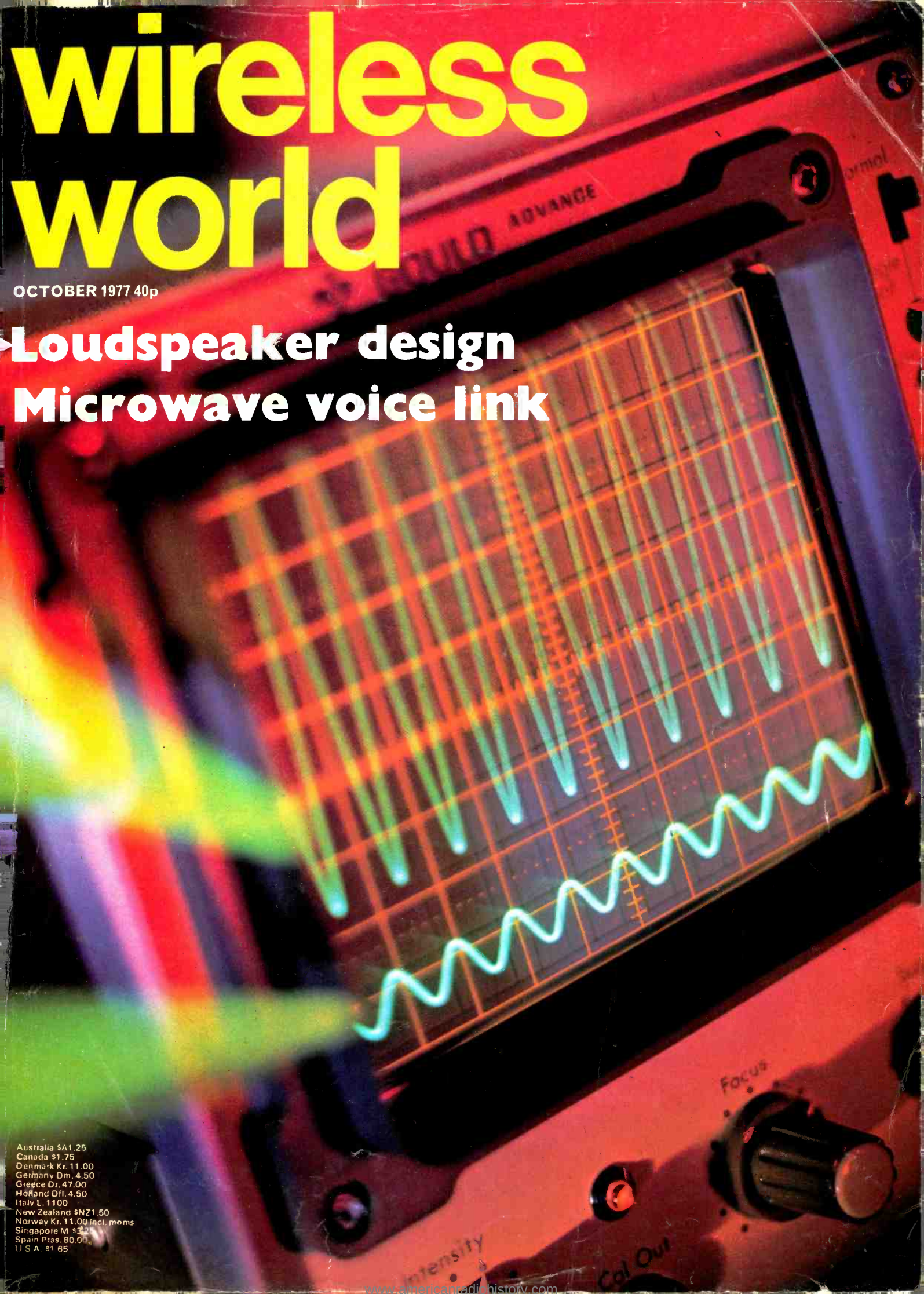
wireless world

OCTOBER 1977 40p

Loudspeaker design
Microwave voice link



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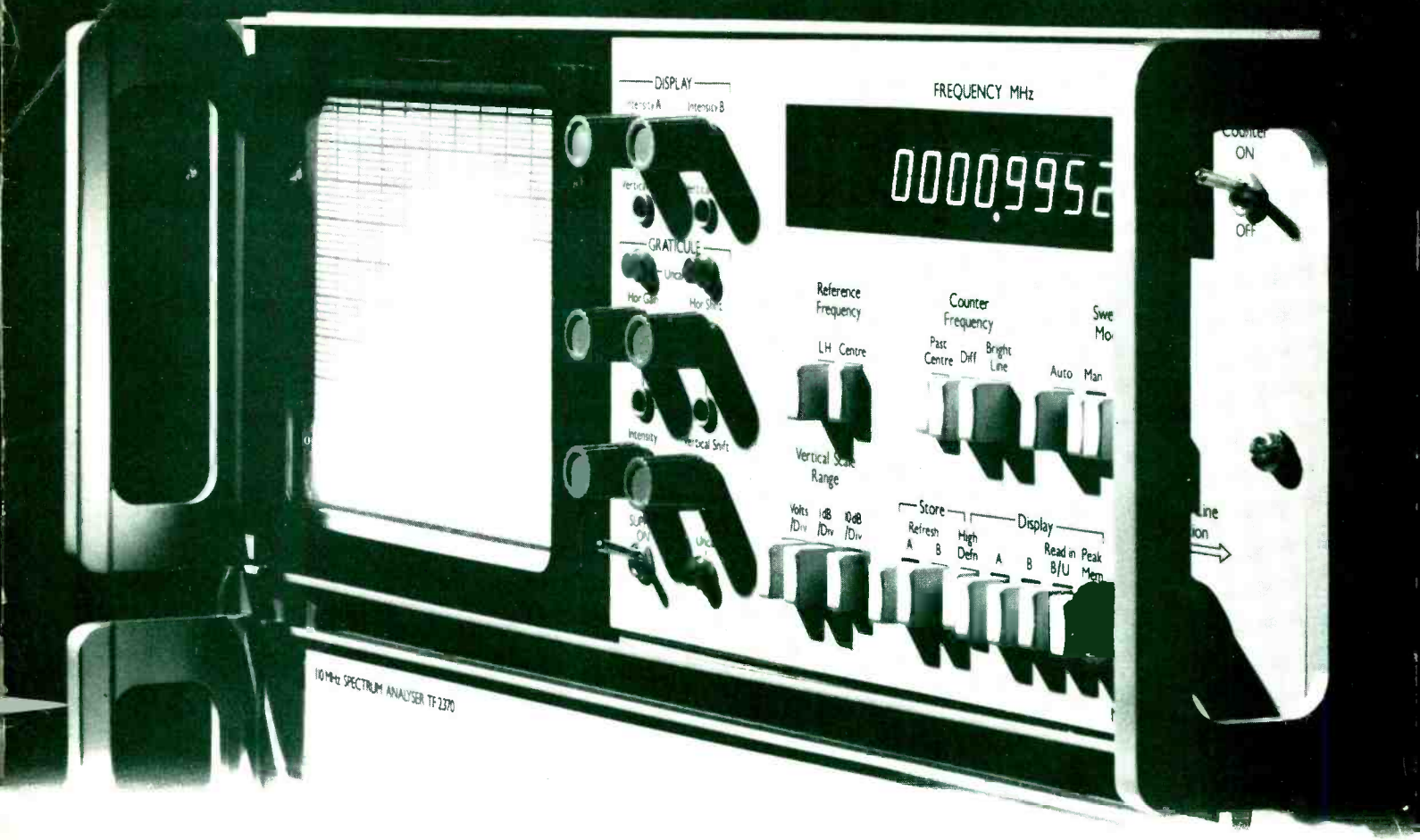
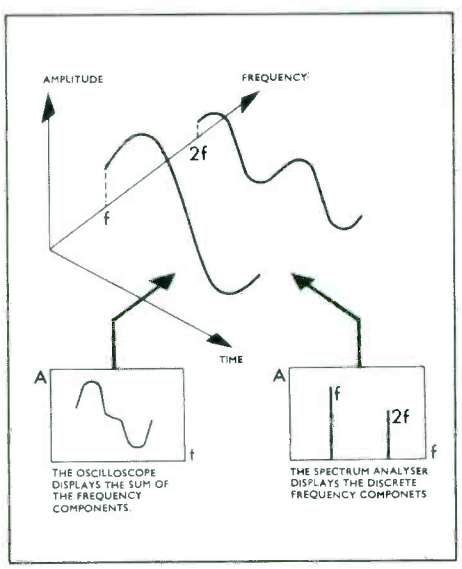
The oscilloscope with a difference...



. . . . . the difference is that it measures amplitude against frequency (instead of time). This comparatively small change has led to our instrument being called a "Spectrum Analyser" which, in turn, has caused oscilloscope users to believe it's for a completely different job, "they are complicated things used only by boffins and people concerned with light waves or something".

But – excuse us – that's where they're wrong. Our TF 2370 is easier to use than many oscilloscopes, it has a frequency range from 30 Hz to 110 MHz and gives much, much more information about waveforms of nearly all types than does a 'scope. And it has a built-in digital frequency meter and sweep (tracking) generator of its own so you can check amplifiers and filters too.

Signals are displayed with the fundamental, harmonics, sidebands and spurious content all clearly indicated and quite distinct from each other. You can see the waveform as it really is and measure hum, distortion, modulation depth and all sorts of things to an accuracy impossible on a 'scope – even on signals which 'scopes show as being 'pure'.



Our special digital store and television display system gives you a steady 'infinite persistance' picture on which you may also compare your ideal waveform with your actual live image. The graticule is electronically generated – so no parallax errors – and you can move it up and down, or sideways, or expand it, all at the twist of a knob or two.

Whether you are involved in design, production, calibration, maintenance or indeed virtually any application where oscilloscopes are used, you will find that the TF 2370 Spectrum Analyser will provide a faster, easier, more informative and accurate answer to nearly all your questions.

If you're still a sceptic ask us for literature or, better still, ring us for a demonstration.

mi MARCONI INSTRUMENTS

Marconi Instruments Limited · Longacres · St. Albans · Hertfordshire · England AL4 0JN · Tel: (0727) 59292 · Telex: 23350
Marconi Electronics Inc · 100 Stonehurst Court · Northvale · New Jersey 07647 **USA** · Tel: (201) 767-7250 · Twx: 710-991-9752
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Electronics, Television, Radio, Audio

OCTOBER 1977 Vol 83 No 1502

Contents

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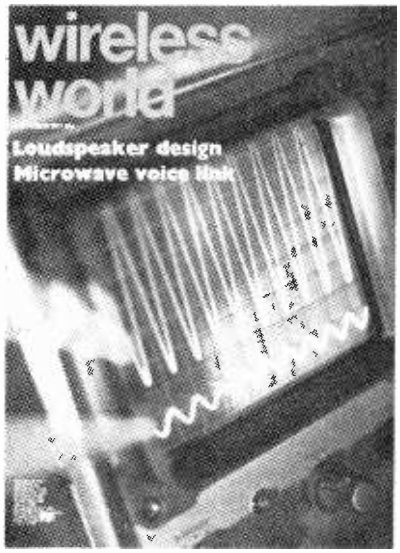


Front cover is an impression by Paul Brierley of a Gould Advance oscilloscope.

IN OUR NEXT ISSUE

Audible amplifier distortion is not a mystery. As a preliminary to a series of practical articles, Peter Baxandall looks at the topical and controversial subject of distortion in its several forms and attempts to bring order to the proliferation of ideas recently advanced.

F.m. transceiver. A design for a two-metre amateur transceiver using a synthesizer to provide 40 switch-selected channels. Features include easy mobile working and low power consumption.

ISSN 0043 6062

It's the engineering we put into the Calinda that makes it sound so much better.

With dozens of speakers on the market, all around the same size, shape and price as the Calinda, how on earth do you choose?

Obviously, you can start with a listening test, using your own ears and judgement.

But demonstration conditions are seldom ideal, and probably quite different from those in your own home.

You can ask your knowledgeable friends; you can read magazine reports; you can plough through bookfulls of comparisons.

More and more of them are recommending speakers made by KEF.

Because KEF loudspeakers, like the Calinda, are designed from start to finish by engineers, whose aim is to give you as near as possible the same sound as the recording engineers put on record.

Beethoven or heavy rock, you want a clearer image than this.

First, look at the cabinet.

There's a lot of thought gone into that.

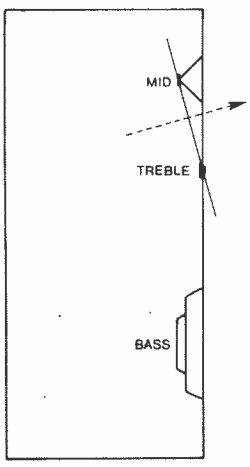
For a big, 45 litre capacity it is tall and elegant, so that a pair of Calindas can fit happily into most people's sitting rooms.

It's fairly narrow; for technical reasons this permits a wide dispersion of sound.

It's deep, from front to back; this keeps the sound radiating units well away from the wall or furniture behind, cutting down on disturbing reflections.

It's quite tall; so that we can put the all important mid-range unit well away from the floor. Reflections from the floor, reaching your ear, can give a nasty 'double impression'; you don't want that.

And it's still, heavy and well damped. When choosing a loudspeaker, give it a sharp knock with your knuckles. A good one, like the Calinda, gives you a solid, dull 'thud', with no rattles, twangs or reverberations.



The Drive Units.

The treble, mid-range and bass radiator units in the Calinda are all designed, developed and made by KEF, using advanced, acoustically damped plastics materials which give much better performance than conventional, paper cones.

We put the mid-range unit above the tweeter.

This is unconventional.

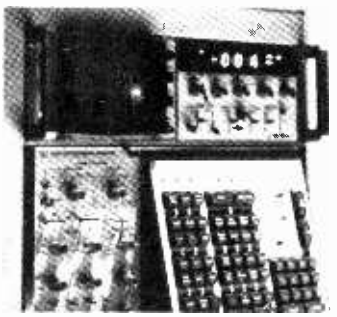
And it's a very good idea. Not only does it take the mid-frequencies away from the floor (as mentioned above, you only want even Beethoven once), it also has a very valuable effect at the crossover frequencies, where the mid and treble units radiate the same notes.

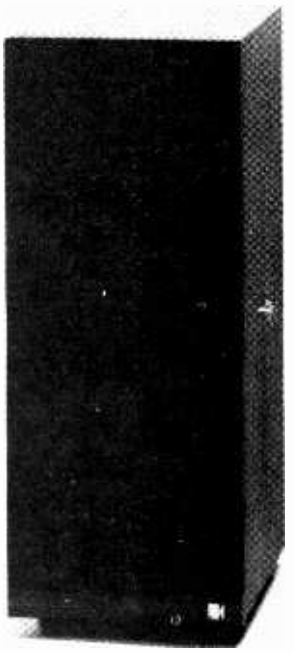
Because the effective sound source in the mid unit is further back than that of the tweeter, this means that sound from each will travel the same distance to the listeners' ears, with no audible inter-unit time delay, another cause of distortion and loss of clarity.

Or, to put it another way, crossover frequency sound is 'aimed' at the head of a seated listener, and not his feet.

The KEF 'total system' design approach.

But perhaps the biggest reason for the high performance of the Calinda is the KEF 'total system' approach to design and development, using computerised measurement and calculation techniques which are a thousand times faster than manual methods, cutting out the old guesswork and mumbo jumbo previously associated with loudspeaker design.





In this system, the cabinet, drive units and dividing network are developed together, to reach an ideal target performance.

As a result, the Calinda gives a truer frequency response, greater clarity and a sharper stereo image than any previous speaker of equivalent size and price.

Write to KEF for the latest leaflet on the Calinda, its smaller brother the Corelli bookshelf speaker and the big, 150W Cantata.

To KEF Electronics Limited, Tovil, Maidstone, Kent ME15 6QP
Please send me full details of the Calinda and the rest of the KEF range.
Stamps for return postage appreciated.

Name .....

Address .....

.....

.....

.....

KEF

KEF Electronics Limited, Tovil, Maidstone, Kent ME15 6QP. Tel. 0622 672261. Telex 96140

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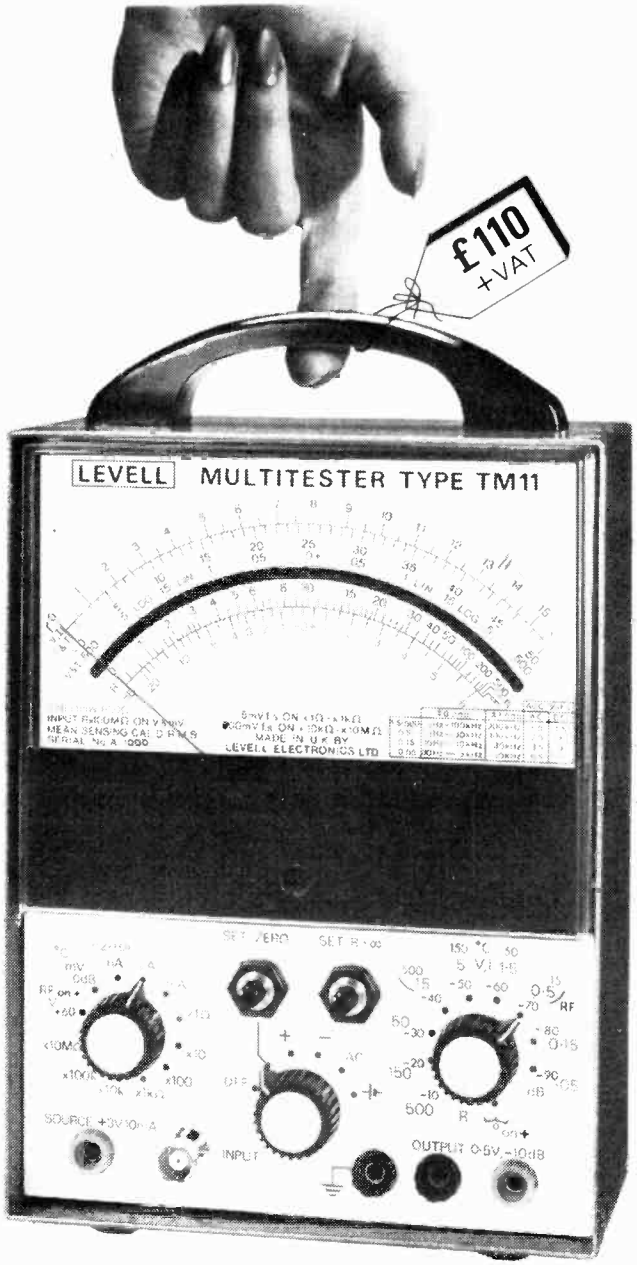

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30 OPTIONAL RANGES

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HIGH CURRENT	:	1.5A/50A fsd, AC/DC, using Current Shunt. Price £15 + VAT.
TEMPERATURE	:	-150°C/+500°C fsd in 7 ranges using Temperature Probe. Price £38 + VAT.

The instrument operates from a 9 volt battery, life 1000 hrs., or, AC mains when optional Power Supply Unit is fitted. Size is 240mm x 150mm x 80mm. Weight is 1.75 kg. Meter scale length is 140mm. Leather case is available at £13 + VAT.

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WW—063 FOR FURTHER DETAILS

News of the Decade

RESISTANCE
CAPACITANCE
INDUCTANCE

over 60 different models available, many from stock

CONTACT US IF YOU NEED MORE INFORMATION OR DEMONSTRATION

DECADE BOXES

"Junior" Series—Resistance—1%

	Decades	Ohms Range	Ohms Resolution	£
J1	5	0— 1,111,100	10	**35.70**
J2	5	0— 111,110	1	**35.30**
J3	4	0— 111,100	10	**29.00**
J4	4	0— 11,110	1	**28.70**
J5	3	0— 11,100	10	**23.90**
J6	3	0— 1,110	1	**23.70**
J60	6	0— 1,111,110	1	**43.00**
J70	7	0—11,111,110	1	**50.50**

"Junior" Series—Capacitance—1%

	Decades	pF Range	pF Resolution	£
JC1	3	100— 111,000	100	**25.70**
JC2	2 + var	30— 11,140	"Infinite"	**26.90**

"Point One" Series—Resistance—0.1%

	Decades	Ohms Range	Ohms Resolution	£
R3	4	0— 1,111	0.1	**57.40**
R4	4	0— 11,110	1	**57.00**
R5	4	0— 111,110	10	**56.10**
R7	5	0— 1,111,100	10	**69.70**
R9	5	0— 111,110	1	**70.40**
R10	5	0— 11,111	0 1	**71.00**
R11	5	0— 11,111,000	100	**81.00**
R20	6	0— 1,111,110	1	**84.40**
R21	6	0— 111,111	0 1	**85.50**
R22	6	0— 11,111 1	0 01	**92.90**
R30	7	0— 11,111,110	1	**106.50**
R31	7	0— 1,111,111	0 1	**99.00**
R32	7	0— 111,111.1	0.01	**99.80**
R41	8	0— 11,111,111	0.1	**121.00**
R42	8	0— 1,111,111.1	0 01	**116.10**

"Hundred" Series—Resistance—0.03%

	Decades	Ohms Range	Ohms Resolution	£
R400	4	0— 111,100	10	**105.60**
R401	4	0— 11,110	1	**110.50**
R402	4	0— 1,111	0 1	**111.70**
R403	4	0— 111 1	0 1	**119.40**
R600	6	0— 11,111,100	10	**143.60**
R601	6	0— 1,111,110	1	**146.20**
R602	6	0— 111,111	0 1	**148.70**
R603	6	0— 11,111 1	0 01	**155.70**
R701	7	0— 11,111,110	1	**170.30**
R702	7	0— 1,111,111	0 1	**172.80**
R703	7	0— 111,111 1	0 01	**179.20**
R802	8	0— 11,111,111	0 1	**193.80**

DECADE BOXES continued

					£
R803	8	0— 1,111,111.1	0 01	+10%	**197.00**

High Dissipation—Resistance—1%

	Decades	Ohms Range	Ohms Resolution	£
HD1	5	0— 1,111,100	10	**121.00**
HD1/L	5	0— 111,110	0.2 Approx	**127.40**

"Point One" Series—Inductance—5%

	Decades	mH Range	mH Resolution	£
L1	3	0— 1,110	1	**110.40**
L2	2	0— 110	1	**77.60**
L3	2	0— 1,100	10	**86.10**

"Hundred" Series—Inductance—0.3%

	Decades	mH Range	mH Resolution	£
L300	3	0— 1,110	1	**320.00**
L400	4	0— 11,110	1	**415.80**

CAPACITANCE BOXES

Decades

	Decades	pF Range	pF Resolution		Accuracy	£
C3	3	100— 111,000	100		1%	**55.80**
PC3	3	100— 111,000	100		0 5%	**77.10**
C4	4	100— 1,111,000	100	+7½%	1%	**85.00**
PC4	4	100— 1,111,000	100		0.5%	**120.00**

Decade plus Variables

	Decades	pF Range	pF Resolution	Accuracy	£
VC4	3	50— 111,150	INFINITE	1%	**70.50**
VC5	4	50— 1,111,150	+7½%	1%	**99.80**
PVC5	4	50— 1,111,150		0 5%	**148.90**
SVC5	4	50— 1,111,150	+12½%	0 05%	**763.90**
C500	4	50— 1,111,150	+7½%	0 2%	**275.60†**

SVC5 special. Details on application

Variables

	pF Range			£
PVC1 Mk 2	5— 200		0.5%	**141.60**
PVC2 Mk 2	20— 1,120		0 5%	**127.60**
VC2	20— 1,130	+7½%	1%	**49.20**
PVC4	0— 10		1%	**89.20**
PVC1/S	20— 120		0 5%	**85.30**

Switched

	uF Range	uF Resolution	Accuracy	£
C140	0—140 1 0		5%	**180.30†**
C100	0—100 1 0		5%	**152.50†**
C60	0— 61 0 1	+7½%	5%	**135.90†**
C60P	0— 61 0 1		1%	**276.20†**

† Packing and Handling extra Prices do not include VAT

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Telephone: 0382 89321 Telex: 76166
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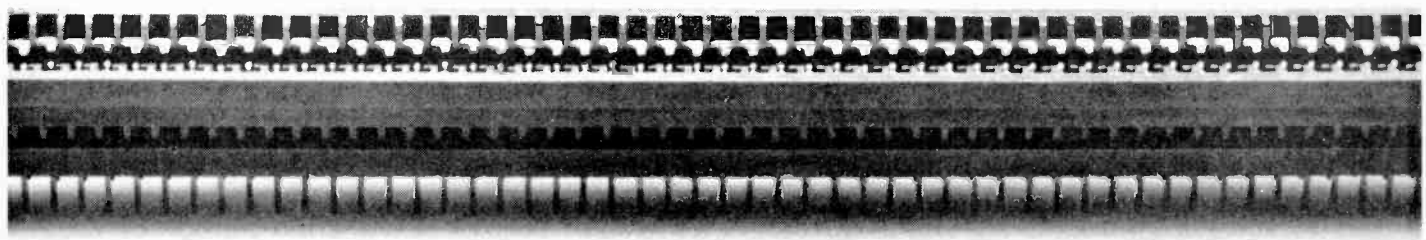

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GenRad

77/1

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Low Power Schottky TTL cuts down on everything.

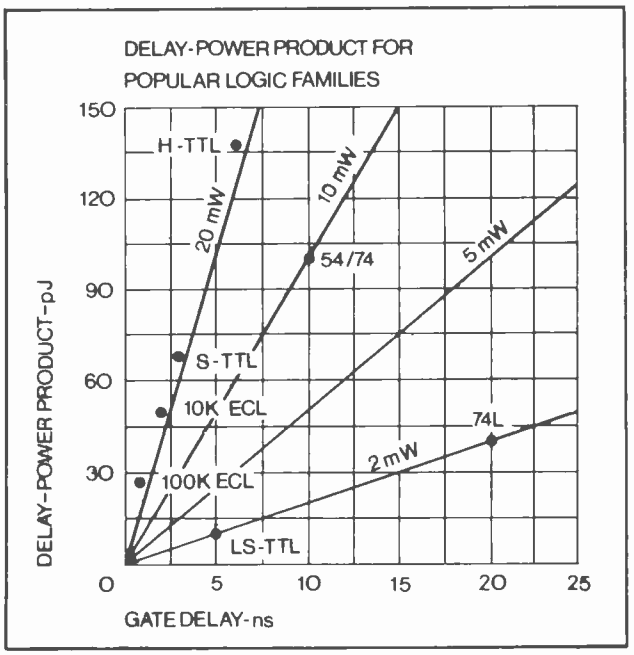
Except performance.

Motorola Low Power Schottky TTL cuts down on supply current and noise. As well as the size, cost and weight of equipment.

But it additionally offers far more than that. Now you don't have to choose between speed and power in performance terms. As the graph clearly shows, it dissipates eleven times less power than 74S, suffering a delay of only 1.7 times.

There are no problems with interfacing, as it is compatible with other TTL types and CMOS. It's faster than CMOS, and due to the Bipolar technology, no special handling is necessary.

Reliability, economy and speed. These are the areas that Motorola Low Power Schottky TTL hasn't cut back on.



Crellon Electronics Ltd.,
380 Bath Road, Slough, Berks SL1 6JE.
Tel: Burnham (06286) 4434
Telex: 847571

Please send me full information on the Motorola Low Power Schottky TTL.

Name _____

Company _____

Address _____

_____

Tel: _____

WW 10/77

Crellon Electronics Ltd.,
(incorporating ECS and GDS Sales)

MOTOROLA

WW—026 FOR FURTHER DETAILS

F.M. TUNERS, MODULES & KITS by Icon Design

This tuner must surely provide the best value for money available today Combining the best of the modules shown below, it includes a full digital readout of frequency to a resolution of 0 1 MHz, so that exact station identification can be made. In addition, six pre-set stations may be selected by touch controls having internal solid state lamps, while manual tuning allows easy searching for distant stations under the guidance of the digital meter

A switchable mute system allows reception of the weakest stations while muting inter-station noise and spurious responses. Perfect reception is assured by not permitting any station to be heard which is far enough out of tune to cause distortion. The tuning indicator lamp provides a means of very fine tuning, and is automatically extinguished between stations

A powerful A.F.C. system is also incorporated which holds all stations in tune, while not preventing manual tuning

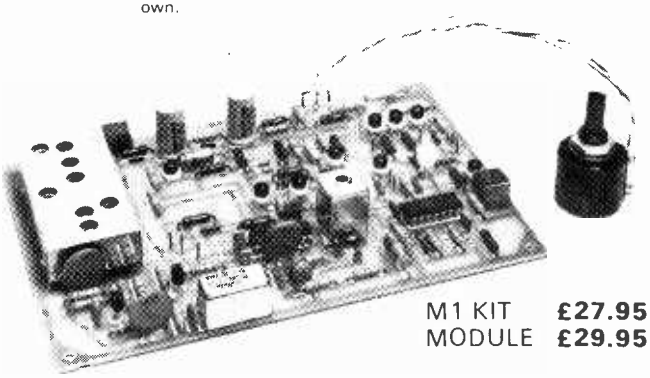
Good stereo reception is assured by the use of a phase locked decoder with full 'birdie' and spurious output filtering

Finally, but not least, the external appearance and styling bring a fresh new look to Hi-Fi. The sturdy wooden cabinet is finished in mat teak veneer, housing an attractive gold and brown, anodised aluminium front panel, which carries black controls and inscriptions. The indicator lamps and digital displays are in red, giving the finishing touches to a tuner you will be proud to own.

	Tuner	Kit
T2 TOUCH TUNED	**£121.00**	**£109.00**
T3 DIGITAL (AS SHOWN)	**£149.00**	**£139.00**

MAIN RECEIVER MODULE M1

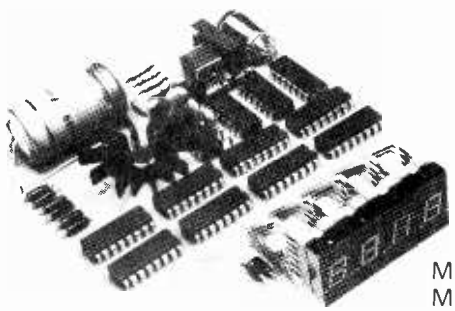
We have claimed before that this F.M. system is the most advanced on the market, and after nearly three years we repeat our claim. Some have borrowed ideas, some have not, but no other tuner gives you all the features of this unit How many tuners mute the spurious tuning effects found at either side of a correctly tuned station? How many tuners fade the sound out as you tune too far off station for good quality sound? How many tuners kill the tuning indicator so that it does not indicate when there is no station there? How many offer you drift free tuning? We could go on. If you want a tuner that has been well thought out and engineered, start with this module



M1 KIT **£27.95**
MODULE **£29.95**

DIGITAL FREQUENCY METER M6

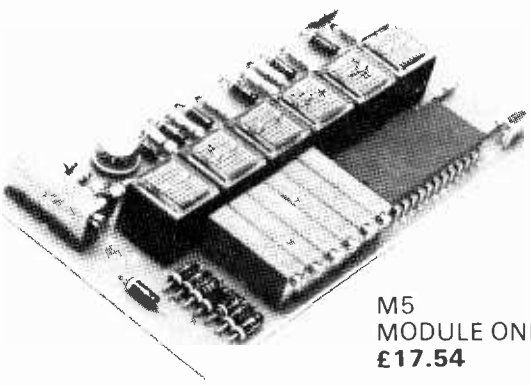
We are very proud of this one We don't have to say it's the best, as far as we know it's the only one! On a board less than 4" square is all the electronics of a stable counter with i.f. offset (added) and a stabilized power supply! With the aid of a small daughter board (not shown) which fits neatly into the above module (M1), the exact station frequency is displayed to the nearest 0 1 MHz. It's a tuning scale 20" long with accurate calibrations every 0 1"! You get the transformer, daughter board (ready wired in), polarized filter, and a list of station frequencies What more do you want?



M6
MODULE ONLY
£44.40

TOUCH TUNE MODULE M5

This module must put the finishing touches to an outstanding combination. Six pre-set stations at the touch of a button No moving parts to go wrong, or contacts to get dirty. Internal illumination shows you which button has been touched, while the tuning adjustment is made using high reliability multi-turn cermet pots for repeatable selection of the most used stations, yet retaining the use of separate manual tuning. This module interfaces directly with the M1 above, being wired between the board and the normal manual tuning control A touch of sheer genius!



M5
MODULE ONLY
£17.54

OTHER MODULES etc.

M2 Stereo decoder	**£7.60** kit	**£6.22**
M4 Power supply	**£6.30** kit	**£5.90**
SL1310 decoder IC	**£1.95**	
TBA750 f m. i f	**£1.55**	
20v regulator IC	**£1.50**	
LP1186 front-end	**£7.75**	
Filter, SFJ10 7MA	**£1.55**	
7 segment L E.D (c/a)	**£1.99**	
Descriptive booklet	**£0.50** (£1 50 export)	

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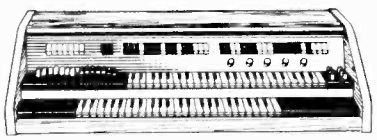
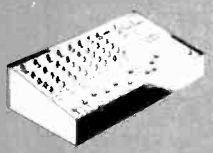
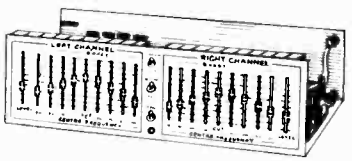
The only organ you can build in stages and tailor to your requirements as you go along — and at each stage you'll have a fully working instrument! We haven't got the gimmicks yet — they're coming soon! but we have got the most beautiful sounds — you won't find them on any organ less than twice our price. So get our MES50 series leaflets now! 65p buys the three available so far.





THE NEW GRAPHIC EQUALISER



This revolutionary new design with no complicated coils to wind. Construction details 60p and all parts available from us.

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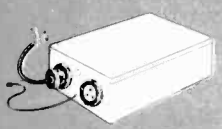

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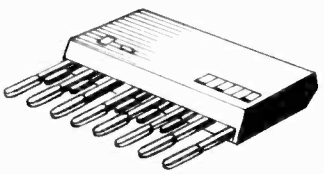
We stock an excellent range of tools especially for the electronics enthusiast. From miniature wiring tools to multimeters including soldering irons and desoldering tools, screwdrivers, cutters, pliers, strippers, miniature electric drills for p.c.b.'s, transistor tester, etc. Full details on catalogue pages 167 to 176.

PEDAL UNIT



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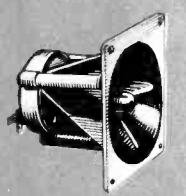
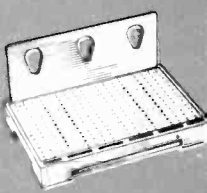
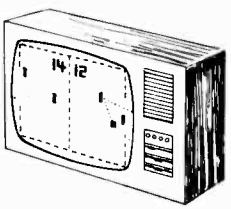




T.V. GAME



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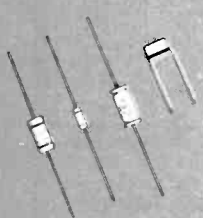

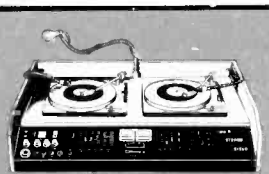

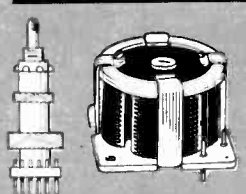

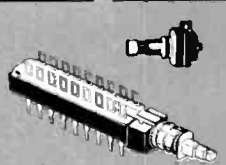

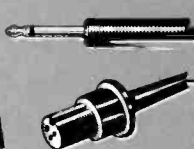

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WW—078 FOR FURTHER DETAILS

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★ DC-COUPLED THROUGHOUT
★ OPERATES INTO LOADS AS LOW AS 1 OHM
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★ 3 YEAR WARRANTY ON PARTS AND LABOUR

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Power Bandwidth	DC-20kHz @ 150 watts + 1db, — 0db	Slewing Rate	8 volts per microsecond
Power at clip point (1 chan)	500 watts rms into 2.5 ohms	Load impedance	1 ohm to infinity
Phase Response	+0, —15 DC to 20kHz. 1 watt 8Ω	Input sensitivity	1.75 V for 150 watts into 8Ω
Harmonic Distortion	Below 0.05% DC to 20kHz	Input Impedance	10K ohms to 100K ohms
Intermod. Distortion	Below 0.05% 0.01 watt to 150 watts	Protection	Short, mismatch & open cct. protection
Damping Factor	Greater than 200 DC to 1kHz at 8Ω	Power supply	120-256V. 50-400Hz
Hum & Noise (20-20kHz)	At least 110db below 150 watts	Dimensions	19" Rackmount. 7" High. 9¾" Deep

Other models in the range: D60 — 60 watts per channel D150A — 150 watts per channel

Other models available from 100 watts to 3000 watts

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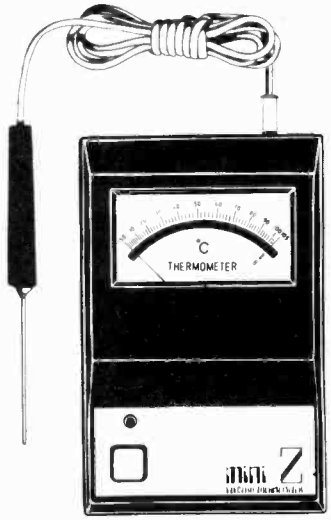
WW—039 FOR FURTHER DETAILS

ELECTRONIC INDUSTRIAL THERMOMETER



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WW—036 FOR FURTHER DETAILS

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100 Antistatic Agent for Plastics.
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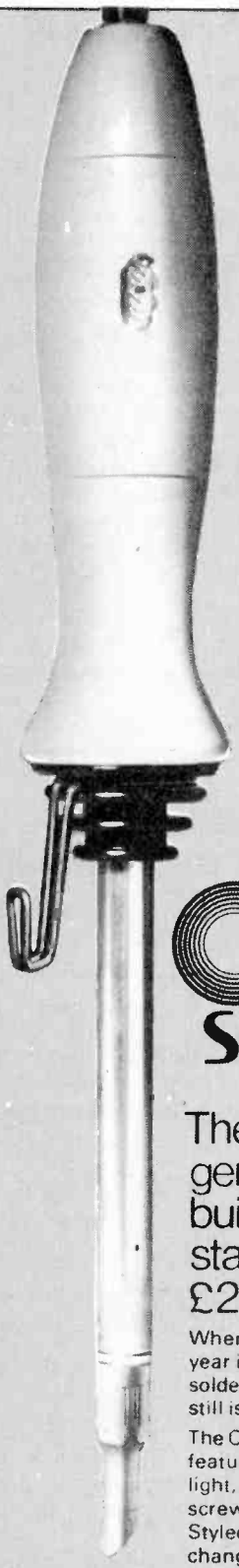
WW—014 FOR FURTHER DETAILS



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Greenwood Electronics, Portman Road, Reading, RG3 1NE
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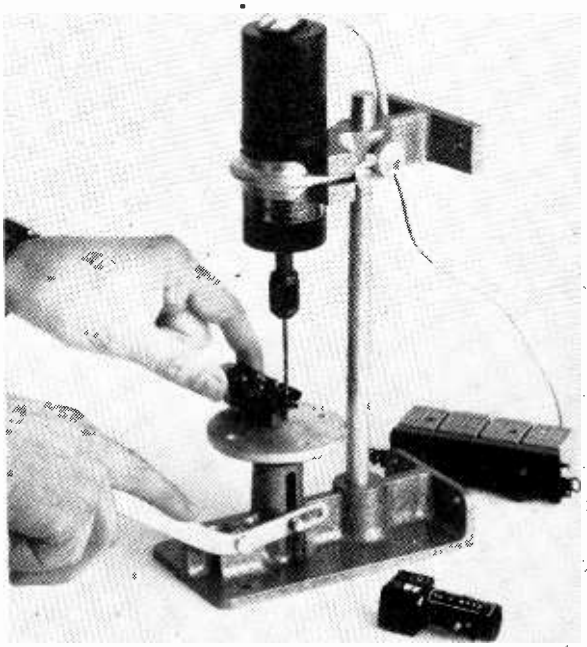

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What you may not know is that our reputation for switches is just as impressive.

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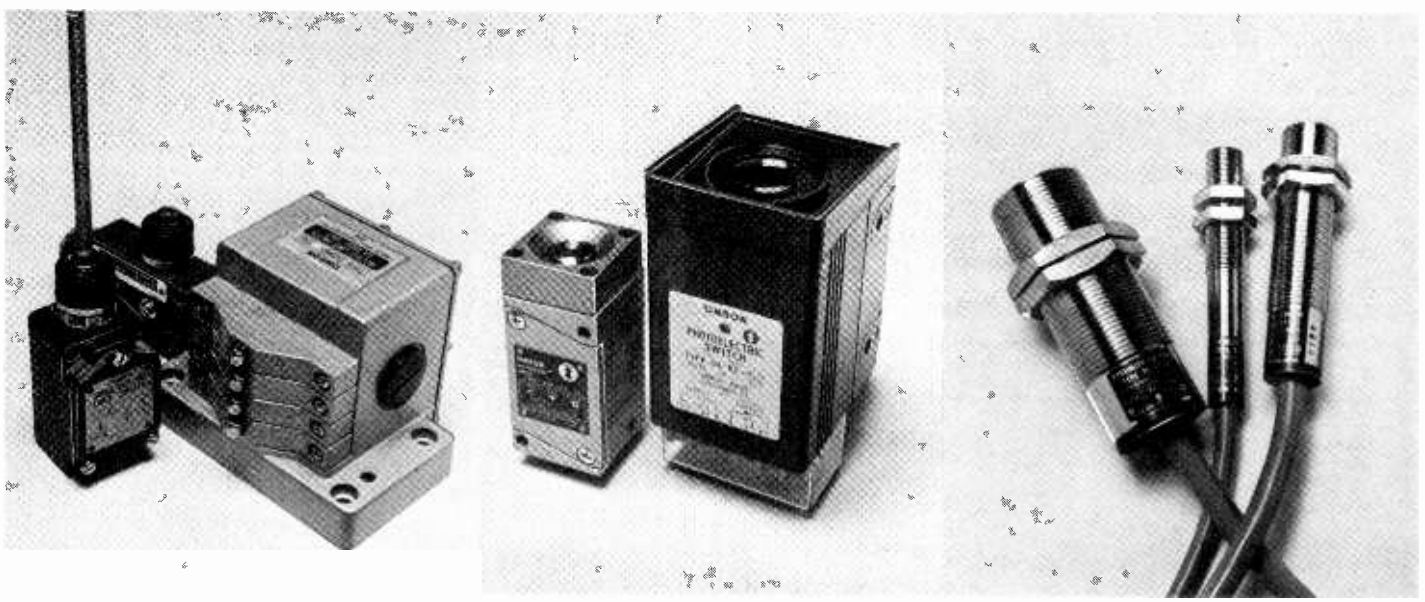
Something of interest if you're impressed with our relays.

Limit Switches **Photoelectric Switches** **Proximity Switches**



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WW10

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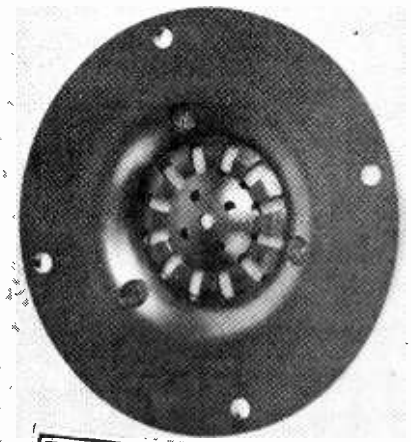

Technical Data

Frequency response:
2 Kc s to 15 Kc s within 3db

Impedance:
15 ohms or 8 ohms

Flux Density:
10.000 gauss

Dimensions Front Mounting:
Body 2¼" (70.2 m m) dia x 1¼" (31 m m) deep
Flange 3¾" (95 m m) x 1/8" (3 m m) thick
o all 1⅜" (35 m m)

Power Handling:
For use on 30 - 50 watt Amplifiers

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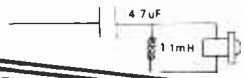

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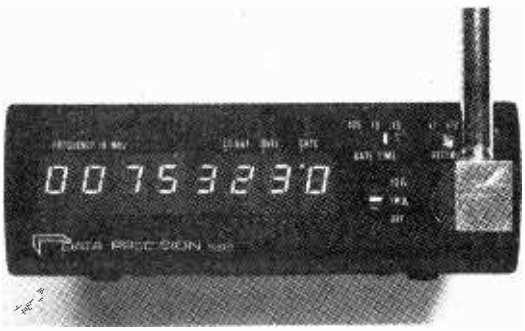
WW—044 FOR FURTHER DETAILS

Portable Frequency Counter



Model 585

- 8-Digit Resolution, 0.3" LED display.
- Frequency measurements to 250 MHz.
- Battery/Line Operation.
- 4-hour rechargeable battery module and charger incl.
- Gate, Overflow, and Low Battery indicators.
- Selectable Input Impedance, 50Ω or 1 MΩ
- x1, x10, x100 Attenuator.
- Sensitivity: 10 mV RMS to 50 MHz, 50 mV RMS to 250 MHz.

CONDENSED SPECIFICATIONS

FREQUENCY: Sinewave, 10Hz to 250MHz. Accuracy: ±(1 count + time base accuracy).

STANDARD TIME BASE: Frequency, 6.5536MHz; Stability: ±0.01 PPM/sec, ±0.6 PPM/per month, ±4 PPM/year.

RESOLUTION: 10 Hz at 0.1 sec gate time; 1 Hz at 1 sec.; 0.1 Hz at 10 sec.

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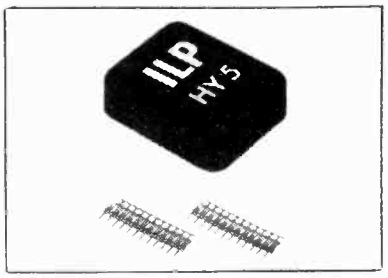

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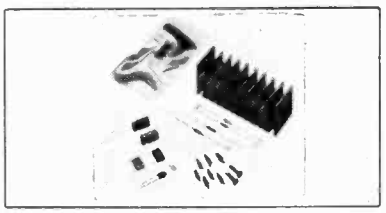

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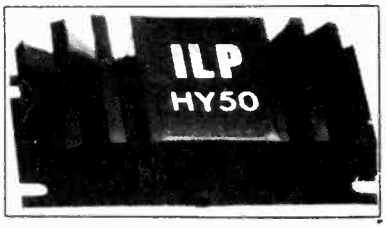

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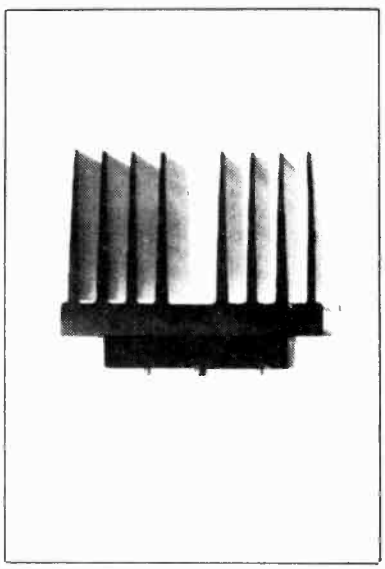

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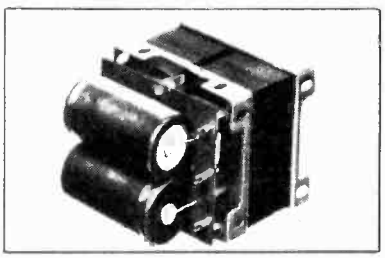

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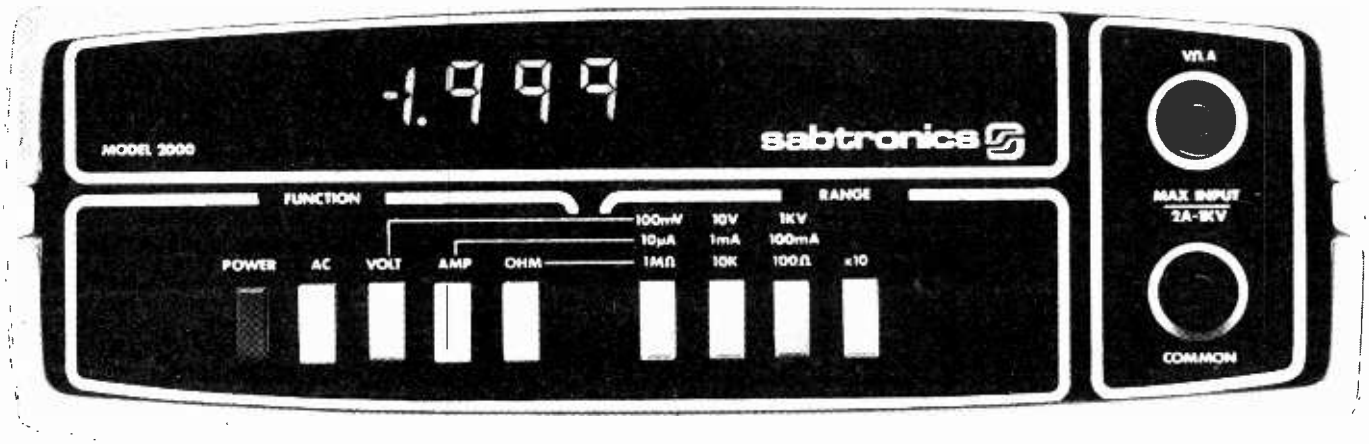

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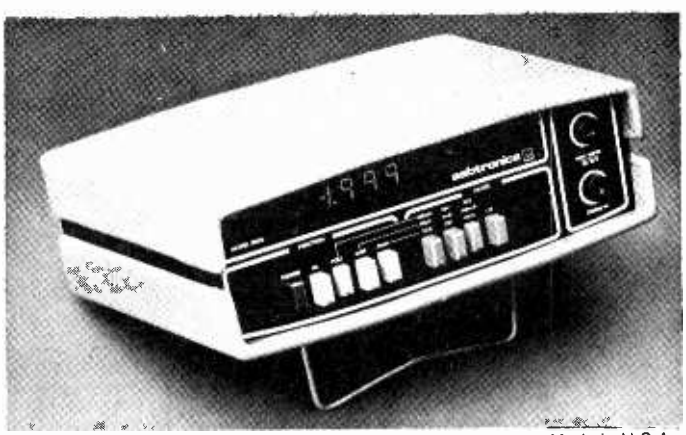

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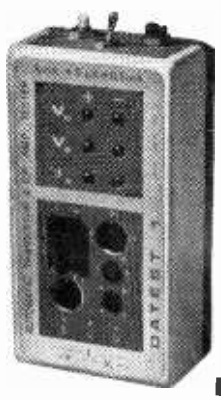

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Digitizing the consumer

It was reported recently that more homes in the UK have television than have main drainage. This little statistic illustrates the extent to which consumer products based on an advanced technology like electronics can, if they are cheap enough, find markets in places where living standards have not reached an equivalent level (taking, say, a prosperous worker's home in Western Europe or America as the level which currently can be achieved). The effect is even more marked in the developing countries. In Africa, for example, it is not uncommon to see a television aerial protruding from a straw hut or a digital watch on the wrist of somebody who is moving his few possessions on a hand cart. The consumer market, however poor the living conditions and however small the disposable income, is considered a source of riches for those equipped industrially to exploit it.

It is the consumer market which the semiconductor industry, among others, sees as the key to its future prosperity and even continuance. The only problem is how to use the key to unlock the door. One industrialist at least sees the door as having a combination lock, to be opened by digits. Dr Gordon Moore, president of the Intel Corporation, recently told a group of consumer equipment manufacturers "The future health of the semiconductor industry in its present form depends on the rapid and broad incorporation of complex digital functions into consumer products". Dr Moore went on to explain the economics of the semiconductor industry, showing how the manufacturing "cost-per-function" had been dramatically reduced by more than 10,000-fold in something like fifteen years. This had been achieved not only by the normal economies of scale inherent in mass-production but by these resulting from the increasing complexity and greater number of active devices in l.s.i. packages. To keep the industry in business with such rapidly decreasing costs and prices to the user it was obviously necessary to sell correspondingly more units. So far this had been possible on the assumption of a "super-elastic market demand. If we cut the price in half the unit volume will more than double". But this happy formula would not go on working forever. "There are always limits to growth, no matter what". It was necessary to find new markets and "the only answer I can see for really large markets [beyond those already known] is in the home. The challenge is to get of the order 10^{13} functions into the household over the next ten years".

If Dr Moore's conclusion is right, the semiconductor industry will be putting itself in a situation familiar to many others in an industrialized economy. It will have to *create* consumer demand. To keep the existing manufacturing plant and organization fully loaded and therefore working efficiently it will have to persuade people that they want products they had not realized they wanted. In theory plant can be discarded when it is no longer needed, but in practice, of course, there are people who have a strong vested interest in keeping it working. There are the employees who rely on it for their livelihood, the managers who have made the initial decision to invest money in it — a decision on which their future careers may depend — and the shareholders who expect an adequate return from their investment. Looked at objectively this is a crazy situation. The ordinary citizen, whom industry is supposed to serve, finds that he himself is serving industry as a mere term in an equation of economic stability, a term which has to be manipulated by known techniques of persuasion to obtain the right solution.

At least Dr Moore had the grace to ask rhetorically during his address "who needs all the electronics"? The answer is surely obvious: not the consumer but the semiconductor industry itself.

High quality book-shelf speaker

An infinite baffle design using two drive units

by J. H. Wilkinson, *Independent Broadcasting Authority*

This article describes a compact high quality speaker which measures approximately 48 x 30 x 28cm. Compensating networks are used to improve the response of the drive units, and the crossover network provides a total filter slope of 24dB per octave. The cabinet design features a staggered baffle which vertically aligns the voice coils of the units.

When deciding on a speaker design the first decision is usually the enclosure size. The author wanted the drive units to be located at ear height when sitting down, which meant either a large floor-standing cabinet or a small wall mounted version. In the interests of domestic peace, the last mentioned was chosen.

To avoid the more complicated bass loading techniques, an airtight enclosed box system was used together with a KEF B200 bass driver. The prototype had internal dimensions of 44 × 27 × 18cm which produced a resonant-frequency around 55 Hz.

The next consideration was a suitable high frequency unit to work with the B200. The frequency limit of the bass driver is 3kHz and it is usual to set the crossover frequency at this point. Normally, the KEF T27 high frequency unit is matched with the B200 but this is a "super" tweeter and the author experienced some problems because the resonant frequency of the unit is around 1.5kHz. This leaves only one octave for the crossover to act. Instead, the KEF T15 was chosen which has a much lower resonant frequency. This unit was first used in the early 1960s but is still a high quality device. Because the T15 has an adequate high frequency response a super tweeter was not used.

Crossover network

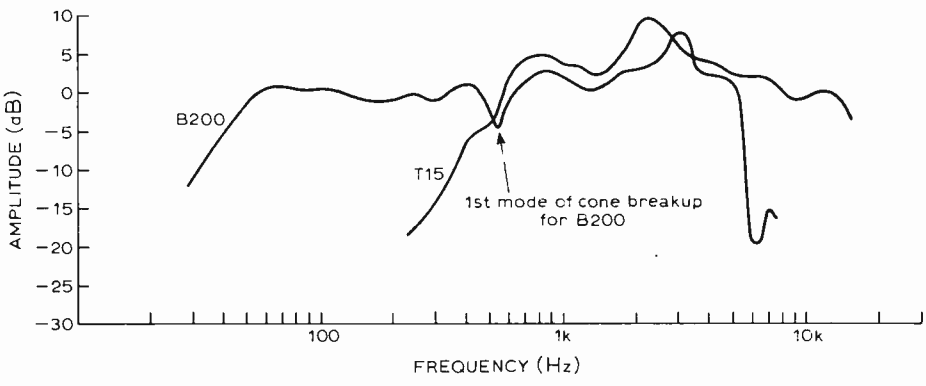
The most rational method of designing a crossover is to study the characteristics of each individual drive unit before trying to match them together. The drive units were mounted in a suitable box and the frequency response of each unit was measured. The responses obtained are shown in Fig. 1. As can be seen, neither drive unit displays a particularly flat response so both have compensation. The acoustic response of the B200 follows the amplitude response of an underdamped second order low-pass filter with a cut off frequency of 3kHz and a damping factor of approximately 0.35. In designing a crossover network it is essential to realize that the mechanical filtering action of the drive unit must be added to the action of any electrical filter. The T15 shows a response which extends below 1kHz although it is not particularly well controlled. In practice the crossover network can be adjusted to compensate for this. However, the T15 must have additional crossover components because there is no mechanical filtering around the crossover region.

Before designing the electrical network one must ensure that the impedance seen by the network will be fairly constant and resistive at least one octave either side of the crossover region. By calculation and a little experimentation, compensation for both units can be achieved quite accurately. The impedance and phase of the resulting network is shown in Fig. 2 together with the original response. The impedance of both drive units rises with an increase in frequency and appears more inductive. As a result the electrical response is between that of a first-order and second-order filter. If the response is treated as a first-order low-pass filter, the impendance can be made resistive by simply adding a series C and R in parallel with the drive unit terminals. Although this is not perfect it does produce a reasonably constant resistive load at least one octave either side of the crossover region.

The most difficult decision in a crossover network is the rate of attenuation. There are four practical options, i.e. 1st, 2nd, 3rd and 4th order. The first can be ruled out because the B200 has a mechanical second order response which cannot be ignored. Also, odd-order networks have a 90° phase shift between the signals applied to the drive units. This means that when the listener is equidistant from the drive unit voice coils, the sound will sum correctly, but when the listener is off that axis a 3dB peak at the crossover region can occur. This effect is shown in the diagram of Fig. 3(a). Even-order networks, however, ensure that each drive unit is fed with a signal of the same phase and consequently the off-axis effect does not occur — Fig. 3(b).

A crossover slope of 24dB/octave was eventually chosen because the higher rate means a less demanding performance from each drive unit. It also reduces the "phasey" effects which occur around the crossover frequency. The B200 already has a second-order mechanical network needing extra damping which can be effectively carried out by the addition of an

Fig. 1. Frequency response of the B200 and T15 units. Measurements were made 15cm from each unit.



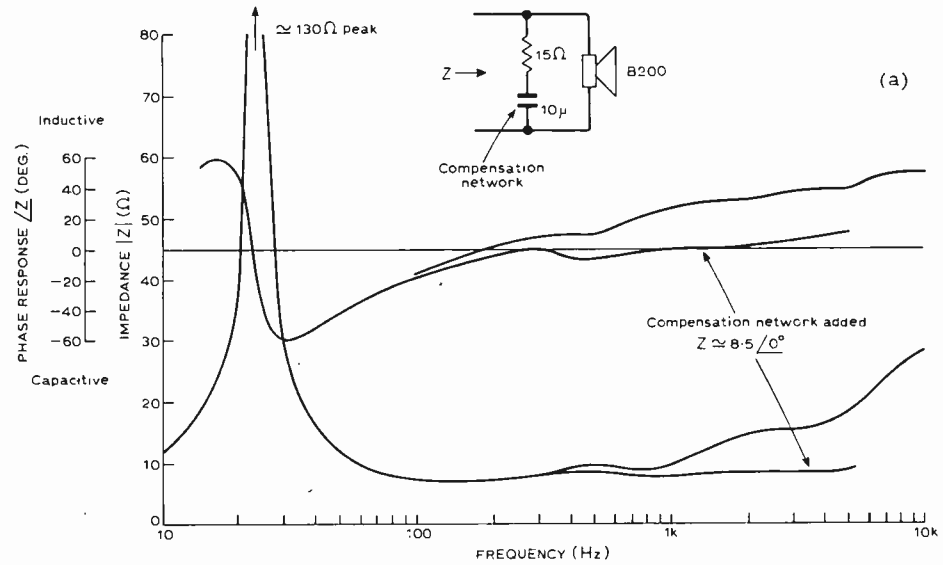
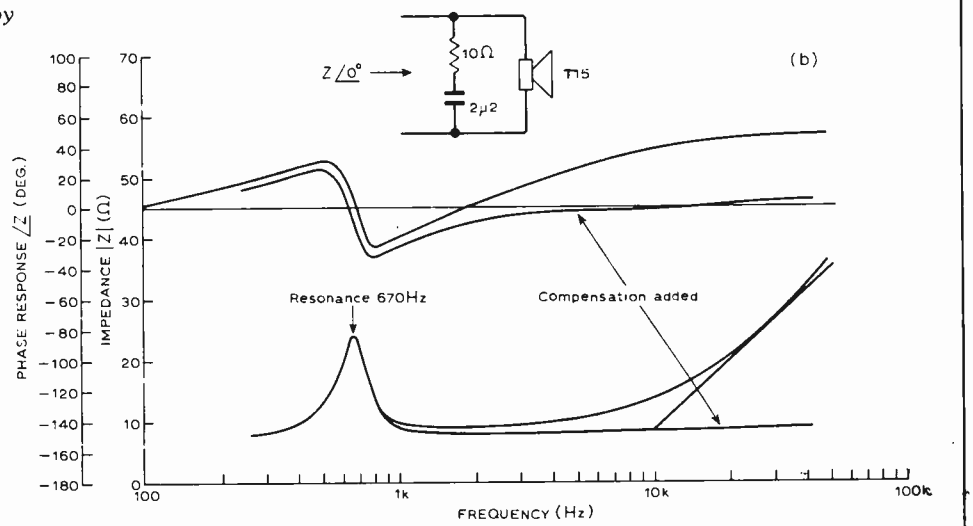


Fig. 2. Impedance and phase response of the B200 (a) and T15 (b) drive units. The series RC circuit across each unit is optimized by experimentation.



overdamped second-order electrical network. In choosing a fourth-order network it should be noted that the loudspeaker becomes a fourth-order all-pass system.

This is not a linear phase design because the author believes that the advantages of using a linear phase network are outweighed by the complexity of the network required. The author does, however, believe that the networks should be designed so that the acoustic outputs from the speakers are in phase for at least 1½ octaves, for a fourth-order network, either side of the crossover frequency. The acoustic-to-electrical response for each drive unit is represented by the following transfer functions.

Bass unit + tweeter unit = $TF_B + TF_T$ which equals

$$\frac{\omega_n^4}{(S^2+\sqrt{2}\omega_n S+\omega_n^2)^2}+\frac{S^4}{(S^2+\sqrt{2}\omega_n S+\omega_n^2)^2}$$

where ω_n is the crossover frequency in radians per second, and ω is also in radians per second. Because each unit

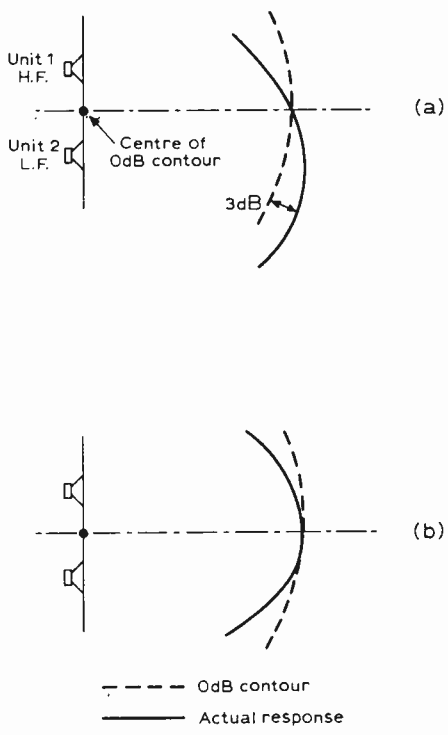
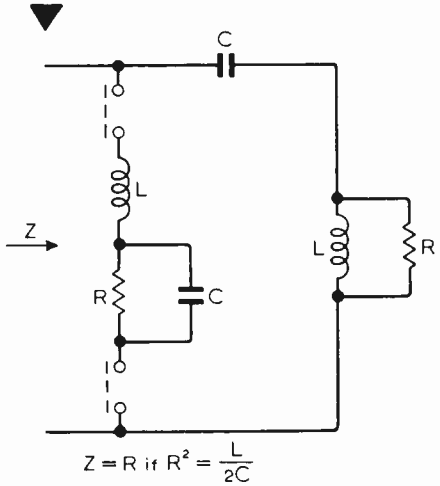


Fig. 3. Vertical polar diagram of the two unit loudspeaker with an odd-ordered crossover network (a), and an even ordered crossover (b).

Fig. 4. Network corresponding to the transfer function of a high pass filter.



has the same denominator they both have the same phase of signal at any frequency in the domain where $s = jw$ The magnitude of this equation is given by

$$/T.F._B + T.F._T/ = \frac{\omega_n^4 + \omega^4}{((\omega_n^2 - \omega^2)^2 + 2\omega_n^2\omega^2)}$$

$$= \frac{\omega_n^4 + \omega^4}{\omega_n^4 - 2\omega_n^2\omega^2 + \omega^4 + 2\omega_n^2\omega^2} = 1$$

This shows that the amplitude response is flat. The practical design will not be perfect because of the mechanical filter in the B200, but it will be near enough for this application. Summation of the voltage, rather than the electrical power, applied to each drive unit is used because the voltage across the voice coil is proportional to the sound pressure.

It is easy to realize the filter corresponding to the bass unit because it consists of only one low pass second order electrical network driving a resistive load. The tweeter, however, requires two cascaded second order high pass filters. The transfer function of each high pass filter is given by

$$\sqrt{T.F._T} = \frac{S^2}{S^2 + \sqrt{2}\omega_n S + \omega_n^2}$$

The network corresponding to this transfer function is shown in Fig. 4.

The addition of a low-pass network in parallel with a high pass network presents a resistive load and enables two high pass filters to be cascaded. Only the second network in the final design needs to be made resistive, the first can use any values for C and L. The practical network is shown in Fig. 5.

The last design consideration is the now common feature of staggered drive units. The electrical to mechanical conversion takes place at the voice coil and it is at this point that the sound begins to radiate. If the voice coils of each unit are not in vertical alignment there will be a time delay between the signal radiated from the two units. Without staggering the units, there is a 6dB dip in the frequency response at 3.5kHz. This can be removed effectively by inverting the tweeter connection but this is only satisfactory at one frequency because it is using a phase reversal to compensate for a time delay. The only satisfactory solution is to stagger the drive units.

