wireless world

SEPTEMBER 1977 40p

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Band II ferrite aerial

Aerials in the Orkneys

A Synthesized Signal Generator from mi

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Somehow some of our customers have been persuaded that our prices are as big as we are. Sometimes the biggest brains are the most cost-conscious brains. For example, our illustration shows a synthesized signal generator which costs £1,800*: the new 520MHz TF2015/1 Signal Generator with its associated Synchronizer. With this combination, synthesizer operation is obtainable without any degradation of generator signal purity, performance and versatility.

Leakage specification is lower than any other available VHF/UHF source and output accuracy at low levels beats all others in the price range.

Building on the enviable reputation of the TF2015 for performance, reliability and value, we have now introduced two new a.m./f.m. versions: the TF2015/1 for narrow band mobile radio testing and TF2015/2 for telemetry and other wideband applications. The U.K. price for TF2015/2 with Synchronizer is £1,950*. All have a frequency coverage of 10 to 520MHz with calibrated a.m. and f.m.

Tuning in 100Hz steps whilst under locked conditions provides a valuable facility for bandwidth measurements and channel stepping. Digital setting of frequency with direct readout means no waiting for counter gate times when you want high resolution, and no r.f. leakage from display holes.

*Special U.K. price

One in four

Only one in four of our customers tells us he needs the stability of a synthesizer. So the other three can save almost half the cost of the synthesizer combination by buying the analogue part alone. So, whether you require a synthesizer or a signal generator you can now obtain quality at ordinary prices.

Optional accessories include Pulse Modulator TF2169, i.f. probes for 'squelch killing', multiple calibration plates for units of output level, matching pads, attenuators, reverse power protection and carrying case.

Write or 'phone for full details:

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Electronics, Television, Radio, Audio

SEPTEMBER 1977 Vol 83 No 1501

Contents

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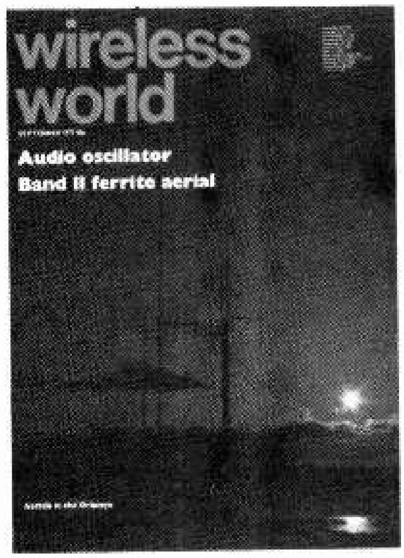

Front cover shows aerials of the National Air Traffic Services at Wideford Hill, Orkney Islands. *Photograph by K. M. Jones*

IN OUR NEXT ISSUE

High-quality loudspeaker. An article on the design and construction of a small, closed-box speaker, using the KEF B200 and KEF T15 drive units.

Microwave voice link. A low-power communication link, using a similar type of microwave diode and amplifier to those in the intruder alarm previously described. Full constructional details are given.

Phase distortion — can it be heard in audio systems? Some experiments involving live performances throw fresh light on this controversial subject.

ISSN 0043-6062

LOW COST VOLTMETERS

from the range of

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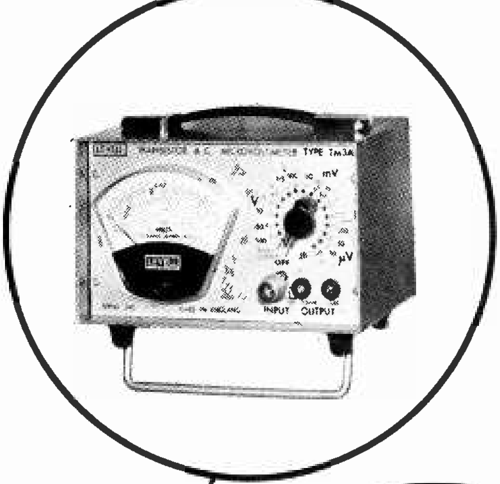

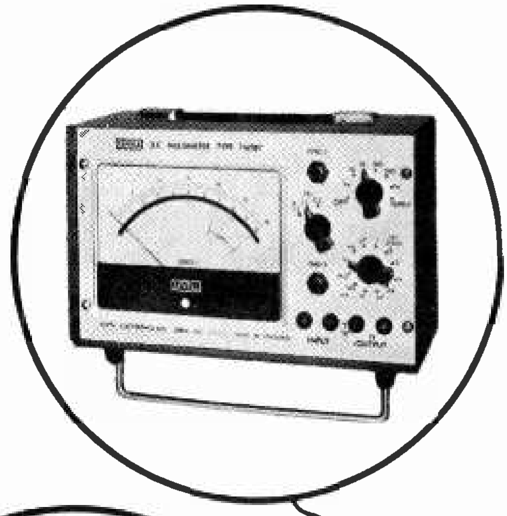

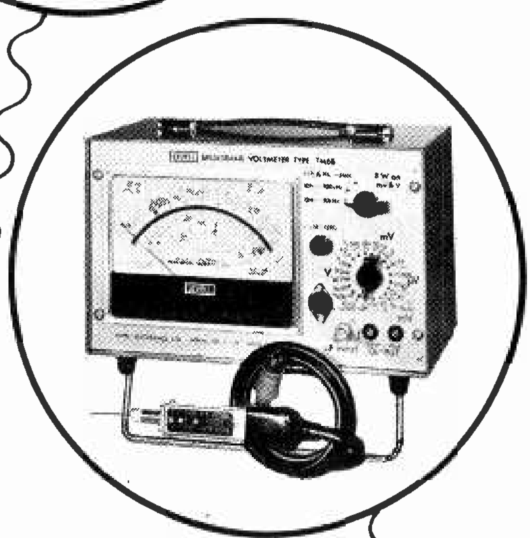

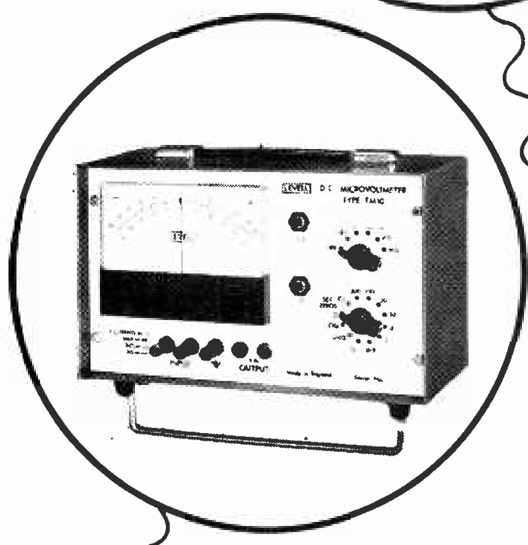

A.C. MICROVOLTMETERS

VOLTAGE & dB RANGES: 15µV, 50µV, 150µV . . . 500V
Acc. ± 1% ± 1% f.s.d. ± 1µV at 1kHz — 100, — 90 + 50dB
Scale — 20dB/ + 6dB rel. to 1mW/600Ω
RESPONSE: ± 3dB from 1 Hz to 3MHz, ± 0.3dB from 4Hz to 1MHz above 500µV. Type TM3B can be set to a restricted B.W. of 10Hz to 10kHz or 100 kHz
INPUT IMPEDANCE: Above 50mV >4 3MΩ< 20pf. On 50µV to 50mV > 5MΩ < 50pf.
AMPLIFIER OUTPUT: 150mV at f.s.d

type TM3A **£85** type TM3B **£95**

D.C. MULTIMETERS

VOLTAGE RANGES: 3µV, 10µV, 30µV . . . 1kV.
Acc. ± 1% ± 1% f.s.d. ± 0.1µV. LZ & CZ scales.
CURRENT RANGES: 3pA, 10pA, 30pA . . . 1mA (1A for TM9BP)
Acc. ± 2% ± 1% f.s.d. ± 0.3pA. LZ & CZ scales.
RESISTANCE RANGES: 3Ω, 10Ω, 30Ω . . . 1 GΩ linear Acc ± 1% ± 1% f.s.d. up to 100MΩ.
RECORDER OUTPUT: 1V at f.s.d. into > 1kΩ on LZ ranges.

type TM9A **£125** type TM9BP **£135**

BROADBAND VOLTMETERS

H.F. VOLTAGE & dB RANGES: 1mV, 3mV, 10mV . . 3V.
Acc. ± 4% ± 1% f.s.d at 30MHz — 50dB, — 40dB, — 30dB to + 20dB. Scale — 10dB/ + 3dB rel. to 1mW/50 Ω ± 0.7dB from 1MHz to 50MHz, ± 3dB from 300kHz to 400MHz.
L.F. RANGES: As TM3 except for the omission of 15µV and 150µV
AMPLIFIER OUTPUT: Square wave at 20Hz on H.F. with amplitude proportional to square of input. As TM3 on L.F.

type TM6A **£135** type TM6B **£145**

D.C. MICROVOLTMETERS

VOLTAGE RANGES: 30µV, 100µV, 300µV . . . 300V.
Acc. ± 1%, ± 2% f.s.d., ± 1µV. CZ scale.
CURRENT RANGES: 30pA, 100pA, 300pA . . . 300mA.
Acc. ± 2%, ± 2% f.s.d., ± 2pA. CZ scale.
LOGARITHMIC RANGE:
± 5µV at ± 10% f.s.d., ± 5mV at ± 50% f.s.d., ± 500mV at f.s.d.
RECORDER OUTPUT: ± 1V at f.s.d. into > 1kΩ.

type TM10 **£77**

These highly accurate instruments incorporate many useful features, including long battery life. All A type models have 83mm scale meters, and case sizes 185x110x130mm. B types have 127mm mirror scale meters and case sizes 260x125x180mm.

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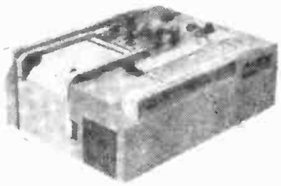
WW—027 FOR FURTHER DETAILS

FAST RESPONSE STRIP CHART RECORDERS

Made in USSR

Series H3020

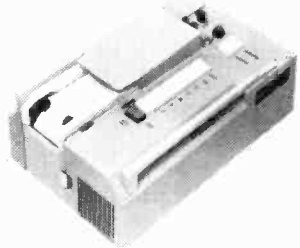


Basic error 2.5%
Sensitivity 8mA F.S.D.
Response 0.2 sec
Width of each channel
Single and three-pen recorders: 80mm
Five-pen recorders: 50mm

Chart speeds, selected by push buttons 0.1-0.2-0.5-1.0-2.5-5.0-12.5-25 mm/sec.
Chart drive 200-250V 50Hz
Recording: Syphon pen directly attached to moving coil frames. Curvilinear co-ordinates.
Equipment: Marker pen, timer pen, paper footage indicator, 10 rolls of paper, connectors, etc.

H3020-1 (Single pen): 285mm wide x 384mm deep x 165mm high .... **PRICE £108.00**
H3020-3 (Three pen): 475mm wide x 384mm deep x 165mm high .... **PRICE £160.00**
H3020-5 (Five pen): 475mm wide x 384mm deep x 185mm high .... **PRICE £295.00**

Series H327



Polarized moving iron movements with syphon pens directly attached. Built-in solid state amplifier (one per channel) provides 8 calibrated sensitivity steps. Two marker pens are provided.
Basic error 4%. Frequency response from DC to 100Hz 2dB.

Sensitivity 0.02 - 0.05 - 0.1 - 0.2 - 0.5 - 1 - 2 - 5 volts/cm
Width of each recording channel: 40mm
Chart drive: 220-250V 50Hz
Chart speeds: 1-2-5-10-50-125-250mm/sec.

Type H3271-1. Single pen: Dimensions 259 x 384 x 165mm Weight 15 kilos .... **PRICE £265.00**
Type H327-3. Three pen: Dimensions 335 x 384 x 165mm Weight 20 kilos .... **PRICE £520.00**
Type H327-5. Five pen. Dimensions 425 x 385 x 165mm Weight 25 kilos .... **PRICE £770.00.**

Note: Prices are exclusive of VAT

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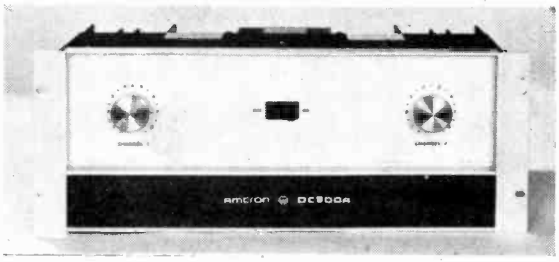
HIGH POWER DC-COUPLED AMPLIFIER



- ★ **UP TO 500 WATTS RMS FROM ONE CHANNEL**
- ★ **DC-COUPLED THROUGHOUT**
- ★ **OPERATES INTO LOADS AS LOW AS 1 OHM**
- ★ **FULLY PROTECTED AGAINST SHORT CCT, MISMATCH, ETC.**
- ★ **3 YEAR WARRANTY ON PARTS AND LABOUR**

The DC300A Power Amplifier is the successor to the world famous DC300 which is so widely used in Industrial, and Research applications in this country. It is DC-coupled throughout so providing a power bandwidth from DC to over 20,000Hz.The ability of the DC300A to operate without fuss into totally reactive loads while delivering its full power, and maintaining its faithful reproduction of Pulse or complex waveforms has established the DC300A as the world's leading power amplifier. Each of the two channels will operate into loads as low as 1 ohm, and the amplifier can be rapidly connected as a single ended amplifier providing over 650 watts RMS into a 4 ohms load, and still providing a bandwidth down to DC. Below is a brief specification of the DC300A, but if you require a data sheet, or a demonstration of this fine equipment please let us know.

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

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

Other models available from 100 watts to 3000 watts

MACINNES LABORATORIES LTD.

Macinnes House, Carlton Park Industrial Estate
Saxmundham, Suffolk IP17 2NL. Tel: (0728) 2262 2615

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And because whatever the application the optimum price/performance ratio can be achieved. We believe that these alternatives, not readily found with competitive instruments, make Philips the right choice of dmm's for you.

PM2513A New 3½-digit Battery operated dmm with 11mm LED display

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PHILIPS Test & Measuring Instruments

PHILIPS

WW — 064 FOR FURTHER DETAILS

Ferrograph – manufacturer of highest-quality reel-to-reel recorders – has designed two time-saving test sets suitable for checking any type of audio system.

In seconds, the ARA1 Audio Response Analyser gives precise response information, displayed as a gain/frequency plot on a long-persistence CRT. A unique feature of this fast, accurate test set is its frequency-sensing facility. Operation is entirely independent of synchronising or trigger signals. Consequently, there are no problems resulting from a time-lapse between input and output signals.

Other features include:

- Range 20Hz to 200kHz, resolution to 0.1dB.
- X-Y plotter outputs for permanent records.
- Large display on 27cm CRT; choice of graticules.
- Manual and automatic tuning for one-shot and repetitive sweeps.

Full details and comprehensive specification are included in a new leaflet.

The RTS2, sold in thousands round the world, is a comprehensive low-cost test set that will run up to ten different checks on an audio system's performance – using just one pair of leads. You don't need to put up with an array of incompatible test gear, improvising and compromising with numerous lead connections, wasting time sorting out hum loops. With the RTS2 you get fast, push-button operation. And accurate results.

Ferrograph audio test equipment: used by broadcast and recording studios throughout the world. Send for full details today.

Ferrograph

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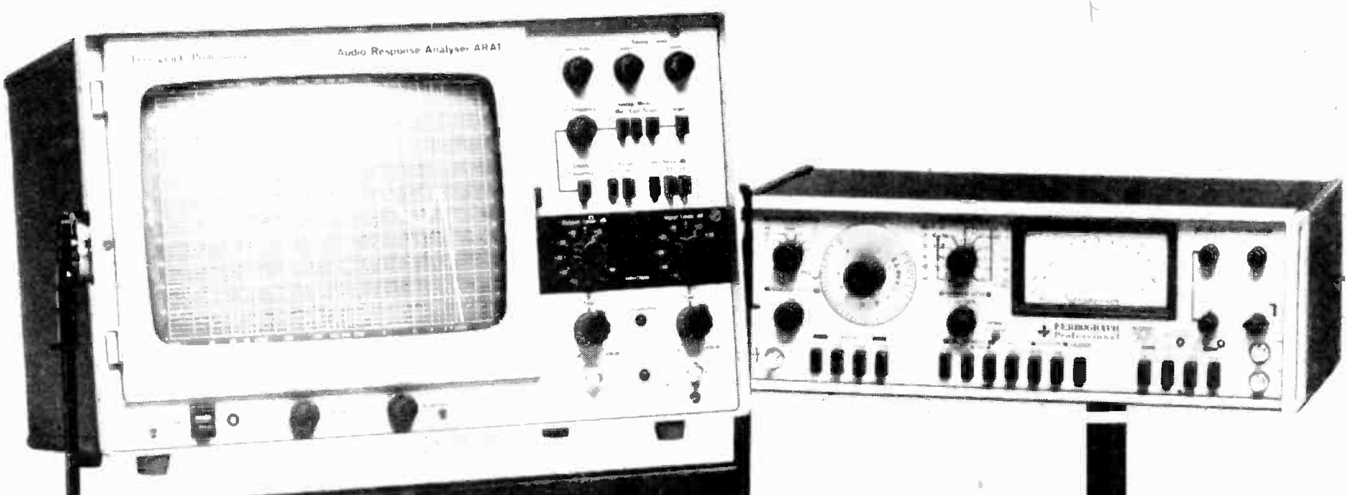
Telephone: Burnham (06286) 62511
Telex: 847297

Ferrograph will give you an unbiased opinion on any audio system.



Name

Company

Address

Telephone

☐ Please send full details of the ARA1 Audio Response Analyser and the RTS2 Audio Test Set.

☐ I would like these equipments to be demonstrated. Please phone me to arrange an appointment.

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Ferrograph Test Equipment. For fast and accurate audio analysis.

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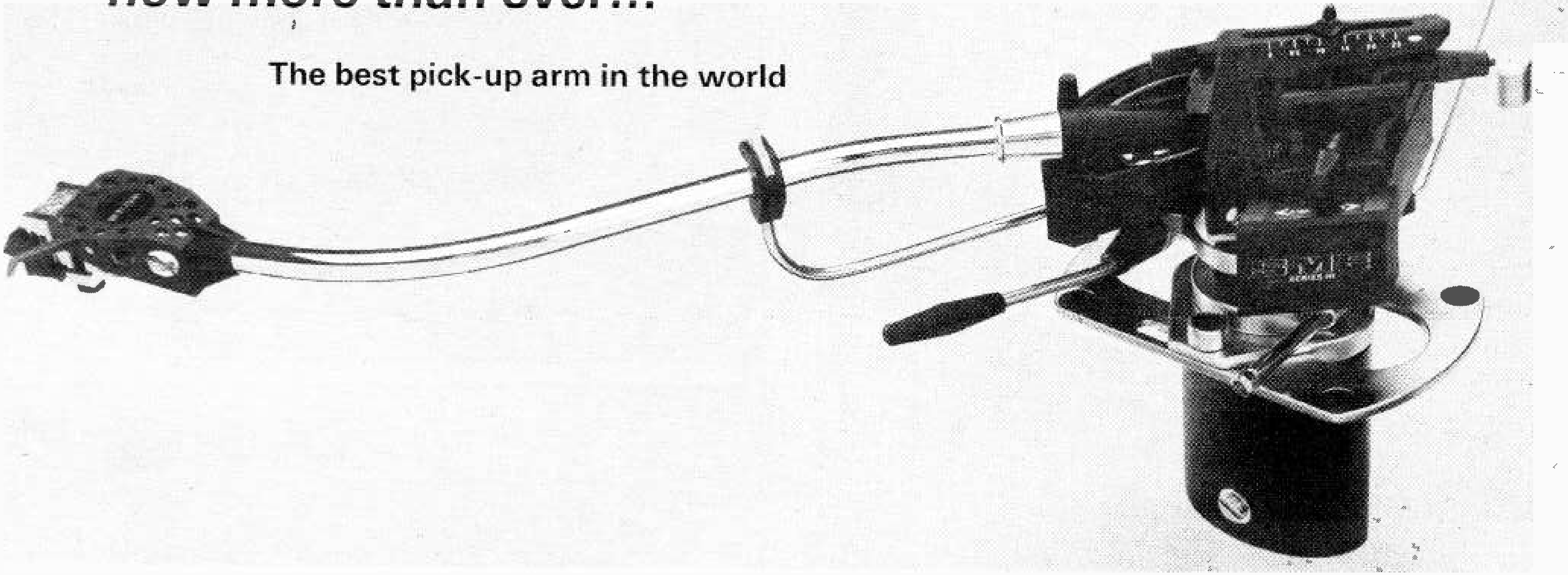
3009 Series III

now more than ever...

The best pick-up arm in the world



- Unique balance system to give minimum-inertia operation for cartridges weighing anything from 12g down to zero.
- Ingenious construction, with high-density metal cores in precision plastic mouldings.
- Conventional tone-arm and shell are replaced by an integral carrying arm which is interchangeable for multi-cartridge use. Carrying arm is formed of moulded carbon fibre and nitrogen-hardened titanium, achieving a rigidity many times that of aluminium or other conventional materials, and providing a natural loss of unwanted acoustic information.
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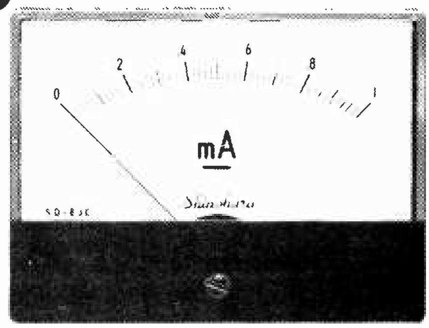

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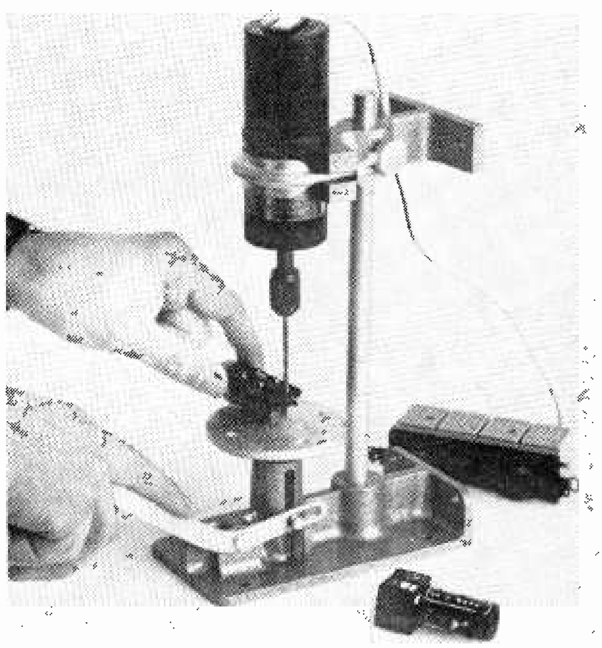

Illustrated right is a **TITAN DRILL**

Mounted in a multi-purpose stand This drill is a powerful tool running on 12v DC at approx 9000 rpm with a torque of 350 grm cm Chuck capacity 3 00 m/m
The multi-purpose stand is robustly constructed of steel and aluminium The base and bracket are finished in hammer blue
Also available for use in the stand is the RELIANT DRILL which is a smaller version of the Titan Approx speed 9000 rpm, 12v DC torque 35 grm cm Capacity 2 4 m/m

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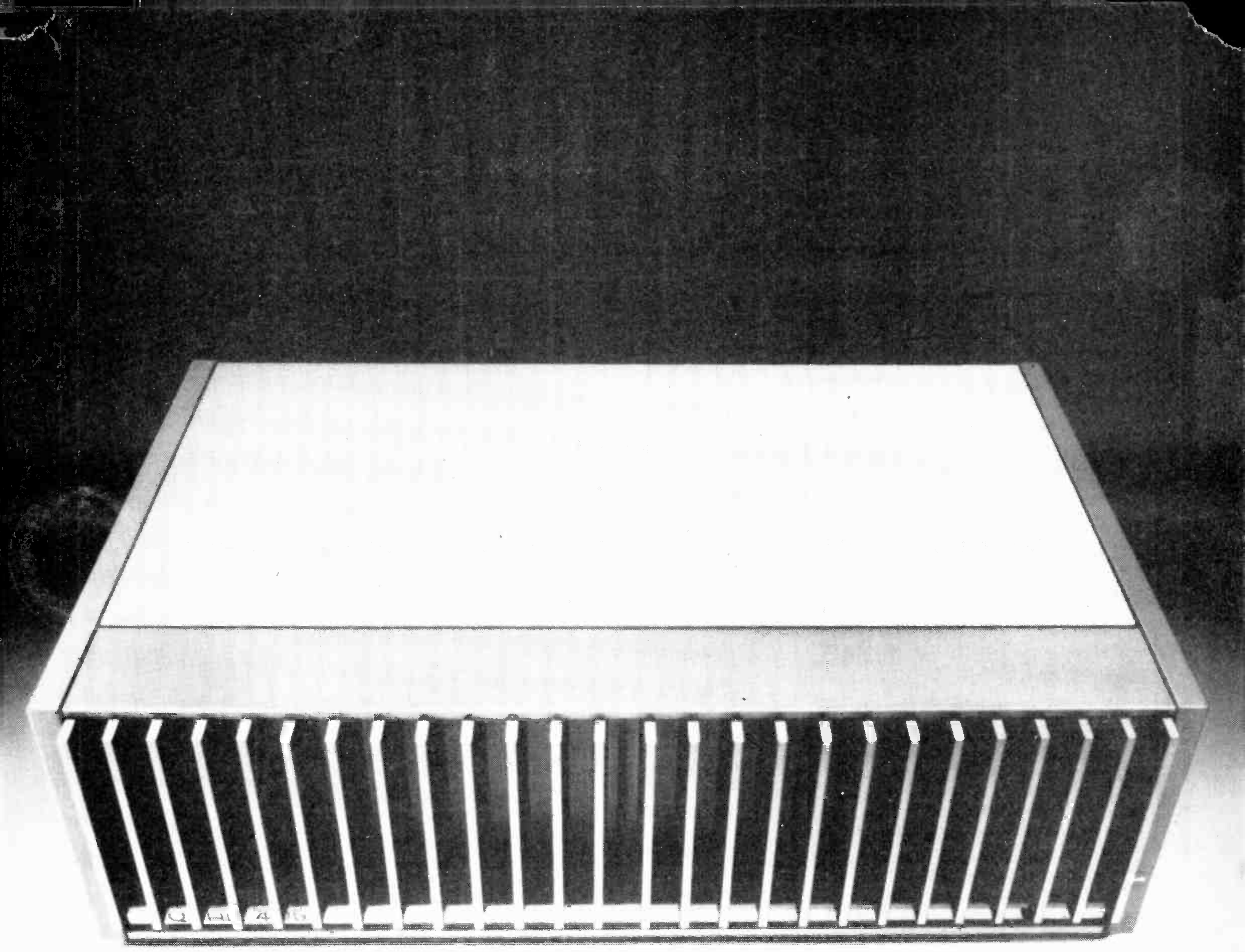

Sweet sixteen

The Quad 405 is only the sixteenth product to carry the Quad name, each of which, has made a significant contribution to the development of sound reproduction and acquired a following of loyal and satisfied customers

The Quad 405 current dumping amplifier represents another step forward in amplifier technology, executed with the attention to engineering and aesthetic detail, and manufactured with the concern for reliability which have been the hallmarks of Quad equipment for twenty-five years.

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Each containing a basic filter function, adjustable for cut-off or centre frequency and response type. Adjustment is simple. No filter knowledge is required. The modules are available in low-pass, high-pass, universal and notch designs with a pass band capability from d.c. to 1 MHz. Complete details are in freely available literature, yours on request.

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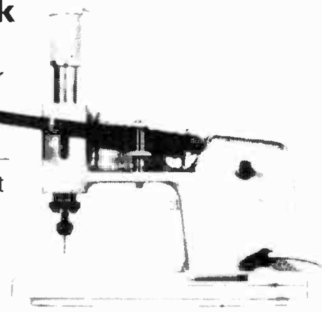
WW—090 FOR FURTHER DETAILS

For printed circuit boards . . .

It pays to know the right drill

KB-2 drilling machine by Kema Elektronik



The KB-2 is a compact, high-speed drill ideal for all precision drilling tasks in workshop or laboratory – especially printed circuit board work.
With a 2mm maximum drill diameter, and a 20mm maximum drill depth, it runs at 15,000 rpm with voltage (variable) 220 volts and maximum power 25 VA. Measuring $13\frac{1}{2}$"x $5\frac{1}{2}$"x 10", the KB-2 is Swiss precision engineered, extremely reliable and moderately priced.

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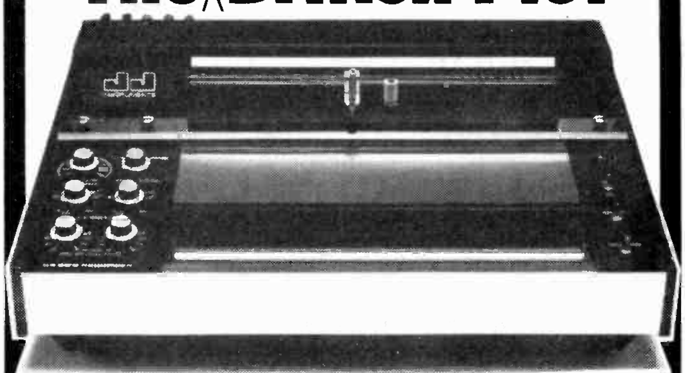
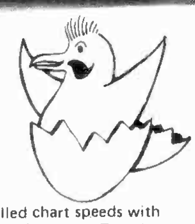
The New British Plot



The CR600 and CR700 Chart Recorders have been designed for the discerning user who requires a combination of fast writing speed, high accuracy plus versatility and good looks.



- 1000 mm/sec. writing speed
- 0.05% Linearity
- 0.05% Repeatability
- 0.1% Accuracy
- 0.02 mm/min. – 20 mm/sec. Chart speed

Standard features include:– 18 electronically controlled chart speeds with forward/reverse and remote operation. Chart feed and take up for Z fold or roll chart paper. Two separate channels with full pen overlap, self calibrate stepped range attenuators and span controls, 1000% precisely calibrated zero suppression. Remote operated event marker, pen lift and chart control. Both recorders are suitable for mains or battery operation and may be mounted horizontally or vertically.

Write today for full illustrated specification.

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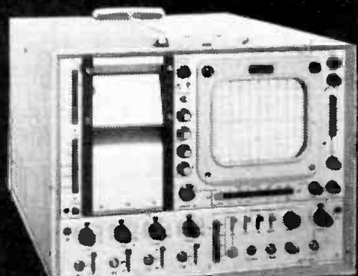

The FOR-4 Mark 2

The new Medelec FOR-4-2 fibre optic recording oscilloscope is the result of a constant research and development policy. It incorporates many refinements which have been made to customers' special requirements.

The FOR-4-2 provides industrial and research users with high quality recording facilities at really low cost. X-Y Plot, Transient and Raster mode are all available in a single instrument.

Special features of the Medelec FOR-4-2 include:

- **10 times gain X and Y (1mV/cm on 4 Y channels)**
- **Fully automatic triggering (with higher sensitivity)**
- **Improved recording facilities (for greater flexibility)**
- **Light control filter (for excellent contrast)**
- **Wide speed range (from 0.1 to 1000 mm/sec – in 3 models)**
- **Internal loudspeaker (for audio monitoring)**

For further information on the new FOR-4-2 or instruments in the range, contact:

MEDELEC LIMITED
Manor Way, Woking
Tel: Woking (048 62) 70331
Telegrams: Medelec, Woking

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Leaders in Fibre Optic Recording

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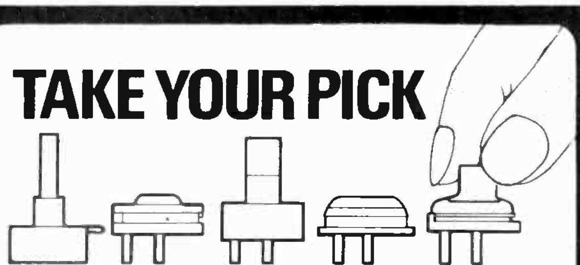

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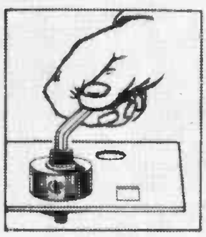

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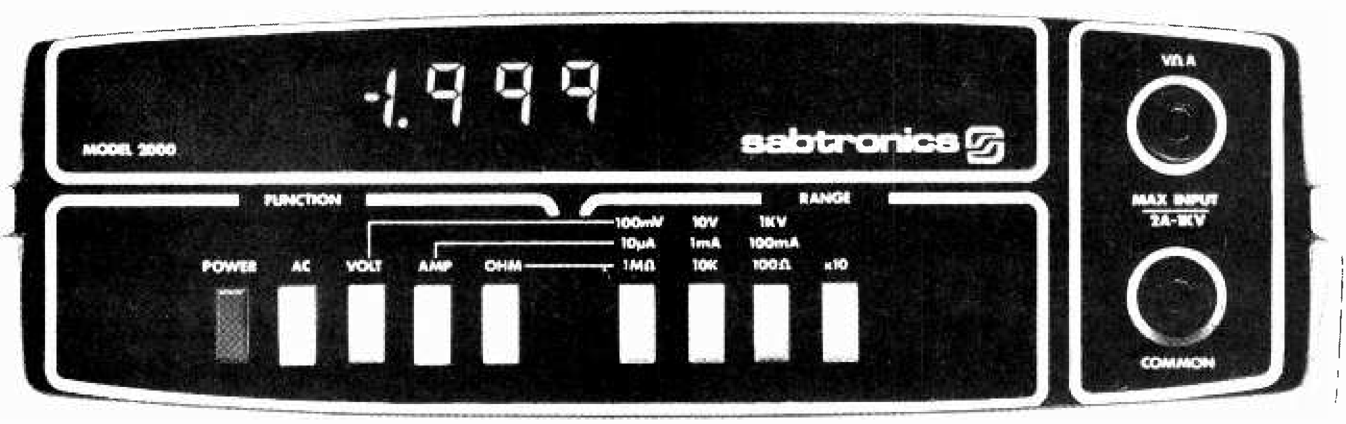

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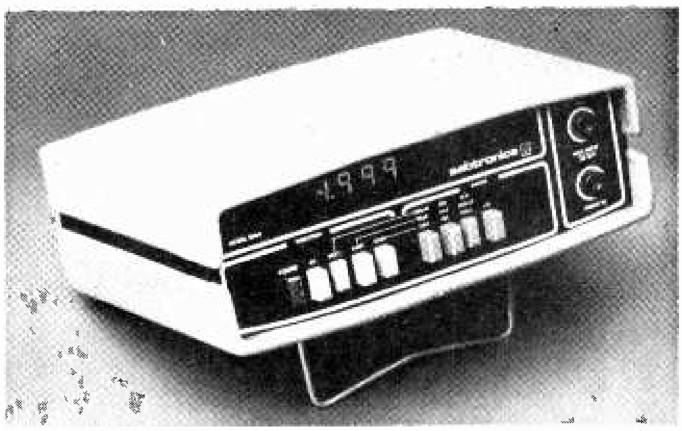

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WW7

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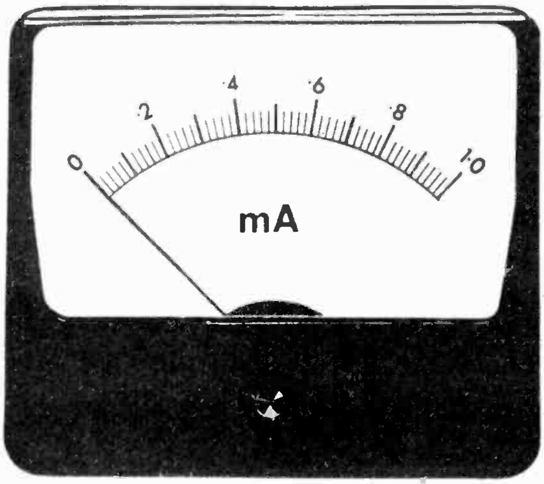

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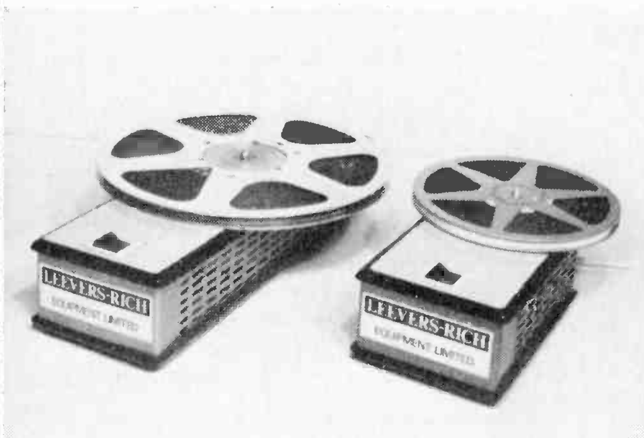

LR71
MAX REEL SIZE 11½"

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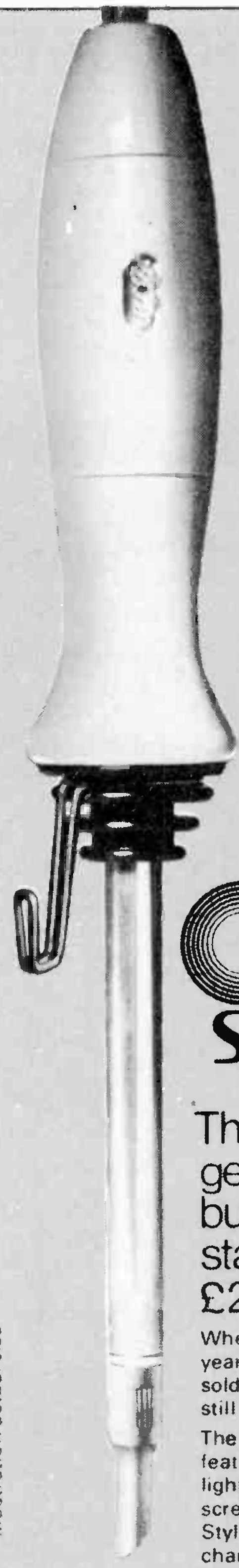

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Greenwood Electronics, Portman Road, Reading RG3 1NE
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It's the engineering we put into the Calinda that makes it sound so much better.

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

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

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

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

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

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

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

First, look at the cabinet.

There's a lot of thought gone into that.

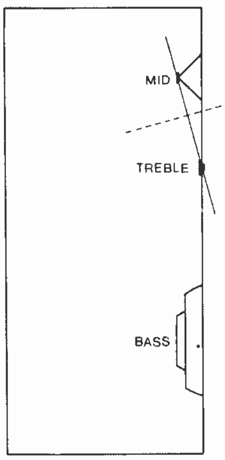
For a big, 45 litre capacity it is tall and elegant, so that a pair of Calindas can fit happily into most people's sitting rooms.

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

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

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

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



The Drive Units.

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

We put the mid-range unit above the tweeter.

This is unconventional.

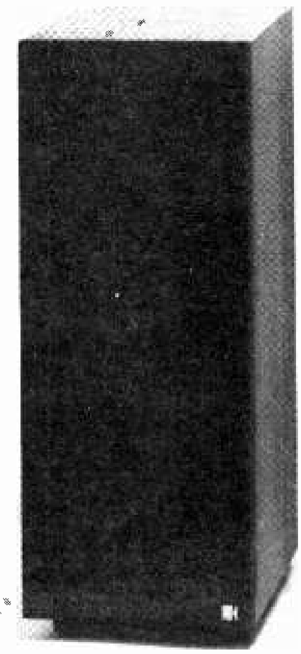
And it's a very good idea. Not only does it take the mid-frequencies away from the floor (as mentioned above, you only want even Beethoven once), it also has a very valuable effect at the crossover frequencies, where the mid and treble units radiate the same notes.

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

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

The KEF 'total system' design approach.

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



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

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

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

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

Name ....

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KEF

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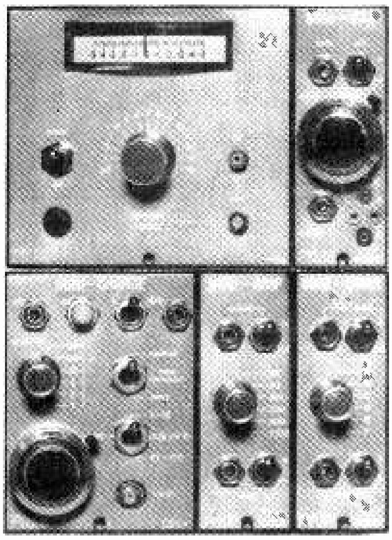

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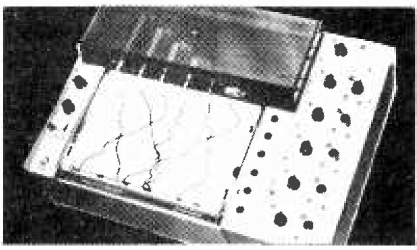

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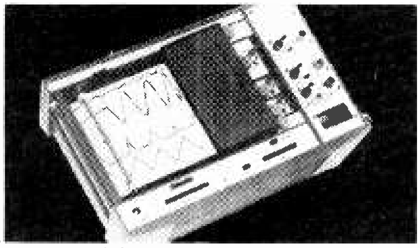

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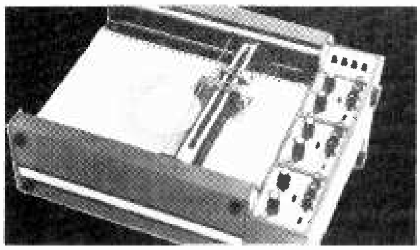

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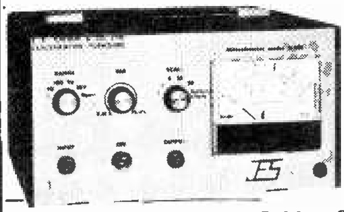

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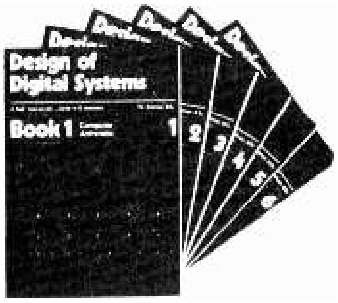

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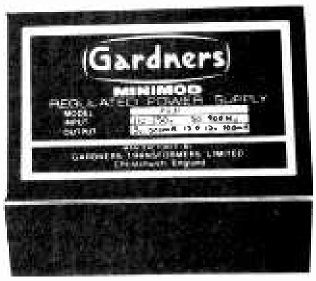

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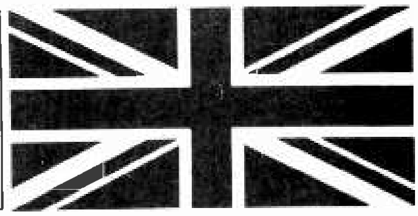

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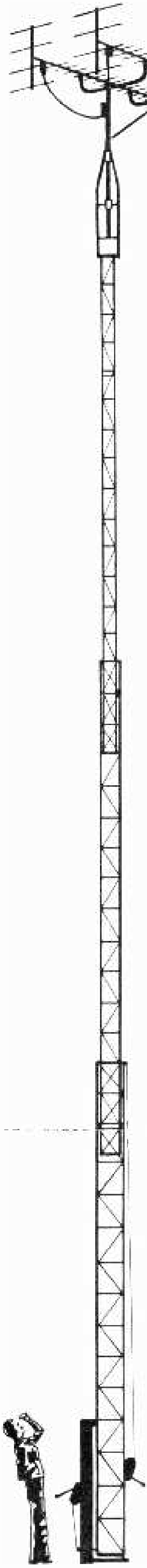

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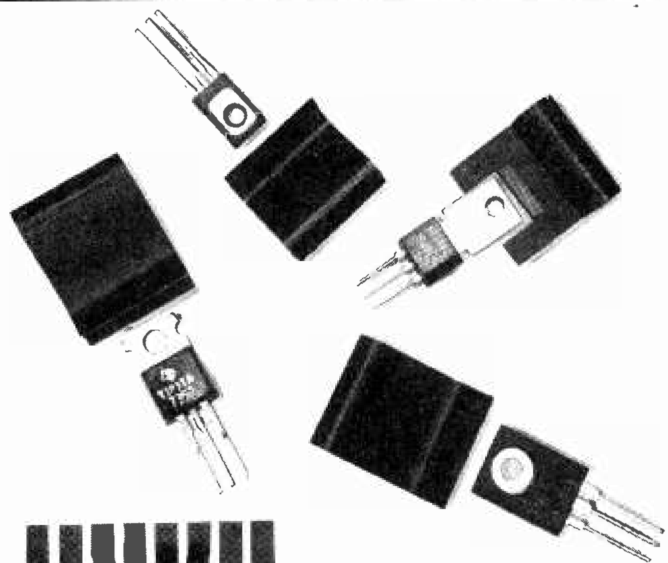

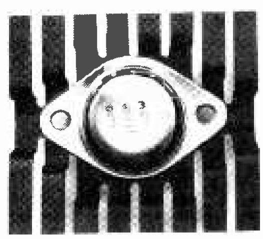

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WW 9/77

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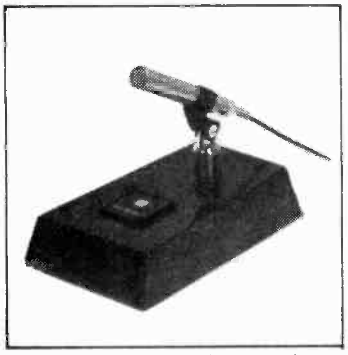
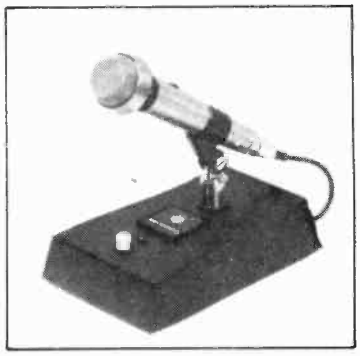


ODM2 on solid mahogany base.



