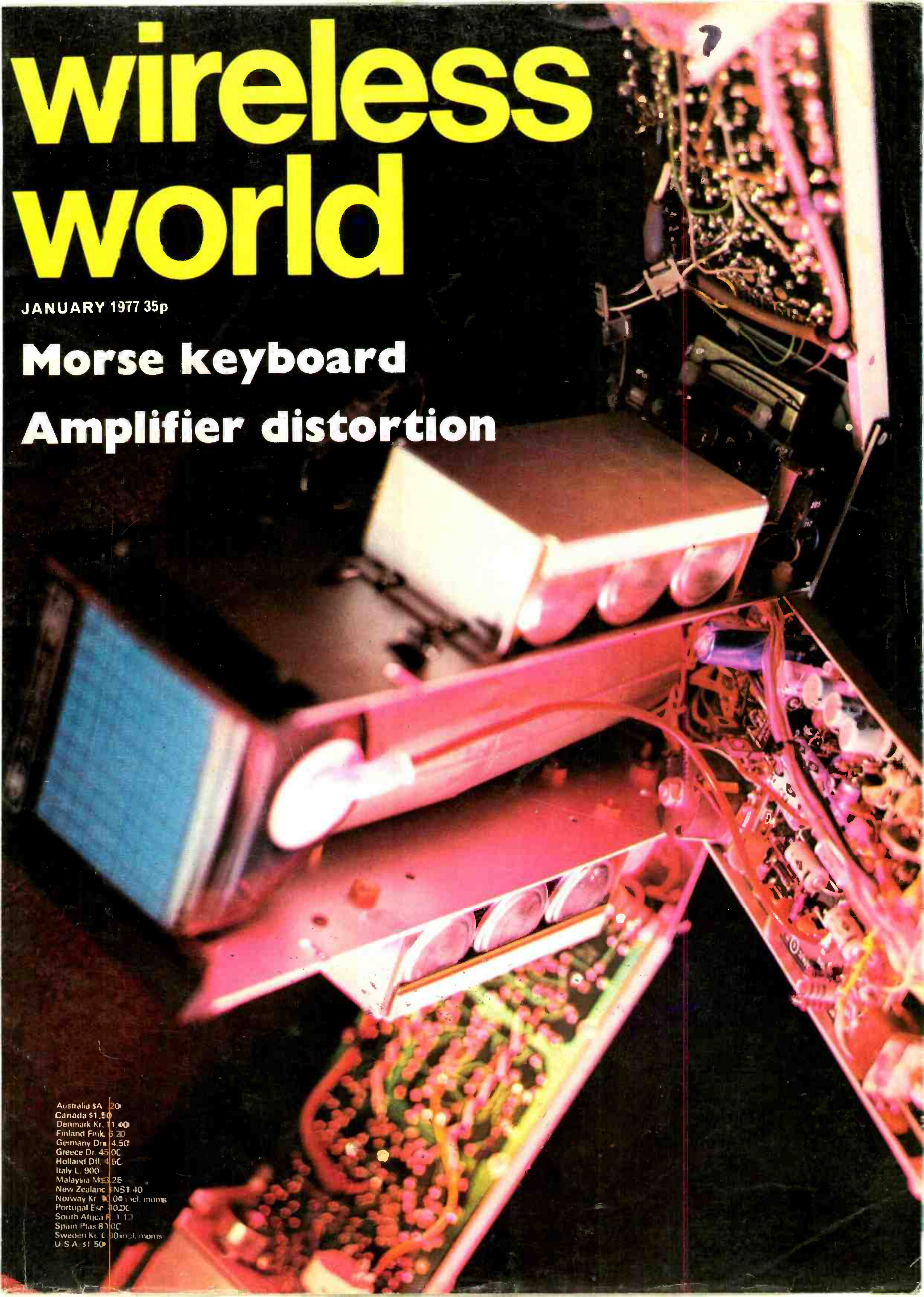
wireless world

JANUARY 1977 35p

Morse keyboard

Amplifier distortion



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Canada $1.50
Denmark Kr. 11,00
Finland Fmk. 6.20
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Sweden Kr. 6.90 incl. moms
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mi's TF 2015 a wider view of signal generation...

The TF 2015 is a versatile 10-520 MHz signal generator with calibrated a.m. and f.m. and an accuracy of output level setting normally found only in instruments costing three times as much. A special system gives very fast tuning across the bands yet provides smooth control within the narrowest of passbands. Leakage radiation is carefully screened out to enable accurate measurements to be made even at levels below 1μV.

Matched Synchronizer

The clip-on Synchronizer TF 2171 transforms the performance of TF 2015 into the equivalent of a synthesizer at less than half the comparable cost. The frequency is locked to crystal stability and can be dialled in 100 Hz. steps. Tuning is quick and easy – set the decade dials, switch to "lock" and tune the generator to the approximate frequency and the synchronizer will finish the job for you. Now you can change the frequency by up to 2% using the decade dials **without touching the generator** - and all to an accuracy of 2 parts in 10^7. It stays locked all day and doesn't degrade **any** aspect of the generator performance.

I.F. Probes

These are an invaluable aid to the testing of receivers with squelch or battery economiser circuits. These circuits are inactivated when the crystal-controlled signal from the probes is brought into the proximity of the receiver's i.f. strip. This makes it easy to tune the generator to a receiver when its channel frequency is unknown. The probes can also be used to check exact tuning by adjusting for zero beat.

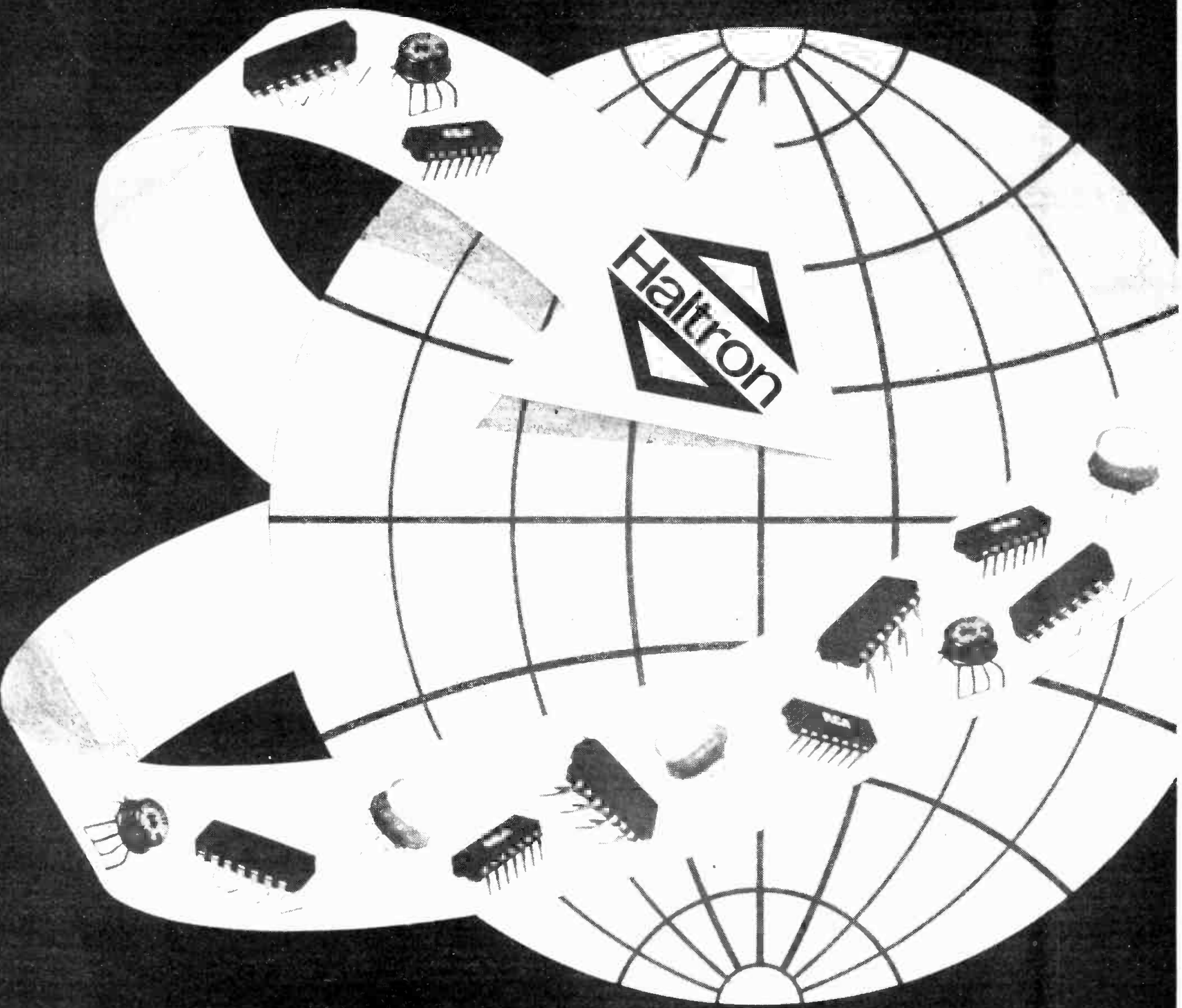
mi: THE SIGNAL GENERATORS

MARCONI INSTRUMENTS LIMITED

Longacres, St. Albans, Hertfordshire, England, AL4 0JN · Telephone: St. Albans 59292. Telex: 23350.

A GEC–Marconi Electronics company.

WW—001 FOR FURTHER DETAILS


Haltron

EEV is still making image orthicons.

LA36

Why change equipment which has many more years of useful life ahead?

EEV is still making image orthicons in very large numbers. And we're constantly developing them with improved performance.

So you can be sure of continuity of supply of high-quality 3″ and 4½″ tubes.

Our prices are competitive. Our service backup is worldwide. All the knowhow and skill of 24 years production goes into every EEV image orthicon.

Our tubes are all you need – to keep on getting good pictures, colour or black and white, from older generation cameras.

Write for data and prices. If you have a specific requirement, contact your local EEV agent or call Camera Tube Sales at Chelmsford, England.

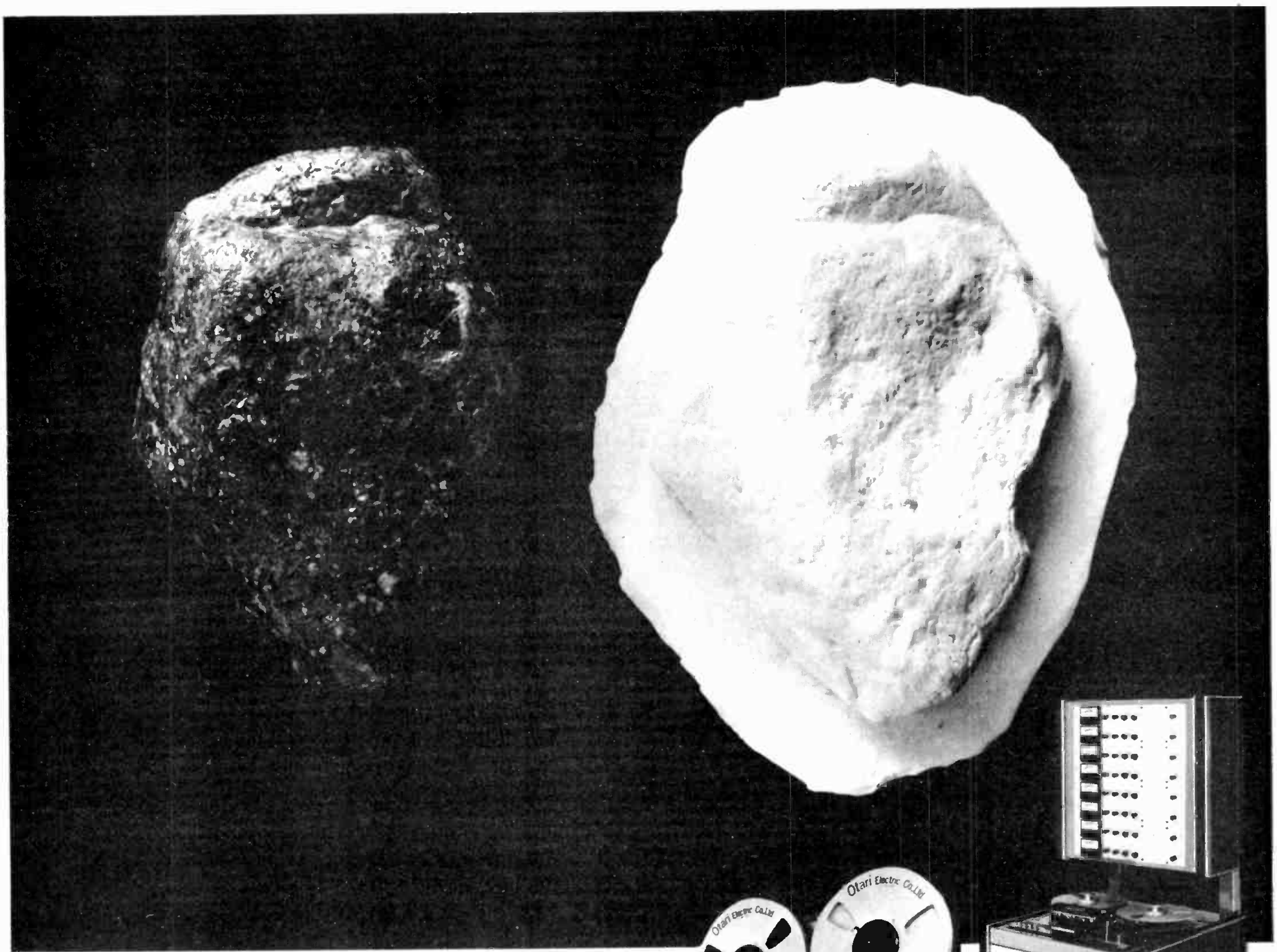
EEV and M-OV know how

Members of GEC – turnover £1902 million

ENGLISH ELECTRIC VALVE CO LTD, Chelmsford, Essex, England CM1 2QU. Tel: 0245 61777. Telex: 99103 Grams: Enelectico Chelmsford. GEC

WW—006 FOR FURTHER DETAILS

once is enough!



MX-5050-2S MX-7308

Perfect reproduction stems from creating
a perfect system and then
recreating the memory contents exactly.
A plaster cast makes a fairly good replica
of an original, but it is far from perfect.
To improve the replica, you must improve the cast.
It is the only way.
At Otari, it is our fundamental policy to plan on
the basis of creating extremely accurate,
highly precise data recorders and duplicators.
Only by concentrating in this way on the heart of
the duplicating process can we provide product which
fill the professional's need for the most perfect
reproduction of live sound that is possible.

Trust through experience— one encounter with OTARI equipment and from then on, You will trust the OTARI name.

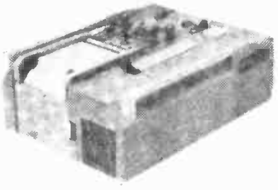
OTARI

OTARI CORPORATION: 981 Industrial Road, San Carlos, California 94070, U.S.A. Phone: California 415-593-1648 Telex No. 259103764890 OTARICORP SCLS
OTARI ELECTRIC CO., LTD 4-29-18, Minami Ogikubo, Suginami-ku, Tokyo, 167 Japan Phone: (03) 333-9631 Cable: OTARIDENKI TOKYO Telex: J26604 OTRDENKI

WW—075 FOR FURTHER DETAILS

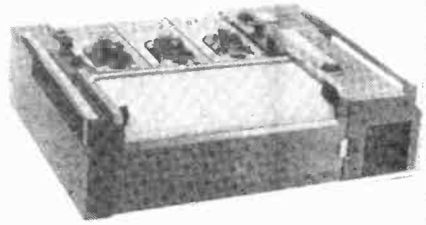
FAST RESPONSE STRIP CHART RECORDERS

Made in USSR



Type H3020-1
Single pen

Type H3020-3
Three-pen



Specification

Basic error	2.5%
Sensitivity	8mA F.S.D.
Response	0.2 sec.
Width of each channel	80mm
Chart speeds, selected by push buttons	0.1—0.2—0.5—1—2.5——5—12.5—25mm/sec.
Chart drive	200-250v 50Hz

Recording: Syphon pen directly attached to moving coil frame, curvilinear co-ordinates

Equipment: Marker pen, Timerpen, Paper footage indicator, 10 rolls of paper, connectors, etc.

Dimensions: H320-1: 285x384x16.5mm
H320-3: 475x384x16.5mm

PRICE: H320-1 £108.00
H320-3 £160.00
Exclusive of VAT

Available for immediate delivery

Z & I AERO SERVICES LTD.

44A WESTBOURNE GROVE, LONDON W2 5SF
Tel. 01-727 5641 Telex: 261306

WW—041 FOR FURTHER DETAILS

Problem

Where to obtain a low-cost device to use as a linear output stage for mobile and marine radio under SSB conditions.

Solution

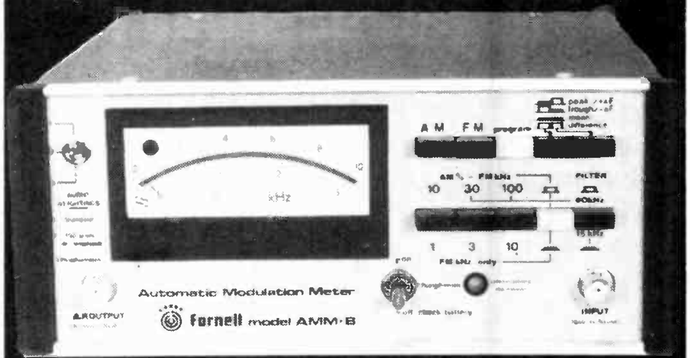
M-OV long-life beam tetrodes.
A single TT21/22 gives 100W PEP at 1200V H.T. and one TT100 delivers 180W PEP at 850V H.T.

EEV and M-OV know how
Members of GEC
turnover £1902 million

THE M-O VALVE CO LTD, Hammersmith, London, England W6 7PE.
Tel: 01-603 3431. Telex: 23435. Grams: Thermionic London. GEC

WW—004 FOR FURTHER DETAILS

new automatic mod meter



- Frequency range 1.5GHz to 2GHz
- A.M. and F.M. measurement over full range
- Automatic tuning and level setting
- Positive indication of lock and level
- Psophometric 'A', 750μS de-emphasis and standard audio weightings
- Remote control of all functions
- Mains/battery version available (AMM—B)
- Rackmounting option (AMM—R)

Details from:-

Farnell

FARNELL INSTRUMENTS LTD.
SANDBECK WAY, WETHERBY
WEST YORKSHIRE LS22 4DH
TEL: 0937 3541 TELEX 557294

WW—025 FOR FURTHER DETAILS

Safe, tough, efficient and versatile – that's our new miniature CX iron.

Safe because it is virtually leak-free (leakage current less than 1μA). Earth it if you like – three core lead. It is made to conform with B.S. 3456 and has a breakdown voltage of more than 4000V.

Tough because the handle is almost unbreakable and the ceramic shaft is covered by a stainless steel shaft.

Efficient because the element is situated right inside the soldering bit and the heat generated by its 17 watts is not wasted.

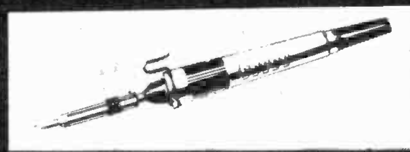
Versatile because the iron can be used for a wide variety of soldering jobs; with six easily interchangeable, slide-on bits, ranging from $\frac{1}{4}$" right down to $\frac{3}{64}$" (1mm). It's suitable for small, miniature and micro miniature joints.

Available for 220-250 volts *or* 100-120 volts. *Weight* – 1$\frac{1}{2}$oz (40 gram). *Length* 7$\frac{1}{2}$" (19cm). *Price* – **£3.20** fitted with standard bit $\frac{3}{32}$" (2.3mm). *Spare bits* £0.46; £0.72; £0.84 exclusive of VAT.

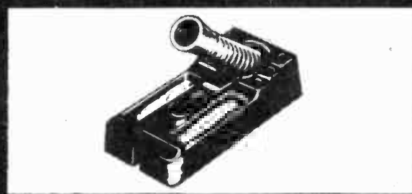
Stocked by most of the well-known wholesalers and many retailers. Or direct from us if you are desperate.

Send for colour catalogue from:
Antex Freepost, Plymouth PL1 1BR

Model X.25 is a general purpose soldering iron, also with two shafts for toughness and perfect insulation. Available for 220-250 volts *or* 100-120 volts at 25 watts and priced at **£3.20** exclusive of VAT.



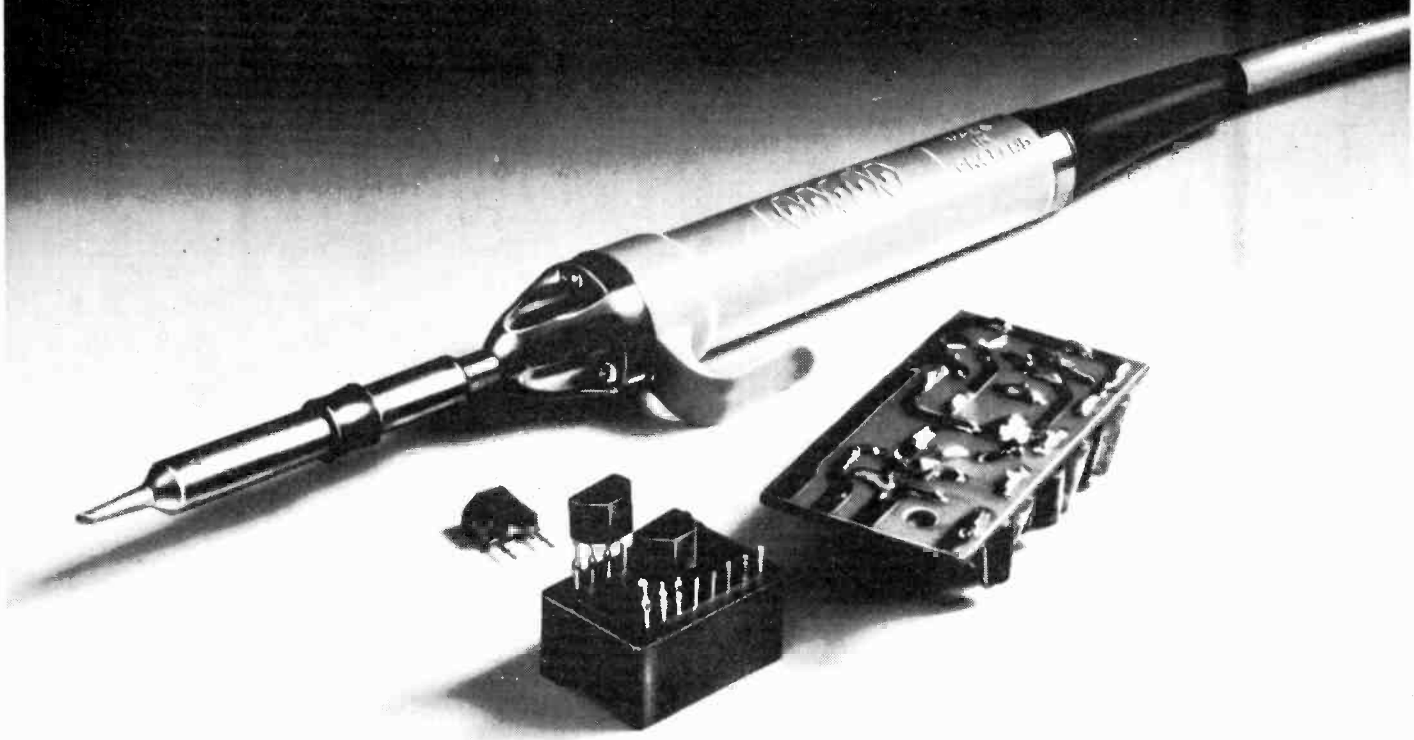
Stand model S.T.3 has a chromium plated steel spring, two sponges for cleaning the bits and is priced at **£1.40** exclusive of VAT.



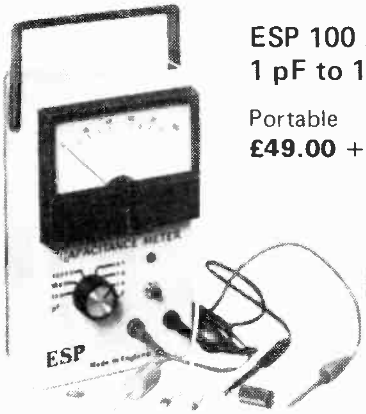
ANTEX

Mayflower House, Plymouth.
Telephone (0752) 67377/8 *Telex* 45296
Giro 2581000

Forget all you've ever read about miniaturised soldering irons. This is the NEW ANTEX CX.



ESP Capacitance measuring

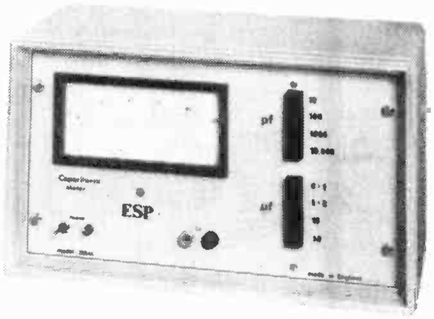


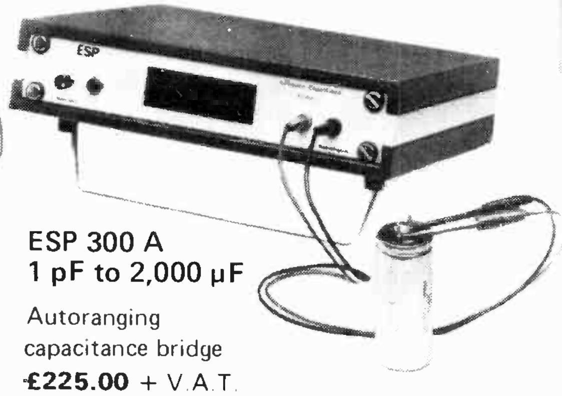
ESP 100 A
1 pF to 10 µF

Portable
£49.00 + V.A.T.

ESP 200 A
1 pF to 50 µF

Wide scale
laboratory model
£90.00 + V.A.T.





ESP 300 A
1 pF to 2,000 µF

Autoranging
capacitance bridge
£225.00 + V.A.T.

Now capacitance is easier to measure than resistance

A complete range of British-made instruments designed to simplify capacitance measuring

- Accurate and sensitive
- Requires no manual balancing
- Takes less than a second to measure a capacitor
- Updates changes in capacitance automatically
- Wide range of applications

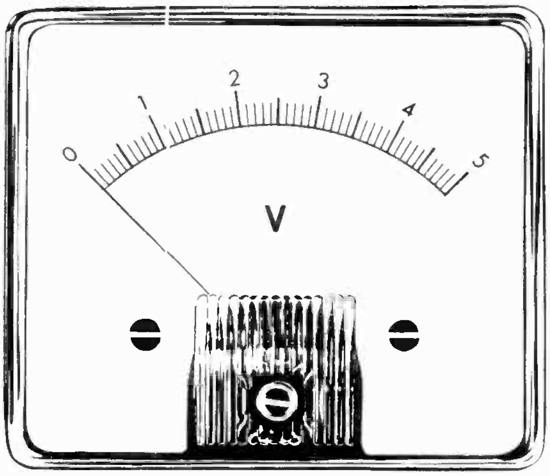
Send for technical literature and free booklet: "Modern methods of capacitance measuring"
Suppliers to: Ministry of Defence, Post Office, B.B.C., Government departments and Electronic Laboratories world-wide.

Electronic Services and Products Limited
Cross Lane, Braunston, Near Daventry,
Northamptonshire NN11 7HH
Telephone: Rugby (0788) 890672

KWP/ESP2 7619

WW027 FOR FURTHER DETAILS

METER PROBLEMS?



137 Standard Ranges in a variety of sizes and stylings available for 10-14 days delivery. Other Ranges and special scales can be made to order.

Full Information from:

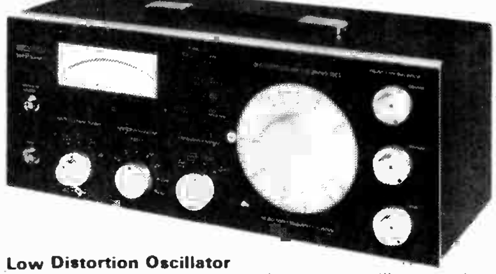
HARRIS ELECTRONICS (London)

138 GRAYS INN ROAD, W.C.1 Phone: 01/837/7937

WW—023 FOR FURTHER DETAILS

RADFORD

AUDIO LABORATORY INSTRUMENTS
for the professional



LDO3 Low Distortion Oscillator
A continuously variable-frequency laboratory oscillator with a range 10Hz-1.00kHz, having virtually zero distortion over the audio frequency band with a fast settling time.

LDO3.B Low Distortion Oscillator, balanced output.
A LDO3 but fitted with an output amplifier and screened balanced transformer providing a 600 ohm floating / balanced output, and 150 ohms unbalanced output.

DMS3 Distortion Measuring Set *(Illustrated)*
Measures total harmonic distortion down to 0.001% speedily and accurately. Direct reading from calibrated meter.

HSV1 High Sensitivity Voltmeter
An accurate voltmeter with 16 ranges, 10µV-300V f.s.d. Average responding.

HSV2 High Sensitivity Voltmeter.
As HSV1 but true r.m.s. reading.

ANM1 Audio Noisemeter
An accurate voltmeter and noisemeter with 16 ranges, 10µV-300V f.s.d. Fitted weighting characteristics: Wide band, DIN Audio Band, IEC/DIN Curve 'A', and CCIR. Average responding.

ANM2 Audio Noisemeter
As ANM1 but true r.m.s. reading.

ANF1 Audio Noisefilter
An active filter to CCIR weighting characteristic for use with external voltmeter. (Ref: Dolby Laboratories Inc., Bulletin No. 43, Mar. 76).

Full descriptive leaflets available from:
RADFORD ELECTRONICS LTD.
Laboratory Instruments Division
Ashton Vale Road, Bristol, Avon BS3 2HZ Tel. 0272 662301

WW—019 FOR FURTHER DETAILS

Unique full-function 8-digit wrist calculator... available only as a kit.

A wrist calculator is the ultimate in common-sense portable calculating power. Even a pocket calculator goes where your pocket goes – take your jacket off, and you're lost!

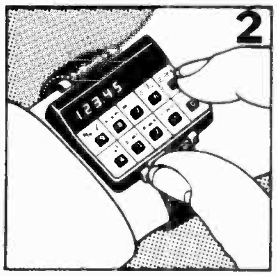
But a wrist-calculator is only worth having if it offers a genuinely comprehensive range of functions, with a full-size 8-digit display.

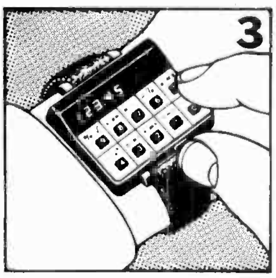
This one does. What's more, because it *is* a kit, supplied *direct* from the manufacturer, it costs only a very reasonable £9.95 (plus 8% VAT, P&P). And for that, you get not only a high-calibre calculator, but the fascination of building it yourself.

How to make 10 keys do the work of 27

The Sinclair Instrument wrist calculator offers the full range of arithmetic functions. It uses normal algebraic logic ('enter it as you write it'). But in addition, it offers a % key; plus the convenience functions $\sqrt{x}$, $1/x$, x^2; plus a full *5-function memory*.

All this, from just 10 keys! The secret? An ingenious, simple three-position switch. It works like this.





1. The switch in its normal, central position. With the switch centred, numbers – which make up the vast majority of key-strokes – are tapped in the normal way
2. Hold the switch to the left to use the functions to the left above the keys...
3. and hold it to the right to use the functions to the right above the keys.

The display uses 8 full-size red LED digits, and the calculator runs on readily-available hearing-aid batteries to give weeks of normal use.

Assembling the Sinclair Instrument wrist calculator

The wrist calculator kit comes to you complete and ready for assembly. All you need is a reasonable degree of skill with a fine-point soldering iron. It takes about three hours to assemble. If anything goes wrong, Sinclair Instrument will replace any damaged components *free*: we want you to enjoy assembling the kit, and to end up with a valuable and useful calculator.

Contents

Case and display window.
Strap.
Printed circuit board.
Switches.
Special direct-drive chip (no interface chip needed).
Display.
Batteries.

Everything is packaged in a neat plastic box, and is accompanied by full instructions. The only thing you need is a fine-point soldering iron.

All components are fully guaranteed, and any which are damaged during assembly will be replaced free.

The wrist-calculator kit is available only direct from Sinclair Instrument. Take advantage of this 10-day money-back undertaking.

Send the coupon today.

KIT ONLY £9.95 PLUS VAT, P&P

Sinclair Instrument Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN. Tel: Cambridge (0223) 311488.

To: **Sinclair Instrument Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.**

* Please send me . . . (qty) Sinclair Instrument wrist-calculator kits at £9.95 plus 80p VAT plus 25p P&P (Total £11).

* I enclose cheque/PO/money order for £ ....

* Complete as applicable.

Name ____________________

Address ____________________

____

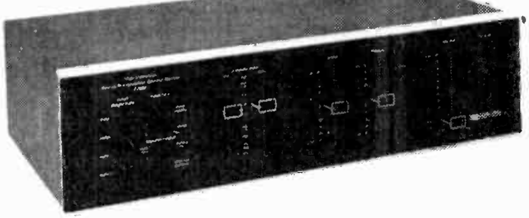
____

(Please print)
I understand that you will refund my money in full if I return the kit undamaged within 10 days of receipt. WW/1

RADFORD

HIGH PERFORMANCE AMPLIFIERS

for the enthusiast and professional



ZD22 Stereo Pre-amplifier Control Unit
A stereo pre-amplifier of virtually zero distortion. Inputs for disc, tuner, and two tape machines, providing comprehensive recording and reproducing facilities. Sensitivities: Disc 1mV, and Auxilliaries 50mV., for 1V output. Exceptional signal/noise ratio. Output at clip level 18V r.m.s.

ZD50 Power Amplifier
A stereo power amplifier of all aluminium construction. Output of 110 watts per channel into 4 ohms and 70 watts into 4 ohms at typically less than 0.002% distortion.

ZD100 Power Amplifier
A stereo power amplifier of all aluminium construction with high thermal mass and designed for continuous operation at high output level. Provides 150 watts per channel into 4 ohms and 90 watts per channel into 8 ohms at virtually zero distortion.

ZD200 Power Amplifier
Characteristics as ZD100 amplifier but provides an output of 250 watts per channel into 4 ohms and 150 watts per channel into 8 ohms.

HD250 Stereo Integrated Amplifier
Uses ZD22 pre-amplifier with a power amplifier having a power output in excess of 50W per channel into 4-8 ohms. Distortion: less than 0.02% at rated power, typically less than 0.01%. True complementary symmetry output. Headphone output. Inputs: Disc, tuner, and two tape machines. Sensitivities: Disc 1mV. Auxilliaries 50mV for 20W output.

Full descriptive leaflets available from:
RADFORD ELECTRONICS LTD.
Audio Division
Ashton Vale Road, Bristol, Avon BS3 2HZ. Tel: 0272-662301

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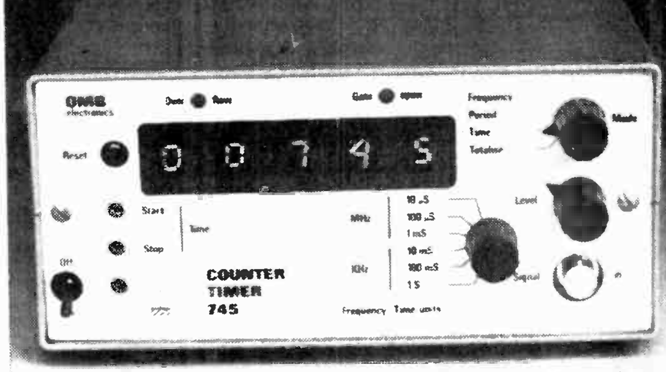
745 COUNTER TIMER

DC-32 MHz

FREQUENCY, PERIOD, TIME & TOTALISE

±5ppm STABILITY @ 25°C



745 COUNTER TIMER £88 + £2 p&p WW078

Other products include:

744 Counter Timer £79	WW 079
643 Function Generator £95	WW 080
643A Function Generator £79	WW 081
631 Filter Oscillator £98	WW 082

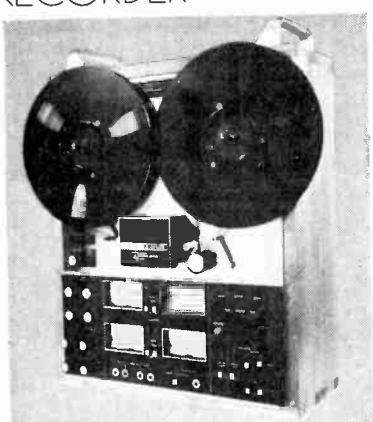
Delivery is normally ex-stock — telephone for confirmation
Prices correct at time of going to press, subject to change without notice

***OMB** electronics, Riverside, Eynsford, Kent. Tel: 0322 863567*

TICK THE APPROPRIATE REPLY NO. FOR DETAILS

TEAC®

TEAC A3340(S) 4-CHANNEL RECORDER



Industrial version upgraded to studio requirements, with increased signal to noise performance and improved reliability. Four totally independent channels each with sel sync, input mixing, switchable VU's and all the facilities for easy multitracking. This industrial model is in more studios than any other version.

Available only from ITA
(Semi-pro version also available)
IMMEDIATE DELIVERY

REVOX

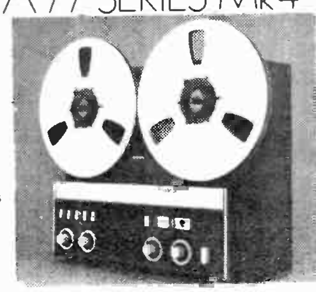
REVOX A-700 SERIES

IMMEDIATE DELIVERY

The new big Revox — ideal for all studio requirements. Highly sophisticated design features include servo tape tension, full deck logic, crystal controlled servo electronics, 3 speeds, tape footage counter.

A-77 SERIES Mk4

The famous A77 has been consistently improved over the past 8 years and is now available in the latest Mk 4 version. The wide choice of specifications includes versions for duplicating and logging applications. Backed by UK's latest fastest service.



Hire service. Check our prices
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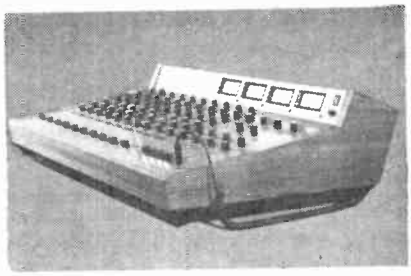
ITA

ITA 10-4 MODULAR MIXER



Ten balanced inputs, four output groups, 4 limiters, bass mid and treble EQ, modular construction, headphone monitoring. Extremely high quality construction only matched by mixers costing around £1,000.

10-4	**£690**
20-4	**£1190**
EIGHT OUTPUT	**£1260**

IMMEDIATE DELIVERY
Also available for hire

PRICES EXCLUSIVE OF V.A.T.

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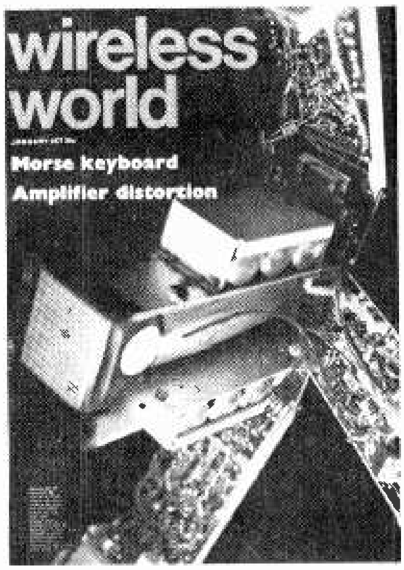
Electronics, Television, Radio, Audio

JANUARY 1977 Vol 83 No 1493

Contents



Front cover, by Paul Brierley, shows a Tektronix B32 oscilloscope with modules opened out for servicing.

IN OUR NEXT ISSUE

Viewdata, the Post Office's textual information system using the telephone line and the tv set. First of a series explaining how it works.

Transient intermodulation distortion. An article by Bert Sundqvist argues that use of a very large bandwidth in a power amplifier is not the only way to avoid transient intermodulation distortion.

Nickel cadmium cells. Reviving these re-chargeable cells, which are sometimes found to be unreliable and short-lived.

Current issue price 35p, back issues (if available) 50p, at Retail and Trade Counter, Paris Garden, London SE1. By post, current issue 55p, back issues (if available) 50p, order and payment to Room 11, Dorset House, London SE1 9LU.

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Subscription rates: 1 year: £7.00 UK and overseas ($18.20 USA and Canada). Student rate: 1 year, £3.50 UK and overseas ($9.10 USA and Canada).
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Subscriptions: Oakfield House, Perrymount Rd, Haywards Heath, Sussex RH16 3DH. Telephone 0444 59188. Subscribers are requested to notify a change of address.

New portable DMMs.

Only Fluke make them-only ITT sell them.

New Fluke DMMs Fluke have introduced two new digital multimeters. That is big news in itself, because when you are already producing the best selling instruments on the market, how do you bring off another success? The answer has been to take an outstanding specification and shrink it into a truly portable instrument.

True RMS a.c. This is the most important feature – especially when you realise that it is incorporated in a battery operated instrument that measures less than 6 x 5 x 2½in. and weighs only 2½ lb. It means that you can take lab. quality measurement out in the field, free from the shackles of size, weight and power points.

Two versions – 8030 & 8040 Both models offer five ranges over five measurement functions and include autozero. The 8030 is a 3½ digit instrument with a useful diode test facility. The 8040 has 4½ digits and incorporates autoranging.

The only way to buy Both these briefcase sized DMMs are available from ITT Instrument Services; and from nobody else, not even from Fluke. Which brings together the best sellers among portable DMMs and the biggest name in the instrument distribution business. That means no-delay telephone ordering, streamlined internal processing, and delivery from stock.

Ask for a spec. sheet now. Or better still, get ITT to arrange a demo. You will be more amazed by the performance than the price!

Fill in this coupon for your copy of the data sheet on the 8030 and 8040 and send it to:
ITT Instrument Services.
Edinburgh Way, Harlow, Essex.

Name ____________________

Company ____________________

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Address ____________________

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Tel No ____________________

ITT instrument services

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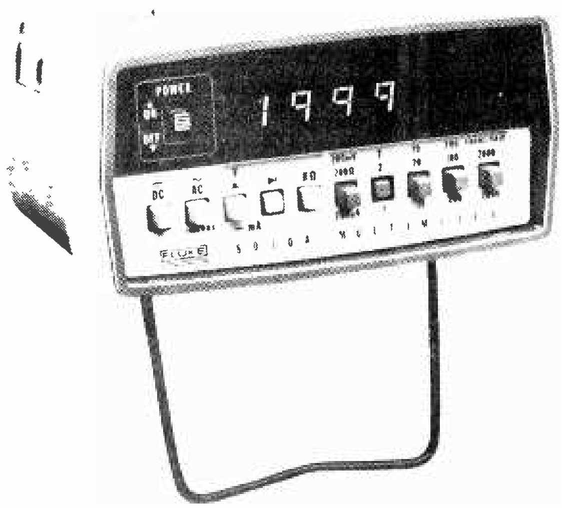

wireless
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Editor:
TOM IVALL, M.I.E.R.E.

Deputy Editor:
PHILIP DARRINGTON
Phone 01-261 8435

Technical Editor:
GEOFFREY SHORTER, B.Sc.
Phone 01-261 8443

Assistant Editors:
MIKE SAGIN
Phone 01-261 8429
RAY ASHMORE, B.Sc., G8KYY
Phone 01-261 8043
JOHN DWYER
Phone 01-261 8620

Production:
D. R. BRAY

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Phone 01-261 8622

NIGEL LITTERICK
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GORDON HENDERSON

The case for Citizens' Band

Over the past year we have published many letters arguing for and against the establishment of Citizens' Band radio in the UK. In this issue is an article which explains and interprets the current attitudes of the interested parties including the Home Office. One thing that emerges clearly from all this is that the decision whether or not we should have CB in Britain will not be a technical decision, although technical facts are being used to support various points of view. It will be a decision based on value judgments of the public's presumed needs and wants. If an overwhelming case could be made that the public wants CB, then the technical means (frequencies, transmission mode etc.) would be found without much difficulty.

It is, of course, the Home Office that decides. At the moment their attitude is that CB would be seen as "a luxury we can ill afford" when it is already difficult to meet all the frequency requirements of public services and commercial users (March 1976 issue, p.54). That CB is a luxury is clearly a value judgment. We must accept this view in so far as the Home Office makes its judgments under the aegis of a democratically elected government. But we do not have to agree with it. In the first place, one of the public services with which the Home Office is concerned is broadcasting, and in so far as much of this is entertainment, it, too, is a luxury. Why can we afford broadcasting, with its hundreds of megahertz of spectrum occupancy, and not CB?

The radio spectrum is a natural resource, like air and water, and it is a fundamental principle that all members of the public should have access to it under properly regulated conditions with policing as necessary. We all have access in the case of public broadcasting. That access is permissible by personal radio communication is already accepted as a principle in the case of the radio amateurs and those who have radio telephones in their cars. There is no reason why access by Citizens' Band personal radio communication should be denied. The fact that CB as we know it in the United States is predominantly a "fun thing" and can be criticized as frivolous is beside the point. After all amateur radio is basically a hobby, a form of entertainment, and much of broadcasting is undoubtedly frivolous. If it can be shown that a substantial number of people in the UK want Citizens' Band radio then the means should be made available for them to have it. At the same time, one cannot but agree with the Radio Society of Great Britain that the administration must be able to exercise complete and effective control.

The citizens' band debate

Reporting the attitudes of the UK protagonists

By John Dwyer

If citizens' band radio is never heard of again at least it will have given us something other than Denis Healey to remember 1976 by. In America the growth in the c.b. market, worth $1.5 billion in 1975 if accessories are taken into account, has left its administrators breathless. As a comparison the entire US record industry was worth $1 billion. On this side of the Atlantic the interest in c.b. has been largely expressed by newspapermen and television pundits: what the man in the street thinks about it, or whether he would even know what it was, remains obscure. More certain is that those who supervise radio here aren't keen to see his interest develop. The Home Office regard c.b. as a kind of electronic hula hoop, a vulgar catchpenny diversion, the pressure for which will evaporate as soon as it becomes clear that they intend to adhere to a strictly-controlled, high-quality communications service. Those the Home Office descry across no-man's-land are just as determined that this time the bureaucrats will be routed.

The protagonists in the controversy are the Radio Regulatory Division of the Home Office (the successor to the Ministry of Posts and Telegraphs, itself the successor to the Postmaster General's office); the Radio Society of Great Britain, which is the largest body representing amateurs; the manufacturers (whether those who would like to supply for or make c.b. equipment, or those who already make other kinds of communications equipment, generally represented by the Electronic Engineering Association); the mobile radio users; and the general public.

At the moment there are two Acts which prevent the use of citizens' band equipment: Section 1 of the 1949 Wireless Telegraphy Act prevents the installation and use of any piece of any wireless telegraphic apparatus without a licence; and Section 7 of the 1967 Wireless Telegraphy Act gave the Postmaster General powers to introduce prohibiting orders at any future time to prevent the spread of equipment that caused interference to licensed users of other apparatus. It was as a result of this latter Act that, on April 1, 1968, the Postmaster General, Mr Edward Short, issued Statutory Instrument 61:1968, the Radiotelephonic Transmitters (Control of Manufacture and Importation) Order 1968. This prohibited the making or importing of radiotelephone equipment which transmitted on any frequency between 26.1 and 29.7MHz and 88 and 108MHz. It was aimed at 27MHz walkie-talkies from Japan which had begun to appear as a result of the introduction of the Class D citizens' band on that frequency in the United States ten years before. In addition to these two Acts the Post Office Act, 1969, gives the Post Office a complete monopoly of electromagnetic communication. If the letter of this Act were ruthlessly pursued one presumes that it would make illegal, among other things, the red rear lights on cars and bicycles.

Note that there is no provision preventing the sale of c.b. equipment. SI61 dealt with the immediate problem but took no account of the fact that c.b. sets with a 29.8MHz channel crystal in them could be imported, then sold with a 27MHz channel crystal in them. It is probably safe to say that that is how most of the c.b. sets freely available in shops came to be there, and equally justified to assume that the Home Office wished there were some effective method of preventing their sale.

Any introduction of c.b. in the UK would bring these sets back into legal use, especially if 27MHz a.m. were to be adopted. Once you admitted the legal use of two way radios it would be difficult to tell which were new, approved sets and which had come in before or during the ban.

The Home Office view

There is a further legal flaw in the Wireless Telegraphy Act in that, although it is illegal to use equipment without a licence, the Act requires that an offender be caught in the act of using it, something that makes the Act quite difficult to enforce.

Students of official inconsistency should note that despite our prohibition of the import, manufacture, installation or use of even the 100mW walkie-talkies that need no licence at all in America, Customs and Excise have overcome their distaste sufficiently to issue a notice (VAT News No 8) showing that walkie-talkie radios "of a kind suitable for domestic or recreational use" would attract the higher rate of value-added tax.

The Home Office view is that at the moment the 27MHz band cannot be used for c.b. because it is already occupied by model controllers and paging systems, including some in hospitals, as well as all sorts of other non-speech devices. More important, the frequencies just aren't available to put either them or c.b. elsewhere. The performance of the transmitters would have to be good if they were not to cause gross interference and overcrowding, as they say has happened in the United States. That would put the cost of the sets up to the point where the system defeated its own object. There had been gross overcrowding in the United States and a lot of illegal use, both in the sale of unlicensed sets and in the way the sets were used. The use of the radio spectrum had to be ordered and the Home Office would have to agree the use of any unallocated frequency with France, Holland, Ireland and Scandinavia. With all the chaos in America, they say, it would need an army to police the thing properly. "We don't want to deprive people at all," a spokesman said. "It's the art of doing what is possible." Even for business use there was a limited amount of space available, saturation might be reached, and "business use is more important than private chit-chat."

Citizens' Band Association

Indeed a recurring theme in the opposition to citizens' band was that somehow the use of radio was justified for commerce but not for mere private communication. C.b. is thought a "trivial" use of radio, even though 60% of the spectrum between 30 and 1000MHz is taken up by broadcasting, mostly used for entertainment. But Redifon managing director John Brinkley found the argument about overcrowding shaky: "Experience hasn't shown this. People are going for this in a big way and they don't spend the money unless they are getting use and enjoyment out of it." The secretary of the Mobile Radio Users' Association, which represents commercial users of private mobile radios, Alan Ford, thought that if the bands allocated to c.b. became overcrowded this would be "self-correcting" and might encourage the use of more sophisticated radio. Speaking of the illegally imported c.b. sets already in use he said, "We have so far not had a complaint of interference from any of these devices from any of our members." Although J. O. Stanley, chairman of the Air Call radio telephone answering service, is opposed to the introduction of citizens' band radio, he said it "wouldn't affect our paging service", and Brinkley agreed that the problems with the hospitals could be overcome. Not so easy to deal with would be the radio modellers, whom the Home Office says number 40,000, but this assumes that any British c.b. service would be on 27MHz a.m.

James Bryant, applications manager of Plessey Semiconductors, said he formed the Citizens' Band Association because "I saw that the other groups were campaigning for 27MHz and I felt that this was a mistake. I became very worried about the Home Office attitude. They would dig their heels in until forced to change their minds by a change of government or a change of minister, even, and would go for 27MHz."

He proposed 40, 25kHz channels at a power of 2W on f.m. with an audio bandwidth of 3.4kHz and specified tight tolerances on maximum deviation and spurious emission. Where would the frequencies come from? "There are gaps between some of the tv channels. The v.h.f. channels are no longer very heavily used. There is 6MHz between channels that is allocated and not used ... We are not broadcasting in this country between 100 and 108MHz. The police are there but they're moving out and there would be no harm if they kept back a megacycle there, but broadcasting will hold on to that on the basis that what you have you keep."

Why not f.m.?

What was his objection to 27MHz? "27MHz has lots of long-range radiation problems, and it would put hundreds of thousands of pounds' worth of model control equipment out of service." He advocated a strict licensing policy. "Each set would have a built-in station identification signal. It would be the duty of the person selling the equipment to copy the auto ident from the bottom of the set on to a form which he has for sending off to the Home Office." The person responsible for the set would be the last registered owner. If you didn't register the new owner you were liable. There would be penalties for the sale of non-type-approved sets without the auto ident.

It has frequently been said that the American Federal Communications Commission, given the chance again, would go straight for their proposed Class E system. This, at 220MHz, would provide 80 f.m. channels designated for specific uses. The 27MHz band, which the FCC hopes will eventually be turned over entirely to 80 single-sideband channels, is being expanded from 23 to 40 a.m. channels from January 1, 1977.

Pye Telecommunications, in their Pannell report suggesting mobile radio frequency allocations for the 1979 World Administrative Radio Conference, say that for any c.b. system set up in the UK, "a likely solution may be that section of the band currently being considered by the USA, namely 220 to 225MHz," but add that there may be some advantage in the use of a lower portion of the v.h.f. band "and that part of the band just above 100MHz would seem to offer a compromise between range, interference possibilities, antenna size, etc".

The Japanese

One of the Home Office's comments on all this was that any c.b. set which had all the features Mr Bryant wanted to incorporate would cost "more than personal mobile radio." Mr Bryant doesn't think so: "High or low band, you could do it for under £80. In the US, a.m. sets meeting the FCC spec (which is tough) are imported f.o.b. for under \$40. They sell for about \$100. In some respects it's easier to make an f.m. set than an a.m. set. Less tuning is needed. Land mobile sets have to be made broadly tuned and then specially tuned individually to the frequency allocated to the customer. C.b. sets are all the same."

But there are those who think, as John Brinkley does, "that it might be quite wrong to do it on a pattern different from the American pattern." Alan Ford of MRUA agreed: "I'm not convinced of the objections to 27MHz," and his view was even echoed by a Home Office source who said, "I don't know that the American way of doing it isn't the right way". Brinkley thought there were sound commercial reasons for sticking to 27MHz which would outweigh any threat from Japanese imports: "I'm against getting up some grotty special that we sell to nobody. We could become a prime exporter, and I would hope that if an intelligent and constructive view of c.b. is taken by the administrators and industry we could get a good result without creating a spec that you can't sell elsewhere."

The threat of Japanese imports looms large in the thoughts of those who have considered c.b. Bryant suggested that a c.b. service on f.m. in the v.h.f. band would preserve us from the worst effects of Japanese competition and would make sure that the sets used here were of a high standard. Others who have been to America say, on the contrary, that the standard of Japanese sets, which account for up to 90% of the market, is very high. "We are concerned," said Roy Pierce, managing director of mobile radio communications equipment makers Burndept, "that if we do establish a new type of market that UK industry has at least an equal chance in supplying this market. This can be achieved either by tariff barriers, to which I am generally opposed, or by specifying the requirement in a way which starts our development off on an equal basis."

Does allocation equal use?

Elsewhere it has been suggested that the specification for the type-approval of sets might be used, as safety regulations already have been, as a trade barrier. J. O. Stanley didn't think this was either a good idea or that it would work. "The Japanese would get type-approval, the good Japanese anyway." More fundamentally, our World of Amateur Radio columnist, Pat Hawker, wondered, "How are we justified in saying we don't want Japanese equipment in?" Brinkley thought public access was much more important: "In considering whether there should be c.b. or not the most important thing is whether it would be useful and valuable to the public. It's important but it's not the first consideration as to whether imported equipment should be eligible."

There was widespread agreement that the spectrum was poorly used and that the Home Office had confused the availability of frequencies with the fact that they were "allocated". However, our Home Office spokesman did admit that "there are parts of the spectrum where allocation is not entirely satisfactory." Also recurrent was Bryant's and Pye's suggestion that the allocation of Band I might be transferred to two-way radio. It appears that we are one of the few countries in the world that uses television channel I, which often turns up under freak conditions in Australia and South Africa. J. O. Stanley feels strongly about Band I: "To have 405-line channels warming the ether for the benefit of a couple of thousand sets that are mainly in the Western Isles is indefensible."

The amateur view

The Home Office have tried to make clear that the only frequencies that could be used for any future citizens' band would have to come from the radio amateurs. They must know that this is untrue, but it would be considerably easier to nip the c.b. fad in the bud if the amateurs thought they might suffer from c.b. and so mobilised themselves against it. The amateurs are very influential and have considerable prestige.

British amateurs seem to have mixed feelings about c.b. I have yet to meet one who is opposed and one even wrote to this journal to suggest that his colleagues ought to give up some space to it, but others have said that some amateurs are bitterly antagonistic to c.b. In the United States they formed a "Save 11" campaign to oppose their being moved from the 27MHz (11m) band. A similar feeling is developing over amateur space above 200MHz. Amateurs are all too aware that there are 250,000 of them sharing 42MHz of American radio space, while around ten million c.b. enthusiasts have only 250kHz.

Some ill-feeling was also caused in the early days when misdemeanours by c.b. users were attributed by ignorant journalists to radio amateurs. Coupled with this is a notion shared by a number of amateurs here that they are an elite, a select group who, unlike others, have earned by their knowledge and exerience the right to transmit and take a pride in doing so responsibly. The thought of anyone being allowed to use radio without having to take a test and for such trivial matters as seem to preoccupy its American users appals him because he feels it lowers his own status.

But many amateurs already use their licences just as a citizens' hand licence would be used. Such amateurs are not interested in radio any more than was necessary for them to get their licences. They are less often inclined to join in what they regard as the esoteric chatter about technical matters that tends to preoccupy other users of the amateur bands. By law amateurs are not allowed to transmit business messages or information for or about third parties. They also have to keep a log. The introduction of c.b. would be the excuse for a lot of these amateurs to abandon their licences and many of the rest would not be opposed to their departure since the general level and status of the true amateurs who remained would be enhanced. There is also the hope that a generally-available, two-way or multi-way radio service might encourage those who had not had any previous contact with radio to find out more about it.

In many European countries the relationship between the amateurs and the c.b. fraternity is said to be very close. In the German Federal Republic the amateur and c.b. magazines emanate from the same publishing house in Stuttgart.

The Radio Society of Great Britain, with a membership of 19,000, about ⅓ of whom are listeners-only, out of a possible 20,000 or so, claims to represent all UK radio amateurs. When interest in c.b. first began to be shown in this country the RSGB wrote an editorial in their journal, *Radio Communication*, saying that "At the present time the opinion of the council is that no support can be given to the establishment of a communications band in this (27MHz) part of the spectrum." The editorial reflected closely the present Home Office view, confining its discussion entirely to the impracticality of using 27MHz, taking no account of the possibility of moving elsewhere, and pointing to the violations that had taken place in the US. No attempt was made to draw any comparison between the numbers of violators prosecuted and the total number of those using c.b., or to point to the occasions when c.b. radio had helped the police catch criminals or had saved life.

During the months since that editorial was published last April, however, the RSGB has considerably changed its stance. The November editorial repeated a statement issued by the Society at the beginning of October. "The RSGB is aware of the numerous items that have appeared on this subject in various journals both as correspondence and as feature articles. It is apparent that much of this material has been generated by those who will profit financially from the introduction of the facility rather than by potential users."

The RSGB was "not opposed to the introduction of a short-range personal communications facility", provided that its frequency and the equipment used for it were suitable — 27MHz was not because it was too near the 28MHz amateur band, it allowed long distance propagation and consequent increased interference during the sunspot cycle, and it interfered with television reception in Band I.

Significantly the editorial, unlike the statement said: "Having regard to equipment now available it would appear that a v.h.f. or u.h.f. f.m. service with power limitation, crystal control and type-approved apparatus could be suitable."

One reason for the change,, slight though it may seem, is that, as RSGB General Manager and Secretary George Jessop explained, the Society might benefit financially from the introduction of c.b.: "The administration of c.b. could be serviced by us out of which we could take money to support the amateur." The RSGB was not supported by any industry or organisation or by the government, he said, despite the charity work it did. No other organisation was as well suited to ministering to the needs of future c.b. users, and the Post Office counter staff were already so overloaded that it was unlikely they would accept the extra burden of handing out c.b. licences. He thought 27MHz was bad because with the powers some of the Americans were using they could be picked up over here. As to where the service could be put he was non-committal: "Somebody has got to do a lot of homework; somebody needs to think about it, about whether it's going to be a useful thing." He was emphatic, however, that the spectrum wasn't full, and that the allocations, particularly those for the military, needed looking at. He would choose somewhere between 300 and 400MHz. "Between a quarter of a million and 400,000 people would want this facility and this would be a dreadful thing unless it were properly controlled, but I can't see how you can stop people having access to a legitimate development."