Practical design

Because the sealed box is constructed from wood the following construction techniques were used to reduce colouration. Bracing struts of 2 × 1in hardwood run diagonally across each panel to prevent all modes of resonance within any flat panel. Car underbody sealing compound is used on the inside of the enclosure to dampen the panels. Note that the box must be painted at least one week before the installation of the front baffle because petroleum vapours affect the B200 cone suspension. A laminated panel structure consisting of ½in chipboard with ¼in plywood glued on top is used for strength and appearance. Also, screw holes created by the bracing struts are conveniently covered up. The use of plywood on the front baffle is essential because it is used for mounting the tweeter flush with the baffle front. The rear of the speaker is made from two sheets of ½in chipboard which makes it

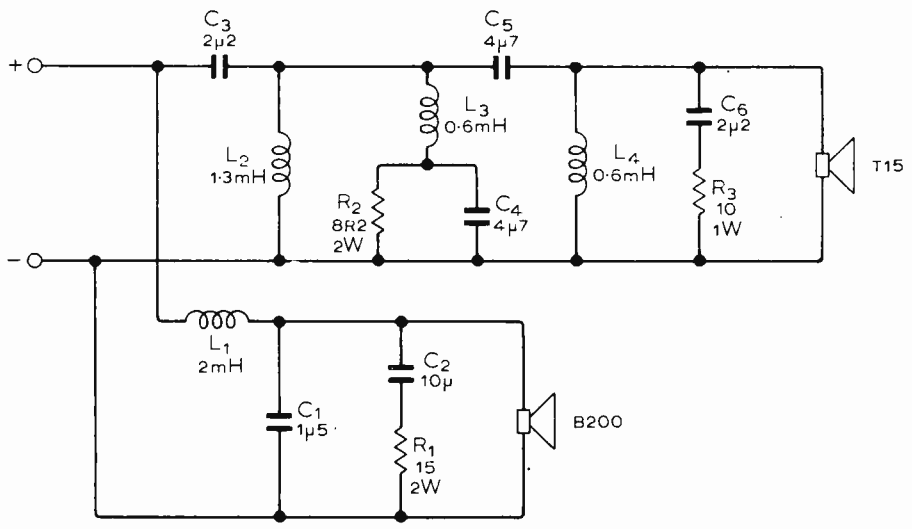


Fig. 5. Complete crossover network with compensating elements in parallel with each unit. All the electrical components for the crossover networks can be obtained from Falcon Acoustics, Tabor House, Norwich Road, Mulbarton, Nr. Norwich, Norfolk.

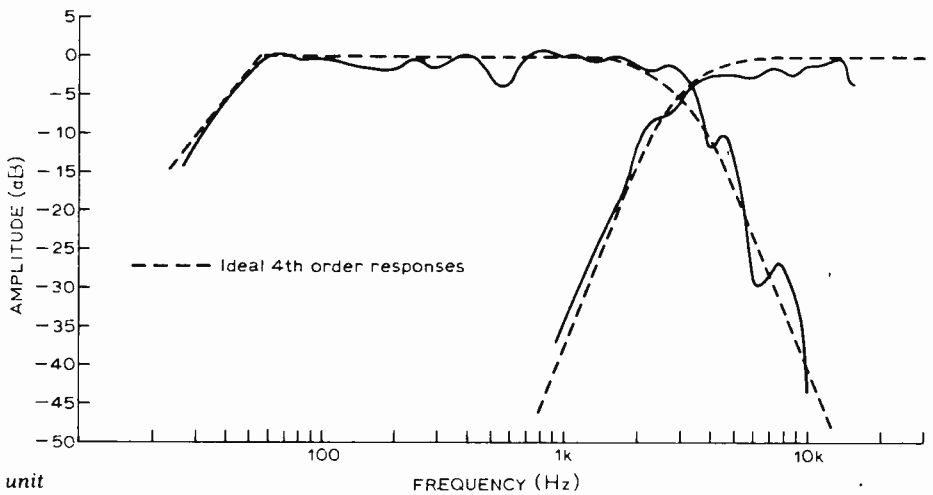


Fig. 6. Amplitude response of each drive unit when connected to the crossover network.

the thickest panel in the speaker.

The baffle is the most difficult item to make and should be constructed separately from the box with the drive units and crossover network fitted prior to mounting in the enclosure. When the baffle is finally fixed in place, after fitting the roll of B.A.F. wadding, and the speaker has been tested it is recommended that the joints between the baffle and the box, and around the tweeter mounting, are filled with a wood filler to seal any possible leaks.

The grille cloth frame has been carefully tested to ensure that it produces little audible degradation. After the Tygan has been glued and allowed to dry for 24 hours it can be heat shrunk. This should be carried out with care to prevent any distortion of the frame. The completed assembly can be either a push fit on to the box or a loose fit, held in place with Velcro pads. The acoustic attenuation of the grille assembly is just noticeable but is a very low level and has proved very acceptable in everyday use.

Fig. 7. Author's prototype speaker. The grille cloth frame is a push fit within the plywood surround, and can be removed as shown.

Loudspeaker performance

The graphs of Fig. 6 show the response of each unit when connected to the crossover network. The amplitude response was adjusted by varying the *L* and *C* ratio in both the low pass and high pass filters. This experimental approach is necessary because the drive units respond to the source impedance. Although the compensating networks can easily be designed for resistive loads, in practice they do not have the correct characteristics. Provided that the *L C* product is constant, experimental variation with the ration of *L* to *C* is acceptable to achieve the correct acoustic response.

Measurements were made in an ordinary room using an AKG-202-E1 microphone. To prevent room reflections having any great effect, the microphone was placed 6in away from the unit to be measured. This proved to be very effective for testing one unit. With two units combined, the microphone needs to be much further away so that the drive unit dispersion angle does not have too much effect.

It was found necessary to compensate for the small errors generated by the microphone in order to get meaningful results because a frequency response which varies by 2dB when measuring a high quality loudspeaker can seriously degrade its apparent performance. The overall frequency response, which is shown in Fig. 7, is within 4dB from 50Hz to 15kHz with the exception of one frequency at 550Hz. This limitation does not seem to affect the overall quality of the loudspeaker.

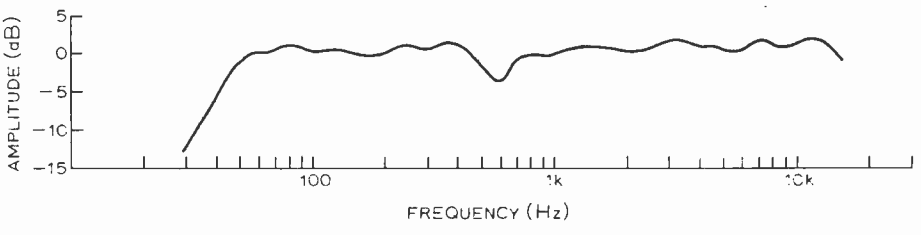
No attempt was made to measure the loudspeaker with an impulse or square wave input because the system is represented by an all pass network and has a phase response varying from 0° through 180°, at the crossover frequency, to 360°.

Conclusion

This speaker design is very easy to listen to even with long and complex orchestral works played at high levels. The performance with voice material is particularly pleasing especially as this was a prime requirement. The main limitation is the size of the enclosure which reduces the low frequency performance. This is noticeable on some organ music where there is a lack of very deep bass. This, however, is to be expected from a small enclosure. The following points may be considered for the experimenter although any improvements would be small.

The addition of a constant impedance variable level control in the tweeter circuit. The use of an active crossover. A triangular cabinet and bitumous pads as a replacement for the car body underseal.

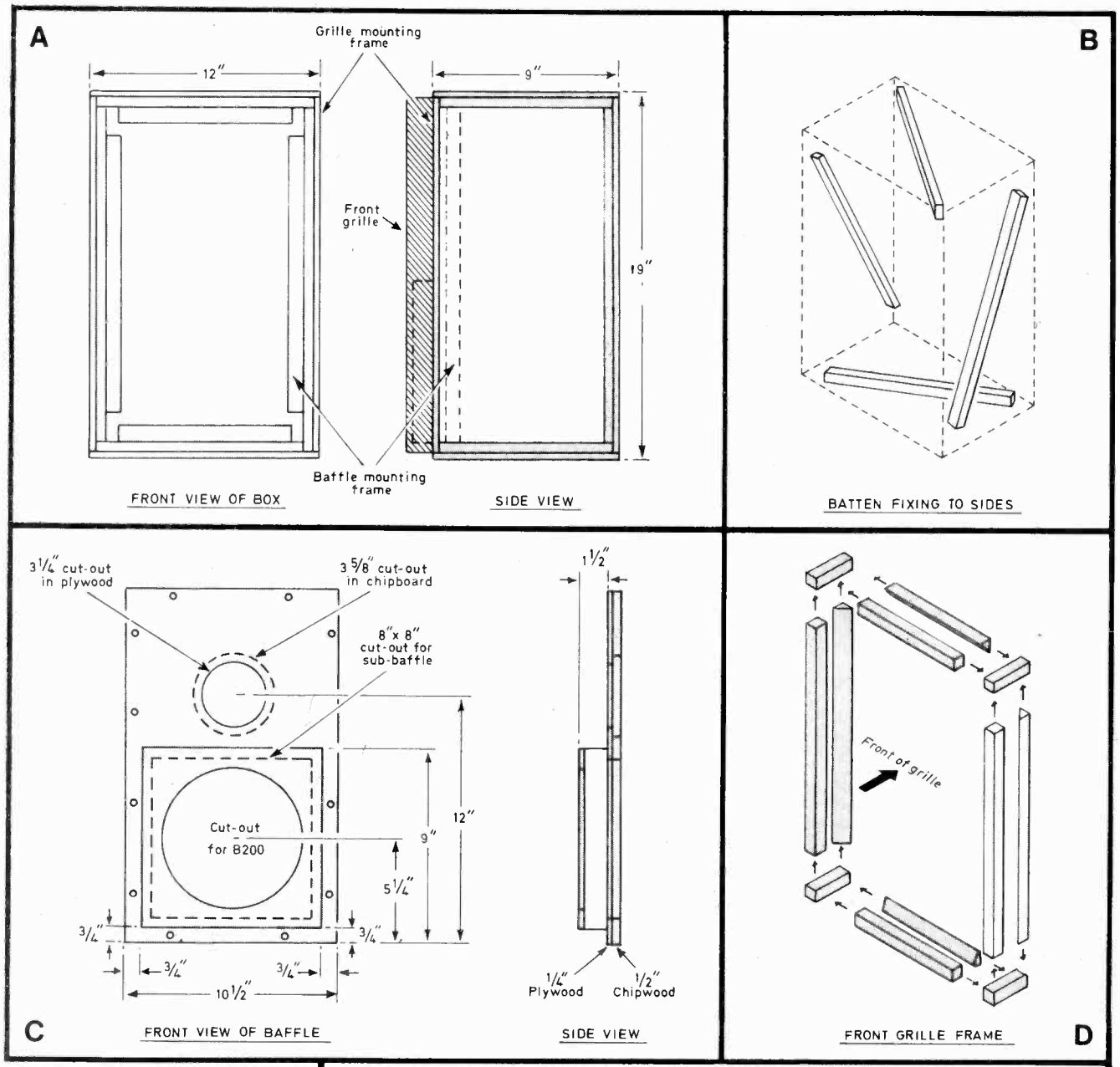
Fig. 8. Amplitude response of complete speaker. The response is within 4dB from 50Hz to 15kHz except for a dip at 550Hz.



Panels required for two speakers.

Rear inner panel
2 off 10½ x 17½in high density chipboard
Rear outer panel
2 off 11½ x 18½in high density chipboard
Right side panel
2 off 8 x 17½in high density chipboard
2 off 8½ x 18½ ¼in plywood
Left side panel
2 off 8 x 17½in high density chipboard
2 off 8½ x 18½in ¼in plywood
Top panel
2 off 8 x 11½in high density chipboard
2 off 8½ x 12in ¼in plywood
Bottom panel
2 off 8 x 11½in high density chipboard
2 off 8½ x 12in ¼in plywood

Rear batten panel
2 off ¾ x 1½ x 18in hardwood
Right side panel batten
2 off ¾ x 1½ x 17½in hardwood
Left side panel batten
2 off ¾ x 1½ x 17½in hardwood
Top panel batten
2 off ¾ x 1½ x 10in hardwood



Bottom panel batten
2 off ¾ x 1½ x 10 in hardwood

Baffle mounting battens
4 off ¾ x ¾ in 10½in softwood
4 off ¾ x ¾ x 16in softwood

Front grille mounting frame
4 off 18½ x ½ x 1¼in
4 off 9 x ½ x ¼in

Main baffle
2 off 10½ x 17½ x ½in chipboard

Main baffle
2 off 10½ x 17½ x ¼in plywood

B200 baffle
2 off 9 x 9 x ½in chipboard

Sub baffle vertical spacers
4 off 1 x 9 x ½in chipboard

Sub baffle horizontal spacers
4 off 1 x 8 x ½in chipboard

Front grille
8 off 2¼ x ½ x ½in hardwood square section
4 off 10 x ½ x ½in hardwood square section
4 off 17 x ½ x ½in hardwood square section
4 off 10 x ½ x ½in hardwood triangular section
4 off 17 x ½ x ½in hardwood triangular section
Two pieces 24 x 16in Tygan.

Fig. 9. Construction details for one enclosure.

Glue and screw battens to the inner chipboard panels.

Assemble the sides, top and bottom chipboard panels around the rear inner chipboard panel.

Glue and screw the rear outer chipboard panel into place.

Glue and screw in place the baffle mounting frame.

Glue and pin the plywood panels to the sides, top and bottom of the chipboard box.

Glue and pin the front grille mounting frame into place.

Paint the inside of the box with underseal.

Fit the loudspeaker terminals onto the rear panel, recessed if possible to prevent damage.

Cut out the holes for the sub-baffle and the T15 in both the chipboard and plywood panels.

Glue and pin the plywood baffle onto the chipboard. This should leave a hole suitable for mounting the T15 from the rear.

Cut out the hole for the B200. Glue and screw the sub-baffle in place.

Paint the front of the baffle with blackboard paint.

Fit the B200 and T15 into place using foam strip to ensure a good seal.

Assemble the crossover board and fit onto a side wall in the box. Wire up drive units.

When the underseal is thoroughly dry, roll up the BAF wadding and fit into the box.

Fit the baffle into the box and screw down after checking that both drive units are receiving the correct signals.

Seal all gaps with wood filler and check for leaks.

Assemble the front grille frame, leaving 1/32in clearance for the thickness of the Tygan.

When the glue is dry, paint the frame and glue the Tygan onto the frame using contact adhesive.

When dry, push fit the frame into place and heat shrink the Tygan with an electric blower until just taut.

Home Office sifts WARC evidence

It cannot give the Home Office much pleasure to be subjected at once to two separate, though related, blizzards of letters. Both result from requests by the Home Secretary for comments from the public, in the first place on the 1979 WARC (WW, March p.37) and in the second on the Annan report.

The flow of information is mostly one way. Once the letters disappear into the Home Office machine, we have little way of telling whether they have any influence on what emerges at the far end of the ministerial meat grinder. In the case of Annan it is easy to see why the Home Office should be reluctant to publish even a summary of the incoming views. For one thing, it could be argued that the sheer volume of information they are receiving could not be published entire or even adequately summarised. For another the Annan debate has largely been conducted in public anyway.

The WARC is rather more esoteric than Annan, and it would be feasible, logical and just for the Home Office to publish, at cost, a summary of the contents of most of the submissions from public companies, trade organisations and professional bodies. The FCC published such a document 18 months ago, but the leader of the British delegation to the recent broadcasting satellite conference, Mr D. E. Baptiste, told *Wireless World* that America was the only country to do such a thing. "The whole of the frequency table is a security document," he said. To suggest that the Home Office should do as the Americans did was "naive".

So far, the Home Office has received submissions from 88 organisations like the BBC, the IEE, the IERE, the Mobile Radio Users' Association, the Selective Paging Committee, and the Cable Television Association, the manufacturers, including Pye and Motorola and the public. As far as one can judge, some of these have been shots in the dark, since they cannot have been reasoned critiques of a published view by the Home Office; the Home Office's refusal, so far, to publish a single document around which a debate could take place has caused a great deal of concern, as expressed in the IEE submission, particularly among those with less pull than the broadcasting battalions, such as the somewhat diffuse mobile radio lobby

A number of sources are complaining that, far from opening up the consultatinon process, the Home Office are letting out less information than ever. Some members of the Home Office Mobile Radio Committee were so upset, according to one source, by the lack of information they were receiving from civil servants that there was talk of resignation. The members of the committee feel that there is no point in having an advisory committee unless they receive full details of all the submissions. It appears that what they will get is the filleted summary of the proposals which the Home Office is preparing, and many of them are busy collecting the evidence by swopping it among themselves in an effort to outflank the mandarins.

The Home Office say they are not aware of any pressure from the committee for more information, and that the Mobile Radio Committee is not, as merely an advisory committee, part of the framework within which the brief for the WARC delegates will be decided. That is the task of a panel of the Frequency Policy Branch which is entrusted with studying the submissions. They also cite the difficulty of photocopying and distributing a large number of bulky documents the author of one of which has asked should not be circulated outside Waterloo Bridge House.

All the replies have now come in and a summary has been drafted which will be subjected to the criticism of interested parties, a group from which the Home Office disdainfully excludes "the man in the street". In this way the Home Office say they can hope to reconcile the various conflicting interests of those wishing to consume airspace without getting bogged down in too much detail. Specific companies or individuals will be approached in cases where there is a conflict of interests between submissions or where the Home Office believe a submission contains errors of fact in the hope they will agree to changes. Mr Baptiste told *Wireless World* that the submissions had contained "some very good stuff". Many of the proposals were in line with the Home Office's view, he said. Another spokesman told us that the Home Office believed there was no point in trying to steamroller those interested in the allocation of frequencies: "It's much better to try to get people to go along with us."

Alone among the mobile radio lobby, Motorola say that the Home Office is doing the best it can, and is consulting as much as any other country. Like the Home Office, they say that America is the only country committed to prior publication, and they sympathise with the pressures the civil servants are under to agree as much of their approach in advance with other Western countries in order to withstand the onslaught that is bound to come from the developing countries in 1979, Mr Walter Stevenson, Motorola's director of government liaison, cited the call for broadcasts to vacate band 3, which he described as "irresponsible" since most other countries, particularly the developing nations, used v.h.f. for television broadcasting: "A proposition which wiped out tv services in these countries would find no favour at the conference", he said, so there was no point putting it forward. In his view the arguments so far had directed the energies of the industry away from pursuing the best for the industry, for example by harmonising standards, to merely fighting the Home Office.

The rest of the industry seem suspicious of Motorola, whether justifiably or not, on a number of counts. There is suspicion of any American, therefore foreign, corporation, particularly one which is likely to see, as indeed Motorola does, its British policies as part of a global strategy. Motorola see the development of mobile radio moving towards the digital techniques which found favour with Warden, and regard any reduction in channel widths below 25kHz as a backward step. The British manufacturers are determined to adhere to speech communication, and believe that, if necessary, any future changes in technology could be used to reduce channel spacing, certainly to 12.5kHz possibly as low as 6.25kHz.

Another worry for the mobile radio men is that they feel the broadcasters, particularly the BBC, have a great deal more pull than they do: "After all," said one, "it's a propaganda medium." The BBC proposal, published in shortened form in a booklet, will hardly have set their minds at rest. The Corporation, far from bowing out of, say, bands 1 and 3, would like massive increases in its allocations throughout the spectrum: shared frequencies either side of the long wave should be reallocated exclusively to broadcasting; an extra 10kHz should be found below the m.f. broadcasting band for the proposed motoring service; bands now used for tropical broadcasting should be allocated, though shared if necessary, to broadcasting world wide; the ten or so h.f. broadcasting bands below 20MHz should each be doubled in size and a further band allocated between 11.975 and 15.1MHz; band 2 should be extended to 88-108MHz; band 1 should remain the same but band 3 increased to 173-223MHz, and there are minor changes to the satellite broadcasting frequencies.

Despite the differences among the various lobbies, a consistent point of agreement has been the need for revision in the method of frequency allocation. Most sources say this is more important even than what happens in 1979. Walter Stevenson says he personally would be in favour of some kind

● *continued on page 74*

World of Amateur Radio

Pecking nuisance!

It would be an understatement to report that the Russian "woodpecker" continues to intrude into amateur bands; nearer to reality would be to say that from time to time this pernicious noise seems once again to be taking over great chunks of the h.f. spectrum in disregard of all international radio regulations. One wonders why hold WARC 1979 when one country can apparently take over the spectrum whenever it wishes; even more worrying is whether such military systems are likely to proliferate in the years ahead. If this form of radar works for the Russians will there soon be a NATO woodpecker or a North American species?

14MHz to the rescue

A young German amateur, an exchange-student on his very last evening in the United States, recently picked up a distress message on 14MHz. He initiated action by alerting the Miami Coast Guard and this led to an aircraft picking up the crew of a sinking 91ft Panamanian vessel between Cuba and Panama.

Unfortunately not all such distress messages — no matter how authentic they appear — are genuine, as I discovered in October 1973 when I was one of the recipients of an elaborate series of hoax messages which resulted in a fruitless search by an aircraft of the Canadian Maritime Patrol for a non-existent vessel claiming to be on fire.

Here and there

The 1977 National Field Day winners were the Channel Contest Group, with Glenrothes the runners up. In the restricted section, Swansea came first, followed by the Surrey Radio Contact Club. Band leaders were 1.8MHz Gloucester; 3.5MHz Shefford, Bedfordshire; 7MHz Edgware; 14MHz Telford, Salop; 21MHz Glenrothes; and 28MHz Swansea. A. Smith, G31AS, of Warlingham, Surrey (c.w.) and F. C. Handscombe, G4BWP, (s.s.b.) were the two leading stations in the RSGB's special Silver Jubilee contest.

W. S. Carey, ZE5JJ, has enabled a handful of radio amateurs to achieve "worked all continents" on 432MHz by means of moonbounce contacts. But neither he nor VK2AMW in Australia have yet been able to claim this distinction for themselves as they are the only active "moonbounce" stations in Africa and Australia. Early this year ZE5JJ completed a large new dish aerial which he uses both for earth-moon-earth contacts and as a radio telescope. He intends to use this aerial also on 1296MHz.

According to *Oscar News*, Bob Holmes, G6RH, of Bexley has worked over 1400 stations in 5 continents through the Oscar amateur satellites using home-built equipment.

September is enrolment month for many evening classes for the Radio Amateurs Examination and those interested in joining a class this autumn should make enquiries at their local adult education centres; some centres include morse classes and Slough is again running an "advanced" course for those who have already passed the RAE.

"Jamboree-on-the-air" is being held this year on October 15 and 16 although a few overseas centres reported "disappointing attendance" of Scouts at last year's event. To overcome the problem that Scouts feel that they are "not able to do anything but listen" the Cape Town group are organising additional activities such as direction-finding "hunts" in which the Scouts can participate fully.

"Continued misuse of the existing repeaters and growing volume of criticism up to Ministerial level" are reasons advanced by the Home Office for their present reluctance to licence any additional repeater stations "until the trouble is resolved".

The RSGB's controversial "Amateur Radio Observation Service" has begun operation. A group of ten observers, with D. M. Pratt, G3KEP, as honorary organizer is keeping a look out for any serious breaches of licence conditions on the amateur bands.

Evaporated spirit?

In CQ-QSO, the journal of the Belgian amateur radio society, a 20-year-old student listener (who has been interested in radio for ten years) reports sadly on his attempts to obtain advice from local amateurs on taking his licence examinations. From some he received such off-putting replies as "I do not like modern youth" or "I have not the time" or "There are books for that". He is equally disillusioned with those enthusiasts who spend all their time discussing the merits of their factory-built TS700 transceivers, or engaging in controversy over telegraphy versus telephony, or closing down when any newcomer attempts to use their "exclusive" repeaters. He suggests sadly that it is time for the different strands of the hobby to draw together and ensure a revival of the old "ham spirit".

Yet it would be totally misleading to suggest that such reports indicate that the old spirit is entirely going out of the hobby. One has only to read the specialist newsletters, or note the rising tide of enthusiasm for such activities as 10GHz microwave operation, or 1.8/3.5MHz exploitation of the "grey-line" or twilight paths, often involving operation in the very early hours of the mornings, or the many novel equipments still being constructed on kitchen tables, to realise that there is still plenty of spirit left in the hobby.

An interesting example of amateur persistence in attempting to exploit difficult techniques can be found in the work on "flea-power" coherent c.w. mentioned in this column in March 1975.

Recent developments in this difficult technique have been described in two recent articles by Andrew Weiss, K8 EEO, (CQ, June and July, 1977) based on the work not only of W7GHM but also W6NEY and WA7ZVC. Although frequency stability of the order of 1Hz is necessary, the system provides some 20dB of system gain and, it is claimed, opens the way to "working the world on a torch battery". A coherent c.w. net frequency of 3562.500 or 14,062.500 kHz has been adopted and a regular "coherent cw Newsletter" is being published with a subscription of $10 but with "a free subscription offered to anyone who will build his own c.c.w. station" (Chas Woodson, W6NEY, 2301 Oak Street, Berkeley, California, USA).

In brief

The deaths have been announced of Reg Silverstone, GW2BG, of Abergavenny, who was first licensed in the days of 1000m and 440m amateur bands and remained active on many bands over many years, and also Frank Hennig, G3GSW, of Worthing, a well-known author, radio broadcaster, and presenter in recent years of the BBC's World Radio Club. (It so happened that the editor of this journal, Tom Ivall, was interviewed on Frank's last WRC programme). . .The new Republic of Djibouti has the amateur prefix J28 replacing FL8 . . . The callsign series H6A to H6Z has been allotted by the ITU to the Solomon Islands . . . The RSGB is proposing to hold a v.h.f. convention at the Winning Post, Whitton, Twickenham again in 1978 but this will be in the form of a specialised seminar and will not include a trade exhibition . . . 1977 has proved a notable year for Sporadic E openings on 144MHz and is being compared to the memorable year of 1965 . . . VE3DDS will be a special station at the World Dental Congress, Toronto, Canada from October 22 to 28 . . . The 7th annual South East Asia Network Convention (SEANET) is being held at Bangkok from November 18 to 20 .

PAT HAWKER, G3VA

Microwave voice link — 1

10GHz unit uses Gunn oscillator

by M. W. Hosking, M.Sc., M.I.E.E., *British Aircraft Corporation*

The reduction in cost of microwave semiconductor devices due to their large scale use has brought professional microwave techniques to a much wider audience. Two examples are the Doppler intruder alarm technique and short-range microwave speech links. The low-power communication link described in this article uses a similar type of receiver to that used in the domestic intruder alarm circuit described in the July and August issues. This two-part article gives full constructional details of a 10GHz pulse-modulated voice link, including waveguide and horn antenna and a simple calibration procedure.

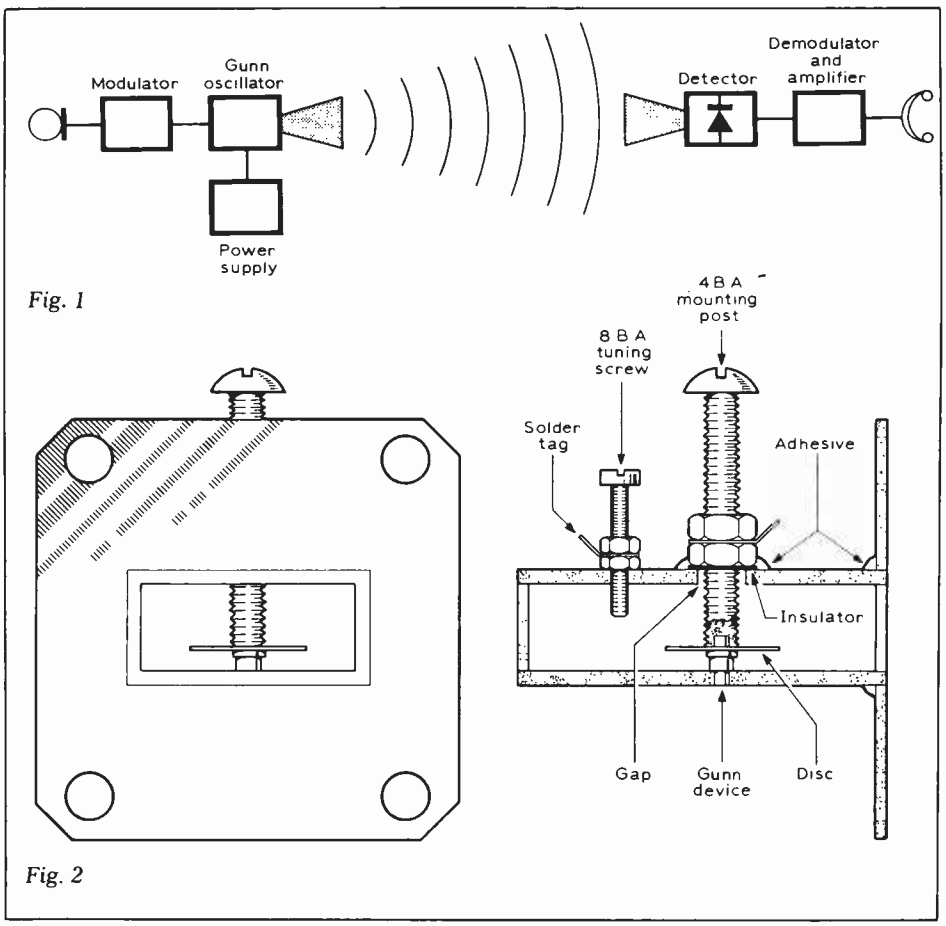
The voice link comprises two main component blocks – the transmitter-modulator and receiver-demodulator, Fig. 1. The transmitter is a solid-state Gunn device mounted in a rectangular waveguide cavity and oscillating in the vicinity of 10GHz. The device operates from a low voltage d.c. supply which, in this particular application, is continuously switched on and off with a rectangular wave modulation at high repetition rate. Speech information is carried by varying the mark/space ratio in proportion to the voice frequency.

At the other end of the link, the modulated carrier is rectified by a microwave detector diode mounted in a waveguide circuit and the variation of the mark/space ratio is extracted and amplified. No power-output stage is included here; instead, high-impedance headphones are specified. This enables the receiver to be completely self-contained and portable, with a low current drain battery supply. It is a simple matter to feed the receiver signal to a conventional audio amplifier system if required.

A design is also given (part 2) for a pair of pyramidal horns for both transmitter and receiver, to give a directive radiation pattern and increased range.

Fig. 1. Main components of the link system comprising a voice-modulated transmitter and receiver/decoder.

Fig. 2. Cross-sectioned details of the Gunn oscillator with front view.



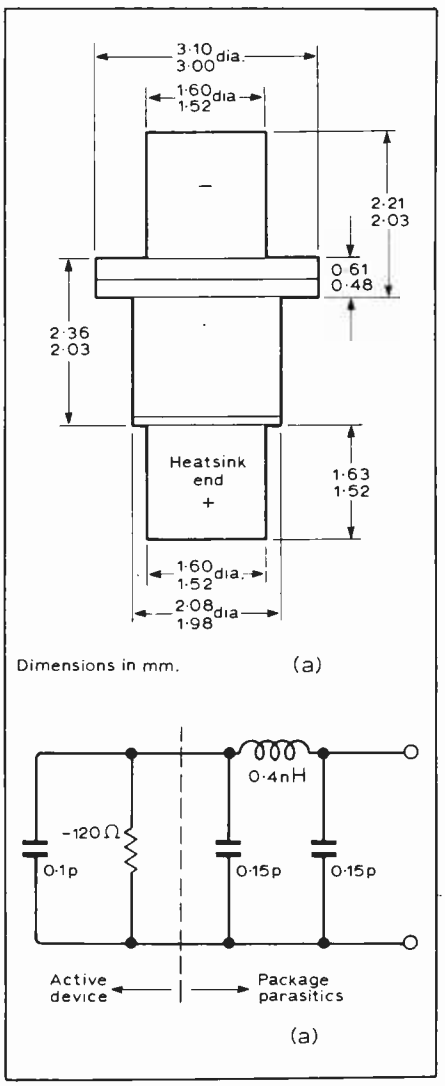


Fig. 3. Microwave devices are packaged in the standard form shown at (a) whilst the parasitic elements shown in the equivalent circuit must be taken into account in circuit designs (b).

A practical means of realising a resonant RLC circuit at microwave frequencies is a length of transmission line short-circuited at each end. This type of cavity is resonant at a wavelength corresponding to twice the length of the cavity. In the application here, an oscillator can be produced by removing one of the short circuits and replacing it with the Gunn device, together with the associated impedance matching and mounting structure. Fig. 2 shows the general design evolved for this project. It was chosen on the grounds of being easy to construct consistently, could be made from readily-available materials and has a high enough Q-factor to provide a good spectrum and frequency stability. The internal dimensions of the waveguide, together with the flange hole positions are those used for standard X-band components.

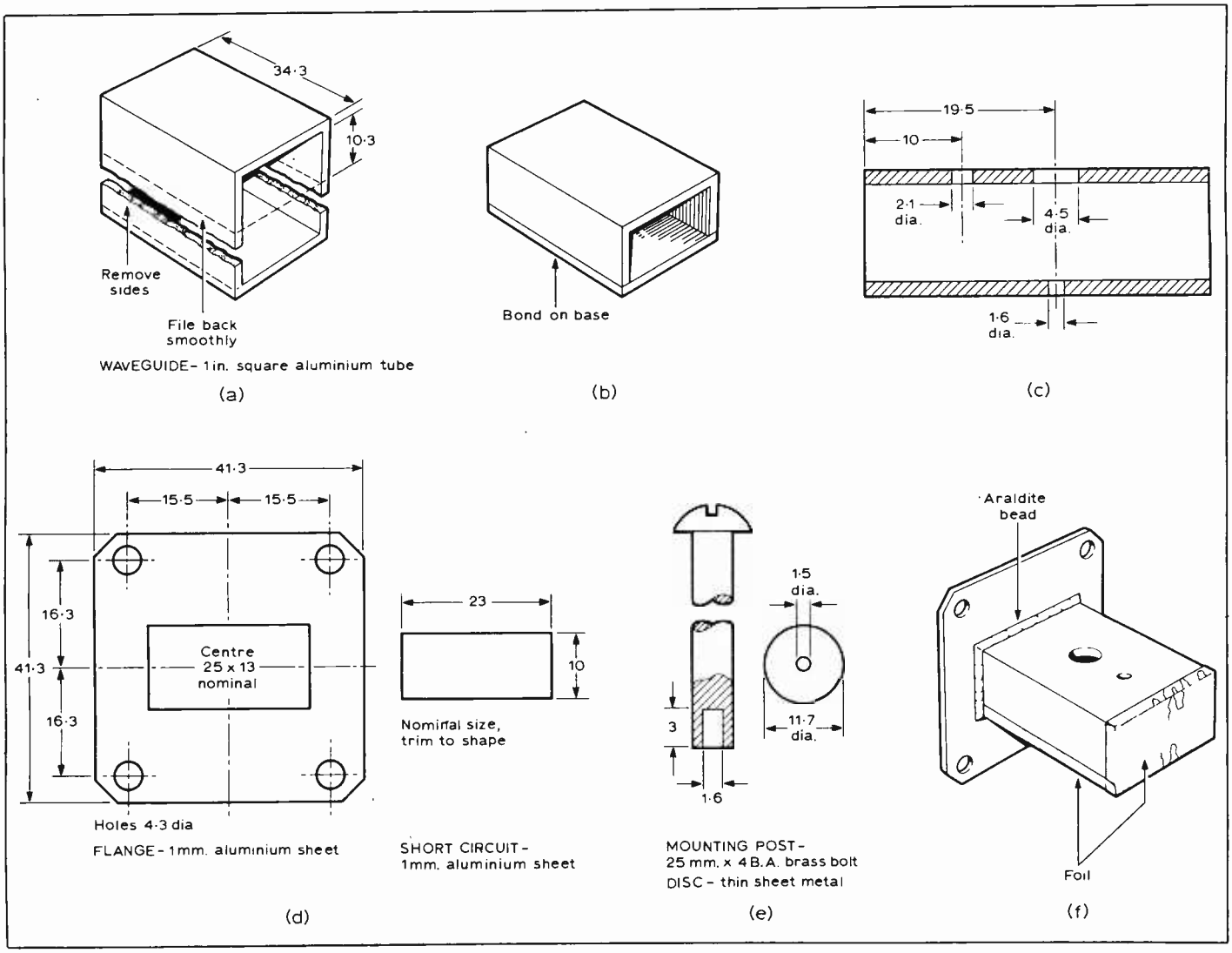
Even though small, the Gunn device package – Fig. 3(a) – has a capacitance associated with its physical size and an inductance associated with the internal chip bonding leads which both have a significant reactance at the operating frequency. Fig. 3(b) shows a simple equivalent circuit of the Gunn device, the general electrical effect of which is to make the resonant cavity appear longer than it actually is and so to lower the frequency. Thus, the resonant length is slightly lower than that calculated for an empty guide to compensate for this effect.

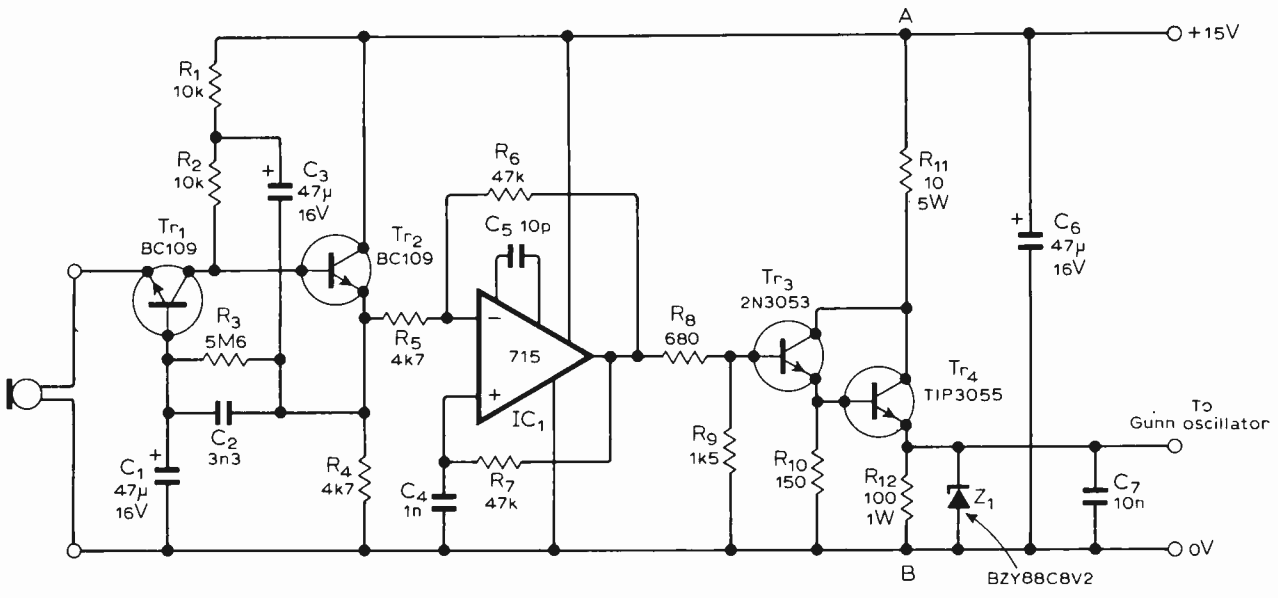
Referring back to Fig. 2, the Gunn device is mounted with the heat-sink end of the package against the waveguide wall and is held in position, with a light clamping pressure, by the mounting post. The circular disk on top of the diode helps to match the Gunn device impedance to the guide and also to suppress spurious mode oscillations associated with the post. The post must be electrically isolated from the top wall of the guide so that the d.c. bias can be applied. Hence, the locating nut is held clear of contact by the insulating layer, which also serves as the dielectric of an r.f. bypass capacitor and helps to prevent microwave leakage from the hole. Frequency tuning is possible by two methods: coarsely by moving the short circuit and finely by inserting the tuning screw. The first-mentioned is specified in a fixed position and, with the tuning screw withdrawn, will give a frequency of about 10.7GHz. Inserting the screw will perturb the electric field within the cavity and initially will appear as an increase in inductance (see Realm of Microwaves, part 9, Oct. 1974

The Gunn diode further reading

The Gunn device is a small, semiconductor chip of gallium arsenide capable of generating a microwave signal on the application of a small d.c. bias. Its output power, output frequency and spectral purity are all influenced very strongly by the circuit in which the device is mounted. The action of an applied d.c. bias gives rise to a series of current pulses which traverse the semiconductor chip at the appropriate frequency; in this case, once every 10^{-10}s. If the device is mounted in a suitable resonant circuit, then these pulses can be used to induce oscillations at the resonant frequency. The resonant cavity has a dominant effect in controlling the output frequency, so that tuning is possible if a means exists to vary the resonant frequency. To a much lesser extent, the period of the current pulses can be varied with the bias voltage. For a given bias, the output power from the oscillator is a function of the impedance match of the Gunn device to the cavity and of the cavity to the external world. Readers are referred to Realm of Microwaves, *Wireless World*, February 1973 and to Gunn effect and avalanche oscillators, *Wireless World*, February 1976, for further details.

Fig. 4. Stages in the fabrication of the waveguide resonant cavity from standard 25mm square aluminium tube. Neatness and careful sealing of the joins are most important.





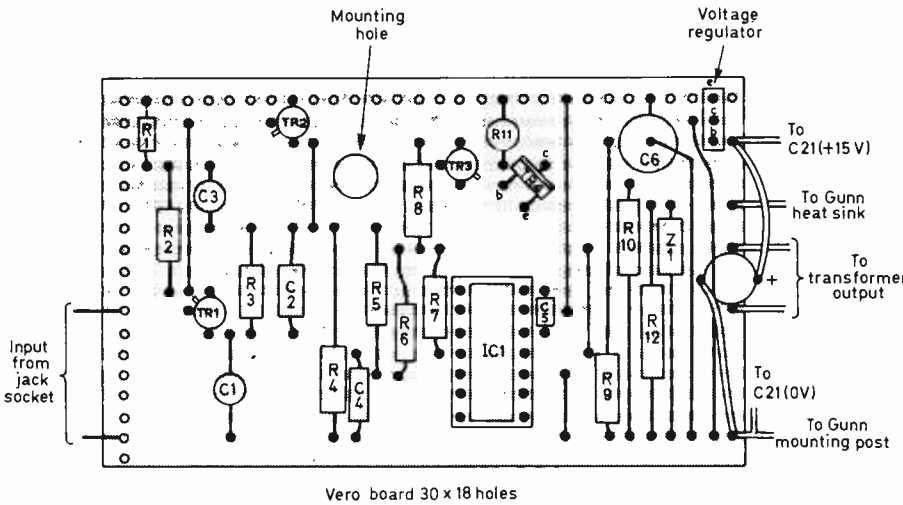


Fig. 5. Pulse-position modulator for the Gunn transmitter using a high slew-rate operational amplifier. Capacitors, except electrolytics, are 10% tolerance, resistors ¼-watt, 5% unless otherwise shown.

Fig. 6. Component layout of the modulator board showing the interconnection pattern on Veroboard. See note at foot of page 52 for printed board availability.

issue) causing the resonant frequency to decrease. By this means, the frequency can be varied by about 400MHz and thus permits a setting of between 10 and 10.5GHz, necessary to comply with the Home Office regulations.

Construction

The waveguide cavity could be made from many materials such as copper, brass, aluminium or tin sheet soldered or bonded together, the wall thickness being relatively unimportant. However, a convenient method used for the prototype, was to cut it from standard 1in (25.4mm) square aluminium tube available from most hardware or DIY shops. The wall thickness of the tube is 0.060in (1.5mm) which gives an internal guide dimension of 0.880in (22.4mm) and is close to the standard X-band guide width of 0.900in (22.9mm).

Cut a length of the tubing and file the ends smoth and square to a final dimension of 1.35in (34.3mm). Then, as indicated in Fig. 4(a), cut along the length of the tube to leave a three-sided section of at least 0.4in (10.3mm) internal dimension. File back smoothly to this size and then remove the sides of the off-cut, leaving a flat base. The waveguide is completed by bonding these two pieces together as in Fig. 4(b) using a two-part epoxy adhesive such as Araldite. It is essential that the mating surfaces are clean and free from grease – a wipe with one of the proprietary stain removers is very effective – and it is preferable to heat-cure the adhesive. Before curing, remove any surplus from the inside of the guide.

Mark the positions of the holes from the dimensions shown in Fig. 4(c) and drill them out. It is easiest to start with the small, heatsink hole and to drill through both sides of the guide, thereby ensuring accurate alignment with the mounting posthole. Flange and short circuit can be cut from 0.040in (1.0mm) aluminium sheet to the dimensions give in Fig. 4(d) with particular attention being paid to trimming the short circuit to be a good fit inside the guide. This last point is particularly important in achieving the correct frequency performance. The mounting post is a 1in (25.4mm) long 4BA bolt with a hole drilled in the end to accommodate the Gunn package and the circular disc is cut from this sheet as in Fig. 4(e).

Isolation of the mounting post is achieved by inserting a thin insulator between the locating nut and the guide wall. The best method found was to stick a piece of thin (0.005in, 0.1mm) double-sided tape over the large hole, cut a corresponding hole out of the tape and then place the nut in position. With a sharp blade, trim the tape to the external dimension of the nut and, finally, bond to the guide wall with a bead of Araldite. Before the adhesive sets, assemble the Gunn device and mounting post in the guide and ensure that the post and locating nut are not in contact with the rest of the mount. If a multimeter or other electrical means is used as a check, then remove the Gunn device first as a mistake on the polarity would almost certainly damage it. Place the flange in position and secure with the adhesive, taking care that the end of the guide is flush with the flange face. When set, push the short circuit in position and, as the final operation, cover all the joins on the side and shorted end of the cavity with aluminium foil as in Fig. 4(f). This is conveniently held in place with double-sided tape. The Gunn device, mounting post and tuning screw can now be fitted together with their locking nuts and solder tags and the oscillator is complete.

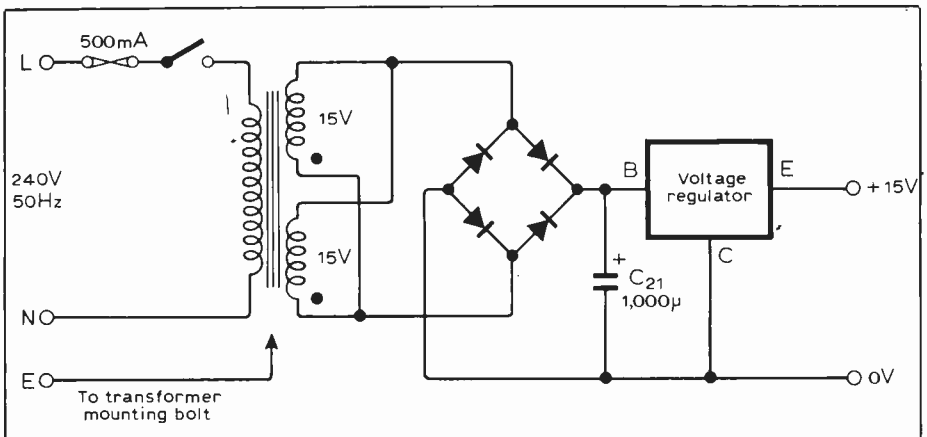


Fig. 7

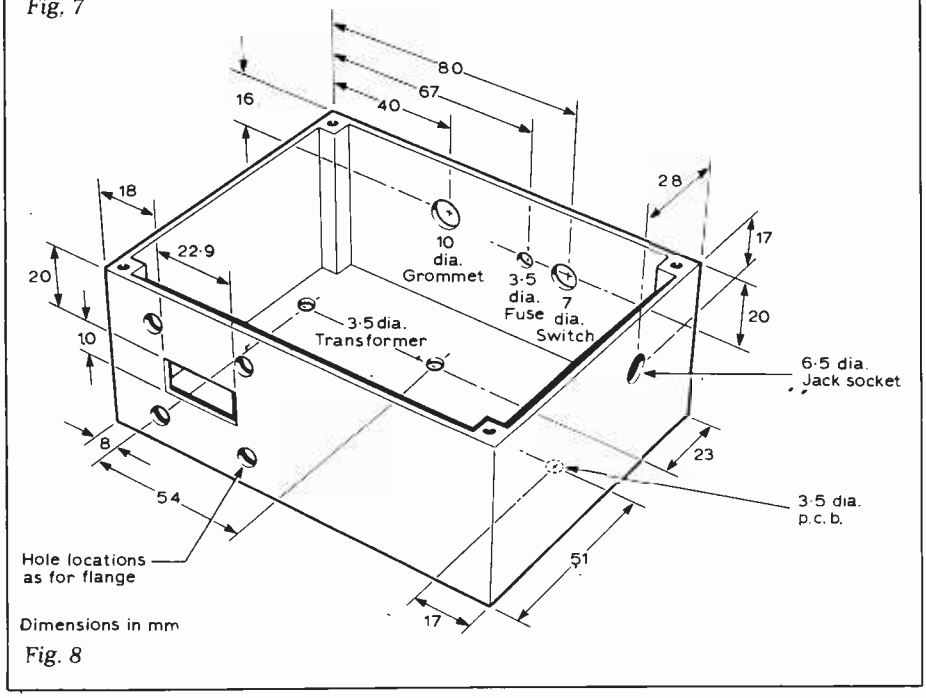


Fig. 8

Fig. 7. Power supply for the modulator uses a miniature mains transformer (e.g. RS Components type 196-397) and a voltage regulator (15V 1A type, e.g. 7815) for ripple suppression and accurate Gunn supply voltage. Rectifier is 1A, 50V type.

Fig. 8. Mounting-hole locations in the transmitter box. Take particular care that the rectangular hole matches the waveguide.

Transmitter alternative

For those who do not wish to construct the basic microwave oscillator, a ready built and tested one can be obtained. This is similar in external appearance to the one just described and works out only slightly more expensive. Its frequency, however, requires retuning to comply with the Home Office regulations in this application. Further details are given in the components section.

Modulator

Of the various techniques available to encode speech or other analogue data onto a microwave carrier, the one chosen here is pulse position modulation. Normally, the Gunn oscillator would generate a c.w. microwave signal upon the application of a 7V constant bias at a current drain of about 150mA. Switching this bias on and off will pulse modulate the microwave carrier and information can then be encoded by varying the time interval between the pulses. Fig. 5 shows the circuit of the voice modulator, the heart of which is the 715 operational amplifier, capable of a high slew rate. This op-amp in conjunction with C_4, R_5 and the feedback resistors R_6 and R_7 forms a triangular ramp generator whose frequency lies between 50kHz and 60kHz. However, R_5 is bootstrapped to the potential divider R_1, R_2 and with no input signal the input to the 715 is held at half the supply rail voltage. Thus, whenever the triangular ramp rises above or falls below this voltage, the output from the operational amplifier will change polarity. The result is that a 50 to 60kHz square wave is fed into R_8 to be amplified by the Darlington output stage and applied to the Gunn oscillator at the required 7V level. Resistor R_3 is chosen so as to give a one-to-one mark/space ratio.

With no input signal, R_5 is held at the stable level of half the supply voltage and regular pulses are generated. When the microphone is activated and a voltage appears at T_1, it is amplified with a small-signal gain of about 400 and appears as an amplitude modulation of the d.c. level at R_5. As this level rises and falls, so too does the point on the triangular ramp at which the operational amplifier switches polarity. Hence, the spacing between pulses is being modulated in time at the frequency of the input signal.

Modulator construction

The components were assembled on 0.1in matrix Veroboard to the layout shown in Fig. 6 keeping all component leads as short as possible. Capacitor C_7 is to suppress low frequency oscillations of the bias circuit and must be connected directly across the cavity terminals. shown in Fig. 7 is the power supply details for the modulator; the 15V regulator is used both to provide an accurate voltage at the Gunn device and to reduce the ripple content of the d.c. rails. It was mentioned earlier that the frequency of the microwave oscillator could be varied by changing the supply voltage. The exact amount depends largely on the loaded Q-factor of the cavity, this particular design giving about 10MHz/volt variation. Thus a 1mV supply ripple will produce 10kHz of f.m. noise on the pulse. In addition, the microwave output power can also be varied by the supply voltage and thus ripple will add an a.m. component to the noise level.

The modulator board power supply and Gunn oscillator have been designed to fit into a standard die-cast box 4¾×3¾×2in (150×120×50mm) a photograph of the assembly being shown in part 2. Place a piece of thick card or, preferably, ⅛in (3mm) hardboard under the modulator card and make sure that no burrs from the copper tracks touch the sides of the box. Because the positive pulse is applied to the heat sink end of the Gunn device, it is also necessary to isolate the complete oscillator from the metal box. This is easily achieved by attaching a layer of adhesive tape to the front face of the flange and using nylon screws for bolting the oscillator in place. Details of the various hole locations on the box are given in Fig. 8.

To be concluded.

Components

Mullard microwave devices CXY11A and BAV46 with collet are obtainable from Townsend-Coates Ltd, Loneford Road, Leicester LE5 0HH. IC_1, Fairchild type μA715DC, is obtainable from Macro Marketing Ltd, 396 Bath Road, Slough, Bucks Sl1 6JD. Printed boards for modulator and receiver will be available from M. R. Sagin, 23 Keynes Road, London NW2 costing £4 inclusive.

Logic design — 8

Shift register counters

by B. Holdsworth* and D. Zissos†

*Chelsea College, University of London † Department of Computing Science, University of Calgary, Canada.

An alternative method of designing digital counters or sequence generators is to use a shift register chip: a typical shift register counter configuration is shown in Fig. 1. The individual flip-flops form part of an n stage shift register and the connexions between individual flip-flops are internal to the chip. The output of each stage and its complement are both available and they may be used to drive combinational-feedback logic which provides the J and K inputs to the first stage of the shift register. Such a circuit can be used to generate specific binary sequences or, alternatively, it can operate as a modulo-M counter.

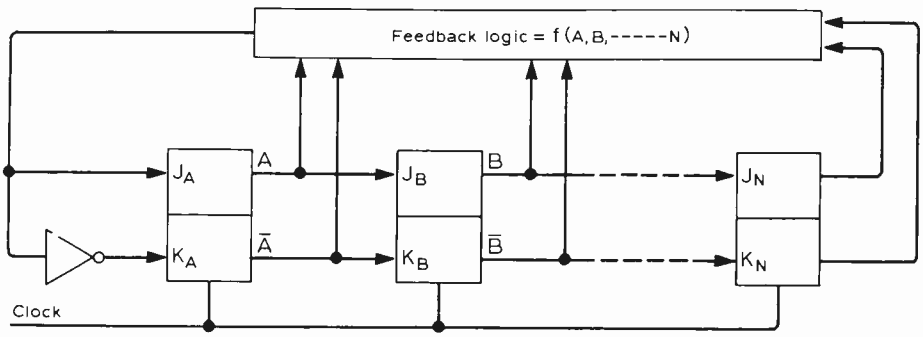


Fig. 1. Basic configuration of a feedback shift register counter.

Input-output relations

The input-output relationships for each stage of the counter shown in Fig. 1 are defined by the following set of equations:

$$A^{t+\delta t} = f(A, B,...N)^t$$
$$B^{t+\delta t} = A^t$$
$$C^{t+\delta t} = B^t$$
$$N^{t=\delta t} = (N-1)^t$$

The feedback circuit produces either a 1 or a 0 which is fed to the input of flip-flop A where it determines the next state of A on the receipt of the next clock pulse. For example, assuming that then n-stage shift register is in the state N...CBA = 0...001, the next stage of the shift register will be either 0...010 or 0...011, depending upon whether the feedback logic provides a 0 or a 1 at the J-input of flip-flop A.

Universal state diagram

The transition table for a two-stage shift register is shown in Fig. 2(a). If the shift register is initially in the state 00 then there are two possible next states. These are 00 if the J-input to the first flip-flop is a 0 or alternatively 01 if the J-input is a 1. Similarly, if the initial state of the shift register is 01 then the two possible next states are either 10 or 11.

The transition table of Fig. 2(a) can be translated into the universal state diagram shown in Fig. 2(b), alternatively called the de Bruijn diagram. It will be noticed that the shift register is permantly "locked" in the state 00 if the feedback logic is a 0 and, similarly, it is "locked" in the state 11 if a 1 is provided by the feedback logic.

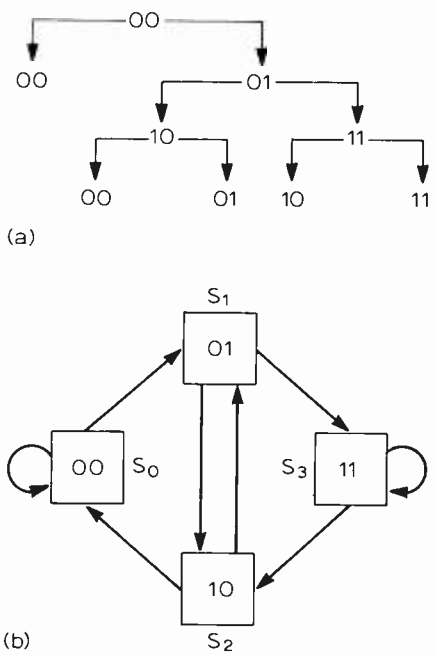


Fig. 2. Transition table for a two stage shift register is shown at (a), while (b) shows the de Bruijn or universal state diagram for a two stage shift register.

A similar transition table can be developed for a three-stage shift register and this can be translated into a universal state diagram as shown in Figs. 3(a) and 3(b). The universal state diagram for a four-stage shift register is shown in Fig. 4 and clearly the complexity of this type of diagram increases rapidly with the number of stages in the shift register.

The universal state diagram is a departure from the kind of state diagram that defines a specific sequence, as seen in earlier articles in this series. All possible internal states and all possible transitions between states are shown on the universal state diagram. The logic designer may now choose a suitable sequence of states on the diagram and design the feedback logic so that the shift register will cycle through the chosen sequence of states. If for example a decade counter is required, then a ten-state sequence should be chosen on the de Bruijn diagram and the feedback logic required to produce the sequence is then determined by the methods described in the next section.

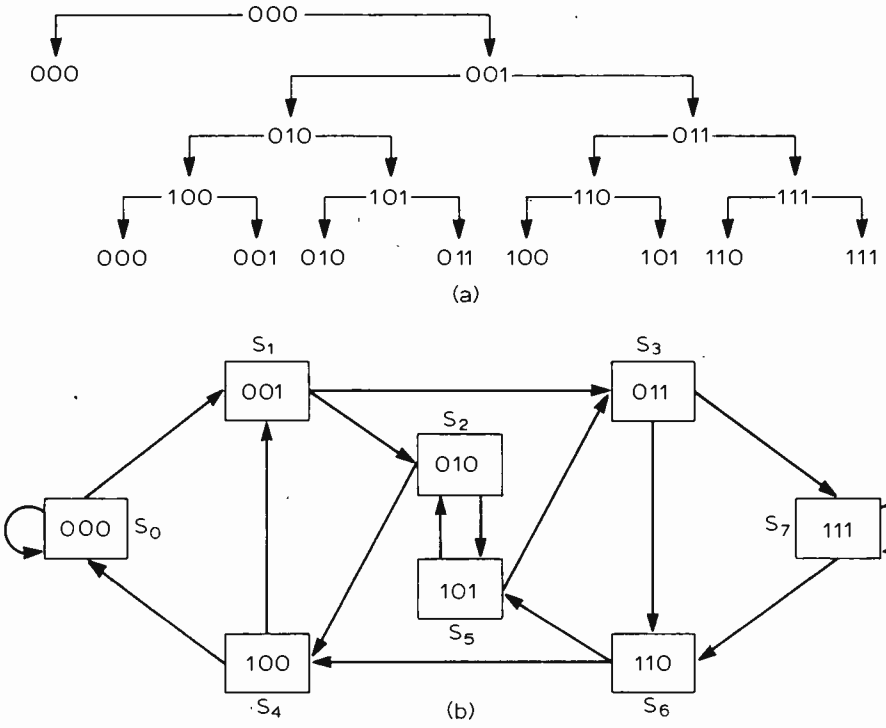


Fig. 3. Transition table for a three-stage shift register (a) and universal state diagram for a three-stage shift register (b).

Designing a decade counter

Step 1. Choose a ten-state sequence on the universal state diagram for a four-stage shift register. Examination of Fig. 4 reveals the following two possible sequences:

(a) $S_0-S_1-S_2-S_5-S_{11}-S_7-S_{15}-S_{14}-S_{12}-S_8-S_0$ and
(b) $S_0-S_1-S_3-S_7-S_{15}-S_{14}-S_{13}-S_{10}-S_4-S_8-S_0$.

There are, of course, other ten-state sequences besides those detailed above.

The state diagram for the second of the above sequences is shown in Fig. 5(a).

Step 2. Draw up a state table, as shown in Fig. 5(b), and determine the logical value of the feedback function for each transition. For example in going from S_0 to S_1, the state of flip-flop A must change from 0 to 1 and hence the required input $J_A = 1$. This is the logical value of the feedback function required for this transition, and it is entered in the final column of the state table.

Fig. 4. The universal state diagram for a four-stage shift register.

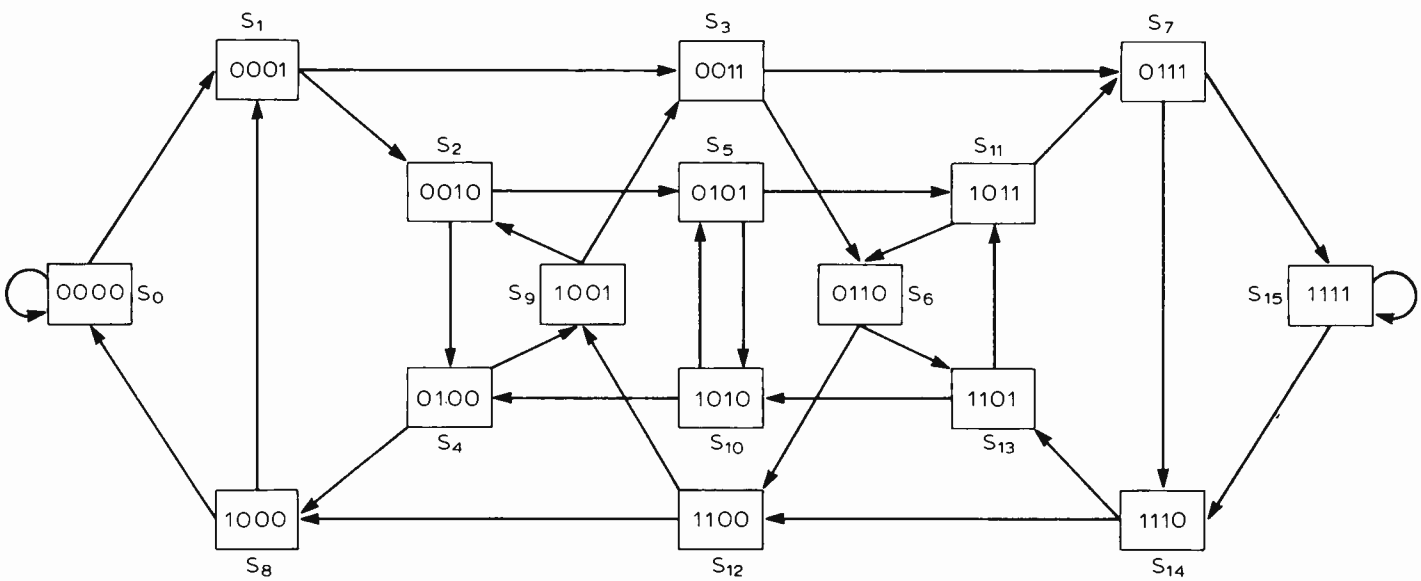
Step 3. Plot the feedback function and the unused states on a four-variable Karnaugh map as shown in Fig. 5(c). The feedback function is marked by a 1 in the appropriate cells of the map, whilst the unused states are marked with a "d".

Using normal minimization techniques the feedback function is found to be $f = \bar{C}\bar{D} + A\bar{D} + \bar{A}BC$. If the circuit enters an unused state the logic of the unused states, $f = A\bar{C}D + \bar{A}B\bar{D} + ABCD + A\bar{B}C\bar{D}$, can be used to stop the counter, raise an alarm, and reset all the flip-flops in the shift register to zero.

If this counter enters an unused state due to circuit misoperation, and if the logic of the unused states is not utilised, it will return to the correct sequence after a maximum of five clock pulses. The behaviour of the circuit is then described by the two tables shown in Fig. 5(d).

A perfectly general rule that should be observed when designing this type of counter is that the entry in the S_{15} cell on the K-map should always be a 0 and that in the S_0 cell should always be a 1, irrespective of whether these two states are in the counting sequence. This ensures that the counter will never be locked in either the 0000 or 1111 states.

The implementation of the basic counter is shown in Fig. 5(e). If a decimal output is required then a 4-to-16 line decoder can be used. For example when $AB\bar{C}D = 1$ the decoder output should be the decimal digit two.



Alternatively, if a decimal display is required then the counter in conjunction with the appropriate combinational logic can be used to drive a seven segment indicator.

Shift register sequence generators

A shift register counter with feedback logic can be modified, to produce any required binary sequence, with the aid of output logic. The length of the binary sequence generated, l, will be the same as that of the count from which it has been derived. For an n-stage shift register the length of the binary sequence $l \leqslant 2^n$. The basic configuration of such a sequence generator is shown in Fig. 6.

Design. As an example, a circuit that will generate the binary sequence 0–0–1–0–1–0–1–1 will be designed. Since there are eight bits in this sequence a three-stage shift register will be required. The eight three-bit combinations required to generate this sequence are tabulated in Fig. 7(a), where the binary digits in the column headed g_a are the required sequence whilst those in the columns headed g_b and g_c are the same sequence delayed in time with respect to the sequence in the column headed g_a, by one and two clock pulses respectively.

It will be observed that the shift register states 010 and 101 both occur twice in the tabulation. In the case of state 101 an ambiguity exists, since in one case the next state of the shift register is 010, whilst in the second case it is 011. Consequently these eight combinations cannot be generated by the method of direct feedback logic employed in the last design example, and output logic has to be used to produce the required sequence.

The method employed is to develop an eight-state sequence using direct feedback logic, the required binary sequence then being derived from this eight-state sequence with the aid of output logic.

Step 1. An eight-state sequence is obtained from the de Bruijn diagram for a three-stage shift register shown in Fig. 3(b). Such a sequence is:

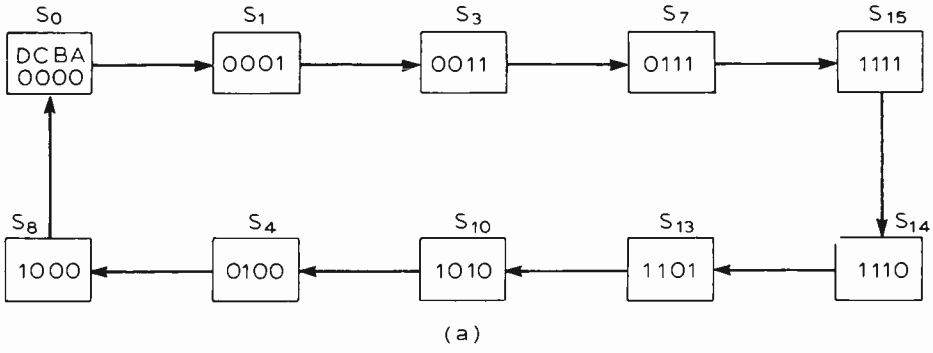
$$S_0–S_1–S_2–S_5–S_3–S_7–S_6–S_4–S_0$$

and the state diagram for this sequence is shown in Fig. 7(b).