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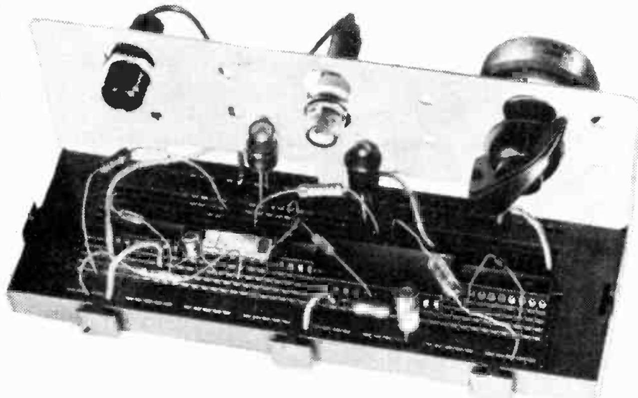

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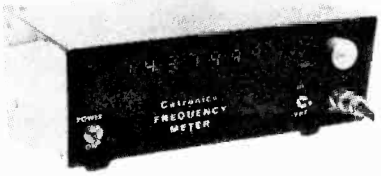

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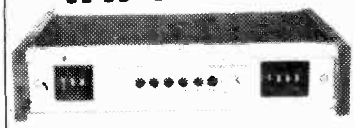

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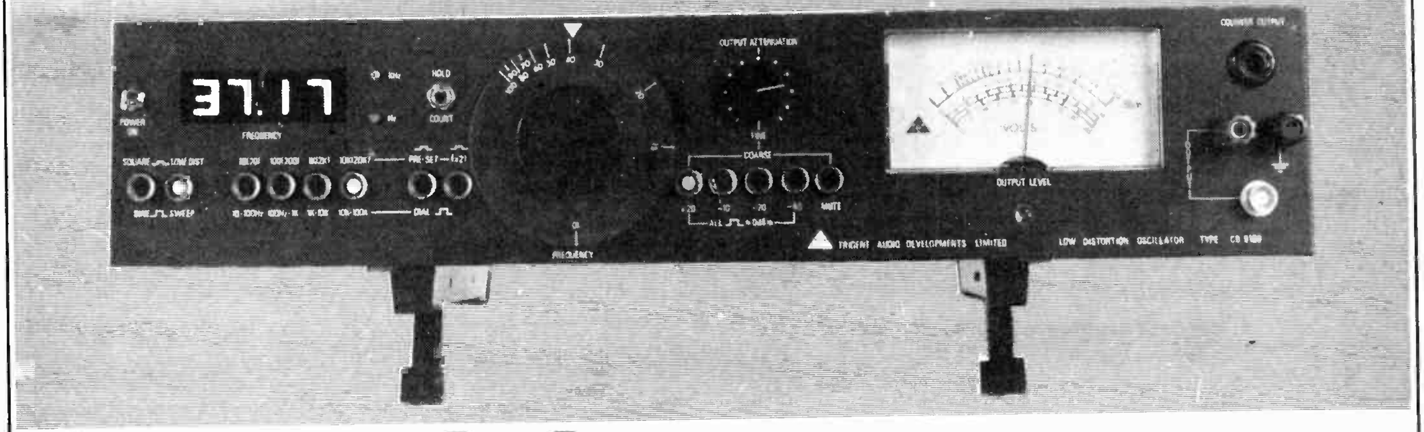

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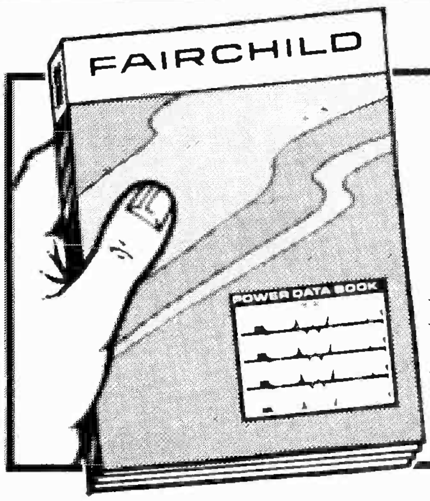

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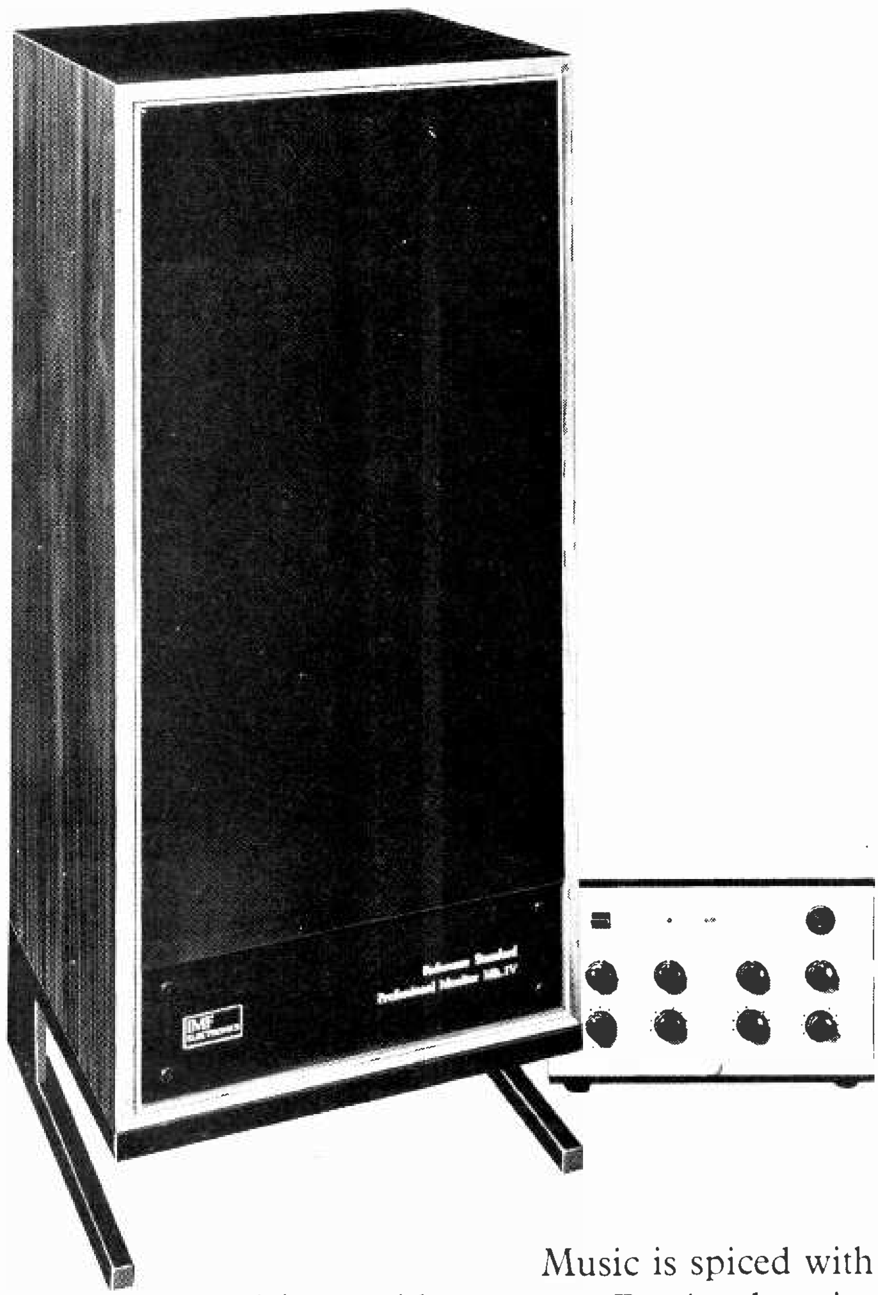

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The engineering class

As *Wireless World* predicted in the June issue, an enquiry has been announced into the engineering profession. The Commons statement from the Secretary of State for Industry, on July 5, made it clear that the educational standards in engineering will be closely studied, since education is considered either the source of, or the remedy for, many of the discontents that engineers have voiced.

Unfortunately the level of debate so far has not been very high. Many of the public utterances on the subject have merely been the battle cries of sectional interests, even though the nation never needed unity of purpose quite so much as it does now. Currently the discussion seems awash with mistaken notions, among which the most wrong-headed must be that status should, or even can, be pursued in isolation from esteem well-earned from the public at large. Nearly as foolish is the idea that a calling, by putting aspiring entrants though as many academic hoops as possible, can pull itself up by its own bootstraps. Another fallacy is that engineering is a learned profession in the same way that medicine or the law are. The nearest one could get to classifying engineering is that it is probably somewhere between a trade and a profession, but it is only a result of the British preoccupation with social class that engineers would not be just as proud to be members of one as of the other.

Sadly, some of these ideas ran through a major speech by the president of the Institution of Electrical Engineers, Mr Eric Booth, at the IEE's annual dinner some months ago. To be fair, he did insist that status "must be earned," but it is revealing and depressing that such an eminent man should worry any further about status, as such, at all. At the heart of the matter is the shortage of recruits into engineering, but status is a side-issue; everyone is aware, for example of what the world thinks of the journalist, yet the number of aspiring scribblers far exceeds the number of vacancies open to them.

Mr Booth complains that the engineer does not enjoy the status of the doctor or the lawyer, and says this is because in the past "our engineers were mainly self-taught men of imagination who had an intuitive grasp of engineering principles. On the other hand, doctors and lawyers, who represent high status professions, had for centuries been the products of the universities and the Inns of Court when the rest of the community was largely illiterate." On this he bases his argument that status will follow if academic standards are increased.

Yet Mr Booth has confused cause and effect. The engineer in the industrial revolution compared so unfavourably with doctors and lawyers not because of education but because of, again, differences in social class. Those of higher social standing were the only ones to whom a university education, and a degree at the end of it, were open. They were then able to go into the law and medicine, and did so partly because an upper middle class gentleman felt that, in return for his good position in society, he was obliged to render some service to the community, an element that has been all too absent from the current debate. It can be argued, therefore, that the law and medicine have accrued status as a result of the natural status of those who practised them, not just as a result of their superior education.

If engineers are not highly thought of it is because they seem not to have made the contribution society has been led to expect. It may even be that our industrial performance is undermined by the eagerness of some sections of our society, engineers among them, to spend twice as much energy forcing their superior view of themselves on other people as they do in earning their own and the nation's living. Perhaps, too, engineering, and the whole community, would benefit if the routes towards an engineering qualification were less diverse, less class-ridden. The committee might consider why the distinction made at first between the engineer who has taken a degree course and his "less well qualified" colleague so often turns out to have been artificial.

Low distortion oscillator

1 — An improved Wien bridge design

by J. L. Linsley Hood

This instrument uses a modified circuit to reduce the typical output harmonic distortion of a Wien bridge oscillator by a factor of up to 10. A sine wave output from 10Hz to 100kHz in four switched ranges is available together with a square wave. A constant impedance output attenuator is also provided with four switchable levels from 1V to 1mV. The complete unit can be powered from two 9V batteries.

The Wien bridge arrangement shown in Fig. 1 is one of the most convenient circuit configurations for use in a wide range variable frequency oscillator circuit because the operating frequency can be made continuously variable by means of a twin-gang potentiometer for R_x, R_y, or ganged capacitor for C_x, C_y. However, most of the conventional Wien-bridge oscillators using this type of circuit, such as the example in Fig. 2, have a minimum distortion figure of

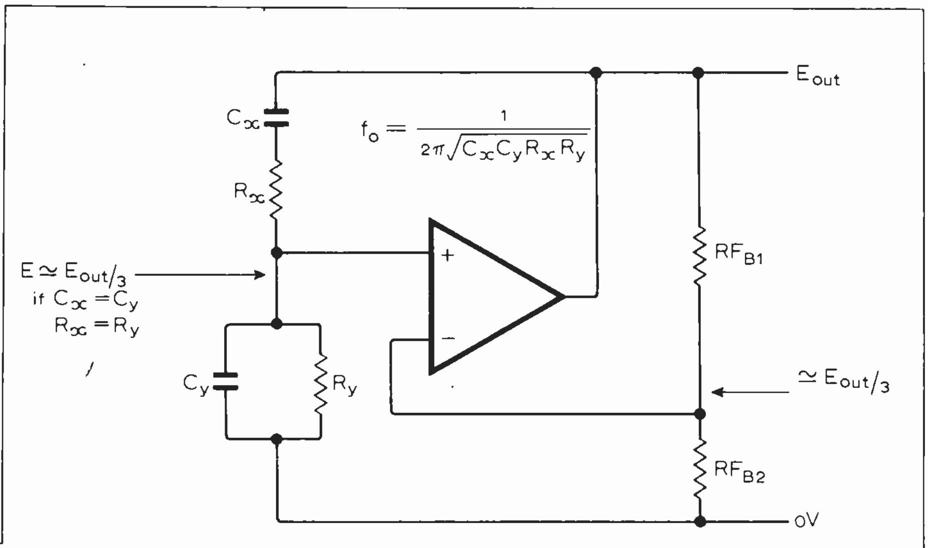

Fig. 1. Basic Wien bridge oscillator circuit. For frequency variation either R_x and R_y are used as a twin gang potentiometer or C_x C_y as a ganged capacitor.

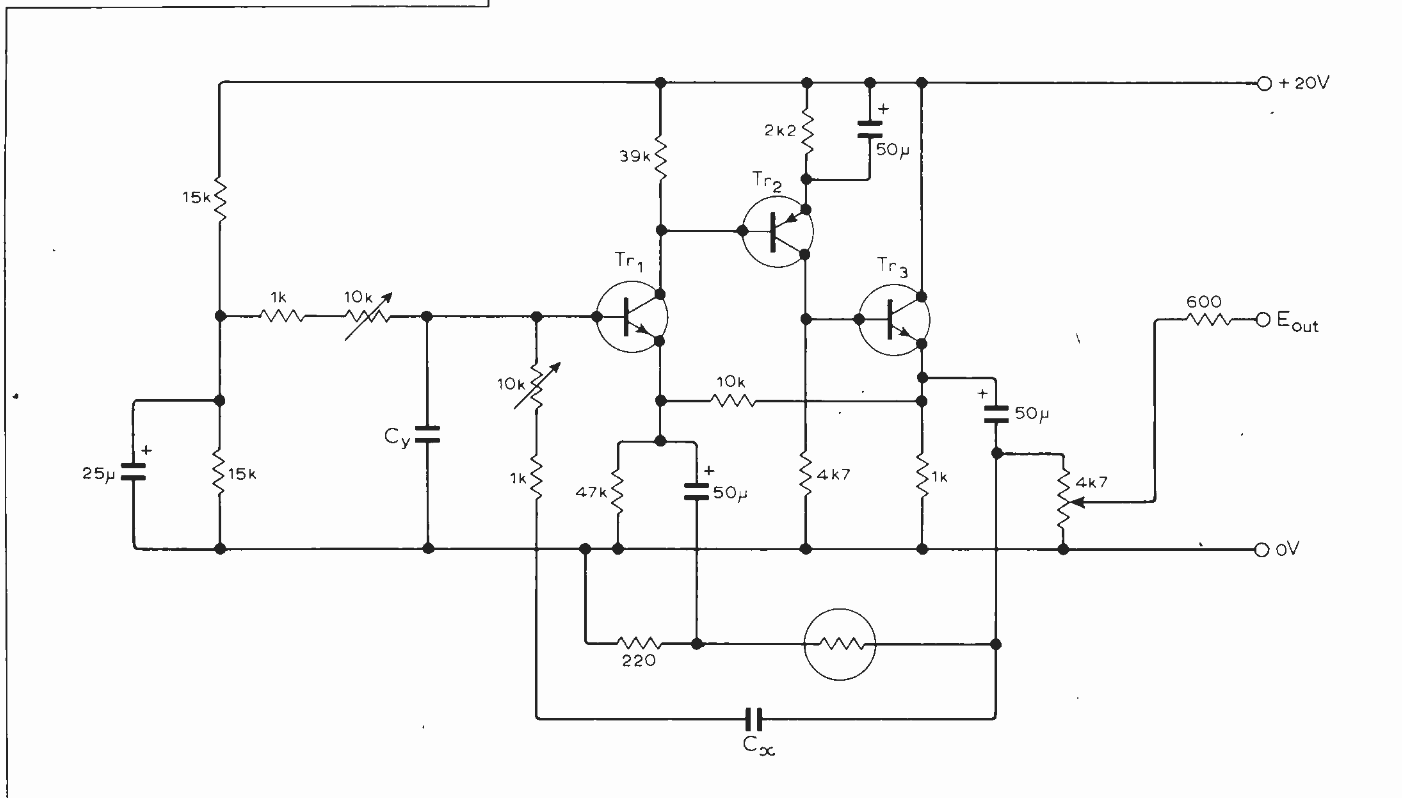

Fig. 2. Conventional Wien bridge circuit which produces around 0.01% harmonic distortion.

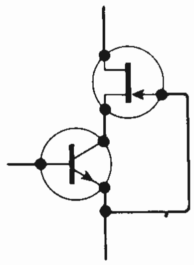

Fig. 3. Bipolar f.e.t. cascode arrangement.

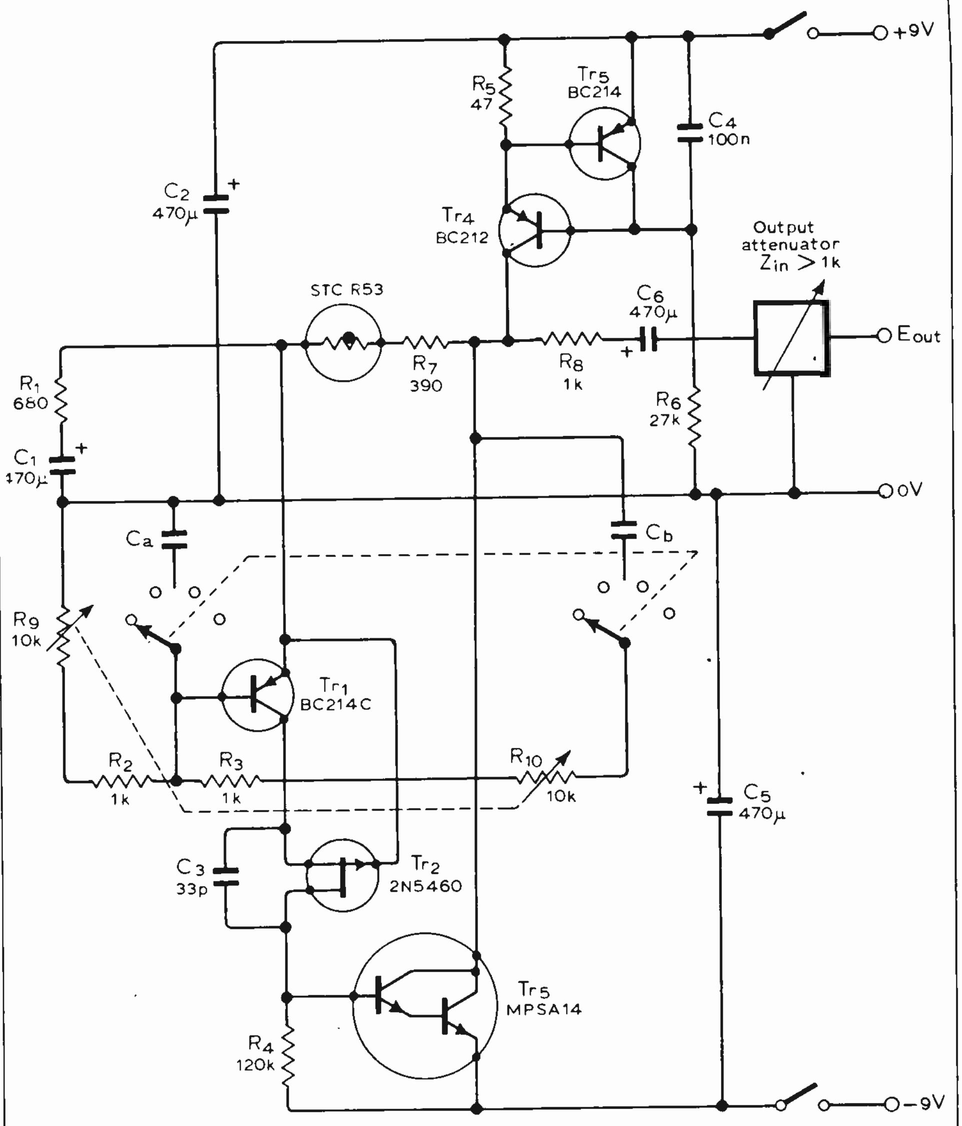

Fig. 4. Modified Wien bridge oscillator circuit. To reduce surface recombination noise a p.n.p. bipolar device is used in the input.

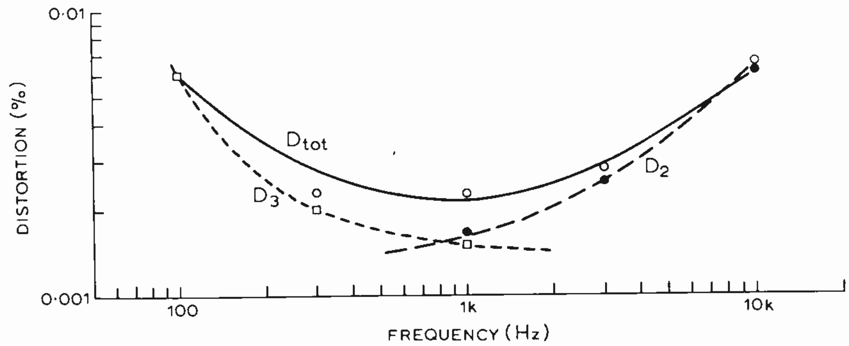

Fig. 5. Spot frequency distortion measurements of improved circuit.

around 0.01 to 0.02% which is barely adequate for test purposes with modern amplifier designs. This has encouraged the more widespread use of the less convenient parallel T oscillator arrangement for producing very low distortion reference signals.

On analysis it is apparent that the major cause of residual harmonic distortion in the conventional thermistor stabilized Wien-Bridge oscillator circuit, at frequencies high enough for thermal modulation of the thermistor to be unimportant, is due to common mode failure[2,3] in the first stage amplifying device. Here the peak signal voltage applied in common mode to the base and emitter of Tr_1 is approximately $2\sqrt{2}/3\ V_{out}$ r.m.s., which can be a significant proportion of the available V_{ce} in Tr_1. Improved performance can be achieved in three ways; by reducing the ratio of V_{out} to V_{cc}, which may not be convenient. By reducing the magnitude of the signal voltage fed back to Tr_1, or, finally, by reducing the sensitivity of the input stage to common mode malfunction. In view of the high independence of output impedance and drain current with respect to drain voltage in most junction f.e.t.s, the use of an f.e.t. as the input device is attractive. The straight substitution of an f.e.t. for the input bipolar transistor, however, results in a large reduction in loop gain. The use of a bipolar device in cascode with an f.e.t. as shown in Fig. 3 overcomes this problem and offers a gain which is characteristic of the bipolar device together with an output impedance and common mode rejection ratio typical of a junction f.e.t. Moreover, the collector-emitter voltage of the bipolar input device is maintained at a constant potential, appropriate to the drain current drawn from the f.e.t., and as such provides a bootstrap action.

A practical circuit using this type of input configuration is shown in Fig. 4. Some small additional improvements in this circuit are the use of a p.n.p. input device, which produces less surface recombination noise in the junction, and the use of a constant current load for the output amplifying stage which gives greater output linearity and improved independence of V_{cc}. The typical t.h.d. of this design is shown in Fig. 5. Over the frequency range 200Hz to 3kHz, for an output of 1.5V r.m.s. into a 2kΩ load, the distortion content is between 0.0015 and 0.003% associated with a settling time of less than 2 seconds. This is independent of V_{cc} in the range 13 to 20V or ±6.5 to 10V if a split supply is used as shown in Fig. 4.

Because most of the residual distortion arises in the output stage, somewhat lower values can be obtained for a given output load if the current, determined by R_5, is increased. For the values shown this is about 10mA.

The settling time of low distortion oscillators has been examined by Oliver[4,5] with the general conclusion that this will lengthen as the t.h.d. becomes lower, especially at lower frequencies because this is related to the number of cycles of signal applied to the thermally sensitive element. However, this is less of a problem with a Wien-bridge system compared to feedback networks which produce a transmission null at the operating frequency.

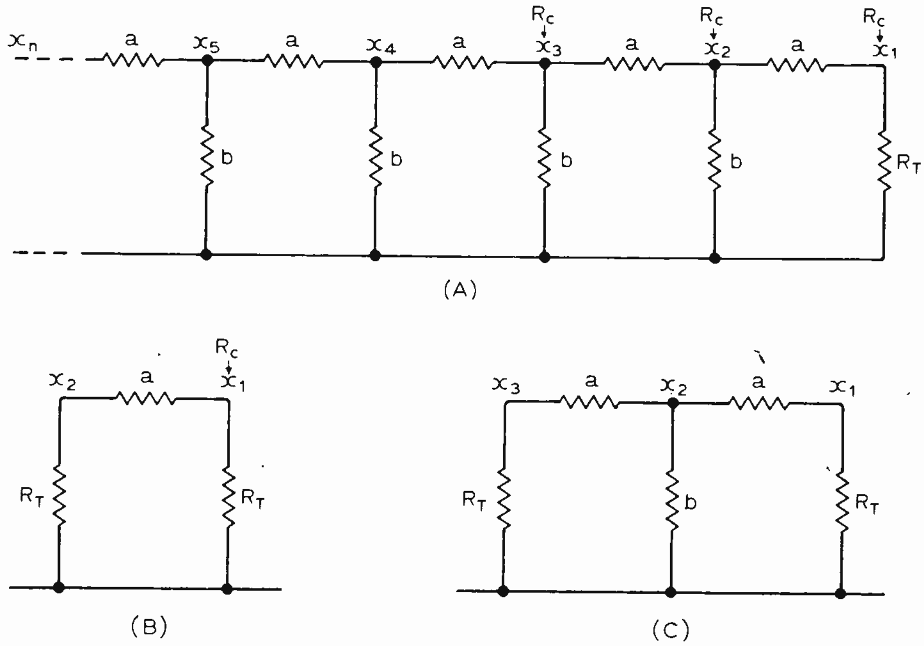

Fig. 6 Basic resistive transmission line attenuator and the sections which are considered when calculating the resistor values.

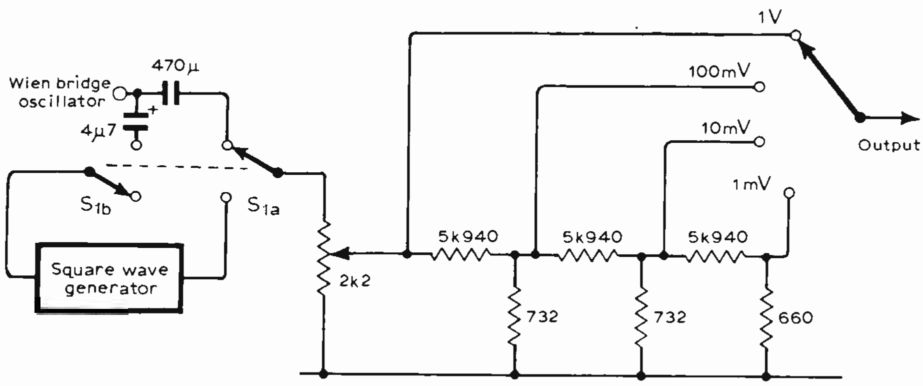

Fig. 7 Practical attenuator. The 5k940Ω resistors can be formed by a 6k8//47kΩ, the 733Ω by a 6k8//820Ω, and the 660Ω by a 22k//680Ω.

Output attenuator

It is accepted as a practical convention that low frequency signal sources should have an impedance of 600Ω. The easiest method of achieving this is to take outputs from tapping points along a conventional resistive transmission-line attenuator as shown in Fig. 6 (A). Resistor values can be calculated for any desired characteristic impedance and attenuation factor, provided that the line is either of infinite length or is correctly teminated at both ends by resistor R_T.

The attenuation of the line from x_2 to x_1 is $R_T/\ a+R_T$ and if this is defined as $1/K$ then $K=a+R_T/R_T$ where K is the reciprocal of the attenuation factor. If this definition is correct it must hold true for the shortest element of transmission attenuator as shown in Fig. 6 (B). The characteristic impedance of this line, as seen at x_1 and x_2 (R_C) is $R_C=R_T//(a+R_T)$, so

$$\frac{R_C}{R_T}=\frac{R_T}{R_T}//\frac{(a+R_T)}{R_T}$$

therefore $R_C/R_T=1//K$ which equals

$$\frac{K}{(1+K)}.R_T$$

therefore $R_T=\frac{(1+K)}{K}.R_C$

This defines the terminating resistors.

For calculation of the series resistor a, if the characteristic impedance of the line is specified and the attenuation characteristic is known,

$$K=a+R_T/R_T \text{ or } K.R_T=a+R_T$$

therefore $a=K.R_T-R_T$, which equals $R_T(K-1)$. As already shown,

$$R_T=\frac{(K+1)}{K}R_C$$

therefore $a=\frac{(K+1)(K-1)}{K}R_C$

so $a=\frac{(K^2-1)}{K}R_C$.

To calculate the shunt resistor b, consider a line with these elements as in Fig. 6(C).

The impedance at x_2, as defined by R_C, is

$$b//\frac{(a+R_T)}{2}$$

or $\frac{1}{b}=\frac{1}{R_C}-\frac{2}{(a+R_T)}$

therefore $\frac{1}{b}=\frac{1}{R_C}-\frac{2R_T}{(a+R_T)R_T}$

$$=\frac{1}{R_C}-\frac{2}{R_TK}$$

$$=\frac{R_TK-2R_C}{R_CR_TK}$$

therefore $\frac{1}{b}=\dfrac{\frac{(K+1)}{K}.KR_C-2R_C}{\frac{(K+1)}{K}.KR^2{}_C}$

which equals $\frac{K+1-2}{(K+1)R_C}$

therefore $b=\frac{(K+1)}{(K-1)}R_C$

which allows the value of b to be calculated.

If a step attenuation of × 10 or greater is used, the influence of the source impedance to the line can be ignored. In the practical circuit of Fig. 7 the attenuator is fed from a potentiometer to give amplitude variation between ranges. The non-standard resistor values can be produced by the parallel combinations detailed in the caption.

Printed circuit board

A p.c.b. which accommodates the Wien bridge oscillator, frequency range capacitors, square wave generator and output attenuator will be available for £3.00 from M. R. Sagin at 23 Keyes Road, London, NW2. The board follows the authors complete circuit to be published next month.

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Letter from America

by G. W. Tillett

This year the eleventh annual Consumer Electronics Show in the USA opened with a great feeling of optimism. Exhibitors numbered well over 700 — a record — and they were spread out in the huge exhibition halls at McCormick Place in Chicago while another 150 had audio demonstration rooms or suites at the nearby plush McCormick Inn. A further contingent of nearly a hundred were dispersed in hotels all over Chicago, making it quite an ordeal for anyone determined to see most of the exhibits! Although there was this feeling of optimism, there have been some disturbing setbacks in some areas. For instance, sales of the new 40-channel citizens' band radios have not been as high as expected, partly because of the stocks of 23-channel models left over. Consequently, prices of both types have been ruthlessly cut and neither dealers or importers are making any money. On the other hand, companies like SBE and TI (yes, Texas Instruments) have introduced expensive models using microprocessor technology with keyboard tuning, programmable memory, fast and slow scanning and all kinds of refinements. The TI model is an s.s.b. unit and all the controls are in a small hand-held unit which looks like a calculator. Readouts show the channel number, sideband mode and signal strength. Two m.p.us are employed, one in the control unit and the other in the main section. Hy-gain also use m.p.u. circuitry in their Model 16 which has all the controls plus the loudspeaker built into a neat hand-held unit. Two push-buttons control the volume level and there are digital readouts for channel numbers, r.f. output power and the time!

It is more than likely that the present emphasis on high quality c.b. products is a reaction to the chaos caused by price-cutting in the calculator and digital watch industries where $100 items were eventually cut right down to $10 or less. Many of the "fly-by-night" companies have picked up their profits and stolen away, leaving the dealers with faulty watches and calculators plus impossible servicing problems. Some of the larger firms, like Benrus have moved out of the digital watch business, but all-in-all it looks as if the industry will settle down to a more stable growth pattern — let the chips fall where they may (sorry about that!) Already, digital watches are responsible for nearly half the total watch sales and there is no sign of a decrease. Windert were showing several interesing models, one of which was combined with a 9-digit calculator and another having full chronograph features with elapsed time, lap time and split-time. It boasts a 6-digit display for hours, minutes, seconds, tenths and hundreths of a second! But the model which was attracting most of the attention was a Programmable Message model that gave the user a choice of a 5-letter, 5-word programme from any 26 letters, 10 numerals and 5 symbols. It was said to be very easy to change displays — which might appeal to those who elect to show the name of their girl friends!

There are several calculators that use solar power but only one that required no batteries at all. This was the Teal 14-function model which measures only 63mm by 111mm by 7mm thick — and it has no on-off switch. The Sharp EL-8130 features an electronic auto-sensing panel with no keys or moving parts and it includes a four-key memory system, overflow error check device and automatic power-off circuit. It is less than 5mm thick and the price? Just $34.95. Most manufacturers have a bottom-of-the-line model in the range and the Sharp EL-203 is fairly typical. It is an l.c.d. model with total memory, square root and percent keys listing at under $10.

Video games were well in evidence, although many of the smaller firms have disappeared from the scene. Most of the games seen last year used simple paddles but present-day models are much more sophisticated, offering the user all kinds of alternatives. Some use cartridges so the customer can buy additional programmes later. One of the new games I saw involved a wall of bricks and the player must remove them one at a time before he can escape. A four-position switch gives a choice of "handicaps".

As far as turntables were concerned, there is no doubt that the new BSR Accutrac was the hit of the Show but there were some other models of note. Infinity were showing a prototype which had a built-in pump to provide an "air cushion" for the platter and Fisher introduced a model with a linear motion motor. The field coils are mounted all round the turntable, just underneath, and a 120-pole ferrite magnetic band is attached to the under-rim of the platter — not unlike the old Simpsons turntable. Sensing coils control the speed via a servo system.

Burwen were demonstrating a new record "pop, crackle and scratch" remover which uses the steep wavefront of the noise to operate a gating circuit. To fill the "hole" a portion of the preceding signal is "tailored in". This appears to be quite similar to the SAE 5000 but it was stated that the switching times are much less and it would reduce low amplitude "hash". The SAE unit uses a delay circuit, and programme material prior to and after the impulse noise is patched in. A switch marked "invert" allows the user to hear the actual pops and clicks the unit is removing. In a demonstration, a brand new Sheffield record was gouged with a knife but no scratches were audible when the record was played!

The trend towards higher powered amplifiers and receivers continues and it was interesting to see the various methods used to obtain higher efficiency and reduce the size of the heat sinks, etc. Infinity have had a p.w.m. amplifier for some time now and Sony were also showing a prototype. Hitachi had amplifiers and receivers with "class H" amplifier. A "class G" output stage consists of four devices, two to handle the positive swings and two to take the negative swings. One pair is fed from a low voltage supply and functions as a low power class B amplifier, but when the signal reaches a certain value it cuts-off and the high power stage takes over.

Soundcraftsmen take a rather different approach in their "class H" circuit. Two power supplies are employed with one supply voltage being about two-thirds of the other. As the signal input increases, a "vari-portional" circuit turns on the high voltage supply long before the clip point. Thus the amplifier is operating at a lower voltage most of the time, reducing power stage dissipation. It should be emphasised that the high voltage supply is only on for peaks, so a sinewave signal will cause the second supply to function for a fraction of the waveform. This was clearly demonstrated on an oscilloscope and it was possible to gradually increase the input signal until the high voltage trace began to show a rise too! Most ingenious, and the big advantage is that there is no switching inside the amplifier, as all the control functions are outside the feedback loop. So distortion, slew rate and stability is not affected. The amplifier demonstrated had a rated output of 250 watts per channel and it features l.e.d. indicators showing operation of the "vari-portional" circuit, VU meters and a "crowbar" protection circuit.

This year, more than twenty-one British exhibitors were showing their products under the aegis of the Federation of British Audio, plus another four or five independents like Sinclair and Rank-Wharfedale. Goodmans have returned after more than ten years' absence from this market and both Leak and Wharfedale are making a bid for recognition again. There is a growing number of people who are satisfied with nothing less than the finest audio equipment money can buy and already at least six magazines are catering to their needs — and a new one seems to appear every month! It is in this area of super amplifiers, loudspeakers and so on that British companies can compete successfully and there is no doubt whatsoever that their share of the market will increase very substantially as time goes on.

Logic design — 7

Designing synchronous and asynchronous counters

by B. Holdsworth* and D. Zissos†

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Counters are cyclic sequential circuits which return to their initial state after a specified number of changes in the input state. The output of a counter in its specified code gives the number of changes of the input signal or the number of input pulses received since the circuit was last in its initial state. Counters are being used extensively in industrial plants for such functions as controlling the position of a machine tool or for packing a specified number of items in a box. They are also used in laboratory environments for such functions as counting frequency, recording time, speed and acceleration.

Codes

The most commonly used codes in electronic counters are:

- True binary (8-4-2-1) code,
- Gray codes,
- B.c.d. codes and
- Ordered codes, for example the excess-3 (XS-3).,

The true binary code, often referred to simply as the "binary code" is the simplest because each digit is represented in a conventional binary system. Gray codes are those in which adjacent numbers differ in one bit only, eliminating races which arise when two or more bits attempt to change simultaneously. The true binary code is shown in Table 1, for four binary digits.

If all the sixteen combinations in the sequence in Table 1 are used, the counter is called a maximum-length counter; if, on the other hand, only the first ten combinations are used the counter is called a scale-of-ten counter.

A Gray code in which only one digit changes at a time is called a single-step code, the best known one being the reflected binary code. This code is tabulated in Tables 2(a) and 2(b) for both three and four binary digits. Examination of Table 2(a) shows that reflection of the three least significant digits takes place about the centre line of the code. All those combinations above the centre line have a most significant digit of 0 whilst those below have a most significant digit of 1. Similar comments can be made about the three-digit code except that, in this case, reflection of the two least significant digits takes place.

The sequence of the 4-bit reflected binary code is shown plotted on a Karnaugh map in Fig. 1(a). The plot shows that, as the code proceeds from one combination to the next, only one cell boundary is crossed. It is clear that any single-step Gray code can be developed immediately from a Karnaugh map by tracing a single step path through the map as shown in Fig. 1(b). The code sequence for this example is shown in Fig. 1(c).

d	D	C	B	A
dec.	8	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	0	1	0	1
6	0	1	1	0
7	0	1	1	1
8	1	0	0	0
9	1	0	0	1
10	1	0	1	0
11	1	0	1	1
12	1	1	0	0
13	1	1	0	1
14	1	1	1	0
15	1	1	1	1

Unused code combination in decade counters (rows 10–15)

Table 1. True binary code, with unused combinations for decade counters.

In b.c.d. (binary-coded-decimal) codes, each of the ten decimal digits 0 to 9, is represented by a binary code, frequently the 8-4-2-1 code. For example the b.c.d. (8-4-2-1) representation of 456 is 0100, 0101, 0110. B.c.d. codes provide a useful link between the counting systems used by digital machines and those used by human beings.

The codes tabulated in Tables 3(a) and 3(b) are examples of weighted b.c.d. codes.

In a weighted code a weight W_j is assigned to the j^{th} binary digit. For example, for the 8-4-2-1 code combination 1001, $W_4 = 8$, $W_3 = 4$, $W_2 = 2$ and $W_1 = 1$

Hence,

$$Z_{dec} = \sum_{j=1}^{j=4} W_j S_j$$

d	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	1	0
5	0	1	1	1
6	0	1	0	1
7	0	1	0	0
8	1	1	0	0
9	1	1	0	1
10	1	1	1	1
11	1	1	1	0
12	1	0	1	0
13	1	0	1	1
14	1	0	0	1
15	1	0	0	0

℄ (between 7 and 8) — Reflection

d	C	B	A
0	0	0	0
1	0	0	1
2	0	1	1
3	0	1	0
4	1	1	0
5	1	1	1
6	1	0	1
7	1	0	0

℄ (between 3 and 4) — Reflection

Table 2. Four-bit reflected binary (a) and three-bit (B) reflected binary code.

d	D	C	B	A
o	2	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	1	0	1	1
6	1	1	0	0
7	1	1	0	1
8	1	1	1	0
9	1	1	1	1

d	D	C	B	A
	5	4	2	1
0	0	0	0	0
1	0	0	0	1
2	0	0	1	0
3	0	0	1	1
4	0	1	0	0
5	1	0	0	0
6	1	0	0	1
7	1	0	1	0
8	1	0	1	1
9	1	1	0	0

Table 3. Weighted codes. 2-4-2-1 code is at (a) while (b) shows 5-4-2-1 code.

d	D	C	B	A
0	0	0	1	1
1	0	1	0	0
2	0	1	0	1
3	0	1	1	0
4	0	1	1	1
5	1	0	0	0
6	1	0	0	1
7	1	0	1	0
8	1	0	1	1
9	1	1	0	0

Table 4. Excess-3 code (XS-3).

d	D	C	B	A	p
0	0	0	0	0	1
1	0	0	0	1	0
2	0	0	1	0	0
3	0	0	1	1	1
4	0	1	0	0	0
5	0	1	0	1	1
6	0	1	1	0	1
7	0	1	1	1	0
8	1	0	0	0	0
9	1	0	0	1	1

d	D	C	B	A	p
0	0	0	0	0	0
1	0	0	0	1	1
2	0	0	1	0	1
3	0	0	1	1	0
4	0	1	0	0	1
5	0	1	0	1	0
6	0	1	1	0	0
7	0	1	1	1	1
8	1	0	0	0	1
9	1	0	0	1	0

Table 5. Parity. 8-4-2-1 code at (a) has extra bit to give odd parity and that at (b) has even parity.

where S_j is the value of the j^{th} binary digit, and

$$Z_{dec} = 1\times8+0\times4+0\times2+1\times1=9.$$

The various code combinations in the 2-4-2-1 and the 5-4-2-1 codes can be evaluated in a similar manner.

In an ordered code, the various combinations are assigned to the different decimal digits by means of a mathematical equation. An example of this is the XS-3 code. For this code

$$Z_{dec} = \sum_{j=1}^{j=4} W_j S_j - 3, \quad \text{where}$$

$W_4=8, W_3=4, W_2=2, W_1=1.$

Hence, the code combination 0100 = (0 × 8 + 1 × 4 + 0 × 2 + 0 × 1) − 3 = 1. The XS3 code is shown tabulated in Table 4.

Codes can be made error-detecting by the addition of extra bits, called parity bits. In Table 5(a) the 8-4-2-1 code has an additional bit in the column headed *p* which establishes odd parity in each code combination, i.e., each code combination contains an odd number of 1's. Similarly in Table 5(b) a parity bit has been added to the same code which, in this instance, establishes even parity for each code combination. Detection equipment is now required at the receiving end which, in the case of odd parity, is used to determine whether each code combination has an odd number of 1's.

Codes can also be made error-correcting by the addition of extra bits whose function is to detect an error and its position. The most important codes of this kind are the Hamming codes, in which the bit positions are numbered in sequence from left to right. Those positions numbered as a power of 2 are reserved for parity check bits, whilst the remaining positions are used for the information bits.

For a seven bit code combination:

$$\begin{matrix} 1 & 2 & 3 & 4 & 5 & 6 & 7 \\ p_1 & p_2 & x_3 & p_4 & x_5 & x_6 & x_7 \end{matrix}$$

p_1, p_2 and p_4 are the parity bits and x_3, x_5, x_6 and x_7 are the information bits. The parity bits are obtained from the information bits as follows:

p_1 is selected to establish even parity over bits 1,3, 5 and 7

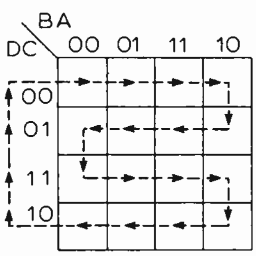
p_2 is selected to establish even parity over bits 2, 3, 6 and 7

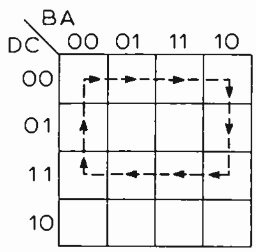
p_4 is selected to establish even parity over bits 4, 5, 6 and 7

The Hamming code combinations for the natural n.b.c.d. code are shown below in Table 6.

The correction process for this code is carried out on the assumption that only one bit is in error and that it is only necessary to locate that bit. This is achieved by checking for odd parity over the same three code combinations for which even parity was established at the transmitting end. The check is carried out with the aid of the exclusive-OR function.

For the exclusive-OR function $A \oplus B = \bar{A}B + A\bar{B}$ and hence





d	D	C	B	A
0	0	0	0	0
1	0	0	0	1
2	0	0	1	1
3	0	0	1	0
4	0	1	1	0
5	1	1	1	0
6	1	1	1	1
7	1	1	0	1
8	1	1	0	0
9	0	1	0	0

Fig. 1. Karnaugh plots of reflected binary (a) and Gray code (b). Tabulation of Gray code is at (c).

d	p_1	p_2	x_3	p_4	x_5	x_6	x_7
0	0	0	0	0	0	0	0
1	1	1	0	1	0	0	1
2	0	1	0	1	0	1	0
3	1	0	0	0	0	1	1
4	1	0	0	1	1	0	0
5	0	1	0	0	1	0	1
6	1	1	0	0	1	1	0
7	0	0	0	1	1	1	1
8	1	1	1	0	0	0	0
9	0	0	1	1	0	0	1

Table 6. Hamming combinations for n.b.c.d. code.

$$0 \oplus 0 = 0$$
$$0 \oplus 1 = 1$$
$$1 \oplus 0 = 1$$
$$1 \oplus 1 = 0$$

The above tabulation shows that the value of the exclusive-OR function is 1 when either A or B are 1, and is 0 when both A and B are either 0 or 1. In other words the value of the exclusive-OR function is 1 when odd parity exists.

The check functions are:

$$c_1 = p_1 \oplus x_3 \oplus x_5 \oplus x_7$$
$$c_2 = p_2 \oplus x_3 \oplus x_6 \oplus x_7$$
$$c_4 = p_4 \oplus x_5 \oplus x_6 \oplus x_7$$

If $c_1 = 1$ there must be an error in p_1, x_3, x_5 or x_7. The bit in error, E, may be obtained from the table below

c_4	0	0	0	0	1	1	1	1
c_2	0	0	1	1	0	0	1	1
c_1	0	1	0	1	0	1	0	1
E	0	1	2	3	4	5	6	7

For example, suppose the code combination received is 1101101. Then $c_1=1$, $c_2=0$ and $c_4=1$. Hence the 5^{th} bit is in error and the code combination should read 1101001.

Synchronous counters

The design steps for synchronous counters are (1) draw a state diagram, (2) code the states with the selected counting code, and (3) derive the input equations for the counter flip-flops.

Binary counters (maximum length). For the sake of consistency, variable A is assigned to the 2^0 bit, B to the 2^1 bit, C to the 2^2 bit and so on. In deriving the general form of maximum-length binary counters, use will be made of the fact that the addition of higher order counting stages does not affect the lower order counting stages. This, of course, is also the case in conventional decimal counts – for example, the "units" and "tens" of a car odometer change at the end of every one and ten miles travelled, irrespective of the number of stages in the odometer.