The military

The Home Office has no control over frequencies used by the military, and so any mention of these is notably absent from discussion of possible candidates for a c.b. slot. But it was surprising how often those who might have been expected to defend the amount of space the military has access to suggested, without prompting, that the military were not using their frequencies properly. From other sources it is widely known that the forces leave 10MHz of the 225 to 400MHz band fallow because these frequencies are also used by countries signatory to the Warsaw Pact.

Our forces operate their allocations as what one observer called "a mobile radio right of way", meaning that as long as they were used once a year or so the military had established their right to keep them. In the case of the "red" 10MHz, when it is used, usually on an exercise, the arrangements are agreed secretly in advance with the Warsaw Pact. The Ministry of Defence will not confirm or deny any of this information on the grounds that it is classified, but their NATO allies across the Atlantic have publicly acknowledged that, apart from objections by Canada and Mexico, one of the difficulties about establishing a Class E service in America was that the US Army used it for radar installations and tracking stations. There is no more depressing contrast between American government and our own than that, in June, the acting assistant director of the American Office of Telecommunications Policy, Edward Probst, announced the OTP's intention to examine all federal government frequencies between 50 and 900MHz as a direct result of the pressure for more space for citizens' band.

Since the technical objections to citizens' band could, on balance, be so easily overcome, why is the Home Office so steadfastly refusing to allow it? One suggestion, made only half-facetiously, was that most of those concerned with such matters are due to retire in 1979 and don't want to face the effort of introducing c.b. before their successors take over. There's no doubt that a lot of work would be involved, but one is forced to ask who pays for it to be done.

Security

The real reason for the Home Office attitude may be a concern for internal security. Many of those opposed to c.b. see it being used for bank robberies and other capers, and one explained: "I can't see the army in Northern Ireland being all that pleased if everybody over there had walkie-talkies, can you?" One informed commentator noted that in Northern Ireland the Wireless Telegraphy Act was a dead letter even for the security forces. Deeper down is a political worry. It hasn't escaped the notice of civil servants that the beginning of the c.b. boom was its use to block roads during a strike.

Many are worried about its use at demonstrations. The magazine *Autocar* said in August: "Naturally, it is an opening to what some would call misuse of radio, warning other drivers of police speed traps — with which we are in sympathy — in another, lone case, to co-ordinate a riot, with which we are not."

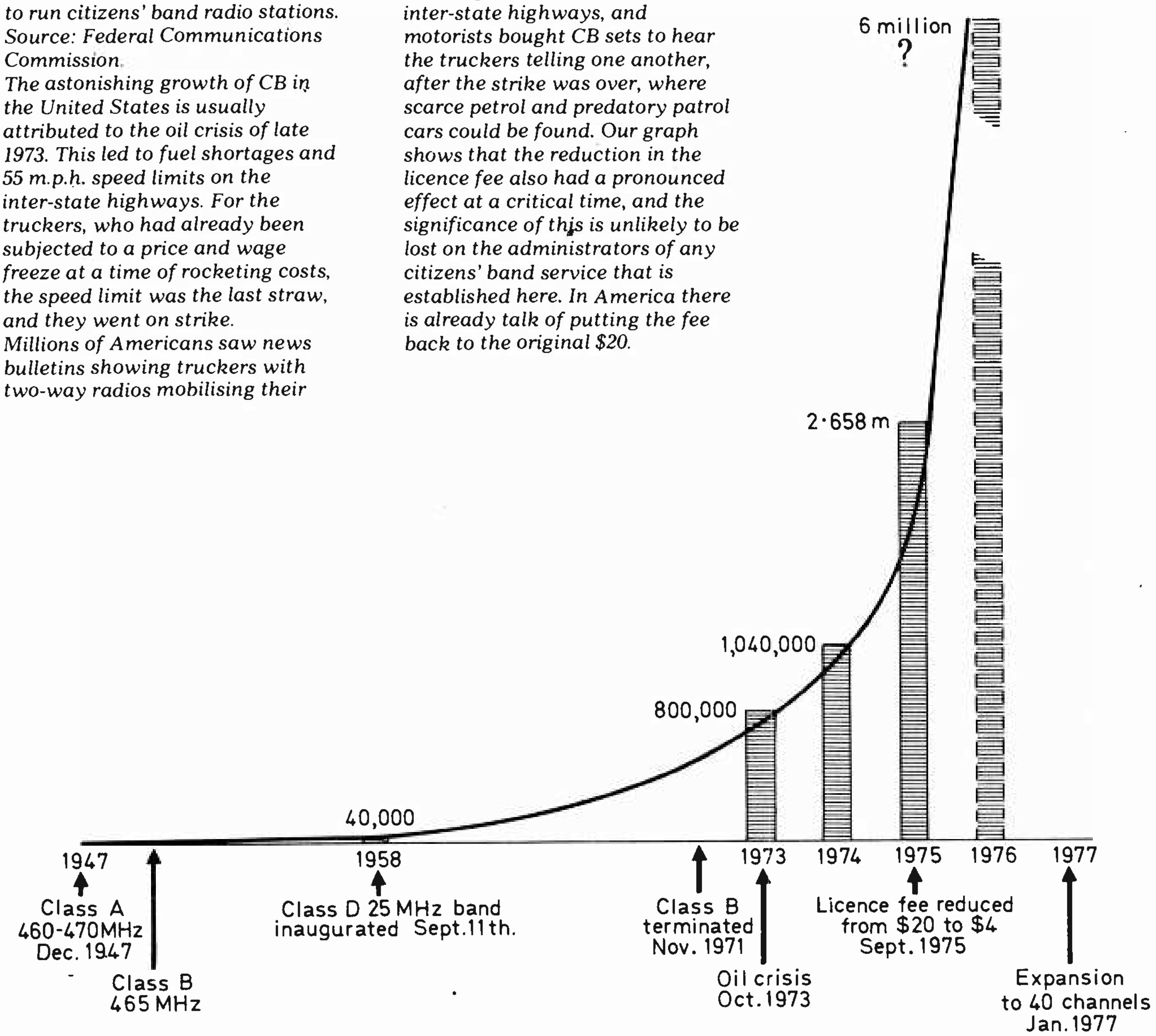
Others argued that if rioters killed as many people as motorists did then we'd be under martial law. As to the illegal use of c.b., Redifon managing director John Brinkley said, "Bank robbers and people like that are going to have two-way radios anyway, whether they're legal or not. Two things would prevent their use for such things if you had a citizens' band: firstly the politeness and formality of the operators; and secondly you're on an open circuit and everybody can hear everybody else." The police in America were in favour of c.b. and put sets in their cars, he said.,

The Home Office believed that the police in the United States *didn't* like c.b., partly because it interfered with their communications. On the other hand, according to Tom Graham, editor of *Canadian Transceiver*, writing in *Electronics Today International*, the Ohio police have done a survey which "proved conclusively that c.b. mobile operators are a positive benefit to the general public." The state of Mississippi has installed c.b. transceivers in 140 patrol cars and one report, in *The Sunday Times*, has said that their police rapidly caught 21 fugitive lawbreakers and 221 other offenders as a result of tip-offs from c.b. users. The state of Missouri has installed c.b. radios in all 750 patrol cars. In Atlanta, Georgia, a man with c.b. in his van spotted a car that c.b. messages had told him was carrying three men who had just killed a policeman. He rammed it, causing the three to be arrested. The New York police are reported to be working with the local Radio Emergency Action Citizens' Team (REACT).

Social effects

A visitor to the United States even noted a profound change in social attitudes: "If you want to pass on a message people relay everything for you. Everyone's falling over themselves to be helpful to each other. And you know what motoring is like. The motor car itself is a selfish thing. Drivers used

Growth in applications for licences to run citizens' band radio stations. Source: Federal Communications Commission.
The astonishing growth of CB in the United States is usually attributed to the oil crisis of late 1973. This led to fuel shortages and 55 m.p.h. speed limits on the inter-state highways. For the truckers, who had already been subjected to a price and wage freeze at a time of rocketing costs, the speed limit was the last straw, and they went on strike. Millions of Americans saw news bulletins showing truckers with two-way radios mobilising their blocking of the tollgates and inter-state highways, and motorists bought CB sets to hear the truckers telling one another, after the strike was over, where scarce petrol and predatory patrol cars could be found. Our graph shows that the reduction in the licence fee also had a pronounced effect at a critical time, and the significance of this is unlikely to be lost on the administrators of any citizens' band service that is established here. In America there is already talk of putting the fee back to the original $20.



not to care about one another, but a friend of mine said to me, 'We're all talking to each other now'." An article in the *New York Times Color Magazine* predicted, "If the people who regulate its use can prevent it from becoming a monster, it might well have a cultural and social impact on American life almost as profound as the last electronic communications gadget to sweep the country – the television set."

One of the most compelling weapons that the pro-c.b. lobby has in its armoury is that it would provide farmers, doctors and others with a method of continuous communication. The Home Office counter this by saying that such people already qualify for personal mobile radio, since they can prove a case for using it for business.

Those in the mobile radio industry have little but praise for the way the Home Office administers mobile radio: "It's not that bureaucratic," said Roy Pierce. But the difficulty with p.m.r. is that you have to prove your case for having it, you need to spend a great deal of money on the equipment, and, even more important, no real effort is being made to encourage its use. The Post Office radio telephone has a similar drawback in that it is not widely advertised in Post Offices. The advantage of citizens' band would be that the sets would be so cheap and so easy to get that nothing need stop the district nurse, the pensioner, the doctor, and the housebound from getting them; for the last in the list the telephone is no use unless you have someone to phone or are phoned. C.b. would enable them to talk to the outside world, not just members of their own circle. Getting p.m.r. is so difficult, several sources told me, that very often the supplier has to fill in all the forms for the customer.

Selling p.m.r. seems quite difficult. With another product a customer is usually reacting to having seen someone else using it and wanting to try it out. The p.m.r. salesman can't let the customer near the set until a frequency has been allocated by the Home Office. Mobile radio frequencies are so short that the authorities have to work out complicated regional variations which take account of the greater demand for frequencies in areas that are already congested. This can take nine months. All of this applies equally, of course, to the amateur, who has no opportunity to try radio out before he has been through all those tedious exams.

But who can use it?

If c.b. were allowed there is a danger that the big users of mobile radio, from taxi firms to the electricity, gas and water authorities, British Rail, large petrol companies and, to a lesser extent, the fire and ambulance services, might in these inflationary times turn to c.b. rather than carry on with p.m.r. This explains the reticence of some of those in the industry. For the users Alan Ford said: "We can see problems and we can see advantages. Over 80% of mobiles in this country are owned by our members, on our estimate. Anything that harms them we are against. But if, as I suspect, the introduction of citizens' band in the UK were to make the public generally more radio conscious then this could clearly be an advantage, and could only be a good thing for radio users and the industry."

The chief concern of the mobile radio industry is the effect it would have on their businesses. Mr Stanley thought c.b. "about as likely to happen as the nationalisation of the banks." He wouldn't welcome its coming because of the shortage of frequencies and the need, with mobile radio growing at 15 to 20% a year, for p.m.r. to get more. He agreed however that "there are a lot of channels that have got to be utilised better," and that a lot of groups, the newspapers, the Post Office and so on, "have generous allocations that they are using less efficiently than they could." But he said he was against anything that gave radio a bad name. "The amount of damage c.b. does and the bad reputation it gets is worse than the amount of selling it would get."

Pye Telecommunications said they had not committed themselves one way or the other. "We are taking a considerable interest in what's happening in America," sales promotion manager Bill Wheel told me. "If it were to come in with a bang we would want our share of it, but whether we would actively campaign for its introduction is another matter." Like Mr Stanley he was worried that it might "give the wrong impression of mobile radio." It was a totally different business, as demonstrated by the high Japanese interest in it: "They want something that can be made in thousands and put in a box with their label on it, and they have no interest for what use that is put to after they sell it. C.b. falls into that category. They're looking for mass production goods that can be sold over the counter. That's not our business because we as professionals provide a professional service in the design, installation and maintenance of whole systems."

It's not on

Paradoxically there are many, many reasons why c.b. will never be allowed here and just a few, though they are compelling ones, why it is inevitable. As we have seen, the technical objections can be overcome, if the will is there. The greatest obstruction is that the will is absent. To begin with, although the American and European citizens' radio services take advantage of the 27MHz spot frequency assigned by the ITU to "industrial scientific and medical" use on the condition that users accept any "harmful interference that may be experienced," there is no mention of citizens' band radio or anything like it in the document published after the last conference in Geneva in 1959. As far as the international control of radio is concerned, therefore, Citizens' band radio does not exist. The countries that operate a service are taking advantage of another agreement made in Geneva that countries may use frequencies allocated elsewhere provided such use has no effect outside their own borders. It was because of this provision that the FCC had to shelve their plans to introduce a Class E service on 220MHz. Canada and Mexico said it would interfere with their television services.

It is not entirely realistic to say that because other countries can operate a citizens' band service there is no reason why we should not. There are several important differences between conditions in Europe and the United States. Nearly all of the European "Public radio" services are run by small businessmen and are not as generally available to the public as is believed.

The social and political differences between the United States and the United Kingdom as they affect radio communications are not generally realised. The most elementary is that the United States has a written constitution, the first amendment to which forbids congress to pass any law restricting freedom of speech. The second amendment allows citizens to carry guns, and there would be something absurd about a national law which allowed its populations to carry 0.45s and not walkie-talkies. America also has a Freedom of Information Act and a civil service which resigns upon the election of a new president. Consequently the government is more accountable than here.

More fundamental even than these things, however, is that there had never been a government monopoly of radio. Planning of any kind, notably town planning, is suspect, and state ownership is anathema. This also applies to the American telephone service, which is shared, generally speaking, between the Bell Telephone Company and AT&T. Like our own telephone service it is profitable but, unlike our own, it does not have to support a costly postal service. For that reason, in many cities in the US, local telephone calls up to a certain number are free. Thus there is no reason to fear the undermining of the telephone service by c.b. in the States because the service is cheap enough to be accessible to everyone anyway.

It must be remembered that until a year ago 15 of the 23 c.b. channels in the US were set aside solely for the use of calls between different transceivers belonging to the same station. These are the calls that would compete directly with the telephone service. The rule change by the FCC allowing interstation calls to be made on any c.b. channel may be as much a reflection of the effect on the telephone service as on the need to ease some of the congestion on the other channels and the fact that, since so many people have them, fewer c.b. stations are now bought for intra-station communication.

The Post Office block

What may worry the Post Office as much as the loss of local calls is that so much of its revenue is derived from recorded information services, which receive hundreds of millions of calls a year. If the American evidence is any guide at all, the motoring information service would be severely hit; information from a motorist travelling north along the M1 would be more reliable than anything the Post Office could manage.

In addition the Post Office has just announced the extension of its own Radiophone service to Scotland. It now covers London, South Lancashire, the Midlands, East Pennines, Severnside, South East Wales and the North East of England. Motorists in these areas can call anywhere in the UK, principal towns in Ireland, the Isle of Man and the Channel Islands and most of Western Europe, the United States and the Far East. The cost of a local call, however, is 8p a minute with a three minute minimum, and a trunk call costs 6p a minute over normal rates. These charges do not include v.a.t.

This service is far too expensive for the normal "I'll be home in 20 minutes" type of message that the public could easily pass on with present technology. Even more significant perhaps is that the Post Office's Viewdata will, if it is ever introduced on a large scale, provide just that. Callers will be able to leave messages which will appear on the television screen. On present form the service is unlikely to be cheap, to us at any rate, and c.b. would affect it badly.

The Post Office and the Home Office are likely to receive substantial support in their objections to c.b. from the BBC, who are now pressing for their own radio motoring information service and who wish to retain their Band I frequencies either for a "re-engineered" 625-line tv service or a dedicated teletext service. The broadcasting organisations in the USA have presented some opposition to the expansion of c.b. there on the grounds of excessive television interference, and Senator Barry Goldwater, no less, has retorted in congress that the trouble was not the poor quality of the transmitters but the poor standard of television set manufacture. More worrying for the broadcasters here, perhaps, are US reports that local radio stations have been losing audiences since the c.b. explosion.

Who wants c.b.?

Another difference between here and America, and indeed between here and Europe, is that road distances are so much shorter. While it is true that the last twenty years have seen a massive motorway building programme, providing less opportunity for drivers to have the company of hitch-hikers, the American trucker can travel for days in an unchanging landscape. It has also been said that Englishmen can be travelling in the same train for years and never talk to one another, that the Ameicans are more garrulous than we are, and that we are "too conservative" to make use of c.b. And social class is not based on the spoken word in the United States; one view was that a lorry driver and an executive would have nothing to say to one another. Yet another difficulty that occurs to people is that if you are one of the first people to have a c.b. set you will have very few to talk to. After all, c.b. had been dormant 27 years in the United States before it made any impact, although for much of that time it was available only on 456MHz.

All these difficulties are insuperable unless public pressure for citizens' band radio becomes so intense that the Home Office is no longer able to resist it. There seems very little evidence that public pressure has reached anything near that point, and it is difficult at the moment to see how it ever could. Although the Citizens' Band Association had been going for something like four months when I spoke to him, James Bryant told me that he would get his hundredth member by the middle of the following week. That doesn't seem to show overwhelming public interest in c.b.: as one comment had it, "Last week I heard that a club had been formed for people who had walked from John O'Groats to Lands End. In a week 600 people had joined."

The precedents for changes in telecommunications policy aren't all that numerous. One was the introduction of commercial television and the other was the introduction of commercial local radio. In both cases the campaigns took a long time even though they were conducted on a massive scale by powerful industrial and financial interests who saw the money that could be made from advertising. There is no money to be made from advertising in citizens' band since the only possible form of advertising would be a sort of swop-shop on one channel. Even that might upset local newspaper and publishing interests, who have the ear of the Home Office because most use some personal mobile radio frequencies.

Another crucial point is that in both those previous cases, as in most other things, the public were willing to back the lobbyists because they had seen the product and wanted more. In the case of commercial television they wanted a second channel to compete with and destultify the one they already head, and in the case of commercial radio they had heard the pirates and wanted more of the same. Until mobile communications and two-way radio become so plentiful through normal p.m.r. use then the public will now know what they are missing. It was noticeable in America that it was not until people bought c.b sets to find petrol and dodge speed limits, that they discovered they had other uses.

It is noteworthy too that after pirate radio began to operate in 1964 successive Postmaster Generals, Bevins, Benn, Short and Stonehouse, were told that it was interefering with vital services. One comment on this was, "Had [the Postmaster General] known anything about it he would have known that this wasn't the case, but the same people that advised him are still advising at the Home Office."

Distrust of the media

At the moment there are some factors that may worry the Home Office into changing its position. The first is that the Home Office is split over attitudes to its entire policy, and its resistance to public accountability may not be as solid as its official statements suggest. Another sign that may help the pro lobby is that many who expressed serious reservations for the record told me as soon as our interview was over: "Mind you, if it does come in I can't wait to get a set." Some of the mobile radio industry are already falling off an already-crowded fence; Pye's Pannell reports, their submission to the Home Office on frequency allocation, is broadly quite favourable to c.b. Last of all, though they sometimes seem to behave like it, those at the Home Office are not totally unameable to argument. The murrain that grips this civil service is that they do not understand, never mind sympathise with, the view that it is up to *them* to prove *their* case, and not up to *us* to prove *ours*. So far, on the arguments they have advanced, they could be said to have failed. What is wrong is that this will make no difference.

Citizens' band reflects a growing distrust in popular sources of information, a desire to tell one another what is going on without the intermediary news editors or tv chat experts. No less important is that the so-called triviality of the messages that are passed belies their importance. This is not just true of c.b. When a lorry driver is told over p.m.r. "There's a load of fish'eads waiting to be collected from Billingsgate," the deeper meaning of the message is "Do this and we'll make some money." The c.b. lobby cannot see why that is more important than giving a man or woman in a lonely community, which can exist in the middle of a city or in the unwelcome gregariousness of a traffic jam, the opportunity of talking to someone they haven't met, and going away feeling that the other person is just the same as they are.

Whoever seeks to deny them that contact in a world that gets more difficult and dangerous by the minute had better have a good reason.

News of the Month

Analogue quarts into digital pint pots

The BBC is examining a digital frequency-division multiplex companding process which may save enough bits to allow a 7kHz speech channel to be coded into a 64kbit/s bit rate. This is the bit rate for a single telephone channel in the national and international digital communications networks now being introduced, "and access to such channels for data links and other purposes may ultimately be possible," say the BBC.

The companding process, one of many the corporation is looking at, digitally compands programme components in three separate bands: up to 1.75kHz; 1.75kHz to 3.5kHz; and 3.5kHz to 7kHz. Six bits are transmitted for each of the first two ranges and three for the third, "a near-instantaneous companding technique enabling moderately good speech quality to be achieved. Only a single analogue-to-digital converter is required, acting on the three audio bands in time-division multiplex."

The sampling rate for the top two bands need not be twice the maximum frequency of the band concerned. Since they are only an octave wide, sampling each band at its maximum frequency yields alias components which meet but do not overlap the wanted part of the spectrum and which can therefore be eliminated by filtering. A similar effect, say the BBC, can be obtained less economically by frequency-shifting each band down to baseband before coding and restoring to correct frequency after decoding.

Teletext and cable

The Home Secretary has authorized the BBC and IBA to continue the transmission of teletext services up to July 31, 1979. (When started, BBC's Ceefax in 1974 and IBA's Oracle in 1975, the services were intended to run only for an experimental period of two years.) Announcing this at the annual luncheon of the Cable Television Association, Lord Harris, Minister of State for Home Affairs, said: "We shall, of course, have to look again at the position in the light of any recommendations made by Lord Annan's Committee. But I hope that the extension of the authority I have just announced will encourage industry rapidly to provide equipment which can be put within the reach of members of the public at large."

Lord Harris also said that, as a result of discussions between the CTA and the Home Office, it had been agreed that telext services will be available in decoded and modified form on some of the cable networks. This statement was in fact an authorization of what has been going on experimentally for some time at Swindon, Brighton and Hull. At the last-mentioned two towns, for example, Rediffusion decode the teletext signal at the distribution centre and put it out in analogue form on their h.f. network, using the BBC2 channel in those hours when the BBC is not transmitting programmes. Of course the subscribers cannot select pages themselves, and Rediffusion are using an automatic "page turner" which presents selected pages at about one per minute.

In a statement issued after Lord Harris's announcement, the BBC said that television sets with integral Ceefax decoders would be available to the public during 1977 and at least two manufacturers were beginning limited production of add-on adaptors which would enable viewers to receive the service on their present sets.

Doping an amorphous semiconductor

A p-n structure has been made from non-crystalline silicon by a group at the University of Dundee. This demonstrates that amorphous material can be doped by impurities, an achievement not previously thought possible. A silicon film was made either p-type or n-type by the addition of boron or phosphorus, although more dopant was needed for this "amorphous" (glassy or disordered) film than would have been the case for the ordered, crystalline silicon used in present transistors and solar cells. The Dundee workers, under Professor Walter Spear and Dr P. G. Le Comber, deposited the silicon films by glow-discharge decomposition of silane (silicon hydride) on glass, using phosphine or diborane as dopant gases. This is a well-known technique but this is the first technologically successful study of the product.

They found that the conductivity of the films could be controlled in unprecedented fashion. For amorphous materials, conductivity values could be varied over five orders of magnitude. In the past, amorphous semiconductor films, which can be deposited very cheaply, were not very useful because they would not conduct well enough for use in a device (excepting the abortive "Ovshinsky devices"). This new ability to control conductivity could open up the technological uses of thin film amorphous silicon, a very desirable thing because of the cheapness and large possible areas of such films; even thin film tv displays have been talked about.

However, some formidable fundamental and technological barriers may need to be surmounted before devices which compete with those made from single-crystal silicon can be manufactured. The efficiency of doping as it affects conductivity is still quite poor, because many carriers are immobilised in a class of energy states special to amorphous semiconductors, the so-called "mid-gap states". The achievement of Spear and LeComber is to reduce these states until at least a small proportion of the electrons and holes, freed from the dopant atoms, appear in conduction states. Further research may show how to free more carriers and also answer some fundamental questions about this new "second generation" of amorphous semiconductors.

Carter wants "better use of mobile radio"

President-elect Jimmy Carter says telecommunications represent perhaps "the greatest potential area of application for space research and technology." The effective use of telecommunications technology — including the telephone, mobile radio, television, satellites and computers — were an important part of a comprehensive energy conservation programme.

Carter had been asked, in the journal of the American Society of Mechanical Engineers, what he saw as the future role, priorities and funding of NASA, and what importance he attached to aeronautical research and development, space science and space applications. "In a time of widespread inflation and high unemployment telecommunications is one of the few sectors of the economy which has consistently provided more jobs with increased productivity.

"I am pleased to note the efforts at NASA and a number of universities and research institutes to evaluate the potential of telecommunications for increasing the efficiency of energy-intensive activities such as travel. New ways of using telecommunications — such as telephones linked to computers or video conferencing via satellite —

bring the promise of substantial time, money and energy savings in the use of transportation. In other areas we can, for example, make better use of mobile radio or satellites and computers for on-the-spot diagnosis of heart attacks and delivery of emergency medical services. The technology is here today. What we need are the institutional mechanisms and commitment in both the public and private sectors to make best use of our assets."

Asked how he intended to use the Office of Science and Technology, he said: "It is crucial that the advice of the scientific and engineering community of this nation be actively and permanently sought by elected officials in the evolution of national policy dealing with the complicated, unpredictable and rapidly changing technological problems of this modern world. The day when political leaders could make effective policy decisions independently and turn to the scientific community only for assistance in implementation has long passed.

On engineering education he said imaginative reforms were needed to strengthen colleges and universities in times of financial difficulty.

Carter said he felt that one of the greatest failures of national leadership in the USA had been the failure to convince Americans of the urgency of the energy problem. The national policy for energy must combine energy conservation and development. Ironically, in view of his remarks about mobile radio, his list of conservation measures included "rigid enforcement of energy-saving speed limits."

Ten women leave England in January to film and study the great Atrato Swamp in Columbia. They will be away about three months. Tony Wright of Racal-Tacticom (left) shows Carolyn Oxton (second right), the leader of the expedition, and two other members of the team, how to work the Syncal radios which will link them with a base camp which may be up to 500 miles away.

Waveguide go-ahead

The Post Office have decided to install their first main line millimetric waveguide between Reading and Bristol, a distance of 123km, to come into revenue service by 1982.

Announcing this decision at the opening of the IEE November conference on millimetric waveguide systems, Professor J. H. H. Merriman of Post Office Telecommunications HQ made it clear that this was still subject to Post Office Board approval, which probability one source put at 80%. (Amounts over £1½ million require board approval.) Value of the work is thought to be around £4½ million, with Marconi Communication Systems supplying terminals and repeaters (worth about a third of the value) and a joint P.O.-BICC venture providing the waveguide, which will be similar to that used in the P.O. Research Centre field trial (see report on page 69). BICC have recently mentioned a price of £20 per metre for their waveguide but the Post Office say this figure is based on developmental quantities; they are "certainly hoping to pay much less for production quantities" said a spokesman.

Work over the last decade by the Post Office, culminating in the 14km field trial from the P.O. Research Centre at Martlesham Heath to Wickham Market in Suffolk, has "been extremely successful in demonstrating that the design, construction and installation of an operational waveguide system could be achieved" said C. A. May, director of research at the centre.

And with the Post Office belief that their system is the most cost-effective they are naturally hopeful for its export potential. The high density nature of the system limits the market of course and the USA, Japan, France and Italy have made their own investment and developed systems tailor-made to their own requirements. Nevertheless the Post Office-industry team (Marconi and BICC) believe its features are attractive enough to interest Middle Eastern countries and some smaller European countries. And now the conference has finished and the international scene appraised the team will be starting to sound-out the market.

One of the attractions of the system is its modular basis; a basic capacity of approximately 60,000 voice circuits could be provided initially and further capacity added later at little extra cost. Another feature is the repeater spacing, of the order of 20km compared to the 2km of cable systems. The waveguide itself is simple to make, light in weight, easy to handle and joint, and is cheap to make, say the Post Office. More details on page 69.

Europe a net electronic importer

European electronics production should reach $39,536 million in 1977, an increase of 12.9% over the previous year, according to the latest edition of the Mackintosh Yearbook of West European Electronics Data 1977. Output increased only 4% during 1975 compared with the previous year, compared with a mean growth rate of around 14% in previous years. During 1974 total European production was $31,239 million, while Japan produced $16,400 million, and the US $39,000 million. The following year the European figure was $34,068 million and even that was inflated by a 5% devaluation of European currencies against the dollar. Mackintosh have prepared a table from the previous four editions of the yearbook which eliminates currency fluctuations and shows the real growth of European electronics output: taking 1972 as the base at 100, the production figures given for the following five years are 104.7, 106.2, 97.5, 110.8, 125.1.

In 1975 Europe exported $15,878 million, an increase of $2,101 million over the 1974 figure, but imports were $16,380 million, up $1,337 million, a trade deficit of $502 million. Every country in Europe had a deficit with the exceptions of West Germany and France.

The deficit in computers was $1,020 million, with imports running at $3,396 million; video and audio consumer goods with imports of $3,475 million had a deficit of $976 million; and active, passive and audio components had a deficit of $741 million with imports of $5,394 million.

France became a net exporter of electronics products for the first time in 1975, with a surplus of $32 million on imports of $2,523 million. Mackintosh point out that French government heavily subsidises the electronics industry. West Germany, however, has been in surplus since the first edition of the yearbook in 1972. In 1975 the West Germans had a $1,264 million surplus on imports of $2,974 million.

In communications, telecommunications and control and instrumentation equipment Europe is a net exporter, with exports of $6,350 millions compared with imports of $4,115 million in 1975. The United Kingdom, however, has a positive trade balance only in communications and telecommunications. In 1975 exports, at $2,370 million were $137 million less than imports.

Turning to the electronics market, video and audio consumer goods show the smallest increase, 17%, projected for the period from 1976 to 1980, while components, the largest market, is expected to increase 41%.

Who is warden over the Wardens?

The International Telecommunication Union will, if it keeps its present membership, have delegates from 152 countries at the World Administrative Radio Conference in Geneva in 1979. The latest country to claim membership is the People's Republic of Angola, which registered with the ITU on October 13 last. The unwieldiness of such a gargantuan talk-fest beggars the imagination, and the obstacles of procedure and language will be such that, while a little matter like independence for Rhodesia can take only a few weeks, sorting out the world's demands on the electromagnetic spectrum is expected to take two and a half months from the September 24 opening date.

Those interested in telecommunications policy also expect results to depend on the demands of the newly-independent nations such as Angola. Some have said that their views will not affect Western Europe much. Others, notably our own Home Office, are saying that the distribution of the whole spectrum could look vastly different as a result of the emergence of countries that hardly mattered when the last conference was held in 1959.

The Agenda includes a review, and where necessary, revision of the provision of the regulations relating to terminology, the allocation of frequency bands and the associated regulations (articles 1 to 7); a review and, where necessary, revision of the provisions applicable for the co-ordination, notification and recording of frequency assignments (articles 9 and 9A), except those articles relating to a single service; a review and, where necessary, revision of other regulations applicable to services in general (articles 12 to 20); and a review and report on the activities of the International Frequency Registration Board.

The International Radio Consultative Committee (CCIR) is now studying recent technical advances, new services, more intensive use of the frequency spectrum and the use of higher frequencies than those now used so that the information will be available to the conference. A special joint meeting of the CCIR study groups is expected to be convened next autumn.

In the United States the process of public consultation is well under way. In March the Federal Communications Commission issued a 127-page public notice tabulating the non-government requirements submitted to it for 1979. "These requirements stem from comments and reply comments to the second notice of enquiry," said the first page of the document, released September 19, 1975; . . . Additional formal notices of inquiry regarding preparatory work for the 1979 WARC, including proposed changes to the international allocations table will continue to be issued wherein comments will be solicited from the general public . . . "

In the table of frequencies and present allocations, each frequency band shows the requirements placed on it by interested parties, and a key shows the source of the request, any of 17 categories including citizens' band (category 35), even though c.b. does not yet exist in the eyes of the ITU.

In Britain there is no consultation and, at the moment, there are no plans for any. Two years ago an engineer in the Radio Regulatory Division of the Home Office, James Warden, was asked to begin a series of reports which would form the basis for briefing delegates to the 1979 WARC. The delegates will be instructed by the minister, now Lord Harris, who in turn is responsible to the Home Secretary. In reality the instructions will be delivered, and indeed drawn up in their final form, by the minister's permanent secretary, who receives reports from a number of committees he has formed to agree policy on various aspects of telecommunications. The committees brief the permanent secretary after discussing their proposals with a selected group of those outside the Home Office who have a direct interest in each committee's subject but who can be trusted to be discreet, for the reports are secret. The basis for the secrecy is that in theory the delegates are told what "Britain's attitude" is to be at the conference by the Home Secretary himself, and we cannot learn anything of what our officials will say on our behalf because to do so would be to break Cabinet secrecy.

Warden has now finished two of his main reports, as well as a number of minor ones, and is at present engaged on a third. The first was on the largest activity within the Home Office's jurisdiction, broadcasting. The second was on mobile radio, and was presented to the Mobile Radio Committee of the Home Office about a year ago. The information we have been able to gather about this report is an interesting example of how telecommunications policy is decided. Like the others, it was restricted to ten or 20 numbered copies. Some of these were passed out to the mobile radio industry for comment, and this meant the senior officials of the Electronic Engineering Association, which represents nearly all the mobile radio equipment manufacturers. The Home Office Mobile Radio Committee is not composed entirely of full-time civil servants, and the joint secretary of the MRC is also secretary of the Mobile Radio Users Association, Alan Ford, who can give the users' view.

The Warden report on suggested allocations for mobile radio frequencies contained 16 recommendations. The EEA agreed with some of these, disagreed with others, and were unable to agree among themselves about the rest. The report had reached the conclusion that the growth in mobile radio use was small or static and that there was therefore no further need for any allocation above what it had already got. Any further channels that did become available should go to the Post Office, and any unforeseen growth in the demand for mobile radio could be handled by new technology, particularly digital techniques, already evident in the United States. Here Warden may have been influenced by technical developments he had seen in America when he stayed for two months as a guest of the FCC.

It is fair to say that the report astonished those in the industry who were privy to it. They had minor reservations about its lack of detail, as they saw it, but they could not accept the major conclusions about the growth in their industry. To begin with, of the portion of the spectrum from 1000MHz down to 30MHZ, broadcasting takes 60% of the available space, the military another 30% and mobile radio has a mere 3% share. Even a member of the Home Office telecommunications directorate, Willam Nicol, had to admit in a speech at the Communications '76 conference at Brighton in June that the allocation "would scarcely reflect very strong interest or a fair share of the frequency spectrum for mobile radio..."

The Post Office's own estimate of the growth of the market is that the number of mobiles will double to over 500,000 by 1985, rising to about 1.5 million by the year 2000. J. R. Humphries of Marconi Communications Systems wrote in *Electronics Weekly* recently: "It is generally agreed that the growth of land mobile radio services in the United Kingdom will mean an expansion in the number of users by at least 2.5 times within ten years." The rest of the article showed that, like everyone connected with mobile radio, he was aware of the pressing shortage of frequencies for mobile radio.

In addition to all this the industry has the evidence of the American Frost and Sullivan report, which predicted a rise in the mobile radio market in the US from \$900 million in 1975 to over \$4.2 million by 1984, and asserted that digital techniques would supplement existing radio signals and channels, not replace them.

Another irritant was that mobile radio users had accepted channel reductions from 100kHz to 12.5kHz in 20 years and that now there was talk of a further reduction to 6.25kHz while Post Office channels were still 25kHz.

The result of all this was that the report was sent back for further work to be done on it in consultation with the industry's representatives in the EEA. It would be interesting to know what else the Home Office is preparing to take away to Geneva, and fascinating to discover how different it would look if we did.

Non-linear distortion in audio amplifiers

Why do some amplifiers pass static distortion tests but fail listening tests?

by M. Otala, *Technical Research Centre, Oulu, Finland*

The debate about amplifier distortion and especially its audibility has always been an interesting subject. Most of us still remember the battle over triodes and pentodes, and a few years ago such epithets as "transistor sound" were discussed intensely. Right now we are in the middle of "operational amplifier sound", and although these negative attributes may seem ridiculous at first glance, there really seems to be some clearly audible differences. These differences must be "distortion", whatever that may then mean.

It is a commonplace to divide distortion in amplifiers into two classes: linear distortions, i.e. linear departures from straight frequency or phase characteristic, and non-linear distortions, i.e. distortions caused by non-linear amplitude relationship between the input and output signals. This article concentrates on the last-mentioned form of distortion and divides it into two groups according to their dependence on the signal

- static non-linear distortion, dependent solely on the amplitude of the signal, and
- dynamic non-linear distortion, dependent not only on the amplitude but also on the time properties or frequency composition of the signal.

Historical perspective

In the early valve era the cost of gain was high. This led to the use of few active devices and careful design to yield acceptable harmonic and intermodulation distortion figures. When the benefits of feedback were discovered, it was applied mostly locally. The presence of an output transformer with its stray reactances made the amplifier transfer function so complicated and dependent on the momentary signal and load conditions at high frequencies that heavy overall feedback could not be used without loss of stability. The average overall feedback varied between 15 and 30dB, and the static harmonic and intermodulation distortion were the primary sources of audible amplifier quality impairment.

The introduction of transistors and especially the transformerless amplifier circuits permitted the use of heavy overall feedback. This led to the unwarranted myth of the amplifier being the better, the higher the feedback. The following advantages were attributed to the use of feedback

- static distortions decreased to practically zero
- bandwidth of the amplifier increased
- output impedance of the amplifier decreased and hence the damping factor increased

The decreasing cost of components and the trend toward monolithic integration made possible the use of almost-unlimited gain resources, and consequently the main trend in the design philosophy has been the use of very high open-loop gain and high values of feedback.

This trend has been further intensified by the use of operational amplifiers, which more and more are finding their way into audio equipment as low-level amplifiers and power amplifier drivers. The need to minimize the size, weight and power dissipation of amplifiers also led to another trend: the minimization of the class A operation region of an amplifier. The result is cross-over distortion, which sounds ghastly and is difficult to eliminate with feedback or any circuit tricks.

Those two effects, the overdose of feedback, causing dynamic non-linear distortion, and the almost class B operation causing near-incurable cross-over distortion, seem to be the main distortion problems of present-day audio amplifiers.

Static non-linear distortion

Every stage of an amplifier has a more or less non-linear transfer function. Fig. 1 shows the typical static non-linearities usually encountered in audio amplifiers, namely s-type, cross-over and clipping distortions.

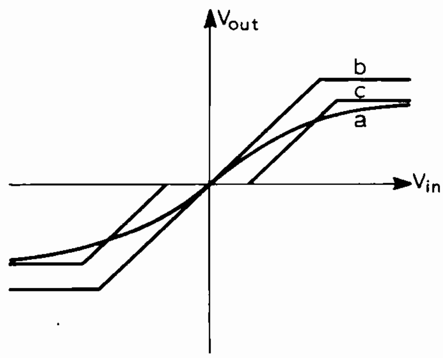


Fig. 1. Different kinds of static non-linear distortions (a) s-type, (b) clipping and (c) cross-over.

S-type non-linearity. There are numerous reasons for the s-type non-linearity. In the case of transistors it may, for instance, be caused by the non-linear dependence of current gain, *versus* collector current and voltage, by the non-linear base-emitter voltage characteristic, or by possible avalanche-type collector current non-linearity due to collector-emitter voltage. In the case of vacuum tubes, the list of sources for non-linearity includes the space-charge effects around the control grid, the change of mutual conductance and anode resistance as function of voltage, the possible negative impedance contribution of screen grid in beam tetrodes and pentodes, etc.

On the circuit side the most notable method of minimizing the non-linearity is the choice of interstage resistors to ensure that the stage interface transfer function is as linear as possible. If transformers are used, their non-linearities are important too. All of these sources of s-type non-linearity are well understood and design rules exist for their minimization. The effects are, however, too numerous to be considered here. Furthermore, the remaining s-type non-linearities can easily be decreased with the use of local or overall feedback.

Cross-over distortion. The operation of power amplifiers in class B presents some important special problems. The first is cross-over distortion, and the second the time asymmetry of the amplifier halves, Fig. 2. Both occur around the class B transition from one circuit half to another. The source of these distortions is the decrease of the gain of each half to almost zero at almost zero collector current, and the different transition frequency behaviour of each half. In the cross-over region, therefore, the open-loop gain of the amplifier drops drastically. Feedback has little effect on this type of distortion, as there is no open-loop gain available for the feedback. The only possibility is to allow sufficient quiescent current to ensure the full gain at all times. These two forms of distortion are very clearly audible, probably because they generate harmonic and intermodulation products of high odd order. In the case of harmonic products, the high order components are non-musical and therefore annoying. In the case of intermodulation products, a high order means a multiplicity of products falling within the audio band. Being non-musical, the musical masking of these kinds of products is small. However, the sensitivity of the ear may also stem from the strong phase modulation they introduce in heavily feedbacked amplifiers. The details of this effect are outlined later in the section on dynamic non-linear distortion.

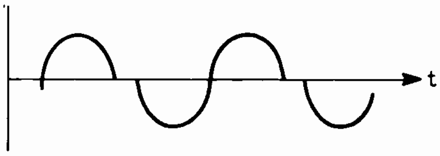


Fig. 2. Cross-over distortion caused by time asymmetry of the class B amplifier halves.

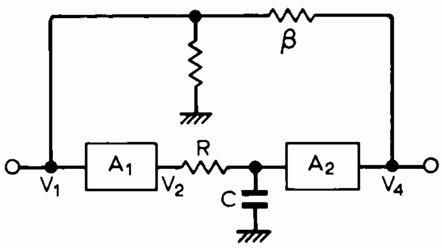


Fig. 3. Division of a feedback amplifier incorporating the driver A_1, the output stage A_2, the compensation network RC and the feedback network β.

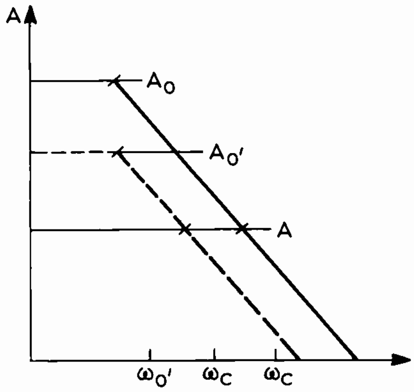


Fig. 4. Bode plot of the feedback amplifier.

Clipping occurs when an amplifier is overloaded. Therefore it is not an operational non-linearity in the proper sense of the definition. However, as overloading peaks do exist in usual programme material, the amplifier overload performance becomes important. The audibility of clipping is dependent on the clipping mechanism, soft s-type clipping being less audible than hard limiting, which may be aggravated further by saturation recovery effects. This increased audibility depends again on the generation of higher-order harmonic and intermodulation distortion products.

It would be desirable to "soften" the clipping. The problem is, however, that the overall feedback effectively linearizes the clipping, making it hard, and may also cause an internal excess drive signal within the feedback loop during the clipping, thus aggravating the saturation problems and delaying recovery. The desire for a soft clipping and the present use of feedback are therefore incompatible, and it remains to be seen which one will be considered more important in the future.

Static distortion versus feedback

Suppose that in a given circuit all the possible means for minimizing distortion *in situ* have been used by selecting linear active devices, by choosing optimum load and generator impedances for all stages, and by careful selection of the working points. Suppose further that so far no feedback has been used. The interesting question then arises: whether one should use local feedback stage by stage, or overall feedback around the whole amplifier to reduce remaining static distortion. Most present-day amplifiers seem to be constructed according to the last mentioned principle, i.e. the main design objective has been to realize as high (and often very non-linear) a gain as possible and to rely on overall feedback to make the amplifier behave correctly.

The use of local feedback has some drawbacks which make its use unpopular

–it increases the number of parts in the amplifier

–if the amplifier uses i.cs, linear unbypassed emitter resistors may be difficult to manufacture

–local feedback often limits the available voltage swing of the stage (Crucial at driver stages and may necessitate separate power supplies for them)

–large unbypassed resistors at the output transistor emitters may severely limit output power

However, local feedback has some advantages:

–it linearizes and stabilizes each stage separately, eliminating certain difficult cross-coupling linearity and stability troubles between stages.

–it decreases the effect of individual device tolerances, which may cause some working point problems, especially in d.c.-coupled multi-stage amplifiers.

–it increases the cut-off frequency of the stage

The last remark is important. For the same total gain, the use of overall feedback alone yields the same distortion figures as the use of local feedback alone but with one significant exception: whereas local feedback increases the usable frequency range of the amplifier, the overall feedback usually decreases it. This apparent contradiction may be explained as follows:

To ensure stability, the amplifier open-loop frequency response must have a −6dB/octave roll off. For heavy overall feedback, the amplifier must then be frequency compensated to eliminate the influence of the second, third, etc. poles of the transfer function[1]. If overall feedback is increased, this compensation must be made proportionally heavier, resulting in the closed-loop small-signal frequency response remaining the same. The generally held belief that overall feedback increases the small-signal frequency range is thus invalid in the case of multiple-stage amplifiers. However, the large-signal frequency range usually decreases with increasing feedback. This is caused by the heavier frequency compensation requiring more error signal headroom from the driver stages. If there is not much of this headroom available, and such is usually the case, the driver stages will clip at proportionally lower frequency as the compensation is made heavier. High overall feedback therefore has the tendency of decreasing the power-bandwidth of an amplifier.

The optimum choice with present-day components is probably to use all the possible local linearization methods available, and thereafter to use local feedback until the open-loop large-signal total harmonic distortion is around 0.2 to 2%. Moderate overall feedback is then added, the optimum value being around 20 to 40dB. It seems possible with this kind of technique to obtain harmonic distortion figures as low as 0.05% without increased risk to dynamic non-linear distortions.

Dynamic non-linear distortions

If the frequency content or the time properties of the input signal affect the transfer function of the amplifier, the resulting non-linearities may be called dynamic. We know at present of at least one dynamic distortion of this kind, namely the transient intermodulation distortion (t.i.m.) which has been described in detail elsewhere[2]. It stems from overall feedback in the following way.

Consider an amplifier with heavy feedback, and consequently heavy compensation, shown in Fig.3, having the Bode plot of Fig.4. The raw, open-loop gain is A_0 and the corresponding open-loop upper cut-off frequency is ω_0, typically 5 to 500Hz. The open-loop transfer function of A_0 is shown in Fig.5.

Now consider an input signal consisting of a transient and a sinusoid. The error voltage V_2 is proportional in amplitude to the frequency of V_1 (Fig.6) due to the compensation network RC. Suppose that the input transient has sufficiently low rise time to let V_2 excurse to V_2'. The incremental open-loop gain now drops to A_0', also shown in Fig.4 with a dashed line. If the feedback is large, the closed-loop gain A is not affected, but the closed-loop upper cut-off frequency ω_c (typically 20 to 200kHz) drops momentarily one or two decades to ω_c' during the rise of the transient. This causes phase modulation of the sinusoid if it is smaller in frequency than ω_c', and combined amplitude and phase modulation of the sinusoid if it is between ω_c' and ω_c in frequency. In both cases, the phase and amplitude modulations give rise to interference components between the transient and the sinusoid, thereby creating non-harmonic audible components in V_4, the output signal[3]. In an extreme case, driver A_1 is driven into saturation and A_0 drops to zero. This corresponds to momentary 100% intermodulation distortion of the sinusoid.

This effect is phenomenologically equivalent to intermodulation distortion caused by rapidly sweeping the upper cut-off frequency of the amplifier in synchronism with the frequency content of the input signal. Whereas t.i.m. is principally caused by the overall feedback, similar effects occur with the so-called dynamic noise limiters, although there the speed of the sweep is limited. A similar effect occurs in power output transistors, where the cut-off frequency f_β depends on the instantaneous collector current and collector-emitter voltage.

Heavy cross-over distortion causes almost identical phase and/or amplitude modulation effects to those produced by t.i.m. although in principle it is a static non-linearity. This is due to the fact that it causes the same kind of momentary variation in the open-loop gain.

Amplifier distortion budget

The distortion compromise that a designer must make in designing an amplifier consists of at least the following parts:

1. The smooth, s-type non-linearity of the transfer function caused by device and circuit non-linearities. These are easy to correct to a certain extent by local feedback, optimum load and generator impedances and by overall feedback. Usually this type of distortion is neither difficult to handle nor severely audible, the only prerequisite being the necessity of a few extra stages to compensate for the losses of gain caused by the corrections mentioned above.

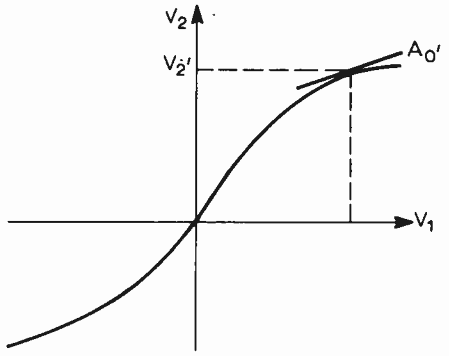


Fig. 5. Open-loop transfer function of the amplifier A_0 is the incremental gain.

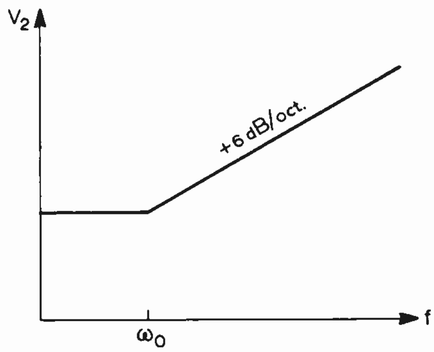


Fig. 6. Error voltage V_2 as function of frequency.

2. The abrupt distortion such as cross-over distortion. These are difficult to cure, sound very bad and usually overall feedback has little effect on them. The possibility is to allow operation deeply enough in class A, a practical target specification being 14 to 20dB below maximum output power[4]. As compared to many present designs, this leads to higher quiescent power losses and consequently a larger heatsink.
3. The dynamic non-linear distortions. As the dynamic distortions are principally effects caused by poor frequency behaviour of an amplifier, they can be cured completely by following certain simple rules in the design[1, 5], and not by using too much overall feedback.
4. Some presently unknown dynamic distortion mechanisms such as the clear effect of loudspeaker load on the audible sound quality of some amplifiers.

–phase modulation effect, probably caused by power transistor cut-off frequency sweeping with the output power

–possible importance of reproducing faithfully the higher derivatives of the signal.

Of these distortions, cases 1 and 2 may be made very small with good design of the amplifier, and by a readiness to meet the cost of added components and a larger heatsink. Case 3 is easy to eliminate totally by proper design with practically no increase in parts cost. Case 4 remains to be studied but at least until it has been solved, the final sound quality measuring instrument must be the ear.

Conclusion

Dynamic distortions were unknown until recently. There seems to be some correlation with the phenomenology presented above and subjective listening tests. It is commonplace to find an amplifier having a good harmonic and SMPTE intermodulation distortion specification (and thus probably high overall feedback) which fails in the listening tests. It has also been shown that irrespective of unmeasurable harmonic and SMPTE intermodulation distortion, an amplifier may produce dynamic intermodulation products having amplitudes of tens of percent[3]. The t.i.m. seems to explain a part of this dilemma but, certainly, there must be other similar effects.

With the static non-linearity measurements, we have only stated that an amplifier must be capable of reproducing the absolute value of the signal correctly. What the dynamic non-linearity considerations show is that the amplifier must in addition be capable of reproducing faithfully the first and the higher-order derivatives of the signal as well. The t.i.m. is part of the non-linearity of first derivative reproduction. What the other parts are and what requirements the higher-order derivatives of the signal impose on the amplifier remains to be discovered.

At this moment we are living through a very exciting phase in electro-acoustics, the challenge of explaining the clear contradiction between our measurements and our subjective sound quality sensation. I forecast lively activity in this field in the near future.

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World of Amateur Radio

Second thoughts

The Home Office is to be congratulated on having "second thoughts" on the double-sideband suppressed-carrier mode (see "World of Amateur Radio" October 1976). It has reversed its decision to ban this mode which will, it seems likely, be made available to all British amateurs under the terms of the new consolidated licence due to be introduced during 1977 — a sensible and generous decision to think again.

The RSGB has modified its official attitude towards the introduction of Citizens' Band facilities in the UK (now legally available in most European countries including several in East Europe). In a recent statement of attitudes, the Council of the Society insists that anything less than the ability of the administration to exercise complete and effective control would not be acceptable. However, it is no longer opposed to the introduction of a short-range personal communications facility with power limitation, crystal control and type-approved apparatus on v.h.f. or u.h.f. The Society urges that this should not be within or close to any existing amateur allocation, but in a part of the spectrum sufficiently remote from any amateur frequencies as to discourage illegal operation of CB equipment in the amateur bands.

Here and there

1976 will long be remembered by v.h.f. and u.h.f. enthusiasts. Apart from the 10GHz 521km record (November issue) other notable contacts included Norfolk (G4BYV) to Sweden (SK6AB) on 1296MHz; East Suffolk (G3LQR) to Denmark (OZ90R) on 2.3GHz; Scotland (GM30XX/P) to Northern Ireland (GI30LK/P) on 10GHz. In the United States the use of "moonbounce" techniques has enabled Allen Katz, K2UYH, to gain the first-ever 432MHz "worked all continents" award (contacts over three years with C3LTF, VE7BBG, JA1VDV, ZE5JJ, VK2AMW and HK1TL) while Dick Hart, K0MQS, has completed a 7-year task of achieving the first "Worked All States" on 144MHz. There were also more California-to-Hawaii contacts on the 144MHz and the first USA to Bermuda contacts on that band. Unusual "openings" also occurred on 28MHz, not accountable by scatter or double-hop sporadic E, and usually in the evening rather than the noon peaking of m.u.f.

Lord Wallace of Coslany is being installed as the 1977 president of the RSGB on January 22 . . . F. J. ("Dud") Charman, G6CJ, made a big impact on Australian and New Zealand amateurs with his new 3.3GHz solid-state "aerial table" which he uses to demonstrate techniques from dipoles to circularly polarized helical aerials . . . Although most British amateur direction-finding contests are on 1.8MHz, the U.K. FM Group (London) recently held a successful 144MHz "fox hunt" won by M. H. Tooley, G8CKT in 1 hour 23 minutes. J. F. C. Johnson, ZL2AMJ, has suggested that there is need for a new "award" that does not show merely that an operator has had time on his hands. He wants to see one that combines operating skill, technical skill and experience and suggests that the award could be based on the ability to work the antipodes (e.g. Europe from New Zealand) "using a station of own design and construction". He feels this would show the recipients have enough technical knowledge to build a transmitter, receiver and aerial from scratch; enough code experience to obtain a full operating licence; and enough operating experience to put out an effective signal on the right frequency at the right time to achieve the ultimate "long distance" contact.

With the closing of the American "Milliwatt" publication, "Sprat" — the newsletter of the G-QRP-Club — appears to be the only specialist publication concerned exclusively with low power operation. One member, Bruno Settinger, OE1SBA, after working all continents with 2 watts s.s.b. from his home in Vienna is now concentrating on low-power mobile operation.

In the 1976 All-Asian Contest, c.w. section, participants are expected to indicate their age in the form of a "serial number". An analysis of the first 20 Asian stations heard indicated an average age of 29 years, with a range of 17 and 44 years.

Power f.e.ts

Over the past decade, amateur radio has been absorbing a large number of new semiconductor techniques such as small-signal f.e.ts, digital, linear c.m.o.s. integrated circuits, Schottky double-balanced diode mixers and the like. But of late it has seemed as though the pace of development of entirely new devices may have slowed down. However, this year has seen the appearance of vertical-structure power r.f. mosfets (such as the Siliconix VMP-1 and VMP-4 series) opening the way to greater use of mosfet devices in transmitters. Examples of designs using this approach include a transverter providing 10-watt p.e.p. output on 144MHz when driven by 1mW 28MHz ssb input (described in *Ham Radio* and using a pair of VMP-1 devices) and a broadband driver extending from 40 to 265 MHz using a single VMP-4 device (Siliconix note TA76-1 by Ed Oxner). These devices appear to have some useful advantages over bipolar rf power devices in not being subject to thermal runaway or secondary breakdown and having no minority carrier storage time. Apart from transmitter applications such devices also provide receiver front-end amplifiers of wide dynamic range and low noise.

The next OSCARs

Although the prospects for an early launch of the next phase of Amsat-Oscar satellites seem to have receded to 1979-80, a recent bulletin from Amsat-UK suggests four launch possibilities over the next few years: (1) the ITOS launch around June, 1977 may be able to carry an Oscar 6 type satellite; (2) the new National Space Translocation Systems (the new name for the "Shuttle" reusable vehicles) may be able to carry communications satellites into low orbit; (3) military synchronous communications satellite launches, although it is recognised that the problems presented by a truly synchronous satellite (particularly the need for good operating discipline) are formidable; (4) European "Ariane" launches from French Guiana.

Several active transposers are currently being planned or built, including a 21-to-29 MHz unit by the British group, although much work and experienced assistance is still sought; a Japanese "Jamsat" unit for 70cm to 2m has been built and is currently being tested on a mountain site; the highly sophisticated "Phase 3" long-life, high-orbit satellites with output powers of up to 50 watts p.e.p. for 70cm/2m and 2m/70cm are, as indicated earlier, unlikely to be launched before 1979-80.

RTTY — the easy way

The British Amateur Radio Teleprinter Group has been very active recently promoting more extensive use by amateurs of radio teleprinter techniques and has recently published an entirely new edition of a useful 32-page (plus parts list) booklet "RTTY — the easy way" by Brian Hodgson, G3YKB, with contributions from G2FUD, G3LLZ, G3NTT, G3VDB and W6FFC. This includes, a good deal of down-to-earth information on available surplus machines and the construction design and alignment of terminal units, afsk oscillators and fsk circuits, operating practices, some recommended further reading and a glossary of terms. Copies are available from Brian Hodgson, BARTG, 234 Gillingham Road, Gillingham, Kent (85p post free).

PAT HAWKER, G3VA

Letters to the Editor

CITIZENS' BAND IN UK?

One small organization campaigning vigorously for CB is the Citizens' Band Association, which advises its members to write to government ministers, Members of Parliament and magazine editors to presumably create the illusion that there is massive public support for CB. No doubt there are other vested interests doing the same thing. However, have any of these groups commissioned a proper, professional, unbiased survey to discover the true demand? If not, then on what evidence do they base their assumptions?

The proponents of CB suggest that cheap two-way radio would be an asset to hikers, mountaineers, bored or lost motorists, lonely people and those living in remote areas. As so succinctly reasoned by Mr Friel (September 1976 Letters) they could become radio amateurs with very little effort, thus having at their disposal a number of frequency bands and a network of v.h.f. and u.h.f. repeaters.

Crowd control and marshalling at public functions have been cited as instances where CB would be useful. At the numerous amateur radio mobile rallies and exhibitions in the UK, amateur radio operators often provide excellent "talk-in" for visitors. There is no reason why other organizers of fêtes and shows should not contact a local amateur radio club to invite them along to assist. It need not necessarily be an infringement of the licensing conditions to pass information about crowds.

A recurring theme is that a CB service in the UK would create big business for the British electronics industry. However, we should recall that in the mass market for radio, tv, hi-fi and amateur radio, foreign exporters have a king-size slice of the action. Even Mr Bryant, the president of the Citizens' Band Association, himself an employee of a large British electronics company, only names Japanese firms as potential suppliers (June 1976). As to cost, the prices of Post Office approved v.h.f. or u.h.f. transceivers are bound to be higher than those of comparable, single mode amateur products.

Let nobody fool themselves into thinking that the Home Office could take in its stride the processing of a large number of CB licences without a considerable increase in staff. Some time ago, the Radio Regulatory Division stopped the issue of a few special amateur callsigns and says it cannot contemplate the re-writing of the amateur licence for some time, due to pressure of work. One has visions of another white elephant like the Vehicle Licensing Centre in Wales being created.