Step 2. The state table is drawn up as shown in Fig. 7(c) and the value of the feedback function, either 0 or 1, is determined for each transition as described previously.

Step 3. Plot the feedback function and any unused states on a Karnaugh map as shown in Fig. 7(d). Using normal minimisation techniques the feedback function is found to be:

$$f = B\bar{C} + ABC + A\bar{B}C$$



(a)

S	D	C	B	A	Feedback function
S_0	0	0	0	0	1
S_1	0	0	0	1	1
S_3	0	0	1	1	1
S_7	0	1	1	1	1
S_{15}	1	1	1	1	0
S_{14}	1	1	1	0	1
S_{13}	1	1	0	1	0
S_{10}	1	0	1	0	0
S_4	0	1	0	0	0
S_8	1	0	0	0	0

(b)

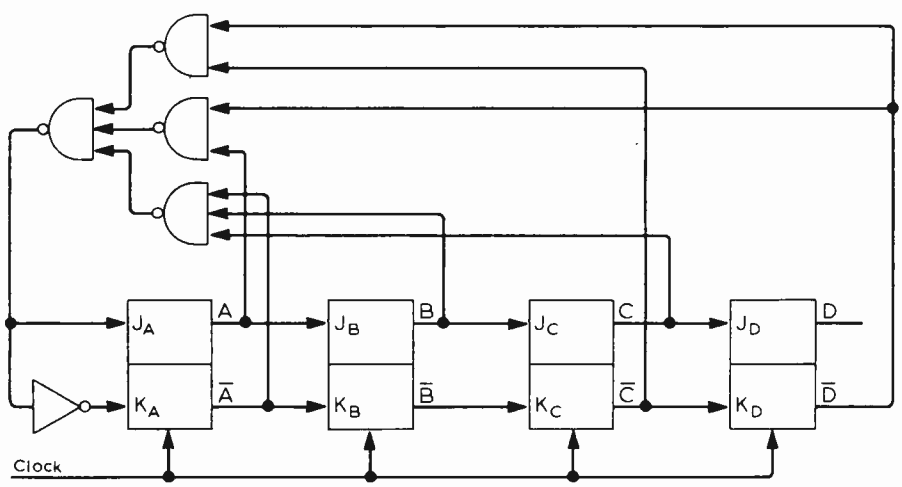
DC \ BA	00	01	11	10
00	1	1	1	d
01		d	1	d
11	d			1
10		d	d	

(c)

S	D	C	B	A	f
S_9	1	0	0	1	0
S_2	0	0	1	0	1
S_5	0	1	0	1	1
S_{11}	1	0	1	1	0
S_6	0	1	1	0	1
S_{13}	1	1	0	1	0

S	D	C	B	A	f
S_{12}	1	1	0	0	0
S_8	1	0	0	0	0

(d)



(e)

Step 4. The output binary sequence required is now tabulated by the side of the eight-state shift register sequence as shown in Fig. 7(e) and the minimal form of the output function

$$g_a = B\bar{C} + \bar{A}C$$

Fig. 5. State diagram for a decade counter (a), state table (b), Karnaugh map of the feedback function (c). The behaviour of the counter after entering an unused state is at (d) and (e) shows a shift register decade counter.

is obtained from the Karnaugh map shown in Fig. 7(f).

There are other output sequences such as g_b and g_c in Fig. 7(a), which are merely displaced in time from the sequence in the g_a column of Fig. 7(e), and the logic for these sequences can be examined to see which requires the least hardware. As it happens, in this example, the equation for g_a contains the term BC which is one of the product terms of the feedback function; hence, very little additional hardware is required to generate the output equation. The implementation of the sequence generator is shown in Fig. 7(g).

In the second half of this part of the series, the authors continue the discussion of shift-register counters, going on to describe ring counters and maximum-length sequence generators.

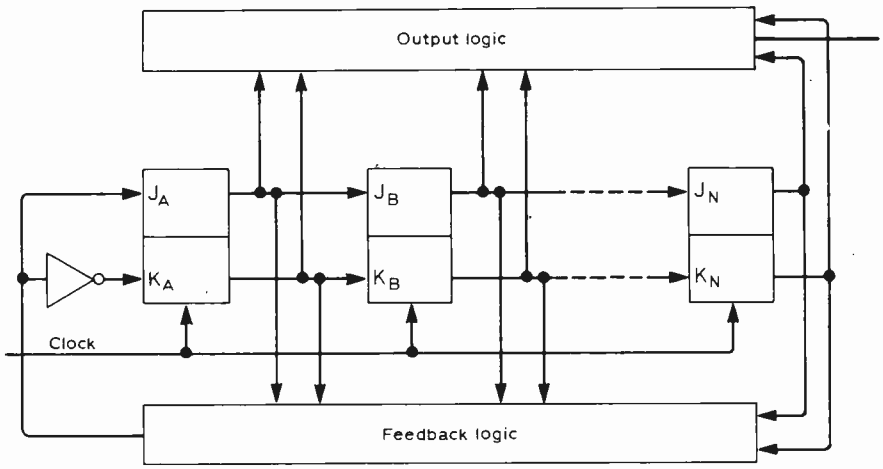
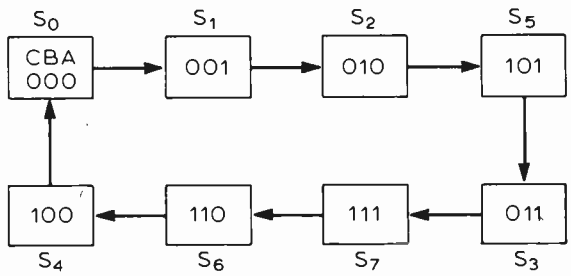


Fig. 6. Basic configuration of a binary sequence generator.

Fig. 7. (a) shows eight, three-bit combinations needed for 8-bit sequence, and the state diagram to give the eight-state sequence is at (b). State table for feedback function and its K-map are at (c) and (d) while the state table and K-map for the output function are at (e) and (f). Fig. 7(g) is the implementation of binary sequence generator.

Clock pulse	g_c	g_b	g_a
1	1	1	0
2	1	0	0
3	0	0	1
4	0	1	0
5	1	0	1
6	0	1	0
7	1	0	1
8	0	1	1

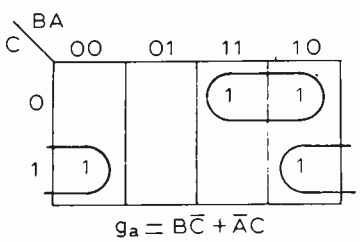
(a)



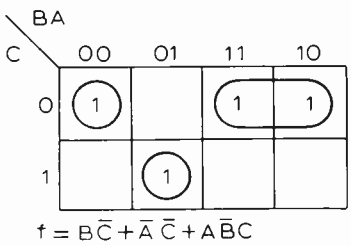
(b)

S	C	B	A	Feedback function f
S_0	0	0	0	1
S_1	0	0	1	0
S_2	0	1	0	1
S_5	1	0	1	1
S_3	0	1	1	1
S_7	1	1	1	0
S_6	1	1	0	0
S_4	1	0	0	0

(c)



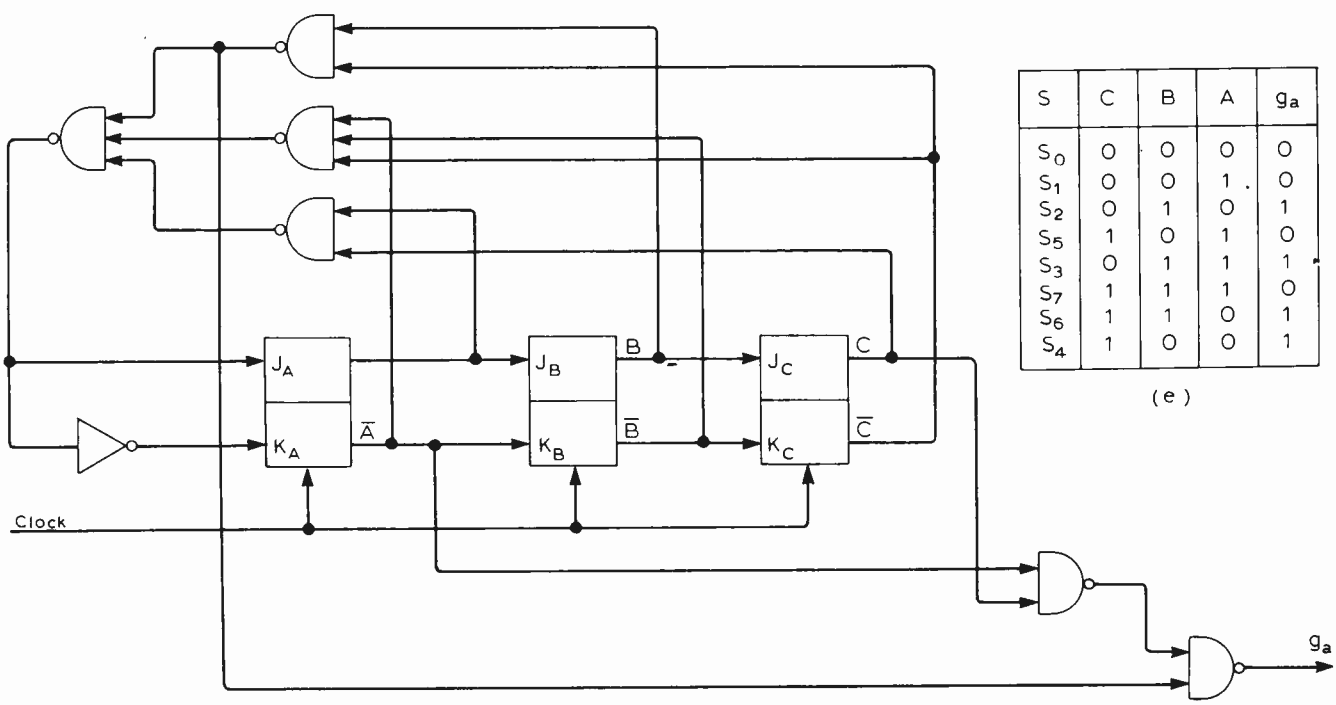
(f)



(d)

S	C	B	A	g_a
S_0	0	0	0	0
S_1	0	0	1	0
S_2	0	1	0	1
S_5	1	0	1	0
S_3	0	1	1	1
S_7	1	1	1	0
S_6	1	1	0	1
S_4	1	0	0	1

(e)



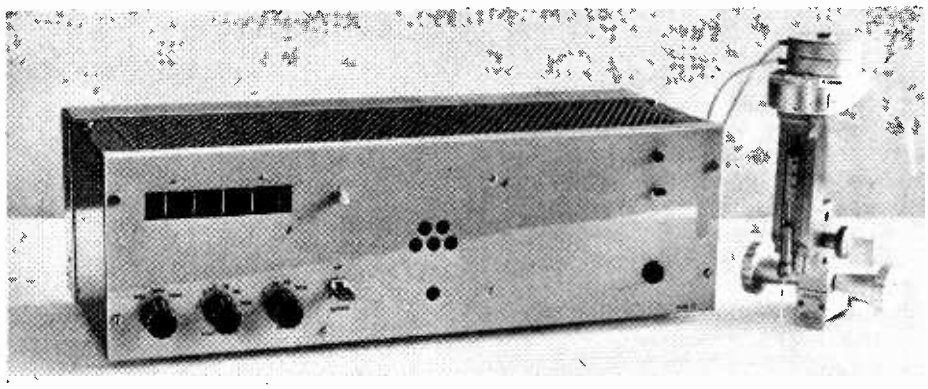
A stepping motor drive

Digital control and position indicator for 2000 revolutions

by W. J. Bannister *University Laboratory of Physiology, Oxford*

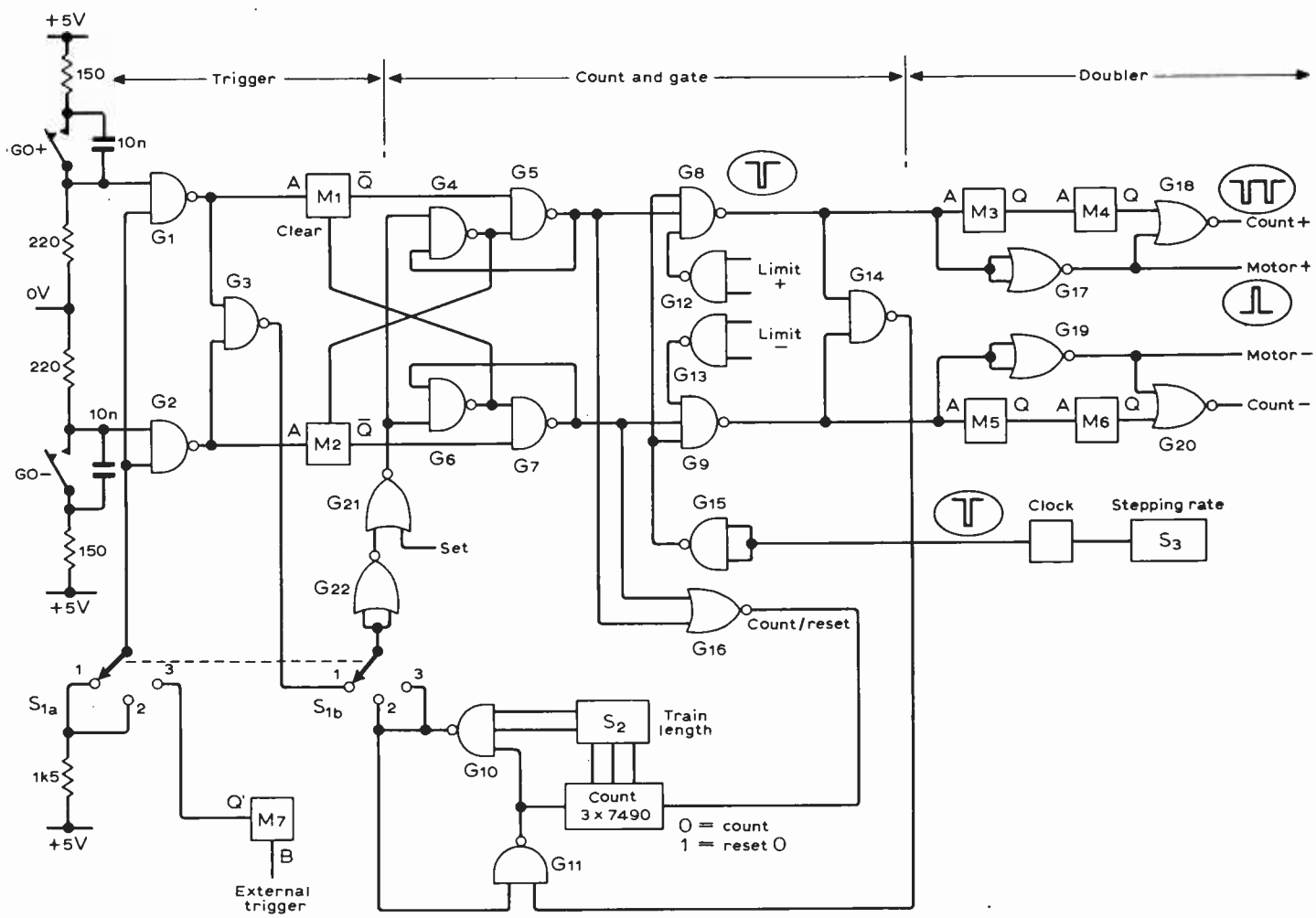
The appearance of the stepping motor has solved a number of problems in the control of both rotational and linear movement, previously the province of the D.C. motor and servo-system.

A typical motor (Impex series ID.07) has four stator coils and twelve pairs of rotor poles, and so can take up 48 distinct positions in one revolution. When the stator coils are energised in the correct sequence, the rotor can be made to move from one stable position to the next (7½° in either direction), at rates of over 1000 steps/s. The ener-



The motor mounted in the drive assembly. This was used for the accurate positioning of micro-electrodes in neurophysiological research.

Fig. 1. The gating circuit



gising waveforms can be provided electronically, or by mechanical switching.

The system described can be used for the general control of such a motor, the five digit readout indicating its position for more than 2000 revolutions. Limits can be chosen so that the motor will not overrun a chosen count in either direction, and the motor can be run continously, or in gated 'trains' of steps from 1 to 999, the stepping rate itself being variable up to 200 steps/second.

Our specific requirement was to drive an electrode along a 25mm track, and know its position to an accuracy of 2μm, and my thanks are due to Mr Lionel Gale for developing the gearbox which achieved this.

The photograph shows the motor mounted on the drive assembly. By driving a micrometer leadscrew of 0.5mm pitch, through a 125:24 anti-backlash gear-train, a movement of 2μm/s along the leadscrew is produced.

Fig. 1 shows the gating circuit. Consider the action for driving forward (Go+). The bistable G4G5, at 'ready', has its two inputs at logical 1, and its output at 0. A '0' pulse on the G5 input will cause the output to go to 1, and hold itself there until a 0 pulse into G4 resets the output to 0.

Continuous mode. Switch 1 position 1.

When the Go+ switch is closed, a 1 → 0 transition is applied to the inputs of G3 and M1 (half monostable type 74123). G3 output goes to 1, making G4G5 ready, and the M1 (200 μs) Q pulse into G5, flips the output to 1. The main gate, G8, has two control inputs, from G5 and G12(limit +). When these are both at 1, the clock pulses go through to the display and motor drive. The limit input is derived from the display counters, and we chose 24,000 since the mechanical drive limit was 25mm. The circuit will now continue to drive until either a count of 24,000 is reached, or the Go+ switch is opened, when G3 output will go to 0, resetting the bistable. The action for Go— is identical, except that the limit, counting backwards, is 99,998.

Gated train mode. Switch 1/2.

Normally, as G6 and G7 outputs are 0, G16 output is 1. This is fed to the 'reset to 0' line of the 7490 counters. The BCD outputs for the chosen train length are switched by S2 to the G10 control inputs. At 'reset to 0', G10 output holds the bistable ready. For Go+ 50 steps, S2 feeds decade 2 A and C outputs to G10, and the Go+ switch is closed, triggering M1. This toggles the bistable, activating G8 (subject to the limit input), and through G16, setting the 7490s to 'count'. G8 will now pass clock pulses to the motor and display, and via G14 and G11, to the 7490s. When a count of 50 is reached, the end of the 50th clock pulse will drive G10 output to 0. This will reset the bistable, shutting

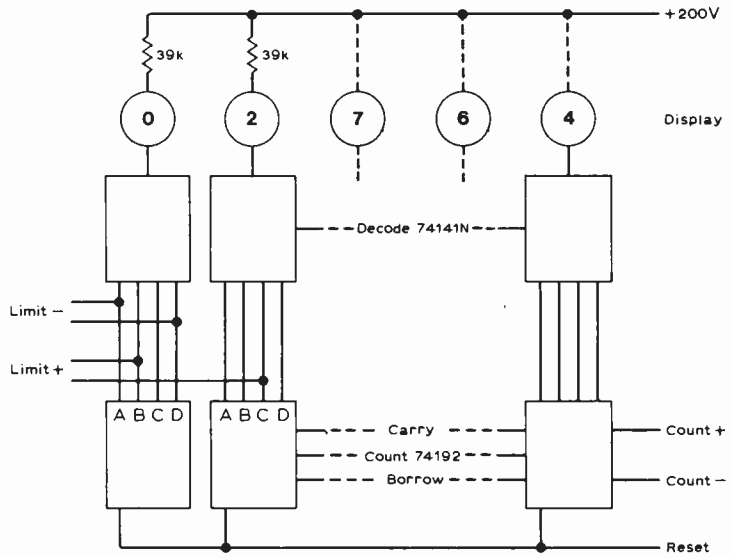


Fig. 2. The count / display unit

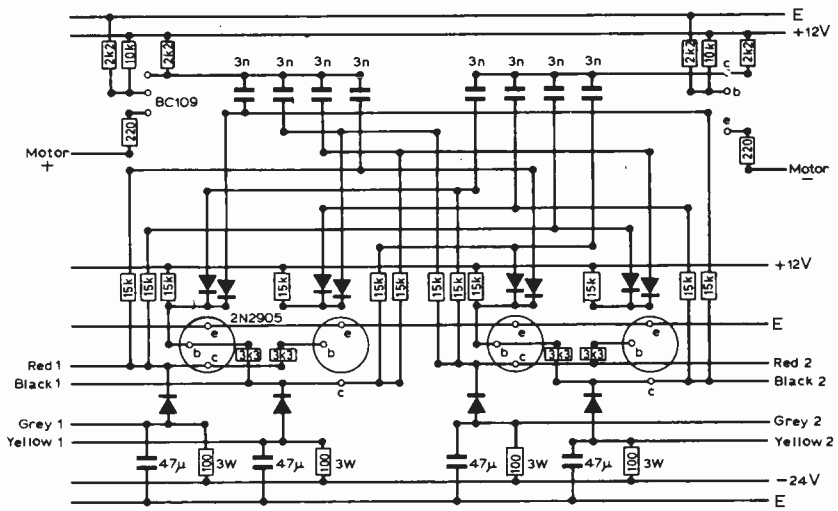


Fig. 3. The Veroboard layout

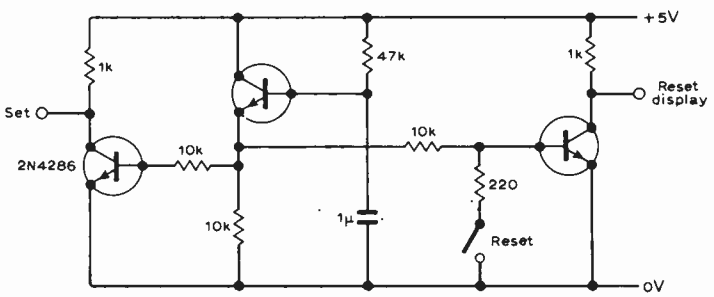


Fig. 4. The reset-zero delay monostable

$\overline{G8}$. G16 goes to 1, resetting the 7490s to 0, G10 to 1, and the bistable to the 'ready' state. During the train of pulses, M1 and M2 are cross-inhibited, disabling the Go + Go- switches.

External trigger mode. Switch 1/3.

In this mode, the gating and counting system is the same, but the trigger is derived from M7. A positive going pulse from an external source, applied to the B input of M7, feeds a Q pulse (200μs) into the common input of G1 and G2. If the Go+ switch is closed, this pulse passes through G1, and triggers M1, initiating a train.

Pulse doubler

M3 M4 and M5 M6 are 74123 monostables, M3 and M5 set to 1ms duration, and M4 and M6 to 200μs. For each input pulse, two output pulses are produced, separated by 800μs. These are fed to the count/display unit, which consists of five decades of up/down counters, decoders and Nixie indicators (Fig. 2). The display progresses by two counts per motor step, and indicates displacement in microns.

Clock generator

A 555 type timer is used in the astable mode, to produce 200μs pulses. The device works reliably on a 5V supply, and S3 switches the rate between 2 and 200 pps.

Motor drive

The motor pulses from the gating unit trigger a conventional drive circuit of two bistables with diode steering to effect forward/reverse rotation of the motor. Fig. 3 shows the vero-board layout for driving the Impex type ID.07. Drive units are available commercially to suit the motor used from Impex Electrical Ltd, Market Road, Richmond, Surrey.

In general

When switching the instrument 'on', it is necessary to reset the display to zero. This is done automatically by a delay monostable (Fig. 4), which produces a 10ms, 5V pulse, when the 5V line is energised. This 'set' pulse is also fed to the 'set' input of G21, to ensure the correct initial state of the bistable G4G5. The reset switch on the front panel also sets the display to zero, and if held on, overrides the electronic limits, enabling the electrode drive to be aligned on its mechanical zero indicator.

The power supplies required are:

5V at 1A for gating and counting.

12V at 50mA and —24V at 300mA for the motor.

200V at 25mA for the display.

By using later types of 5V motor, and also l.v. filament or l.e.d. display, the whole unit can be run off 5V, but this simplification must be weighed against the increased cost involved. How much is your time worth?

Literature Received

Microwave test instruments and a range of attenuators and components made by Weinschel Engineering are described in two catalogues, obtainable from the UK distributors, Marconi Instruments Ltd — Sanders Division, Gunnels Wood Road, Stevenage, Herts SG1 2AU WW401

Test equipment for use in the servicing of two-way radio is the subject of a short-form catalogue from Motorola. Equipment described includes p.s.us, meters, signal generators, counters and test sets, together with the new Motorola oscilloscope and power meter. Motorola Inc., Communications Group, 1313E. Algonquin Road, Schaumburg, Illinois, 60196, USA . WW402

Further leaflets in the BBC series 'Engineering Design Information,' in which mention is made of BBC designs available for commercial development, are now published. They are as follows: a low-noise (<7dB) 15dB video amplifier (AM5/526), u.h.f. test equipment for transmitters (EP14M/507), an i.t.s. generator and inserter (GE4M/556), a Band II f.m. monitor receiver (RCl/12), video amplitude measuring unit (UNl/715) and pulse delay unit (UN14L/532). Copies are obtainable from the Liaison Engineer, Designs Department, BBC, Broadcasting House, London W1A 1AA WW403

"Electronic Measuring Instruments" is the title of Wayne Kerr's new catalogue which briefly describes, in English, French and German, most of their range of test gear, including the new B424 component bridge. A section is devoted to the Dimeq capacitive contactless gauging system. Wayne Kerr Sales, Wilmot Breeden Electronics Ltd, 442 Bath Road, Slough LS1 6BB WW404

A short-form catalogue of equipment for stripping, marking, sleeving, identifying and trunking cables is produced by Hellermann Electric, Gatwick Road, Crawley, West Sussex, RH10 2RZ. WW405

Four ranges of pliers, cutters and nippers in the Lindstrom range are fully described in catalogue No. 99-74, from Wm A. Meyer Ltd, 9 Gleneldon Road, London S.W.16 . WW406

Slewing rates of 50V/μs and 240V/μs are provided in a high-voltage power supply series CPS 7000, which is intended for the control of the beam-penetration type of colour tube. A leaflet describing the series can be had from CPS, Inc., 722E. Evelyn Avenue, Sunnyvale, California 94086, U.S.A. WW409

We have received a copy of the technical standard for v.h.f./u.h.f. television and radio domestic receiving aerials from the British Aerial Standards Council, dealing with terminology, specifiable parameters, measurement and mechanical parameters. Copies can be obtained from Jack Hum, Secretary BASC, 27 Ingarsby Lane, Houghton on the Hill, Leicester LE7 9JJ at £1.25 by post or £5.00 for five copies.

The applications of Marconi's TF2370 spectrum analyser in an impedance measuring and matching role is described in a booklet (No. 18) in the Measuretest series. The booklet has been written by A. V. Griffiths of AWA and B. R. Webster of Marconi Instruments and is obtainable from the Publicity Dept, Marconi Instruments Ltd, Longacres, St. Albans, Herts AL4 0JN WW408

Sixty Years Ago

The measurement of frequency was not, in 1917, anywhere near as easy and precise as it was to become a few years later. In our October, 1917 issue, "D.J." wrote describing one of the first heterodyne wavemeters, using a valve and designed for frequencies between 500kHz and 200kHz. It consisted of a feedback valve oscillator and detector and relied for its accuracy, in part at least, on the fact that the frequency couldn't be more than 10kHz out, since a higher note was inaudible.

"A wavemeter with the connections given above may be used for a variety of purposes. As it generates continuous waves of a frequency varying with the value of the condenser, it can be used as a sending wavemeter as well as a receiving wavemeter without making the slightest alteration whatever to the circuits.

Let us, however, for the time being, consider only its use as a measurer of the length of continuous waves. Suppose the instrument is brought up to a set which is sending out waves of, say, 800 metres length. These waves will have an interference effect on the oscillations already taking place in the wavemeter. If the wavemeter is set to, say, 750 metres, the system will be oscillating at a frequency of 400,000. When the wavemeter receives the 800 metre continuous waves, oscillations of 375,000 frequency are set up in addition. These two sets of oscillations, superimposed upon each other, will produce a resultant oscillating current, with beats when the two sets of oscillations are momentarily assisting one another. The frequency of these beats will be equal to the difference of the two separate frequencies, and will in the present case be 25,000.

The valve is also acting as a detector in addition to generating oscillations. The beats, therefore, are rectified, and will produce in the telephone receivers a note having a frequency equal to the beat frequency. This note, to be audible to the human ear, must be below a frequency of about 14,000. It is obvious then that if the wavemeter be set to 750 metres nothing whatever will be heard in the 'phones. Only when the wavemeter condenser is turned round till 770 metres is reached will anything at all be heard in the ear pieces, and then only an exceptionally high note. As the wavemeter is turned nearer to 800 metres — i.e. as the two frequencies approach each other — the note in the telephones gradually gets lower and lower till at 800 metres nothing whatever is heard. The two frequencies, local and superimposed, are now identical, and, whether in phase or not, produce resultant oscillations of constant amplitude, and which therefore are unable to affect the telephone even when rectified."

Letters to the Editor

THE LANGUAGE OF HI-FI

Your balanced and sensible leader in the August issue came as balm to my inflamed spleen after also reading in one of your considerably less distinguished contemporaries that a highly respected preamplifier "sounded boring" and "made the music sound as if played by amateurs". Surely the nadir of lunacy in the use of subjective language! One gets the impression that these terminological outrages are being perpetrated on gullible readers by a new breed of journalistic *wunderkind*, who would probably be hard pressed to define a decibel. The reasons for this development are beyond me – probably it is either an effort to conceal technical incompetence or because it makes saleable copy; or a mixture of both.

Of course, I am not against the use of subjective language. What I am against is the increasing tendency to use language of imprecise meaning. To misquote Gertrude Stein "a volt is a volt is a volt" and I hope no one is going to question that or challenge that a volt measured in hi-fi equipment is any different from any other. But when someone says vis-à-vis the performance that the "information retrieval efficiency was low" (yes, really — I didn't make it up) then like the late and quite unlamented Hermann Goering, I reach for my axe. If I as an experienced professional engineer cannot understand it, then heaven help the poor layman.

We commentators in engineering journalism have a heavy responsibility and should never resort to language that is capable of alternative interpretation or is open to doubt: and if there is a slight doubt, then it should be clearly defined or explained. At the risk of being accused of pedantry, I will go further and say that every observed phenomenon in reproduced sound is measurable and may be expressed in quantitative terms. Some subtle effects perhaps may be harder to measure than others; but I am with Galileo and Lord Kelvin. Inventing new words is not the way out.

May I finish with another observation, and a warning against another tendency not confined to the popular hi-fi press? This is the lack of a sense of proportion and a failure to appreciate the realities of the technical side of audio. I have just been reading with interest an article in a well-known technical publication. The writer discusses with great insight, the technical desiderata for a pickup input stage; then spoils it all by proudly declaiming in the final paragraphs that the improvements result in a reduction of the t.h.d. to 0.0004%. Marvellous. Then if someone is able to make a gramophone record and cartridge capable of the same order of inherent *Dt* we might just be able to notice the difference.

Reg Williamson
Norwich

AURAL SENSITIVITY TO PHASE

I fear that Mr Moir (Letters, July 1977 issue) has misunderstood the point which I was trying to make in my letter on the audibility of polarity reversals (Letters, May 1977). Far from the distortion of one stage in the amplifier chain being cancelled by a complementary distortion in a subsequent stage, as suggested by Mr Moir as an explanation for the effects I discussed, I was at pains in my letter to make clear that this was *not the case*. All subsequent stages in the chain, including the transducer, were shown not to be responsible for the effect in question. (In the case of the loudspeaker, this was done by listening from both front and back of the dipolar electrostatic panels, thus introducing a polarity reversal in the acoustic waveform, which was found to reverse the effect.) The change in quality of the signal was due entirely to its *own* asymmetry, not to subsequent distortion. This confirms the earlier work cited in my letter.

An even more vivid demonstration of this effect can be obtained by linearly combining two sinusoidal oscillator signals, one a "fundamental" frequency of around 400Hz and the other an adjustable-level "second harmonic" of around 800Hz. If the second harmonic is allowed to drift *slowly* in phase relative to the fundamental a very pronounced cyclic change in the sound quality of the signal will be heard, and it is instructive to listen to it while observing the asymmetric waveform on an oscilloscope. No such effect appears to occur if the 800Hz signal is shifted to the third harmonic, i.e. 1200Hz; the waveform is now always symmetric with respect to polarity reversals. With a fourth harmonic, however, the effect is again subtly audible if the level is suitably chosen.

Towards the end of his letter, Mr Moir in fact seems to support my argument, by agreeing that *on good signals* a polarity reversal *is* indeed subtly audible. This strikes me as being an important conclusion! Even more than just standardizing the absolute polarity of the whole audio chain, as I suggested, it would seem that the non-linear-phase errors inherent in the use of pressure and/or velocity microphones in recordings, which are reproduced indiscriminately via either pressure or velocity transducers, also requires serious investigation.

Stanley P. Lipshitz,
University of Waterloo,
Ontario, Canada.

Mr Driscoll, responding in the July issue to my letter of last February, asserts of himself "My grasp of basic principles is not so uncertain that I could believe Coleman's claim that "tone bursts which differ in the framing of phase" (I wrote "OR 'phase' ") of the sine wave with respect to the burst envelope have spectra of different shapes." My claim can easily be checked, and is correct. Where does that leave his "grasp of basic principles"?

If the members of a regular sequence of tone bursts are well separated, so that they are heard as separate bursts, it is enough to calculate the Fourier transform or spectrum of any one of them. If a particular burst consists of the sinusoid $\sin(2\pi f_0 t+\epsilon)$ gated on for $2n$ periods centred about the time $t=0$ then its transform is

$K\sqrt{(f-f_0)^{-2}+(f+f_0)^{-2}+(f^{-2}-f_0^{-2})\cos 2\epsilon}\ \sin(2\pi nf/f_0)e^{j\phi(f)}$ where $\phi(f)=\epsilon-\tan^{-1}((f-f_0)\sin 2\epsilon/(f+f_0+(f-f_0)\cos 2\epsilon))+\pi/2$ and K is is independent of both f and ϵ. If the burst is not a whole number of periods long the expression becomes more complicated.

This spectrum peaks at $f=f_0$ and the width of the peak, taken between neighbouring zeros, is f_0/n, inversely proportional to the burst length, and compatible with the requirements of the acoustic uncertainty relationship. Its shape, i.e. the variation of its modulus with f, clearly does change when the value of ϵ changes, and in addition the reference phase $\phi(f)$ of the component of frequency f depends in a non-linear fashion on both f and ϵ. If the centre of the burst occurs, not at time $t=0$, but at $t=T$, then $\phi(f)$ contains a further additive term $-2\pi fT$. If $\epsilon=\pi/2$ the spectrum of the burst decays at frequencies far from f_0 as f^{-1}, whereas if $\epsilon=0$ it decays as f^{-2}. This is understandable since in the latter case the burst has discontinuities of slope at its ends, but in the former has amplitude discontinuities, which will splash the spectrum out much further, a point about which I warned Mr Driscoll in my February letter. He doesn't have to take my word for these statements – presumably one of his brighter students could check the calculations, or he could ask one of the enterprising loudspeaker manufacturers who have set themselves up with minicomputers, f.f.t. programmes, and graphics terminals to let him see for himself what a sinewave toneburst spectrum really looks like, in phase as well as in amplitude.

It is all too easy for those acquainted in principle with Fourier transforms to mention the use of transfer functions and Fourier transforms for calculating network responses to signals of finite duration, leaving the impression that this is essentially a trivial extension of normal a.c. calculations. It is not, and exposure to the specific Fourier transforms of a few simple signals, such as tone bursts, can go a long way towards driving the point home.

C. F. Coleman,
Wantage,
Oxon.

CONFUSION ABOUT DISTORTION?

In a letter in your August issue Mr Greenbank quotes an earlier correspondent who states: ". . . 'loss of information' occurs during amplifier 'latch-up' – when, as we all know, 100% intermodulation distortion occurs." This statement is symptomatic of a general confusion which has resulted from harmonic distortion, intermodulation distortion, "latch-up", "clipping", "slew-rate limiting", and transient intermodulation distortion all being regarded as "distortion".

The use of distortion as a generic term is probably responsible for it being generally unnoticed that the above list may be the

results produced by two fundamentally differing mechanisms.

Consider the case of an amplifier which, though it has a non-linear transfer function, has no clipping point or slew-rate limit. Such an amplifier may be modelled by a "one-to-one" mapping function, and because of this an inverse mapping function may be discovered which precisely restores any mapped set of points back to their initial positions. With any distortion which may be described this way, therefore, we always (in principle, at least) perform another process which gives us the information in its "undistorted" form.

Such is not the case with "latch-up", "clipping" and "slew-rate limiting". Each of these may *not* be regarded as a "one-to-one," mapping – rather, they are characterised by a "many-to-one" mapping function. In these cases no inverse mapping function exists which may be employed to restore any arbitary initial point to its original position. We have created a singularity, and a set of points are "doomed to fall down it".

For this reason it will unfortunately tend to cloud the issue to regard "many-to-one" imperfections in a transfer function as "distortion". Hence it is misleading to regard clipping or latch-up as "100% intermodulation distortion". Similarly, it is unhelpful to call the effects of slew-rate limiting "transient intermodulation distortion."

I would not wish to argue that "many-to-one" imperfections are not "distortion" as the word is currently defined—only that we are here clouding the problem by our choice of terms.

As for the "loss of information" concept which prompts Mr Greenbank's letter, all I can do is point out that this may be defined in terms of "many-to-one" rather that "one-to-one" functions. It remains to be seen, however, if either form of imperfection proves inherently "audibly more objectionable".

J. C. G. Lesurf,
Armstrong Audio Ltd,
London N7.

THE E.M. EQUATIONS — ALTERNATIVE REPRESENTATION

Maxwell's equations relating the electromagnetic field to charge and current densities are usually presented in vector form:

$$\nabla . D = \rho \qquad \text{(i)}$$

$$\nabla \times H = J + \frac{\partial D}{\partial t} \qquad \text{(ii)}$$

$$\nabla . B = 0 \qquad \text{(iii)}$$

$$\nabla \times E = -\frac{\partial B}{\partial t} \qquad \text{(iv)}$$

Tensor formulation of Maxwell's equations is even more concise and expresses better the interdependence of electric and magnetic fields.[1-4]

An alternative method of representing equations (i) and (ii) is shown in Fig. 1. Starting from six components of D and H (circled symbols) we operate on them as indicated by the direction of arrows. We then obtain three components of the current

Fig. 1

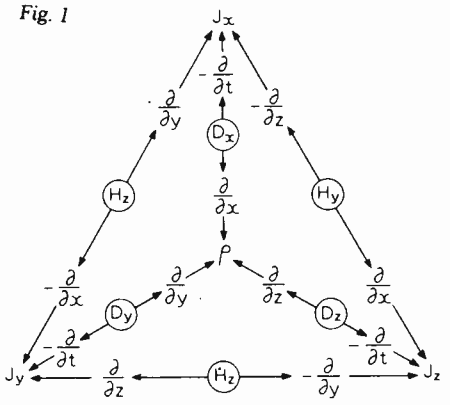
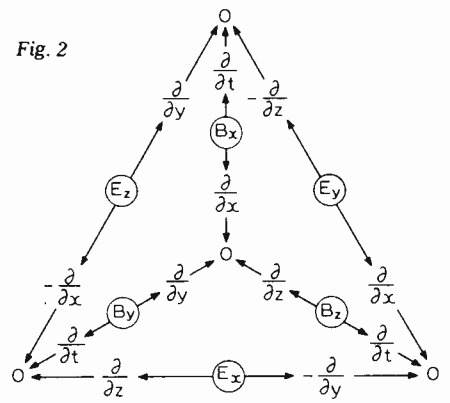


Fig. 2



density in the apices of the triangle and charge density at the middle.

In the same way we can express the remaining two Maxwell's equations (iii) and (iv), as shown in Fig. 2.

Using the same method we can represent the relations between electric and magnetic fields and the four-vector potential (V, A_x, A_y, A_z) viz. the equations:

$$B = \nabla \times A \qquad \text{(v)}$$

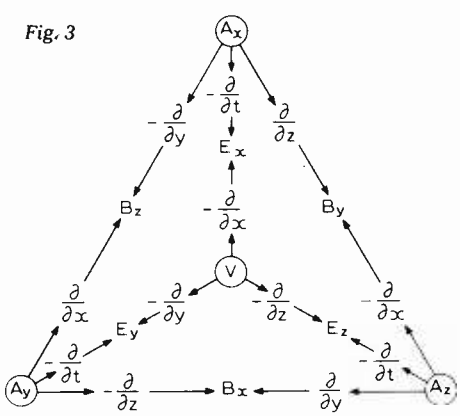
$$E = -\nabla V - \frac{\partial A}{\partial t} \qquad \text{(vi)}$$

The alternative representation of the above equations is shown in Fig. 3.

Here we start from the components of the four-vector potential (circled symbols in the middle and at the apices of the triangle), and operate on them as indicated. We obtain the six components of E and B.

The advantage of the above representation of four differential equations, relating six vector components of the electromagnetic field and four components of the four-vector current or four-vector potential, is mainly mnemonic, but it also helps to grasp the essential unity of electric and magnetic fields.

Fig. 3



T. A. Kasinski,
Kingston-upon-Thames,
Surrey

References

1. A. Lichnerowicz, "Elements of Tensor Calculus" pp. 143-150, Methuen & Co. Ltd., London, 1962
2. A. N. Matveyev, "Principles of Electrodynamics" pp. 329-337, Reinhold Publishing Corporation, New York, 1966.
3. G. Taylor, "Special Relativity" pp. 65-71, Clarendon Press, Oxford, 1975

COMPUTING FOR LOCAL COMMUNITIES

We want to discover if it's truly possible to introduce computing into one of London's most derelict areas as a community resource.

We are the Vauxhall Media Project and our primary aim is to initiate a meeting place and facilities for film, video, photography, printing and computing. These are facilities which groups and individuals from the local community can use to fulfil their own projects and the needs of their community by pooling talent and resources.

The story so far is that a group of people working in the computer industry and in the local community have been meeting regularly to analyse the type of system needed.

John Pemberton of London University has been very helpful with advice and there is a probability that computer time may be found there to run a graphic computer terminal five nights a week.

We want to see if computing can be brought into the community as a tool and as a medium for creative entertainment, and we would welcome information, advice, help, participation, equipment — anything.

Peter Fotheringham,
Vauxhall Media Project
132 South Lambeth Road,
London SW8.

INCONSIDERATE TV CAMERA OPERATION

One in seven persons in the United Kingdom suffers from migraine. In addition, a considerable number are subject to epilepsy. All such people in their capacity as television viewers are badly affected by flashing lights, repidly rotating symbols and most kinds of unsteady image thrown at them from the television screen.

As these facts are well known, why do the BBC and the IBA continue to allow their producers and cameramen to indulge in flashing light techniques, to "hosepipe" their lenses, and — worst of all — to pump zoom lenses back and forth?

Significantly, these are the first pitfalls that a beginner in movie photography is taught to avoid. This in itself should be enough to justify their discontinuance. But their dire effect on very many viewers of the small

screen is a further and even more important reason why they should be discarded forthwith.

V. R. Hartopp,
Northampton.

Editor's note: The Medical Research Council, at its Applied Psychology Unit at Cambridge, is well aware of the risk of epileptic fits caused by watching television. They say that television pictures combine pattern and flicker "to provide one of the most epileptic environmental stimuli and many patients have seizures only, or chiefly, during tv viewing". They have developed a simple optical technique to reduce this danger. It uses two polarized filters, one in front of the tv screen and the other, with opposite polarization, in one half of a pair of spectacles, to prevent binocular viewing. The television picture is invisible to one eye but the rest of the world remains unaffected.

CONTROL OF SOLAR HEATING

Householders who have invested £400-£600 in solar pre-heating of domestic water tend to lose much of the benefit due to heat losses from pipes and tanks, mismatch between panel area, tank capacity and cylinder capacity, mixing of hot water with feed water and other system deficiencies.

There would seem to be a world market for a neat instrument panel, suitable for location in a modern kitchen capable of: scanning, say, five temperatures (and recording one, if possible); indicating pump current; and monitoring pressure drop (to detect lime deposition etc. in water passages). If this panel formed part of a differential temperature control for the pump (and diverter valve, if fitted), so much the better.

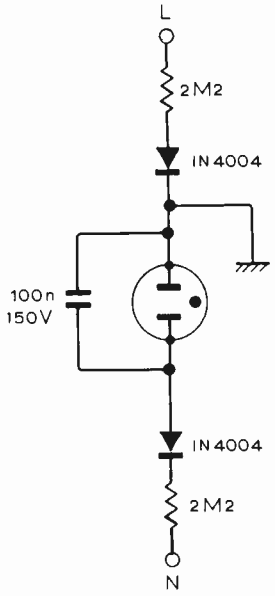
In the present state of solar technology, householders are well advised to optimise their own plumbing, and housewives need guidance in timing their laundry, and the type of person currently investing in solar heating is likely to appreciate any assistance the instrumentation and electronics industries can offer.

K. D. C. Passey,
Derby.

WARNING INDICATOR

A small modification to the "Earth warning indicator" described by R. H. Troughton (Circuit Ideas, April issue) will enable it to give further warnings of potential danger, especially when the layperson is connecting electrical equipment to the mains supply. Connecting wires to the wrong pins so as to produce a hazardous condition would be indicated immediately if the accompanying circuit were fitted in electrical appliances – ahead of the fuse and on/off switch.

As well as warning of an unearthed unit, it will repeatedly flash if the live and neutral wires are reverse connected (meaning usually that the equipment fuse is in the wrong line for full protection). It will flash if the earth wire is mistakenly connected to the live pin of a plug – provided the neutral wire



is connected to either the neutral pin or the earth pin (laypersons usually manage to connect each of the three wires to different pins – it's just that they aren't always the right ones).

Should the earth and neutral wires be connected in reverse, it is not immediately dangerous (where neutrals are made earth potential) but would become potentially dangerous if the neutral wire then became open circuit. The instant this happened, the neon would begin flashing a warning of the danger – and the misconnections.

Possible instructions to the purchaser could read: "After fitting the plug (follow the colour coding carefully), stand away from the appliance, plug into the wall-socket and switch on. Do not touch the appliance if the warning lamp is flashing – Simply switch off, pull the plug and recheck the connections. . . .

Ralph Lewis,
Liverpool 7.

ELIMINATING ADJACENT-CHANNEL INTERFERENCE

Congratulations to Mr P. L. Taylor for his work on interference elimination (July issue, pp. 55-57). I am delighted to see that research into this problem area is continuing. Some five years ago I did some work myself in an attempt to discover whether the symmetrical sideband structure of a.m. could be used firstly to identify and then to eliminate co-sideband interference. Particularly motivating of course was the realisation, shared no doubt by every radio engineer that ever was, that a solution would represent perhaps the most important development in radio spectrum utilisation since the thermionic valve. Unfortunately the work was purely theoretical but only because, unlike Mr Taylor, I never reached the stage where I felt I had a workable system.

The way Mr Taylor obtains the 90° phase shift in the unwanted channel (in the first method), that of multiplying by twice the (translated) carrier frequency, is particularly neat. I agree that this re-arranges the sidebands and carrier together in a quadrature shift strongly suggesting that a subtraction from the "wanted" signal channel in Fig. 4(c) is all that is required. Sad experience has taught me, however, to beware of the obvious in cases like this as things are seldom what they seem.

If we examine Taylor's series S_1 $(W-U)$ and the effect of multiplying a general case signal sin ω by this in demodulator 3, we discover

$$\sin\omega \times S_1(W-U)$$
$$= \tfrac{1}{2}[\cos[\omega-2(W-U)] - \cos[\omega+2(W-U)]$$
$$+\cos[\omega-4(W-U)] - \cos[\omega+4(W-U)]$$
$$+ \ldots$$
$$+ \cos[\omega-2n(W-U)] - \cos[\omega+2n(W-U)]$$
$$\ldots (1)$$

Putting $\omega=(W-U)$ for the unwanted carrier gives

$\sin (W-U)\times S_1 (W-U)=\tfrac{1}{2} \cos (W-U)$, the result quoted by Mr Taylor.

However, this is a special case. Whilst we are certainly interested in eliminating the carrier whistle (although there are several ways of doing this), what we are really after are the sidebands.

Look at it this way: multiplying simply by 2 $(W-U)$ certainly gives a term in 3 $(W-U)$ but this is not strictly a harmonic. It is a sum component equal to $(W-U)+2\ (W-U)$. The series in my equation (1) contains sum and difference terms centred on every harmonic of 2 $(W-U)$ up to the n^{th}. Therefore any given non-zero sideband component of U will appear on each side of 4 $(W-U)$, 6 $(W-U)$ etc. and could, if $(W-U)$ is low, be difficult to filter out. What is most difficult, however, is the difference frequency corresponding to 2 $(W-U)-\omega$.

Without recourse to maths it can be seen intuitively that demodulator 3's output spectrum is inverted: the upper output sideband being caused by the lower input sideband. This means we are relying on the upper sideband of U, transposed by demod. 3, to cancel its lower sideband at the output of demod. 1. The reason for the symmetry mentioned by Mr Taylor is now clear, not only in the wanted signal but in the interfering signal as well. If the sidebands are out of balance in either phase or amplitude they can't cancel each other.

My Fig. 1 shows the relationship between the unwanted spectra at the outputs of demod. 1 and demod. 3. A lower sideband component (after reflection) at (i) in (a) is transposed to the position (ii) above 2 $(W-U)$ in (b) where it can cancel the symmetrically corresponding component at (iii) in (a). In addition, however, from equation 1, a component due to this frequency appears *below* 2 $(W-U)$ at (iv). This is a lonely component as it has no counterpart in (a) to cancel it, so it appears as an unwanted sideband in the output. All is not quite lost yet, because, as drawn, the lowest frequency component is above the highest wanted sideband component and stands a chance of being filtered out. Where you're really stuck is where this lies within the audio bandwidth or baseband or W, and the limiting condition for this is

$$(W-U)=2b/3$$

where b is the half-bandwidth of each signal (assumed equal).

If the interfering signal is any closer than this, it is not possible to remove it. As an example for medium wave reception where $b=4.5$kHz the closest spacing $(W-U)$ is 3kHz, only 1.5kHz better than single-sideband reception.

Having identified this as a filtering problem which is more acute than that of

removing 3 ($W-U$) and higher, it may be better to replace the complex function generator by 2 ($W-U$) obtained by simply doubling the p.l.l. oscillator output.

I seriously wonder, though, given the relatively limited range of protection, the requirement (very difficult to satisfy!) of strict symmetry in the *interfering* signal and two phase-lock loops to worry about, whether a conventional "phasing method" s.s.b. demodulator might not be a better bet in a practical world. This gives first class elimination of interference anywhere in one sideband from any number of signals (including noise) and works excellently with practical (i.e. fading and asymmetric) signals, both wanted and unwanted. It is not, strictly speaking, single sideband reception ... but that's another story.

A. J. Henk,
Surbiton,
Surrey.

SUPERIOR SOUND OF MOVING-COIL PICKUPS

While investigating the feasibility and costs of building a moving-coil head amplifier recently a thought occurred to me which may help explain the current supposed superiority of moving-coil cartridge/head amplifier combinations.

It is well known that the various types of pre-amplifier equalisation stages, i.e. series feedback, shunt feedback, passive equalisation and buffered input, have different "sounds" (as well as different signal-to-noise ratios), even though they may have identical sinewave responses.

A possible reason for the different sounds may lie in the fact that whereas such input stages are usually tested with a constant impedance source (oscillator), they are used with a variable impedance source (cartridge).

Since the inclusion of a head amplifier changes the mode of input of the pre-amplifier from a variable to a constant impedance source, might it not be this that provides the "superior" sound from moving-coil cartridges rather than any significant difference in the cartridges themselves?

Also, as amplifiers are now tested into "realistic" output loads (8Ω/1μF), might not a case be made for testing the phono inputs with a "realistic" source impedance, say 500mH in series with 600Ω?

R. B. L. Hood,
Bovingdon,
Herts.

RADIO AND AIR SAFETY

May I comment on the letters from Messrs Keall and Wiltshire in the August issue concerning the audio quality of aircraft communications? Everything, of course, is relative and I recall my days with early Service equipment when the quality was so appalling that the use of a phonetic alphabet was essential and every digit had to be repeated as a sequence (e.g. three-four-FIFE). Then came the transformation of v.h.f. (to the eternal credit of RAE Farnborough), the enhanced clarity of communication having such a marked effect on our air operations, not the least because it allowed our development of r.d.f. to be exploited to the full. Since then, however, we seem to have made little advance in the transmission of intelligence by speech and little technical progress save in physical size of equipment and in a reduction in aircraft background noise levels by virtue of substituting gas turbines for piston engines. Even so, the quality of speech reproduced does not compare with that enjoyed by the mariner using f.m. and Mr Keall's argument that "the capture effect of f.m. would be undesirable since it can be important for a weak and distant transmitter to be able to break into a crowded channel" applies equally to the marine case as to the aircraft.

I have no wish to foster the argument between the relative merits of a.m. and f.m. since Mr Keall hits the proverbial nail on the head by his advocacy of L-band data links as offering the best prospect for improvement and one might, with advantage, direct some of Mr Wiltshire's condemnation of British bureaucracy towards slowness of development in this area rather than in that of speech communication — though tempering it by adding that American diplomacy based on American vested interests has been the greater offender.

You were right to draw attention to this subject in your June 1977 leader and I suggest the answer lies in realising the limitations of speech as a medium for operational commands and information as opposed to speech for social and artistic purposes; aircraft communications should be confined to operational necessities transmitted as data to eliminate the need for speech, or, at least, to reduce the required number of channels from the present ridiculous figure of 720 and make the national development of suitable equipment less costly than it now is.

Finally, let us not delude ourselves over the international use of "our" language for aircraft communications. It so happens that a version of English is in transatlantic use, otherwise our pilots could well have been obliged to learn, for example, Spanish or Dutch, had the course of history been different.

R. T. Townson R.A.F. (ret'd)
Reading,
Berkshire.

Editor's note: Early experimental work in the USA on data links suggests that pilots will not find visual data acceptable as an alternative to voice communication but only for back-up or confirmatory purposes.

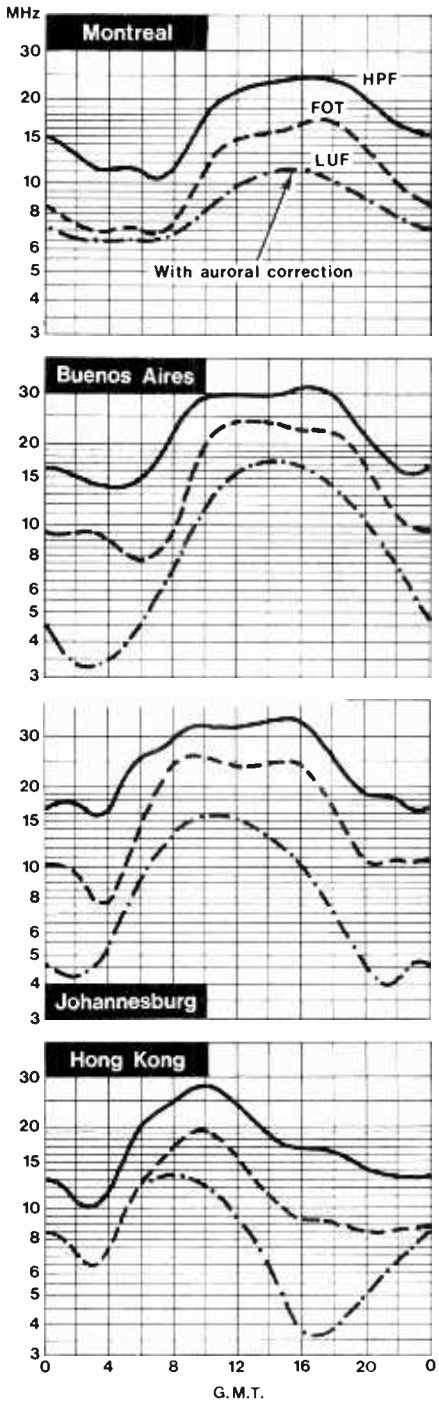
INTRUDER ALARM: RISK OF DAMAGE

As I have some experience of the Mullard CL8960 module, used in the microwave intruder alarm (July and August issues), I suggest that any reader handling the module should take particular care with the BAV46 mixer diode. As the author mentioned in the July issue, the mixer could be damaged by mains transients. The mixer diode is sensitive to static discharges and precautions should be taken similar to those for c.m.o.s. integrated circuits. Nylon clothing should not be worn, nor polystyrene packing material placed in the vicinity of the module. An earthing strap connected to the person would be advisable.

John M. Cotterill,
Didsbury,
Manchester.

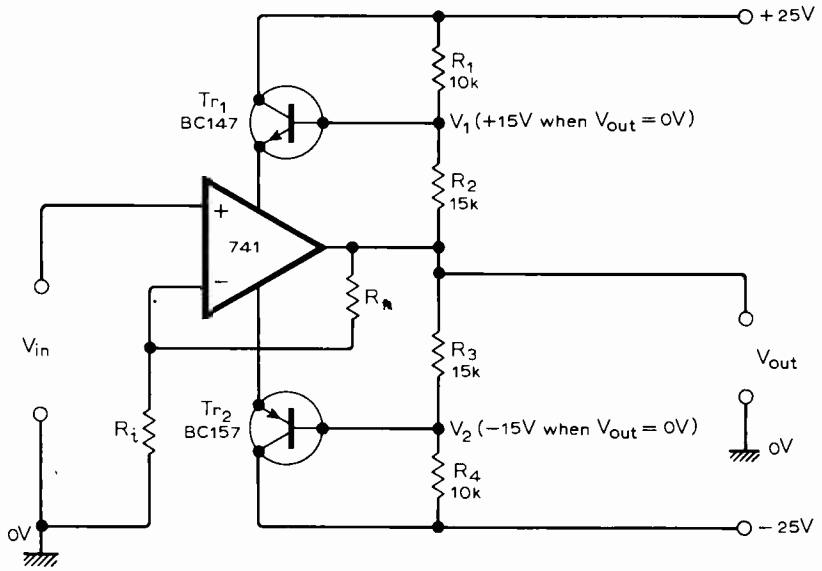
HF predictions

Circuit reliability is the product of the probability of ionospheric reflection and the probability of achieving a desired signal to noise ratio and is thus at a maximum somewhere between FOT and LUF. The term FOT, which is the French equivalent of OWF (optimum working frequency), is thus a misnomer since it relates only to skywave probability. However since LUF is dependent on many factors which cannot be generalised it is found satisfactory in practice to take FOT as being what it says it is.



Circuit Ideas

Increased output voltage for op-amps



The circuit shown uses a 741 i.c. and will produce a typical peak to peak output voltage swing of 37V using a ±25V supply. Power is supplied to the i.c. by Tr_1 and Tr_2 whose bases are kept 30V apart by the divider chain. As the output voltage varies, the current in one half of the divider chain increases and the current in the other half decreases by the same amount. This causes the potential between the bases of Tr_1 and Tr_2 to remain constant and allows the power supply for the i.c. to vary between the limits of ±Vcc in sympathy with the output signal. For the non-inverting amplifier shown

$$\frac{R_1}{R_2}=\frac{(+V_{cc})-V_1-V_{out}}{V_1-V_{out}}$$

and

$$\frac{R_4}{R_3}=\frac{(-V_{cc})-V_2-V_{out}}{V_2-V_{out}}$$

and gain

$$=\frac{V_{out}}{V_{in}}=\frac{R_f+R_i}{R_i}$$

The gain must not exceed a value dependent upon the output voltage swing otherwise the input voltage will exceed the power supply voltage of the i.c. Therefore,

$$\text{Gain}\leqslant\frac{V_{out\,pk}}{\dfrac{R_4\,(V_{out\,pk}-(-V_{cc}))}{R_3+R_4}+a+(-V_{cc})}$$

for positive half cycles, and

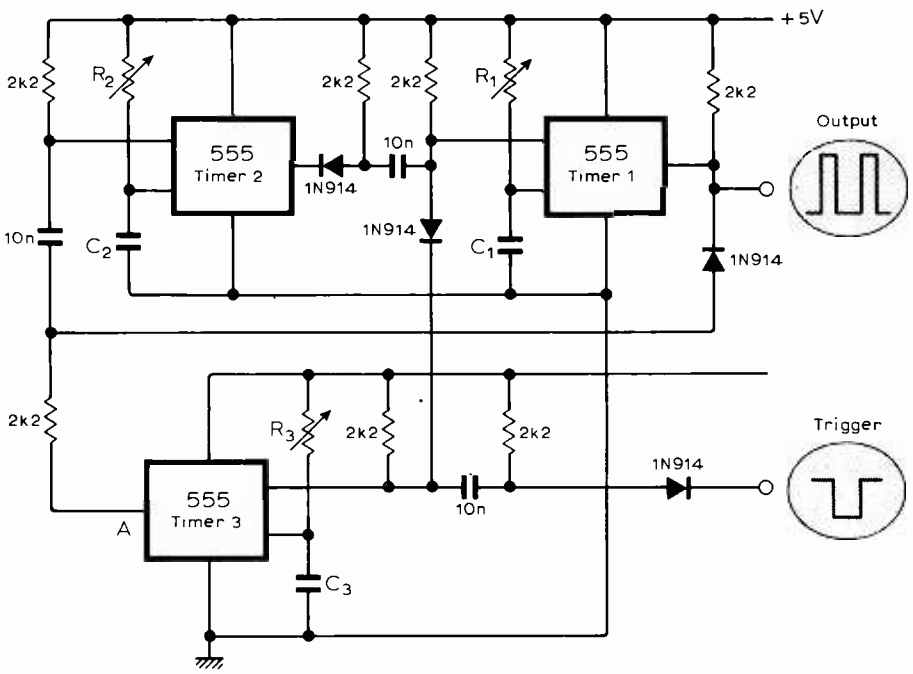
$$\text{Gain}\leqslant\frac{V_{out\,pk}}{\dfrac{R_1\,(V_{out\,pk}-(+V_{cc}))}{R_1+R_2}-a+(+V_{cc})}$$

for negative half cycles, where $-a$ is absolute maximum input voltage − input voltage range (3V typical) and $V_{out\,pk}$ is peak output voltage.

Further restrictions are imposed if the amplifier is connected in the inverting mode because the i.c. inputs are always at 0V and therefore the power supply voltage can only swing by ±12V.

Colin D. Ride,
Mickleover,
Derby.

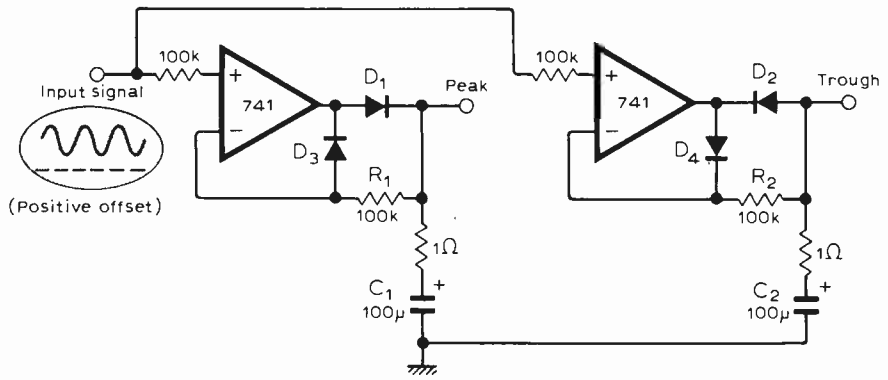
Pulse train generator



The circuit shown will generate a pulse train in which the pulse duration, pulse interval, and number of pulses can be varied independently by setting the time-constants R_1C_1, R_2C_2 and R_3C_3, respectively. When a negative-going trigger pulse is applied, timers 1 and 3 are activated. With A high, T_2 is triggered at the end of T_1 timing interval, and T_1 is triggered at the end of T_2 timing interval. A train of pulses is generated at the output. When A goes low at the end of T_3 timing interval, T_2 can no longer be triggered by T_1. The pulse train ends when T_1 completes its last timing cycle.

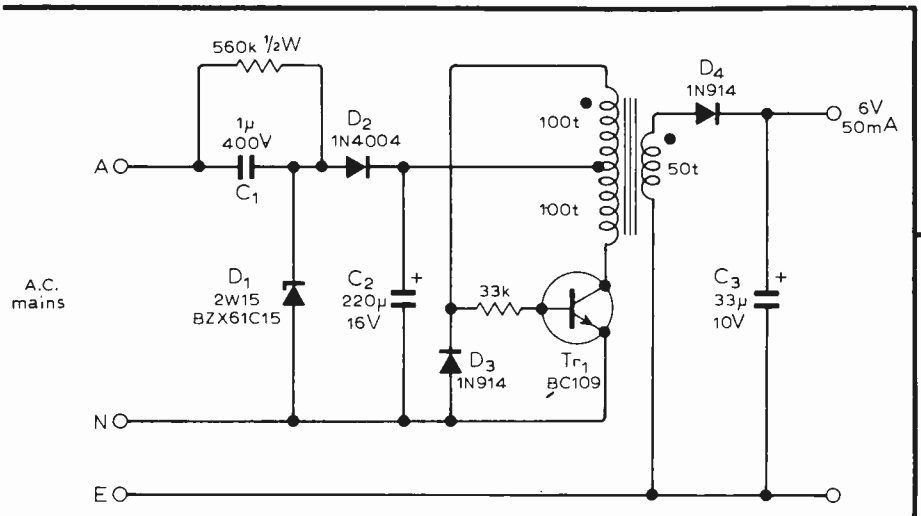
Dr N. H. Sabah,
American University of Beirut,
U.S.A.

Precision peak and trough detector



This circuit uses only two op-amps to detect the peak and trough voltages of a non symmetrical waveform. The peak detector is fairly conventional, but the trough detector uses a similar circuit with the diodes reversed. During the trough period, D_2 conducts discharging C_2 quickly to the lowest trough voltage. However, C_2 will only charge slightly via D_4, R_2 during the positive peak thus retaining the trough voltage. The 1Ω resistors are necessary to prevent overshoot.