Scale-of-2 'up' counter. Figure 2(a) shows the state diagram and codes. The flip-flop equations are:

$S_A = S_0 = \bar{A}$, therefore, $J_A = 1$

$R_B = S_1 = A$, therefore, $K_A = 1$

The corresponding circuit is shown in Fig. 2(b)

Scale-of-4 'up' counter. $J_A = K_A = 1$, as for a scale-of-2 counter. The state diagram and codes are in Fig. 3(a). The flip-flop equations are:

$S_B = S_1 + (S_2) = AB$, therefore, $J_B = A$

$R_B = S_3 + (S_0) = AB$, therefore, $K_B = A$

The corresponding circuit is shown in Fig. 3(b).

Scale-of-8 'up' counter. $J_A = K_A = 1$ and $J_B = K_B = A$, as for the scale-of-4 counter. The state diagram and codes are in Fig. 4(a) and the flip-flop equations are;

$S_C = S_3 + (S_4) + (S_5 + (S_6) = AB\bar{C}$, therefore, $J_C = AB$

$R_C = S_7 + (S_0) + (S_1) + (S_2) = ABC$, therefore, $K_C = AB$

The corresponding circuit is shown in Fig. 4(b).

Scale-of-2ⁿ 'up' counter. By observation, the flip-flop equations are;

$J_A = K_A = 1$

$J_B = K_B = A$

$J_C = K_C = AB = BJ_B$

$J_D = K_D = ABC = CJ_C$

$J_E = K_E = ABCD = DJ_D$ and so on.

If speed is essential, large input gates must be used to implement directly the functions in the third column.

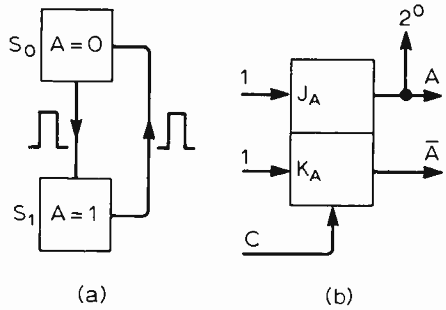


Fig. 2. State diagram for one-stage (scale-of-two) counter (a) and its circuit realization (b).

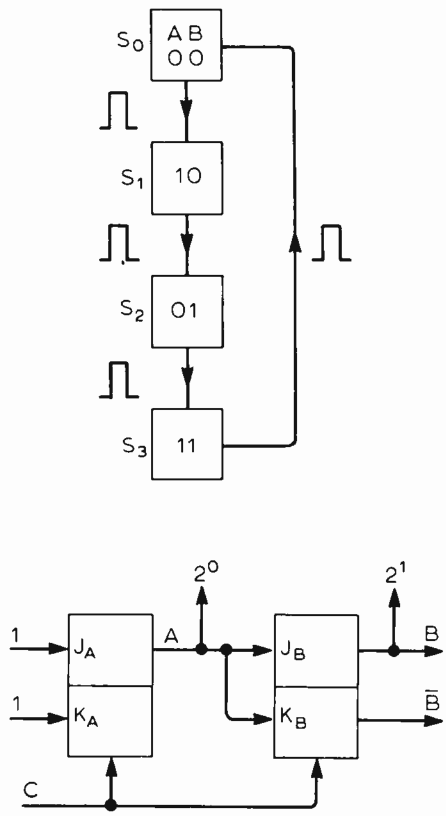


Fig. 3. Two-stage (scale-of-four) counter state diagram and codes (a) and circuit embodiment (b).

Synchronous 'down' binary counters (maximum length) can be designed in precisely the same manner and the following flip-flop equations are obtained.

$J_A = K_A = 1$

$J_B = K_B = \bar{A}$

$J_C = K_C = \bar{A}\bar{B} = \bar{B}J_B$

$J_D = K_D = \bar{A}\bar{B}\bar{C} = \bar{C}J_C$ and so on

Note that in the case of binary counters it is possible to use an 'up' counter to count down by utilizing the complementary flip-flop outputs as shown in Table 7.

d	C	B	A	d	$\bar{C}$	$\bar{B}$	$\bar{A}$
0	0	0	0	7	1	1	1
1	0	0	1	6	1	1	0
2	0	1	0	5	1	0	1
3	0	1	1	4	1	0	0
4	1	0	0	3	0	1	1
5	1	0	1	2	0	1	0
6	1	1	0	1	0	0	1
7	1	1	1	0	0	0	0

Table 7. Using the complementary outputs of a chain of flip-flops to count down.

The next part of this article will continue the treatment of counters, going on to discuss Gray code types, up-down counters and their control and ripple-through counters.

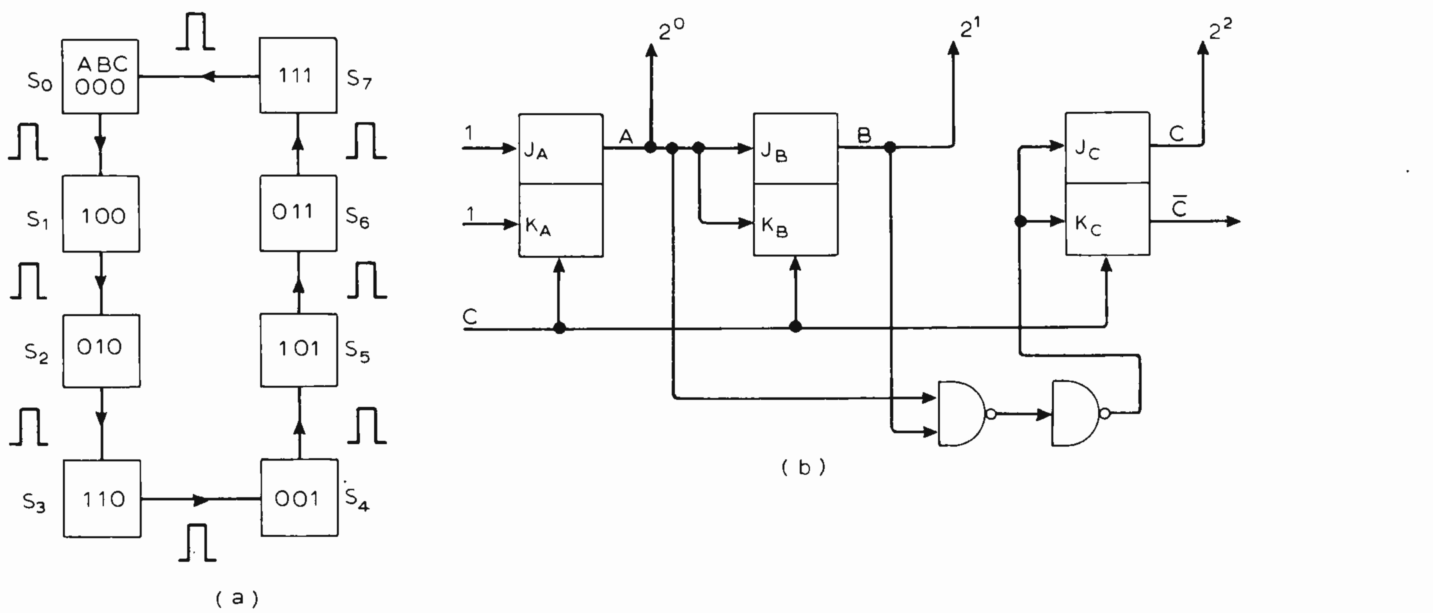


Fig. 4. State diagram (a) and circuit (b) of three-stage (scale-of-eight) counter.

Band II ferrite aerial unit

Eliminating the whip aerial used for v.h.f. reception in portable radio sets

by R. D. C. Thoday, M.I.E.R.E. *BBC Research Department*

V.H.F. radio transmissions provide a high quality service to listeners, but wide acceptance for more general listening[1] (for news, background music, etc.) has been discouraged by competition from l.f./m.f. portable receivers with built-in ferrite aerials. While the availability of portable receivers for v.h.f. has been improving steadily, one of the great disadvantages of present models is the whip aerial which must be extended and oriented for maximum signal each time the set is moved to a new location. It tends to be affected by hand capacitance and the proximity of conducting objects, so that an optimum position is not readily found. Moving the receiver with the aerial extended can also prove hazardous. Experimental v.h.f. receivers using ferrite aerials[2] have been built in the past but they do not appear to have been brought into general production because of the high cost of the ferrite materials employed.

A cheap ferrite material has recently become available which has good characteristics at v.h.f. and so opens up the possibility of built-in aerials for v.h.f. portables. A ferrite aerial unit has been built and added to a small inexpensive portable receiver.[1] Generally the performance, in terms of sensitivity, of the ferrite aerial has proved to be approximately equal to that of the whip aerial.

The rod employed is a nickel-zinc ferrite rod manufactured by Neosid Limited under the code number F29, which is 123mm long by 8mm diameter.* The initial permeability of the material is 12 and it has a small loss angle at 100MHz.

The arrangement of the aerial circuit is similar to that used for ferrite rod aerials in m.f. receivers. A tuned coil and a coupling coil are wound on the rod. Variable tuning is provided by means of a varicap diode. A f.e.t. pre-amplifier buffer stage is inserted between the coupling coil and the receiver input. The circuit diagram is shown in Fig. 1 and the layout of the unit on a printed circuit board is shown in Fig. 2.

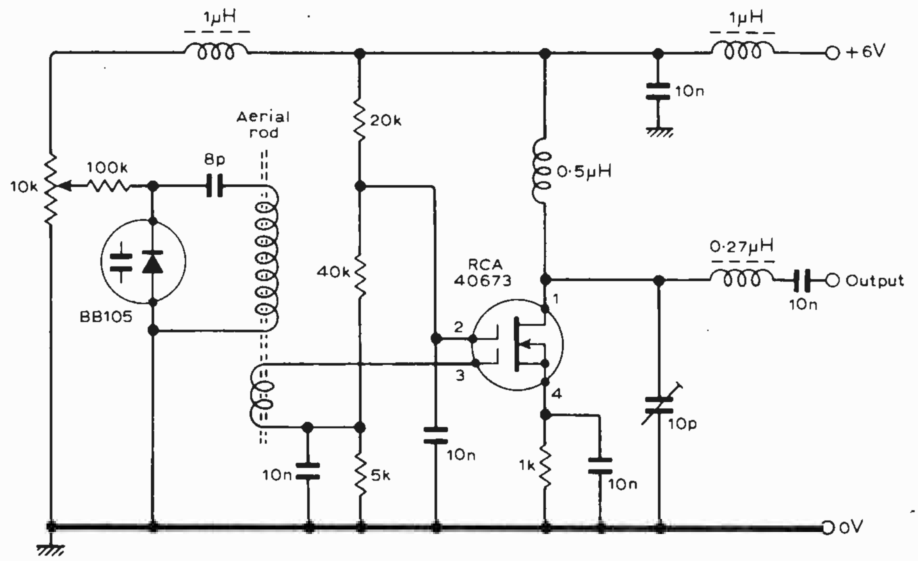
As the permeability of the rod is relatively low, the prime consideration for the aerial circuit design is maximum sensitivity. This is achieved by matching the transferred input resistance of the f.e.t. amplifier to the tuned circuit loss resistance. The signal developed at the input gate of the f.e.t. amplifier is then independent of the number of turns wound on the rod.

The choice of tuned circuit inductance was largely dependent on the capacitance range of the varicap diode when operated from the receiver battery supply (6V). Three turns of enamelled 26 s.w.g. wire wound on the rod give an inductance of 0.35μH with a circuit magnification factor (Q) of 195 measured at 50MHz. The tuned-circuit Q is also dependent on the capacitor losses. The maximum series loss resistance for the varicap diode is quoted by the manufacturers at 0.8Ω, giving an unloaded Q of 110 for the combination of these components. The effective Q under matched conditions is half of this value. In the above considerations the radiation resistance has been neglected since it is small compared with the circuit loss resistance. The input admittance of the f.e.t. amplifier is approximately $(0.3 + j3.5)$mS. The mutual inductance between the tuned and coupling coils on the ferrite rod required to match the resistive component of the primary and secondary circuits is 0.12μH. A coupling coil of two turns has been used and the separation between the two coils has been adjusted to achieve this. Initial adjustments were made using an inductance bridge but the final adjustments were made on the assembled unit to give maximum sensitivity.

A simple circuit is used to transform the receiver input impedance to a suitable load value for the f.e.t. amplifier. The measured voltage gain of the amplifier when terminated in a 50Ω load is 5dB.

The calculated ratio between the output of the ferrite rod aerial unit and that of a λ/2 dipole is −11dB. Little improvement can be made to the sensitivity of the unit by increasing the length/diameter ratio of the rod or by increasing the number of turns on the rod.

Fig. 1. Circuit diagram of the ferrite aerial unit.



*The use of these rods for v.h.f. aerials for broadcast receivers was originally suggested by P. A. Tingey of BBC Designs Department.

Incorporation in the receiver

The aerial unit has been substituted for the whip aerial in a small domestic portable receiver. The receiver tuning is performed with a mechanically variable capacitor that is unsuited for direct coupling to the aerial unit tuning control. Purely for experimental purposes a separate potentiometer tuning control has been used, and a meter, indicating the receiver a.g.c. level, has been added so that the user can tune the aerial unit for maximum signal and correct r.f. alignment. In a properly designed receiver the use of varicap diodes for all circuits can provide ganged tuning in a simple way, and no tuning complication arises.

At present nearly all European v.h.f. transmitters radiate† a horizontal electric field component; although it may be weaker than the vertical field component near the ground for the few stations which radiate a vertical component additionally (slant, circular or mixed polarizations), the horizontal field component is always present. The ferrite rod has therefore been set with its axis vertical to give maximum signal pick-up for horizontally polarised signals.

An idea of the receiver performance with the ferrite rod unit can be obtained from Fig 3. This shows the measured signal-to-noise radio with the receiver placed in a known field strength. (The measurements were unweighted in the band 0-15kHz when the reference signal was a 400Hz tone at 22.5kHz peak deviation.)

The performance at low signal strengths is limited by the noise generated in the tuned circuit loss resistance. Calculation shows that the Johnson noise voltage equals the available signal when the field strength is 20μV/m. The performance of the receiver with the ferrite rod aerial was similar to that when used with its own whip aerial. This may seem somewhat surprising in view of the estimated ratio between the output of the ferrite unit and a λ/2 dipole output, but it can probably be attributed to the fact that the whip aerial will not be very efficient when untuned, using a small chassis as a counterpoise.

Although the main reason for this work has been to eliminate the whip aerial from the receiver, it is possible that it should be retained and positioned in the receiver near the ferrite rod, so that under difficult reception conditions it can be extended and oriented to enhance the signal induced in the ferrite rod.

Some further development would be necessary to incorporate a simple control, tuning both aerial unit and the receiver together. For receivers using varicap diode tuning throughout this should not be unduly difficult.

It is hoped that this idea will be taken up and developed by industry as a means of providing a vital improvement in portable receivers that could help to increase the popularity of listening on v.h.f.

†The main exception is Radio Telefis Eireann of Eire which makes systematic use of vertical polarization. In the United Kingdom, one low power local radio relay station serving parts of Derby also radiates with vertical polarization only.

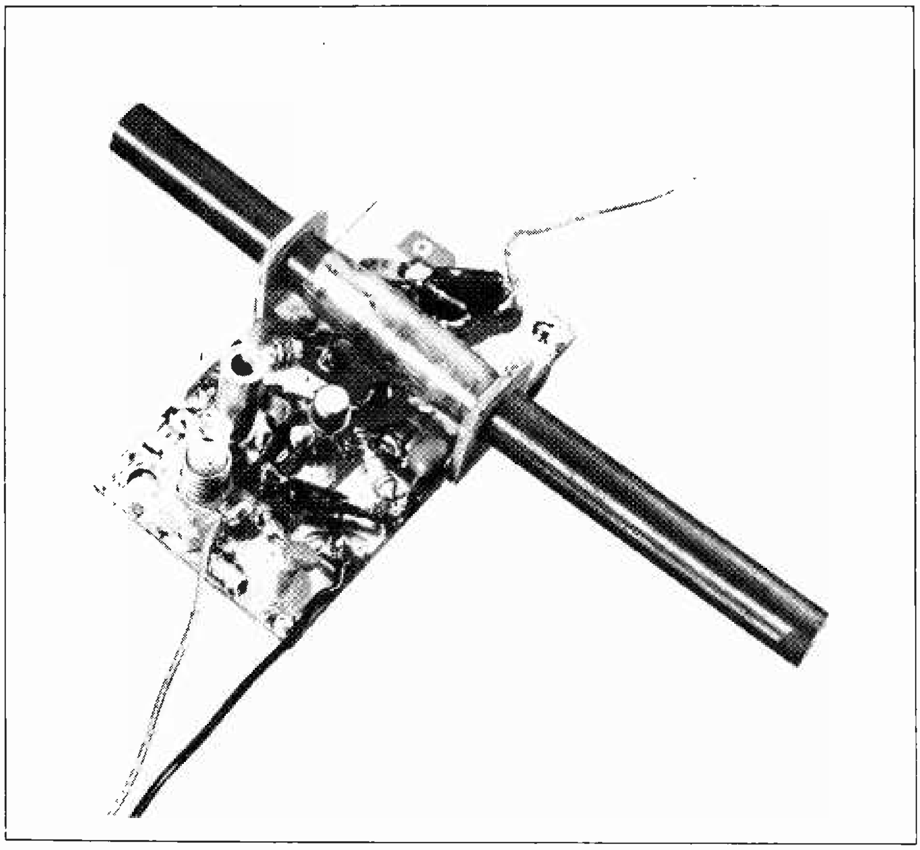


Fig. 2. The complete ferrite aerial unit mounted on a printed circuit board.

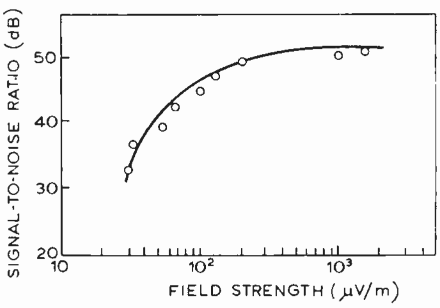


Fig. 3. Receiver signal-to-noise output vs. field strength level.

Acknowledgements

The author thanks the Director of Engineering of the BBC for permission to publish this article.

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2. Schieffer, C. A small Ferroxcube aerial for v.h.f. reception. *Philips Technical Review*, vol. 24, 1962/3, pp. 332-336.

Books Received

Problems and Solutions in Logic Design, by D. Zissos, is the source book for our current series of articles on logic design. The book is written with the needs of teachers and students in mind, but is also for engineers looking for a reliable and economical method of design. No engineering or other specialized knowledge is assumed: the procedure is simply set out as (a) draw a flow-chart, (b) derive logic equations and (c) draw the circuit. A potential reader will be considerably heartened by the author's statement in the preface that "all our circuits work!" The book is published by the Oxford University Press at £1.75 in paperback form. A hardback version is available.

Television Video Transmission Measurements, Published by Marconi Instruments and written by the former head of the BBC Measurements Systems Laboratory, this book is firmly based on much practical experience. Techniques described are not given a gloss of perfection and difficult areas glossed over; where problems exist, they are discussed. Essentially, this is a practical treatment of video measurements.

A description of the manner in which picture quality can be assessed is followed by a chapter on the measurement of signal level. Distortion in the signal path and noise are well covered, as are the effects and measurement of return loss. The use of insertion test signals is discussed, with descriptions of national and international test signals and methods of measurement. The effects of distortion contributions from all the elements in a PAL transmission path are estimated in an appendix and there is a reference list of picture impairments. Department 345, Marconi Instruments Ltd, Longacres, St Albans, Herts, pp.113, £7.50.

News of the Month

Computer links for the battlefield

The Ministry of Defence is evaluating what is claimed to be the first effective computerised field command and control system. Changes in command and field dispositions now relayed by secure telephone links will, when the system becomes operational, be disseminated automatically from terminals at corps and divisional headquarters, forward positions and step-up units to all other points in the network.

The contract for the pilot scheme, which will end with user trials by the British Army of the Rhine early next year, is worth £2 million to the radar division of Plessey Electronic Systems. The original requirement for Wavell, as the automatic data processing project is code-named, was accepted by the Army Combat Development Committee in 1975 and, if the field trials prove successful, the system is expected to come into service in the early 1980s. Preliminary studies took place as long ago as 1970.

At the moment much of the time of staffs at each level of command involves logging, sifting, collating, recording and passing on information over the Bruin telephone network. Bruin is a secure six channel trunk network capable of a total t.d.m. data rate of 250kbit/s. The army estimate that over half of the divisional operational staff time on the Bruin system is spent disseminating, confirming and handling location information, and although Wavell will be used in the future for a much greater range of data, as a first step its use will be confined to sending location information automatically according to predetermined instructions. Eventually the computer will up-date maps automatically.

Bruin has been in operation since 1967 and, according to one army source, is currently "chock-a-block". A lot of calls are made to check that the system itself is working, so that although one of the channels has to be made switchable to Wavell, the elimination of such system-checking calls, together with the availability of the other five channels, should reduce the traffic load on the system. The army say the combined communications system will be more efficient, increasing the speed of dissemination to match the greater mobility of troops and enabling staff to deal with the greater volume of information both from normal sources and those they refer to mysteriously as "improved surveillance techniques". Bruin is nearing the end of its useful life and will be replaced eventually with Ptarmigan, which will be built around the Plessey PP250 processor.

The difficulties of using computers in the battlefield before have centred around the hostile conditions in which they have to work. Besides the problems caused by throwing or building normally delicate disc hardware into trucks and jeeps, they have to be able to operate in high temperature and humidity, and to respond even when used by soldiers under battle stress. They must be demountable, for use in barns and so on, and must tolerate poor power supplies. Yet withal the army's policy is to buy readily-available commercial equipment, use it, and develop it as the system becomes more familiar. They argue that this is more cost-effective.

This does have a bonus for the suppliers in that it avoids their having to make specials for the MoD and provides, or should do, a product which can be readily sold abroad. In this case the army is helping Plessey to find markets abroad, particularly since a Nato project on a joint communications system collapsed some years ago and the Americans have not so far produced their battlefield automatic data processing system. Wavell is already being looked at "very carefully" by our Nato allies, say Plessey, "and we hope it's to be adopted as a Nato standard." It could easily be changed to meet the needs of other armies; each potential customer's application "would be treated on its merits".

Swindon cable station near closing

Unless "substantial" funds are forthcoming in the near future, Swindon Viewpoint, one of the only two remaining cable tv stations, will close by the end of September. A statement issued after a board meeting on July 1 said that the station was short by £7,500 of £23,500 promised to the station, including £2,000 from Thamesdown Borough Council. Much of the pledged cash depended on Swindon reaching its £65,500 complete operating budget. "It is possible," said the statement, "that further finance may come from the voluntary services unit of the Home Office, and from the Gulbenkian Foundation – and further, in a full year Swindon Viewpoint can earn about £6,000 from advertising, hire of facilities and video programmes for industry." A year ago Swindon Viewpoint said they could definitely continue for three more years. (*WW*, October 76, p.44).

CEI inquiry to be "experimental"

Sir Monty Finniston is to chair a Committee of Inquiry into the engineering profession, the Industry Secretary, Mr Eric Varley, announced in the House of Commons on July 5. The terms of reference are to review, in the light of national economic needs: the requirements of British manufacturing industry for professional and technician engineers, the extent to which those needs are being met, and the use industry makes of engineers; the role of the engineering institutions in relation to the education and qualification of professional and technician engineers; the advantages and disadvantages of statutory registration and licensing of UK engineers; and the arrangements in other countries, particularly the EEC, for handling these problems.

The terms of reference are very similar to those suggested to Mr Varley in a joint letter from the IEE and IMechE at the end of January, though there is not a specific reference to the CEI. (See *WW* April 77, p.53 and June 77, p.39).

Mr Varley's statement in the Commons was in response to a question from Mr Arthur Palmer, chairman of the Commons Select Committee on Science and Technology, who has led the fight to get an inquiry set up. Mr Palmer, who represents the Electrical, Electronic, Telecommunication & Plumbing union, told *Wireless World*: "The terms of reference are broadly as I suggested. As I see it this is an inquiry into the electrical engineering profession, the part it should play in the life of the nation, and engineers' status – their pay will come into it because I don't see how you can avoid it – and the particular problems of engineers." He thought there should be statutory registration of engineers since, at the moment, an engineer could cease to be chartered if he forgot to pay an annual subscription to one of the institutions. The registration of engineers would overcome that, and an engineer would be free to join an institution if he wanted.

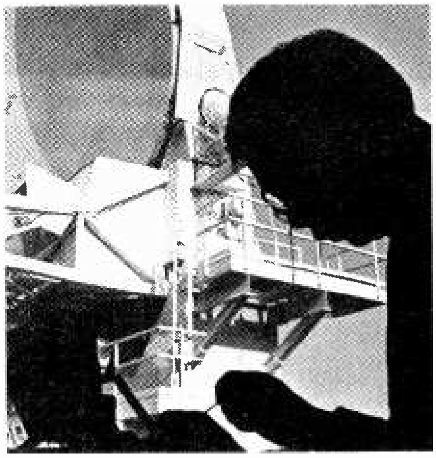
Some confusion has been caused by the inclusion of the words "to review for manufacturing industry". Sir Monty Finniston told *Wireless World*, however, that the phrase was used because manufacturing was an essential element in the industrial strategy, as well as "the major base from which the economy would develop." The scope of the enquiry had to be limited: "You would need infinite time if you were to examine everything."

Asked what he thought the inquiry,

which he hopes will report to the Industry Secretary by the end of 1978, would achieve, Sir Monty said: "Engineers are a very important and essential element of the industrial strategy by which the country hopes to regenerate its industrial life and its economy. I hope engineers will be reorganised so that they will be able to meet the demands made on them in the future. I hope they will gain a more collective voice in their own fields of interest, a new sense of status, and a greater sense of responsibility, and accountability, to the community at large as well as the industrial community."

It would be conducted openly, receiving written submissions and interviewing individuals, groups and institutions. "I also want to try some experiments, things that haven't been tried before at these inquiries." He could not say what they were until they had been agreed elsewhere.

"We are a nation of engineers . . . We are experts if only we could organise ourselves to give of our best. The profession has been denigrated, but the British engineer is a man of high quality and should be regarded as such. But he has got to work for it."



A Bell Labs scientist silhouetted against Bell's new millimetre-wave aerial. This sensitive radio antenna is being used, according to Bell, to study "the highest frequency signals ever continuously beamed down to earth from orbiting satellites." The experiments will help tell if these higher frequency signals, from two satellites transmitting at 19 and 28GHz, could be used reliably for future satellite systems. A third satellite will join them in May next year.

Remote software

As teletext decoders become more widespread an increasing number of people are seeking to use them other than to receive ORACLE or CEEFAX. One very interesting idea (*writes John Hedger of the Independent Television Companies Association*) is called Telesoftware, or "software at a distance". The technique enables the transmission of computer programs in object code form via teletext. The program, which is transmitted using normal teletext characters, is stored after receipt in the decoder RAM. This memory can be accessed by a microprocessor, so forming quite a powerful stand-alone computer: the teletext keypad provides input and commands and the television screen becomes a video display unit. The applications of the microprocessor are limited only by the range of software transmitted and, of course, its own processing capacity.

With a number of decoder manufacturers already basing their decoders on a microprocessor, Telesoftware could be an inexpensive yet efficient way of extending the uses of an expensive item, provided, of course, the broadcasters agree to transmit the software.

ITCA made some experimental software transmissions using ORACLE in February. They consisted of a simple demonstration program and a bootstrap loader written in the instruction set of the 2650 microprocessor. The software was written by Telesoftware's inventor, Will Overington, who sees a big future in it.

He would eventually like to see Telesoftware being broadcast by ATS6-style satellite to developing countries where its computing power could be used in community groups for such purposes as computing sterilisation processes for community food canneries. A special feature of the design is the ability to condition a standard terminal to display information in languages using non-roman character founts by means of software.

But perhaps the most marketable use for Telesoftware might be in video games. With the present boom in sales of these plug-in tv extras, a manufacturer in the USA has already developed a programmable version of video games. In this device, ROMs containing the programmes for individual games are housed in plastic cassettes, which are simply inserted into the machine. However, these ROMs are expensive to produce and a much cheaper alternative would be to send the program for the game via teletext. In this way broadcasters could send a variety of games, changing them each week. They could even transmit a weekly chess problem into the heart of the games unit.

IBA 3-channel surround sound "milestone"

IBA engineers have made a significant step forward in demonstrating the feasibility of a surround-sound broadcast system using a narrow-band third channel. They have shown that the bandwidth of a third channel in the NRDC 45J system can be reduced to around 2kHz without significant loss in surround-sound realism. Tests on an initial batch of 20 stereo receivers showed that distortion due to addition of a 2kHz quadrature-phased third signal about the subcarrier frequency is not noticeable on program when its level is reduced to −7dB (though it is noticeable with pure-tone signals). "We are now able to see where we are going in the future" said T. S. Robson, deputy director of engineering, at a press open day. "We have reached a milestone point in surround-sound."

Sufficient theoretical and laboratory work has been done in the last year or so at the IBA Engineering Centre, Winchester, that it is now possible to formulate a tentative proposal for a surround broadcast system based on a two-channel coding similar to H or 45J but with a third channel of narrow bandwidth added in quadrature to the difference signal in the manner of 45JT proposals. Even if a two-channel system were to be adopted initially, the IBA view is that it should be capable of expansion into such a "2½"-channel type of system. IBA engineers say that the "undoubted merits of the 45J system must not be neglected" whilst pointing out that it is highly desirable that the same system should be used widely, not only by broadcasters but also by the recording companies.

Before a formal proposal can be formulated and put to interested parties it is necessary to "optimize the compromise" according to F. H. Wise, head of network and service planning and IBA representative on EBU Working Party 'S'. For, although a lot has been learned in the last few years and enough is probably known about the compromises to be made in two-channel systems, 2½-channel systems now appear to be feasible and it is necessary to take stock and think again. IBA engineer Ian Collins says, "45J is somewhere near optimum but some refinement is probably desirable" – extra work on stereo compatibility is planned if the Authority decide to continue work in this area. "We'd like to see some further tests, later this year, to explore what the (centre front) phase angle should be," Fred Wise told *Wireless World* and he feels it likely to be in the region of 35 to 40°. Further work would also test more models of stereo receiver and the effects of reducing the bandwidth of the third channel to 1.5kHz, and would include a comprehensive series of pilot transmissions in various formats, probably making use of the two London v.h.f. transmitters.

There is a marked difference of opinion between the BBC and IBA over the feasibility of a three-channel system. The BBC have consistently set themselves against the idea, claiming that it would produce an unacceptable worsening of signal-to-noise ratio. They used a wider bandwidth, but never published their evidence, and it was not clear how detailed were their investigations into effects of bandwidth restriction. "We're not convinced of the interpretation of results of the BBC's three-channel studies" commented one engineer. For a 2kHz third-channel bandwidth, at a level of −10dB, the loss in signal-to-noise-ratio , for stereo reception is 0.2dB (worst case azimuth), according to IBA calculations, and the resultant loss of service area would be insignificant. This rises to 0.5dB at −6dB level for 2kHz bandwidth, the figure quoted in our February story (page 43) and which a BBC spokesman subsequently rejected. Signal-to-noise ratio for 2½-channel reception relative to that for stereo would be −4.4dB unweighted, or −1.4dB C.C.I.R.-weighted (worst case azimuth).

One advantage of the J system in practice is that the effect of cross modulation in the receiver would be a symmetric reduction of stereo stage width, which would be difficult to detect. Other codings would give rise to an asymmetric effect called image "slewing" which would be more noticeable.

Call for British FCC

Most communication users and manufacturers in the UK "feel that the administration and control of frequencies, which is under the political control of the Home Office and the Home Secretary, is unsatisfactory," according to Air Call Ltd, who supply car telephone answering services. In a statement commenting on the Annan Committee's report on broadcasting, Air Call says "Small or independent users cannot do anything to put right the many things that are wrong with the control of frequencies. For instance, radio links fill up the mobile bands, defence and marine allocations are much greater than required, channel widths vary and agencies such as the BBC and the police use frequencies incorrectly allocated or commandeered in the wrong parts of the spectrum." It was an advantage of the independent agency, as exemplified by the FCC in Washington, that "all the hearings are in public and 'John Citizen' is supreme instead of having a hidden political man in charge who may be motivated by reasons that are quite outside the public interest".

Air Call suggest the setting up of a Royal Communications Commission which would not have any control over the broadcasting authorities but would be responsible only for the regulation of frequencies, channel usage, interference and so on.

"We want the same sort of legal processes as the FCC . . . It is extremely undesirable that the Minister in the form of the Home Office should be going to the next world conference on frequency allocation without the real power and responsibility for talking for the whole nation. What we require is a non-political, permanent body which can speak for Britain in this conference."

Carter: "End the PO monopoly"

The Post Office has fallen well behind other countries, particularly America, in taking advantage of new telecommunications technology and should, if necessary, buy a foreign stored programme control design to add to TXE4, says the Carter committee on the Post Office. The cost of supplying the telecommunications service is higher than it should be, says the committee, partly because Britain has fallen behind in the installation of economically maintained systems.

The committee visited the United States and report that the stored programme control network in use there since last year has reduced maintenance by half, doubled the productivity of the remaining staff because of centralised maintenance, reduced installation cost and time, decreased capital costs dramatically, improved traffic measurement and management information, and eased the sending of more accurate bills. As a result, Bell Telephones have been able to reduce surplus capacity to a minimum, and introduced a number of new services to customers.

By contrast, although there have been two experimental s.p.c. exchanges, not one is in regular use in the British Post Office network. "The Post Office has told us that the development of s.p.c. for the new exchange TXE4 was considered in the late 1960s but rejected because the estimated cost and the risk of delay associated with its development were too high. However right that decision appeared at the time, the unmistakable consequence is that the Post Office and the British telecommunications industry have no operationally proven s.p.c. system available either for use at home or for export, whilst their main competitors abroad have this desirable product available and are five or six years ahead of them in the world league. This may not seem a serious matter to the Post Office, because TXE4 may satisfy its operational requirements for some years to come, nor are the advantages forgone readily apparent to its captive customers. It is, however, a very serious matter for the prosperity of the major suppliers in the United Kingdom and for British exports of telecommunications equipment."

The committee adds that regardless of the improvement offered by TXE4A "without *full* s.p.c. we will be building a considerable long term disadvantage into the telephone system . . ." The question should be re-examined and the possibility of introducing a proven design of full s.p.c. through licensing from a foreign manufacturer considered.

The committee found the management of the System X project "a major cause for worry." When, in six years' time, the first generation of the new technology appears in the UK, it will have to compete with the second generation of foreign control equipment. (See "Telephones and new technology," p.71.)

Above all, the project must be completed on time, yet the Post Office appears to feel no urgency about developing System X, "indeed the Post Office has yet to make any firm commitment to its eventual purchase." Added to that uncertainty, the required close co-operation between all three suppliers and the Corporation is inhibited by mutual suspicion among the suppliers and bureaucracy at the Post Office: "This project is falling behind schedule, retarded by a complex apparatus of committees and discussions."

On the Post Office equipment monopoly the committee says: "Experience in the United States of America seems to have shown that it is feasible to establish workable rules and conditions for subscribers to connect their own terminal equipment to the telephone lines without endangering the network . . . We are therefore not convinced that the balance of advantage to the community favours the continuation of the present monopoly situation in the United Kingdom." They recommend a trial of privately supplied equipment but at first of only one type of apparatus, such as a small private automatic branch exchange.

●●●

New energy adviser: Sir Hermann Bondi, Defence Ministry chief scientist, has moved to the Energy Department. The July 28 announcement follows the abrupt departure of Dr Walter Marshall from Energy a month earlier, partly because of a conflict of interest. (*WW*, Dec 76, p.76). According to the Energy Department, Secretary Tony Benn wanted a full time chief scientist – Marshall had been only part-time – and it is believed Benn could not have promoted him to the post without presenting a public rebuff to Marshall's boss at the United Kingdom Atomic Energy Authority, Sir John Hill, who advises the department on nuclear matters.

Using a microprocessor

2 — Hardware and programming

by J. Skinner, *Leafields Engineering Ltd*

At the end of the first part of the article, the flow chart had been derived. Consquently, the designer is now able to develop the programme and translate his thoughts into hardware.

Programming

In the completed programme, each instruction is denoted by a mnemonic and a binary machine-code word. The binary coding is used by the microprocessor and programmed instructions must end up in this form, but the procession of ones and zeros is not the easiest way to see what is happening. It is common, therefore, to use the mnemonic form of the instruction for juggling about with a programme and to convert it into machine code later, with the aid of the instruction-set table. Assembler programmes will, when run on a microprocessor, convert mnemonic codes into machine codes. The abbreviated instruction set for the 8080 is shown in Table I.

Points to bear in mind when tackling the programme include the way in which each instruction is handled by the c.p.u. Two or three bytes are needed to carry out each instruction and this fact must be taken into account to preserve the logical sequence. The programme is held in memory in a sequence in which the step number is the actual memory address, so that the order of addressing the memory by the c.p.u. is vital.

Table 1. *Abbreviated instruction set for the 8080, showing only those instructions used in the programme discussed.*

Mnemonic	Machine code	Machine code (hex)	Function
MVI, A	00111110	3E	Load accumulator
OUT	11010011	D3	Output
E1	11111011	FB	Enable interrupt
HLT	01110110	76	Halt
MVI, D	00010110	16	Store in register D
MOVA, D	01111010	7A	Move data from register D to accumulator (A)
IN	11011011	DB	Input
ANI	11100110	E6	AND with data in accumulator immediately
FO	11110000	FO	Bits generated to perform AND function in text of article Not part of instruction set
RRC	00001111	OF	Shift accumulator right
CMPL	10111101	BD	Compare the content of L with content of accumulator
JM	11111010	FA	Jump if result of last operation is minus quantity
DCRD	00010101	15	Decrement or count down content of register D
JNC	11010010	D2	If the relevant "flag" is zero, jump (Jump on no carry)
DI	11110011	F3	Disable interrupt
JMP	11000011	C3	Jump to assigned address unconditionally

Register code	Register letter
000	B
001	C
010	D
011	E
100	H
101	L
110	Memory
111	Accumulator

I/O. The simplest way of selecting the I/O block required for a particular function is to use binary code (1, 2, 4, 8, 16, etc.) which can be produced automatically by the c.p.u. This binary code can be read into the c.p.u. in the ordinary way as data and transferred to the address lines when needed. In this way, each address line calls up a separate I/O block, as in Fig. 4 of part 1.

Jump instructions. Instructions which call for the programme to jump consist of three bytes, the second and third of which are the least significant and most significant bits respectively of the address to which the programme is to jump.

Rotation. The data held in the accumulator can be shifted to the right or left. As it moves out of the register, the data will be lost unless it is fed back to the beginning, in which case eight shifts will return an 8-bit register to its ordinary state. This process is termed "rotation" for obvious reasons. A bit shifted out of the register can be tested for a value of 1 or 0 and a condition "flag" signal set or reset. For example, at address 52 (34 in hexadecimal or 00110100 in binary) the contents of the control valve register E have been transferred to the accumulator, rotated right and transferred back to E. If the flag bit is zero, the programme is to jump to the next control line address.

Initializing. It may be necessary, as in this programme, to see that the output ports are in the correct condition, since the reset function of the 8080 (wired) is only concerned with the programme counter; c.p.u. registers must be set to their initial conditions. Immediately on switching on, therefore, the accumulator and valve controls are set to zero. Since the programme has now started, it must be halted and an interrupt start signal awaited for the main part of the programme to continue.

Coding. It is common to translate the pure binary of the machine code into hexadecimal for ease of handling. The code is shown in Table 2 for those who are unfamiliar with it. For example,

Table 2. *Decimal, binary and hexadecimal equivalents.*

decimal	binary	hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

using the eight-bit word of the 8080, the instruction to read in data is 'IN' (mnemonic), 11011011 (binary), DB (hexadecimal).

Programme. The final form of the programme is seen in Table 3, in which the hex. code is used for the programme address and machine-language instructions, for which mnemonics are also given. Incidentally, the division of the eight-bit machine code into two four-bit words, each being given a hex. code, does not mean that this is how the code is made up. In the MOV instructions, for example, the first two bits are always 01, followed by two, three-bit addresses for destination and source of the data to be moved. Register B has the code 000 and register D is coded 010; as in Table 2, so that the instruction "Move the contents of register B to register D" would be coded 01 010 000, which can be grouped 0101 0000, translating into hex. code as 50.

Table 3. *Complete programme*

Address (Hx)	Mach. Code (Hx)	Mnemonic	Function
0	3E	MVI. A	Set accum
1	00	0	=0
2	D3	OUT	Output 'O' to valve controls
3	08	8	(I/O block address=8)
4	FB	EI	Enable interrupt
5	76	HLT	Halt (and await interrupt start signal)
6	D3	OUT	Output 'O' to card select column and complete flag
7	10	16	(I/O block address=16)
8	16	MVI. D	Store number of card columns to be read in register 'D'
9	07	7	(0 to 7)
A	1E	MVI. E	Store number of valves to be processed in register E
B	80	80H	(0 to 7 in binary)
C	7A	MOVA. D	transfer from register D to select
D	D3	OUT	next card column
E	10	16	I/O address
F	DB	IN	Fetch card m s.b. data from
10	01	1	I/O address 1
11	67	MOVH. A	Store card m.s.b. data in register 'H'
12	DB	IN	Fetch card l.s.b. data and d.v.m. l.s.b. data
13	02	2	from I/O address 2
14	E6	ANI	Blank off d.v.m. l.s.b. (This is the AND function
15	FO	FO	referred to in part 1 of the article.)
16	OF	RRC	
17	OF	RRC	Shift right 4 times
18	OF	RRC	
19	OF	RRC	
1A	6F	MOVL. A	Store card l.s b. data in register 'L'
1B	7B	MOVA. E	Transfer data from register E to
1C	D3	OUT	select next valve
1D	08	8	I/O address
1E	DB	IN	Fetch card l.s.b. and d.v.m. l.s.b. data
1F	02	2	from I/O address 2
20	E6	ANI	Blank off card l s b (The AND function)
21	OF	OF	
22	BD	CMPL	Subtract card l s.b. from d v.m l s.b
23	FA	JM	Return to Fetch if result negative
24	1E		l s.b jump address
25	00		m s.b. jump address
26	DB	IN	Fetch d.v.m. m.s.b. data
27	04	4	I/O address 4
28	BC	CMPH	Subtract card m s b from d v m m.s b
29	FA	JM	Return to fetch if result negative
2A	26		l s b. jump address
2B	00		m.s.b. jump address
2C	3E	MVI. A	Set accum. to
2D	00	0	='O'
2E	D3	OUT	Output '0' to control valves
2F	08	8	I/O address
30	15	DCRD	Count down card column select register
31	7B	MVA. E	
32	OF	RRC	Count down control valve select register
33	5F	MOVE. A	
34	02	JNC	If flag is zero, return and select next
35	7A	C	control line l s b. jump address
36	00		m s b jump address
37	3E	MVI A	
38	08	8H	Output signal to 'complete flag
39	D3	OUT	
3A	10	16	
3B	F3	DI	Disable interrupt
3C	CB	JMP	Return to start
3D	00		l s.b. jump address
3E	00		m s.b jump address

Use of r.a.m. Where the data storage provided in c.p.u. is not sufficient, extra capacity in the form of r.a.m. may be included, as shown in Fig. 1. The memory element is coupled to address data-bus lines in exactly the same way as the r.o.m. and I/O elements, but an additional control function has to be provided in order to distinguish between the r.o.m. amd r.a.m. elements in the read mode. Usually, there are spare address lines available and these can be used to control the memory elements via the chip-select (CS) function provided. Thus if A0-A7 are used for normal addressing for 8-bit, 256-word r.o.m. and r.a.m. A8 can be used to supply CS for r.a.m. For the r.o.m. it is necessary to invert A8 and gate with memory read (MR). Instructions involving r.a.m. must then include an address code starting at 2`. A similar technique starting at higher addresses may be used where a larger r.o.m. is required. If insufficient address lines are available for this technique to be used, address decoding must be used, following the same general philosophy.

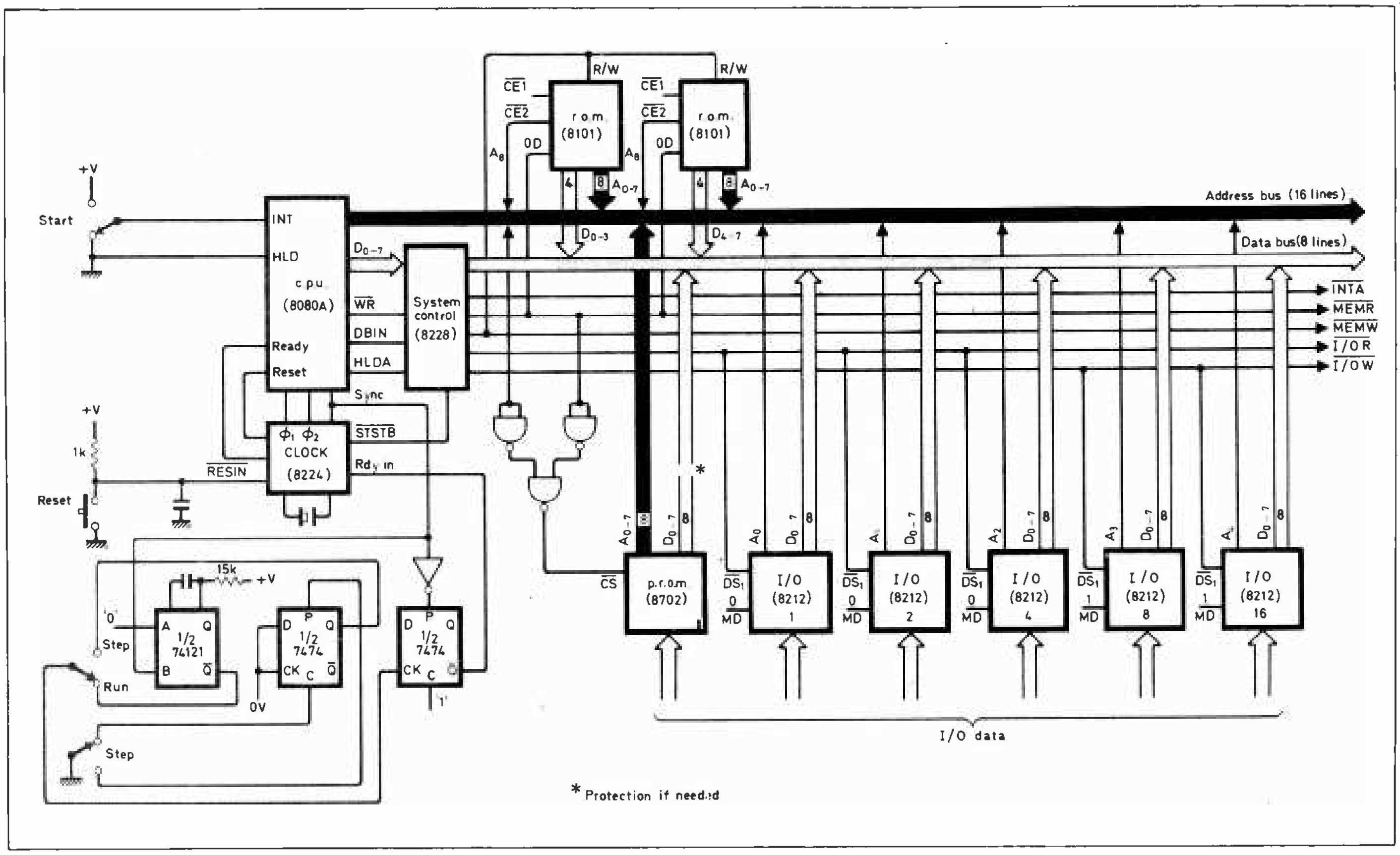
A technique known as "memory mapping" is described in the INTEL users manual. This technique treats the I/O elements as part of the memory array, selection being via the appropriate address code. This has the advantage of allowing direct transfer of data between I/O and registers of memory, without data having to be routed through the accumulator.