Mr Jenkins (May 1976 Letters) stated it was not too costly to track down illegal operators. In many cases in the amateur bands, the identities of illegal operators or those breaking the rules are known. The problem is to catch them in the act and this can be very time consuming, all the more so if mobile stations are involved. One can envisage a huge increase in Post Office engineering staff to cope with similar situations on the CB band, in dealing with both deliberate and unintentional interference. It would be revealing to learn if the Home Office has looked into the costs overall of licensing and monitoring say, half a million CB sets, all over the realm.

So far in this correspondence, the question of law and order has not been mentioned in the CB context. There can be no disputing that many crimes can be more effectively perpetrated if two-way radio is used. At present, any non-uniformed person using a walkie-talkie is regarded with curiosity and suspicion. Should the use of walkie-talkies become commonplace, the police could be at a disadvantage in spotting and preventing a wages snatch, for example. Furthermore, it is inconceivable that the military and police forces in Ulster should be faced with this situation.

Perhaps it is time that those who oppose CB in the UK, for whatever reason, formed an association as vociferous as those supporting the idea. Meantime, they should adopt the advice the CBA gives to its members and bombard MPs, ministers, magazine and local paper editors with letters opposing CB by reasoned argument in reply to any published support for it.

Norman Fitch,
Purley,
Surrey

SHORTWAVE BAND CONGESTION

As an h.f. user, may I be permitted to comment on Jim Vastenhoud's article in the November issue? His solution appears to be based on the long-established creed of expansionism: if something you have is running out, go out and grab someone else's instead of making the best use of your own resources. A glance through a list of broadcasting stations is enough to indicate that a few organisations in particular use several frequencies in the same band for the same broadcasts, and a listen across the bands will verify this.

Accepting, reluctantly, that the majority of current stations will continue, there is still an important factor in the inefficiency of s.w. broadcasting. Seventy-five per cent of the information and fifty per cent of the frequency-space of an a.m. signal is redundant and in a lot of cases is detrimental because of selective fading. It must not be beyond the skills of the manufacturing companies to produce and market cheap, reasonable equipment for h.f. s.s.b. reception. And once that step has been taken, it cannot be beyond the budgets of government propaganda departments to convert a.m. transmitters to cope with s.s.b. This will immediately lighten the pressure on h.f. broadcasting allocations by about a third.

I also feel concerned about the wish of the broadcasters to remove restrictions in the use of the 41m broadcasting band. The 40m amateur band is in a bad enough state with Radio Tiranë and Radio Pekin every 10kHz in the world-wide section and European stations "illegally" beaming to the Americas above 7.1 MHz, but to allow broadcasting stations, now, to beam to America is likely to increase friction between two traditional h.f. users.

Mr Vastenhoud hopes that the broadcasters can settle their differences by WARC 1979. I hope they do. I also hope that the broadcasters, amateurs, aeronautical and maritime services and the various security services can settle their differences, and if not before 1979 then at least I hope they won't turn the conference into a slanging and grabbing match.

P. V. Rose, G3ZZA,
Manchester

PHASE AND SOUND QUALITY

I write in response to the letter from Paul Furindle in the July issue. Mr Furindle described an experiment in which he listened to two tones nearly an octave apart and was unable to hear beats. He conducted the experiment to see if his ear could tell the difference as the phase relationship between two sinusoids changed. He reported a negative result except when gross intermodulation was deliberately caused "by introducing a diode across the loudspeaker terminals."

I was interested in, and concerned by his negative result, particularly as he tried it at "various levels and ratios of level."

In a paper in the *Journal of the Acoustical Society of America* in September 1954, entitled "Onset and growth of aural harmonics in the overloaded ear," M. Laurence and P. A. Yantis describe a very similar experiment. Their aim was to measure distortion in the ear by listening for beats between a harmonic born of aural distortion of a low frequency note. They found that the beats were detectable over a wide range of "levels and ratios of level" indicating that there is significant distortion in the ear detectable at sound pressure levels as low as 60dB.

These results seem to be very significant to the high fidelity enthusiast. What's the point in setting up a system that can go to 115dB s.p.l. without significant distortion if your little pinkies are going to muck it all up?

Another hint that aural distortion is significant was picked up by a local audio engineer who was given the task of eliminating some gross distortion in the sound system during the run of the rock opera "Hair" in Melbourne. He fixed the distortion, but arranged for the levels to be as before, only to find that some of the teenage audience found the comparatively distortionless signal to be "not loud enough." It appears that distortion in low level signals reminds us of the aural distortion we experience with louder ones, and makes us think the sound we hear is louder than it is.

The moral appears to be: Unless you have distortionless ears of the "Furindle type", listen to reproduced music at the same level that you would hear it in real life. Perhaps "loudness" controls should add distortion as well as bass and treble boost at low settings.

R. Schürmann,
Hawthorn East,
Victoria,
Australia.

THE VU METER

In his article "Low-noise, Low-Cost Cassette Deck" (May 1976) Mr Linsley Hood describes a "VU meter." It is clear from the description that the device concerned is very far from being a VU meter, particularly in respect to its impedance and ballistic response. It could properly be referred to as a "recording level meter" or "level indicator," but never as a "VU meter."

A VU meter has its properties rigorously defined by the relevant American Standard, and it is very bad practice to use this name for signal level indicators which do not meet that standard. While it is to be deplored that commercial organisations are regularly guilty of this mistake, it is tragic that a quality journal such as *Wireless World* either does not know what constitutes a VU meter, or does not bother to ensure that the term is used correctly.

It is ironic that this apparent carelessness occurs in the issue with an editorial headed "Plain words to the word-bound."

E. G. Warren,
West Ryde,
N.S.W., Australia.

SURROUND SOUND

In his review of the Harrogate exhibition (November issue) J.T.D. mentioned the decline and possible demise of four-channel sound. In the scramble for recognition of alternative surround sound systems, I wonder if adequate consideration has been given to priorities among the various requirements.

Excessive emphasis has been placed on the exact positioning of individual sound sources and their distribution completely around the listener, while neglecting far more important factors such as clarity and cleanness of sound, depth perspective and natural reverberation.

The advantage of 60° stereo over mono is that it separates individual sources from each other and from the reverberation. For small groups of performers it would be quite adequate provided the reverberation was extended to 360°. For large orchestras, big bands and particularly choral music, opera and drama an extended spread of sound images to 180° would be a considerable advantage and quite adequate provided full use was made of depth perspective and 360° of reverberation. The further spread of sound images to 360° would only give a marginal, if any, advantage.

The problem with two-channel matrices is in getting a satisfactory compromise between relative phase shift; evenness of sound image distribution; cross-talk and compatibility.

The relative phase shift between speakers has no great significance for reverberation as it has random phase. On the other hand, if sound images have too much relative phase shift between speakers and image becomes blurred and less distinctive from the reverberation, listening position and other factors which influence phase become more critical; compatibility deteriorates; positional distribution and balance are affected.

If the principle of restricting sound images to 180° in the front sector while allowing 360° of reverberation could be accepted, a two-channel matrix could be chosen, which should have relative phase balance between right and left. The whole of the front sector could then be shifted in relative phase after encoding to provide optimum phase conditions for compatibility. If required the incoming signal would again be shifted in relative phase to provide the conditions required for decoding each of the four output channels. After decoding the four output signals would be finally adjusted in relative phase to provide optimum subjective results for images in the front sector.

Such a system could give a better combination of performance and compatibility than any two-channel full surround system.

Although at the time of writing the BBC have not yet published details of their "H" matrix, if one may assume that the "H" refers to the shape of its relative phase/relative amplitude characteristic, then it would probably be an ideal matrix for the suggested purpose.

D. Kirkman,
Ifield,
Crawley.

Editor's note: The H matrix was described in a BBC Research Department report dated November 1974.

ADVANCED RADIO MONITORING

Those of your readers who have ever been interested in h.f. surveillance, either professionally or as amateurs (for amateur radio has much in common with this facet of communications), will have read "Advanced radio monitoring" (November 1976) with great interest – but a little sadness and puzzlement.

It is no criticism of this interesting computer-enhanced system to regret that according to the authors, h.f. surveillance has become if only in part "a soul destroying, time consuming and very boring task." Or to wonder how it becomes less so by taking away from the operators the responsibility for tuning to the correct frequency at the correct time with the correct aerial etc.

In the wartime days when "ultra" and "pearl" and the intercept stations and voluntary interceptors feeding Bletchley Park – as revealed in recent books – made a significant contribution to military intelligence, such work was not usually regarded as particularly "soul destroying" but rather an interesting, often exciting, responsible and highly skilled form of radio operating. If it has since become "boring" then may not that be a question of how the work is organised and rewarded, and whether the operators are able to feel that they are not just human-computers still carrying out those functions for which the computer proper is unsatisfactory: signal identification, knowledge of h.f. propagation and the ability to read bad morse from a possible drifting, weak, fading and interfered-with signal?

The work of Geoffrey Perry and his team of schoolboys at Kettering Grammar School is a recent example of how much information can be obtained by diligent monitoring and the intelligent evaluation of results, using just the basic tools of the trade to unravel much information about the Cosmos space satellites.

The authors state "the existing pool of highly skilled operators has begun to dry up and it is proving difficult to find replacements." This may well indeed be true, not only for surveillance but for other forms of radio operating. This is the inevitable result of many years of neglect and down grading in this country of the skills of manual telegraphy and the radio communicator, and the long-term efforts of industry to de-skill all such systems, rather than to encourage the use of human as well as electronic skills.

This is very far from suggesting that surveillance, and other forms of radio communication, should not take full advantage of modern technology, as in CERES. But rather it is a mild protest at the implication that h.f. c.w. reception or monitoring is necessarily any more "boring, time-consuming or soul destroying" than computer operating.

Pat Hawker,
London SE22.

CITIZENS' BAND IN THE USA

In my Letter from America in the September issue, I said "the average CB mobile transceiver has 23 channels selected by a rotary switch and it would most likely use four crystals in a synthesis circuit." This should read "fourteen crystals" and the extra "synthesized" frequencies are obtained by heterodyning two crystals together to produce a third frequency. Some designers use only 11 crystals — a triumph of ingenuity! However, the more recent models with p.l.l. circuitry need only 3 or 4 crystals and those now at the drawing board stage designed for use with the Siemens S187 digital frequency synthesizer require only a single crystal — which make the makers of these items very unhappy.

G. W. Tillett,
Seminole,
Florida, USA.

HARROGATE SOUND DEMONSTRATION

Contrary to your statement that Sansui were demonstrating four-channel equipment through two speakers, in the article "Alive and just kicking," in the November issue, I would point out that at the Harrogate exhibition we did not in fact demonstrate any four-channel equipment, due to the limitations on space available. Most people would agree that an area of 10 ft by 18 ft would not allow adequate definition of position to warrant demonstration to the public.

We therefore demonstrated our stereo equipment only. The four-channel equipment was on show only and not in use.

Peter Gibson,
Vernitron Ltd
Southampton

Correction

In the article by J. H. Cook on the Remote Control Servo published in our December issue a number of errors appeared. Fig. 2 and 4 became transposed and line 9 of the centre column of page 60 should read "the conditions in Fig. 2 prevail". The caption to Fig. 4 should refer to I_3G_2, not C_2.

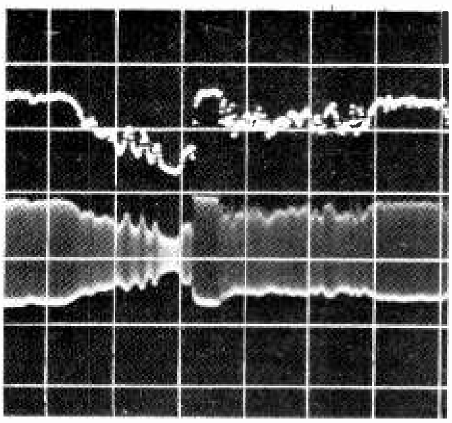
Weather-satellite picture facsimile machine — 2

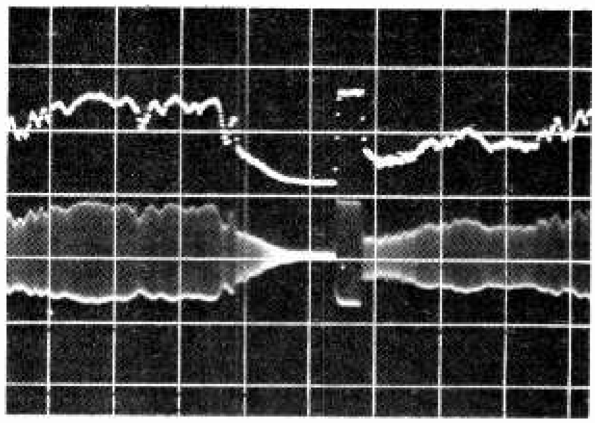
Sample-and-hold detector and line dividers

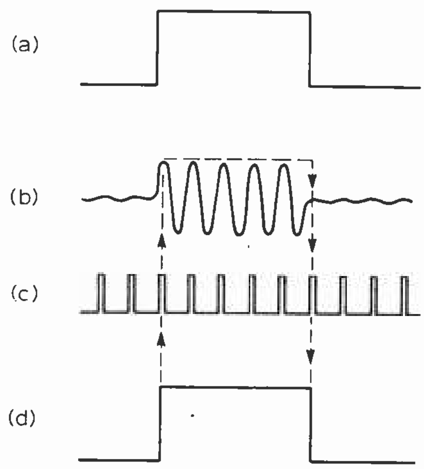
by G. R. Kennedy

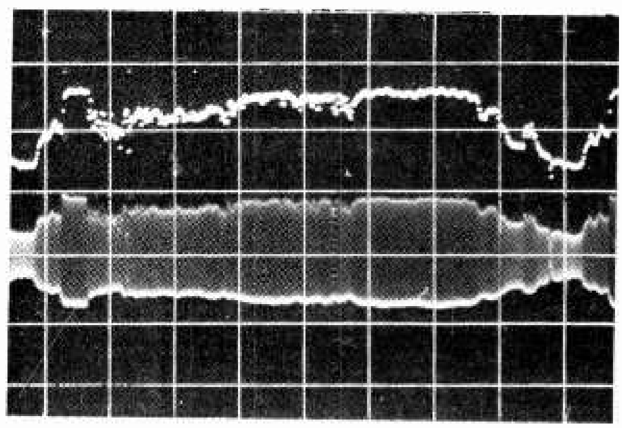
Video detector and amplifier. Unlike the case of modulating an oscilloscope c.r.t., as described in the previous article[4], the 2.4kHz signal cannot be applied directly to the light source because the light beam needs to be bright for a low signal and dim for a high signal to give a positive print. A conventional diode-capacitor detector has a certain inherent time constant, but to demodulate a 2.4kHz signal, this would need to be rather long. The sample-and-hold detector used in this machine has a time constant or integration period of one cycle of the 2.4kHz waveform and can virtually change from a low to a high modulation level in one cycle. Its bandwidth then extends from zero to approximately the carrier frequency. Although a little complex to arrange, it is an ideal detector for relatively fast modulation of a slow carrier. The principle is shown in Fig. 6. A modulating waveform is applied to a carrier and the resulting modulated carrier is sampled at each peak. The amplitude of each sample is held until the next sample, which then holds that value, and so on. Assuming the settling time of the holding circuit is very short, then even with a slow carrier a squarewave demodulated waveform is possible. In practice the settling time will not be infinitely short and there will be some leak or droop of the holding level from one peak to the next. However, the frequency response of this type of demodulator is much higher than that of the simple diode-capacitor detector. Fig. 6 shows actual sample-and-hold detector waveforms.

Fig. 6. Diagrams show the basic principle of the sample-and-hold detector, see text. (a) – original modulating waveform. (b) – modulated carrier. (c) – sampling pulses. (d) – idealized demodulated waveform. Photographs show actual detector waveforms. Upper traces are from the light source monitor (200mV/div. inverted). Lower traces show the 2.4kHz modulated carrier input (5V/div.) Horizontal scale is 30ms/div.









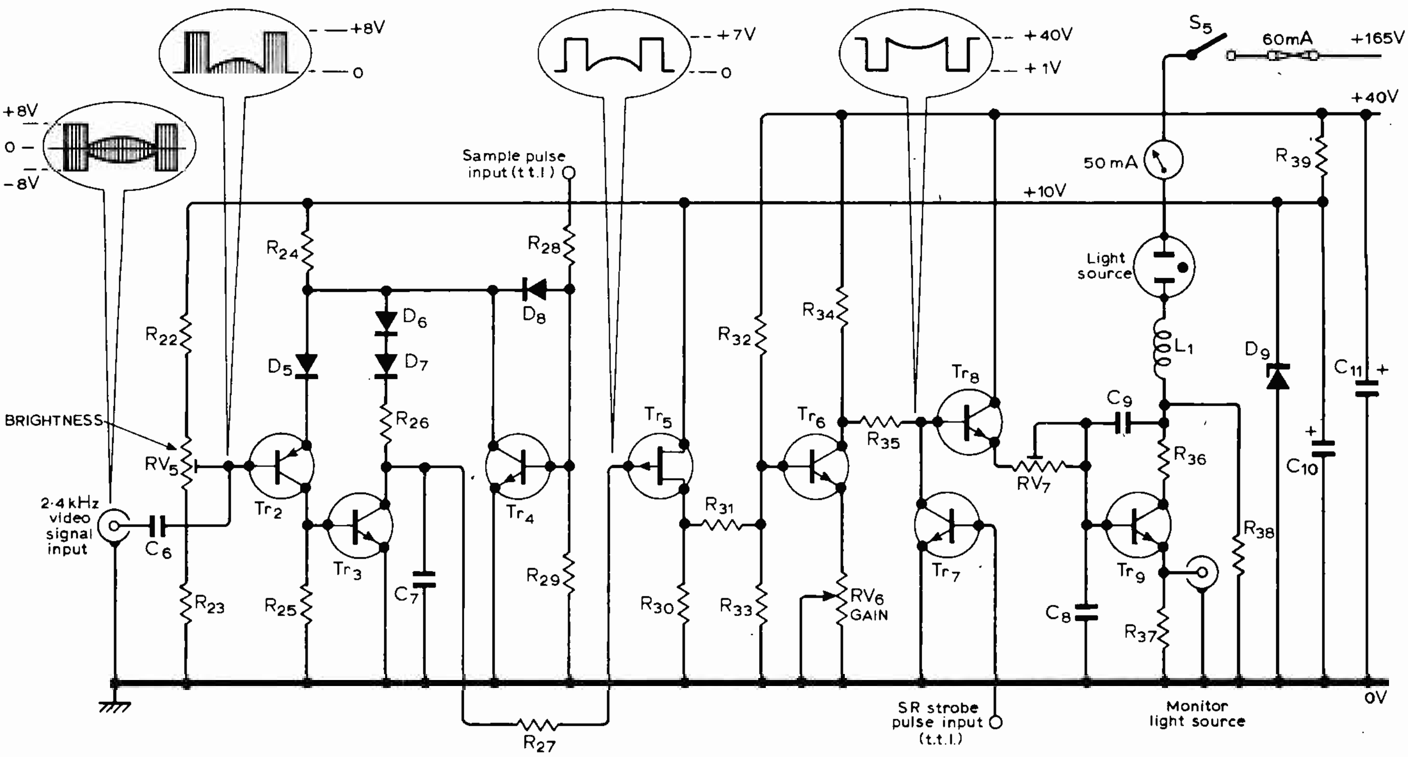


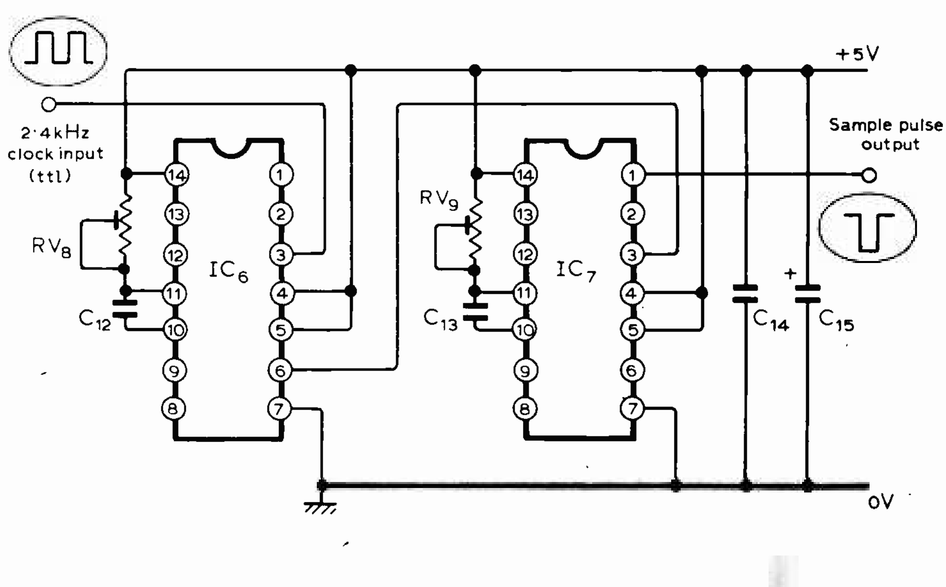
Fig. 7. Sample-and-hold detector and light-source drive amplifier. S5 is the crater tube on/off switch.

The detector circuit and the following amplifying stages are given in Fig. 7. The 2.4kHz input signal is applied to the sample-and-hold section Tr_2, Tr_3, Tr_4 (Ref. 7). Tr_2 and Tr_3 form a voltage follower which drives the store capacitor C_7. The input bias network R_{22}, RV_5, R_{23} set the zero input following level and in practice set the brightness level of the final picture. Tr_4 is a switch which, when off, allows Tr_2 and Tr_3 and hence C_7 to follow the input voltage. When Tr_4 turns on due to a positive sample pulse via R_{28}, diodes D_5, D_6 and D_7 reverse bias; Tr_2 turns off, turning Tr_3 off isolating C_7. If the internal and external leakage paths of C_7 are of high resistance and the holding period is not long, the voltage across C_7 will remain virtually constant until the next input voltage following period. Since the circuit driving C_7 has a low output impedance, it is capable of conducting a high current in and out of C_7, and therefore the circuit is able to rapidly follow changing sampled levels. Diode D_5 ensures that the input transistor base-emitter voltage is not exceeded when Tr_4 switches on: D_7 balances the forward voltage drop of D_5. D_8 is a speed-up diode to stop Tr_4 saturating during fast following. The maximum input signal is approximately 9Vpk-pk. The sampled voltage on C_7 is followed by the very high input impedance stage Tr_5 and voltage amplified by Tr_6. Transistor Tr_9 is the light source modulator which is current driven by the d.c.-coupled emitter follower Tr_8. The gain is set by the un-decoupled 50Ω 10-turn potentiometer RV_6 in the emitter of Tr_6, and the maximum safe drive to the light source is set by RV_7 in the base feed to Tr_9. C_8, C_9, R_{36} and L_1 prevent high-frequency ringing of the light source signal, and the transistor by-pass R_{38} provides a "keep-alive" path for the light source, once struck. The light source current is monitored by a 50mA meter in series with its supply, and is protected against mishap by the 60mA fuse F_1. This has appreciable resistance and forms a small resistive collector load. The light-source modulating waveform is monitored across the 10Ω resistor R_{37} in the emitter line of the output transistor Tr_9. Tr_7, which is a shunt switch controlled by the t.t.l.-level strobe pulse, keeps the light source at very low drive during the off period, when it is fully on, and allows light source modulation during the strobed-on period. The 40V supply which is used for the later stages is dropped by R_{39} and partially stabilized by D_9 and C_{10} to form a +10V supply for the input stages. The light source supply is + 165V and Tr_8 and Tr_9 have very high voltage ratings to allow for all contingencies.

Since a positive print is required from the bromide paper – itself a reversing medium – the sample-and-hold detector and light-source drive circuit reverse the sense of the signal modulation. A high (white) signal virtually cuts off the light beam, whereas a low (black) signal turns the light source fully on. Typical waveforms are shown on the circuit diagram.

The **sample-pulse generator,** see Fig. 8, uses two integrated circuit monostable chips. Monostable IC_6 is triggered by the 2.4kHz clock-rate signal, producing a delay pulse, the duration of which is

Fig. 8. Sample pulse generator.



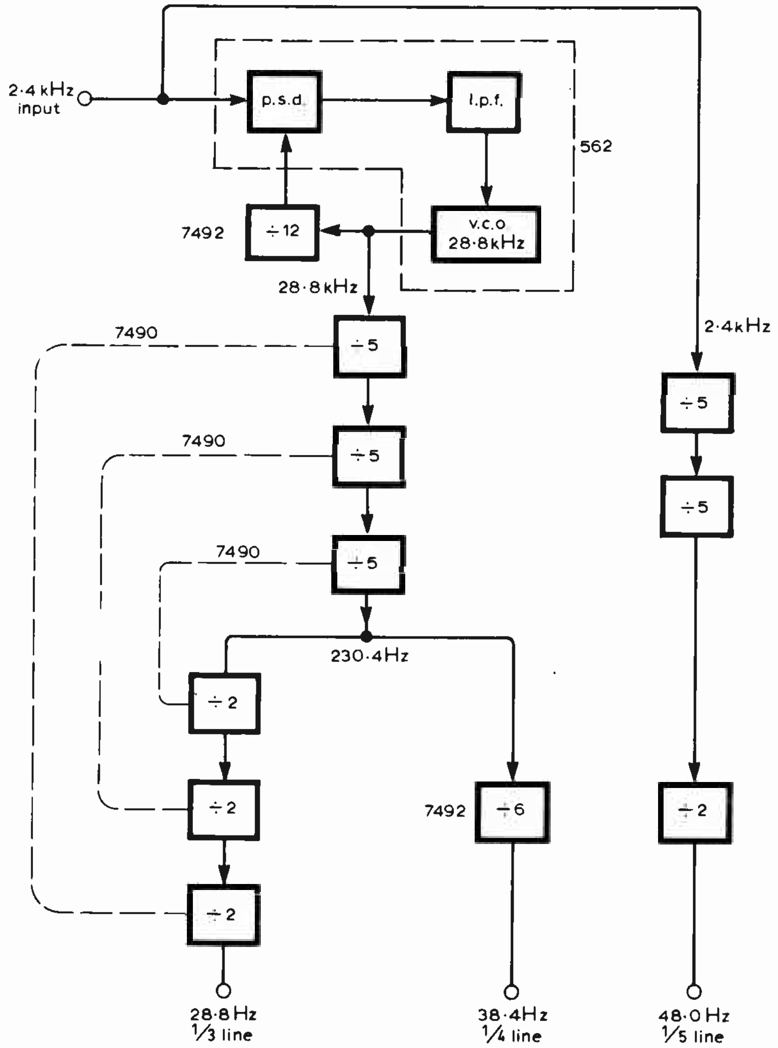


Fig. 9. Block diagram of SR line divider. Divide-by-5 and divide-by-2 dividers are paired, each pair being derived from a 7490 i.c.

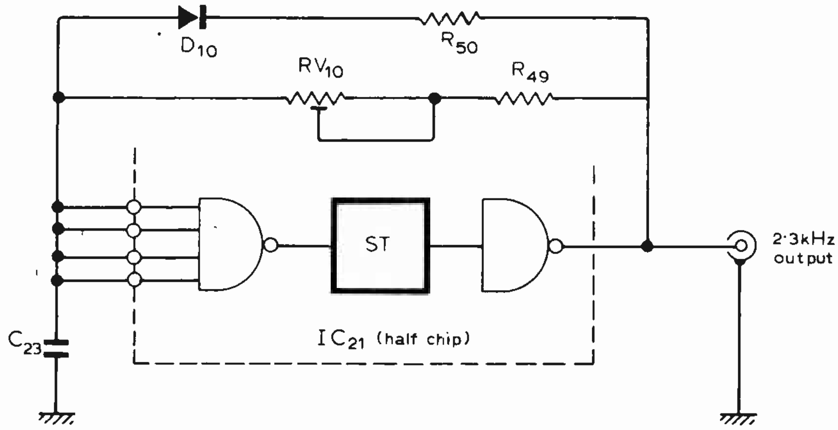
set by RV_8 and C_{12}. The trailing edge of this pulse triggers IC_7, which produces the sample pulse, the duration of which is set by RV_9 and C_{13}, from the Q output terminal. The supply rail is decoupled by C_{14} and C_{15} to prevent power supply transients from falsely triggering the monostables.

A low frequency drive for the drum and traverse motors is generated by the **SR Line divider**. The drum rotation is then locked to each SR line so that 1/3, 1/4 or 1/5th of the line is printed, according to the setting of the line division switch. The traverse is driven from the same frequency as the drum so that the correct aspect ratio (index of co-operation) of the final picture is maintained. Drive frequency generation for the 1/3 and the 1/4 lines is difficult to arrange since a simple division of the satellite sub-carrier or clock frequency of 2400Hz is not possible. For a synchronous drum motor giving 240rev/min at 48Hz drive, one drum revolution takes 250ms, which is 1/5th of an SR line period. For the same motor, the frequencies are 28.8Hz for the 1/3rd line and 38.4Hz for the 1/4 line. Fig. 9 shows how these rather awkward frequencies are produced so that SR picture magnification can be achieved. A phase-lock-loop, with a 28.8kHz v.c.o., is arranged with a divide-by-12 circuit inserted in the loop between the v.c.o. and the phase-sensitive detector (p.s.d.). This compares the phase of the divided oscillator with the clock signal and keeps the v.c.o. phase-locked to the clock frequency. The 28.8kHz v.c.o. frequency is divided by 125 giving 230.4Hz, which is then divided in parallel by 8 and 6 to give 28.8Hz and 38.4Hz for the 1/3 and the 1/4 lines respectively. The 1/5 line frequency is obtained by simple division of the 2.4kHz clock signal by 50. Details of the 1/3 and 1/4 line division circuitry are shown in Fig. 10(a). C_{16} couples the clock signal to the phase-lock-loop chip IC_8. The v.c.o. output at 28.8kHz is buffered to t.t.l. level by Tr_{10} and taken via C_{22} to IC_9, the divide-by-12 stage, and via C_{22} to IC_{10}, one of the divide-by-10 chips. The divided signal, at 2.4kHz, is fed back to the loop via C_{21} to the p.s.d. These are arranged as a divide-by-5 and a divide-by-2 on each chip. The divide-by-5 output of IC_{10} is connected to the subsequent stages in IC_{11} and IC_{12} and the 230.4Hz thus obtained is then passed through the divide-by-2 stages in IC_{10}, IC_{11} and IC_{12} to give the 1/3 line 28.8Hz output from IC_{12}. The 230.4Hz is also divided by 6 in IC_{13} to give the 1/4-line 38.4Hz output. Since the final stages of both IC_{12} and IC_{13} are bistables, the outputs are square waves of equal mark-space.

The 1/5th line division circuit is shown in Fig. 10(b). Here, an alternative divide-by-5 circuit is shown, which can also be used in the previous section if more convenient. It uses two synchronous modulo-5 unweighted up-counters, IC_{14}, IC_{15} and IC_{16}, and IC_{17}, IC_{18} and IC_{19}, and a divide-by-2 toggle IC_{20}. It is shown in generalised form for utilizing any cheap surplus J-K flip-flop integrated circuits. The feedback of each modulo-5 counter modifies the count of the three bistables to give 5 instead of 8. As before, the final stage gives a 1:1 mark-space ratio square wave. It should be noted that the 1/5th line 48.0Hz output is used when printing APT and WEFAX.

Picture slip oscillator. A square-wave signal is generated, which can be switched into the motor drive chain divider to give a slightly different drum rotation speed for setting the picture edge position. The signal cannot be derived from the 2.4kHz clock signal since servo action of the whole circuit

Fig. 11. Picture slip oscillator. A squarewave signal generator which, when switched into the motor drive chain divider, may be used to adjust the drum rotation speed for setting the picture edge position.



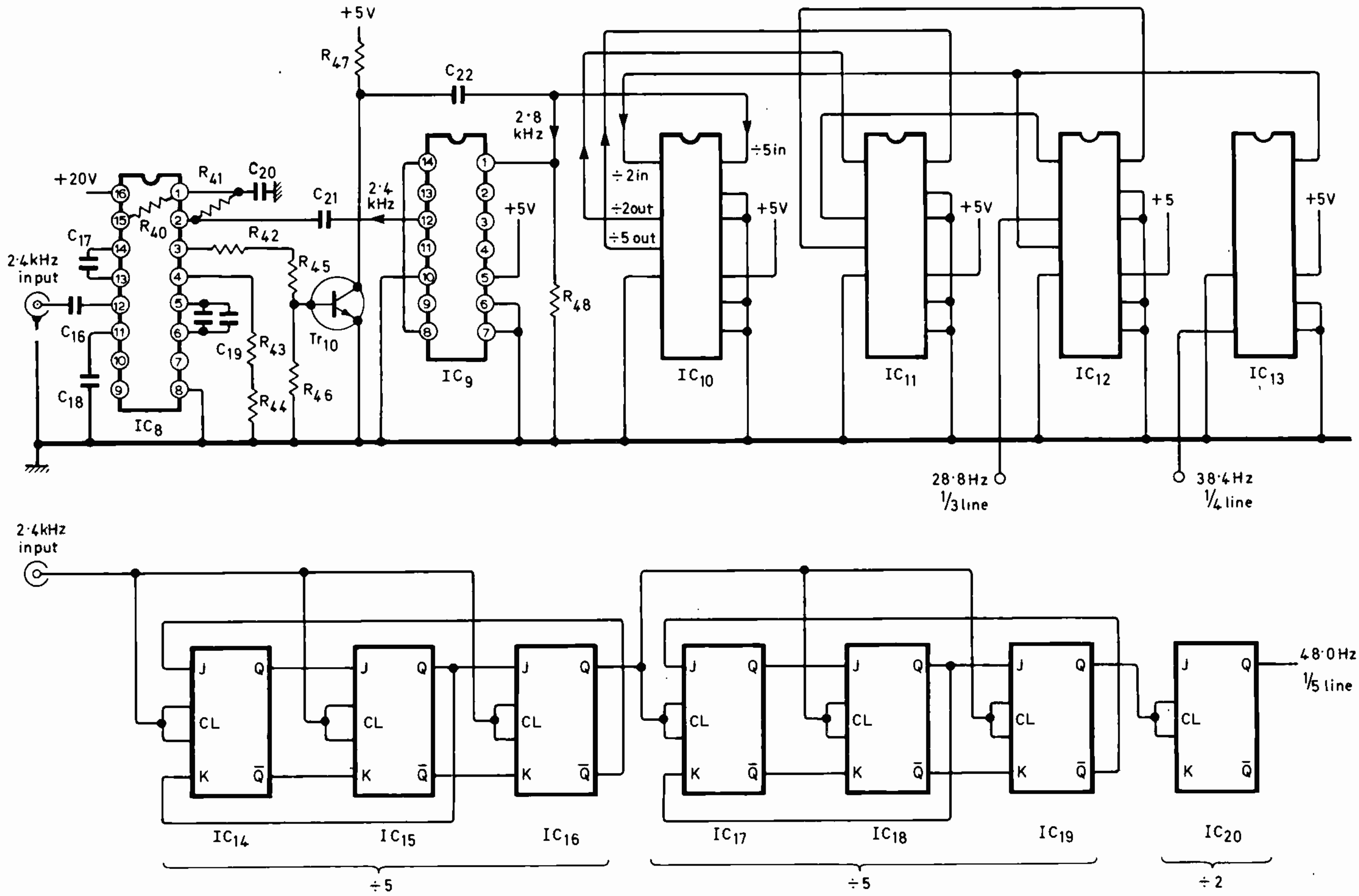


Fig. 10. Top – SR line divider for 1/3 and 1/4-line division. Bottom – SR line divider for 1/5-line division.

keeps the drum locked to the picture, wherever the edge happens to be. Almost any multivibrator would be adequate, with fine adjustment to bring the frequency near to 2.4kHz. A suitable circuit, given in Fig. 11, uses half a dual Schmitt trigger i.c. as a feedback square-wave oscillator. The action is as follows: assuming the output of the Schmitt trigger to be high, C_{23} charges through R_{49} and RV_{10} until the voltage across it equals the Schmitt rising trigger level and the circuit switches turning the output low. The potential across C_{23} falls until the falling trigger level is reached, when the circuit switches and the output goes high again, and so on. Diode D_{10} prevents the circuit from being reverse biased at the moment of switching, and also ensures that the output has an approximately 1:1 mark/space ratio. The frequency is determined by the time constant of C_{23}, R_{49} and RV_{10}.

Correction
In the list of capacitors, published last month, C31 should be 0.1μF not 2μF/25V as stated.

CRANFIELD AUDIO WEEKEND

Wireless World, in association with the Cranfield Institute of Technology, will be holding an Audio Weekend at the Institute on Saturday, 1st and Sunday, 2nd April, 1978. Designed for those involved in the manufacture, sale and use of the highest quality audio equipment, the event will make use of the unique resources of Cranfield, the national postgraduate university for advanced technology and management. The programme will cover the complete sound reproducing chain, turntables, arms and cartridges, amplifiers and tuners, loudspeakers, tape cartridge and cassette recorders, microphones and headphones and programme sources.

- *Lectures and demonstrations will be given by internationally known experts. A live versus recorded sound demonstration will form part of the programme. An associated exhibition of equipment will run throughout the weekend and delegates will have full opportunities to assess and inspect equipment and to discuss their requirements with experts, not only during formal sessions but informally.*
- *A special social programme will include a recital of discs and tapes, a "live" musical recital and a buffet dance. Also planned is a non-technical alternative ladies' programme.*
- *All meals and refreshments will be provided and will be included in the fee. Limited accommodation in single study bedrooms will be available at Cranfield for an additional charge.*
- *Cranfield is in a pleasant country situation mid-way between London and Birmingham, ten miles from Bedford. It is four miles from the M1 motorway, and is approached from junction 13 or 14.*
- *The Cranfield Audio Weekend provides a unique opportunity to study in a perfect environment the present and future of sound reproduction. If you are interested in participating, please write to the following address and full details will be sent to you as soon as possible:*

The organisers, CRANFIELD AUDIO WEEKEND, IPC Business and Industrial Training Limited, Surrey House, Throwley Way, Sutton, Surrey SM1 4QQ. (Tel. 01-643 8040.)

Logic design

1 — Boolean algebra and Karnaugh maps

by B. Holdsworth and L. Zissos *Chelsea College, University of London*

Up to 1969, when the Boolean sequential equations were developed, the design of sequential circuits was achieved through an empirical choice of unrelated informal techniques paying little attention to engineering constraints until, in most cases, the implementation stage. The advent of the sequential equations has made possible the development of clear-cut step-by-step design procedures in which realistic circuit constraints are taken into account at the design level. No engineering or other specialist knowledge is necessary to use these design procedures.

The design philosophy adopted in this series is one that allows the emphasis to be placed on optimal rather than minimal design. This is to enable technicians, users with no specialist knowledge of electronics, and the less experienced designer, to produce sound and economical designs, while at the same time providing the means whereby the specialist designer may improve his technique in dealing with more sophisticated assemblies involving such devices as r.o.ms, r.a.ms, microprocessors, and so on.

The primary design objective is to produce sound and reliable digital systems which are meaningful not only to the designer but also to the user.

Basic concepts

As in conventional algebra, so in Boolean algebra variables are combined into expressions with operators that obey certain laws. The Boolean variables, denoted by letters of the alphabet such as A,B,C etc., are binary variables and may assume one of two values, 0 or 1, or they may be alternatively read as 'false' and 'true' respectively. They are not the 'zero' and 'one' of arithmetic and the operations that can be performed on them are somewhat different and more limited than the normal arithmetical processes.

Although there exists a wide number of Boolean operators, such as NAND, NOR, etc., we need only consider three operators at this stage — all other operators can be expressed in terms of these three. They are:

- Boolean addition,
- Boolean multiplication,
- Boolean inversion.

The addition operator is written as + and may be interpreted as 'OR'. $A+B$ may be read 'A or B' or 'A plus B'. It is true if either A is true or B is true or both are true, otherwise it is false. Thus,

$$0+0=0$$
$$0+1=1$$
$$1+1=1$$
$$1+0=1$$

The multiplication operator is written as . or ×, or omitted when its factors are variables denoted by single letters, and may be interpreted as 'AND'. A.B (or AB) may be read 'A and B' or as 'A times B'. It is true if A and B are both true, and false otherwise. Thus,

$$0\times0=0$$
$$0\times1=0$$
$$1\times1=1$$
$$1\times0=0$$

The inversion operator is written as a bar over the variable and the bar may be interpreted as "NOT". For example, $\bar{A}$ may be read as "NOT A".

$$\text{If } A=1 \quad \text{then } \bar{A}=0$$
$$\text{and if } A=0 \quad \text{then } \bar{A}=1$$

Boolean theorems

Redundancy.

$$A+AB = A$$

Fig. 1. The redundancy theorem implemented in a relay circuit. From the three relays giving $f=A+AB$ is derived the single-relay circuit giving $f=A$, since AB contains A and is therefore redundant.

$$\begin{aligned}\text{Proof:}\quad A+AB &= A.1+AB\\ &= A(B+\bar{B})+AB\\ &= AB+A\bar{B}+AB\\ &= AB+A\bar{B}\\ &= A.1\\ &= A\end{aligned}$$

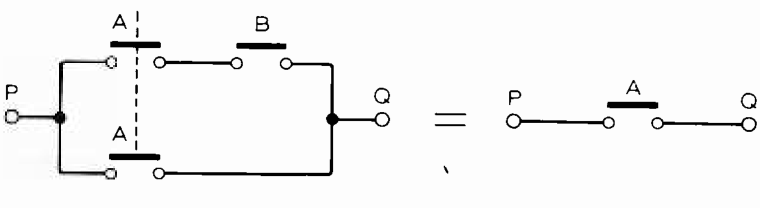
This theorem states that in a sum-of-products Boolean expression, a product that contains all the factors of another product is redundant. As a consequence it allows the elimination of redundant products in a sum-of-products expression. For example, in the Boolean function $f=AB+ABC+ABD$, the products ABC and ABD can be eliminated, because each contains all the factors present in AB.

The application of this theorem to a relay circuit is shown in Fig. 1.

Race-hazards. The main interest of the logic designer in this theorem is in its use in logic circuits for the suppression of race-hazards, which result in the generation of unwanted spikes. For example consider the Boolean function $f=AB+\bar{A}C$. Following changes in A, there is a race-hazard when $B=1$ and $C=1$, since the function then reduces to $f=A+\bar{A}$. The use of an inverter to generate $\bar{A}$ from A implies a delay between the waveforms of A and $\bar{A}$ as shown in Fig. 2. This leads to the generation of a transient signal as indicated in the same diagram.

The unwanted transient can be averted by the introduction of an optional product, that is a Boolean product whose presence in an expression does not affect the value of the Boolean function. A suitable optional product for the function $f=AB+\bar{A}C$ is formed by taking the product of the coefficients A and $\bar{A}$.

Hence, $\quad AB+\bar{A}C = AB+\bar{A}C+BC$



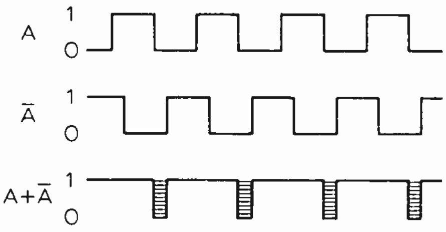


Fig. 2. A race hazard. $\bar{A}$ is obtained by inverting A and is subject to a delay, resulting in the interval during which neither $\bar{A}$ nor A is 'up.' The output $f=A+\bar{A}$ is therefore not true, or 'down' during this time.

Proof: $AB+\bar{A}C+BC$
$$=AB+\bar{A}C+(A+\bar{A})BC$$
$$=AB+\bar{A}C+ABC+\bar{A}BC$$
$$=AB(1+C)+\bar{A}C(1+B)$$
$$=AB+\bar{A}C$$

The product BC is optional so long as its parent products, AB and $\bar{A}C$ remain in the expression. Should, however, one of its parent products be eliminated (by applying the redundancy theorem), then such a product is no longer optional and cannot be removed from the expression.

If now $B=C=1$ the expression $f=AB+\bar{A}C+BC$ reduces to $f=A+\bar{A}+1$, which always has the value 1 irrespective of the values of A and $\bar{A}$.

The use of optional products will now be demonstrated with the aid of three examples.

(1) **Elimination of parent product.**
$$f=A+\bar{A}BC,$$

Form the optional product BC:
$$f=A+\bar{A}BC+BC,$$
Eliminate parent product $\bar{A}BC$ using theorem of redundancy:
$$f=A+BC.$$

(2) **Elimination of non-parent product.**
$$f=AB+\bar{A}C+BCD$$

Form the optional product BC:
$$f=AB+\bar{A}C+BC+BCD.$$
Eliminate non-parent product BCD using theorem of redundancy:
$$f=AB+\bar{A}C+BC.$$
But BC is an optional product and is redundant, hence
$$f=AB+\bar{A}C.$$

(3) **Elimination of non-parent product and parent product.**
$$f=AB+\bar{A}BC+BCD$$

Form the optional product BC:
$$f=AB+\bar{A}BC+BCD+BC.$$
Eliminate non-parent product BCD and parent product $\bar{A}BC$ using theorem of redundancy:
$$f=AB+BC.$$

De Morgan's theorem. The complement of a Boolean expression can be obtained by replacing each variable by its complement in the corresponding dual expression. For example, the dual of $f=A+BC$ is obtained by replacing the operator + by . and vice versa.

Hence the dual expression is
$$f_D=A(B+C)$$
and
$$\bar{f}=\bar{A}(\bar{B}+\bar{C})$$
that this is so can be confirmed with the aid of a truth table as shown in Fig. 3. Examination of columns 8 and 10 of this table show that $\bar{A}(\bar{B}+\bar{C})$ is the complement of A + BC.

A	B	C	$\bar{A}$	$\bar{B}$	$\bar{C}$	BC	A+BC	$\bar{B}+\bar{C}$	$\bar{A}(\bar{B}+\bar{C})$
0	0	0	1	1	1	0	0	1	1
0	0	1	1	1	0	0	0	1	1
0	1	0	1	0	1	0	0	1	1
0	1	1	1	0	0	1	1	0	0
1	0	0	0	1	1	0	1	1	0
1	0	1	0	1	0	0	1	1	0
1	1	0	0	0	1	0	1	1	0
1	1	1	0	0	0	1	1	0	0

Fig. 3. The truth table shows that $\bar{A}(\bar{B}+\bar{C})$ is the complement of A + BC.

Example. Find the complement of $f=A(BC+\bar{B}\bar{C}+BCD)$.

Apply redundancy
$$f = A(BC+\bar{B}\bar{C})$$
dualise: $f_D=A+(B+C)(\bar{B}+\bar{C})$
invert: $\bar{f}=\bar{A}+(\bar{B}+\bar{C})(B+C)$
$$\bar{f}=\bar{A}+B\bar{C}+\bar{B}C$$

Fan in. This theorem has its application in those logic circuits where there is a fan-in restriction placed on the designer by the availability of gate inputs. This matter will be dealt with more fully in a later article.

It is frequently convenient, when multiplying out two Boolean sums to refer to one section of the sum as its head, H, and to the remaining section as its tail, T. The statement of the theorem then is:
$$(H_1+T_1)(\bar{H}_1+T_2)=H_1T_2+\bar{H}_1T_1$$

Proof: l.h.s. $=(H_1+T_1)(\bar{H}_1+T_2)$
$$=H_1\bar{H}_1+H_1T_2+\bar{H}_1T_1+T_1T_2$$
Now $H_1\bar{H}_1=0$ and T_1T_2 is redundant by theorem of race-hazards; therefore
$$\text{l.h.s.}=H_1T_2+\bar{H}_1T_1$$

This theorem allows us to multiply out two Boolean sums, two sections of which are the complement of each other, without generating algebraically redundant products.

The partition of a Boolean sum into head and tail is arbitrary. For example in the case of the Boolean sum A + B + C any of the following partitions is allowable

head	tail
A	B+C
B	A+C
C	A+B
A+B	C
A+C	B
B+C	A

Example. $f=(A+B+C)(\bar{A}+DE+F)$
Let $H_1=A$ and $T_1=B+C$
$H_2=\bar{A}$ and $T_2=DE+F$,
then $(A+B+C)(\bar{A}+DE+F)$
$$=A(DE+F)+\bar{A}(B+C)$$
$$=ADE+AF+\bar{A}B+\bar{A}C$$

If there are terms common to both of the sums to be multiplied the process of multiplication can be further simplified by noting that such terms appear in the product in their original form. For example
$$(A+BC)(A+DE)$$
$$=AA+ADE+ABC+BCDE$$
$$=A+BCDE.$$
Hence, if $P=(I+X)$ and $Q=(I+Y)$ where I is the common term, then $PQ=(I+XY)$.

Finally, if $P=(H_1+T_1+I)$ and $Q=(\bar{H}_1+T_2+I)$,
then $PQ=H_1T_2+\bar{H}_1T_1+I$

Boolean reduction

A Boolean function is said to be irredundant, or reduced, if it contains no optional products. For example, the factor $\bar{A}$ in the function $f=A+\bar{A}B$ is redundant, since $A+\bar{A}B=A+B$. Redundancies in two-level Boolean expressions can be removed in three steps, using the theorems of redundancy and racehazards. If an expression contains more than two levels, it is converted into its two-level sum-of-products form by multiplying out.

The three steps for eliminating redundancies in Boolean expressions are:

(1) Multiply out.

Consider the Boolean function
$$f=BC+(AB+C)\bar{C}+A$$
Apply (1):
$$=BC+AB\bar{C}+C\bar{C}+A$$
$$=A+BC+AB\bar{C}$$

(2) Apply redundancy theorem:

In (1) the expression $f=A+BC+AB\bar{C}$ was derived. Step (2) is commenced by considering the first product, in this case A. Now scan the products to the right of A, looking for a product that contains the factor A. Here $AB\bar{C}$ is such a product and this is eliminated, resulting in $f=A+BC$. Since there are no products to the right of BC the step is not repeated.

(3) Apply theorem of race hazards:

The first variable in the first product is selected and the remainder of the expression is scanned for a product that contains the complement of the selected variable. When such a product is found, an optional product is formed using the second theorem. The optional product is used to eliminate non-parent products and/or to replace parent products as previously described. If a parent product has been replaced, the optional product is inserted at the beginning of the expression and (3) is repeated. If the optional product has not been used, it is discarded. Step (3) is repeated until all first-level optional products have been generated. Repeat (3) if necessary using higher level optional products[1]. For example:
$$f=A+\bar{A}B+BC+\bar{A}\bar{B}D.$$
Form the optional product B:
$$f=A+\bar{A}B+BC+\bar{A}\bar{B}D+B.$$
Eliminate parent product $\bar{A}B$ and non-parent product BC:
$$f=B+A+\bar{A}\bar{B}D.$$

Form optional product $\bar{A}D$:

$$f = B + A + \bar{A}\bar{B}D + \bar{A}D.$$

Eliminate parent product $\bar{A}\bar{B}D$:

$$f = \bar{A}D + B + A.$$

Form optional product D:

$$f = \bar{A}D + B + A + D.$$

Eliminate parent product $\bar{A}D$:

$$f = A + B + D,$$

which is the required result.

Minimisation

A Boolean sum-of-products expression is said to be minimal if (a) no other sum-of-products expression for the same function has fewer products, and (b) of other sum-of-products expressions for the same function with the same number of products, none has fewer factors.

There are three main methods for minimising Boolean expressions.

These are:

- The Karnaugh map method. In this method the function is displayed on a map and by suitable looping arrangements the minimal form is obtained.
- The Quine-McCluskey method[2]. In this method all irredundant forms of a given Boolean function are generated and the shortest one chosen.
- A step-by-step algebraic method[3] which does not involve expansion of the function.

In this article the Karnaugh map method will be described.

Consider the Boolean function:

$$\begin{aligned} f &= \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}C + ABC + \bar{A}B \\ &= (A+\bar{A})\,BC + (A+\bar{A})\,\bar{B}C + \bar{A}B \\ &= BC + \bar{B}C + \bar{A}B \\ &= (B+\bar{B})\,C + \bar{A}B \\ &= C + \bar{A}B \end{aligned}$$

The original expression has been transformed algebraically into a simpler Boolean function which requires less hardware for implementation. Certainly in the era before the advent of the integrated circuit, minimization of Boolean functions was a positive advantage. In these days of integrated circuits the advantages of Boolean minimisation at the gate level are less obvious and the designer is now thinking in terms of minimizing the number of chips, both from the point of view of economy of space and cost. However, the formal process of simplification does lead the designer to a facility for handling Boolean equations and in that sense it is still useful.

The simplest and most widely used method of simplification employs a mapping technique. Maps for two, three, four and five variables are shown in Fig. 4, and are called Karnaugh maps.

For the two-variable map there are four cells, each of which represent one of the four possible combinations of the two variables. In the top left hand cell of the map A = 0 and B = 0, that is, the cell represents the minterm $m_0 = \bar{A}\bar{B}$, where a minterm may be defined as a Boolean product which contains all the variables in their true or inverted form. The decimal number in a cell is the decimal equivalent of the binary representation of the minterm associated with that particular cell. For example, the minterm associated with the top right hand cell of the two variable Karnaugh map is $\bar{A}B$ and its binary representation is 01 which has a decimal equivalent of 1.

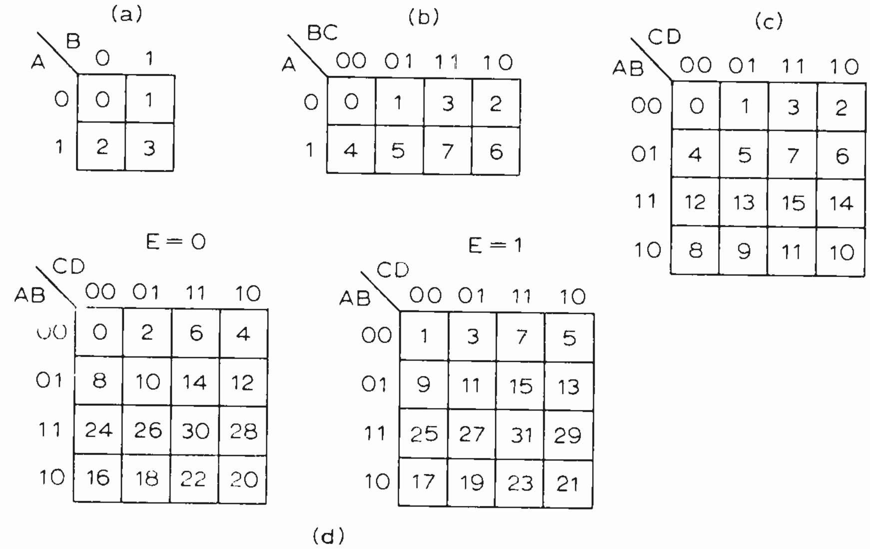


Fig. 4. Karnaugh maps for two(a), three(b), four (c) variables. In the case of five variables, two maps are needed, as shown at (d).

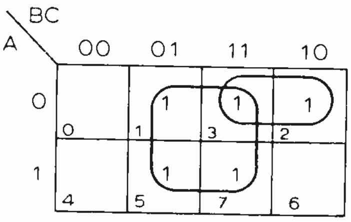


Fig. 5. The Karnaugh map for $f = \bar{A}\bar{B}C + \bar{A}BC + A\bar{B}C + ABC + \bar{A}B$. The ringed '1's show that the expression can be minimized to $f = C + \bar{A}B$.

Any Boolean function of a given number of variables can be plotted on a Karnaugh map. For example, consider again the function:

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

The first term in the expression $\bar{A}\bar{B}C$ has a binary representation of 001 and the cell corresponding to 001 on the map shown in Fig. 5 is marked with a 1. It follows that the terms $\bar{A}BC$, $A\bar{B}C$, and ABC can be plotted on the map using the same method. The remaining term $\bar{A}B = \bar{A}B(C + \bar{C}) = \bar{A}BC + \bar{A}B\bar{C}$ and the binary representation of these two terms is 011 and 010 respectively, corresponding to cells 2 and 3, but cell 3 has already been covered by the term $\bar{A}BC$ and it is only necessary to enter a 1 in cell 2 to complete the plot of the function.

The above example has shown that a 3-variable term occupies one cell only on a 3-variable map, a two variable term occupies two adjacent cells on the map and a single variable term will occupy four adjacent squares on the map. For example, the term A would be plotted in the cells marked 4, 5, 7 and 6 on the map and these four adjacent squares represent that term.

The process of simplification therefore reduces to the process of identifying plotted adjacencies on the Karnaugh map and then looping these adjacencies as shown in Fig. 5. The four-cell adjacency represents the term C and the two cell adjacency represents the term $\bar{A}B$ and the minimal function is

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

as was previously determined by algebraic methods.

Clearly to get the minimal form of the function the largest possible adjacencies should be chosen.

Example Minimize the Boolean function:

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

The function is shown plotted on the Karnaugh map in Fig. 6 and the adjacencies giving the minimal function are shown looped.

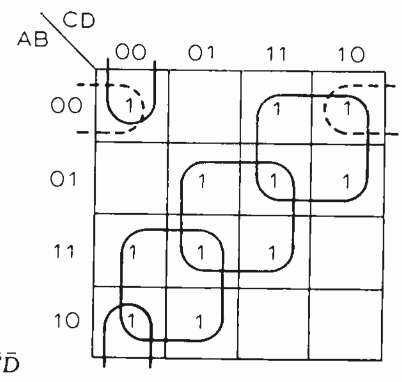


Fig. 6. Minimal function of $f = BD + \bar{A}\bar{B}C + A\bar{B}\bar{C}ABC + \bar{A}C\bar{D} + \bar{A}\bar{B}\bar{C}\bar{D} + ABC\bar{D}$ is shown to be $f = BD + \bar{A}C + A\bar{C} + \bar{B}\bar{C}\bar{D}$.

From the map

$$f = BD + \bar{A}C + A\bar{C} + \bar{B}\bar{C}\bar{D}$$
$$\text{or } f = BD + \bar{A}C + A\bar{C} + \bar{A}\bar{B}\bar{D}$$

Example Minimize the Boolean function shown plotted in Fig. 7.

For five-variable functions two maps are required as shown in Fig. 7 and the minimisation process can then be carried out in two steps:

Step (1): Minimize the functions plotted in the E=0 and E=1 maps as if dealing with two separate four-variable problems.

This gives $f_1 = \bar{B}\bar{D}\bar{E} + ABD\bar{E} + BCD\bar{E}$
and $f_2 = BDE + A\bar{B}\bar{D}E + A\bar{C}\bar{D}E$

Note that in this case there are two equally valid minimal solutions for the E=1 map, one of which has been chosen.

Step 2: Look for combinations between cells on the E=0 and E=1 maps which will lead to the elimination of factors from any of the terms in f_1 or f_2.

For example, the term $\bar{B}\bar{D}\bar{E}$ in f_1, may be written as $\bar{B}\bar{D}\bar{E} + A\bar{B}\bar{D}\bar{E}$ and the term $A\bar{B}\bar{D}\bar{E}$ can be combined with the term $A\bar{B}\bar{D}E$ in f_2 to generate the term $A\bar{B}\bar{D}$ thus eliminating the factor E between these two terms. The minimal sum is then given by the logical sum of f_1 and f_2 after all possible combinations have been made between the two maps. This leads to the following minimal solution.

$$f = \bar{B}\bar{D}\bar{E} + BDE + ABD + BCD + A\bar{B}\bar{D} + \bar{A}\bar{C}\bar{D}E$$

Obviously, the process of minimization using maps becomes more complicated as the number of variables in a problem increases. However, the method is readily usable up to six variables.

It was shown earlier in this article in the section on the race-hazard theorem that unwanted transient signals can be averted by the introduction of optional products. For example, for the Boolean function $f = \bar{A}B + AC$ a race-hazard occurs, following changes in A, when B=C=1, and it is eliminated by introducing the optional product BC so that the function becomes $f = \bar{A}B + AC + BC$. The original function is shown plotted in Fig. 8(a) and the new function including the optional product is plotted in Fig. 8(b).

Before the introduction of the optional product the Boolean function was irredundant in that it contained no loops, when plotted on Fig. 8(a), that are already covered by other loops. The function was also minimal. However with the introduction of the optional product a loop BC is formed which is already covered by the loops for $\bar{A}B$ and AC. The function is now no longer minimal in that it contains a redundant product BC. This example shows that the introduction of redundancy into a Boolean function is necessary to eliminate race hazards and that the minimal solution is not always the best solution.