C. Spain,
Walton-on-Thames,
Surrey.



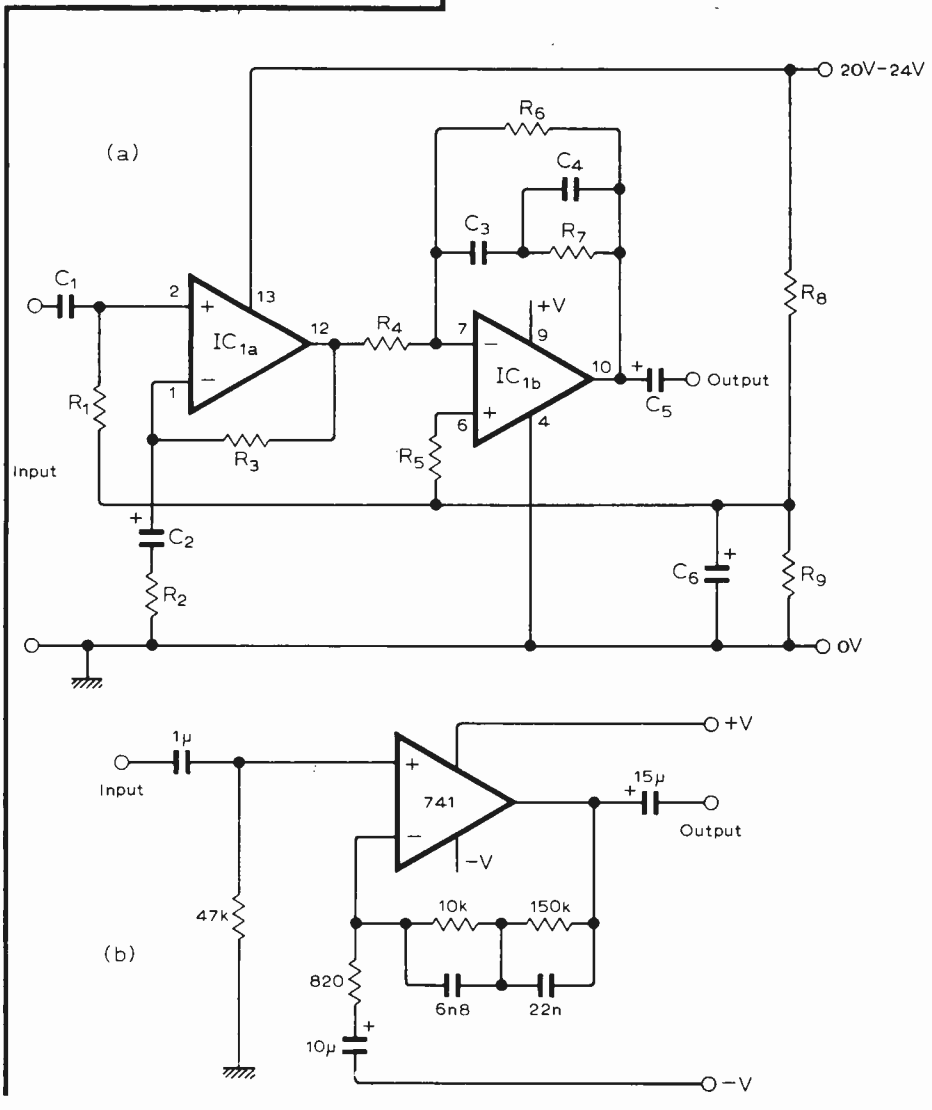
Low noise RIAA amplifier

The circuit shown in Fig (a) offers a 12dB improvement in signal to noise ratio compared with the more traditional circuit in (b).

Miniature switch mode power supply

This unit was designed to fit into the battery compartment of a small transistor radio or calculator. In operation C_1, D_1 and D_2 produce 15V d.c. across the smoothing capacitor C_2. This forms the supply for a one transistor inverting circuit and D_3 returns the magnetising current to the supply during the negative half of a cycle. The output is isolated from the mains input and, provided that the transistor and D_1 have sufficient heat sinking, will stand an indefinite short or open circuit. An inverter frequency of 13kHz permits the use of a small transformer such as the Phillips P14/8 337 pot core. Wire size should be 37 gauge and the primary windings are bifilar. The unit requires an earthed shield to reduce radiated switching noise.

M. Faulkner,
Queanbeyan, N.S.W.,
Australia.

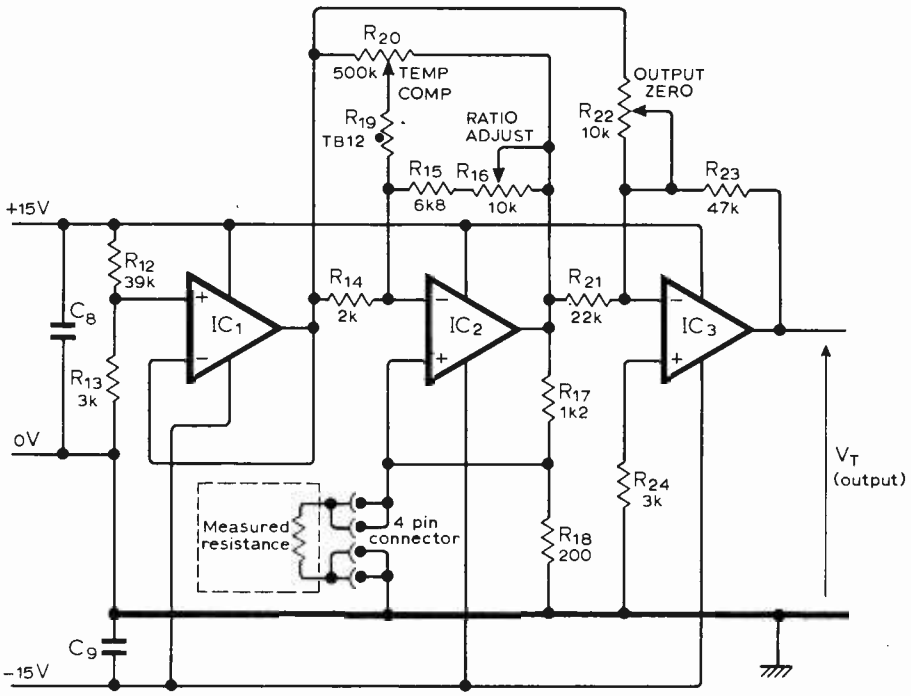


Linear resistance bridge

In general, resistance bridge networks are only approximately linear. This circuit uses an operational amplifier in a positive feedback mode to provide a linear resistance-input/voltage-output characteristic. Two per cent metal film resistors throughout the circuit reduce temperature effects to very small proportions, but to reduce it even further a thermistor network is added to the circuit. Output voltage V_t has any bias present removed by adjustment of the zero potentiometer.

Although the circuit has very good linearity characteristics, resistance probes are not linear with temperature. However, the output of the circuit could be scaled to some convenient value say 1V per 100 deg C to give a reading directly related to temperature.

G. J. Phelps,
Swindon,
Wilts.



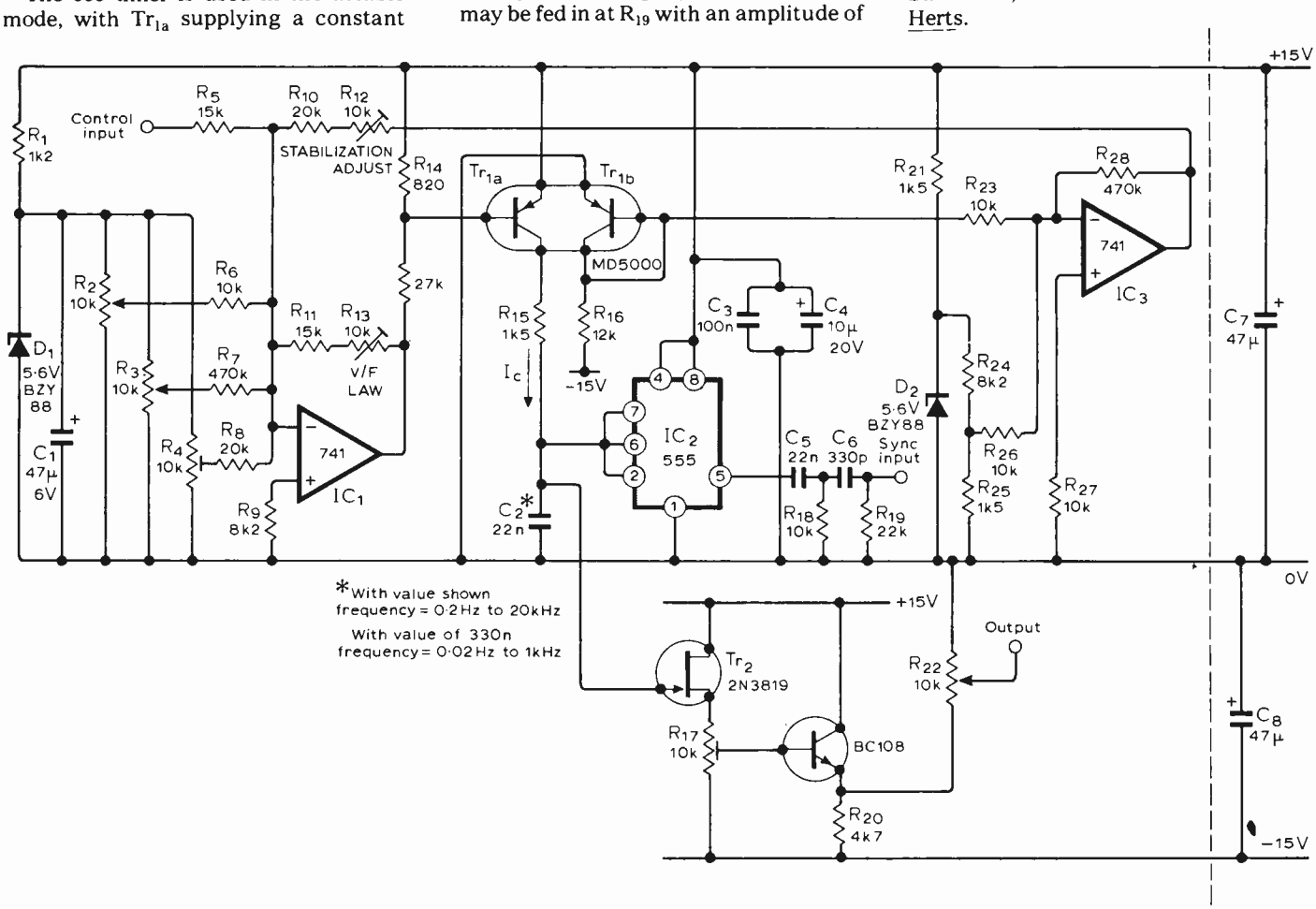
Voltage controlled oscillator

This exponential law voltage-controlled oscillator, which produces a linear ramp output waveform, is based on a circuit idea by J. L. Bride, *Wireless World* June, 1976. This design is perhaps more suitable for use in sound synthesizers because it has high frequency stability and a provision for synchronization to another oscillator.

The 555 timer is used in the astable mode, with Tr_{1a} supplying a constant current to C_2. If the temperature rises, the V_{be} of Tr_{1a} and Tr_{1b} falls at a rate of about 2mV per deg C. The fall in V_{be} of Tr_{1a} is fed back via IC_3 to IC_1 and causes the applied V_{be} of Tr_{1a} to fall which keeps I_C constant. Preset R_{12} adjusts the amount of feedback, and hence the temperature stability. The circuit exhibits a maximum instability of ±0.1% to ±0.2% over a 24 hour period. Both R_{12} and R_{13} should be multi-turn components.

A synchronizing square wave signal may be fed in at R_{19} with an amplitude of 5 to 10V pk. This signal is differentiated and the resulting spikes control the threshold voltage of the 555. Resistor R_4 sets the minimum frequency, R_{22} sets the average output level to zero volts, and R_2, R_3 provide coarse and fine frequency controls respectively. Equivalents for the MD500 are a BFX11 or BFX36. If either of these are used, R_{25} should be reduced to compensate for the lower V_{be}.

T. W. Stride,
St. Albans,
Herts.



Low distortion oscillator

2 — Constructional design

by J. L. Linsley Hood

The basic oscillator design was described in the first part of the article, with the modifications to the normal Wien bridge circuit. Because this design is very suitable for the construction of a battery operated instrument, constructional details of a portable unit are given. A few modifications have been made to the basic circuit, for reasons of practical convenience, and these are noted where appropriate.

Output attenuator

It was mentioned previously that the desired output impedance for an instrument of this type was 600Ω, and this is provided on all ranges, except the 0 to 1V, by a resistive transmission line attenuator. However, the impedance from the 0 to 1V output will vary from zero, at the minimum output setting of the potentiometer, to 800Ω. If a twin gang potentiometer is used, with the second gang connected as a variable resistance, shunted by a fixed resistor in the line to the 1V output point, a reduced range of output impedance values can be arranged. For example, with a 2.2kΩ second gang, shunted by a 680Ω fixed resistor, the output impedance would range from 519Ω at zero output, to about 1250Ω at the maximum impedance point, and down to 680Ω at the maximum setting. This arrangement is shown in the circuit diagram.

Squarer circuit

It is very convenient in audio work if a good square-wave output is also available from the oscillator. This waveform can be derived from a sinewave by using successive stages of amplification in a c.m.o.s. 74C04 hex inverter or similar i.c.

To obtain automatic balancing of the mark-to-space ratio, the first stage is made self-biasing as a d.c. unity-gain amplifier, by a 1MΩ resistor connected between the input and output. Because the a.c. gain of each inverter stage is at least 100, the overall gain of the four stages in series is about 10^8. The two output gates are connected in parallel to obtain a lower output impedance. The output stages are driven from one state to the other by very small excursions from the mid-point value of the 3V pk-to-pk input signal. A typical rise and fall time from such a configuration is 200ns, which is adequate for audio work. If very fast transition times are required for logic applications, the output signal can be used via a suitable interface device to drive a conventional t.t.l. element. Care is needed in the layout and termination of high speed circuitry if the potential rise and fall times are not to be degraded.

H.f. loop correction

Any amplifier system having several stages within the feedback loop is prone to unwanted parasitic oscillations unless gain/phase correction is operative in those regions where the phase shift approaches 180°. In direct coupled systems the l.f. phase shifts can be ignored, but the h.f. phase shifts may be troublesome, and can cause the problem of "squegging". In this circuit a small capacitor of between 33 to 100pF is connected across the source and drain of the bootstrap f.e.t. Because the capacitor required will depend on the stray capacitance, it is difficult to predict the value necessary. To preserve the circuit gain, and lowest t.h.d. for the highest practical frequency, this capacitor should be the smallest value which avoids "squegging"; therefore, some experimentation is worthwhile.

In the original circuit the gate of the bootstrap f.e.t. was connected to the emitter of the input transistor. This configuration gives the highest loop gain and the lowest distortion in the 100Hz to 2kHz region. However, the value of capacitor between the source and drain of the f.e.t., which is necessary to give the required h.f. loop compensation, is greater in this case than if the gate of the f.e.t. and the base of Tr_1 are connected in parallel as shown in the circuit. The author's prototype used the last mentioned configuration to produce a less rapid increase in t.h.d. towards the high-frequency end of the operating range.

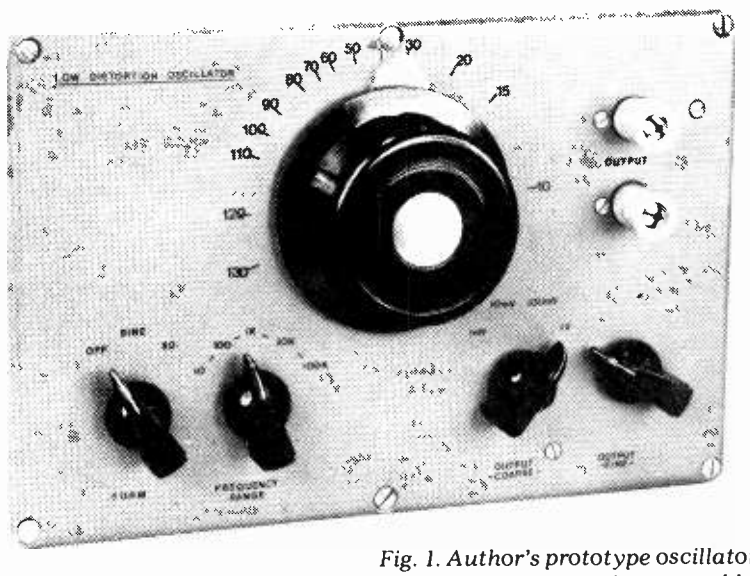


Fig. 1. Author's prototype oscillator. The complete instrument is powered by two 9V batteries which fit inside the case.

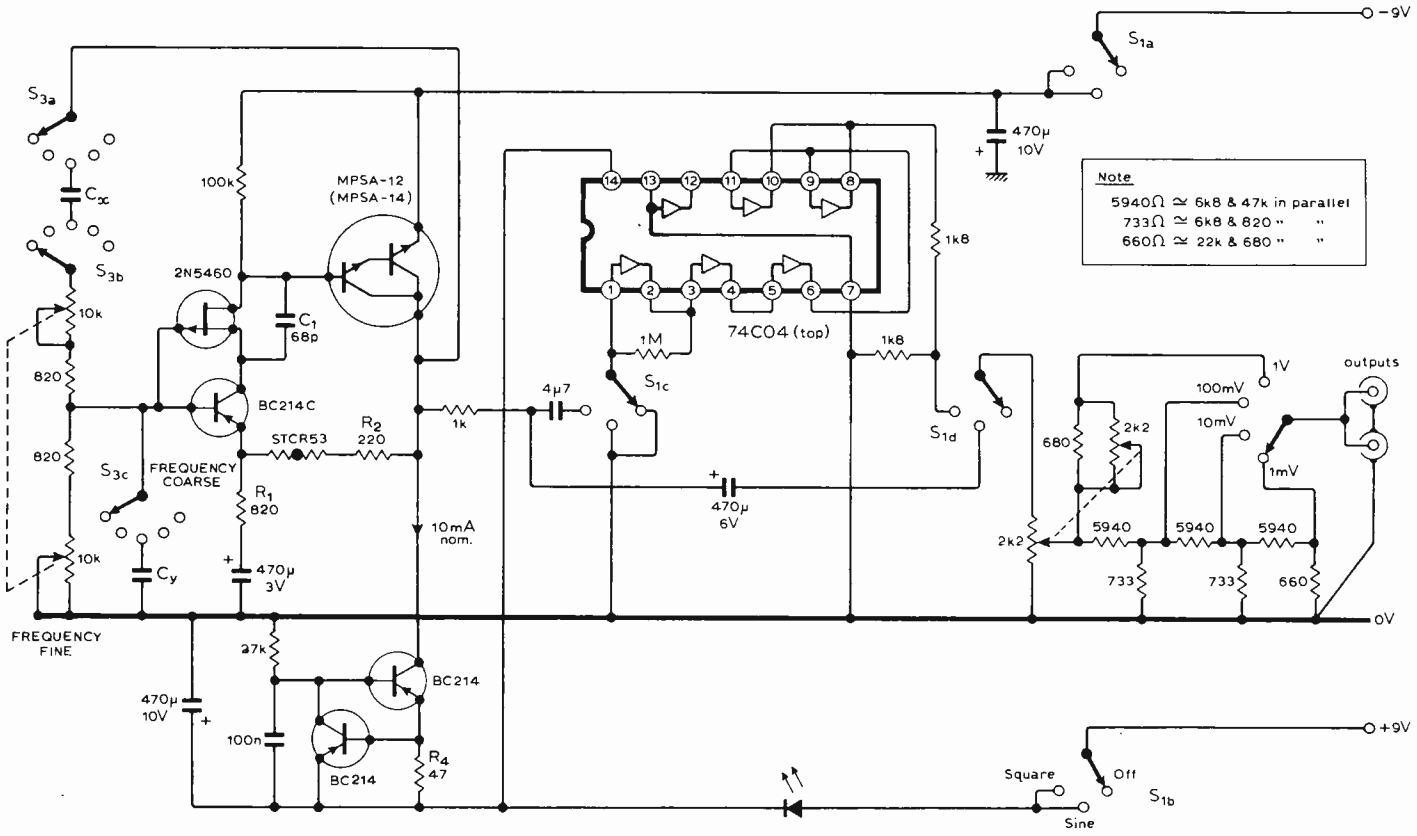


Fig. 2. Full circuit as used in the author's final prototype.

Amplitude stabilization

The problem of amplitude stabilization with low-distortion oscillators generally arises because any low distortion system approximates to a high Q tuned circuit. As a result the oscillator can only respond slowly to a step-function change in amplitude. A voltage sensitive device such as a thermistor, which provides a convenient method of amplitude stabilization when used in a feedback network, must also have a long time-constant. Therefore, negative feedback applied to a low distortion oscillator through a long time-constant voltage dependent device, results in a second order feedback system, whose response when switched on is a characteristic overswing, followed by a damped train of excursions about the final value.

It is undesirable to resolve this dilemma by increasing the t.h.d. of the oscillator, so various artifices are used in practical designs to overcome the difficulty. In this circuit the cold resistance of the thermistor is reduced to a value approaching its normal operating condition by passing the 10μA emitter current of Tr_1 through the device which pre-heats it. In addition, a small fixed resistor is connected in series with the thermistor to limit the lower, hot, circuit resistance value.

Construction

For reasons of practical simplicity the oscillator was built in a standard die-cast aluminium alloy box measuring 22×14.5×6cm. The unit is powered by two PP7 9V batteries which fit conveniently in the box. Frequency control is by a twin-gang 10kΩ potentiometer. If a logarithmic law is used and connected so that the minimum resistance value occurs when the control is turned anti-clockwise, the final frequency scale will be more linear than if a linear potentiometer is used. Also, if the limit resistors R_2 and R_3 in Fig. 4 of the first article are reduced to 820Ω, the 1 to 10 range required from this control can be accommodated in a 180° swing which avoids any overlap of the scales.

The frequency range capacitors can be mounted between the tags of the three-pole four-way wafer switch to minimise stray capacitance. Although the suggested values for the capacitors are in the 1.47 series, made up by paralleling 1μF and 0.47μF etc, an adequate alternative is the 1.5μF component range.

Two output sockets wired in parallel are used to allow the connection of an oscilloscope. In the case of stereophonic equipment, the two signals can be applied to both channels simultaneously. Note that this is only suitable when the two inputs have a high impedance, and do not have any significant voltage or current feedback.

As current consumption of the circuit is approximately 10mA on sinewave, and about 15mA on square wave, battery life should be adequate for normal use.

Calibration

In the absence of a frequency counter, the oscillator may be calibrated on the 100Hz to 1kHz range by Lissajous figures on an oscilloscope, with an input to one axis derived from the 50Hz mains supply. If the components are of reasonable quality, the other ranges should have a similar scale pattern. Alternatively, the mean resistance value of the two halves of the potentiometer can be measured and the frequency of the oscillator calculated, assuming accurate values for the capacitor and for R_2 and R_3, using the formula $F = 1/2\pi RC$. The overall frequency stability of the instrument is very good, which makes it suitable for low distortion measurements using a sharply tuned notch circuit.

Printed circuit board

A p.c.b. which accommodates the Wien bridge oscillator, frequency range capacitors, square wave generator and output attenuator will be available for £3.00 inclusive from M. R. Sagin at 23 Keyes Road, London, NW2. The board follows the author's complete circuit as shown.

Correction

In the article 'Amateur radio equipment — 1' on p.64 of the August issue, the stability figure for the Eddystone 1001 receiver was shown as "one part in 10 per dec. C". This should have read "one part in 10^4 per deg. C."

News of the Month

Europe closer to own space communications

By 1980 the European Space Agency hopes that its European Communication Satellites (ECS) programme will offer a system which can route most of the expanding telephone, telegraph and telex traffic within Europe via satellites, as well as relaying Eurovision tv programmes. In the ten years after 1980 traffic forecasts show that the number of telephone circuits needed will increase from 5,000 to 20,000. A 1970 report estimated that between one and two thirds of all long distance telephone links of over 1,200 km could be handled by satellite after 1980. In addition the European Broadcasting Union want a permanent allocation for two wideband repeaters able to transmit high quality television. At least one large earth station will handle telephone and tv traffic in each of the countries needing the services, though some earth stations in, for example, the Middle East and North Africa, will only handle television.

After years of preparation the experimental forerunner of this service, the Orbital Test Satellite (OTS) is due for launching from Cape Canaveral on September 8. OTS will be placed in stationery orbit at longitude 10°E and will carry out a number of tests to confirm the soundness of the satellite's design. OTS is an assembly of modules: an aerial assembly, payload module, service module and solar array. ESA want the number of possible applications of the satellite to be as large as possible with minimum alteration to the design for different missions.

ESA hope that the maritime communications satellite, due to follow OTS into orbit later this year, will provide early proof of the flexibility of the satellite's design. ESA also have their eye on direct radio and tv broadcasting, offshore communications, data transmission, teleconferencing, and educational television distributed between small ground terminals instead of being broadcast.

OTS will test propagation, frequency re-use by signal polarisation, transmission impairments, and time division multiple access. Its six transmit and receive antennae will have three coverage zones: a moveable spotbeam focussed on, say, central Europe, and two wider coverage beams called Eurobeams A and B. The signals will be processed through two communications modules, for which the prime contractors are AEG-Telefunken. Module A has four transmission-reception channels, two each of 40MHz and 120MHz, and Module B has a single 5mHz channel. Each of the two channels of the same frequency are polarised mutually perpendicularly. The transmission frequency is 11 GHz, and the receive frequency is 14GHz. ESA say it is the first communications satellite to operate in these frequency regions, most others operating around 4 to 6 GHz.

The European Communications Satellite programme began ten years ago. In the early stages a number of projects were considered, including a television broadcasting satellite for the EBU, but in November 1969 it was decided to study a common radio and tv distribution mission. The Conférence Européene des Postes et Télécommunications (CEPT) and the EBU prepared a report showing the future growth of telecommunications from 1975 to 1980 and the satellite capacities they would need. Meanwhile on June 6, 1967 France and Germany had agreed to go ahead with an initial experimental satellite, Symphonie, and Italy had a programme of their own for a Sirio satellite, also begun in 1967. It was only later, in December 1971, that the European nations entrusted the European Space Research Organisation, later ESA, with a programme of satellites to meet the needs of the CEPT and EBU. Symphonie and Sirio were to continue but they then suffered delays, in Symphonie's case because the Europa 2 European rocket which was to have launched it was abandoned because of an explosion shortly after a test launch. The Franco German CIFAS consortium then had to rely on the Thor Delta 2914 launch vehicle. As a result of the various delays Symphonie, Sirio and OTS are all to operate at much the same time — Sirio's launch was recently rescheduled for August 11 because of the same problems that have hit the rest of ESA's programme.

The prime OTS contractors are Hawker Siddeley Dynamics, part of British Aerospace. Hawker are co-ordinating the engineering of the vehicle by other members of the MESH consortium which comprises Matra of France, Erno of Germany, Saab of Sweden, Selenia of Italy and Hawkers. The original launch date had been June 16 but delays were caused first by the failure of Geos (see *WW* August, p.33) and an accident causing damage to the OTS launcher in the early hours of May 18, when one of the nine solid fuel booster rockets fell to the ground after a bolt sheared. As it fell it damaged the first stage, which then needed replacement. According to one source there have also been difficulties within McDonnell Douglas, who supply the Thor Delta 3914 launch vehicle. ESA's Meteosat project, originally scheduled for September 15, is now retimed for launch on November 3.

Teletext now a permanent service

The Home Office has told the set makers' association, BREMA, that the official attitude of the government on broadcast teletext services (Ceefax and Oracle) is that they "are here to stay". This acknowledges a situation which has existed effectively for some time. Experimental transmissions were authorised for a two-year period starting in September 1974, and these merged into a form of service which, in November 1976, was authorized to continue up to 31 July 1979, when the BBC's charter and the IBA's licence expire.

Teletext prototype receivers were shown by major UK television receiver manufacturers at the HEDA exhibition at the National Exhibition Centre, Birmingham, in May 1976 (*WW* August 1976, p. 30). This year teletext will be featured and the Berlin radio and tv exhibition by British and other manufacturers to satisfy the considerable interest that exists in Germany. There has been international interest in teletext, and several countries, particularly those in the European Broadcasting Union, are making their own assessments. But so far there is no other regular service of teletext transmissions comparable with those in the UK. (See *WW* **July 1977, p.49)**

BREMA say that they expect substantial quantities of teletext receivers will be in the hands of the public by Spring of 1978.

The IBA on Annan

In comments to the Home Secretary recently, the IBA paid tribute to the work of the Annan Committee and to the quality of its report on the future of broadcasting. Although they agreed with most of the report they made recommendations for the areas in which they differed. These differences, in most instances, concerned the means rather than the ends. In addition, the Authority stated that there were passages in the report where they found inconsistencies, "where the conclusions or recommendations appear not to follow from the argu-

ment, or where evidence appears to be no more than hearsay."

While acknowledging much of the report's comments regarding relations between broadcasters and the public, the Authority doubted the value of the institutional proposals which it makes. Neither did it share the committee's belief that increased choice and diversity can be achieved by increasing the number of regulating bodies, or that broadcasting should be categorised into three sections, namely: national, regional and local, with the IBA being re-named the Regional Television Authority. The IBA believe that this will not make for greater diversity of programming, and if new bodies are set up on a weak financial basis, the result will be to defer the achievement of the committee's aims.

On the subject of independent local radio (ILR) and the fourth tv channel, the IBA wished to see immediate developments and believed that these advances would go ahead more quickly under their authority than under any new authorities. In short, the IBA believed that it could realise these aims because of its experience and expertise to deal with the complexities of developing local radio.

Local radio programming, the IBA agreed, should seek to serve local needs, with different stations having different characteristics. However, they wished to see a small amount of networked material, for example national and international news, and they thought it important that local radio should finance a national news service.

While agreeing that educational broadcasting has a place in local radio, the Authority had reservations about party political broadcasts because of the problems of allocating suitable quotas of air time to each area without quotas towards strong local parties.

Although most of Annan's recommendations regarding finance were endorsed by the IBA, the Authority believed that it would be imprudent to rely on non-commercial sources to make any sizeable contribution to the funding of new stations, but that by cross-subsidization and the setting up of associate stations, it would be possible to extend local radio to areas that could not otherwise be served.

The Authority also believed that, although frequencies can be found to bring ILR to over 90% of the UK population, the extent of the coverage would depend on other uses being made of available frequencies. They were not convinced, however, that there was room, as the BBC had stated, for 85 BBC stations and 60 or more ILR companies (*WW* June 1977, p. 39), with the IBA and the BBC each operating up to 55 of these on v.h.f. and m.f.

Provided frequencies are allocated such that they do not affect future local radio, the Authority agreed that traffic information could be appropriately carried on local radio.

American military technician inserts a memory disc into the Hughes fault-finding aid prior to repairing electronic equipment in the field.

Interactive servicing

Traditionally maintenance technicians use printed manuals which describe equipment and give procedures for fault finding. For large systems these manuals can form a stack several feet high which is difficult and unwieldy to handle. This problem is avoided by a microprocessor-based fault-finding aid developed by Hughes Aircraft Company which stores the detailed information of the technical manual and allows rapid access to it.

Servicing becomes an interactive process comparable with the use of teaching machines. The aid has a keyboard and display unit, and a microprocessor with a floppy disc memory unit. A few such floppy discs can store all of the fault-finding data contained in a large stack of manuals. To deal with a fault the technician enters a brief description of the symptom, then the aid displays one or more queries, the technician responds, and the aid searches its stored information and displays a list of possible causes and the required corrective action. The system can identify the failure from answers the technician provides and tell which component needs to be replaced, then pictorially show where it is located, and tell him how to change it. It will also state what tools and test equipment are needed and how to use them.

The aid uses a machine language that allows large data base management using microprocessor architecture, while permitting simple English language access to the system. Hughes says the most significant savings from its use will be in the area of technician staffing and training. According to them it allows the use of general technicians on even the most advanced equipment.

Doubts about air-to-ground data links

The International Civil Aviation Organization has reported that the introduction of automatic data interchange systems to v.h.f. air-to-ground communications "has been sensitive to economic pressures" and ICAO say that its work on the development of suitable procedures "has been adjusted accordingly." If a report from the US Federal Aviation Authority is anything to go by these data link systems, which are intended for communication between pilots and controllers, are likely to be sensitive also to the pressure of opinion from aircrew.

The report, "Human factors experiments for data link," describes an assessment of input/output devices for possible use and the reaction of airline pilots to them. The tests were done in DC-9 and B-727 flight simulators, and pilots were principally from TWA and United Airlines. One type of device tested was a short-message air traffic control (s.m.a.t.c.) display mounted on the captain's and first officer's instrument panels. This was found to be easy to read and well positioned, and, with the exception of a small number of commands, the abbreviations used were not considered confusing. In most phases of flight the display was not considered distracting — although most pilots felt that during an instrument approach some distraction was possible. But the s.m.a.t.c. display was not considered effective for emergency or time-critical messages, for, even with an

audio alert, it did not hold the crew's attention well enough under high workload conditions. The display was very popular when used as a recall instrument for information already assigned to the aircraft, such as altitude and airspeed.

Use of a printer appeared to be desirable for longer messages such as a.t.c. clearances, Aerodrome Terminal Information Service information and some company traffic. Paper management problems arising from the printing and line feeding of every message were severe and it would have been highly desirable for crews to be able to obtain copies of only the specific messages they needed.

In comparing the relative desirability of air traffic control by conventional voice, s.m.a.t.c. display, or a voice synthesizer for various phases of flight, the s.m.a.t.c. was slightly preferred in airport traffic areas, with the s.m.a.t.c. and conventional voice being ranked approximately equal in arrival and departure phases.

Comments of pilots taking part in the tests indicated that there was an operational requirement for the continuance of conventional voice communication to supplement the data link communication. Voice was required for pilot/controller discussions, and advice on en-route weather, etc. The report suggested that certain abbreviated voice procedures should supplement the data link to overcome the feeling of isolation expressed by some pilots during pure data link communication and to provide some indication of traffic flow and other events in the surrounding area.

Medium-wave transmitters to be unattended

Not many people realize that the BBC's m.f. broadcast programmes come to them from transmitters which are about 40 years old. It is a great tribute to the Marconi company, who built and installed the transmitters in the 1930s, that they are still going strong. Their main disadvantage, in the light of modern broadcasting methods and economics, is that they need the continuous attention of operating staff. Now they are to be replaced by new transmitters which are fully automatic and designed for unattended operation. These transmitters will be built from standard 50kW units made by Marconi Communication Systems, used singly to provide 50kW, in pairs to provide 100kW or in groups of three to provide 150kW.

Twenty-four of the 50kW transmitters are being supplied under a contract worth nearly £2 million. Twelve of them will be delivered in time for the BBC to make the changes of frequency agreed by the Geneva conference on l.f./m.f. broadcasting frequency allocations (*WW* January 1976, p. 42) which comes into effect on November 23rd next year. All the equipment is due to be delivered by May 1979.

The Marconi 50kW transmitter to be used measures 12ft × 5ft × 6ft 9in, which is less than half the size of its 50kW predecessor. The solid-state design incorporates only four valves, for the high power stages, and it uses an improved version of the Doherty modulation system. The operating frequency range is 525kHz to 1605kHz.

New equipment for interference service

Over eighty 10Hz to 520MHz frequency meters have been ordered by the Post Office for their radio interference service, which they operate for the Home Office. The service's job is to control interference affecting broadcasting radio and television reception in the UK, and the instruments, which will be fitted in the fleet of vans used by the Post Office, will enable operators to make precise measurements so that sources may be identified and the interference abated in the shortest possible time.

Racal Instruments Ltd are supplying the meters, their model 9915, which was designed to a specification drawn up by the Home Office's Directorate of Radio Technology.

"Precise frequency measurement will be essential for dealing with the interference problems raised by the huge growth in international radio communications," said a spokesman for Racal.

The 9915 is an eight-digit frequency meter having a sensitivity of better than 10mV. Extensive use of l.s.i. has greatly improved reliability, it is claimed. Major features include instantaneous input protection, a frequency burst measurement facility for short duration signals, a.g.c. for increased dynamic range and a choice of frequency standards with ageing rates as low as $\pm 5 \times 10^{-10}$ per day. Particular attention has been given to the mechanical design to ensure a rugged construction and excellent r.f.i. performance.

This order comes within weeks of one from the Directorate of Telecommunications for Racal's 9081 synthesized signal generators to be used at the Home Office's regional wireless depots.

Negative feedback jubilee

"I was looking at the Statue of Liberty when the idea crystallized. I quickly sketched a diagram and wrote my equations on a copy of the morning newspaper, which fortunately had a blank page." Thus, Harold S. Black reminisced about the day fifty years ago (August 2, 1927) when, travelling on a Hudson River ferry boat in New York, he had the idea of negative feedback. Black, now retired, was then working for Bell Telephone Laboratories, and the stimulus for the new technique came from the need to design good amplifiers for long-distance telephony. At first the idea was received with scepticism and it was several years in fact before a satisfactory negative feedback amplifier could be developed. But in 1931 a successful field trial of a transcontinental cable telephone system, which used 70 of Black's negative feedback amplifiers, finally silenced the doubters.

The patent on negative feedback, US Patent No. 2,102,671, was then widely licensed by the Bell System to the nascent electronic and control industries, and in January 1934 Black published his now classic paper "Stabilized Feedback Amplifiers" in *Electrical Engineering*. The less well known error correction process of feedforward was invented by Black some time before negative feedback.

Radio set cabinet designers

In preparation for its forthcoming exhibition of early domestic radio receivers "The Wireless Show!", the Victoria & Albert Museum would like to contact designers of radio set cabinets who were working at any time in the period 1922 to 1956. Please contact Mr Carol Hogben, Acting Keeper Regional Services, V & A Museum, Exhibition Road, London SW7 2RL (tel: 01-589 6371). The exhibition will be running from October 20 to December 11.

OBITUARY

John Brinkley, F.I.E.R.E., M.I.E.E., who was well known for his work in the field of mobile radio, died on August 15 after a short illness.

After early training at the Post Office, Mr Brinkley transferred to the Home Office Communications Directorate where, during the war, he was responsible for many of the first mobile radio systems. After the war, he went to Pye Telecommunications in 1948 and in 1956 became managing director. While at Pye, he was appointed a member of the Postmaster General's Frequency Advisory Committee and was a member of the Mobile Radio Advisory Committee. During this period, his involvement with the Mobile Radio Users Association began. On leaving Pye in 1967, he went to Standard

Telephones as executive director of the radio group and eventually became director of ITT world-wide mobile radio activity, being appointed advisor to the American ITT Corporation. From 1971, Mr Brinkley was with Redifon, where he became deputy chairman. Among the many committees on which his advice was invaluable were the Electronic Engineering Association Council (he was chairman of the EEA for eleven years) and the Electronics Economic Development Committee.

Cable radio sites named

In a Commons reply on July 26, the Home Secretary, Mr Merlyn Rees, said that five experimental cable radio stations would be authorised. They will be at Southwark and Thamesmead, London, Basildon, Essex, Newton Aycliffe, County Durham, and Telford, Shropshire.

The announcement came exactly a year after the Home Office announced that they would licence up to six cable radio stations. (*Wireless World*, October 1976, p.44). On both occasions the Home Secretary has spoken in reply to questions from Mr Eric Moonman, the Member for Basildon, one of the five successful sites. A Home Office spokesman said that, although there had been a number of applicants, many of them simply wanted to know what the experiments involved, and several were unable to meet the conditions of the licence, their applications then being withdrawn. The spokesman cited one condition which said "All programmes must be specifically designed to meet the needs of the community" to be served.

Another condition was that the number of hours devoted to pre-recorded music should be limited. In the end the five named were the only ones to make formal applications, the spokesman said.

The Times reported last September that there had been "a rush of applicants" for licences to run cable radio stations under the new scheme. Twenty organisations had already shown interest by the end of August, 1976.

Swindon Viewpoint are to run a lottery to save the cable tv station (WW September, p.49), backed by a large, national betting organisation. As a result Thamesmead Borough Council are to go ahead with a grant of £2,000 for this year, Radio Rentals are underwriting any shortage of funds up to the end of this year, and the Home Office Voluntary Service Unit may come up with a further grant.

College courses

Enquiries about Mr Harry Leeming's amateur radio course at Blackburn should be addressed to The Principal, College of Technology and Design, Fielden Street, Blackburn, Lancs.

The first Amateur class at North and West Farnborough Further Education Centre, Hampshire, will begin on September 22 at 7.30pm. Enquiries to J. Brett, Principal, Cove School, St John's Road, Farnborough.

In Cornwall the amateur course will be at S Mid-Cornwall College of Further Education, Palace Road, St Austell. Mr J. S. Kennedy of the Electrical Department says that the class will be held every Tuesday from September 27, starting at 7pm, and enrolment will take place between 5 and 7.30pm on September 21 and 22.

Enrolment for the Amateur course at Crawley will be on September 14 at 7pm. The course, run by Mr R. Scrivens G3LNM (Crawley 22540), will be at Sarah Robinson School, Ifield, Crawley, West Sussex, starting September 26.

Mr D. R. Loveday (G3FPE) is holding a radio amateurs' course at Gosforth, near Newcastle upon Tyne, starting in September. Enquiries to the principal, Gosforth Adult Association, Gosforth High School, Knightsbridge, Gosforth, or by phoning Mr Loveday on Newcastle 668439.

The South London College telecommunications and electronics department will be running a number of short courses of special lectures at West Norwood starting in October and November. The subjects are basic electronic construction, electricity in the home, teletext systems, and colour television practical servicing. Contact Mr A. A. Rowlands, head of department. 01-670 4488.

A modern filter design course will be held from September 20 to 23 at Portsmouth Polytechnic. Further information from Dr J. N. Torry, department of electrical and electronic engineering, Portsmouth Polytechnic, Anglesea Road, Portsmouth PO1 3DJ.

An integrated circuit design workshop will be held on one afternoon a week for 12 weeks beginning November 9 at the Barking Precinct, North East London Polytechnic. Write to the department of electrical engineering, Longbridge Road, Dagenham, Essex RM8 2AS. (01-599 5141).

Roger Driscoll is running a course on audio design and acoustics at the North London Polytechnic, beginning October 27. Write to the department of electronic and communications engineering, NLP, Holloway Road, London N7 8DB.

Bleasdale computer systems are running a number of training courses in the use of Motorola microprocessors. Enquiries to the course registrar, Bleasdale, 32 Eastway, Morden, Surrey SM4 4HW, 01-540 8611.

The fourth annual conference of the Cybernetics Society will be held on September 13 at the School of Pharmacy, University of London. L. Johnson, department of cybernetics, Brunel University, Kingston Lane, Uxbridge, Middlesex UB8 3PH.

The fourth international conference on digital satellite communications will be held in Montreal from October 23 to 25 next year, sponsored by the International Telecommunications Satellite organisation (Intelsat), Teleglobe Canada, the Canadian Society for Electrical Engineering, and the Canadian Region of the Institute of Electrical and Electronics Engineers. More information from the manager of the administrative office of the conference, Teleglobe Canada, 680 Sherbrooke Street West, Montreal, Quebec, Canada H3A 2S4.

● *continued from page 47.*

of independent body which would arrive at joint proposals on important matters.

As for WARC, most of the European mobile radio manufacturers, in Britain under auspices of the Electronic Engineering Association, have agreed a common approach and are trying to persuade the individual governments to go along with them. Their proposals include the taking over of bands 1 and 3 for mobile radio, and standardisation on 12.6kHz channel spacing. What worries the British industry is that the Home Office is not taking enough heed of these proposals, despite the Government's concern that British policies should take account of international conditions, and the apparent willingness of, for example, the French and German governments to set up joint working parties to see how the proposal could be implemented (*Electronics Weekly*, April 27).

Time is now growing short, since the preliminary submissions to the ITU must be in by October. The feeling among mobile radio men that the Home Office has still not realised the importance of their industry, and that as a result Warden will remain the final form of the British submission, has reached such a pitch that they are wondering whether some hidden military or political force lies behind the Home Office's intransigence. Adding to this feeling is the long decline in the influence of the Mobile Radio Committee, which a decade ago issued mobile radio policy in the form of white papers, and the apparent inactivity of the interdepartmental Frequency Advisory Committee.

All in all the Home Secretary's call for submissions is beginning to be seen as nothing more than an empty political gesture, and the opponents of Home Office policy are seeking political responses as a result. If the Home Office does not publish its October preliminary submission to the ITU, and subsequent amendments to it, the mobile radio industry is likely to press for a Commons Select Committee of enquiry into the process of preparation for WARC, a move that is already being widely canvassed.

Advanced preamplifier additions

Rumble and scratch filter, virtual earth mixer, meter suppression circuit

by D. Self, B.A. *Electrosonic Ltd*

This article describes a number of additional facilities that may be easily added to the preamplifier design published in the November 1976 issue of *Wireless World*. These additions are in the form of independent circuits, one or all of which may be added to a completed preamplifier with a minimum of disturbance to the existing circuitry. Even if all the circuits are incorporated, the extra demands on the stabilized power supplies should cause no problems.

The original design did not include a scratch or rumble filter because it was felt that an attempt to make no compromise in the range of facilities provided, as well as in performance, could lead to a design that was over-complex. Furthermore, use of the treble control in the 5kHz setting was thought to give some of the advantages of a variable-slope scratch filter. Nevertheless, the ultimate slope is only 6dB/octave, and therefore the high-frequency rejection is less than that obtainable with the usual second-order low-pass filter. It should also be noted that the low-frequency response of the original preamplifier was not extended to d.c., but rolled-off in a controlled manner to be 3dB down at 7Hz. However, a good deal of interest has been shown in further filtering facilities, and therefore the design shown in Fig.1 was evolved. This uses a switched-frequency second-order low-pass filter, and a fixed-frequency third-order high-pass filter that discriminates against the subsonic disturbances generated by record warps etc. The last mentioned is not really a rumble filter because it does not attenuate within the audio band. The frequency response is —1dB at 20Hz and —17dB at 10Hz, hence subsonic signals are greatly attenuated without perceptible loss of lower bass frequencies. The filter has a Butterworth characteristic. The low-pass filter incorporates switch-selected cut-off frequencies at 10kHz and 7.5kHz as measured at the —3dB point. These frequencies were chosen after listening to records suffering from varying degrees of damage and wear, and are believed to be a good compromise. The 10kHz filter has a relatively subtle effect which gives a smoother upper frequency response with records that are only slightly past their best. The 7.5kHz setting is effective with more severe cases, while discs in very poor condition may be improved by the use of an even lower cut-off frequency using the treble control. Restricting the low-pass filter to two switched frequencies allows the use of a 3-way 4-pole rotary switch. With the switch in the out position the low-pass filter still operates but the —3dB point is at 40kHz. This prevents

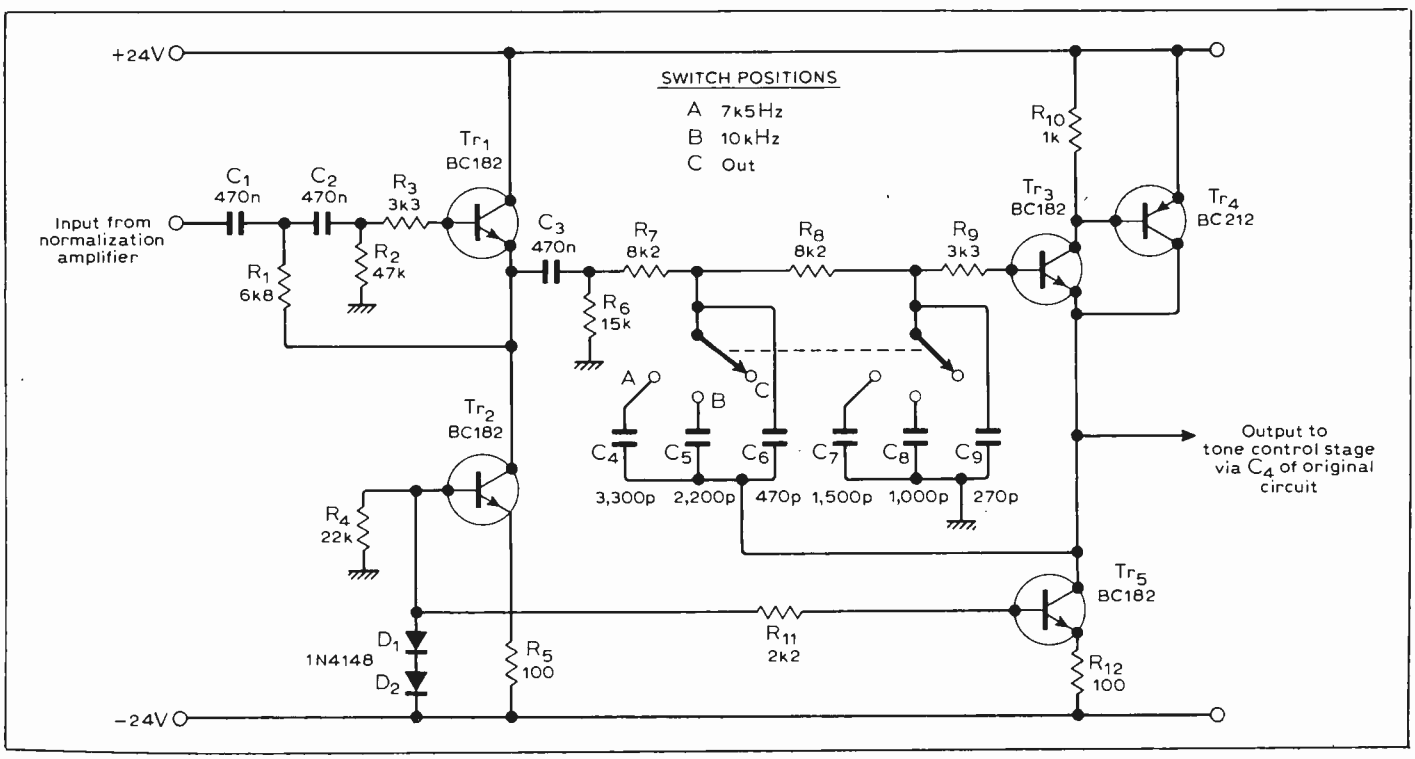


Fig. 1. Rumble and scratch filter. This circuit has a switched frequency low pass stage and a fixed frequency third-order high pass stage.

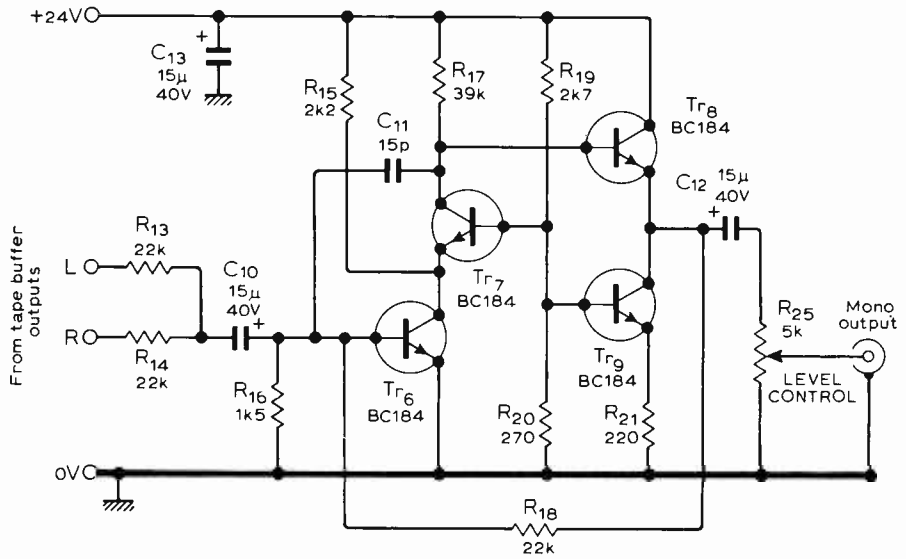


Fig. 2. Virtual earth mixer. This circuit allows simultaneous stereo and mono signals from the original preamplifier.

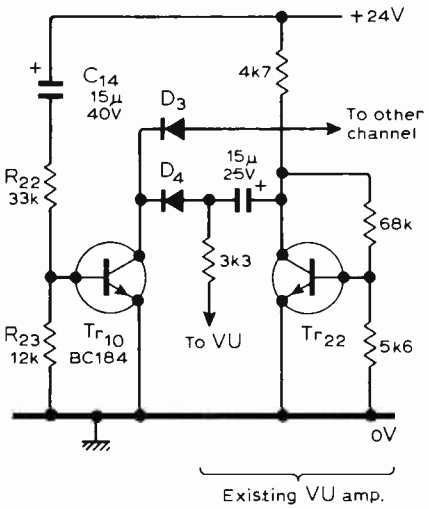


Fig. 3. Meter suppression circuit.

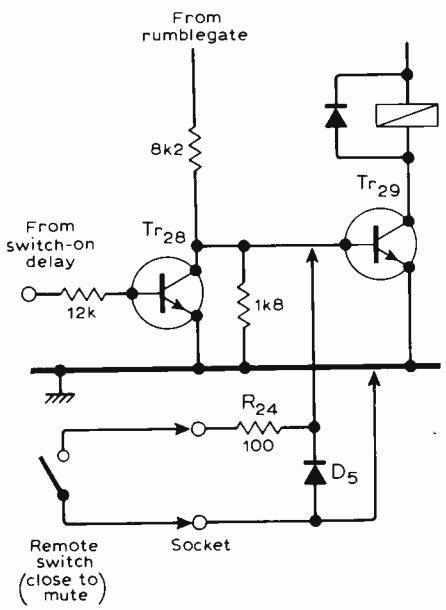


Fig. 4. Remote muting arrangement.

out-of-band frequencies from being fed to the power amplifier, which could cause t.i.d.

Both high and low-pass sections use the well-known Sallen & Key configuration, with unity-gain buffering provided by emitter-followers with current-source loading. As described in the original article, current-source emitter-followers generate very low levels of distortion and have better load-driving characteristics than conventional emitter-followers. Both current sources are biased from diodes D_1, D_2. Resistor R_{11} prevents Tr_5 from affecting Tr_2 in the event of a fault. The prevention of interaction makes fault diagnosis much easier. One point of interest is that the final unity-gain buffer is in fact a compound emitter-follower incorporating a complementary pair. This is desirable because the second unity-gain buffer, unlike the first, is driven from a substantial resistive source impedance, and under these conditions a simple emitter follower would generate a relatively high level of t.h.d. The circuit shown produces a t.h.d. figure of about 0.008% for 12V r.m.s. at 1kHz.

It is recommended that the filter is connected between the normalization amplifier and the tone-control stage so that the filters come immediately before C_4 on the original diagram. Note that the feed to the rumble gate must be taken off before the filters because the detection of subsonic frequencies is fundamental to the correct operation of the gating circuitry. The signal to the tape output emitter-followers may be taken before or after the filter system. A stereo filter draws an additional 30mA from the two stabilized supply rails.

The original preamplifier design had no provision for mono/stereo switching, as it was felt that it was unlikely to be used with a mono power amplifier/speaker system. It should also be appreciated that mode selection circuitry that does not compromise headroom or distortion performance in either mono or stereo would add a significant amount of circuitry to the preamplifier. The prototype preamplifier has now been in regular use for over a year, and in this time the only real need for a mono output has been for recording stereo material on a single-track tape machine. It was therefore decided to design a virtual-earth mixer that would give a mono tape output while the main preamplifier outputs remained in stereo. This simultaneous mono approach has the advantage that it can be easily added to an existing preamplifier without the need of a mode switch on the front panel. The prototype mono mixer incorporates an internal preset for controlling the output level. This can be brought out to the front panel or omitted as required.

The circuit of the mixer is shown in Fig.2. Mixing resistors R_{13} and R_{14} are fed from the existing tape buffer outputs, see Fig.3. of the original article. Shunt feedback is applied through R_{18} to give unity voltage gain and a virtual earth point at the junction of C_{10} and R_{16}. The design is derived from a configuration described by Butler[1] and offers a very low t.h.d. figure without the use of the usual circuit artifices such as bootstrapping or current-source collector loads. At an output level of 5V r.m.s. the t.h.d. is below 0.005% from 1kHz to 20kHz. Transistors Tr_6 and Tr_7 produce all of the voltage gain and are arranged as a cascode. Resistor R_{15} bypasses Tr_7 and allows Tr_6 to operate at a much higher current level than the collector load R_{17}. This arrangement appears to be crucial for good distortion performance. Transistors Tr_8 and Tr_9 operate as the now-familiar current-source emitter-follower so that low-impedance loads down to 3kΩ may be driven without loss of headroom due to premature clipping on the negative half-cycle. Note that current-source Tr_9 is biased from the same potential divider as Tr_7. The mixer circuit draws an additional 26mA from the +24V rail.

When the prototype preamplifier is switched on, the VU meter needles smartly strike their end-stops and then fall back. This behaviour is due to the initial charging current of the 15µF capacitor, coupling the collector of Tr_{22} to the meter, see Fig.3, passing through the meter movement itself as the supply rail rises. The degree of overload does not appear to be excessive as no degradation of meter accuracy has occurred during the past year. Nonetheless, the sound of meter needles against end-stops is not pleasing and the circuit shown in Fig.3 has been provided to prevent this effect. At the moment of switch-on, the +24V rail rises rapidly and current flows through C_{14}, R_{22} and R_{23}, to turn on Tr_{10}. This transistor shorts the switch-on surge to ground via D_4, and reduces the overswing to an inoffensive twitch. After a few hundred milliseconds C_{14} becomes fully charged and insufficient current flows through R_{22}, R_{23} to keep Tr_{10} conducting. The transistor then

Continued on page 86

Precision Performance Servomotors

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WW—040 FOR FURTHER DETAILS.

Further experiments on phase audibility

A new method of estimating phase distortion in audio systems and some listening tests

by Daniel Shanefield, Ph.D. *Bell Telephone System*

Like many developments in physics, this study arose from an *in*ability to do something. Although my attempts to fool people with live-versus-recorded comparisons have succeeded when the listeners were far from the sound source (more than twenty feet), my most diligent attempts to fool the same listeners have utterly failed when they were close to the loudspeakers (less than twenty feet away). This was true with both "one-eared" and "two-eared" experiments.

There are several possible explanations, and among them is "phase distortion" – by which I mean that the bass and the treble are delayed by different amounts of time during the record/playback process. According to this hypothesis, at a distance from the speaker, a large percentage of the sound is reflected, and therefore is phase-distorted, for *both* the live and the recorded cases. You can't tell the difference, and therefore you can be fooled. But close up, where the sound is mostly direct, the live sound would not be greatly phase-distorted, while the recorded sound would be distorted because of imperfections in the record/playback process. Presumably the ear could tell the difference and wouldn't be fooled.

New commercial loudspeakers with improved phase response have been appearing all over the place. Some are "linear phase,"[1] some are "minimum phase,"[2] and some are claimed to be essentially "phase constant."[3] I say "essentially" because it is not practical to be exactly coherent, since a motion of your head up or down from the centre axis of a two-way, non-coaxial loudspeaker can put you out of exact coherence when it comes to frequency pairs such as 800Hz and 8000Hz. If exact coherence is important, then the whole thing is hopeless from the standpoint of commercial loudspeaker design.

At the other end of the scale, extreme phase distortions, corresponding to differential delays of 10 milliseconds or so, have been shown by telephone researchers to be audible and bad. But initial wavefronts (almost like square waves) and the only way to preserve these fronts during recording is to keep the high frequencies and low frequencies travelling together. But this is probably wrong, because live musical sounds do *not* have steep initial wavefronts, and, quite the contrary, they take at least a few tenths of a millisecond to build up to full volume. That has been shown for music and handclaps by Duncan *et al.*,[4] and you can see it yourself if a storage oscilloscope is available. A few tenths of a millisecond is several complete cycles at 8kHz, so initial wavefronts do not have to be steep – at least from that line of reasoning they don't.

However, it is well known that we don't fully understand these things, and "lines of reasoning" do not always correlate with audio realities. If phase distortion is audible, maybe it does affect realism, even if we can't say why. Anything that is a "distortion" and is audible should probably be eliminated. So is it audible? Many previous experimenters have said, "no" for monophonic sound. But V. Hansen and E. R. Madsen of B&O in Denmark have claimed[5] that small monophonic phase changes can be audible under some circumstances. A few acousticians that extreme sort of distortion is not what we are discussing here, either.

It has been hypothesized from time to time that a fair degree of phase coherence is necessary for realism because live musical sounds have steep

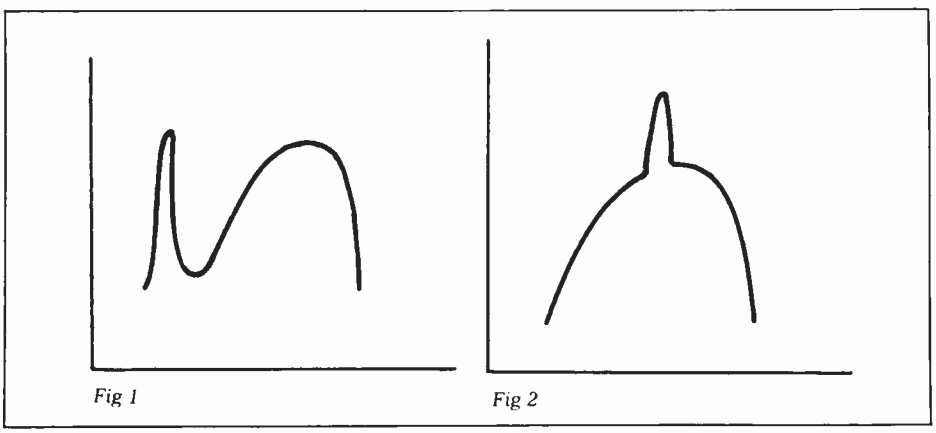
Definitions and examples

In a sound reproduction process, which inevitably involves some sort of a time delay, the term "phase distortion" refers to a change in the shape of a complex waveform, such that the low frequency parts of the wave are delayed by times which are different from the delay times of the high frequency parts. (These are absolute times, measurable in seconds, not the relative times measurable as multiples of a variable such as a peak-to-peak wave period.)

To clarify the concept, let us consider a short musical note consisting of a 1kHz wave plus some harmonic content at 2kHz and 3kHz. Suppose it is reproduced through a microphone, amplifier, and loudspeaker with perfect overall phase coherence, that is, zero phase distortion. Suppose the three frequencies are uniformly delayed by the same absolute time, namely one millisecond. The 1kHz part of the waveform will be delayed one whole cycle, but the 2kHz part will be delayed longer *relative* to its own time period, that is, two whole cycles, and the 3kHz part will be delayed 3 cycles. So the relative delay, sometimes expressed in the form of angles, depends linearly on the frequency. There can be linear phase *relationships* to the original signal, even though there might be zero phase *distortion* (all harmonic components remaining perfectly in-phase with each other).

Suppose, however, that the loudspeaker system imposed some absolute-time phase distortion, causing the output to have a two-cycle delay at 1kHz (2 milliseconds absolute delay), a three-cycle delay at 2kHz (1.5 millisecond), and a four-cycle delay at 3kHz (1.33 millisecond). The number of cycles of phase delay could still be plotted against frequency and show a linear relationship to the original signal, but the absolute time delays in milliseconds would each be different from each other, with accompanying distortion of the waveform. There are also many other ways to plot phase angle versus frequency which are linear (especially on the usual semi-logarithmic paper!) but which actually involve phase distortion of the waveform.

Fig. 1. Wave used in new test method for estimating phase distortion.
Fig. 2. The test wave in Fig. 1 after being subjected to phase distortion.



believe that Hansen and Madsen are correct, and a few others don't. (Of course, everyone agrees that *inter*aural phase changes are audible, and this contributes to stereo localization.)

I think that Hansen and Madsen overlooked a serious potential problem in their technique, which I happened to uncover while trying to duplicate part of it. They used Koss ESP-9 electrostatic headphones, which I also used, and they assumed that the acoustic output of these headphones has a wave shape that is a very accurate reproduction of the electrical input. However, my impulse tests show that the ESP-9 in an essentially anechoic environment rings a little bit, and it therefore acts in some ways like a slightly reverberant room. Hansen and Madsen admit that a reverberant situation will give a falsely enhanced audibility to phase shifts, due to destructive interference effects. This causes loudness changes at certain frequencies, which the ear can hear very well indeed. So maybe we just don't have enough transducers to do the experiment unequivocally.

I don't think we really need to know whether a *pure* signal of some kind is audible, although it is an academically interesting subject. What we do need is an experiment that directly compares a phase-coherent loudspeaker with an incoherent one, keeping everything else identical, and playing music. We need to determine which one is more realistic.

B&W Loudspeakers Ltd have published a report that seems at first sight to be concerned with just that very experiment.[6] They arranged listening tests of music with two nearly identical loudspeakers, one phase-coherent and the other non-coherent. The jury was polled on its preferences, which turned out to be strongly in favour of coherence. Frankly, I think their results are inconclusive. First of all, their experiment was evidently not done blind, and we really might expect a jury to choose a sophisticated-looking speaker (their model DM6) as opposed to a plain one (which the incoherent one certainly was). Secondly, the "better" sound was chosen without immediate access to the live performance, so "better" might not be "more realistic."

Estimating phase distortion

Before we can compare different degrees of phase distortion, we have to be able to measure it. I would like to offer here a new method for estimating the amount of phase distortion present in any one link of the record/playback chain, or in the whole chain. The advantage of this method is that it is easy to use, as compared with phase meter approaches (which are not as simple as they might appear to be), and compared with the "raised cosine"[7] or "sine-squared"[8] and fast Fourier transform[9] approaches. (By the way, the Fourier method is subject to considerable error, unless the frequency response and other critical attributes are measurable to a high degree of accuracy.)

The new method involves running a 60Hz square wave through an octave-type graphic equalizer. If the slide that controls the 8-kHz frequency band is set at +6dB, and the other slides are all set at -12dB, each square wave will become a skinny spike, as viewed on an oscilloscope. Now, if the 60-Hz slide is also raised to +6dB, the waveform becomes the thing shown in Fig. 1. I call this an "S-wave," because it looks like what an American cattle rancher with a branding iron would call a "lazy S."

If an S-wave is now run through a tape recorder, in most cases it will become "phase-distorted" and look something like the wave shown in Fig. 2, because there now is a difference in the delays applied to the treble and the bass frequencies.

A disadvantage of this testing method is that one cannot easily obtain a continuous reading of phase shift versus frequency during a sweep through the audible spectrum. However, we usually don't need a continuous reading, and looking at only four or five points on the frequency scale will tell us a lot. For improved accuracy at the treble end, it is best to break the frequency span into smaller steps such as 8kHz/2kHz, then 2kHz/500Hz, then 500Hz/120 Hz, etc. This way, small time delays in the higher of the two frequencies being studied will show up better.

Using a sequence of S-wave tests, I have found that, while the extreme bass and treble of the Tandberg 3300X cross-field tape recorder are badly phase-distorted (unequally delayed), the range from 120Hz to 8kHz is essentially constant phase. (Note that this is not "linear phase"[1] or "minimum phase"[2] but is essentially zero phase distortion.[3])

S-waves can also be sent through a complete record/playback system, and my experiments with that can be summarized as follows. The recording chain consisted of an S-wave going through a Bose 901 equalizer, a Dynaco 400 power amplifier, a single Bose 901 loudspeaker facing forward (not reflecting), an air link, a Thermo Electron 814 microphone, and a Tandberg 3300X tape recorder with Maxell UD tape at 7½ in/s. (Only four coplanar cones of the Bose 901 were used. The other five cones were covered with lead-loaded vinyl sound absorbing sheets.) Playing the Tandberg back through the equalized Dyna 400, the Bose 901 speaker (facing forward again), and the 814 microphone to an oscilloscope showed no phase distortion visible with the S-wave test, from 120Hz to 8kHz. Therefore, the whole system was essentially phase-coherent.