Hardware.
The complete system, used for developing and proving the programme described above, is shown in Fig. 1, with a glossary in Table 4. Although r.a.m. was not required for this application, it has been included so as to be available for future use. This configuration will, we hope, prove to be universal. There are several proprietary m.p.u. systems now available in p.c. form, although none has yet been seen with the I/O structure as described in this article, most of the products being best suited to data-transmission applications. It is appreciated that most of the interface elements, such as the universal, asynchronous, receiver-transmitter (u.a.r.t.) and programmable peripheral interface (p.p.i.) could be used in the system of Fig. 1; but they are unnessarily complicated and more expensive that the simple device described (actually, little more than an 8-bit latch). Most of the system components have already been described but some additional comments may be helpful.

System control. This is a single element provided by Intel for decoding and synchronizing the control bus. A bi-directional data bus driver is included, as is isolation of memory and I/O controls.

I/O. The Intel 8212 element is used, as mentioned above, for sheer simplicity. It is basically an 8-bit latch with 3-state output for bus operation. A mode control enables either input or output function to be selected. In the system of Fig. 1, this is determined by a wired link, but could also be programmed by the c.p.u. Interrupt and clear facilities are provided, these not being required in this application.

R.a.m. 8 bits × 256 words of storage are provided in the form of 2, 4-bit, 256-word elements. The two sets of four data bits appear side by side to form the 8-bit data word. Addresses are common to both elements. Gating for r.a.m./r.o.m. selection is provided by a single 7400.



P.r.o.m. An 8 × 256-bit p.r.o.m. is shown, whose size can easily be increased, since there are spare address lines available. A r.a.m. was used for this function during development, a plug-in version simulating the 8702 p.r.o.m. being purchased. This could be constructed very easily and cheaply but, since we were more interested in developing the m.p.u. technique than developing a r.o.m. simulator, we decided to buy one. The simulator is provided with hex. coded programme and address thumbwheels and binary display of the data which, apart from its usefulness for programming, we found useful during programme check out.

R.a.m. and r.o.m. speed. The 8080 c.p.u. is designed to operate with memory components having an access time of approximately 450-550ns, although times of up to 850ns are suggested as being suitable. Cost is, of course, related to speed and many users will wish to use the slower devices — the 8702 for example has a maximum access time of 1.3μs. Provision for slower devices can be made by controlling the "ready" input to the c.p.u. (the clock controller in this example). One or more clock periods are used to provide a "wait" state suited to the access time of the memory system used. The two functions of 850ns memory access and single-step drive are incorporated in the complete system of Fig. 1.

De-bugging. Faults are of two kinds — hardware and software. Monitoring the data lines enables the programme sequence to be verified, and address-line monitoring can also be useful, while buffered l.e.ds plugged into a spare socket or even wired in permanently will prove invaluable even to the experienced. Checking correct operation of all components, with the exception of the c.p.u. is straightforward. The c.p.u. can prove difficult to test because of its high operation speed and also because of its complexity. Fault finding equipment is costly and substitution is the usual way out.

Fig. 1. The complete circuit of a universal microprocessor. The three modules at the lower left form the 850ns memory access (right and left i.cs) and a single-step function (centre and right i.cs).

P.r.o.m. protection. Intel mention in their Memory Design Handbook the need to protect p-type p.r.o.m. data inputs from the negative levels produced on the data bus by an n-type r.a.m. The 8702 p.r.o.m. is a p-type and the 8101 r.a.m. is an n-type so that protection should be provided in order to avoid damaging the p.r.o.m. All that is required is the inclusion of a series limiting resistor of 250Ω and shunt diode, in each of the p.r.o.m. data input lines.

Conclusion

This is a system which has been tried and proved. The programme may be used to prove hardware. It is hoped that the stages in development of both hardware and software have been dealt with in sufficient detail for constructors to proceed with their own designs. Neither the hardware nor software is considered to be unique but it is hoped that it will prove to be applicable to many future problems.

Table 4. *Abbreviations used in system diagram.*

CE1	Chip enable
CE2	
R/W	Read/write input
OD	Output disable
INT	Interrupt request
INTA	Interrupt acknowledge
HLD	Hold
WR	Write output
DBIN	Data bus in. Signal to system controller that data bus is in input mode
HLDA	Hold acknowledge. Signal in response to hold signal
STSTB	Status strobe
CS	Chip select input
DSI	Device select input
MD	Mode
MEMR	Memory read
MEMW	Memory write
I/OR	I/O read
I/OW	I/O write

Negated names indicate that the function is active when the signal is low

The author gratefully acknowledges the assistance of Howard Kornstein of Intel and the staff of Rapid Recall Ltd., in developing the system. Thanks are also due to K. Sharman who constructed and tested the system and also developed the single stepping facility.

Distortion in low-noise amplifiers

Low-noise, low-distortion preamplifier design with RIAA equalization

by Eric F. Taylor, *Electrical Engineering Laboratories, The University, Manchester.*

The first part of this article considered the effects of transistor non-linearities on the distortion performance of feedback amplifiers. This concluding part illustrates the practical application of some of the low distortion design principles established, by the design of a low-noise, low-distortion, audio preamplifier equalized for use with a magnetic pickup. With a nominal output of 100mV for 5mV input at 1kHz, it has 30dB overload capability and an harmonic distortion of 0.005% at all frequencies and all overload levels.

The primary function of an audio preamplifier is to raise the input signal above the system noise level whilst meeting certain specifications regarding distortion and overload. Nominal output level should be high enough to prevent the design of subsequent stages being compromised by noise considerations but should not be so high as to severely restrict the overload capability of the amplifier. A nominal output level of 100mV is a reasonable compromise but even so an overload capability of 30dB demands a peak-to-peak output swing of approximately 9V.

In Part 1 of this article attention to the non-linearity of the differential gain of a low-noise amplifier was confined to the non-linearity of the input stage on the ground that the output stage could be made as linear as required by local feedback. Adopting a similar approach and assuming that all distortion is produced by the exponential $I_C V_{BE}$ characteristic of the transistors in the input stage, allows the minimum open-loop gain necessary to meet the distortion specification to be determined as follows.

The peak output amplitude V_o is determined for the specified overload capability; in the present design it is equal to 4.47V for 30dB overload referred to 100 mV. For a given value of open-loop amplifier gain A the differential input voltage to the amplifier is then V_O/A and the harmonic distortion can then be found either from the graph of Fig. 7 (Part 1) or more conveniently from the table given in Appendix 3. Thus if for example the gain A was equal to 1000, the differential input signal for 30dB overload would be 4.47mV and the distortion generated by a single common-emitter stage would be 4.3%.

It is now necessary to determine the feedback factor of the amplifier, $(1 + A\beta)$, as distortion in the open loop gain is reduced by this factor in the closed-loop configuration.* The feedback factor is readily determined from the expression for the closed-loop gain A_f.

$$A_f = \frac{A}{(1+A\beta)} \qquad (1+A\beta) = \frac{A}{A_f}$$

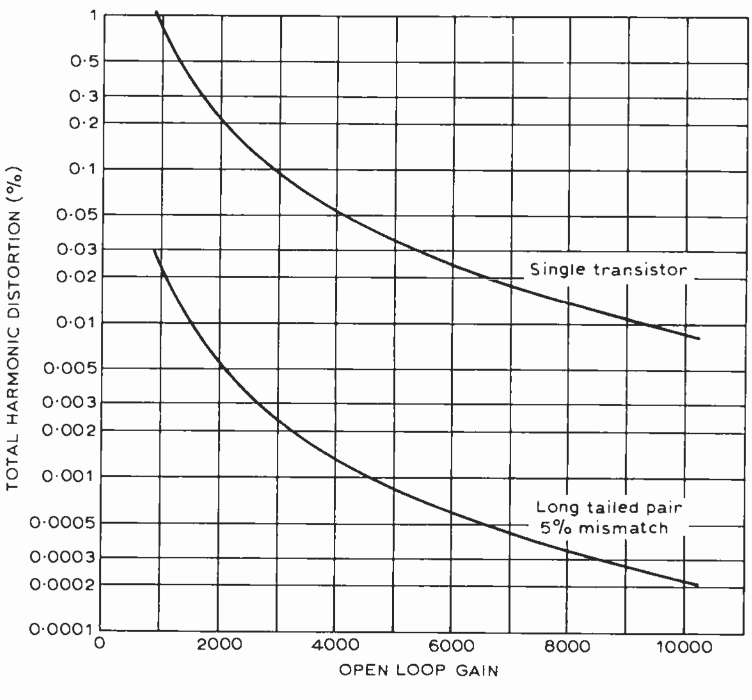
With RIAA equalization the feedback factor should be determined for frequencies below 50Hz as the amount of feedback reaches a minimum at these frequencies. In the present design the sensitivity is specified as 100mV output for a 5mV input at 1kHz and therefore at frequencies below 50Hz the closed-loop gain of the amplifier will be 200. From this equation the feedback factor is therefore equal to 5 and the closed-loop distortion will be 4.3/5 = 0.86%.

Repeating these calculations enables the distortion to be plotted as a function of the open-loop gain and this has been done in Fig 8 for a single transistor stage and a two transistor long-tailed pair stage in which the collector currents are matched to within 5%. With the single transistor input stage an open-loop gain of at least 9500 is required to meet the 0.01% distortion specification whereas with the two transistor long-tailed pair input stage the open-loop gain need only be 1500.

The open-loop gain also needs to be sufficient for the closed-loop gain to be

*This is not strictly correct because with frequency-dependent feedback all harmonic components are not subject to the same attenuation. With equalization which has a falling gain-frequency characteristic the distortion will therefore be less than the calculated value.

Fig. 8. Calculated distortion due to input stage of preamplifier as a function of open-loop gain.



closely defined as a function of frequency according to the RIAA equalization characteristic. At frequencies below 50Hz a closed-loop gain of 200 is required and an open-loop gain of 2000 would give an acceptable 20dB of negative feedback.

With a long-tailed pair input stage the minimum open-loop gain is therefore dictated by feedback requirements and should be approximately 2000, whereas with a single transistor input stage the open-loop gain is dictated by the distortion specification and should exceed 9500.

The input stage

The superior distortion performance of the long-tailed pair input stage compared to the single transistor input stage has been established beyond question. The signal-to-noise ratio of a long-tailed pair input stage is of course inferior to that of a single transistor input stage, but as shown in Appendix 4 the deterioration in the signal-to-noise ratio of an amplifier designed for use with a magnetic pickup is only 0.22 dB.* There seems to be little reason therefore for not using the long-tailed pair input stage unless the ultimate in noise performance is required.

Figure 9 shows the complete circuit diagram of the preamplifier. The long-tailed pair input transistors each operate at a collector current of approximately 90μA for optimum noise performance with a magnetic cartridge input and the tail current is derived from a current source to give a good positive supply rejection ratio and improve the common-mode performance of the amplifier. A single-ended output is taken from the input stage via a current mirror, the advantages of this arrangement being

—the useful gain of the input stage is doubled

—a good negative supply rejection ratio is achieved

—the current mirror can be used to balance the collector currents of the long-tailed pair.

The importance of balancing the long-tailed pair stage to obtain optimum distortion performance was emphasised in the first part of this article. With 10kΩ, 1% resistors in the current mirror overall negative feedback around the preamplifier maintains the collector currents of Tr2 and Tr3 to within 5% for up to 25mV mismatch in V_{BE} of Tr4 and Tr5.

The output stage

The noise contribution of the output stage of a preamplifier cannot be ignored but the design is primarily influenced by the overload capability, and therefore output voltage swing, that is required.

Large voltage swings in any transistor circuit inevitably lead to distortion because of the effects of base-width modulation. Even the popular current-driven common-emitter stage is subject to this type of distortion, because variations of β with V_{CE} are not insignificant. A current-driven common-base configuration would probably be the most linear single-transistor output stage because the current gain α is relatively independent of V_{CE}. However the high output impedance of both the common-emitter and the common-base stage make them unsuitable for use as an output stage in a feedback amplifier unless the output is buffered to prevent instability with capacitive loads.

An output stage consisting of at least two transistors is therefore indicated

*Experimentally it has been found that with 2N5087 transistors the signal-to-noise ratio of the long-tailed pair input stage is approximately 0.6 dB worse than that of the common-emitter stage.

Low noise of series feedback + high overload of shunt

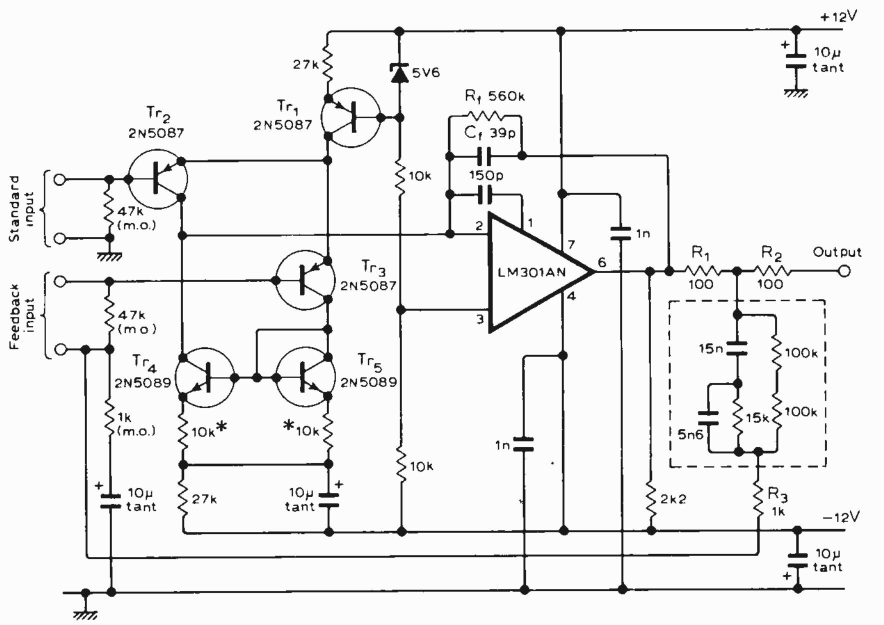
A low-noise, low-distortion audio pre-amplifier, equalized for use with a magnetic pick-up cartridge, has been developed using low cost, readily available components. The basic amplifier can however be considered as a high performance, 7.5 MHz unit-gain bandwidth operational amplifier which can easily be adapted for other purposes, e.g. different sensitivities and/or equalization.

Distortion measurements on the preamplifier have verified much of the theoretical treatment and have clearly shown that the distortion performance of a series feedback amplifier with a standard input is limited at high audio frequencies by distortion resulting from the common-mode input signal and the non-linearity of the common-mode input impedance. The common-mode input signal can however, be virtually eliminated by using an unconventional feedback connection in which the input signal is introduced directly in the feedback path of the amplifier. With this connection it is possible to achieve the low-noise performance of the series feedback connection with the high overload capability of the shunt feedback connection.

At low frequencies the distortion of a low-noise audio amplifier is dominated by the non-linearity of the differential-mode gain and ultimate performance is limited by the exponential relation between collector current and base-emitter voltage of the input stage transistor or transistors. The two-transistor long-tailed pair has a much more linear transfer characteristic than a single common-emitter input stage and enables a significant improvement in distortion performance to be achieved with only a slight deterioration in signal-to-noise ratio.

The design example shows how low-distortion design can be treated quantatively and that it is not difficult, at least in an audio preamplifier, to achieve an harmonic distortion of less than 0.005%. It may be argued that this level of performance is academic when other imperfections in an audio system are considered, but if it has been achieved at low cost then such an argument can only conform that progress at least has been made towards the ideal preamplifier.

Fig. 9. Complete circuit diagram of RIAA equalized preamplifier. Unused input must be shorted. Resistors marked 10kΩ are matched to within 2%. Three of the input resistors should be metal oxide types.*



and at this point the use of an operational amplifier becomes attractive in terms of cost and performance. An integrated circuit operational amplifier with shunt feedback and the output stage operating in class A is used in the present design, the advantages of this arrangement being

—large output swing capability
—low distortion due to local feedback and class A output
—low output impedance
—virtual earth input minimizes voltage changes and therefore distortion of the preamplifier input stage
—optimum feedback configuration for low-noise amplification of the signal from the input stage
—the open-loop gain of the pre-amplifier is well defined.

The operational amplifier used in the output stage of the preamplifier has to meet certain large signal voltage swing and slew rate specifications to operate satisfactorily under overload conditions. The preamplifier is designed to give a nominal 100mV r.m.s. output with a 30dB overload capability which demands a maximum peak-to-peak output of approximately 9V. The maximum slew rate under these conditions for a sine wave output is calculated as follows

$$V_{out} = V_o \sin 2\pi f t$$

$$\frac{dV_{out}}{dt} = 2\pi f V_o \cos 2\pi f t$$

$$\left.\frac{dV_{out}}{dt}\right|_{max} = 2\pi f V_o$$

Evaluated at f = 20kHz for V_o = 4.47V (30dB overload) this indicates a maximum slew rate requirement of 0.56 V/µs.

The ubiquitous 741 operational amplifier is just capable of meeting the voltage swing and slew rate requirements but the LM301 is a much better alternative at little extra cost. With feedforward compensation[1] the LM 301 has a limiting slew rate of 10V/µs and a peak-to-peak voltage swing in excess of 24V at 20kHz. In addition whereas the 741 has a unity-gain bandwidth of 1 MHz, feedforward compensation extends the unity-gain bandwidth of the LM301 to 10MHz, a significant improvement as the loop roll-off frequency of the preamplifier is a function of the unity-gain bandwidth.

Little information is available concerning the distortion performance of general purpose integrated circuit operational amplifiers. However, Linsley Hood[2] has obtained figures of less than 0.02% harmonic distortion at 1V r.m.s. output with a 741 in a shunt feedback configuration and measurements by Walker[3] show that intermodulation distortion in an LM 301 under similar conditions is less than 0.03%. As the output stage of the preamplifier is contained within the overall negative feedback loop, it would appear that both of these amplifiers would enable the 0.01% distortion specification to be achieved.

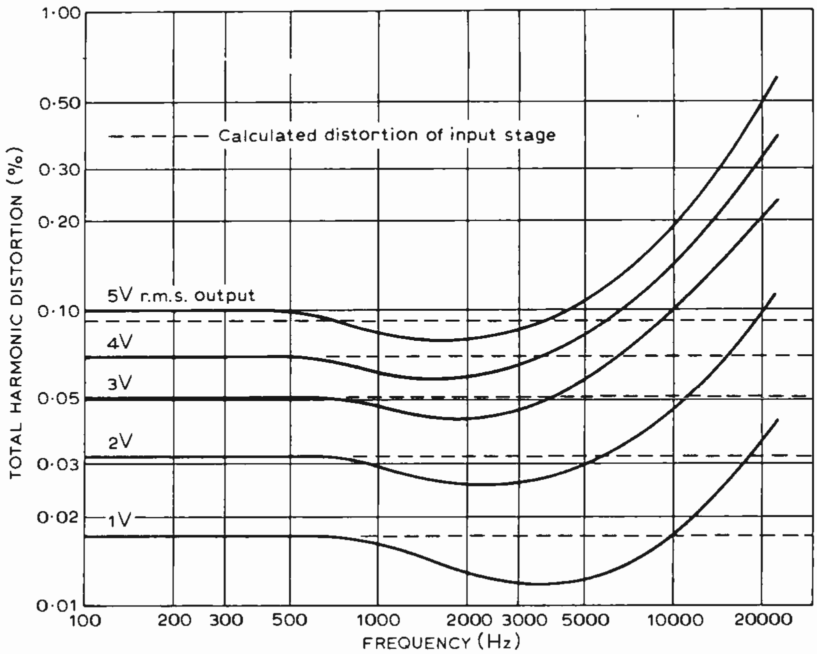


Fig. 10. Open-loop distortion of the preamplifier as a function of frequency and output amplitude.

Frequency compensation

The low-frequency open-loop gain of the amplifier is

$$A_o = -g_m R_f$$

where the mutual conductance of the input transistors g_m, is equal to 3.6mA/V with the transistors operating at a collector current of 90µA. The high-frequency break point of the input stage is calculated to be 12.0MHz and the h.f. break point of the output stage is 10MHz. Compensating the amplifier for unity loop gain at 7.5MHz gives a reasonable stability margin.

It is not necessary for the amplifier to be compensated for unconditional closed-loop stability as the feedback network which defines the equalization characteristic can be used to attenuate the loop gain. Thus the resistor R_3 in the equalization network (Fig. 9) usefully extends the frequency at which the loop gain must be rolled off by the compensation network to ensure stability by a factor of two.

The amplifier is compensated by the capacitor C_f in the output stage which gives a dominant pole in the open-loop response. The required value of C_f is given by

$$\frac{1}{2\pi C_f R_f} = \frac{7.5\times10^6}{A_o/2} = \frac{2\times7.5\times10^6}{g_m R_f}$$

which gives 38pF. For an open-loop gain of 2000 R_f needs to be 560kΩ (A_o/g_m) and the loop gain then rolls off at 7.5kHz.

It is interesting to note that the value of C_f necessary for stability is a function only of the input stage transconductance and the high frequency attenuation of the loop gain by the feedback network. If the high frequency attenuation of the feedback network can be increased, as may be possible for example in a high-gain equalized preamplifier, then the value of C_f may be reduced proportionately to maintain the 7.5 kHz break frequency in the loop response. It is not recommended that C_f is reduced below 10pF however as the operational amplifier output stage may become unstable within its own local feedback loop.

Resistors R_1 and R_2 in series with the output are used to isolate the LM301 from any load capacitance and prevent high frequency instability.

Performance

The distortion performance of the amplifier is presented graphically in Figs 10 & 11. Figure 10 shows the open-loop distortion of the amplifier as a function of frequency for several values of output voltage. At low frequencies the distortion corresponds closely to that predicted for the input stage. As the frequency is increased above 1kHz there is a slight reduction in distortion, probably as a result of the 3.25kHz break frequency in the output stage (for these measurements the amplifier was compensated for unconditional closed-loop stability) which will attenuate the predominantly third-order harmonic distortion components generated in the long-tailed pair input stage. Above 5kHz the distortion increases rapidly with frequency and must be attributed to the output stage of the amplifier as distortion generated in the input stage is independent of frequency. At 3.0V r.m.s. output however, corresponding approximately to 30dB overload, the distortion has only risen to 0.2% at 20kHz.

The distortion of the amplifier with

RIAA equalization is shown in Fig. 11. These characteristics were obtained using the standard input configuration and a source impedance equivalent to that of a 600mH cartridge. At low frequencies the distortion decreases with increasing frequency as expected because of the increase in loop gain of the amplifier. The distortion reaches a minimum at 1.5kHz and with a 3V output (30dB overload) the distortion is less than 0.001%. Above 2kHz the distortion increases rapidly with frequency until at 20kHz the distortion with a 3V output has risen to 0.1%.

Measurement with the feedback input connection have shown that the distortion is less than 0.005% at all frequencies up to 20kHz and all overload levels up to 30dB. Unfortunately it has not been possible to plot any meaningful distortion characteristics for the feedback input connection because of the difficulty in making reliable distortion measurements below 0.001%.

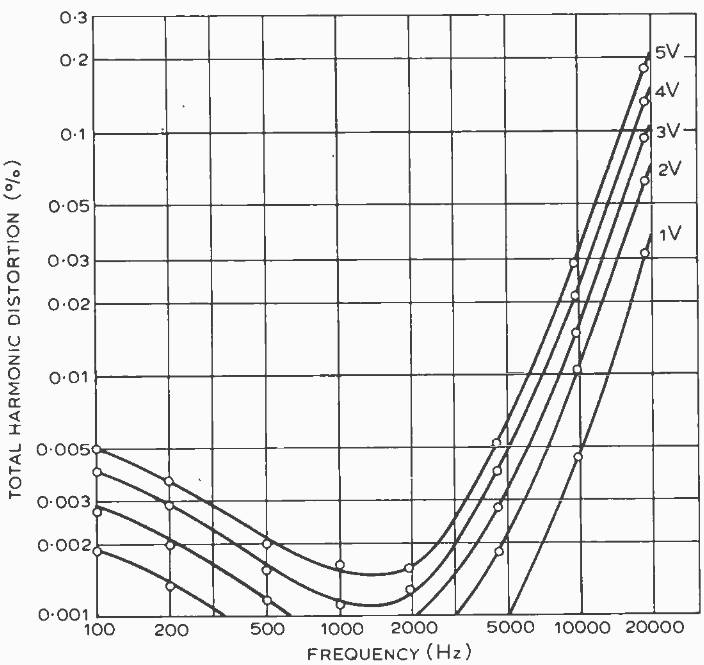
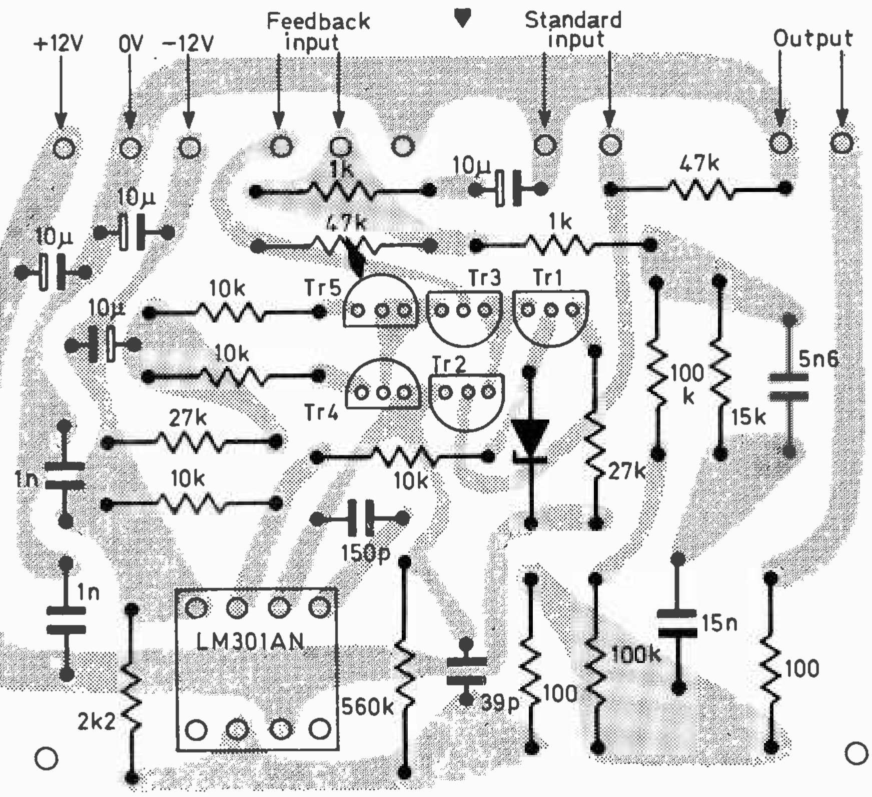


Fig. 11. Total harmonic distortion of the preamplifier, with RIAA equalization, as a function of frequency for various output amplitudes for standard input configuration.

Fig. 12. Printed circuit board layout viewed from component side. Ready-made and drilled boards will be available from M. R. Sagin, 23 Keynes Road, London, NW2.



The maximum output signal amplitude before clipping is 5.6V r.m.s. which gives a 35dB overload capability referred to 100mV.

Signal-to-noise ratio of the preamplifier is greater than 75dB ref. 5mV at 1kHz for both the standard and feedback input connection with a 600mH source inductance.

Construction

Figure 12 shows a printed circuit board layout of the preamplifier and two amplifiers for stereo operation can easily be mounted in an Eddystone 7134P die-cast box measuring 111×60×31mm. The printed circuit board allows for either the standard input or floating input connection. In my system the preamplifier is mounted directly adjacent to the pickup and no problems with hum or instability have been encountered with the floating input connection.

The power supply is not critical and the circuit operates satisfactorily with the positive and negative supplies derived from a simple half-wave rectifier with Zener stabilization. The positive and negative supplies should be capable of providing approximately 10mA.

Acknowledgements. The assistance of Dr D. A. Edwards with the computer programming and Mr D. H. Warne with the design of the printed circuit board is acknowledged.

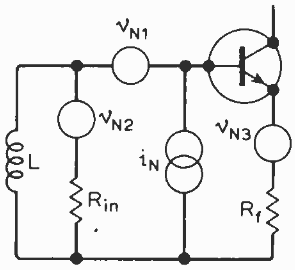
Appendix 3 —Total harmonic distortion (%) of a common emitter and long-tailed pair transistor stage due to the exponential relation between collector current and base-emitter voltage of a transistor.

Amplitude (mV)	Single transistor	Long-tailed pair 0% Mismatch	5% Mismatch	10% Mismatch
0.1	0.0967	0.0000312	0.00242	0.00484
0.2	0.193	0.000125	0.00484	0.00967
0.3	0.290	0.00218	0.00726	0.0145
0.4	0.387	0.000499	0.00968	0.0194
0.5	0.484	0.000780	0.0121	0.0242
0.6	0.580	0.00112	0.0146	0.0290
0.7	0.677	0.00153	0.0170	0.0339
0.8	0.774	0.00200	0.0194	0.0387
0.9	0.870	0.00253	0.0219	0.0435
1.0	0.967	0.00312	0.0244	0.0485
2.0	1.93	0.0125	0.0499	0.0975
3.0	2.90	0.0280	0.0777	0.148
4.0	3.87	0.0498	0.109	0.199
5.0	4.83	0.0778	0.143	0.253
6.0	5.79	0.112	0.182	0.309
7.0	6.76	0.152	0.226	0.368
8.0	7.72	0.198	0.276	0.431
9.0	8.68	0.251	0.330	0.497
10.0	9.63	0.309	0.390	0.566
11.0	10.6	0.373	0.455	0.640
12.0	11.5	0.443	0.526	0.718
13.0	12.5	0.519	0.602	0.800
14.0	13.4	0.600	0.683	0.887
15.0	14.4	0.687	0.770	0.978

Note. % mismatch for the long-tailed pair stage is defined by $2(I_{C1}-I_{C2})\ /\ (I_{C1}+I_{C2})$, where I_{C1} and I_{C2} are the collector currents of the transistors.

Appendix 4 — Input stage noise

The noise generators of an amplifier with a single transistor common-emitter input stage and designed for use with a magnetic pick-up cartridge can be represented as



where v_{N1} is the equivalent noise voltage generator of the transistor, v_{N2} the equivalent noise voltage generator of the input resistance R_{in}, v_{N3} the equivalent noise voltage generator of the equivalent feedback network resistance R_f, i_N the equivalent noise current generator of the transistor, and L the inductance of the magnetic cartridge, assumed purely inductive.

The total mean square noise voltage at a frequency f for a bandwidth δf referred to the input can be shown to be

$$4kT\delta f\left\{R_{Nv1}+R_f+R_{in}\left[\frac{j\omega L}{R_{in}+j\omega L}\right]^2+\frac{1}{R_{Ni}}\left[\frac{R_{in}j\omega L}{R_{in}+j\omega L}\right]^2\right\}$$

$$=4kT\delta f\left\{R_{Nv1}+R_f+R_{in}\left[\frac{(\omega/\omega_o)^2}{1+(\omega/\omega_o)^2}\right]+\frac{R_{in}^2}{R_{Ni}}\left[\frac{(\omega/\omega_o)^2}{1+(\omega/\omega_o)^2}\right]\right\}$$

where the noise voltage and current generators have been replaced by equivalent noise resistors and $\omega_o=R_{in}/L$. If this noise is now passed through an RIAA equalizing network with a transfer function A(jf), the total mean square noise voltage over a band of frequencies is

$$\overline{V_N^2}=4kT\int\left\{R_{Nv1}+R_f+R_{in}\left[\frac{(f/f_o)^2}{1+(f/f_o)^2}\right]+\frac{R_{in}^2}{R_{Ni}}\left[\frac{(f/f_o)^2}{1+(f/f_o)^2}\right]\right\}|A(jf)|^2df \quad \ldots (5)$$

With L of 600mH and R_{in} of 50kΩ, if can be shown[3] that

$$\int_{50}^{20,000}\frac{(f/f_o)^2}{1+(f/f_o)^2}|A(jf)|^2df=298.4$$

and it is readily shown that

$$\int_{50}^{20,000}|A(jf)|^2df=8.015\times10^3.$$

For a 2N5087 transistor operating at I_c of 100μA with a β of 250 and neglecting flicker noise the equivalent noise resistors are[4]

$$R_{Nv1}=(r_{bb'}+1/2g_m)\approx200\Omega$$
$$R_{Ni}=2\beta/g_m=1.25\times10^5\Omega$$

Putting $R_f=1000\Omega$, the value used in the design example, and substituting for all values in equation 5 gives

$$\overline{V_N^2}=2.655\times10^{14}+1.327\times10^{-13}+2.472\times10^{-13}+9.887\times10^{-14}$$

where the components are due to the noise voltage of the transistor, the noise voltage of the feedback network; the noise voltage of the input resistance and the noise current of the transistor respectively. Thus

$$V_N=\sqrt{5.053\times10^{-13}}=0.711\mu V$$

which corresponds to a signal-to-noise ratio of 76.94dB referred to 5mV.

With the long-tailed pair input stage two additional noise generators are introduced into the equivalent circuit as shown in Fig. A4. These noise generators are identical with the noise generators of the transistor in the common-emitter input stage (they are not correlated however) and the total mean square noise voltage is now

$$\overline{V_N^2}=5.053\times10^{-13}+2.655\times10^{-14}\times7.14\times10^{-16}$$

The first term of this expression is the noise present in the single transistor input stage and the last two terms represent the additional noise due to the noise voltage and noise current generators respectively of the second transistor. Thus

$$V_N=\sqrt{5.326\times10^{-13}}=0.730\mu V$$

which corresponds to a signal-to-noise ratio of 76.72dB referred to 5mV. The deterioration in signal-to-noise ratio of the long-tailed pair compared with the single transistor is therefore 0.22dB.

The reason for only a small deterioration in signal-to-noise ratio with the long-tailed pair is that the noise voltage generator associated with the additional transistor is small compared with the noise voltage associated with the 50kΩ input resistance and the noise voltage produced across the source impedance by the noise current generator of the original transistor. The noise current generator of the additional transistor produces a negligible noise voltage across the low impedance of the feedback network.

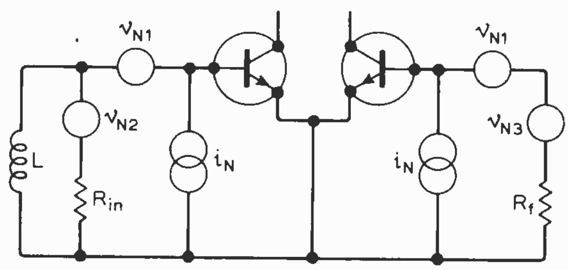


Fig. A4. Equivalent noise circuit of long-tailed pair stage.

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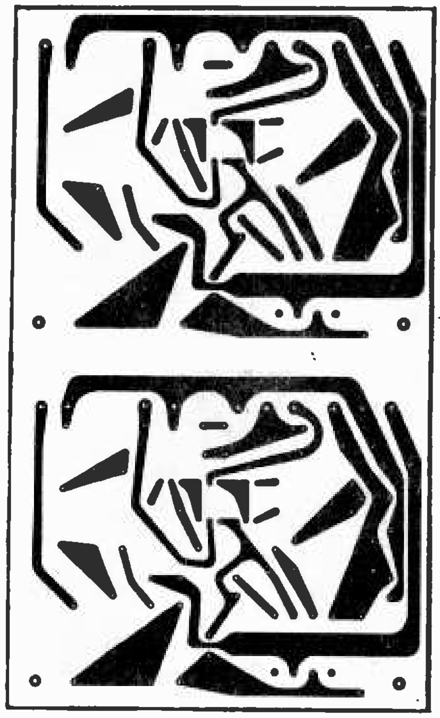
2. Linsley-Hood, J. L., Feedback amplifiers, *Wireless World* Letters, Vol. 79 1974, pp. 11/12.
3. Walker, H. P., Feedback amplifiers, *Wireless World* Letters, Vol. 79 1973, pp. 193/4.
4. Baxandall, P. J., Noise in transistor circuits, *Wireless World* vol 74 1968, pp. 454-9.



Drilled boards to this design, shown actual size, will be available for £1.65 inclusive from M. R. Sagin, 23 Keynes Road, London NW2.

Surround-sound decoders — correction

An error in the components list for the Sansui Variomatrix decoder circuit (September 1976 issue) was regretably perpetuated in the variable-matrix H decoder list on page 38 of the June issue. Values of C_{63} to C_{65} and of C_{87}, C_{90} and C_{91} should be ten times greater than shown. (In the original QS list this also applies to C_{55}, C_{56} and C_{73} to C_{75}. QS kit constructors will also have noticed values for R_{91} and R_{92} were transposed in the list with those of R_{125} and R_{126}, and that R_{107}, R_{108} are 6.8kΩ and not 68kΩ.) Input capacitors for the output phase shift circuits on page 35 are 4.7μF.

Should constructors of either circuit find that the voltages on pins 5-8 and 12-15 on the HA1327 i.cs do not reach their proper value of 5V, Sansui recommend a modification, which we understand is now applied to all Variomatrix circuits. Capacitors C_{58} to C_{61} and C_{79}, C_{80}, C_{85} and C_{86} should be taken to the +24V rail rather than 0V; this means capacitor polarity must be reversed.

Automatic gain control systems

Design considerations and parameters

by N.A.F. Williams, B.Sc. M.I.E.E.

The purpose of all automatic gain systems is to control a variable gain amplifier so that its output voltage stays approximately equal to a reference voltage for all values of input signal within certain limits. These limits define the working range of the system. To carry out this function, negative feedback is used. It is therefore worthwhile considering the parameters which define the operation of a negative feedback amplifier, as shown in Fig. 1.

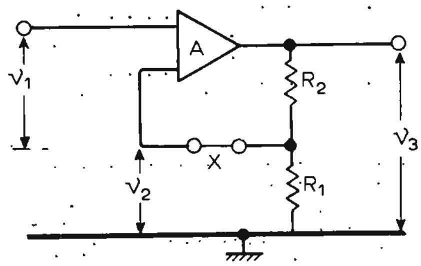


Fig.1. Basic negative feedback amplifier.

The differential amplifier has a gain A, and the output voltage V_3 is equal to $A(V_1 - V_2)$. Voltage V_2 is that fraction of V_3 defined by the potential divider R_1 and R_2. If $R_1/(R_1 + R_2) = B$, then $V_2 = BV_3$ and a simple calculation shows that provided $AB \gg 1$ the magnitude of the gain V_3/V_1 is approximately equal to $1/B$. It should be noted that open loop gain A is the ratio V_3/V_1 when feedback link X is broken. The closed loop gain is approximately equal to $1/B$, and is the ratio of V_3/V_1 when the link is closed. The loop gain, of magnitude AB, is the gain around the feedback loop which determines the stability and precision of the amplifier.

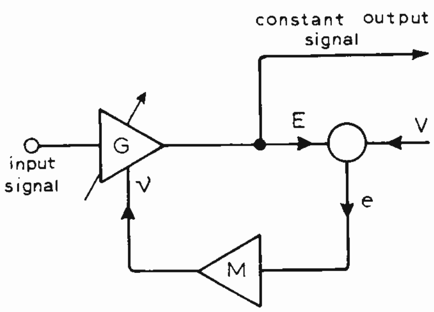


Fig.2. Negative feedback arrangement used in automatic gain control systems.

The negative feedback arrangement used in automatic gain control systems differs from Fig.1, and is shown in Fig.2. The input signal passes through an amplifier of variable gain G and, usually after rectification, is compared with the reference voltage V. The error voltage e is then passed through an amplifier of gain M whose output is control voltage v. Loop gain is determined by M multiplied by the transfer functions of any networks present in the loop. For example, a rectifier converting the output of amplifier G to the direct voltage E before comparison with V, and the factor relating v to G. Let us assume that these are all constants, so that the loop gain $L = KM$ where K is a constant. Besides being responsible for the stability and transient response of a negative feedback system, the loop gain decides what error may exist in the loop under steady state conditions, or under varying input signal conditions where the frequency of variation lies within the bandwidth of the feedback system. In the case of a.g.c. systems, it determines the accuracy of control as shown by the following equations. In Fig.2, $E = Le$ and $e = V - E$. Therefore, $e = V - Le$ or $e\ (1 + L) = V$. From the last equation, if the loop gain $L = 100$ then $e = V/101$ so the actual output differs from that required by only about one per cent. Changes in loop gain will cause corresponding changes in the accuracy of control. For example, reducing the gain to ten reduces the accuracy to within ten per cent. Also, the loop gain is not independent of frequency because all practical systems include frequency sensitive components. In general L has the characteristic of a low pass filter which has a constant amplitude C up to frequency F. Beyond this point the frequency sensitive components begin to take effect and reduce the magnitude of L. The a.g.c. system will respond with an accuracy determined by loop gain $L = C$ for variations of input signal which occur within the frequency range 0 to F. For frequencies greater than F the system will respond with a reduced accuracy. In operation the output of amplifier G is nearly constant for all values of input signal. Hence, for constant loop gain a constant absolute change of output voltage from amplifier G for a given change of v is required for all values of G. If the relationship is considered to be linear, as shown in Fig.3 (a) a change of v gives a constant

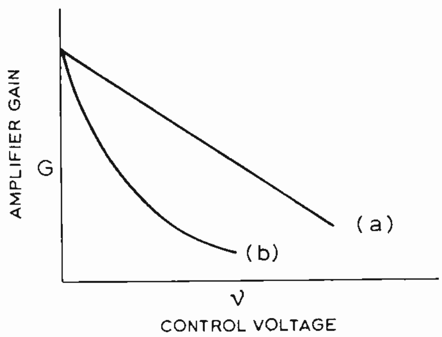


Fig.3. Relationships of amplifier gain G versus control voltage v. Linear trace (a) will not provide a constant loop gain but exponential curve (b) produces a constant loop gain for all values of G.

change of G. Numerically however, it does not provide the desired output voltage for all values of G. For example, let G vary from 100 to 1000 and let the required output voltage be 10V. When the gain is 1000, the input voltage is $10/1000 = 0.01$V, and when the gain is 100, input voltage is $10/100 = 0.1$V. In each case let v change by an amount which causes G to change by say 20 while the input voltage remains constant at either of the two values corresponding to a gain of 100 and a gain of 1000. When the gain is 1020 the output voltage is $0.01 \times 1020 = 10.2$V, and when the gain is 120 the output voltage is $0.1 \times 120 = 12$V. Thus when G is 1000 a given change of v alters the output voltage by 0.2V, but when G is 100 the same change of v alters the output voltage by 2V. This means that the loop gain has changed by a factor of ten, and is greater at the lower value of G. It should be noted that this is a variation in the low frequency flat part of the loop gain characteristic. For any given setting of this zero-frequency-response, reactive elements that may exist within the loop will modify this curve in the usual way as it extends into the higher frequency region.

As a linear relation between v and G will not provide a constant loop gain the preceding calculation shows that a constant percentage change of G is required, that is $dG/dv/G$ = a constant, or $dG/dv = KG$ where K is a constant. Curve (b) of Fig.3 shows such a characteristic. If $G = Ke^{-av}$ then $dG/dv = -Kae^{-av}$ and $dG/dv/G = -Kae^{-av}/Ke^{-av} = -a$. This indicates that the relationship between v and G should be exponential if the loop gain is to remain constant for all values of G. Because $G = Ke^{-av}$, $\log_e G = \log_e K - av = K_1 - av$ where K_1 is another constant, and as $\log_n m = \log m / \log n$ to any base of logarithms, $\log_{10} G = \log_{10} e(K_1 - av) = K_2 - K_3 v$ where K_2 and K_3 are two more constants. This is the equation of the straight line shown in Fig.4 and shows that G in decibels versus v produces a straight line with the desired characteristic.

Variations in the zero-frequency loop gain not only cause changes in the accuracy of the a.g.c. system but can cause instability at settings of G that give the highest value of loop gain. This is demonstrated in Fig.5 where curves (a) and (b) have the same form but different zero-frequency gain. The amplitude falls off at 6dB per octave from frequency F to frequency W, and at 12dB per octave from frequency W onwards. The system represented by curve (b) is stable because unity loop gain (0dB) occurs with a phase shift around the loop of only 90 (+180) degrees, as indicated by the 6dB per octave rate of change of amplitude assuming a minimum phase network. The system of curve (a), however, is unstable because the 0dB line is crossed at a slope of 12dB per octave, corresponding to a loop phase shift of 180 (+180) degrees. It is difficult to maintain the loop gain constant, and in some systems considerable variations may be permissible. Knowing the extent of the variation allows its effect to be calculated, and gain controlled amplifier circuits which approximate to an exponential relation between G and v will therefore be suitable.