Clearly the possibility of a race-hazard occurring can easily be spotted on a Karnaugh map plot of the Boolean function to be minimized.

The minimal form of the function shown plotted in Fig. 9(a) is $f = \bar{A}D + A\bar{B}C + AB\bar{C}$ but race-hazards will occur at the places indicated by arrowheads on the map. To eliminate these race-hazards two extra loops should be added to the Karnaugh map plot as shown in Fig. 9(b) and the minimum hazard-free function becomes

$$f = \bar{A}D + A\bar{B}C + AB\bar{C} + B\bar{C}D + \bar{B}CD$$

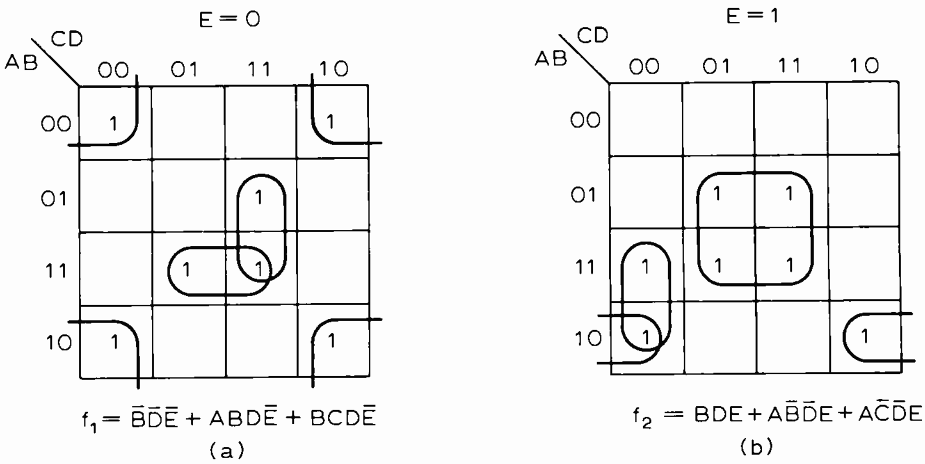


Fig. 7. A further example of minimization.

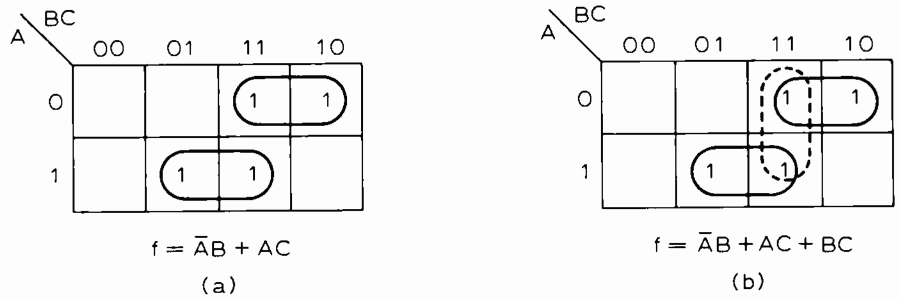


Fig. 8. The use of optional product BC in (b) eliminates the race hazard with changes in A.

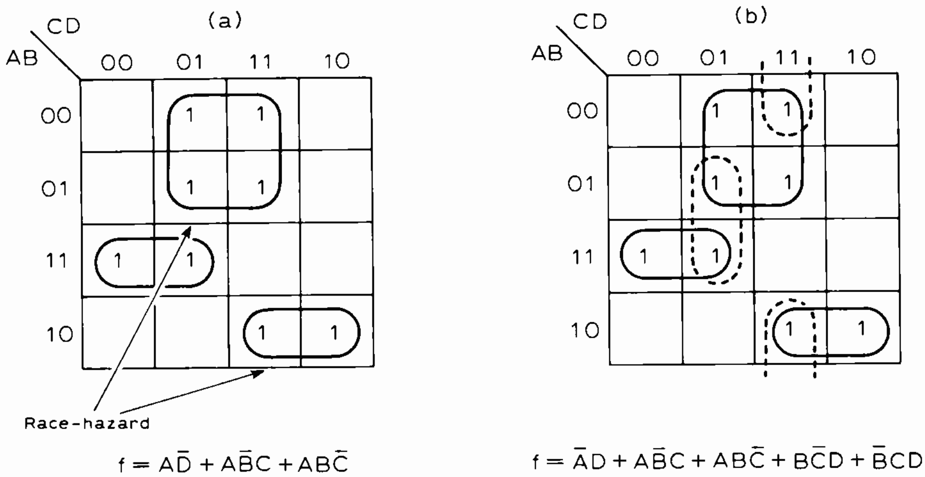


Fig. 9. More elimination of race hazards, shown by arrows in (a) by optional products shown at (b).

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Morse keyboard and memory

The key to perfect c.w. sending

by C. I. B. Trusson, M.Sc., M.I.E.E., G3RVM *Plessey Semiconductors*

This article describes a c.w. keyer which enables the operator to send perfect morse simply by typing out the messages on an alphanumeric keyboard. A f.i.f.o. (first in - first out) memory is used to store the keyboard output before it is converted into morse code, suitable for keying a transmitter. The prototype keyer was constructed by the author who was motivated by a desire to send good high-speed c.w., particularly during amateur-band contests. Despite his persevering with an el-bug for eight years, perfectly-timed error-free high speed c.w. was never achieved. With this keyer, however, perfect international c.w. is guaranteed at very low error rates, determined only by the operator's typing skill.

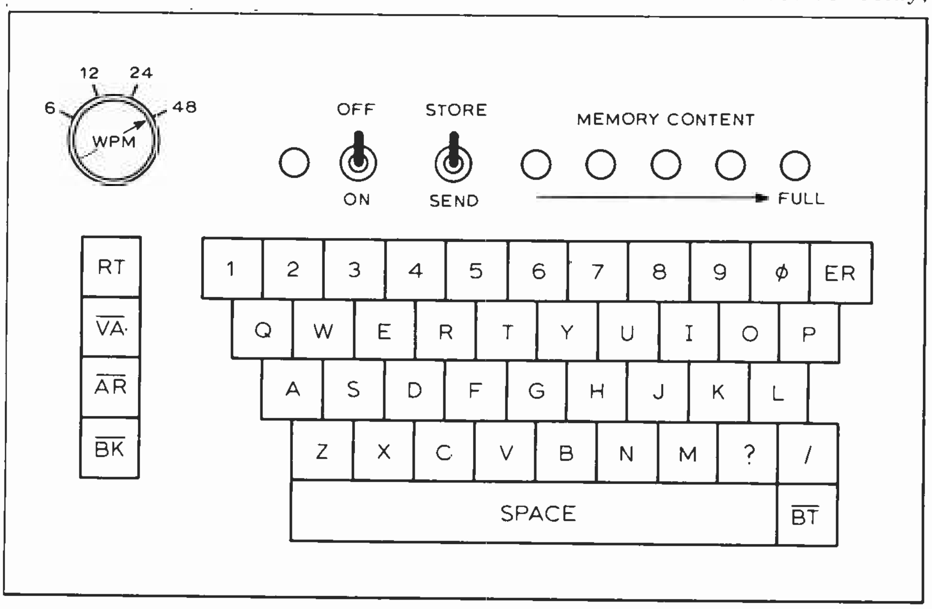
The keyboard-and-f.i.f.o. morse keyer uses an RC oscillator to accurately control the mark/space ratio of morse characters and the duration of inter-character and inter-word spaces. The keyer also uses a basic oscillator clock which is divided down and switched to allow morse code outputs at 6, 12, 24 and 48 words-per-minute, four discrete speeds being sufficient for amateur-band operating. Six w.p.m. is suitable for sending to very weak DX stations and 12 w.p.m. can be used for DX stations and novice operators. 24 w.p.m. is the speed used for 90% of QSOs (contacts) and 48 w.p.m., which demands a fair degree of typing skill, is only suitable for sending to extremely good operators. During sending, the c.w. output is fixed at one of these speeds while the character input speed is controlled by the operator via the keyboard.

When using a keyboard sender without a f.i.f.o. memory the operator has to monitor the outgoing c.w. and accurately synchronise his typing to it. However, because c.w. characters are of very variable length and typing speed is difficult to keep constant from one character to the next, the resulting c.w. can include very variable operator-determined inter-character spaces. A f.i.f.o. memory is incorporated in this design so the operator only needs to ensure that his typing speed is faster than the outgoing c.w. speed. Each character is then immediately available at the output of the f.i.f.o. with no operator delay. The f.i.f.o. will hold up to 63 characters, which represents a message of about 12 words. A line of five l.e.ds on the front panel indicates how full the memory is at any time. This indication provides the operator with a crude method of controlling his typing speed so that there are always a few characters in the memory, but not sufficient to exceed its capacity. As a result, there is no need to monitor the outgoing c.w. when using this keyer.

The f.i.f.o. may also be used as a pure memory for storing messages of up to 63 characters for later transmission. The message is keyed in with the store/send switch in the "store" position and is keyed out when the switch is returned to the "send" position. A reset key is provided for clearing the memory of messages keyed into the keyboard, but no longer required for transmission. Circuitry is incorporated to reset the memory automatically when the power is switched on.

Fig. 1. Front panel of morse keyboard showing the alpha-numeric, punctuation, reset, space bar and special character keys, the four-position switch for the selection of morse speed and the store-end switch which allows storage of messages for later transmission.

The morse code output, used to key the transmitter, is provided by a high-speed reed relay having a 400V, 0.5A, 10W rating, which should present no transmitter interfacing problems. A second reed relay output is provided for automatic transmit/receive switching. This relay switches on just before the first character of a message is keyed out and stays on as long as there are still un-sent characters in the f.i.f.o. memory. When the memory empties, the transmit/receive relay switches off just after the last character has been keyed out. This relay avoids the need for manual transmit/receive switching by the operator, which can waste valuable seconds in amateur contest operating. Alternatively, most s.s.b./c.w. transceivers use their v.o.x. circuitry for automatic transmit/receive switching on c.w. These systems, which switch to transmit on detecting the start of the first morse character, tend to cause clipping of the first dot/dash which would be particularly significant at the high speeds attainable with a keyboard sender. Also, to ensure that the switch from transmit to receive does not occur during inter-word spaces at slow speeds, the transmit hold time is normally set fairly long. As a result, the first few characters being sent by the next transmitting station may be missed. This keyboard sender, with its own automatic transmit/receive relay,



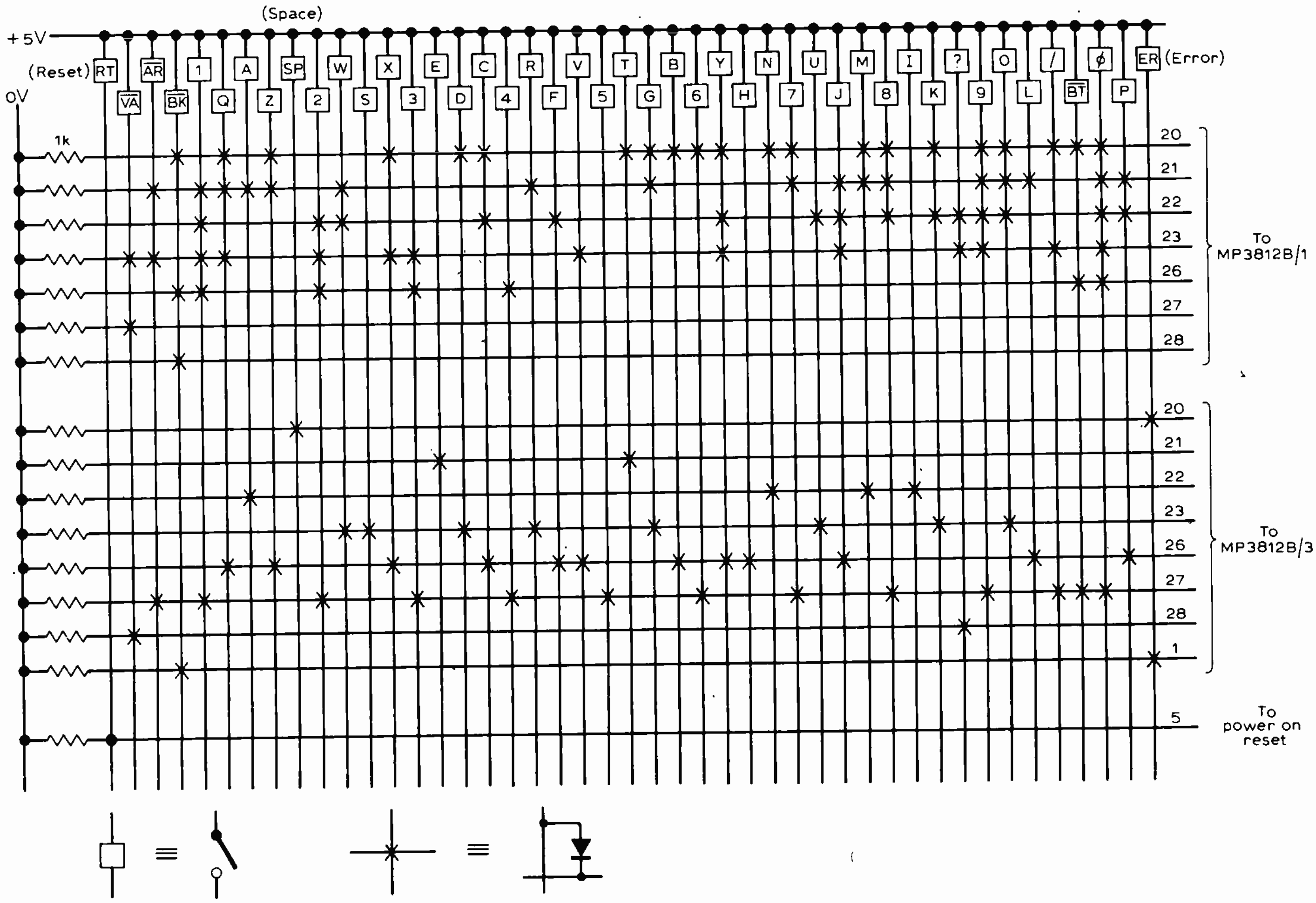


Fig. 2. Encoder for converting outputs from keyboard into a 15-bit code. Typical silicon switching diodes are 1N914 or equivalent.

avoids both of these problems.

In addition to the alphabet and numbers 0-9, morse code characters exist for punctuation marks and special operating instructions. These characters are often thought of as normal alphabet characters strung together without inter-character spaces. Examples are $\overline{\text{IMI}}$ for ? and $\overline{\text{VA}}$ for "end of transmission". The keyboard sender, however, automatically inserts inter-character spaces so that it is not possible to use the alphabet keys to generate these characters. Additional keys are therefore added to the basic alpha-numeric keyboard. On this keyboard sender, the following keys have been included: $\overline{\text{VA}}$, $\overline{\text{AR}}$, $\overline{\text{BK}}$, $\overline{\text{IMI}}$ (?), $\overline{\text{XE}}$ (/), $\overline{\text{BT}}$ and an eight-dot error code. These keys are quite sufficient for normal operating on the amateur bands, but additional ones are easily added if required. In fact the keyer can generate any morse character up to seven bits in length by suitably programming a diode r.o.m. Some special logic had to be added to cater for the eight-bit error code.

Having described the basic facilities provided by the keyboard sender, its operation will now be described in detail.

The basic controls on the front panel of the prototype keyer are shown in Fig. 1. This includes the keyboard containing the alpha-numeric, punctuation, and reset keys, the inter-word space bar and the special character keys; a four-position switch to select the morse output speed; an on-off switch with a l.e.d. indicator; a store/send switch to allow the entry of messages into the memory ready for later transmission, and five l.e.d. indicators to indicate the fullness of the memory.

The outputs from the keyboard switches are converted into a 15-bit code by means of a diode r.o.m. as shown in Fig.2. This code was especially chosen for ease of conversion into serial c.w. characters. The upper seven bits, which drive into the MP3812B/1, represent the dot/dash content of the characters. The lower eight bits, which drive into the MP3812B/3, determine the length of the characters. A diode in the seven-bit word corresponds to a dash, with the word being read sequentially starting at the top. This particular polarity was chosen as there are less dashes than dots in morse code. For the eight-bit word, a diode in the top line corresponds to an inter-word space, a diode in the second line corresponds to a one-bit long character and a diode in the third line corresponds to a two-bit long character etc., up to a diode in the eighth line which corresponds to a seven-bit long character. The error code, which is the only eight-bit morse character, uses a special unique code with a diode in the first and last bit positions of the eight-bit word. As an example of the coding, the letter 'A' key line contains no diode in the top line of the seven-bit word, to represent the dot, followed by a diode in the second line to represent the dash. A diode in the third line of the eight-bit word indicates that the character is two-bits long.

The possibility of encoding the keys into a shorter code such as a.s.c.i.i. was considered in order to reduce the width of the f.i.f.o. memory. A keyboard encoder i.c. could possibly be used instead of a diode r.o.m. This would be followed by a f.i.f.o. memory containing two MP3812Bs instead of four. However, after the memory the code would have to be decoded into a line per key and encoded into a morse-related code similar to the one already proposed. The decoder, realised as a diode r.o.m., would be enormous and for this reason, together with the added complexity of the system, the technique was abandoned.

The logic diagram of the keyboard sender is illustrated in Fig. 3. All the logic elements are marked with the commercial number of the i.c. which

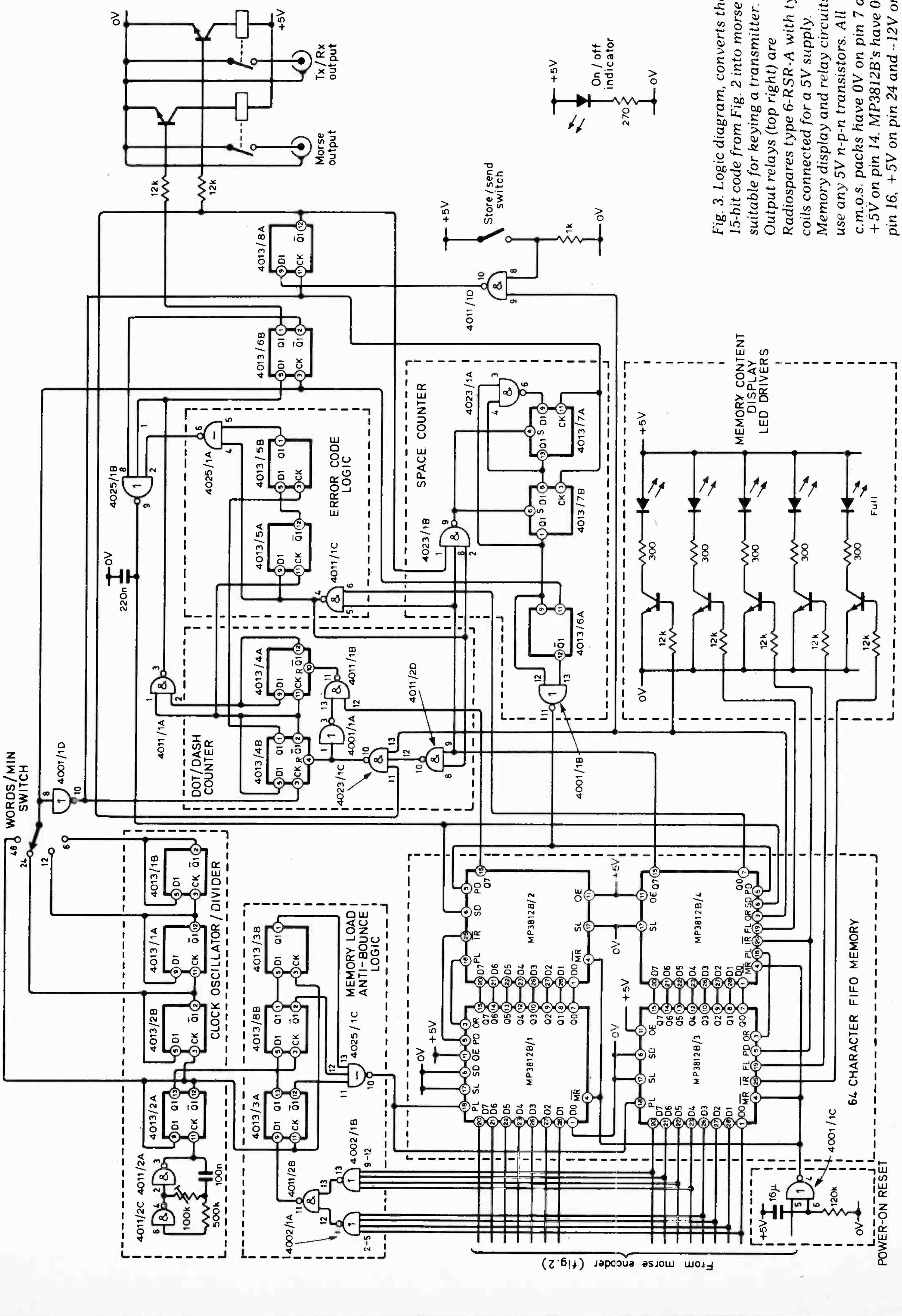


Fig. 3. Logic diagram, converts the 15-bit code from Fig. 2 into morse code suitable for keying a transmitter. Output relays (top right) are Radiospares type 6-RSR-A with type 3 coils connected for a 5V supply. Memory display and relay circuits may use any 5V n-p-n transistors. All c.m.o.s. packs have 0V on pin 7 and +5V on pin 14. MP3812B's have 0V on pin 16, +5V on pin 24 and −12V on pin 2. All supply points can vary by ±5%.

contains them followed by a unique number and letter. The number represents an arbitrary numbering of the i.c. packs and the letter represents an arbitrary lettering of the elements within those packs. For example, the c.m.o.s, dual D flip-flop i.c., commercial number 4013, pack 2, contains two flip-flop elements marked 4013/2A and 4013/2B. In addition, the pin numbers of the i.cs are marked on the logic diagram to aid the constructor and to make references to the logic diagram clearer in the text. A positive logic convention is used throughout.

When the power is switched on, a logic 1 is applied to input 6 of gate 4001/1C via the discharged 16μF capacitor which forces a 0 onto the output of this NOR gate and resets all four MP3812B f.i.f.o. i.cs. The 16μF capacitor is charged via the 120kΩ resistor, while the power supply voltages reach their correct level and the f.i.f.o. memory reset takes place. After approximately 1.5s, the input voltage to pin 6 will pass below the mid-supply voltage and charge to a 0. This removes the reset signal and the keyer is ready to be operated. Input 5 to gate 4001/1C is fed directly from the reset key on the keyboard to allow manual reset of the f.i.f.o.

The system clock is obtained from an RC oscillator which uses two c.m.o.s. inverters, gates 4011/2C and 4011/2A, and the output frequency is preset to 80Hz. The oscillator drives into four series connected divide-by-2 circuits, 4013/2A, 4013/2B, 4013/1A and 4013/1B. The first divider generates anti-phase clocks for the memory load/anti-bounce logic and also the clock to all the logic, which converts the 15-bit characters from the keyboard encoder into morse code when 48 w.p.m. is selected. The second, third and fourth dividers generate the clocks for operation at 24, 12 and 6 w.p.m. respectively.

Before any keys are operated, the 15 lines from the keyboard encoder are all at a 0. When any key is pressed one of the eight lines into the MP3812B/3 always goes to a 1, causing pin 11 of gate 4011/2B to go from 0 to 1. On the next positive going clock from the $\overline{Q}$ output of 4013/2A this 1 is clocked into 4013/3A. On the following negative edge the 1 is also clocked into 4013/8B causing the output of gate 4025/1C to go from a 0 to a 1. On the next positive clock edge a 1 is clocked into 4013/3B which causes the output of gate 4025/1C to return to a 0. This logic 1 pulse from gate 4025/1C drives the parallel load inputs of the MP3812B/1 and /3 f.i.f.os causing the 15-bit word to be loaded. With the 80Hz oscillator frequency, the period of the clock from the 4013/2A is 25ms. From the start of a key depression, the positive edge of the parallel load pulse is delayed between 0.5 and 1.5 clock periods, i.e. 12.5 to 37.5ms, depending on the phase relationship between the key depression and the clock. This delay ensures that contact bounce will have ceased before the f.i.f.o. memory is loaded. A key depression should last for a minimum period of 50ms to ensure that the memory load logic completes its cycle. Following a key depression, there must be a further minimum period of 50ms before the start of the next key depression to allow 4013/3A, /8B and /3B to be clocked back to all 0s. This input timing circuit, despite its simplicity, has been found to operate reliably at typing speeds up to the maximum necessary for 48 w.p.m. sending.

The f.i.f.o. memory uses four MP3812B 32 × 8-bit p-channel m.o.s. i.cs to make up a f.i.f.o. 15 bits wide and 63 bits long. The MP3812B/1 is operated in parallel with the MP3812B/3 and the MP3812B/2 in parallel with the MP3812B/4. The MP3812B/1 is connected in series with the MP3812B/2 and the MP3812B/3 in series with the MP3812B/4. The first 15-bit word to be parallel loaded, seven bits into the MP3812B/1 and eight bits into the MP3812B/3, ripples through them, into the MP3812B/2 and MP3812B/4, reaching their output registers after a few microseconds. The output ready signal from pin 3 of the MP3812B/4 goes to a 1 indicating that there is a character waiting at the end of the f.i.f.o. memory. Subsequent characters queue behind the first in order of entry. If the store/send switch is in the "store" position the data is held in the memory for later transmission. If it is in the "send" position, the data is serially clocked out of the Q7 outputs of the MP3812B/2 and MP3812/4. The data from the MP3812B/2 is converted into morse code dots and dashes until the end of the character marker is detected from the MP3812B/4 at which time the inter-digit pause is timed, and a parallel dump signal is generated. This shifts all the data in the f.i.f.o. one row nearer the output and the next character is clocked into the output registers of the MP3812B/2 and MP3812B/4 ready to be sent next. The process continues until the memory empties and the output ready signal returns to a steady 0.

The number of characters stored in the memory at any time is indicated by five l.e.d.s. The output ready signal of MP3812B/4 drives the first l.e.d. to indicate when at least one character is in the memory and returns to a 0 during serial and parallel dump pulses. Therefore, when this l.e.d. is flickering it provides an indication that the keyer is outputting morse code. The second l.e.d. is driven from the flag output of the MP3812B/4 which goes to a 1 when the MP3812B/4 is half full, i.e. when the total f.i.f.o. is at least a quarter full. Similarly, the third, fourth and fifth l.e.d.s are driven from the MP3812B/4 $\overline{IR}$ pin, the MP3812B/3 FL pin and the MP3812B/3 $\overline{IR}$ pin respectively to indicate when the f.i.f.o. memory is half, three-quarters and completely full.

The remaining logic circuitry which converts the 15-bit characters from the f.i.f.o. memory into morse code will now be described in detail. It has already been mentioned that the first character arriving at the output registers of the f.i.f.o. causes the output ready signal from MP3812B/4 to go to a 1. If the store/send switch is in the "store" position with the switch open, the output of gate 4011/1D remains at a 1 and this inhibits sending until the switch is closed. When the switch is closed and the output ready is a 1, the output of gate 4011/1D goes to a 0 and is then clocked into 4013/8A causing its $\overline{Q}$ output to go to a 1. This signal operates the transmit/receive relay which switches the transmitter on and the receiver off ready for the first morse character to be sent. The inputs 11 and 13 to gate 4023/1C are at a 1. Input 12 is also a 1 for all characters except the inter-word space. Therefore, the output of gate 4023/1C goes to a 0 removing the reset to 4013/4B. If the first bit to be sent is a dash, input 12 to gate 4011/1B is a 1 and this also causes the reset to be removed from 4013/4A. The two-stage serial counter, consisting of 4013/4B and 4013/4A, is then clocked through states 10, 01, 11 and back to 00. Gate 4011/1A gives a 1 output for the three states 10, 01 and 11 which corresponds to the period of a dash. For a dot, input 12 to gate 4011/1B is a 0 so that the second stage of the counter, 4013/4A. is held reset. Therefore, in this case, a pulse of one clock period width is produced at the output of gate 4011/1A. The keyer, therefore, generates the correct 1:3 ratio between the width of a dot and that of a dash, to comply with the requirements of international morse code.

The dot and dash pulses were generated on the negative edge of the clock from the w.p.m. switch. On the positive clock edge the output from gate 4011/1A is clocked into 4013/6B and the Q output of this D-element then drives the morse output relay via an interface circuit. The output of gate 4011/1A also feeds a gate 4025/1B together with the Q output of 4013/6B such that, on the negative edge of the logic 1 pulse from 4011/1A, a half clock-period pulse is generated to drive the serial dump inputs of MP3812B/2 and /4 ready to start the generation of the next dot/dash.

The serial dump following the last dot/dash in a character causes the end of character logic 1 marker to be clocked to the Q7 output of MP3812B/4. This inhibits the dot/dash counter by applying a 1 to input 9 of 4011/2D which in turn puts a 0 into 4023/1C and resets 4013/4B and 40134A. At the same time the output of gate 4023/1B goes to a 0, removing the set input to 4013/7B and 4013/7A and enabling the space counter. The special logic used to generate the error code will be described later, but for all other characters 4013/5A and 4013/5B remain in the 10 state so that input 2 to gate

4025/1B remains at a 0, and input 8 to gate 4011/2D and input 2 to gate 4023/1B remain at a 1 during the above logic sequence. The 0.22μF capacitor on the output of gate 4025/1B was added to ensure that decoding spikes from gate 4011/1A, during the generation of a dash, do not cause spurious serial dump signals to be generated.

The space counter is enabled by a 1 from the Q7 output of MP3812B/4 which is applied to input 8 of 4023/1B after every character has been keyed out and also when a space character occurs. The space counter is a divide-by-3 feed-back shift-register consisting of 4013/7A, 4013/7B and 4023/1A, and is followed by 4013/6A and 4001/1B which generates a half clock period pulse to drive the parallel dump inputs of MP3812B/2 and /4. The parallel dump pulse occurs after the counter has been clocked twice such that the total delay between the end of the last dot/dash of one character and the start of the next one is three clock periods. When a space character occurs, the counter remains enabled and continues to be clocked for two periods before another parallel dump pulse is generated, such that the overall space between two words is six clock periods. These inter-character and inter-word spaces, of three dots width and six dots width respectively, conform with the requirements of international morse code.

The coding of the eight-bit word, which determines the length of the morse characters, can accommodate any character from zero length (the inter-word space) to seven bits in length. To accommodate the eight-dot error signal, a special code is used with a 1 in the first and last bit positions, and logic is incorporated to decode and generate this one awkward character. The 1's at the Q0 and Q7 outputs of MP3812B/4 are decoded by gate 4011/1C causing a 0 to be clocked into 4013/5A. The output of gate 4025/1A then goes to a 1 and masks the normal serial dump pulse to MP3812B/2 and /4 after the first dot causing that dot to be repeated. Meanwhile a 0 is clocked into 4013/5B, the output of 4025/1A returns to a 0 and the remaining seven dots are sent in the normal way.

Finally, when the last character of a message has been parallel dumped from the f.i.f.o. memory, the output ready signal from MP3812B/4 goes to a steady 0 and this is clocked via gate 4011/1D to the $\overline{Q}$ output of 4013/8A to switch off the transmit/receive relay. The $\overline{Q}$ output of 4013/8A is prevented from going to a 0 when output ready goes to a 0 during parallel and serial dump pulses by clocking the 4013/8A just before output-ready changes.

Having described the facilities provided by the keyer, its design philosophy and its operation, the last section of this article outlines methods of construction. The prototype keyer used an old keyboard modified to give the arrangement as shown in the front panel layout of Fig. 1. The arrangement of the alpha-numeric keys should be as a normal typewriter; however, the other keys can be placed as desired. An alternative to modifying an existing keyboard is to purchase the individual keyboard switches and mount them on veroboard or a printed circuit board. The diode encoder r.o.m. was constructed using double-sided veroboard, with the tracks in the x and y directions, mounted underneath the keyboard. The key switches are connected to the x tracks with the y tracks connected to the f.i.f.o. memory and the diodes are soldered at the appropriate cross-points. The logic i.cs and the relay and l.e.d. driver components were mounted on a single 8 × 8in veroboard, specially designed for point-to-point wiring of d.i.l. i.c. packs (part number 12490). To make the whole keyer r.f. proof it was enclosed in an aluminium case connected to the mains earth and the 0V supply.

The c.m.o.s. i.cs are produced by many manufacturers and can be obtained through most i.c. distributors. The f.i.f.o. i.cs used in the design are dual-sourced. Suitable i.cs are the Plessey Semiconductor MP3812B or the A.M.D. 2812.

Once constructed, only the period of the clock oscillator needs adjustment to calibrate the 6, 12, 24 and 48 w.p.m. keying speeds. The output period of the oscillator can be trimmed, using the preset potentiometer, to 12.5ms with an oscilloscope. Alternatively, if the w.p.m. switch is set to six w.p.m. and four error characters are typed in, the morse code output, as timed with a watch, should last for 15 secs. The keyer is then ready to use.

Printed circuit boards
If a sufficient number of readers are interested, a double-sided glass fibre printed circuit board will be made available for this design. It is anticipated that the layout will accommodate the logic circuitry and the diode matrix. Enquiries should be sent to M. R. Sagin at 11 Villiers Road, London N.W.2.

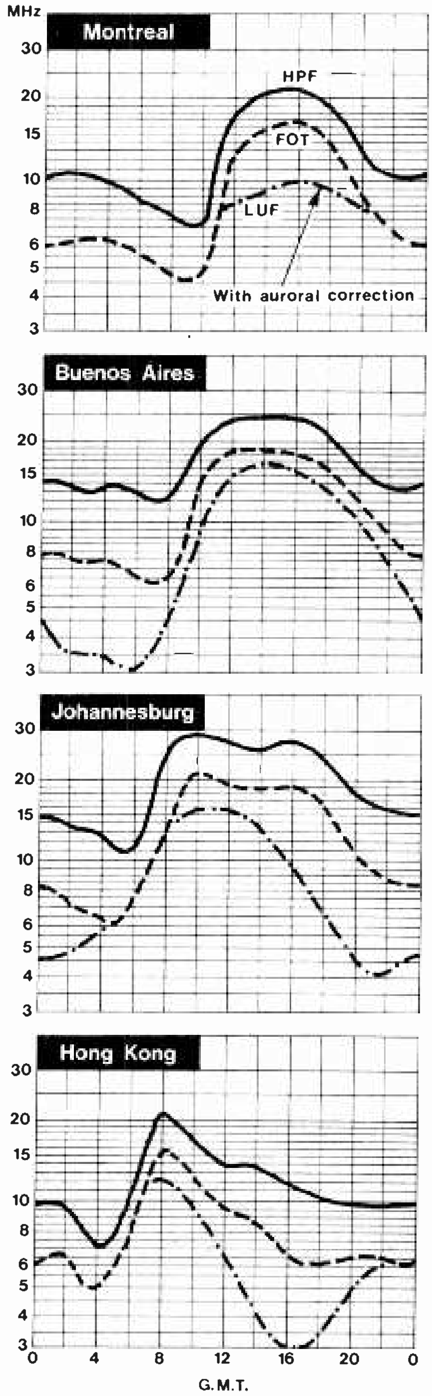
Announcement
This year the annual Wireless World index will be published separately. It will cost 50p including postage from the General Sales Department, Room 11, IPC Business Press Ltd, Dorset House, Stamford Street, London SE1 9LU. The date of publication will be announced shortly.

HF predictions

Ionospheric absorption or skywave loss is greater during winter than in summer months. This is known as the winter anomaly as it is the opposite effect to that deduced from simple reasoning of the seasonal changes in sun/earth relationship.

The high absorption is continuously present over a large area for several days and then shifts to another area, for example Europe to Western Russia. This results in short routes having "patchy" conditions and long routes having day-to-day variations in signal strength about four times greater than in summer.

However, with the availability of higher frequencies (compare this month's Montreal chart with that for June) winter daytime communication is overall better than that experienced during summer.



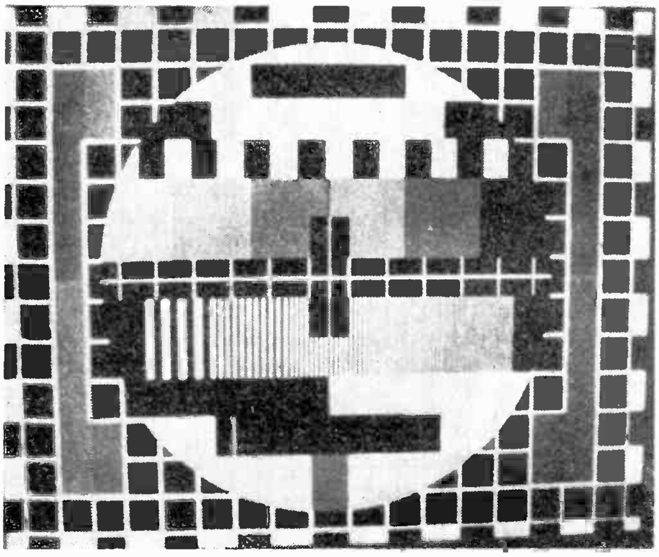
Identifying European television — 1

by G. Smith and K. Hamer

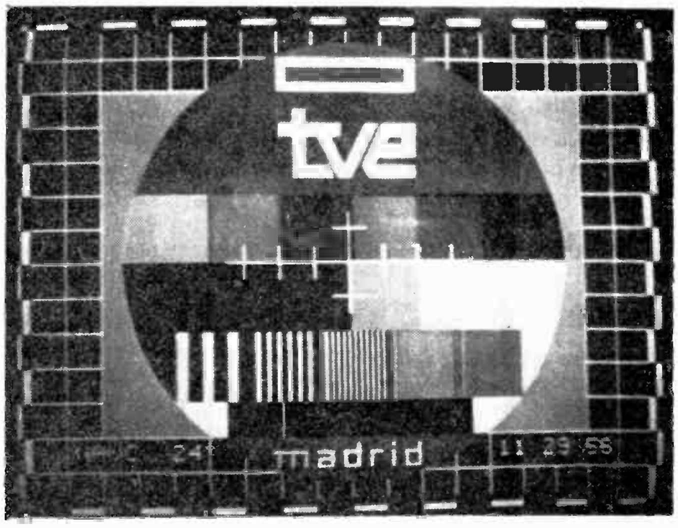
In the September 1969 issue of Wireless World an article was published which gave details of certain European television test cards. Since that article appeared, the interest in receiving long distance television has increased and many new test cards have been introduced including electronically generated types. A selection of these test cards is shown here. Readers requiring further information should obtain the Guide to World-Wide Television Test Cards from HS Publications, 17 Collingham Gardens, Derby.

The various transmission standards are shown in the table and the standard used by a particular service is shown next to the appropriate test card.

System	Line No.	Channel band-width (MHz)	Vision band-width (MHz)	Sound/Vision spacing (MHz)	Vision modulation	Sound modulation	Areas in use
A	405	5	3	−3.5	+	a.m.	UK Eire (v.h.f.)
B	625	7	5	+5.5	—	f.m.	Western Europe, parts of Africa, Middle East, Australasia (v.h.f.)
C	625	7	5	+5.5	+	a.m.	Belgium (v.h.f.)
D	625	8	6	+6.5	—	f.m.	Eastern Europe, USSR, China (v.h.f.)
E	819	14	10	±11.15	+	a.m.	France (v.h.f.) possible future change to system L on v.h.f.
G/H	625	8	5	+5.5	—	f.m.	Western Europe (u.h.f.)
I	625	8	5.5	+6	—	f.m.	UK (u.h.f.) Eire (v.h.f.)
K	625	8	6	+6.5	—	f.m.	French territories overseas
L	625	8	6	+6.5	+	a.m.	France (u.h.f.) Luxembourg (v.h.f./u.h.f.)
M	525	6	4.2	+4.5	—	f.m.	North & South America, Caribbean parts of Pacific, Far East, US Forces broadcasting (AFRTS) Japan
N	625	6	4.2	+4.5	—	f.m.	Argentina, Uruguay, Bolivia

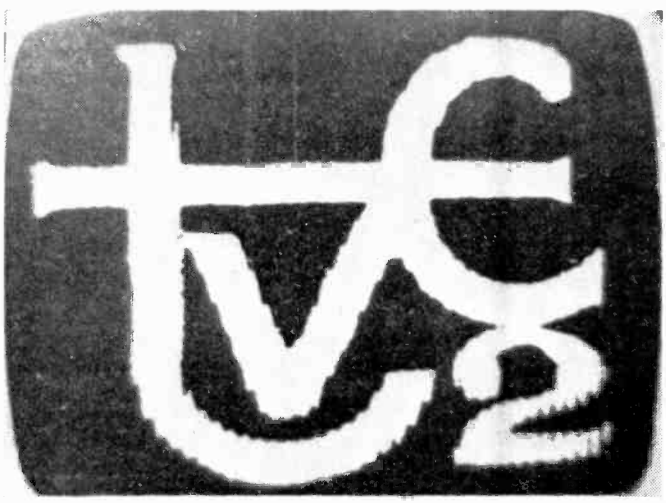


Philips PM5544 — This electronically generated test card is now used by most European services.

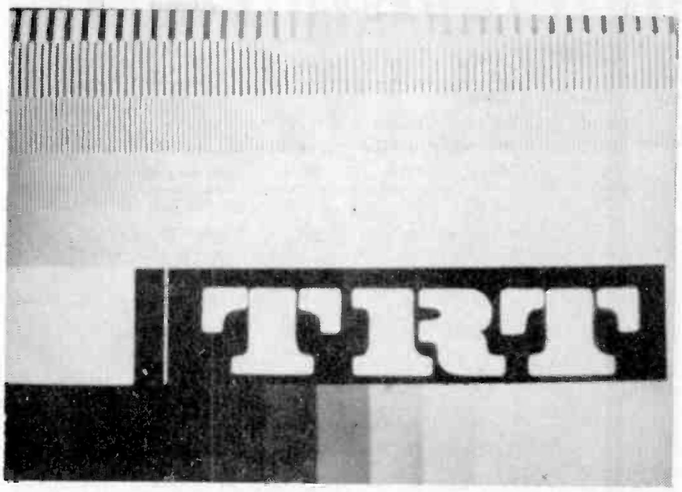


Spain RTVE (B, G) — Electronic test card which includes a digital clock. RTVE are experimenting with PAL colour.

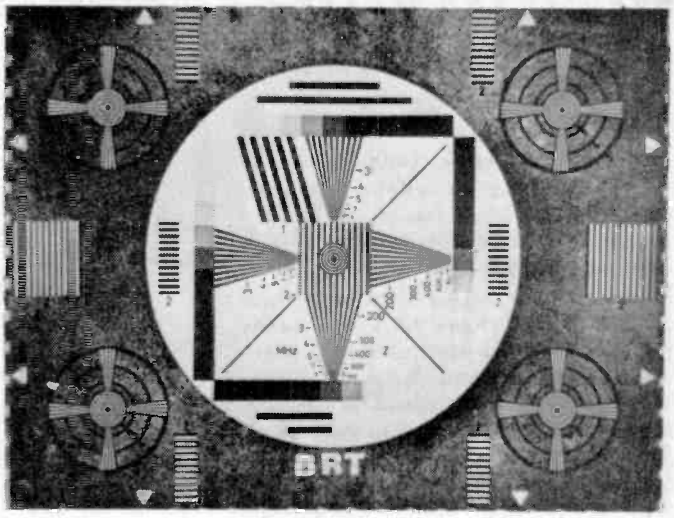
East Germany (B, G). DDR-F — Deutscher Fernsehfunk's identification caption.



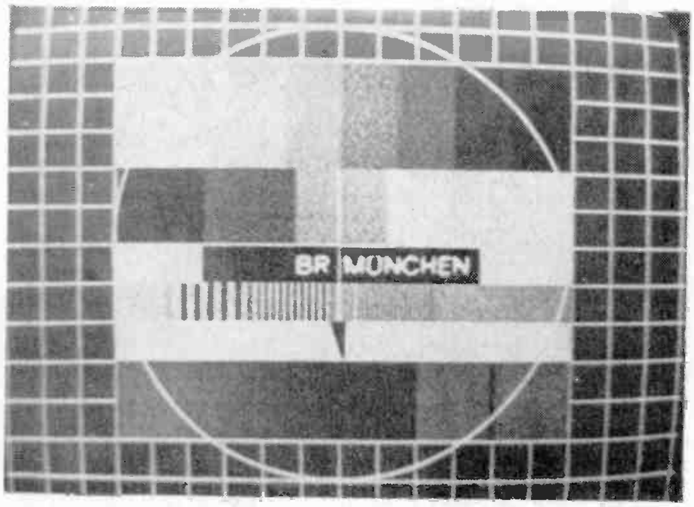
Spain RTVE-2 (B, G) — Identification caption. The Second Network has one high-powered transmitter in the v.h.f. band.



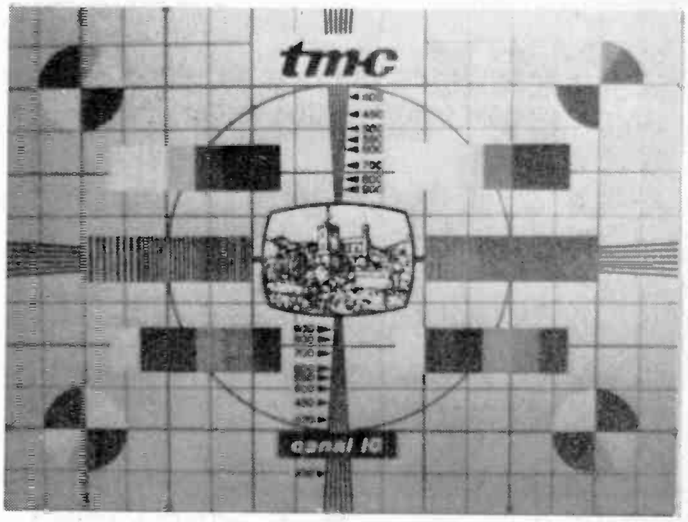
Turkey TRT (B) — This electronic test card is used by most E.B.U. Members with suitable identification.



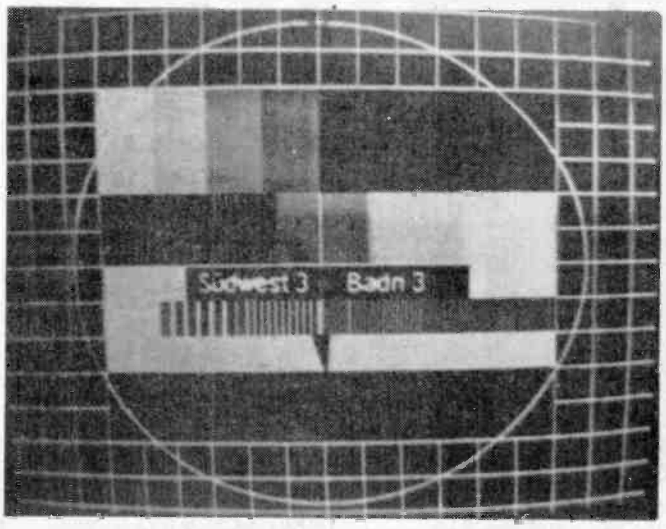
Belgium BRT/RTB (C. H) PAL colour — BRT produce programmes in the Dutch language and RTB produce programmes in French.



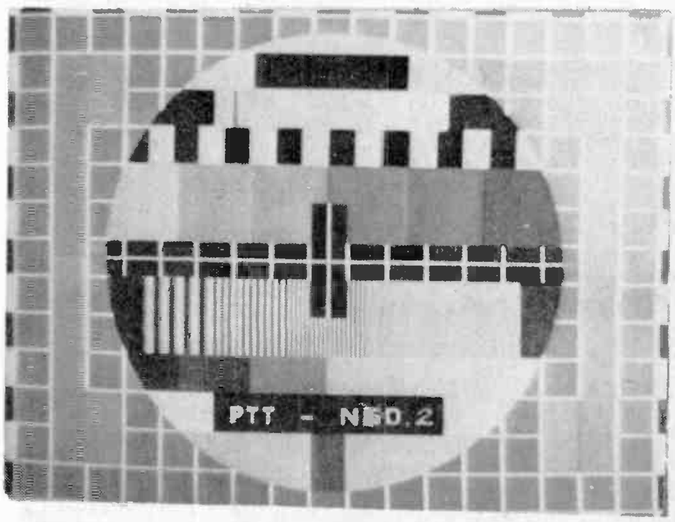
West Germany (B, G) A.R.D. PAL colour. — Electronic test card used by Bavarian Television.



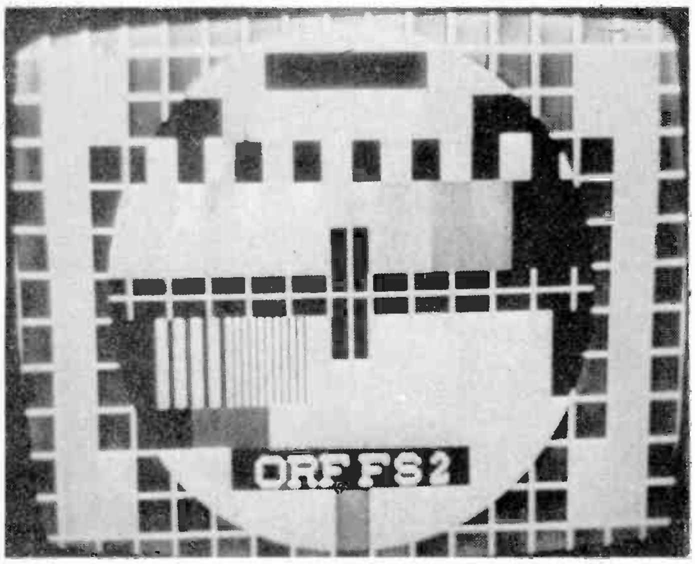
Monaco TMC (E, L) SECAM colour — Also on u.h.f. with Canal 35 identification.



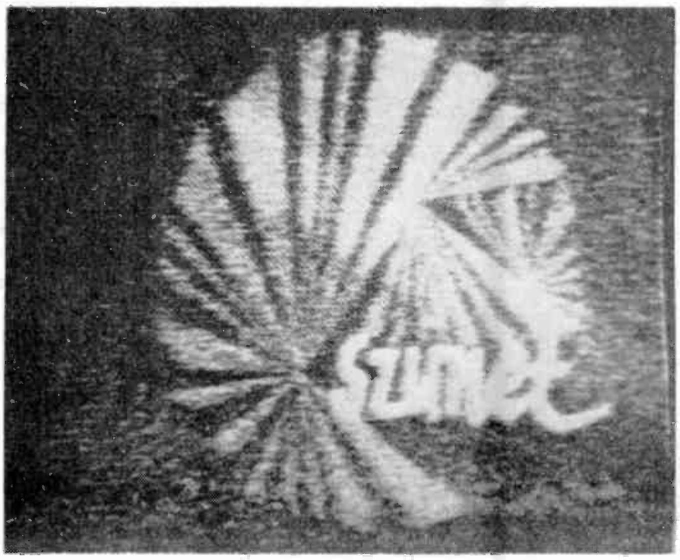
West Germany (B, G) A.R.D. PAL colour. — The FUBK test card is used by most members of the A.R.D.



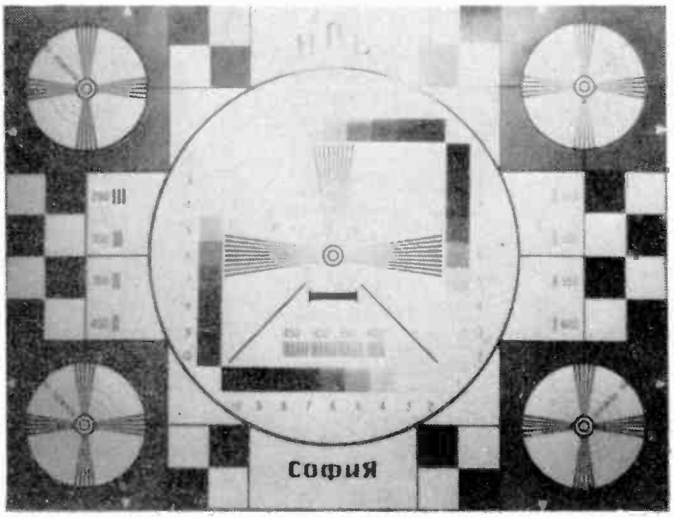
Netherlands NOS (B, G) PAL colour — The First Network also uses this electronic test card with appropriate identification.



Austria ORF (B, G) PAL colour — O.R.F. uses a similar test card to BRT/RTB.

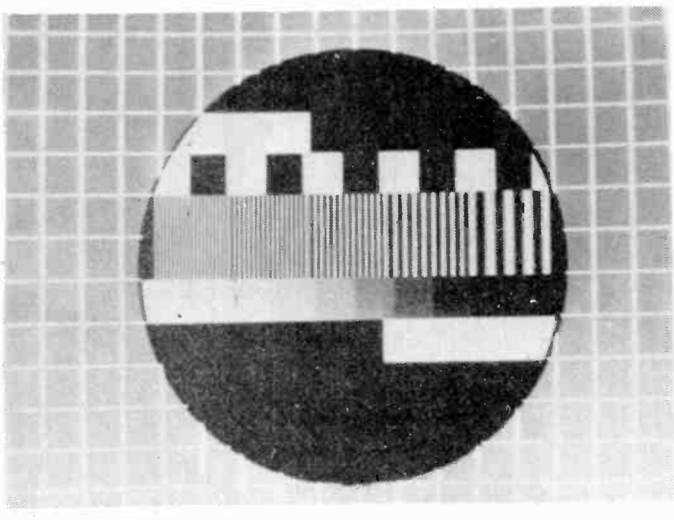


Hungary MTV (D, K) SECAM colour — The "Szunet" caption indicates an interlude between programmes. (Off screen photograph.)



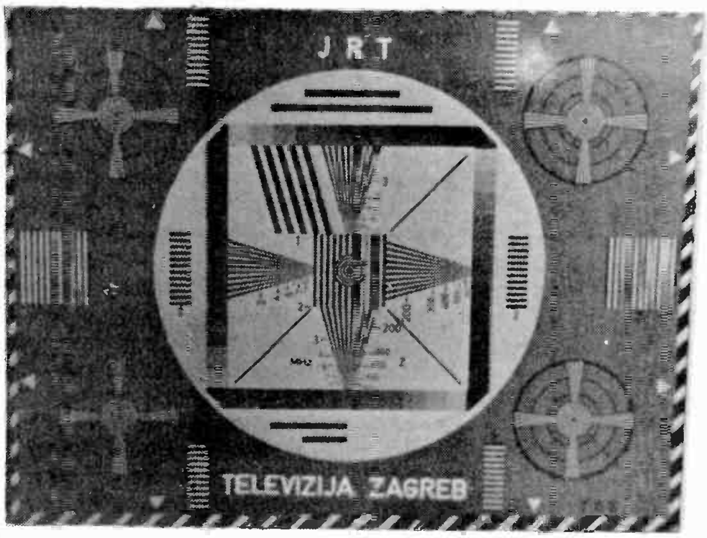
Bulgaria (D) B.T. — Boghlarskoie Televidenie also uses test card "G".

USSR TSS (D) SECAM colour — An identification caption used by Televidnie Sovietskogo Soiuza, Latvia.

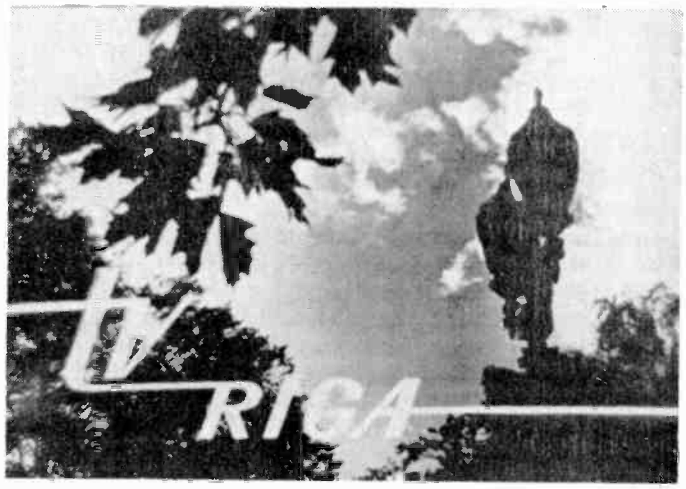


Iceland RUV (B) — This electronic test card does not normally carry identification. There are three high-powered v.h.f. transmitters.

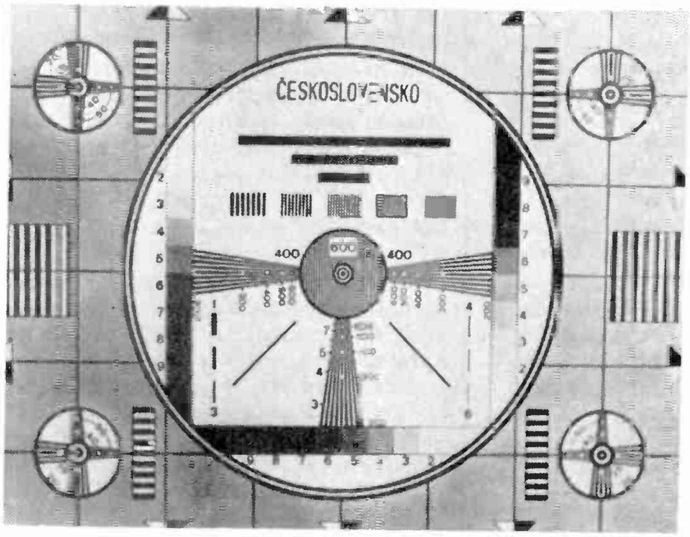
Norway NRK (B) PAL colour — Test Card "F" as used by Norsk Rikskringkasting. (Off screen photography.)



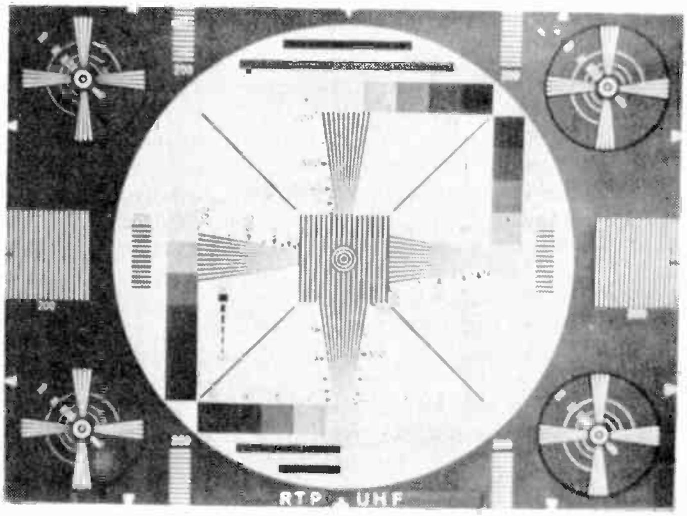
Yugoslavia JRT (B, H) PAL colour — Telefunken TO5 test card transmitted by JRT-Zagreb. JRT have three high-powered Band I transmitters.



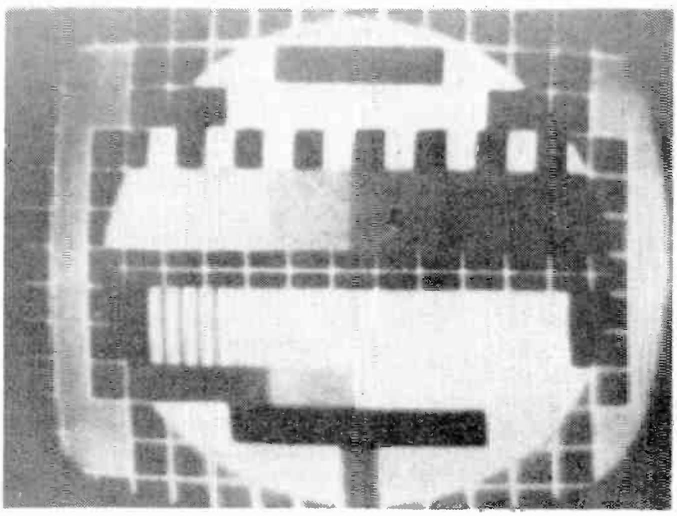
USSR TSS (D) SECAM colour —An alternative caption from Latvia. T.S.S. reception is very common in the UK.



