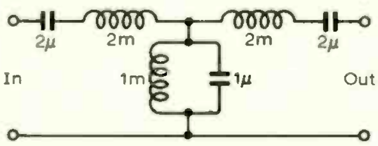


Fig. 6

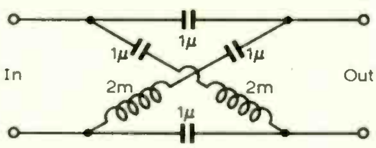


Fig. 7

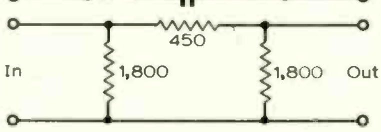


Fig. 8

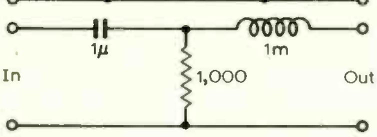


Fig. 9

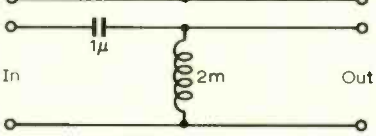


Fig. 10

8. The network of Fig.8 is connected between a generator and a load. The voltage appearing across the output terminals is half that at the input terminals
(a) under all conditions
(b) only if the load impedance is 600 Ω resistive
(c) only if both the load impedance and the generator internal impedance are 600 Ω resistive
(d) if either the generator internal impedance or the load impedance or both are 600 Ω resistive.

9. The outputs of the networks referred to below are all short-circuited. The input impedance will be purely reactive in all but one case. It is
(a) Fig.4
(b) Fig.6
(c) Fig.9
(d) Fig.10.

10. The network shown in Fig.1 may be regarded as a T section from a ladder network (this allows us to use well known standard formulae to determine its transmission properties). The elements of the ladder network are series capacitors and shunt inductors of values respectively
(a) 2μF and 1mH
(b) 2μF and 2mH
(c) ½μF and 1mH
(d) ½μF and 2mH.

11. The network of Fig.7 is high-pass filter with a cut-off frequency of 3560Hz and a design impedance of 45 Ω. IT is used to terminate a transmission line of characteristic impedance 45 Ω and its output terminals feed a 45 Ω load. A signal of frequency 1kHz is applied to the input of the line. Most of the energy reaching the end of the line is
(a) absorbed in the load
(b) absorbed in the network
(c) reflected back along the line
(d) radiated away.

12. The network of Fig.5 is
(a) a constant k high-pass filter
(b) a constant k low-pass filter
(c) a constant k band-pass filter
(d) not constant k, and has transmission properties which are not obvious by inspection.

13. The network of Fig.6 is
(a) a constant k high-pass filter
(b) a constant k low-pass filter
(c) a constant k band-pass filter
(d) not constant k, and has transmission properties which are not obvious by inspection.

14. The transmission properties of a symmetrical lattice network of pure reactances, such as the one shown in Fig.7, can be deduced by considering the frequencies at which poles and zeros occur for the reactances of the series and diagonal arms. A transition between a stop and a pass band occurs at each frequency where
(a) a pole for one arm coincides with a zero for the other
(b) a pole for one arm coincides with a pole for the other, or a zero coincides with a zero
(c) either a pole or a zero for one arm coincides with either for the other
(d) a pole or zero occurs for one arm, but neither occurs for the other.

Answers and comments, pages 345

World of Amateur Radio

How much compromise in transceiver design?

A major change in recent years in professionally designed equipment for the amateur market has been the emerging of the compact h.f. transceiver, usually intended primarily for s.s.b. operation. British, American and Japanese equipments and kits have appeared on the market in considerable numbers. While, in the best examples, such equipments provide extremely effective performance, despite their small size, there is some concern that, in order to keep prices as low as possible, performance specifications have sometimes been pared to a minimum. For example, to give the stability required for s.s.b. working, multi-conversion receivers with crystal-controlled first oscillators are almost always used. When high-gain, automatic-gain-controlled r.f. amplifers and high-gain mixers are used, such equipments tend to become vulnerable to cross-modulation from loud, local stations. To some extent, this problem can often be overcome by modification of the a.g.c. arrangements or the fitting of additional r.f. gain controls. Another problem arises from the very different duty cycle imposed on power supplies during s.s.b., c.w., and r.t.t.y. operation. For whereas s.s.b. has a duty cycle of the order of 12%, that for c.w. is about 45%, while r.t.t.y. is 100%. There is thus a tendency to skim the "iron" in the power units on the grounds that s.s.b. is the main requirement; similar considerations often result in selectivity characteristics tailored to s.s.b. rather than c.w. requirements. While the task facing designers in this field is a difficult one, there can be little doubt that, in some respects, the demand for all-purpose, low-cost equipments for the amateur is resulting in compromise designs.

U.K. "B" licences still soaring

Amateur licence totals in the U.K. at April 30th again underlined the impact of the 1968 concession to holders of the "B" licences (for which no Morse Test is demanded, and which carry a G8-three-letter callsign) when it was agreed that operation would be permitted on the popular 144-MHz band. With 1530 "B" licences in force at April 30th (compared with 872 a year ago), these now represent over 10% of the total of fixed amateur station licences. This increase of 658 compares with the corresponding figure of 390 (from 12785 to 13175) for "A" licences. The "B" licence is now not only attracting substantially more newcomers than the full "A" licence, but appears to have resulted in a substantial falling off in numbers applying for "A" licences. There has also been a remarkable increase in "B" mobile licences which have shot up in the 12 months from 55 to 172. Amateur television licences at 188 show practically no change.

L12B for another Heyerdahl expedition

The callsign LI2B, made famous by its use during Thor Heyerdahl's Kon Tiki expedition in 1947, has again been allocated to his re-creation of an ancient Egyptian papyrus boat, the *Ra*. This has set out from Africa in an attempt to show that it would have been possible for such vessels to have sailed to South America, and thus explain similarities between the Egyptian and Aztec civilizations. Radio equipment is carried primarily for emergency purpose, but, as on the Kon Tiki raft, is to operate also as an amateur station.

V.H.F. changes discussed at Brussels

The recent I.A.R.U. Region 1 meeting in Brussels is understood to have recommended the introduction of a number of important changes for European v.h.f. operation, including the voluntary allocation of more frequency space for c.w. (telegraphy) and amateur television operation, as well as the moving of regular beacon transmissions to the higher frequency, rather than the lower frequency, edges of the bands. Concern is also being expressed among European amateurs at the increasing tendency of some stations to operate on telephony in the c.w. segments of the h.f. bands. Frequencies voluntarily reserved for c.w. are: 3500–3600; 7000–7040; 14000–14100 (r.t.t.y. around 14090); 21000–21100; 28000–28200 kHz.

Moonbounce contacts and v.h.f. news

A further "moonbounce" contact has been made by Peter Blair, G3LTF, of Chelmsford, Essex, with the Californian amateur, Peter Laakmann, WB6IOM, on 1296 MHz. The American signals peaked 12dB over noise in a bandwidth of 100Hz and signals were copied for 80 minutes. These amateurs have developed a new code to facilitate passing simple messages by varying the dash frequency and spacing, claimed to be effective at signal-to-noise ratios some 6dB lower than for morse. A group of Danish amateurs using the callsign OZ8EME is conducting 432-MHz moonbounce tests with 900 watts transmitter output and a 20ft parabolic aerial. A two-way contact on 2300MHz exceeding 100 miles was achieved on May 11th when A. Wakeman, G3EEZ, on Clee Hill, communicated with L. W. G. Sharrock, G3BNL, on the Chilterns, using pulse modulation. A new 433.81 MHz beacon station, callsign G3SUT (later to be changed to GB3SC), has its aerials mounted 300ft up on the B.B.C. Sutton Coldfield television transmitter mast. F.S.K. is used, and aerials are beamed north and south-east.

The "Amateur" Prisoner-of-War

A well-known amateur who, while a prisoner-of-war from 1941-45 in Oflag 9 A/Z, built and operated secret radio sets, has died at his home in Harrogate. He was Ernest Shackleton, M.B.E., who held the amateur licence G6SN since 1935, and who was widely respected for his knowledge of workshop practice and skill in constructing equipment. After the end of the war, Capt. Shackleton returned to the P.o.W. camp to retrieve the equipment; one of the receivers is in the Imperial War Museum in London.

July contests and mobile rallies

Enhanced activity on the bands concerned can be expected during the following R.S.G.B. contest periods (times in G.M.T.) 1.8 MHz c.w. 21.00 July 5th to 02.00 July 6th; 144 MHz 16.00 July 5th to 14.00 July 6th; 3.5 to 28 MHz c.w. high-power field day 17.00 July 12th to 17.00 July 13th; and 432 MHz portable July 20th 10.00–16.00.

Large attendances continue to be recorded at mobile rallies. Among those being held during July are: South Shields (Bents Park Recreation Ground) on July 6th and intending visitors should obtain free parking tickets from D. Foster, G3KZZ, 4 Marlborough Street, South Shields; July 6th Colchester Zoo; July 13th New Forest (Stoney Cross Airfield); July 13th Worcester; July 27th Cornish Radio Amateur Club.

In Brief: Stratford-on-Avon Radio Club will be operating GB3SUA from July 11th to 13th to celebrate the 700th anniversary of the formation of the Guild of the Holy Cross, the beginning of local government in the town. Operation will be on 3.5, 14, 21 and 28 MHz. Information on the event from M. J. W. Webb, G3OOQ, 14 Townsend Road, Tiddington, Stratford-upon-Avon . . . GB3WRA is to be operated by a group of local amateurs from the annual Wycombe Show on the Rye, High Wycombe on September 6th on all bands from 1.8 to 70 MHz. Information from A. C. Butcher, G3FSN, 70 Hughenden Avenue, High Wycombe, Bucks . . . The U.S. Navy recently closed down its amateur operations in the Far East, apart from hospital ships . . . A new Radio Amateur Satellite Corporation has been formed in Washington, D.C., to try to obtain facilities for further launchings of amateur communications satellites.

PAT HAWKER, G3VA

Answers to "Test Your Knowledge"—14

Questions on page 343

-1. (*c*). Fig.4 appears at first sight to be asymmetrical, but each series arm can be split into two equal parts (both parts consisting of an inductor in series with a capacitor) without altering the electrical properties.

2. (*b*).

3. (*c*). Fig.1 and Fig.2 are equivalent; series impedance can be moved from one arm to the other without altering the transmission properties provided it is not moved to the other side of a shunt impedance. Fig.7 is the lattice equivalent of Fig.1 (as can be seen by applying Bartlett's bisection theorem). Fig.1 and Fig.5 are sections of the same ladder network, so that their propagation constants are the same, but their characteristic impedances are different.

4. (*b*). The network is quite obviously asymmetrical.

5. (*a*). If the network were symmetrical it would give the characteristic impedance. Note that the terms image or iterative impedance are sometimes applied to a symmetrical network, but in that case they are synonymous with characteristic impedance.

6. (*a*). Fig.10 is a half-section of Fig.1 and also of Fig.5. The image impedance at the port marked "in" in Fig.10 is the same as the characteristic impedance of Fig.1; the image impedance of the port marked "out" is the same as the characteristic impedance of Fig.5.

7. (*d*).

8. (*b*). The solutions to this and the previous question imply that if we have a switched attenuator matched at its input but not at its output, the attenuator setting will not indicate correctly the relationship between output and input voltages, but a *change* in the attenuator setting in dB will give the same change in output voltage in dB.

9. (*c*). The other three networks contain only reactances. Whatever currents flow in these reactances no power is absorbed, therefore the input impedance cannot have a real part.

10. (*c*). The reactance of a series element from the ladder must be twice the reactance of a 1μF capacitor. Hence its capacitance must be $\frac{1}{2}\mu$F.

11. (*c*). In its stop-band a filter attenuates by reflecting energy, not by absorbing it.

12. (*a*).

13. (*d*). A network of this configuration is a constant band-pass filter if the series and shunt arms have the same resonant frequency. This network has in fact two pass-bands.

14. (*d*). Foster's reactance theorem indicates that for either arm a reactance versus frequency plot has a positive slope at all points, and that poles and zeros alternate on the frequency axis. For a lattice network $Z_0=\sqrt{Z_S Z_D}$ so that Z_0 changes from real to imaginary (the criterion for a cut-off frequency) where Z_S and Z_D change from having opposite signs to having the same sign. If the reactance curves for Z_S and Z_D are plotted on the same graph it will be apparent that this will occur where one has a pole or zero and the other neither.

Literature Received

CATALOGUES

The 1969 **components stock catalogue** of ITT Electronic Services (Edinburgh Way, Harlow, Essex) is now available. It contains over 1,000 pages and lists numerous components. **WW 401** for further details

"Electronic Grade Chemicals" (Hopkin & Williams Ltd, Chadwell Heath, Essex) lists and gives the composition of a wide variety of chemicals. **WW 402** for further details

Printed circuit edge connectors and plugs and sockets are the main subject of a catalogue from Ultra Electronics (Components) Ltd (Fassets Road, Loudwater, Bucks), although some switches and tools are also included. **WW 403** for further details.

The range of "Cermet" **trimming potentiometers** and "Filmet" **metal film resistors** are described in a catalogue received from Morganite Resistors Ltd, Bede Trading Estate, Jarrow, County Durham. **WW 404** for further details.

"Numerals and Indicating Tubes" is the title of a leaflet listing the alphanumeric cold cathode tubes manufactured by AEG-Telefunken, Fachbereich Röhren, Vertrieb, 7900 Ulm, Soflinger Strässe 100. **WW 405** for further details.

The components group of S.T.C. have produced an **Acoustic Products** catalogue. S.T.C. Ltd, Acoustic Sub-Division, West Harlow, Essex. **WW 406** for further details.

Test equipment manufactured by Wayne Kerr (New Malden, Surrey) — bridges, analysers, oscillators, special purpose instruments, etc.—are described in a new catalogue. **WW 407** for further details.

We have received four catalogues describing **components** produced by the Japanese Mitsumi group available from Ataka & Co., (U.K.) Ltd, Roman House, Wood St., London E.C.2. They are: **(1)** Polivaricon trimmer capacitors—i.f. transformers; **(2)** Micro synchronous motors—trimming potentiometers; **(3)** f.m. and television tuners and sub-assemblies; **(4)** Cs photoconductive cells—cell lamps. (1)—**WW 408,** (2)—**WW 409,** (3)—**WW 410,** (4)—**WW 411** for further details.

A supplement to the XceLite catalogue (No. 166) contains details of professional **hand tools** (mostly various screw and nut drivers) fabricated in beryllium—copper or nickel—chrome. XceLite products are marketed by Special Product Distributors Ltd, 81 Piccadilly, London, W1V OHL. **WW 412** for further details.

Saturable core output/driver transformers, inverter transformers, converter/inverter drive modules and communication inductors are described in a catalogue available from Gardners Transformers Ltd, Somerford, Christchurch, Hampshire. **WW 413** for further details.

Copper clad laminates to (1)—DIN40802 and (2)—DIN7735 are described in two catalogues received from Dynamit Nobel AG, 521 Troisdorf, Cologne, Germany. (1)—**WW 414** and (2)—**WW 415** for further details.

Entertainment semiconductors produced by Ates Componenti Elettronici S.P.A. of Milan are described in a quick selection guide obtainable from their London office at Prospect House, Boston Manor Road, Brentford, Middx. **WW 416** for further details.

Two booklets describing the range of **PIXIE and NIXIE** readout tubes and associated equipment manufactured by the Burroughs Corporation are available from Walmore Electronics Ltd., 11-15 Betterton Street, Drury Lane, London W.C.2. The information given includes technical data and some application notes. **WW448** for further details.

"The World's Most Complete Electronic Tube Purchasing Directory" is the title of a booklet produced by the Metropolitan Supply Company, 468 Park Avenue South, N.Y., N.Y. 10016, U.S.A. It lists some 500 currently popular industrial, entertainment and military valve types. Manufacturers names, price (U.S.A. currency) and quantity discounts are supplied, but no technical information. **WW 449** for further details.

APPLICATION NOTES

"Hybrid Microcircuits for D-to-A converters" is the title of an application note (TP 691) we have received from Sprague which discusses thin film hybrid microcircuits and tantalum nitride and nickel chromium resistor networks. Literature Service, Sprague Electric Company, Marshall St., North Adams, Mass. 01247, U.S.A. **WW 417** for further details.

The title of this next application note is self explanatory **"Design and application of a Monolithic Voltage Regulator with Foldback Current Limiting".** It is available from Transitron Electronic Ltd, Gardner Road, Maidenhead, Berks. **WW 418** for further details.

"How to measure Group Delay on a Swept-frequency Basis" (77/4) is a very good publication explaining what group delay is and how it may be measured. Hewlett-Packard, 224 Bath Road, Slough, Bucks. **WW 419** for further details.

We have received six application notes from Ates, (Prospect House, Boston Manor Road, Brentford, London) they are **(1)** "A New supply circuit for solid-state TV without mains transformers"; **(2)** "Audio Hi-Fi Preamplifier"; **(3)** "High Fidelity 20-W Audio Amplifier"; **(4)** "Design of a Particular D.C.-D.C. Converter"; **(5)** "Low-cost Complementary Symmetry 15W and 5W Hi-Fi Audio Amplifiers"; **(6)** "Design of Transistorized Vertical Deflection Output Stages for Monochrome TV Receivers." (1)—**WW 420** (2)—**WW 421,** (3)—**WW 422,** (4)—**WW 423,** (5)—**WW 424,** and (6)—**WW 425** for further details.

"Processing Instructions for Trolitax Glass/Epoxy Laminates" gives advice on handling problems. Dynamit Nobel AG, 521 Troisdorf, Cologne, Germany. **WW 426** for further details.

"C Series Selenium Surge Suppressors" (19-13) gives a number of applications and other information on the range manufactured by Westinghouse Brake and Signal Company, Semiconductor Division, 82 York Way, London N.1. **WW 427** for further details.

"An Introduction to the Techniques of Mass-Soldering Printed Circuits" details methods and gives hints. Multicore Solders Ltd., Hemel Hempstead, Herts. **WW 428** for further details.

PRODUCT DATA

"High Speed Clock Channels" describes a device for retiming clock rates for glass delay line memories where severe ambient conditions preclude the use of normal techniques. Corning Glass International, S.A., 3 Cork St., London W.1. **WW 429** for further details.

The **Radio telephone** model FM-5 (148-170MHz) is described in a leaflet from Hallicrafters Co., 600 Hicks Rd., Rolling Meadows, Illinois 6008, U.S.A. **WW 430** for further details.

C.R.Ts and associated products. We have received details of the following products from Ferranti, Gem Mill, Oldham, Lancs:— c.r.ts **(1)** type 5G/75 **(2)** type 5J/75 and **(3)** type 9B/75; **(4)** c.r.t. mounting unit M400; (5) computer display unit CDU 21A and **(6)** guard ring diode GRD7. (1)—**WW 431,** (2)—**WW 432,** (3)—**WW 433,** (4)—**WW 434,** (5)—**WW 435** and (6)—**WW 436** for further details.

Received from Electrosil Ltd, P.O. Box 37, Pallion, Sunderland, Co. Durham data on the C3 **glass-tin-oxide resistor. WW 437** for further details.