Integrated circuit amplifiers, intended mainly for r.f. or i.f. amplification, are available from several manufacturers. Some of these amplifiers give an approximately straight line characteristic when their gain in decibels is plotted against their a.g.c. control voltage, at least over most of their working range. These are very suitable for applications requiring high constancy of loop gain. Considering simple bipolar transistor and field effect transistor amplifiers, neither has an inherent suitable relationship between gain and some easily controllable parameter such as emitter or drain current. However, if the gain of the common-emitter bipolar transistor amplifier is plotted in decibels against emitter current it is found that the gain varies approximately linearly with emitter current in the low emitter current region. The gain of a common-source field effect transistor amplifier is proportional to the square root of the drain current, and this relationship also approximates to the desired characteristic for low values of drain current. An alternative use for the f.e.t. is as a voltage controlled variable resistor, and Fig.6 shows a well known arrangement of feedback from drain to gate which linearises the effective resistance of the f.e.t. The drain to source resistance R_{ds} of this circuit is given by the expression $R_0/(1 - V_c/2V_p)$ where R_0 is the drain to source resistance when the voltage between gate and source is zero, V_p is the pinch off voltage, and V_c is the control voltage shown in Fig.6. For a given device, R_0 and V_c are constants, and the expression can be written as $R_{ds} = k_1/1 - k_2 V_c$ where k_1 and k_2 are constants. Plotting this equation gives a curve which, although not an exponential, does approximate to one and is suitable for some applications. The maximum possible slope of the R_0 versus V_c graph is fixed by the values chosen for the feedback resistors in Fig.6 although for clarity the effect of these resistors has not been included in the previous expression for R_{ds}. By adjusting the values of R the degree of approximation to an exponential curve can be altered. To make use of this voltage controlled variable resistor the controlled amplifier gain must be made proportional to R_{ds}. This can be achieved by letting R_{ds} form the collector load resistor of a grounded emitter transistor amplifier, as shown in Fig.7, in which R_2 is very much greater than R_{ds}.

Another method of maintaining roughly constant loop gain for varying amplifier gain is to make straight line approximations to the desired response curve by using diodes to provide the break points in the slopes of the straight lines. No doubt readers will visualise other possibilities.

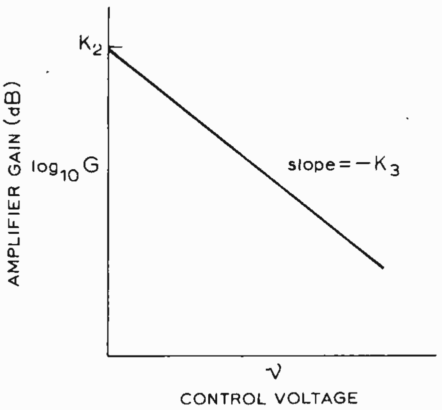


Fig.4. Gain in dB versus control voltage v produces a straight line with the desired characteristic.

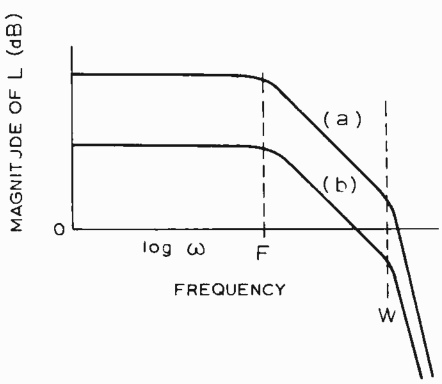


Fig.5. Graphs illustrating that variations in zero-frequency loop gain can cause instability. Curve (a) crosses the 0dB point (unity-loop gain) with a slope of 12dB per octave corresponding to a loop phase shift of 180 degrees. Curve (b) is stable because the loop phase shift is 90 degrees at unity loop gain.

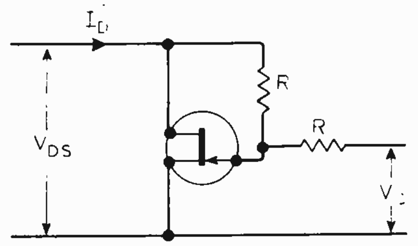


Fig.6. Variable resistor using a f.e.t. The feedback resistor linearises the effective resistance.

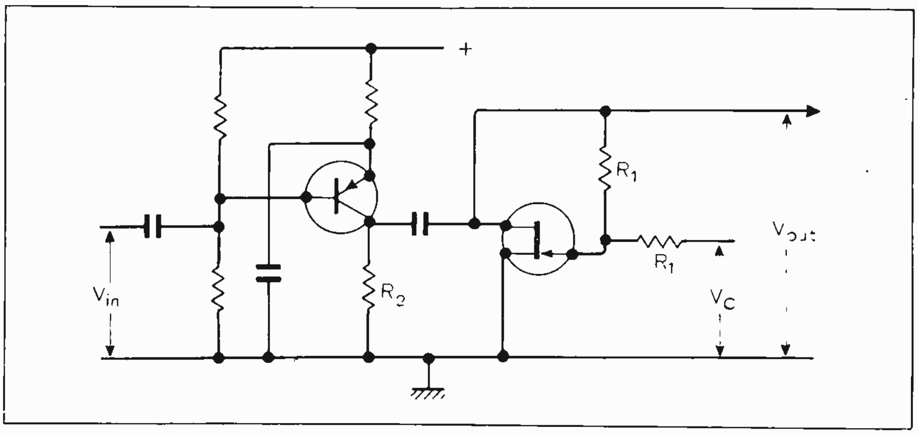


Fig.7. A.g.c. system where a f.e.t. used as a variable resistor forms the collector load of a grounded emitter amplifier.

Amateur radio equipment — 2

A survey of modern commercially-built receivers, transmitters and transceivers

by Ray Ashmore, G8KYY

Part 1 of this survey discussed commercially-built receivers which are available today. This second part is mainly concerned with transmitters and transmitter-receivers, or transceivers. Today, however, there are few separate transmitters available and most of the design changes can be seen in the receiver sections of transceivers. In fact, it is here that receiver design trends such as the use of single-conversion superhets and synthesizers are most common.

Amateurs, licensed by the Home Office, may operate their stations according to the terms, provisions and limitations (all of which we shall call "conditions") laid down by the wireless telegraphy Act of 1949. They must also comply with the relevant provisions of the International Telecommunication Convention. The conditions vary slightly according to the type of licence in question, for example whether it is a Class A or a Class B licence.

There are also conditions for mobile or portable operation. Briefly, the licensee is entitled to set up his station at a particular address, or temporarily or alternatively at another location – for a limited period – for the purpose of sending to, and receiving from, other licensed amateur stations as part of the self-training of the licensee in communication by wireless telegraphy. Note that the word "telegraphy" is used here to mean both c.w. and telephony. He, or she, is also entitled, under the same conditions, to use the station during disaster relief operations conducted by certain societies and forces in the UK, as requested by those societies or forces, and for the reception of transmissions in the Frequency Service.

The term "as part of self-training of the licensee in communication" outlines the main difference between amateur licences and the Citizens' Band type licences issued in most countries. Typical operative words in CB licences could be summarized as "for business or pleasure communications."

Of particular importance to the amateur licence is the condition that a satisfactory method of frequency stabilization should be employed in the sending apparatus and that equipment for frequency measurement should be provided capable of verifying that the sending apparatus is operating with emissions within the authorized frequency bands. In addition, the apparatus should be designed, constructed, maintained and used so that it does not cause any undue interference to any wireless telegraphy. At all times every precaution should be taken to avoid over-modulation, to keep the radiated energy within the narrowest possible frequency band and to ensure that the radiation of harmonics and other spurious emissions are suppressed to such a level that they cause no undue interference to any wireless telegraphy.

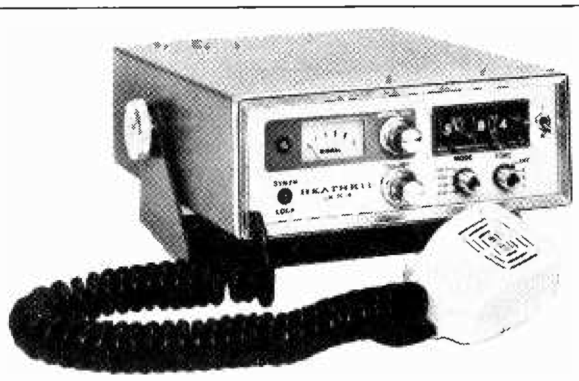
Also included in the licence is a schedule stating the classes of emission (a.m., s.s.b.-reduced, suppressed or full carrier, p.d., f.m., c.w., etc.), the frequency bands authorized within the terms of the licence and the maximum input or output powers which may be used in the station. In brief, the Class A schedule permits telephony on a.m., s.s.b. and f.m. and telegraphy (c.w.) on a.m. and f.m. in the ham bands from 1.8 to 146MHz and 432 to 24,250MHz with maximum d.c. input powers of from 10 to 150W (or peak-envelope-power outputs of from 26⅔ to 400W) depending on the frequency range. From 430 to 432MHz the schedule permits a.m. or f.m. telephony or telegraphy with a maximum effective-radiated-power of 10W, and in selected ham bands between 2,350 and 10,450MHz it permits pulse-type modulation of maximum input powers of 25W mean or 2.5kW peak. Some of the bands in the above frequency ranges may be used for slow-scan tv, facsimile and high definition tv. However, extra conditions are written into the schedule and certain bands can only be used upon the receipt of written consent from the Secretary of State.

All of these conditions form the basis of the specifications on commercially-built amateur equipment.

Transmitters

Since 1959 when Collins Radio introduced the KWM-1, probably the first transceiver suitable for the amateur, commercially-built separate transmitters have slowly reduced in number. *Wireless World* could find only four examples on the current amateur market, namely; the Trio T-599D, the Drake T-4XC, the Yaesu Musen FL-101, and the STE Milan ATAL-228, a 2m transmitter. There was also the all-valve Decca KW-204, which has recently been withdrawn, and a 2m module transmitter, the AT-23 from STE Milan. The former transmitters were designed specifically for operation with the following receivers: the Trio R-599D, the Drake R-4 series, the Yaesu Musen FR-101, and the STE ARAC-102.

Apart from the increased use of semiconductors there have been very few changes in the design of transmitters or the transmitter stages of transceivers over recent years. The amateur transmitter may still be considered in terms of five main stages:



A 2m f.m. mobile transceiver; one of Heath's easy-to-build kits. The HW-2036, as it is called, is frequency synthesised to provide a 2MHz frequency range which is selected in 5kHz steps by conventional thumbwheels. It also includes 600kHz frequency shifts and tones for repeater operation.

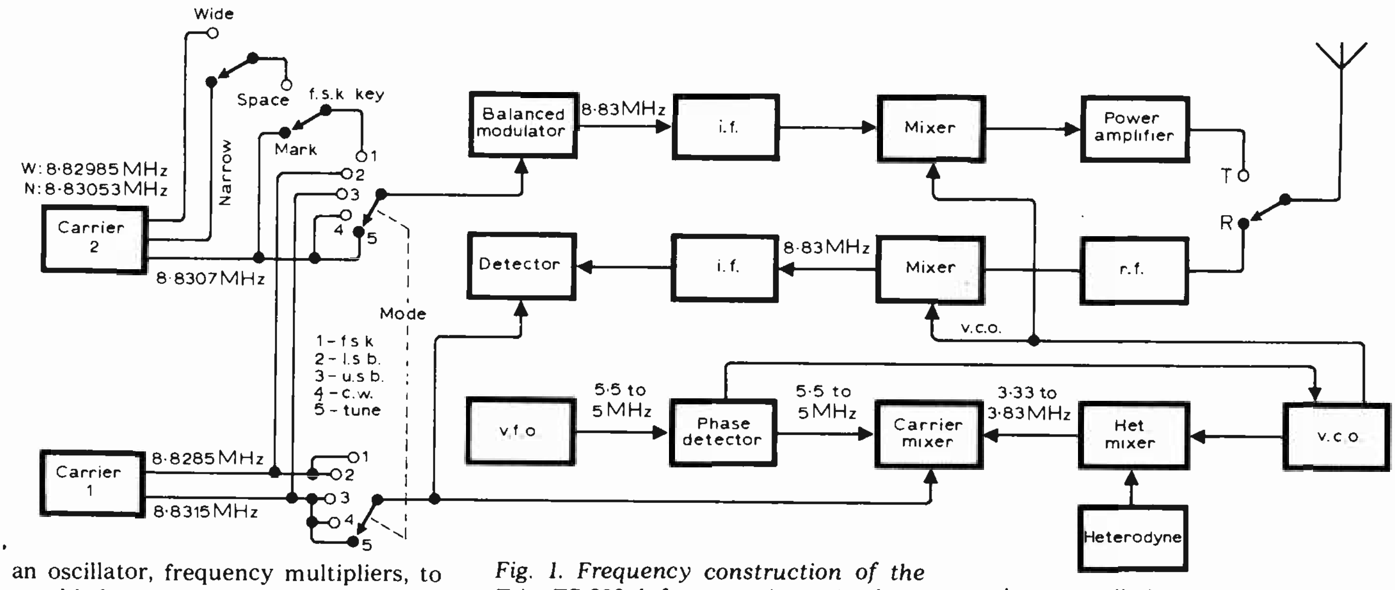


Fig. 1. Frequency construction of the Trio TS-820 h.f. transceiver. A phase lock loop is used for frequency derivation and the circuit employs a double carrier system to allow sideband switching without re-calibration. See text.

an oscillator, frequency multipliers, to get this frequency up to the transmitter frequency, a modulator, a power amplifier and a tank circuit for aerial matching. In most cases the transmitter stages in amateur equipment use a mix of discrete semiconductors, valves and often i.cs.

Normally valves, operating in Class AB1, are preferred for the driver and p.a. stages of the transmitter. It has been claimed that some amateurs, upon comparing the 'back-end' circuits of all-solid-state transceivers with circuit diagrams in instruction manuals have found extra components or component changes. This could be due to out-of-date manuals or it could equally be evidence of design changes which the manufacturers have found necessary to bring individual units into specification, perhaps because of differences in characteristics between devices having the same type number. *Wireless World* has been unable to find confirmation of this practice.

A pi-network filter arrangement is normally used in the anode circuit (tank circuit) of the power amplifier because it is more efficient at suppressing harmonics, and this is important in order to avoid television interference. Harmonic radiation figures for commercially-built transceivers are typically 40 to 60dB down.

Transceivers

Transceive operation is normally obtained by using one common oscillator as both the local oscillator of the receiver superhet, and as the v.f.o. of the transmitter. Therefore, once the receiver has been tuned to the exact frequency of an incoming signal, the transmitter is already set to transmit on the same frequency. To allow for drift and inaccuracies the receiver can usually be tuned over a range of about 1 to 5kHz using a receiver-incremental (or independent) tuning (r.i.t.) control, without altering the transmission frequency.

Fig. 1 shows a more complex system, as used in the Trio TS820. This transceiver uses phase-locked-loop (p.l.l.) circuitry to provide an accurate mixer frequency for the transmitter circuit and the single-conversion receiver circuit, and to keep spuriae to a minimum. The carrier oscillator circuit is divided into Carrier 1 and Carrier 2 such that the former serves c.w. and f.s.k. receive, u.s.b. and l.s.b. and the latter serves c.w. and f.s.k. transmit. This system enables the p.l.l. frequency to remain the same when switching sidebands without the need for re-calibration every time.

Because semiconductors are being used, many of the transceiver designs are now based on modular boards. Providing the modules can be easily removed so that they may still be operated while under test they can be of advantage to the amateur, but if the circuit makes access to certain parts of the circuit difficult under test conditions they serve only to make the inside of the unit neat and tidy. However, semiconductors and modules do save space in modern transceivers, and this allows more facilities to be fitted into any particular-sized chassis.

Automatic level control, gain control, noise limiter and squelch facilities are now standard on most transceivers. Microphone- or voice-operated control switching (m.o.x. or v.o.x.) and noise blanker circuits are now also fairly standard on h.f. transceivers and v.h.f. multimode transceivers.

Some h.f. transceivers include a built-in speech processor for increasing speech power in DX communications. One system of processing is clipping, which simply cuts off loud peaks in the audio signal, but this makes the voice sound harsh and creates harmonics. Speech compression systems, which use an automatic volume control to amplify quiet passages in the audio, are preferred. The speech processor used in the TS-820 converts the audio frequency into a 455kHz s.s.b. signal, compresses it using a small time constant, and then converts it back to an audio signal again.

Typical specifications

There are now so many transceivers on the amateur market that it would not be practical to print all of their specifications here. However, Table 1 gives some idea of the types and models available.

In general, h.f. transceivers have maximum frequency coverages of from 1.8 to 29.7MHz, normally in up to nine ranges of about 500kHz each, including the 160, 80, 40, 20, 15 and 10m ham bands. About a half of the transceivers available do not have the 160m band and a few do not have the 10m band, or they have only a portion of it. However, the ranges that are missing can often be fitted using optional crystals in auxiliary bands. Common additions are receive-only ranges for the 27 to 27.5MHz band and WWV frequencies.

Modes of operation normally include u.s.b., l.s.b. and c.w. with facilities for f.s.k. and r.t.t.y. Some units also have an a.m. mode.

Maximum input powers, in peak-envelope-power (p.e.p.) on s.s.b. and for a 50% duty cycle on c.w., range between about 140 and 700W, although these are normally a little lower for the 160m and 10m bands. A.m. and f.s.k. inputs in general range between 50 and 75W. For comparison against the output p.e.p. figures quoted in the licence one would need to know the overall p.a./tank circuit efficiency for each transceiver, but by using rule-of-thumb values of 60% for valve outputs and 50% for solid-state outputs, approximate figures can be obtained.

Carrier and unwanted-sideband suppression figures are normally greater than between 40 and 60dB down for a 1kHz audio tone. Selectivity and sensitivity figures are generally as good as or better than the figures quoted for the receivers in Part 1 of this article, that is, typically 2.4kHz at 6dB down and 3.5 to 7kHz at 60dB down (for s.s.b.) and from 0.25 to 0.5μV for a 10dB (S + N)/N ratio.

Because most of the transceivers

available are carefully designed using only single or double conversion receivers (see Part 1), spurious response figures are typically as good as or better than 1μV equivalent to the antenna input.

V.h.f. transceivers

Transceivers designed for v.h.f. operation differ considerably from h.f. transceivers. They normally cover only a small frequency band of about 2 to 4MHz, and rarely need much band-switching. If the transceiver is a multi-mode unit it will usually incorporate a v.f.o., but if it is a single mode unit it is more likely to have switched-channel frequency selection. An r.i.t. is therefore necessary for s.s.b. models. Table 1 lists most of the v.h.f. transceivers available and some of their main features.

Most v.h.f. transceivers are designed with mobile operation in mind. Usually they require a direct voltage supply of about 12 to 13.8V, but incorporate a power supply either as a built-in unit or as an add-on unit.

Some transceivers, normally f.m. instruments, are designed specifically for portable or hand-held use. Examples are the KP-202, the HW-2021 and the IC-202.

The FDK Multi-2700, from Fukuyama, includes a 29MHz receiver specifically for Oscar satellite reception. There are two amateur satellites in operation at the present time. The Oscar 6 satellite, which is likely to go out of service shortly, after more than completing its operational lifetime, has a two-to-ten metre, 100kHz bandwidth, transponder (repeater) on board. Its input frequency range is 145.9 to 146MHz and its output range is 29.45 to 29.55MHz. The second satellite, Oscar 7, has two repeaters on board, one for two-to-ten metre operation and one for a 432.125 to 432.175MHz input. This mode has a transmit output from 145.975 to 145.925. The 2700 is therefore suitable for the two-to-ten metre satellite modes on both Oscars.

Most v.h.f. f.m. or multimode transceivers include devices for repeater operation. A repeater is a device which retransmits signals primarily in order to provide improved communications range and coverage for mobile stations or for amateurs in dwellings, such as city flats or bedsits, where it is difficult to fit high gain aerials and rotators. The improved communications are made possible by siting the repeater on a hill or tall tower.

A simple repeater would consist of a receiver with its audio output connected to the audio input of a transmitter which is tuned to a second frequency, and is 'accessed' by a carrier-operated relay (c.o.r.). In practice repeaters tend to be more complex than this. Most of the UK repeaters require a 1750 ± 25Hz, 500ms tone to switch the repeater on before the c.o.r. can operate. In addition, transmission time-out systems, protection circuits etc, are normally fitted by amateur repeater groups to make the repeater suitable for its local operating conditions.

Repeaters common to the UK operate in the 2m and 70cm bands. In the former case the repeater receive frequency is 600kHz below its transmission frequency, hence it shifts the operator's transmission frequency up by 600kHz. In the latter case the transmission is shifted down by 1.6MHz. This means, of course, that transceivers designed for repeater operation require both tone-bursts and frequency shift.

At present there is a trend towards greater use of u.h.f. repeaters in preference to v.h.f. repeaters. The main reason for this is that coverage is increased in built-up areas due to the improved signal penetration obtained with u.h.f. Since repeater antennas are sited high up, and both u.h.f. and v.h.f. give line-of-sight communication, the range is little different to that obtained using a v.h.f. repeater. This trend will almost certainly result in an increase in the number of u.h.f. mobile transceivers in the near future.

Transverters, suitable for use with h.f. transceivers, are readily available for v.h.f. communications at frequencies of 70, 144 and 1,296MHz. These modules enable amateurs who already have a h.f. transceiver to operate in the v.h.f. bands without having to purchase a separate v.h.f. transceiver. Fig. 2 shows a block diagram of a typical 432MHz transverter suitable for use with a h.f. transceiver tuned to the 28MHz band.

Typical specifications for a transverter suitable for a frequency coverage of 144 to 146MHz, with an input of 28 to 30MHz, and input and output impe-

Table 1. Most of the transceivers currently on the UK amateur market. Key gives limited information, according to literature in author's possession, about each product.

Trio-Kenwood
TS820 h.f. SCDR*PV3/TK1JEW9B200 i/p
TS520 h.f. SCV3/TEY7BK2J140//180 i/p
TR7500 v.h.f. FZ40TEH2m10o/p
TR7400 v.h.f. FZ(5k/4M)RTK2EH2m25o/p
TR700G v.h.f. SCAFJX11TK2H2m10o/p
TR7010 v.h.f. SCX48T2m8o/p
TR7200G v.h.f. FX22TK2H2m10o/p
TR2200GX v.h.f. FX12TK2H2m2o/p
TR3200 u.h.f. FX12TK2H70cm2o/p

Yaesu Musen
FT101E/EE h.f. SCAP*V3/TK2JW6B260i/p
FT301/D h.f. SCAR*PTK1JW6B200i/p
FT200B h.f. SCAJY5T260i/p
FT620B v.h.f. SCAJT6m24i/p
FT221R v.h.f. FX23K2T2m10o/p
FT2 v.h.f. X8 Autoscan FTH2m10o/p

Heath (Heathkits)
HW101 h.f. SCJV20/TY8B180i/p
SB104 h.f. SCJRTY8B100o/p
HW104 h.f. SCJY8B100o/p
HW2036 v.h.f. FZ(5k/2M)DTK2H2m10o/p
HW202 v.h.f. FX6TK2H*2m10o/p
HW2021 v.h.f. FX10TK1H2m1o/p handheld

Inoue (Icom)
IC211E v.h.f. SCFJDRTK1/2EH2m10o/p
IC240 v.h.f. FZ22DTK2EH2m10o/p
IC245E v.h.f. SCFJDRTK1/2EH2m10o/p
IC202 v.h.f. SCX4 (vxo)T2m3o/p portable
IC30A u.h.f. FX22TK2H70cm10o/p
IC215 v.h.f. FX15TK2H2m3o/p portable

Fukuyama (FDK)
Multi-11 v.h.f.
X4Autoscan + X23 FK2T2m10o/p
Multi-U11 u.h.f.
X4Autoscan + X23FK3T70cm10o/p
Multi-2700 v.h.f.
SCAFZJRTK1/2EHO2m10o/p
Quartz-16 v.h.f. FX25K2T2m10o/p

Garex
Twomobile v.h.f. FAJ2m
Fourmobile v.h.f. FAJ4m

Nippon Electric Company
CQ110E h.f. SCAJRDV6/TK1W11B300i/p
CQP2200 v.h.f. FX12H2m3i/p portable

Atlas
210-X h.f. SCJK1Y5BN200i/p
215-X h.f. SCJK1W5N200i/p

Swan
700CX h.f. SCJY5B700i/p

CIR Industries
Astro 200 h.f. SCJDRTK1Y5BM200i/p

Signal-one
CX-11 h.f. SCJRPW7B150o/p

Hy-Gain
Model 3750 h.f. SCJRV3/TK2EW9B200i/p

ST Communications
KF430 u.h.f. FX12TH70cm10o/p

Uniden
Model-2030 v.h.f. FX12TK2H2m10o/p

Belcom
Liner 430 u.h.f. SCX(vxo)K2T70cm10o/p

Drake
TR-4CW h.f. SCAJV20/TY5B300i/p

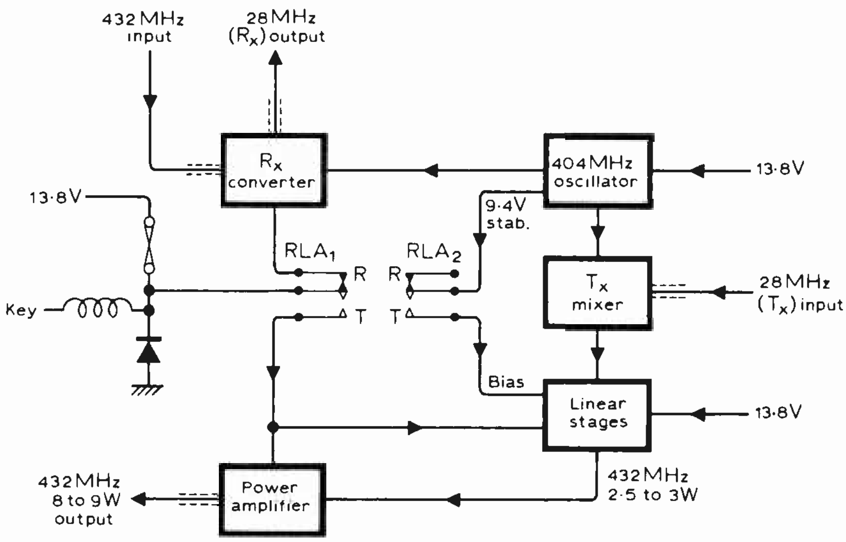
Kyokuto
Digital-2 v.h.f.
FZ(5k/2M)DRTK2EH2m10o/p

KP-202 v.h.f. FX6TH*2m2o/p handheld.

STE Milan
AK-20 v.h.f. FX12TH2m3o/p

Signamizer
Model-200R v.h.f. FZ(10k/2M)TH2m

Key:
S: s.s.b., **C:** c.w., **A:** a.m., **F:** f.m., **J:** v.f.o., **M:** momentary switch v.f.o. tune, **X( ):** number of switched crystal channels, **Z( ):** number of switched synthesized channels or kHz-steps/freq.-range, **D:** digitally synthesized, **R:** digital readout, **P:** speech processor, **T:** solid state, **V( ):** number of valves, **K( ):** number of receiver conversions, **E:** phase locked loop employed, **W( ):** total number of ranges including 160 to 15m ham bands, **Y( ):** total number of ranges including 80 to 15m ham bands, **B:** some or all of 10m ham band included, **H:** repeater facility, **O:** Oscar satellite facility, **N:** no r.f. amp. stage, * after key signifies option, Final figures are typical Hi i/p or o/p p.e.ps in watts (for h.f. or v.h.f. multimodes, s.s.b. figure is given, for v.h.f. metre band is given also).



dances of 50Ω, are as follows: converter gain is typically 30dB, converter noise is about 2.5dB max, and the input required for 10W continuous rated transmit output is about 5mW.

Synthesizers

Digital synthesizers are being used increasingly in v.h.f. equipment. In the not too distant past synthesizers were avoided because of the risk of spuriae due to the many frequency components produced by the number of multiplication stages used. Now the use of phase-locked-loop techniques has enabled synthesizers to be made without introducing spuriae. One main advantage with synthesizers is that, in channel-switched transceivers, large numbers of expensive crystals are avoided.

The use of digital synthesizers in amateur radio equipment can perhaps best be shown by the latest Icom v.h.f. transceivers. In the IC-240, a synthesizer is used to provide a number of 25kHz channels, the frequency of which can be programmed by a diode matrix. In the IC-211E and IC-245E multimode transceivers digital synthesizers are used to give v.f.o. frequency selection.

Let us first consider the IC-240. (See Fig. 3). Since this transceiver uses a first i.f. of 10.7MHz, for receive frequencies from 144 to 146MHz, an oscillator having frequencies from 133.3 to 135.3MHz is required for the first mixer oscillator. This is provided by a free-running voltage controlled oscillator (v.c.o.), in this case a junction f.e.t. Clapp oscillator. This oscillator has a good noise ratio and a frequency stability of the order of ±50 p.p.m. per degree C. Its output is fed to a buffer amplifier to minimise the effects of load variation.

The v.c.o. is controlled by a phase detector which compares a 12.5kHz pulse output from a quartz crystal reference oscillator and divider with a 12.5kHz pulse output derived from the

Fig. 2. A typical 432MHz transverter suitable for use with a 28MHz transceiver. This block diagram represents a Modular Electronics design.

v.c.o. output, a local oscillator and a diode matrix. The diode matrix being the reference which governs the required v.c.o. output for the selected channel. If the output frequency derived from the matrix and the feedback from the v.c.o. output becomes higher than the reference frequency, the output voltage of the lag-lead filter in the phase detector becomes low and the v.c.o. frequency is lowered. When the derived output becomes low the action is the reverse, and so the v.c.o. synchronises the output with the reference frequency.

The local oscillator consists of an overtone oscillator of 43.9MHz. Connected to its collector is an inductor which is tuned to three-times the overtone oscillator frequency to give an

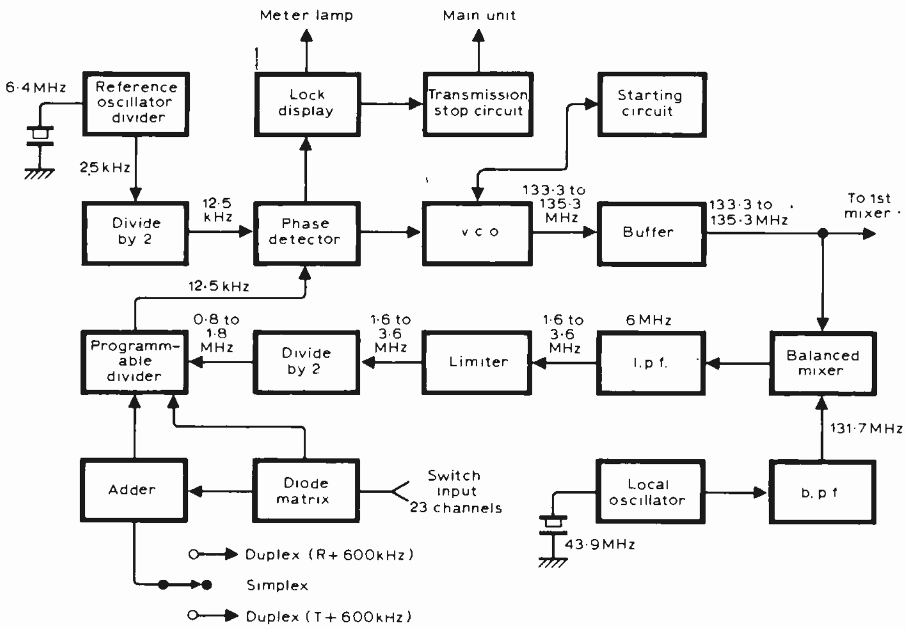


Fig. 3. Block diagram for the first mixer oscillator used in the Icom IC-240 digitally-synthesized transceiver. Operating frequency is determined by a diode matrix r.o.m. which decides the dividing ratio of a programmable divider in the phase lock loop. See text.

output of 131.7MHz. A portion of the buffer output and the local oscillator output are fed to a frequency transducer which is in fact a low-noise balanced mixer. Since this heterodyne process produces many frequencies at the transducer outputs a l.p.f. is used to limit them to 6MHz or lower. These signals are then amplified by the broadband limiter-amplifier and divided by two before being input to the programmable divider i.c.

For any operating frequency the divided pulses out of this i.c. should be at 12.5kHz and, for any particular operating frequency, the dividing ratio is determined by the diode matrix. This is a matrix of 23 arrays (representing 23 channels) of eight possible diode positions. The diode matrix is in effect a r.o.m. which defines a frequency as a binary number equal to the dividing ratio (N). For example, for a receive frequency of 145.000MHz, the p.l.l. output frequency would need to be 134.300MHz. This corresponds to an output of 2.6MHz from the transducer which when divided by two is 1.3MHz. Therefore, to give a 12.5kHz output at the divider, this should be divided by 104, which in binary corresponds to a diode array of 01101000.

In IC-240s intended for Europe, N is normally selected from 64 to 144 (for 144 to 146MHz) — a choice of 81 possible 25kHz-spaced receive channels.

An adder, shown at the bottom left of Fig. 3, provides the repeater shifts of 600kHz for repeater or reverse-repeater (duplex) operation.

In the IC-211E and IC-245E, v.f.o. tuning is by a strobe device on the tuning dial. The strobe sensing device consists basically of two l.e.ds firing into two photocells, which are slightly offset from the dial strobe. A large-scale-integration (l.s.i.) chip forms most of the digital circuitry in these transceivers (see Fig. 4).

The circuit shown at the top-right corner of the diagram determines the direction in which the dial is being turned, and provides a series of pulses to the l.s.i. The chip has two up-or-down counters which are fed by the output

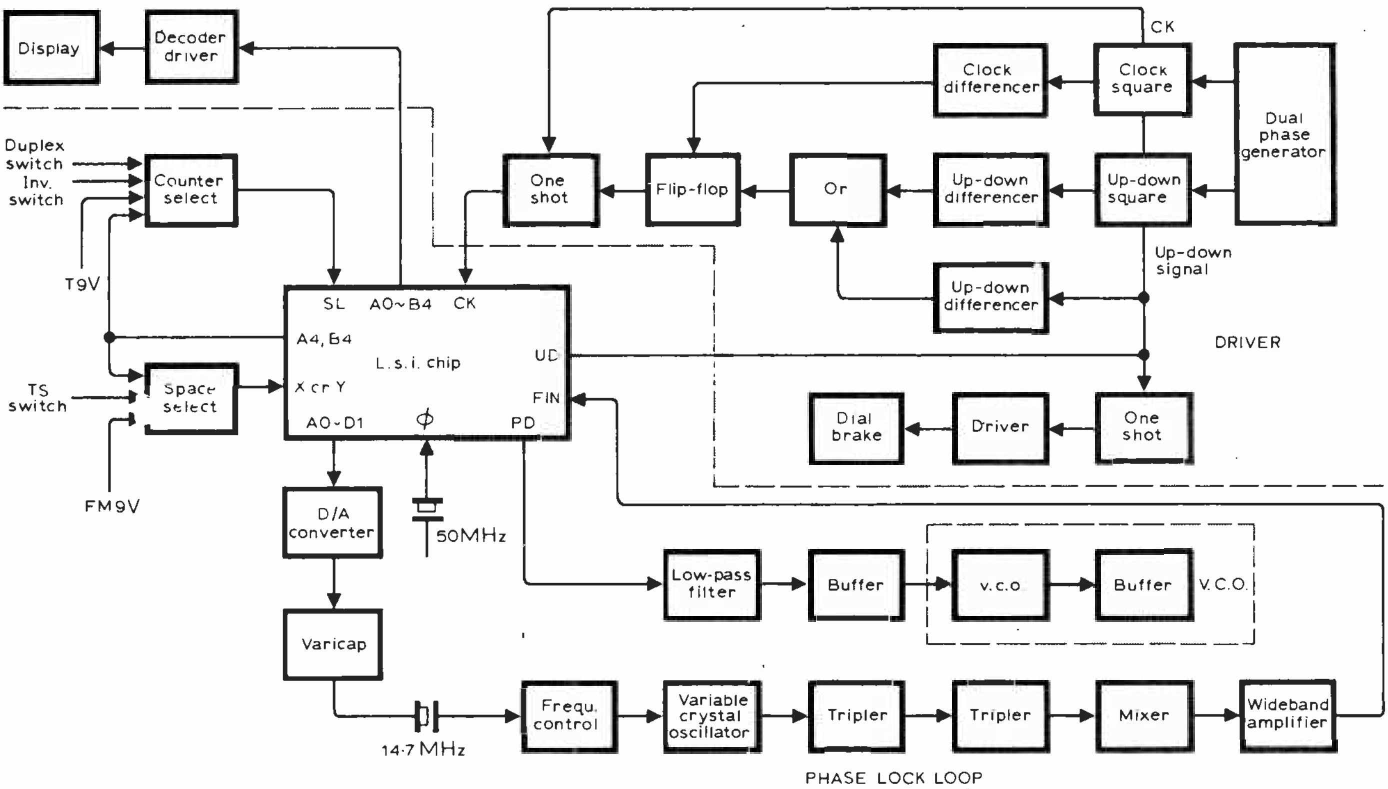


Fig. 4. Block diagram for the first mixer oscillator used in the Icom IC-211E and IC-245E transceivers. This system uses a m.o.s. l.s.i. chip to provide v.f.o. tuning coupled with p.l.l. digital-synthesized circuitry. See text.

from the clock at CK. Inputs X or Y at 'space select' determine whether the counters are updated in 5kHz or 100Hz steps, and these are selected by the speed switch TS on the front panel of the transceiver.

Counter select determines which of the counters are to be clocked. For example, if the transceiver is being used for simplex operation both counters are clocked together, but if it is being used for duplex or reverse-duplex operation the counters are clocked separately, one for receive and one for transmit, depending upon the duplex and invert switch positions.

The counter outputs (A0 to B4), which are in groups representing binary-coded-decimals, are fed to the decoder driver and the internal programmable divider. Each group represents a digit of a frequency readout display, that is, 1/10kHz, 1kHz, 10kHz and 100kHz. The last two groups indicate whether the frequency band is 144.4, .5, .6 or .7.

The running oscillator, which is a v.c.o., operates in the range 133.3 to 135.3 and is fed through a buffer to a mixer. This mixer oscillator frequency is derived from a 14.7MHz crystal, which, when multiplied by nine, gives 132.3. Hence the mixer output, which is fed to the FIN input of the l.s.i., has a bandwidth of 1 to 3MHz. In the same way as in the IC-240 system, the programmable divider then divides these frequencies down to 10kHz for comparison with another 10kHz reference derived from a 50MHz oscillator. As before the output from the phase detector (PD) is used to control the frequency of the v.c.o.

However, this only gives frequencies in 10kHz steps, it does not provide v.f.o. tuning. In order to obtain full v.f.o. selection the logic is used to actually move the master 14.7MHz oscillator frequency. Outputs AO to DI, which are binary coded-decimals representing the last two digits of the required frequency (e.g. the 01 in 144.6001), are passed through a digital-to-analogue converter to produce a signal suitable to adjust a varicap diode circuit. This circuit then pulls the crystal frequency slightly to move the oscillator frequency up by 100Hz. In this way all the frequencies within the 10kHz band can be obtained, and the frequency can be recorrected every 10kHz.

Japanese imports

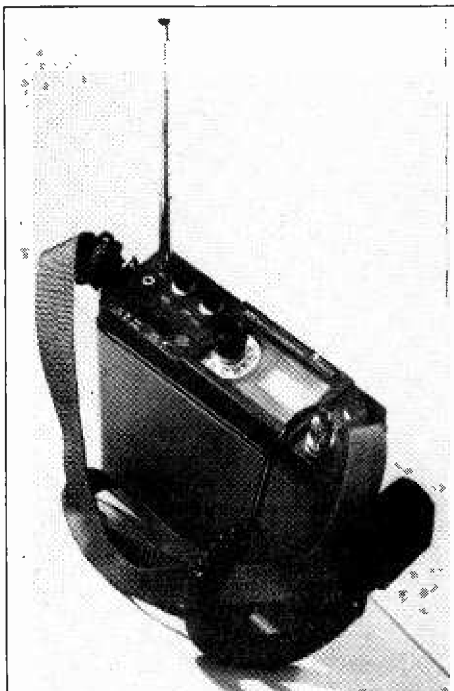
When buying or contemplating buying Japanese equipment the amateur cannot help but wonder how much the same rig would cost in Japan and what he is paying on top of this. Some feel that they are perhaps lining the importers' pockets. The following analysis is based purely on the information given to *Wireless World* by importers, traders and Japanese representatives.

Most Japanese equipment is purchased by UK importers through letters of credit (l.o.c.) which may be valid for about 2 to 3 months. These are agreements between UK banks and Japanese banks that payment for goods will be transferred as soon as the goods leave Japanese shores. In Japanese banks an l.o.c. is regarded as security just as if it was money. It is normally drawn up in yen at the going exchange rate.

Most of the bulk orders arrive by sea and once the equipment is on board ship, having been purchased at the free-on-board (f.o.b.) price, the importer must pay for freight and insurance cover for the goods and capital invested. This cost, insurance and freight (c.i.f.) charge is usually between 5 and 6% of the equipment value.

Freight is dependent on weight and volume. Typical freight charges for a batch of between 20 and 50 transceivers would be about £1.50 each for a small mobile unit and £4.50 for a large transceiver – this is comparable with carriage from Scotland.

When the equipment reaches the UK



The CQ-P-2200E 2m f.m. portable transceiver, from the Nippon Electric Company.

port an import duty must be paid. For amateur equipment this payment varies between 11% for a transmitter and 14% for a transceiver or receiver and it is added to all payments made up to this point. Other expenses which the importer meets, some of which are subject to the import duty, include the bank charges for letters of credit, currency exchanges, interest on cash used by banks and clearance charges from Japanese agents.

So far, then, this is the price at which the importer can expect to get the equipment.

According to figures given to *Wireless World*, a mark-up of up to about 25% may be made by the importer, and a further 25% by the retailer. However, equipment prices are usually competitive from all traders despite the fact that many of the importers are also retailers. This is because the importers normally give up to 20% discount (equivalent to up to 25% mark-up) to the retailers. These profit margins are low compared to the domestic markets, where mark-up is not usually less than 30%. Unlike domestic goods, however, one rarely sees amateur equipment carrying a discount tag. This is not surprising because a 25% mark-up can represent only about 8 to 12% profit after overheads – a typical trader's profit margin.

Table 2 is a comparative analysis of Japanese equipment prices before and after importing. Most of the figures and percentages used in this analysis are not necessarily accurate because they are based on typical values which are subject to variation with each product and with time. However, this article should make the reader aware of where these variations can occur so that they can be taken into account For example, although wholesale prices in Japan are usually 80% of the recommended retail price (r.r.p.), in the Akihabara district of Tokyo and the Nihonbashi district of Osaki, the wholesale price is from 73 to 80% of the r.r.p. depending in the retailer.

In addition, variations in exchange rates, import duties, freight, bankers and agents charges and UK carriage can also affect the final price in each case.

The negative percentage figures for the Yaesu Musen (FT range) products may be a result of the fact that these units are imported by three independent companies. If this is so, it is almost certainly the mark-up figures which are reduced. In the case of the Icom (IC range) products, since there are no exact equivalents of the transceivers quoted, the prices shown are for units which are as alike as possible. Unlike the other products, Icom transceivers are purchased against the American dollar instead of the Japanese yen.

It should also be noted that these figures may also reflect differences in the type of equipment, and other products from the same companies may give completely different results.

Delivery of Japanese goods is normally very good and reliability is said to be nothing short of excellent. Typically four to six weeks from placing an order the goods are released from Japan. They then spend about four weeks on the boat and up to two weeks going through customs. Consequently, traders can say with confidence that the goods will arrive within three months of placing an order.

Basing one's conclusions on the above analysis, it would be fair to say that, without exception, the British amateur is getting Japanese equipment at a fair price, especially when considering the excellent deliveries and after-sales service given.

Table 3 shows a comparison of some transceiver prices in the UK, America and West Germany. These prices have been obtained from UK-bank "selling" exchange rates and r.r.p. values (including taxes) in the respective countries.

Prices in America are seen to be generally lower than in the UK; the one exception in the table being the FT221R which was also shown to be low priced in Table 2. The main reason for the lower prices is that US import duty and tax is lower than in the UK. For transceivers, US import duty is only 6% and tax, which may change slightly in each state or city, is only about 4% of the value of the goods — this is a zonal tax, they are not subject to excise tax. The third column in the table shows what these prices would be if subject to UK duties and tax.

Prices in Germany, however, are higher, even though import duties and taxes are the same. One reason for this could be that, unlike in the UK, most of their equipment is sold through retailers, and not directly from the importers, and consequently mark-ups, which may be higher anyway, are being taken on both importing and retailing.

Other price differences could be explained by the fact that a transceiver designed for one country's market may

Table 2. Wholesale price of Japanese equipment (taken as 80% of Japanese recommended retail price (r.r.p.) and at exchange rate of £1 = 470 Yen) plus c.i.f. charges at 5%, import duty at 14%, a single mark-up of 25% and v.a.t. at 12½% compared with r.r.p.s (including v.a.t.) for the same equipment in the UK. These estimates do not include bank charges, agents charges or carriage in the UK. In addition the wholesale price quoted is not necessarily the free-on-board (f.o.b.) price.

Model	*r.r.p. in Japan*	*Wholesale price in Japan*	*(a) Price after c.i.f., duty, mark-up and v.a.t.*	*(b) r.r.p. in UK*	*Percentage difference (b—a)/b*
FT-101E	374.47	299.57	504.27	448.87	−12
FT-221R	287.23	229.78	386.79	336.37	−15
TS-820 Dig	489.36	391.49	658.98	751.00	12
TS-520	297.45	237.96	400.55	432.00	7
TS-700G	286.80	229.44	386.21	392.62	2
IC-211E	314.89	251.91	424.04	529.00	20
IC-240	122.34	97.87	164.74	198.00	17
MULTI-2700	318.72	254.98	429.20	489.00	12

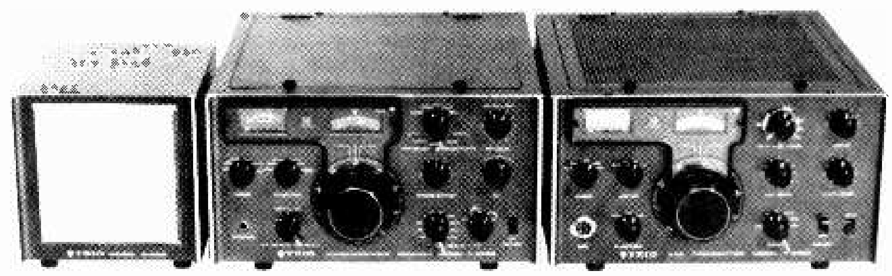


Photo shows a complete Trio-Kenwood separates' station, the S-599 speaker console, the R-599 receiver and the T-599 transmitter.

The Icom IC-211E 2m v.h.f. transceiver from Inoue. It uses a patented Icom m.o.s. l.s.i. synthesiser to give v.f.o. tuning on the s.s.b., c.w. and f.m. modes. Other features include repeater facilities and a digital frequency display giving a readout to the nearest 100Hz.

Table 3. Comparison of amateur transmitter and transceiver prices in UK, USA and West Germany based on exchange rates of 470¥, $1.715 and 3.98DM.