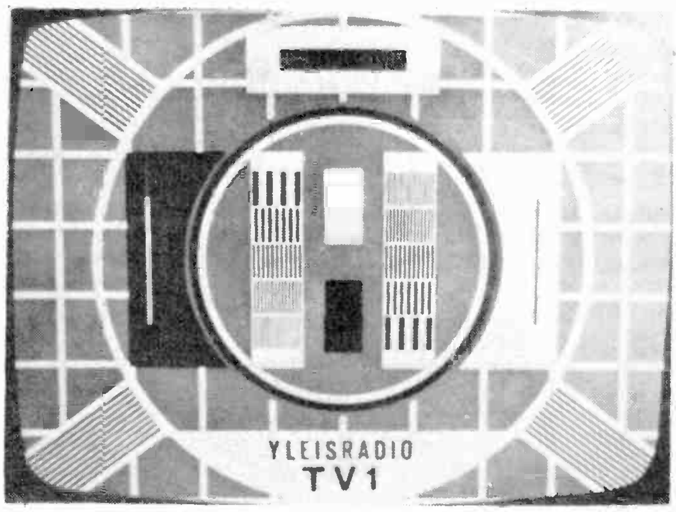
Czechoslovakia CST (D, K) SECAM colour — Ceskoslovenska Televize have two Band I and two Band II high-powered television transmitters which can be received in the UK.



Portugal RTP (B, G) — RMA 1946 test card used by Radiotelevisao Portuguesa on their second u.h.f. network.



Poland TVP (D, K) — Normally identification is not included on this PM5544 which has a dark background. (Off screen photograph.)



Finland YLE (B, G) PAL colour — Oy-Yleisradio Ab, can be received in the UK even though their highest powered transmitter in Band I is only 20kW (e.r.p.).

Microwave device developments

M. W. Hosking reports the 6th European microwave conference from Rome

Each year sees a steady increase in the understanding, performance and application of acoustic surface-wave devices with most emphasis on their role in signal processing and waveform shaping. However, another important function they can perform is as stable oscillators at relatively high fundamental frequencies. An article by A. Schaer of Thompson-CSF compared such oscillators using both surface acoustic wave and bulk acoustic wave devices. The technique is to use the acoustic wave device as a delay line of defined bandwidth and insert it into the feedback loop of a low-noise amplifier. If ϕ_D and ϕ_A are the phase shifts caused by the delay line and amplifier respectively and if d is the delay then, oscillation can occur when $\phi_D + \phi_A = \omega d$ and will be self-sustaining if the gain of the amplifier is greater than the losses of the loop. Thus, many frequencies are possible, each of them spaced at $1/d$ intervals and the desired one is selected by giving the acoustic wave delay line a narrow-band frequency response such that only one spectral line can pass. However, as the amplifier phase shift is a function of gain, a means exists for varying the operating frequency.

Surface wave oscillators had been built on quartz substrate with the crystalline cut chosen for optimum temperature performance. Centre frequencies in excess of 400MHz with 100mW output power and short-term stability of 5×10^{-9} per second were achieved with the complete device packaged to about the same size as a 14-pin dual in-line package.

Bulk wave oscillators are generally more suited to higher frequencies and, in this instance, were fabricated from sapphire or quartz rod with lithium niobate transducers at each end. A similar performance to the surface wave oscillators was achieved at a centre frequency of about 1GHz.

Continued development of these acoustic wave oscillators will be followed with interest as they offer a compact and cheap replacement of stable v.h.f. and micro-wave sources and transmitters, reducing the need for conventional frequency – multiplier chains. In general, experimental surface wave oscillators have already been built in the 1-2GHz region and corresponding bulk devices up to 10GHz.

Of the 32 papers devoted to aspects of semiconductor devices, one quarter were involved with microwave f.e.t. operation, acknowledging the importance and interest of this topic. As reported last year, f.e.ts exist as low-noise and high-power devices to X-band (8.2 to 12.4GHz) and above and many are now commercially available. Emphasis at the conference was given to improvements in fabrication and characterization. With most attention being paid to the various aspects of low-noise pre-amplifiers, it was interesting to review a presentation by P. Harrop *et al.* of L.E.P. (France) in the use of f.e.ts as microwave mixers. Much of the work to date has been carried out by RCA and many of the advantages highlighted. Primarily, these are: the possibility of obtaining conversion gain, as opposed to loss with diode mixers; intrinsically good decoupling between l.o., i.f. and r.f. ports, and operation with a low power local oscillator.

Four different mixer designs were investiagated using a microwave input signal of 7GHz, local oscillator of 8GHz and a 1GHz i.f. The active device was a 0.8μm-gate m.e.s.f.e.t. which had a 3dB noise figure with 10dB associated gain when used as an amplifier. Firstly, a single m.e.s.f.e.t. was used with r.f. fed to the gate and the l.o. to the source. With the gate biased near pinch-off, the source voltage is modulated at the l.o. frequency and mixing takes place by virtue of the non-linear relationship between this voltage and the drain current. The i.f. is extracted at the drain. A minimum noise figure of 7.8dB with 8dB associated gain was achieved.

Secondly, a balanced arrangement used two m.e.s.f.e.ts with earthed source and with split r.f. and l.o. signals fed to each gate. The i.f. was extracted from each drain and an output power combiner was used to add both signals Mixing occurs, once again, in the non-linear transconductance variation caused by modulation of the gate voltage. In this case, the noise figure was 10.8dB at 5dB gain.

The third arrangement used two m.e.s.f.e.ts with their sources coupled by a resistor. Power from the l.o. was fed to the gate of one and the r.f. signal to the gate of the second with the i.f. being extracted from the drain of the second transistor. In similar fashion, a fourth method used the two f.e.ts in series with l.o. and r.f. injected into one gate each. The required i.f. thus exists in the current flowing between the two transistors and is extracted from the appropriate drain port. Both of these last two techniques gave a lower gain of 4dB, a noise figure of 9.8dB but could operate with low l.o. signals of about 1mW.

A further semiconductor device which has seen steady development is the trappatt or trapped plasma avalanche and transit time diode. Similar in many respects to the more-frequently encountered impatt diode (see for instance Realm of Microwaves, Part 1 *Wireless World* Feb. 1973) the device is forced to operate in the trappatt mode by the microwave circuit design at a frequency many times lower than the natural impatt resonance. The result is a device capable of delivering high peak powers with very good efficiency.

Five years ago trappatts were mainly confined to the 1.5GHz and below region and faced a short career due to competition from pulsed, bi-polar transistors. However, some significant work has gone on in this country since then and two papers, from Plessey and Mullard sum-up very well the state of the art. C. H. Oxly *et al.* of Plessey reported results in X-band with diodes mounted in both co-axial and microstrip circuits. The trappatts were made from n-type silicon, with a major design improvement being the electroplating of a gold heat sink directly to one side of the device, plus a small gold "button" to the other, to suppress thermal transients, such as occur in short-pulse operation. As oscillators, peak powers of 10-12 watts at 9GHz were obtained with efficiencies up to 35%. Second harmonic extraction produced several watts around 20GHz with 10% efficiency. Using the same types of circuit, the devices could also be operated as amplifiers and small-signal gains of 7dB with efficiencies up to 25% were achieved.

From Mullard Research Laboratories, J. G. Summers *et al.* reported the continuing trappatt work in the 1 to 5GHz region with specific applications in all-solid-state radar systems. Peak powers up to 120 watt with 44% efficiency were achieved at 2.3GHz with associated mean powers of 1 watt. Once again, considerable attention was paid to the thermal design of the diode and circuit, a necessary factor as the trappatt's were operating at power densities up to 10,000A/cm^2. A good picture of reliability, failure mechanisms and circuit-interaction effects was being built up as the result of testing several hundred devices.

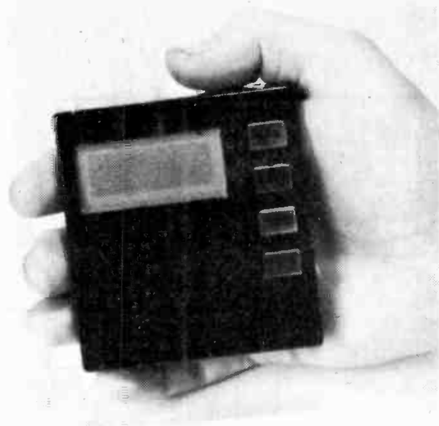
On the exhibition side, there were about 100 exhibitors from many different countries, all of whom had done an excellent job in re-deploying their stands in a new building at short notice. Most people spoken to on the stands were happy at the extent of the enquiries and my own impression was that the exhibition was better attended than the previous year's.

Venue for 1977 will be the Bella Centre, Copenhagen from 5th to 8th September. Professor P. Gudmandsen will be the conference chairman.

Digital event timer — 2

Construction

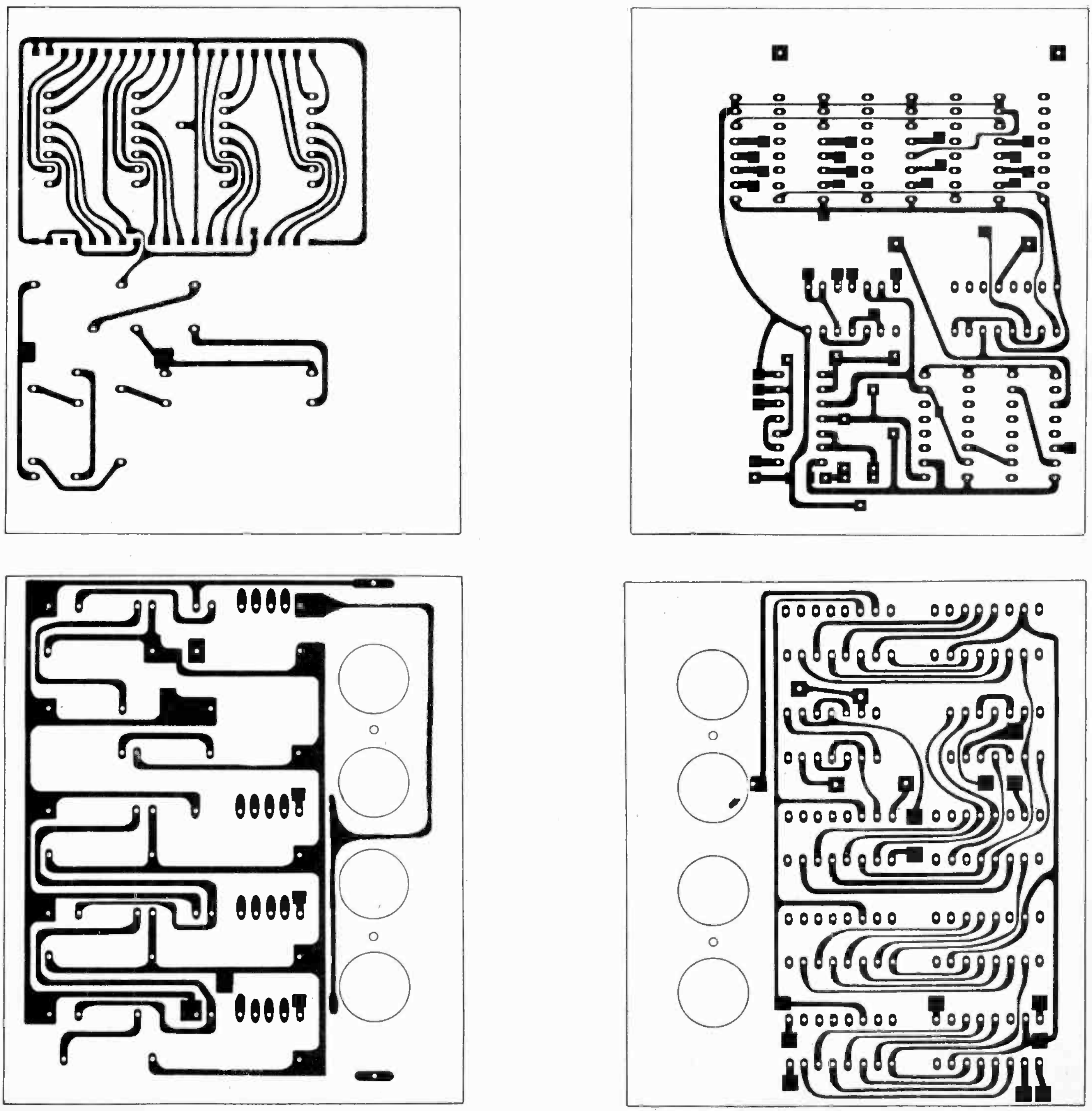
by P. A. Birnie



The construction is based on two double-sided printed circuit boards,(see Fig. 7,)which are made from 1mm glass fibre. The layouts can be drawn using an etch resist pen although the accuracy required presents a few difficulties. Both boards should be first drilled using a 0.8mm bit and a piece of 0.1in Veroboard as a template. The tracks are then drawn in on both sides of the board. Care must be taken to ensure registration between both sides of the board.

The display is mounted on the p.c.b.

Fig. 7. Printed circuit board layout diagram actual size. Note that due to inaccuracies of the printing process and small distortions in the paper, correct registration of the layouts cannot be guaranteed.



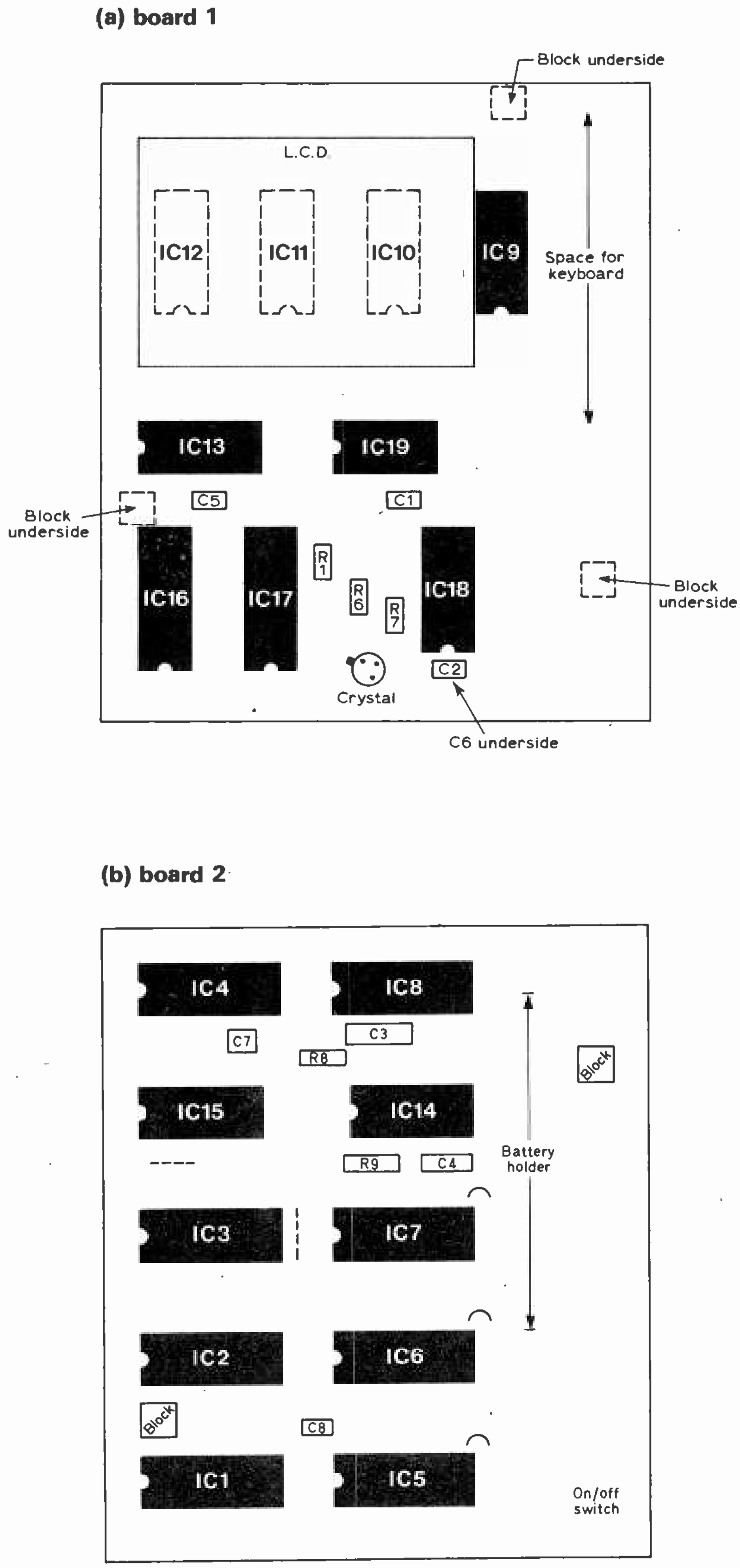


Fig. 8. Component location diagrams. Some of the discrete components are mounted on undrilled pads. Capacitors $C_{5,6,7,8}$ decouple the supply. Five links are fitted on board (b), three on top and two underneath as shown.

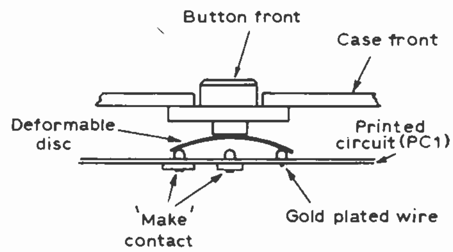


Fig. 9. Button mechanism as used in calculator keyboards.

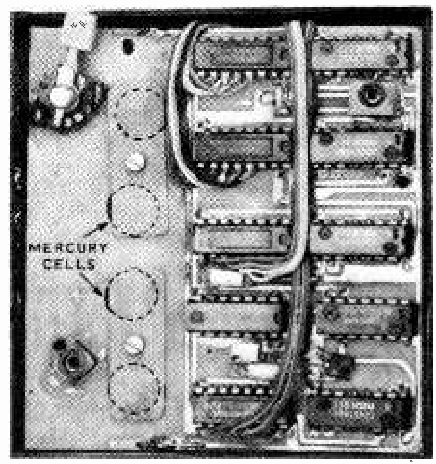


Fig. 10. Component side of p.c.b.2, showing the mounting position of four mercury cells, two blocks for securing the back plate, and the change-over battery switch.

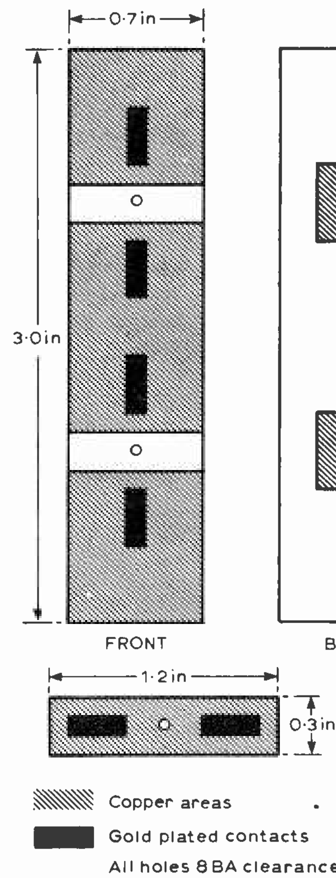


Fig. 11. Construction details for the ancillary p.c.bs. Boards 4 and 5 are identical and single sided. Board 3 is double sided, the back areas of copper are used to solder the 8BA nuts in place.

using Soldercon i.c.-socket pins. Thirty six of the sockets are mounted and soldered onto the component side of the board and these should be trimmed to remove the unwanted pin. Four socket pins go through the board and are soldered on both sides. All of the pins should be kept in the carrier while they are soldered in place as this makes alignment easier.

The 19 i.cs should be mounted as shown in Fig. 8(a) and (b) using an earthed soldering iron and taking the normal c.m.o.s. precautions. Some of the discrete components do not have holes drilled in the board and these are soldered onto pads on the component side. The TO5 can crystal is mounted upside down with the legs bent over and through 180°. When mounting the display great care should be taken because the pins are delicate. Orientation of the display can be determined by examining the readout under strong light. If any of the sockets become detached during insertion, it is safer to continue, and resolder the sockets when the display is in place. Links interconnect pin 9 of $IC_{5,6,7,8}$ via a track on the component side as shown in Fig. 8(b), pin 11 of IC_{15} to pin 15 of IC_{13}, and pin 9 of IC_{14} to pin 1 of IC_7 via pads on the track side of the board.

Switches in the prototype were constructed from a scrap calculator keyboard, and the mechanism, which is based on a flexible disc of gold-plated metal, is shown in Fig. 9. Construction details of the switches are not given because these components can be adapted to suit the individual.

Four RM675H mercury cells are mounted on p.c.b.2 as shown in Fig. 10. Three small boards are made using 1mm double sided fibre glass, see Fig. 11, and two of these have the copper removed from one side. Gold battery-contacts are made by carefully removing the gold-plated edge connector strips from a scrap board. These strips should be cleaned and soldered in the appropriate positions. It is important to use only a small amount of solder, otherwise contact will be made with the solder rather than the gold. Two 8BA clearance holes are drilled in board 3 and 8BA nuts are soldered to square pads on this board. Using two narrow strips of 1mm Perspex as spacers, board 3 is glued to the non component side of board 2, ensuring that the gold pads align with the 0.5in holes. To make subsequent construction easier, a flying lead is soldered to each end of p.c.b.3 before assembly. The four cells are placed into the cavities which now exist so that the top flying lead is at +5.2V with respect to the bottom lead. Boards 4 and 5 are screwed to board 3 using short 8BA screws threading into the nuts already provided.

A change-over switch is needed for the battery because when the power is turned off the decoupling capacitors supply sufficient current to operate the stopwatch for about 8 seconds. After this period the crystal oscillator stops and d.c. is applied to the display for a few seconds. To prevent this potentially damaging situation a 1kΩ resistor is placed across the supply when the switch is in the off position. The switch is connected to board 2 so that the toggle projects out of the case.

Case construction

The author's case was made from 1/16in black Perspex and Fig. 12 shows the parts required. The panels should be cut from a Perspex sheet by scoring deeply with a sharp knife and snapping off over a block of wood. This produces a clean edge which should be smoothed off using fine wet and dry paper. Holes for the buttons and display should be cut using the completed p.c.b.1 as a guide. When the case has been glued using a Perspex cement three blocks are built to support board 1. The blocks are glued to the front plate as indicated in Fig. 12, but exact positions require checking to

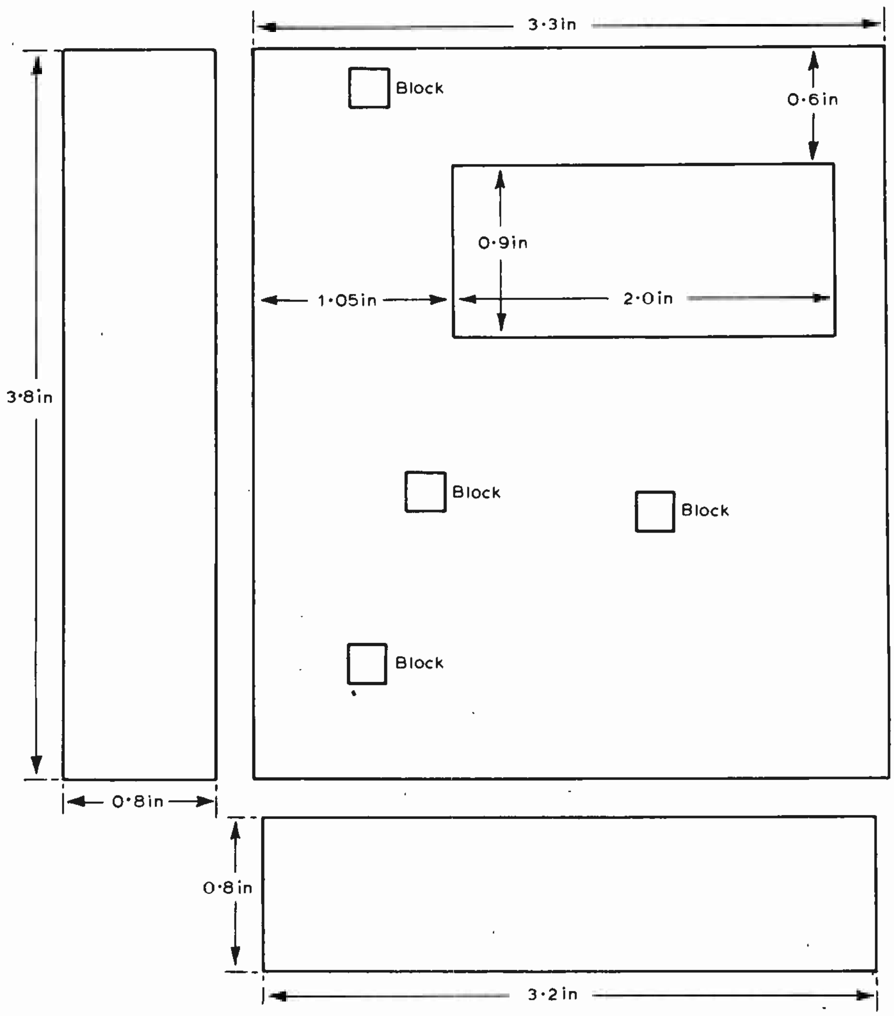


Fig. 12. Case construction details. Panels are cut from 1mm black Perspex by scoring and snapping over a block. The back plate has the same overall dimensions as the front.

Connection on p.c.b.1	**Signal**		**Connection on p.c.b.2**
IC_{19}, 14	+5.2V		IC_1, 16
IC_{18}, 7	EARTH		IC_5, 8
IC_{17}, 7	$\underline{\text{RESET}}$		IC_1, 15
IC_{19}, 11	RESET		IC_{15}, 13
IC_{19}, 8	SELECT X		IC_5, 9
IC_{19}, 10	SELECT Y		IC_5, 14
IC_{19}, 2	ENABLE X		IC_1, 1
IC_{18}, 6	ENABLE Y		IC_1, 9
IC_{16}, 14	10Hz		IC_1, 2
IC_9, 5		2^0	IC_5, 10
IC_9, 3	TENTHS	2^1	IC_5, 11
IC_9, 2	SECONDS	2^2	IC_5, 12
IC_9, 4		2^3	IC_5, 13
IC_{10}, 5	UNITS	2^0	IC_6, 10
IC_{10}, 3	SECONDS	2^1	IC_6, 11
IC_{10}, 2		2^2	IC_6, 12
IC_{10}, 4		2^3	IC_6, 13
IC_{11}, 5	TENS	2^0	IC_7, 10
IC_{11}, 3	SECONDS	2^1	IC_7, 11
IC_{11}, 2		2^2	IC_7, 12
IC_{12}, 5	UNITS	2^0	IC_8, 10
IC_{12}, 3	MINUTES	2^1	IC_8, 11
IC_{12}, 2		2^2	IC_8, 12
IC_{12}, 4		2^3	IC_8, 13
IC_{13}, 3	TENS	2^0	IC_7, 13
	MINUTES		
			Keypad connections
IC_{18}, 5			RUN
IC_{10}, 1			SPLIT
IC_{19}, 8			X
IC_{18}, 1			Y

ensure that no projections exist on the non-component side of board 1. Holes are carefully drilled through this board and into the blocks to accommodate self tapping screws. A similar approach is adopted for board 2 except that the blocks are glued, using Araldite, to board 1 as shown in Fig. 8. Care should be taken not to cut or bridge any pads while drilling the p.c.bs. The back of the case is also secured to board 2 by Perspex blocks. If the block positions shown in Fig. 8 are not used, board 1 should be supported around the push-button switches to prevent excessive flexing during use. The case can be polished using metal polish or T-cut.

Final assembly and testing

The two main component boards are interconnected by two groups of miniature flat ribbon cable as listed in the table. Pads are provided on both sides of the boards for these wires. The first group contains 16 wires interconnecting the outputs of the data selector stages to the display decoder drivers. The second group of wires provides clock and control signals from board 1 to board 2. Connections from the four push-buttons to board 1 are also shown. Final connections are by flying leads from the battery holder to the positive supply rail on board 2, and the negative supply rail, via a multimeter, to the switch. After a final check, and with the multimeter on the 10mA range, switch on. An initial large deflection should take place as all the decoupling capacitors charge. The current should then drop to about 200μA and the display should be active. If this is the case, the button functions can be tested. When all of the operations have been successfully tested the two boards should be inserted into the case and secured in position. It should be noted that the display segments have a relatively long response time. This is normal especially in warm ambient temperatures. It is possible to use other liquid crystal displays in this design provided that they use the same drive of five volts r.m.s.

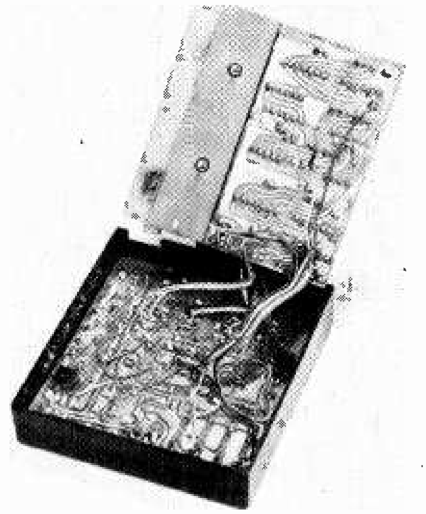


Fig. 13. Internal view of the timer with p.c.b.2 hinged open. Board 2 is supported on board 1 by three Perspex blocks.

Printed circuit boards

Two double-sided p.c.bs will be available for this design. The boards, which are based on the author's layouts, are priced at £6.00 for the set and are available from M. R. Sagin at 11 Villiers Road, London N.W.2.

Literature Received

A wallchart produced at regular intervals by DATA I/O provides basic information on all programmable read-only memories being currently made (140 from 18 manufacturers, in the newest chart). The company's programming equipment is able to programme all devices mentioned. DATA I/O (U.K.), 11 Duke Street, High Wycombe, Bucks WW 401

The latest edition of *ERA News* contains a brochure on the ERA electron microscopy service for industry, using a Cambridge Stereoscan IIA with magnification of 14 to 50,000×, at a resolution of 200Å. There is also a list of published reports on electrical power engineering from 1963-76. ERA Ltd, Cleeve Road, Leatherhead, Surrey KT22 7SA .... WW 402

The two latest volumes of the IBA Technical Review (Nos. 8 and 9) are "Digital Video Processing – Dice" and "Digital Television Developments." The former contains seven articles describing various aspects of the IBA's digital intercontinental conversion equipment (DICE) for two-way television standards conversion, while the second – No. 9 – is concerned with digital techniques in a more general way. Teletext is described in three articles and there is discussion of digital transmission techniques. A glossary of "digital" terms is included. Engineering Information Service, IBA, Crawley Court, Winchester, Hants SO21 2QA..... WW 403

Livingston Hire's new bulletin illustrates additions to the range of equipment for hire, including an instrumentation tape recorder, digital thermometer, Rugby standard-frequency receiver, logic analyser, air-velocity meter and mains interference recorder. Livingston Hire Ltd, Shirley House, 27 Camden Road, London NW1 9NR . WW 404

Relays and counters are described in a catalogue from ITT. Military-style relays are covered, including the M series miniature printed-board variety and the R series medium-power relays. ITT Component Group Europe, Electro-mechanical Division, Edinburgh Way, Harlow, Essex CM20 2DE........................... WW 405

Papers read at the IEE conference on millimetre waveguides are now published in a volume entitled Conference Publication 146, which is obtainable from Marketing Department, IEE, PO Box 8, Southgate House, Stevenage, Herts SG1 1HQ, at a cost of £10.35 in the UK, £12.10 overseas.

Magnetic pick-offs, shaft encoders, photo-electric probes and proximity switches are all covered in a catalogue now available from Orbit Controls, Lansdown Industrial Estate, Cheltenham, Gloucester GL51 8PL WW 406

Sescosem, a division of Thomson-CSF, produces a monthly bulletin giving details of its semiconductor products. The June and July/August issues, which reached us in October, described a microprocessor, a voltage regulator for cars, a car tachometer i.c., a 2k r.e.p.r.o.m., a 400V car ignition transistor and a motor speed control i.c., among others. Thomson-CSF United Kingdom Ltd, Ringway House, Bell Road, Daneshill, Basingstoke, Hants .... WW 407

Announcements

Peter Eardley has left AKG Equipment Ltd after 14 years. Eardley formed AKG (UK) Ltd in 1969 as the British subsidiary of the Austrian parent company. He will retain a shareholding in the company, though his main activity from now on will be in a new photographic studio. Eardley told *Wireless World* he had "inherited" G E Electronics (London) Ltd, which imported colour tv parts from West Germany, and had a number of "semiconductor and similar agencies from the US." Another subsidiary sold British goods. Mr Eardley said the reason for the move was that he felt he had "reached all I could do in microphones." The present general manager of AKG (UK), Mr Cecil Woolf, will take over from Mr Eardley at the end of 1976.

Macro Marketing have been appointed Motorola semiconductor distributor in the UK from February 1, 1977. Motorola's agreement with Semicomps comes to an end on December 31. Motorola's agents now are Celdis, Cramer, GDS, ITT, Jermyn, Lock and Macro.

Miss Geisla Burg has been appointed the first woman chairman of the Federation of British Audio. Some time ago the FBA announced that it would start to promote its activities more aggressively and, after her appointment on October 20, Miss Berg said "During the next year the FBA must become a really effective body presenting the members' views to government and promoting the activities and interests of the British audio industry."

From November 1, Tannoy's R&D, sales and head offices, have been at St John's Rd, Tyler's Green, High Wycombe, Bucks HP10 8HR.

Apex Components, who already distribute Signetics i.cs, have been appointed distributors for the whole range of Mullard discrete semiconductors. They now have Mullard stock worth £80,000.

Progress in millimetric waveguide

Post Office announce field trial results

Details of circular waveguide field trials in the UK and overseas were given at an international conference on millimetre waveguide systems, held in London during November. Post Office engineers almost dominated the IEE conference with their 20 papers, not only reporting results of the field trial but also covering recent work on waveguides, multiplexing, repeaters, semiconductor devices, filters, system and planning aspects. Bell Telephone Laboratories gave no less than 10 papers, with first announcement of their 14km field trial on their dielectric waveguide system. And the Post Office chose the occasion to announce its planned Bristol to Reading waveguide link (see News, page 38).

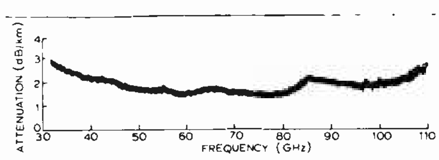
The ability of circular waveguide to provide low loss transmission was demonstrated in the 1950s at University College, PO Research Department at Dollis Hill and at STL, yet it was not until 1967 that the Post Office mounted a comprehensive R & D programme. Out of fifteen possible waveguide structures, four were chosen for detailed cost-benefit comparison, with the conclusion that whilst other organisations had developed helix waveguides with a steel sheath, the Post Office view was that a lightweight helix guide encased in fibreglass/epoxy resin and housed in a steel duct would be easier to install and joint. "The aim has been to develop a sound cost-effective system that could, while showing substantial savings if introduced on routes where only a small proportion of its bandwidth will be used initially, also cater for the very high bandwidth demand of the future".

The 50mm guide is made by a joint PO/BICC plant (BICC Research Engineering Ltd) in 3m lengths. A 40 s.w.g. two-start copper helix is wound on a stainless steel mandrel and surrounded by a layer of lossy iron-loaded resin reinforced with glass fibres. Aluminium foil is wound over this to provide a water and oxygen barrier (the waveguide is normally nitrogen filled to avoid oxygen absorption band at 60GHz) and the whole is enclosed in epoxy-resin impregnated binding tape.

A virtue of this helix guide is its high loss to spurious modes but this has to be set against its attenuation at bends. Two solutions for sharp bends are mitre joints or mode conversion and reconversion in curved reduced-diameter dielectric guides, but Ritchie and Childs reported a modified guide for more gradual bends. By reducing spacing between the helix and the aluminium screen, say to 0.6mm, loss peaks can be moved out of the transmission band.

Actually, the penalty of higher attenuation is "very largely the additional cost of closer repeater spacing, therefore a value can readily be placed on a change in attenuation", say Ritchie and Childs. "A discounted cash flow calculation based on current estimates of repeater costs and assumed growth rates results in a value of £0.6/m for each 0.1dB/km saving in attentuation at 110GHz. Considering the relatively high cost of waveguide production and installation this is a low value and generally makes it difficult to justify the introduction of sophisticated techniques."

Attenuation of the field trial route was less than 2.5dB/km over most of the band, permitting repeaters to be considered at intervals of more than 20km. An error rate of 1 in 10^9 per repeater section can be achieved with a carrier-to-noise ratio of 22dB at the demodulator input. Attenuation curves show some expected losses due to bends at 44, 66 and 93GHz and due to sagging between supports at 56 and 86GHz.



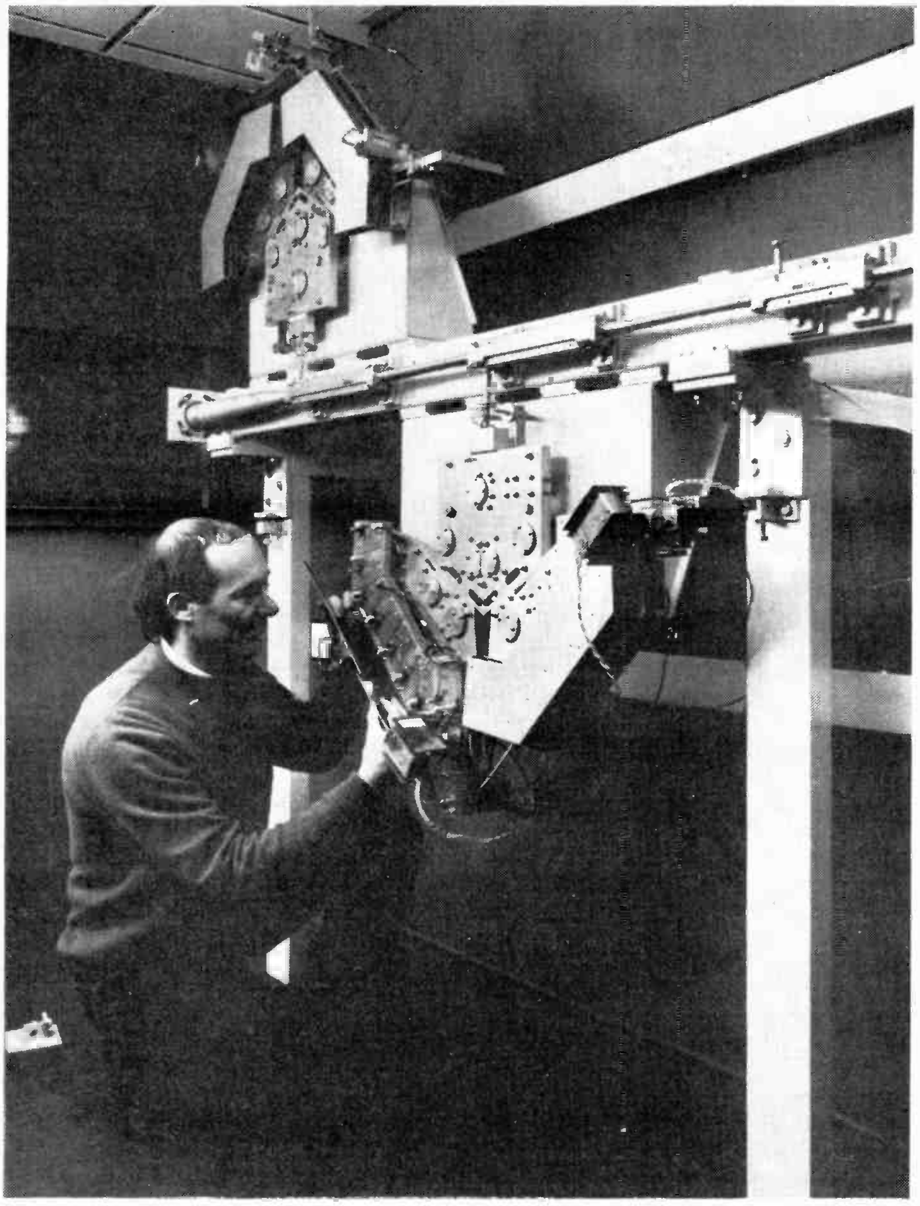
Measured attenuation of 11km of field trial route.

While some unanticipated problems arose in installing the guide, the Post Office are well pleased in general. They expect that improvements made to new waveguide — better duct laying, less joint tilt, increased longitudinal stiffness, in addition to the reduced bending loss — should reduce attenuation at 110GHz by 1dB/km without much extra cost.

Propagation is by a low-loss (0.002dB/m at 100GHz) transverse electric mode, TE_{01}, with its property of falling attenuation with increasing frequency, until checked by geometrical limitations. The region from 30 to 110GHz is divided into eight 10GHz bands, each subdivided into 16 channels of about 500MHz bandwidth. For transmission over the guide, pairs of digital traffic at 140Mbit/s (1,920 telephone channels) are multiplexed to 280Mbit/s on r.f. carriers. Modulation can be at an i.f. of 1.4GHz followed by up-conversion or, more efficiently, directly with an impatt source. The receiver has an i.f. of 1.4GHz and a meander line circuit to equalize the systematic group delay of the waveguide. Differential demodulation, in which carrier phase is compared between adjacent bits, is preferred to coherent demodulation — despite its 2dB lower carrier-to-noise ratio for comparable performance — to avoid the complexities of carrier recovery.

Given certain assumptions (one is a 7% annual growth of traffic) "there could be an important place for waveguide in the truck transmission network of the UK", say D. J. Beckley and A. C. Pigott of the PO network planning department. "However, the quantity and timing of the provision of waveguide links is likely to be very sensitive to changes in estimates."

Waveguide economics are quite different from conventional line systems. There is a very high expenditure in the first two years when waveguide has to be laid in its special steel duct, giving a



Marconi and BICC have been associated with the Post Office development of the new high capacity waveguide communication system which is planned for operational trunk service between Bristol and Reading. Marconi's contribution, consisting of terminal and repeater equipment, was developed by Marconi Research Laboratories following three Post Office contracts for feasibility, development and experimental work on the waveguide system. Photograph shows a waveguide band-branching and channelling unit installed in a field trial terminal. Marconi, BICC and the Post Office are collaborating to market this waveguide system overseas as a package, covering initial planning, manufacture, installation, commissioning, training and maintenance.

high circuit-independent cost, and because of the 20+km repeater spacing there is a low circuit-dependent cost. This means that added-circuit cost will be very low and that savings made will be very dependent on annual growth rates. Savings made by a 500Mbit/s guide over a coaxial cable that might be justified on the basis of a 7% growth could easily be wiped out by an annual circuit growth of 5%.

The Bell WT4 system is committed to a 60mm dielectric-lined waveguide, with small amounts of helix guide (1%) to filter unwanted modes. The 3.7mm thick steel tube is electrolytically plated on its inner surface with a 5μm copper lining, up on which a 180μm polyethylene dielectric is deposited by a complicated bonding process.

Detailed results and techniques used in the Bell System field trial were announced at the conference, the most outstanding result being the extremely low loss achieved. Over the 14km of route loss was 1dB/km or less over the entire band, and about 0.5dB/km mid-band. One paper, with its 11 authors, showed good agreement between measured loss and curvature-predicted loss using a new theory that took account of TM_{11}, TE_{12}, TM_{21} mode conversion. This loss is a rapidly increasing function of frequency and limits the highest transmission frequency.

Work is also under way in France, Germany, Italy, Japan — some of it reflected in the 24 contributions from those countries — but an author from Germany admitted that in that country there is "no actual need for such a high capacity long-haul transmission medium". Newly-developed aluminium-alloy dielectric waveguide with electrochemically-produced aluminium oxide as dielectric to avoid peeling problems will not now be installed in the 48km Darmstadt-Heidelberg test link as originally intended, though it will be tested in 1km ducts before experimental work finally ceases.

Like the American programme, the Japanese work has relied on the most costly dielectric waveguides mixed with helical absorbing guides. Whilst progress in the US, UK and Japan has been described as "fairly level pegging", the Japanese are talking of promising results above 100GHz and together with a new multilevel modem technique makes a 1.2 million voice channel capacity over 40-120GHz possible. They reported silicon IMPATT diode output powers of 62mW at 200GHz and 8mW at 285GHz early in 1976 and oscillation has been observed at 394GHz.

Post Office trunk routes are not the only use of millimetre waveguide; there is a wide variety of applications that can benefit from the wide bandwidths, narrow beamwidths and small size and weight. A 120Mbit/s digital data link operating over 2km at 20GHz, developed at RSRE, Malvern, weighs only 12kg. The narrow beamwidth and low sidelobe levels give a secure link for security surveillance, ship-to-ship and inter-building communications, and disaster area control.

In radar, the trend is to specialist radars having outstanding short-range surveillance capabilities through improved angular and radial resolution, for such applications as harbour traffic control, airport surface detection, railway marshalling yard control, and precision survey work. One Marconi Doppler radar at 90GHz allows large oil tankers to perform delicate docking manoeuvres by resolving speeds of a few ft/min with 1-2ft discimination.

The oxygen absorption at 60GHz breaks up into narrow resonances above a height of 40,000ft and it is thought that aircraft could communicate with one another or with a satellite between these lines without risk of interference from ground stations. And investigations into communicating through the ionized shock wave associated with re-entry vehicles have shown that a system operating at 110GHz could sustain a link through the plasma sheath, normally opaque to radio waves.

Other uses are in radio astronomy, propagation studies, weather radar, a 33GHz radiometric sextant, 94GHz altitude and sink speed indicator for use in snow and ice fields, a 35GHz sea ice detector, control of reagents and catalysts in chemical reactions, and its use in diathermy is being investigated. — GBS

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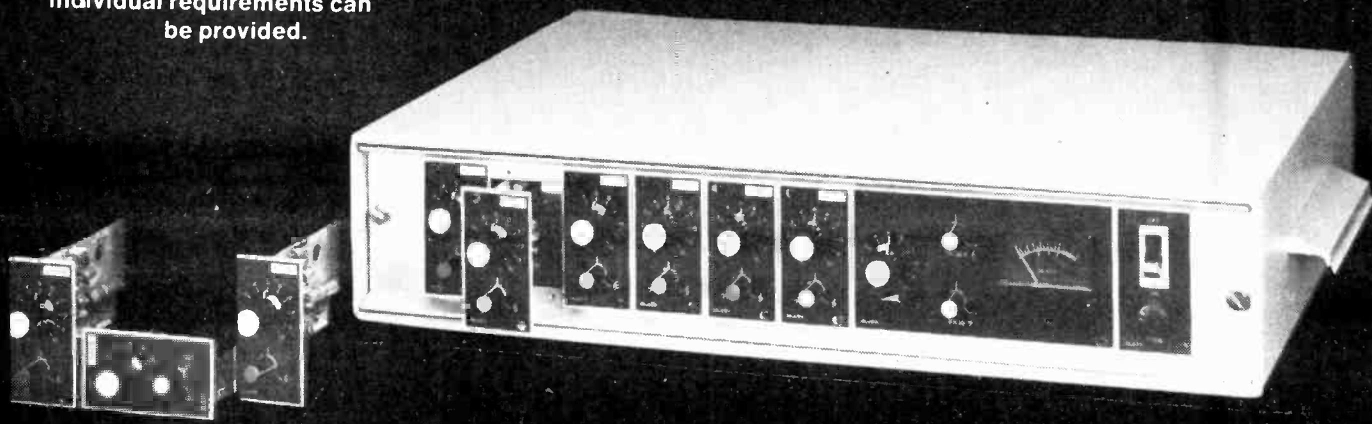

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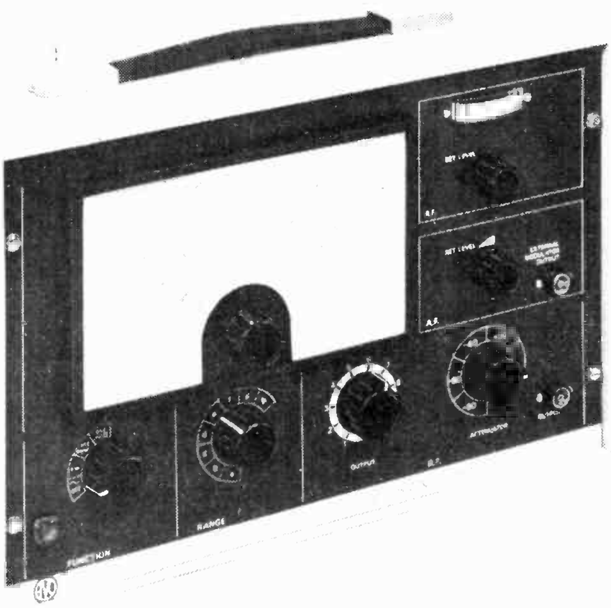

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Circular insert generator for television

A circuit which allows part of a television picture to be inserted into a circular "cut-out" in another picture

by D. E. Burgess, B.Sc., Ph.D. *Royal Signals and Radar Establishment, Malvern*

Commercial television special effects generators which are used to insert part of one television picture into another generally have a number of options on the shape of the inserted picture, for example a square or rectangle, or a circle, and consequently are rather expensive. When the inserted picture is required to have only horizontal and vertical boundaries the experimenter may be tempted to construct a video switch with a timing unit using monostable multivibrators triggered by the television field and line drive pulses, but the choice between building or buying may be a more difficult one when an accurate circular insert is required. However, when a compact low powered unit was specified for a particular application needing only a circular insert, it was decided that construction was still the most sensible choice, and the circuit described here was developed to meet the requirements.

By timing from the television line and field synchronising pulses, the circuit is required to produce two switching points on each television line, the first blanking the primary video signal and replacing it by the secondary inserted signal, the secondary doing the reverse; these switching points being chosen so that the boundary of the insert appears as a circle. A secondary requirement of the circuit was that the position and the size of the circular insert should be variable.

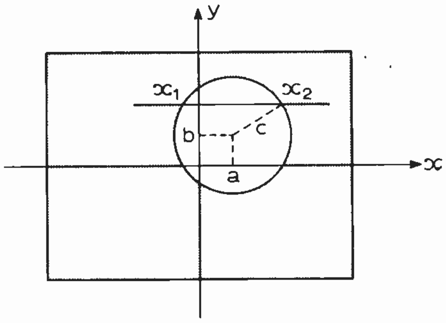


Fig. 1. Representation of the circular insert a secondary signal into the primary television picture.

Theory of operation

The circle, shown in Fig. 1 within the outline of a television monitor, with a radius of c and centred at the point a b is represented by the equation

$$(x-a)^2+(y-b)^2=c^2 \qquad (1)$$

From this equation the values of x_1 and x_2, the switching points for the insert along one television line, are given by

$$x_1=a-\sqrt{c^2-(y-b)^2}$$

$$\text{and } x_2=a+\sqrt{c^2-(y-b)^2}$$

or the switching interval x_1 to x_2 is defined by the relationship

$$-\sqrt{c^2-(y-b)^2}\leqslant x-a\leqslant +\sqrt{c^2-(y-b)^2} \qquad (2)$$

and it is this equation that forms the basis for the circuit.

A sawtooth waveform y is generated in phase with the television vertical field scan and is shifted by an amount b corresponding to the centring of the circle in the vertical direction. The result $(y-b)$ is then squared to give $(y-b)^2$ and this signal is subtracted from c^2, the square of the circle radius. The square-root operation is then performed and the result, the right hand side of equation (2), and its negative, the left hand side of the equation, are compared with a second offset waveform $(x-a)$ which is in phase with the television horizontal line scan. During the interval along each line for which equation (2) holds, a switch is operated to blank the primary video signal and to insert the secondary one.

Circuit description

The circuit diagram is shown in Fig. 2, with the associated waveforms photographed from an oscilloscope in Fig. 3. A decision was made initially to use integrated circuits wherever possible in order to simplify the circuit development and to minimise space, but if cost or the use of readily available components were a major consideration some of the operations could be performed using discrete components. Two synchronising signals are required to operate the circuit, one at the television line frequency and the other at the field frequency. Normally line drive and field drive signals would be chosen but because mixed video blanking is used in another part of the circuit as described below, this same signal was used for synchronisation in the line direction so as to minimise the number of connections to the unit.

Vertical signal processing. Transistor Tr_2 and its associated components R_4, R_5 and D_1 form a 70μA current source to drive the Miller integrator IC_1, a 741 operational amplifier. During the field flyback time the two-volt negative-going field pulse is amplified to 24 volts by Tr_1 to turn on the field-effect transistor switch Tr_3, shorting the integrator output to a preset potential determined by the vertical shift control R_{43}. This integrator produces the 11 volt peak to peak sawtooth waveform $(y-b)$ with a time period of 20 milliseconds which, with the shift control set to mid travel, is shown in Fig. 3(a). R_{43} allows for an 8 volt adjustment of the starting potential of the sawtooth and corresponds to the term b in equation (2).

An analogue multiplier/divider circuit IC_2 having a transfer function of $xy/10$ is used to form the square of $(-b)$ by driving both the x and y inputs with the output of IC_1. The Analog Devices type AD530 amplifier [1], which uses the transconductance technique, is used here and requires four offset nulling trimming resistors, R_8 to R_{11} inclusive. The parabolic output waveform from IC_2, $(y-b)^2/10$ is shown in Fig. 3(b). A second 741, IC_3, is operated as a unity-gain subtractor circuit to produce $(c^2-(y-b)^2)/10$, with the circle radius control R_{45} providing a voltage corresponding to $c^2/10$. Here a linear potentiometer conveniently produces a circle area proportional to spindle rotation. Fig. 3(c) shows the waveform at the output of IC_3.

Somewhere in the chain of operational amplifiers a control is required to set up the roundness of the circle for the situations when a television monitor is poorly adjusted. This control, R_{46}, is conveniently placed between IC_3 and the following amplifier IC_4, a second AD530. This time the AD530 is connected so as to have a transfer function of $-\sqrt{10Z}$ for positive values of Z. For negative Z the output is zero. Ignoring constants, the output of IC_4, shown in Fig. 3(d) is $-\sqrt{c^2-(y-b)^2}$. Again, four offset nulling trimming resistors R_{16} to R_{19} inclusive are required with this amplifier. (A more compact but more expensive solution would be to use the internally-trimmed multiplier/divider type AD532 for both IC_2 and IC_4). The negative form of this function is also required by the switching point detector as shown in equation (2); hence the

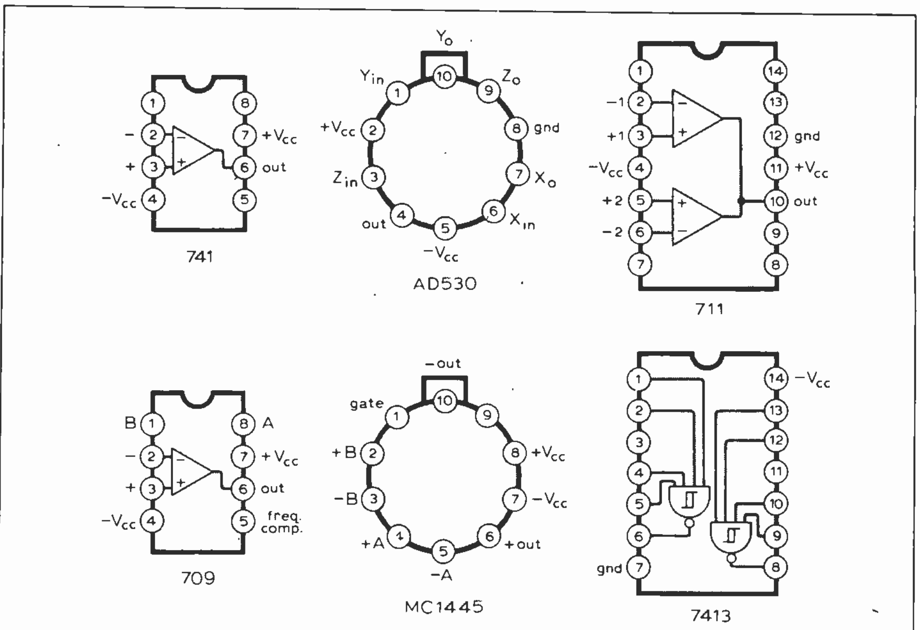
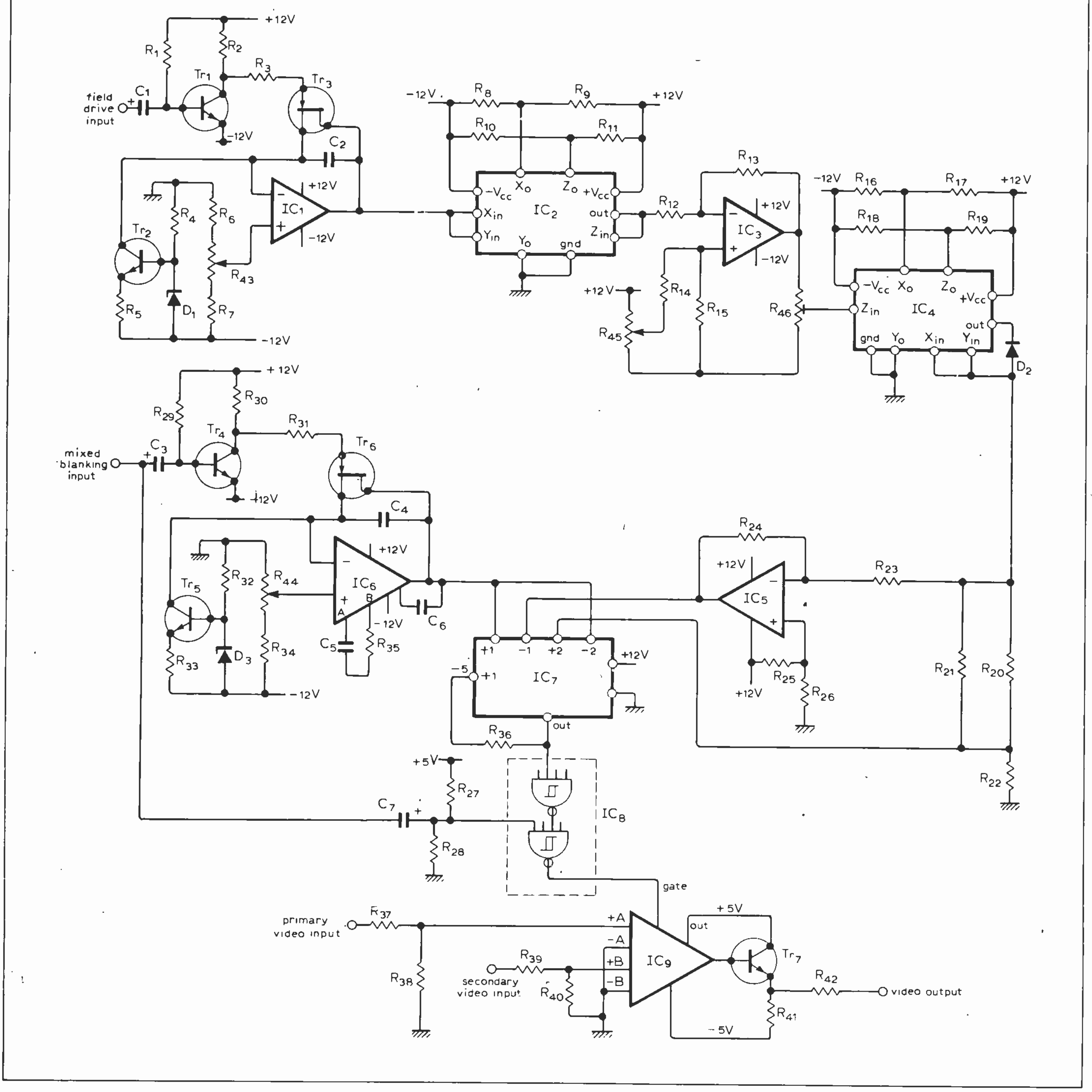


Fig. 2(a). Circuit diagram of insert generator. (b) Device connections.



third 741, IC_5, which inverts the output of IC_4 and also attenuates it to a level compatible with the comparator, IC_7.