The Bose 901 loudspeaker was used because it has no crossovers, and the Tandberg machine was chosen because its cross-field system is reputed to minimize phase shifts. The 814 microphone is an electret type which is very similar to the more commonly known AKG Model C-451E. Having an unusually flat response curve in the entire audible frequency range, it also has minimal phase effects over the important range of 120Hz to 8kHz.

However, a variety of other devices such as dynamic microphones, other tape recorders, and electrostatic headphones each showed gross phase distortion (as in Fig. 2) when they were individually substituted into the chain.

In addition to measuring phase distortion, S-waves can be used to test speakers and microphones for ringing. A very-low-frequency square wave is fed into the graphic equalizer, which causes a gap in the time between successive S-waves. Overswing across the zero-amplitude line on the oscilloscope display indicates ringing (a form of poor "transient response"). The pulses are too short to allow full ringing build-up, so the method is less than ideal. But it is convenient, and it does quite graphically show up any tendency toward undirectional overswing. The room reverberations can usually be separated out, since they come much later.

By adjusting the equalizer pass bands to find those worst-case frequencies that maximize the ringing, it was found that electrostatic transducers (ESP-9 phones and B&W model 70 speakers) and also Magnapan speakers are not Simon-pure after all, and do ring slightly. This was also true with pure treble as well as pure bass. Good-quality cone-type speakers turn out to be just as effectively damped. (I suppose we should have expected this. The Mylar diaphragms might have low mass, but they also have very little mechanical damping action – not much more than in a bass drum!) For confirmation of this, see advertisements for the B&W model DM6 speaker[8].

Audibility of phase distortion

Using the 814 microphone, Tandberg, and Bose chain, I monophonically recorded repetitions of a 698-Hz xylophone note (with its overtones, of course). The loudness was kept at moderate levels so that overload was not a problem. It was played back using separate graphic equalizers as a crossover, splitting the signal into the below-1-kHz part, which went into one 901 speaker, and the above-1-kHz part, which went into another 901 speaker. (The frequencies above 8kHz, were filtered out altogether, since they would have been phase-distorted.) Putting the two speakers approximately side by side (or one above the other) gave no difference in realism from putting them several inches in front of and behind each other.

The graphic equalizer itself has some effect on the phase, so the essentially zero phase distortion (coherent) signal was not obtained with exact side-by-

side placement. Also, the treble tends to come from the apex of the speaker cone, while the bass comes from areas farther forward.[10] A displacement of 1¼ inches did not produce essentially coherent sounds. Both these and the incoherent (5-inch displacement) sounds were compared with live performances of the xylophone notes. (This was also repeated with a variety of other musical notes.)

There were plenty of "differences" in the sounds. In fact, I have never found two loudspeakers that sound exactly alike under ordinary circumstances,[11] so the sound does depend on which Bose 901 handles the treble, etc. Watch out for this when you read other people's reports on similar experiments! No relative speaker position was clearly the most realistic when quickly or slowly A-B'ed against the live performance. (This is an example of what I called the LAB test in a previous article.[12])

The conclusion is that a fairly high level of phase distortion does not affect realism.

This business of speakers each sounding different dredges up another one of those deep philosophical problems. Unless we attack it with very clear thinking, it's liable to become a virtual Loch Ness monster. Suppose all loudspeakers sound different (and S. K. Pramanik of B&O states very definitely in reference 11 that they do). Then how can we ever expect one to sound like the live performer, if it can't even sound exactly like a duplicate loudspeaker? It seems to be impossible to remove all such differences, or at least it seems impractical.

Here is my way of pushing the philosophical monster back down. I am willing to accept a *difference* between the live and recorded sounds, just as I will accept a difference between duplicate live instruments, each being equally "realistic." What I am trying to do is prevent a blindfolded listener from *identifying* which sound is recorded. This is what does happen at a distance, where listeners can actually be fooled. Then, even if a listener practices for a while and does learn to identify the sources, I am trying to get the honest listener to say that neither one is *best*. It should sound like two different "live" instruments. That is what I mean by "realistic."

The main criticism I can see for the whole study is that the Bose 901 loudspeaker facing forward is possibly a too-imperfect device to prove anything, primarily because of the diffraction peaks in its frequency response curve caused by its multiple drivers. (It is not meant to be used facing forward for close listening.) Also the side-by-side arrangement of the two speakers causes additional interference peaks, because the crossover that feeds them is not optimized to prevent this. But actually, the whole loudspeaker-room system was carefully equalized using a "pseudo-performer" method,[12] and it did sound quite good in spite of the diffraction.

It would be useful if other people tried similar experiments with a variety of loudspeakers. Just please be observant of all the snares mentioned above. This is a tar pit surrounded by quicksand.

What is the true explanation of my failure to fool listeners up close, if it is not phase distortion? I don't have a strong opinion at this point. My best results in listener-fooling have been obtained with a Magnapan MG-II loudspeaker*; played through a large, thin curtain which is strongly lit up from the front and dark behind. This speaker has a fair amount of phase distortion, probably because of its crossover design. Maybe the Magnapan's relatively good performance is due to its size, to its bipolar radiation pattern, or to its unusual frequency response curve. It doesn't have a monopoly on realism, though, because a giant pile of conventional speakers arranged to be bipolar and big sounded just about as good.

I have a feeling that the ear is sensitive to subtleties in the back-reflections off the walls of the listening room, and that is how we can tell the live from the recorded sounds. This might be an interference effect that gets translated into a frequency response effect, and it might be affected by the size and shape of the loudspeaker. Maybe small speakers have high-Q (finely tuned) environmental interferences and resonances, causing strong colorations, while large speakers such as Magnapans or electrostatics have diffuse and weaker colorations of this type. Or, maybe it's the shape of the wavefront, with large speakers providing a more nearly planar-shaped wave.

For a xylophone-to-microphone distance of about a yard or more, the wavefront that hits the microphone is nearly planar. If the loudspeaker is put where the microphone was, maybe the speaker should produce a similarly planar wavefront. (However, I suppose that a closer microphone distance might work better with a non-planar speaker, and I feel this ought to be explored further.)

I repeated these tests in the open air, up on ladders, but I am still unable to fool listeners who are closer than 15 feet from the xylophone. Philosophically, this type of negative result is not very meaningful. Large loudspeakers still gave the best results, but I cannot separate such hypothetical factors as diffraction at the loudspeaker cabinet edges from a myriad of other possible factors. Are the inevitable *small* amounts of phase distortion the important thing? Or the residual traces of reflection from the grassy ground? If I had to guess, I would gamble on imperfections in the amplitude-versus-frequency curve being the culprit. But this guess is only being made because a small turn of the tone control knob can have such a great effect on the listener's impressions, and not because of any well-understood weighting of the many factors to be considered.

* For UK readers it should be noted that the Magnapan is a large, diaphragm type loudspeaker, similar to an electrostatic, but operated electromagnetically by a grid of fine wires on the surface of the diaphragm. The electromagnetic field from this grid interacts with an array of small, fixed permanent magnets on the framework of the speaker. The unit has separate woofer and tweeter areas.

References

1. "Linear phase" means that the phase distortion is not zero but is linear with increasing frequency. An unusually clear example of this is shown in graphs for a loudspeaker reported by S. Ishii *et al.* of Panasonic, in a paper delivered at 52nd AES Convention, preprint 1059-3L (available from the Audio Engineering Society, New York, N.Y., U.S.A.). Some Technics and Infinity speakers are claimed to be linear phase.
2. "Minimum phase" does not mean zero phase distortion either, but in this case it refers to the *least* amount of such distortion that is theoretically possible when using conventional LC crossover designs. Many speaker systems are designed this way. See R. C. Heyser, *Audio*, Dec. 1974, p. 71.
3. This is really zero distortion, or nearly zero. It is being claimed for the Sony 880-2 tape deck and for some of the newer Ohm, Dahlquist, B&O and B&W loudspeaker designs. (Some types of "linear phase" can be equivalent to "essentially zero phase distortion," if a constant time delay is subtracted from the wave equation. Unfortunately, not all types of linear phase delay have this relationship. Equipment manufacturers have not always been specific in stating which type of linear phase they are claiming for their products.
4. M. G. Duncan, *et al.*, *J. Audio Engineering Society*, Oct, 1975, p. 610 (Fig 5C).
5. V. Hansen and E. R. Madsen, *J. Audio Engineering Society*, Dec. 1974, p. 783.
6. J. Bowers and S. Roe, *Hi-Fi News and Record Review*, April 1976, p. 56.
7. I. Nomoto, *et al.*, *J. Audio Engineering Society*, Jan, 1976, p. 9.
8. Advertisement for B&W Loudspeakers Ltd., *Wireless World*, Feb. 1976, p. 70.
9. T. Muraoka, *et al.*, 52nd AES Convention, preprint 1088-6G (available from the AES, New York).
10. J. Moir, *Wireless World*, April 1976, p.74.
11. S. K. Pramanik, *Wireless World*, Nov. 1975, p. 531.
12. D. Shanefield, *The BAS Speaker*, March 1975. (This article describes a tape recording playback, arranged so that an A-B comparison between two audio components can be juxtaposed against a live performance (called "L"). If the tape recording was originally made in the same room as the playback, environmental resonance effects will become magnified. However, the article describes a method for minimizing these, by using a special technique for equalization (frequency response adjustment). A standard frequency sweep is played through an extra loudspeaker which has been carefully equalized (called a "pseudo-performer"). Then the tape record/playback system is also equalized, while recording and playing back the psuedo-performer's sounds. The equalized tape system itself is now found to be "flat" and is suitable for the L-A-B test).
13. D. Shanefield, *The BAS Speaker*. Nov. 1974.

Testing logic networks

New method using numerical spectra can be implemented on a computer

by S. L. Hurst, M.Sc.(Eng), Ph.D., F.I.E.E., F.I.E.R.E. *University of Bath*

As digital equipment becomes more complicated there is an increasing need for effective fault diagnosis techniques. This article introduces the subject of Rademacher-Walsh spectra, which can be used in the design of logic networks but have not so far been applied to network testing. The speed with which Rademacher-Walsh spectra may be handled by a digital computer may be of great significance.

While "fault detection" is a go/no-go test to check whether a network performs its required input-output functions correctly, "fault diagnosis" is a more comprehensive test to (ideally) pin-point the source of the fault if one exists. Automatic fault diagnosis is the aim of modern digital testing techniques.

For automatic testing it is normally assumed that faults in logic circuits will be logical faults, that is logic 0 signals are erroneously present instead of logic 1 signals, or vice versa, and that such faults are steady and not intermittent. This implies that a faulty logic network has an input-output behaviour which is logical but not the correct one, and in general a fault may be defined by "stuck-at-1" or "stuck-at-0" to indicate a faulty logic node in the network.

One objective of automatic fault diagnosis is to examine the network under test with the minimum number of test sequences. This involves applying a chosen series of input conditions such that all paths in the network from input to output are verified. Fundamental difficulties may be experienced in practice which no input-output testing can resolve, such as internal faults which do not propagate to the output (which may arise for example in redundant or hazard-free network designs), and faults on different nodes which give rise to the same output fault. However, accepting such fundamental constraints, the test diagnosis methods currently in use are based upon conventional Boolean techniques; such methods are largely derived from the theoretical development of Seshu (1956), Roth (1966), Kautz (1968) and Sellers *et. al.* (1968)[1, 2, 3, 4]. These are well reviewed in recent summary papers[5, 6, 7].

However, instead of truth-tables or Boolean equations to express the input-output relationships of any given logic network, there is a completely different method by which such input-output relationships may be expressed. This is the Rademacher-Walsh spectral method. In the following sections this method is briefly introduced and an indication given of further research in this area.

The Rademacher-Walsh spectra

The Rademacher-Walsh spectrum of any given logic function with n independent input variables, say x_1 to x_n, consists of a series of 2^n integer numbers. The magnitude and sign of these 2^n numbers constitute the spectral coefficient values of the given function. They uniquely define the given function[8], as would a Boolean truth-table, but in a completely dissimilar manner from the 2^n entries of 0 and 1 in a truth-table.

The rigorous mathematical background and possible use of these spectral coefficients in logic synthesis will be found documented[9, 10, 11]. However, here it will suffice to state what the spectral coefficient values represent, and how the values may be calculated by hand for simple functions. The actual coefficient values may differ in sign or by some normalising factor between different authorities, depending upon initial definitions, but the following gives a straightforward definition based upon logic 0 and logic 1 values without any normalising.

Consider a logic network with n independent binary inputs x_1 to x_n. Then the 2^n Rademacher-Walsh spectral coefficients which characterise such a network are labelled:
$R_0, R_1, R_2, \ldots, R_n, R_{12}, R_{13}, \ldots, R_{12\ldots n}$,
where the subscripts are all possible combinations of subscripts 1 to n taken one-at-a-time, two-at-a-time, etc. up to n-at-a-time, in addition to the first subscript R_0. For example, for $n = 4$ we have the sixteen coefficients:
$R_0, R_1, R_2, R_3, R_4, R_{12}, R_{13}, R_{14}, R_{23}, R_{24}, R_{34}, R_{123}, R_{124}, R_{134}, R_{234}, R_{1234}$

The spectral coefficient values for any given Boolean function $f(x_1, \ldots, x_n)$ may be digitally-computed extremely rapidly by an appropriate fast Walsh transform which has been developed[12]. However, hand-computation, which helps to emphasise the meaning and numerical significance of each coefficient value, may be undertaken as follows.

For illustration, take the simple three-variable function $f(x) = [x_1\bar{x}_2 + x_2\bar{x}_3]$. Compile the truth-table shown in Table 1, which as well as listing the given inputs x_1, x_2, x_3, also lists $x_0, x_1 \oplus x_2, x_1 \oplus x_3, x_2 \oplus x_3$, and $x_1 \oplus x_2 \oplus x_3$, where $x_0 \equiv$ always 0, $x_1 \oplus x_2$ is the exclusive – OR of inputs x_1, x_2, and so on. This "primary set" and "secondary set" constitute an augmented set of input variables. They are conventionally labelled r_0, r_1, r_2 etc., as shown in Table 1. The function output is listed in the normal manner.

Table 1. The truth-table for function $f(x) = [x_1\bar{x}_2 + x_2\bar{x}_3]$ in terms of the augmented set of input variables r_i. (Note: the total number of variables r_i will always be 2^n for any n).

"Primary" input set				"Secondary" input set				Function output
$r_0 = x_0$	$r_1 = x_1$	$r_2 = x_2$	$r_3 = x_3$	$r_{12} = x_1 \oplus x_2$	$r_{13} = x_1 \oplus x_3$	$r_{23} = x_2 \oplus x_3$	$r_{123} = x_1 \oplus x_2 \oplus x_3$	$f(x)$
0	0	0	0	0	0	0	0	0
0	0	0	1	0	1	1	1	0
0	0	1	0	1	0	1	1	1
0	0	1	1	1	1	0	0	0
0	1	0	0	1	1	0	1	1
0	1	0	1	1	0	1	0	1
0	1	1	0	0	1	1	0	1
0	1	1	1	0	0	0	1	0

Now the Rademacher-Walsh spectral coefficients for any given function $f(x)$ are given by:

$R_i, i = 0,1,2, \ldots, 12 \ldots n, =$ (Number of agreements between the value 0 or 1 of the input r_i and the output $f(x)$) – (number of disagreements between r_i and $f(x)$).

For the function tabulated in Table 1, this gives:

R_0	R_1	R_2	R_3	R_{12}	R_{13}	R_{23}	R_{123}
0	+4	0	−4	+4	0	+4	0

These spectral coefficient values are illustrated in Fig. 1. This figure is the spectrum of the given function, and may be considered analogous to the familiar Fourier frequency spectrum of a complex analogue waveform.

Points of note are:

- the given function is uniquely defined by the value of the spectral coefficients[8]. Hence if any fault develops in the network which propagates to the output, then the spectral coefficient values for the network will be modified;
- the relative magnitude of each coefficient is a measure of the "importance" of the particular input parameter $r_i, i \neq 0$, in determining the network output value 0 to 1. A high positive value indicates a high degree of dependence of the output on the particular r_i input, while a high negative value indicates a high degree of dependence of the output on the complement of the particular r_i input, i.e. upon $\bar{r}_i$.

For example, in the function illustrated in Fig. 1 the output of the network is relatively highly dependent upon r_1 (=input x_1), not very dependent upon r_1(=input x_2), and relatively highly dependent upon $\bar{r}_3$(=input $\bar{x}_3$). The further spectral coefficients give a measure of the importance of r_{12}, r_{13} etc. (=the exclusive—ORs of the inputs x_1, x_2, etc) in controlling the output value.

Further, for fault diagnosis, suppose a "healthy" network has a certain high-value spectral coefficient, and under some internal fault condition a low value is found for this coefficient, then such a discrepancy indicates that the particular node(s) or path(s) of the network which contributes to this part of the spectrum is suspect.

These ideas, therefore, are the basic ideas underlying the possible use of Rademacher-Walsh spectra for logic-network fault diagnosis.

Basic properties of the spectra

Certain basic properties of the spectra of a logic network may be detailed:

R_0 maximum-valued. If the value for R_0 for a network is found to be $\pm 2^n$ (that is ± 8 for a 3-variable system, ± 16 for a 4-variable system and so on), then the network output is constant, that is stuck-at-0 or stuck-at-1. For a 4-variable system, a stuck-at-0 output gives $R_0 = +16$, and a stuck-at-1 output gives $R_0 = -16$, using the definition of R_0 given in the preceding section.

With $R_0 = \pm 2^n$, all other spectral coefficient values will be zero. There is therefore no need to evaluate them once this maximum value condition for R_0 is known.

R_j maximum-valued. If the value for any primary coefficient R_j, $j = 1$ to n (that is the spectral coefficient value relating directly to a binary input $x_1, x_2, \ldots, x_n$), is found to be $\pm 2^n$, then the output of the network is controlled entirely by the one particular input x_j. All other inputs are redundant or ineffective in controlling the network output. For example should R_2 be +16 in a logic network with four input variables x_1 to x_4, then the network output is entirely dependent upon x_2, the output being $f(x) = x_2$. If R_2 was −16 then output $f(x) = \bar{x}_2$.

With any primary coefficient R_j at a maximum value, then all other spectral coefficients, including R_0, will be zero. There is no need to evaluate them once a maximum condition for R_j is known.

R_{jk} maximum-valued. If the value for any secondary coefficient $R_{jk} \ldots, j \neq k$, $j,k = 1,2 \ldots$, (that is the spectral coefficient values relating to the exclusive—ORs of the binary inputs $x_1, x_2, \ldots, x_n$), is found to be $\pm 2^n$, then the output from the network is controlled entirely by the exclusive—OR of two (or more) inputs x_j, x_k. For example, should R_{234} be + 16 in a network with four input variables x_1 to x_4, then the network output is entirely dependent upon $x_2 \oplus x_3 \oplus x_4, x_1$ being redundant or ineffective. If R_{234} was −16, the output would be $[\overline{x_2 \oplus x_3 \oplus x_4}]$.

With any secondary coefficient $R_{jk} \ldots$ at a maximum value, then all other spectral coefficients, including R_0, will be zero.

R_0 zero-valued. No particular significance may be attached to the situation where R_0 is zero. This only indicates that the output from the network is 1 for exactly the same total number of input minterms as when the output of 0. For example, see the simple network evaluated above. R_0 = zero does not give any indication which input minterms give the network output 0 or 1.

R_j zero-valued. No particular significance may be attached to any one R_j, $j = 1$ to n, being zero-valued. This only indicates a certain symmetry in the network output 0 and 1 values with respect to the 0 and 1 values of the particular x_j input. For example, see R_2 in the example given above.

R_{jk} zero-valued. Similarly no particular significance may be attached to any one secondary coefficient value being zero-valued. However, see the following case.

Multiple zero-valued coefficients. While no great significance may be attached to a single zero-valued coefficient, more than one zero-valued coefficient may have significance.

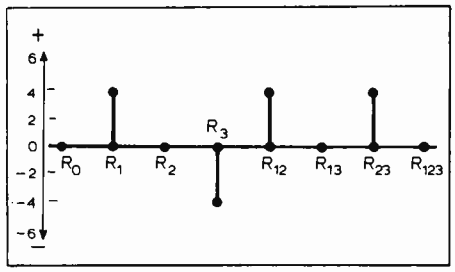


Fig. 1. The Rademacher-Walsh spectrum of the Boolean function $f(x) = [x_1\bar{x}_2 + x_2\bar{x}_3]$

If the value of any primary coefficient $R_j, j = 1$ to n, is zero, and if all the secondary coefficients R_{jk}, R_{jl}, etc. containing this coefficient subscript j are also zero, then (and only then) the network input x_j is redundant or ineffective.

For example, if the spectrum for the function shown in Fig. 1 had been evaluated assuming four inputs x_1, x_2, x_3 and x_4 were present, x_4 in this particular example being unnecessary (redundant), then (i) the value of all the spectral coefficients shown in Fig. 1 would each be twice as great, corresponding to the twice-as-many agreements/disagreements now present in the truth-table, but (ii) the coefficients for $R_4, R_{14}, R_{24}, R_{34}, R_{124}, R_{134}, R_{234}$ and R_{1234} would all be zero-valued.

It will further be noticed that if a necessary input to a logic network becomes stuck-at-0 or stuck-at-1 to the complete network, this fault will result in all the associated spectral coefficients becoming zero-valued.

Certain other restricted zero-valued relationships may be formulated. However these restricted zero-valued relationships do not have such a fundamental importance as cases where all coefficients containing a particular subscript identification are zero.

Relationships of the spectral coefficient values. Collectively the spectral coefficient values define the input-output relationships of the complete network. The zero-value and the maximum-value coefficients have a particular significance, as briefly covered above.

However, in every case there are certain arithmetic relationships which exist between the values of all the coefficients, but these relationships are indirect.* Further, it is known that the coefficient values for any function must lie in a very restricted set of numbers, the actual ordering and signs being the specific spectrum for the given function. For example, there are only eight possible sets of spectral coefficient

*By the very definition of these coefficient values, one is not free to alter the value of any one without automatically altering the value of others. So the freedom in the range these numbers can collectively take is restricted, but in a difficult way to non-mathematically express and appreciate.

magnitudes (the "positive canonic spectra") to cover all possible logic networks with four input variables[13].

The full significance, understanding, and potential usefulness of these considerations are the subject of continuing research. Statistical considerations can come into this area, as it is not necessary to evaluate more than a certain percentage of the total spectrum in order to define certain functions with a high degree of surety. As far as faults within networks are concerned, then it would appear that any fault which propagates to the output will cause a dramatic change in the resulting spectrum, and not a minor change in, say, one of the higher-ordered spectral coefficients only. Thus it may not be necessary to consider all the spectrum in fault-diagnosis procedures.

Effect of logic inversion and logic gates on spectra

It would be attractive to be able to furnish a simple set of arithmetic rules detailing how the spectral coefficient values build up as one considers the progression through a logic network. Unfortunately no such set of rules is available to cover all situations. The following, however, details some simple features for particular cases.

Logic inversion. A logic inversion (NOT) of a Boolean function changes the sign of all spectral coefficient values. Thus the spectrum of a function before and after an inverter gate is related by sign changes only, which mathematically may be regarded as multiplying the spectrum by —1.0. Similarly, the output spectrum from a NAND gate is —1.0 times that of an AND gate with the same inputs, and that of a NOR gate is —1.0 times that of an OR gate.

Fig. 2. Disjoint inputs to a 3-input OR gate.
Input 1 $= \bar{x}_1\bar{x}_2\bar{x}_3$
Input 2 $= \bar{x}_1 x_2 x_3$
Input 3 $= x_1 x_3 \bar{x}_4$
Output $z = [\bar{x}_2\bar{x}_2\bar{x}_3 + \bar{x}_1 x_2 x_3 + x_1 x_3 \bar{x}_4]$

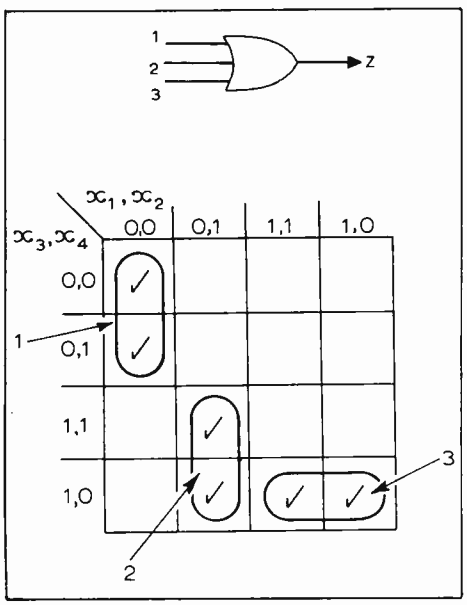


Table 2.

	R_0	R_1	R_2	R_3	R_4	R_{12}	R_{13}	R_{14}	R_{23}	R_{24}	R_{34}	R_{123}	R_{124}	R_{134}	R_{234}	R_{1234}
Input 1:	+12	−4	−4	−4	0	−4	−4	0	−4	0	0	−4	0	0	0	0
Input 2:	+12	−4	+4	+4	0	+4	+4	0	−4	0	0	−4	0	0	0	0
Input 3:	+12	+4	0	+4	−4	0	−4	+4	0	0	+4	0	0	−4	0	0

and the output spectrum is:

	+4	−4	0	+4	−4	0	−4	+4	−8	0	+4	−8	0	−4	0	0

Table 3.

	R_0	R_1	R_2	R_3	R_4	R_{12}	R_{13}	R_{14}	R_{23}	R_{24}	R_{34}	R_{123}	R_{124}	R_{134}	R_{234}	R_{1234}
Input 1:	−12	+4	+4	+4	0	+4	+4	0	+4	0	0	+4	0	0	0	0
Input 2:	−12	+4	−4	−4	0	−4	−4	0	+4	0	0	+4	0	0	0	0
Input 3:	−12	−4	0	−4	+4	0	+4	−4	0	0	−4	0	0	+4	0	0
Output:	−4	+4	0	−4	+4	0	+4	−4	+8	0	−4	+8	0	+4	0	0

This example is illustrated in Fig. 4.

Output spectrum of an OR gate. Neglecting for the moment the R_0 term, which as we shall see is a special case, then if and only if the input signals to an OR gate are disjoint (that is they have no logic 1 minterms in common) the output spectrum of the gate is given by the arithmetic sum of the individual input spectra.

The R_0 spectral components do not obey this simple arithmetic summation; instead the R_0 spectral component of the gate output is given by

$$\left\{ \sum_{1}^{m} (\text{input } R_0\text{s}) + (m-1)2^n, \right\}$$

where m is the number of inputs to the OR gate. The reason for this exception can be demonstrated very simply.

As an example, a three-input ($m=3$) OR gate with the inputs shown in Fig. 2 is in the category of an OR gate with disjoint inputs. The spectra are given in Table 2.

However, when the input signals are not disjoint, and "overlap" occurs between logic 1 input minterms, then simple addition of the input spectral component values is not valid. This, unfortunately, is more often the case than not in logic networks, unless the designer deliberately sets out to make all inputs disjoint.

Output spectrum of a NOR gate. The situation with a NOR gate is precisely that of the OR gate, except for the output inversion which is equivalent to multiplication of the output spectrum by —1.0. Again, therefore, only if the input signals are disjoint can simple addition of the input spectra be made.

Output spectrum of an AND gate. The AND relationship can be generated by inverter and NOR gates as shown in Fig. 3. Therefore if, and only if, the complements of the inputs to an AND gate are disjoint, the output spectrum of the gate excepting R_0 may be obtained by the arithmetic sum of the individual input spectra. The output R_0 value is given by

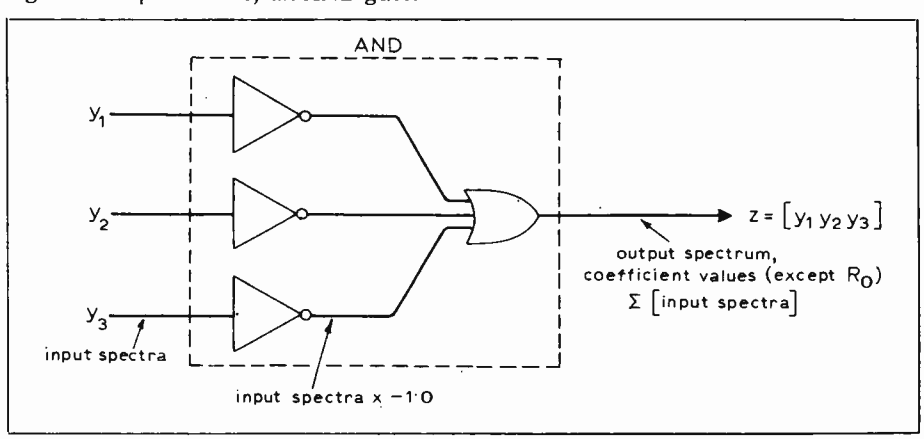
$$\left\{ \sum_{1}^{m} (\text{input } R_0\text{s}) + (m-1)2^n \right\}$$

As an example, taking the complements of the inputs used in the previous disjoint OR of Fig. 2 as inputs to a 3-input AND gate, see Table 3.

Output spectrum of a NAND gate. The situation with a NAND gate is precisely that of the AND gate, except for the multiplication by —1.0 of the output spectrum.

Thus all these OR and NOR, and AND and NAND cases now considered are special cases, and are therefore of restricted use. For the more general case, the numerical relationships between spectra before and after a logic gate are given by matrix manipulations, which can readily be handled by a digital computer. The cases here considered with their simple arithmetic relationships are particular cases of such manipulations.

Fig. 3. The equivalent of an AND gate.



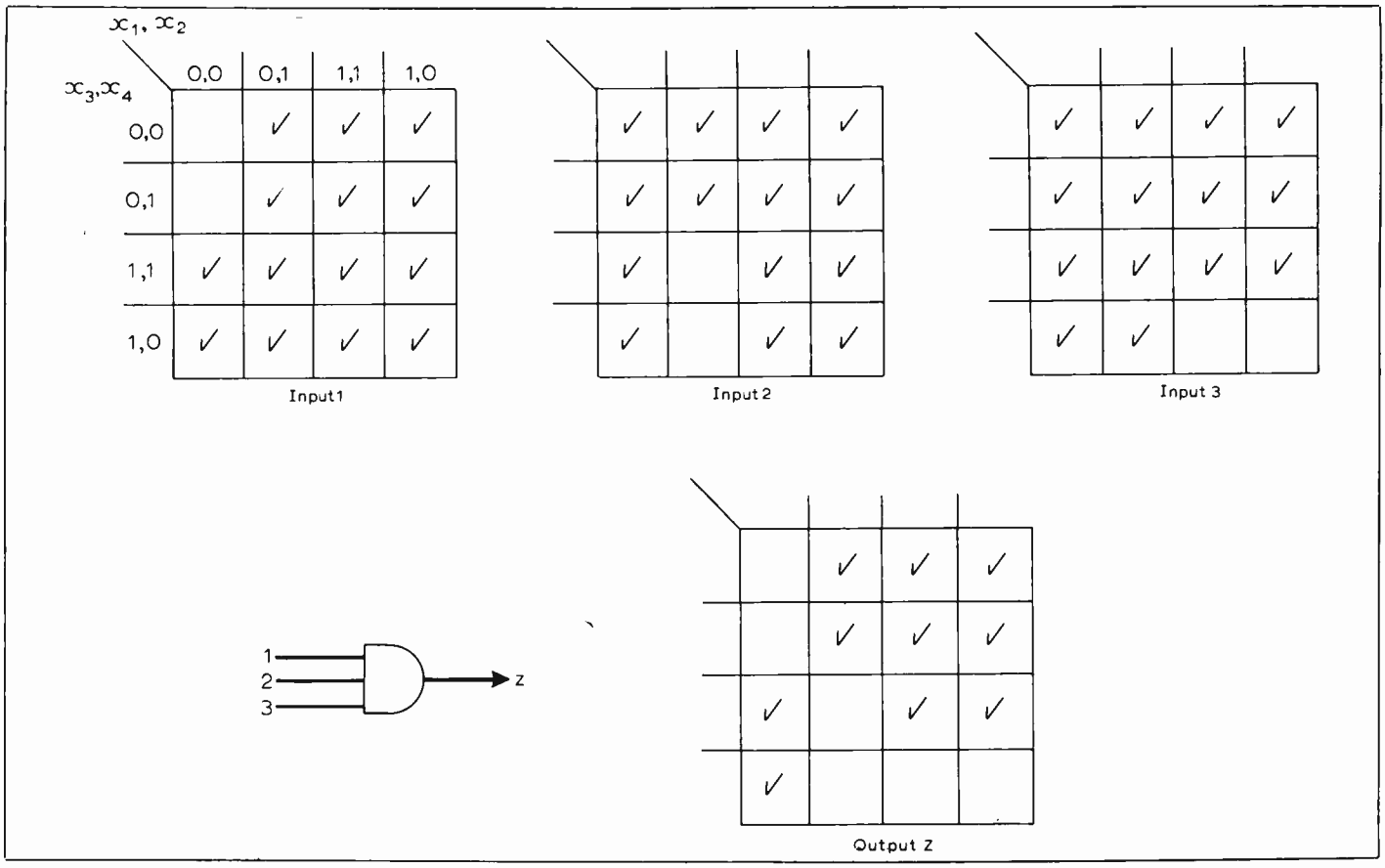


Fig. 4. Inputs to a 3-input AND gate, with disjoint complementary inputs.
Input $1 = x_1 + x_2 + x_3 = NOT\bar{x}_1\bar{x}_2\bar{x}_3$
Input $2 = x_1 + \bar{x}_2 + \bar{x}_3 = NOT\bar{x}_2x_2x_3$
Input $3 = \bar{x}_1 + \bar{x}_3 + x_4 = NOTx_1x_3\bar{x}_4$
Output $z = [(x_1 + x_2 + x_3)\ (x_1 + \bar{x}_2 + x_3)\ (\bar{x}_1 + \bar{x}_3 + x_4)]$

The effect of logical faults, an example

Any logical fault in a network which propagates to the output will cause a change in the output spectrum. However the change is unlikely to be a simple arithmetic change, except in restricted cases such as considered above.

As an exercise, consider the simple all-NAND circuit shown in Fig. 5. This circuit deliberately has no strong characteristics or disjoint properties which might give rise to simple manipulations of spectral coefficient values. It is a network not strongly dependent upon any one or more input parameter.

The fault-free spectral coefficient values at nodes (c), (k) and (o) and at the output are as shown in Table 4 (note, + signs have now been omitted for brevity):

A computer-run of the output spectrum with each individual node stuck-at-0 and stuck-at-1 yields the output coefficient values under each single-fault condition as shown in Table 5.

From this tabulation it will be noted that all faults which are logically distinguishable at the output give rise to a distinct output spectrum. In this particular network it is sufficient to examine the primary spectral components R_0 to R_4 only to diagnose the fault classification, the information contained in the remaining components being unnecessary. However further research is necessary to show whether this is always so.

Fig. 5. NAND network, output $z = [x_1x_2 + \bar{x}_1\bar{x}_2\bar{x}_3 + x_2x_3x_4]$ *with internal nodes (a) to (o) as the source of potential stuck-at-1 or stuck-at-0 faults.*

Summary and further research

The underlying mathematics of the Rademacher-Walsh transform, and the advantages of computer-handling of data in the spectral domain as compared with the Boolean domain, have not been covered, as these may be found in existing literature. The software for computing the spectral component values for given circuits, both with and without "stuck-at" faults present, is straightforward and fast.

At this early stage of research, the outcome and potential of this technique in fault diagnosis lies in the future.

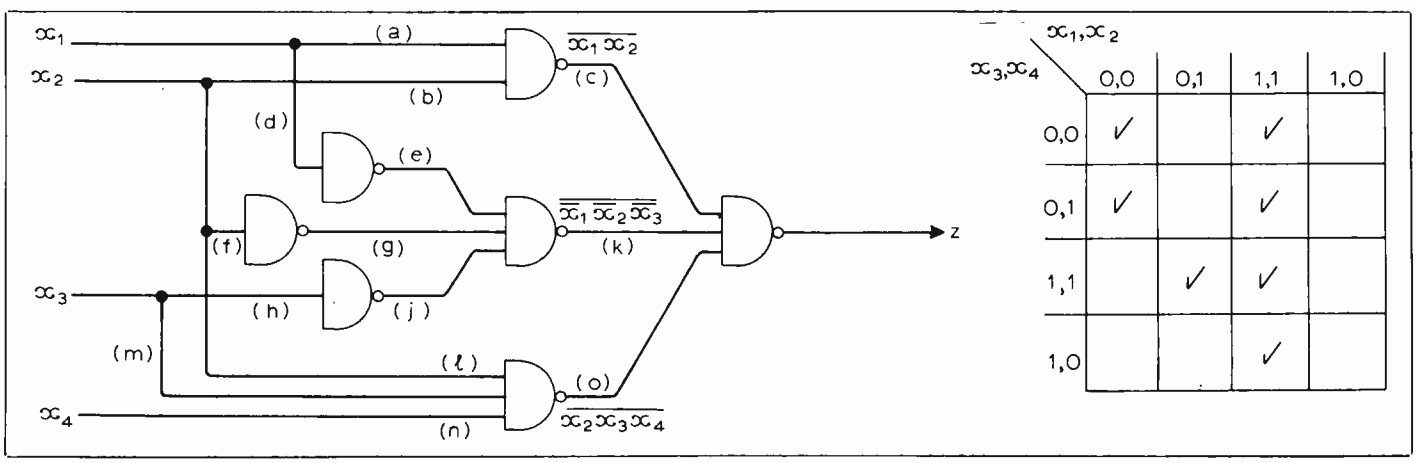


Table 4.

	R_0	R_1	R_2	R_3	R_4	R_{12}	R_{13}	R_{14}	R_{23}	R_{24}	R_{34}	R_{123}	R_{124}	R_{134}	R_{234}	R_{1234}
Node (c):	−8	−8	−8	0	0	8	0	0	0	0	0	0	0	0	0	0
Node (k):	−12	4	4	4	0	4	4	0	4	0	0	4	0	0	0	0
Node (o):	−12	0	−4	−4	−4	0	0	0	4	4	4	0	0	0	−4	0
Output z:	2	2	6	−2	2	−10	−2	2	−6	−2	−2	−6	−2	−2	2	2

Table 5.

(a) or (b) stuck-at-0, or (c) stuck-at-1	8	−4	0	0	4	−4	−4	0	−8	−4	−4	−4	0	0	4	0
(d), (f) or (h) stuck-at-1, or (e), (g) or (j) stuck-at-0, or (k) stuck-at-1	6	6	10	2	2	−6	2	2	−2	−2	−2	−2	−2	−2	2	2
(l), (m) or (n) stuck-at-0, or (o) stuck-at-1	4	4	4	−4	0	−12	−4	0	−4	0	0	−4	0	0	0	0
(a) stuck-at-1	−4	−4	12	−4	0	−4	−4	0	−4	0	0	−4	0	0	0	0
(b) stuck-at-1	−6	10	−2	−2	2	−2	−2	2	−6	−2	−2	−6	−2	−2	2	2
(d) stuck-at-0, or (e) stuck-at-1	−2	6	2	−6	2	−6	2	2	−10	−2	−2	−2	−2	−2	2	2
(f) stuck-at-0, or (g) stuck-at-1	−2	−2	10	−6	2	−6	−6	2	−2	−2	−2	−2	−2	−2	2	2
(h) stuck-at-0, or (j) stuck-at-1	−2	−2	2	2	2	−14	2	2	−2	−2	−2	−2	−2	−2	2	2
(l) stuck-at-1	−2	2	2	2	6	−10	−2	2	−2	2	−6	−6	−2	−2	−2	2
(m) stuck-at-1	0	0	8	−4	4	−8	−4	4	−4	−4	0	−4	−4	0	0	0
(n) stuck-at-1	0	0	8	0	0	−8	0	0	−8	0	0	−8	0	0	0	0
(c), (k) or (o) stuck-at-0	−16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

Fundamentally the spectra contain a very high and inter-related information content, which must be usable in many ways apart from network synthesis which has been its main research use to date. For fault diagnosis, the following are some of the immediate problems under consideration:

- Does the spectrum of a fault-free network itself provide sufficient or partial data for determining diagnostic test sequences?
- Can the spectrum of a faulty network be used to control automatic diagnostic procedures by controlling the input test sequences?
- Because all logic functions may be grouped into positive canonic spectra classfications, can standard test techniques be outlined for each such group of functions?
- Is it possible to compute a useful "partial spectrum" by considering only a limited number of "agreements — disagreements" (see above), instead of all 2^n?
- How best can the network-under-test/computer-interface be engineered?
- Can useful all-hardware (not computer-based) field test sets be formulated, for testing relatively small digital networks[14]?
- Do these ideas, even if satisfactory, give any advantages over existing digital a.t.e. techniques?

It is hoped that this introductory article may stimulate continuing research in this new area.

Acknowledgements

Valuable conversations with C. R. Edwards, Research Fellow, School of Electrical Engineering, The University of Bath, are gratefully acknowledged.

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Continued from page 76

turns off and has no further effect on the VU circuitry. Diodes D_3 and D_4 isolate the two VU circuits from each other and also prevent Tr_{10} from being driven into conduction on negative half-cycles.

A further point about the VU system, which should have been emphasized in the original article, is that the 10kΩ resistor and germanium diode associated with the meter itself are only relevant if inexpensive milliammeter movements are fitted. If professional VU meters are used, which contain internal bridge rectifiers, the above components are unnecessary.

Because the amplifier is already fitted with a relay that switches off the main outputs, it is simple to add a socket for remote muting. Fig.4 shows part of the original rumble-gate system, together with the new components required. All that is involved is the closure of a switch between the base and emitter of Tr_{29} so that the transistor turns off and causes the relay contacts to open. Note that, like the switch-on delay, this facility overrides all other control functions. The resistor and diode are included to protect the circuit if a wrong connection to the remote-muting socket is made. As the control lead only handles a small direct voltage the audio signal cannot be degraded.

Reference

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Printed circuit boards

A p.c.b. which accommodates a stereo rumble and scratch filter, virtual earth mixer, and meter surge suppression circuit, will be available for £3.50 from M. R. Sagin at 23 Keyes Road, London N.W.2.

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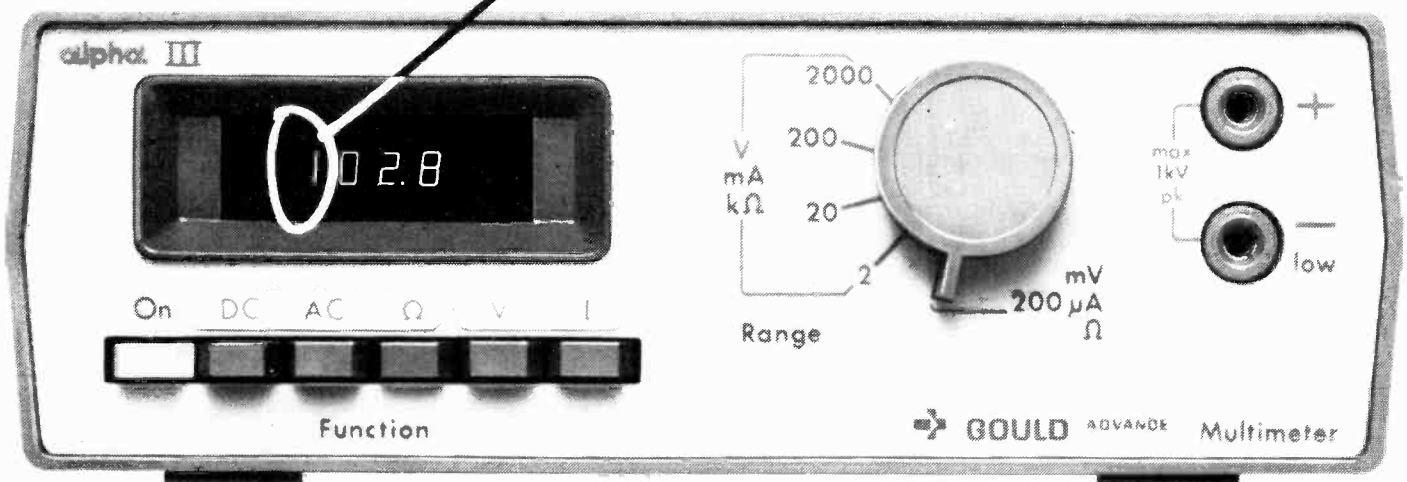

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Broadcast stereo coder

3—Setting up

By Trevor Brook, *Surrey Electronics*

A practical design for a high quality coder suitable as a test instrument was described in the April & June issues. Apart from the audio filtering, inductors have been avoided and a compact board layout produced. A v.h.f. unit, for servicing checks on receiver performance, could also be used by demonstration showrooms to feed programmes of their own choice to stereo tuners.

Part 1 examined the stereo multiplex system and established tolerance limits for signal components. Channel separation was considered as this would assume increased importance if a matrix system of surround sound broadcasting were adopted. Part 2 gave construction details and alignment details follow in this part. Part 4 gives modifications to the Portus and Haywood decoder to provide a low distortion reference decoder.

In this setting-up procedure 0dB level refers to 0.775V.

—With the coder in mono, set A and B gains, by means of R_{44}, R_{54}, so that 0dB input at 1kHz gives —7dB at the output. Check that the amplitude response is +0.5, —1.0dB from 20Hz to 15kHz relative to the 1kHz level for each channel.

For measurements near 15kHz, a frequency counter will prove most useful if the audio signal generator calibrations are not accurate.

—With a grounded crocodile lead on the "oscillator defeat" pin, IC_3 pin 6, check the distortion for each channel with 0dB output at 1kHz. A reading of better than 0.03% will confirm that all is well.

—To align the 38kHz path, set presets R_{23}, R_{32} and R_{87} to mid-position and remove the "oscillator defeat" link.

—Looking at the output of IC_5, pin 6 on an oscilloscope, adjust R_{23} for a rough null in 19kHz content on the 38kHz waveform.

—Connect a nulling distortion meter, tunable to 38kHz, to pin 4 of IC_{10}. (Many distortion meters only cover up to 20kHz, but generally they are easily modified by soldering an extra parallel resistor in each arm of the null bridge so that the upper frequency becomes 40kHz. For the job here accuracy is not very important; all that is required is good rejection of the 38kHz so that the remaining 19kHz component can be nulled.) Looking at the distortion meter output on a 'scope adjust R_{32} and R_{87} alternately to achieve the best rejection of 19kHz.

—Final trimming of R_{23} as well should leave no 19kHz visible amongst the noise, and better than 60dB below the 38kHz level.

—The 38kHz amplitude at this same point may now also be checked as +8dB ±0.5dB.

—With the oscillator system now set up properly the distortion of the 19kHz at pin 6 of IC_3 can be checked as below 0.1%.

—Switch the coder to stereo and look at the 38kHz at the output, with only the S switched on at the d.i.l. switch. Adjust for minimum carrier with R_{22}. Using broadband metering the 38kHz null will be masked by the residual 76kHz generated by IC_{10}, which does not null out.

—Feed 1kHz at around 0 to +6dB into the left channel and defeat the oscillator. Still with only S switched on adjust R_{23} for a null of audio leak through in IC_{10}.

—Allow the oscillator to run and feed 1kHz at 0dB into the left channel with A, B and S turned on at the d.i.l. switch. Lock the 'scope to the audio and adjust R_{72} for the roughly correct M/S amplitude relationship seen in Fig. 11(a).

—Repeat for the right channel input but this time leave R_{72} alone and adjust the B difference pot, R_{59}.

—Switch the pilot on at the d.i.l. switch and, with no audio input, set its level to —21dB at the coder output, using R_{16}.

—Feeding 1kHz at around —10dB into either left or right channels, turn on only the S and pilot at the d.i.l. switch. Locking the 'scope to the audio should display an "eye" pattern, as in Fig. 11(b). The correct pilot phase is when the eye appears symmetrical and this is more easily seen with some vertical magnification arranged as shown in Fig. 11(d). Resistor R_{14} adjusts the pilot phase and the effect of a slightly incorrect setting is seen in Fig. 11(e).

Table 2: Measurements on prototype coder

No pre-emphasis	
Frequency response +0.5 dB, —1.0 dB	20Hz to 15KHz
Rejection of 19kHz	68dB
Rejection of frequencies above 19kHz	58dB
Crosstalk at 20° C 20Hz-15kHz	55dB
Crosstalk 10-40° C 20Hz-15kHz	45dB
Residual 38kHz	50dB
Pilot phase accuracy	1°
Beat tone distortion, 15kHz full M, full S or L or R overdriven 6dB	0.1%
Spurious responses above 53kHz, full M, full S or L or R overdriven 6dB:	
sidebands of 57kHz	—63dB
carrier and sidebands at 76kHz	—48dB
carrier and sidebands at 152kHz	—84dB
Measurements using reference decoder (part 4) and 50 µs de-emphasis:	
harmonic distortion, 1kHz full M, S, L or R	0.04%
signal-to-noise ratio, 20Hz to 15kHz, mean reading meter, unweighted:	
mono	79dB
stereo	71dB

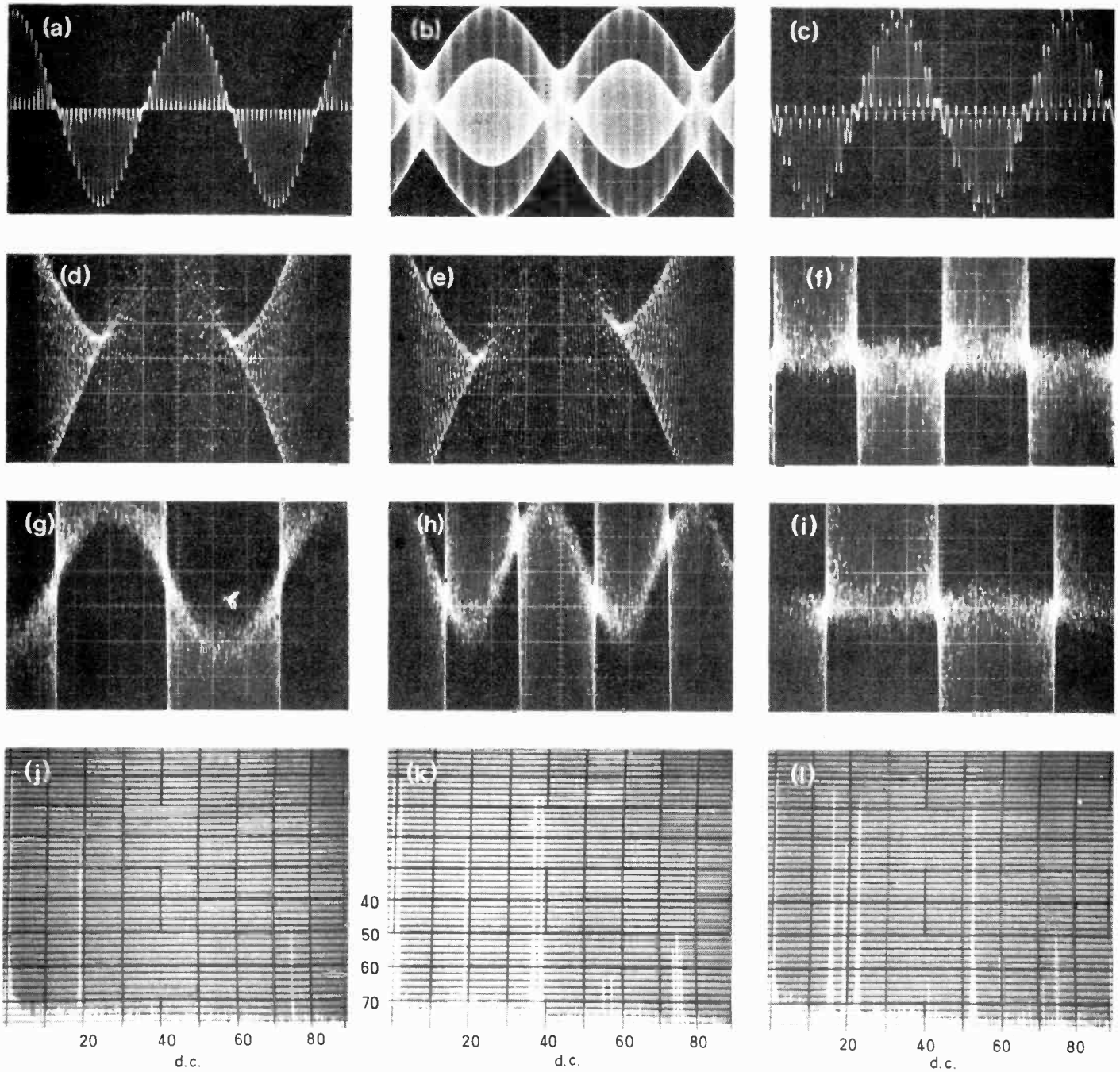


Fig. 11. Correctly set-up coder, with full 1kHz A signal and no pilot is seen at (a) which indicates the flat zero line. The pilot phase "eye" is at (b), with only S and pilot, while (d) shows the zero crossing region of (b) magnified virtually by a factor of 100 – (e) is the same but with an incorrect pilot phase setting. Zero line ripple at (f), with full 1kHz A signal, is obtained by X100 vertical gain and clipping amplifier shown in Fig. 12. Result on zero line ripple of low S amplitude is at (g), while (h) shows too high an S amplitude in wrong phase. Photo (c) is of composite multiplex signal with pilot and full 1kHz signal. Zero-line ripple at (i) is that obtained for 15kHz with coder correctly set up. Spectrum analyser photo at (j) shows noise spectrum when in stereo mode but with no audio. Pilot at 19kHz and main spurious response – 76kHz at −48dB can be seen. Stereo spectrum with A overdriven by 6dB with 1kHz is at (k) and with 15kHz at (l). Analyser measurements were performed by Marconi Instruments TF 2370, 50Hz bandwidth, direct into 50Ω input via 3.3kΩ resistor, not using high-impedance probe.

—Pilot amplitude and phase adjustments are very slightly interdependent, so repeat the last two adjustments.

Clipping amplifier

If all is well to this point, then channel separation will exceed 40dB at 1kHz, but to see the M/S amplitude and phase error more easily for greater separations requires × 100 vertical magnification compared with that in Fig. 11(a). Some 'scopes may manage this without overloading, but most do not so a useful amplifier and clipper circuit is given in Fig. 12. This is simply a 20dB amplifier with diodes arranged to bring the gain below unity as soon as the output swing exceeds 0.6 volts. The amplifier has quick recovery from the clipping so does not degrade the interesting zero voltage area of the stereo waveform.

The clipping amplifier can conveniently be built on a scrap of Veroboard and placed inside a metal 35mm film can. The output resistor stops r.f. instability when driving capacitive loads in the clipping condition. Used in conjunction with a directly-coupled 'scope giving 20dB gain (which should not cause overloads) and at least 5MHz bandwidth, the required × 100 magnification with low phase shift is achieved and a correct stereo waveform appears in Fig. 11(f).

—Using the clipper arrangement repeat first two items in column 3, page 89.

The only limitation to correct setting should be the noise along the zero line of the waveform. Figure 11(g) shows the in-phase zero-line ripple caused by low S signal amplitude corresponding to a loss in S of 2.7%.

—Now change the input frequency to 15kHz and adjust the M/S phase accuracy (C_{26} adjusts for the A and C_{28} for the B channel).

Phase errors appear on the 'scope

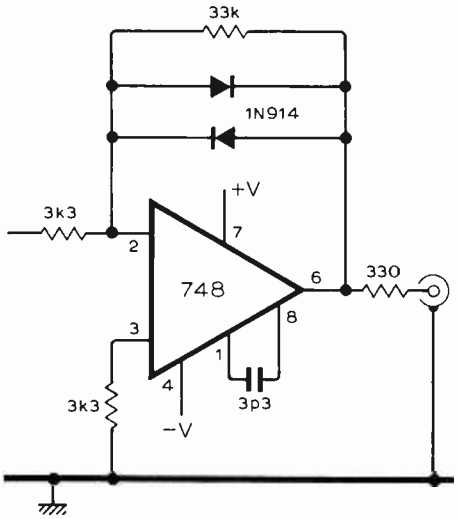


Fig. 12. Amplifier with 20dB gain and clipping arrangement to allow large vertical magnifications of the zero-voltage region without overloading oscilloscope Y amplifiers.

display as a sine-wave zero-line ripple shifted in phase relative to the main pattern and Fig. 11(h) shows the appearance of amplitude and phase errors combined.

—Check now that M/S accuracy is maintained over the whole audio frequency range.

If an audio signal in antiphase and of precisely the same level is available the initial adjustment can be improved upon.

—Feed antiphase audio at 1kHz into left and right channels at 0dB and with the A and B signals only switched on make a very slight trimming adjustment to either R_{44} or R_{54} so that the output nulls. This gives a more accurate channel balance than setting channel gains up on a millivoltmeter.

The audio leakthrough set on p.89 with the oscillator stopped can be adjusted under working conditions for the multiplier if a 15kHz low-pass filter is available.

—Connect to the coder output and with only the S signal turned on at the d.i.l. switch feed left or right input with 15kHz at +6dB (or feed both left and right with antiphase both at 0dB). Potentiometer R_{23} is adjusted for a null in 15kHz leakthrough. Correct setting of R_{23} is important, otherwise false settings in R_{72}, C_{26} and C_{28} can be produced.

Without a spectrum analyser or decoder an estimate of the beat-tone distortion may be made with the aid of a distortion meter.

—Continue as above for the audio leakage check but switch on A, B and the pilot as well as S. Use the distortion meter to null the 15kHz and some of the beat tones will give a reading below 0.1%. (This reading is only an indication that all may be well as no account has been taken of beat tones above 15kHz which will be heterodyned into the audio range in decoding. If a frequency counter is available a check can be made that the pilot frequency is 19kHz ±2Hz.)

—Check temperature stability by feeding 1kHz at 0dB into the left channel, with A, B and S turned on at the d.i.l. switch. Lock the 'scope to the audio and with the × 100 vertical magnification arrangement view the change in relative M/S amplitude and phase. With a temperature rise from 20 to 40°C the S amplitude should fall by 0.8%, i.e. 24mm on a pattern magnified to 6000mm.

Allow at least half an hour for all components on the board to reach the new ambient temperature. What S amplitude loss there is can be shown to be predominantly due to the balanced modulator i.c. by briefly holding a soldering iron on its case. With the methods described here no phase error between the M and S components should be visible over the whole temperature range +10 to +45°C. Incidentally it is quite impossible to align a coder for channel separation by using a decoder, as apparently good separation can be achieved on a particular decoder with quite the wrong phase and amplitude settings.

Three checks on performance can be made using a suitable reference decoder, such as the modified Portus and Haywood design described in Part 4. Using 50μs de-emphasis the noise level referred to 1kHz full level (—1dB at the coder output) should be ≥—70dB, unweighted, mean reading meter, 20Hz to 15kHz. Again with de-emphasis, readings of coder-decoder harmonic distortion for 1kHz full A, B, M or S should be 0.04% and the 15kHz beat tone under the same conditions 0.35%.

Some of the distortion above is contributed by the decoder and the only satisfactory way of assessing the purity of the coder output is by spectrum analysis. Figure 11(j) shows the coder noise spectrum when switched into stereo. The 19kHz pilot tone is at —21dB and the slight mark at 38kHz is the suppressed 38kHz carrier at —71dB. The spurious 76kHz double frequency output from the balanced modulator is at —48dB.

Figure 11(k) shows 1kHz in left or right channels overdriven by 6dB. The baseband signal is at —1dB, normally only reached for full M signal, i.e. full A and B in phase. After the pilot are the two S signal sidebands at —7dB, normally only reached for full S signal i.e. full A and B in antiphase. Above this are two spurious responses, sidebands of 57kHz and the 76kHz signal again. For 1kHz, the 57kHz components are harmless, but for higher audio frequencies the lower sideband of the pair falls into the S signal band. On this photo it is also interesting to notice the slight noise modulation effect (about 4dB) which only becomes visible when the S signal is within 3dB or so of full amplitude.

Figure 11(l) shows the situation as above (6dB left or right overdrive) but with 15kHz input. Apart from the lower sideband of 57kHz, 42kHz at —64dB, other minor beat tones are visible at 4kHz, —67dB, and 7kHz, —68dB. The line at 27kHz seems to have been a noise peak, since it bears no obvious arithmetical relationship with the frequencies involved and does not appear in other photographs taken at the time. The 42kHz component will demodulate to 4kHz at —63dB in the left and right channels and this would indicate a beat tone figure for the coder of 0.1%, and with 50μs de-emphasis 0.07%.

Not covered on the photographs, the only component observed above 100kHz was 152kHz and associated sidebands at —84dB. For decoder and receiver measurements the 76kHz outputs are not troublesome — the presence of odd harmonics would have been more worrying — but for some purposes the use of a precision multiplier might be desirable.

To be concluded.

Correction. In the circuit diagram (on page 76, June issue) capacitors C_{25} and C_{26} should have been shown earthed, rather than returned to the —15V rail, and C_{28} shown variable. The G lead should have R_{77} inserted, and the junction of C_{16} and R_{39} should connect to lead B. Resistor R_{75} should be taken to the upper end of R_{59}, and not Tr_8 emitter, which itself should connect to Tr_9 collector through a 33μF capacitor. Emitter of Tr_8 should have R_{91} connecting it to the —15V rail. Capacitor C_{22} should be short-circuited. In the components list R_{49} is 47kΩ, R_{91} is 3.3kΩ, and C_6 is 4.7μF ±1% and not 47μF. Resistor R_8 can be 2%.

Books Received

Radio TV & Audio Technical Reference Book edited by S. W. Amos.

This chunky reference (60mm thick) is the work of 31 contributors who have written 35 chapters using information provided by 47 companies. The result is a very comprehensive publication which is directed at the technician or student. Most of the information is presented in a practical form with a minimum of mathematics and all of the symbols in the diagrams conform to the recommendations of BS3939.

The first few chapters deal with fundamentals of electronics and following chapters cover specific topics such as antennas, sound receivers, test equipment and radiotelephone communications. There are four chapters dealing with installation and servicing of transmitters, receivers and tape recorders. The final two chapters discuss electrical interference suppression and formulae. Although the price of £24.00 makes it an expensive purchase, the large amount of information (all in one place) makes it a worthwhile addition to any technical bookshelf. Newnes Butterworth, Borough Green, Sevenoaks, Kent.

New Products

Super woofer

The JR 'super woofer' is an add-on bass unit which will extend the low-frequency range of a conventional speaker system. A bass driver unit is mounted at the bottom of a cylinder which has two tensioned end caps. Frequency response is down to about 30Hz and an adjustable attenuator gives an 8dB range for sensitivity control. Because low audio frequencies contain little directional information, only one unit is required for a stereo system. Also, the enclosure does not need to be placed centrally betweeen the existing speakers but can be positioned to one side or even out of sight. The complete unit has been designed as a piece of furniture and we understand that it has undergone the "rattle test" using the enclosure as a coffee table with an empty cup and saucer on top. The cylinder is mounted on castors and matches the existing JR149 speakers.

Power rating is 60W sine wave and the impedance is 8Ω at 120Hz. Outside dimensions are 50cm diameter by 47cm high.

We understand the super woofer will be shown at the Audio Fair (September 12 to 18). JR Loudspeakers, 114 Ashley Road, St. Albans, Herts AL1 5JR.

WW 301

L.f. function generator

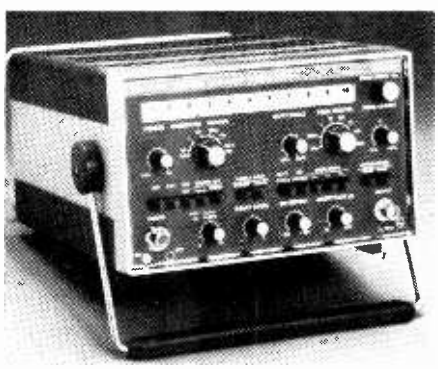
A low-frequency function generator, the Philips PM129 from Pye Unicam, covers the frequency range 0.001 Hz to 1MHz and provides low distortion sine, square or triangle waveforms which can be varied by amplitude, frequency, d.c.-level and duty cycle. The output frequency is set by a linear scale over eight ranges and can be normal, swept by an internal ramp signal or modulated internally by a 2Hz to 20kHz tone. Single-shot outputs may be initiated by pushbutton control, a variable peak-level control or by external t.t.l. signals. In its burst mode the number of cycles in each burst can be varied over a 10:1 ratio. This mode can also be controlled by an external t.t.l. signal. The generator has a maximum output of 30V into 50Ω, and can be step-attenuated down to 60dB. A variable 0 to 20dB amplitude control shows approximate output levels. Pye Unicam Limited, York Street, Cambridge, CB1 2PX.

WW 302

Low-profile connectors

Two polyester-moulded connector ranges, the series 556 (0.150in pitch) and the series 554 (0.156in pitch) from U.E.C.L., provide single- or double-sided assemblies with a choice of contact form, type of termination, quality of plating finish and mounting. All contacts are readily replaceable from the connector face, in the event of contact failure, but are securely retained within the moulding by means of a spring on the contact shank. Series 556 offers from 5 to 56 ways single-sided and 10 to 112 ways double-sided, and series 554 provided 5 to 54 single and 10 to 108 double. Contact faces available are cantilever or inverted (bifurcated) bellows. Other specifications include a nominal current rating of 5A per contact, a contact resistance of 10mΩ and an operating range of from −55 to +100°C. Ultra Electronics (Components) Limited, Fassets Road, Loudwater, Bucks.

WW 303



WW 302

WW 301

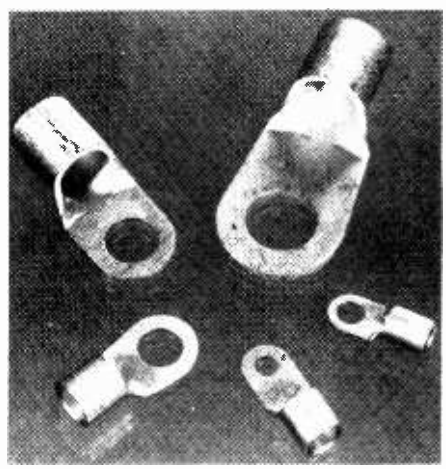
Heavy-duty terminals

The HD series of heavy duty ring terminals has been introduced by H & T Components Ltd. The terminals are heat resistant up to +125°C, and are manufactured from drawn-copper tube with an electro-tinned finish. Terminals are available to suit a variety of wire and stud sizes, as well as in a pre-insulated version up to 120sq.mm. H & T Components Limited, Crowdy's Hill Estate, Kembrey Street, Swindon, Wiltshire.