Model	UK £	USA £	USA** £	W. Germany £
FT101E	448.87	425.07	494.51	477.39
FT221R	336.37	346.94	403.61	437.19
IC211E	529.00	436.73	508.07	518.59
T-4XC*	450.00	349.27	406.33	483.67
TS520	432.00	366.76	426.68	462.31
IC245E	396.00	290.96	338.49	388.69

*Made in USA
**Prices if subject to UK import duties and tax

be slightly different to a transceiver designed for another country's market.

Why Japanese?

One question which has been asked for many years is why the Japanese seem to be able to make amateur equipment cheaper than any other country. It is claimed that in the mid-sixties, when the Japanese importing first started, certain UK companies made complaints to local MPs to the effect that they suspected the Japanese manufacturers were being subsidized by their government and were dumping equipment in this country. *Wireless World* has made enquiries into this to try to find out what conclusions were made at that time.

The Department of Trade could find "no substantial records to indicate that any action was taken" — probably due to lack of evidence. So far the archives of the Department of Industry have not turned up any information either.

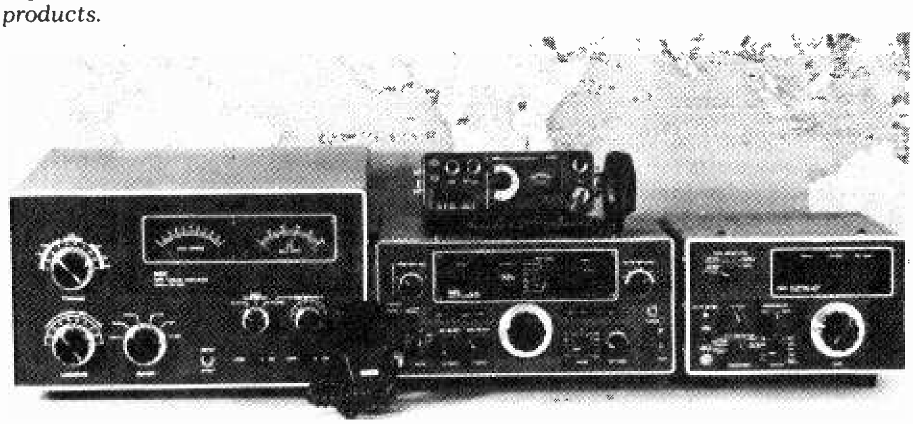
Our investigation did show, however, that UK tarriff headings for imported goods do not, even now, distinguish between amateur, professional, military, commercial or domestic communications equipment. This makes it difficult even to obtain figures for amateur imports, especially when the headings depend to a certain extent on descriptions made by the exporting country. In the mid-sixties the records were even more ambiguous and, because they listed country of consignment and not origin, it would be difficult even to distinguish which goods had come from Japan. This, coupled with the complexity of the Japanese government, banking and industrial structure, would surely have made any serious investigation very difficult indeed.

However, there are good reasons why the Japanese manufacturers could be producing cheaper equipment. Firstly, few could argue that they are not efficient; certainly their good deliveries, excellent after-sales service and flexibility of design shows them to be extremely efficient. Probably the main reason for this is that they have invested large amounts of capital in automation.

Although their labour costs are higher, there is less labour per item, due to the automation, and using the same number of workers they can produce more products. Since materials and components are made on a similar basis, they are cheaper and more readily available within their own country.

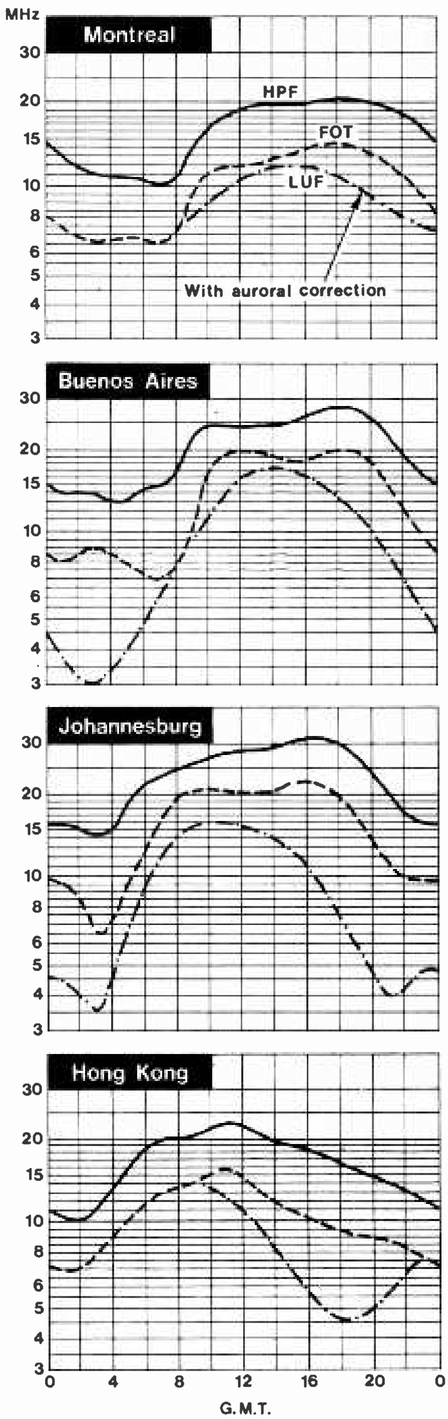
In the amateur field it must also be remembered that the Japanese home-market is one of about ½ million amateurs, compared with only about 25,000 in the UK. Amateur equipment exports represent only a fraction of their overall amateur market.

Photo shows the CQ-301 linear amplifier, CQ-110E, digital v.f.o. CQ-201 and the 2m portable CQ-P-2200 (on top of CQ-110E), all Nippon Electric Company products.



HF predictions

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



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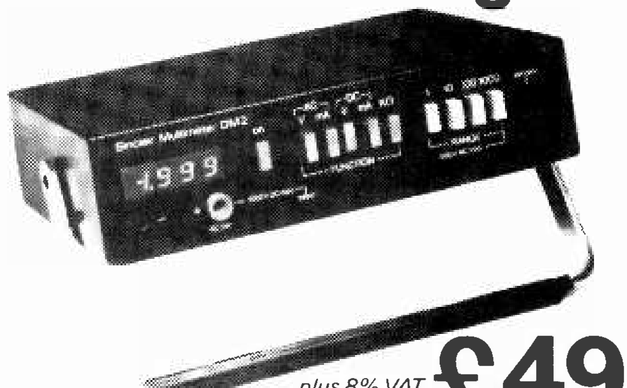

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A wide range AGC system incorporating PIN diode attenuators before the fully balanced RF stage ensures first-class strong signal handling characteristics

Automatic selection of appropriate receiver input band pass filters eliminates the need for front panel preselector controls

IF output at 455 KHz and 600 ohm line output are provided for diversity receiver use and also for remote station monitoring

The construction of the NRD505 is superb and wide use is made of automatic assembly techniques to give a high MTBF

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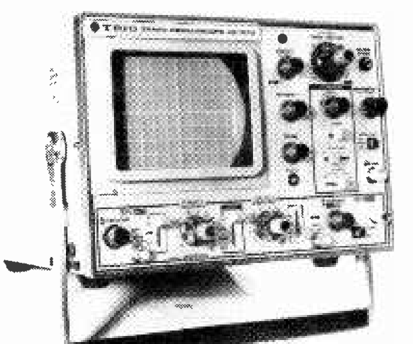

CS-1570

130mm DUAL TRACE TRIGGERED SWEEP OSCILLOSCOPE

- 130mm mesh PDA
- OC 30MHz 5mV
- Delay line
- Auto level triggering
- Display modes (CH1 CH2 DUAL ADD)
- Trigger models (AC LFRej HFRej DC)

•SPECIFICATIONS

Bandwidth	DC to 30MHz (−3dB)
Deflection factor	5mV div to 5V div
Input R C	1MΩ 24pF
Risetime	11 7nsec
Overshoot	Better than 3%
Signal delay	160nsec
Polarity	CH2 can be inverted
Sweep time	0 2µ div to 0 5s div
Magnifier	× 5
Linearity	Better than 3%
Calibrator	0 5Vpp (1kHz square wave
Intensity modulation	More than 5Vpp
Phosphor	P31
Power	AC100 120 220 240V 50 60Hz 25W
Dimensions	W260 × H190 × D375 (mm)
Weight	8 5kg

CS-1570
PRICE £430 + 8%
Includes two X10 probes

CS-1560A

130mm DUAL TRACE TRIGGERED SWEEP OSCILLOSCOPE

- 130mm CRT
- DC 15MHz/10mV
- Automatic sweep (AUTO FREE RUN)
- Display modes (CH1 CH2 DUAL ADD SUB)
- Full sensitivity X Y operation

• SPECIFICATIONS

Bandwidth	DC to 15MHz (−3dB)
Deflection factor	10mV div to 20V div
Input R C	1MΩ 22pF
Risetime	23msec
Overshoot	Better than 3%
Sweep time	0 5 s div to 0 5s div
Magnifier	× 5
Linearity	Better than 3%
Calibrator	1Vpp (1kHz square wave)
Intensity modulation	More than 20Vpp
Phosphor	P31
Power	AC 100 120 220/240V 50 60Hz 23W
Dimensions	W260 × H190 × D385 (mm)
Weight	8 4kg

CS-1560A
PRICE £300 + 8%
Includes two X10 probes

CS-1562

130mm DUAL TRACE TRIGGERED SWEEP OSCILLOSCOPE

- 130mm CRT
- DC 10MHz 10mV
- Automatic sweep (AUTO FREE RUN)
- Display models (CH1 CH2 DUAL)
- Full sensitivity X Y operation

• SPECIFICATIONS

Bandwidth	DC to 10MHz (−3dB)
Deflection factor	10mV div to 20V div
Input R C	1MΩ 22pF
Risetime	35nsec
Overshoot	Better than 3%
Sweep time	1 µs div to 0 5s div
Magnifier	× 5
Linearity	Better than 3%
Calibrator	1Vpp (AC line freq square wave)
Intensity modulation	More than 5Vpp
Phosphor	P31
Power	AC 100 120 220 240V 50 60Hz 20W
Dimensions	W260 × H190 × D375 (mm)
Weight	8 0kg

CS-1562
PRICE £250 + 8%
Includes two X10 probes

FINAL TEXT

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Telephones and new technology

How progress can change an industry

By John Dwyer

The Post Office uses five different types of exchange, apparently as a result of shrinking from unpleasant decisions over the years. The Plessey closures appear to show that the result was the same in the end anyway. This article traces the history of British telephone exchanges and asks whether we have learnt enough from it.

Well into July, some four months after Plessey announced that they would have to sack 4,000 workers as a result of cutbacks in Post Office ordering, 200 women were still occupying Plessey's telecommunications plant at Kirby, Liverpool. The sackings caused a great deal of political heat at the time, and the Prime Minister was moved to appoint Mr Michael Posner of Cambridge University, a specialist in the economics of the public sector and a former deputy chief economic advisor to the Treasury, to examine the Post Office's equipment ordering methods.

His report was published at the end of May and welcomed at once by the Post Office, It is a vague, largely impenetrable document, full of tables and largely innocent of any suggestion of suffering that the tables might convey. At one point the professor offers two equations the Post Office uses to determine its future equipment needs, explaining that the studies which led to changes in the figures used in one of the equations are discussed in appendix 2; on the following page he adds'; "I would not pretend to have understood fully the complex calculations reported in appendix 2." The Post Office's decisions, he concludes, had been broadly correct.

Posner has not even approached the much broader, and more important questions raised by the dismissals: Why are there so many different types of exchange in use? If correct technical decisions had been made at the right time, and adhered to, would those sacked workers now be employed in a thriving, export-led telecommunications industry? Has new technology at last begun to make people surplus to requirements? Who supports either those made surplus or, for that matter, the Posners of this world?

The latest staff cuts are merely an unfortunate acceleration in a process that has been going on largely unobserved for some years. Thirty years ago the GPO, as it was until 1969, was pre-eminent among telecommunications authorities mainly because of its strict adherence to rather conservative but very high technical standards. Also important, however, was Britain's position at the head of the Empire; it was this which attracted Automatic Electric of Chicago to set up, with BICC, a subsidiary in Liverpool to make Strowger exchange equipment. The first British Strowger step by step exchange was opened at Epsom in 1912. Eventually there were five companies making Strowger in Britain: Automatic Telephone and Electric (ATE, taken over by Plessey in 1961); Ericsson (a Swedish company banished in 1948); GEC; Siemens (later taken over by AEI); and STC, now a subsidiary of ITT. Because of the Empire, these companies had available to them a large export market which they could exploit merely by hanging on to the GPO's coat tails. With a quarter of the industry's production going abroad, Britain was the top exporter of telecommmunications equipment even as late as 1963.

As an exporter Britain has now fallen from first place to fifth. The companies and their unions say that this is the fault of the Post Office, which has not ordered the type of equipment that is acceptable abroad and has changed its ordering plans so frequently that it has become impossible for them to plan ahead.

The export story

It is perhaps true that the suppliers and their potential export markets parted company a long time ago. Until the late 60s the Post Office refused to buy a newer alternative to Strowger, the crossbar exchange. As the demand for telephones grew it became clear that the Strowger system had serious limitations. It is noisy, acoustically and electrically, has a lot of moving parts and so needs a lot of maintenance. Crossbar is also an electromechanical system but it has fewer moving parts and needs less frequent adjustment. Crossbar systems have been used in Sweden since 1926. Perhaps more important, though, is that Strowger is a step by step system in which the call has to be routed one step at a time all the way to the dialled number before it discovers that the line is engaged. This wastes line space, a problem which can be overcome if all the calls are controlled from a central point in the exchange. The common control then allocates a route and operates all the switches along it. In Sweden in the late 1930s Ericsson invented a crossbar exchange system which used common control. The control unit takes the dialled number and registers it, then looks at the outlet and, if the number is free, operates the line switches to work a path back to the caller's phone. The system still uses electromechnical switches but is a lot more economical in line space.

If the common control fails, the system fails, unlike a Strowger system, and so duplication is necessary but, during the 1950's, continental exchanges began to standardise on crossbar, and pressure built up in Britain to develop an exportable crossbar system. Plessey developed the 5005 crossbar, which they offered to the Post Office, but the Postmaster General, after consulting the GPO, said that the Government would prefer to wait for the inevitable arrival of all-electronic systems than invest in an intermediate electromechanical system. The manufacturers appear, reluctantly, to have agreed.

The Post Office went ahead with an experimental all-electronic (time division multiplex) exchange in Highgate, North London. This exchange opened one day in 1962. It closed the same day, having collapsed once it reached a quarter of its full traffic load. The Post Office was forced to fall back on Strowger. This helps to explain why even today 85% of the Post Office's 6,000 local exchanges are still Strowger, and why the suppliers have been so dependent on Strowger orders for so long.

Reed relay exchanges

While fulfilling its immediate needs with Strowger the Post Office, more cautious now, accelerated development of a reed relay exchange system first installed in Leighton Buzzard in 1967. This had been developed since 1961 through the Joint Electronics Research Agreement between all the suppliers. The TXE1, as the reed relay system was known, was developed by Plessey into the TXE2 for small rural exchanges. The Post Office now have about 800 of these exchanges in use, some from each supplier, and Plessey have been able to sell a commercial version, Pentex, successfully abroad.

However, there had been no version of TXE2 available which would be suitable for large exchanges. STC went ahead on their own after the JERA was ended and funded development of TXE4.

But in the period just after Highgate failed TXE4 was still a long way off — the first such exchange, at Birmingham Rectory, did not open until February 1976. In addition, demand for telephones was growing, particularly since the nationalised industries were forced to hold prices below what they considered an economic level: demand doubled between 1965 and 1971. The Post Office were forced, after all, to buy crossbar, and the first crossbar exchanges went into service in the late 1960s.

Why more crossbar?

In 1971 the Post Office appears to have decided once again to make all its large exchanges electronic, and the following year they were trying to choose between TXE4 and more crossbar as an interim measure. The dilemma was heightened by the heavy reliance of the manufacturers on crossbar orders, and the smoother transition that TXE4 appeared to offer to electronic technology. See *Wireless World*, March 1976 p.92.

In February 1973 the Government announced approval of a decision to spend £350 million on crossbar and £100 million on TXE4. That this decision may not have been to the Post Office's liking is shown by a £15 million order received the previous year by STC from the Post Office for 16 TXE4 exchanges. In a speech in November 1972 Mr C. A. May, head of exchange systems division of Post Office telecommunications development wrote in the journal of the Institute of Post Office Engineers that TXE4 was "capable of providing the British Post Office's requirements for large scale telephone exchanges over the next decade or more." It was the result of consistent and logical development work since 1956. At that time, however, GEC and Plessey were pressing for the adoption of a computerised stored programme control version of crossbar, TXE4 being, they thought, unexportable.

Then GEC defected. In 1973 the company signed a ten year agreement for the exchange of technical information with STC. Plessey, it was thought, was out in the cold, particularly when it become known three months after the STC/GEC deal that GEC had won the Post Office's contract for the processor to be used with the planned "System X" all-electronic exchanges. The orders for the 2BL processor would be worth £10million a year by the 1980s. All three companies had competed for this contract — Plessey submitted its PP250 processor — but it appears that when large companies compete for government contracts nobody loses. For one thing any company which wins a Post Office contract shares its information, for a price, with the others. For another, by purest coincidence, Plessey were awarded the contract to supply the PP250 for the Ptarmigan military communications system just as the GEC 2BL contract was announced.

Exports? — Forget it.

As a result of all this the Post Office exchange system is a melange of five different interworkable, but not interchangeable, systems. That means five lots of maintenance, five lots of spares, and five lots of training for the personnel associated with them. None of them has given the suppliers any export advantage. The Post Office crossbar system does not use multifrequency signalling, as the foreign market requires. None of them offers common control with a central microprocessor — Plessey's 5005 common control crossbar system failed to compete with those built by Ericsson and Siemens, who had a ten year lead.

Even TXE4 appears to have faults. TXE4 uses a number of smaller distributed processors instead of a central processor. In essence, it keeps a map of the state of all the switches which is updated every few milliseconds, and the call is routed by looking at the map the instant the number has been dialled. As Sir Raymond Brown pointed out in a report to the National Economic Development Council, TXE4 exchanges "do not have the computer control facility which is currently being offered by our competitors." The computer control he refers to is the ability to alter switch instructions electrically. For example, not only can such a system recognise a fault (as can TXE4) but the programme in the computer can route all the calls round the fault. This is known as stored programme control, or s.p.c. According to a report by white collar union ASTMS, TXE4 cannot perform tandem switching economically. A tandem exchange provides a central junction through which all calls are routed instead of providing links from every exchange in an area to every other exchange.

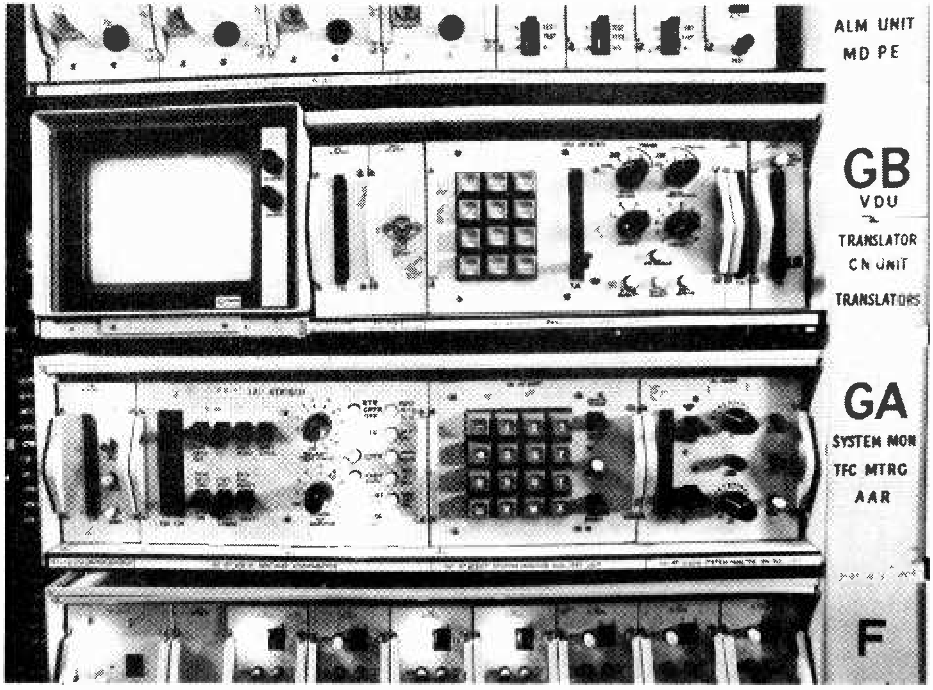
ASTMS also advanced another reason for the poor export performance of the suppliers: "Our main criticisms of the British companies is that they have acted far too conservatively. Because of their extremely close business relationship with the Post Office, they have failed to engage in any serious degree of entrepreneurial enterprise. Their record is one of lack of innovation; they have waited for the Post Office to order and take *(sic)* few risks. In this they are unlike other companies abroad, such as Siemens, which takes initiatives, exporting even if the domestic German Post Office does not order the equipment the company makes." According to ASTMS, Plessey invested 3.2% of its total sales in r & d where Siemens put in 8%. In 1974 52% of the UK suppliers' output was accounted for by public telephone exchange equipment, transmission equipment accounted for another 10% and subscriber equipment 10% more. That is, three-quarters of their output was bought by the Post Office. Sir Ray Brown's figures, based on the Business Monitor for 1975, are rather different, but they still show that the Post Office bought two-thirds of the industry's output in that year.

In addition, the companies appear to have had enough trouble meeting Post Office orders without trying to produce exports as well, if an Arthur D. Little study of 1972 is to be believed. In August that year McKinsey management consultants were brought in to investigate their late deliveries.

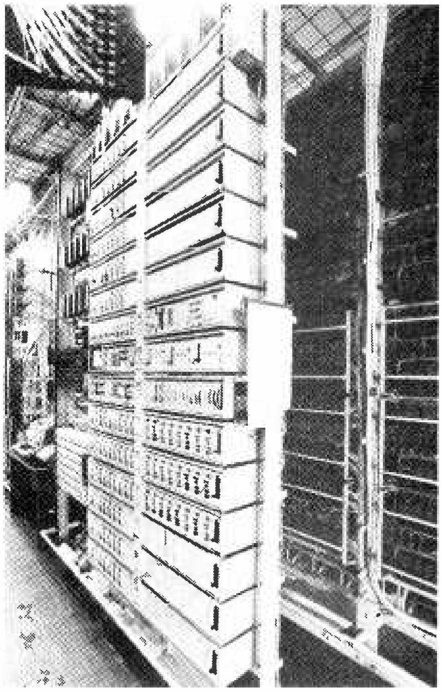
Lack of initiative does not account entirely for the decline in the telecommunications industry. The Post Office had been accused of being inflexible in specifying the equipment it wants without regard for the need of suppliers to sell that equipment elsewhere. One example was the Post Office's choice of a non-standard crossbar system. Another, say STC, is the PO insistence on servicing the equipment from the back, whereas most foreign equipment is serviced from the front. Yet another is the Corporation's choice of Coral 66 as a programming language for System X, the future all-electronic exchanges. Coral 66 is not widely used outside the UK. It happens that Coral 66 is the standard language for military programming. The suppliers also complain that they have to pass any cost reductions they achieve as a result of greater efficiency on to the Post Office.

Where is everybody?

So far these upheavals appear to be more a result of the industry's own peculiar history than of changes in technology. But the changes began to affect the number of people employed the moment the Post Office moved away from Strowger. In a recent speech to the Royal Society STC chairman and



The control panel for the Pye TMC electronic director at Surbiton exchange. The v.d.u. shows the exchange codes and the codes to which they are translated for routing the call to a distant exchange. The pushbutton panel on the lower shelf puts new exchange codes into the director or may change existing ones. This updating used to be done once a week by changing the straps on a hard-wire panel. The new director occupies one fourteenth the space of the previous electromechanical equipment. It has been on test at Surbiton for two years, and development started in 1969.



The prototype electronic director at Surbiton. This equipment rack replaces 14 of the electromechnical type. The equipment has a translation store of 2,000 individual routing instructions, any of which can be rewritten using a keypad, providing for the routing of traffic to several hundred local exchanges, to the trunk network or various information centres. The translators are installed in triplicate in case of failure, but there have been no faults on the equipment in two years.

managing director Kenneth Corfield gave the following figures: to manufacture 500,000 lines of electromechanical equipment a year needed 3,300 directly employed workers; to make the equivalent amount of semi-electronic equipment needed only 1,250, while the wholly-electronic equipment would need only 120 workers.

The same is true of the numbers needed to look after such equipment. A good example is provided by the recent installation of an electronic director by Pye TMC at Surbiton exchange. In large conurbations the calls from a number of exchanges within an area are controlled by directors. Director areas have seven figure numbers. The first three digits are translated by the director into a train of pulses which route the call to the exchange connected to the dialled number. The final four digits are stored by the director until all three code numbers are dialled and translated and these four digits are then transmitted without translation. Without directors those connected to one exchange would need a different telephone directory to subscribers connected to different exchanges in the same area.

Directors are in continual use since they deal with one call and then go on to the next. The electromechanical director needs frequent adjustment, and oiling once a month. In spite of constant attention electromechanical directors often misroute calls. In addition a strap field has to be altered manually once a week to deal with changed numbers and other alterations to the hard-wired programme. At Surbiton a team of eight is needed to keep the director and other equipment working.

The prototype Pye electronic director has been in use in Surbiton for two fault-free years. The translations are changed by a keypad which replaces the strap field, updating the store. It runs silently, enabling the engineers to talk to one another without shouting. It can work next to the electromechanical equipment in the exchange, which produces back-e.m.fs that can reach 1,300V if a section fuse blows: the p-channel m.o.s. l.s.i. logic uses a '1' level of 25V and a '0' of -3V. The electronic director cannot misroute calls and samples one call in every 16 to make sure it is correctly routed. Not only is it actually cheaper than the electromechanical alternative, it takes up only one rack where its equivalent would have taken 14, and this enables the Post Office to take up any increase in telephone traffic without having to move to larger, and very expensive, new buildings. It does not need anything like the maintenance of the electromechanical equipment. With all these advantages it becomes plain that the Post Office cannot afford not to use more of this type of technology wherever it can and, following the Surbiton trial, the Post Office has ordered 280 electronic directors worth £7million to replace the electromechanical ones in 243 exchanges by 1981.

This is bound to have a great effect, as it is meant to, on staff levels. In the rest of the telecommunications industry the effects have bitten deep already. According to Sir Ray Brown's figures, between 1971 and 1975 the number of people employed in telecommunications fell from 91,000 to 77,000. In the first quarter of 1975 there was a halt in the increase in telephone traffic, largely because of the fall in business activity and the large number of bankruptcies.

The recent review

Even more crucial, however, was a change in the method of measuring the flow of calls through the exchanges. In mid-1975 a new computer system for Exchange Equipment Review came on stream. The Post Office estimated that they would have to wait a year before they had built up sufficient data on which to base their predictions. "As a result of that," say the Post Office, "at the end of that year the capacity of switches was much greater than we had thought hitherto." The Posner report estimates that the excess in capacity was about 20%. The Corporation also began to even out the peaks and troughs in telephone traffic by making calls at the most popular time, the morning, more expensive.

On top of all this, in 1975 Post Office charges were increased. In 1976 public spending cuts forced nationalised industries to be more self-reliant. The PO cut back its ordering programme drastically. The revised figures were published last November. £44 million worth of orders for GEC/Plessey Crossbar in 1977/8 had become £25 million. Strowger orders were slashed by three-quarters to £10 million. The investment programme for 1976 to 1980 was trimmed from £884 million to £665 million.

Perhaps the bitterest taste left by these cuts is that, when the Post Office increased its prices in October 1975 the then Prime Minister, Harold Wilson, on advice from the Post Office, said that the Corporation's ordering programme, outlined the previous year, could be regarded as definitive, and there would be no further need for redundancies. STC have since sacked 2,000 working on exchange equipment and GEC have cut their 33,000 work force by a third. The number in telecommunications has fallen a further 10,000 and the unions have said that the Plessey closures in March are but the first instalment in further cuts of 15,000.

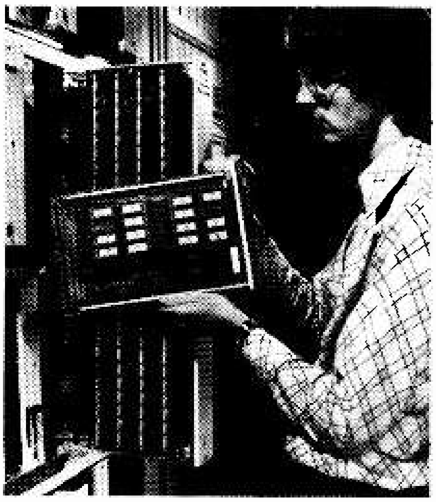
Sir Ray Brown describes System X as "the most ambitious programme ever undertaken by the British telecommunications industry." The Post Office is funding a £100 million development programme, half each to be spent in the Post Office and by the suppliers. Only scattered details are known about System X since Post Office staff involved are covered by the Official Secrets Act and the participating firms have to sign non-disclosure agreements before meetings at which the system is to be discussed. However, we do know that the Advisory Group on System Definitions, set up in 1968 and comprising representatives from the PO and industry, has agreed the basic idea behind the system, and that the first stage, the definition of requirements and the corresponding contracts, have been completed. The contracts are now being prepared so that the equipment can be produced. See *Wireless World* March 1976, p.92-94.

The reason for the secrecy is the manufacturers' heavy dependence on System X for future exports. Yet there have been serious doubts expressed, inside the Post Office as well as outside it, about the way the system is taking shape. One source of disquiet is the Post Office's insistence that System X will be based on "proven technology", meaning that it will use techniques which have been in use for some years.

Some authorities believe, however, that this caution is inappropriate when one takes account of the way modern circuits are manufactured, and may prove disastrous if System X has to rely on being ahead of its rivals. One eminent source told *Wireless World*. "System X will determine whether or not there's a future for the telecommunications industry for the next God knows how many years; it's very, very important." Yet he felt that System X planning was awry, starting with the decision to buy the 2BL processor. To begin with it used t.t.l. technology, which was years behind the times. In addition it was a powerful processor which would be used in large control centres to control a number of exchanges connected by data or modem links. This, he said, went against the tendency in other countries to use distributed systems with a large number of exchanges controlled individually by microprocessors. The architecture of the system had been decided far too early, and its production was taking far too long. "Whether anyone will want System X by the time it appears, since the technology has moved on, is doubtful. I don't think there'll *be* a telecommunications industry in a few years if decisions keep being made as they are."

Until now electronics has been used almost exclusively to control existing systems rather than to provide, as it is hoped System X will do, a technically-improved alternative. One good example is the Pye director. Although the technology used could be applied to some future electronic system, the equipment itself merely replaces electromechanical equipment and does not fit into the framework already decided for System X.

Another example of the improvements electronics can make is the STC-developed variant on TXE4, TXE4A. The Post Office has ordered the first TXE4A exchange for Leicester's Belgrave exchange to come into use in January, 1980. TXE4A uses i.cs instead of discrete components, including m.o.s. reprogrammable read-only memories for the program store. Directory numbers and other information are fed



The new m.o.s. reprogrammable read-only memory store for STC's semi-electronic telephone exchange, TXE4A. The threaded wire equivalent used in TXE4 is in the background. As a whole TXE4 saved around 20% of space on Strowger, and the new version saves a further 20% on that. Both memories contain the programme for the exchange's main control unit which establishes the routing of the calls through the exchange.

from a keyboard to m.o.s. shift registers. "In addition," say STC, "an interface has been incorporated which will enable communication with local and remote processors which will permit the future provision of exchange management processors to give improved administrative control of System X." Other ways in which electronics can support telecommunications were explained in "Electronic telephone exchanges," *Wireless World*, June and July 1974.

Some of the effects of the new technology may be mitigated by the increasing use of the telecommunications network for other purposes than telephone calls. Data transmission, Telex, videoconferences, Viewdata, facsimile, and radio and tv signal transmission all require new techniques and better equipment, and the transmission network is rapidly being modernised. But the number of people in the industry is still bound to reduce. The evidence for this is so overwhelming that even ASTMS, in their report on the industry, (*Wireless World* February, p.46) say that a comprehensive programme of retraining, redeployment and generous compensation is needed to minimise the effects on industrial employees.

But someone has to pay, and it would end up being the Post Office. Even Posner's mild suggestion that perhaps all the Strowger orders for the next 10 years should be concentrated in the next two years would cost the Corporation £5 million. And the Post Office's own manning problems don't end with the closing down, last October 14, of the last manual exchange. It has applied to the EEC for a grant to retrain engineers whose jobs will disappear with the introduction of new technology.

However the problem is tackled it is of much wider interest than a few factories closing down temporarily because of adverse economic conditions. This may be Britain's first taste of what may become a regular diet. The speed at which the Post Office progresses towards all-electronic exchanges may determine the speed at which the industry that made the old technology goes into decline, but nothing will alter the fact that, if Mr Corfield's figures are correct, at the end of that process one worker will be needed where there were once 27. What happens to the 26? Who will support them? What then happens to the price of the product made by the one employee if part of that money has to support his former colleagues? Should nationalised industries support the industries who supply them or should we pay people to do nothing, through taxation, rather than to make out-of-date equipment? These questions have to be tackled, because Plessey's closures are what the effects of technology mean, and the process, in this and other industries, has not yet even begun.

(Carter and the Post Office: see News, this issue)

Identifying European Television—3

A final selection of test cards and identification captions

by G. Smith & K. Hamer

In the previous two articles sporadic E and tropospheric propagation have been mentioned as methods of receiving long-distance television stations in the United Kingdom. Although these two propagation modes are the main sources of reception, there are several other methods.

From time to time there are periods of intense solar activity which gives rise to solar flares. These flares cause a vertical reflecting sheet to be formed due to the magnetic disturbance and ionization of the Earth's D, E and F layers. Signals tend to be received from a northerly direction and there is a characteristic rumbling or sleigh-bell effect on sound, and horizontal bars on vision. It is possible to receive trans-Atlantic signals during exceptionally high solar flares.

An observation of the sun will indicate whether auroral reflection is likely because it is governed by magnetic storms in the sun's photosphere which in turn produce visible sun-spots. The chances of receiving signals by this mode of propagation are increased if there are many sun-spots present. It should be stressed that if a study of the sun is to be made the sun's image should be projected on to a piece of card to show the state of the sun-spot activity. Due to the rotation of the sun, there is a tendency for a re-occurrence of auroral reflection after 27 days but this cannot be guaranteed to affect television channels which, incidentally, are usually in Bands I and II.

Signals can also be received when small meteors enter the Earth's atmosphere at high velocities and produce an ionized trail. These particles can cause signals to be received at any time of the day or night and reception is entirely random. At certain times of the year, however, there are specific showers of meteors which can cause reception on a fairly predictable basis. Signals via this propagation mode tend to be of short duration, typically between 1 and 10 seconds but nevertheless interesting signals can be received. Usually Band I channels are affected. The originating transmitter can usually be identified by using the "List of Television Stations" which is published annually by the European Broadcasting Union.

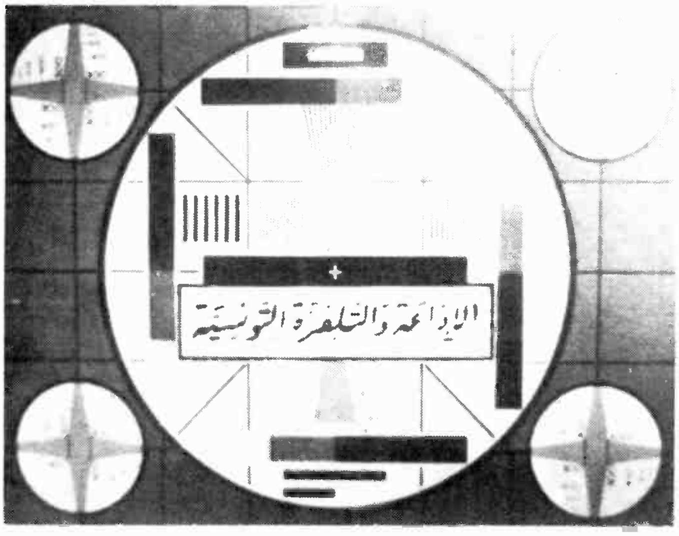
A somewhat dangerous method of reception is via lightning flash. During severe storms, lightning causes the atmosphere to become highly charged and television signals can be received during such periods. With this form of propagation, both v.h.f. and u.h.f. transmissions can be received. Incidentally, if an outdoor aerial mast is used, it should be earthed and insured as a precaution against lightning strikes.

Reception via F2 propagation is also possible during intense solar activity, when the maximum useable frequency rises and the F2 layer is ionized. This layer, which is approximately 200 miles above the Earth's surface, is able to refract television signals which can originate from transmitters over 2,000 miles away. F2 layer reception occurs when solar activity is at maximum and such activity has a cycle of approximately 11 years. Double-skip reception can occur via F2 propagation and leads to interesting possibilities because the reception range is not confined to Europe alone.

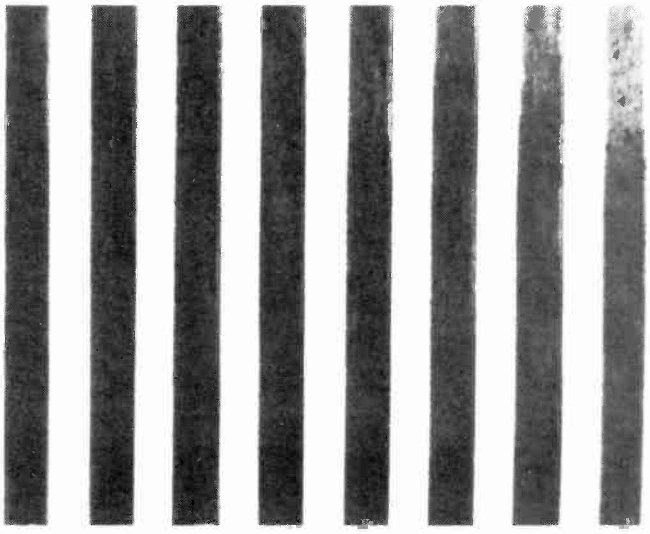
When the F2 layer disintegrates at dusk, another effect can take place called trans-equatorial skip. Due to the 11 year cycle, F2 and trans-equatorial skip propagation modes are not very common but it is hoped that the next peak will produce spectacular reception. Signals can also be received directly from satellites provided that suitably modified equipment is used. Television transmissions intended for Indian villages have been received in the UK from the American ATS-6 satellite. This satellite was in synchronous orbit over the Indian Ocean until last August. The experimental signals were transmitted on u.h.f. at 860MHz with wide band f.m. video modulation. This satellite has now been moved and consequently the transmissions to India have ceased.

Further information about reception techniques can be found in *Television* magazine which has a regular DX column by Roger Bunney. As mentioned in a previous article, a 56 page book entitled "Guide to World-Wide Television Test Cards" is available through bookshops or directly from HS Publications at 17 Collingham Gardens, Derby DE3 4FS, price £1.30 inclusive. Virtually all television services throughout Europe and the rest of the world are featured with over 260 test card and identification caption photographs.

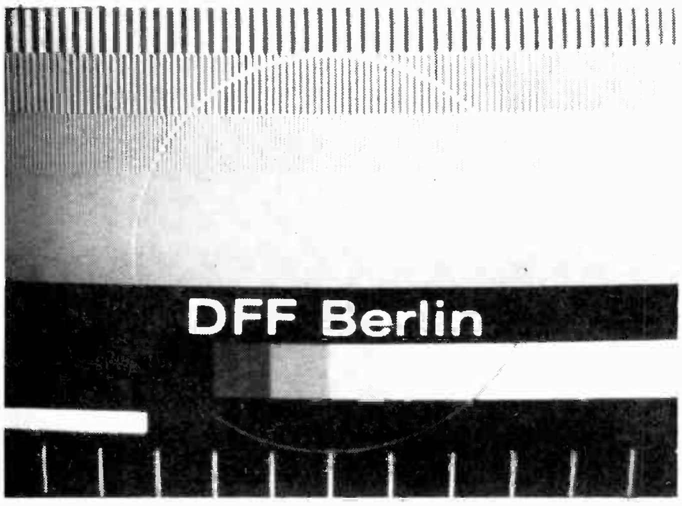
Poland TVP (D, K) — Televizja Polska's news programme caption. The initials DTV are also used.



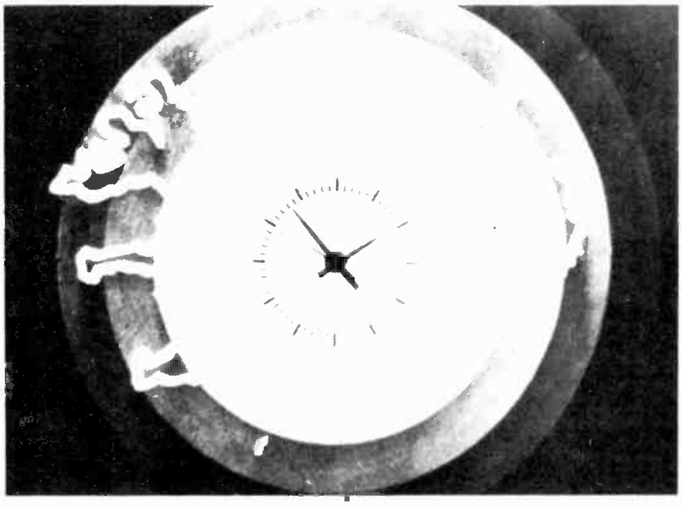
Tunisia RTT (B) SECAM colour — Radiodiffusion-Télévision Tunisienne has ten main transmitters, all of which operate in Band 3.



Vertical bars pattern — This pattern is used by the Polish and Russian Services. Spain also uses it but with a greater number of bars.



East Germany DDR-F (B, G) SECAM colour — Alternative identification used with the DDR-F electronic test card.

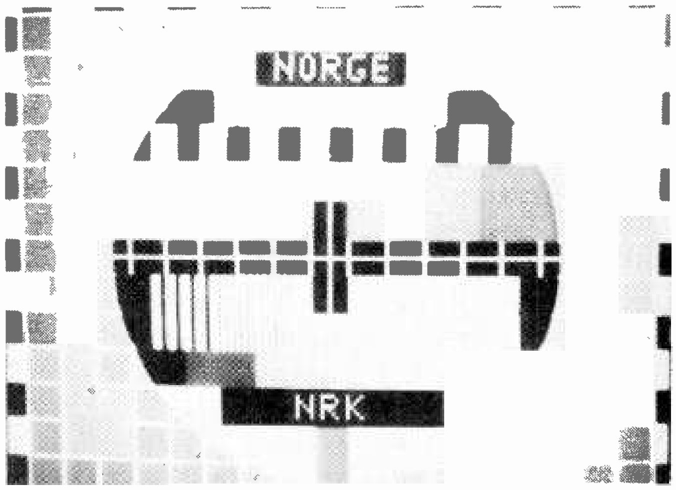


Iceland RUV (B) — Rikisutvarpid Sjonvarp has three high-powered Band I transmitters.

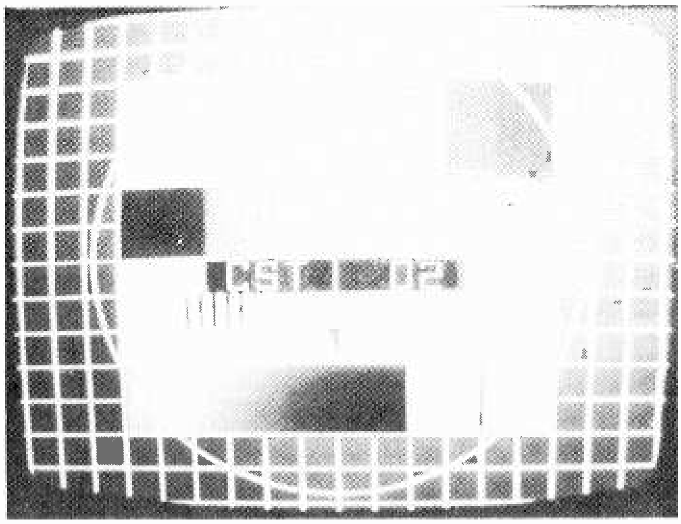
Algeria RTA (B) — Identification caption used by Radiodiffusion Télévision Algérienne. All transmitters are in Band III.

Czechoslovakia CST (D, K) SECAM colour — The new electronic test card as used by Ceskoslovenska Televize.

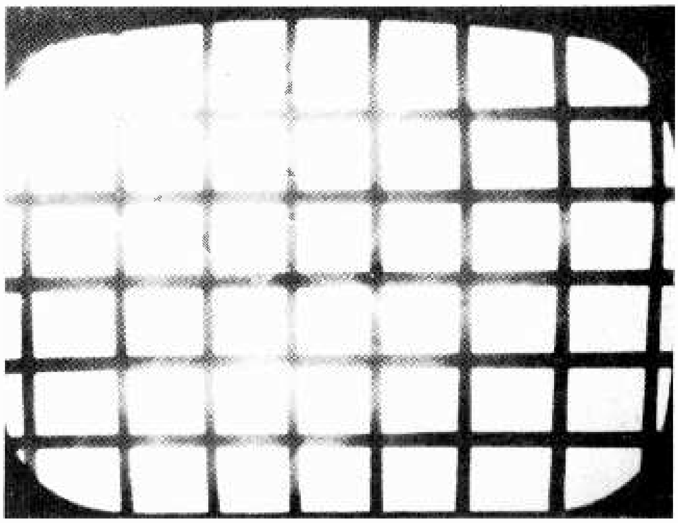
Monaco TMC (L) SECAM colour — The Philips PM5544 electronic test card is now used with the identification "Tele Monte Carlo."



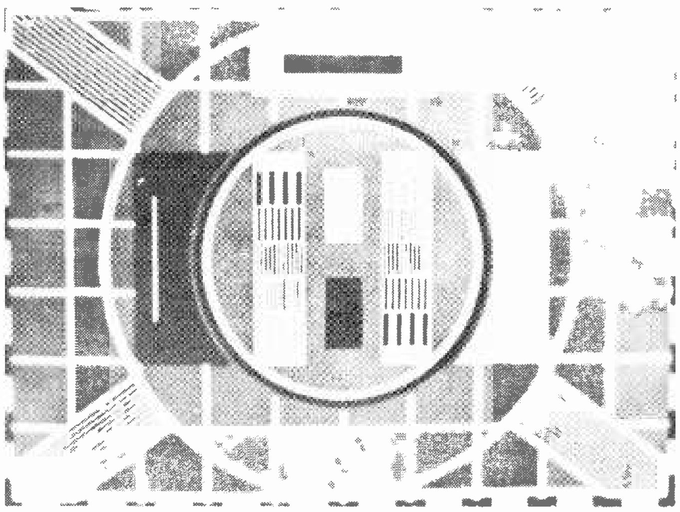
Norway NRK (B, G) PAL colour — At present, Norsk Rikskring-kasting mainly transmits on v.h.f., but u.h.f. transmissions are being introduced.