Various **infra-red detectors** are described in literature available from the Barnes Engineering Co., 44 Commerce Rd., Stamford, Connecticut 0690 U.S.A. **WW 438** for further details.

Brimar have sent us literature on two c.r.ts these are:— **(1)** V4100/P16, 3 flying spot scanner; **(2)** M38-100-/GH, -/W, 15in data display/monitor tube Thorn Radio Valves & Tubes Ltd. 7 Soho Square, London W1V 6D (1)—**WW 439** and (2)—**WW 440** for further details.

A portable **spectrum analyser** for 10Hz to 50kHz is described in a leaflet available from Systron Donner Corp., 14844 Oxnard St. Van Nuys, California 91409, U.S.A. **WW 441** for further details.

A mains operated **crystal clock** manufactured by Venner Electronics Ltd Kingston By-Pass, New Malden, Surrey, is the subject of a new leaflet. **WW 442** for further details.

Soldering products. The following products are described in leaflets obtainable from Multicore Solders Ltd, Hemel Hempstead, Herts. (1) Activated surface preservative. **(2)** non-corrosive liquid flux. **(3)** rosin foam flux. **(4)** protective coating. **(5)** solvent cleaner. (1)—**WW 443,** (2)—**WW 444,** (3)—**WW 445,** (4)—**WW 446** and (5)—**WW 447** for further details.

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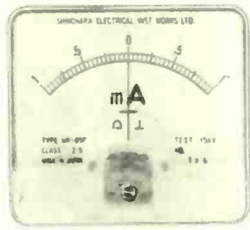

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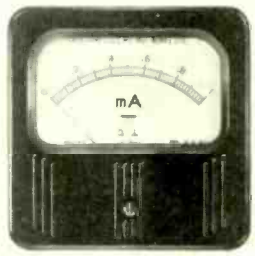

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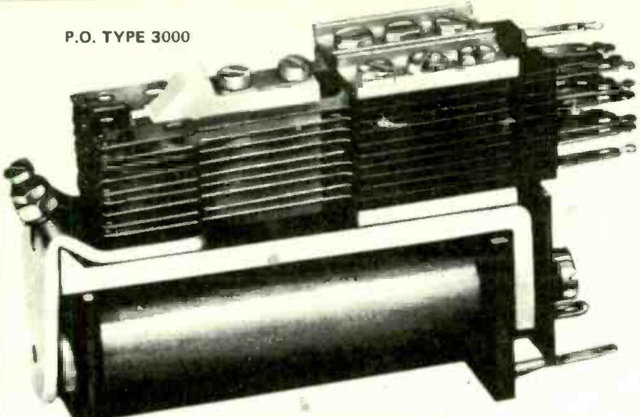

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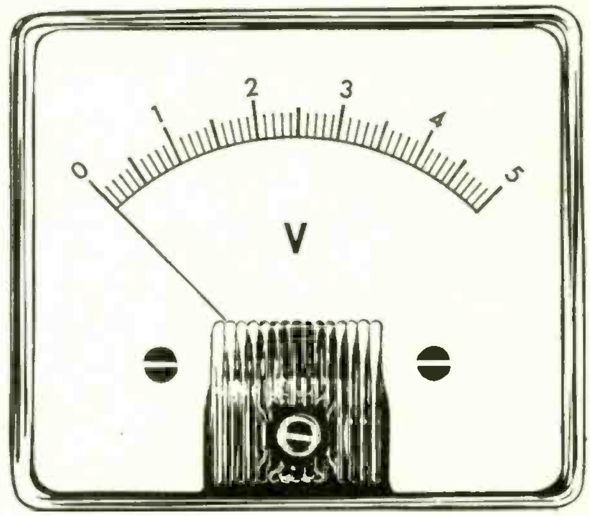

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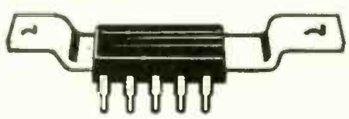

Originally developed for computer and space projects—these tiny modules—size only 25 x 10 x 5 millimetres—represent the most amazing breakthrough in circuit design since the introduction of the transistor. The actual circuit no bigger than a pinhead—is encapsulated in solid plastic fused with the heatsink and connecting pins to make an almost indestructible unit. The IC-403 is an integrated power and pre-amplifier requiring only the addition of tone and volume controls, power source and speaker to form a complete audio amplifier of 3W output.

SPECIFICATION (ratings at 25°C): Output power typically 3W from 250mV input. Frequency response 20Hz to 80KHz ± 3dB. Power amp. distortion 0.3% (at 1W.400Hz). Pre-amp. gain 24dB. Power amp. gain 26dB. Max. operating voltage 21V. Min. operating load 7.5 ohms. Noise level −75dB. Pre-amp. input imp. 2M/Ohms. Power amp. input imp. 100M/ohms. Pre-amp. and power amp. D.C. input current 50nA.

THE IC-403 IS AVAILABLE FROM STOCK EXCLUSIVELY FROM LASKY'S—COMPLETE WITH INSTRUCTION DATA AND SUGGESTED CIRCUIT APPLICATIONS.

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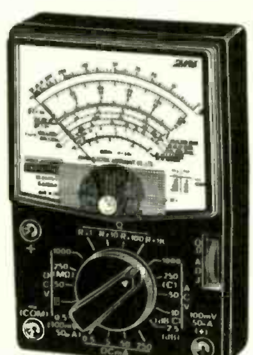
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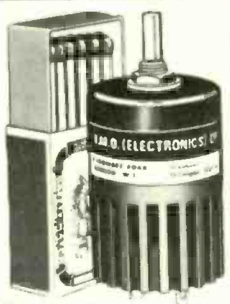

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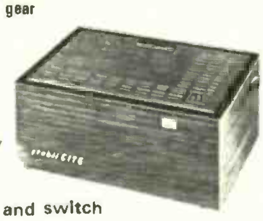

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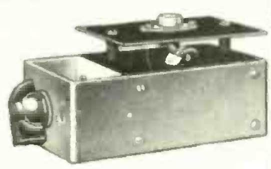

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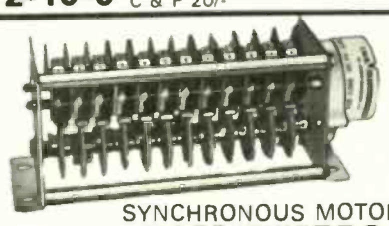

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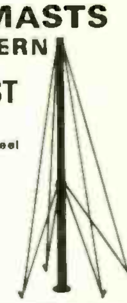

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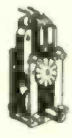
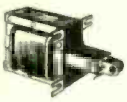
Very powerful 7 r.p.m., operates from standard A.C. mains. 29/6. plus 3/6 P. & P.





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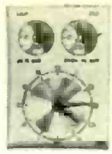
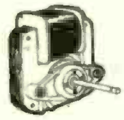


Made by Smith's these units are as fitted to many top quality cookers to control the oven. The clock is mains driven and frequency controlled so it is extremely accurate. The two small dials enable switch on and off times to be accurately set. Ideal for switching on tape recorders. Offered at only a fraction of the regular price—new and unused only 39/6. less than the value of the clock alone—post and insurance 2/9.



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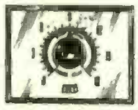

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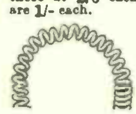

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as fitted to telephones, 4 core 2/6 each, 3 core 2/- each.

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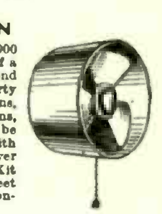

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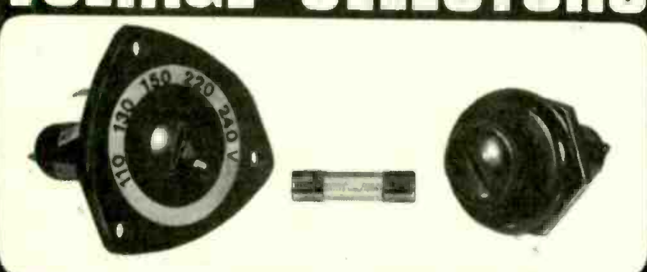

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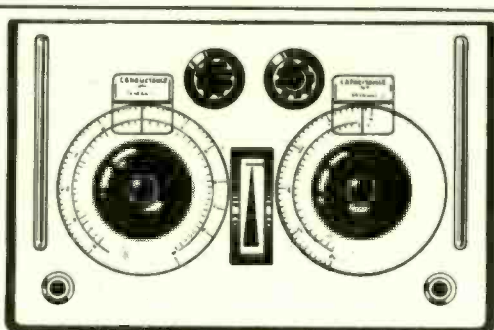
easier  faster

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WITH THE
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Ultra sensitive detector/amplifier for infra-red (Gallium Arsenide) or visible light optical links reception. Spectral response 9500 A. Robust, cylindrical package is coaxial with incident light to facilitate optical alignment and heat sinking.

85/- *post free*

MAX RATINGS

Total dissipation (in free air, T_{amb} = 25°C.)........100mW. Derating Factor........2mW/°C. Output Current Intensity........100mA. Voltage........25V. Operating Temperature........from —30° to +125°C.

Supplied complete with suitable lenses, full Technical Data and Application Sheets, including Line of Sight Speech Link.

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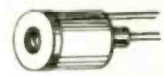
Filamentless, infra-red emitter in a robust, sealed cylinder coaxial with beam to facilitate optical alignment and heat sinking.



35/- *post free*

MAX RATINGS

Forward current I_F max. D.C.........400mA. Forward peak current I_F max.* (pk)........6A*
Power dissipation........600mW. Derating factor for T_{amb} greater than 25°C........7.5mW/°C.*
Reverse voltage V_R max 1-0V.
**When mounted on an aluminium heat sink 1 in. x ½ in. x ½ in.*

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Silicon NPN photo-diode of passivated planar construction, suitable for punched card readers, counters, film sound track, etc.

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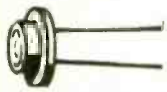
Inexpensive light sensitive resistors which require only simple circuitry to work as light triggering units in a wide range of devices, such as: flashing or breakdown lights, exposure meters, brightness controls, automatic porch lights, etc. Not polarity conscious — use with A.C. or D.C. Spectral response covers whole visible light range.

MKY251

Epoxy sealed 1½ in. diam. x ¼ in. thick. Resistance at 100 Lux – 700 to 3,000 ohms. Maximum voltage 200 A.C. or D.C. Maximum current 500 mW. **12/6** *post free*



MKY101-C

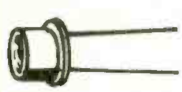
Epoxy sealed. ⅜ in. diam. x ⅛ in. thick. Resistance at 100 Lux – 500 to 2,000 ohms. Maximum voltage 150 A.C. or D.C. Maximum current 150 mW. **10/6** *post free*

MKY71

Glass sealed with M.E.S. base. Glass envelope $\frac{5}{16}$ in. diam., overall length 1 in. Resistance at 100 Lux – 50 Kohms to 150 Kohms. Maximum voltage 150 A.C. or D.C. Maximum current 75 mW. **8/6** *post free*

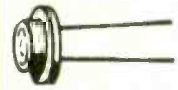
CADMIUM SELENIDE CELLS (Cdse)

These have a higher dark resistance in a given period than Cadmium Sulphide Cells, indicating much faster response. Suitable for all Cds applications plus applications in chopper, electronic musical instruments, computer and other sophisticated circuitry. Time response shown in megohms is dark resistance measured 10 secs. after 400 Lux light intensity is intercepted.



MKB5H

Hermetically metal sealed. ¼ in. diam. x ¼ in. thick. Time response 100 megohms. Resistance at 1,000 Lux – 1 Kohm to 10 Kohms. Resistance at 10 Lux – 50 Kohms to 1 megohm. Maximum voltage 50 A.C. or D.C. Maximum current 10 mW. Continuous current 5 mW. **16/6** *post free*



MKB12H

Hermetically metal sealed ⅜ in. diam. x $\frac{3}{16}$ in. thick. Time response 100 megohms. Resistance at 1,000 Lux – 100 ohms to 1,000 ohms. Resistance at 10 Lux – 1 Kohm to 10 Kohms. Maximum voltage 50 A C. or D.C. Maximum current 80 mW. Continuous 30 mW. **16/6** *post free*

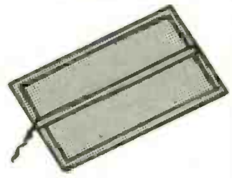
PHOTOGENERATIVE CELLS

Selenium cells in which light energy is converted into electricity directly measurable on microammeter or used with amplifier as light trigger for alarm and counting devices, luminous fluxmeters, exposure meters, colorimeters, etc., Spectral response covers visible light range.

Type 1—1½ x 1$\frac{3}{16}$ in. Output 1 mA at 0.6 volts at 1,000 Lux **5/-** *post free*

Type 2—28 x 18 mm. Output 500 μA at 0.6 volts at 1,000 Lux **3/6** *post free*

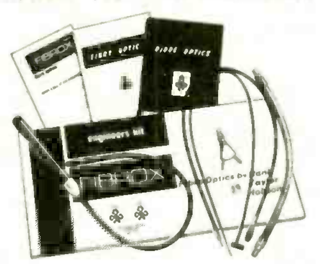
Type 3—100 x 50 mm. Output 4 mA at 0.6 volt at 1,000 Lux **22/6** *post free*



FIBRE OPTICS

Highly flexible light guides that transmit light to inaccessible places as easily as electricity is conducted by copper wires. Fibre optics make it possible to control, miniaturize, split, reflect or transfer light from one source to many places at once and to operate photo devices, logic circuits, or illuminate in ways never before possible. Proops offer both glass fibre optics or inexpensive Crofon plastic fibres for hundreds of experiments or serious applications in a fascinating new science.

RANK TAYLOR-HOBSON ENGINEERS KITS

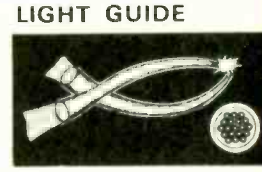


All the basic components needed to demonstrate new ways to use light in serious applications with glass fibre optics consisting of thousands of fibres tightly bundled in a flexible sheath with ferruled, optically polished ends. Kit includes 12, 18, and 24 inch standard light guides in 1.5, 3 and 6 mm widths, 24 inch twin exit guide with 2 x 1 mm. outputs. Non-random 'Y' guide with 2 x 3 mm. outputs, adaptors and battery operated light source. **Supplied complete with card wallets containing technical data and illustrated applications.**

£16 *post free*

LOW-COST CROFON FLEXIBLE LIGHT GUIDE

Newly developed plastic light transmitting media made by Du Pont and consisting of 64 special plastic fibres, each .010 in. diam. and bundled together in a tough, flexible sheath. Can be used for many serious projects and inexpensive prototype work. Ends can be ground flat, dyed or capped with Epoxy resin. Temp. range —40° to 176°F. No loss of light through bending. **12-page data and applications booklet supplied.**



Minimum order—2 ft. **8/6** *per foot post free*

Other advanced Solid-State devices

RCA INTEGRATED CIRCUIT — CA3020

Complete Audio or Servo Amplifier in one tiny package!

Preamp, phase invertor, driver and power output function in a single package only ⅜ in. diam. and $\frac{3}{16}$ in. high. Operates from single D.C. supply of 3 to 9 volts; gives maximum output of more than ½ watt for 22 mA consumption. Low distortion, high gain is coupled with built-in temperature compensation (—55° to 123°C) and wideband operation. **Complete with data and circuit applications.**

42/- *post free*

RCA TRIAC — CA40432

Suitable for light dimming and motor control circuits

Gate-controlled, full-wave, A.C. silicon switch with integral trigger that blocks or conducts instantly by applying reverse polarity voltage. Suitable for A.C. operation up to 250 volts; controls currents up to 1440 watts. Size only ⅜ in. diam. x $\frac{3}{16}$ in. high. **Complete with heat sink, data and applications information.**

45/- *post free*

PROOPS

Proops Bros. Ltd., 52 Tottenham Court Road, London WIP OBA
Telephone: 01-580 0141

R.S.C. SENSATIONAL HIGH FIDELITY STEREO PACKAGE OFFERS

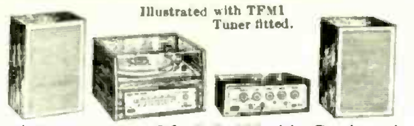
Matching as recommended for optimum performance. Compare prices with equipment and cabinets purchased individually.

'Package 3' 30 Watt Output

★ Goldring Transcription Turntable on Plinth.
★ Shure Magnetic Pick-up Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanton Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in". Really superb performance **86 Gns.** Send S.A.E. for leaflet. Carr. 25/-

Illustrated with TFM1 Tuner fitted.



'Package 2' 30 Watt Output

★ Garrard SP25 Mk. II Turntable on Plinth.
★ Goldring CS90 Ceramic P.U. Cartridge.
★ Super 30 Amplifier in veneered housing.
★ Pair of Stanton Loudspeaker Units.

Special total price. Four fully wired units ready to "plug-in." **76 Gns.** Carr. 25/-

Extremely Attractive and Versatile Plinths finished in Teak or Afrormosia veneer. Tinted Perspex "roll over" cover with satin chrome handle.

'Package 1' 13 Watt Output

★ Garrard SP25 Mk. II 4-speed Player Unit, on plinth.
★ Goldring CS90 Ceramic P.U. Cartridge.
★ TA12 Amplifier in veneered housing.
★ Pair of Dorchester Loudspeaker Units.

Special total price. Transparent Plastic cover 3 gns extra. Or Dep. £10 and 9 monthly payments £5.11.0 (Total £59.19.0) Carr. 25/- **51 Gns.**

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. Exceptional performance at low cost. Impedance 3 or 15 ohms.

Prices include carriage. PLEASE STATE IMPEDANCE

HF 510L	5"	10W	57/9	HF 120	12"	15W	69/9
HF 801D	8"	8W	58/9	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.

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.** Carr. 5/9

Or Senior 15 watt inc. HF 126 15,000 line Speaker **6 Gns.** Carr. 6/6.

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.**

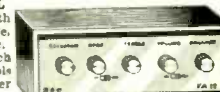
SE8 For optimum performance with any 8in. Hi-Fi 'speaker. Size 22 × 15 × 9in. **5 Gns.**

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. £5/2/6 and 9 mthly pymts. **31/6** (Total £19/6/0). Or in Teak or Afrormosia veneer housing **19½ GNS.** or Dep. £5/10/6 and 9 mthly. pymts. **39/-** (Total £23/1/6.)

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.

DORCHESTER Size 16 × 11 × 9in. Appr. Range 45-15,000 c.p.s. Rating 8-10 watts. Fitted High flux 13 × 8in. Dual cone speaker. Impedance 3 or 15 ohms. **£8.19.9** Carr. 7/6

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. Impedance 15Ω. Gives smooth realistic sound output. **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.**

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. 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. Complete kit. **19½ Gns.**

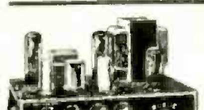
R.S.C. BATTERY/MAINS CONVERSION UNITS

Type BM1. An all-dry battery eliminator. Size 5¼ × 4¼ × 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**.

SELENIUM RECTIFIERS

F.W. Bridged 6/12v. D.C. O/P Input Max. 18v. A.C. 1a., **4/3**. 1½a **5/6**; 2a., **6/11**; 3a., **9/9**; 4a., **12/9**; 6a., **15/9**.