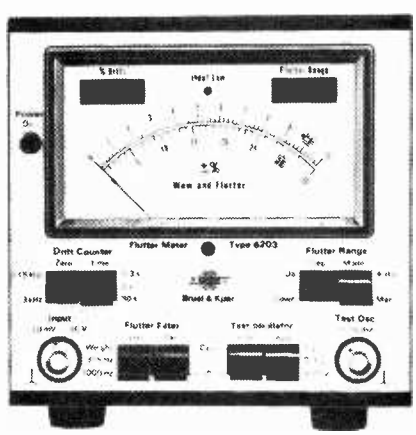
WW 304

Wow-and-flutter meter

An automatic wow-and-flutter meter, the 6203 from B & K Laboratories, uses analogue and digital techniques to measure peak flutter and drift in sound recording and reproduction equipment. It meets DIN45507, IEC386, CCIR409 and IEEE193. specifications and will measure flutter and drift down to 0.001% and 0.01% peak respectively. Flutter measurements are indicated on a large moving coil meter and a three digit l.e.d. indication of the selected range. Drift measurements are indicated on another three-digit l.e.d. display with a range from ±0.01% to ±9.99% relative to 3 or 3.15kHz as selected. Out-of-range and overload indication is automatically provided by flashing



WW 304



WW 305

l.e.ds. Measured times are selectable from 0.3, 3 or 30s. A built-in filter is employed and a weighting mode is available in addition to 0.1/315Hz and 0.1/1kHz linear modes. The 6203 has its own built-in variable level test signal source, which operates at 3.15kHz, and an additional 3kHz signal which can be used as a function check. Alternating and direct current outputs are available for level recorders or XY recorders and there is also provision for external filters. B & K Laboratories Limited, Cross Lances Road, Hounslow, Middlesex.
WW 305

Waveguide v.s.w.r. meters

The type 22/3 slotted-line standing wavemeter, made by Flann Microwave Instruments, is one of a series of 17 models covering the frequency range 1.72 to 140GHz. The residual v.s.w.r. of the series varies from 1.007 for the lower frequency models to 1.02 for the higher frequency instruments. All of the meters are totally enclosed and contain tunable probes of variable insertion, and a built-in crystal detector with a coaxial output. Flann Microwave Instruments Limited, Dunmere Road, Bodmin, Cornwall, PL31 2QL.
WW 306

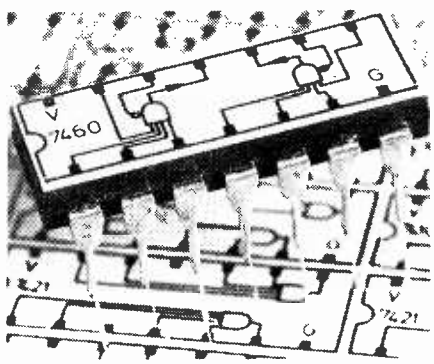
WW 306

Printed labels for ics

Low-cost aids for users of t.t.l. i.cs have been announced by Concept Electronics. The aids, called Stickies, are i.c.-sized self-adhesive printed labels showing pin-outs for the 61 most popular 14-pin and 16-pin i.cs. Stickies can be used for constructing and de-bugging prototypes, fault finding on production circuits, or even designing p.c.b. layouts. They are also a valuable teaching aid. The labels are available in sets of 450 and include comprehensive instructions and a list of logical equivalents which can be used to extend the range to cover 86 i.cs. Concept Electronics, 8 Bayham Road, Sevenoaks, Kent.
WW307

Signal generator for hi-fi

A signal generator has been made specifically for the hi-fi and radio industry by Radiometer Electronics of Copenhagen. The RE101, as it is called, is suitable for f.m./a.m. and f.m. stereo receivers and covers the frequency ranges of 86 to 130MHz and 0.15 to 30MHz. The carrier frequency is indicated on a five-digit l.e.d. display with 10kHz resolution in the v.h.f. range and 1kHz in the h.f. range. Intrinsic modulation distortion is less than 0.05% for f.m. and less than 0.3% for a.m. and, because all r.f. sources are shielded



WW307

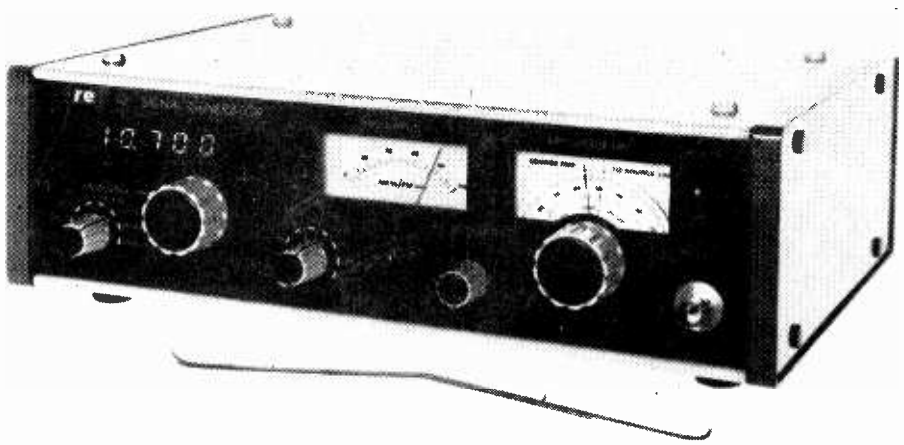
sensitivity measurements down to 0.5μV can be made. The RE101 has a sweep oscillator and a 140dB continuously-variable r.f. attenuator providing an e.m.f. output from 0.1μV to 1V r.m.s. Output impedance is 75Ω. International Instruments Limited, Cross Lances Road, Hounslow, Middlesex.
WW 308

Precision resistor

The K746 is an addition to the Kelvin range of precision wire-wound resistors. It has tolerances from 1% down to 0.005% and is aimed at the instrument, military/avionic and measurement markets. The resistor, which measures 0.32in high by 0.295in long and 0.1in wide, is rated at 200V, 0.3W (at 85°C) and is available with resistance ranges of from 50Ω to 375kΩ in the above package size. This is a 1 p.p.m. resistor, but there are options of 3, 4 and 5 p.p.m. Temperature-coefficient tracking is to ½ p.p.m., stability is 25 p.p.m. per year, and the range exceeds the environmental requirements of MIL-R-39005. Milex Components, 9 High Street, Yiewsley, West Drayton, Middlesex UB7 7SG.
WW 309

High-current transistors

Six Darlington power transistors, from Motorola, have high direct current gains of 1000 at I_C = 20A and 200 at I_C = 30A. V_{CE} and V_{CB} values are rated at 60, 90 and 120 for the three transistors in each n-p-n and p-n-p group. Types MJ11012, 014 and 016 are n-p-n and their complemenatary types are MJ11011, 013 and 015. They all operate at currents up to 30A (I_C) and 1A (I_B) and have V_{BE}'s of 5V. Total dissipations for the devices, which are in TO-3 cases, are 200W at 25°C and the operating temperatures are from −55 to 200°C. The devices are most suited to general-purpose amplifier circuits. Motorola Limited, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0PR.
WW 310



WW 308

Low noise cables

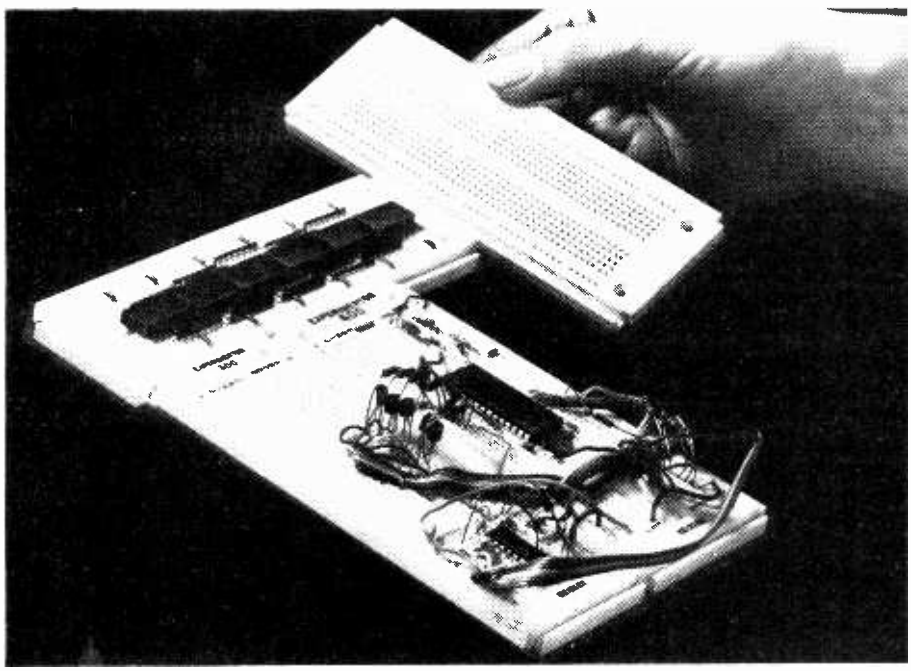
Screened cables attached to equipments that are subject to vibration are apt to pick up electrical noise of the same frequency as the vibration and if the signal carried by the cable is very small, it could be swamped by the noise. Waycom Limited have made available two low-noise treated cables which they say will reduce this kind of unwanted noise almost to zero. They are the CAS85-22, which is rated up to 85°C, and the CAS250-22 which is rated up to 250°C. Waycom Limited, Wokingham Road, Bracknell, Berks.
WW 311

Breadboard system

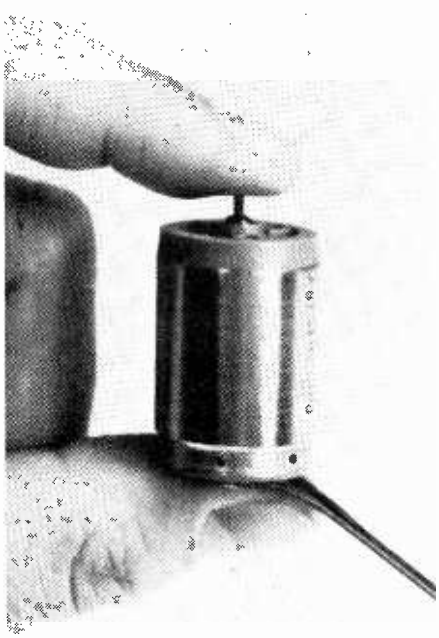
Two breadboarding sockets have been introduced by Continental Specialities Corp. They are suitable for 0.3in and 06in d.i.l. packages and can be locked together to suit any kind of circuit, it is claimed. The boards, called the Experimenter 300 and the Experimenter 600, provide 94 five-contact, terminals, arranged in two rows of 47, plus two integral bus-trips for ground and power, with 40 contacts on each; a total of 550 solderless tie-points. The 600 is claimed to be the first breadboard to be designed for 0.6in devices. It is suitable for microprocessors, clock chips, r.a.ms, r.o.ms etc. The 300 has been designed for any 0.3in d.i.l. package, having six pins or more. Both boards will also accept virtually any kind of discrete components capacitor or potentiometer. Continental Specialities Corporation, 44 Kendall Street, Box 1942, New Haven, Connecticut 06509, USA.
WW 312

Direct-current motors

The Escap 22C series of ironless-rotor precision motors has now been extended to comprise eight models having nominal voltages between 3.5 and 36V and torque constants from 43 to 462 × 10^{-4}Nm per amp. Characteristics of the models in the series include linear voltage/speed and speed/torque relationships; very low rotor inertias (1.5 to 3.46 × 10^{-7} sq.kgm); very fast response times (18 to 21ms); very low starting voltages (from 0.1V); high efficiencies (up to 80%) and high power to volume ratio. Portescap (UK) Limited, 204 Elgar Road, Reading, RG2 0DD.
WW 313



WW 312



WW 313

L.c.d. multitester

The LCD900 multitester is a development of the standard multi-test models available from Sanwa, but, for any setting of its range switch, only the selected scale is visible on the liquid crystal display. This eliminates the possibility of scale misrepresentation. The meter has a movement of 50kΩ/V giving a current sensitivity of 17.5μA full scale. Direct voltage measurement covers the range 20mV to 1000V, and direct current ranges are from 0.3 to 300mA. Alternating current and voltage ranges are 3A and from 10 to 1000V. respectively. Resistance ranges are from 1 to 1000kΩ. Reading errors are between ±3% and ±6% of full scale depending on the range and the lifetime of the l.c.d. is claimed to be 50,000h. The meter movement is protected against displacement due to overload and shock. Quality Electronics Limited, 47 High Street, Kingston-on-Thames, Surrey KT1 1LP.
WW 314

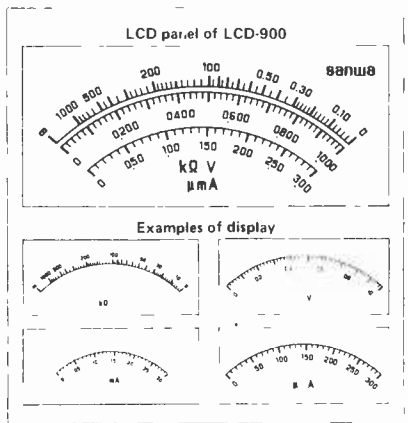
R.f. signal sampler

The model 4275 is a wide-range, variable r.f. signal sampling probe designed for spectrum analysis, signal observation or frequency counting and control applications. The device is suitable for the range 2 to 1000MHz up to 1000W, and it produces at its BNC port an unrectified r.f. sample adjustable between 35 and 80dB below the main signal. The level of the output signal remains essentially flat from 100 to 1000MHz and is not prone to the gain of typically 6dB per octave associated with many conventional couplers. Once adjusted, the output setting can be locked. The insertion loss is only 0.1dB to 512MHz and 0.2dB to 1000MHz and the v.s.w.r. is very low over the whole range of frequency and attenuation. Connectors for the sampler's main-line are Bird Quick-Change QC types which are available to mate with most standard connectors, and can be readily interchanged in the field. Aspen Electronics Limited, 2 Kildare Close, Eastcote, Middlesex, HA4 9UW.
WW 315

Reed vane switch

The RSV06 consists of a reed switch and a magnet, both encapsulated in silicone rubber and an acetal case, separated by a slot which will allow a ferrous vane to pass between them. When the vane is in the slot it shorts the magnetic field and allows the reed switch to open. In the absence of the vane, the magnet closes the switch. It is claimed that, with this switch, more accurate operate release points can be achieved than with the conventional reed and magnet system. Units with normally-open or change-over reeds are available. FR Electronics Ltd, Wimborne, Dorset BH21 2BJ.
WW 316

WW 314



High power source drivers

Eight-stage source drivers from Sprague are intended as interface modules between small-signal logic devices and high-current, high-voltage loads, such as relays, stepping-motors and lamps. Several types are available, capability within the range of devices being provided for interfacing t.t.l, Schottky t.t.l., d.t.l., 5V c.m.o.s. and m.o.s. at between 6 and 16V. The devices sustain 'off' voltages of 50V or 80V and will supply load currents of 500mA. Bulletin Z-29310 from Sprague deals with these devices, series IDN-2980A. Sprague Electric (UK) Ltd, 159 High Street, Yiewsley, W. Drayton, Middlesex.
WW 317

LCR meter

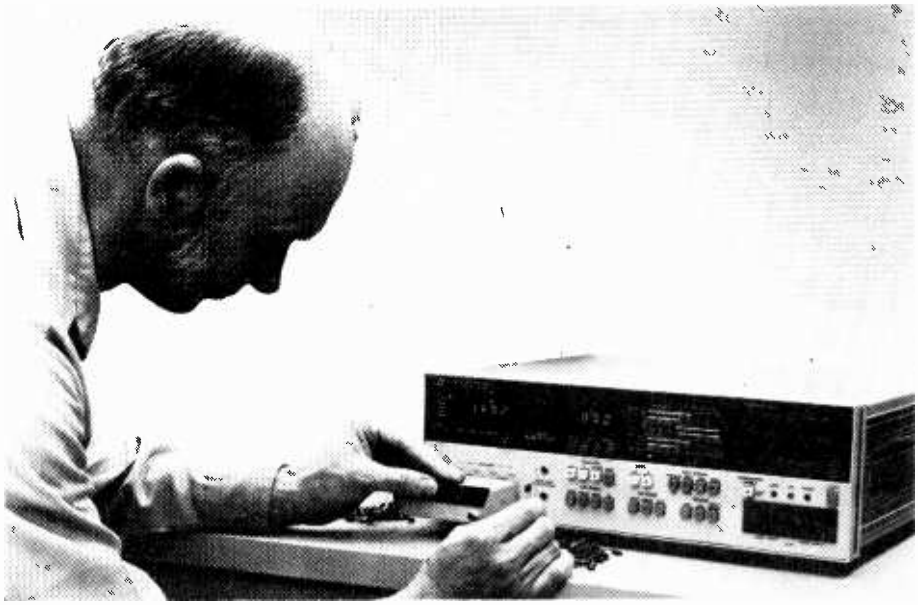
Almost completely automatic in operation, the Hewlett-Packard 4262A digital LCR meter, a 3½-digit instrument, will measure capacitance from 0.01pF to 2000μF, inductance from 0.01μH to 2000H and resistance from 1mΩ to 20MΩ. Loss (D and Q) are determined from 0.001 to 20 and from 0.05 to 1000, and two successive measurements can be compared. The operator must select L, C or R and loss parameter and the test frequency (120Hz, 1kHz or 10kHz) and can then leave the microprocessor in the instrument to select the relevant range and equivalent-circuit mode. Typical error of measurement is 0.2% of reading. Test signal is 1V, three d.c. bias levels can be selected and both series and parallel equivalent circuit modes can be selected. Binary-coded decimal outputs of value and loss are provided and the unit can be made compatible with the HP interface bus. Hewlett-Packard Ltd, King Street Lane, Winnersh, Wokingham, Berks RG11 5AR.
WW 318

De-soldering gun

The removal of components mounted on printed-circuit boards is assisted by the Telpro de-soldering tool, which possesses the feature of ejection of the solidified surplus solder. The joint is heated by a soldering iron, the p.t.f.e. tip of the tool placed in contact and a spring released. Solder is drawn into the barrel of the gun, from which it is ejected the next time the gun is cocked. One-handed operation is possible and no vacuum pump is needed. Tele-Production Tools Ltd, Stiron House, Electric Avenue, Westcliffe-on-Sea, Essex.
WW 319

Crystal oscillator

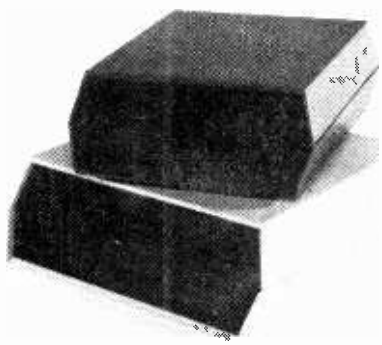
Designed for use with t.t.l. circuitry, the VXO-1 crystal oscillator from Verospeed provides normal and complementary outputs at 1MHz and 2MHz. Temperature coefficient is 1 p.p.m./°C and the output is a square wave with rise

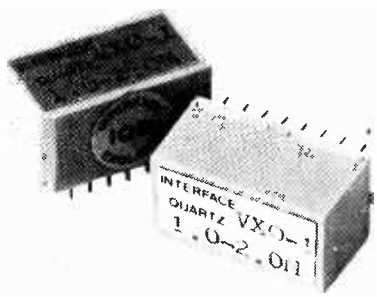


WW 318

WW 319

WW 320





WW 321

WW 322

and fall times of less than 20ns. Supply needed is 5V at 35mA. Verospeed, 10 Barton Park Industrial Estate, Eastleigh, Hants SO5 5RR.
WW 321

Instrument cases

Plastic cases from the Italian firm of TEKO are now available from the sole U.K. agents, West Hyde. All the cases are moulded in ABS and vary in size from the Modulo L20 of 5cc capacity to the sloping-front Nuova design of more than 3000cc. The range of colours is very wide and the cases are designed to withstand 85°C. These units are additions to the existing ranges of plastic/metal Teko cases, which have been available for some time. West Hyde Developments Ltd, Ryefield Crescent, Northwood, Middlesex HA6 1NN.
WW 320

Capacitance meter

Tranchant say the new ESI model 275 capacitance meter measures from 1pF to 20μF with a maximum error of 0.1% and up to 200μF at an error of 0.3%. It also measures dissipation factor in the range from zero to unity. The pushbutton controls select series or parallel capacitance, dissipation factor, and power, and the seven range rotary switch is augmented by three l.e.ds which show which of the three parts of the range the meter is operating in. Tranchant Electronics (UK) Ltd, 100a High Street, Hampton, Middlesex, England. Telephone 01-979 0123.
WW 322

Sidebands by mixer

Bath time with the Rent Act

I must say, I felt a pang of sympathy with businessmen everywhere when I read this circular about the trouble they have in keeping up with the information explosion. But they need worry no more, for help is at hand.

According to the circular, all they need do is buy a cassette player and some recorded cassettes at up to £7 apiece and sit, or rather lie, back in comfort. They will then be able to occupy their, otherwise idle, leisure moments with a soothing rendering of "Inflation accounting — the Sandilands proposals" or a beautifully-played *divertissement* on "Capital transfer tax."

The circular suggests that this can be done anywhere – driving, relaxing or in the bath. Well, I don't know about that! By the time you've sunk the empty shampoo bottle a couple of times and made the sponge float right to the end of the bath *and* bounce all the way back again, there isn't a lot of time left for entertainment. But I dare say you could fit in a quick blast of "The employment protection act" before the water gets too cold.

Not long to '84

Those of us who are of an enquiring turn of mind will be enchanted to hear that one can now possess one's very own lie detector. It is called the Mark IX by its American (who else?) makers and one is prompted to ask whatever happened to the other eight, except that they probably wouldn't tell. Actually, I received a handout leaflet on it last May, but ever since then I've been trying to decide whether to laugh or cry about it. Since one of the uses suggested by the makers is to determine "the credibility of the people you deal with in business," it seems more appropriate to laugh than cry, particularly if the kind of people I deal with are at all prevalent.

Well, just imagine, if you will, a conversation between one of our weasel-faced, news-hungry reporters and the managing director of Tutchitt and Bellow, makers of high-voltage test equipment.

W-f, n-h r: "Ah! Hello there, Dr Tutchitt. A question on your new gigavolt test set, if you have a minute."

Dr T: "Certainly, my boy. Always glad to talk to *Wireless World*."

W-f, n-h r: "You say in your hand . . . press release that it is better than anything ever seen either here or in the States before. Can you positively confirm that?"

Dr T: "I think I can say, without any fear of contradiction, that this fine new monument to British ingenuity is a breakthrough in the field of . . . er . . . what was it? . . . voltage testing. It demonstrates a new insight into the philosophy of non-destructive investigation of. . . . ".

W-f, n-h r: "Er . . . Dr Tutchitt, the . . . er . . . light on my Mk IX Electronic Lie Detector is going berserk. Maybe you'd like to modify what you were saying."

Dr T: "Oh! Well, all right then. We cribbed it from a Japanese one and it's cheap to make. That all right?"

W-f, n-h r: "Thank you, sir. I appreciate your . . . er . . . frankness. Goodbye."

No, I think not. Besides, we all need our illusions.

Double Dutch

Those among you who thoughtthat the development of the human species stopped at homo sapiens are in for a surprise. All those lovely names like *australopithecus* (as Bazza McKenzie is known to his mates) and *homo orientalis* did not come to a mundane end with *homo surbitonis*, because according to ads. in some Dutch magazines, there appears to be a demand for *electronicus*, a kind of homunculus with electronic connexions. The Natuurkundig Laboratorium, for example, is after one.

Now, smoking dogs are bad enough, but this callous and inhuman trapping of wild *electronici* is really the limit and has got to stop. In fact, only in Holland has it really got started, most hunting being carried on around Eindhoven. One can only imagine to what depths of humiliation these creatures are subjected. Rumour has it that they are used for testing audio equipment – if the cowering, cringing thing does not shriek in anguish when the gear is switched on, it is classified as "medium-to-high fidelity", while a tremble of sensual delight puts the equipment in the hi-fi class. It is said that electronici can also be used as "quick-look" indicators of accuracy in computer-aided designs. The circuit diagram is shown to the wretched creature which emits either a snarl or a maniacal howl, something like a human laugh. The snarl appears to mean that the computer has got it right, while the laugh means "No chance". What a way to use one of God's creatures!

(Now I've had another look at the advert, it seems that they're wanting an electronic engineer. Pity – it would have made a spectacular bit of publicity for the Sub-human Rights Association.)

Pull up the ladder

As a less-than-fanatical motorist, I look at the breed of failed grand prix drivers who seem ready and willing to risk killing themselves or, more important, someone else, to gain an extra 100ms away from the lights, with something approaching disbelief. The average driver wouldn't consider, would laugh at, the suggestion that he jump off a tall building and hope someone would catch him, but is perfectly easy in his mind when he takes off like a rocket on the amber and red and hopes that no one is coming across his bows and that if there is, he will stop.

It's as though the real world didn't exist — an illusion fostered by the array of car radio and tape gear one can now buy (in-car entertainment, to use the current pidgin). The feeling seems to be that if you can hear Terry Murrayburn's happy chatter, nothing can harm you, unlikely as that proposition may seem to popphobes. A recent handout from a car radio maker or, rather, from his publicity firm, reads "what we, as motorists, are interested in is protecting and improving our internal environment . . ."

So that's it, then. It's all out in the open. All pretence can now cease. There is no need to give a tinker's about the old lady we have just sent spinning like a top with a careless flick of the wheel, because we're not really interested. The 32-tonner poised at a graceful forty-five degrees across the junction because we're in the way is as chaff compared with our internal environment, which is being greatly protected and improved by wonderful Radio One. It seems to me that, with an outlook like that, one's internal environment would be far better protected and improved by staying at home. Or by taking a couple of aspirin and a cup of strong, black coffee.

Stolen equipment: The Thames Valley Police have asked us to mention the theft of £7,000 of communications equipment. The stolen items are: Microtel wide-range receiver model 1200, serial number 209, fitted with l.f. converter, i.j. reference, level compensator and recording facility; frequency converter model 1201, serial number 209; carrying case model 1204; six waveguide mixers, models, 1205-6 to 1205-11; and a low frequency converter. Any reader who can provide information on the whereabouts of this equipment is asked to telephone Gerrard's Cross 8222 or their local police.

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ITT Components now offer a standard range of crystals – 54 variants in all – which has been designed to meet virtually every requirement. (This does not exclude the provision of crystals to special order if necessary.)

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Telephone: 0279 26811. Telex: 81146

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10 WW 77

Components ITT

WW—076 FOR FURTHER DETAILS

LATEST BARGAINS IN TEST EQUIPMENT

TYPE OF EQUIPMENT AND MANUFACTURER	TYPE NO.	DESCRIPTION	PRICE £
Counter Timers			
Advance	TC15 P1/P3	DC-500 MHz. 1 ms - 100 s in decade steps (systems modified)	270.00 (G)
Hewlett Packard	5255A	Transfer oscillator plug-in 0.05 - 12.5 GHz. CW or pulse	450.00
Microwave			
Hewlett Packard	8475	'S' parameter test set for 8410 series. 0.1 - 2 GHz	1,400.00
Hewlett Packard	11604	Universal extension	415.00
Oscilloscopes			
Hewlett Packard	183A, 1830A, 1840A	Mainframe DC - 250 MHz 1/P 10 mV - IV/Div. 50Ω Dual channel Timebase - 10 ns - 0.1 s/Div.	650.00 (G)
Power Meters			
Hewlett Packard	432A, 478A	Meter 10μ W - 10 mW Thermistor Mount 10 MHz - 10 GHz	
Pulse Generators			
Hewlett Packard	8005A	5 V/50 OHMS 0.3 Hz - 10 MHz. Variable rise and fall	390.00
Recorders & Signal Conditioning Equipment			
Philips	8221/03	2 pen. 10" chart 5 mV - 20 V f.s.d	250.00 (H)
Smiths	RE551.20	X - Y plotter. A3 size 20 OHMS V - 500 MV/CM	450.00 (G)
San-Ei	PR101	Visigraph 'p' light beam recorder. 6 channels. Lightweight speed: 2-100 cm/sec. Galvo's at cost	750.00 (G)
San-Ei		Oscillostore + Oscillofil + Komp III Incorporating 2-channel flat bed recorder with U.V. inverter. 12 V. DC - 230 V. 50 Hz - recorder for fast transient and digital store capability	300.00
Siemens	G240		40.00
Signal Sources & Generators			
Hewlett Packard	8693B/100	3.7 - 8.3 GHz 15 mW	P.O.A. (G)
Wavetek	147	Function generator 0.0005 - 10 MHz	
TV Test Equipment			
Hewlett Packard	3701/02/03	Microwave link analyser	650.00
Voltmeters			
Rohde & Schwarz	URV	RF - DC millivoltmeter 1 KHz - 1.6 GHz (with probe)	250.00 (G)
Dana	5330/700	119999 FSD DC/AC/OHMS. DC 1 μV Res 100 mV	1,450.00 (G)
Hewlett Packard	3470/34702A	0.01% 1 - 1kV .006%. AC 30 Hz - 250 KHz 2%	320.00 (G)
Solartron	A200	AC/DC/OHMS 0.05% DC 9999 FSD	320.00
Wave Analyser			
Rohde & Schwarz	FAT 3	19999 FSD 1μ V Res. 0.01%	295.00
		5 Hz - 2/20 kHz. 0.1μ V - 30 V. 100 db. Includes signal source	275.00
			4,000.00 (G)

Equipment marked (G) is in Germany
Equipment marked (H) is in Holland

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WW — 080 FOR FURTHER DETAILS

RETURN OF POST MAIL ORDER SERVICE

BSR HI-FI AUTOCHANGER
STEREO AND MONO £17.50 Post 75p

Plays 12", 10" or 7" records. Auto or Manual. A high quality unit backed by BSR reliability with 12 months guarantee. A.C. 200/250V. Size 13½-11¼in. 3 speeds. Above motor board 3¾in. Below motor board 2½in. with STEREO and MONO CARTRIDGE. B.S.R. SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable **£13.50**. **B.S.R. P128** with magnetic cartridge. Balanced arm. Cueing device. Bias Compensator **£24.50.** Post £1.

PORTABLE PLAYER CABINET
Modern design. Rexine covered. Vynair front grille. Chrome fittings. Size 17 x 15 x 8in approx. **£4.50** Post 75p. Motor board cut for BSR or Garrard deck.

HEAVY METAL PLINTHS
With P.V.C. Cover. Cut out for most B.S.R. or Garrard decks. Silver grey finish. **£6.50** Post £1.50.
Model A. Size 12½ x 14¾ x 7½in.
Model B. Size 16 x 13¾ x 7in. **£7.50.**
Extra large plinth & cover, teak wood base. Size 20" x 17¼" x 9" **£19.50** (callers only).

COMPLETE STEREO SYSTEM
Two full size loudspeakers 13¾ x 10 x 3¾in. Player unit clips to loudspeakers making it extremely compact, overall size only 13¾ x 10 x 8½in. 3 watts per channel, plays all records 33 r.p.m. 45 r.p.m. Separate volume and tone controls. Attractive Teak finish. 240V a.c. mains. **£22.50** £1 carriage.

ELAC HI-FI SPEAKER 8in. TWIN CONE

Dual cone plastic roll surround. Large ceramic magnet. 50-16,000 c/s. Bass resonance 40 c/s. 8 ohm impedance. 15 watts RMS. **£5.95** Post 35p.

SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0—6 HOURS £3.30 Post 35p

Single pole two-way. Surface mounting with fixing screws. Will replace existing wall switch to give light for return home, garage, automatic anti-burglar lights, etc. Variable knob. Turn on or off at full or intermediate settings. Brand new and fully guaranteed.

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7¾in—**45p**.

R.C.S. "MINOR" 10 watt AMPLIFIER KIT
This kit is suitable for record players, guitars, tape playback, electronic instruments or small P.A. systems. Two versions available. Mono. **£11.25;** Stereo. **£18.** Post 45p. Specification 10W per channel, input 100mV, size 9½ x 3 x 2in approx. S.A.E. details. Full instructions supplied. A.C. mains powered.

VOLUME CONTROLS
5kΩ to 2MΩ. LOG or LIN. L/S **35p.** D.P. **60p.** STEREO L/S **85p.** D.P. **£1.** Edge 5K S.P. Transistor **45p.**

80 Ohm Coax 8p yd.
FRINGE LOW LOSS **15p yd.**
Ideal 625 and colour. PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **50p.**

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM
£3.45 Post 35p
This famous unit now available. 10 watts. 8 ohm.

E.M.I. 13½ x 8in. SPEAKER SALE!

With tweeter and crossover. 10 watt. State 3 or 8 ohm. As illustrated. **£7.95** Post 45p.

Ditto. 15 watts. 8 ohm. **£10.50** Post 65p.

With tweeter and crossover. 20 watt. Bass res. 25 c.p.s. Flux = 11,000 gauss. 4 or 8 or 15 ohm. 20 to 20,000 c.p.s. **£11.50** Post 75p.

Bookshelf Cabinet Teak finish. For EMI 13 x 8 speakers. **£8.50** Post £1.00.

THE "INSTANT" BULK TAPE ERASER AND HEAD DEMAGNETISER. Suitable for cassettes, and all sizes of tape reels. A.C. mains 200/250V. Leaflet S.A.E. Will also demagnetise small tools. **£4.95** Post 50p.

BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70. ANGLE ALI.** 6 x ¾ x ¼in—**15p.**

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VARICAP FM TUNER HEAD with circuit & connections **£4.95.**

TAG STRIP 28-way **12p.**

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SONOTONE stereo **£2.00. SHURE** M75 ECS **£8.**

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Kit of parts to build a 3 channel sound to light unit. 1,000 watts per channel. Post 35p **£14.** Easy to build. Full instructions supplied. Cabinet **£3.**

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS
£2.95 Post 45p
All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a.c. Output voltages available, 6 or 7.5 or 9 or 12V d.c. up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required.

R.C.S. POWER PACK KIT
£3.35 Post 30p
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R.C.S. GENERAL PURPOSE TRANSISTOR PRE-AMPLIFIER — BRITISH MADE
Ideal for Mike, Tape, P.U., Guitar, etc. Can be used with battery 9-12V or H.T. line 200-300V d.c. operation. Size 1¾ x 1¼ x ¾in. Response 25 c/s to 25 kc/s. 26 dB gain. For use with valve or transistor equipment. Full instructions supplied. Details S.A.E. **£1.45** Post 30p

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ALL POST 50p

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250-0-250V 80mA, 6.3V 3.5A, 6.3V 1A or 5V 2A	**£4.60**
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220V 45mA, 6.3V 2A	**£1.75**
HEATED TRANS. 6.3V ½ amp	**£1;** 3 amp **£1.40**

GENERAL PURPOSE LOW VOLTAGE. Tapped outputs at 2 amp. 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V **£5.30.** 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£5.30.** 2 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.50.** 3 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.00.** 5 amp. 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£14.50.** 12V 100mA **£1,** 9V 1 amp **£1,** 12V 300mA. **£1,** 12V 750mA. **£1,** 10V, 30V, 40V, 2 amp., **£2.75,** 20V, 3 amp., **£2.45,** 40V, 2 amp., **£2.95,** 30V 5A and 34V 2ACT **£3.45,** 0, 5, 8, 10, 16V, ½ amp., **£1.95,** 20V ½ amp., **£1.75,** 20V, 1 amp., **£2.20,** 20V 3 amp., **£2.50,** 20-0-20V 1 amp., **£2.95,** 30V 1½ amp., **£2.75;** 20V, 40V, 60V or 20-0-20V, 1 amp, **£3.50.** 30-0-30V 3 amp **£7.** 2×18V 6 amp. **£11.00.**

AUTO TRANSFORMERS, 115V to 230V or 230V to 115V 150W **£5;** 250W **£6;** 400W **£7;** 500W **£8.**

FULL WAVE BRIDGE CHARGER RECTIFIERS: 6 or 12V outputs, 1½ amp **40p;** 2 amp **55p;** 4 amp **85p.**

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12V 1½A HALF WAVE Selenium Rectifier, **25p.**

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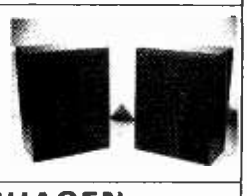

13 x 10 x 6in. 50 to 14,000 cps. 8 watts rms. 4, 8 or 16 ohms. **£16 pair** Post £1.30.

KUBA-KOPENHAGEN STEREO

TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT

This Continental 4-band radiogram chassis uses first class quality components throughout. Features. Large facia panel with 7 push buttons for medium, long, short, VHF-FM, AFC, phono, mains on-off. 4-rotary controls, tuning, volume, tone, balance. Facia size 17 × 4½ inches. Chassis size 17 × 4½ × 5½ inches. DIN-connector sockets for tape record/playback, loudspeakers, phono pick-up, external FM-AM aerials. Automatic stereo beacon light. Built-in ferrite rod aerial for medium/longwave. A.C. 240V mains. Circuit supplied. Above speakers are suitable. **£33.50** Post £1.50.

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1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
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SUB-MIN MICRO SWITCH, 25p. Single pole change over.
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p;** 365 + 365 + 25 + 25pF. Slow motion drive **65p.**
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NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. ¼W, ½W, 1W, 20% **2p;** 2W, **10p;** 10Ω to 10M
HIGH STABILITY. ½W 2% 10 ohms to 6 meg., **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg., **5p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt. 10 ohms to 100K **12p** each.

BAKER MAJOR 12" £15.00
Post £1.00

30-14,500 c/s. 12in. double cone woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells. Bass resonance 40 c/s. Rated 25W. NOTE: 4 or 8 or 16 ohms must be stated.

Module kit 30-17,000 c/s with tweeter crossover, baffle and instructions. **£19.00** Post £1.60 each. Please state 4 or 8 or 16 ohms.

BAKER "BIG-SOUND" SPEAKERS. Post £1.00 each

'Group 25'	'Group 35'	'Group 50/15'
12in. 30W **£12.00** 4 or 8 or 16 ohm	12in. 40W **£14.00** 4 or 8 or 16 ohm	15in. 75W **£26.00** 8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT GROUP 50/12. 4 OR 8 OR 16 OHM HIGH POWER. FULL RANGE PROFESSIONAL QUALITY RESPONSE 30-16,000 CPS. MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME. **£21.00** Post £1.60.

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in. or 10in. speaker 20x13x12in. **£14.50** Post £2
For 13x8in. or 8in. speaker **£8.50** Post £1
For 6½in. speaker and tweeter 12x8x6in. **£5.80** Post 75p
Many other cabinets in stock. Phone your requirements.

SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in. wide **20p** ft.

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order. Send for leaflet. Suitable carrying cab **£16.50.** Price **£85** carr. £2.50.

Horn Tweeters 2.16kc/s. 10W 8 ohm or 16 ohm **£3.60**
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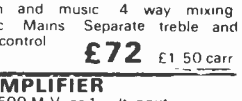
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in **£1.50;** 6½in., **£1.80;** 8x5in., **£1.90;** 8in., **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in., 2¾in., 35 ohm, 3in., 25 ohm, 2½in., 3in., 5x3in., 7x4in., 8 ohm, 2½in., 3in., 3½in., 5in., 15 ohm, 3½in. dia., 6x4in., 7x4in., 5x3in., 3 ohm, 2½in., 2⅝in., 3½in., 5in. dia. **£1.60 each.**
PHILIPS LOUDSPEAKER, 8in., 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in. diameter 4W **£2.50,** 10in. diameter 5W **£2.95;**
12in. diameter 6W **£3.50.** 3/8/15 ohms, please state.
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts. No crossover required **£7.95.**

Tweeter Volume Control 15 ohms 10W with one inch long threaded bush for wood panel mounting. ¼in. spindle **65p.**

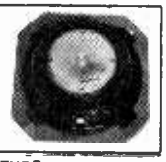
BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised. Ideal for Groups, Disco and P.A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms a.c. Mains. Separate treble and bass controls. Master volume control. Guaranteed. Details S.A.E. **£72** £1.50 carr.

100 WATT DISCO AMPLIFIER
volume, treble, bass controls. 500 M.V. or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor. **£59**

GOODMANS COMPACT 12-INCH BASS WOOFER



Standard 12in. diameter fixing with cut sides 10⅜ square. 14,000 Gauss magnet. 30 watts R.M.S. 4 ohm imp. Bass resonance = 30 cps. Frequency response 30-8000 c.p.s. **£10.95 each** Post £1.

ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 6½" × 4½" × 2¼" **95p.** 6½" × 2" × 2¼" **65p.**
BALANCED TWIN RIBBON FEEDER 300 ohms. 5p yd.
JACK SOCKET Std. open-circuit 20p, closed circuit 25p; Chrome Lead-Socket 45p. Mono or Stereo.
Phono Plugs 8p. Phono Socket 8p.
JACK PLUGS Std. Chrome 30p; Plastic 25p; 3.5mm 15p.
STEREO JACK PLUG 30p. SOCKET 25p.
DIN SOCKETS Chassis 3-pin 10p. 5-pin 10p.
DIN SOCKETS FREE 3-pin 25p; 5-pin 25p. DIN PLUGS 3-pin 25p; 5-pin 25p. VALVE HOLDERS, 10p; CANS 10p.
TV CONVERGENCE POTS 15p each
Values = 5, 7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms

ELECTRO MAGNETIC PENDULUM MECHANISM
1.5V d.c. operation over 300 hours continuous on SP2 battery. Fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p.

SPECIAL OFFER

PERIOD LOUDSPEAKER CABINETS. Two styles available, Regency and Queen Anne. Size approximately 34 x 19 x 16in. These cabinets are slightly soiled and are priced from £10 each. Callers only.

RADIO COMPONENT SPECIALISTS
337 WHITEHORSE ROAD, CROYDON
Open 9-6. Wed. 9-1. Sat. 9-5 (Closed for lunch 1.15-2.30)
Radio Books and Components lists 20p. (Minimum posting charge 30p.) Cash prices include VAT. (We accept Access or Barclaycard. Phone your Order) **Tel. 01-684 1665**

NEW PRODUCTS!

NRDC-AMBISONIC 45J

SURROUND SOUND DECODER

The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug. and Sept. '77.
The unit is designed to decode not only 45J but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC Matrix H.10 input selections.
The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power, wooden cabinet, panel, knobs, etc.

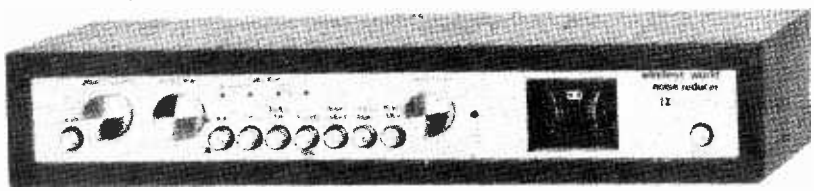
Complete kit, including licence fee £45.00 + VAT

INTRUDER 1 RADAR ALARM

With Home Office Type approval.
As in this issue of "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet. Complete kit. Exclusive designer approved kit £46.00 + VAT, all ready built and tested £54.00 + VAT.

Wireless World Dolby™ noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance
Noise reduction better than 9dB weighted.
Clipping level 16.5dB above Dolby level (measured at 1% third harmonic content)

Harmonic distortion 0.1% at Dolby level typically 0.05% over most of band, rising to a maximum of 0.12%

Signal-to-noise ratio: 75dB (20Hz to 20kHz, signal at Dolby level) at Monitor output

Dynamic Range >90db

30mV sensitivity.

Featuring

- switching for both encoding (low-level h.f. compression) and decoding.
- a switchable f.m. stereo multiplex and bias filter
- provision for decoding Dolby f.m. radio transmissions (as in USA)
- no equipment needed for alignment
- suitability for both open-reel and cassette tape machines
- check tape switch for encoded monitoring in three-head machines

Complete Kit **PRICE: £39.90**+VAT

Also available ready built and tested . . . . . **Price £54.00**+VAT

Calibration tapes are available for open-reel use and for cassette (specify which) . . . . . **Price £2.20**+VAT *

Single channel plug-in Dolby™ PROCESSOR BOARDS (92 x 87mm) with gold plated contacts are available with all components . . . . . **Price £8.20**+VAT

Single channel board with selected fet . . . . . **Price £2.50**+VAT

Gold Plated edge connector . . . . . **Price £1.50**+VAT*

Selected FETs **60p** each+VAT, **100p**+VAT for two, **£1.90**+VAT for four

Please add VAT @ 12½% unless marked thus*, when 8% applies (or current rates)

Buy it with Access · EUROCARD · BARCLAYCARD · master charge

We guarantee full after-sales technical and servicing facilities on all our kits, have you checked that these services are available from other suppliers?

Please send SAE for complete lists and specifications

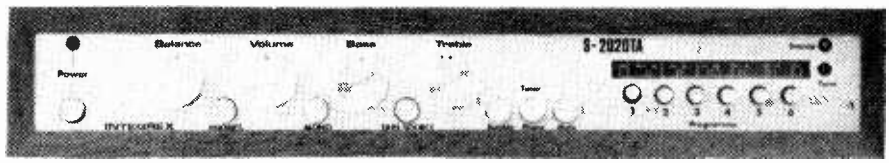
INTEGREX LTD.

Portwood Industrial Estate, Church Gresley,
Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432 Telex 377106

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



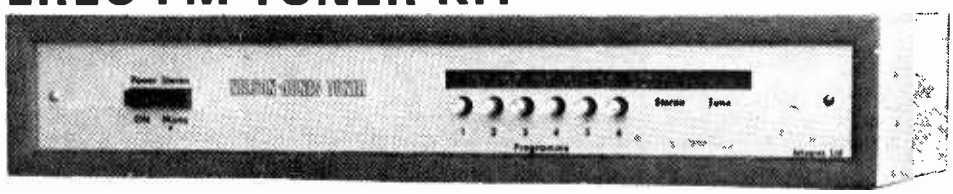
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2μV. THD 0.3%. Pre-decoder 'birdy' filter.

PRICE: £58.95 + VAT

NELSON-JONES STEREO FM TUNER KIT

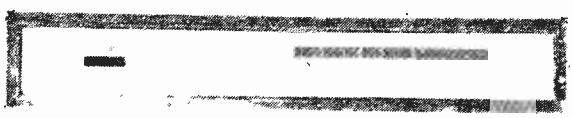
A very high performance tuner with dual gate MOSFET RF and Mixer front end, triple gang varicap tuning, and dual ceramic filter/dual IC IF amp.



Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

Mono £32.40 + VAT
With ICPL Decoder £36.67 + VAT
With Portus-Haywood Decoder £39.20 + VAT

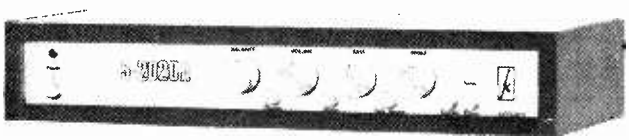


STEREO MODULE TUNER KIT

A low-cost Stereo Tuner based on the 3302 FET RF module requiring no alignment. The IF comprises a ceramic filter and high-performance IC Variable INTERSTATION MUTE. PLL stereo decoder IC. Pre-decoder 'birdy' filter Push-button tuning

Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

PRICE: Stereo £31.95 + VAT



S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring

Power 'on/off' FET transient protection.

Typ Spec. 24+24W r.m.s. into 8-ohm load at less than 0.1% THD. Mag. PU input S/N 60dB. Radio input S/N 72dB. Headphone output. Tape In/Out facility (for noise reduction unit, etc.). Toroidal mains transformer.

PRICE: £33.95 + VAT

ALL THE ABOVE KITS ARE SUPPLIED COMPLETE WITH ALL METALWORK, SOCKETS, FUSES, NUTS AND BOLTS, KNOBS, FRONT PANELS, SOLID MAHOGANY CABINETS AND COMPREHENSIVE INSTRUCTIONS

BASIC NELSON-JONES TUNER KIT	**£14.28** + VAT	**PHASE-LOCKED IC DECODER KIT** . . .	**£4.47** + VAT
BASIC MODULE TUNER KIT (stereo)	**£16.75** + VAT	**PUSH-BUTTON UNIT**	**£5.00** + VAT

PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT . . . . . **£8.00** + VAT

WW — 056 FOR FURTHER DETAIL

LANGREX SUPPLIES LTD

Climax House, Fallsbrook Rd., Streatham, London SW16 6ED

RST **Tel: 01-677 2424 Telex: 946708** **RST**

SEMICONDUCTORS

AA119	0.20
AAY30	0.13
AAY32	0.15
AAZ13	0.25
AAZ15	0.31
AAZ17	0.25
AC107	0.75
AC125	0.30
AC126	0.25
AC127	0.25
AC128	0.25
AC141	0.20
AC141K	0.30
AC142	0.20
AC142K	0.25
AC176	0.25
AC187	0.25
AC188	0.25
ACY17	0.65
ACY18	0.65
ACY19	0.65
ACY20	0.65
ACY21	0.65
ACY39	1.00
AD149	0.70
AD161	0.75
AD162	0.75
AF106	0.45
AF114	0.25
AF115	0.25
AF116	0.25
AF117	0.25
AF139	0.40
AF186	1.50
AF239	0.45
AFZ11	2.75
AFZ12	2.75
ASY26	0.45
ASY27	0.50

ASZ15	1.25
ASZ16	1.25
ASZ17	1.25
ASZ20	0.75
ASZ21	1.50
AU113	1.70*
AUY10	1.70*
BA145	0.15*
BA148	0.15*
BA154	0.10
BA155	0.12
BA156	0.13
BAW62	0.05
BAX13	0.07
BAX16	0.07
BC107	0.12
BC108	0.12
BC109	0.13
BC113	0.15*
BC114	0.18*
BC115	0.19*
BC116	0.19*
BC117	0.22*
BC118	0.16*
BC125	0.18*
BC126	0.25*
BC135	0.15*
BC136	0.19*
BC137	0.16*
BC147	0.10*
BC148	0.10*
BC149	0.13*
BC157	0.12*
BC158	0.11*
BC159	0.13*
BC167	0.13*
BC170	0.16*
BC171	0.14*

BC172	0.13*
BC173	0.15*
BC177	0.19
BC178	0.18
BC179	0.20
BC182	0.11*
BC183	0.11*
BC184	0.12*
BC212	0.14*
BC213	0.14*
BC214	0.17*
BC237	0.17*
BC238	0.12*
BC301	0.45
BC303	0.60
BC307	0.20*
BC308	0.18*
BC327	0.22*
BC328	0.18*
BC337	0.19*
BC338	0.18*
BCY30	1.00
BCY31	1.00
BCY32	1.00
BCY33	0.90
BCY34	0.90
BCY39	3.00
BCY40	1.25
BCY42	0.30
BCY43	0.32
BCY58	0.23
BCY70	0.18
BCY71	0.22
BCY72	0.17
BCZ11	1.50
BD115	0.60
BD121	1.50
BD123	1.50
BD124	1.00

BD131	0.51
BD132	0.54
BD135	0.35*
BD136	0.36*
BD137	0.37*
BD138	0.40*
BD139	0.43*
BD140	0.47*
BD144	2.00
BD181	1.38
BD182	1.48
BD237	0.80
BD238	0.85
BDX10	0.75
BDX32	2.25
BDY20	1.42
BDY60	0.75
BF115	0.39
BF152	0.25
BF153	0.25
BF154	0.25
BF159	0.35
BF160	0.30
BF167	0.39
BF173	0.39
BF177	0.38
BF178	0.45
BF179	0.48
BF180	0.45
BF181	0.45
BF182	0.45
BF183	0.45
BF184	0.39
BF185	0.37
BF194	0.12*
BF195	0.11*
BF196	0.13*
BF197	0.14*
BF200	0.32
BF224	0.20*

BF244	0.35*
BF257	0.37
BF258	0.42
BF259	0.45
BF336	0.50*
BF337	0.53*
BF338	0.55*
BFS21	2.27
BFS28	1.38
BFS61	0.25*
BFS98	0.25*
BFW10	0.90
BFW11	0.90
BFX84	0.38
BFX85	0.41
BFX87	0.35
BFX88	0.32
BFY50	0.28
BFY51	0.26
BFY52	0.26
BFY64	0.30
BFY90	1.32
BSX19	0.34
BSX20	0.34
BSX21	0.32
BT106	1.25
BTY79/400R	3.19
BU205	2.25*
BU206	2.25*
BU208	2.50*
BY100	0.45
BY126	0.14
BY127	0.15
BZX61 Series	0.20
BZY88 Series	0.13
CRS1/05	0.45
CRS1/40	0.60

CRS3/05	0.45
CRS3/40	0.75
CRS3/60	0.90
GEX66	1.50
GEX541	1.75
GJ3M	0.75
GJ5M	0.75
GJ7M	0.75
GM0378A	1.50
KS100A	0.40*
MJE340	0.58
MJE370	0.65
MJE371	0.81
MJE520	0.65
MJE521	0.75
MJE2955	1.25
MJE3055	0.75
MPF102	0.30*
MPF103	0.30*
MPF104	0.30*
MPF105	0.30*
MPSA06	0.25*
MPSA56	0.25*
MPSU01	0.32*
MPSU06	0.40*
MPSU56	0.45*
NKT401	2.00
NKT403	1.73
NKT404	1.73
NE555	0.45
OA5	0.75
OA7	0.55
OA10	0.55
OA47	0.14
OA70	0.30
OA79	0.30
OA81	0.30
OA85	0.30
OA90	0.08
OA91	0.08

OA95	0.08
OA200	0.10
OA202	0.11
OA210	0.75
OA211	0.75
OAZ200	0.65
OAZ201	0.65
OAZ206	0.65
OAZ207	0.65
OC16	1.25
OC20	2.00
OC22	2.50
OC23	2.75
OC24	3.50
OC25	0.90
OC26	0.90
OC28	2.00
OC29	2.00
OC35	1.50
OC36	1.50
OC41	0.50
OC42	0.50
OC43	1.50
OC44	0.50
OC45	0.50
OC71	0.45
OC72	0.45
OC73	1.00
OC74	0.50
OC75	0.60
OC76	0.50
OC77	1.20
OC81	0.75
OC81Z	1.00
OC82	0.75
OC83	0.55
OC84	0.60
OC122	1.50
OC123	1.55
OC139	1.25

OC140	1.95
OC141	2.25
OC170	0.60
OC171	0.60
OC200	1.00
OC201	1.50
OC202	1.25
OC203	1.25
OC204	1.25
OC205	1.75
OC206	1.75
OC207	1.25
OCP71	1.25
ORP12	0.70
R2008B	2.25*
R2009	2.25*
R2010B	2.25*
TIC44	0.36
TIC226D	1.30
TIL209	0.25
TIP29A	0.50*
TIP30A	0.60*
TIP31A	0.62
TIP32A	0.75
TIP33A	1.00
TIP34A	1.20
TIP41A	0.70
TIP42A	0.90
TIP2955	1.00
TIP3055	0.50
TIS43	0.35*
ZS140	0.25*
ZS170	0.12*
ZS178	0.54*
ZS271	0.22*
ZS278	0.56*
ZTX107	0.11*
ZTX108	0.10*
ZTX109	0.12*
ZTX300	0.12*

ZTX301	0.13*
ZTX302	0.17*
ZTX303	0.17*
ZTX304	0.19*
ZTX311	0.12*
ZTX314	0.20*
ZTX500	0.13*
ZTX501	0.14*
ZTX502	0.16*
ZTX503	0.17*
ZTX504	0.20*
ZTX531	0.20*
ZTX550	0.16*
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1N916	0.07
1N4001	0.06
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1N4003	0.08
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1N4007	0.15
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1N5400	0.14
1N5401	0.16
1S44	0.06
1S920	0.08
1S921	0.08
2G301	1.00
2G302	1.00
2G306	1.10
2N404	0.60
2N696	0.25
2N697	0.16
2N698	0.30
2N705	0.80
2N706	0.12
2N708	0.21
2N930	0.26

2N1131	0.26
2N1132	0.26
2N1302	0.37
2N1303	0.37
2N1304	0.45
2N1305	0.45
2N1306	0.50
2N1307	0.50
2N1308	0.60
2N1309	0.60
2N1613	0.33
2N1671	1.50
2N1893	0.33
2N2147	1.40
2N2148	1.65
2N2218	0.33
2N2219	0.42
2N2220	0.35
2N2221	0.22
2N2222	0.25
2N2223	2.75
2N2368	0.17
2N2369A	0.21
2N2484	0.21
2N2646	0.50
2N2904	0.35
2N2905	0.35
2N2906	0.25
2N2907	0.21
2N2924	0.15*
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2N3711	0.15*
2N3771	1.60
2N3772	1.70
2N3773	2.65
2N3819	0.36*
2N3820	0.46*
2N3823	0.60*
2N3866	1.00
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2N4288	0.25*
2N4289	0.25*
2N5457	0.35*
2N5458	0.35*
2N5459	0.35*
3N125	1.75
3N141	0.85

VALVES

A1834	6.00
A2087	10.48
A2134	4.81
A2293	4.10
A2426	8.20
A2521	8.53
A2900	4.85
A3343	18.43
AZ31	1.10*
AZ41	1.15*
BK 448	62.70
BK484	84.70
BS90	27.25
BS810	27.75
BT5	31.15
BT17	55.64
BT19	19.00
BT29	169.70
BT69	173.65
BT75	72.25
BT95	66.80
CBL31	1.50*
CL33	2.00*
CY31	1.00*
C1K	10.00
C3A	10.00
C3JA	10.00
DA41	16.85
DA42	8.81
DA100	31.86
DAF91†	0.40*
DAF96	1.00*
DET22	15.12
DET24	41.00
DF91†	0.40*
DF96	1.00*
DK91†	0.55*
DK92	1.25*
DK96	1.10*
DL92	0.75*
DL94	1.20*
DL96	1.10*
DLS10	8.25
DLS15	8.25
DLS16	8.25
DLS19	8.25
DM70	1.25
DM71	1.25
DM160	1.50
DY86/7†	0.45*
DY802	0.68*
E55L	21.89
E80CC	4.86
E80CF	6.23
E80F	5.57
E80L	5.34
E81CC	5.76
E81L	5.61
E82CC	5.95
E83CC	6.08
E84L	5.25
E86C	8.93
E88C	5.24
E88CC†	1.00
E90CC	4.92

E90F	5.02
E91H	4.65
E92CC	4.86
E99F	5.38
E130L	16.85
E180CC	5.23
E180F	5.64
E182CC	5.72
E186F	7.68
E188CC	4.92
E280F	12.95
E283CC	7.85
E288CC	12.22
EA52	12.92
EA76	1.50
EABC80	0.40*
EAC91†	0.50*
EAF42	1.25*
EAF801	1.75*
EB41	1.75*
EB91†	0.30*
EBC33	1.75*
EBC41	1.25*
EBC81	1.10*
EBC90†	0.65*
EBF80	0.45*
EBF83	1.25*
EBF89†	0.40*
EBL31	2.50*
EC90†	0.40*
EC91†	2.80*
EC92	1.25*
EC157	190.00
ECC33	3.50*
ECC35	3.50*
ECC40	1.25*
ECC81†	0.45*
ECC82†	0.45*
ECC83†	0.45*
ECC84†	0.50*
ECC85†	0.55*
ECC86	2.00*
ECC88†	0.60*
ECC89	0.75*
ECC91†	0.35*
ECC189	1.00*
ECC807	1.75
ECC808	2.25*
ECF80†	0.60*
ECF82†	0.60*
ECF86	0.75*
ECH35	2.00*
ECH42	1.15*
ECH81†	0.50*
ECH83	0.85*
ECH84†	0.85*
ECL80†	0.60*
ECL81	0.75*
ECL82†	0.55*
ECL83	1.50*
ECL84	0.90*
ECL85	0.85*
ECL86†	0.65*
ECLL800	7.00*
EF37A†	1.60*
EF39†	1.60*
EF40	1.15*

EF41	1.20*
EF42	2.00*
EF50†	0.60*
EF54	5.00*
EF55	2.50*
EF80†	0.45*
EF83	1.75*
EF85†	0.50*
EF86†	0.45*
EF89	0.60*
EF91†	0.65*
EF92†	0.75*
EF93†	0.50*
EF94†	0.55*
EF95†	0.30*
EF98	1.25*
EF183†	0.50*
EF184†	0.50*
EF804S	6.50
EF805S	7.00
EH90	0.75*
EK90†	0.65*
EL32	1.50*
EL33	3.50*
EL34†	0.85*
EL36	0.75*
EL41	1.25*
EL42	1.75*
EL81	1.10*
EL83	1.25*
EL84†	0.35*
EL86†	0.50*
EL90†	0.75*
EL91	3.76*
EL95†	0.80*
EL156	16.25
EL360	2.75*
EL500/504	1.50*
EL509	2.16*
EL821	4.32*
EL822	4.65*
EM80	1.10*
EM81	1.00*
EM84	1.00*
EM85	1.25*
EM87	1.50*
EN32	5.50
EN91†	0.55
EN92	1.94
EY51†	0.75*
EY81	1.65*
EY83	1.75*
EY84	3.86*
EY86†	0.50*
EY88	1.75*
EY500A	1.36*
EY802	0.82*
EZ35	0.55*
EZ40	1.25*
EZ41	1.25*
EZ80†	0.30*
EZ81†	0.35*
EZ90†	0.45*
FW4/500	2.50*
FW4/800	2.50*
GI 371K	15.00
G55/1K	9.50

G180-2M	12.90
G240-2D	11.75
G400-1K	13.50
GN4	4.50
GN4A	4.50
GS16	9.00
GTIC	6.95
GU50	9.66
GU51	9.80
GXU1	10.43
GXU2	17.20
GXU3	21.42
GXU4	21.94
GY501	1.32*
GZ32	0.75*
GZ33	4.00*
GZ34†	1.24*
GZ37	4.00*
KT61	3.50*
KT66	4.00*
KT88	4.75*
KTW61	1.75*
KTW62	1.75*
KTW63	1.75*
M8079	8.38
M8080	3.80
M8081	6.16
M8082	4.65
M8083	5.60
M8091	7.70
M8096	3.75
M8097	3.56
M8098	3.20
M8099	5.20
M8100	5.90
M8136	5.95
M8137	6.08
M8140	4.50
M8141	4.85
M8142	4.00
M8144	3.75
M8149	5.10
M8161	5.62
M8162	5.76
M8163	4.50
M8190	4.60
M8195	3.70
M8196	3.40
M8204	3.50
M8212	8.62
M8223	2.30
M8224	2.80
M8225	2.60
M8248	6.54
MU14	1.00*
MX119	17.49
MX123	32.07
MX145	25.25
MX151	11.69
MX152	61.65
MX161	66.60
MX163	11.69
MX164	12.56
MX166	59.40
MX168	22.28
N78	7.50*
OA2†	0.45

OA3	1.10
OA4	1.10
OB2†	0.45
OB3	0.75
OC2	2.30
OC3†	0.45
OD3†	0.45
OZ4	0.75*
PC86†	0.85*
PC88†	0.85*
PC95	0.70*
PC97	0.88*
PC900†	0.75*
PCC84†	0.45*
PCC85	0.45*
PCC88	0.65*
PCC89†	1.05*
PCC189†	0.65*
PCC805†	0.95*
PCC806†	0.95*
PCE82†	1.05*
PCF80	0.72*
PCF82†	0.50*
PCF86†	0.65*
PCF87†	1.00*
PCF200†	1.05*
PCF201†	1.05*
PCF801†	0.55*
PCF802†	0.72*
PCF805	1.28*
PCF806	0.80*
PCF808	1.28*
PCL82†	0.50*
PCL83†	0.92*
PCL84†	0.50*
PCL85†	0.80*
PCL86†	0.65*
PCL805/85†	0.80*
PD500	3.00*
PL66/40N	27.30
PFL200	0.88*
PL36†	0.92*
PL81	0.55*
PL81A†	1.00*
PL82	0.60*
PL83†	0.55*
PL84†	0.60*
PL504/500†	0.96*
PL508†	1.32*
PL509†	2.16*
PL519†	2.96*
PL801	1.10*
PL802†	1.80*
PY33	0.68*
PY81†	0.72*
PY82	0.45*
PY83	0.60*
PY88†	0.68*
PY500A†	1.36*
PY800/81†	0.72*
PY801	0.72*
QQV02-6	9.00
QQV03-10†	1.60
QQV03-20A†	8.50*
QQV06/40A†	8.50*

QQVO7-50	34.80
QQZ03-20A	27.50
QQZ06-40A	38.80
QU37	11.00
QV03-12	3.00
QV04-7	2.50
QV08-100	82.40
QY3-65	40.40
QY3-125†	10.00
QY4-250	51.30
QY4-400	55.50
QY5-500	118.50
QY5-3000A	170.00
QZ06-20	18.95
R10	5.00
R17	1.65*
R18	3.86*
R19	1.00*
R20	1.00*
RG3-250	8.85
RG3-250A	8.85
RG3-1250	20.95
RG4-1250	27.50
RG4-3000	53.45
RR3-250	9.55
RR3-1250	22.00
S11E12	18.00
S130	2.00
S130P	2.50
STV80/40	10.00
STV280-80	20.00
SU41	2.50
SU42	9.00
TD03-10	15.00
TD03-10E	17.50
TD03-10F	17.50
TT15	22.00
TT21	7.00
TT22	7.00
TT100	37.50
TY2-125	40.20
TY4-400	54.00
TY4-500	68.40
TY5-500	160.00
TY6-800	145.00
TY6-5000A	188.00
TY6-5000B	206.00
TY6-5000W	166.00
TY7-6000A	206.00
TY7-6000W	175.00
TZ40	15.00
U18-20	2.50*
U19	8.11
U25	1.16*
U26	1.16*
U37	11.00
UABC80†	0.50*
UAF42	0.75*
UB41	1.25*
UBC41†	0.75*

UCC84	0.75*
UCC85†	0.50*
UCF80	0.75*
UCH42	1.20*
UCH81†	0.50*
UCL82†	0.50*
UCL83	1.20*
UF41	0.75*
UF42	1.25*
UF80†	0.50*
UF85†	0.50*
UF89†	0.50*
UL41	1.00*
UL84†	0.60*
UM80	1.00*
UY41†	0.75*
UY85†	0.65*
VL5631	8.22
XG1-2500	23.10
XG5-500	16.80
XG2-6400	64.95
XGQ2-6400	74.15
XR1-1600A	19.00
XR1-3200	54.00
XR1-3200A	54.00
XR1-6400	59.10
XR1-6400A	59.10
YD1120	206.00
YD1240	206.00
Z759	6.50
ZM1000	4.60
ZM1001	5.38
ZM1020	8.55
ZM1021	7.56
ZM1022	8.22
ZM1023	7.66
ZM1040	11.57
ZM1041	9.67
ZM1042	11.08
ZX1051	87.00
1B3GT†	0.55
1B24	10.00
1B35A	17.00
1B63	45.00
1R5†	0.55*
1S5†	0.40*
1T4†	0.40*
2A515	10.00
2C39A†	9.00
2C43	18.00
2D21†	0.55
2E26	3.00
2J42	60.00
2J55	175.00
2J70A	205.00
2J70B	212.00
2K25†	9.00
3-400Z	35.00
3-500Z	35.00
3A5	1.35
3B24	5.00
3B28†	4.00
3B29	10.00
3B-240M	15.00
3B241M	15.00
3C23	10.00
3C45†	6.00

3CX100A5	20.00
3E29†	5.50
3S4†	0.75*
3V4†	1.00*
4-65A	25.35
4-125A†	12.00
4-250A	36.00
4-400A	37.00
4B32	10.00
4C35	40.00
4CX250B	17.50
4CX350A	31.35
4CX150A	21.00
4X150D	25.00
5B-254M	11.25
5B-255M	11.25
5C22	40.00
5J-180E	495.00
5R4GY†	1.00*
5U4G	1.00*
5U4GB	1.00*
5V4G†	0.65*
5Y3GT	0.85*
5Z3	1.50*
5Z4G	1.00*
5Z4GT	1.00*
6-30L2	1.00*
6AB4	0.75*
6AB7	0.75*
6AC7	0.75*
6AF4A†	0.70
6AG7	0.75*
6AH6†	0.70*
6AK5†	0.30
6AK6	0.95*
6AL5†	0.30*
6AM4	2.30*
6AM5	3.76*
6AM6†	0.65*
6AN5	2.50*
6AN8A†	0.70*
6AQ5†	0.75*
6AR5	0.70*
6AS6†	0.80*
6AS7G†	1.50*
6AT6†	0.65*
6AU5GT	4.26*
6AU6†	0.55*
6AV5GT	3.74*
6AV6†	0.50*
6AW8A†	1.00*
6AX5GT	3.10*
6B7	0.75
6B8	0.75
6BA6†	0.50
6BA7	5.12
6BA8A	3.75
6BC4	3.71
6BE6†	0.45*
6BH6†	1.20*
6BJ6†	0.80*
6BK4	4.21*
6BL6	85.00
6BL7GT	3.86*
6BM6	85.00
6BN6	0.80*
6BQ7A	1.55*
6BR7	4.00*
6BR8†	1.20*

6BS7	4.00*
6BW6	3.75*
6BW7	1.12*
6BX7GT	4.96*
6BZ6	1.78*
6C4†	0.40*
6CB6A†	0.50*
6CD6GA	4.00*
6CG7	1.72*
6CH6	4.32*
6CL6†	0.75*
6CW4	4.72*
6D2†	0.30*
6DK6	2.49*
6DQ6B	3.04*
6EA8	2.21*
6EB8	2.12*
6EW6	0.80*
6F6	0.75
6F23	1.32*
6F28	0.96*
6F33	10.75
6H1	8.00
6H2N	0.75*
6H3N	0.75*
6H6	0.75*
6J4†	0.75*
6J6†	0.35*
6J7	0.75*
6K4N	0.75*
6K6GT	0.75*
6K7	0.75*
6K8	0.75*
6KD6	4.79*
6L6G	2.50*
6L6GA	1.50*
6L6GT	0.75*
6L6GC	1.75*
6L7	0.75
6N2P	0.75
6N3P	0.75
6N7	0.75
6P25	3.50*
6Q7	0.75*
6R7	0.75*
6SA7	0.75*
6SC7	0.75*
6SF7	0.75*
6SH7	0.75*
6SJ7	0.75*
6SK7	0.75*
6SL7GT†	0.55*
6SN7GT†	0.55*
6SQ7	0.75*
6SR7	0.75*
6SS7	0.75*
6U5G	2.00*
6U8†	0.40*
6U8A†	0.55*
6V6GT†	0.60*
6X4†	0.45*
6X5GT†	0.55*
7B7	1.00*
7C5	1.75*
7C6	1.25*
7H7	1.00*
7R7	1.50*
7S7	2.25*
7Y4	0.75*

7Z4	0.75*
11E3	34.00
12AT6	0.45*
12AT7†	0.45*
12AU6	0.50*
12AU7†	0.45*
12AV6	0.60*
12AV7	2.84*
12AX7†	0.45*
12AY7†	0.82*
12B4A†	1.00*
12BA6	0.50*
12BE6	0.60*
12BH7†	0.60*
12BY7†	0.80*
12E1	4.00
12E14	19.80
13E1	43.55
19H4	16.88
19H5	22.50
24B9	30.50
30C15	1.20*
30C17	1.20*
30C18	1.28*
30F5	1.00*
30FL1/2	1.00*
30FL12	1.44*
30FL14	1.28*
30L1	0.68*
30L15	1.32*
30L17	1.32*
30P4	0.92*
30P19	0.92*
30PL1	1.32*
30PL13	1.44*
30PL14	1.68*
30PL15	1.44*
35W4	0.60*
50C5	0.70*
75B1	3.15
75C1	1.55
85A1	7.50
85A2	1.50
90AG	7.26
90AV	7.16
90C1	1.50
90CG	5.74
90CV	5.99
92AG	7.26
92AV	7.16
95A1	4.15
150B2	1.80
150B3	3.30
150C2	1.50
150C4	2.30
211	5.00
723AB†	8.00
803	10.00
805	20.00
807†	0.65
811A†	3.00
812A	7.25
813†	6.00
833A	25.00
866A	8.85
872A	11.40
922	4.36
931A	12.24

1624	1.25
1625	1.00
2050	2.50
4212E	118.95
4212H	118.95
5544	54.00
5545	59.00
5551A	62.70
5552A	84.70
5553A	225.30
5642	3.16*
5654	3.53*
5651	1.80*
5670	2.86*
5675	9.09*
5687	4.30*
5696	1.94*
5718	3.36*
5725	3.40*
5726	2.20*
5727	3.50*
5749	3.30*
5751	2.93*
5763	3.00*
5814A	2.60*
5840	4.40
5842	6.90
5876A	9.38
5879	3.16*
5886	10.50
5963	1.87*
5965	2.20*
6005	3.65*
6021	4.46
6057	5.95
6058	4.56
6059	4.00
6061	4.25
6062	3.75
6063	3.65
6064	5.60
6067	6.08
6072	3.77
6080†	3.40*
6097A + B + C	40.00
6146A	4.27
6146B	4.65
6159	6.00
6189	6.08
6201	4.71
6442	15.00
6883B	4.93
6973	2.61
7025†	1.20
7551	3.65
7586	6.79
7587	12.54
7609	28.75
7868	2.93*
7895	7.48
8005	25.00*
8068	5.50
8122	33.15
8136	1.54
8417	3.40
18042	5.17
18045	5.57

BASES

B7G unskirted	0.15
B7G skirted	0.30
B9A unskirted	0.15
B9A skirted	0.30
Int Octal	0.20
Mazda Octal	0.20
Nuvistor	0.25
Loctal	0.55
8 pin DIL	0.15
14 pin DIL	0.15
16 pin DIL	0.17
Valve screening cans all sizes	0.30

CRT'S

1CP31	31.00
2AP1	8.50
2BP1†	9.00
3BP1	6.00
3DP1†	5.00
3EG1	7.00
3FP7†	3.00
3GP1	6.00
3JP1†	8.00
3JP2†	8.00
3JP7†	10.00
3KP1†	15.00
3RP1†	35.00

4EP1	25.00
4EP7	25.00
4EP11	25.00
5ADP1	35.00
5BP1†	5.00
5CP1†	5.00
5CP1A	40.00
5FP15A	5.00
5FP7†	5.00
5UP7†	5.00
DG7-5	25.00
DG7-32	36.00
DH3-91	31.00
DH7-11	68.00
VCR97†	5.00

VCR138†	10.00
VCR138A†	12.50
VCR139A†	8.00
VCR517A	3.00
VCR517B†	3.00
VCR517C†	3.00

Tube Bases 0.75
† = Surplus
VAT 8%

INTEGRATED CIRCUITS

7400	0.20
7401	0.20
7402	0.20
7403	0.20
7404	0.26
7405	0.23
7406	0.55
7407	0.55
7408	0.28
7409	0.28
7410	0.20
7412	0.26
7413	0.45
7416	0.40
7417	0.40
7420	0.20

7422	0.25
7423	0.35
7425	0.35
7427	0.35
7428	0.50
7430	0.20
7432	0.36
7433	0.37
7437	0.42
7438	0.37
7440	0.22
7441AN	0.92
7442	0.78
7447AN	1.20
7450	0.20
7451	0.20

7453	0.20
7454	0.20
7460	0.20
7470	0.35
7472	0.36
7473	0.36
7474	0.40
7475	0.59
7476	0.42
7480	0.60
7482	0.85
7483	1.00
7484	1.00
7486	0.40
7490	0.52
7491AN	0.85

7492	0.60
7493	0.70
7494	0.80
7495	0.80
7496	0.90
7497	3.67
74100	1.75
74107	0.45
74109	0.86
74110	0.57
74111	0.86
74116	1.89
74118	0.95
74119	2.00
74120	1.10
74121	0.45
74122	0.60
74123	1.00

74125	0.80
74126	0.80
74128	0.80
74132	0.80
74136	0.68
74141	0.85
74142	3.00
74143	3.00
74144	3.00
74145	1.00
74147	2.45
74148	2.00
74150	1.75
74151	0.90
74154	2.00
74155	0.90
74156	0.90
74157	0.90

74159	2.50
74170	2.60
74172	5.00
74173	1.75
74174	1.57
74175	1.00
74176	1.10
74178	1.65
74179	1.65
74180	1.65
74190	1.48
74191	1.48
74192	1.25
74193	1.25
74194	1.25
74195	1.10
74196	1.20
74197	1.00

74198	2.25
74199	2.25
76013N	1.75*
TAA570	2.30*
TAA630S	3.50*
TBA480Q	1.84*
TBA520Q	2.30*
TBA530	1.98*
TBA540Q	2.30*
TBA550Q	3.22*
TBA560CQ	3.22*
TBA673	2.19*
TBA700	1.52*
TBA720Q	2.30*
TBA750Q	2.07*
TBA990Q	2.99*
TCA270Q	
TCA760A	1.38*

Terms of business: CWO. Postage and packing valves and semiconductors 25p per order. CRTs 75p. Items marked * add 12½ % VAT. Others 8%. P&P at 8%.