Horizontal signal processing. A similar circuit to that described above for the production of the vertical ramp is again used to generate a ramp synchronized to the television line scan. In this case IC_6 is a 709 operational amplifier to cope with the higher frequencies involved in the line direction, producing a 2.4 volt peak to peak sawtooth waveform with a time period of 64 microseconds. Two-volt negative-going mixed video blanking signals, amplified by transistor TR_4 to 24 volts, are used to reset the integrator to a voltage determined by the horizontal shift control, R_{44}. This ramp $(x\text{-}a)$ is compared with the positive and negative versions of $\sqrt{c^2-(y-b)^2}$ by IC_7, a 711 dual comparator. During each line whilst $(x-a)$ lies within the limits of equation(2), the output of IC_7 takes up its t.t.l. – compatible low state of 0 volts, and for the remainder of the line its output is at 3 volts. To ensure that the comparator is not triggered by noise during a line outside the required circle, when the output of IC_4 is close to zero, a small offset voltage is applied to IC_5 by means of resistors R_{25} and R_{26}.

Horizontal sync. In the case where the synchronizing and blanking parts of the two television signals are not identical or where, for example, only a d.c. level is required for one of the signals, the switching of the comparator during line or field flyback (equation(2) applies equally to the trace and retrace part of the sawtooth waveforms) is not recommended, as interference would be introduced into the output signal. For this reason the mixed video blanking signal is added to the output of IC_7 in the 7413 Schmitt trigger IC_8, to ensure that the blanking and synchronizing portions of the primary video signal are not interrupted. Because the mixed video blanking waveform is needed for this function it was decided to use it also as the line synchronizing signal to save the additional connection of the line drive pulses. In a system where possibilities of interference in the flyback portions of the output video signal are of no consequence this circuit may be dispensed with, the 711 driving straight into the video switch, IC_9. In situations where commercial equipment is available, the output of IC_8 may be used as a drive for the keying input of a video mixer.

In applications such as circular blanking where the primary video signal is a direct voltage with no blanking or synchronizing information, the circuit may be simply modified to transmit the secondary waveform during the blanking period by connecting the junction of R_{27} and R_{28} to an input of the first half of IC_8 instead of to the second half.

Video switch. During each line on which IC_7 is triggered, a switch is used to insert a section of the secondary video signal into the primary signal. IC_9, a gate-controlled video switch (Motorola MC1445)[2], is a wide-bandwidth, two-channel amplifier with a pre-set internal gain of 9. Whilst its gate input is held at 3 volts by IC_8, the primary video signal on the A inputs is amplified and passed to the output, but when IC_7 is triggered and the gate signal goes low the secondary video signal is transmitted through the device. Both video signals, assuming 1 volt composite video, are attenuated by a factor of 4.5 prior to the switch so that a one-volt output signal is produced when the circuit is terminated with the usual 75 ohm load. Transistor TR_7 connected as an emitter follower provides the necessary low output impedance.

Typical switching transition times between the primary and secondary video signals are 20 nanoseconds, resulting in a very clean periphery to the circle, as shown in Fig. 4, which is a photograph of a television monitor displaying part of the BBC test card inserted in an electronically generated crosshatch pattern. This figure also shows the excellent accuracy of the generated circle.

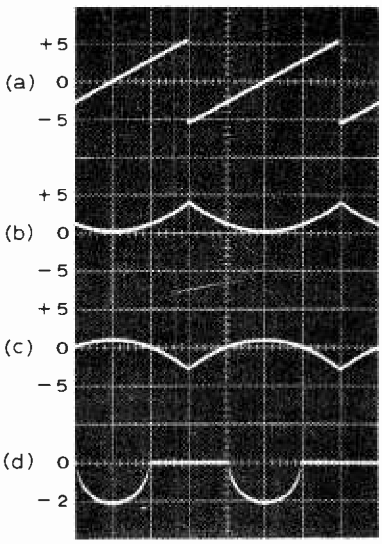


Fig. 3. Photographs taken of oscilloscope traces showing (a) $(y-b)$ the output of IC_1, (b) $(y-b)^2/10$ the output of IC_2, (c) $c^2-(y-b)^2/10$ the output of IC_3, (d) $-\sqrt{c^2-(y-b)^2}$ the output of IC_4. Horizontal scale is 5 millisecond/division. Vertical scale is on volts.

Power supplies

Integrated circuit regulators are used to produce the plus and minus 12 volts for the amplifiers IC_1 to IC_6 from unstabilized 15 volt supplies. Minus 5 volts for IC_7 and IC_9, and plus 5 volts for IC_8 and IC_9 are generated from the 12 volt supplies using 5.6 volt zener diodes and emitter-follower transistors. All power supplies are decoupled to earth at each integrated circuit package by 0.1 microfarad ceramic capacitors, but apart from this precaution no special care needs to be taken over the layout of the components on a piece of Veroboard 8 inches by 4. The measured power consumption of the circuit is 3 watts.

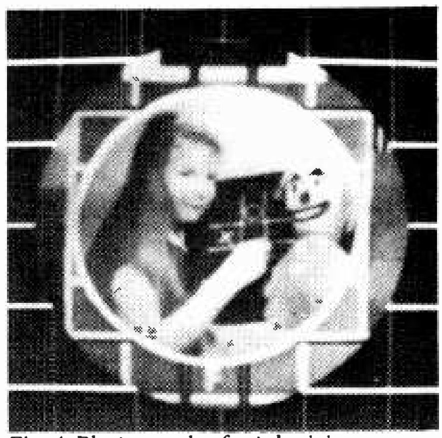


Fig. 4. Photograph of a television monitor showing part of a BBC test card inserted into an electronically generated cross-hatch pattern.

References

1, Analog Devices Product Guide 73 p. 170, 171.
2, Motorola product literature.

Acknowledgement

Contributed by permission of the Director of R.S. & R.E.

Components

Resistors

1	100k	24	2k2
2	10k	25	10k
3	100k	26	39k
4	5k6	27	10k
5	29k	28	3k3
6	2k2	29	100k
7	2k2	30	10k
8	10k select-on-test	31	100k
9	10k select-on-test	32	2k2
10	10k select-on-test	33	5k6
11	10k select-on-test	34	8k2
12	10k	35	1k5
13	10k	36	3k3
14	10k	37	3k3
15	10k	38	1k
16	10k select-on-test	39	3k3
17	10k select-on-test	40	1k
18	10k select-on-test	41	270R
19	10k select-on-test	42	75R
20	4k7	43	10k pot
21	47k	44	2k5 pot
22	1k2	45	1k pot
23	10k	46	10k pot

Capacitors

1	10μ electrolytic
2	100n
3	10μ electrolytic
4	22n
5	220p
6	22p
7	10μ electrolytic

Semiconductors

$Tr_{1,2,4,5}$	2N3904'
$Tr_{3,5}$	2N3819
Tr_7	2N3704
$IC_{1,3,5}$	72741
$IC_{2,4}$	AD530
IC_6	72709
IC_7	72711
IC_8	7413
IC_9	MC1445
D_1	3V3 zener
D_2	1N914
D_3	5V6 zener

Circuit Ideas

Motor revolutions control

In d.c. motor applications this circuit will provide an exact number of revolutions. By using a small resistance, R_s, in series with the motor, a voltage is developed across it which contains an a.c. component whose amplitude and frequency are related to the speed of rotation and the number of armature coils. This signal is amplified by a c.m.o.s. inverter operating in the linear mode. The two following inverters square the signal which is then fed into the counters. The counter outputs are decoded by gate 1 which controls the series switching transistor Tr_1. Gate 2 in conjunction with Tr_2 is used to brake the motor. Thus, when the desired number of revolutions is reached Tr_1 turns off and Tr_2 turns on which rapidly stops the motor. Gate 3 isolates the counters during the braking period. The motor is restarted by pushing the reset button. If the motor is slowed down due to unusual loading conditions it will always complete the desired number of revolutions.

R. McGillivray,
Toronto,
Canada.

Temperature to pulse-length converter

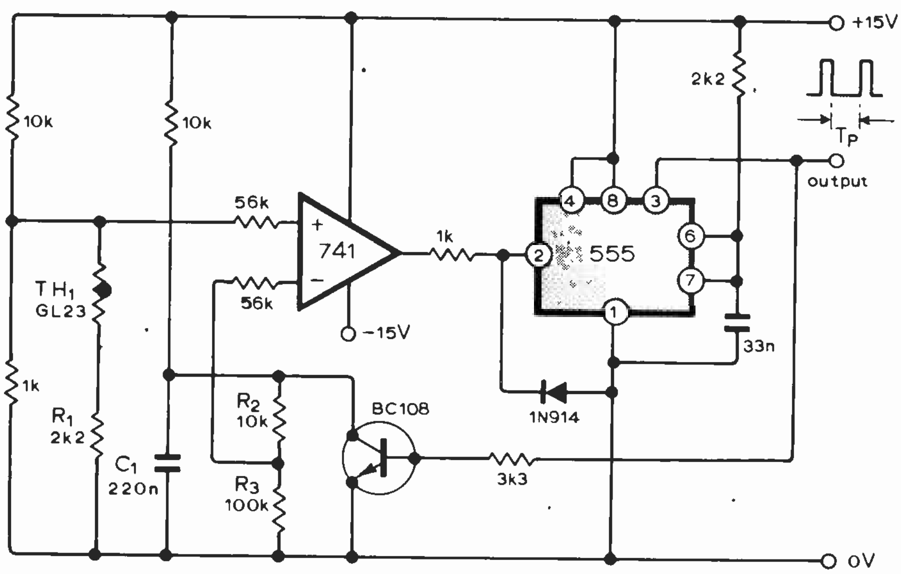
An output pulse whose length is directly proportional to temperature can be produced by using a thermistor in the circuit shown. The design is based on the similarity between the resistance/temperature curve of a thermistor $R_{T1} = R_{T0}.e\ (B/T_1 - B/T_0)$ and the inverse function of voltage across a capacitor charging through a resistor from a voltage after time $t, V_1 = V_0 - V_0 e^{\frac{-t}{cr}}$ Temperature is measured by the thermistor which is supplied from a potential divider to reduce dissipation. The temperature dependent current through the thermistor appears as a voltage across R_1. This is compared by IC_1 with a fraction of the increasing voltage across C_1. the output of IC_1 goes negative and triggers the 555 which is connected as a monstable. The 555 output turns the transistor on for about 100µs and discharges C_1.

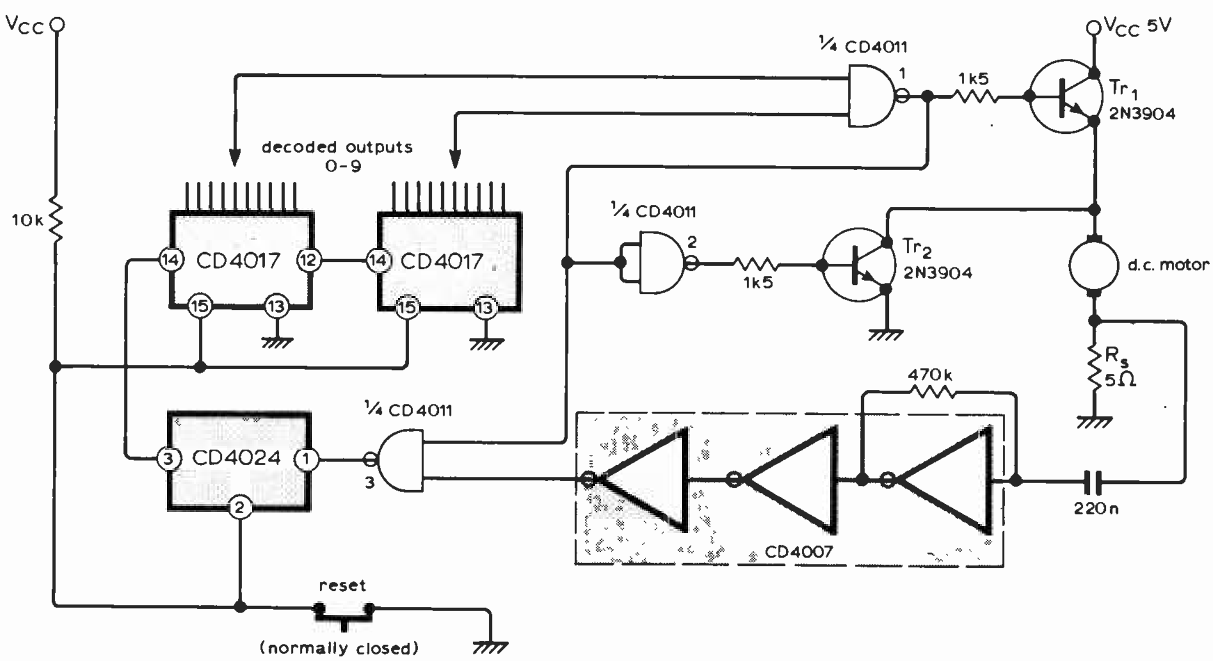
The timer output can be used to gate a clock oscillator so that the resulting number of pulses will be directly proportional to temperature. Alternatively, the output can drive a pulse-length to voltage converter for an analogue output. If a true reading in degrees C is required, the pulse length corresponding to 0 deg C must be subtracted. This may be achieved either by gating the output with a second monostable or by a digital counter operating on the gated clock pulses.

The prototype circuit produced a pulse length of 650µs at 0 deg C, increasing by 20µs/deg C, and was accurate to within ±1.2 deg C over the range 0 to 60 deg C.

Other temperature ranges or thermistor types can be used with suitable changes of R_1, $_2$, and R_3.

T. P. Y. Sander,
Bembridge,
Isle of Wight.





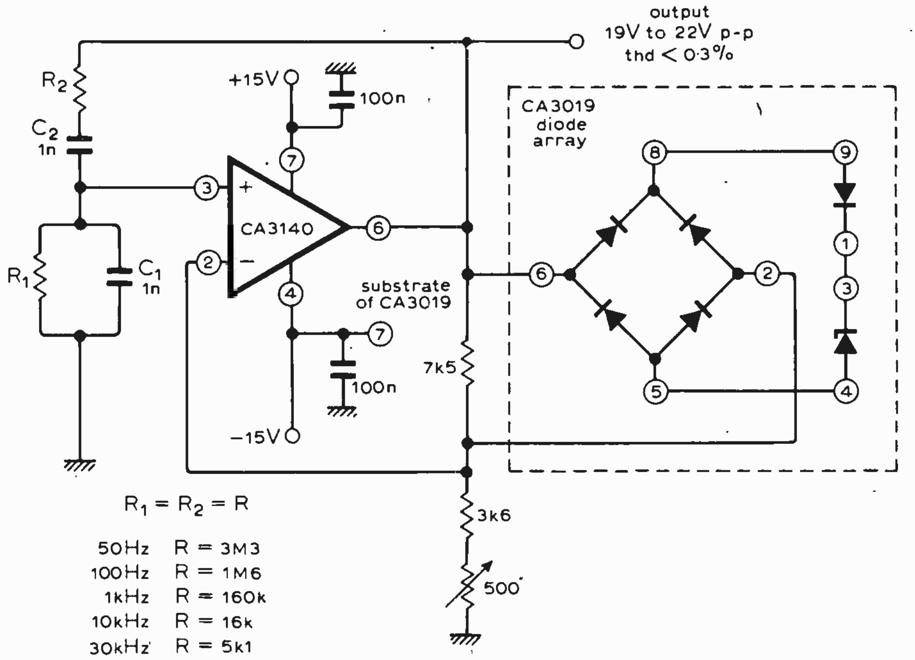
Op-amp Wien bridge oscillator

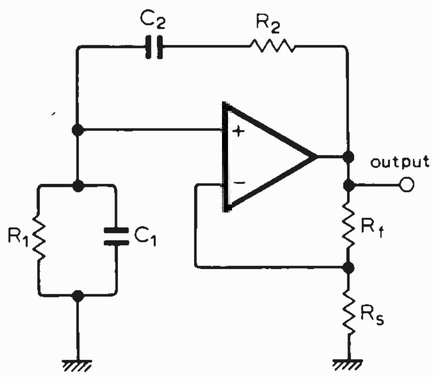
The CA3140 Bi-m.o.s. operational amplifier offers high input impedance, fast slew rate, and high output voltage capability which makes it suitable for use in a Wien bridge sine-wave oscillator. In the basic circuit, when $R_1=R_2=R$ and $C_1=C_2=C$, the frequency equation reduces to the familiar $f=1/2\pi RC$, and the gain required for oscillation is equal to 3. If C_2 is increased by a factor of four and R_2 is reduced by a factor of four, the gain required for oscillation becomes 1.5, thus permitting a potentially higher operation frequency which is closer to the gain-bandwidth product of the CA3140. Oscillator stabilization has to be precise otherwise the amplitude will either diminish or limit. In the full circuit R_s is formed by a zener diode shunting the feedback resistor R_f. As output signal amplitude increases, the zener diode impedance decreases and reduces the gain, thus stabilizing the output amplitude.

Combination of a monolithic zener diode and bridge-rectifier circuit provides practically a zero temperature coefficient for this regulating system. Because the rectifier circuit does not have a time constant there is no lower frequency limit. For example, with 1µF polycarbonate capacitors and 22MΩ for the frequency-determining network, the operating frequency is 0.007Hz.

Output amplitude must be reduced as frequency is increased to prevent the output from becoming slew-rate limited. An output frequency of 180kHz will reach a slew rate of about 9V/µs when its amplitude is 16V peak-to-peak.

Mike Bailey,
RCA Solid State-Europe,
Middlesex.





$$f = \frac{1}{2\pi\sqrt{R_1C_1R_2C_2}}$$

$$A_{OS} = 1 + \frac{C_1}{C_2} + \frac{R_2}{R_1}$$

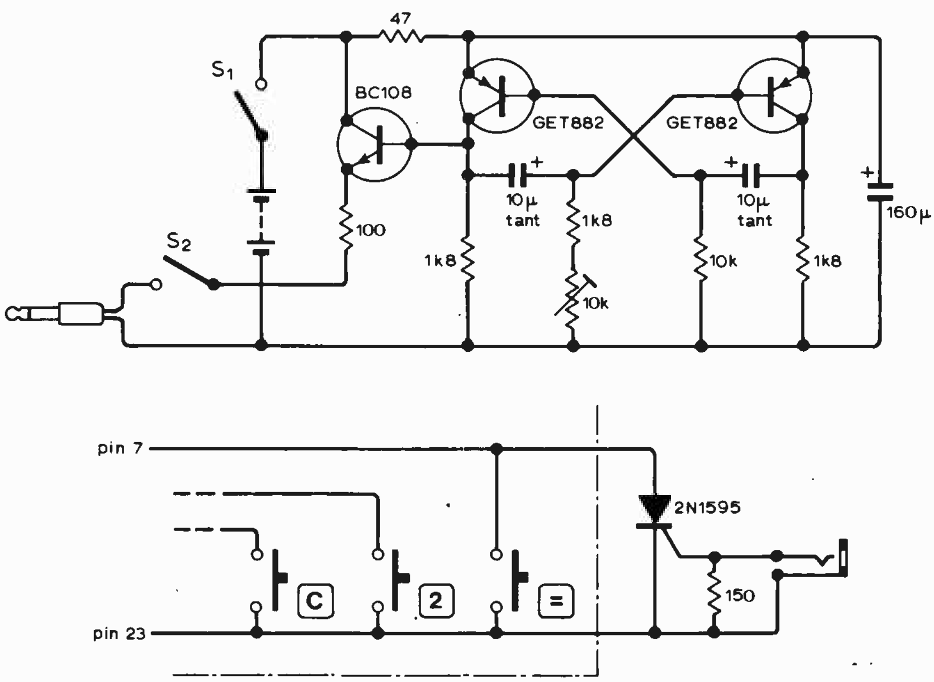
$$A_{CL} = 1 + \frac{R_f}{R_s}$$

Stopwatch facility for calculators

A calculator with a "constant" facility can also be used as a stopwatch. The method will vary between different types of calculator and on a Sinclair Cambridge Memory, if the "+.1" is keyed in and the "=" key is pressed at 10Hz, the calculator will act as a stopwatch.

This function is achieved by wiring a thyristor across the "=" contacts and triggering it from a 10Hz multivibrator. The thyristor will automatically turn off in the absence of a gate pulse because the i.c. sequentially strobes the keys. Accuracy of this multivibrator is adequate for most stopwatch applications over a few minutes.

P. J. Booth,
St. Catherine's College,
Oxford.

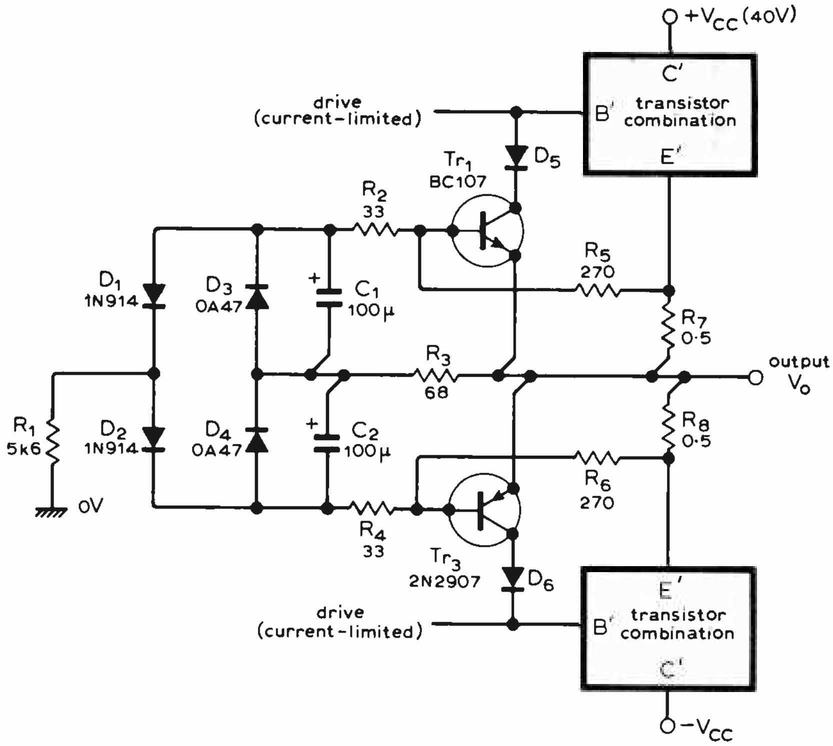


Amplifier output protection

Most power transistor protection circuits are a compromise because they have to limit the dissipation of each transistor and, at the same time, not limit the capabilities of the amplifier when driving a reactive loudspeaker load. This circuit avoids such a compromise.

During continuous a.c. drive into a normal load, R_1 draws current from C_1, via D_1, in opposition to R_5. Full drive into an 8Ω load will give an average V_{C1} and V_{C2} of about 0.12V which is sufficient to enable full drive into a load of $4\sqrt{2} \pm j4\sqrt{2}\Omega$. Continuous drive into a short-circuit will produce an average V_{C1} and V_{C2} of about 0.55V which will limit the average current in each output transistor to about 1.1A (2.2A peak). Diodes D_3 and D_4 ensure that C_1 and C_2 do not have a reverse voltage of more than 0.2V. Diodes D_5 and D_6 are necessary to prevent current flowing from the base to collector of Tr_1 and Tr_2.

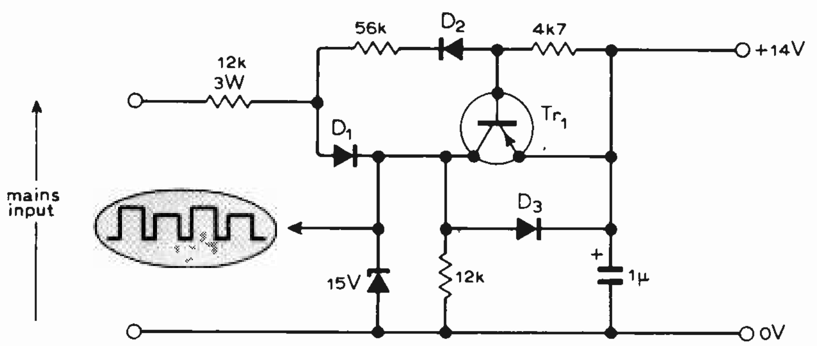
M. G. Hall,
Emsworth,
Hants.



Zero crossing detector

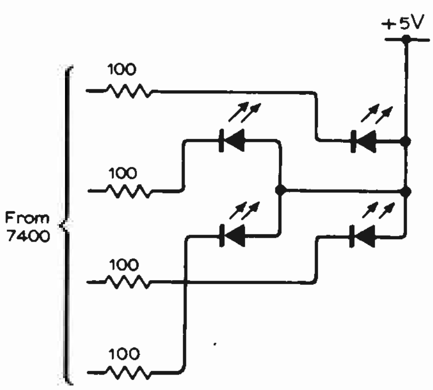
This circuit provides a zero-crossing signal and a d.c. output. Diode D_1 is the only semiconductor which has to withstand the full mains reverse voltage. Positive going half cycles forward bias D_1, which allows C_1 to charge up to 14V via D_3. Negative half cycles forward bias D_2 which turns Tr_1 on and passes current to the output from C_1. The output is about 1V less on negative half cycles and is given by $(V_{D3} + V_{sat\ Tr1})$ less than V_z.

R. J. Torrens,
Scientronics,
Huntingdon.



Beat-frequency indicator

The published circuit in the November issue shows four l.e.ds in a line. To obtain the rotating effect these diodes must be positioned in a square but, because the "firing order" is 2, 1, 3, 4 they should be arranged as shown here. Also, the reference frequency input should be via a BC108 as for the input frequency.



Digital alarm clock

IN the November issue of Wireless World a digital alarm clock was published which used the MM5316 clock chip. National Semiconductor has informed us that the device was designed to supply a maximum segment drive current of 500μA and therefore does not recommend its use with the l.e.d. displays. The MM5387 is a pin compatible device which will supply up to 5mA, and the MM5385, which is not pin compatible, will supply up to 15mA per segment.

The author agrees that the MM5316 is operating out of its specification but points out that he has successfully built four such clocks and two of them have been running for over two years.

Conferences & Exhibitions

LONDON

The All-Electronics Show
Apr. 19-21 Grosvenor House
(The All-Electronics Show, Ars Electronica Ltd., 34-36 High Street, Saffron Walden, Essex.)

Audio Visual at Work (Ex.)
Apr. 19-21 Wembley Conference Centre
(Audio Visual, P.O. Box 109 Davis House, 69-77 High Street, Croydon CR9 1QH.)

Sound 77 International
Apr. 19-21 Wembley's Avon Room
(Association of Public Address Engineers, 47 Windsor Road, Slough, Berks SL1 2EE.)

Remote Supervisory and Control Systems — REMSCON 77 (Ex. and Conf.)
Apr. 27-29 Wembley Conference Centre
(NETWORK, 84 High Street, Newport Pagnell, Bucks MK16 8EG.)

Ultrasonic Transducers (Conf.)
May 11-12 Royal Geological Society
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

Electronic Components Show (Ex.)
May 17-20 Olympia
(Industrial and Trade Fairs Ltd., Radcliffe House, Blenheim Court, Solihull, West Midlands B91 2BG.)

Film 77 (Conf. and Ex.)
July 11-15 Grosvenor House Hotel
(British Kinematograph, Sound and Television Society, 110-112 Victoria House, Vernon Place, London WC1B 4DJ.)

Audio Fair (Ex.)
Sept. 12-18 Olympia
(Iliffe Promotions Ltd., Dorset House, Stamford Street, London SE1 9LU.)

Electron Diffraction 50th Anniversary (Conf.)
Sept. 19-21 Imperial College
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

Power Semiconductors and their Applications
Sept. 27-29 Savoy Place
(IEE Conference Department, Savoy Place, London WC2R 0BL.)

Radar 77 (Conf.)
Oct. 25-28 Savoy Place
(IEE Conference Department, Savoy Place, London WC2R 0BL.)

European Noise Legislation 1977 (Conf. and Ex.)
Nov. 14-17 Wembley Conference Centre
(Institute of Acoustics, 47 Belgrave Square, London SW1X 8QX.)

BIRMINGHAM

Distributed Computer Control Systems (Conf.)
Sept. 26-28 University of Aston
(IEE Conference Department, Savoy Place, London WC2R 0BL.)

BRIGHTON

Computer Systems and Technology (Conf.)
Mar. 29-31 University of Sussex
(IERE, 8-9 Bedford Square, London WC1 3RG.)

Precise Electrical Measurement — EUROMEAS 77 (Conf.)
Sept. 5-9 University of Sussex
(IEE Conference Department, Savoy Place, London WC2R 0BL.)

Developments in Automatic Testing (Conf. and Ex.)
Nov. 30-Dec. 2 Metropole Convention Centre
(Conference: IEE/IERE, Savoy Place, London WC2R 0BL. Exhibition: NETWORK, 84 High Street, Newport Pagnell, Bucks MK16 8EG.)

CAMBRIDGE

Microprocessing and Microprogramming — EUROMICRO (Symposium)
Sept. 20-23 Cambridge University
(IEE Conference Department, Savoy Place, London WC2R 0BL.)

GLASGOW

Electron Microscopy and Analysis — EMAG 77 (Conf.)
Sept. 12-14 University of Glasgow
(The Institute of Physics, 47 Belgrave Square; London SW1X 8QX.)

GUILDFORD

Nuclear Physics (Conf.)
Mar. 23-25 University of Surrey
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

HULL

Computer-Aided-Design of Electronic and Microwave Circuits and Systems (Conf.)
July 12-14 University of Hull
(Dept. of Electronic Engineering, The University, Hull, HU6 7RX.)

LANCASTER

Displays for Man-Machine Systems (Conf.)
Apr. 4-7 University of Lancaster
(IEE Conference Department, Savoy Place, London WC2R 0BL.)

LEEDS

Electron Transport/Molecular Solids (Conf.)
July 26-29 University of Leeds
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

LOUGHBOROUGH

Digital Processing of Signals in Communications (Conf.)
Sept. 6-8 University of Technology
(IERE 8-9 Bedford Square, London WC1B 3RG.)

MANCHESTER

Solid State Physics (Conf.)
Jan. 5-7 University of Manchester
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

NOTTINGHAM

National Conference on Reliability
Sept. 21-23 University of Nottingham
(National Centre of Systems Reliability, UKAEA, Wigshaw Lane, Culcheth, Warrington, WA3 4NE.)

READING

Atomic and Molecular Physics (Conf.)
Apr. 4-7 Reading University
(K. Codling, Conference Secretary, J. J. Thomson Physical Laboratory, Whiteknights, Reading, RG6 2AF.)

SALFORD

Low Energy Ion Beams
Sept. 4-8 University of Salford
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

SOUTHAMPTON

Quantum Electronics (Conf.)
Sept. 14-16 University of Southampton
(The Institute of Physics, 47 Belgrave Square, London SW1X 8QX.)

YORK

Surface Science (Conf.)
Mar. 27-30 University of York
(Dr D. P. Woodruff, Dept. of Physics, University of Warwick, Coventry, Warwickshire CV4 7AL.)

OVERSEAS

Seminex (semiconductor technology) (Conf.)
Jan. 17-21 Frankfurt
(Seminex Ltd., 2 Old Stone Link, Ship Street, East Grinstead, West Sussex RH19 4EF.)

Audio Visual and Communication (Ex.)
Jan. 24-30 Paris
(S.D.S.A., 20 rue Hamelin, F 75116 Paris.)

SMPTE Winter TV Conference
Jan. 28-29 San Francisco
(Society of Motion Picture & Television Engineers, 862 Scarsdale Ave., Scarsdale, NY 10583, USA.)

Solid State Circuits Conference
Feb. 16-18 Philadelphia
(IEEE Conference Secretary: Gary L. Baldwin, Bell Laboratories, Holmdel, NJ 07733, USA.)

AES 56th Convention (Conf. and Ex.)
Mar. 1-4 Paris
(Audio Engineering Society, Inc., European Region Office, Zevenbunderslaan 142/9, B-1190 Brussels, Belgium.)

International Sound Festival (Ex.)
Mar. 7-13 Paris
(S.D.S.A., 20 rue Hamelin F 75116 Paris.)

Paris Components Show (Ex.)
Mar. 31-Apr. 6 Paris
(S.D.S.A., 20 rue Hamelin F 75116 Paris.)

Communications Conference — Eurocon '77
May 3-6 Venice
(Eurocon '77, c/o AEI — Viale Monza, 259 — 20126 Milan, Italy.)

Irish Electronics Exhibition — ITRON
May 24-26 Dublin
(SDL Exhibitions Ltd., 68 Fitzwilliam Square, Dublin 2.)

Frequency Control Symposium (Conf.)
June 1-3 Atlantic City
(31st Annual Frequency Control Symposium, Headquarters United States Army Electronics Command, Fort Monmouth, New Jersey 07703, USA.)

Montreux Television Symposium and Exhibition
June 3-10 Montreux
(International Television Symposium and Technical Exhibition, P.O. Box 97, CH-1820 Montreux, Switzerland.)

Electromagnetic Compatibility Symposium and Exhibition
June 28-30 Montreux
(EMC Symposium & Exhibition, Box 97, 1820 Montreux, Switzerland.)

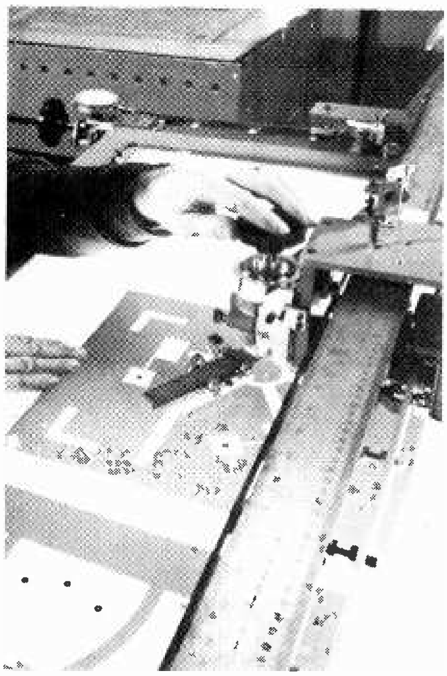
Psychoacoustics of Music (Conf.)
July 11-13 Paris
(IRCAM (Relations Exterieures). 31 rue Saint-Merri 75004 Paris, France.)

Berlin Radio and TV Exhibition
Aug. 26-Sept. 4 Berlin
(Ausstellungs-Messe-Kongress-GmbH, Messedamm 22, D-1000 Berlin 19, W. Germany.)

New Products

Bonded microwave packages

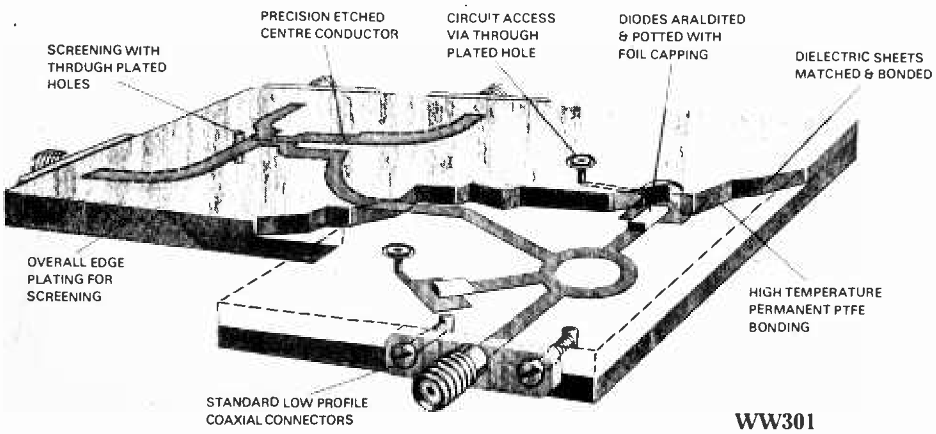
The application of p.c.b. experience to the production of microwave circuits such as ferrite circulators has enabled the microwave equipment designer to realise weight savings of up to 80% and volume savings of up to 50% compared with the more conventional stripline techniques. Exacta Circuits Limited, of Selkirk, Scotland, are now making microwave circuits from a glass-reinforced p.t.f.e. called RT Duriod, manufactured by Rogers Corporation of America. This involves bonding copper onto each side of a Duriod Substrate and then photo-mechanically etching one side to produce the precision conductor required for the circuit. Two such laminates are then bonded together in a temperature-controlled press to form the microwave bonded package, or m.b.p. as it is called.



Resistors, diodes and other active components are inserted into preformed cavities and secured using epoxy resins, and capacitors are milled from the dielectric. When all the holes, cutouts and formed edges have been machined, the m.b.p. is completely encapsulated (tinned) ensuring that the holes and edges are thoroughly plated. This ensures environmental screening and r.f. suppression. Standard, low-profile coaxial connectors are used, these being generally smaller than those used on conventional stripline units, which consist of solid aluminium housings clamped together. Other advantages of the m.b.p. are that it is stable and of predictable design, because the manufacturing process ensures that the dielectrics are uniform and that there are no airgaps. In conventional microwave circuits, any airgaps which are present may alter when parts move, causing dielectric variations with time.

RT Duriod has low loss characteristics and a dielectric content of 2.2, making it suitable for applications in the 1 to 18GHz range. M.b.ps can even be used to replace waveguides, and using the techniques described large antennas up to 40in long can be produced. Less critical circuits can, however, be manufactured using woven materials. Exacta, who are anticipating the demands of the European microwave industry, are setting up a facility to produce prototype m.b.ps. Customers films may be used as a design layout or the circuit negatives can be prepared from dimensioned sketches by Exacta's design department. The technique is expected to find a ready market in airborne equipment fields where space and weight are among the most important of the design parameters. Exacta Circuits Limited, Shawburn Factory, Selkirk, Scotland.

WW 301 for further details



WW301

Liquid-crystal watch circuits

Two four-digit, six-function watch circuits, the ICM7210 and the ICM7210A, are liquid-crystal c.m.o.s. circuits which are claimed to have the unique ability to give the same functions as four-digit l.e.d. wristwatch circuits. Type ICM7210A, which gives the month, day, hours, minutes and seconds, allows date and time changes to be made without affecting the accuracy. The calendar only needs to be reset every four years. Type ICM7210 also provides outputs for a.m./p.m. annunciators. Both circuits display a bar separating the day from the date and a flashing colon separating hours from minutes. Each contains an oscillator, a frequency divider, alphanumeric decoder, voltage multipliers and a 32Hz display driver on a chip. The only external components required for a complete l.c.d. wristwatch are a 1.5V silver oxide battery, a trimming capacitor, two s.p.s.t. switches and up to three capacitors. Since the operating voltage ranges from 1.3 to 1.8 volts, the circuits will continue to run accurately even with a weakening battery. The power consumption for the circuit only is typically 2μA and the operating temperature range is −10 to +60°C. Prices are from £4.96 depending upon quantity. Intersil Incorporated, 8 Tessa Road, Richfield Trading Estate, Reading, Berkshire, RG1 8NS.

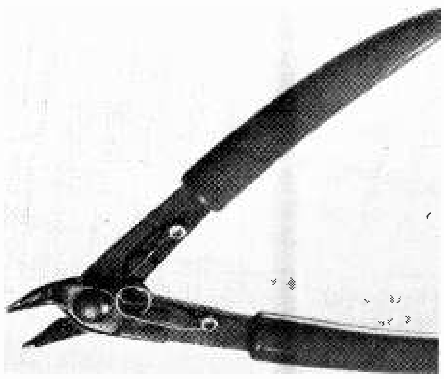
WW 302 for further details

Low-cost wire cutters

Microcutters, low-cost wire cutters from Litesold, are designed for production line use in the electronics industry. The cutters have hardened-steel cutting blades which, it is claimed, will shear leads close to a p.c.b. or a terminal post. A spring retains the cut-off part of the lead until it is rejected by the operator. Microcutters are spring loaded and have soft plastic sleeves to ensure operator comfort during continuous use. Light Soldering Developments Ltd, 97-99 Gloucester Road, Croydon, Surrey.

WW 303 for further details

WW303



Mag-tape reconditioner

The TCR2 Protectape magnetic-tape reconditioning unit is claimed to extend the useful life of tapes by as much as 80%, to eliminate up to 90% of dropouts and to reduce the need for recording head replacements by up to 50%. In addition, it is claimed to improve recording quality and increase tape deck utilization. These results are obtained by transferring and rewinding tapes on to the Protectape, which cleans the tape by passing it over the edge of a precision sapphire block while a moving roll of absorbent cleaning cloth, which snaps out of the way when not in use, gently wipes the particles of dust, dirt and oxide from the tape. During this process the Protectape can quickly rewind a complete spool, or any predetermined length, in either direction with uniform tension. It is adjustable to accept any width of tape up to two inches or spool up to the 12½in NAB size, which it can rewind in less than three minutes. Crow of Reading Ltd, P.O. Box 36, Reading, RG1 2NB.
WW 304 for further details.

V.s.w.r. indicator

A v.s.w.r. meter, type 6593A, offers a high sensitivity, an expanded scale for low ratio measurements and dual-channel facilities for bridge measurements. The instrument, from Marconi Instruments, uses a sensitive tuned amplifier, a meter and a built-in 70dB precision attenuator. An analogue output is available for use with recording instruments such as an X-Y plotter. The meter can also be used with any square-law detector. Both high-impedance inputs have a maximum sensitivity of 0.5μV f.s.d. and the bolometer input has a maximum sensitivity of 0.15μV f.s.d. The amplifier can be tuned to a centre frequency of 1kHz ± 200Hz with a variable bandwidth between 20 and 100Hz. Trickle charge facilities are provided when operating from the mains and an optional internal rechargeable battery-pack is available to provide up to 20h continuous operatio. Marconi Instruments Ltd, Sanders Division, Gunnels Wood Road, Stevenage SG1 2AU.
WW 305 for further details

Power supply for mobiles

A d.c. to d.c. converter, the C301, enables radio-telephones and other electronic equipment to be operated from a 12V car battery. The unit provides a 12V isolated output, which is earth-free, and if required this can be added to the battery voltage to give a 24V output for either positive or negative earth operation. This converter, which has a rated load current of 20A in either configuration, is designed to withstand the severe vibration and shock often experienced in mobile applications. Overload protection is provided by a current-sensing circuit capable of isolating the oscillator, and two fuses protect the battery against short circuits. Filtering and r.f. decoupling protect the load equipment, and controls are included which balance the waveform to provide maximum efficiency (75% at full load on a 12V output and 85% at full load on a 24V output) and minimum audio noise. The electrical noise across both the input and output is 200mV pk-pk at full load. Avel-Lindberg Ltd, South Ockendon, Essex RM15 5TD.
WW 306 for further details

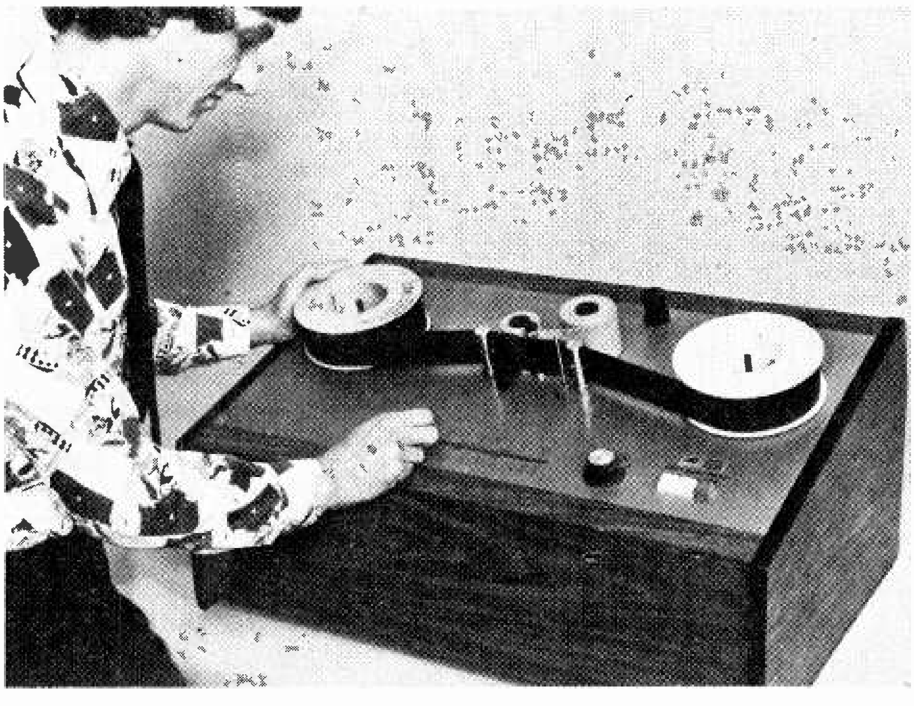
Bench power supplies

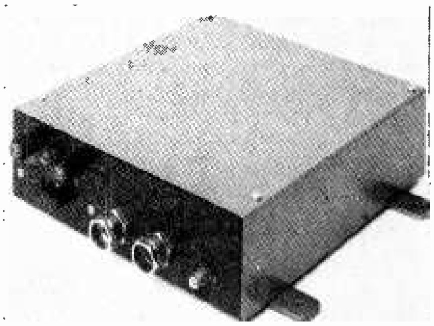
Power units, suitable for bench and laboratory applications, are available from Ver Controls Ltd. Stabilized bench units in the BP series may be either fully adjustable from 5 to 15V at 1A, or voltage-band units adjustable over a limited range in the bands 5V, 6 to 9V, or 12 to 15V at 3A, 24 to 30V at 1A and 40 to 50V at 0.5A. Unregulated units are also available. All units are protected against short circuits and the 5V unit has an additional overvoltage protection. Units in the standard laboratory series are multiways suitable for t.t.l., c.m.o.s., relay and most test applications. They provide ±5 to ±15V outputs at 1A on each rail, with options of extra fixed 5V 1A stabilized and 24V 1A unstabilized outputs. Current limiting and overvoltage logic protection are also included. Ver Controls (St. Albans) Ltd, 27b Townsend Drive, St. Albans, Herts.
WW 307 for further details

Rotary-vane attenuator

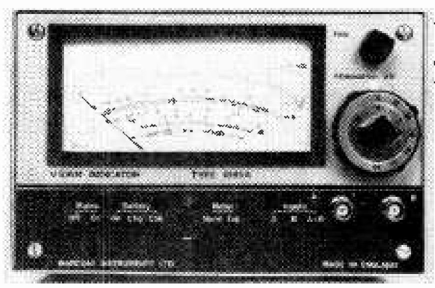
A range of rotary-vane microwave attenuators, designated as series 11, may be used within the frequency range 1.14 to 140GHz. The attenuation may be read directly from a scale and is accurate to 0.1dB or 1% of the reading, whichever is the greater. Voltage standing-wave ratios are less then 1.15 and the insertion losses are from 0.5 to 1dB depending upon the model. Model 11A/11 has a c.w. rating of 10W max, an insertion loss of 0.5dB and it may be used over the range 3.3 to 4.9GHz. Flann Microwave Instruments Ltd, Dunmere Road, Bodmin, Cornwall PL31 2QL.
WW 308 for further details

WW304





WW306



WW305

Solid State Devices

Names of suppliers of devices in this section are given in abbreviation after each entry and in full at the end of the section.

Clock oscillators

The range of K1100A crystal clock oscillators from Motorola has been extended to cover any fixed frequency from 250kHz to 32MHz. The clocks are in hermetically-sealed d.i.l. packages and have stabilities of 0.01% inclusive of the effects of changes in load and supply voltage, shock, vibration and ageing. The K1100A can drive up to ten t.t.l. gates, while operating over a temperature range of 0 to +70°C. It has a maximum current consumption of 115mA and requires a direct supply voltage of +5V±0.5.
WW 309 **Auriema**

Low-noise amplifiers

An amplifier, from Ferranti, has a noise characteristic of only 1nV per root of frequency (Hz) of the input noise (or 60Ω equivalent noise resistance) and a typical bandwidth of 15MHz at —3dB. The ZN459TC, as it is called, was first developed for the M.O.D. for thermal imaging applications, forming the buffer between cadmium mercury tellurides or c.m.t. detectors and c.c.d. arrays for signal processing. It has a gain of 60dB ±1dB and is contained in a six-lead T0-18 package.
WW 310 **Ferranti**

U.h.f. prescalers

E.c.l. divide-by-64 prescalers, from the SP8750 series, operate at frequencies up to 1.2GHz and are intended for use in u.h.f. phase-locked loops and counters. The devices have two input ports, u.h.f. and v.h.f., selected by a t.t.l./m.o.s.-compatible band-change input signal. For a sinewave the v.h.f. input has a typical frequency response of 40MHz. Both inputs are self-biased and require an a.c.-coupled signal of from 300 to 900mV pk-pk. The output is t.t.l. with an active pull-up. This device requires a 6.8V±0.35V supply and consumes about 68mA. Each device is in a 14-lead d.i.l. package.
WW 311 **Plessey Semiconductors**

Opto-coupled isolators

Three optically-coupled isolators, which use gallium-arsenide infrared l.e.ds and silicon photo-transistors, have been made by Elfein. Two of the isolators, type 520 in a 14-pin d.i.l. package and type 521 in a 24-pin d.i.l. package, have minimum isolation resistances better than 10^{11}. Type 525 is also in a 14-pin d.i.l. package and has a minimum isolation voltage of 10kV and an insulation resistance of typically 10^{14}.
WW 312 **G.E.E.**

Mixer diodes

PMD500 series diodes operate either as zero-bias detectors or high sensitivity mixers over the frequency range 12.4 to 18GHz. Over this frequency range the overall maximum s.s.b. noise figure is 6.2dB. The diode junctions provide a detector sensitivity of −56dBm at zero-bias, eliminating d.c. drift caused by biasing.
WW 313 **Tranchant**

Fast-recovery rectifiers

Axial-lead silicon power rectifiers, designated the 1N6079-81 series, have 30ns reverse recovery times and peak-inverse-voltages of 50, 100 and 150V. The rectifiers, which are intended for high frequency applications, also have low forward voltage drops (typically .95V at 5A), low thermal impedances and surge ratings of up to 175A. These devices, from Semtech, are of monolothic, non-cavity construction and have fused - metal - oxide hermetic sealing.
WW 314 **Bourns**

Low dynamic-impedance zener

A linear i.c., 6.9V reference diode with a dynamic impedance of only 1Ω, two orders of magnitude less than discrete zener diodes, is available from National Semiconductor. The LM129 operates from 0.5 to 15mA and has characteristics which are independent of operating current. A sub-surface breakdown zener in the i.c. has a low noise characteristic, claimed to be less than 20μV and a long term stability typically 20 p.p.m. This reference, which is in a TO-46 hermetic transistor package or a plastic TO-92 package, is available in selected temperature coefficients from 0.001 to 0.01%/°C for use in either 0 to 70°C or −55 to 125°C temperature ranges.
WW 315 **National Semiconductor**

Fast hybrid op-amp

The model AM-500 hybrid operational amplifier combines the characteristics of a low drift d.c. amplifier with those of a fast a.c. amplifier to give fast settling and an open-loop gain roll-off of 6dB per octave to beyond 100MHz. The output settling time is 200ns(max) to 0.01% and 70ns to 1%, for 10V step changes. Other characteristics include a slew rate of 1000V/μs, for positive output transitions, and 1800V/μs for negative transitions, allowing for an undistorted reproduction of a full-load, 20V pk-pk sinewave output up to 16MHz. Direct current characteristics include an open-loop gain of 106dB, a 30MΩ input impedance and a 1nA bias current.
WW 316 **Datel Systems**

C.m.o.s. quartz oscillators

A range of c.m.o.s.-compatible quartz oscillators has been developed for frequencies from 250kHz to 10MHz. The type QC1579 oscillators are housed in hermetically-sealed cans measuring 36.1 x 26.7 x 19mm and are suitable for any supply voltage from 5 to 15V. A buffered output stage will drive up to ten c.m.o.s. devices or, if used with a 5V supply, will drive two standard t.t.l. unit loads. The normal adjustment tolerance is ±25 p.p.m. and over the temperature range —10 to +60°C the stability is ±25 p.p.m. Devices meeting tighter frequency tolerances, or devices with similar specifications for frequencies ranging from 38Hz to as low as 1Hz are also available.
WW 317 **Salford Electrical Instruments**

Suppliers

Auriema Limited, 442 Bath Road, Slough, SL1 6BB.
Bourns (Trimpot) Limited, Hodford House, 17/27 High Street, Hounslow, Middlesex TW3 1TE.
Datel Systems Incorporated, 1020 Turnpike Street, Canton, Mass. 02021 U.S.A.
Ferranti Limited, Electronic Components Division, Gem Mill, Chadderton, Oldham, OL9 8NP.
G. E. Electronics (London) Ltd, Eardley House, 182/4 Campden Hill Road, Kensington London W8 7AS.
National Semiconductor (U.K.) Ltd, 19 Goldington Road, Bedford MK40 3LF.
Plessey Semiconductors, Cheney Manor, Swindon, Wiltshire SN2 2QW.
Salford Electrical Instruments Ltd, Peel Works, Barton Lane, Eccles, Manchester M30 0HL.
Tranchant Electronics (U.K.) Ltd, Tranchant House, 100a High Street, Hampton, Middlesex.