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. Suitable for High Impedance mic. or pick-ups. 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**. Or factory built with EL34 output valves and 12 months' guarantee for **17 gns.** Tech. figs. apply to factory built units. Carr. 12/6 **14 Gns.**

TERMS: Deposit £6 and 9 monthly payments of 32/- (Total **£20/8/0.**) Send S.A.E. for leaflet.

R.S.C. MAINS TRANSFORMERS

FULLY GUARANTEED. Interleaved and Impregnated. Primaries 200-250 v. 50 c/s. Screened

MIDGET CLAMPED TYPE 2½ × 2¼ × 2¼in.

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**. 10a. **55/11**.

AUTO (Step UP/Step DOWN) TRANSFORMERS

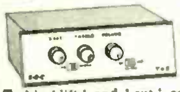
0-110/120v.-200-230-250v. 50-80 watts	15/9
150 watts, **29/11**; 250 watts **49/9**; 500 watts	99/9

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. TA6 6 Watt HIGH FIDELITY SOLID STATE AMPLIFIER



200-250v. A.C. mains operated Frequency Response 30-20,000 c.p.s. —2dB. Harmonic Distortion 0.3% at 1,000 c.p.s. Separate Bass and Treble 'lift' and 'cut' controls. 3 input sockets for Mike, Gram, Radio or Tape. Input selector switch. Output for 3-15 ohm speakers. Max. sensitivity 5mV. Output rating I.H.F.M. In fully enclosed enamelled case, 9¼ × 2¾ × 5¼in. Attractive brushed silver finish facia plate 10¼ × 3¼in. and matching knobs. Complete kit of parts with full wiring diagrams and instructions. Carr. 7/6. **£6.19.9** Or factory built with 12 months' guarantee. £8.19.9

INTEREST CHARGES REFUNDED

On Credit Sales settled in 3 months.

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. Output rating I.H.F.M. Size 9¼ × 2¾ × 5¼in. 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 **£4/13/6** and 9 monthly payments **25/6** (Total **£16/3/0**).

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. five 7 × 4in. spkrs. **£7/19/11**. Type C48S, 30 watts. Fitted four 8in. high flux 8 watt speakers. Overall size approx. 42 × 10 × 5in. **16 Gns.** Or deposit **67/-** and 9 mthly pmts. **34/9** (Total **£18/19/9**). Carr. 10/-.

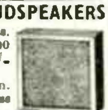
Type C412s, 50 watts. Fitted four 12in. 11,000 lines 15 watt speakers. Overall size 56 × 14 × 9in. approx. **24 Gns.** Or Deposit **£4/13/6** and 9 monthly payments of **52/6** (Total **£28/5/-**). Carr. 15/-

R.S.C. TFM1 SOLID STATE VHF/FM RADIO TUNER

Total cost of parts with detailed wiring diagrams & instructions. Inc. Carr. **14 Gns.** Or factory built **16½ gns.** Or in Teak finished cabinet as illustrated **19½ gns.** Terms: Deposit **£5** and 9 monthly payments **£2**. Total £23.

★ High-sensitivity ★ 200-250v. A.C. Mains operation. ★ Sharp A.M. Rejection. ★ Drift-free reception. ★ Output ample for any amplifier (approx. 500 m.v.). ★ Simple alignment instructions. ★ Output available for feeding tuning meter. ★ Output for feeding Stereo Multiplexer. ★Tuner head using silicon Planar Transistors. ★ Designed for standard 80 ohm co-axial input. Visually matching our Super 15 and 30 amplifiers and of the same high standard of performance and reliability. The pre-wired tuning head facilitates speed and simplicity of construction. Printed circuitry. Only high grade transistors and components used. A quality product at considerably less than the cost of comparable units. Stereo version. All parts **20 gns.** Inc. Carr. Assembled **22½ gns.** Inc. Carr.

12in. High Quality LOUDSPEAKERS



In teak veneered cabinets. 15 Watt Model. Gauss 11,000 lines. 3 or 15 ohms. **£5/15/-** Carr. 7/6

20 Watt Model. 15 ohm. Size 18 × 18 × 10in. Gauss 10,000 lines. Rexine covered **10/-** extra. **£8/19/9** Carr. 8/9

TWO-WAY 'PHONE AMPLIFIER

Listen and speak with both hands free. Handsome black case. Battery operated. **59/9**

R.S.C. SUPER 15 HI-FI AMPLIFIER

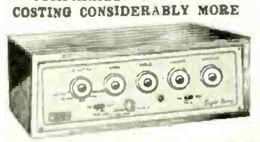
SOLID STATE SPECIFICATIONS COMPARABLE WITH UNITS COSTING CONSIDERABLY MORE

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. **12½ 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 ill. **19 Gns.**

COMPONENTS ETC. ARE OF A HIGH STANDARD AND SUPPLIED BY LEADING MANUFACTURERS.



R.S.C. SUPER 30 STEREO AMPLIFIER

A DUAL CHANNEL VERSION OF THE SUPER 15. Employing Twin Printed Circuits. High quality Ganged Pots. Matched Components. **CROSS TALK:**—52dB at 1,000 c.p.s. **CONTROL:** 5 position Input Selector, Bass Control. Treble Control. Volume Control. Balance Control. Stereo/Mono Switch. Tape Monitor Switch. Mains Switch. **INPUT SOCKETS** (Matched Pairs). (1) Magnetic P.U. (2) Ceramic or Crystal P.U. (3) Radio/Aux. (4) Tape Head/Microphone. Operation of the Input Selector Switch assures appropriate equalisation. Rigid 18 s.w.g. Chassis. Size approx. 12in. wide, 3in. high and 8in. deep. Neon Panel indicator. Attractive Facia Plate and Spun Silver Matching Knobs. Above facilities, etc., except for Ganging and Balance control, apply also to Super 15.

THESE UNITS ARE EMINENTLY SUITABLE FOR USE WITH ANY MAKE OF PICK-UP OR MICROPHONE (Crystal, Ceramic, Magnetic, Moving Coil, Ribbon) CURRENTLY AVAILABLE. SUPERB SOUND OUTPUT QUALITY CAN BE OBTAINED BY USING WITH FIRST RATE ANCILLARY EQUIPMENT. All required parts, point to point wiring diagrams and detailed instructions. Carr. 15/- **21 Gns.**

Unit factory built **28 Gns.** or deposit **£7/5/-** and 9 monthly payments **56/3**. (Total **£32/13/3**). Or in Teak or Afrormosia Veneered housing. **31 Gns.** Carr. 15/- or Deposit **£7/3/6** and 9 monthly paymts. **64/-** (Total £35/19/0). *Send S.A.E. for leaflet*

Record Playing Units

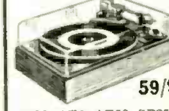
MONEY SAVING UNITS Ready to plug into Amplifier

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. **22 Gns.**

RP3 As above but with Goldring Lenco GL68 Transcription unit and CS90 Cartridge. Cover included. Carr. 21/-. ONLY **£28**

Various other types with Magnetic P.U. Cartridges and 'Lift off' or 'Roll over' transparent covers at lowest prices.

R.S.C. PLINTHS



for Record Playing units. Teak finish cut for Garrard 1000, 2000, 3000, AT6, AT60, SP25 etc. etc. **59/9** Available with clear Perspex cover as illustrated. Inc. carr. **6 Gns.**

Perspex cover sold separately at 3 Gns. Limited number of covers slightly damaged but repaired by Manufacturer. **39/9** to clear.

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GLASGOW 326 Argyle St. (Half-day Tues.). Tel. CITy 4158; 403 Sauchiehall St. (opp. Locarno) (Half-day Tues.). Tel. 332-1572
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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. **Open all day Sats. Mail orders MUST NOT be sent to shops.**

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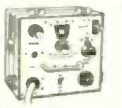
RACAL RA-17

First ministry release of these world famous communication receivers. Frequency range 500 Kc/s.–30 Mc/s. Available in excellent condition fully tested and guaranteed. £150 Carr. 40/-.

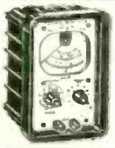
CLASS D. WAVEMETERS



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.

CLASS D WAVEMETERS No. 2

Crystal controlled. 1.2-19 Mc/s. Mains or 12v. D.C. operation. Complete with calibration charts. Excellent condition **£12/10/0**. Carr. 30/-.



MARCONI CT44 TF956 AF ABSORPTION WATTMETER

1 u/watt to 6 watts. **£20**. Carr. 20/-.

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/-.

AVOMETERS

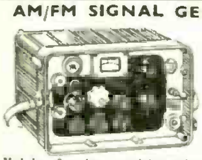
Supplied in excellent condition fully tested and checked. Complete with prods, leads and instructions.

Model 47A **£9/19/6** P. & P. 7/6.

SOLARTRON CD. 1016. OSCILLOSCOPE

Double beam. D.C. To 5 Mc/s. Excellent condition. **£55** each. Carr. 20/-.

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/-.

GEARED MAINS MOTORS

Parslux type 8D19 230/250 v. A.C. Reversible. 30 r.p.m. 40 lb. ins. Complete with capacitor. Excellent condition. **99/6**. Carr. 10/-.

AMERICAN RECORDING TAPES

First grade quality American tapes. Brand new and guaranteed. Discounts for quantities. Postage 2/-. Over £3 post paid.	3in. 225ft. L.P. Acetate	3/6
	3¼in. 600ft. T.P. Mylar	10/-
	5in. 600ft. Std. plastic	8/6
	5in. 900ft. L.P. acetate	10/-
	5in. 1,200ft. D.P. Mylar	15/-
	5¾in. 1,200ft. L.P. acetate	12/6
	5¾in. 1,200ft. L.P. Mylar	16/-
	5¾in. 1,800ft. D.P. Mylar	22/6
	5¾in. 2,400ft. T.P. Mylar	39/6
	7in. 1,200ft. Std. acetate	12/6
	7in. 1,800ft. L.P. acetate	15/-
	7in. 1,800ft. L.P. Mylar	20/-
	7in. 2,400ft. D.P. Mylar	25/-
	7in. 3,600 ft. T.P. Mylar	45/-

SINCLAIR EQUIPMENT

Z12. 12 watt amplifier **89/6**.
PZ4. Power supply Unit **89/6**.
STEREO 25, Pre-amplifier **£9/19/6**.
Q.14 Speakers **£7/19/6**.
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2 Z12 amps. PZ4 Power Supply, Stereo 25, Preamplifier £22
or with two Q.14 Speakers £37

NEW SINCLAIR 2000 SYSTEM

35 watt Integrated Amplifier, **£29**. Carr. 5/-. Self-powered FM Tuner, **£25**. Carr. 5/-.

ECHO HS-606 STEREO HEADPHONES

Wonderfully comfortable. Lightweight adjustable vinyl headband, 6ft. cable and stereo jack plug. 25-17,000 cps., 8Ω imp. **67/6**. P. & P. 2/6.

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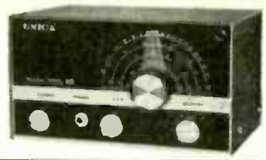
Our new walk around shop is now open at 311 Edgware Road, fully stocked with all Hi-Fi, Communication and Test Equipment. *Call into your nearest shop—Edgware Rd. for all Equipment—Lisle Street for all Equipment and Components.*

UNR-30 4 BAND COMMUNICATION RECEIVER



Covering 550 Kc/s-30 Mc/s. Incorporates BFO. 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

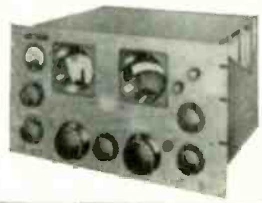
4 band receiver covering 500 Kc/s to 30 Mc/s, continuous and electrical bandspread on 10-15, 20, 40 and 80 metres. 8 valve plus 7 diode circuit. 4/8 ohm output and phone jack. SSB-CW ● ANL ● Variable BFO ● S meter. ● Sep. Bandspread dial ● IF 455 Kc/s ● audio output 1.5 w. ● Variable RF and AF gains controls. 115/250 v. A.C. mains. Beautifully designed. Size 7 x 15 x 10in. With instruction manual and service data. **£42.10.0.** Carriage paid **Trio Communication Type Headphones.** Normally £5.19.6. Our price **£3.15.0** if purchased with above receiver.

TRIO JR-500SE 10-80 Metre AMATEUR RECEIVER

Covers all the amateur bands in 7 separate ranges between 3.5 and 29.7 Mc/s. 7 valves, 2 transistors and 5 diodes plus 8 crystals: output 8 and 500 ohm and 5,000 ohm phone jack. Crystal controlled oscillator. Variable BFO. VFO. AVC. ANL. S meter. SSB-CW. Stand-by switch. Special double gear dial drive with direct reading down to 1 kHz. Remote control socket for connection to a transmitter. Audio output 1 watt. 115/250 v. A.C. mains. Superb modern styling. Size 7 x 13 x 10in. with instruction manual and service data. **£69.10.0.** Carr. Paid.

SPECIAL BONUS OFFER! TRIO SP5D Matching Speaker Mate and TRIO HS4 Communication Headphones. Normal Value £10.7.0. FREE OF CHARGE with every JR.500SE purchased.

HAMMARLUND SP600JX COMMUNICATION RECEIVER

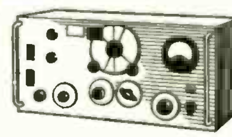


High quality professional dual conversion communication receivers available once again in this country at a reasonable price. Frequency range 540 Kc/s-54 Mc/s in 6 bands, variable tuning or 6 channel crystal controlled. 2.5 watt output into 600 ohms. Input 110/230 v. A.C. 20 valve circuit incorporating: Xtal filter, B.F.O., A.N.L., Xtal calibrator, S meter etc. Size 19 x 12 x 22 in. (List £520). Offered in excellent condition fully tested and checked. **£100** each. Few only.

RCA COMMUNICATIONS RECEIVERS AR88D

Latest release by ministry BRAND NEW in original cases. 110-250v. A.C. operation. Frequency in 6 Bands. 535 Kc/s—32 Mc/s continuous. Output impedance 2.5-600 ohms. Incorporating crystal filter, noise limiter, variable BFO, variable selectivity, etc. Price **£87.10.0.** Carr. £2.

MARCONI TEST EQUIPMENT Ex-Military Reconditioned.

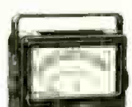


TF 144G Standard Signal Generators, 85 Kc/s-25 Mc/s, **£25**. Carr. 30/-.
TF 885 Video Oscillator 0-5 m/cs. **£45**. Carr. 30/-.
TF 195M Beat Frequency Oscillator, 0-40 kc/s, 200/250 v. A.C. **£20**. Carr. 30/-.
TF 142E Distortion Factor Meter, **£20**. Carr. 20/-. All above offered in excellent condition, fully tested and checked.
TF 1100 Valve Voltmeter, Brand New, **£50**.
TF 1267 Transmission Test Set, Brand New, **£75**.
TF 1371 Wide Band Millivolt Meter, Brand New, **£50**.

MULTIMETERS *for EVERY purpose!*

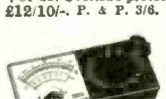
LAFAYETTE DE-LUXE 100 KΩ/VOLT "LAB TESTER." Giant 6½in. scale. Built in meter protection, 0/.5/2.5/10/50/250/500/1,000 v. D.C. 0/3/10/50/250/500/1,000 v. A.C. 0/10/100µA/10/100/500 MA/2.5/10 Amp. 0/1K/10K/100K/10M/100M Ω. —10 to 49.4dB. **£18/18/-**. P. & P. 5/-.

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. 0/2K/200K/20 MEG. OHM. **£15/-/-**. P. & P. 5/-.



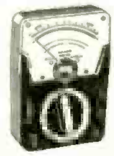
LAFAYETTE 57 Range Super 50K Ω/V. Multimeter. D.C. volts 125mv—1000v. A.C. volts 1.5v—1000v. D.C. Current 25µA—10 Amp. Ohms 0—10 Meg Ω. D.B.—20 to +81 db. Overload protection. **£12/10/-**. P. & P. 3/6.

MODEL AS-100D. 100K Ω/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/200M Ω. —20 to +17dB. **£12/10/-**. P. & P. 3/6.



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.

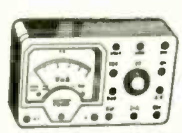
MODEL TE-70. 30,000 O.P.V. 0/3/15/60/300/600/1,200 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/30µA/3/30/300mA. 0/16K/160K/1.6M/16 Meg Ω. **£5/10/-**. P. & P. 3/-.



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/-.

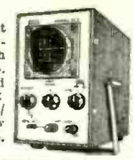
MODEL TE-12. 20,000 O.P.V. 0/0.6/6/30/120/600/1,200/3,000/6,000 v. D.C. 0/6/30/120/600/1,200 v. A.C. 0/60µA/6/60/600 mA. 0/6K/600K/6Meg./60 Meg. Ω. 50 PF. .2 MFD **£5/19/6**. P. & P. 3/6.

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/-.



MODEL PT-34. 1,000 O.P.V. 0/10/50/250/500/1,000V. a.c. and d.c. 0/1/100/500 mA. d.c. 0/100 K Ω **39/6**. P. & P. 1/6.

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 x 180 x 230 mm. Weight 8lbs. 220/240v. A.C. Supplied brand new with handbook. **£22/10/-**. Carr. 10/-.

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/-.

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/-.

AUTO TRANSFORMERS

0/115/230v. Step up or step down. Fully shrouded.
150 W. **32/6**. P. & P. 3/6
300 W. **47/6**. P. & P. 4/6
500 W. **£3/10/0**. P. & P. 6/6
1,000 W. **£5/10/0**. P. & P. 7/6
1,500 W. **£6/10/0**. P. & P. 8/6
7,500 W. **£15/10/0**. P. & P. 20/-.

SOLARTRON CD.711S.2 OSCILLOSCOPES

Double Beam. D.C. to 9 Mc/s. Perfect order. **£65**. Carr. 50/-.

EDDYSTONE V.H.F. RECEIVERS

770R. 19-165 Mc/s. **£150**.
770U. 150-500 Mc/s. **£100**.
Both types in excellent condition.

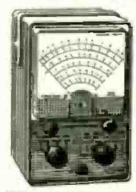
COSSOR 1049 DOUBLE BEAM OSCILLOSCOPES

D.C. coupled. Band width 1 Kc/s. Perfect order. **£25**. Carr. 30/-.

RECORDING HEADS

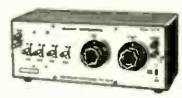
Reuter ¼-track. As fitted to Collaro Mk. IV and Studio Decks, High imp. record playback, low imp. erase. Lower track only. Brand new **19/6** pair.
Cosmocord ½ track heads:
Record/replay. High imp. 65/-
Erase. Low imp. 20/-
Marriott ½ track heads:
Record/Playback, high imp. 65/-
Erase, low imp. 20/-
Post extra.

TE-65 VALVE VOLTMETER



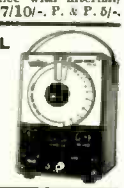
High quality instrument with 28 ranges. D.C. volts 1.5-1,500 v. A.C. volts 1.5-1,500 v. Resistance up to 1,000 megohms. 220/240v. A.C. operation. Complete with probe and instructions **£17/10/0**. P. & P. 6/-. Additional Probes available; R.F. 35/- H.V. 42/6.