† Indicates cheap quality version or surplus, but also available by leading UK and USA manufacturers. Price ruling at time of despatch.

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PAKS - PARTS - AUDIO MODULES

PANEL METERS

4" RANGE
Size 4¼" x 3¼" x 1¾"

Value	No	Price
0-50UA	1302	£4.50
0-100UA	1303	£4.50
0-500UA	1304	£4.50
0-1MA	1305	£6.00
0-50V	1306	£6.00

2" RANGE
Size 2⅜" x 1¾" x 1½"

Value	No	Price
0-50UA	1307	£3.50
0-100UA	1308	£3.50
0-500UA	1309	£3.50
0-1MA	1310	£3.50
0-50V	1311	£3.50

MR2P TYPE
Size 42x42x30mm

Value	No	Price
0-50UA	1313	£4.80
0-1MA	1315	£3.20

EDGEWISE
Size 3½" x 1⅜" x 2¼"
Cut out 2¾" x 1¼"

Value	No	Price
0-1MA	1316	£4.05
0-500UA	1317	£4.05

MINIATURE BALANCE/TUNING METER
Size 23x22x26mm
Sensitivity 100/0/100MA

No	Price
1318	£1.95

BALANCE/TUNING
Size 45x22x34mm
Sensitivity 100/0/100UA

No	Price
1319	£2.00

MIN. LEVEL METER
Size 23x22x26mm
Sensitivity 200UA

No	Price
1320	£1.95

Vu METER
Size 40x40x29mm
Sensitivity 130UA

No	Price
1321	£2.00

MINI-MULTI-METER
Size 60x24x90mm
Sensitivity 1000 ohms/V
AC VOLTS 0-10, 50, 250, 1000
DC VOLTS 0-10, 50, 250, 1000
DC CURRENT 0-1-100mA
Resistance 0-150K ohms

No	Price
1322	£5.95

HIGH SENSITIVITY TEST METER
Sensitivity 50,000 ohms/V
Size 6½" x 4½" x 2¼"

AC Volts	0-1.5 to 0/500 in 10 Ranges
DC Volts	0-0.5 to 0/500 in 12 Ranges
DC Current	0-25 ua to 0/10A in 10 Ranges
Resistance	0-100 ohms to 0/16 meg in 4 Ranges
Decibels	—20 to 62dB in 10 Ranges

No	Price
1324	£19.76

P&P

Postage and Packing add 25p unless otherwise shown. Add extra for airmail. Minimum order £1

TRANSISTORS
BRAND NEW — FULLY GUARANTEED

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
AC126	£0.18	BC109C	£0.08	BC550	*£0.14	BFY52	£0.14	TIP2955	£0.95	2N3708	*£0.07
AC127	£0.18	BC147	*£0.10	BC556	*£0.14	BIP19	£0.38	TIP3055	£0.75	2N3708A	*£0.07
AC128	£0.18	BC148	*£0.10	BC557	*£0.13	BIP20	£0.38	TIS43	£0.24	2N3709	*£0.07
AC128K	£0.26	BC149	*£0.10	BC558	*£0.12	BIP19/		TIS90	*£0.22	2N3710	*£0.07
AC132	£0.20	BC157	*£0.10	BC559	*£0.14	20 MP	£0.80	UT46	*£0.22	2N3711	*£0.07
AC134	£0.20	BC158	*£0.10	BD115	£0.50	BRY39	£0.45	ZTX107	*£0.10	2N3819	£0.20
AC137	£0.20	BC159	*£0.10	BD116	£0.80	BU105	£1.70	ZTX108	*£0.10	2N3820	£0.40
AC141	£0.22	BC167	*£0.12	BD121	£0.65	BU105/02	£1.95	ZTX109	*£0.10	2N3821	£0.60
AC141K	£0.30	BC168	*£0.12	BD123	£0.65	BU204	£1.70	ZTX300	*£0.12	2N3823	£0.60
AC142	£0.20	BC169	*£0.12	BD124	£0.70	BU205	£1.70	ZTX500	*£0.14	2N4058	*£0.12
AC176	£0.18	BC169C	*£0.12	BD131	£0.38	BU208	£2.40	2N1613	£0.20	2N4059	*£0.14
AC176K	£0.26	BC170	*£0.10	BD132	£0.40	BU208/02	£2.95	2N1711	£0.20	2N4060	*£0.14
AC178	£0.25	BC171	*£0.10	BD131/		E1222	£0.38	2N1889	£0.45	2N4061	*£0.12
AC179	£0.25	BC172	*£0.10	132 MP	£0.85	MJE2955	£0.98	2N1890	£0.45	2N4062	*£0.12
AC180	£0.20	BC173	*£0.12	BD133	£0.60	MJE3055	£0.60	2N1893	£0.30	2N4284	*£0.18
AC180K	£0.28	BC177	£0.16	BD135	£0.40	MJE3440	£0.52	2N2147	£0.75	2N4285	*£0.18
AC181	£0.20	BC178	£0.16	BD136	£0.40	MP8113	£0.52	2N2148	£0.70	2N4286	*£0.18
AC181K	£0.28	BC179	£0.16	BD137	£0.42	MPF102	£0.35	2N2160	£0.80	2N4287	*£0.18
AC187	£0.18	BC180	£0.25	BD138	£0.45	MPF104	£0.38	2N2192	£0.38	2N4288	*£0.18
AC187K	£0.20	BC181	*£0.25	BD139	£0.54	MPF105	£0.38	2N2193	£0.38	2N4289	*£0.18
AC188	£0.18	BC182L	*£0.10	BD140	£0.60	MPSA05	*£0.30	2N2194	£0.38	2N4290	*£0.18
AC188K	£0.20	BC183	*£0.10	BD139/		MPSA06	*£0.30	2N2217	£0.22	2N4291	*£0.18
AD140	£0.60	BC183L	*£0.10	140 MP	£1.20	MPSA55	*£0.28	2N2218	£0.22	2N4292	*£0.18
AD142	£0.85	BC184	*£0.10	BD155	£0.80	MPSA56	*£0.28	2N2218A	£0.20	2N4293	*£0.18
AD143	£0.75	BC184L	*£0.10	BD175	£0.60	OC22	£1.50	2N2219	£0.20	2N4921	*£0.55
AD149	£0.60	BC207	*£0.11	BD176	£0.60	OC23	£1.50	2N2219A	£0.24	2N4923	*£0.65
AD161	£0.42	BC208	*£0.11	BD177	£0.68	OC24	£1.35	2N2904	£0.18	2N5135	*£0.10
AD162	£0.42	BC209	*£0.12	BD178	£0.68	OC25	£0.60	2N2904A	£0.21	2N5136	*£0.10
AD161/		BC212	*£0.11	BD179	£0.75	OC26	£0.60	2N2905	£0.18	2N5138	*£0.10
161 MP	£0.35	BC212L	*£0.11	BD201/		OC28	£0.80	2N2905A	£0.21	2N5194	*£0.56
AF114	£0.21	BC213	*£0.11	202 MP	£1.70	OC29	£0.95	2N2906	£0.16	2N5245	*£0.40
AF115	£0.21	BC213L	*£0.11	BD203	£0.80	OC35	£0.90	2N2906A	£0.19	2N5294	*£0.34
AF116	£0.21	BC214	*£0.12	BD204	£0.80	OC36	£0.90	2N2907	£0.20	2N5296	*£0.56
AF117	£0.21	BC214L	*£0.12	BD203/		OC70	£0.24	2N2907A	£0.22	2N5457	*£0.32
AF118	£0.40	BC237	*£0.16	204 MP	£1.70	OC71	£0.15	2N296G	*£0.09	2N5458	*£0.32
AF124	£0.30	BC238	*£0.16	B0Y20	£0.80	TIC44	*£0.29	2N2926Y	*£0.08	2N5459	*£0.38
AF125	£0.30	BC251	*£0.15	B0X77	£0.90	TIC45	*£0.35	2N2926R	*£0.08	2N5551	*£0.36
AF126	£0.30	BC251A	*£0.16	BF457	£0.37	TIP29A	£0.44	2N2926B	*£0.08	2N6027	£0.39
AF127	£0.32	BC301	£0.28	BF458	£0.37	TIP29B	£0.52	2N3053	£0.16	2N6121	£0.70
AF139	£0.58	BC302	£0.28	BF459	£0.38	TIP29C	£0.62	2N3054	£0.40	2N6122	£0.70
AF180	£0.40	BC303	£0.28	BF594	*£0.30	TIP30A	£0.50	2N3055	£0.40	40311	£0.38
AF181	£0.60	BC304	£0.38	BF596	*£0.28	TIP30B	£0.60	2N3414	*£0.16	40313	£0.95
AF186	£0.58	BC327	*£0.16	BFR39	£0.25	TIP30C	£0.70	2N3415	*£0.16	40316	£0.95
AF239	£0.50	BC328	*£0.15	BFR40	*£0.25	TIP31A	£0.45	2N3416	*£0.29	40317	£0.40
AL102	£0.38	BC337	*£0.15	BFR79	*£0.28	TIP31B	£0.47	2N3417	*£0.29	40326	£0.40
AL103	£1.20	BC338	*£0.15	BFR80	*£0.28	TIP31C	£0.49	2N3614	£0.85	40327	£0.45
AU104	£1.18	BC440	£0.30	BFX29	£0.25	TIP32A	£0.49	2N3615	£0.90	40346	£0.45
AU110	£1.00	BC441	£0.30	BFX30	£0.30	TIP32B	£0.51	2N3616	£0.90	40347	£0.65
AU113	£1.00	BC460	£0.38	BFX84	£0.23	TIP32C	£0.53	2N3646	*£0.09	40348	£0.80
BC107A	£0.08	BC461	£0.38	BFX85	£0.24	TIP41A	£0.49	2N3702	*£0.08	40360	£0.36
BC107B	£0.08	BC477	£0.20	BFX86	£0.25	TIP41B	£0.51	2N3703	*£0.08	40361	£0.36
BC107C	£0.08	BC478	£0.20	BFX87	£0.22	TIP41C	£0.53	2N3704	*£0.07	40362	£0.38
BC108A	£0.08	BC479	£0.20	BFX88	£0.22	TIP42A	£0.53	2N3705	*£0.07	40406	£0.45
BC108B	£0.08	BC547	*£0.12	BFX90	*£0.55	TIP42B	£0.55	2N3706	*£0.08	40407	£0.35
BC108C	£0.08	BC548	*£0.12	BFY50	£0.14	TIP42C	£0.57	2N3707	*£0.08	40408	£0.52
BC109B	£0.08	BC549	*£0.12	BFY51	£0.14					40409	£0.75

74 SERIES TTL ICs
FULL SPECIFICATION GUARANTEED ALL FAMOUS MANUFACTURERS

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
7400	£0.14	7409	£0.15	7441	£0.64	7482	£0.85	7493	£0.40	74122	£0.50
7401	£0.14	7410	£0.14	7442	£0.64	7483	£0.95	7494	£0.88	74123	£0.70
7402	£0.15	7411	£0.23	7445	£0.90	7484	£0.98	7495	£0.75	74141	£0.80
7403	£0.15	7412	£0.23	7446	£0.90	7485	£1.20	7496	£0.80	74154	£1.30
7404	£0.15	7413	£0.27	7447	£0.78	7486	£0.30	74100	£1.00	74180	£1.10
7405	£0.15	7414	£0.58	7448	£0.80	7489	£2.90	74110	£0.50	74181	£2.00
7406	£0.30	7416	£0.28	7475	£0.48	7490	£0.42	74118	£0.90	74190	£1.50
7407	£0.30	7417	£0.28	7480	£0.50	7491	£0.75	74119	£1.85	74198	£2.00
7408	£0.15	7440	£0.15	7481	£0.95	7492	£0.45	74121	£0.30	74199	£1.90

CMOS ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CD4000	£0.20	CD4012	£0.20	C04022	£0.98	C04031	£2.20	CD4046	£1.30	C04071	£0.23
CD4001	£0.20	C04013	£0.52	C04023	£0.20	C04035	£1.60	CD4047	£1.10	CD4072	£0.23
CD4022	£0.20	CD4015	£0.98	CD4024	£0.80	CD4037	£0.95	CD4049	£0.55	CD4081	£0.22
CD4006	£0.98	CD4016	£0.52	CD4025	£0.20	CD4040	£0.95	CD4050	£0.55	CD4082	£0.23
CD4007	£0.20	CD4017	£0.98	CD4026	£1.95	CD4041	£0.82	CD4054	£1.20	4510	£1.30
CD4008	£0.98	CD4018	£1.00	CD4027	£0.60	CD4042	£0.82	CD4055	£1.85	4511	£1.60
CD4009	£0.58	CD4019	£0.55	CD4028	£0.98	CD4043	£0.98	CD4056	£1.35	4516	£1.40
C04010	£0.58	CD4020	£1.10	CD4029	£1.15	CD4044	£0.94	C04069	£0.40	4518	£1.25
C04011	£0.20	CD4021	£0.98	CD4030	£0.55	CD4045	£1.40	C04070	£0.40	4520	£1.25

LINEAR ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CA3011	£1.05	LM304	£2.00	MC1352P	£1.40	72702	£0.46	748P	£0.35
CA3014	£1.70	LM308	£1.40	MC1456G	£1.40	uA703A	£0.25	SN76013N	£1.40
CA3018	£0.75	LM309K	£1.50	MC1466L	£4.50	uA709C	£0.25	SN76023N	£1.40
CA3020	£1.70	LM320-5v	£1.85	MC1469R	£2.95	72709	£0.46	SN76110	£1.50
CA3028	£1.02	LM320-12v	£1.85	MC1496G	£0.98	709P	£0.25	SN76115	£1.90
CA3035	£1.70	LM320-15v	£1.85	NE536	£3.50	uA710C	£0.40	SN76660	£0.75
CA3036	£1.35	LM320-24v	£1.85	NE515A	£3.50	72710	£0.30	SL414A	£1.95
CA3042	£1.50	LM380-14P	£0.98	NE540	£1.50	uA711C	£0.32	TAA550B	£0.35
CA3043	£1.85	LM381	£1.55	NE550	£0.95	72711	£0.32	TAA621A	£2.00
CA3046	£0.80	LM3900N	£0.65	NE550D	NLA	uA723C	£0.50	TAA661A	£1.65
CA3052	£1.60	MC724P	£1.50	NE555	£0.40	72723	£0.50	TA0100	£1.30
CA3054	£1.35	MC1303L	£1.48	NE556	£0.82	uA741C	£0.24	TBA540Q	£2.20
CA3075	£1.50	MC1304P	£2.95	NE561	£3.95	72741	£0.24	TBA641B	£2.25
CA3081	£1.50	MC1310P	£1.80	NE562B	£3.95	741P	£0.24	TBA800	£0.80
CA3089	£2.10	MC1312PQ	£1.90	NE565A	£1.75	uA747C	£0.70	TBA810S	£1.05
CA3090	£4.25	MC1330P	£1.20	NE566	£1.70	72747	£0.79	TBA820	£0.90
CA3123	£1.90	MC1350	£1.20	NE567	£2.50	uA748	£0.35	TBA920Q	£3.40
LM301	£0.39	MC1351P	£1.20	uA702C	£0.46	72748	£0.35	TCA270S	£3.90

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Type	Price	Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
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AAY30	£0.09	BB104	£0.15	BY128	£0.16	BYZ16	£0.41	OA90	£0.07	IN914	£0.06
AAZ13	£0.15	BAX13	£0.07	BY130	*£0.17	BYZ17	£0.36	OA91	£0.07	IN916	£0.06
AAZ17	£0.15	BAX16	£0.08	BY133	*£0.21	BYZ18	£0.36	OA95	£0.07	IN4148	£0.06
BA100	£0.10	BY100	£0.22	BY164	£0.51	BYZ19	£0.36	OA182	£0.13	IS44	£0.05
BA102	£0.32	BY107	£0.22	BY176	*£0.75	OA10	£0.35	OA200	£0.08	IS920	£0.06
BA148	£0.15	BY105	£0.22	BY206	£0.30	OA47	£0.08	OA202	£0.08		
BA154	£0.12	BY114	£0.22	BYZ10	£0.45	OA76	£0.08	SD10	£0.06		
BA155	£0.14	By124	*£0.22	BYZ11	£0.95	OA79	£0.13	SO19	£0.06		
BA156	£1.14	BY126	*£0.15	BYZ12	£0.45	OA81	£0.13	IN34	£0.07		

SILICON RECTIFIERS

Type	Price	Type	Price	Type	Price	Type	Price
IS920	£0.06	IN4003	£0.08	IS021	£0.11	IN5401	£0.15
IS921	£0.07	IN4004	£0.09	IS023	£0.13	IN5402	£0.16
IS922	£0.08	IN4005	£0.10	IS025	£0.14	IN5404	£0.17
IS923	£0.09	IN4006	£0.11	IS027	£0.16	IN5406	£0.21
IS924	£0.10	IN4007	£0.12	IS029	£0.20	IN5407	£0.25
IN4001	£0.05½	IS015	£0.09	IS031	£0.25	IN5408	£0.30
IN4002	£0.07	IS020	£0.10	IN5400	£0.14		

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THYRISTORS

600ma — TO 18 Case

Volts No	Price
10 THY600/10	£0.13
20 THY600/20	£0.13
30 THY600/30	£0.19
50 THY600/50	£0.22
100 THY600/100	£0.25
200 THY600/200	£0.38
400 THY600/400	£0.45

1 amp — TO 5 Case

Volts No	Price
50 THY1A/50	£0.26
100 THY1A/200	£0.27
200 THY1A/200	£0.28
400 THY1A/400	£0.36
600 THY1A/600	£0.45
800 THY1A/800	£0.58

3 amp — TO 66 Case

Volts No	Price
50 THY3A/50	£0.25
100 THY3A/100	£0.27
200 THY3A/200	£0.33
400 THY3A/400	£0.42
600 THY3A/600	£0.50
800 THY3A/800	£0.65

5 Amp — TO 66 Case

Volts No	Price
50 THY5A/50	£0.36
100 THY5A/100	£0.48
200 THY5A/200	£0.50
400 THY5A/400	£0.57
600 THY5A/600	£0.69
800 THY5A/800	£0.81

5 Amp — TO 220 Case

Volts No	Price
400 THY5A/400P	£0.57
600 THY5A/600P	£0.69
800 THY5A/800P	£0.81

7 Amp — TO 48 Case

Volts No	Price
50 THY7A/50	£0.48
100 THY7A/100	£0.51
200 THY7A/200	£0.57
400 THY7A/400	£0.62
600 THY7A/600	£0.78
800 THY7A/800	£0.92

10 Amp — TO 48 Case

Volts No	Price
50 THY10A/50	£0.51
100 THY10A/100	£0.57
200 THY10A/200	£0.62
400 THY10A/400	£0.71
600 THY10A/600	£0.99
800 THY10A/800	£1.22

16 Amp — TO 48 Case

Volts No	Price
50 THY16A/50	£0.54
100 THY16A/100	£0.58
200 THY16A/200	£0.62
400 THY16A/400	£0.77
600 THY16A/600	£0.90
800 THY16A/800	£1.39

30 Amp — TO 94 Case

Volts No	Price
50 THY30A/50	£1.18
100 THY30A/100	£1.43
200 THY30A/200	£1.63
400 THY30A/400	£1.79
600 THY30A/600	£3.50

No	Price
BT101/500R	£0.80
BT102/500R	£0.80
BT106	£1.25
BT107	£0.93
BT108	£0.98
2N3228	£0.70
2N3535	£0.70
BTX30/50L	£0.33
BTX30/400L	£0.46
C106/4	£0.60

ORDERING

Please word your orders exactly as printed, not forgetting to include our part number.

V.A.T.

Add 12½% to prices marked* Add 8% to others excepting those marked †. These are zero.

BI-PAK

Dept. W10, P.O. BOX 6, WARE, HERTS

SHOP AT 18 BALDOCK ST., WARE, HERTS. OPEN 9 to 5.30 MON./SAT.

BI-PAK

High quality modules for stereo, mono and other audio equipment.

NEW

PUSH-BUTTON STEREO FM TUNER

OUR PRICE ONLY

£20.45

Fitted with Phase Lock-loop Decoder

The 450 Tuner provides instant program selection at the touch of a button ensuring accurate tuning of 4 pre-selected stations, any of which may be altered as often as you choose, by simply changing the settings of the pre-set controls.

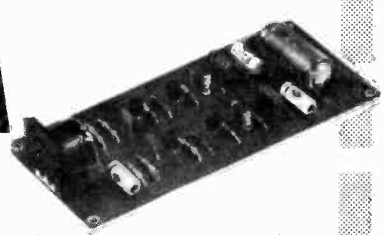
Used with your existing audio equipment or with the BI-KITS **STEREO 30** or the **MK60** Kit etc. Alternatively the **PS12** can be used if no suitable supply is available, together with the Transformer **T538.**

The S450 is supplied fully built, tested and aligned. The unit is easily installed using the simple instructions supplied.

- ★ FET Input Stage
- ★ VARI-CAP diode tuning
- ★ Switched AFC
- ★ Multi turn pre-sets
- ★ LED Stereo Indicator

Typical Specification:
Sensitivity 3μ volts
Stereo separation 30db
Supply required 20-30v at 90 Ma max.

MPA 30



Enjoy the quality of a magnetic cartridge with your existing ceramic equipment using the new M P A. 30, a high quality pre-amplifier enabling magnetic cartridges to be used where facilities exist for the use of ceramic cartridges only. It is provided with a standard DIN input socket for ease of connection. Full instructions supplied.

£2.85

VAT ADD 12½%

POSTAGE & PACKING

Postage & Packing add 25p unless otherwise shown. Add extra for airmail. Min. £1.00

STEREO PRE-AMPLIFIER

PA100

OUR PRICE £13.75

A top quality stereo pre-amplifier and tone control unit. The six push-button selector switch provides a choice of inputs together with two really effective filters for high and low frequencies, plus tape output.

MK. 60 AUDIO KIT: Comprising 2 x AL60's. 1 x SPM80. 1 x BTM80. 1 x PA100. 1 front panel and knobs. 1 Kit of parts to include on/off switch, neon indicator, stereo headphone sockets plus instruction booklet. **COMPLETE PRICE £34.90** plus 85p postage.

TEAK 60 AUDIO KIT:
Comprising Teak veneered cabinet size 16¾"x11½"x3¾" other parts include aluminium chassis, heatsink and front panel bracket plus back panel and appropriate sockets ect. **KIT PRICE £13.25** plus 85p postage.

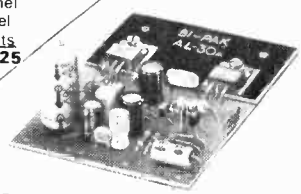
Frequency Response + 1dB 20Hz 20KHz. Sensitivity of inputs
1 Tape Input 100mV into 100K ohms
2 Radio Tuner 100mV into 100K ohms
3 Magnetic P U 3mV into 50K ohms
P U Input equalises to R1AA curve with 1dB from 20Hz to 20KHz
Supply — 20-35V at 20mA

Dimensions 299mm x 89mm x 35mm

NEW AL30A

10w R.M.S. AUDIO AMPLIFIER MODULE

The AL30A is a high quality audio amplifier module replacing our AL20 & 30. The versatility of its design makes it ideal for record players, tape recorders, stereo amps, cassette and cartridge players. A power supply is available comprising a PS12 together with a transformer T538, also for stereo, the pre-amp PA12.



SPECIFICATION

- Output Power 10w. R.M.S.
- Supply 22 to 32 volts.
- Load Impedance 8 to 6ohms.
- Input Impedance 50K.
- Sensitivity 90mv for full output.
- Total Harmonic Distortion Less than .5% (Typically .3%).
- Frequency Response 60Hz to 25KHz + 2db.
- Max. Heat Sink Temp 80°c.
- Dimensions 90 x 64 x 27mm

ONLY £3.65

STEREO 30

COMPLETE AUDIO

7+7 WATTS R.M.S.

P & P 45p

£16.25

The Stereo 30 comprises a complete stereo pre-amplifier, power amplifiers and power supply. This, with only the addition of a transformer or overwind will produce a high quality audio unit suitable for use with a wide range of inputs i.e. high quality ceramic pick-up, stereo tuner, stereo tape deck etc. Simple to install, capable of producing really first class results, this unit is supplied with full instructions, black front panel knobs, main switch, fuse and fuse holder and universal mounting brackets enabling it to be installed in a record plinth, cabinets of your own construction or the cabinet available. Ideal for the beginner or the advanced constructor who requires Hi-Fi performance with a minimum of installation difficulty (can be installed in 30 mins).

TRANSFORMER £3.25 plus 50p p & p
TEAK CASE £5.45 plus 70p p & p

AL 60 25 Watts (RMS)

★ Max Heat Sink temp 90C. ★ Frequency response 20Hz to 100KHz ★ Distortion better than 0.1 at 1KHz ★ Supply voltage 15-50v ★ Thermal Feedback ★ Latest Design Improvements ★ Load — 3,4,8, or 16 ohms ★ Signal to noise ratio 80db ★ Overall size 63mm. 105mm. 13mm.

Especially designed to a strict specification. Only the finest components have been used and the latest solid-state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A F enthusiast.

£4.35

NEW

PA12

NEW PA12 Stereo Pre-Amplifier completely redesigned for use with AL30A Amplifier Modules. Features include on/off volume. Balance, Bass and Treble controls. Complete with tape output.

Frequency Response 20Hz-20KHz (—3dB). Bass and Treble range, 12dB. Input Impedence 1 meg ohm. Input Sensitivity 300mV. Supply requirements 24V .5mA. Size 152mm x 84mm x 33mm.

£6.70

PS12

Power supply for **AL30A, PA12, SA450,** etc.

OUR PRICE £1.30

Stabilised Power Supply Type SPM80

SPM80 is especially designed to power 2 of the AL60 Amplifiers, up to 15 watts (R.M.S.) per channel simultaneously. With the addition of the Mains Transformer **BMT80,** the unit will provide outputs of up to 1.5A at 35V. Size 63mm. 105mm. 30mm. Incorporating short circuit protection.

Transformer BMT80 £5.30 + 86p postage

£3.75

Input voltage 15-20v A.C. Output voltage 22-30v D.C. Output current 800 mA Max. Size 60mm x 43mm x 26mm.
Transformer T538 £3.20

BI-PAK

P.O. BOX 6, WARE, HERTS.

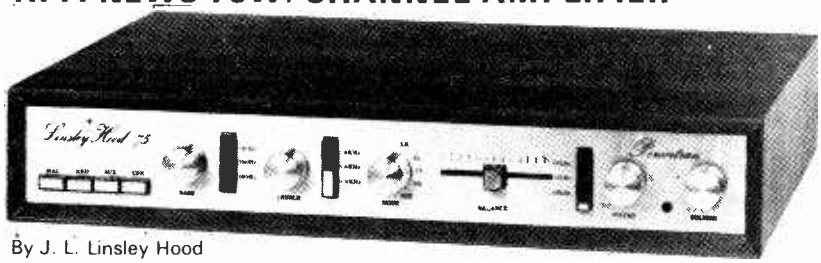
SHOP AT 18 BALDOCK ST., WARE, HERTS
OPEN 9 to 5.30 Mon./Sat.

Zambia Gibraltar Chile Spain United Arab Emirates Singapore New Guinea Israel Falkland Islands Portugal Guyana India Greece Jordan United States of America Yugoslavia Ascension Island Malaya

POWERTRAN ELECTRONICS

INCORPORATING AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

In Hi-Fi News there was published by Mr. Linsley-Hood a series of four articles (November, 1972-February, 1973) and a subsequent follow-up article (April, 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0.01% even at very low power levels. The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system namely the equalization stage and tone control stage positions where most conventional designs run out of gain at the extremes of the frequency spectrum. Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level. The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer.

Pack	Price
1. Fibreglass printed-circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.50
3. Set of semiconductors for power amp	£6.50
4. Pair of 2 drilled, finned heat sinks	£1.10
5. Fibreglass printed-circuit board for pre-amp	£1.90
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.50
9. Set of 4 push-button switches, rotary mode switch	£5.40
10. Toroidal transformer complete with magnetic screen/housing primary: 0 117-234 V: secondaries: 33-0-33 V, 65-0-65 V	£10.95
11. Fibreglass printed-circuit board for power supply	£0.85
12. Set of resistors, capacitors, secondary fuses, semi-conductors for power supply	£5.40
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£6.20
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc	£8.20
15. Handbook (free with complete kit)	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70
2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs	£90.80

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£79.80**

WIRELESS WORLD FM TUNER

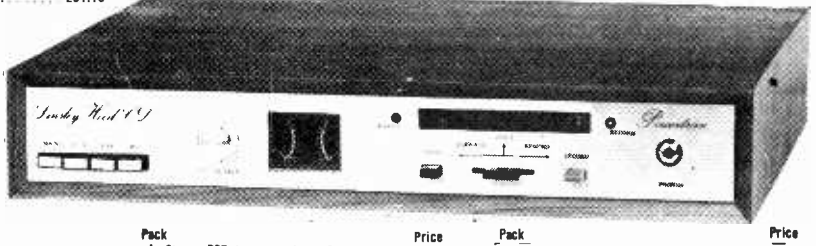
Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson — April, May 1974) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout.

Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermister, capacitors, cermet preset for mounting on pack 1	£4.80
3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£5.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc.	£9.40
9. Function switch, 10 turn tuning potentiometer, knobs	£5.80
10. Frequency meter, meter drive components, fibreglass printed circuit board	£10.35
11. Toroidal transformer with electrostatic screen. Primary: 0-117V 234V	£4.90
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.10
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£2.05
14. Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£8.30
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 10.3" x 12.7" x 3.1"	£10.70
One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs	£81.15

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£70.20**

LINSLEY-HOOD CASSETTE DECK



Published in Wireless World (May, June, August 1976) by Mr. Linsley-Hood, this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier.

Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 meter amps, bias/erase osc, relay)	£3.35
2. Stereo set of capitors, M.O. resistors, potentiometers for above	£9.80
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB, all components for solenoid, speed control circuits	£3.80
6. Goldring Lenco mechanism as specified	£21.95
7. Function switch, knobs	£1.90
8. Dual VU meter with illuminating lamp	£8.70
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V. Sec. 15V	£4.90
10. Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertree design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc.	£3.40
12. Set of metalwork including silk screened facia panel, internal screen, fixing parts, etc.	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70
One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs	£90.05

SPECIAL PRICE FOR COMPLETE KITS **£85.90**

PRICE STABILITY

Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until November 30th, 1977, provided that this month's advertisement is quoted with your order. E&OE VAT rate changes excluded.

All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

Value Added Tax not included in prices.

EXPORT ORDERS. No VAT charged. Postage charged at actual cost plus 50p documentation and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order — no minimum order charge. Alternatively send Irrevocable Letter of Credit (£500 minimum) payable at sight in London.

SECURICOR DELIVERY: For this optional service (U.K. Mainland only) add £2.50 (VAT INC.) per kit.

U.K. ORDERS: **Subject to 12½% * surcharge for VAT.** Carriage free.

ORDERING: By mail or call at Sales Counter (at rear of factory) — Open 1 p.m.-4.30 o.m. Mon.-Thurs.

Further details of above given in our FREE CATALOGUE

EXPORT CUSTOMERS. Please send five INTERNATIONAL REPLY COUPONS OR £0.50 for catalogue to be sent by airmail

DEPT WW10

POWERTRAN ELECTRONICS

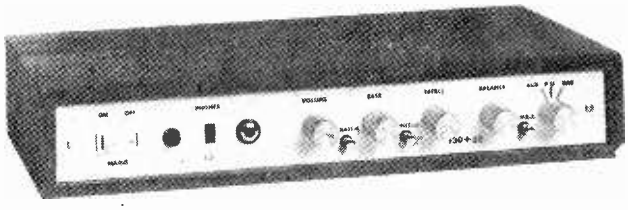
PORTWAY INDUSTRIAL ESTATE
ANDOVER, HANTS SP10 3NN

ANDOVER 64455

Indonesia Brazil Switzerland Canada Saudi Arabia New Zealand Norway Iceland Sweden

Guernsey Cyprus Belgium Uganda Brunei Trinidad South West Africa Italy Java Grenada Sierra Leone Jamaica Holland Kenya Malta Windward Isles Austria Czechoslovakia South Africa Finland Nigeria Luxembourg

AUDIO KIT SUPPLIERS TO THE WORLD



T20+20 AND T30+30 20W, 30W AMPLIFIERS

Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success. Now, developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20 + 20 delivers 20W per channel of true Hi-Fi at exceptionally low cost. The design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers, including scratch and rumble filters, adaptable input selector and head phones socket. In a follow up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30 + 30. These include RF interference filters and a tape monitor facility. Power output of this new model is 30W per channel.

Pack	T20	T30
1. Set of low noise resistors	1.60	1.70
2. Set of small capacitors	2.60	3.40
3. Set of power supply capacitors	2.20	2.50
4. Set of miscellaneous parts	3.50	3.50
5. Set of slide, mains, P.B. switches	1.50	1.50
6. Set of pots, selector switch	2.80	2.80
7. Set of semiconductors, ICs, skts.	7.25	7.75
8. Toroidal transformer – 240V prim. e.s. screen	5.60	7.20
9. Fibreglass PCB	3.50	3.90
10. Set of metalwork, fixing parts	5.20	6.20
11. Set of cables, mains lead	0.40	0.40
12. Handbook (free with complete kit)	0.25	0.25
13 Teak cabinet 15.4" x 6.7" x 2.8"	4.50	4.50

SPECIAL PRICES FOR COMPLETE KITS!

T20+20 KIT PRICE only **£34.20**

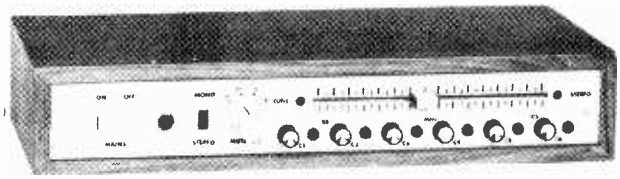
T30+30 KIT PRICE only **£39.50**

2 MATCHING TUNERS!

WW SFMT II

Following the success of our Wireless World FM Tuner kit we are now pleased to introduce our new cost reduced model, designed to complement the T20 and T30 amplifiers. The frequency meter of the more advanced model has been omitted and the mechanics simplified, however the circuitry is identical and this new kit offers most exceptional value for money. Facilities included are switchable afc, adjustable switchable muting, channel selection by slider or readily adjustable pre-set push-button controls and LED tuning indication. Individual pack prices in our free list.

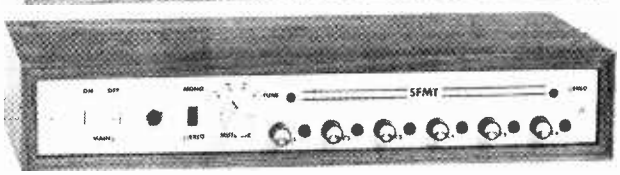
KIT PRICE **£47.70**



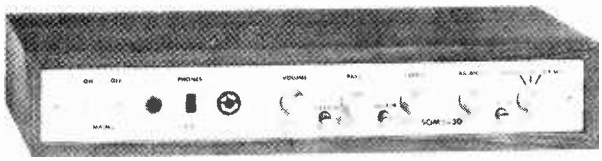
POWERTRAN SFMT

This easy to construct tuner using our own circuit design includes a pre-aligned front end module, PLL stereo decoder, adjustable, switchable muting, switchable afc and push-button channel selection. As with all our full kits, all components down to the last nut and bolt are supplied together with full constructional details.

KIT PRICE **£35.90**



CONVERT NOW TO QUADRAPHONICS!



SQM1 — 30 KIT PRICE **£40.75**

With 100s of titles now available no longer is there any problem over suitable software. No problems with hardware either. Our new unit the SQM1-30 simply plugs into the tape monitor socket of your existing amplifier and drives two additional speakers at 30W per channel. A full complement of controls including volume, bass, treble and balance are provided as are comprehensive switching facilities enabling the unit to be used for either front or rear channels by-passing the decoder for stereo-only use and exchanging left and right channels. The SQ matrix decoder is based upon a single integrated circuit and was designed by CBS whilst the power and tone control sections are identical to those used in our T30 + 30 amplifier which the SQM1-30 matches perfectly. Kit price includes CBS licence fee.

Special offer to T20 + 20 and Texan owners!
Owners of T20 + 20 and Texan amplifiers, which have no tape monitor outlet, purchasing an SQM 1-30 will be supplied on request, a free conversion kit to fit a tape monitoring facility to the existing amplifier. This makes simple the connection to the highly adaptable SQM 1-30 quadraphonic decoder/rear channel amplifier.

Wireless World Amplifier Designs. Full kits are not available for these projects but component packs and PCBs are stocked for the highly regarded Bailey and 20W class AB Linsley Hood designs together with an efficient regulated power supply of our own design. Suitable for driving these amplifiers is the Bailey Burrows pre-amplifier and our circuit board for the stereo version of it features 6 inputs, scratch and rumble filters and wide range tone controls which may be either rotary or slider operating. For those intending to get the best out of their speakers we also offer an active filter system described by D. C. Read, which splits the output of each channel from the pre-amplifier into three channels each of which is fed to the appropriate speaker by its own power amplifier. The Read/Texas 20W or any of our other kits are suitable for these. For tape systems a set of three PCBs have been prepared for the integrated circuit based high performance Stereo Tape design. Details / component packs are in our free catalogue.

30W Bailey Amplifier	
BAIL Pk 1 F/Glass PCB	£1.00
BAIL Pk 2 Resistors, Capacitors, Potentiometer set	£2.35
BAIL Pk 3 Semiconductor set	£4.70
20W Linsley Hood Class AB	
LHAB Pk 1 F/Glass PCB	£1.05
LHAB Pk 2 Resistor, Capacitor, Potentiometer set	£3.20
LHAB Pk 3 Semiconductor set	£3.35
Regulator Power Supply	
60VS Pk 1 F/Glass PCB	£0.85
60VS Pk 2 Resistor, Capacitor set	£2.20
60VS Pk 3 Semiconductor set	£3.10
60VS Pk 6A Toroidal transformer (for use with Bailey)	£8.80
60VS Pk 6B Toroidal transformer (for use with 20W LH)	£7.25
Bailey Burrows Stereo Pre Amp	
BBPA Pk 1 F/Glass PCB stereo	£2.80
BBPA Pk 2 Resistor, capacitor, semiconductor set stereo	£6.70
BBPA Pk 3R Rotary Potentiometer set Stereo	£2.85
BBPA Pk 3S Slider Potentiometer set with knobs Stereo	£3.10
Active Filter	
FILT Pk 1 F/Glass PCB	£1.40
FILT Pk 2 Resistor, Capacitor set (metal oxide 2% polystyrene 2½%)	£4.20
FILT Pk 3 Semiconductor set	£2.25
2 off Pks 1, 2, 3 rqd for stereo active filter system	
Read/Texas 20W Amp	
READ Pk 1 F/Glass PCB	£1.00
READ Pk 2 Resistor, Capacitor set	£1.20
READ Pk 3 Semiconductor set	£2.30
6 off pks 1 2 3 required for stereo active filter system	
Stuart Tape Recorder	
TRRP Pk 1 Replay Amp F Glass PCB stereo	£1.30
TRRC Pk 1 Record Amp F Glass PCB Stereo	£1.70
TROS Pk 1 Bias Erase Stabilizer F Glass PCB stereo	£1.20

Further details of above and additional packs given in our FREE LIST

SQ QUADRAPHONIC DECODERS

Feed 2 channels (200-1000mV as obtainable from most pre-amplifiers or amplifier tape monitor outlets) into any one of our 4 decoders and take 4 channels out with no overall signal level reduction. On the logic enhanced decoders Volume, Front-Back, LF-RF balance, LB-RB balance and Dimension controls can all be implemented by simple single gang potentiometers.

These state-of-the-art circuits used under licence from CBS are offered in kits of superior quality with close tolerance capacitors, metal oxide resistors and fibre-glass PCBs designed for edge connector insertion. All kit prices include CBS licence fee.

M1 Basic matrix decoder with fixed 10-40 blend. All components PCB **£5.90**

L1 Full logic controlled decoder with wave matching and front back logic for enhanced channel separation. All components PCB **£17.20**

L2A More advanced full logic decoder with "variable blend" for increased front back separation. All components, PCB **£22.60**

L3A Decoder similar to L2A but with discreet component front end with high precision 6-pole phase shift networks for increased frequency response. All components (carbon film resistors), PCB **£25.90**

Also available with M.O. resistors, cermet pre-set – add **£4.20**

SEMICONDUCTORS as used in our range of quality audio equipment.

2N699	£0.20	BC107	£0.10	BDY56	£1.60	MJ491	£1.45	TIP30A	£0.45
2N3055	£0.45	BC108	£0.10	BF257	£0.40	MJE521	£0.60	TIP29C	£0.55
2N3442	£1.20	BC109	£0.10	BF259	£0.47	MPSA05	£0.25	TIP30C	£0.60
2N3711	£0.09	BC109C	£0.12	BFR39	£0.30	MPSA12	£0.35	TIP41A	£0.70
2N3904	£0.17	BC125	£0.15	BFR79	£0.30	MPSA55	£0.25	TIP42A	£0.80
2N3906	£0.20	BC126	£0.15	BFY51	£0.20	MPSA65	£0.35	TIP41B	£0.75
2N5087	£0.25	BC182	£0.10	BFY52	£0.20	MPSA06	£0.40	TIP42B	£0.90
2N5089	£0.25	BC212	£0.12	CA3046	£0.70	MPSU05	£0.50	1N914	£0.07
2N5457	£0.45	BC182L	£0.10	LM301AN	£0.55	SBA750A	£1.90	1N916	£0.07
2N5459	£0.45	BC184L	£0.11	LP1186	£6.50	SL301	£1.30	1S920	£0.10
2N5460	£0.50	BC212L	£0.12	MC1310	£2.20	SL3045	£1.20	**FILTERS**	
2N5461	£0.50	BC214L	£0.14	MC1351	£1.05	SN72741P	£0.40	FM4	£1.00
2N5830	£0.35	BCY72	£0.13	MC1741CG	£0.65	SN72748P	£0.40	SFJ10.7MA	£1.50
40361	£0.40	BD529	£0.55	MFC4010	£0.95	TIL209	£0.20		
40362	£0.45	BD530	£0.55	MJ481	£1.20	TIP29A	£0.40		

EXPORT NO PROBLEM

Our Export Department will be pleased to advise on postal costs to any country in the world. Some of the countries to which we sent kits in 1976 are shown surrounding this advertisement.

Tunisia Germany Nauru Hong Kong Australia Eire Gambia Denmark France Muscat & Oman

The new Ditton 15 XR gets more inside...out!

Outside the only obvious sign that anything has changed is the symbol. Inside it s a different story.

The Celestion design team has taken the Ditton 15—one of the world's most popular high-quality, high-fidelity bookshelf loudspeakers—and, by outstanding skill in the use of the latest technological developments, smoothed and considerably extended its frequency response.

The result is a completely new model, with a new name—Ditton 15 XR.

The new 8" bass unit and A.B.R., and the latest HD1000 tweeter, are all purpose designed and built by Celestion, offering a sound quality normally associated with larger and more expensive systems.

We've put more into a similar space to the standard 15 and *you* get more out for your listening enjoyment.

Hear the new Ditton 15 XR...a sound response to popular demand!

Please send me full details of the Ditton 15 XR.
Rola Celestion Limited, Ditton Works, Foxhall Road, Ipswich, Suffolk IP3 8JP.
Telephone: Ipswich (0473) 73131.
Cables: Voicecoil Ipswich. Telex: 98365.

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Address _____

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07-13-10

Celestion

Celestion loudspeakers bring home the world of sound

DIY SPEAKER KITS

15-WATT KIT IN CHASSIS FORM

When you are looking for a good speaker, why not build your own from this kit. It's the unit which we supply with the enclosures illustrated below Size 13" 8" (approx.) woofer (EMI), tweeter, and matching crossover components. Power handling capacity 15 watts rms. 30 watts peak.

£17.00 PER STEREO PAIR
+ P & P £3.40

EASY-TO-BUILD WITH ENCLOSURE

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13" 8" (approx.) woofers, two tweeters and a pair of matching crossovers. Easily constructed, using a few basic tools. Supplied complete with an easy-to-follow circuit diagram, and crossover components. Input 15 watts rms. 30 watts peak, each unit. Cabinet size 20" 11" 9" (approx.).

£28.00 PER STEREO PAIR
+ p & p £5.50

COMPACT FOR TOP VALUE

How about this for incredible bookshelf value from RT-VC! A pair of high efficiency units for only £7.50 – just what you need for low-power amplifiers. These infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures 12" 9" 5" (approx.) deep, and is in wood simulate. Complete with two 8" (approx.) speakers for max. power handling of 7 watts.

per stereo pair £8.50
+ p & p £2.20

SPEAKERS Two models – Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18½" 13" 7½" (approx.).

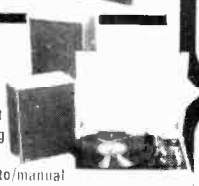
★£34 PER PAIR
+ p & p £6.50

Duo III, 20 watts rms, 40 watts peak, 27" 13" 11½" (approx.)

★£52 PER PAIR
+ p & p £7.50

EASY TO BUILD RECORD PLAYER KIT

Ideally suited for the constructor who requires a complete stereo unit at a budget price, comprising ready assembled stereo amp. module, Garrard auto/manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record / replay socket

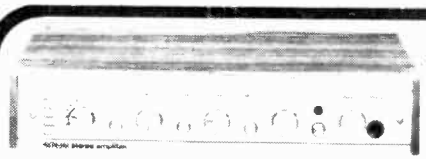


£26.95
p & p £4.05

CAR RADIO KIT

Complete with speaker, baffle and fixing strip. The Tourist IV for the experienced constructor only. The Tourist IV has five push buttons, four medium band and one for long wave band. The tuning scale is illuminated and attractive small aluminium control knobs are used for manual tuning and volume control. The modern style fascia has been designed to blend with most car interiors and the finished radio will slot into a standard car radio aperture. Size approx. 7" 2" 4½". 12 volts pos or neg earth (altered internally) p & p £1.50 £12.50
Output 4 watts into 4 ohms.

● FREE TO PERSONAL SHOPPERS BUYING CAR RADIO KIT ELECTROMATE Rear window heater modern line element all wiring and switch worth £3.00



SPECIAL OFFER

TO PERSONAL SHOPPERS See Below

20 x 20 WATT STEREO AMPLIFIER

Superb Viscount IV unit in teak-finished cabinet. Silver fascia with aluminium rotary controls and pushbuttons, red mains indicator and stereo jack socket. Function switch for mic., magnetic and crystal pick-ups, tape, tuner, and auxiliary. Rear panel features two mains outlets. DIN speaker and input sockets, plus fuse. 20 + 20 watts rms. 40 + 40 watts peak

★ £29.90 p & p £2.50

● **FREE** To cash or cheque personal shoppers

A 4 channel Stereo Adaptor to all buyers of the Viscount 20 x 20 Amplifier at £29.90 limited offer. Available separately at £3.95 + £1.00 p & p

SPECIAL OFFER For example Duo speaker system II or III Viscount Amplifier, MP60 type turntable complete

DEDUCT 10% DEDUCT 15%

Mail order only (not on postage) | Personal Shoppers only

★ on complete stereo systems using starred Products

PERSONAL SHOPPERS ONLY

PAIR STEREO 8 WATT SPEAKERS 8" bass units with 3½" approx. tweeters power handling 8 watts imp 8 ohms. Size 16½" 11" 8½" approx. £12.95

PLINTH & COVER BSR OR GARRARD TEAK FINISH £4.95

GOODMAN 5" approx. 7 watt bass speaker £2.70

AM. FM. TUNER P.C.B. with Mullard L.P. 1186, 1185, 1181 modules £9.50

CROWN 5 push button car radio, LW. MW. 12v Pos. neg. earth 5 watts output tone control complete with speaker and fixing kit, in dash type £15.95

STEREO CASSETTE TAPE PLAYER Negative earth only. 3 watts per channel output £16.50

AM. FM. STEREO MULTIPLEX CAR RADIO/cassette player in dash fixing. Negative earth 5 watts output £36.00

I.C. Stereo 8 Track to Cassette adaptor converts, any 8 track player to cassette player £18.95

GLOBAL Spherical speaker 8 ohms. 5 watts £3.50

100K Multiturn Varicap tuning pots 6 for £1.00

HEAVY DUTY FIBRE GLASS COPPER CLAD BOARD 27" x 17" x 1/16" Approx. per sheet only £1.90

DECCA DC1000 Stereo Cassette Record deck P.C.B. complete with switch oscillator coils and tape-heads and circuit diagrams. £2.95

VISCOUNT COMBI £65.00

For personal shoppers only, this unit comprises: The 20 + 20 Viscount amplifier BSR MP60 Type turntable housed in an attractive teak finished console with smoked acrylic cover. Approx. 30½" 14½" 7½" complete ready to connect to the speaker system of your choice.

BSR TURNTABLES

BSR MP60 TYPE Single play record player (Chassis form) £15.95 less cartridge. P & P £2.00

Cartridges to suit above
ACOS MAGNETIC STEREO £4.95
CERAMIC STEREO £1.95

BSR automatic record player deck (Chassis form) with cueing device and stereo ceramic head. £9.95 P & P £2.00

TURNTABLE illus. Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. Ready wired

★ £29 + p & p £4.50

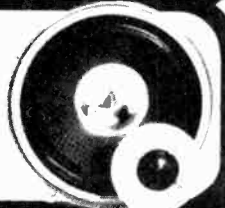
30 x 30 WATT AMPLIFIER KIT

Specially designed by R T-VC for the experienced constructor, this kit comes complete in every detail. Same facilities as Viscount IV amplifier. Chassis is ready punched, drilled and formed. Cabinet is finished in teak veneer. Silver fascia and easy-to-handle aluminium knobs.

Output 30 + 30 watts rms, 60+60 peak £29.00 + p & p £2.50

DECCA 20 WATTS STEREO SPEAKER

This matching loudspeaker system is hand made. kit comprises of two 8" diameter approx base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C. surrounds, two 3½" diameter approx. domed tweeters comp with crossover networks £4.00 p & p stereo pair £20.00



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ACTON. Mail Order only No callers

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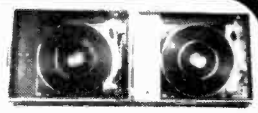
Prices correct at going to press 1.8.77

PORTABLE MONO DISCO



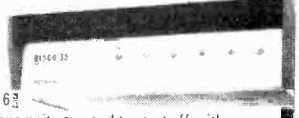
with built-in pre-amplifiers

Here's the big-value portable disco console from RT-VC! It features a pair of BSR MP 60 type auto-return, single play professional series record decks. Plus all the controls and features you need to give fabulous disco performances. Simply connects into your existing slave or external amplifier.

p & p £6.50 £64.00

45 WATT MONO DISCO AMP

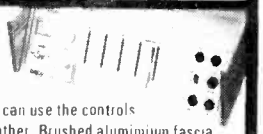
£35.00 + p & p £2.50



Size approx 13⅜" 5¼" 6¾"

Here's the mono unit you need to start off with. Gives you a good solid 45 watts rms, 90 watts peak output. Big features include two disc inputs, both for ceramic cartridges, tape input and microphone input. Level mixing controls fitted with integral push-pull switches. Independent bass and treble controls and master volume.

70 & 100 WATT MONO DISCO AMP



Size approx. 14" 4" 10½"

Sloping facia, you can use the controls without fuss or bother. Brushed aluminium fascia and rotary controls. Five smooth acting, vertically mounted slide controls – master volume, tape level, mic level, deck level, PLUS INTER-DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level. 70 watt £57 100 watt £65
Output 100 watts RMS 200 watts peak. p & p £4.00

FLASH **A SUPERSAVE SPECIAL**

100 + 100 watt Stereo RMS 400 watts peak. 200 watt mono 400 watt peak.
Stereo Slave amp. £60
Stereo pre amp. £45 NEW
PERSONAL SHOPPERS ONLY

PRACTICE GUITAR AMPLIFIER WITH BUILT-IN SPEAKER

This budget practice amplifier has been specially designed for the amateur, who requires a quality self-contained unit with all facilities. 2 inputs 1 for mic or guitar, the 2nd for record player or cassette deck, it also can be used for cine-sound amplification. 2 volume controls, 1 for each input, also base and treble controls. Power output with internal speaker, 10 watts RMS, with remote speaker (not supplied) 20 watts RMS. Size approx. 17" 9" 11" p & p £3.00 £32.50

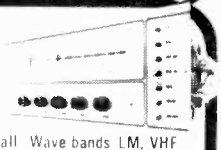
HOME 8 TRACK CARTRIDGE PLAYER

Output 125 Mv

Automatically switches programmes monitored by indicators, with manual override track selection. This unit will match with the Unisound modules and is compatable with the Viscount IV amplifier with Sim teak cabinet. approx. 9" 8" 3" p & p £2.50 £14.60

PYE STEREO GRAM CHASSIS

(Complete with circuit diagrams)



Complete ready to install. Wave bands LM, VHF STEREO, VHF MONO. Controls for tuning volume, balance, bass and treble. Power output 7 watts R.M.S. per channel 14 watts peak 8 ohms 2" 8" approx chassis speakers and BSR auto record player deck

PERSONAL SHOPPERS ONLY £35.00

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COMPONENTS LTD
315, 317, 364 EDGWARE ROAD, LONDON W2
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Shops and mail order dept (mail to 364) open 9 to 6 Mon to Sat. inc

Prices include VAT Carr /p & p quoted U K only

ACCESS & BARCLAY accepted Minimum order £5 otherwise C W O For credit on approved accounts invoicing costs necessitate a minimum order of £20

TTL BULK USERS

Please note we have purchased a distributor's entire stock and can offer the following items in substantial quantities at half current 1000 up prices

7416N	7441AN	7470	7495J	74151N
7417N	7443J	7476N	7495N	74153N
7420N	7445N	7480N	7410N	74155N
7423N	7445J	7482N	74105N	74155J
7423J	7446AN	7483	74107J	74156N
7430J	7446N	7485N	74107N	74180N
7437J	7448N	7485J	74126J	74180J
7437N	7453N	7491AN	74145J	74181N
7440N	7454N	7494J	74150N	74182N
7441AJ	7460N	7494N	74151J	74182J
				9601N

Also: 7401. 7403. 7410. 7430. 7451. 7474.

PHONE FOR QUOTATION

NIXIE TUBES

ITT GN4 Red Standard numerals 0-9 Complete with ceramic base for PCB mounting 1 08" dia × 1 38" high plus ½" base depth inc pins Operating voltage 170v DC min Complete data and connections supplied Brand new **£1.50.** p & p 20p 10 off £1 00 each 100 or more 85p each p & p 40p any quantity

ITT 5870 S Special Offer **95p.** p & p 20p

ROTARY STUD SWITCH

PLESSEY. 30 way 2 bank Single pole Contacts 1 amp 240v AC DC 005Ω res Make before break Stop infinitely adjustable allowing for any desired arc of travel Ideal for instrument and model switching Size 2⅛" dia overall × 2⅛" deep plus 1⅜" × ¼" dia spindle **£2.25.** p & p 20p **5 off £1.95 each.** p & p 40p

UNI-SELECTOR

240v AC or DC operation Split 30-way double bank contacts Overall size approx 2¼" dia × 2½" deep Brand new Bargain at **£4.50.** p & p 65p

TRANSFORMERS

DAVENSET AUTO

2KVA continuously rated Tapped for any voltage from 5-260v in steps of 5v With an isolated winding of 0 5-10v at 8½ amps this transformer is an extremely useful buy Push on connections Size 8" × 5¼" × 6½" A really robust job Bargain at **£23.50.** Carr £3 00

750VA continuously rated Tapped as above with 0 5 10V isolated winding of 5 amps Same connections Size 4½" × 3¾" × 4¾" Also bargain at **£12.50.** Carr £2 00

GOODYEAR 1KVa auto transformer 0 110 115 120 200-220 240v Fully shrouded Terminal block connections Size 5" × 4¼" × 5½" plus block Cannot be bettered at **£13.95.** p & p £1 50

TORROIDAL

Pri 15-0 210-240v Sec 140v at 35 m a 31v at 500 m a c t 10v at 1 9 amps Scr Size 3½" dia × 1½" **£3.95** p & p 30p

MINIATURE

Pri 240V Sec 6v at ½ amp Size 1¼" × 1½ " × 1¼" Ideal as power supply base for models radios cassettes etc **£1.50** ea p & p 20p 6 off £1 00 ea p & p 45p

ARROW SWITCH

Press on off Single hole fixing SP ST Size 1 8" x ⅝" Stud extends ½" Rated 1 amp at 240v 2½ amps at 125v Price for 5 (min qty) **£1.75** p & p 30p 10 or more 30p each p & p 40p

REED SWITCHES

Glass encaps N o contacts Glass length 1 8" dia ⅛" overall length 1"a" 10 off £1 00 p & p 25p **100 off £8.00,** p & p free **1000 off £68.00,** p & p free

SYLVANIA SWITCH

Complete with magnet Contacts N C 3 amp Vacuum sealed 1⅛" × ¼" dia

10 for £2.50
50 for £11.00
100 for £18.00
Plus 50p p & p any quantity

MOTORS

RANCO 1/6 H.P. 1425 rpm 240v 50Hz Split phase ½" × 3" long shaft Unused Normally cradle mounted offered without cradle hence low price of **£6.65** plus £1 50 carriage

CITENCO F.H.P. reversible geared motor 220 240v 50 Hz 1 Ph cap start cont rating 0 2 amps Gearing 144/1 final drive 19 rpm Torque 14 5 Kg/cm 5/16" dia shaft Size 6" x 3⅜" dia plus base Brand new Limited quantity **£14.50** p&p £1 50

1/8 H.P. reversible geared motor 220 240v 50 Hz 1 Ph cap start cont rating Gearing 5 1 Final drive approx 280 rpm ⅛" dia shaft Size 14" inc gearbox x 5½" dia plus cap and base New Robust **£23.95,** carr £3 00

ACADEX shaded pole motor Open frame 230v 50 Hz Double ended 5 32" dia spindle each 1¾" long Ideal for fans models etc Size 1¾" × 2⅛" × 1⅜" deep plus spindles **£1.50** p & p 45p

CROUZET shaded pole motor Open frame 115/230v 50 Hz 1425 rpm Size 2½" × 2¼" × 1⅜" deep plus ¼" long × 5 32" dia spindle **£3.50** p & p 62p

PAPST MOTORS. Noted for advanced design and superb construction Rotating diecast outer body acts as flywheight and eliminates wow and flutter 50 Hz capacitor start

MODEL HSKZ 32 80 6 12 220v Dual speed tape deck motor 500 1000 rpm 12 mm drive shaft gives tape speeds of 9 53 19 05 cm sec (3¾ 7½ ins sec) respectively Size approx 5½" dia × 3½" plus 1⅜" spindle **£16.50.** p & p £1 10

MODEL RO 32 65 4 Dual voltage 125 250v Size 2¾" × 3⅛" Spindle 5 16" dia **£12.50,** p & p £1 10

MODEL HSZ 20 25 2 Basically 42v but can be operated from mains with additional capacitor A magnificent small motor Size 1⅜" × 2⅜" Spindle 5/16" dia **£5.95,** p & p 45p

SOLENOIDS 240V A.C.