Czechoslovakia CST (D, K) SECAM colour — The FUBK electronic test card is used as an alternative to the PM5544.

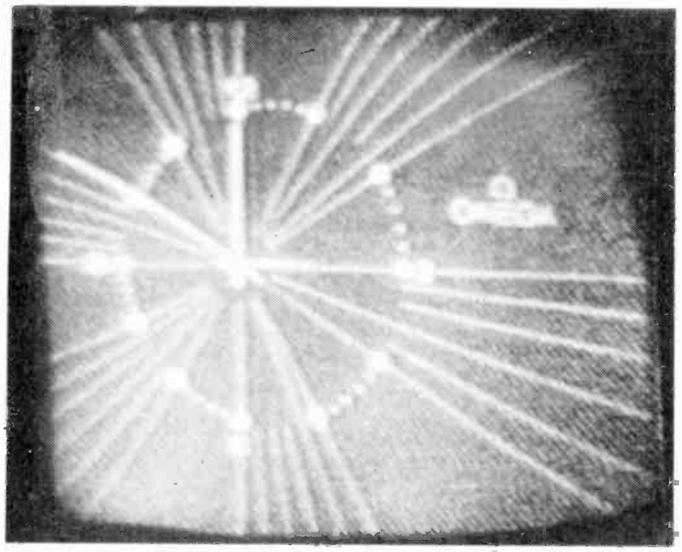


Lebanon CLT (B) SECAM colour — Compagnie Libanaise de Télévision has been received in the U.K.

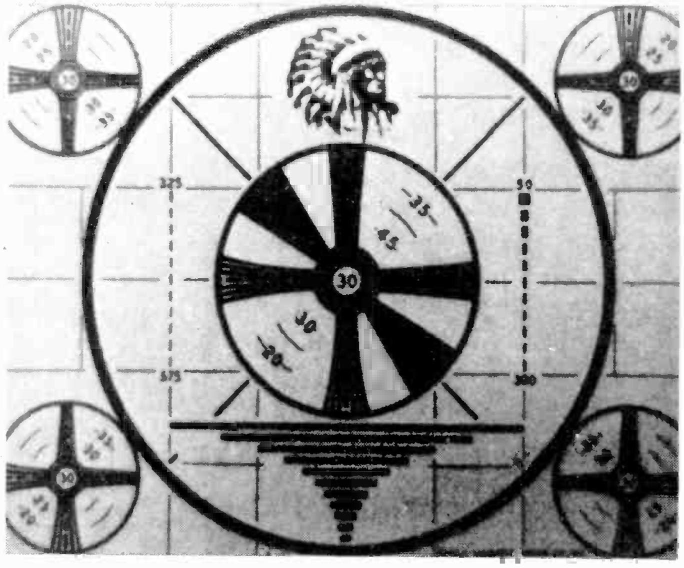


Cyprus PIK (B, H) — The PIK test card "G". The service is also identified by the letters "CBC" and "RIK".

Hungary MTV (D, K) SECAM colour — Magyar Televizio has three high-powered Band I and one Band II transmitters in operation.

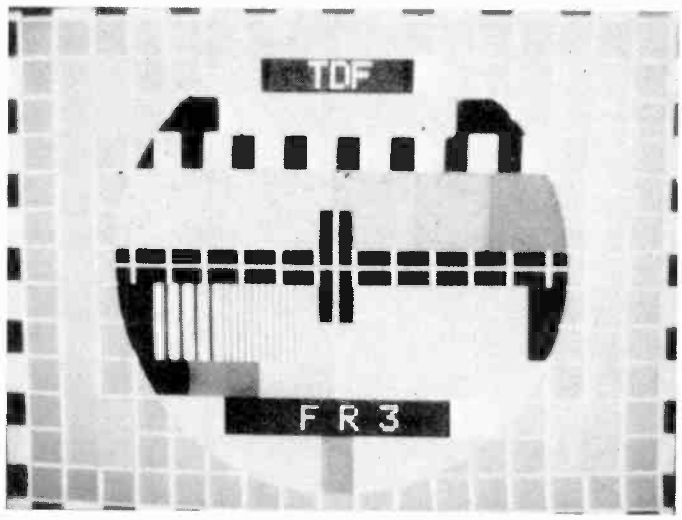


RTVE-Spain/PTT: SRG: SSR: TSI-Switzerland — Off-screen photograph from RTVE. The Swiss service replaces "Ω Omega" with "tv".

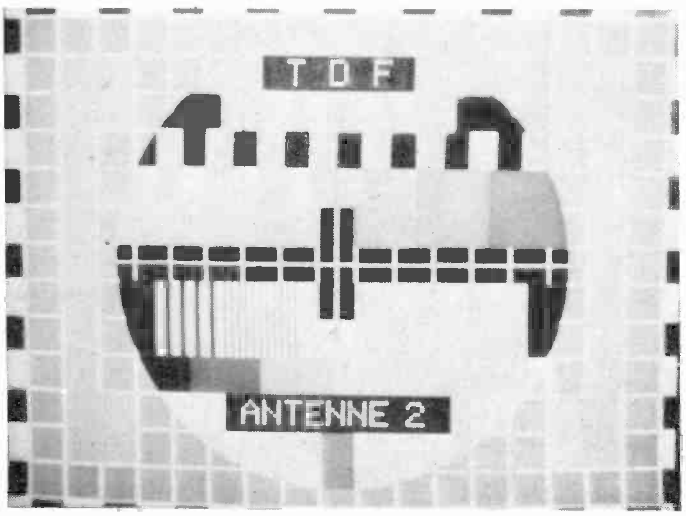


Saudi Arabia HZ 22 (M) — The Indian Head test card as used by Aramco Television in Dhahran.

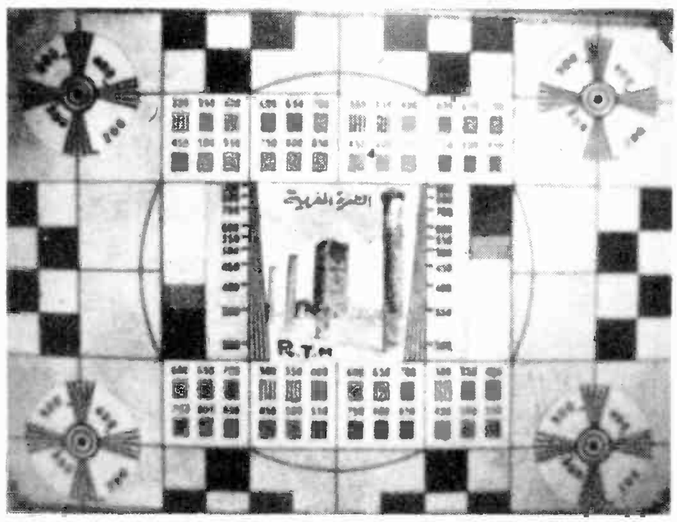
Ghana GBC (B) — Although not in the official E.B.U. European Broadcasting Area, the Ghana Broadcasting Corporation has been received in the U.K.



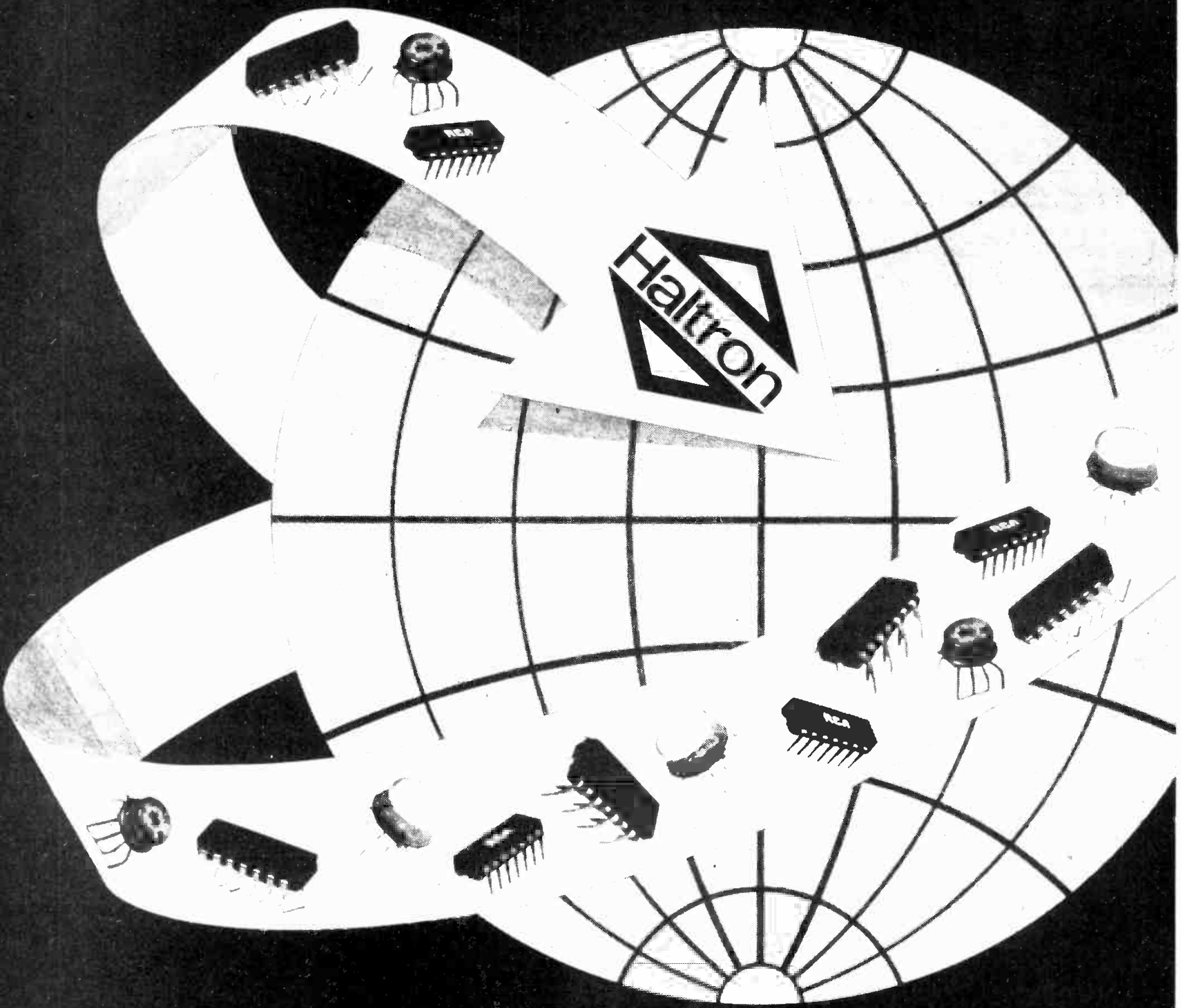
France FR3 (L) SECAM colour — France Region 3 is the third network of T.D.F. The first network uses a similar electronic test card with the identification "TDF TF 1".



France A2 (L) SECAM colour — "Antenna 2" is the second network of Télévision de France. The photograph was taken off a monitor.



Morocco RTM (B) — Morocco's transmitters are at present confined to Band III which makes reception of this service difficult.


Haltron

Letters to the Editor

PRICE OF SMALL COMPONENTS

As a director of a business which certainly would have met the description of a "local shop" beloved by "Mixer" in the Ally Pally day (July issue), may I please comment on his horror at the price of small components?

Certainly in the early 'fifties we supplied many local constructors with their bits and pieces. Although we employed a shop assistant for about ten pounds a week in those days, and paid about the same in rent, I doubt if we actually made a profit in meeting their needs. We did get a lot of fun from meeting individuals with like minds, and this made it worth while.

Today we employ knowledgeable salesmen highly trained to help our customers select their teak furniture with knobs on; they earn five or six times as much as our old shop assistants and a high-street location is costing nearly as much per square foot today as the whole shop cost then.

Despite our trade accounts, we often find it cheaper and quicker to pop up the Edgware Road to one of your advertisers when we need some bits to make the odd construction. The same manufacturers who will not supply "Mixer" as a member of the public will not supply us, either, in the quantities we could buy. It is only the purchasing power in the hands of a relatively small number of mail order firms, sited away from costly high streets, that enables "Mixer" to buy his components at all.

Maurice Sokel,
JMS Radio and Television Ltd.,
Edgware
Middlesex.

SLEW-RATE IN AMPLIFIERS

In his letter in the June issue Mr Nalty misleadingly states that a low slew-rate amplifier may be represented by a high slew-rate amplifier followed by an (unqualified but "suitable") RC filter, presumably low-pass.

This is suggesting that an essentially non-linear effect can be represented by cascading two linear circuits and is clearly unreasonable.

Slew-rate distortion occurs when the demanded output rate-of-change of voltage exceeds the maximum output slew-rate of the amplifier. The usual mechanism for slew-rate limitation (especially in op-amps) is a constant current source charging a compensation capacitor. Once the limit has been exceeded the output will therefore be a linear ramp until the output voltage "catches up" with the demanded output voltage, although, as pointed out by Professor Otala previously, and in a letter (June issue), in many cases the amplifier is detectably non-linear at a tenth of the slew-rate.

Slew-rate distortion is hence a non-linear distortion, and as the input sinewave amplitude is increased the output tends towards a triangular wave of peak-to-peak amplitude $Sr/2_f$ where Sr is the slew-rate in volts/second and f is the input frequency in Hz. Some reduction from the expected output fundamental will occur, but as this depends on the input amplitude, as well as frequency, it cannot be synthesised by a combination of ideal amplifiers (i.e. high slew-rate) and RC circuits.

G. J. Barton,
Department of Engineering and Cybernetics, University of Reading.

SURROUND SOUND

Ever since it was introduced, I have been highly sceptical of surround sound as a form of reproduction for use in the domestic environment. My scepticism remains undiminished in respect of all "quadraphonic" systems (which I will henceforward refer to simply as "quad") and arises from two reasons.

The first reason is the difficulty of installing the speaker array in the required fashion in the average (UK) living room. Living rooms have to be used as living rooms as well as auditoria. The second revolves around the technical aspects, and it is with these that I am really concerned. However, before going into these I must digress briefly and discuss objectives.

There are basically two uses for surround sound systems: for reproducing what I would like to call "surround" presentations and "ambience" presentations.

It is normal for music and drama to be presented on a stage. This is convenient for the performers. It is also convenient for the audience, who need only concentrate their attention in one general direction. It is disturbing for an audience if important sounds are produced from directions remote from the stage. Thus, whilst an ability to reproduce surround presentations realistically might be hailed by some as opening up great new vistas, this facility would mostly be used for material which was either gimmicky or trivial. What I think I could best call the *mainstream* requirement for surround systems is the reproduction of ambience presentations. Nevertheless, the touchstone of the quality of any quad system appears to be its ability to reproduce surround presentations, so I will assume that for quad this is the prime objective.

Now back to the technical aspects. "Quad" implies four of something: in this case, four channels of information and four speakers. There appears to be a theory that reproducing four discrete channels through four speakers in a square array will produce the required effect. The theory is based on the idea that adjacent speakers will behave as stereo pairs and reproduce sounds in their correct locations in the intervening spaces. In his January / February 1972 *Wireless World* articles, Mr Shorter very aptly called quad "four-channel stereo". So let us take a look at quad from this multiple-stereo angle.

I have at this address an excellent stereo system. It gives a wide spread of sound between the speakers with good localisation of solo instruments. Most importantly, with "serious" music, except on very rare occasions it is impossible to hear any sound as apparently originating from the speakers: one cannot detect the speaker positions by ear, even when trying hard to do so. The speakers are at the conventional angle of 60°. Widening the angle to 70°, the stereo image gets a bit diffuse. Widen it to 90° and the effect is very ping-pongy, so that I am very much aware of the presence of two sound sources. Quad requires the speaker pairs all to be at 90°, so with quad I would expect to hear not surround sound but four speakers. And at demonstrations of quad that is just what I have heard. And I am not the only one. "Ping-pung-pang-pong", as Mr Gerzon so nicely puts it. To some people's ears, including mine (and I suspect to just about everybody's), *quad does not work.* It is quite simply based on false premises. I have long wondered whether we were all being conned or whether those researching quad systems were kidding themselves (or both).

Quad requires four discrete channels of information. These can be put on to discs using carrier techniques, but it is simpler if the public can use their standard stereo pickups. So we have "matrixed" systems in which the four channels are compressed into two and the listener has a decoder to sort them out again. Simple decoders give heavy crosstalk, so some very complex ones have been devised to improve the "discreteness" of the recovered signals: albeit with some undesirable side-effects. Whilst one can admire the ingenuity which has gone into developing circuits such as the Variomatrix, one can only regret that it has been fundamentally misdirected.

For some years there have been several competing matrixed systems on the market, and these have recently been joined by the BBC's Matrix H. This is another quad system, its originators exhibiting the four-discrete-channel syndrome with its obsession regarding crosstalk, and not surprisingly their preferred approach is to use a Variomatrix to sort it out. As may be imagined from what I have already said, I read parts of Messrs Ratliff and Meares' article with a certain amount of disbelief.

Matrix H is claimed to be compatible with stereo and mono reproduction. However, I must question its stereo compatibility on ambience presentations. Messrs Ratliff and Meares say that "The front quadrant spans most of the stereo stage. . . ." Does it? Looking at the encoding equation (panpot form), I see that there is 36% (—9dB) crosstalk for sources in the front quadrant. Now a receiver giving only 9dB stereo separation would be regarded as exceedingly poor, so this looks bad. However, the crosstalk is phase-shifted, and if I have read him correctly, Mr Gerzon implies that this widens the apparent stereo image. Well, I have here a tape of a Matrix H-encoded broadcast from the Royal Festival Hall, London. I find that whilst the stereo image is well enough defined, it is unusually narrow, the orchestra occupying barely half the angle between the speakers. This is roughly what I would expect for —9dB crosstalk. A single sample is not necessarily representative, but I regard it as indicative.

Following hard on the heels of Matrix H we have Ambisonics and System 45J. Ambisonics is (are?) not quad. Four channels are not used, and whilst four amplifiers and speakers can be, they are not obligatory. The concepts of discreteness and multi-stereo have gone out of the window, and concern about crosstalk has gone along with them. I think it can hardly be disputed that the Ambisonics approach is the right one, and it looks as if it actually works. With the publication of the decoder design (and the availability of some 45J-encoded material?) we should be able to find out for ourselves. If, as I anticipate, the claims for Ambisonics and 45J turn out to be justified, then the BBC would surely be ill-advised to continue promoting Matrix H. I hope that the present "experimental" broadcasts will not turn out to be the thin end of a wedge.

It appears that two-channel ambisonic decoders have the unavoidable disadvantage of giving a certain amount of phasiness and that for best results a third (or two-and-a-half) channel is desirable: at least for surround presentations. Perhaps Mr Gerzon could let us know whether there is any significant disadvantage in having only two channels available for ambience presentations. Also, for ambience presentations is the four-speaker arrangement of his Fig. 7(a) (July) significantly poorer than his preferred six-speaker arrangements?

Finally, might I suggest that Mr Gerzon and his colleagues should round their work off by investigating the desirable speaker characteristics for their system? They have studied all the earlier parts of the chain. The speakers I use are a non-directional type, and for stereo I regard them as significantly superior to the conventional box-type with its multiple units aimed at the listener. With the latter, unless they are spaced rather closer than the conventional 60°, I find that I am always aware to a greater or lesser extent of the presence of the individual speakers. Why the difference? I don't know and can only speculate, though the sound fields produced will be different and that's for sure! I would expect the difference in bahaviour to be greater, if anything, with surround sound.

J. E. A. Fison
Abu Dhabi
Arabian Gulf

IMPROVING SURROUND SOUND ENCODING

The letter of Mr Andrew Sturt, of London Weekend Television, in the July issue, is particularly welcome for its engineering approach to the problem of optimising 2-channel encoding specifications. Certainly a front-centre phase of 48° can be objectionable to discriminating listeners under some conditions, and we would ourselves prefer to reduce it to 45° or less.

Moreover the average phase-angle of the Matrix H encoding over the front sector is larger than its front-centre value, particularly for the pairwise-blended locus. This could be justified if the boundaries of the "impairment zones" could be taken literally, but on actual programme material this front-sector phasiness seems to have a cumulative effect not fully accounted for in the single-source tests used to delineate the impairment zones.

We agree also that insistence on the locus passing through the left-only and right-only points is an unnecessary restriction which curtails the quality of optimisation, and that very precise conditions have to be fulfilled, as they are in the 45J specifications, in assigning azimuths to points on the encoding locus.

However it is necessary to correct the misapprehension that in the choice of 45JB, the two-channel member of the intercompatible 45J hierarchy of encoding specifications, any less attention has been paid to mono and stereo compatibility than in Matrix H. The essential difference lies rather in our preference for optimising the performance averaged over the whole range of likely programme material, whereas the BBC have aimed at minimising the single-source impairment that can occur in the worst possible case, however rarely this case may happen in real programme listening. This is a reason for the significantly lower phasiness of 45JB over the front sector where important sound-sources are most likely to be found. There are also many other aspects to consider. There should for example be an even distribution of direct and, more especially, ambient sound in stereo reproduction avoiding distracting concentrations of sound from the direction of the two loudspeakers. Robustness to transmission errors also needs to be considered.

We naturally believe that our criteria for optimisation are the more realistic. Equally the BBC will have their own opinion, but this does not mean that the BBC claims for better mono and stereo compatability need to be taken at face value. Neither do we think that 45JB is so perfect that it cannot be improved. In fact the difference between the 45JB and Matrix H encodings is quite small by "quadraphonic" standards, and what remains to be done is a fine-tuning of the 2-channel specification for best results both now and in the future when higher standards may be demanded. This is taking place through the recently announced agreement between the BBC and NRDC to exchange technical information and experience with the aim of finding a common specification optimised for both broadcasting and recordings on disc or tape.

P. B. Fellgett
Department of Engineering
and Cybernetics
University of Reading

ADVANCED PRE-AMPLIFIER DESIGN

It was interesting to read the correspondence in your March issue relevant to the "Advanced preamplifier design" published in the November 1976 issue.

Mr Nalty makes an excellent point on the susceptibility of feedback equalized pre-amplifiers regarding high level, high frequency distortion. As he correctly concludes, it seems that many designers are unaware of the problem, and this is unfortunate indeed. Mr Self would seem to be included in this category as he maintains that slew limiting is caused by the open loop characteristics of the amplifier itself and not the feedback network.

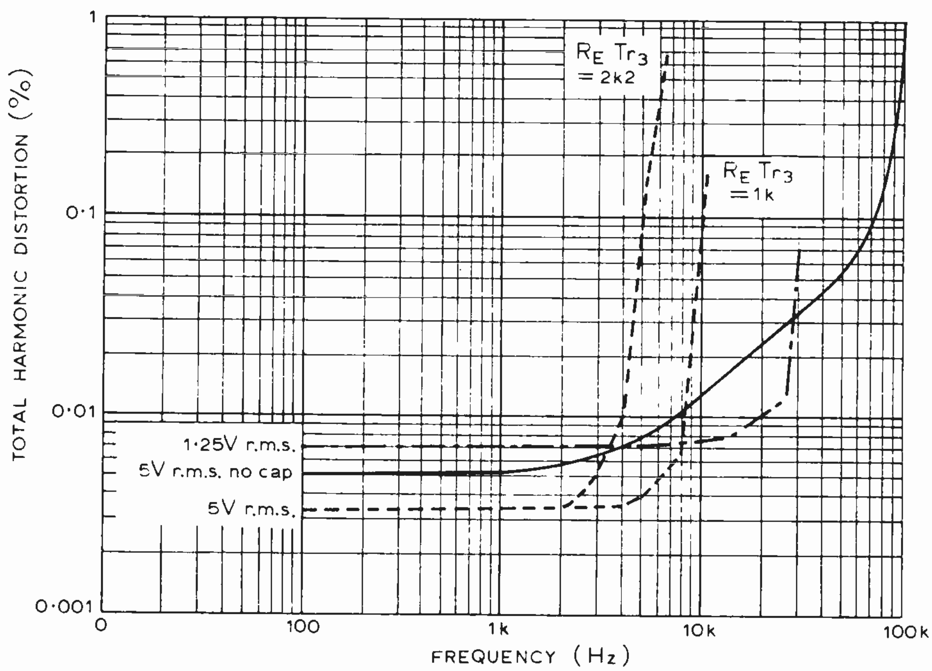
In actuality, slew limiting can be caused by *either* the amplifier itself *or* load capacitance. The mechanism is simply a taxing of the I/C voltage rate of change, a basic relationship. In the case of RIAA pre-amps, insufficient current to support a full level high frequency output will result in distortion. This is easily measured by a full voltage level output t.h.d. sweep, or by a swept two-tone difference i.m. method.

To further illustrate these points, Mr Self's input amplifier was built and tested. In its published form it is severely slew limited by the single ended current available from Tr_3 to charge the 10nF feedback capacitor. In the graph, this is indicated by the 5V r.m.s. t.h.d. versus frequency curve. Distortion begins at roughly 4kHz, but doubling the emitter current in Tr_3 moves this break point upward by a factor of two.

Without the capacitance, the distortion follows a more gradual rise, which is bandwidth related and eventually slew limits at 80kHz. The difference between these two curves, both taken at 5V r.m.s. out, is that in one case the slew limiting is caused by the capacitive feedback load, while in the other it is the amplifier's internal limit which is the culprit.

At lower levels, the slew limit break point is pushed outward in frequency, approximately 20kHz, for a level of 1.25V r.m.s., roughly the ratio of amplitudes.

A point to be made relevant to all of this is that this form of distortion can very readily



be heard, and it often sounds as Mr Nalty has described. Pre-amps are particularly susceptible to slew limiting as they must handle the full dynamic range on the disc regardless of volume control settings. This dynamic range must be present with full fidelity across the entire audio band, and even beyond, not solely at 1kHz where overload specs are typically cited.

W. G. Jung
Forest Hill
Maryland, USA

References

1. W. G. Jung, "Slew induced distortion in audio amplifiers." *The Audio Amateur*, issue 1, 1977.
2. W. G. Jung, M. Stephens, C. C. Todd, "Slewing induced distortion and its effect on audio amplifier performance – with correlated measurement/listening results". AES Spring Conference, May 1977.

AURAL SENSITIVITY TO PHASE

It may well be that, if one makes the assumptions about the auditory system suggested by J. H. Asbery (July letters), the arguments about phase audibility are resolved, but, unfortunately, we are in no way justified in regarding the ear in the manner proposed by Mr Asbery.

I would concede that the ear begins as a non-linear transducer, in the sense that the outer ear modifies the energy spectrum of the sound entering it, but so do recording machines. As I pointed out in my letter of July 1976, this modification is of use to the system, not detrimental. However, except at high intensity levels, there is no evidence for harmonic distortion; in other words Mr Asbery's 2nd harmonic cannot be detected.

It is not possible to state the exact Q of the auditory filters, as its value varies with frequency and method of testing, and the filter shape has steep cut-off on one side and shallow on the other. A simple test procedure based on the detection of a tone in a band of noise leads to very modest values for the Q; say around 6 at 1kHz.

One certainly cannot accept that the only information reaching the brain, concerning each frequency, is its amplitude. The auditory nerve, leading from ear to brain, is tonotopically organised; in other words the different fibres of which it is composed seem to be carrying information about different frequencies, with the higher frequencies towards the outside of the bundle. Placing an electrode in a fibre and measuring its electrical activity shows any given one to have a characteristic frequency, to which it responds best. If a series of tones are presented to the ear, then the activity of a fibre falls off at frequencies above and below the characteristic frequency. The loudness of an auditory stimulus is encoded as rate of "firing" of the nerves — a kind of amplitude-to-frequency conversion. However, a given nerve fibre does not fire at random intervals; it has been shown that firing occurs near peak displacements of the initiating waveform and so remains in phase with it, although for a sound of low intensity a nerve does not respond to every displacement.

From the above necessarily abbreviated account it can ben seen that phase information is indeed available to the brain, but does it use this information? In general it is a safe rule that, if an organism has the necessary apparatus to extract a certain facet of knowledge from its environment, then the organism is using that knowledge. That the human brain not only has available, but also responds to, phase information in a sound can be demonstrated by a simple experiment. One listens, via headphones, to a tone embedded in white noise; the connections being such that the sounds are in phase at each ear. The intensity of the tone is then reduced until just subthreshold. It can now be rendered audible again by inverting its phase at one ear, the phase of the noise being left unaltered. Readers will see immediately that this ability of the auditory system to use phase information is of enormous benefit when trying to listen to some sound source in a noisy environment.

In conclusion I will repeat the theme of my 1976 letter. The ear-brain combination is undoubtedly sensitive to relative phases in the components of a signal, but at the same time the system is remarkably adaptable, as it has to be to recognise and understand a voice a few steps away, at the other end of a telephone, or across a crowded room. The particular distortions of a given environment are quickly recognised as constants, allowances are made and at the conscious level they are ignored. All of which does not imply that a difference cannot be detected when rapid switching between two conditions is possible.

Peter Naish
Department of Experimental Psychology
University of Oxford

INTERFERENCE FROM AMATEUR STATIONS

I have one or two pertinent comments to make concerning the letter in the June issue from Mr D.P. Doo of the British Radio Equipment Manufacturers' Association.

Under the heading "Interference from Amateur Stations", I find it difficult to imagine that manufacturers get "so few complaints", and one can only surmise the computer backfired; furthermore, the number of complaints would vary inversely with the country of origin. In view of the fact that large quantities of high fidelity equipment, radio and television sets, etc., sold over here emanate from Japan, Germany, Scandinavia and other foreign countries, it is possible that this category would not be brought to Mr Doo's attention.

The writer has held an amateur licence for 45 years and has been a member of the Radio Society of Great Britain for 32 years, and on behalf of the amateur fraternity, we appreciate your correspondent's "clear and sympathetic understanding of the technical and social problems involved". However, I am afraid he is somewhat behind the times if he imagines the amateur licensee takes the matter into his own hands by having a technical relationship with a complainant. Granted, we used to do this in days of yore (and I, for one, would dearly like to have continued this service), but just breathe on somebody's £250 hi-fi or television receiver today and the "pattern" is always the same: "It was fine until he came and fitted that gadget — it's never been right since!"

No, Mr Doo, it's more than we dare, in this modern age, and one has to rely implicitly on the Home Office authorities for such liaison as may be necessary.

The implication that the Post Office do not notify the manufacturer of unsolved cases of interference is ludicrous. Provided the correct Division is handling the matter, and this is vitally important, I guarantee not one case ever goes unheeded. The engineering staff have to carry out most of their work at night-time and do so in a most efficient and capable manner and, to put it mildly, far exceed the call of duty.

With the advent of solid state devices, one must be brutally frank and state that manufacturers of all countries are still not taking adequate steps to screen and by-pass both low gain audio stages from r.f. pick-up — and, let's face it, this is ninety percent of all troubles as far as amateurs are concerned — and audio amplifiers without radio are not covered by any licensing terms of reference.

Rex J. Toby, G2CDN
Isleworth
Middlesex

TELEPHONE ANSWERING MACHINES

It was interesting to read your report on page 39 of the July issue entitled "An end to listen-only answering machines".

The comment "hideously unsociable devices" is, of course, an odd one to make and I only assume that the author of this emotive and inaccurate phrase was not aware of the thousands upon thousands of companies from ICI to Brooke Bond Oxo relying heavily upon Ansafone machines for efficient throughput of information and in some cases directly linked with a computer system in order to save considerable amount of turn-round time on deliveries, etc. Also, the author apparently did not realise that the remote recall facility in telephone answering machines is quite common and by no means new. This facility has been extensively used for many years.

Apart from the many large industrial applications of these machines, the report also demonstrates by omission a lack of appreciation of their global use throughout business and the professions not only in this country but in the whole world.

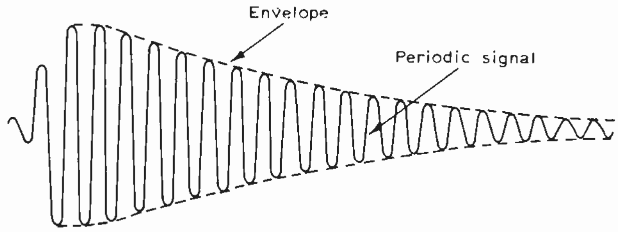
The report referred to also states that "operation hitherto has been cumbersome". This again of course is nonsense, particularly when one refers to the Ansafone range of sophisticated compact machines and especially the new 800 with its many exclusive features.

Leo Jewell
Ansafone Ltd
London W1

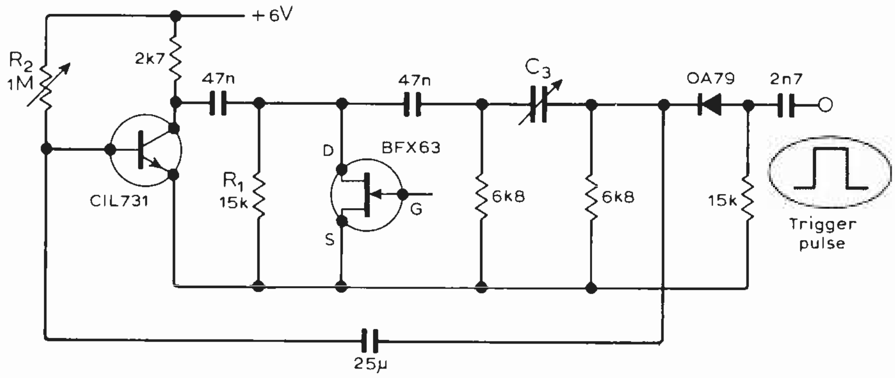
Stolen transmitters

We have been asked by the police at Oakham, Leicestershire, to inform readers of the theft of two Pye transmitters from an EMEB site at Tinwell, Leicestershire. The instruments, Model T470, a u.h.f. transmitter (serial number 3193), having an operating frequency of 462.465MHz, and Model T30AM, a v.h.f. transmitter (serial number 2688), having an operating frequency of 139.71875MHz, were stolen on 18 or 19 April. If you can offer information which could lead to the recovery of this equipment, please contact the Oakham police on (0572) 2626, or your local police.

Circuit Ideas



(a)

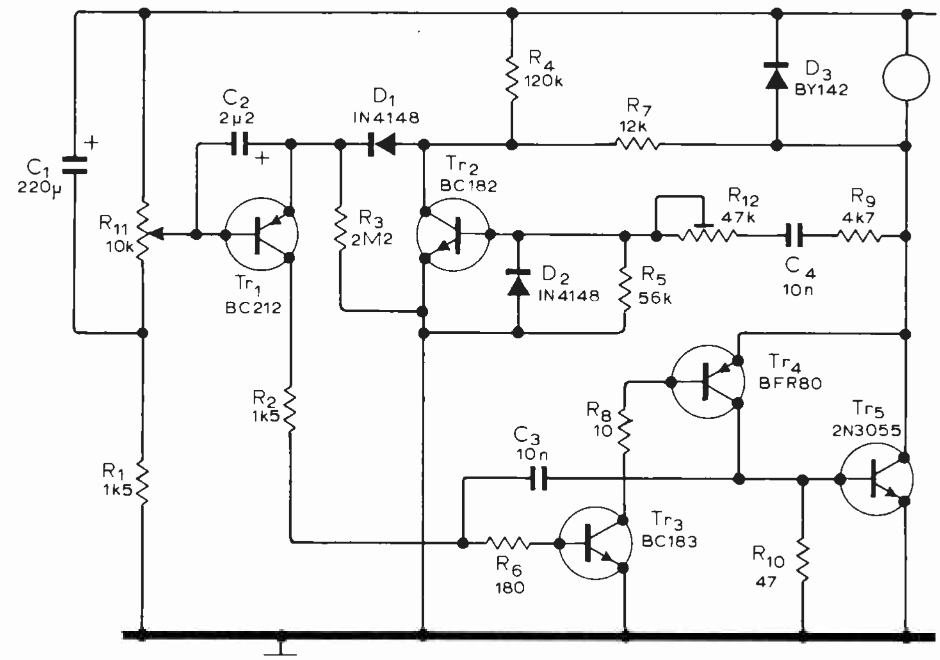


(b)

Phase shift oscillator for electronic music

The envelope of an electrical waveform from any percussion instrument has a sharp rise and gradual decay as shown in Fig (a). The periodic signal within this envelope can be approximated to a sine wave and the frequency is normally in the range 100 to 400 Hz. The decay time of this envelope is dependent on the form of the beat. A modified phase shift oscillator can be used to obtain the damped sinusoidal waveform which gives an audio output similar to that of a drum. To obtain oscillations it is not necessary to have equal values of resistances and capacitances in the *RC* sections of the oscillator. By applying a positive trigger pulse at the transistor base, the circuit starts to oscillate. Resistor R_2 is adjusted so that the oscillations cannot be sustained and hence decay gradually. One method of obtaining drum sounds of different tonal quality is to vary C_3 which changes both the frequency and the envelope of the waveform. Quality and diversity of the drum sound can be increased by adding a f.e.t. in parallel with R_1, as a voltage controlled resistor. The f.e.t. gate voltage is varied from 0 to −250mV which alters the decay time.

V. C. V. Pratapa Reddy, S. Anantha Narayanan
& P. V. Raghavan,
Madras,
India.



D.C. motor control

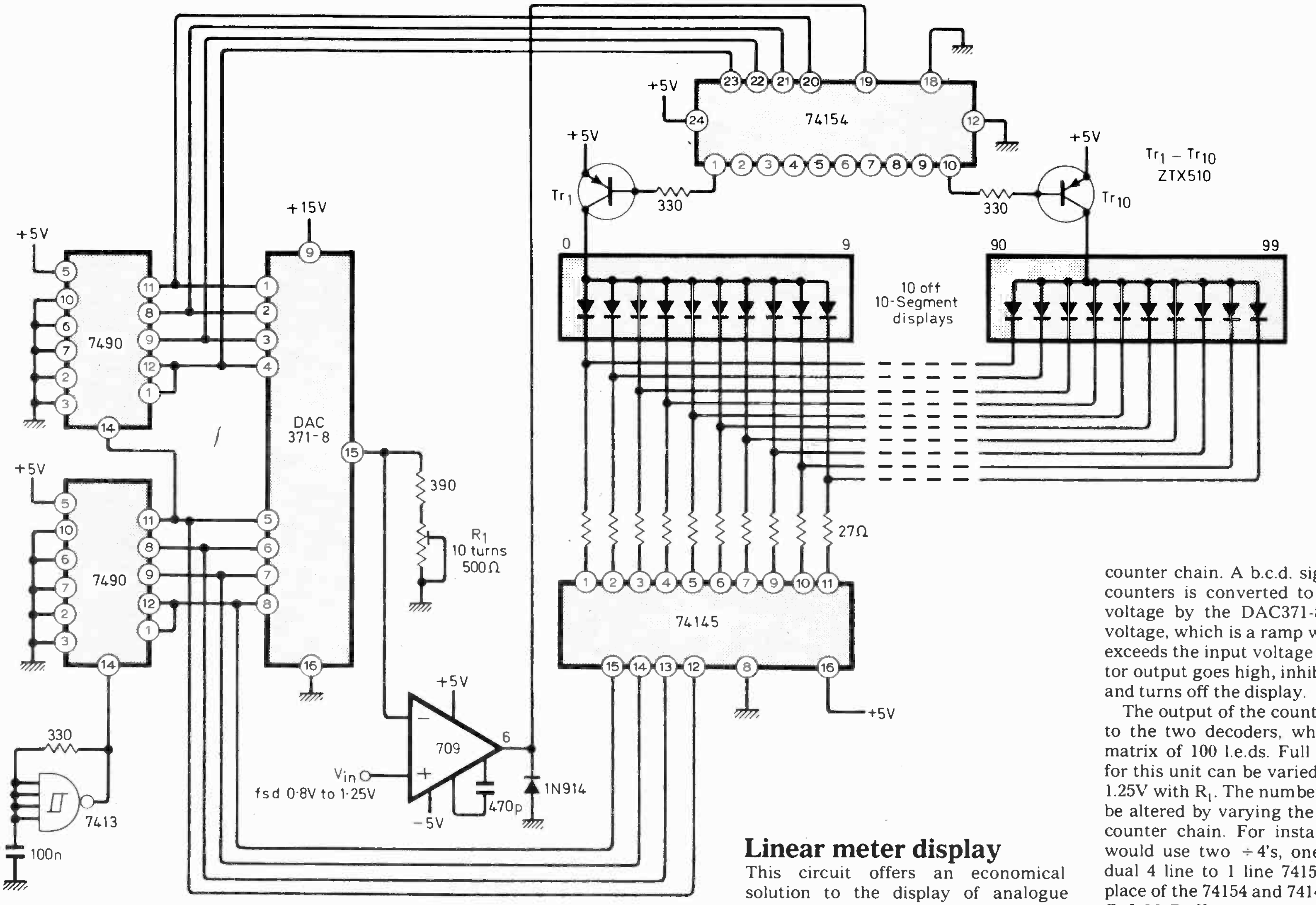
This circuit will control most types of d.c. motor and enable full torque to be produced at any speed from maximum down to below 100 r.p.m. Transistors Tr_3, Tr_4 and Tr_5 form a switching regulator where the base drive for Tr_3 is derived from the on-state base-emitter drop of Tr_5. Advantages of this unusual configuration are the ability to control high currents with a low on-state voltage drop, and the elimination of protection diodes at Tr_3 base as the voltage swing on C_3 is automatically limited to around 1V pk to pk.

When Tr_5 is off, the motor back-emf is compared with a reference from R_{11}. The resulting collector current in Tr_1 determines the mark/space ratio of the regulator. Resistors R_4 and R_7 attenuate the motor voltage by 10% to ensure that full speed may be reached within the range of R_{11}.

To prevent the inductive overshoot pulse, produced when Tr_5 switches off, from overcharging C_2, the circuit around Tr_2 is included which senses this pulse and clamps the junction of R_4 R_7 to ground. Resistor R_{12} provides adjustment of the clamp pulse length to suit the characteristics of different motors, and is adjusted to the point where the applied power responds to load changes in a critically damped manner.

The circuit will operate from almost any power supply, even rectified a.c., although the addition of a smoothing capacitor improves the speed stability. Because no attempt has been made to stabilize the supply to R_{11}, the motor speed will be proportional to the supply voltage. If accuracy of speed is important, R_{11} may be fed from a zener diode or i.c. regulator.

I. W. Rudge,
Edinburgh.



Linear meter display

This circuit offers an economical solution to the display of analogue information on a l.e.d. array of up to 100 segments. Half of a 7413 forms a clock generator which is fed to the ÷100 counter chain. A b.c.d. signal from the counters is converted to an analogue voltage by the DAC371-8. When this voltage, which is a ramp with 100 steps, exceeds the input voltage the comparator output goes high, inhibits the 74154, and turns off the display.

The output of the counters is also fed to the two decoders, which drive the matrix of 100 l.e.ds. Full scale voltage for this unit can be varied from 0.8V to 1.25V with R_1. The number of l.e.d.s can be altered by varying the length of the counter chain. For instance, 16 l.e.ds would use two ÷4's, one 7493, and a dual 4 line to 1 line 74155 decoder, in place of the 74154 and 74145.

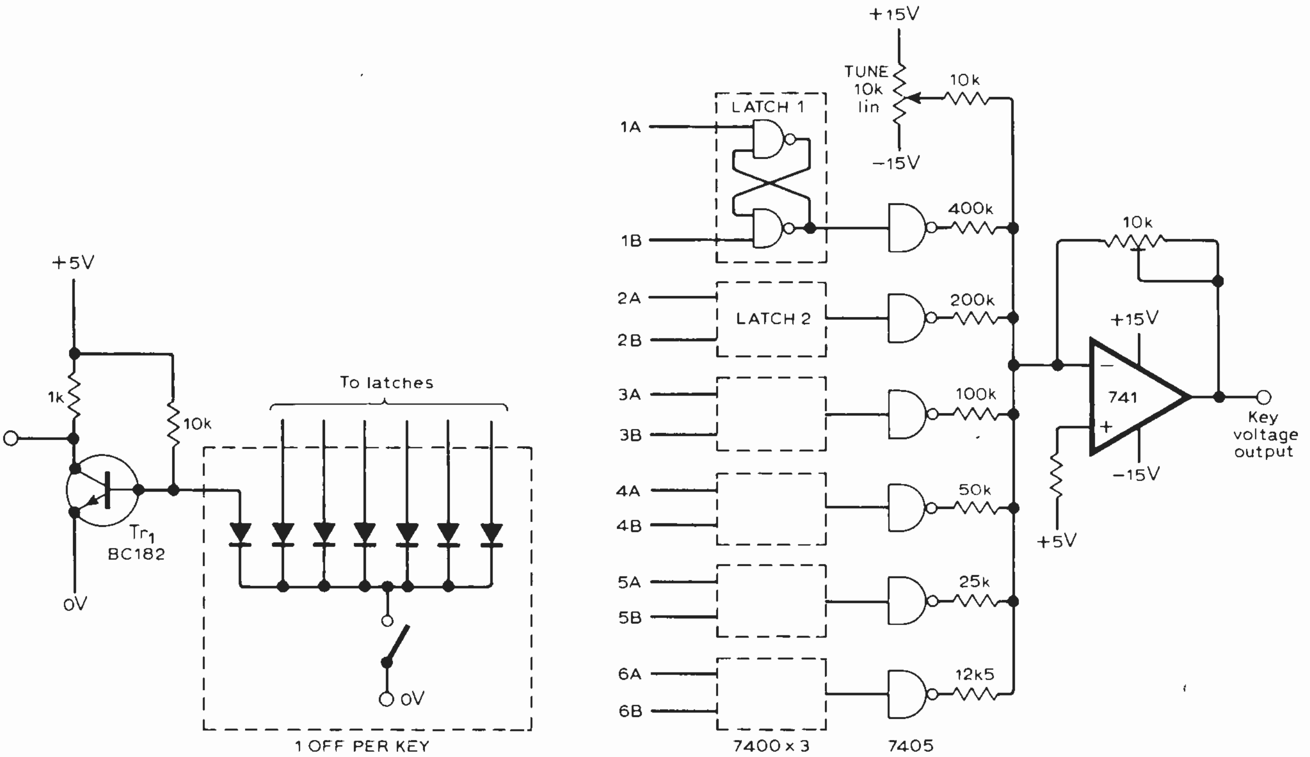
G. J. McDuff,
Hove,
Sussex.