TE111 DECADE RESISTANCE ATTENUATOR



Variable range 0-111 db. Connections. Unbalanced T and Bridge T. Impedance 600 ohms. Range (0.1 db x 10) + (1 db x 10) + 10 + 20 + 30 + 40 db. Frequency: DC to 200 KHZ (—3db). Accuracy: 0.05 db. + indication db x 0.01. Maximum input less than 4 watts (50 volts). Built in 600 Ω load resistance with internal/external switch. Brand new **£27/10/-**. P. & P. 5/-.

TY75 AUDIO SIGNAL GENERATOR



Sine Wave 20 CPS—200 Kc/s. Square Wave 20 CPS—30 Kc/s. High and low impedance output. Output variable up to 6 volts. 220/240 volts A.C. Brand new with instructions. **£16**. Carr. 7/6. Size 210 x 150 x 120 mm.

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 Kc/s—500 Mc/s on 6 bands. Directly calibrated. Variable RF. attenuator, audio output. Xtal socket for calibration. 220/240V. A.C. Brand new with instructions. **£15**. Carr. 7/6. Size 140 x 215 x 170 mm.

FULL RANGE OF ● Components ● Valves ● Semi-Conductors ● Test Equipment ● Receivers ● Hi-Fi AT DISCOUNT PRICES

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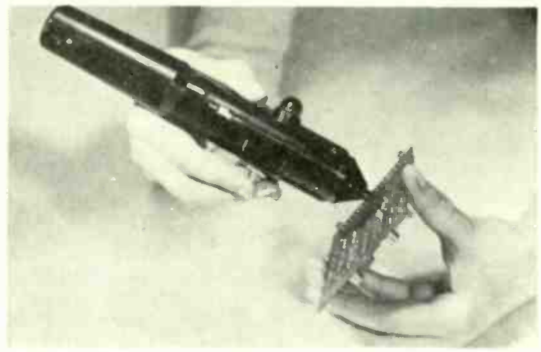

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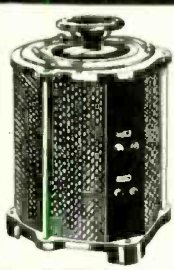
WW—099 FOR FURTHER DETAILS

NO EXCUSES! NO DELAYS! FROM STOCK!

VARIABLE VOLTAGE TRANSFORMERS



50 AMPS

1 AMP.

INPUT 230 v. A.C. 50/60

BRAND NEW. Keenest prices in the country. All Types (and spares) from ½ to 50 amp. available from stock.

0–260 v. at 1 amp.	£5	10	0
0–260 v. at 2.5 amps. ..	£6	15	0
0–260 v. at 4 amps.	£9	0	0
0–260 v. at 5 amps.	£9	15	0
0–260 v. at 8 amps.	£14	10	0
0–260 v. at 10 amps. ...	£18	10	0
0–260 v. at 12 amps. ...	£21	0	0
0–260 v. at 15 amps. ...	£25	0	0
0–260 v. at 20 amps. ...	£37	0	0
0–260 v. at 37.5 amps. .	£72	0	0
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Double Wound Variable Transformers

Fully isolated, low tension Secondary winding. Input 230 v. A.C. OUTPUT CONTINUOUSLY VARIABLE 0-36 v. A.C.

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These fully shrouded Transformers, designed to our specifications, are ideally suited for Educational, Industrial and Laboratory use.

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HIGH VOLTAGE HIGH FREQUENCY GENERATOR

Input 100/110 volts or 200/250 volts AC/DC. Output 19KV variable. Ideal for testing insulation, vacuum, leakage path, gas discharge lamps, neon etc. A useful ozone and HF supply. Manufactured by Edwards High Vacuum Ltd. Brand new in maker's polished wooden carrying case Offered at fraction of maker's price. £10.0.0 plus 7/6d. p. & p.

5Amp.AC/DC VARIABLE VOLTAGE OUTPUT UNIT

Input 230 v. A.C. Output 0-260 v. A.C. Output 0-240 v. D.C. Fitted large scale ammeter and voltmeter. Neon Indicator, fully fused. Strong attractive metal case 15in.×8¾in.×6in. Weight 24 lb. Infinitely variable, smooth stepless voltage variation over range. Similar in appearance to illustration below.

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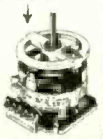
Designed for Panel Mounting. Input 230 v. A.C. 50/60 Output variable. 0-260 v.

½ amp	£3	10	0
1 amp.	£5	10	0
2½ amp.	£6	12	6

P. & P. 7/6

½ AMP. 1 AMP.



PORTABLE

VARIABLE VOLTAGE TRANSFORMER

Input 230 v. A.C. Output variable 0-260 v. A.C. at 1.5 amp. Fitted in beautifully finished steel case. Complete with voltmeter, pilot lamp, fuse, switch, carrying handle. **£9/5/-.** P. & C. 10/-. Also 2.5 amp. as above. £11/7/6. P. & C. 10/-.

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LT constant voltage Transformer. Input 205/250 volts. Output 6.3 volts. RMS Load 7-10 amps. £3. 6/6 p.p.

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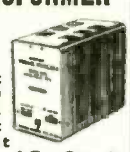

Input 185-250 v. A.C. Output constant at 230 v. AC. Capacity 250 watt. Attractive metal case. Fitted red signal lamp. Rubber feet. Weight 17lbs. Price £11/10/-, P. & P. 10/-.

LATEST TYPE SOLID STATE VARIABLE CONTROLLER

Ideal for lighting and heating circuits, compact panel mounting. Built in fuse protection. CONTINUOUSLY VARIABLE.
Input 230v AC output 25-230v AC
5 amp model **£8. 7. 6**
10 amp model **£13. 5. 0**

INSULATION TESTERS (NEW)

Test to I.E.E. Spec. Rugged metal construction, suitable for bench or field work, constant speed clutch. Size L. 8in., W. 4in., H. 6in. Weight 6lb. 500 volts, 500 megohms. Price £22 carriage paid. 1,000 volts, 1,000 megohms, £28 carriage paid.

36 volt 30 amp. A.C. or D.C. Variable L.T. Supply Unit

INPUT 220/240 v. A.C.
OUTPUT CONTINUOUSLY VARIABLE 0-36 v.

Fully isolated. Fitted in robust metal case with Voltmeter, Ammeter, Panel Indicator and chrome handles. Input and Output fully fused. Ideally suited for Lab. or Industrial use. £55 plus 40/- p. & c.

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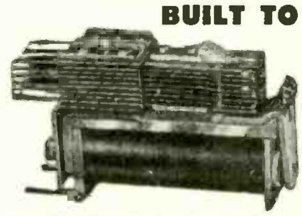

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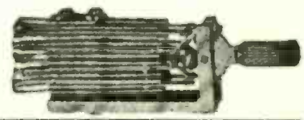

KEY SWITCHES. 3 POSITION Type 212 2C lock/2C lock 12/6. Type 198 4C lock/4C lock 17/6.
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LEDEX ROTARY SOLENOIDS AND CIRCUIT SELECTORS, size 5S. 4 pole 11 way and off 110/-. 24 pole 11 way and off 210/-. 54 pole On/Off 150/-.

SOLENOIDS only size 3E 115·2 ohms 48 V DC 17/6 each.

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HIGH SPEED COUNTERS. 3½"×1". 10 counts per second with 4 figures. The following D.C. voltages are available: 6v., 12v., 24v., 50v. or 100v. 35/- each.

VEEDER ROOT MAGNETIC COUNTERS with zero reset 800 counts per minute, counting to 999,999, 110 volts or 125 volts A.C. or 110 volts D.C., 65/- each, post 3/-.

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MINIATURE SILVER ZINC ACCUMULATOR. 1·5 volt 1·5 ampere size 2"×1·13" ×0·63", only 1½ oz. quantities available, 12/6 each, 120/- doz., post 1/6.

BRIDGE MEGGERS 1000 Volts 0/100 Megohms with Resistance Box 0/9999 Ohms, £60 each.

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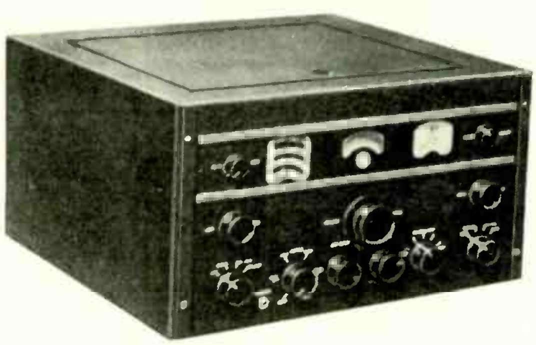
LATEST RELEASE OF

RCA COMMUNICATION RECEIVERS AR88



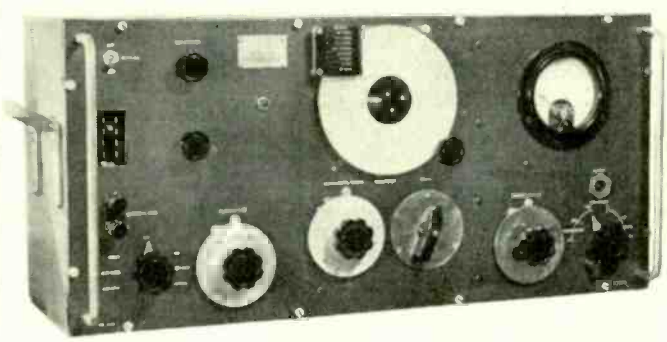
BRAND NEW and in original cases—A.C. mains input. 110V or 250V. Freq. in 6 bands 535 Kc/s-32 Mc/s. Output impedance 2.5-600 ohms. Complete with crystal filter, noise limiter, B.F.O., H.F. tone control, R.F. & A.F. variable controls. Price **£87/10/-** each, carr. £2.

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.

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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.)

AIRCRAFT RECEIVER ARR. 2: Valve line-up 7 × 9001; 3 × 6AK5; and 1 × 12A6. Switch tuned 234-258 Mc/s. Rec. only £3 each, 7/6 post; or Rec. with 24 v. power unit and mounting tray £3/10/- each, 10/- post.

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. 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 2.5 Kv. Price £1 for 5. Post 2/6. Capacitor: 0.125 mfd, 27,000v wkg. £3.15.0 each, 10/- post.

AVO MULTIRANGE No. 1 ELECTRONIC TEST SET: £25 each, carr. £1.

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: 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:** BC-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 with 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.

DE-ICER CONTROLLER MK. III: Contains 10 relays D.P. changeover heavy duty contacts, 1 relay 4P, C/O. (235 ohms coil). Stud switch 30-way relay operated, one five-way ditto, D.C. timing motor with Chronometric governor 20-30 v., 12 r.p.m.; geared to two 30-way stud switches and two Ledex solenoids, 1 delay relay etc., sealed in steel case (4 × 5 × 7 ins.) £3 each, post 7/6.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. £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: BC-221, meter only £30 each, BC-221 complete with stabilised power supply £35 each, carr. 15/-. LM13, 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.

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.

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/-.

AVOMETERS: Model 47A, £10 each, 10/- post. Model 7, £12/10/- each, 10/- post. Excellent secondhand cond. (Meters only—batteries and leads extra, at cost.)

DECADE RESISTOR SWITCH: 0.1 ohm per step. 10 positions. 3 Gang, each 0.9 ohms. Tolerance ±1% £3 each, 5/- post. 90 ohms per step. 10 positions, total value 900 ohms. 3 Gang. Tolerance ±1% £3/10/- each, 5/- post.

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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, 500W, 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/-.

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BSY29	3/-	OC28	7/6
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OC72	2/6	Diodes	
OC73	3/6	AAY42	2/-
OC81	2/6	OA95	2/-
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OC139	2/6	OA81	1/9
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Germanium PNP type transistors, equivalents to a large part of the OC range, i.e. 44, 45, 71, 72, 81, etc.

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B79	4	IN4007 SIL. REC. DIODES 1000 PIV 1 AMP. MINIATURE	10/-
B81	10	REED SWITCHES COMP. WITH COILS & MAGNETS	10/-
B89	2	5 SP5 LIGHT SENSITIVE CELLS LIGHT RES. 400 Ω DARK 1 M Ω	10/-
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B91	8	NKT163/164 PNP GERM. TO—5 EQUIVALENT TO OC44, OC45	10/-
B92	4	NPN SIL. TRANS. AO6 = BSX20. 2N2369. 500MHz. 360mW	10/-
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B96	5	2N3136 PNP SIL. TRANS. TO—18 HPE100-300 IC. 600mA. 200MHz	10/-
B98	10	XB112 & XB102 EQUIV. TO AC126 AC156, OC81/2, OC71/2, NKT271, ETC.	10/-

Return of the unbeatable P.1 Pak. Now greater value than ever

Full of Short Lead Semiconductors & Electronic Components, approx. 170. We guarantee at least 30 really high quality factory marked Transistors PNP & NPN, and a host of Diodes & Rectifiers mounted on Printed Circuit Panels. Identification Chart supplied to give some information on the Transistors.

Please ask for Pak **P.1.** Only **10/-**
2/- P & P on this Pak.

TRANSISTORS ONLY 1/- EACH

SILICON • PLANAR • N.P.N. • P.N.P

All these types available

2N929	2N706	2S131	2S103	2N696	2N1613	2S733	BFY10
2S501	2N706A	2S512	2S104	2N697	2N1711	2N726	2S731
BSY38	2N3011	2S102	2N2220	2N1507	2N1893	2N2484	2S732

All tested and guaranteed for gain and leakage—unmarked. Manufacturers' fall outs from the new PRE-PAK range.

NEW UNMARKED UNTESTED PAKS

B78	12	INTEGRATED CIRCUITS. DATA & CIRCUITS OF TYPES. SUPPLIED WITH ORDERS	10/-
B80	8	DUAL TRANS. MATCHED O/P PAIRS NPL-SIL. IN TO—5 CAN	10/-
B82	10	OC45, OC81D & OC81 TRANS. MULLARD GLASS TYPE	10/-
B83	200	TRANS. NEWMARKET REJECT AND OTHER TYPES NPN & PNP	10/-
B84	100	SILICON DIODES DO—7 GLASS EQUIV. TO OA200, OA202	10/-
B66	150	HIGH QUALITY GERM. DIODES MIN. GLASS TYPE	10/-
B86	50	SIL. DIODES SUB. MIN. IN914 & IN916 TYPES	10/-
B87	100	GERM. PNP TRANS. EQUIV. TO OC44, OC45, OC81, ETC	10/-
B88	50	SIL TRANS. NPN, PNP. EQUIV. TO OC200/1, 2N706A, BSY95A, ETC.	10/-
B60	10	7 WATT ZENER DIODES, MIXED VOLTAGES	10/-

PRE-PAK. N.605 POWER TRANSISTOR EQUIVALENT TO NKT301-2-3-4 **5/- each**

COMPLIMENTARY SET NPN/PNP GERM. TRANS. **2/6 pair**

Make a Rev. Counter for your Car. The 'TACHO BLOCK'. This encapsulated block will turn any 0-1mA meter into a perfectly linear and accurate rev. counter for any car. State 4 or 6 cylinder. **20/- each**

FREE CATALOGUE AND LISTS for: —

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MINIMUM ORDER 10/- CASH WITH ORDER PLEASE. Add 1/- post and packing per order. OVERSEAS ADD EXTRA FOR AIRMAIL.

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NEW PRICES ON NEW COMPONENTS

RESISTORS
High stability, carbon film, low noise. Capless construction, molecular termination bonding.
Dimensions (mm.): Body: ¼W; 8×2·8
½W; 10×4·3
Leads: 35
10% ranges; 10 Ohms to 10 Megohms (E12 Renard Series).
5% ranges; 4·7 Ohms to 1 Megohm (E24 Renard Series).
Prices—per Ohmic value.

		each	10 off	25 off	100 off
¼W	10%	2d.	1/6	3/3	10/4
¼W	5%	2½d.	1/9	3/8	11/8
½W	10%	2½d.	1/9	3/8	11/7
½W	5%	3d.	2/-	4/-	12/10

CAPACITORS
Subminiature Polyester film, Modular for P.C. mounting. Hard epoxy resin encapsulation. Radial leads.
±10% tolerance. 100 Volt working.
Prices—per Capacitance value (µF)

	each	10 off	25 off	100 off
0·001, 0·002, 0·005, 0·01, 0·02	6d.	4/3	8/4	30/-
0·05	8d.	6/-	12/6	41/8
0·1	10d.	7/1	15/6	51/-
0·2	1/2	10/-	20/10	68/6

Polystyrene film, Tubular, Axial leads. Unencapsulated ±5% or ±1pf tolerance, 160 Volt Working.
Prices—per Capacitance value (µµF)

	each	10 off	25 off	100 off
10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82, 100, 120, 180, 220, 270, 330, 390	5d.	3/7	7/9	24/-
470, 560, 680, 820, 1.000, 1,500	6d.	4/-	8/8	26/8
2,200, 3,300, 4,700, 5.600	7d.	5/-	10/10	33/4
6,800, 8,200, 10,000, 15,000	8d.	6/-	13/-	40/-
22,000	9d.	6/9	18/-	45/4

POTENTIOMETERS (Carbon)
Superior grade enclosed controls. Low rotational noise. Body dia., 1in. Spindle, 2in. × ¼in. Tolerance, 20%.
Linear: 1K to 2M. (½W at 40°C).
Logarithmic: 5K to 2M. (¼W at 40°C).

Prices per ohmic value	each	10 off	25 off	100 off
	2/-	18/4	41/8	150/-

GANGED STEREO POTENTIOMETERS (Carbon)
¼W at 70°C. Long Spindle.
Logarithmic and Linear: 5k + 5k to 1M + 1M.

Prices per ohmic value	each	10 off	25 off	100 off
	8/-	70/-	162/6	575/-

SKELETON PRE-SET POTENTIOMETERS (Carbon)
High quality pre-sets suitable for printed circuit boards of 0·1in. P.C.M. 100 ohms to 5 Megohms (Linear only). Miniature: 0·3W at 70°C. ±20% below ½M. ±30% above ½M. Horizontal (0·7in + 0·4in. P.C.M.) or Vertical (0·4in. × 0·2in. P.C.M.). Subminiature: 0·1W at 70°C. ±20% below 2·5M. ±30% above.

Prices—per ohmic value	each	10 off	25 off	100 off
Miniature (0·3W)	1/-	8/9	18/9	66/8
Subminiature (0·1W)	10d.	7/1	14/7	46/8

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	1/4	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, 0·022µF, 7d. 0·033, 0·047 µF, 8d. 0·068, 0·1 µF, 9d. 0·15 µF, 11d. 0·22 µF, 1/-. 0·33 µF, 1/3. 0·47 µF, 1/6. 0·68 µF, 2/3. 1 µF, 2/8. 400V: 1,000, 1,500, 2,200, 3,300, 4,700pF, 6d. 6,800pF, 0·01, 0·015, 0·022 µF, 7d. 0·033 µF, 8d. 0·047 µF, 9d. 0·068, 0·1 µF, 11d. 0·15 µF, 1/2. 0·22 µF, 1/6. 0·33 µF, 2/3. 0·47 µF, 2/8.

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/-. (6A): 200 P.I.V., 3/-. 400 P.I.V., 4/-. 600 P.I.V., 5/-. 800 P.I.V., 6/-.