MAGNETIC DEVICES LTD (No 1) has 20lb pull for 50 4 duty 1½" travel push or pull Shackle both ends Size 1¾" wide × 3⅛" high × 4" long plus 3" arm travel **£6.75** plus p & p £1 00

(No 2) has 2lb pull continuously rated ¼" travel Size 1½" × 1½" h × 2¼" plus travel **£1.80,** 30p p & p

PYE ETHER LTD Thrust operates through spring loaded hinged lever giving a 1lb pull or push Complete with mounting bracket and push-on connections Size overall inc bracket 2½"w × 3"h × 3½" long **£2.25** p & p 45p

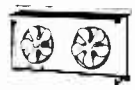
RELAYS

Octal base 2 C O 6 amp contacts Following voltages 6v 12v 230v A C 12v 24v 48v 110v D C all **£1.25** each plus base **15p** postage and packing 15p 11 pin 3 C O 6 amp contacts 48v 115v A C 24v 48v 110v D C all at **£1.50** each base **15p** plus 15p p & p

PRESSURE SWITCH

BY TEDDINGTON CONTROLS Adjustable 1 to 2 lbs sq in SPDT Rated 15 amps 250v A C **£1.95,** p & p 25p

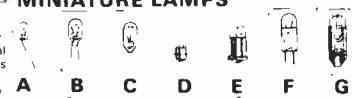
FANS



DUAL EXTRACTOR FAN. 240v 50 Hz Two thick stack shaded pole motors make this a highly efficient unit producing a powerful airflow Mounted in heavy steel frame each has five element 6½" blades Size 22½" × 14" × 5½" deep **£8.95,** carr £2 75

SINGLE FAN with motor similar to above Very useful in home and workshop Remember last summer Keep cool this year **Only £3.95,** p & p 65p

MINIATURE LAMPS



	A	B	C	D	E	F	G
		Size			Size		

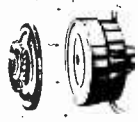
Type	(Dia)	Volt Curr	Type	(Dia)	Volt Curr
A	3MM	5 6V 60 MA	D	3MM	2 5V 360 MA
B	4MM	4V 250 MA			5-6 60 MA
		5V 60 MA	E	4MM	6V 200 MA
		12V 40 MA			6 3 200 MA
		12V 100 MA			14V 40 MA
		14V 75 MA	F	4MM	2 7V 60 MA
		28V 40 MA			12V 160 MA
C	5MM	28V 40 MA			14V 80 MA
G					

Small telephone jack type 6 or 24V

Price Types A F £4 00 for 25 50 and upwards **13p** each Type G **45p** each p & p 20p per order

BENDIX MAGNETIC CLUTCH

Dozens of uses in Home Farm, Workshops & Lab



Superb example of electro-mechanics Main body in two sections coil section fixed with ⅜" sleeve drive section rotating on outer perimeter Uniting plate has ⅛" ID bearing concentric with main section and 18 tooth cog wheel Extremely powerful transmission 24V D C 240 m a **£3.75** plus p & p 40p

PCB EDGE CONNECTOR

CINCH 156" pitch 27 way but designed with adjustable fixing endplates enabling connector to be cut and used in any length desired **45p.** p & p 15p **10 for £4.00,** p & p 30p

MEM LIMIT SWITCH

Snap action 5 amps at 240 410 A C size base 3⅛" × 1⅛" × 1⅛" plus heavy duty roller plunger 1½" ext or 1" when compressed Very robust for tireless operation weatherproof Price **£2.20** plus p & p 40p

JABSCO (ITT) ROTARY PUMP

Self priming Works from electric drill or suitably powered motor for ¼" drive shaft ½" hose connections Throughput 2 3 galls per min at 2400 rpm Dozens of uses in home and workshop Giveaway at **£2.75,** p & p 20p

---

TRANSISTORISED 3cm RADAR AMPLIFIER SWITCH: with 24v waveguide switch, .9 x .4 cm ins. with crystal CV.2355 and spark gap VX.1046. **£16.20** + £1.00 post.

TRANSISTORISED VIDEO INDICATOR (used with above amplifier): 1½" C.R.T. **£10.80** + £1.00 post.

RADAR RECEIVING ANTENNA TYPE X443 Mk. D: Suitable for detecting signals on X, K, J and Q bands. 9gHz-60gHz. Complete with waveguide horns, associated crystals. Transistnrised amplifier and geared motor, etc. **£135.00,** carr. approx. £5.00.

DIODES: CD.384 — **£2.00** per 100 + 20p pnst.

VACUUM & PRESSURE SEAL TEST EQUIPMENT: Complete with 3 x 4" gauges indicating 0-20lbs p.s.i., 0-30lbs vacuum. With stand, hand pump, etc., **£32.40** + £3.00 carr.

ASHCROFT DEADWEIGHT GAUGE TEST SET TYPE 1300: 0-25lbs **£64.80** + £3.00 carr.

E.A.L. ANALOGUE DIGITAL CONVERTER TYPE MPD. 120-0: 7-bit or 8-bit mode. **£70.00,** carr. £2.00.

INSULATION TEST SET 0 to 10 KV, negative earth, with Inisation Amplifier, 100/230 Volts. AC **£45.90,** carr. £3.00.

UNISELECTORS: Reversible action. Twin coils 120Ω 25-way 6-bank. **£4.90** + 75p post.

FAMOUS 1154 TRANSMITTER as used in Lancasters in World War II (collector's item). **£12.50,** carr. £4.00.

RACAL RA-17 RECEIVER 500KHz—30mHz. s/hand. good condition. **£365.00** (including VAT 12½%).

EVERSHED SAFETY OHM METER: Max 10mA. Test pressure 30v. Complete in leather case. **£27.00,** post £1.00.

AVO TRANSISTOR ANALYSER CT.446: £37.80, carr. £2.20.

MARCONI FREQUENCY METER 1026/4: 2000-4000mHz 'as new' condition **£32.40** or secondhand condition **£24.30.**

1026/2: 100-160mHz £32.40 'as new' or s/hand **£24.30.** Carriage for all type £2.00.

ANTENNA MAST 36ft: Aluminium, diameter at base 3", tapering to 2" at top, complete with red hazard lights, stays, guys, etc. Normally used with direction finding equipment. Approx. weight 3cwt. **£106.90** (including 12½% VAT), carriage rates on request. WITH rotating Antenna suitable for 200-400mHz **£16.90** extra (including 12½% VAT).

BURGLAR ALARM BELL: 6-8v. d.c. **£3.24** + £1.00 post.

MEGGER (Record): 500 volts **£21.60** £1.00 post.

R-216 RECEIVER MANUAL (Photostat copy): £1.50 inc. post.

MUIRHEAD ATTENUATORS: 75 ohms 0-8Mc/s 3V. MAK 3 ranges 0-5, 0-25, 0-50dB. **£3.24** + 75p post.

POWER UNIT TYPE 234: 200-250v. a.c. input, 250-0-250v. d.c. at 100mA and 6 3v at 4 amps output. **£8.10,** carr. £2.50.

REDIFON TELEPRINTER RELAY UNIT NO. 12: ZA-41196 and power supply 200-250v. a.c. Polarised relay type 3SEITR 80-0-80v. 25mA. Two stabilised valves CV-286 Centre Zero Meter 10-0-10. Size 8" x 8" x 8". New condition. **£10.80,** carr. £2.50.

SOLARTRON PULSE GENERATOR TYPE G1101-2: £81.00, carr. £2.50.

TELEPRINTER TYPE 7B: Pageprinter 24v. d.c. power supply, speed 50 bauds per min. S/hand cond. (excellent order). no parts broken **£21.60,** carriage £3.50.

AUTO TRANSFORMER: 230v. 50c/s. 1000 watts. Mounted in strong steel case 5" x 6½" x 7". Bitumen impregnated. **£12.96,** carr. £2.00.

CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3,000-10,000kHz. Mains 230v 50hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£27.00,** carr. £2.00.

CATHODE RAY TUBES: 5" screen, tupe CV-1536 **£4.32** + £1.00 post. Type 95J20 square face 5" x 3" **£8.10** + £1.00 post.

WEATHERPLOTTER RECEIVING SET AN/GMH-5: Facsimile reproducing system for weather maps. Further details on request. **£459.00** (inc. 8% VAT).

CLASS 'D' WAVEMETER NO. 1: Crystal controlled heterodyne frequency meter covering 2-8mHz. Power supply 6v. d.c. Good s/hand cond. **£9.20** + £2.00 carr.

RING TOROIDAL DUST CORES: Size 2½" outside, 1¼" inside, 5/16" thick. Box of two **£1.10** + 30p post.

ROTARY INVERTERS TYPE PE-218E: Input 24-28v. d.c. 80 amps. 4,800rpm. Output 115v. a.c. 13 amp 400 c/s 1Ph. P.F.9 **£21.60** + £3.00 carr.

FREQUENCY METER BC-221: 125-20,000kc/s complete with original calibration charts. Checked out, working order. **£22.70** + £2.00 carr.

RECTIFIER UNIT: 200-250v. a.c. input, 24v. d.c. at 26 amps output continuous rating. **£37.80,** carr. £5.00.

PAPER TAPE: ½" roll (teleprinters, etc.). Box of ten rolls **£1.50** + £1.00 post.

CREED 75 TELEPRINTER: Rec./Tx. s/hand. good condition **£48.60** + £4 Carr.

CREED TELEPRINTER TABLE: £25.00 + £5 Carr.

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Large stocks of unused U.S.A.F. surplus maps, weather charts, etc. including:—

ONC-E1 — U.K. in full and part N.W. Europe. Scale 1:1,000,000.
JNC-9N — N. Europe, U.K., Scandinavia. Scale 1:2,000,000.
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SIZE: 58" x 42", colour. Many others. Please send S.A.E. for list.

Price each 70p (inc. p + p)

25 x Maps (either same type OR assorted) **£10.00** + £1.00 p + p.
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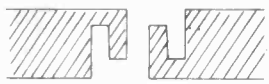
3 & 3a BALDOCK STREET, WARE, HERTS. SG12 9DT
WARE 66312 (STD 0920)

Mini-priced breadboards for maxi-sized projects.

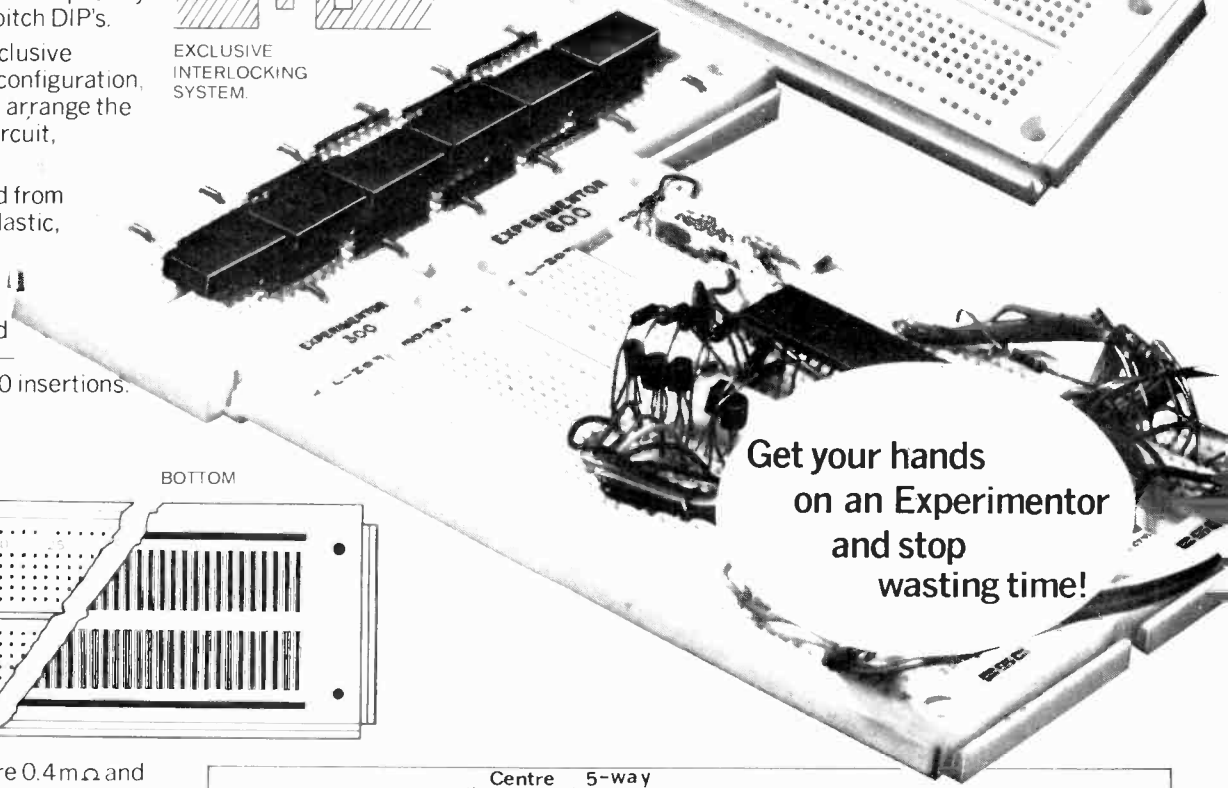
Experimentor low-cost solderless breadboards are the first in the world specially designed for 0.3" and 0.6" pitch DIP's.

They clip together by an exclusive interlocking system in any configuration, (just like dominoes), so you arrange the breadboards to suit your circuit, not vice-versa.

They are precision moulded from durable, flame-retardant plastic, and feature alphanumeric coding for easy circuit building, and non-corrosive, pre-stressed nickel-silver alloy contacts—reliable for well over 10,000 insertions.



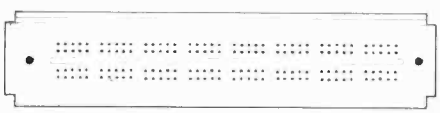
EXCLUSIVE INTERLOCKING SYSTEM.



Get your hands on an Experimentor and stop wasting time!

Contact resistance is a mere 0.4 mΩ and interterminal capacitance is typically less than 5 pF. The **Experimentor** is usable to over 100 MHz.

Experimentor 600 and 650 models are ideal for RAM's ROM's and PROM's (0.6" centre IC's) while the 300 and 350 models are for smaller DIP's (0.3" centres). All four models, of course, also take all standard components, the 0.1" grid being compatible with transistors, diodes, LED's, capacitors, resistors, pots—in fact any component with lead sizes between 0.015" and 0.032".



A useful quad bus strip (EXP4B) further expands the versatility of the system for the MPU user.

Model	Length"	Width"	Centre channel"	5-way tie points	Bus	Price
EXP300	6.0	2.1	0.3	94(470)	2(80)	**£6.77**
EXP350	3.6	2.1	0.3	46(230)	2(40)	**£3.69**
EXP600	6.0	2.4	0.6	94(470)	2(80)	**£7.35**
EXP650	3.6	2.4	0.6	46(230)	2(40)	**£3.99**
EXP4B	6.0	1.0	N/A	N/A	4(160)	**£2.83**

All units are 0.330" deep.
Prices include VAT (8%) and p&p for £3.69 UK Orders.
Add 5% to all orders outside UK.
All prices and specifications correct at the time of going to press.

Experimentor breadboards can be used alone or mounted on any convenient flat surface, thanks to moulded-in mounting holes and vinyl insulation backing that prevents short circuits. Mount them from the front with 4-40 flathead screws or from the rear with 6-32 self tapping screws.

But however you use them, **Experimentor** breadboards are the quickest and easiest way to build and test circuits.
If you're working on IC's, MPU's, memories, displays or any other circuits, buy the breadboards that are designed for you.

Ring us (01-890 0782) with your Access, Barclaycard or American Express number and your order will be in the post that night.

Alternatively, send a cheque, or postal order (don't send credit cards!) and it still only takes a few days.
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ANNOUNCEMENT

FURTHER INFORMATION ON Z80 COMPUTER SYSTEMS AVAILABLE SOON FROM SINTEL

We will be offering two different packages. The first system, the **RESEARCH MACHINES 380Z**, will be available built and tested and also in kit form. This is a fully independent computer system when used in conjunction with a television and cassette recorder.

The second system, the **RESEARCH MACHINES 280Z**, will be available in uncased kit form, with a low cost keyboard. The RESEARCH MACHINES 280Z is designed to set a new low in computer system pricing and it will bring a full computer system within reach of many more private computer enthusiasts.

(These computers are designed and manufactured in Oxford by SINTEL S parent company RESEARCH MACHINES LIMITED, and will be sold through SINTEL.)

RESEARCH MACHINES 380Z has the following specifications:

INTEGRAL VDU The 380Z has a UHF output which plugs into the aerial socket of a **completely unmodified** domestic television. The TV screen will then display 24 rows of 40 characters (960 characters). The unit can display the 128 character ISO7 set, including upper and **lower** case ASCII. Each character position on the VDU is written in to and can be read by the CPU as a memory location. This means that the VDU is software controlled and can be programmed to operate in any mode, including page mode, scrolled, immediate mode editing, or fully addressable cursor. The whole VDU can be filled with new data in less than 10mSecs! Screen refreshing does not use any of the Z80 s time. VDU GRAPHICS The 380Z can display graphics on the TV screen or, a matrix of 80 (horizontal) x 72 (vertical). Graphics and alphanumeric characters can be intermixed. Because of the high speed software control, the VDU can display dynamic graphics for games and simulations. INPUT Very high quality, robust keyboard with ASR-33 standard layout. CASSETTE INTERFACE CUTS Kansas City standard, 300 bits per second. CPU SPEC Z80 Microprocessor. Fully buffered bus. RANDOM ACCESS MEMORY 4K bytes dynamic RAM minimum. The system can accommodate up to 32K bytes without adding any memory PCBs. Using a page select mode, the computer memory can be expanded indefinitely. FIRMWARE (Software supplied and available at Switch-On, in ROM, otherwise known as the MONITOR) MONITOR COMMANDS List Memory, Modify Memory, Load from Cassette, Dump On Cassette, Single Step, Trace, Go To User Programme, Breakpoint, etc.

SOFTWARE We will be offering; Extended Monitor, Various Basics, Text Editor with both sequential and immediate mode, Machine Language Graphics Subroutines, Games Packages, Resident Assembler.

HARDWARE CONFIGURATION Computer is housed in an instrument case with power supply, and a lot of room for expansion. Keyboard is in a separate case.

RESEARCH MACHINES 280Z

An exciting new low cost computer using the Z80 microprocessor, suitable for amateur use or as a professional Engineer s Computer Development Kit. RESEARCH MACHINES 280Z features optional power supply, a low cost keyboard, VDU UHF output providing an ASCII alphanumeric display on a domestic television, cassette interface and a reasonable amount of random access memory. This system offers exceptional value for money. It will cost somewhere between the price of a Manufacturer s Development Kit using hex display and keyboard, and a fully cased computer system.

STOP PRESS: FOR PRICES CONTACT SINTEL

A RANGE OF SINTEL INDUSTRIAL MODULE KITS

KITS FOR LATCHED COUNTER MODULES

Latched Counter modules are now available from SINTEL using both CMOS and TTL ICs. These kits will give you a very compact unit at less than the cost of the components bought separately and will save you considerable design, purchasing, building and debugging time. Each kit has a set of red LED displays, two PCBs and the appropriate number of TTL or CMOS ICs, plus brackets, etc., resistors, capacitors, single in-line plug and sockets and instructions.

Digits	TTL Part No.	TTL Price	CMOS Part No	CMOS Price
2 digit	526-412	£10.52	548-470	£10.42
4 digit	657-412	£17.98	191-470	£18.11
6 digit	721-412	£25.66	869-470	£25.85

COUNTER PCB SETS

Sets of 2 PCBs plus brackets, layout, circuit and instructions

2 digit	915-950	£2.97	855-950	£2.48
4 digit	246-950	£4.53	462-950	£3.73
6 digit	610-950	£6.16	719-950	£5.01

For other Counter Sets and Modules available from SINTEL please send for our *FREE CATALOGUE* which will be sent by return post.

SETS OF JUMBO DISPLAYS WITH DISPLAY HOLDING PCBs

These display holding PCBs will make your circuits neater, more attractive and save you time. Each kit consists of the appropriate number of 0.5" red LED displays (either common anode TIL321, FND507s or common cathode TIL322, FND500s) and a display holding PCB. OPTIONS PCBs wired for multiplexing or non-multiplexing, clock format or counter format.

TYPE Non-Multiplexed	COMMON ANODE Part No	COMMON ANODE Price	COMMON CATHODE Part No	COMMON CATHODE Price
2 digit Counter	574-822	£3.37	446-822	£2.97
4 digit Counter	777-822	£6.63	128-822	£5.83
6 digit Counter	684-822	£9.89	271-822	£8.69
Multiplexed				
4 digit Clock	301-822	£6.66	262-822	£5.86
6 digit Clock	417-822	£10.15	452-822	£8.95
8 digit Counter	119-822	£13.09	515-822	£11.49

Our offices are at 209 Cowley Road, Oxford, but please do not use this as a postal address

ALL PRICES ARE VALID UNTIL DECEMBER 31, 1977

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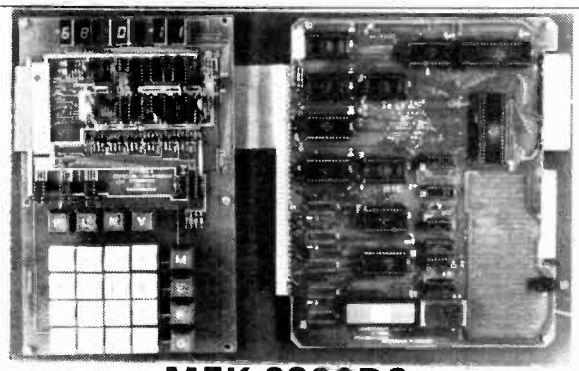

MEK 6800D2

A SELF-CONTAINED MICROCOMPUTER KIT

- KEYBOARD DATA ENTRY
- 6 DIGIT HEX DISPLAY
- INTEGRAL CASSETTE INTERFACE
- 256 WORDS OF RAM
- SINGLE + 5V POWER SUPPLY

£190.00

CMOS

Mainly RCA

		CD4014	1.04	CD4031	2.30	CD4048	0.58	CD4071	0.23	CD4098	1.13
		CD4015	1.04	CD4032	1.02	CD4049	0.58	CD4072	0.23	CD4099	1.90
		CD4016	0.58	CD4033	1.44	CD4050	0.58	CD4073	0.23	CD4502	1.24
		CD4017	1.04	CD4034	1.97	CD4051	0.94	CD4075	0.23	CD4510	1.41
		CD4018	1.03	CD4035	1.22	CD4052	0.94	CD4076	1.34	CD4511	1.72
		CD4019	0.58	CD4036	3.29	CD4053	0.94	CD4077	0.45	CD4514	2.84
CD4000D	0.17	CD4020	1.28	CD4037	0.98	CD4054	1.20	CD4078	0.23	CD4515	3.24
CD4001	0.18	CD4021	1.04	CD4038	1.10	CD4055	1.36	CD4081	0.23	CD4516	1.40
CD4002	0.17	CD4022	0.94	CD4039	3.20	CD4056	1.36	CD4082	0.23	CD4518	1.25
CD4006	1.20	CD4023	0.23	CD4040	1.11	CD4059	4.93	CD4085	0.74	CD4520	1.19
CD4007	0.18	CD4024	0.80	CD4041	0.86	CD4060	1.15	CD4086	0.74	CD4527	1.64
CD4008	1.00	CD4025	0.23	CD4042	0.86	CD4063	1.13	CD4089	1.60	CD4532	1.39
CD4009	0.58	CD4026	1.78	CD4043	1.01	CD4066	0.63	CD4093	0.92	CD4555	0.90
CD4010	0.58	CD4027	0.58	CD4044	0.96	CD4067	3.85	CD4094	1.94	CD4556	0.90
CD4011	0.20	CD4028	0.92	CD4045	1.45	CD4068	0.23	CD4095	1.08	MC14528	1.22
CD4012	0.23	CD4029	1.18	CD4046	1.37	CD4069	0.23	CD4096	1.08	MC14553	4.68
CD4013	0.58	CD4030	0.58	CD4047	1.04	CD4070	0.51	CD4097	3.85	IM6508	8.05

COMPONENTS

SUNDRIES

CA3130	0.94
A741	0.40

MPUs

$6800_{\mu}P$	15.97
6820	8.02
$Z80_{\mu}P$	28.44
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Z80 PIO	12.80
Z80-CTC	12.80

DISPLAYS

FND500	1.30
TIL321	1.50
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SLT01	4.90

CRYSTALS

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5.12MHz	3.60

MEMORIES

9131	16.42
2102A 6	2.05
2112A 4	2.90
5.5.8	8.05

CLOCK CHIPS

AY51202	3.10
AY51224	3.50
MK50253	5.60

FLAT CABLE

20w 1m	1.00
1m for	8.50

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100	0.50
1,000	4.00
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751237J	2.50
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751239K	3.58

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4 red digit Desk clock	£15.50
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THE SINTEL FREE CATALOGUE

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Requests by post or telephone to SINTEL, P.O. Box 75C, OXFORD. Tel. Oxford (0865) 49791

DATABOOKS

Intel Memory Design Handbook	£5.20
Intel 8080 Microcomputer System User's Manual	£5.25
Intel 8085 Microcomputer System User's Manual	£5.15
Motorola Booklet From the Computer to the Microprocessor	£1.80
Motorola McMOS Databook (Vol. 5 Series B)	£3.50
Motorola M6800 Microprocessor Applications Manual	£12.95
Motorola M6800 Programming Manual	£5.35
National SC/MP Introkit User's Manual	£0.75
National SC/MP Technical Description	£1.80
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RCA CMOS and Linear IC Databook	£5.45
Texas Instruments Pin Configuration Guide	£2.95
Z80 Assembly Language Programming Manual	£7.50
Zilog Z80-CPU Technical Manual	£5.60
Zilog Z80-CTC Product Specifications	£0.80
Zilog Z80-PIO Technical Manual	£0.50

DATASHEETS at 75p each on IM6100, 6800, SC/MP, CDP1802, 2650, TMS5501, TMS8080, 9131, Z80uP, Intel 88085. Also free data on some components.

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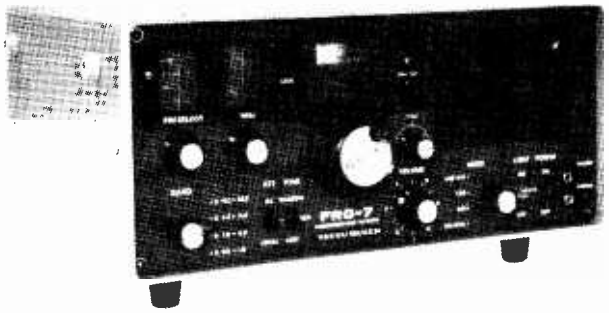
FOR THE FINEST VALUE IN THE WORLD

THE FRG7 Synthesised General Coverage Communications Receiver

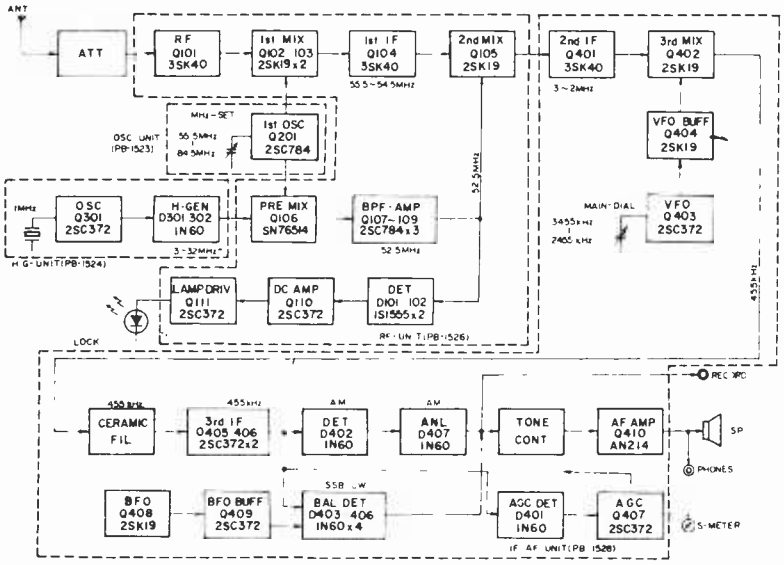


The FRG7 is a solid state mains and 12v. receiver offering continuous coverage 0.5—30 MHz with specifications unparalleled in its price range.

Its advanced circuitry provides superb performance for professional or amateur alike: search, monitor, test, amateur or broadcast band applications.

The use of a Wadley loop (using the same VHF oscillator to mix up, then after pre-mixing with a stable crystal source down again (this cancelling all drift from the variable oscillator). It provides equivalent performance to 30 crystal controlled converters feeing a low IF, but without the image problems of such an arrangement.

The signal path starts with the choice of 3 antenna connectors: for 1.6-30 MHz, a 50/75 ohm feed (to a SO239 (UHF) coax socket and a binding post) and for 0.5-1.6 MHz (medium wave) a separate high impedance binding post. A 3 position 0-40dB switchable attenuator aids reception of very strong signals and reduces adjacent channel interference. The low noise MOSFET RF amplifier provides a SSB sensitivity of 0.25 uV (for 10dB N+S/N at 10.5 MHz) and is sharply tuned by a well calibrated "pre-selector" capacitor with 4 band switched coils. Its output is low pass filtered (fc=35 MHz) removing VHF image problems from the following mixer. This comprises a pair of JFETS, driven by the "MHz set" 55.5—84.5 MHz, oscillator, which upconverts the signal to the band pass first IF to 55 MHz ± 500 KHz where it is MOSFET amplified. The second IF of 2-3 MHz is produced by a FET mixer by hetrodyning with the synthesiser derived 52.5 MHz signal. A I MHz crystal oscillator and diode harmonic generator produces a 3-32 MHz comb spectrum. This, with the first hetrodyne oscillator (MHz set) is fed to a dual balanced i.c. pre-mixer. The output is expurged by a multiple stage selective amplifier producing the 52.5 MHz second oscillator. A small fraction of this is rectified, DC amplified and lights the 'lock' LED (saving power) when the MHz oscillator is malset. The 2-3 MHz signal is MOSFET amplified and fed to the third mixer (a JFET whose input and output are tuned by capacitors ganged to the main tuning control) where it is hetrodyned to the final IF by the main VFO which covers a 1 MHz range (2.455-3.455), is clearly calibrated, to 5 kHz (or better), well buffered and highly stable. The third (455 kHz) IF starts with the ceramic selectivity element and is followed by two stages of bipolar (the first in the signal path) amplification before the choice of detectors; twin diodes for AM, or a 4 diode product detector, with well buffered switched frequency (for selectable sidebands) B.F.O. A diode rectifies, a fraction of the output from the final IFT, this is boosted to drive the illuminated "S" meter and automatically gain control the MOSFET amplifier in the RF, second and third IF stages, reducing fading and distortion. Immediately following the demodulator is an automatic noise limiter, highly effective in suppressing pulse type interference on AM signals, and a three position "tone" switch a (high, low or band pass) audio filter, reducing the bandwidth to that required. A transformerless AF amplifier : delivers a generous 2W to the internal 5" x 3", or external speaker, drives a phone jack, and a "volume" independent output for tape recorder. The receiver is, mains (234VAC), external (12v DC) or internal dry cell powered, the most economic source being automatically chosen. This is reduced to a stable regulated 10v. (or 9v. for oscillator and the harmonic generator). A dial lamp switch is provided to conserve power on battery operation.



PERFORMANCE WITH ECONOMY
WORLD WIDE WIRELESS

CONSERVATIVE SPECIFICATIONS

FREQUENCY RANGE 0.5-30MHz
General coverage in 4 bands
AUDIO DISTORTION less than 10% at 2W output

AUDIO OUTPUT more than 2W.
ANTENNA IMPEDANCE 50-75 ohms. Unbalanced for 1.6-30MHz. High impedence for 0.5-1.6MHz.

MODES SSB (selectable USB&LSB) AM, AM/ANL, or CW
CIRCUITRY 13 bipolar and 9 field effect transistors 2 ICs and 16 diodes
SIZE 13½" W x 6" H x 11½" D
POWER REQUIREMENTS 13.5V DC Neg ground or 8 off HP11 or 100/110/117/220/234V AC 50/60 Hz

FREQUENCY STABILITY within 500HZ during any 30 mins after warm up.
SELECTIVITY ±3KHz at 6dB (nominal) and ±7KHz at —60dB down.
WEIGHT 15½lbs without batteries.
SENSITIVITY 0.25 uV for 10dB N+S:N ratio for SSB and CW. 0.7uV for 30% modulated AM at 10.5 MHz.

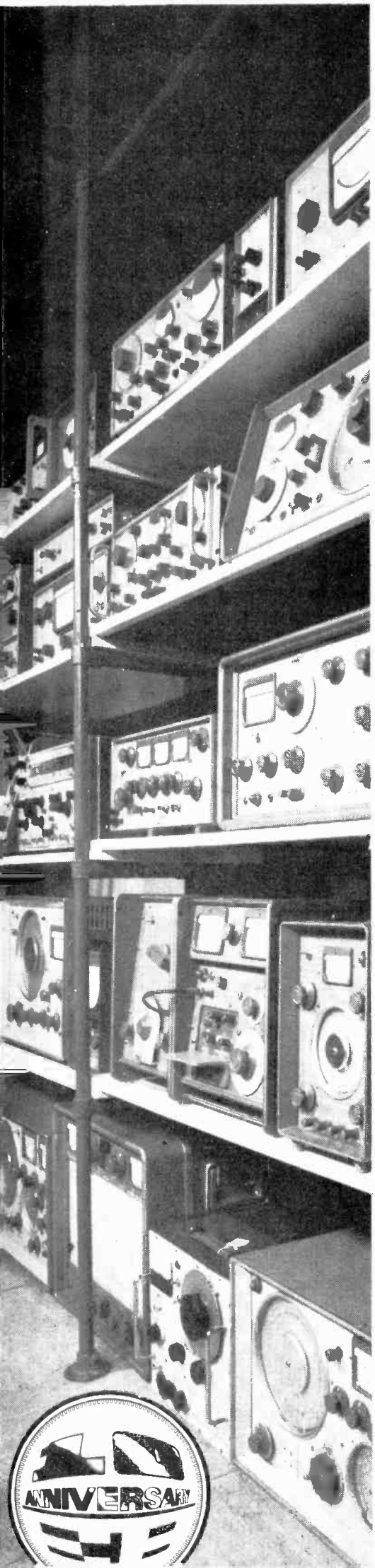
OUR AGENTS

Amateur Electronics
508-514 Alum Rock Road
Alum Rock
Birmingham B8 3HX

South Midlands Communications Ltd.
S.M. House, Osborne Road
Totton
Southampton, Hampshire SO4 4DN

Western Electronics (UK) Ltd.
Fairfield Estate
Louth
Lincolnshire LN11 0JH

WW—092 FOR FUTHER DETAILS



Electronic
The Test Equipment People

SIGNAL SOURCES

ADVANCE

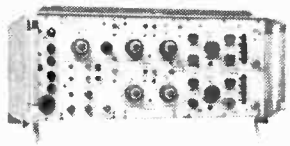
Signal Generator J4. 10Hz-100KHz 600 ohms impedance. Sine & Square Brand new condition **£150.00**

V.H.F. Square wave Generator SG21. 10 KHz-100MHz Max. o/p 2V **£50.00**

H1 Audio Signal Generator. 15Hz-50KHz Sine and Square **£35.00**

E2 R.F. Signal Generator. 10KHz-100MHz **£76.00**

H1E Audio Signal Generator. Sine & Square Wave 15Hz-50KHz. 200V to 20V (Sine). Distortion 1% 1.4mV to 140V (Square). Brand new condition **£70.00**



Type PG59 Pulse Generator. 2 Channel, double pulse. Functions: Frequency, Width, Rise & Fall Time, Amplitude, Offset, Delay, Prepulse & Gate. Repetition Freq. 1Hz to 10MHz (20 MHz in double pulse mode. Delay & Width 25 nsecs/1sec. Full specification on request **£625.00**

Type SG67A Wide Range Oscillator Freq. Range 1Hz-1MHz. Sine or Square. Output Amplitude up to 2.5V. Battery operated **£95.00**

Type J1 Audio Signal Generator. 15Hz-50KHz. Output 0.25V to 25V at impedance 600 ohms or 5 ohms **£50.00**

AVO

R.F. Signal Generator HF134. 100KHz-240MHz 75Ω Int mod. 1KHz @ 30% Ext. mod facility **£150.00**

HEWLETT PACKARD

10515A Frequency Doubler. Extends the usable frequency range of signal generators. Operating on input frequencies 0.5MHz to 500MHz it provides a doubled output in the range of 1MHz to 1GHz. The frequency response of this 50 ohm device is very flat (< ±2dB typically) over the entire frequency range and undesired harmonics are well suppressed **£75.00**

F.M./A.M. Signal Generator 202H. F.M. A.M. C.W. & pulse coverage 54 to 216 MHz. R.F. o/p 0.1μV-0.2V. 50ohms Impedance **£495.00**

Audio Signal Generator 206A. 20Hz-20KHz ±2% accuracy. Distortion ∠1% **£90.00**

612A-U.H.F. Signal Generator. 450-1230MHz. 0.1μV-0.5V (50ohms) A.M. Internal & external Pulse mod facilities. SUPERB CONDITION **£1250.00**

MARCONI INSTRUMENTS

TF1060 U.H.F. Signal Generator. 450-1250MHz. Sine wave and pulse a.m. **£350.00**

Signal Generator **TF867**. 15KHz-30MHz o/p 0.4μV-4V. Int. & Ext. mod. Supplied with Terminating unit **£185.00**

TF2005R Two Tone Source. The instrument comprises two identical low distortion a.f. oscillators and a monitored attenuator unit, to form a compact test set for the measurement of inter-modulation distortion **£485.00**

Solid State Generator 6058B. Freq. range 8-12.5GHz. Int. & Ext. mod. freq. Stab. 0.003% 50Ω impedance **£530.00**

Modulation Int. A.M. 1KHz. Ext. A.M. 30Hz-20KHz. Low spurious F.M. & drift V.S.W.R. 1.2 or less **£400.00-£800.00**

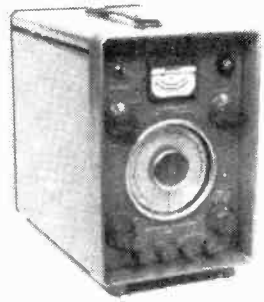
A.M. Signal Generator TF801D/1S. Military version 10-485MHz **£450.00-£800.00**

R.C. Oscillator TF1370A. 10Hz-10MHz. Square Wave up to 100KHz. High Outputs up to 31.6V **£285.00**

Phase/A.M. Signal Generator TF.2003. 0.4-12MHz **£150.00**

F.M./A.M. Signal Generator TF 995A/3S. Ministry type No. CT402. 1.5MHz-220MHz. R.F. o/p 2μV-200mV. Internal & External Mod. Facilities. V. good condition **£385.00**

A.M. Signal Generator TF801D/1. Freq. range 10-470MHz. R.F. output 0.1μ-1V. Piston attenuator. 50ohms Impedance. AM Signal Generator TF 801B/3S. 12.485MHz. 0.1μV-1V **£195.00**



R.C. Oscillator TF1101. Frequency range 20HZ-200KHz. Output Direct into 600Ω 0-20V variable. Attenuator 0.6dB in 10dB steps. Impedance. 600Ω. Distortion. Via 1KHz Filter less than 0.1% Direct or via Attenuator. Less than 0.5% 50Hz-20KHz. Less than 1% 20Hz-200KHz **£120.00-£150.00**

Signal Generator TF144H/4. Later models in super condition **£500.00 to £650.00**

MF/HF Signal Generator TF2002. 10KHz-72MHz. 100% A.M. depth Int. A.M. Variable from 20Hz to 20KHz. R.F. o/p. 0.1μV to 2V. Solid State **£675.00**

AM/FM Signal Generator TF995B/2 **£675.00**

MARCONI-SANDERS

Microwave Sweep Generator type 6600A c/w 6619 plug in 1.7GHz-4.2GHz **£2,900.00**

MUIRHEAD L.F. Decade Oscillator D880A. 2-phase 0.01Hz-11.2KHz **£295.00**

Decade Oscillator D890D. 1Hz-11.2KHz **£260.00**

PHILIPS

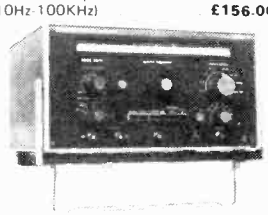
PM5501 Colour bar generator. Extremely light and compact instrument for mobile maintenance. 5 different test patterns for colour and black/white TV installation and service. R.F. output signal switchable. VHF. Band III and UHF Band IV. 1KHz tone for sound performance checks (sine wave) **£165.00**

50MHz Pulse Generator PM5712 **£435.00**

Pulse Generator PM5775 **£800.00**

Pulse Generator PM5776 **£900.00**

L.F. Generator PM5105. 10Hz-100KHz. Sine & Square Wave 2V(R.M.S.) Stabilised o/p. Low Distortion <0.8% (10Hz-100KHz) **£156.00**



Type PM5334 TV Sweep Generator. 8 ranges 3MHz-860MHz. Sweep freq. adjustable 8-50Hz. 1 variable and 3 fixed markers. 75 ohm impedance **£465.00**

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Model 7x **£40.00**

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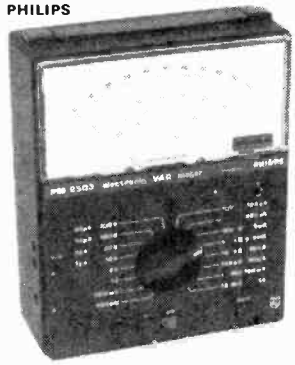
DVM type 3430A 3 digit 5 ranges 100mV to 100V. FS input resistances 10Mohms. Overload protection **£145.00**

Digital Multimeter 34702A with Display 34740A. 4 digit display. 4 ranges both AC & DC plus 6 ranges of ohms. AC function covers 45Hz to 100KHz. Ohms ranges are 100ohms to 10Mohms FS LED display. New condition. A much sought-after device still in current production **£400.00**

PHILIPS



Electronic Analogue Multimeter PM2503 DC & AC Volts, 100mV-1KV f.s.d. Resistance 100 ohms-10M Ohms. DC & AC Current 1μA-1A f.s.d. **£85.00**

SIGN/ROGERS

A.F. Voltmeter AM324 **£50.00**

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A.C. Converter LM1219. 30mV—300V mean reading. Freq. range 10Hz—10KH. **P.O.A.**

D.C. Digital Voltmeter LM1420.2. 2.5μV—1Kv in 6 ranges. ±0.05% DC accuracy **£235.00**

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D.M.M. 7050 (Autoranging) **£245.00**

OSCILLOSCOPES

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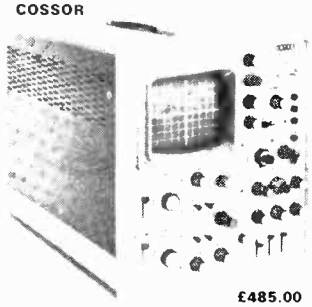

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Type 175A. 50MHz. Bright, sharp trace. 6 × 10cm display. Plug-ins provide bandwidths to 50MHz. Vertical and time axis plug-ins for specific applications. Eight plug-ins provide maximum versatility. Easy to calibrate and maintain. few adjustments. no distributed amplifiers or delay line adjustments. Positive syncing over entire bandwidth. Plug-in Units: 1750A Dual Trace Vertical Amplifier 40MHz. 50mV/cm. 1781B Sweep Delay Generator. Sweep Selector provides (a) Main Sweep (b) Delaying Sweep, brightened segment of trace indicates

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200 μV/cm. Scope 130C 500KHz bandwidth Identical X and Y amps X2 to X50 sweep mag **£205.00**

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CD1740 50MHz Scope System c/w CX1741 & CX1744 Dual Trace. DC-50MHz 10 × 8cm display Sensitivity 5mV/cm to 20V/cm Delayed sweep. Solid State **£485.00**
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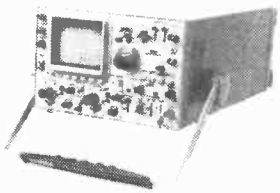
DC30MHz Oscilloscope 545A c/w CA & L Plug-ins **£445.00**
Type 475 200MHz Portable Dual Trace 2mV/div 1nsec/div sweep rate Delayed sweep **£1,750.00**



Type 485 350MHz Portable. Dual Trace 5mV/div 1nsec/div sweep rate Delayed sweep. Auto focus, variable trigger hold off 50 ohms internal input protection **£3,250.00**
Type 531A DC-15MHz c/w CA Plug-in — Dual Trace **£275.00**
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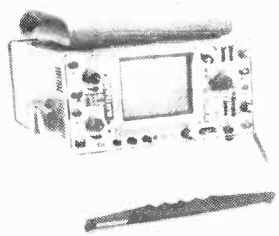
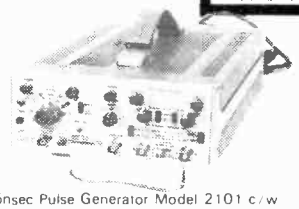
TELEQUIPMENT RACK MOUNTING SCOPE S54AR



UNUSED P7 long persistence CRT fitted Single trace DC-10MHz 10mV/cm. **£205.00**

SCOPE TEST EQUIPMENT

Time Mark Generator 184 **£275.00**



5nsec Pulse Generator Model 2101 c/w loads and connectors **£575.00**
Time Mark Generator 2901 **£450.00**
Pulse Generator Model 110 **£95.00**

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AIRMEC/RACAL
Wave Analyser 248A 5-300MHz **£250.00-£300.00**
Wave Analyser 248 Freq range 5MHz-300MHz **£145.00**
Modulation Meter 409 **£295.00**
Type 210 Modulation Meter (earlier version of 210A) **£85.00-£100.00**
Type 210A Modulation Meter 2 5-300MHz AM Range 0-100% FM Range 0 to ±100KHz in 4 ranges **£185.00-£245.00**

GENERAL RADIO
Type 1900A Wave Analyser c/w Graphic Level Recorder 1521B
Spec 1900A 20Hz-50KHz 3 bandwidths 3, 10 and 50Hz Tracking averages 30mV-300V F.S.D. Input impedance 1M ohm 3 meter speeds
Spec 1521B 4.5Hz-200KHz 1 mV sensitivity Linear dB plot of r.m.s. ac-voltage level 20, 40 or 80 dB range **£2,000.00**

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Sweeping Local Oscillator 3595A Plug-in for use with 3590A Wave Analyser Freq range 20Hz to 620KHz **£650.00**

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MF Transmission Test Set TF2333 Freq range 30Hz to 550KHz Measures response of active and passive transmission network Full spec on request **£600.00**
Distortion Factor Meter TF142F Fundamental Freq Range 100Hz-8KHz Dist measuring ranges 0-5% 0-50% Measures all spurious components up to 30KHz **£60.00-£80.00**
A.F. Transmission Measuring Set Model TF2332, Frequency Range 20Hz to 20KHz **£400.00**

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+Hz	−Hz
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Voltage range 100μV-1KV Auxiliary Oscillator Range 0Hz to 1.6KHz and 1.5 to 1.6KHz o/p — 10V (EMF) continuously variable impedance 1 Kohms 16μF **£275.00**

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TFT245 CCT Magn. Meter c/w Oscillator TF1246 **£685.00**

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Timer Counter TC12A 5 digit 2Hz to 15MHz Time & Period 10mV sensitivity. Brand new condition **£160.00**
Type TC18 Time Counter Freq measurement 10Hz-512MHz 6 digit LED display UNUSED CONDITION **£275.00**

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VENNER
3MHz Freq counter TSA 6674 **£80.00**

RACAL
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MISCELLANEOUS

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Digital Panel Meters DPM 102, 103 112P, 201, 204, 301, 302, 303, 306, 343 **Price and specs. on application**

BIRD
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Wattmeter Termaline 6835 3 ranges 0-120 / 0-600 / 0-1200W 30-500MHz **£425.00**
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HEATHKIT
Distortion Meter 1M-12U **£40.00**

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R.F. Power Meter TF1152/1 **£75.00**
R.F. Power Meter TF1152A/1 **£80.00**
Colour Gain and Delay Test Set TF2904 625 line **£505.00**
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L.F. Extension Unit TM6448 for use with OA 1094A sereis **£200.00**

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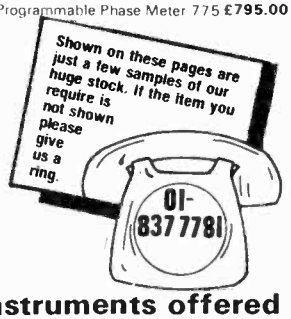

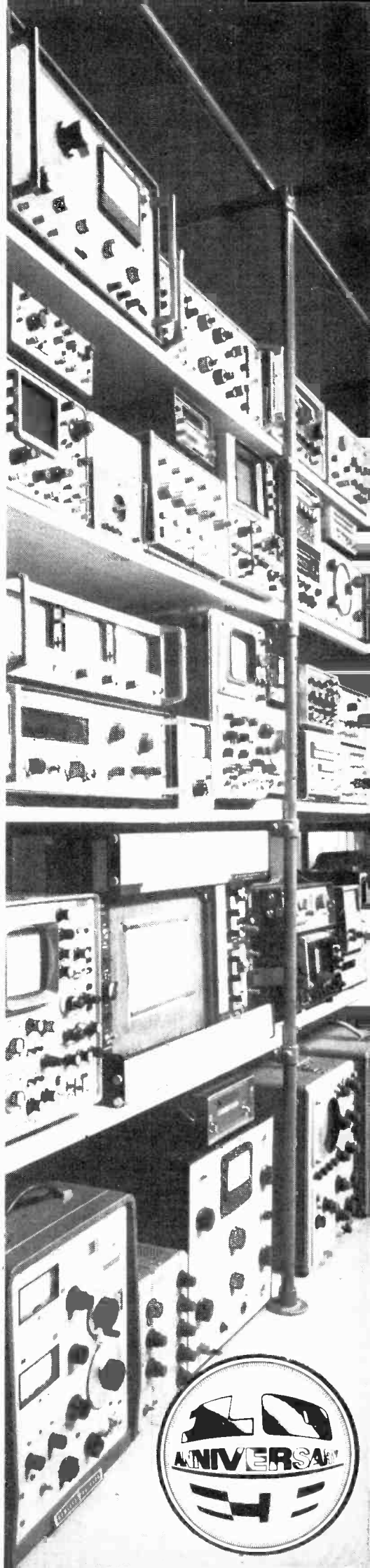

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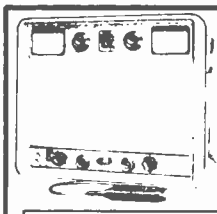

MARCONI TF 867 SIGNAL GENERATOR Range 15KHz to 30MHz Output 0 4V to 4V Built in crystal **£138**

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133A PULSE GENERATOR. Features ultra linear ramp rise and fall independently variable 50v output into 50 ohms either polarity Automatic overload protection Synchronous gating all solid state **£275**

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UHF SIGNAL GENERATOR TYPE SMLM from 30 to 303MHz
UHF SIGNAL GENERATOR TYPE SLSD from 300 to 300-940MHz
FREQUENCY INDICATOR TYPE FKM from 30 to 1 000MHz
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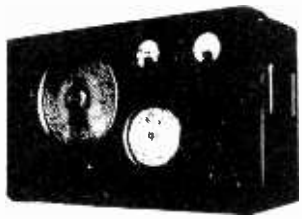
DECADE OSCILLATOR D-890-A. With high voltage output from 1Hz to 110KHz frequency accuracy without crystal check facility x 1 range ± 0 2% or ± 0 2 c s whichever is greater x 10 range ± 0 4% (above 10 Kc s) **£249**



TF 801D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges R F output 0 1 V 1V Source C M 50Ω output impedance Internal modulation at 1KHz at up to 90%

TF 801B/2. Spec as for 801D but minor circuit differences Few only left **£150.**

TF 995A/1 or A/2 or A/2M or A5 SIGNAL GENERATORS. Very high class AM/FM 1 5MHz to 220MHZ Detailed spec and price on application

Please ask for technical details and prices of all equipment.

TF 934 DEVIATION METER. 250MHz

500/250 MEDIUM WAVE BROADCAST TRANSMITTERS. Export only Price and details on application

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TF1370 R.C. OSCILLATOR FOR SQUARE & SINE WAVE. Freq –31 6V rms 10Hz 1MHz square wave 0-73 2pp 10Hz-100KHz Attenuator range –50dB to + 10dB Impedance 75 100, 600Ω **£145.**
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RADIOMETER TYPE MS111 SIGNAL GENERATOR. High quality Danish production 10KHz 110MHz **£200.**
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SOLARTRON

DIGITAL VOLTMETER. LM1426 LM1420 2BA LM1420 LM1440 3

SIEMENS

LEVEL OSCILLATOR TYPE BEL 3W518. Frequency from 10KHz to 17MHz Modulation is external output from +10dB to –60dB in 8 steps and in continuance with wobbler step generator Imp output 150 145 135 75 65 ohms
LEVEL OSCILLATOR TYPE REL 3W29. Frequency from 0 3 to 1200Kc s Mod ext output from +16dB to –60dB Impedance output 75 140 600 ohms

TEKTRONIX

OSCILLOSCOPE TYPE 561A with plug in type 3S76 sampling dual trace and plug in type 3T77
SAMPLING OSCILLOSCOPE TYPE 661 with plug in type 4S1 dual trace sampling unit and probes
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SINGER PANORAMIC SPECTRUM ANALYSER TYPE SPA 10. Frequency range 10MHz-43KMHz Full spec and price on request

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English Electric—£20

PLUMBICON TUBES TYPE XQ.1020
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DANA EXACT FUNCTION GENERATOR MODEL 121. Frequency range 0 2Hz to 2MHz (7 ranges) voltage controlled to 10V sweep generator ims to 10 sec
RACAL UHF FREQUENCY METER 9839. Frequency range 40MHz to 560MHz
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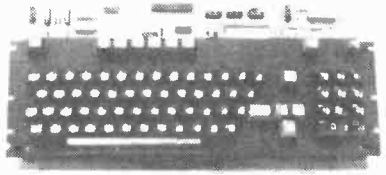

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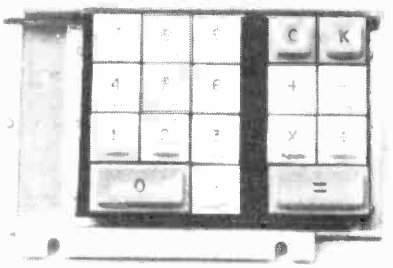

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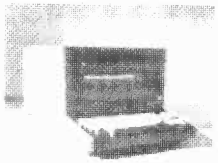

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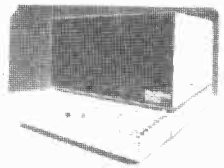

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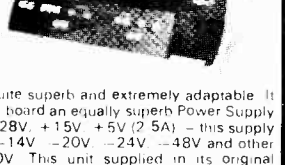

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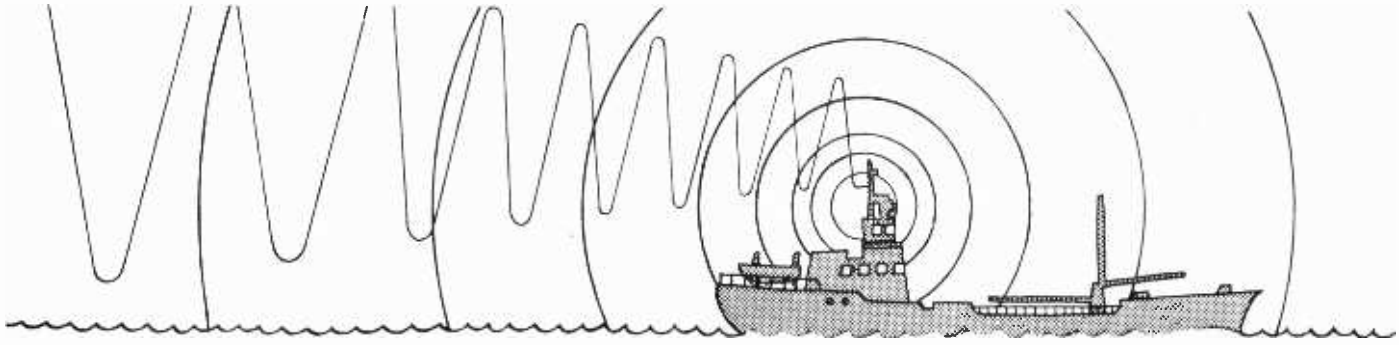

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Post Office Telecommunications

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(7000)

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DEPARTMENT OF ELECTRICAL ENGINEERING & ELECTRONICS

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(7547)

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Grade 5

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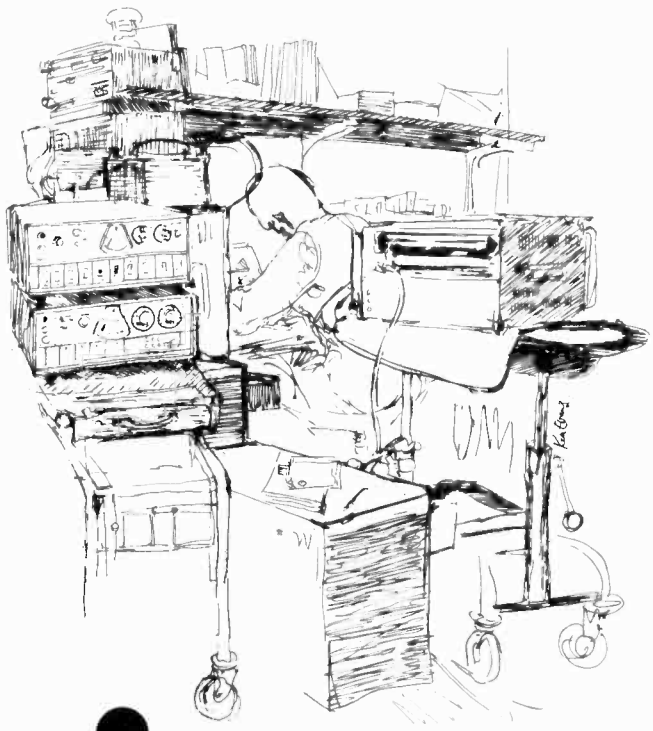

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HOME OFFICE

(7533)

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ilea

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Maintenance Engineering

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Salary within the scale £5072-£5399 (Studio Technician 3).

Application forms, returnable within 14 days of the publication of this advertisement, from the Education Officer, Estab. 2A/2, Room 4A, Addington St. Annexe, County Hall, London SE1 7UY. Tel: 01-633 7456.

(7501)

SENIOR TEST EQUIPMENT ENGINEER

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(7565)

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Rugged, all-around durability and a field-serviceable design keeps this new breed of lavalier on the air when you need it most. Without batteries or unnecessary wiring. And without a big price tag either.

The SM11 has everything: size, performance, durability, price. That's not just small talk!

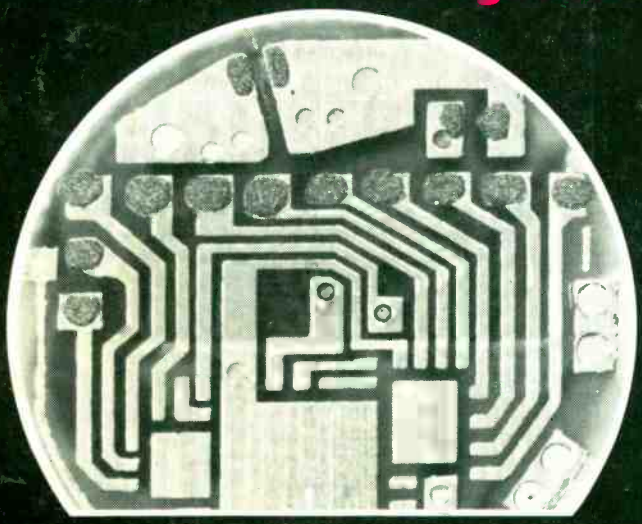
Shure Electronics Limited
Eccleston Road,
Maidstone ME15 6AU
Telephone: Maidstone (0622) 59881

TECHNICORNER
Frequency Response: 50 to 15,000 Hz
Polar Pattern: Omnidirectional
Impedance: 150 ohms (200 ohms actual) for connection to microphone inputs rated at 25 to 200 ohms
Hum Pickup: Less than 35.3 dB equivalent SPL in a 1 millioersted field
Accessories Supplied: Specially designed lavalier assembly; clip-on clasp; tie-tack assembly; connector belt clip.

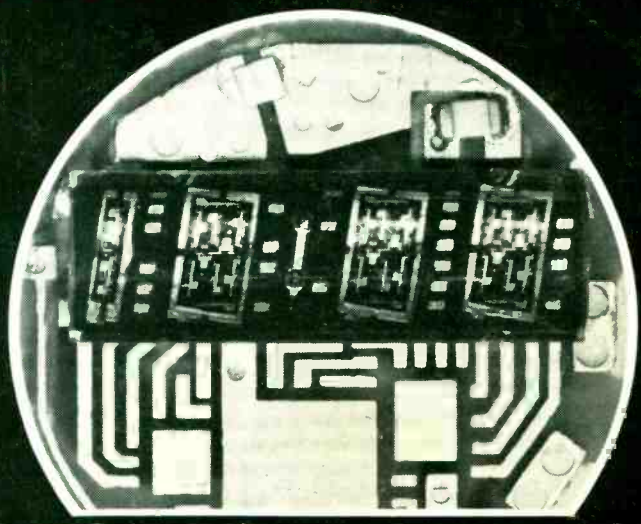
SHURE®

WW—002 FOR FURTHER DETAILS

To see how Multicore Oxide-Free Solder Creams offer you higher profits – just watch



Applications don't come much more critical than digital watch manufacture.
Here, discrete deposits of Multicore Oxide-Free Solder Cream are screened onto the PCB. A precision job, with no risk of operator error or fatigue. And, a convenient temporary adhesive for the positioning of components.



Solder-flow is accomplished by simply passing the units over a hot plate.
Fast. No oxide to contend with. No dirty residues.
This manufacturer says Multicore Oxide-Free Solder Cream has *reduced reject rate substantially* and offers superior soldering quality.

ordinary solder creams cannot match this profitable performance. Here's why...

...because ordinary solder creams or pastes contain rosin-based flux mixed with solder powder produced by atomisation. This means that every particle of the powder is covered with a layer of oxide – slowing down the soldering process, leaving a dirty flux residue and causing solder globules to stick to the flux and possibly fall loose into the equipment after shock or vibration. But, Multicore have developed a very special method of producing solder powders that are virtually oxide-free.

These can be used in cream form – comprising an homogeneous stable mixture of pre-alloyed powder and flux, designed specifically for hybrid microcircuits, PCB's and critical component joints.

When heated, Multicore Oxide-Free Solder Creams melt and flow as quickly and cleanly as rosin-cored solder wire, leaving a pale clear flux residue without solder globules.

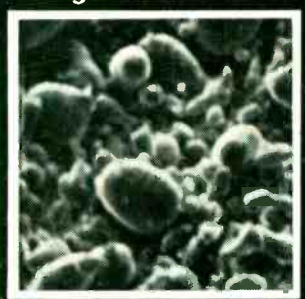
The in-built quality of Multicore Oxide-Free Solder Creams make them the ideal specification for almost any application calling for low cost yet high reliability.

They are available in a wide range of combinations of solder alloys, fluxes, particle sizes, flux contents and viscosities – often replacing solder preforms.

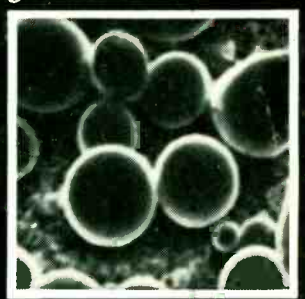
However, if you have an application that specifically requires preforms, remember that Multicore supply a wide variety of those as well.

Multicore Solders Ltd are Ministry of Defence Registered Contractors and on Qualified Products List QQ-S-571E of U.S. Defense Supply Agency for solder creams and preforms.

Compare these electron-microscope enlargements at x 240 magnification:



'Ordinary' cream solder powder, revealing poor particle shape and dross.



Solder powder from Multicore Oxide-Free Solder Cream displays clean, uniform particles.

Multicore

For full information on Oxide-Free Solder Creams or any other Multicore products, please write on your company's letterhead direct to:

Multicore Solders Limited,
Maylands Avenue, Hemel Hempstead, Herts, HP2 7EP.
Telephone: Hemel Hempstead 3636. Telex: 82363.