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WW — 054 FOR FURTHER DETAILS

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BF240	17	BU208	£2.20
BF241	17	BU208/02	£2.75
BF257	28	BUY69B	£2.50
BF258	26	BUY69A	£2.65
BF259	30	E1222	38
BF336	37	MJE340	45
BF337	35	MJE520	44
BF338	34	2N696	30
BF355	50	2N706	15
BF457	37	2N3053	20
BF458	37	2N3054	65
BF459	38	2N3055	55
BFT42	35	2N3702	12
BFT43	35	2N3703	12
BFX29	29	2N3704	10
BFX84	29	2N3705	10
BFX85	30	2N3706	10
BFX86	28	2N3819	38
BFX88	25	2N5296	40
BFY50	19	2N5496	53
BFY51	19	OC71	29
BFY52	20	OC72	29
BFY90	£1.10	R2008B	£1.90
BR100	32	R2010B	£1.90
BR101	38	RCA16334	80
BRC4443	80	RCA16335	80
BRY39	38	S2802	£2.99
BSY52	30	S6080 A KIT	£4.90
BT106	£1.20		
BT108	£1.50	TIP31A	52
BT116	£1.25	TIP32A	62
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BU108	£1.80	TIP42A	75
BU126	£1.49	TIS91	27
BU204	£1.80		

Diodes

Type	Price (p)	Type	Price (p)
BA115	9	OA90	6
BA145	16	OA91	7
BA148	16	OA95	5½
BA154/201	12	OA202	8
BA155	15	IN914	6
BAX13	6	IN4001	4
BAX16	6	IN4002	5
BY126	11	IN4003	5
BY127	10	IN4004	5
BY199	25	IN4005	5
BY206	17	IN4006	6
BYX10	14	IN4007	6
OA47	8	IN4148	4

★20p or less. Minimum 5 items

EHT Multipliers

Type	Order Code	Price
Thorn 950 MK II 1400	D101P	£2.07
Thorn 1500 3 stick	D102Y	£1.98
Thorn 1500 5 stick	D103G	£2.17
Thorn 1590 Stick	D104E	£0.35
ITT, Philips Mono Large Screen	D105C	£0.61
Rank Z 718	D106A	£1.54
Thorn 3000/3500	D107J	£5.34
Thorn 8000	D108H	£1.98
Thorn 8500	D109F	£4.14
Thorn 9000	D110Y	£6.50
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Decca 30 Series	D112E	£4.96
Decca 80 Series	D113C	£5.30
G.E.C. Hybrid	D114A	£4.96
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ITT CVC 1-5	D116H	£4.96
ITT CVC 20	D117F	£5.30
Philips G8	D118D	£4.96
Philips 550	D119B	£4.96
Pye 691/693	D120E	£3.66
Pye 731	D121C	£4.92
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New Mono Tubes (110°)

Screen	Type	Equivalent	Price
12"	Toshiba E2117A	TMT 31/101 A31/ 250W	£17.75
14"	Toshiba M6529 FZP	TMT 34/101	£17.95
20"	A50-120WR	CME 2013	£15.50
24"	A61-120WR	CME 2413	£17.30

New Colour Tubes (90°)

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19"	A49-191X,	A49-192 and A49-120X	£57.70
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22"	A56/120X		£69.90

Aerial Accessories

Type	Price
Coax Plugs	each 10.5p
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Superverters with variable gain	each £15.95
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0-500UA	1304	£4.50
0-1MA	1305	£6.00
0-50V	1306	£6.00

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Size 2⅜" x 1¾" x 1½"

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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
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0-50UA	1313	£4.80
0-1MA	1315	£3.20

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AC127	£0.14	BC147	*£0.09	BC556	*£0.14	BIP19	£0.38	TIP3055	£0.75	2N3708A	*£0.07
AC128	£0.12	BC148	*£0.09	BC557	*£0.13	BIP20	£0.38	TIS43	£0.22	2N3709	*£0.07
AC128K	£0.26	BC149	*£0.09	BC558	*£0.12	BIP19/		TIS90	*£0.18	2N3710	*£0.07
AC132	£0.15	BC157	*£0.12	BC559	*£0.14	20 MP	£0.80	UT46	*£0.20	2N3711	*£0.07
AC134	£0.15	BC158	*£0.12	BD115	£0.50	BRY39	£0.45	ZTX107	*£0.10	2N3819	£0.20
AC137	£0.15	BC159	*£0.12	BD116	£0.80	BU105	£1.90	ZTX108	*£0.10	2N3820	£0.40
AC141	£0.18	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	£0.40
AC142	£0.18	BC169	*£0.12	BD124	£0.70	BU205	£1.70	ZTX500	*£0.14	2N4058	*£0.12
AC176	£0.12	BC169C	*£0.12	BD131	£0.35	BU208	£2.40	2N1613	£0.20	2N4059	*£0.14
AC176K	£0.26	BC170	*£0.10	BD132	£0.38	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	£0.80	MJE2955	£0.88	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	£0.30	BC177	£0.16	BD135	£0.36	MJE3440	£0.45	2N2147	£0.75	2N4285	*£0.18
AC181	£0.20	BC178	£0.16	BD136	£0.36	MP8113	£0.45	2N2148	£0.70	2N4286	*£0.18
AC181K	£0.30	BC179	£0.16	BD137	£0.38	MPF102	£0.35	2N2160	£0.80	2N4287	*£0.18
AC187	£0.16	BC180	£0.25	BD138	£0.45	MPF104	£0.39	2N2192	£0.38	2N4288	*£0.18
AC187K	£0.26	BC181	*£0.25	BD139	£0.54	MPF105	£0.39	2N2193	£0.38	2N4289	*£0.18
AC188	£0.16	BC182L	*£0.10	BD140	£0.60	MPSA05	*£0.20	2N2194	£0.38	2N4290	*£0.18
AC188K	£0.26	BC183	*£0.10	BD139/		MPSA06	*£0.20	2N2217	£0.22	2N4291	*£0.18
AD140	£0.60	BC183L	*£0.10	140 MP	£1.20	MPSA55	*£0.20	2N2218	£0.22	2N4292	*£0.18
AD142	£0.85	BC184	*£0.10	BD155	£0.80	MPSA56	*£0.20	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	£0.36	BC208	*£0.11	BD177	£0.68	OC24	£1.40	2N2904	£0.18	2N5135	*£0.10
AD162	£0.36	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	£0.75	BC212L	*£0.11	BD201/		OC28	£0.90	2N2905A	£0.21	2N5194	£0.56
AF114	£0.20	BC213	*£0.11	202 MP	£1.70	OC29	£1.00	2N2906	£0.16	2N5245	*£0.28
AF115	£0.20	BC213L	*£0.11	BD203	£0.80	OC35	£0.90	2N2906A	£0.19	2N5294	£0.34
AF116	£0.20	BC214	*£0.12	BD204	£0.80	OC36	£0.90	2N2907	£0.20	2N5296	£0.35
AF117	£0.20	BC214L	*£0.12	BD203/		OC70	£0.15	2N2907A	£0.22	2N5457	£0.32
AF118	£0.40	BC237	*£0.16	204 MP	£1.70	OC71	£0.15	2N2926G	*£0.09	2N5458	£0.32
AF124	£0.30	BC238	*£0.16	BDY20	£0.80	TIC44	*£0.29	2N2926Y	*£0.08	2N5459	£0.38
AF125	£0.30	BC251	*£0.15	BDX77	£0.90	TIC45	*£0.29	2N29260	*£0.08	2N5551	*£0.30
AF126	£0.30	BC251A	*£0.16	BF457	£0.37	TIP29A	£0.44	2N2926R	*£0.08	2N6027	£0.32
AF127	£0.32	BC301	£0.30	BF458	£0.37	TIP29B	£0.52	2N2926B	*£0.08	2N6121	£0.70
AF139	£0.58	BC302	£0.28	BF459	£0.38	TIP29C	£0.62	2N3053	£0.16	2N6122	£0.70
AF180	£0.58	BC303	£0.32	BF594	*£0.15	TIP30A	£0.50	2N3054	£0.40	40311	£0.36
AF181	£0.58	BC304	£0.38	BF596	*£0.17	TIP30B	£0.60	2N3055	£0.40	40313	£0.95
AF186	£0.58	BC327	*£0.16	BFR39	£0.25	TIP30C	£0.70	2N3414	*£0.16	40316	£0.58
AF239	£0.38	BC328	*£0.15	BFR40	*£0.25	TIP31A	£0.54	2N3415	*£0.16	40317	£0.36
AL102	£0.95	BC337	*£0.15	BFR79	*£0.28	TIP31B	£0.66	2N3416	*£0.29	40326	£0.36
AL103	£0.95	BC338	*£0.15	BFR80	*£0.28	TIP31C	£0.68	2N3417	*£0.29	40327	£0.45
AU104	£1.00	BC440	£0.30	BFX29	£0.25	TIP32A	£0.64	2N3614	£0.85	40346	£0.42
AU110	£1.00	BC441	£0.30	BFX30	£0.30	TIP32B	£0.76	2N3615	£0.90	40347	£0.55
AU113	£1.00	BC460	£0.38	BFX84	£0.23	TIP32C	£0.80	2N3616	£0.90	40348	£0.70
BC107A	£0.08	BC461	£0.38	BFX85	£0.24	TIP41A	£0.66	2N3646	*£0.09	40360	£0.38
BC107B	£0.08	BC477	£0.20	BFX86	£0.25	TIP41B	£0.70	2N3702	*£0.08	40361	£0.38
BC107C	£0.08	BC478	£0.19	BFX87	£0.22			2N3703	*£0.08	40362	£0.38
BC108A	£0.08	BC479	£0.20	BFX88	£0.22	TIP41C	£0.80	2N3704	*£0.07	40406	£0.40
BC108B	£0.08	BC547	*£0.12	BFX90	*£0.55	TIP42A	£0.72	2N3705	*£0.07	40407	£0.28
BC108C	£0.08	BC548	*£0.12	BFY50	£0.14	TIP42B	£0.78	2N3706	*£0.08	40408	£0.48
BC109B	£0.08	BC549	*£0.12	BFY51	£0.14	TIP42C	£0.95	2N3707	*£0.08	40409	£0.52

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	£0.14	CD4012	£0.18	CD4022	£0.95	CD4031	£2.20	CD4046	£1.30	CD4071	£0.28
CD4001	£0.18	CD4013	£0.50	CD4023	£0.18	CD4035	£1.05	CD4047	£1.10	CD4072	£0.28
CD4002	£0.18	CD4015	£0.90	CD4024	£0.72	CD4037	£0.95	CD4049	£0.55	CD4081	£0.18
CD4006	£0.98	CD4016	£0.50	CD4025	£0.18	CD4040	£0.95	CD4050	£0.55	CD4082	£0.28
CD4007	£0.18	CD4017	£0.90	CD4026	£0.98	CD4041	£0.82	CD4054	£1.20	CD4510	£1.30
CD4008	£0.95	CD4018	£1.00	CD4027	£0.60	CD4042	£0.82	CD4055	£1.20	CD4511	£1.60
CD4009	£0.55	CD4019	£0.52	CD4028	£0.85	CD4043	£0.98	CD4056	£1.40	CD4516	£1.40
CD4010	£0.55	CD4020	£1.10	CD4029	£1.15	CD4044	£0.94	CD4069	£0.40	CD4518	£1.08
CD4011	£0.18	CD4021	£0.98	CD4030	£0.55	CD4045	£1.40	CD4070	£0.40	CD4520	£1.25

LINEAR ICs

Type	Price	Type	Price	Type	Price	Type	Price	Type	Price
CA3011	*£0.80	LM304	£3.00	MC1351P	*£0.85	UA703A	*£0.25	SN76013N	*£1.40
CA3014	*£1.37	LM308H	*£0.95	MC1352P	*£0.85	UA709C	*£0.25	SN76023N	*£1.40
CA3018	*£0.70	LM309K	£1.75	MC1456G	*£0.85	72709	*£0.46	SN76110	*£1.50
CA3020	*£1.40	LM320-5V	£2.00	MC1466L	£3.95	709P	*£0.25	SN76115	*£1.90
CA3028A	*£1.10	LM320-12V	£2.00	MC1469R	£2.50	UA710C	*£0.40	SN7666	*£0.75
CA3035	*£1.30	LM320-15V	£2.00	MC1496G	*£0.90	72710	*£0.30	SL403D	*£1.75
CA3036	*£1.35	LM320-24V	£2.00	NE536	*£2.00	UA711C	*£0.32	SL414A	*£1.75
CA3042	*£1.15	LM380N	*£1.00	NE515A	*£2.10	72711	*£0.32	TAA550B	£0.35
CA3043	*£1.55	LM381AN	*£1.15	NE540	*£2.40	UA723C	£0.50	TAA621A	*£2.00
CA3046	*£0.50	LM3900N	*£0.63	NE555	£0.40	72723	£0.50	TAA661A	*£1.50
CA3052	*£1.60	MC724P	£1.50	NE556	£0.82	UA741C	*£0.20	TAD100	*£1.30
CA3054	*£1.94	MC1303L	*£1.45	NE561	*£3.25	72741	*£0.20	TBA540Q	*£2.50
CA3075	*£1.50	MC1304P	*£3.50	NE562B	*£2.95	741P	*£0.20	TBA641B	*£2.25
CA3081	*£1.50	MC1310P	*£1.80	NE565A	*£2.00	UA747C	*£0.70	TBA800	*£0.80
CA3089E	£1.50	MC1312PQ	*£1.50	NE566	*£1.50	72747	*£0.79	TBA810S	*£0.95
CA3090AQ	*£4.25	MC1330P	*£1.35	NE567	*£2.50	UA748	*£0.35	TBA820	*£0.90
CA3123E	*£1.40	MC1339	*£1.50	UA702C	*£0.46	72748	*£0.35	TBA920Q	*£3.40
LM301AH	*£0.47	MC1350	*£0.75	72702	*£0.46	748P	*£0.35	TCA270S	*£3.90

DIODES

Type	Price	Type	Price	Type	Price	Type	Type	Type	Price		
AA129	£0.08	BA173	£0.15	BY127	*£0.16	BYZ13	£0.26	OA85	£0.09	IN34A	£0.07
AAY30	£0.09	BB104	£0.15	BY128	£0.16	BYZ16	£0.41	OA90	£0.07	IN914	£0.06
AAZ13	£0.10	BAX13	£0.07	BY130	*£0.17	BYZ17	£0.36	OA91	£0.07	IN916	£0.06
AAZ17	£0.10	BAX16	£0.08	BY133	*£0.21	BYZ18	£0.36	OA95	£0.07	IN4148	£0.06
BA100	£0.10	BY100	£0.16	BY164	£0.51	BYZ19	£0.28	OA182	£0.07	IS44	£0.05
BA102	£0.32	BY107	£0.12	BY176	*£0.75	OA10	£0.35	OA200	£0.08	IS920	£0.06
BA148	£0.15	BY105	£0.18	BY206		OA47	£0.07	OA202	£0.08		
BA154	£0.12	BY114	£0.12	BYZ10	£0.36	OA70	£0.07	SD10	£0.06		
BA155	£0.14	BY124	*£0.12	BYZ11	£0.31	OA79	£0.07	SD19	£0.06		
BA156	£0.14	BY126	*£0.15	BYZ12	£0.31	OA81	£0.07	IN34	£0.07		

SILICON RECTIFIERS

Type	Price	Type	Price	Type	Price	Type	Price
IS920	£0.06	IN4003	£0.07	IS020	£0.10	IS031	£0.25
IS921	£0.07	IN4004	£0.08	IS021	£0.11	IN5400	£0.13
IS922	£0.08	IN4005	£0.09	IS023	£0.13	IN5401	£0.15
IS923	£0.09	IN4006	£0.10	IS025	£0.14	IN5402	£0.16
IS924	£0.10	IN4007	£0.11	IS027	£0.16	IN5404	£0.17
IN4001	£0.05	IS015	£0.09	IS029	£0.20	IN5406	£0.21
IN4002	£0.06					IN5407	£0.25

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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/5D	£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

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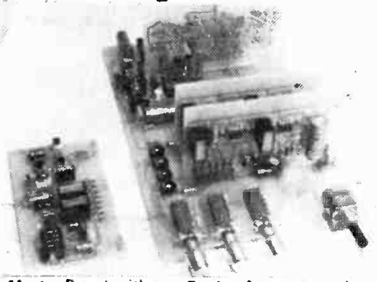
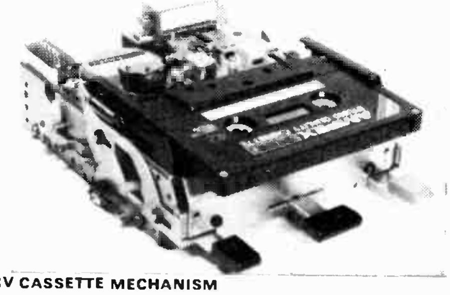


Master Board with one Replay Amp removed

As these circuits in recent issues of "Wireless World" are capable of such an excellent performance we feel that it is not sensible to sacrifice this potential by designing a kit down to a price. We have therefore spent a little more on professional hardware allowing us to design a very advanced modular system. This enables a more satisfactory electrical layout to be achieved, particularly around the very critical input areas of the replay preamps. These are totally stable with this layout and require no extra stabilising components. Many other advantages also come from this system which has separate record and replay amps for each channel plugging in to a master board with gold plated sockets. The most obvious is the reduction of crosstalk and interaction which could cause trouble on a single plane board, with our modular system the layout is compact but there is no component crowding. Testing is very easy with separate identical modules and building with the aid of our component-by-component instructions is childishly simple, but the finished result is a unit designed not to normal domestic standards but to the best professional practice.



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- 73x Complete set of parts for stereo Replay Amps and VU Meter Drive. £8.02 + £1 VAT.
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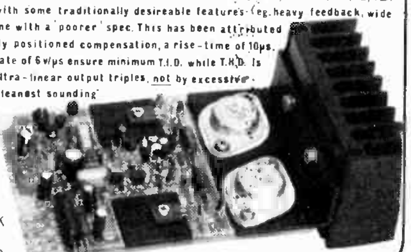
WE BELIEVE OUR MODULES ARE UNEQUALLED IN SOUND QUALITY, OVERALL PERFORMANCE & VALUE FOR MONEY

★S/N > 110dB ★ 120x80x25mm. ★ Fully protected ★ 250mv/56kΩ ★ 12Hz–35kHz, –3dB ★ 14Trs, 4Di

It has recently been shown that an amplifier with some traditionally desireable features (eg. heavy feedback, wide bandwidth) can actually sound worse than one with a 'poorer' spec. This has been attributed to distortion caused by transients (T.I.D.) Carefully positioned compensation, a rise-time of 10µs, settling-time of 10µs (8Ω, 2µF) and slewing-rate of 6v/µs ensure minimum T.I.D. while T.H.D. is reduced to typically ·01% (·04max) at 1kHz by ultra-linear output triples, not by excessive feedback. This approach has yielded one of the cleanest sounding amplifiers available, regardless of cost.

CE608 60Wrms/8Ω, ±35v, £14·55
CE1004 100Wrms/4Ω, ±35v, £17·55
CE1008 100Wrms/8Ω, ±45v, £21·55
H/sinks: 50mm. 85p; H/duty 100mm. £1·50

Cheque/P.O. to: CRIMSON ELEKTRIK
S.A.E. for full details 74 STATION ROAD,
Tel. (9-5) 0533 386211 RATBY, LEICESTER.



CE1008 + Domestic heatsink (50mm.)

WW—048 FOR FURTHER DETAILS

ARROW ELECTRONICS LTD.

Our New "CAT" now available price 40p. Genuine fastest service in the U.K. Most modern components shop in East Anglia. Best Semiconductor selection in the South East. 15 years in Mail-Order Electronics. Over 2,000 square feet of Stores.

I'M YOURS FOR 40p!!

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Address: ....

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Please print clearly

WW—065 FOR FURTHER DETAILS

For those who appreciate Quality...

a complete electronic kit

The Forgestone 400

high quality

colour television receiver

SUPERB PICTURE QUALITY
TOGETHER WITH PROVEN RELIABILITY

- 9 integrated circuits
- Thick film resistor units
- Ready-built and aligned IF module
- Glass epoxy printed circuit panels
- High quality components
- Fully isolated power supply
- Plugs and sockets for easy panel removal
- Each module kit available separately
- Full technical construction manual
- LT supply regulator

The isolated chassis makes the receiver ideal for the addition of Teletext decoders, remote controls etc. Please send stamp for further details of these quality products.

Forgestone Colour Developments Limited

Ketteringham, Wymondham, Norfolk, NR18 9RY, U.K.

Telephone: Norwich 810453 (STD 0603)

MAIL ORDER – Barclaycard & Access accepted

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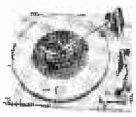
RETURN OF POST MAIL ORDER SERVICE

BSR HI-FI AUTOCHANGER

STEREO AND MONO



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 **£11.95** Post 75p

B S R SINGLE PLAYER similar to above with stereo cartridge and cueing device, large turntable **£15.50.**

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 75p

Model A Size 12½ x 14¾ x 7½in

Model 'B' Size 16 x 13¾ x 7in **£7.50.**

Extra large plinth & cover, wood base. Size 20"×17½"×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

SPECIAL OFFER!

SMITH'S CLOCKWORK 15 AMP TIME SWITCH

0—60 MINUTES £2.95 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 7⅞in—**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. AC mains powered

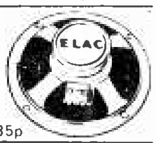
VOLUME CONTROLS

5kΩ to 2MΩ LOG or LIN L/S **25p.** D P **40p.** STEREO L/S **65p.** D P **85p.** Edge 5K S P Transistor **30p.**

80 Ohm Coax 8p yd.

STANDARD TYPE VHF FRINGE LOW LOSS **15p** yd. Ideal 625 and colour. PLUGS **10p.** SOCKETS **10p.** LINE SOCKETS **18p.** OUTLET BOXES **50p.**

ELAC HI-FI SPEAKER 8in. TWIN CONE



Dual cone plasticised roll surround. Large ceramic magnet 50-16,000 c/s. Bass resonance 55 c/s. 8 ohm impedance. 10 watts music power **£3.95** Post 35p

E.M.I. 13½ x 8in. SPEAKER SALE!

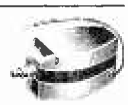
With tweeter and crossover. 10 watt. State 3 or 8 ohm. As illustrated **£5.95** Post 35p

Ditto 15 watts. 8 or 15 ohm **£8.50** Post 45p

With tweeter and cross over. 20 watt. Bass res 25 c p s. Flux=11,000 gauss. 8 or 15 ohm. 20 to 20,000 c p s **£9.50** Post 45p

Bookshelf Cabinet **£7.50** Post 75p
Teak finish, for EMI 13 x 8 speakers

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 **£3.95** Post 30p

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 ¾ in—**15p.** **ALUMINIUM PANELS.** 6 x 4—**17p;** 8 x 6—**24p;** 14 x 3—**25p;** 10 x 7—**35p;** 12 x 8—**43p;** 12 x 5—**30p;** 16 x 6—**43p;** 14 x 9—**52p;** 12 x 12—**68p;** 16 x 10—**75p.**
MANY ALI BOXES IN STOCK

ELAC 9 x 5in HI-FI SPEAKER TYPE 59RM **£3.45** Post 35p

This famous unit now available. 10 watts, 8 ohm

RCS LOW VOLTAGE STABILISED POWER PACK KITS

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 **£2.95** Post 45p

RCS POWER PACK KIT **£3.35**

12 VOLT, 750mA. Complete with printed circuit board and assembly instructions. Post 30p
12 VOLT 300mA KIT **£3.15.** 9 VOLT 1 AMP KIT **£3.35.**

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 **£1.45** Post 30p. Full instructions supplied. Details S.A.E.

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

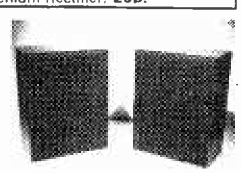
MAINS TRANSFORMERS

ALL POST 50p

250-0-250V 70mA, 6 5V, 2A	£3.45
250-0-250 80mA, 6.3V 3.5A, 6 3V 1A or 5V 2A	£4.60
350-0-350 80mA, 6 3V 3.5A, 6 3V 1A or 5V 2A	£5.80
300-0-300V 120mA, 6 3V 4A C.T, 6 3V 2A	£7.00
MIDGET 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 **£4.60.** 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£4.60.** 2 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£7.00.** 3 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.70.** 5 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.25.** 6 06V 500mA **£1,** 9V 1 amp **£1,** 12V 300mA, **£1,** 12V 500mA, **£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,** 16V, ½ amp, **£1,** 16V, 2 amp., **£2.20,** 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, 1A, **£3.50.**
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.**
CHARGER TRANSFORMERS 1½ amp **£2.75;** 4 amp **£4.60.**
12V 1½A HALF WAVE Selenium Rectifier, **25p.**

R.C.S. ROSEWOOD SPEAKERS



Size 12½in x 9¾in x 5½in. Response 50 to 14,000 cps. 8 watts rms. 3, or 8, or 16 ohms

£12 pair Post 75p

KUBA - KOPENHAGEN STEREO

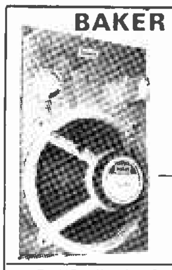
TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT

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 **£33.50** Post £1 50. Circuit supplied

LOW VOLTAGE ELECTROLYTICS
1, 2, 4, 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 50V **57p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
5000mF 6V **25p;** 12V **42p;** 25V **75p;** 35V **85p;** 50V **95p.**

SHORT WAVE 100pF air spaced gangable tuner **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0 01mF, **5p.** Silver Mica 2 to 5000pF **5p.**
PAPER 350V-0 1 **7p;** 0 5 **13p;** 1mF 150V **15p;** 2mF 150V **15p;** 500V-0.001 to 0.05 **5p;** 0 1 **10p;** 0 25 **13p;** 0 47 **25p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
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.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
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, 15watt, 10 ohms to 100K **12p** each.
TAPE OSCILLATOR COIL. Valve type **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES S P **20p.** D P S T **25p.** D P D T **30p.**
MANY OTHER TOGGLES IN STOCK.
PICK-UP CARTRIDGES ACOS GP91 **£1.50.** GP93 **£2.50.**
SONOTONE stereo **£2.00.**

BAKER MAJOR 12" £12.35



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. 3 or 8 or 15 ohms must be stated.

Module kit 30-17,000 c/s with tweeter, crossover, baffle and instructions **£15** Post 60p each
Please state 3 or 8 or 15 ohms

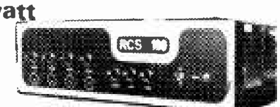
BAKER "BIG-SOUND" SPEAKERS. Post 50p each.

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£10.95**	12in 40W **£12.50**	15in. 75W **£22.50**
3 or 8 or 15 ohm	3 or 8 or 15 ohm	8 or 15 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT. GROUP 50/12, 8 OR 15 OHM HIGH POWER FULL RANGE PROFESSIONAL QUALITY. 30-16,000 CPS. MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME **£16.50** Post 80p

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in. speaker 20x13x12in. **£14.50** Post 95p
For 13x8in or 8in. speaker **£7.50** Post 75p
For 8x5in speaker 12x8x6in **£5.80** Post 50p

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

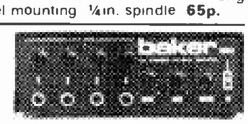


Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order. Send for leaflet. Suitable carrying cab **£14.** Price **£85** carr £2.50

SPEAKER COVERING MATERIALS. Samples Large S A E.
LOUDSPEAKER CABINET WADDING 18in. wide **20p** ft.
Horn Tweeters 2-16kc/s. 10W 8 ohm or 15 ohm **£3.60**
De Luxe Horn Tweeters 3-18kc/s. 30W 8 ohm. **£7.50.**
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. **£1.25 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
VALVE OUTPUT TRANS. 40p; MIKE TRANS. 50 1, **40p.**
Mike trans mu metal 100 1 **£1.25.**

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 8/15 ohms a c Mains. Separate treble and bass controls. Master volume control. Guaranteed. Details S A E **£68** £1 50 carr

NEW MODEL MAJOR—50 watt, 4 input, 2 vol. Treble and bass. Ideal disco amplifier **£49** Carr £1

100 WATT DISCO AMPLIFIER CHASSIS

volume, treble, bass controls. 500 M.V. or 1 volt input. Four loudspeaker outputs 4 to 16 ohm. All transistor. **£52**

BARGAIN 4 CHANNEL TRANSISTOR MONO MIXER
Add musical highlights and sound effects to recordings. Will mix Microphone, records, tape and tuner with separate controls into single output. 9V. **£5.20**

TWO STEREO CHANNEL VERSION **£6.85**

BARGAIN 3 WATT AMPLIFIER. 4 Transistor Push-Pull Ready Built, with volume, Treble and bass controls. 18 volt d c Mains Power Pack **£3.45** **£3.95**

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.

R.C.S. SOUND TO LIGHT KIT

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel **£12.50.** Post 35p. Easy to build. Full instructions supplied. Cabinet **£3.**

E.M.I. TAPE MOTORS. 240V a c 1,200 r p m 4 pole. Spindle 0 187x0 75in. Size 3¼ x 2½ x 2¼in **£2.** Post 50p
Collaro gram motor 120V **75p.**
E M I gram motor 240V **£1.25.**

RADIO COMPONENT SPECIALISTS

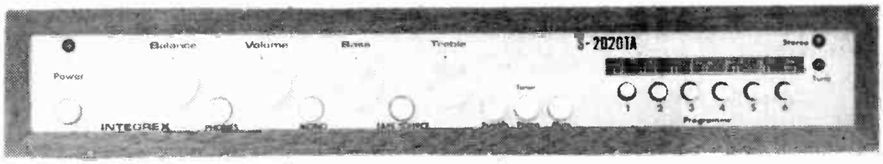
337 WHITEHORSE ROAD, CROYDON
Open 9-6. Wed. 9-1. Sat. 9-5 (Closed for lunch 1.15-2.30)

Radio Books and Components Lists 10p. (Minimum posting charge 30p.) All prices include VAT. (We accept Access or Barclaycard. Phone your order.) **Tel. 01-684 1665**

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: £53.95+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 £29.15+VAT
With ICPL Decoder £33.42+VAT
With Portus-Haywood Decoder £35.95+VAT

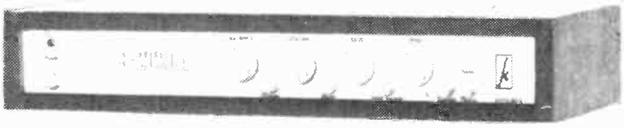
STEREO MODULE TUNER KIT

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

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

PRICE: Mono £26.85+VAT
Stereo £29.95+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.

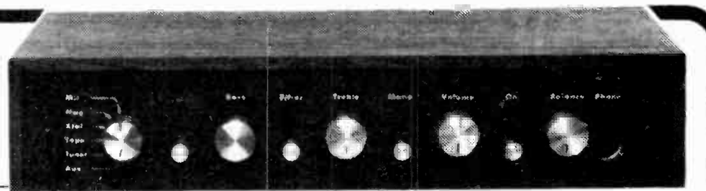
PRICE: £31.95+VAT

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**	**£4.50**+VAT

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

20x20 Watt STEREO AMPLIFIER



Superb Viscount IV unit in teak-finished cabinet. Black 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 £2.10

HOW YOU CAN SAVE

SYSTEM 1B

For only £80, you get the 20+20 watt Viscount IV amplifier; a pair of our 12-watt-rms Duo Type IIb matched speakers; a BSR MP 60 type deck complete with magnetic cartridge, de luxe plinth and cover. **£80.00** + p & p £6.50

SYSTEM 2

Comprising our 20+20 watt Viscount IV amplifier; a pair of our large Duo Type III matching speakers which handle 20 watts rms each; and a BSR MP 60 type deck with magnetic cartridge, de luxe plinth and cover. **£92.00** + p & p £7.60

Carriage surcharge to Scotland: System 1b £2.50, System 2 £5

SPEAKERS

Two models – Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18½"x13½"x 7¼" approx. **£34** + p & p £6.50 PER PAIR

Duo III, 20 watts rms, 40 watts peak, 27"x13"x11½" APPROX. **£48** + p & p £7.50 PER PAIR

TURNTABLE

Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover.

£24.00 + p & p £3.50

VALUE

DIY 30x30 AMPLIFIER KIT

Specially designed by RT-VC for the experience 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. Black fascia and easy-to-handle aluminium knobs. Output 30+30 watts rms, 60+60 peak. **£29.00** + p & p £2.10

STEREO CASSETTE DECK KIT

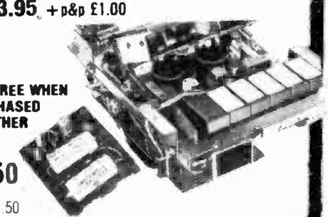
Again, this kit is specially designed for the experienced constructor – for mounting into his own cabinet. Features include solenoid-assisted AUTO-STOP, 3-digit counter, record/replay PC board, mains transformer and input and output controls. AC BIAS AND ERASE. **£32.50** + p & p £1.50

DELUXE ACCESSORY KIT

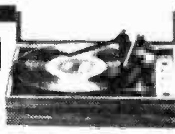
Comprises of a matched pair of dynamic mics. and two replacement slider level controls.

£3.95 + p&p £1.00

P&P FREE WHEN PURCHASED TOGETHER



DIY STEREO SYSTEM



COMPLETE WITH SPEAKERS

Here's real value in DIY! Comprises ready-built amplifier module, 3-speed Garrard auto-return deck, and teak-veneer simulate cabinets with clear plastic top. Easily built by hobbyists. **£26.95** + p & p £4.05

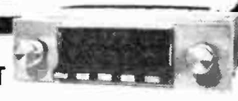
NEW sinclair I.C 20, 20 WATTS STEREO AMPLIFIER KIT WITH PZ 20 POWER UNIT

FANTASTIC SAVING. A build-it-yourself stereo power amplifier with latest integrated circuitry, 10W RMS per channel output, full short-circuit and overheat protection.

LIST £14.50 OUR PRICE **£4.95** p+p £1.

TOURIST IV PUSH-BUTTON CAR RADIO KIT

(MOTOR TOP 10 AWARD)



Complete with speaker, baffle and fixing strips. The Tourist IV – for the experienced constructor only.

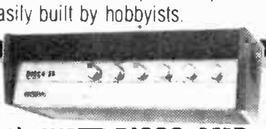
The Tourist IV has five push-buttons, four medium band and one for long wave band.

The tuning scale is illuminated and attractive spun aluminium control knobs are used for manual tuning and volume control.

The modern style facia 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" x 4¾".

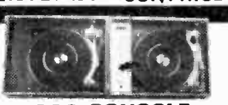
Power Supply: Nominal 12 volts positive or negative earth (altered internally). Power output: 4 watts into 4 ohms.

£10.50 + p&p £1.50



35-WATT DISCO AMP

Here's the mono unit you need to start off with. Gives you a good solid 35 watts rms, 70 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. **£27.50** + p & p £1.50



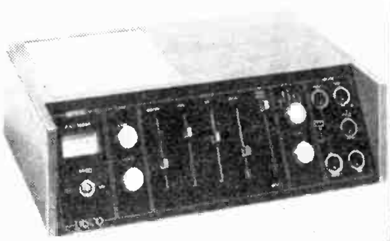
PORTABLE DISCO CONSOLE with built-in pre-amplifiers

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. **£55.00** + p & p £6.50

70 and 100 WATT DISCO AMPLIFIERS

Brilliantly styled for easy disco performance! Sloping fascia, so that 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 watts rms, 140 watts peak output. **£49.00** + p & p £3.00

All the big features as on the 70-watt disco amplifier, but with a massive 100 watts rms, 200 watts peak output power. **£65.00** p & p £4.00



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 3¼" (approx.) 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" × 9½" (approx). **£25.50** PER PAIR + p & p £5.50

DIY SPEAKER KITS

15-WATT KIT IN CHASSIS FORM

YOU CAN'T DO BETTER

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 above enclosures. Size 13" × 8" (approx.) EMI woofer, 3¼" (approx.) tweeter, and matching crossover. Power handling capacity 15 watts rms, 30 watts peak. **£7.50** PER SET + p & p £1.50

'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. The infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures 12" × 9" × 5" (approx.) deep, and is finished in rosewood. Complete with two 8" (approx.) speakers for max. power handling of 7 watts.

£7.50 p&p £1.70 per pair

DECCA 20 WATTS STEREO SPEAKER

This matching loudspeaker system is hand-made, as only Decca know how, built to a specification, not down to a price.

The kit comprises of two 8" diameter approx. base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C. surrounds of two 3½" diameter approx. Two domed tweeters complete with crossover networks.

Our price per stereo pair **£30.00** + £4.00 P & P

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All brand new from reputable international manufacturers

PACK 1. Containing 30 mixed Electrolytic valves from 4.7 mfd to 47 mfd. Minimum 16 volt working. 55p + 20p p&p.

PACK 2. Containing 17 mixed Electrolytic valves from 100 mfd to 2200 mfd. Minimum 16 volt working. Majority 40 volt working. 75p + 20p p&p

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RTVC

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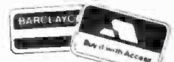

Minimum order on Access and Barclaycards £15

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VALVES

A1065	1.25
AR8	0.60
ARP3	0.60
ATP4	0.50
B12H	3.00
DAF96	0.60
DF96	0.60
DK96	0.75
DL92	0.50
DL96	0.70
DY86/87	0.45
DY802	0.45
E88CC/01	1.30
E180CC	1.00
E182CC	3.00
EA50	0.40
EABC80	0.40
EAF42	0.70
EB91	0.30
EBC33	1.00
EBC41	0.75
EBF80	0.40
EBF83	0.45
EBF89	0.40
EC52	0.40
ECC81	0.45
ECC82	0.35
ECC83	0.35
ECC84	0.35
ECC85	0.45
ECC86	1.25
ECC88	0.55
ECC189	0.30
ECF80	0.45
ECF82	0.45
ECF801	0.75
ECH42	0.85
ECH81	0.40
ECH84	0.60
ECL80	0.60
ECL82	0.40
ECL83	0.75
ECL86	0.60
EF36	0.65

EF37A	1.10
EF40	0.70
EF41	0.75
EF80	0.35
EF83	1.25
EF85	0.40
EF86	0.40
EF89	0.35
EF91	0.60
EF92	0.50
EF95	0.45
EF183	0.40
EF184	0.40
EFL200	0.75
EL34	0.70
EL35	0.70
EL37	2.20
EL41	0.80
EL81	0.60
EL84	0.35
EL85	0.60
EL86	0.50
EL90	0.50
EL91	1.00
EL95	0.70
EL504	0.80
EL821	1.60
EM31	0.70
EM80	0.55
EM81	0.60
EM84	0.40
EM87	1.00
EY51	0.45
EY81	0.45
EY86/87	0.45
EY88	0.50
EZ40	0.70
EZ41	0.75
EZ80	0.30
EZ81	0.35
GT1C	5.00
GY501	0.80
GZ32	0.65
GZ34	0.80

GZ37	1.00
KT66	3.00
KT88	4.50
MH4	1.00
ML6	0.75
OA2	0.45
OB2	0.45
PABC80	0.40
PC86	0.65
PC88	0.65
PC900	0.55
PCC84	0.45
PCC89	0.60
PCC189	0.65
PCF80	0.40
PCF82	0.40
PCF84	0.65
PCF86	0.65
PCF200	0.90
PCF201	0.90
PCF801	0.55
PCF802	0.55
PCF806	0.90
PCH200	0.80
PCL81	0.60
PCL82	0.40
PCL83	0.70
PCL84	0.50
PCL86	0.60
PCL805/85	0.60
PFL200	0.70
PL36	0.60
PL81	0.55
PL82	0.50
PL83	0.50
PL84	0.50
PL504	0.85
PL508	0.95
PL509	1.35
PL802	1.85
PY33	0.60

A lot of these valves are imported and prices vary for each delivery so we reserve the right to change prices for new stock when unavoidable

PLUMBICON TUBES TYPE XO 1071 Mullard £150.00

PY80	0.60
PY/81/800	0.50
PY82	0.45
PY83	0.50
PY88	0.50
PY500	1.10
PY801	0.55
QQV03-10	1.70
QQV06-40A	14.00
QVD3-12	1.70
SC1/400	3.60
SC1/600	5.50
SP61	0.80
TT21	6.00
U25	1.00
U26	0.80

U27	1.00
U191	0.75
U801	0.80
UABC80	0.45
UAF42	0.70
UBC41	0.60
UBF80	0.50
UBF89	0.50
UBL1	1.00
UBL21	0.75
UCC85	0.50
UCF80	0.80
UCH42	0.80
UCH81	0.50
UCL82	0.45
UCL83	0.70
UF41	0.70
UF80	0.40

UF85	0.50
UF89	0.50
UL41	0.70
UL84	0.50
UY41	0.50
UY85	0.50
VR105/30	0.45
VR150/30	0.45
X61M	1.50
X66	0.75
Z759	4.50
Z800U	3.00
Z801U	3.00
Z900T	1.50
1A3	0.55
IL4	0.30

IR5	0.50
IS4	0.35
IS5	0.35
IT4	0.35
IX2B	0.75
2D21	0.50
2K25	9.00
3A4	0.60
3D6	0.40
3E29	5.50
3S4	0.50
3V4	0.85
5B/254M	5.00
5B/255M	5.00
5B/258M	5.50
5R4GY	1.00
5U4G	0.55
5V4G	0.65

5Y3GT	0.60
5Z3	1.20
5Z4G	0.60
5Z4GT	0.65
6AB7	0.60
6AC7	0.60
6AH6	0.70
6AK5	0.45
6AK8	0.40
6AL5	0.30
6AL5W	0.60
6AM5	1.00
6AM6	0.60
6AN8	0.70
6AQ5	0.55
6AQ5W	0.70
6AS6	0.80
6AS7G	1.00

6AT6	0.60
6AU6	0.40
6AV6	0.50
6AX4GT	0.75
6AX5GT	1.00
6B7	0.70
6BA6	0.40
6BE6	0.40
6BG6G	1.00
6BJ6	0.75
6BQ7A	0.60
6BR7	1.30
6BW6	1.10

VIDECON TUBE TYPE P 863 B English Electric £20.00

TRANSISTORS 12½% Please add VAT 12½% for valves, etc.

Please write or phone for current price of any of the transistors

AAZ12-BAV10	AF186	BCY72	GET116	OC35	OC204	2N3638A
AC113	AF239	BF115	GEX66	OC36	OC206	2N3730
AC126	AFZ12	BF167	NKT222	OC42	ZR11	2N3819
AC127	ASY26	BF173	NKT304	OC44	ZR21	2N4038
AC128	ASY27	BF185	NKT404	OC45	ZR22	2N4058
AC176	ASY28	BFY51	OA5	OC70	2N456A	2N4061
ACY17	BC107	BFY52	OA47	DC73	2N525	2N4172
ACY18	BC108	BSY27	OP70	OC75	2N696	2N5295
ACY19	BC109	BSY38	OA71	OC78	2N708	3N126
ACY20	BC113	BSY95A	OA73	OC78D	2N918	3N128
ACY39	BC116	BY100	OA79	OC81	2N1305	3N154
ACY40	BC118	BYZ16	OA91	OC82	2N1307	3N159
AD149	BC136	CRS1/20	OA200	OC820M	2N1309	SX754
AD161	BC137	CRS1/30	OA202	OC83	2N2062	2S303
AD162	BC148A	CRS3/10	OAZ200	OC83B	2N2411	T12082
ADZ11	BC172	CRS3/20	OC22	OC139	2N2989	40235
AOZ12	BC172A	CRS3/30	OC25	OC140	2N3053	40250
AF114	BC212A	CRS3/40	OC26	OC170	2N3054	40251
AF115	BCY31	CRS25/025	OC28	OC172	2N3055	IN23A
AF116	BCY33	GET115	OC29	OC200	2N3391	IN25
AF117						IN38A
AF118						IN43
AF124						IN70
AF125						IN677
AF126						IN4148
AF127						IN4785
AF139						
AF178						

VALVES AND TRANSISTORS

Telephone enquiries for valves, transistors, etc. retail 749 3934, trade and export 743 0899

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6F8G	0.75
6F12	0.60
6F17	1.00
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6H6	0.45
6J4WA	1.25
6J5	0.65
6J5GT	0.55
6J6	0.35
6J7	0.65
6J7G	0.40
6K6GT	0.80
6K7	0.55
6K7G	0.35
6K8GT	0.55
6L6M	1.90
6L7G	0.40
6SA7	0.55
6SC7	0.75
6SG7	0.55
6SJ7	0.60
6SJ7GT	0.55
6SK7	0.60
6SL7GT	0.55
6SN7GT	0.55
6SQ7	0.60
6V6GT	0.60
6X4	0.45
6X5G	0.40
6X5GT	0.55
6Y6G	0.95
6Z4	0.65
6/30L2	0.90
7B7	0.80
7Y4	0.80
9D2	0.60
9D6	0.50
11E2	6.00
12A6	0.60
12AT6	0.45
12AT7	0.45
12AU7	0.35
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12BH7	0.55
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12Q7GT	0.50
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12SG7	0.55
12SJ7	0.55
12Y4	0.40
14S7	1.00
19AQ5	0.70
19G3	8.00
19G6	6.50
19H5	15.00
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20P4	1.10
25L6GT	0.70
30C15	1.00
30C17	1.10
30F5	1.00
30FL1	1.10
30FL12	1.10
30L15	1.00
30L17	1.00
30P12	1.00
30P19	1.00
30PL13	1.10
30PL14	1.10
35L6GT	0.80
35W4	0.55
35Z4GT	0.70
50C5	0.65
50C06G	1.20
75	1.00
75C1	0.75
76	0.75
78	0.70
80	0.75
85A2	0.75
803	6.00
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954	0.50
955	0.50
956	0.50
957	0.50
1629	0.70
2051	1.00
5763	1.70
5933	3.00
6057	0.80
6060	0.70
6064	0.60
6065	1.00
6067	0.80
6080	3.50
6146	3.35
6146B	5.00
6360	1.70
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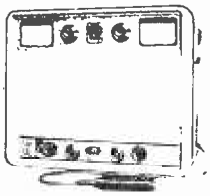

MARCONI TF 867 SIGNAL GENERATOR Range 15KHz to 30MHz Output 0 4 uV to 4V at 13 or 75 ohms Impedance with termination (supplied) Built in crystal check facility with handbook **£138** including carriage

PHILIPS AUDIO GENERATOR TYPE GM 2308. 0-16kc/s Attenuator 0 0001 0 0003 0 001 to 1 with output asym & sum and matching impedance 5 250, 600 & 1,000 ohms Price **£98.00** carriage £4 00

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Z-g DIAGRAPH TYPE ZDU 30-420MHz 50Ω Directly measures multiterminal net-works phrase shift, phrase angle with complimentary POWER SIGNAL GENERATOR TYPE SMLM high freq resolution internal external mod up to 3v out

FREQUENCY SYNTHESIZER TYPE XUA. 30Hz-30MHz with FREQUENCY INDICATOR TYPE FKM 15-30MHz, 30-100MHz

HEWLETT-PACKARD

AUDIO GENERATOR MODEL 206-A. Freq. 20c to 20,000c, matching impedance 50, 150, 600 ohms Price **£85.00** carriage £4.00

SPECTRUM ANALYZER. Model 8551 with R F display section Model 851 Frequency coverage! 10MHz-40GHz, spectrum width 2HGz Price and spec on request

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RATIO METER. Model 416B Full specification on request

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PULSE GENERATOR. Model 212A Full specification on request

CALORIMETRIC POWER METER. Model 434A Frequency range dc to 12 4GHz power 10mW-10 watts **£275,** packing & carriage £5 00

AVO NOISE GENERATOR CT 410 **£30** carriage £2 00

RACAL RECEIVERS MODELS. RA17 in fully working and tuned condition Prices on application RA98A ADAPTOR **£85.00.**

KAHN SSB ADAPTOR TYPE RSSB — 62 — 18. Designed for receivers with 455-500KHz IF at 100mV (max) input Features electronic AFC carrier freq diversity to combat fading 20 sce R C memory to maintain tuning during severe fading Individual carrier meters, nuvishers, 10W distortion production demodulator **£65** carriage £5 00

HR 23 TRIPLE DIVERSITY SSB RECEIVERS. Frec 3-275MHz V F O at 6 Xtal positions Reception of independent single or double side band transceivers Full spec on application **£350** carriage £35 00

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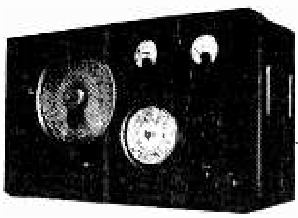

TF 801D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges R F output 0 1 uV-1V Source C M Dial calibrated in volts decibels and power relative to thermal noise Piston type attenuator 50Ω output impedance Internal modulation at 1 KHz at up to 90% depth also external sine and pulse modulation Built in 5MHz crystal calibrator Separate RF and mod meters P O A

TF 1066 SIGNAL GENERATOR. Freq 10-470MHz with attenuator EMF from 50Ω square. —6dB Pnce on application

TF 801B/2. Spec as for 8010 but minor circuit differences Few only left **£120** carriage £5 00

GENERAL RADIO TYPE 1910A RECORDING WAVE ANALYSER. 20Hz to 57kHz Price and full specification on request

MUIRHEAD

PAMETRADA WAVE ANALYSER TYPE D-489-G. Freq range 19 c/s-21 Kc/s continuously variable in nine ranges 19-90 c/s 79-150 c/s 139-210 c/s (x 1, x 10, x 100) Freq accuracy x 1 and x 10 ranges ± 0 3% Input voltage for full scale deflection of meter 1 mV minimum to 300V maximum Maximum permissible input is 300V r m s

ANCILLARY EQUIPMENT: D-625-A LOW FREQ. MODULATOR. Freq range 2 c/s-20 c/s (down to 1 c/s when analyser is used in High Q') Freq accuracy ± 0 1 c/s (providing supply freq is first measured) Specification on request Price **£275.00,** packing and carriage £4 00

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VAT FOR TEST EQUIPMENT
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REDIFON SSB TRANSMITTER/RECEIVER TYPE GR410. Full particulars and price on request

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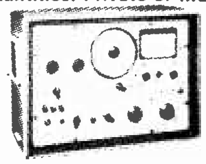

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CT480 SIGNAL GENERATOR. 7 KMC/S to 12 KMC/S mod C W F M Pulse **£160** carriage £5 00

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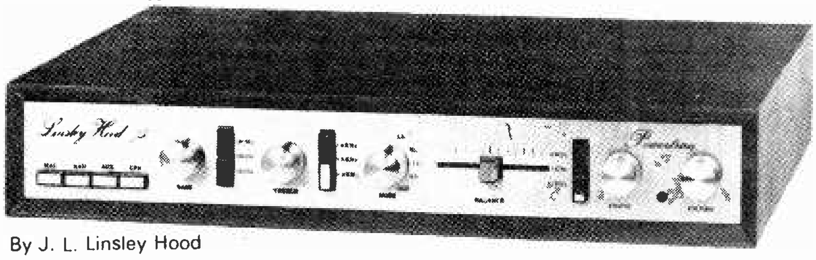
HI-FI NEWS 75W/CHANNEL AMPLIFIER



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	£2.15
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	£1.75
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£3.40
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.15
9. Set of 4 push-button switches, rotary mode switch	£4.50
10. Toroidal transformer complete with magnetic screen/housing primary: 0 117-234 V; secondaries: 33-0-33 V, 25-0-25 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	£4.60
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£5.35
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£7.30
15. Handbook	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

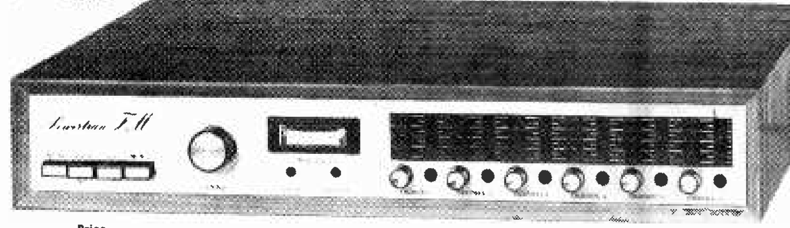
2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £83.75

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£73.90**

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 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, thermistor, capacitors, cermet preset for mounting on pack 1	£4.30
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 selecter switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters, etc.	£8.80
9. Function switch, 10 turn tuning potentiometer, knobs	£5.30
10. Frequency meter, meter drive components, fibreglass printed circuit board	£9.45
11. Toroidal transformer with electrostatic screen. Primary: 0—117V—234V	£4.45
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.95
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£1.50
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.	£7.50
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 18.3" x 12.7" x 3.1"	£9.85

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £76.85

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£66.75**

NEW KIT!

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	£8.90
4. Miniature relay with socket	£2.45
5. PCB, all components for solenoid, speed control circuits	£3.20
6. Goldring Lenco mechanism as specified.	£19.10
7. Function switch, knobs	£1.60
8. Dual VU meter with illuminating lamp	£7.20
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V	£4.45
10. Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc.	£2.50
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"	£9.85

One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs £82.55

SPECIAL PRICE FOR COMPLETE SETS £78.50

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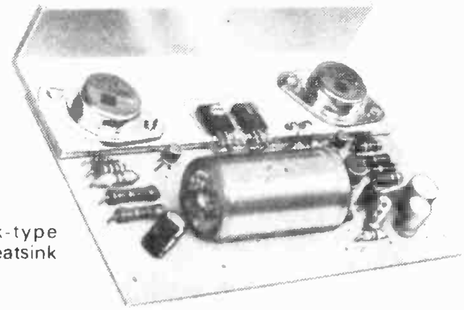

SS.1100
£9.45*

with heatsink-type bracket. Large heatsink — £1* extra

Most recent addition to Stirling Sound's wide range of power amplifiers, the SS 1100 is a solidly constructed heavy duty module to deliver 100 watts r.m.s. into 4Ω using 70 volts. Ideal for discos, P.A. and similar applications. With built-in output capacitor and heatsink mounting bracket. Size approx. 140 x 76 x 32mm. A guaranteed Stirling Sound QV module. Compatible with other Stirling Sound modules. Supreme value. Designed and built for long unbroken spells of work.

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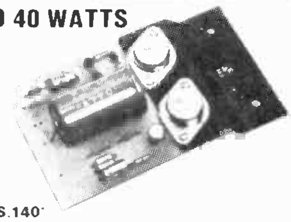

SS.105
5 watts R.M.S. into 4 ohms using 12V supply. Ideal for use in in-car entertainment. Size — 89 x 51 x 19mm
£2.25

S.110
Similar in size and design to SS 105, this QV module delivers 10 watts R.M.S. into 4 ohms using a 24V supply, e.g. SS.324. Of great use in domestic applications.
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SS.120
Using a 34 volt supply, such as SS.334, this amplifier will deliver 20 watts into a 4 ohm load. Same dimensions as above.
£3.25

SS.140*
Mk. 3 version, complete with output capacitor and heatsink-type bracket. Delivers 40 watts R.M.S. into 4 ohms from a 45 volt supply such as the SS.345. Designed specially for long and heavy work.
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FOR POWER SUPPLY UNITS SEE BELOW

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Combined pre-amp with active tone-control circuits. 200mV output for 50 mV in. Runs on 10 to 16V supply. Treble ± 15 dB at 10KHz. Bass ± 15 dB at 30Hz. Stereo. Balance, vol., treble and bass controls.
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SS.101
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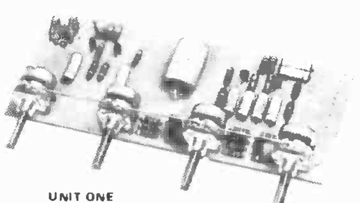
SS.102 STEREO PRE-AMP
R.I.A.A. corrected for mag., plus tape, radio, etc. **£2.65**



UNIT ONE
Pre-amp with active tone control circuits.

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149	60	**5.39**	80
150	100	**6.13**	95
151	200	**9.82**	1.25
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18	4	2	**3.42**	80
70	6	3	**5.09**	.80
108	8	4	**5.85**	.95
72	10	5	**6.33**	.95
116	12	6	**6.67**	1.10
17	16	8	**3.60**	1.10
115	20	10	**12.55**	1.73
187	30	15	**16.33**	1.73
226	60	30	**20.32**	OA

50 VOLT RANGE

Primary 220-240V
SEC. TAPS 0-19-25-33-40-50V

Ref.	Amps	£	P&P
102	0.5	**3.12**	.65
103	1.0	**4.08**	.80
104	2.0	**5.69**	.95
105	3.0	**7.02**	1.10
106	4.0	**9.18**	1.25
107	6.0	**14.62**	1.37
118	8.0	**15.56**	1.73
119	10.0	**20.41**	OA

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Primary 220-240V
SEC. TAPS 0-12-15-20-25-30V

Ref.	Amps	£	P&P
112	0.5	**2.27**	.65
79	1.0	**2.90**	80
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20	3.0	**5.41**	.95
21	4.0	**6.39**	.95
51	5.0	**7.74**	1.10
117	6.0	**8.65**	1.25
88	8.0	**11.73**	1.37
89	10.0	**11.91**	1.53

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SEC TAPS 0-24-30-40-48-60V

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127	2.0	**6.13**	.95
125	3.0	**9.09**	1.10
123	4.0	**10.57**	1.53
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121	8.0	**18.11**	BRS
122	10.0	**22.31**	BRS
189	12.0	**23.30**	BRS

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Ref.	VA (Watts)	TAPS	£	P&P
113	20	0-115-210-240V	**2.01**	.59
64	75	0-115-210-240V	**3.51**	.80
4	150	0-115-210-220-240V	**4.98**	.80
66	300	" "	**7.03**	.95
67	500	" "	**10.76**	1.37
84	1000	" "	**16.51**	1.73
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238	200	3-0-3	**1.86**	.46
212	1A, 1A	0-6, 0-6	**2.22**	.65
13	100	9-0-9	**1.79**	.32
235	330,330	0-9, 0-9	**1.89**	.32
207	500, 500	0-8-9, 0-8-9	**2.32**	.59
208	1A, 1A	0-8-9, 0-8-9	**3.53**	.65
236	200, 200	0-15, 0-15	**1.79**	.32
214	300, 300	0-20, 0-20	**2.33**	.65
221	700 (DC)	20-12-0-12-20	**2.74**	.65
206	1A, 1A	0-15-20, 0-15-20	**4.17**	.80
203	500, 500	0-15-27, 0-15-27	**3.62**	.80
204	1A, 1A	0-15-27, 0-15-27	**4.76**	.80
S112	500	0-12-15-20-24-30	**2.27**	.65

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S Dec 70 contacts	**£1.98**
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2000VA	**£33.02**	O.A.	Ref 95W

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200v	2A	**45p**
400v	2A	**55p**
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P&P £1.25. VAT 8%

NEW STEREO 30

Complete chassis, inc. 7+7w r.m.s. amps, pre-amp, power supply, front panel, knobs (needs mains trans.), **£15.75.** Mains trans. **£2.45.** Teak veneered cab. **£3.65. P&P 88p.** VAT 12½%.

C1000 MINI-MULTIMETER

DC-1000V AC- 000V
AC/DC-1000Ω/V
DC-100mA. Res — 150K
Bargain at **£3.80**
VAT 8% P&P 45p

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CC12-05. Output 3, 4.5, 7.5, 9, 12v at 500mA. **£4.08.**
HC244R. Stabilised 3, 6, 7.5, 9v at 400mA **£5.95.**
3300. 6, 7.5, 9v at 300mA plugs direct into 13A socket **£3.15.**
P&P 48p VAT 12½%.

STEREO F.M. TUNER

4 Pre-selected stations
Switched AFC
Supply 20-35v 90Ma Max.
£19.95. P&P 25p. VAT 12½%

MAGNETIC TO CERAMIC CARTRIDGE CONVERTER

Operating Voltage 20/45v
ONLY **£2.65** P&P 18p
VAT 12½%

ANTEX SOLDERING IRONS

15W **£2.90.** 18W **£2.75.** 25W **£2.45**
Soldering iron kit **£3.90**
Stand for above **£1.13.** P&P 25p. VAT 8%.

GARRARD SP25 Mk. IV

(Chassis) **£19.23**
BSR 144R Chassis with magnetic cartridge **£23.54**
P&P £1.10 VAT 12½%

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WW — 053 FOR FURTHER DETAILS

DRILL CONTROLLER
Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. **£3.45** including post & VAT. Made-up model **£1.00** extra.

NUMICATOR TUBES

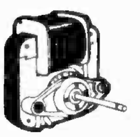
For digital instruments, counters, timers, clocks, etc. Hi-vac XNII. Price **£1.25** each, inc. Post and VAT.

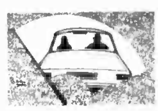
RADIO STETHOSCOPE

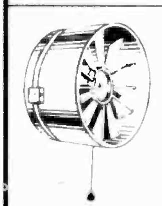
Easiest way to fault find, traces-signal from aerial to speaker, when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything. Complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. **£2.95** twin stetho-set instead of earpiece inc. VAT & Postage.

MAINS TRANSISTOR PACK
Designed to operate transistor sets and amplifiers. Adjustable output 6v, 9v, 12 volts for up to 500mA (class B working). Takes the place of any of the following batteries PP1, PP3, PP4, PP6, PP7, PP9 and others. Kit comprises main transformer rectifier, smoothing and load resistor condensers and instructions. Real snip at only **£1.90** including Post & VAT.

MOTORISED DISCO SWITCH
With six 10 amp changeover switches, adjustable over 360° switches are rated at 10 amp each so a total of 2000w's can be controlled and this would provide a magnificent display for mains operating **£4.25** Post & VAT paid.
Ditto 9 switch **£4.95** Post & VAT paid.
Ditto but 12 switch **£5.75** Post & VAT paid.

MAINS MOTOR

Precision made — as used in record decks and tape recorders — ideal also for extractor fans, blower heaters etc. New and perfect. Snip at **95p** + VAT & Postage 35p.
1" stackmotor **£1.50** + VAT & Postage 35p. 1½" stackmotor **£2** + VAT & Postage 40p.

WINDSCREEN WIPER CONTROL

Vary speed of your wiper to suit conditions. All parts and instructions to make. **£3.75** plus post and VAT.



EXTRACTOR FAN
Cleans the air at the rate of 10,000 cubic feet per hour. Suitable for kitchens, bathrooms, factories, changing rooms, etc. It's so quiet it can hardly be heard. Compact, 5½" casing comprises motor, fan blades, sheet-steel casing, pull switch, mains connector and fixing brackets. **£5.25** including post & VAT.
Monthly list available free: send long stamped envelope.

28 R.P.M. GEARED MAINS MOTOR
This is a substantial motor (1" stack induction type) quite powerful, definately large enough to drive a rotating display or a tumbler for polishing stones etc. Approximate overall size 4" x 3¼" x 2½" these are ex-unused equipment, carrying our normal ex-equipment guarantees.
PRICE **£2.95** POST & VAT PAID.

GLAMORISE YOUR ROCKS
The way to make rock samples, stamps etc really show themselves off is to light them by means of our miniature UV tube. This is only **6w**'s so the electricity costs are negligible. Complete kit comprises UV tube and its 2 mounting holders, control choke and starter.
Total price **£4.75** POST & VAT PAID.

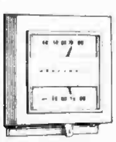
TELESCOPIC AERIALS

for portable, car radio or transmitter. Chrome plated — six sections, extends from 7½ to 47in. **50p** + 15p Post & VAT.
KNUCKLED MODEL FOR F.M. **80p** + 17p Post & VAT.

SPEED CONTROLLED 9V MOTOR
This is a motor with a governor 9v operation intended for record players and tape recorders. These are reversible and electro magnetically and acoustically screened. Size approx. 1½" diameter by 1" deep with good length spindle. Japanese made, portable replacement in a good many popular cassette and record players.
PRICE **95p** inc. POST & VAT.

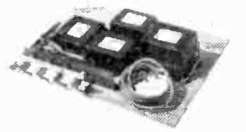
NEED A SPECIAL SWITCH

Double Leaf Contact. Very slight pressure closes both contacts **12p** each. Plastic pushrod suitable for operating **10p** each, 10 for **68p**.

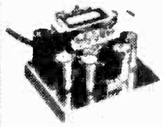


THERMOSTAT WITH THERMOMETER
Made by Honeywell for normal air temperatures 40-80 F (5-25 C). This is a precision instrument with a differential which can be adjusted to better than 1.5 F. A mercury switch breaks on temp. rise. Elegantly styled and encased in an ivory plastic case with clear plastic windows, thermometer above and switch setting scale below — size approx 3 8"×3 2"×1 4" deep — can be mounted on conduit box or directly on wall. Price **£2.25** plus 50p Post & VAT.

MULLARD UNILEX
A mains operated 4 + 4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost any one. In easy-to-assemble modular form this would sell at about £30 — but due to a special bulk buy and as an incentive for you to buy this month we offer the system complete at only **£14.00** including VAT and postage.
SPECIAL OFFER: Pair of 8" Celestion 15 watt speakers, normally £8.00 — yours for **£3.00** if you buy the Unilex.

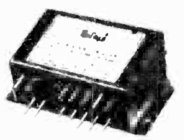


GPO PUSH-BUTTON DIALLING UNIT
Will take the place of the normal rotating dial, has 10 numbered keys, so suitable for other digital systems. A desk mounting unit with rubber feet, this is a very intricate and expensive piece of apparatus. New and unused — our price only £9 each including post and VAT.

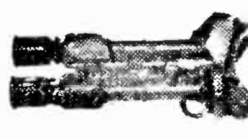


TWIN OUTPUT POWER PACKS
These have two separately R.C. smoothed outputs so can operate two battery radios on a stereo amp without cross modulation (they will of course operate one radio tape cassette calculator in fact any battery appliance and will save their cost in a few months). Specs. Full wave rectification, double insulated mains transformer — total enclosed in a hard P.V.C. case — three core mains lead terminal output — when ordering please state output voltage 4½v 6v 7½v 9v 12v or 24v. Price **£3.95**. Post and VAT included.

MULLARD THYRISTOR TRIGGER MODULE
This produces pulses for phase control triggering, it has two isolated outputs, so one thyristor or two thyristor (in separate arms of bridge) may be controlled by one module. The timing circuit is synchronised to the mains frequency and control is by an external variable resistor or from a voltage or current source. Provision is made for feed-back where automatic control is required. Price **£5.95.**

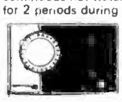


THIS MONTH'S SNIP
250 WATT TRANSFORMER
Heavy duty power transformer which can be used for many purposes. Rated at 250 watts it is very well built with frames for upright mounting and is varnish impregnated. Its primary is for 230/240 volts 50 cycles, it has four secondaries each 10v very high current windings. Just a few of the circuits it can power are 10-0-10v at up to 12 amps, 20-0-20v at up to 6 amps, single 10v at 25 amps, single 20v at 12½ amps, single 30v at 9 amps, single 40v at 6.5 amps. The transformer can be used for power circuits (charging, etc.) or for amplifiers, there being an earth screen between primary and secondaries. A transformer like this today would cost at least £15 from the makers, however, we are making a special offer at **£4.50** + 36p. post £1 + 8p each. Grab some while you can, our stock may not last long.



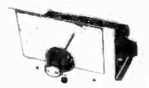
INFRA RED BINOCULARS
Made for military purposes during and immediately after the last war to enable snipers, vehicle drivers, etc. to see in the dark. The binoculars have to be fed from a high voltage source (5KV approx.) and providing the objects are in the rays of an infra red beam then the binoculars will enable these objects to be seen. Each binocular eye tube contains a complete optical lens system as well as the infra red cell, technical data on which is available. The binoculars are unused, believed to be in good order. In fact they were never issued and are still in original cases, but since they were made a long time ago they can hardly be called new. Sold without guarantee. Price **£17.50** per set. Post & VAT £2.50.