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.

SEND S.A.E. FOR 1969 CATALOGUE

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MINIMUM ORDER VALUE 5/- C.W.O. Post and Packing 1/6

CURRENT RANGE OF BRAND NEW L.T. TRANSFORMERS. FULLY SHROUDED (*excepted*) TERMINAL BLOCK CONNECTIONS. ALL PRIMARIES 220/240v.

No.	SEC. TAPS	AMPS	PRICE	CARR.
1A	25-33-40-50	15	£9 10 0	10/6
1B	25-33-40-50	10	£6 19 6	8/6
1C	25-33-40-50	6	£5 19 6	8/6
1D	25-33-40-50	3	£3 12 6	7/6
2A	4-16-24-32	12	£6 10 0	7/6
2B	4-16-24-32	8	£4 17 6	7/6
2C	4-16-24-32	4	£3 5 0	6/-
2D	4-16-24-32	2	£2 2 6	5/-
3A*	25-30-35	40	£14 17 6	15/-
3B*	25-30-35	20	£9 7 6	9/6
3C	25-30-35	10	£6 10 0	7/6
3D	25-30-35	5	£3 15 0	6/6
3E	25-30-35	2	£2 15 0	6/6
4A*	12-20-24	30	£11 15 0	10/-
4B	12-20-24	20	£7 10 0	8/6
4C	12-20-24	10	£4 15 0	7/6
4D	12-20-24	5	£3 5 0	6/6
5A	3-12-18	30	£8 15 0	7/6
5B	3-12-18	20	£6 10 0	7/6
5C	3-12-18	10	£3 17 6	6/6
5D	3-12-18	5	£2 12 6	6/6
6A	48-56-60	2	£3 5 0	5/6
6B	48-56-60	1	£2 7 6	5/6
7A*	6-12	50	£9 7 6	9/6
7B	6-12	20	£5 10 0	7/6
7C	6-12	10	£3 10 0	6/6
7D	6-12	5	£2 10 0	5/6
8A	12-24	1	£1 9 6	5/6
9A	17-32	8	£5 12 6	5/6
10A*	9-15	2	£1 5 0	5/6
11A	6·3	15	£2 5 0	5/6
12A	30-25-0-25-30	2	£3 5 0	5/6

Note: By using the intermediate taps many other voltages can be obtained.
Example: No. 1. 7-8-10-15-17-25-33-40-50V.
„ 2. 4-8-12-16-20-24-32V.
„ 5. 3-6-9-12-15-18V.

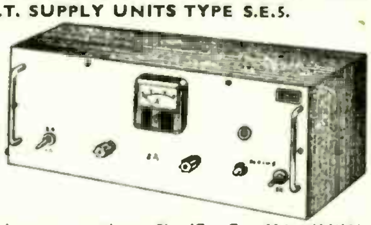
AUTO TRANSFORMERS
240v.-110v. or 100v. Completely Shrouded fitted with Two-pin American Sockets or terminal blocks. Please state which type required.

Type	*Watts*	*Approx. Weight*	*Price*	*Carr.*
1	80	2½ lb	£1 17 6	4 6
2	150	4 lb	£2 7 6	5 0
3	300	6½ lb	£3 7 6	6 0
4	500	8½ lb	£4 15 0	6 6
5	1000	15 lb	£6 12 6	7 6
6*	1750	25 lb	£13 10 0	10 6
7*	2250	30 lb	£16 10 0	12 6

*Completely enclosed in beautifully finished metal case fitted with two 2-pin American sockets, neon indicator, on/off switch, and carrying handle.

Samson's
(ELECTRONICS) LTD.
9 & 10 CHAPEL ST., LONDON, N.W.1
01-723-7851 01-262-5125

L.T. SUPPLY UNITS TYPE S.E.5.



A.C. input 220-240 volts. D.C. output 12 or 24 volts 10 amps rating. Selenium full wave bridge rectification. 3 inch scale ammeter, neon indicator, housed in strong metal case. Size 17 × 7 × 6½ in. £14/10/-.

L.T. SUPPLY UNITS TYPE S.E.6
As above, but 50 volts 6 amps. £14/10/- Carr. 15/-.

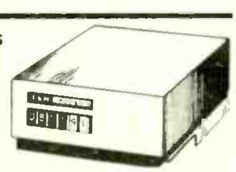
SPECIAL OFFER OF L.T. TRANSFORMERS
Pri 110-120v.-200-240v. Sec. tapped 12, 18, 24, 30 v. 8a. Table top connections. Fully tropicalised. **75/-**. Carr. 7/6. As above 5 amp rating. **59/6**. Carr. 6/-. Supplied brand new manufactured for the Phoenix Telephone Co.

Pri tapped 200-250v. Sec. 46v. Very conservatively rated at 29 amps. Size 11×7×7ins. Weight 75 lbs. approx. Manufactured by Partridge. **£12.19.6.** Carr. 15/-.

Pri tapped 110v. 220-250v. Sec. 55v. 24a., 14v. 10a., 60v. 2a. All windings very conservatively rated. Tropically finished. Terminal connections. Size 9×7½×7ins. Weight 65lbs. **£10.19.6.** Carr. 15/-.

CROUZET GEARED MOTORS
A.C. 110-230v. 10 watts. R.p.m. 80, 10, 1. Size: dia. 2½ ins., depth 2 ins., length of spindle ⅜ ins. **22/6**. Any type. P & P 3/6. Smith's 200-250v. 4 r.p.m. Size: 3 ins. dia., depth 2 ins., length of spindle ¾ in. **25/-**. P & P 3/6.

DIGITAL HOUR METERS
6 figs inc. 1/10ths, 1/100ths 40v. A.C. but complete with transformer for 240v. A.C. operation. All in plastic case. Size 6½ × 6½ × 3in. Condition as new 45/-. P & P 5/-.

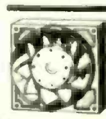


T.C.C. VISCONOL CAPACITORS
25 mfd. 275v. wkg. A.C. **17/6**. P & P 5/-. 60 mfd. 275v. wkg. A.C. **37/6**. P & P 5/-. 0.5 mfd. 2000v. wkg. D.C. **8/6**. P & P 2/-. 4 mfd. 600v. wkg. D.C. sub-chassis mtg. **6/-**. P & P 2/-. 8 mfd. 750v. wkg. D.C. sub-chassis mtg. **10/6**. P & P 2/6.

AMERICAN TYPES
Aerovox 8 mfd. 1000v. wkg. D.C. **12/6**. P & P 2/6. Micamold 8 mfd. 600v. wkg. D.C. **8/6**. P & P 2/-. Micamold 4 mfd. 600v. wkg. D.C. tubular single hole fixing. **7/6**. P & P 2/-. All capacitors supplied new and guaranteed.

SPECIAL OFFER. BLOCK CAPACITORS
G.E.C. 8 mfd. 600v. D.C. wkg. Six for **29/6**. Carr. 7/6. Dubliner. 1 mfd. 600v. wkg. Six for 9/-. P & P 3/6. T.C.C. 2 mfd. 500v. wkg. Three for **7/6**. P & P 2/6. T.C.C. 0.1 mfd. 500v. wkg. Six for **6/6**. P & P 2/6.

PORCELAIN GIANT E.S. LAMP HOLDERS
Length 4 ins. Dia. of skirt 3 ins. Three for **17/6**. P & P 5/-. E.S. standard size. Three for **8/6**. P & P 2/-.



COMPUTER EXTRACTOR FANS
Manufactured by Papst. A.C. 220-240v. Cap start. 100 c.f.m. 2800 r.p.m. Size 4½ × 4½ × 2ins. Ex-equipment. Guaranteed in perfect order. 45/-. Carr. 5/-.

G.P.O. 20-WAY JACK STRIPS
Type 320BN. New. 15/-. P & P 2/-.

FIELD TELEPHONE CABLE
Type D3 Single. 1/3 mile drums. Ideal for outside telephone systems. Unused. Fraction of maker price. **50/-**. P & P 7/6.

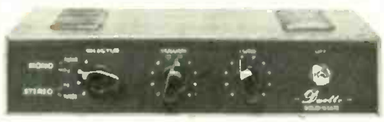
PYREX AERIAL INSULATORS
Type 13. Length 7in. **8/6**. P & P 2/-.

SANGAMO WESTON
Special offer 3½ inch Round Panel Meters. Double reading, 0-50 and 0-100 micro/A. Scaled 0-8 and 0-16 Kilovolts. Brand new in maker's cartons. List price over £5. Our price **25s.** P & P 2/-.

3 INCH SQ. FLUSH 0-80V. D.C. METERS
1000Ω/V. 2½in. hole. By famous maker. Brand new. Boxed. **17/6**. P & P 2/-.

Latest 12-page Price List of transformers, chokes, capacitors and electronic components. Please send 6d. stamp.

a complete stereo system for 28 gns



The new Duo general-purpose 2-way speaker system is beautifully finished in polished teak veneer, with matching vynair grille. It is ideal for wall or shelf mounting either upright or horizontally.

Type 1 SPECIFICATION:—

Impedance 10 ohms. It incorporates Goodmans high flux 6" x 4" speaker and 2½" tweeter. Teak finish 12" x 6¾" x 5¾". 4 guineas each. 7/6d. p & p. Type 2 as Type 1 Size 17½" x 10¾" x 6¾". Incorporating Elac. 10½" x 6½" 10,000 lines and 2½" tweeter. 3 ohms impedance 5½ guineas + 7/6 p & p.

Garrard Changers from £7.19.6d. p & p 7/6d. Cover and Teak finish Plinth £4.15.0d. 7/6d. p & p.

The Duetto Integrated Transistor Stereo Amplifier **9 GNS.** +7/6 p. & p.

The Duetto is a good quality amplifier, attractively styled and finished. It gives superb reproduction previously associated with amplifiers costing far more.

SPECIFICATION:—

R.M.S. power output: 3 watts per channel into 10 ohms speakers.

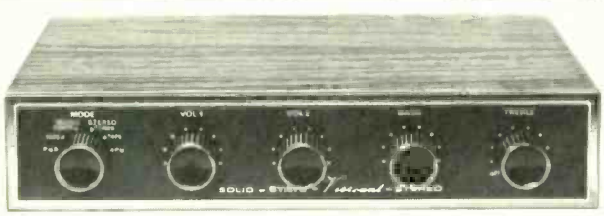
INPUT SENSITIVITY: Suitable for medium or high output crystal cartridges and tuners. Cross-talk better than 30dB at 1Kc/s.

CONTROLS: 4-position selector switch (2 pos. mono & 2 pos. stereo) dual ganged volume control.

TONE CONTROL: Treble lift and cut. Separate on/off switch. A preset balance control.

The Classic Teak finished case **8½ GNS.** plus 7/6 p. & p.

SPECIFICATION: Sensitivities for 10 watt output at 1 KHz. Tape Head: 3mV (at 3¾ i.p.s.) Mag. P.U.: 2 mV. Cer.P.U.: 80 mV. Radio: 100mV. Aux. 100 mV. Tape/Rec. Output: 100 mV. Equalisation for each input is correct to within ±2dB (R.I.A.A.) from 20 Hz to 20KHz. Tone Control Range: Bass ±13 dB at 60 Hz. Treble ±14 dB at 15 KHz. Total Distortion: (for 10 watt output) < 1.5%. Signal Noise: < −60dB. AC Mains 200-250v. Size 12½" long, 4¼" deep, 2¾" high. **Built and tested.**



The Viscount Integrated High Fidelity Transistor Stereo Amplifier **13½GNS.** +7/6 p. & p.

SPECIFICATION:—

OUTPUT: 10 watts per channel into 3 to 4 ohms speakers (20 watts) monoral.

INPUT: 6-position rotary selector switch (3 pos. mono and 3 pos. stereo). P.U. Tuner. Tape and Tape Recout Sensitivities: All inputs 100mV into 1.8M ohm.

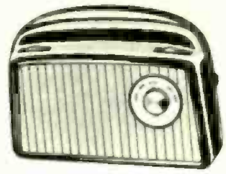
FREQUENCY RESPONSE: 40Hz-20KHz ± 2DB.

TONE CONTROLS: Separate bass and treble controls. TREBLE 13dB lift and cut (at 15KHz) BASS 15dB lift and 25dB cut (at 60Hz).

VOLUME CONTROLS: Separate for each channel.

AC MAINS INPUT: 200-240v. 50-60Hz.

SIZE: 12½" x 6" x 2¾" in teak-finished case. Built and tested. p & p 7/6d.



THE DORSET

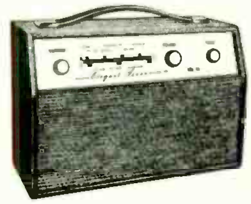
(600mW Output)

7-transistor fully tunable M.W.-L.W. superhet portable—with baby alarm facility. Set of parts. The latest modulized and pre-alignment techniques makes this simple to build. Sizes: 12" x 8" x 3".

MAINS POWER PACK KIT: 9/6 extra.

Price **£5.5.0** plus 7/6 p. & p. Circuit 2/6. FREE WITH PARTS

The ELEGANT SEVEN MK. III (350mW Output)

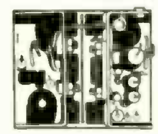


7-transistor fully tunable M.W.-L.W. portable. Set of parts. Complete with all components. Including ready etched and drilled printed circuit board—back printed for foolproof construction.

MAINS POWER PACK KIT: 9/6 extra.

Price **£4.9.6** plus 7/6 p. & p.
Circuit 2/6. FREE WITH PARTS

X101 10w. SOLID-STATE HI-FI AMP WITH INTEGRAL PRE-AMP.



Specifications: Power Output (into 3 ohms speaker) 10 watts. Sensitivity (for rated output): 1mV into 3K ohms (0.33 microamp). Total Distortion (at 1 KHz): At 5 watts 0.35%: At rated output 1.5%. Frequency Response: Minus 3 dB points 20 Hz and 40 KHz. Speaker: 3-4 ohms. (3-15 ohms may be used). Supply voltage: 24v D.C. at 800 mA. (6-24V. may be used).

Price **69/6** plus 2/6 p. & p.

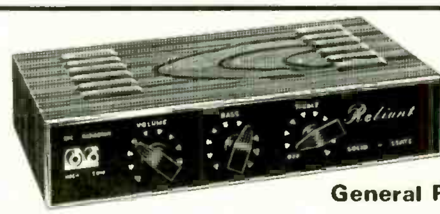
CONTROL ASSEMBLY: (Including resistors and capacitors). 1. Volume: **Price 5/-.** 2. Treble: **Price 5/-.** 3. Comprehensive bass and treble: **Price 10/-.** The above 3 items can be purchased for use with the X101. **POWER SUPPLIES FOR X101:** P101 M (mono) **35/-** p. & p. 4/6: P101 (stereo) **42/6** p. & p. 4/6.

50 WATT AMPLIFIER

AC MAINS 200-250V

An extremely reliable general purpose valve Amplifier—with six electronically mixed inputs. Suitable for use with: mics, guitars, gram, tuner, organ, etc. Separate bass and treble controls. Output impedance 3, 8 and 15 ohms.

Price **27 gns.** plus 20/- p. & p.



THE RELIANT

Solid State General Purpose Amplifier

SPECIFICATION:—

OUTPUT: 10 watts into a 3 ohms speaker.

INPUTS: (1) for mike (10 m.v.). Input (2) for gram. radio (250 m.v.) individual bass and treble control.

TRANSISTORS: 4 silicone and three germanium.

MAINS INPUT: 220/250 volts.

SIZE: 10¼" x 4¼" x 2½".

MIKE TO SUIT (CRYSTAL): 12/6d. + 1/6d. p. & p.

8" x 5" speaker 14/6d. + 3/- p. & p.

Mk. I 5½ gns. + 7/6 p & p. Teak-finished case.

Mk.II **6½ gns** +7/6 p. & p. In teak-finished case.

CYLDON 2 TRANSISTOR U.H.F. TUNER

Brand new. Complete with circuit diagram.

£2.10 +1/- p. & p.

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(by famous manufacturer)

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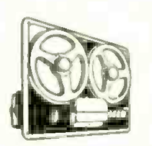

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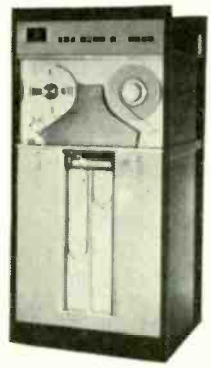

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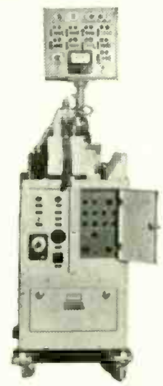
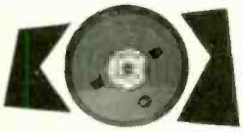


AUTOMATIC CRYSTAL THICKNESS SORTING MACHINE

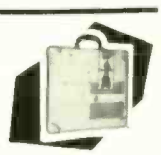
Fully automatic dice gauging and sorting system, eliminates all manual operations. This instrument is of extreme interest to manufacturers of semi conductors. It is offered in good condition at a quarter of its original list price. It is suitable for the sorting of germanium and silicon dices 0.055 in.–0.16 in. dia. or 0.04 in.–0.12 in. sq. ± 2.5 microns. The unit can sort up to 2,400 pieces an hour. Pick-up compressed air line 40 lb. max. required. Our price **£750.** Further information available on request. Complete with manual and spares.



BRAND NEW COMPUTER TAPES

Made by well-known manufacturers, 2,400 ft. **£6.10.0** complete with cassettes. These tapes can be re-certified to customer's requirements at extra cost. Brand new tape storage cassette cases for 10½ in. spools **17/6**. For 8½ in. **15/-**. Brand new empty spools 10½ in. **17/6**. 8½ in. **15/-**.

TAPE TRANSFER CASES



For sending data by personal carrier, GPO post, passenger train. etc. ideal. Suitable for despatching tape **20/-**.

PROGRAMME BOARDS BY SEALECTRO.

These boards are basically a multi pole multi throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 24 × 60 2 plane. **£12/10/0.** Diode loaded pins available 1/3 each.

MEMORY PLANES

Ferrite core memory planes with wired Ferrite cores. Used for building your own computor or as an interesting exhibit in the demonstration of a computer. Mounted on plastic material, frame 5 × 8 in. Consisting of matrixes 40 × 20 × 4 cores each one individually addressable and divided into 2 halves with independent sense and inhibit wires. **£8.10.0.**

Memory Core Store consisting of 10 planes each of 8 K cores complete with X Y selection diodes. Each plane is divided into 2 independent halves each with 2 sense and inhibit wires. **£49.10.0.**

FERRANTI HIGH SPEED 5 HOLE 200 CHARACTERS

per second optical reader. **£19/10/0**

HOLLERITH 80 COLUMN CARD VERIFIER

By ICT, Type No. H 129/2489. Good condtion **£95.**

FILE DRUM STORES TYPE

Can store up to 1 million words, excellent condition but less recording heads. We regret we are unable to give further information at time of going to press. **£79.10.0.**

Creed Reperforators Model 25 7 hole. Creed Verifiers 84136. P.o.A.

BRAND NEW S.E. LABORATORIES TRANSDUCER

complete with encapsulated Amplifier/demodulator S.E. 441/2
Frequency D.C.—60 c.p.s.
Available in the following ranges:
SE150, SE50 or SE165A.

0 - 25 p.s.i.	0 - 350 p.s.i.	0 - 2000 p.s.i.
0 - 50 p.s.i.	0 - 500 p.s.i.	0 - 3000 p.s.i.
0 - 200 p.s.i.	0 - 750 p.s.i.	0 - 4000 p.s.i.

Also available differential types ± 5 p.s.i., ± 10 p.s.i.
List price £70 + Our price **£15**

VACTRIC 144-WAY HIGH SPEED MINIATURE SAMPLING SWITCHES,

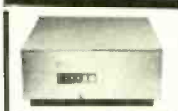
consisting of 24 segments in six bank. 8000 samples per second can be obtained from these switches. Ideally suitable for data logging application. Low inherent noise and contact resistance permitting high speed sampling of the most difficult transducers. Pulse generator for digital counting. Brand new. **£25.**

EVERSHED & VIGNOLE
3 Channel Mk I Pen Recorder with Amplifier

F.S.D. ± 10V, with sensitivity control set to maximum. F.S.D. ± 51V. Accuracy: Response such as to provide a record of a 3-5 c/s signal with not more than 30% less of amplitude as compared with a d.c. signal of value equal to the peak a.c. amplitude. Power required: 230 volts and any of the following polarised voltages:

50V—50 c/s 115V—60 c/s 120V— 400 c/s
58V—60 c/s 200V—60 c/s 20V—1,100 c/s
50V/1,100 c/s

Performance: Using Teledeltos paper enabling three separate channels to be recorded simultaneously. Chart speed 12in./min., chart width 12in. 3¼in. per channel. Wt. 67½ lb. Size: 22 × 21 × 11 in. **£59/10/0.**



HOUR METER

6 fig. incl. 1/10ths and 1/100ths. 40v. A.C. complete with transformer for 240v. A.C. use. **39/6** + 5/- p.p.

Cossor 1035 overhauled.............. **£22.10.0**
Cossor 1035 Mk. III overhauled........ **£32.10.0**
Cossor 1049 overhauled.............. **£25.0.0**

LINEAR THYRISTER CONTROLLED LIGHT DIMMER

600w. module. Ideally suitable for photoflood or speed controller, etc. Will mount into standard socket boxes. Our price **49/6** + p. & p. 3/-,

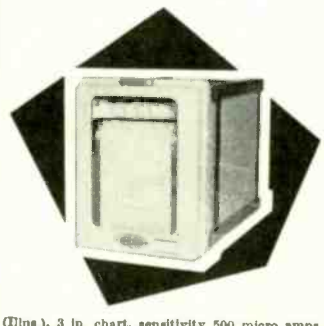
SOLA CONSTANT VOLTAGE TRANSFORMERS

210-250-600 watts **£25.**

ADVANCE TRANSISTORISED DC STABILISED POWER UNITS

	Input Volts	Output Volts	Amps	Price
DC 4	200-245 ± 15%	12	4	£17/10/-
DC 3	200-245 ± 15%	12	1.25	£10/10/-

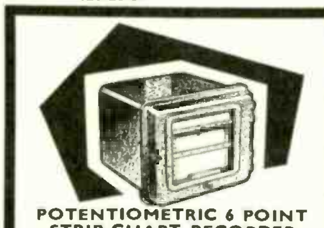
SINGLE PEN RECORDER BY RECORD ELECTRICAL



(Illus.). 3 in. chart, sensitivity 500 micro amps. Coil res. 1.53k. Fully interchangeable gears available to make a wide range of chart speeds. 200/250v. Size: 8 × 11 × 6 in. Brand new—complete with chart and ink. List over £100. Our price **£49.10.0.**

DIFFERENTIAL PRESSURE TRANSDUCERS

by Sifam Ltd. G.B. Type H33
Range ± 900MB Resistance 942 ohms.
Our price **£19.10.0.**



POTENTIOMETRIC 6 POINT STRIP CHART RECORDER BRAND NEW

For use with thermocouplers, pyrometers and other e.m.f. sources. 6 point. Range (—100)—0—(+100) mV; 0—1,600 deg. C. 6½ in. chart width; pen speed 8 secs. Accuracy ±0.5%; 10 chart speeds 20-720mm/hr. Tropicalised. Including tools and spares. Listed at over £200. Our price **£79.10.0.** 12 point version available £99.10.0.

KENT STRIP-CHART INDICATING RECORDER

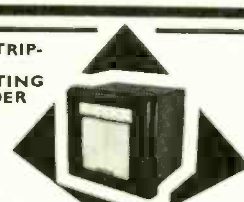
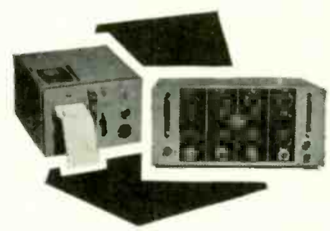


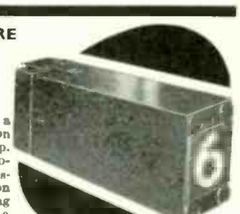
Chart width 9¾ in. 10 mV. Sensitivity ± 0.17 of full scale. Source impedance 100 ohms. Speed of operation 33 sec. for full-scale travel. Chart speeds ½ in., 3 in., 6 in. per hour. Single point **£49.10.0.**

FOUR CHANNEL HIGH SPEED PEN RECORDER



By Kelvin Hughes, with four channel amplifier, giving a frequency range of 0-100 c/s.
The Recorder consists basically of a magnet carrying in its poles four stiffly suspended moving coil units, each with a stylis arm attached. The stiffness of the coil unit suspension enables the instrument to withstand the effects of vibration and acceleration. Sensitivity ± 3V input for full scale deflection of ± 7.5 mm. Mains operated. 6 chart speeds: 0.5; 1; 2; 4; 8; and 16 cm/sec. Excellent condition. **£149/10/0.**
N.B. Two channel version available, giving ± 16.5 m.m. deflection.

MINIATURE DIGITAL DISPLAY



Operates on a rear projection 6.3 pilot lamp. The lamp projects the corresponding digit on the condensing lens through a projector lens, on to the viewing screen at the front of the unit. 1 in. width. 3 5/16 in. deep. 1 5/16 in. high. Weight 3½ oz. Character size ¾ in. high. 0.9 with 8 right hand decimal point and degree. Available to special order, words and other characters or colour, at cost of artwork or plates. List price 6 gns. Our price **49/6.**

EAC DIGIVISOR Mk. II DIGITAL READ-OUT DISPLAY

Ideally suitable for use in conjunction with transistorised decade counting devices. No need for amplifiers or relays as only a few milliwatts of power are required to charge the digits. The DIGIVISOR incorporates a moving coil movement which moves a translucent scale through an optical system and the resultant single plane image is projected on a screen. The translucent scale is made to represent digits 0-9. Specifications: 6.3 volt, 250 microamp. Image height ¾ in. Size 4 9/16 × 2 39/64 × 1¾ in. Our price 3½ Gns. List price 8½ gns.

ALL ORDERS ACCEPTED SUBJECT TO OUR TRADING CONDITIONS A COPY OF WHICH MAY BE INSPECTED AT OUR PREMISES DURING TRADING HOURS OR WILL BE SENT ON APPLICATION THROUGH THE POST.

B LOW COST ELECTRONIC AND SCIENTIFIC EQUIPMENT AND COMPONENTS

HYSTERESIS REVERSIBLE MOTOR. Incorporating two coils. Each coil when energized will produce opposite rotation of the output shaft. 240 volt 50 cycle. ½ r.p.m., ¼ r.p.m., 1/6 r.p.m., 1/10 r.p.m.. 120 volt 60 cycles 1/10 r.p.m. 80/-, reduced to 30/-.

LOW TORQUE HYSTERESIS MOTOR MA23

Ideal for instrument chart drives. extremely quiet; useful in areas where ambient noise levels are low. Having a high starting torque a relatively high inertia load can be driven. 6 oz./in. at 1 r.p.m. 240 volts 50 cycles. 10 r.p.m. R. 1 r.p.m. R & L, ½ r.p.m. L. ½ r.p.m. R, 1/5 r.p.m. R, 1/10 r.p.m. R, 1/12 r.p.m., 1/20 r.p.m., 1/40 r.p.m., 1/60 r.p.m., 1/180 r.p.m., 1/360 r.p.m.; 1/6 r.p. hour, 1/12 r.p.h.; 1 r.p.m., 1½ r.p.m. 25/-.

HYSTERESIS CLUTCH MOTOR with integral clutch allowing the motor to drop out of engagement with the gear train. thereby facilitating easy resetting when used in timers or in conjunction with a light spring. 6 oz. torque at 1 r.p.m. 240 v., 50 c/s. L = left. R = right. 15 r.p.m. L, 8 r.p.m. R & L, 6 r.p.m. L. 4 r.p.m., ½, ¼, ¼ r.p.m. L, 1/5 r.p.m., 1/6 r.p.m., R & L, 1/10 r.p.m., 1/12, 1/15 r.p.m. L. Also 120 v. 50 c/s 2, 1/6, 1/12, 5/12, 4/11, 1/10 r.p.m. 25/-.

VIBRON ELECTROMETER Type 33

This unit is a vibration condenser amplifier which is suitable for the measurement of small D.C. potentials covering the range of 1M-1V. This unit can also be used as high impedance null detector for the comparison of ironation currents of very high resistances. £89.10.0.

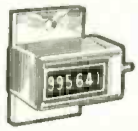
VARI-PACK High Stability Power Supply

Light. portable and rugged construction. Controlled output voltage of zero to 500 volts D.C./A.C. Output 2 × 3.15 at 3 amps. A.C. current 100 m/a. Ripple 0.2 volts max. £19.10.0.

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 deg. C. Operating Humidity: Up to 80% R.H. Dimensions: 200 × 110 × 65 mm. Weight: 0.9 kg. List price £25. Our price £9/19/6.

MINIATURE SQUARE COUNTER 6 DIGIT by Veeder Root. Rotary ratchet type, adds 1 count for each 36° movement of shaft 9/6 + 2/6 p. & p.



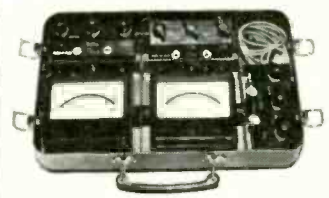
HI-SPEED QUICK RESET ELECTRO MAGNETIC COUNTERS

Push button reset 6 digits. 48v. DC 3.5 watts. 20 counts per second. Size 3.875 × 2.625in. Panel mounting. List £8. Our price 59/6.

REPEAT CYCLE TIMERS

These timers repeat a set cycle of switching operations via a cam and micro switch. for as long as the motor is energised. Single Cam RB 21 in 2 min., 3 min., 4 min., 5 min., 6 min. cycles @ 45/-. Twin Cam RD 22 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 55/-. 4 Cam RD 24 in 4 min., and 5 min. cycles @ 75/-. 6 Cam RD 26 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 95/-. 8 Cam RD 28 in 1 min., 2 min., 3 min., 4 min., 5 min. cycles @ 115/-. All + p. & p. 5/-.

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.

PRECISION POTENTIOMETERS

TEN TURN 3600° ROTATION BRAND NEW

Res. Ohms	Linearity Per cent	Manufacturer	Model	Price
100/100/100		Beckman	A	180/-
100	0.5	Beckman	A.8	60/-
200	0.5	Beckman	A	60/-
500	0.1	Beckman	8	70/-
500		Colvern	2501	45/-
500		Foxes	PX4	40/-
500		Colvern	2610	50/-
2K	0.5	Beckman	8A1101	60/-
2K		Beckman	7216	60/-
2K		Reliance	GPM15	40/-
10K	0.5	Beckman	A	60/-
10K	0.1	Beckman X	A	70/-
15K		Foxes	GPM15	50/-
18K		Beckman	A	60/-
20K	0.5	Beckman	A	60/-
30K		Colvern	2402	30/-
30K		Beckman	8A95C	60/-
30K	0.1	Beckman	A.88	70/-
30K	0.5	Beckman	8A 1692	60/-
30K	0.25	Beckman	8A 1692.	65/-
50K		Reliance	07.10	45/-
50K			07.5	45/-
50K		Colvern	2503	45/-
50K	X	Foxes	PX4	45/-
50K	0.5	Beckman	A	60/-
50K	0.1	Beckman	A	70/-
100K/100K		Ford	A	100/-
100K	0.1	Beckman	A	70/-
100K	0.5	Beckman	A	60/-
100K		Colvern	2501	45/-
100K		Colvern	2610	50/-
298K	0.1	Beckman	8A3902	70/-
300K	0.1	Beckman	A	70/-

THREE TURN 780° ROTATION

100/100	0.5	Beckman	A	60/-
300		Beckman	9303	45/-
10K	0.5	Beckman	C.88	45/-
20K/20K	0.1	Beckman	C.8	60/-
10K/10K	0.1	Beckman	C	60/-
50K	0.5	Beckman	C.8	35/-

FIFTEEN TURN 5400° ROTATION

25K/25K .... Beckman B ... 10 watts £6-10s
46/K/46K .... Beckman B ... 10 watts £6-10s

TWENTY TURN 7200° ROTATION

250 ohms .. General Controls .. PXM130 .... 80/-
1 Meg ..... General Controls .. PXM130 .... 80/-
50K Reliance 40/-

156 TURN 56, 160° ROTATION

460 ohms .... Kelvin Hughes ...... KTP0701 ... £9 10s.

FIVE TURN 1800° ROTATION

500 ohms .... Colvern .... CLR 2505 ...... 40/-
U1.5K ...... Colvern .... CLR 2605 ...... 40/-

SINE COSINE

Colvern 8601 .... 10K .... £12-10s.
Colvern 9501 .... 11K C.T .... £16-10s.
CLR 9604—Cam Corrected 25K £20
9101A/A 20K .... £16-10s.

PRECISION BECKMAN 40 TURN 14,400° ROTATION

Wirewound Precision Potentiometer. 8E 107A 20 watts at 40°C. 3 1/16 ' Diameter. Servo Mounting. 200 K. Brand New £12-10s. List Price £30.

Marconi VHF circuit magnification meter. Range: Max. Q 1200. Frequency 1-4 M Hg £69-10-0

Wide Range Oscillator Type 400

This unit covers the range from 0.1-1000c/s. This unit due to its extremely low frequency drift and constancy of output permits accurate checking of low frequency amplifiers and equipment £45-0-0

WAYNE KERR V.H.F. Admittance Bridge B801 & Q801 Transistor Adaptor C.

Balanced measurements from 1-100 meg. Impedance Range capacitance 0-± 230 rf. Conductance 0-100 millohms. Inductance 0.1 microhenry to 50 millihenrys with adaptor will measure A.C transistor parameters from 1Mc-100Mc £149-10-0

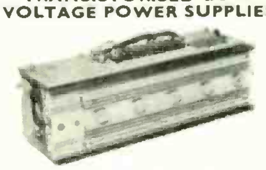
PHILLIPS D.C. Microvoltmeter GM 6020

Range 10° Micro volt - 1000 volt D.C. - 10 Micro amps
100 pA - Input impedance 1Mohm/10 rf. £69-10-0

TRANSFER FUNCTION ANALYSER OS103/VP 253

Frequency range 0.1 c/s to Kc/s covering electro-mechanical applications and servo-mechanisms. Resolves network response signals simultaneously into in-phase or quadrature components. Permits direct polar diagram plotting of a servo system frequency response using cartesian co-ordinates. Establishes data for Nyquist diagram. attenuation phase response and other servo characteristics. Gives network phase/amplitude response from 0.1 c/s to 1 K c/s. Deflection sense of two centre zero-meters gives immediate identification of vector quadrant involved. 40 db rejection on amplitude. High sensitivity 50 mV/fsd. High accuracy measurement of true R.M.S. volts. List price £1,600. Our price £595.

★ HIGH PRECISION ★ FULLY STABILISED TRANSISTORISED LOW VOLTAGE POWER SUPPLIES



incorporating
- S.C.R. Panel for overload projection.
- OVERLOAD & CIRCUIT BREAKER WITH MANUAL RESET button.
- RIPPLE belter, better than 3000 : 1.
- CHOKE OF CAPACITOR transistorised 120/130 volt A.C. INPUT.

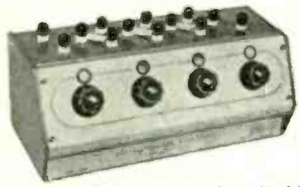
Available in the following types:

6 Volt 9 Amp £12.10.0
6 Volt 12 Amp £17.10.0
6 Volt 16 Amp £22.10.0
12 Volt 8 Amp £22.10.0
12 Volt 16 Amp £25. 0.0
12 Volt 22 Amp £25. 0.0
20 Volt 16 Amp £25. 0.0
24 Volt 4 Amp £22.10.0
30 Volt 8 Amp £18.10.0
56 Volt 7 Amp £25. 0.0

Ex-equipment but fully tested in our laboratory. Carr. 30/-

BRAND NEW LABORATORY TEST EQUIPMENT—*AT LESS THAN HALF PRICE!*

HIGH VALUE RESISTANCE BOX TYPE R.7003



Specification. Range: 0.01–111 Meg. in 0.01 Megohm divisions. Accuracy: 0.05%. Maximum power rating: 0.1W per step. Case: Hammer finished stove enamel. List price £60. Our price £22/10/-.

DECADE CAPACITANCE BOX TYPE R.7004

Specification. Range: 0.00002uF-1uF in 0.00002uF steps. Accuracy: 0.5%. Frequency Range: 40 c/s-10 Kc/s for all decades except X1 = 40 c/s-5 Kc/s. Case: Hammer finished stove enamel. List price £60. Our price £22/10/-.

MUTUAL INDUCTANCE BOX TYPE R.7005

Specification. Range: 0–11.110 mH in 0.002 mH divisions. Accuracy: $\pm(0.3 \times \frac{0.012}{M})\%$ where M = value of mutual inductance in mH set on the box. Frequency range: 0–2.5 K/cs for all decades except X1 = 0–15 Kc/s. 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.

★ A Special price of £65 is offered if the following equipment is ordered together: High Value Resistaoce Box, Decade Capacitance Box, Mutual Inductance Box, Mutual Inductance Coil.

PORTABLE MULTIRANGE METER

Specification. Ranges: 0-60 & 0-300μA. D.C. 0-3, 0-30 & 0-120mA, D.C. 1.2 & 12 amps D.C. 0.6-3 & 6-30 mA. A.C. 24-120 mA. A.C. 0.24-12A. A.C. 3-12-30-300-600-1,200 & 6,000 V. D.C. 0.6-3, 2.4-12, 6-30, 60-300, 120-600, 240-1,200 & 1,200- 6,000 V. A.C. 3-333 ohms, 0.3-30 Kohms. 0.03-3 megohms D.C. Resistance —12 to +78 Decibels. Frequency: 50 cps. Input Resistance D.C.: 20,000 ohms/volt. Input Resistance A.C.: 2,000 ohms/volt. Temperature Range: —10 to +50 deg. C. Dimensions: 255 × 215 × 170mm. Weight: 8 kg. Supplied with 2 voltage dividers, H.V. leads, spare rectifiers, 1.5 & 22.5 V. battery. List price £25. Our price £12/19/6.