SMITHS CENTRAL HEATING CONTROLLER
push-button gives 10 variations as follows (1) continuous hot water and continuous central heating (2) continuous hot water but central heating off at night (3) continuous hot water but central heating on only for 2 periods during the day (4) hot water and central heating both on but day time only (5) hot water all day but central heating only for 2 periods during the day (6) hot water and central heating on for 2 periods during the day time only — then for summer time use with central heating off (7) hot water continuous (8) hot water day time only (9) hot water twice daily (10) everything off.



A handsome looking unit with 24-hour movement and the switches and other parts necessary to select the desired programme of heating. Supplied complete with wiring diagram. Originally sold we believe at over **£15** — we offer these, while stocks last at **£7.50** each including VAT & Postage.

SHORTWAVE CRYSTAL SET
Although this uses no battery it gives really amazing results. You will receive an amazing assortment of stations over the 19, 25, 31, 29 metre bands — Kit contains chassis front panel and all the parts. **£1.50** — crystal earphones **55p** including VAT & Postage.



TANGENTIAL HEATER UNIT
This heater unit is most efficient and quiet running. Is as fitted in Hoover and blower heaters costing £15 and more. Comprises motor, impeller, 2kW element and 1kW element allowing switching 1, 2 and 3kW and with thermal safety cut-out. Can be fitted into any metal line case or cabinet. Only needs control switch. **£5.82** plus VAT & post £1. 2kW Model as above except 2kW **£4.25** plus VAT & post 75p. Don't miss this. Control switch **44p**. P&P 40p.

PAPST MOTORS
West German make, these fine motors are noted for their performance and reliability. Special features are the rotating heavy outer which acts as a flywheel to eliminate wow and flutter and switchable reversing.

We have four types in stock, all 1,350 revs, including starting capacitor.

(1) Reference No. KLZ 20/50-4	230 volts 50HZ.	Price **£5.50**
(2) Reference No. KLZ 32.50-4	230 volts 50HZ.	Price **£6.50**
(3) Reference same as above	115 volts 50HZ.	Price **£2.50**
(4) Reference same as above	110 volts 60HZ.	Price **£2.50**

Post and VAT 80p each extra.

ROOM THERMOSTAT
Famous Satchwell, elegant design, intended for wall mounting. Will switch up to 20 amps at mains voltage, covers the range 0-30°C. Special snip this month. **£2.90**, post & VAT paid.

ISA ELECTRICAL PROGRAMMER

Learn in your sleep. Have radio playing and kettle boiling as you awake — switch on lights to ward off intruders — have a warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp on/off switch. Switch-on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price **£2.95**, VAT & postage 60p, or with glass front, chrome bezel, **£1.50** extra.

AEROSOL RELEASE LUBRICANT
Dry Film Lubricant. In aerosol can for easy application and for putting lubricant into places where the normal oil can cannot reach. Home and everyday uses. We have purchased a large quantity of these from the Liquidator and are able to offer them to you for about half of the original list price. **88p** per 8oz can or 12 cans for **£3**, post paid. The lubricant is I.C.I. fluon L169.

SALE
LIST FREE SEND SAE

SWITCH TRIGGER MATS

So thin is undetectable under carpet but will switch on with slight pressure. For burglar alarms, shop doors, etc.
24in. x 18in. **£2.33**, post & VAT 30p. 13in. x 10in. **£1.85**, post & VAT 25p.

MAINS TRANSFORMERS
All standard 230/250 volt primaries

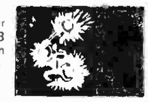
		£ P
1v	1 amp (special)	2.33
2.4v	5 amp	1.05
6.3v	2 amp	1.57
6.3v	3 amp	2.19
9v	1 amp	1.19
9v	3.5 amp	3.13
12v	1½ amp	1.85
12v	1 amp	1.25
6.5v-0-6.5v	1 amp	1.85
18v	1 amp	1.85
24v	2 amp	2.82
24v	3 amp	4.75
12-0-12v	50mA	1.56
6-0-6v	50mA	1.56
8-0-8v	½ amp	1.85
25v	1½ amp	2.44
50v 2 amp & 6.3v	1 amp	5.63
60v 5 amp & 5v	1 amp	9.35
27v	8 amp	5.63
30v	37 amp	27.50
80v tapped 75v & 70v	4 amp	6.87
250v-60mA & 6.3v	1.5 amp	2.19
275-0-275v at 90mA & 6.4v	3 amp	2.82
EHT Transformer 5000v 23mA	(intermittent)	6.87
Charger Transformers		
6v and 12v	2 amp	1.87
6v and 12v	3 amp	2.82
6v and 12v	5 amp	4.25

Add 30p per £1 to cover postage and VAT

MULTI-SPEED MOTOR
Six speeds are available 500, 850 and 1,100 r.p.m. and 8,000, 12,000 and 15,500 r.p.m. Shaft is ¼in. diameter and approximately 1in. long 230/240v. Its speed may be further controlled with the use of our Thyristor controller. Very powerful and useful motor, size approx. 2in. dia. x 5in. long. Price **£2.00** including post & VAT.
SPEED CONTROL SWITCH **50p** + 4

SPIT MOTOR WITH CARTER GEARBOX
Probably one of the best spit motors made. Originally intended to be used in very high priced cookers, however, this can be put to plenty of other uses, for instance your garden barbecue or to drive a colour disc for a dance or display or to drive a tumbler for stone polishing; in fact, there is no end to its uses. Normal mains operation. **£3.25** including post & VAT.

SOUND TO LIGHT UNIT
Add colour or white light to your amplifier. Will operate 1, 2 or 3 lamps (maximum 450W). Unit in box all ready to work **£8.95** plus 95p VAT & Postage.



SMITHS 24-HR. TIMER HEART
Really the "Autoset" without its plastic case. This is a 24-hr, twice on, twice off, clock switch which will repeat until re-programmed. Switches rated at 15 amps. Limited supplies — **£4.45** including VAT & post.

PRESSURE SWITCH

Containing a 15 amp change over switch operated by a diaphragm which in turn is operated by air pressure through a small metal tube. The operating pressure is adjustable but is set to operate in approx. 10in. of water. These are quite low pressure devices and can in fact be operated simply by blowing into the inlet tube. Original use was for washing machine to turn off water when tub had reached correct level but no doubt has many other applications. **£1.95** including post & VAT.

DC HIGH CURRENT PANEL METERS
3½" wound wide angle 240° movement meters, flush mounting fitted with external shunts made by Crompton Parkinson, brand new, still in maker's cartons. These are a real bargain at **£6.00** each including post & VAT. Reasonable quantities available in the following ranges, 0-10 amps, 0-20 amps, 0-30 amps, some 100 amp but less Shunts **£5.00**.

MULLARD AUDIO AMPLIFIERS
all in module form, each ready built complete with heat sinks and connection tags, data supplied.

Model 1153 500mW power output **£1.50** including post & VAT
Model 1172 1w power output **£1.85** including post & VAT
Model EP9000 4 watt power output **£2.90** including post & VAT
EP9001 twin channel or stereo pre-amp. **£2.90** including post & VAT

MORE CENTRAL HEATING CONTROLLERS
Randell **£6.50** inc. post & VAT.
Horstman **£5.00** inc. post & VAT.

Terms: When order under £5 please add 40p to offset handling and packing charges. Cash with order except Institutions and Public Companies.

J. BULL (ELECTRICAL) LTD.
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7400	16p	7494	90p
74H00	28p	7495	70p
74S00	45p	7496	84p
74LS00	30p	7497	340p
7401	18p	74100	120p
7402	18p	74104	55p
7403	18p	74105	55p
7404	23p	74107	36p
74H04	36p	74109	89p
7405	25p	74110	55p
7406	43p	74111	90p
7407	36p	74112	96p
7408	22p	74116	200p
7409	22p	74118	84p
7410	18p	74120	120p
74H10	28p	74121	32p
7411	24p	74122	54p
7412	25p	74123	76p
7413	36p	74125	73p
7414	75p	74126	70p
7416	33p	74128	75p
7417	36p	74132	70p
7420	18p	74136	75p
7421	40p	74141	75p
7422	22p	74142	320p
7423	37p	74145	90p
7425	30p	74147	190p
7427	37p	74148	160p
7428	36p	74150	140p
7430	18p	74151	72p
7432	30p	74153	85p
7437	30p	74154	150p
7438	30p	74155	90p
7440	19p	74156	90p
7441	75p	74157	90p
7442	70p	74158	140p
7443	140p	74159	190p
7444	140p	74160	104p
7445	140p	74161	104p
7446	140p	74162	104p
7447	85p	74163	104p
7448	80p	74164	120p
7450	18p	74165	220p
7451	20p	74166	126p
7453	20p	74167	340p
7454	18p	74170	250p
7460	18p	74173	160p
7470	36p	74174	120p
7472	30p	74175	85p
7473	34p	74176	120p
7474	34p	74177	100p
7475	45p	74180	110p
7476	36p	74181	298p
7480	50p	74182	82p
7481	95p	74185	150p
7482	90p	74186	920p
7483	90p	74190	165p
7484	110p	74191	165p
7485	120p	74192	120p
7486	34p	74193	160p
7489	320p	74194	120p
7490	40p	74195	95p
7491	85p	74196	120p
7492	55p	74197	120p
7493	40p	74198	210p
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CD4007AE	20p
CD4009AE	61p
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CD4013AE	55p
CD4015AE	90p
CD4016AE	50p
CD4017AE	100p
CD4018AE	110p
CD4019AE	52p
CD4020AE	120p
CD4022AE	100p
CD4023AE	22p
CD4024AE	80p
CD4025AE	22p
CD4026AE	170p
CD4027AE	65p
CD4028AE	98p
CD4029AE	120p
CD4030AE	55p
CD4042AE	90p
CD4043AE	100p
CD4046AE	140p
CD4047AE	100p
CD4049AE	63p
CD4050AE	57p
CD4054AE	120p
CD4055AE	140p
CD4056AE	135p
CD4060AE	130p
CD4069AE	27p
CD4071AE	27p
CD4072AE	27p
CD4081AE	21p
CD4082AE	27p
CD4510AE	130p
CD4511AE	160p
CD4516AE	112p
CD4518AE	130p
CD4528AE	120p
MC14553	525p

TEXAS 75 SERIES

75107	160p
75450	120p
75451	72p
75452	72p
75453	72p
75454	72p

TEXAS OTLs

930	36p
936	40p
946	40p
955	60p
962	36p
963	40p

OP. AMPS

1458	Dual Op. Amp. Int. Comp	8 pin DIL	70p
301A	Ext. Comp.	8 pin DIL	36p
3130	COSMOS/Bi-Polar MosFet	8 pin DIL	100p
3900	Quad. Op. Amp	14 pin DIL	70p
536T	FET Op. Amp	TO-99	275p
709	Ext. Comp.	8/14 pin DIL	30p
741	Int. Comp	8/14 pin DIL	22p
747	Dual 741	14 pin DIL	70p
748	Ext. Comp.	8/14 pin DIL	38p
776	Programmable Op. Amp.	TO-5	140p

LINEAR I.C.s

★AY-1-0212	Tone Generator	16 pin DIL	600p
★CA3028A	Diff. Cascade Amp.	T05	95p
ICA3046	5 Transistor Array	14 pin DIL	70p
★CA3048	Quad. Low Noise Amp	16 pin DIL	200p
★CA3053	Diff. Cascade Amp.	T05	60p
CA3080E	Op. Transcond Amp	8 pin DIL	90p
★CA3089E	FM IF System	16 pin DIL	225p
★CA3090	FM stereo Multi. Dec	16 pin DIL	400p
ICL8038BC	VCO Fun. Gen	14 pin DIL	550p
ICL8038CC	VCO Fun. Gen	14 pin DIL	340p
★LM380	2W Audio Amp	14 pin DIL	99p
★LM381	Stereo Preamp	14 pin DIL	175p
★LM389N	Aud. Amp.+3 Trs. Array	18 pin DIL	130p
★M2S2	Rhythm Generator	16 pin DIL	800p
★MC1310P	FM Stereo Dec.	14 pin DIL	190p
★MC1351P	Lim/Det. Aud Preamp	14 pin DIL	97p
MC1495	Multiplier	14 pin DIL	300p
★MC1496L	Bal. Mod/Demod	14 pin DIL	100p
★MC3340P	Electronic Attenuator	8 pin DIL	140p
★MFC4000B	1/4W Audio Amp.	PCB	70p
★NE540L	Audio Pwr driver	TO99	140p
NE555	Timer	8 pin DIL	40p
NE556	Dual 555	14 pin DIL	100p
NE561	PLL with AM Demod.	16 pin DIL	425p
NE562	PLL with VCO	16 pin DIL	425p
NE565	PLL	14 pin DIL	200p
NE566	PLL Fun. Gen	8 pin DIL	200p
NE567	PLL Tone Dec.	8 pin DIL	200p
2567	Dual 567	16 pin DIL	370p
SN72710	Diff. Comparator	14 pin DIL	50p
★SN72733	Video Amp	14 pin DIL	120p
★SN76003N	Pwr Aud Amp with int HS	16 pin DIL	245p
★SN76008	10W Amp in 4 ohms	5 pin Plastic	250p
★SN76013N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76018	10W Amp in 8 ohms	5 pin Plastic	250p
★SN76023N	Pwr Aud Amp with int HS	16 pin DIL	140p
★SN76033N	Pwr Aud Amp with int HS	16 pin DIL	230p
★TAA621A	Aud Amp for TV	QIL	225p
★TAA661B	FM IF Amp-Limiter/Det.	QIL	120p
★TBA641B	Audio Amp	QIL	250p
★TBA651	Tuner & IF Amp	16 pin DIL	200p
★TBA800	5W Audio Amp	QIL	90p
★TBA810	7W Audio Amp	QIL	100p
★TBA820	2W Audio Amp	QIL	80p
★TDA2020	20W Audio Amp	QIL/DIL	325p
XR2240	Prog. Timer/Counter	16 pin DIL	370p
★ZN414	TRF Radio Receiver	TO-18	110p

Basic data sheets on above at 20p each + S.A.E.

OPTO-ELECTRONICS

Phototransistors		L.D.Ro	
OCP70	30p	ORP12	60p
OCP71	120p	ORP60	75p
2N5777	48p	ORP61	75p
LEDS		0.2"	
TIL209 Red	16p	Red	18p
TIL211 Green	34p	Green	30p
TIL32 Infrared	75p	Yellow	30p

SEVEN SEGMENT DISPLAYS

3015F 0.3" Red	160p	Xciton:	
DL704 0.3" Red	140p	0.3" Green	160p
DL707 0.3" Red	140p	0.3" Green	160p
DL747 0.3" Red	225p	0.6" Green	225p
Drivers: 75491	84p	75492	96p

TRANSISTORS

AC125	20p	BFY52	16p	★2N3704	12p
AC126	18p	BRY39	45p	★2N3705	12p
AC127	18p	BSX19	20p	★2N3706	12p
AC128	16p	BSX20	20p	★2N3707	12p
AC141	18p	★BU105	140p	★2N3708	12p
AC142	18p	BU108	250p	★2N3709	12p
AC176	18p	★MJE340	45p	2N3773	250p
AC187	18p	MJ2955	120p	2N3866	90p
AC187K	25p	MJE2955	120p	★2N3903	18p
AC188	18p	MJE3055	70p	★2N3904	16p
AC188K	25p	★MPS6534	25p	★2N3905	20p
AD149	49p	★MPSA06	30p	★2N39D6	16p
AD161	36p	★MPSA12	50p	★2N4058	15p
AD162	36p	★MPSA56	32p	★2N4059	10p
AF114	20p	★MPSU06	62p	★2N4060	13p
AF115	20p	★MPSU56	78p	★2N4123	22p
AF116	20p	OC28	75p	★2N4124	22p
AF117	20p	OC35	75p	★2N4125	22p
AF127	25p	OC36	75p	★2N4126	22p
AF139	43p	★OC71	20p	★2N4289	20p
AF239	48p	★TIP29A	40p	2N4347	130p
BC107/B	9p	★TIP29C	55p	2N4348	160p
BC108/B	9p	★TIP30A	48p	★2N4401	27p
BC109/B	10p	★TIP30C	60p	★2N4403	27p
BC109C	12p	TIP31A	52p	2N4427	90p
★BC117	22p	TIP31C	52p	★2N5089	27p
★BC147	9p	TIP32A	58p	2N5296	55p
★BC148	9p	TIP32C	82p	★2N5401	50p
★BC149C	10p	TIP33A	90p	2N6034	160p
★BC157	11p	TIP33C	115p	2N6107	55p
★BC158	10p	TIP34A	115p	2N6247	190p
★BC159	11p	TIP34C	160p	(Comp to 2N3055)	
★BC169C	12p	TIP35A	225p	2N6254	130p
★BC172	11p	TIP35C	290p	2N6292	65p
BC177	18p	TIP36A	270p	40360	40p
BC178	17p	TIP36C	340p	40361	45p
BC179	18p	TIP41A	65p	40362	45p
★BC182	10p	TIP41B	70p	40364	120p
★BC183	10p	TIP41C	78p	40409	65p
★BC184	11p	TIP42A	70p	40410	65p
BC187	30p	TIP42B	76p	40411	300p
★BC212	11p	TIP42C	82p	40594	88p
★BC213	10p	TIP2955	78p	40595	97p
★BC214	14p	★TIS93	30p		
BC478	30p	★ZTX108	10p		
BCY70	18p	★ZTX300	13p		
BCY71	22p	★ZTX500	15p	**FETs**	
BD124	90p	★ZTX502	18p	★BF244	25p
BD131	36p	2N457A	190p	★MPF102	40p
BD132	40p	2N697	22p	★MPF103	40p
★BD135	48p	2N698	36p	★MPF104	40p
★BD136	50p	2N706	20p	★MPF105	40p
★BD139	52p	2N708	20p	★2N3819	25p
★BD140	58p	2N918	40p	★2N3820	63p
BDY20	100p	2N930	18p	2N3823	57p
BDY56	160p	2N1131	18p	★2N5457	40p
BF115	22p	2N1132	18p	★2N5458	40p
BF167	23p	2N1304	45p	★2N5459	40p
BF170	23p	2N1305	45p		
BF173	25p	2N1306	45p		
BF177	26p	2N1307	45p		
BF178	28p	2N1308	40p		
BF179	33p	2N1309	40p	**MOSFETs**	
BF180	33p	2N1613	25p	3N128	85p
BF184	22p	2N1711	25p	3N140	85p
★BF194	10p	2N1893	30p	3N141	85p
★BF195	9p	2N2219	20p	3N187	180p
★BF196	14p	2N2222	20p	3N202	120p
★BF197	15p	2N2369	14p	40603	58p
BF200	32p	2N2484	30p	40673	58p
BF257	32p	2N2904/A	25p		
BF258	36p	2N2905/A	25p		
★BFR39	30p	2N2906/A	24p		
★BFR40	30p	★2N2926R	7p	**UJTs**	
★BFR79	30p	★2N2926B	7p	★TIS43	34p
★BFR80	30p	★2N29260	9p	2N2160	95p
★BFR88	30p	★2N2926Y	9p	2N2646	45p
BFX30	34p	★2N2926G	9p	★2N4871	34p
BFX84	30p	2N3053	18p		
BFX85	30p	2N3054	50p		
BFX86	30p	2N3055	50p		
BFX87	30p	2N3439	67p		
BFX88	30p	2N3442	140p		
BFY50	16p	★2N3702	12p	**PUJT**	
BFY51	15p	★2N3703	12p	★2N6027	48p

DIODES

★ **SIGNAL**

OA47	7p
OA70	9p
OA81	15p
OA85	15p
OA90	7p
OA91	7p
OA95	7p
OA200	8p
OA202	10p
IN914	4p
IN916	9p
IN4148	4p

RECTIFIER

★BY100	25p
★BY126	12p
★BY127	10p
IN4001	5p
IN4002	5p
IN4004	6p
IN4005	6p
IN4007	7p
IN5401	13p
IN5404	18p
IN5407	23p

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2.7V to 33V★

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★1W	18p

NOISE

★Z5J	110p

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★1A 50V	22p
★1A 100V	24p
★1A 200V	26p
★1A 400V	27p
★1A 600V	30p
★2A 50V	30p
★2A 100V	35p
★2A 200V	40p
★2A 400V	45p
★3A 200V	60p
★3A 600V	72p
6A 50V	75p
6A 100V	78p
6A 200V	84p
6A 400V	90p

TRIACS

Amp	Volts	
3	400	120p
6	400	150p
6	500	180p
10	400	185p
10	500	195p
15	400	210p
15	500	250p
40430		120p
40669		120p
DIAC		
BR100		30p

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18V	7818	140p	18V	7918	200p
24V	7824	140p	24V	7924	200p

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LM309H 100mA 5V TO5 75p

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			1A/700V	Stud	110p
			C106D		
1A 50V	TO5	40p	4A/400V	Plastic	63p
1A100V	TO5	42p	★MCR101		
1A400V	TO5	45p	0.5A/15V	TO-92	25p
1A600V	TO5	70p	2N3525		
3A100V	Stud	65p	5A/400V	TO-66	99p
3A400V	Stud	75p	2N4444		
7A100V	TO5+HS	84p	8A/600V	Plastic	185p
7A400V	TO5+HS	90p	★2N5060		
8A 50V	Plastic	130p	0.8A/30V	TO-92	34p
12A400V	Plastic	160p	★2N5062		
16A100V	Plastic	160p	0.8A/100V	TO-92	37p
16A400V	Plastic	180p	★2N5064		
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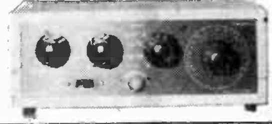

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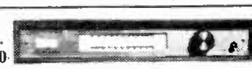

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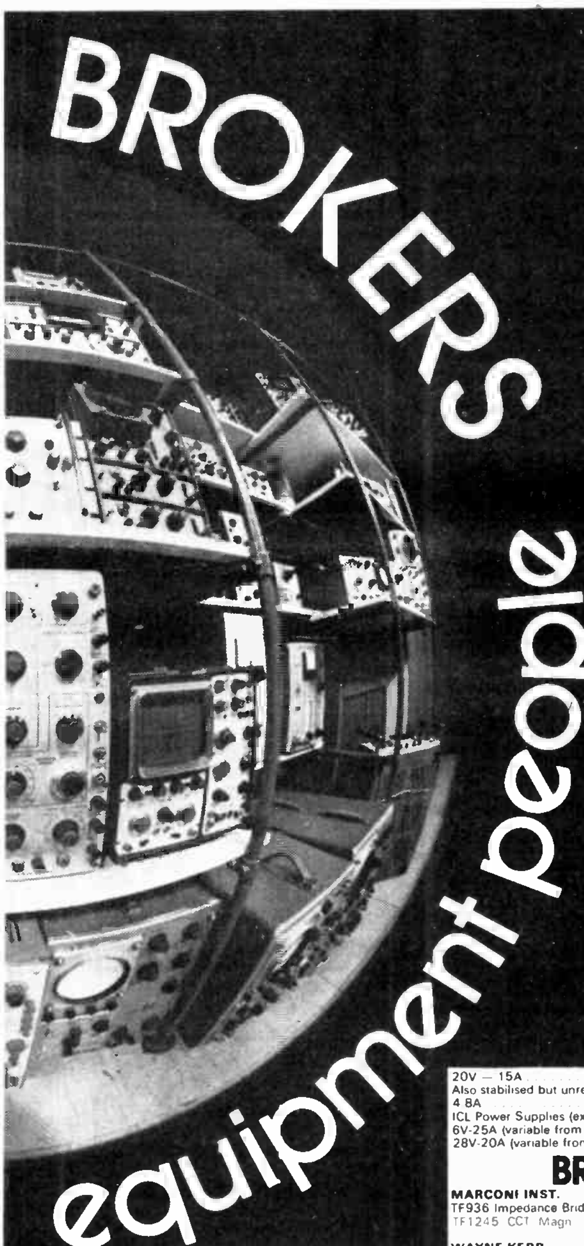

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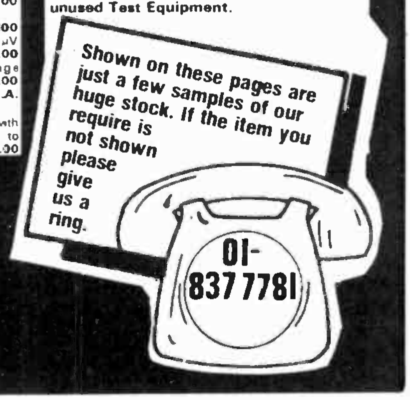

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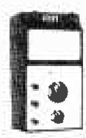

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110 r.p.m. **£2.25** P.P **75p**

MAGNETIC COUNTERS
6 digit 48v D.C. (Non-Reset) 92 x 32 x 22 m m.
New/Boxed **£1** ea P.P **15p**
NUMICATORS 0-9 (L.H/R.H. Decimal Point)
light conducted from individual 12v bulbs onto display. Character size 20 x 10 mm overall size 25 x 60 x 68 mm **£1.50** P P. **25p**

D.C. POWER SUPPLIES Input 240v A C.
TYPE 1 20v D.C. at 1 amp. Fully regulated 155 x 155 x 75 mm totally enclosed **£5** P.P. **75p**
TYPE 2 20v D.C at 500 m/a stabilised on open chassis 170 x 100 mm **£2.50** P.P. **75p**

PHILIPS MOBILE RADIO P.S.U.
Input 240V A.C Output 32V at 1 5 Amp D.C **£5.25** P.P **75p**

TELEPHONE HANDSET with "Press to Speak" switch **£1.50** P P. **25p**

PLEASE ADD 8% V.A.T.

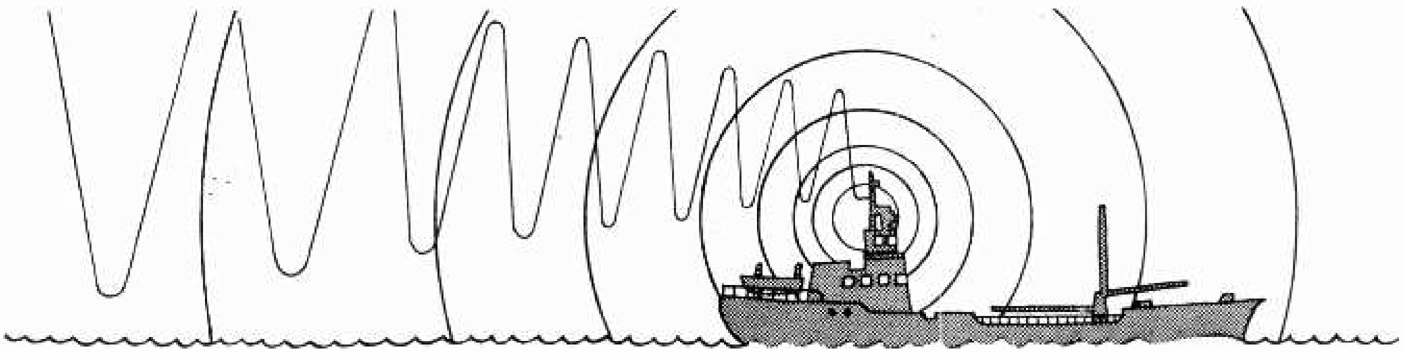
J. B. PATTRICK

191/193 LONDON ROAD
ROMFORD, ESSEX
RM7 9DJ
ROMFORD 44473

Appointments

Advertisements accepted up to 12 noon Tuesday, January 4, for the February issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £6.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1 per line, minimum three lines.
BOX NUMBERS: 45p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Owen Bailey on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



Radio Officers–now you can enjoy the comforts of home.

Working for the Post Office Maritime Services really makes sense. You still do the work that interests you, but with all the advantages of a shore-based job: more time to enjoy home life, job security and good money. To qualify, you need a United Kingdom Maritime Radiocommunication Operator's General Certificate or First Class Certificate of competence in Radiotelegraphy, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting salaries, at 25 or over, are £2905 rising to £3704 after three years service. Between 19 and 24, the starting salary varies from £2234 to £2627 according to age. In addition, a supplement of £312 p.a. is payable. You'll also receive an allowance for shift duties which at the maximum of the scale averages £900 a year and there are opportunities to earn overtime. There's a good pension scheme, sick pay benefits and prospects of promotion to senior management.

Right now we have a few vacancies at some of our coastal radio stations, so if you're 19 or over, preferably with sea-going experience, write to:
ETE Maritime Radio Services Division (L690),
ET 17.1.1.2., Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

ROYAL COLLEGE OF MUSIC

Audio Electronic Technician

Full-time non-residential vacancy late January

Interest in and knowledge of music essential.

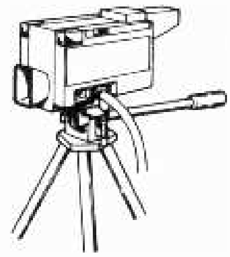
Responsibilities: general maintenance and repairs in Electronic Music and Recording Studios plus other equipment, storekeeping, ordering supplies, assisting P.A. and recordings, some work with students.

Salary range £3,500 to £4,000.

Apply in writing by 17th January latest to Bursar, Royal College of Music, Prince Consort Road, London, SW7, giving relevant experience.

(6722)

LINK
TELEVISION



Increasing orders for our sophisticated equipment, from both the home and export markets, give us the opportunity to recruit additional electronic engineers. Our products cover a complete range of monochrome and colour cameras as well as a whole variety of studio broadcast equipment.

TEST ENGINEERS

Experience of working with broadcast TV equipment is more important than the academic level of degree/HNC In any case, you must have had some years working with modern communications equipment and experience solely of domestic television is not sufficient. Knowledge of the latest circuit techniques is essential as you will be expected to have the ability to rapidly come to terms with our designs

DEVELOPMENT ENGINEERS

You would be working with our R & D team on design and development of anything from amplifiers and coders to broadcast colour cameras Some knowledge of television would be a great advantage as experience could have been gained in your present job or at university.
We have a modern factory in a very pleasant part of Hampshire, within easy reach of several major towns, London, the South Coast and the Midlands are all easily accessible. Our terms of employment are excellent and include free life and health insurance, pension scheme, generous holidays, staff restaurant and relocation expenses where necessary.

Please write or phone (reverse charge) Mic Comber, Personnel Manager, Andover (0264) 61345. Brief details only at this stage as we will ask you to complete an application form on which you can give as much details as you think relevant.

LINK ELECTRONICS

Walworth Industrial Estate,
Andover, Hampshire, England Telephone: Andover (0264) 61345

(6737)

Re advertisement for Link Electronics in December issue, Wireless World would like to apologise for the ommission of the Company's name from this advertisement.

Service Engineers

F W O Bauch Limited is a principle supplier of professional recording and broadcast equipment and has recently become sole UK agents for a range of quality Hi-Fi equipment.

Arising from this broadening of the product range, we are currently seeking experienced engineers to work in our service department on the entire product range.

If you have a good knowledge of tape recorders and audio equipment and would like to work in our modern laboratory, write in confidence to:

The Managing Director
F W O Bauch Limited
49 Theobald Street, Boreham Wood
Herts WD6 4RZ

R. & D. ENGINEERS

Required to work on cable television systems for the domestic and surveillance market. Engineers should hold a degree, or equivalent qualifications, and have some knowledge of either linear H.F., video, or modulator / demodulator circuit design.

One of the posts will be at a senior level and in this case relevant experience is expected.

Salaries will be commensurate with qualifications, age. and experience.

Fringe benefits include a contributory pension / life assurance scheme, subsidised canteen and outdoor facilities for mini-golf, tennis and free car parking.

If you are seeking a responsible position in R. & D. write, giving full details of your career to date, or telephone:

Dr. G. O Towler, B.Sc., Ph.D. (Manager)
Research & Development Establishment
British Relay (TV) Ltd.
Cleeve Road
Leatherhead, Surrey
Tel. Leatherhead 76056

BRITISH RELAY

(6755)

Revitalised economy — superb location!

Together with most other countries, Zambia has recently been affected by the worldwide economic recession. Now our economy is surging forward strongly again, revitalised partly by significant advances in the country's agricultural industry and rising copper prices on world markets. Come here on a 3-year contract and your skills will be welcomed – and broadened. You'll enjoy the warm, pleasant climate in this totally land-locked country, larger than France, Belgium, the Netherlands and Switzerland combined. You'll enjoy the scenery too; although mainly a broad plateau, Zambia also features spectacular mountains, a certain amount of dense forest, imposing rivers, vast lakes and extensive game reserves. Its many large cities and towns contain all the normal modern facilities and are linked by excellent roads and rail services.

Post & Telecommunications Corporation

Chief Engineers

K6756-K7200 (c.£5067-£5400).
Supplement £4902 (married), £2784 (single)

Requirements:

Electrical or Telecommunications Degree plus senior management experience.

Responsibilities:

Either: planning switching and external plant networks; or planning budgets and methods including long-term income/expenditure forecasts, staffing and training requirements and long/medium/short-term national planning; some training is involved and you will report to the Assistant Director, Planning.

Principal Engineers

K6324-K6756 (c.£4755-£5067).
Supplement £4704 (married), £2586 (single)

Requirements:

Electrical, Electronic or Telecommunications Engineering degree; senior management experience.

Responsibilities:

Either: (a) controlling switching planning groups, including major projects management, requiring crossbar/electronic switching systems experience; or (b) controlling, advising on planning, budgets methods, staff; co-ordinating long/medium/short-term plans and preparing capital estimates; some staff training. You will report to the Chief Engineer.

Senior Engineer

K5700-K6108 (c.£4275-£5281).
Supplement £4524 (married), £2406 (single)

Requirements:

C & G Final or equivalent; initiative and responsible managerial experience of at least 3 years.

Responsibilities:

(a) For external plant – preparing development scheme and contract specifications; familiarity with latest overhead and underground system methods is essential.
(b) For switching – implementing plans, preparing for and evaluating tenders; crossbar systems experience is essential.
(c) For planning, budgets, methods – preparing plans and engineering instructions, studying/reporting on new techniques, recommending new methods in radio/transmission, switching and external plant.
(d) Planning, budgets and methods – preparing/maintaining an annual works programme, preparing time/resource diagrams, monitoring project progress.

Engineers

K5316-K5700 (c.£3987-£4275).
Supplement £4296 (married), £2232 (single)

Requirements:

C & G Final or equivalent plus initiative.

Responsibilities:

Either for: (a) telegraph and subscribers' apparatus including specifications/tender evaluation/type approval;
(b) power and accommodation – liaising with field staff/contractors in such areas as power plant maintenance;
(c) Liaison with engineering, sales, traffic sections, special investigations, co-ordination of such staff as aerial riggers and diesel mechanics. In all cases staff training is probably involved.

Technician I posts

K4416-K5136 (c.£3312-£3852).
Supplement £4134 (married), £2070 (single)

Requirements:

C & G Intermediate or equivalent plus appropriate experience.

Responsibilities:

Either: (a) External (underground/overhead) plant; (b) switching; (c) radio and transmission; (d) power and air-conditioning; (e) stores liaison; (f) power/accommodation maintenance; (g) diesel maintenance; (h) shift leader – earth station (non-automatic satellite ground station and its links); (i) day-to-day maintenance of a small rural area; (j) switching construction supervision; (k) transmission construction supervision. In all cases staff training may be necessary.

Technician II posts

K3756-K4416 (c.£2817-£3312).
Supplement £3846 (married), £1830 (single)

Requirements:

C & G Intermediate or equivalent plus appropriate experience.

Responsibilities:

Either: (a) external plant – including line surveys, and estimate preparation; (b) external works supervision – cable/duct installation by contractors, underground/overhead work by Government staff. In both cases staff training will be included in duties

Technician III posts

K2388-K4410 (£1791-£3308).
Supplement £3804 (married), £1788 (single)

Requirements:

C & G Intermediate, initiative, 4 years' experience after training.

Responsibilities:

Either: (a) Microwave maintenance; (b) strowger maintenance; (c) Pentaconta maintenance (BXB 1121); (d) LM Ericsson maintenance (ARK, ARF, and/or ARM); (e) Multiplex maintenance; (f) PABX maintenance.

Strong financial attractions

As well as the salary quoted, you will enjoy TAX-FREE supplements, a TAX-FREE terminal gratuity, low-cost accommodation, low taxation and free passages. Together, these add up to exceptional real earnings. Starting salaries relate to qualifications/experience, while gratuities total 25% of basic salary. Salary-related supplements are reviewed annually and paid by the British Government to designated British nationals (annual maximum is shown), while appointment grants, education allowances, car loans, medical aid assistance and free holiday visits for children educated in Britain are also provided for those receiving supplements. N.B. Sterling equivalents given are approximations only due to constant exchange rate fluctuations.

For further information please send full personal/professional details (without obligation and in total confidence), indicating which position interests you, to: Recruiting Officer (Room 33), Zambia High Commission, 7-11 Cavendish Place, London W1.

(6538)

ZAMBIA

ELECTRONIC MAINTENANCE

MEDICAL PHYSICS TECHNICIAN II
SALARY £4,182 - £5,205

To implement a maintenance, calibration and repair service for electronic equipment at St. George's Hospital, SW17. The work will involve a wide range of electronic equipment both from Clinical Departments and from Works Services.

The person appointed will have at least 5 years' experience in electronics, either in industry or in the N.H.S. or similar fields. Knowledge of maintenance systems would be an advantage.

Minimum qualifications are ONC in electrical engineering or equivalent, but HNC would normally be expected. The post combines responsibility in the Physics and Engineering Departments and provides a challenging opportunity for the right calibre of person to build up a vital service to the hospital.

For further information please contact Mr. D. Ritchie on 01-672 1255 ext. 58.

For a job description and application form please write to or telephone Miss M. R. Felsenstein, Personnel Officer (Recruitment), Wandsworth and E. Merton Teaching District, 72 St. James' Drive, LONDON, SW17 7RS. Telephone 01-672 1222, ext. 41.

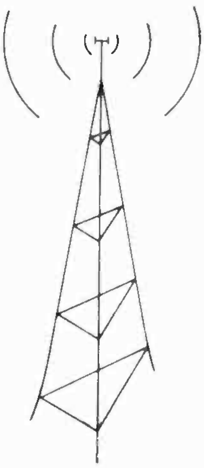
Closing date: 14th January, 1977.

Wandsworth & E. Merton Teaching District

Merton, Sutton and Wandsworth A.H.A. (Teaching)

Are You Interested In

Radio or Television



and do you have practical experience in either of these fields

if you have City and Guilds Intermediate Certificate in Electronics or Telecommunications; ONC; or an equivalent qualification

then the Metropolitan Police may have a job for you as a Radio Technician.

we offer
Good pay
Excellent prospects
Secure employment
4 weeks holiday
Day release

Phone our Engineer Mr. H. G. Fielding on 01-653 0881, during office hours, to arrange an informal interview, or write to Metropolitan Police, Room 1634, New Scotland Yard, Broadway, London SW1H 0BG.

(6741)

UNITED NATIONS FIELD SERVICE

Openings for RADIO OPERATORS to service United Nations missions on rotating basis in any part of the world.

Requirements: Must hold 1st or 2nd class Radio Operator's licence from Telecommunications Authority. Minimum International Morsecode speed 30 wpm on semi-automatic key (Vibroplex), teletype minimum 50 wpm — must be able operate and maintain telegraph and voice radio transmitters, receivers, and ancillary equipment such as trailer power units, TTY, TD, etc. and be familiar with erection of mobile radio stations' antennae and emergency repairs.

All candidates must have a valid driver's licence. Appointments are for 1 year, with possibility of renewal, and are subject to medical examination. Starting salary US \$9,240 gpa (net after Staff Assessment \$7,430), plus monthly allowance varying from US \$137 to US \$507 depending on duty station, payable in local currency. Good additional benefits.

Candidates may apply in writing to:

Mr. Soleiman Tarbah, Office of Personnel

UNITED NATIONS

New York, N.Y. 10017

(6733)

Electronics Maintenance Engineer

To an Electronics Engineer with an HND/HNC or equivalent technical knowledge and some experience in either design or maintenance of electronic equipment we offer the opportunity to join our maintenance team responsible for laser systems and automatic test equipment. Consequently experience with digital systems or precision measuring instruments would be advantageous.

While we are an electronic component manufacturing company which has been established at this seaside resort for over 30 years, our recent merger into ITT Components Europe has necessitated a re-invigoration of our automatic testing and machine control activities in order to build for the growth of our exports of multi-layer capacitors, microcircuits and resistors. We will help to re-locate you if necessary.

ERIE ELECTRONICS LIMITED

Interested? Write in confidence for an application form to R. Walpole, Personnel Manager, Erie Electronics Ltd., South Denes, Gt. Yarmouth NR30 3PX, or telephone Gt. Yarmouth 730688 after 8 p.m. for an informal exploratory discussion.

(6736)

A British Company of ITT

APPOINTMENTS CONT.

Radiomobile

Britain's Car Radio Specialists

Production Engineering Opportunities

The following vacancies have arisen within our Production Engineering Department.

Production Engineer

(Electronics)

Working in the electronic engineering section, and reporting to the Senior Electronic Engineer you should have experience of audio and radio or engineering, and be qualified to HNC Level. You will most probably be in your mid-twenties, and keen to be involved in the entire range of the Company's products.

Electronic Engineer

(A.T.E.)

The Company is investing heavily in automatic testing equipment, and consequently requires an energetic engineer to assist in its introduction on the full range of the Company's products.

You will be required to work with a minimum of supervision, and should be in your late twenties with some general electronic experience within a manufacturing environment. Qualifications should be ONC/HNC level.

Starting salaries will be negotiated. Fringe benefits are those associated with a large and progressive organisation.

These posts are open to applicants of either sex.

Telephone or write for Application form and Job Specification to:

Miss I. S. Thom
Personnel Manager
Radiomobile Limited
Goodwood Works
North Circular Road
London, NW2
Tel. 01-452 3333 ext. 4518

a subsidiary of SMITHS INDUSTRIES LIMITED (6710)

FOREIGN AND COMMONWEALTH OFFICE
COMMUNICATIONS DIVISION

has a continuing commitment for

BROADCAST RELAY ENGINEERS

To serve a one year (unaccompanied) tour of duty on the island of Masirah (off the coast of Oman).
Applications are invited from engineers with experience of the operation and maintenance of high-powered radio transmitters, and who hold a third year City and Guilds Certificate in Telecommunications or its equivalent.
SALARY: £8,575 per annum, plus a tax-free allowance of £810 per annum for a single officer, or £1,295 per annum for a married unaccompanied officer.
Free furnished accommodation and passages are available.

For an application form and further details please write to:

Recruitment Section
Foreign and Commonwealth Office
Hanslope Park, Hanslope
Milton Keynes, MK19 7BH

(6712)

ARTICLES FOR SALE

MTV
Best choice for used TV
Worldwide exporters of colour and mono TV. Unlimited supplies.

Midland TV Trade & Retail Services.
Worcester Road, Kidderminster, England
Tel: Kidderminster 61907 or 67390

Quartz Crystal Units
ACCURATE
RELIABLE

Private enquiries, send 13p in stamps for brochure

THE QUARTZ CRYSTAL CO. LTD.
Q.C.C. WORKS, WELLINGTON CRESCENT, NEW MALDEN, SURREY 01-942 0334 & 2988

VACUUM is our speciality, new and secondhand rotary pumps, diffusion outfits, accessories, coaters, etc. Silicone rubber or varnish outgassing equipment from £40. V. N. Barrett (Sales) Ltd., 1 Mayo Road, Croydon. 01-684 9917. (24

60KHz MSF Rugby Receiver. BCD TIME OF DAY OUTPUT. High performance, phase locked loop radio receiver. 5V operation with 1 second LED indication. Kit complete with tuned ferrite rod aerial £14.08 (including postage and VAT). Assembled circuit and cased-up version also available. Send for details Toolex, Sherborne (4359), Dorset. (21)

RECHARGEABLE NICAD BATTERIES. 'AA' (HP7) £1.05, 'Sub C' £1.29 (HP11) £2.02, 'D' (HP2) £2.92, PP 'C' £4.89. Matching chargers respectively £4.48, £4.48, £5.24, £5.24, £3.98, all prices include VAT. Add 10% post & package. SAE for full list, plus if wanted 35p, for 'Nickel Cadmium Power' booklet. Sandwell Plant Ltd., 1 Denholm Road, Sutton Coldfield, West Midlands, B73 6PP. Tel. No. 021-354 9764. (6554)

ARTICLES FOR SALE

DOKORDER

4 CHANNEL TAPE DECKS for Mini Studio use

DOKORDER 8140
Ideal machine for mini domestic studio use. Allows possibility for multi-tracking with built-in sync facility. High specification at low price. Superb for making demo tapes.

DOKORDER 7140
Basically similar to 8140 but slightly less luxurious version.

DOKORDER 1140
Top quality high speed multi-sync, 4-channel recorder.

DOKORDER 1120
Two channel ¼-track deck offering facilities and performance normally found in much higher priced decks.

DOKORDER 7100
Budget priced stereo deck, ideal for the domestic user.

REW 146 Charing Cross Road, London WC2. Tel: 01-240 3064/5

TRADE ENQUIRIES: D.E.S. Technical Co., 10-12 High St., Colliers Wood, London SW19. Tel: 01-540 8944.

(6705)

Classified

APPOINTMENTS

JKN

DESIGN & ELECTRONIC ENGINEERS
R & D ENGINEERS
JUNIOR ELECTRONIC ENGINEERS
TECHNICIANS
INSTRUMENT & CONTROL ENGINEERS
P C B, E/M, DRAUGHTING
CUSTOMER SERVICE & TEST ENGS.
SALES ENGINEERS

Middx., Surrey, Herts., Hants., Berks., Bucks., Essex, London & U.K.

JKN Eng'Recruitment Ltd
Sunbury on Thames
Tel 09 327 88985

CA CAPITAL APPOINTMENTS LTD.

FIELD SERVICE ENGINEERS (ELECTRONICS)

If you're not earning over **£3,500 p.a. plus a car — then you had better contact us!** (6711)

34 Percy Street, London, W.1
01-636 9659 (day) or
550 0836 (evening)

ELECTRONICS TECHNICIAN (Grade 5) required for geology department. Duties include fault finding and maintenance of a wide range of electronic equipment, also construction and testing of circuits mainly solid state, from instructions. Experience of digital and linear circuitry essential. Vacuum and X-ray control systems knowledge an advantage. Preferred qualifications: ONC C&G electronic engineering, and not less than 7 years' experience including training. Salary range £3,377 to £3,856 gross according to qualifications and experience. Application forms from Departmental Superintendent, Geology Department, Imperial College, London SW7 2BP.

SOUTH COAST VACANCIES. If you would like to get out of the rat race and enjoy the pleasures of living on the South Coast we can certainly help. We have hundreds of jobs in Electronics at all levels, along the South Coast. Just drop us a line or phone with your name and address and we'll do the rest. No fees. Jeff Minards, CBS Appointments, 224 Old Christchurch Rd. Bournemouth. Tel. 292155 or after 7 pm and weekends, Wimbourne 4891. (6753)

BUSINESS OPPORTUNITIES

EXPORTER REQUIRES CONTRACTOR able to produce 50/100 belt drive turntables weekly. Pick-up arms supplier also required. — Box No W/W (6541).

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Our Professional Teams..

...of Engineers are developing the next generation of Telecommunications Measuring Instruments and Automatic Test Equipment. We are now strengthening our project teams and need more men, or women, with relevant qualifications and experience, to help us with:–

Microprocessor Applications
RF Circuit Development
Hybrid Circuit Engineering
Test Procedures
Market Development
Real-time Programming

For details of relocation and salaries call John Prodger
MARCONI INSTRUMENTS LIMITED
Longacres, Hatfield Road, St. Albans, Herts.
Tel: St. Albans 59292

A GEC MARCONI ELECTRONICS COMPANY (6747)

ARTICLES FOR SALE

ENAMELLED COPPER WIRE

swg	1lb reel	½lb reel
10 to 19	£2.95	£1.60
20 to 29	£3.15	£1.80
30 to 34	£3.45	£1.90
35 to 40	£3.65	£2.10

All the above prices are inclusive of postage and packing in UK

COPPER SUPPLIES
102 Parrswood Road, Withington, Manchester 20
Telephone 061-445 8753 (100)

SPOTWELDERS new from £85. Sameside from £220. — Ring 01-540 7337/8. Rentweld's, 14 Clarendon Road, London S.W.19. (6518)

MODERN LANGUAGE teaching equipment — little used, at one tenth of today's cost this offer cannot be repeated. Ring Mr Wright, 061-764 2931. (6515)

CMOS WITH DISCOUNTS! Any mix: 10% for 25+, 25% for 100+, 33⅓% for 1000+

4000	0.20	4028	1.00	4053	1.04	4086	0.80	14163	1.18	14526	2.15	14566	1.67
4001	0.20	4029	1.27	4054	1.29	4089	1.74	14174	1.08	14527	1.76	14568	3.15
4002	0.20	4030	0.60	4055	1.46	4093	0.89	14175	1.04	14528	1.22	14569	3.72
4006	1.31	4031	2.46	4056	1.46	4094	2.08	14194	1.17	14529	1.72	14572	0.27
4007	0.20	4032	1.19	4057	29.81	4095	1.16	14419	2.67	14530	0.95	14580	8.35
4008	1.07	4033	1.55	4059	6.20	4096	1.16	14490	6.51	14531	1.74	14581	4.30
4009	0.60	4034	2.11	4060	1.24	4097	4.13	14501	0.20	14532	1.39	14582	1.64
4010	0.60	4035	1.31	4061	25.60	4098	1.22	14502	1.38	14534	8.15	14583	0.84
4011	0.20	4036	3.09	4062	10.10	4099	2.03	14503	0.75	14536	4.00	14585	1.10
4012	0.20	4037	1.06	4063	1.22	40101	1.76	14505	4.38	14537	13.17	74C00	0.25
4013	0.60	4038	1.20	4066	0.69	40102	2.16	14506	0.57	14539	1.24	74C02	0.25
4014	1.12	4039	3.09	4067	4.13	40103	2.16	14507	0.60	14541	1.62	74C04	0.25
4015	1.12	4040	1.19	4068	0.24	40104	2.26	14508	3.08	14543	1.82	74C08	0.25
4016	0.60	4041	0.93	4069	0.24	40107	0.66	14510	1.51	14549	4.10	74C10	0.25
4017	1.12	4042	0.93	4070	0.65	40108	6.18	14511	1.74	14552	10.50	74C20	0.25
4018	1.12	4043	1.12	4071	0.24	40109	2.21	14512	1.03	14553	4.66	74C30	0.25
4019	0.60	4044	1.04	4072	0.24	40181	4.30	14514	3.47	14554	1.67	74C32	0.25
4020	1.24	4045	1.56	4073	0.24	40182	1.73	14515	3.47	14555	1.01	74C42	1.84
4021	1.12	4046	1.48	4075	0.24	40194	2.26	14516	1.51	14556	1.01	74C48	2.26
4022	1.07	4047	1.01	4076	1.71	40257	2.26	14517	4.02	14557	4.65	74C73	0.87
4023	0.20	4048	0.60	4077	0.65	4700	1.75	14518	1.39	14558	1.25	74C74	0.80
4024	0.87	4049	0.60	4078	0.24	7083	4.25	14519	0.57	14559	4.10	74C90	0.86
4025	0.20	4050	0.60	4081	0.24	14160	1.18	14520	1.39	14560	2.17	74C93	0.86
4026	1.92	4051	1.04	4082	0.24	14161	1.18	14521	2.77	14561	0.70	74C95	1.25
4027	0.60	4052	1.04	4085	0.80	14162	1.18	14522	2.15	14562	5.59	74C926	7,89

TERMS: Add VAT to all prices at 8%. Postage etc. UK 25p (+2p=27p) per order, export £2.00 (no VAT). Orders processed same day.

GREENBANK ELECTRONICS (Dept W11W)
94 New Chester Road, New Ferry, Wirral, Merseyside L62 5AG, England. Tel: 051-645 3391

SALE

Amps, Mics, X-overs, Power Supplies, Inverters, Loudspeakers, Cartridges, etc.

Send SAE for details:
MARTIN AUDIO LTD.
54-56 Stanhope Street
London NW1 3EX
01-388 7164 (6742)

C.R.T. REGUNNING PLANT. New and secondhand reconditioned training; demonstration colour or B/W. Barretts, Mayo Road, Croydon Surrey CRO 2QP. 01-684 9917.

16mm BELL HOWELL 631 750/100 W lamp, separate speaker and transformer. £150 + VAT. Hilton's 9 West Hill, Dartford, Kent. Tel: 20009. (WW15)

APPOINTMENTS

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APPOINTMENTS

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Appointments Vacant Advertisements appear on pages 122-134

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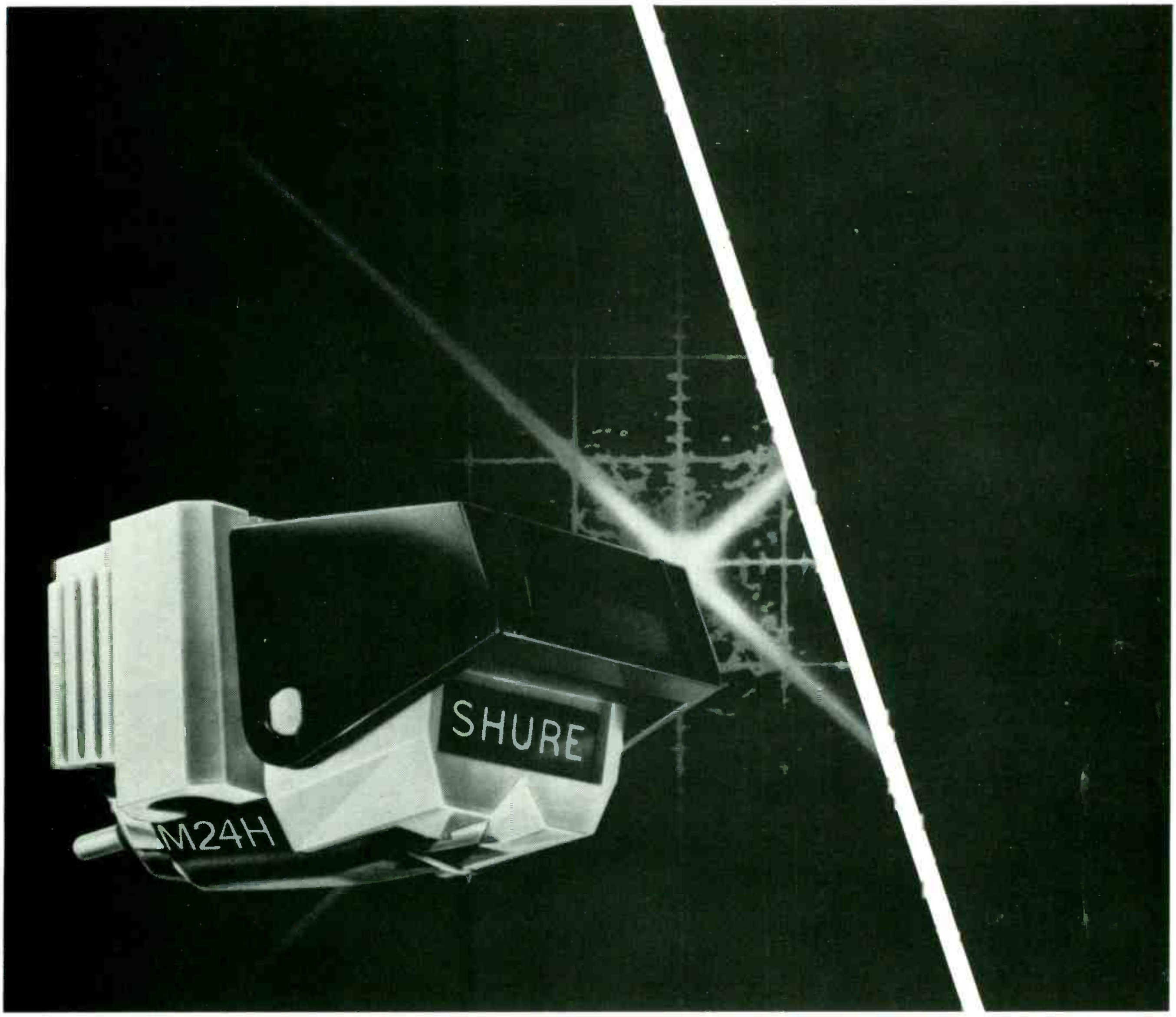

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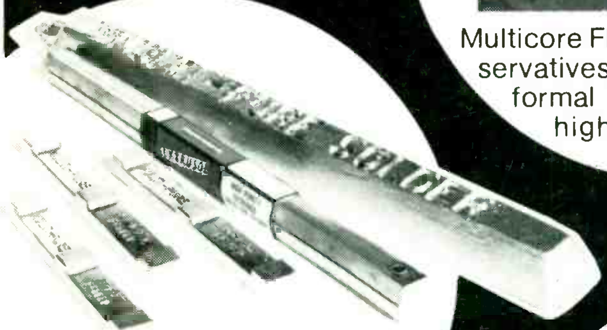

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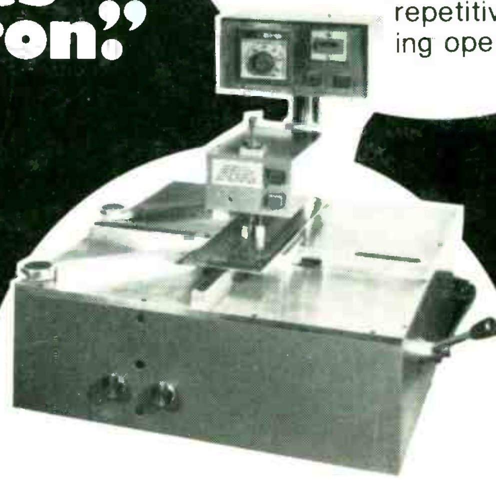

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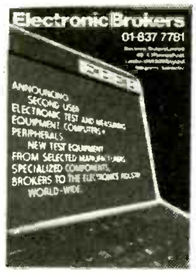

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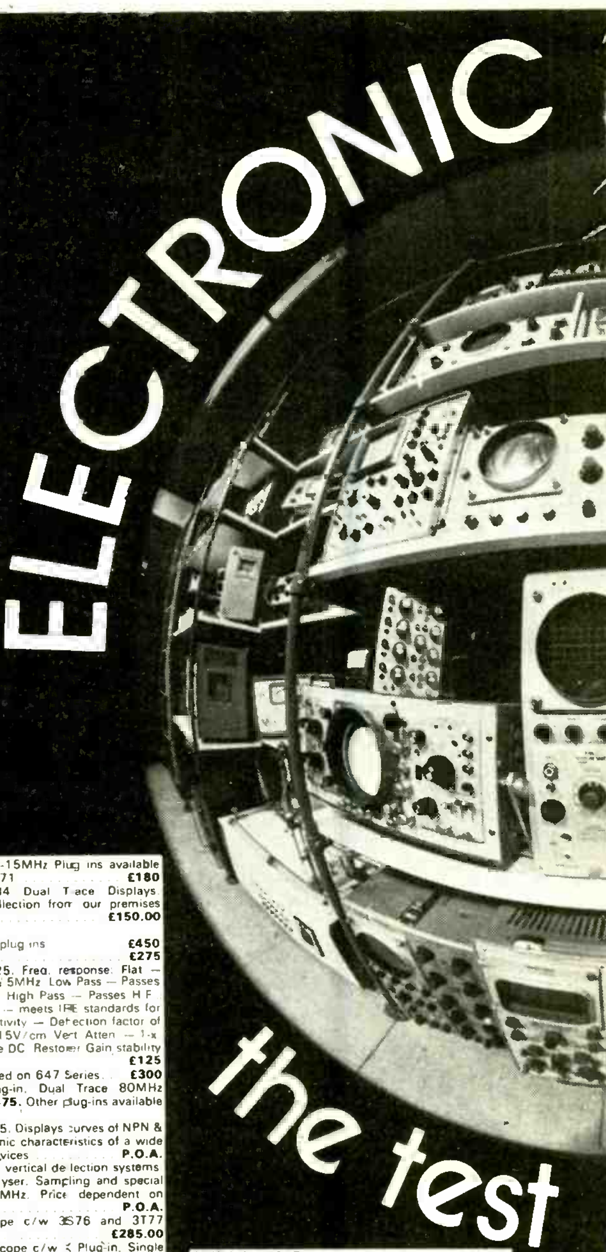

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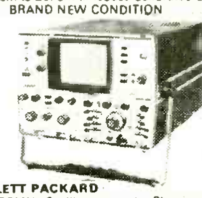

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