PORTABLE RECORDING AMMETER

Specification. Type: Moving Coil. D.C. Range: 0–1 amp. D.C. Chart Width: 100 mm. Scale Length: 127 mm. Chart Speeds: 20, 60, 180, 600, 1800 and 5400 mm/hr. Precision: 1.5%. Shunts: 75mV (Internal). Operating Temperature: + 5 to + 50°C. Dimensions: 180h × 163 w × 245mm. Weight: 5.5kg. Complete with: 10 chart rolls, gears, inks, pipette, scale template and component case. List price £65. Our price £35.

Recording Ammeter 0.5 amps. A.C. rectified version available.

MUTUAL INDUCTANCE COIL TYPE R.7006

Specification. Value: 0.001 H. Accuracy: ± 0.3%. Operating Frequency: 5 Kc/s, 10 Kc/s. Maximum current: 1A, 3A. Resistance of coils: 4 ohm, 1 ohm. Case: Moulded plastic. List price 8 gns. Our price 50/-.

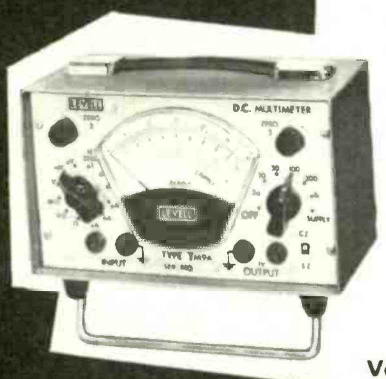
★ ILLUSTRATED LEAFLETS AVAILABLE ★

ELECTRONIC BROKERS LTD., 49-53 PANCRAS ROAD, LONDON, N.W.1. Tel: 01-837 7781/2 Cables: SELELECTRO

DC multimeters

These instruments have dc ranges covering the measurement of voltage from 0.3μV to 1kV, current from 1pA to 1mA or 1A, and resistance from 0.3Ω to 1kMΩ. Left zero and centre zero scales are provided and a recorder output exists on all ranges.

Features are high input impedance on voltage ranges, low test voltage on linear resistance ranges, and large overload rating. The instruments are solid state powered by a self-contained battery. Low power consumption results in negligible warm-up drift.



Type TM 9 Series

Voltage Ranges:
3μV, 10μV, 30μV .... 1kV. Accuracy ± 1% ± 1% f.s.d. ± 1μV. Noise <0.5μV p-p on the 3μV range for source resist. up to 30kΩ. Drift <0.7μV/°C and <0.7μV/day after warm-up of 2 mins. Input resist. >1MΩ/μV up to 10mV. >10kMΩ from 30mV to 1V, 100MΩ above 1V. Rise time on 3μV, 10μV, 30μV, 100μV to 1kV is 10s. 3s, 1s. <1s.

Current Ranges:
3pA, 10pA, 30pA .... 1mA (1A for Type TM9BP). Accuracy ± 2% ± 1% f.s.d. ± 0.3pA. Noise < 0.7pA p-p on the 3pA range. Drift < 1pA/°C and < 1pA/day after warm-up of 2 mins. Input resistance 1MΩ up to 1nA, 100kΩ from 3 nA to 1μA, 100Ω from 3μA to 1mA, 0.12Ω from 3mA to 1A on type TM9BP. Rise time on 3pA, 10pA, 30pA, 100pA to 1mA is 15s, 5s, 1.5s, < 1s.

Resistance Ranges:
3Ω, 10Ω, 30Ω .... 1kMΩ. Accuracy ± 1% ± 1% f.s.d. up to 100MΩ rising to ± 10% at 1kMΩ. Test voltage is 3mV at f.s.d. on Ω ranges. Test currents are 1μA and 1nA on kΩ and MΩ ranges.

Recorder output:
0 to +1V at f.s.d. into not less than 1kΩ on left zero ranges. −0.5V to +0.5V into not less than 5kΩ on centre zero ranges.

Max. Overload:
2kV peak on V ranges. 350V peak on mV, μV, and pA ranges. 50mA peak on μA ranges. 2mA peak on nA ranges.

Power Supply:
One type PP9 battery, life 1000 hours; or AC mains when a Levell Power Unit is fitted.

Sizes & Weights:
TM9A: 5" x 7¼" x 4½" 4½lbs. Meter scale length 3¼".
TM9B: 7" x 10¼" x 5½" 8lbs. Meter scale length 5", fitted with mirror.
TM9BP: As TM9B + current ranges up to 1A.

TYPE TM9A	TYPE TM9B	TYPE TM9BP
£75	**£89**	**£93**

Optional Extras
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D.C. current ranges: 500µA-10-100mA.
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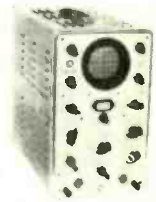

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U22	8/-
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U281	8/-
U282	8/-
U301	11/6
U403	8/-
U404	5/-
U801	17/6
UABC80	6/-
UAF41	9/-
UAF42	9/6
UBC41	8/6
UBC81	8/6
UBF80	6/6
UBF89	7/-
UBL1	8/6
UC92	6/-
UCC84	9/-
UCC85	7/-
UCF80	9/6
UCH21	9/6
UCH42	12/-
UCH43	10/-
UCH81	6/6
UCL81	10/-
UCL82	7/-
UCL83	11/-
UF9	10/-
UF42	11/-
UF43	10/-
UF80	7/-
UF85	7/3
UF89	7/-
UL41	11/-
UL84	6/6
UM4	10/-
UM80	5/-
UM84	7/-
UU5	9/-
UU8	7/-
UU10	10/-
UY1N	9/-
UY11	20/-
UY21	9/6
UY41	7/-
UY82	9/6
UY85	6/-
VU111	8/6
VU120	13/-
VU133	8/-
VU134	8/-
W76	7/-
W107	7/-
W729	10/-
X65	9/-
X76M	7/6
XB1	15/-
XC11	12/6
XC12	6/6
XC12T	8/-
XC15	4/6
XC15T	7/-
XC23	17/-
XN3	22/-
Y61	9/-
Y65	5/-
Z309	8/-
Z319	55/-
Z520M	30/-
Z700U	8/-
Z700W	15/-
Z719	4/6
Z729	6/-
Z800U	30/-
Z801U	30/-
Z803U	16/6
Z900T	13/-

BECAUSE OF INCREASE IN PURCHASE TAX AND IMPORT RESTRICTIONS WE ARE FORCED TO INTRODUCE A SURCHARGE OF 1d. PER SHILLING. THIS SURCHARGE MUST BE ADDED TO THE TOTAL OF EACH ORDER.

Head Office:

44a WESTBOURNE GROVE, LONDON, W.2

Tel.: **PARK 5641/2/3**
Cables: **ZAERO LONDON**

Retail branch (personal callers only)
85 TOTTENHAM COURT RD., LONDON W.2. Tel: LANgham 8403

A.R.B. Approved for inspection and release of electronic valves, tubes, klystrons, etc.

WE WANT TO BUY:

723A/B; 2K25; 4C35—50/- paid subject to test. Please offer us your special valves and tubes surplus to requirements.

Please send foolscap s.a.e. for full list of valves, tubes and semiconductors

APPOINTMENTS VACANT

DISPLAYED SITUATIONS VACANT AND WANTED: £6 per single col. inch.
LINE advertisements (run-on): 7/- per line (approx. 7 words), minimum two lines.
Where an advertisement includes a box number (count as 2 words) there is an additional charge of 1/-.
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 JULY 11 for the AUGUST issue, subject to space being available.

UNIVERSITY OF ST. ANDREWS

Department of Chemistry

Applications are invited from candidates with an ordinary degree, H.N.C. or equivalent qualification in Electronics for the position of TECHNICAL OFFICER in the Department of Chemistry. The successful applicant will be expected to assist in the servicing of spectrometers and in the development of electronic equipment. The new chemistry building is equipped with Mass Spectrometers (MS-902 and MS-10), N.M.R. Spectrometers (HA100 and R-10) and a Decca E.S.R. Spectrometer in addition to I.R. and U.V. Spectrometers. Salary in the range: £1,050-£1,400; grant towards removal; pension scheme. Applications with the name of a referee should be sent before 10th June, 1969, to the Deputy Secretary, University of St. Andrews, College Gate, St. Andrews, from whom further particulars may be obtained.

2266

University of Salford Audio-Visual Media Centre; Television and Film Service

Applications are invited for the following posts:

EXPERIMENTAL OFFICER (Ref VM/2/WW)

To be responsible to the Director for the alignment, testing and maintenance of the technical equipment associated with the University Television and Film Service—cameras, monitors, videotape recorders, telecine, and sound recording and reproduction systems. He will supervise all technical operations in the TV studios, including picture quality and sound balance.

The successful candidate should have a degree or equivalent qualification in Electrical Engineering. Some understanding of closed-circuit TV operations and experience of videotape recording would be an advantage.

Commencing salary will be on the scale £1,095-£1,485 (bar)—£1,715 p.a.

TECHNICIAN (Ref VM/3/WW)

To work under the supervision of the Experimental Officer in the Television and Film Studios. He will be responsible for the adjustment, maintenance and operation of Studio equipment; cameras, lighting, and sound facilities.

Qualifications should include the equivalent of "O" level GCE passes in Mathematics and Physics (ONC or City and Guilds Intermediate Technicians' Certificate will be considered acceptable). Candidates will be expected to demonstrate knowledge of TV. Experience in Television engineering will be an advantage.

Salary will be on the scale £815-£1,075 p.a.

Applications, giving details of age, qualifications and experience, together with the names and addresses of two referees, should be sent to the Registrar, University of Salford, Salford M5 4WT, by 5 July, 1969, quoting appropriate reference number.

2268

COMMUNICATIONS – INTERNATIONAL

Our clients enjoy the enviable reputation of being not only one of Britain's most progressive companies, but also one of the world's largest manufacturers of telecommunications and electronics equipment. As such, they have made a substantial contribution in the field of microwave communications electronics and have pioneered the application of highly advanced systems on an international scale.

The Company can provide virtually unlimited scope for a really worthwhile career in one of the most stimulating and challenging areas of work available today. With its expansion activities, the Company is able to offer opportunities to

DESIGN DRAUGHTSMEN

who will have an O.N.C. or equivalent qualification and machine, tool or model shop experience, preferably with some practical electrical knowledge. They will be responsible for the preparation and completion of drawings from sketches, and the design of wiring and circuits, as well as mechanical/electrical jigs. They will be able to work from advanced engineers' drawings and specifications.

Salaries will be negotiable and will be generous in accordance with experience. First-class working conditions in rural surroundings. Assistance with housing. (Reference number C/581/S/WW).

TEST TECHNICIANS

who will hold an O.N.C. in electrical engineering and/or have considerable practical experience in the field of testing and fault-clearing all types of land-line and microwave equipment.

Very attractive salaries and excellent opportunities for promotion and advancement are offered.

The location is a modern, spacious plant in Basildon, Essex, and the Company offers first-class working conditions in rural surroundings. (Reference number C/582/S/WW).

Write to A K Appointments Limited, London W1A 1DS, or telephone 01-734 6404 (day) or 01-734 2476 (after 5.30 p.m.) for an application form, quoting relevant reference number. Your identity will not be disclosed without your permission.

AK APPOINTMENTS

PROFESSIONAL AND MANAGEMENT SELECTION

WIRELESS TECHNICIANS

The Home Office requires Wireless Technicians to work on installation and maintenance of VHF and UHF communications systems throughout England & Wales.

WE OFFER

- Starting salary up to £1130 (according to age) rising to £1304 with additional allowances if working in the London area.
- Good prospects of promotion.
- 40 hour week with overtime payable.
- 18 working days paid holiday a year, rising to 30 days, plus public and privilege holidays.
- Prospects of qualifying for a pensionable post after one year's service.

WE REQUIRE

- City and Guilds Intermediate Telecommunications Certificate or evidence of an equivalent standard of proficiency.
- Sound practical experience of construction and maintenance of VHF and UHF equipment.
- Working knowledge of modern workshop techniques.

For further information and application forms please write to:—

DIRECTORATE OF TELECOMMUNICATIONS, (W.W.)
HOME OFFICE, RUSKIN AVENUE,
KEW, RICHMOND, SURREY

2270

Product Test Technicians

Career Opportunities with IBM Manufacturing

We need high calibre men to fill vacancies created by promotion and programme expansion.

The job

Is to commission the latest IBM products and systems in production at the Scottish plant, near Greenock, and requires an intimate knowledge of the equipment under test, which can include computers, punched card and tape peripherals, magnetic disk and tape storage, high and low speed printers, visual display units, multiplexors, Teleprocessing and optical character recognition equipment. The products have to be tested thoroughly, and all faults traced and rectified. The work is interesting and absorbing, and the prospects for the right man are good.

Training

Will be a mixture of formal and "on the job" instruction. We will teach you all you need to know about IBM equipment—providing your basic knowledge is to the required level.

Pay and conditions

Starting salaries will be excellent.

Benefits include a non-contributory pension, immediate free life assurance and full sickness pay for up to 26 weeks in any 12 months. The 254,000 square feet plant is modern and situated in a pleasant rural valley. There is a subsidised restaurant.

Working conditions are excellent and there are good recreational facilities in the area. IBM will assist with removal expenses where applicable.

The man

Will be at least 18 and probably less than 30 and have a strong electronic background, with experience in, for example, the testing of electronic products, maintenance of radio, radar or TV or similar work in the armed forces.

He will probably have, or be near to attaining, a qualification such as HNC, ONC, first class PMG, final RTEB, or final City and Guilds (Course Nos. 47, 48, 49, 57, 300). A knowledge of transistor circuitry and the use of oscilloscopes will be a distinct advantage.

If you have what we need, and are keen to join a vigorous, expanding and up-to-the-minute industry, please write, giving details of your age, experience and qualifications, and quoting ref. No. PT2/WW/968 to: Personnel Selection Officer, IBM United Kingdom Limited, P.O. Box 30, Spango Valley, Greenock.

IBM

GOVERNMENT OF MALAWI

requires

TELECOMMUNICATIONS OFFICER

[CIVIL AVIATION]

To serve on contract for one tour of 24-36 months in the first instance. Salary in scale £955–£1905 a year (inclusive of Overseas Addition), point of entry according to experience. In addition, a supplement of £196 – £244 p.a. is payable by the British Government direct into officer's bank in U.K. Gratuity at rate of 25% provided officer completes 30 month tour. Generous paid leave. Furnished accommodation. Education and outfit allowances. Free passages. Contributory pension scheme available in certain circumstances.

Candidates, 25-45, should possess City and Guilds Telecommunications Technician's Certificates (Intermediate) plus at least two 'B' year certificates and in addition not less than four years' experience in radio/radar maintenance after serving a recognised apprenticeship or similar training. Applicants lacking formal educational qualifications but with extensive experience can be considered.

The officer will be responsible for the installation and maintenance of telecommunications and radio navigational equipment at airports throughout Malawi.

Apply to CROWN AGENTS, 'M' Division, 4 Millbank, London, S.W.1., for application form and further particulars stating name, age, brief details of qualifications and experience and quoting reference number M2K/681117/WF

2261

UNIVERSITY OF SOUTHAMPTON

Department of Physiology and Biochemistry

SENIOR TECHNICIAN to undertake developmental and maintenance work in electronics workshop. Experience in construction and maintenance of electronics equipment used in advanced scientific laboratories preferable. The person appointed will be expected to fill a vital role in a rapidly expanding research and teaching department. Salary scale: £957-£1,195 per annum plus supplementation for approved qualifications. Applications, giving details of age, qualifications, experience and the names of two referees should be sent to the Deputy Secretary, The University, Southampton, SO9 5NH, quoting Reference WW. 2221

UNIVERSITY OF KENT AT CANTERBURY

Applications are invited for a post of technician from 1st August, 1969, on the salary scale £722-£1,007 for the University's audio-visual aids service. The person appointed will assist in the operation and maintenance of the University's closed circuit television network which is to come into operation in the autumn together with work on other audio-visual aids.

Further particulars and application forms may be obtained from the Registrar, Beverley Farm, The University, Canterbury, quoting reference T.69/4.

2227

GEC-Marconi Electronics

ELECTRONIC TECHNICIANS

Marconi can offer you

Attractive salary. Annual salary reviews

Good working conditions. 37-hour working week

Non-tied housing in a new town in certain circumstances

At Basildon we have a number of vacancies for technical test staff to work on advanced aeronautical electronic systems, maintenance and building of test equipment and other major projects. These positions will be of particular interest to men with experience of transmitters, receivers, aerials, closed circuit T.V. or digital systems.

Marconi

THE QUEEN'S AWARD TO INDUSTRY 1966 1967 1968 1969

Please telephone or write for an application form to: Mr. R. McLachlan, Personnel Officer, The Personnel Dept, The Marconi Company Limited, Christopher Martin Road, Basildon, Essex. Phone: Basildon 22822.

Member of GEC-Marconi Electronics Limited

GLOBE TROTTERS

We need Engineers with a yen for travel to commission our Radio Equipments which are selling in ever expanding world markets.

If you have experience on high power HF Equipments or Ground Navigational Aids and would like to see the world at our expense, then we want to hear from you. You will be responsible for carrying out trials and handing equipment over to the customer in good working order. You may also be required to instruct the customers engineers and take charge of teams of local labour.

You should be between the ages of 25 and 45, highly mobile and preferably single (most jobs are unaccompanied).

You should have an H.N.C. in electronics, and comprehensive understanding of modern circuit theory, and preferably practical experience in the field.

In return you will receive an excellent salary with generous allowances for overseas travel.

Please write or phone:

Tom Anderson,
Personnel Officer,
Radio Products Group,
Standard Telephones and Cables Ltd.,
Oakleigh Road, New Southgate, N.11.
Tel: 01-368 1234. Ext. 2578.

STC

Science Research Council

RADIO AND SPACE RESEARCH STATION

Staff are required for research on radio techniques used to study the Earth's environment and to provide basic information needed in the development of communications. The work involves the design of apparatus, measurement programmes in the laboratory and in the field, and the analysis and interpretation of results. The programme includes experiments in rockets and satellites, often in close liaison with Universities. Posts are mainly at Slough but some staff are needed for work near Winchester using the Station's 82 ft. steerable aerial.

Posts are available for qualified Electronics Engineers and Physicists as Assistant Experimental Officers. Well-qualified people over the age of 26 with several years' research or other suitable technical experience can be appointed in the higher grade of Experimental Officer. A.E.O's can also be appointed with A level passes and could be given opportunities for further study to gain higher qualifications.

QUALIFICATIONS

University or C.N.A.A. degree, H.N.C. or equivalent qualification. Applicants under 22 years of age require five G.C.E. passes, two of which must be at 'A' level in science or mathematical subjects.

SALARIES

A.E.O. between £650 and £1,385. Commencing salary at 26 years or over £1,150.
E.O. between £1,514 and £1,910.
Non-contributory superannuation scheme.

Please write or telephone SLOUGH 24411 for an application form.

**The Secretary,
Radio and Space Research Station,
Ditton Park, Slough, Bucks.**

2224

ENGINEER

Overseas Telemetry-Telecommunications

BP wish to recruit an engineer qualified to H.N.C. standard, to operate and maintain a telecommunications/telemetry network in the Arabian Gulf.
Applicants, aged 25-35, should have experience with microwave radio, solid state digital data telemetry and control systems. Ideally, they should also be conversant with modern medium power, MF, HF and VHF single and multichannel radio, radar and small auto telephone exchange.

The posting will not provide married accommodation, but three weeks leave granted in U.K. after three months in the Gulf. Two-year contract initially with possibility of pensionable service.
Please write giving brief details of age, qualifications and experience, quoting reference F. 645/2/8/9WW to:

**Mr. M. J. Telfer,
External Recruitment,
The British Petroleum Company Limited,
Britannic House, Moor Lane,
London, E.C.2.**

BP

2220

AGRICULTURAL RESEARCH COUNCIL

Unit of Invertebrate Chemical Physiology

Applications are invited for the post, described below, in the newly formed Unit of Invertebrate Chemical Physiology under the Hon. Directorship of Professor A. W. Johnson, F.R.S., of the University of Sussex. The appointment would however be to the Sub-Unit which is under the direction of Dr. J. E. Treherne and is situated at the University of Cambridge.

ASSISTANT EXPERIMENTAL OFFICER with experience in the design and construction of electronic laboratory equipment, to work with a group carrying out research on comparative Neurophysiology and membrane biophysics.

Qualifications

A.E.O., age 22 and over—pass degree, H.N.C. or equivalent: under 22, G.C.E. in 5 subjects including 2 at advanced level.

Salary Scale: Assistant Experimental Officer £650 (at age 18) to £1,150 (maximum starting salary at age 26 or over) to £1,385.

Applications with two referees to:

Dr. J. E. Treherne, University of Cambridge, Department of Zoology, Downing Street, Cambridge.

2269

RADIO TECHNICIANS

INSTALLATION AND MAINTENANCE

£1 100 – £1 500

THE WORK

Opportunities exist for Radio Technicians to undertake interesting work involved with the maintenance and installation of equipment at airfields, inland and marine mobile networks and on North Sea drilling rigs.

THE REQUIREMENTS

Applicants should have experience in one or more of the following types of equipment.

* VHF/UHF base station/mobile equipment.
* HF Receivers and Transmitters up to 1KW using SSB, ISB and FSK techniques.
* Remote control systems operating over GPO landlines.
* Teleprinters and Telegraph machines and error correction equipment.

Applicants must have a UK driving licence and be willing to work outside working hours on a call-out roster basis.

THE OFFER

The posts offer excellent career prospects and you would be based at Southall and London Airport. Benefits include membership of a good Contributory Pension and Life Insurance Scheme and concessions on holiday air fares can be obtained to most parts of the world after one year's service.

THE COMPANY

IAL are a fast expanding world-wide company engaged in the fields of communications, aviation services and engineering.

Please write stating brief details of age and career to date to: Personnel Officer (R), International Aeradio Limited, Aeradio House, Hayes Road, Southall, Middlesex.

2228

ELECTRONICS ENGINEER

Required by MEDICAL RESEARCH COUNCIL CYCLOTRON UNIT. 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 £1,169-£1,518 according to age and experience.

Initial application, giving career particulars, should be sent to the Director, M.R.C. Cyclotron Unit, Hammersmith Hospital, Ducane Road, London, W.12.

2230

COLLEGE OF I.M.R. COMMNS., Brooks' Bar, Manchester 16, invite applications from suitably qualified persons for the following:

ASSISTANT LECTURER IN MARINE RADIO. P.M.G. Cert., and up-to-date knowledge of the technical syllabus essential. Radar and other qualifications and/or teaching experience an advantage, taken into account when fixing salary, based on the Burnham Scale.

ASSISTANT LECTURER IN MARINE RADAR. Applicants must hold the B.O.T. Radar Maintenance Certificate, and should also have had Radar experience as a marine Radio Officer and/or service engineer.
Both positions available September 1969.

Write Principal, giving in confidence full details of experience, education, present salary, etc.

2271

Use your HND with the New Post Office in COMMUNICATIONS ENGINEERING

The Post Office, with its £2000 million development programme is in the top ten of the world's industrialised concerns and offers you tremendous scope for the application of your talents.

You will find yourself in the expanding world of communications assisting in planning, design and management of such demanding projects as:

- Electronic telephone exchanges
- Postal mechanisation
- Digital and analogue transmission and switching systems
- Application of computer techniques
- Micro-wave radio and satellite communications

To be eligible, you need 'O' level English Language and one of the following: HND in electrical or mechanical engineering or in physics, IEE (pts. 1, 2 & 3), IERE (sections A & B), I.MECH.E. (pts. 1, 2 & 3), or CEI (pts. 1 & 2) in subjects acceptable to one of the institutions named, or exempting qualifications. Starting salaries can range up to £1397 (Inner London). There are good prospects of promotion to posts with salaries above £2000 in four to five years.

For full details ask your operator for a free call to
FREEFONE 284. Or write to:
Richard Mayne B.Sc. (Eng), C.Eng., MIEE,
Post Office Appointments Centre,
(ref. no ZH. 155/77/1),
23 Howland Street, LONDON W1P 6HQ.

THE NEW POST OFFICE

THORN AUTOMATION

RUGELEY STAFFORDSHIRE

TEST ENGINEERS

Several vacancies have arisen for engineers who wish to be engaged in testing a wide range of valve and semi-conductor industrial control equipment, including digital systems. A working knowledge of electrical/electronic circuitry is essential.

These are interesting permanent staff situations, and the salary paid will be commensurate with ability and experience.

The Company is situated in rural surroundings, and yet is close to several large towns. Housing is available at moderate prices.

Applications for these positions, stating age, qualifications and previous relevant experience, should be addressed to the Personnel Officer.

GEC-Marconi Electronics

ELECTRONIC TECHNICIANS

are required to work on calibration, fault-finding and testing of telecommunications measuring instruments. The work is varied and will enable technicians with experience of r.f. circuits to broaden their knowledge of the latest techniques employed in the electronics and telecommunications industries by bringing them into contact with a wide range of the most advanced measuring instruments embracing all frequencies up to u.h.f.

Entrants may be graded as Testers, Test Technicians or Senior Test Technicians according to experience and qualifications. Our expanding production programme geared to our recognised export achievement provides security of employment combined with good prospects of advancement, not only within these grades, but into other technical and supervisory posts within the Company.

Salaries are attractive and conditions excellent. A Pension Scheme includes substantial life assurance cover provided by the Company. Assistance with removal may also be given in appropriate cases. Please apply in writing, giving brief details including age, experience and salary to:

The Recruitment Manager,
Marconi Instruments Ltd.
Longacres, St. Albans, Herts.

mi

Member of GEC-Marconi Electronics Limited

CITY AND COUNTY OF BRISTOL

BRISTOL TECHNICAL COLLEGE

DEPARTMENT of NAVIGATION MARINE RADIO and RADAR

Applications invited for following posts:

Ref. No. L696/40/1

LECTURER GRADE II in RADIO and RADAR

Duties to commence 1st September 1969, or as soon as possible thereafter.
Applicants must hold a First Class P.M.G. Certificate in Wireless Telegraphy and the B.O.T. Radar Maintenance Certificate. Additional qualifications such as H.N.C. (Electronics) Aircraft Radio Maintenance Engineer's Licences A and B an advantage.

Ref. No. L696/41/1

LECTURER GRADE I in RADIO and RADAR

Duties to commence on 1st January 1970.
Applicants must hold a First Class P.M.G. Certificate in Wireless Telegraphy and the B.O.T. Radar Maintenance Certificate.
Additional qualifications an advantage.
Salary Scales: Lecturer II .. £1,725-£2,280
(under review) Lecturer I* .. £1,035-£1,735
* A higher salary scale for candidates with degree or equivalent qualifications. Starting salary dependent upon teaching and industrial experience.
Further particulars and application forms (to be returned within fourteen days of this advertisement) from Registrar, Bristol Technical College, Ashley Down, Bristol BS7 9BU.
Please quote appropriate Reference Number in all communications. 2265

SERVICE TECHNICIANS

Experienced Electronic Engineers, minimum qualifications O.N.C./City and Guilds or 2/3 years' Bench experience, to service and repair a wide range of electro-acoustic instruments. Driving experience essential. Excellent salary and opportunities for advancement.

Write or telephone for immediate interview:

**Personnel Department,
Amplivox Limited,
Beresford Avenue,
Wembley, Middlesex.
Telephone 902-8991.**

2237

ELECTRONIC ENGINEER

required by leading telecommunications company, experience in digital techniques and modern telephone and telegraph equipment desirable.

TELEPRINTER MECHANICS

Top grade teleprinter mechanics required with experience in Tele-type and CREED equipment, knowledge of electronics and general telegraph circuits advantageous.

Good prospects, Non-contributory pension plans.

COMMERCIAL CABLE COMPANY
Mackay House, Wormwood Street, E.C.2
2236

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

SITUATIONS VACANT

AIRCRAFT RADIO ENGINEERS and Mechanics with specific workshop experience in one of the following: VHF/HF, ILS/VOR, ADF or WEATHER RADAR. Pension Scheme. 3 weeks holiday per year. Apply: MANAGING DIRECTOR, Air Transport (Charter) (C.I.) Ltd., Willow Road, Colnbrook, Bucks. Tel.: Colnbrook 2654. [2291

A FULL-TIME technical experienced salesman required for retail sales; write giving details of age, previous experience, salary required to—The Manager, Henry's Radio, Ltd., 303 Edgware Rd., London, W.2. [67

B.B.C. has a vacancy in Engineering Division for HEAD OF PRODUCTION UNIT, DESIGNS DEPARTMENT. He will be responsible for the overall manufacture of prototype electronic units for use by the television and sound services. These units are made in the Department's Model Shop or by contractors working from preliminary drawings or sketches. The postholder will organise the work of the technicians, instrument makers and wiremen in the Model Shop and will also be responsible for the operation of the Department's component stores. Applicants must be qualified engineers, possessing HNC or the equivalent in electrical engineering. They must possess such mechanical knowledge as will enable them to contribute to the design of equipment from the manufacturing point of view. Experience of the problems involved in development work in the electronic field and a knowledge of drawing office practice would be an advantage. Commencing salary £2,130 to £2,360 p.a. in a scale having a maximum salary of £2,705 p.a. Quoting reference no. 69E.2126W.W. apply for application forms to the Engineering Recruitment Officer, BBC Broadcasting House, London, W1A 1AA. [2281

ELECTRONICS ENGINEER required to develop instruments for biochemical research and maintain and modify existing equipment. Previous experience with electro-optical instruments an advantage. Applicants should hold an H.N.C. in Electrical Engineering or Applied Physics. Commencing salary £1,200-£1,400. Applications to the PROFESSOR OF CHEMICAL PATHOLOGY, Westminster Medical School, London, S.W.1. [2282

ENGINEERS interested in spare time writing income please contact Technical Journalist and indicate electronic subjects on which they are prepared to write. Box W.W 2283 Wireless World.

EXPERIENCED ENGINEER required for repair and calibration of electronic test equipment. Apply: A. J. WHITTEMORE (AERADIO) LTD., Biggin Hill Aerodrome, Kent. Tel: Biggin Hill 2211. [2292

PHILIPS RECORDS LIMITED have a vacancy for an Electronics Engineer in the Maintenance Department. Applicants would be responsible for the maintenance and servicing of disc transcription and tape duplicating equipment. A thorough knowledge of latest transistor techniques and up to date test equipment will also be required A good knowledge of Neumann Cutting Lathes would be an advantage. Candidates should be between twenty-three and thirty years old and should possess H.N.C. or O.N.C. in electronics. Please apply in writing to the PERSONNEL MANAGER, Philips Records Limited, Record Works, Walthamstow Avenue, London, E.4. [2284

REDIFON LTD. require fully experienced TELECOMMUNICATIONS TEST ENGINEERS and ELECTRONICS INSPECTORS. Good commencing salaries. We would particularly welcome enquiries from ex-Service personnel or personnel about to leave the Services. Please write giving full details to—The Personnel Manager, Redifon Ltd., Broomhill Road, Wandsworth, S.W.18. [26

THE University of Sheffield. C.C.T.V. Engineer. Applications are invited for the post of ENGINEER in the CLOSED CIRCUIT TELEVISION SERVICE tenable from 1st October, 1969, to take charge of all technical aspects of the work, including the operation and maintenance of the present equipment, distribution and the planning of future developments. Applicants should be university graduates or have comparable professional qualifications in electronic engineering and good experience in broadcasting or C.C.T.V. The appointment will be made in the academic grade of **Senior Experimental Officer**: salary in the range of £1,685-2,565 with F.S.S.U. provision. Further particulars from the Registrar, to whom applications (4 copies) should be sent by 30th June, 1969. Quote Ref.: R.2/BH. [2293

UNIVERSITY OF BRISTOL. Department of Physiology. Electronics Technician required for development work. Previous experience of biological work would be an advantage although not essential. Salary according to age, qualifications, and experience. Applicants should send full details to THE SECRETARY, Department of Physiology, The Medical School, University Walk, Bristol, BS8 1TD. [2285

WE HAVE VACANCIES for Four Experienced Test Engineers in our Production Test Department. Applicants are preferred who have Experience of Fault Finding and Testing of Mobile VHF and UHF Mobile Equipment. Excellent Opportunities for promotion due to Expansion Programme. Please apply to Personnel Manager, Pye Telecommunications Ltd., Cambridge Works, Haig Road, Cambridge. Tel. Cambridge 51351, Extn. 327. [77

SITUATIONS WANTED

PHYSICIST, Experienced Graduate, Optics and Electronics, seeks Technical Work at home, writing, editing, etc., good French and German.—Phone 01-459 0873 (London). [378

MISCELLANEOUS

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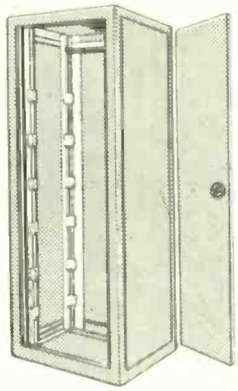

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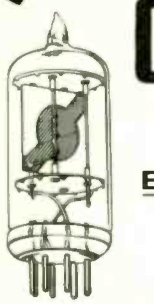

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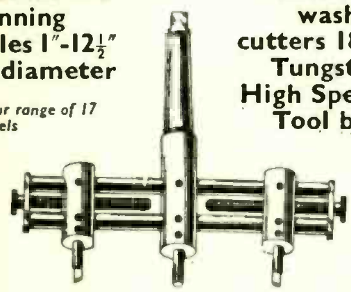

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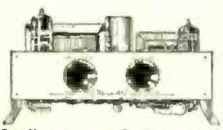

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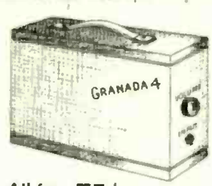

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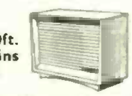

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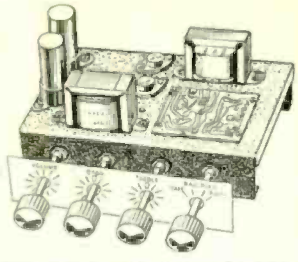

A really high fidelity monaural amplifier with performance characteristics to suit the most discriminating listener. 6 transistor circuit with integrated preamplifier assembled on special printed sub panel. AD-161-AD162 operating in symetrical complementary pair. Output transformer coupled to 3 ohm and 15 ohm speaker sockets. Standard phono input sockets. Full wave bridge rectifier power supply for A.C. mains 200-240 v. Controls: Bass, Treble. Volume/on/off. Function selector for PU1, PU2, Tape, Radio. The HSL.700 is strongly constructed on rigid steel chassis, bronze hammer enamel finish, size 9¼ in. × 5 in. × 4¼ in. high. Performance figures:

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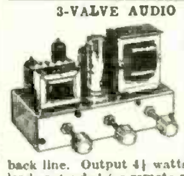

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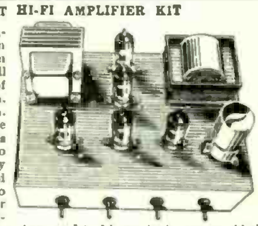

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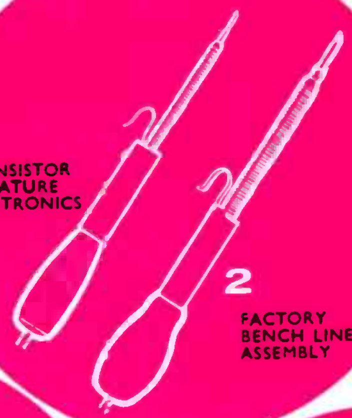
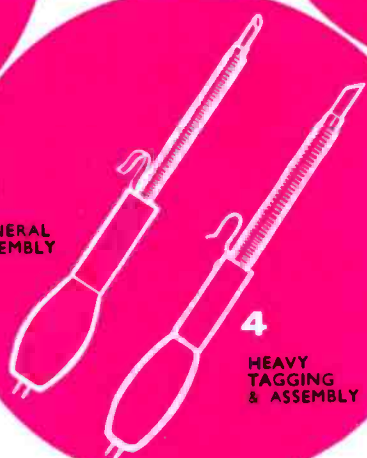
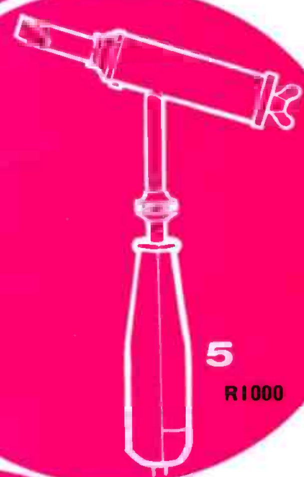
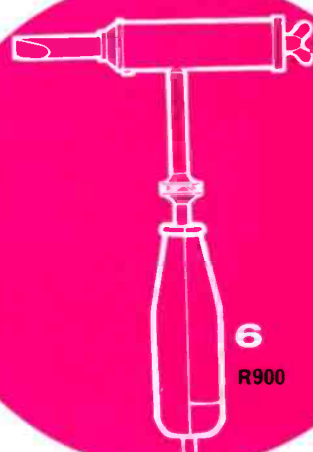






1. $\frac{1}{8}$" DIA.—3.2 mm. dia. detachable bit. Standard temp. 340 c at 19 watts. Special temps. from 250 c 400 c Weight 4.5 ozs. 127 grms.
2. $\frac{3}{16}$"—4.75 mm. dia. detachable bit. Standard temp. 360 c at 23 watts. Special temps. from 250 c 410 c. Weight 6 ozs. 170 grms.
3. $\frac{1}{4}$"—6.34 mm. dia. detachable bit. Standard temp. 360 c at 27 watts. Special temps. from 250 c–410 c. Weight 6.5 ozs. 184 grms.
4. $\frac{5}{16}$"—7.9 mm. dia. detachable bit. Standard temp. 360°c at 30 watts. Special temps. from 250 c–410 c Weight 7 ozs. 198 grms.
5. OFFSET BIT SIZE $\frac{1}{2}$" 12.7 mm. diameter.
6. RIGHT ANGLE BIT SIZE $\frac{1}{2}$" 12.7 mm. diameter.

BOTH AVAILABLE IN THE FOLLOWING TEMPERATURES 250 c—27 watts, 360 c—50 watts, 410 c—60 watts, 500 c—90 watts. Supplied in all voltages from 6 volts to 250 volts.



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