Digital keyboard

Note	Latch					
	6	5	4	3	2	1
C	A	A	A	A	A	A
C♯	A	A	A	A	A	B
D	A	A	A	A	B	A
D♯	A	A	A	A	B	B
E	A	A	A	B	A	A
	etc					

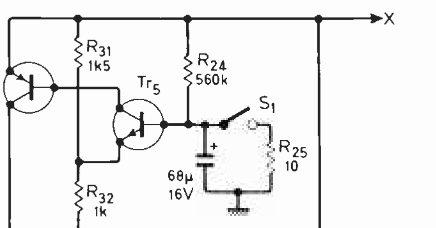
Most music synthesizers have keyboards where each key selects a voltage from a resistor chain and applies it to an analogue sample and hold circuit. Due to the very short sample time and long hold time required this unit becomes complex. The accuracy of each note also depends on the degree to which 49 or 61 resistors can be matched. A better solution is to use a digital keyboard as shown. Each key has 7 associated diodes which set six latches to give a binary representation of the note selected. The seventh diode feeds a transistor invertor to give an output for triggering an envelope generator. The outputs of these latches are fed to a d-a converter using an open collector l.e.d. invertor and an operational amplifier. For a C to C keyboard, the diodes are connected as shown in the table.

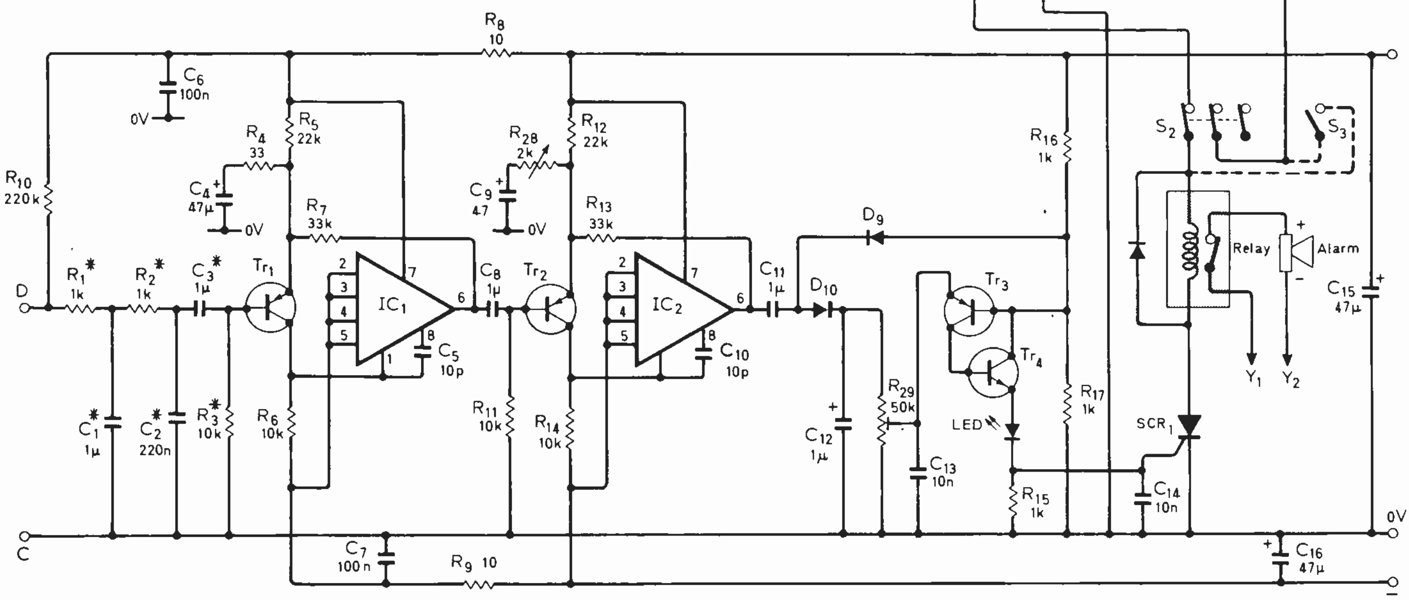
D. Bryant,
Totton,
Hants.



Modified intruder alarm circuit

This revised circuit of the Doppler movement detector (July issue, page 38) incorporates the improved delay circuit and includes C_4 and R_4, inadvertently omitted from Fig. 5. Capacitor C_8 is 1μF not 1nF and C_{13} shown as 10nF, was incorrectly labelled C_{12}. Resistor R_{15} has a new value. Components marked with an asterisk have different values in the kit version. Transistor Tr_5 and other n-p-n types is a ZTX300, 302 or A11; the p-n-p transistors are ZTX500 or ZTXA21.





Audio Fair '77

The complete home entertainment show

As is evident from its subsidiary title, the Audio Fair has markedly broadened its horizons this year. Only a couple of years ago, anything which did not have an exclusively 'hi-fi' flavour could not be exhibited, which meant that the newer expressions of the electronic engineer's art were ignored. Now, anything to do with the use of electronics in any kind of entertainment equipment is to be shown, from teletext to tv tennis, from cassettes to cabinets. High-quality audio equipment will, of course, be well to the fore.

Thames Television will be showing displays of their Oracle teletext system, which is now beginning to be seen in commercial form in the more recent television receivers, and the Post Office intend to demonstrate Viewdata, the two-way information display system using telephone lines. Viewdata is to be evaluated by a thousand users during 1978 and it is expected that a full service will start in 1980. The BBC will show their version of teletext, Ceefax, and are also expected to demonstrate Matrix H, the recently-developed method of broadcasting surround-sound material, for which we have published decoder designs in the last few months.

Wireless World will, of course, show examples of recent constructional projects and intends to present a series of lectures by well-known figures in the field of high-quality sound reproduction. John Linsley Hood is to speak on cassette-deck design and on the causes and methods of reducing several types of distortion. The "audibility of phase" controversy will be tackled by James Moir, who will include the results of his own investigations, while Arthur Bailey intends to review the design of loudspeakers, demonstrating different types of enclosures and drive units. Jack Dinsdale will present his view of the most recent advances in the whole audio field, with a look at his own work on horn loudspeakers. The production of electronic music and effects will be described and demonstrated by Desmond Briscoe from the BBC Radiophonic Workshop and Peter Zinovieff of EMS and a view of the contribution made by amateur radio to professional communication will be given by an RSGB speaker.

Audio Fair '77

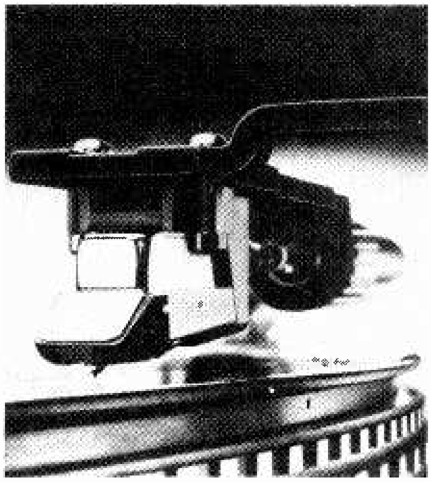
Olympia, London. 12-18 September, 1977

The exhibition is open for trade visitors between 2 p.m. and 7 p.m. on Monday, 12th, and 10 a.m.-2 p.m. on Tuesday, 13th. From 2 p.m. to 9 p.m. on Tuesday and from 10 a.m. to 9 p.m. Wednesday to Saturday (8.30 on Sunday) the show is open to the public. Admission is 60p for visitors of all ages.

Public transport to the show is probably easier than motoring, since car parking is fairly difficult. Tube trains (District and Piccadilly lines) stop at Earl's Court, where a special shuttle service runs to Olympia. Red buses 9, 9(a), 27, 28, 33 and 73, and Green Line coaches 704, 705, 714 and 716 pass the door.

Audio

There is a continual drive to improve the quality of reproduction provided by both domestic and professional equipment, but it is in the domestic sphere that innovations are most frequently discussed. This is possibly because of marketing pressures, which force the appearance of new styling, new facilities and sometimes even new designs, which are copiously reviewed and discussed in the consumer electronics press.



ADC QLM Mk II 36 induced-magnet cartridge. Mass is claimed to be low for better tracking.

Solid advances continue to be made in technique, however, and recent months have brought the BBC's system for surround-sound broadcasting, Matrix H. This has been test broadcast since May, 1977, and has produced reactions ranging from indifference to ecstasy. Decoders for this system are being produced in kit form and in some receivers. The NRDC-backed Ambisonic System 45J is still a contender, both here and abroad, and the fight for eventual adoption by broadcast authorities is not yet over, although there is now agreement between the proposers of the two systems to exchange knowledge ("News of the Month" — August).

Record decks, until recently, were the only fully mechanical piece of audio equipment left. It seems that these days are now numbered with the introduction of the parallel tracking arm — more electronics than an amplifier—and the remote controlled turntable with memories for track selection — more electronics than many hi-fi systems. BSR, the originators of the last mentioned deck, will be showing the Accutrac +6. This is another remotely-controlled instrument which has the features of the original deck plus the ability to play the tracks on six separate albums in any sequence and as often as required. Remote volume control is also provided. The heart of this turntable is the "Accuglide computer-activated record transport system". Unfortunately very few details were available at the time of going to press, but we understand that record selection is by a small platter which spirals up through the main platter, seeks out the correct record and lowers it on the deck proper — sounds as though it should be shovelling up soil samples with Viking 2. Visitors to the Audio Fair will be able to see demonstrations of the Accutrac

List of Exhibitors

The following list is as complete as we can make it at the time of going to press.

Adam Imports
Agfa-Gevaert
A.M.S. Trading (Amstrad)
Artifact Designs

BASF (UK)
BBC Radio Publicity
Beyer Dynamics (GB)
Bib H-Fi
BSR

Cambra Cases
Chuo Senko (UK)
Contek Magnetics
Countdown

Decca Radio & Television
Decimo
DTR Electronics

Electronic Manufacturing

Gale Electronics & Design
Grabern Audio
Grundig (GB)

Haymarket Publishing
Hitachi Sales (UK)

IBA
ILP Electronics

JR Loudspeakers
JVC (UK)

Kirsten, G. & A.
Koss Stereophones

Link House Group
London Car Radio Centre

Metrosound Audio Products

National Panasonic
Natural Sound System

Omex Products

Parkar, J. & Co. (London)
Plustronics
Post Office Telecommunications
Purpax Manufacturers
Pye
Pyral Magnetics
Pyser

Rank Hi Fi
Record Housing
RI Audio

Sanyo Marubeni
Shure Electronics
SME
Steepletone Products

Tannoy Products
Tape Music Distributors
Training Services Agency

Videotone
Vor International

Wavelength
Wilmex
Wireless World

+6, although it will not be available until early next year.

Another area in which electronics has been introduced is speed control. Technics have produced a quartz-controlled, phase-lock loop, direct-drive turntable. The rotational speed of this unit is independent of the a.c. power supply and temperature. Maximum drift is quoted as ±0.036 sec over the 30-minute playing time of an l.p. side which should be adequate for most records in the average collection!

The modern equivalent to the radiogram of old, the music centre, is out-growing its initial, somewhat shamefaced, image and some of the recently-introduced models are of very high quality (and price!) indeed. This is a trend reversal – a few years ago no high-fidelity buff worth his salt would have considered a ready-assembled outfit a fit subject for discussion. There is still some resistance: after all, a top-level music-centre can look very like its more pedestrian counterpart, whereas a collection of separate units leaves no doubt in the mind of a casual onlooker that one's equipment is 'hi-fi'.

The NAD 120 receiver, which produces 20W per channel (20Hz-20kHz) both channels driven. Total harmonic distortion and intermodulation distortion at 20W are better than 0.2%. The receiver is distributed by Pyser Ltd.

Audio power amplifiers are forced to provide greater and greater amounts of power, at lower levels of various kinds of distortion, as ears become better educated and loudspeakers more inefficient. Output-stage configurations proliferate and we have now reached Class G in the chain of evolution, offering improved efficiency and a reduction in weight. The basic principle is an output arrangement which has two supply voltages V_{cc} and approximately $\frac{1}{2}V_{cc}$. A conventional push-pull pair operate between the two low voltage rails of a positive and negative supply. When high level signals are applied and the complementary pair begins to saturate, two more transistors, which are in series with the first pair, begin to turn on. This second pair of output transistors is connected to the full supply rail and handles signal peaks. The main snag with this system is the crossover points, one in the middle and two either side. Even so, the designers have managed to keep the t.h.d. figures to around 0.006% for 100W at 1kHz rising to 0.035% at 20kHz. Class D has made something of a comeback, now that faster, beefier transistors are with us and Peter Walker's current-dumping amplifier is another Quad success. Power field-effect transistors made an impression but, at the other end of the evolutionary process, valves have been seen in recent amplifier designs.

On the subject of speakers, progress is made in size reductions and in the design of crossover networks – chiefly to reduce phase anomalies. The LS3/5A BBC monitor speaker is probably the smallest high-quality reproducer available and is capable of truly remarkable performance, while the latest Tannoy and Radford products are in the outsize class, the Radford ISO360 using no less than eighteen drivers to provide all-round emission. The 'stepped' appearance of some speakers, notably the Bowers and Wilkins and Technics designs, are an additional attempt to get the radiation from the separate drive units in phase. Together with a minimum phase-shift crossover network, this approach is intended to provide a linear phase response over the whole frequency range.

Remote control of domestic equipment is usually the province of television receivers, but there are now one or two remotely-controlled pieces of audio gear – and why not, indeed? The Bang and Olufsen music centre provides control of most of its functions by means of an ultrasonic control pad, which we have operated from one side of a large hall to the other. Control of the BSR Accutrac turntable is also by ultrasonic keypad, which allows the user to select tracks according to a preselected programme, the arm using an infra-red detector and m.o.s. circuitry to count and identify the tracks.

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L10-3C*	0-10V, 3A	LT30-1 twin output unit	2 x 0 – 30V, 1A
L30-2	0-30V, 2A	LT30-2 twin output unit	2 x 0 – 30V, 2A
L30-5	0-30V, 5A		

*with adjustable overvoltage protection

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World of Amateur Radio

Opposition to repeaters

There is still considerable opposition to (as well as support for) the use of amateur v.h.f./u.h.f. repeaters in the U.K. – to an extent where an amateur operator recently pleaded guilty in a magistrate's court to causing damage to the GB3SN repeater in Hampshire. It was claimed by the prosecution that four other amateurs were present at the time although no charges were brought against them. A conditional discharge was accompanied by damages and legal costs of almost £100.

Two UK FM Groups (London and Southern) have set up a fund to allow them to take legal action to stop deliberate jamming and interference to repeaters. In an attack on the anti-repeater groups who take the law into their own hands, the Newsletter of the UK FM Group (London) states: "The amateur who only has a black-box and restricts himself to repeater operating (and there must be precious few such amateurs) is to be pitied and not despised. He is cutting himself off from many of the pleasures and rewards that this hobby has to offer. The solution, however, is not to prevent him from using his equipment (and those who do so by unlawful means do a great disservice to the amateur movement as a whole) but rather should be concerned with encouraging the newcomer to look at a wider horizon."

Oscar 6 fading fast

The condition of the ni-cad battery on the highly-successful Oscar 6 amateur satellite – launched October 15, 1972 – deteriorated rapidly during the period May 23 to June 10. Martin Sweeting, G3YJO of the University of Surrey Amsat Telecommand Centre, reported in late June that the battery voltage plummeted alarmingly from 27V on May 23 to 13V on June 1 and 5V on June 10, adding:

"It was decided to shut the spacecraft down until mid-July when the sun angle improves and the battery receives more charge. On Sunday, June 12, however, the downlink telemetry became garbled and since then has been reading constant values for each frame, although the transponder and command system were still fully operational.

"On June 16, W3UN switched the satellite on for telemetry tests and was unable to switch it off during that orbit. Since then it has not responded well to ground command and at times the transponder may be found on: however, it is imperative not to use it in order to maintain the possibility of re-activation later this year.

"Extensive experiments are being carried out here in an attempt to analyse the failure mechanism in detail to increase command reliability."

Oscar 7 remains operational and the next Amsat satellite is now scheduled for launch about February/March 1978, rather than November 1977. There are also persistent rumours that a Russian-built amateur spacecraft, carrying a 144 to 28 MHz transponder, with beacons on 20.08 and 29.5 MHz, has been built and is awaiting launch.

Squaring up for WARC 1979

Amateurs in many countries are watching the preparations for the World Administrative Radio Conference in 1979 with concern. For it is becoming clear that many administrations anticipate major revisions to the international table of frequency allocations – as occurred at Atlantic City 1947 – rather than just a few tidying-up amendments as at Geneva 1959.

The provisional Home Office proposals for h.f. amateur allocations, though still unpublished, are believed to represent a favourable attitude towards amateur allocations, including several attractive new bands. The latest FCC proposals, though less radical, seek to maintain or enlarge most existing amateur bands with a new 13m (25.76 to 28.86 MHz) band. But there is growing evidence of strong pressures in some countries for new h.f. broadcasting allocations that represent a real or potential threat to the amateur bands (since unfortunately world broadcasters seldom stick rigidly to the frequency table in the way that amateurs have to!).

Tom R. Clarkson, ZL2AZ, the veteran overseas liaison officer of NZART with much experience of these conferences, has recently circulated a long and detailed appraisal of the problems facing amateurs, noting particularly how Atlantic City 1947 represented an important defeat of idealism and the abandonment of world-wide uniformity in frequency usage in the creation of the three Regions and the hundreds of footnotes to the table. This has meant that traditional American support for the amateurs is no longer as effective as in the period 1927 to 1947.

He notes that, since 1945, in placing value on h.f. broadcasting, developing countries have attacked amateur allocations. Yet the amateur service, Tom Clarkson believes, not only helps the advance of all radio communication services but, for developing countries, participation in amateur radio is in their national self-interest, in introducing an environment favourable to self-sufficiency in radio talent.

In brief

The number of British Class A licences has now passed the 16,000 mark . . . Sporadic E propagation as high as 144 MHz occurred during June and also produced periods of extremely 'short skip' on 14, 21 and 18 MHz . . . A Dutch 10.1 GHz Gunn-diode beacon transmitter, PA0HSM, at Zaandan, north-west of Amsterdam, has four horn antennas, one beamed on London. It is planned to install a higher-power crystal-controlled transmitter at Noordwyk soon. Efforts are also being made to link the UK with Holland for 10 GHz amateur television pictures . . . Another slow-scan television convention is being organised by the British Amateur Television Club at the University of Aston, Birmingham, on Saturday, November 19, from 10 a.m. to 5.30 p.m. Amateurs are invited to bring equipment to show and demonstrate and all known s.s.t.v. firms are being invited to exhibit products; there will be lectures in the afternoon. Non-members of BATC are welcome (50p admission with free car parking. Details and map from Mike Crampton, G8DLX, 16 Percival Road, Rugby, Warwickshire CV22 5JS (please include return postage) . . . September events include the Scottish Amateur Radio Convention, Adam Smith Centre, Kirkcaldy, on September 10; North-west Amateur Radio Convention at the University of Lancaster on September 17-18; Welsh Amateur Radio Convention, Oakdale Community College, Blackwood, Gwent, on September 25 . . . Mobile rallies include Preston at Walton le Dale County Secondary School, Bamber Bridge, Preston, on August 21; Torbay at Haldon Racecourse near Exeter on August 28; Peterborough at Walton Secondary School, Mountsteven Avenue, Peterborough, on September 18; Harlow at Netteswell Comprehensive School, Harlow, on September 25 . . . There will be an amateur station at the National Town and Country Festival, National Agricultural Centre, Stonleigh, Warwickshire, on August 27-29 . . . New Australian 3.4 GHz record of 114 km established recently with a contact between VK2AHC/P and VK2SB . . . The FCC recently issued several hundred amateur callsigns with the prefix "WC" but these are being changed to WB or WD. No, the reason is that WC is allotted to the Radio Amateur Civil Emergency Service.

PAT HAWKER, G3VA

New Products

High-stability receiver

A general-purpose, high-stability communications receiver, operating over the frequency range 100kHz to 30MHz, has been developed by Eddystone Radio Limited. The receiver, type 1837/2, combines very high stability and a digital frequency readout with a continuous tuning system, which allows absolute freedom for search purposes. It provides reception facilities for c.w., m.c.w., and a.m. signals together with upper and lower sideband reception of A3A, A3H and A3J signals. The receiver can be operated from any 100/130V or 200/260V, 40-60Hz a.c. supply or from a 12/24V direct source using an external inverter.

There are nine frequency ranges on the instrument and once one is selected the receiver is operated in the search mode as a normal medium stability receiver, the tuned frequency being displayed on the digital readout. When the lock control is pressed an error-correcting circuit locks the receiver to the tuned frequency at that moment and the high-stability mode comes into operation. The receiver continues to function in this mode until the lock facility is dispensed with, when it reverts to a medium-stability receiver, enabling search to be continued. The receiver conforms to the climatic, shock and vibration requirements of MPT1201, MP1204 and CEPT draft recommendations and it is designed generally to meet British Defence Specification 133 Class L2. An optional f.s.k. unit, suitable for transmissions having frequency shifts of 85 to 1100Hz with baud rates in excess of 300, is also available. Eddystone Radio Limited, Alvechurch Road, Birmingham, B31 3PP.

WW 301

Cordless soldering gun

A soldering gun now available from Greenwood Electronics is rechargeable, feeding solder automatically and illuminating the working area. The Isotip MK III, as it is named, has powerful, rechargeable, nickel-cadmium batteries which can provide power for up to 400 electronic joints. A 'dead' soldering gun can be fully recharged overnight. By operating the trigger of the gun, the Isotip achieves soldering heat in five to eight seconds. On squeezing the trigger a little further the solder feed tube automatically positions the solder for quick accurate work. A choice of four different snap-in tips is offered; the tip operates under low voltage and is isolated to eliminate electrical leakage, so reducing the risk of damage to electronic components. Price, including solder feed, spool, recharger, one high temperature bevelled tip and one chisel tip is £33 plus v.a.t. Greenwood Electronics, Portman Road, Reading, Berkshire, RG3 1NE.

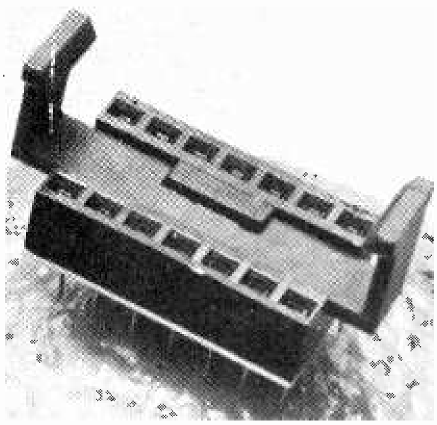
WW 302

Retaining clips

Retaining clips in the RC series, from Astralux, are designed to prevent 'walk-out' – the tendency of cable plugs to separate from their sockets regardless of the retention forces of the socket contacts on the plug pins. Although a force of at least 4.5kg is required to overcome the effect of one of these clips, the cable plug can be removed at any time by a simple procedure. Four sizes of clip are available and a selection chart indicates which clips can be used with different manufacturers' cable plugs. Astralux Dynamics Limited, Brightlingsea, Colchester, CO7 0SW, Essex.

WW 303

WW 302



WW303

WW 301

Robust power supply

A variable voltage power supply, manufactured by Roband Electronics, was built to meet a rigorous Ministry of Defence requirement for a rugged instrument for use in mobile and laboratory applications. The Rovar, as it is called, will provide outputs from 0 to 33V at 0 to 12A, and its circuitry gives high stability, an improved over-current protection system, over-voltage protection, two-wire or four-wire operation, and facilities for remote programming. It is approved to DEF 133 and is coded Z4/6625-99-637-0740. In addition, it has military-pattern connectors at the rear and a circuit breaker mains switch. Roband Electronics Limited, Charlwood Works, Charlwood, Surrey, RH6 0BU.
WW 304

Systems trainers

Equipment designed for the A-level course in Electronic Systems is announced by Feedback Instruments and, together with teacher's notes and handbooks, is named the ESP700 Electronic Systems Teaching Programme. The course includes basic electronics, processing systems, communication systems and feedback systems, the equipment needed comprising seven circuit boards with components, and a few basic instruments.

The TT179 Transformer Trainer, also from Feedback, consists of a transformer which can be taken apart and a four-meter measuring instrument for the display of primary and secondary current, voltage and power under various conditions. A handbook is provided.

Further teaching equipment from Feedback includes the Communications Teknikit, which is in twelve modules (signal source, tuned circuits, modulator, detectors, etc) and teacher's and student's manuals. Feedback Instruments Ltd, Park Road, Crowborough, Sussex TN5 2QR.
WW 305

Microprocessor analyser

In use with any microprocessor which has accessible data and address buses, the Model 50 analyser will display the contents of the buses on 32 l.e.d.s. A built-in match register is compared with the address bus of the micro under test and initiates a delay period when the comparison is positive. The register controlling the delay determines the interval before a strobe signal appears, at which time the contents of the address and data buses of the micro are latched and displayed. The clock rate can be varied from slow to 4MHz, up to eight machine cycles being displayed in an instruction cycle. The match and delay registers are set by front-panel switches, the delay being specified as a number of clock or instruction cycles or a number of times matching must occur before the strobe is generated. The programme can also be stepped slowly or can be 'searched' for fault conditions. Systron Donner Ltd, St. Mary's Road, Sydenham Industrial Estate, Leamington Spa, Warks.
WW 306

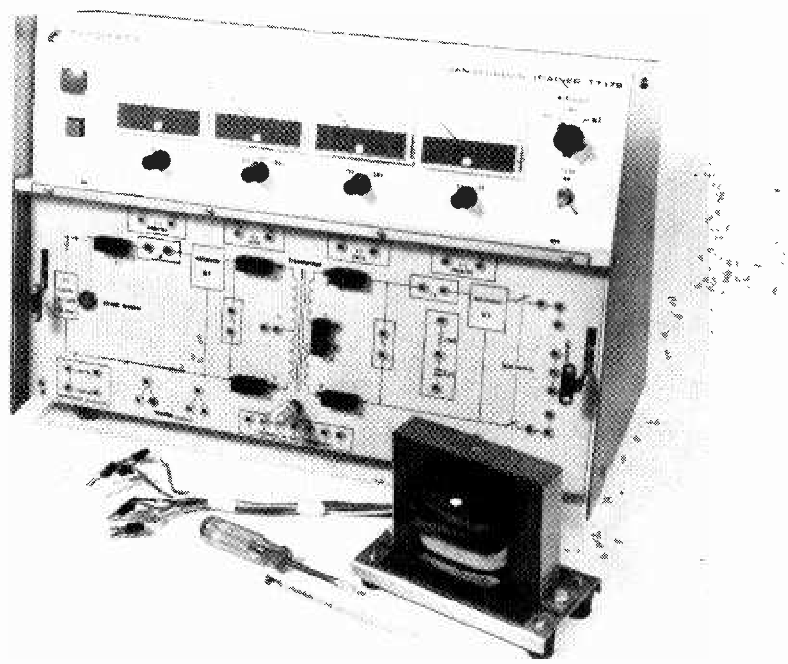
Function generator

A frequency range of 0.003Hz to 30MHz is covered by the Model 2000 function generator from Krohn-Hite. Waveforms produced are sine, square, ramp with variable slopes, positive and negative-going pulses and a pulse for use with fast t.t.l. circuitry (6ns edges), all waveforms being subject to a variable symmetry control. The frequency of the generator can be externally voltage-controlled to a linearity of around 99%. Output voltage is a maximum of 30V p-p from 50 ohms, with a calibrated minimum of 2mV, and fixed and variable offset controls are provided to set positive or negative peaks at zero or at a maximum of 15V above or below zero. The instrument is imported by Keithley Instruments Ltd, 1 Boulton Road, Reading, Berks RG2 0NL.
WW 307

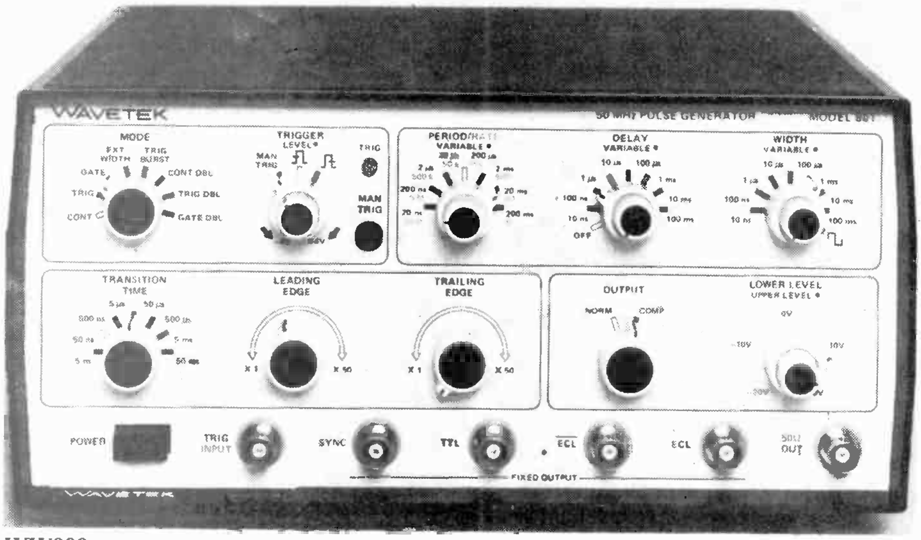
Matched transistors

Two n-p-n transistors in an integrated circuit, matched for V_{be} to better than 50μV, form the National LM194. The noise figure is claimed to be immeasurably low and is said to be at the theoretical minimum of 1.8nV/√Hz. Matching between the two base-emitter junctions tracks to within 0.1μV/°C between 1μA and 1mA, the minimum current gain is 500, matched to 2%, and a c.m.r.r. of 124dB is said to be obtainable using this device. A TO-5 can is used for the LM194, which is for operation between −55°C and 125°C – the cheaper LM394 working between 0 and 70°C. National Semiconductor U.K. Ltd., 19 Goldington Road, Bedford MK40.
WW 308

WW304



WW305

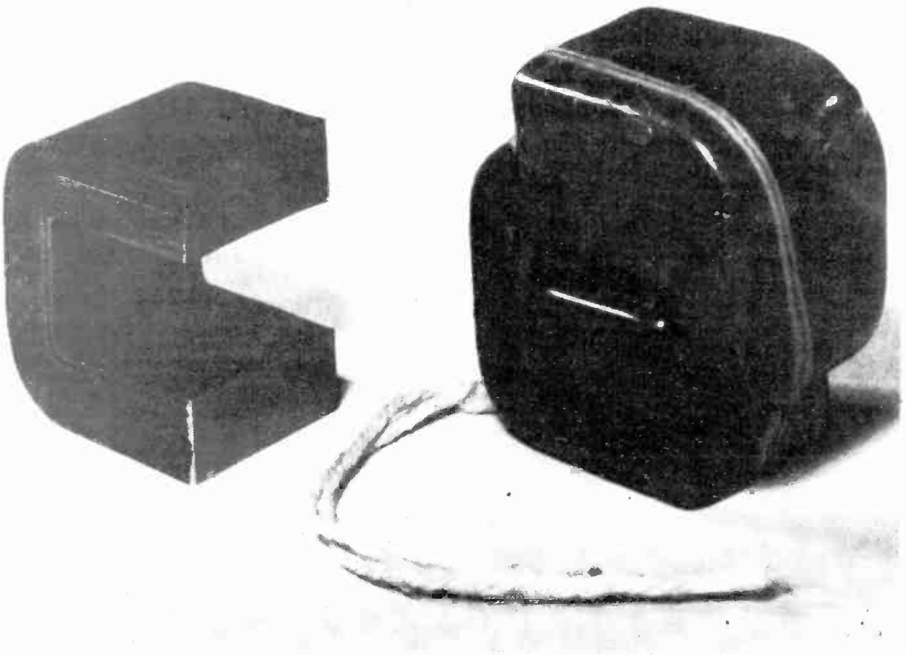


WW309

Pulse generator

The model 801 is a 5MHZ pulse generator designed for general purpose laboratory use. It gives full control of primary pulse triggering and shaping plus simultaneous t.t.l., e.c.l., $\overline{\text{e.c.l.}}$ and sync pulses. Offset, amplitude, pulse width, delay and independent rise and fall times may be controlled and positive, negative or complimentary outputs may be chosen. It provides ten volts into 50Ω with a minimum rise and fall time of 5ns. External triggering can be set to any point on the leading or trailing edge of the trigger signal. In addition, single or double pulses may be triggered, pulse width may be trigger controlled, continuous pulses may be gated and a precise number of pulses may be triggered for a burst output. Manual and external triggering is indicated by a l.e.d. on the front panel. Wavetek Electronics Limited, 109 Crockhamwell, Woodley, Reading, Berks.

WW 309

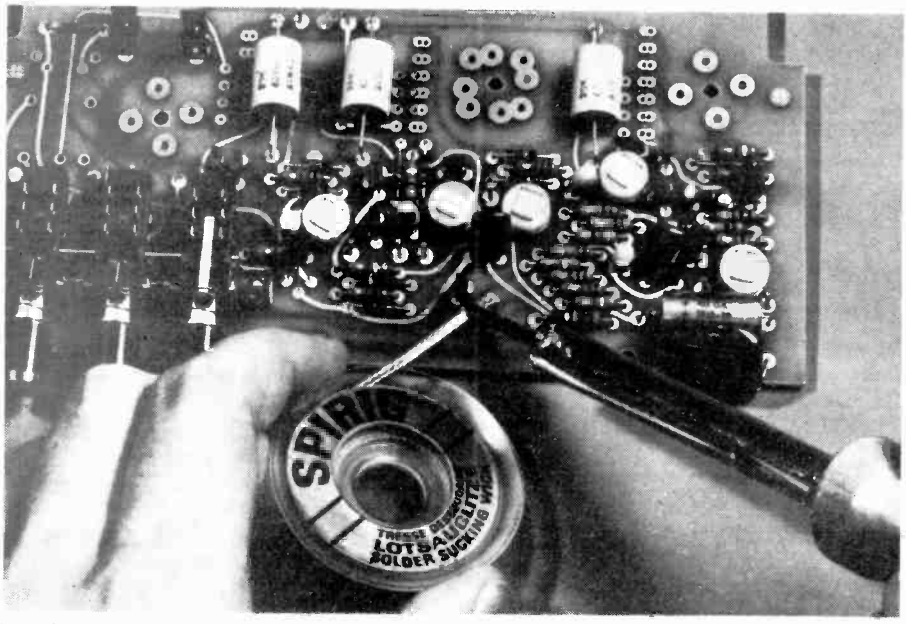


WW310

Magnetic C cores

Magnetic C cores, manufactured using Supermendur alloy, have been made available by Walmore Electronics. These cores can operate at 21,000 gauss with core losses of 12W per pound at 400Hz. The cores enable transformer sizes to be reduced by 15 to 40%. This is claimed to be the first basic improvement in magnetic cores for airborne power transformers since the introduction of super-oriented silicon steel about 15 years ago. Supermendur is a highly purified cobalt, iron, vanadium alloy which exhibits superior magnetic properties when field annealed. The cores are available in 1, 2 or 4 thousandths-of-an-inch material in any of the standard toroidal core sizes, as well as in C core form. Walmore Electronics Limited, 11-15 Betterton Street, Drury Lane, London WC2H 9BS.

WW 310



WW311

Desoldering wick

The type 3S-wick, from the Swiss company, Ernest Spirig, is claimed to be the answer to the problems associated with desoldering. The copper braid is de-oxydised and coated with several layers of flux and protection lacquers under vacuum. This vacuum technique produces a capillary action between the molten solder and the wick, thereby removing the solder and leaving no corrosive residue – the wick contains practically no chlorines or halogens. Spirig wick is available in three standard sizes: AA for small joints, AB for medium and BB for large. Each reel contains 5½ feet of wick and is priced from 45 pence per reel. Tele- Production Tools Limited, Stiron House, Electric Avenue, Westcliff-on-Sea, Essex, SS0 9NW.

WW 311

Packaged double Darlington

L149 is a quasi-complementary Darlington pair intended as a power driver for use in direct-current servos, capstan drivers, magnetic deflection yokes and general-purpose audio power stages, as well as in a closed feedback loop to augment the output current of an operational amplifier. The biasing circuitry and an inhibit facility are included and safe operating area, thermal and short-circuit protection are also provided. Current gain is typically 10,000, supply voltage can be up to 44V and the device can take up to 3A. SGS-Ates (UK) Limited, Walton Street, Aylesbury, Bucks.
WW 312

CECC-approved transistors

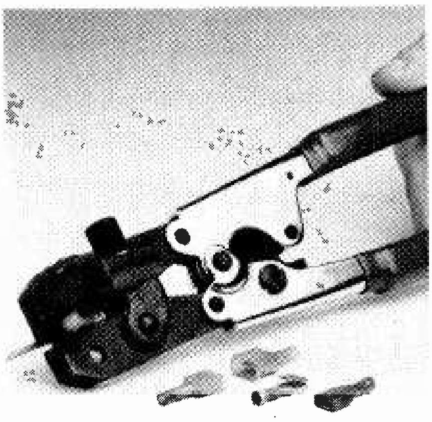
Approval from the CENELEC Electronics Components Committee has been received by Ferranti for some commercial transistors, including the BC140 and BC141. Both these devices are silicon diffused types in TO-39 cans, rated to 1A and designed for medium power applications. CENELEC being the European body for standardization and unification of national specifications, future BS E9000 specs will carry an additional CECC number which will eventually supplant it. Ferranti Ltd, Electronic Components Division, Gem Mill, Chadderton, Oldham OL9 8NP.
WW 313

Axial ceramic capacitors

The AVX Spinguard range of dipped multilayer ceramic-capacitors provides axial equivalents to the well known radial Skycap range. These capacitors are lead taped and reeled to EIA RS-296 for automatic insertion. Four temperature coefficients are available in four case sizes rated at either 50 or 100V. Capacitance values range from 10pF to 0.82µF. Waycom Limited, Wokingham Road, Bracknell, Berkshire.
WW 314

Wide-band op. amps

Dual operational amplifiers MC4558 and 4558C are wide-band versions of the MC1558/MC1458, the extended unity-gain bandwidth being increased to 2.8MHz (typical) from 1MHz. The new devices are otherwise similar in performance and pin configuration to the original types, being offered in metal, ceramic and plastic packages. Supplies are ±18V for the C and ±22V for the extended temperature version, which works between -55 and 125°C. Motorola Ltd, Semiconductor Products Division, York House, Empire Way, Wembley, Middlesex HA9 0PR.
WW 315



WW316

Crimping tool

A ratchet-controlled hand tool, from Hollingsworth Terminals Ltd, is designed to crimp various sizes of Hollingsworth fully-insulated slip-on terminals, nylon female couplers and piggy back slip-ons. The H13 crimps through the insulation on to the conductor, alleviating the need for separate insulated housings. H13 dies are also available for fitting to the Hollingsworth H28-13 portable air tool, which can be hand held or bench mounted. Hollingsworth Terminals Limited, Barwell Trading Estate, Leatherhead Road, Chessington, Surrey.
WW 316

Triple-output power supply

A triple-out power supply, the HP-62312D from Hewlett-Packard, is designed specifically for microprocessor systems that need independently adjustable and isolated voltages. The main output is rated at 4.75 to 5.25V at 3A, while the other two each range from 4.75V at 0.38A to 12.6V at 0.6A. All outputs are isolated from each other and from the chassis, providing the user a wide selection of polarities. Periodic and random deviation is 1mV r.m.s. or 3mV pk-pk at 20Hz to 20MHz. The supply also features remote programming terminals to control the main 5V output for margin testing. Input voltage taps can be changed by the user to cover the a.c. ranges of 104 to 127V or 208 to 250V at 48 to 63Hz. Protection features include an internal a.c. fuse, a fixed foldback current limit and standard overvoltage protection on the main 5V output (optional on the other two outputs). Hewlett-Packard Limited, King Street Lane, Winnersh, Wokingham, Berkshire, RG11 5AR.
WW 317

U.h.f. linear amplifiers

A range of custom-built, u.h.f. class A power amplifiers, from Microwave Associates Ltd, have excellent linearity and are suitable for a.m. television or other applications where low distortion amplification of a.m. signals is required. These amplifiers are designed to meet customers' specific requirements, the final performance capability being dependent on the operating centre frequency, required bandwidth and certain other factors. A typical amplifier now in production has been designed for 450MHz a.m. signals. It is capable of delivering a mean carrier power output exceeding 10W into a 50Ω load with up to 100% modulation (40W p.e.p.) giving very low envelope distortion. It is a non-resonant circuit but performance is optimized for the working frequency, giving a -3dB bandwidth of 80MHz centred on 450MHz. The input power required is nominally 200mW and the input v.s.w.r. is better than 1.3:1. Power supply requirement is 13.8V ±1.5V direct at 10A. Microwave Systems Division, Microwave Associates Ltd, Woodside Estate, Dunstable, LU5 4SX.
WW 318

Tuning fork oscillators

A range of miniature tuning fork oscillators and ancillary modules, from Straumann of Switzerland, are robust, compact sources of standard frequency and timing signals in the range 0.25Hz to 192kHz. The tuning fork oscillators have frequencies from 960Hz to 6kHz and are accurate to ±25 p.p.m. ±1 p.p.m. per degree C. Short term stability is 2×10^{-8} and long term stability is less than 10 p.p.m. per decade of time. In addition a selection of divider modules are available in fixed ratios from 1:2 to 1:4096 to provide outputs down to 0.25Hz. A frequency multiplier having simultaneous X2, 4, 8, 16 and 32 outputs, to provide frequencies to 192kHz, is also available. Finally a range of sinewave shapers, for frequencies from 30Hz to 10kHz, are available to provide low distortion sine outputs from the c.m.o.s.-compatible outputs of the dividers, multiplier, or oscillators. All of the modules are t.t.l.- and c.m.o.s.-compatible and will operate at supply voltages from 5 to 15V d.c. Lyons Instruments Limited, Hoddesdon, Herts.
WW 319

Epi-base power transistors

A range of epitaxial-base power transistors, including a version of the 2N3055, is announced by RCA. The new devices are designed for wider bandwidth and lower cost than the hometaxial variety. Complementary to the 2N3055 in the new range is the BDX18, which is rated at 115W – the MJ2955 is a 150W alternative, while a further pair is formed by the 100W 2N6569 and 2N6594 40V. For 60W output the RCS617 and 618 are 115W devices, working at 80V. RCA Ltd, Solid State-Europe, Sunbury-on-Thames, Middlesex.
WW 320

Sidebands by mixer

Goldfish-breeder becomes Prime Minister

Well, no, perhaps that's a bit too alarmist, although maybe if he'd stuck to that we'd all be a lot better off. What made me think of that, though, was this peculiar handout I got through the post, which soberly informs me that "Karate expert joins sales force" or something like that. Now, press handouts (which are usually called 'press releases', as though they'd finally been released to the world in reluctant response to the importunate pleas of journalists) are often very funny in lots of ways, but this one has an extra dimension — a kind of pointed irrelevance. Probably the chap is quite good at karate, just as the chairman of his company may well be a whizz at carving chessmen out of billiard balls or the sales manager the country's leading exponent of giraffe racing, but it seems less than likely that these, no doubt fascinating pursuits figured prominently on their job applications. I see the point, of course. They thought we'd be hooked on this karate bit and mention the company's name just to poke fun at them. Well, really! Who do they think they're dealing with, these people? Let me tell them that while *Wireless World* continues in its great tradition, no-one, not even Coutant, will get a mention that way.

Radio-assisted bankruptcy

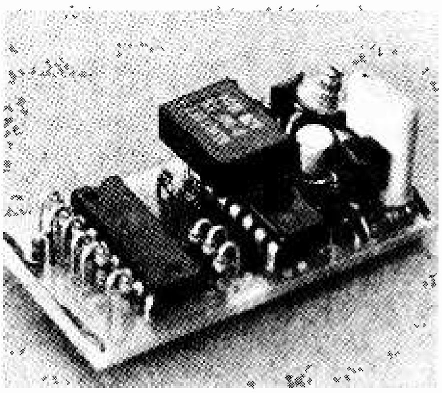
It must take a lot of courage to experiment with electronics in the form of radio control ("telearchics" as Free Grid was fond of calling it). If ever there were an activity where one's money had to go where one's mouth formerly was, this must surely be it. And, in particular, model aircraft. Ships? well, they can sink, of course, but solid earth is never all that far below and they can be recovered. But just imagine a carefully-made, six-foot span Spitfire, with its engine and electronics, costing anything up to three or four hundred pounds. Everything is going fine – all systems GO, as they say – when the mean time to failure of a 3p resistor suddenly expires. Can you imagine the expression on the chap's face as his creation peels off, stands on its prop. and screams earthwards in a tight spin? And then the slow shamble over to the wreckage, accompanied by the inevitable urchin who wishes to know whether you can stick it together again, Mister? I remember once seeing a man bring a beautiful model of an S.E.5 to the flying field, make all the radio tests, fill the tank and take the model off in a smooth climb into the sun. He tweaked all the knobs by the right amount at the right times and the S.E.5 didn't turn a hair. It went straight on and disappeared out to sea. It was the most roundabout way of throwing £200 away I've ever come across. And yet, as the 'pilot' collected together his attenuated belongings he was heard muttering that he'd never liked the thing and was going to build a Tiger Moth next.

The scale of things

Have you ever thought that maybe we are all taking rather a lot for granted? In electronics, I mean. For instance, the MSF frequency standard from Rugby is maintained at 60kHz within one part in ten to the eleventh, so that a digital clock such as those we have recently described will still be giving the correct time, within a second, in about 3,000 years from now, barring accidents. It is unimaginable. If you think in terms of waveforms, think of a counter, clocking at 100MHz, the period of the input being 10ns. Now apply a burst of the input and simultaneously switch on a torch, aimed at a wall 100 feet away. Keeping one eye on the output from the decade counter and trying not to blink, while the other watches the wall, you will possibly notice that the counter will count ten pulses and produce its output before the light hits the wall. Your eyes have to be pretty sharp for this sort of thing, mind you.

Or again, how about an audio power amplifier with a low average S:N ratio of 92Bb, power output of 20W and speaker impedance of eight ohms. That means that the power rail is 40V and the noise voltage forty thousand times less at 1mV. And the better amplifiers are often said to give S:N figures of 110dB or more.

This trick we have of camouflaging terably(!) large or small quantities as friendly little expressions like GHz and ns sometimes makes us (me, anyway) forget what we are really talking about. I suppose if we did use the real numbers, we would assume it was all impossible and stop trying.



Picture by Kelvin Portman.

EGGS WITH CHIPS. The transmitter from one of the glass-fibre eggs referred to in the August issue. This one goes in a swan's egg, but Mr Howey is trying to make smaller transmitters using un-encapsulated i.cs.

CB — Complete Balderdash?

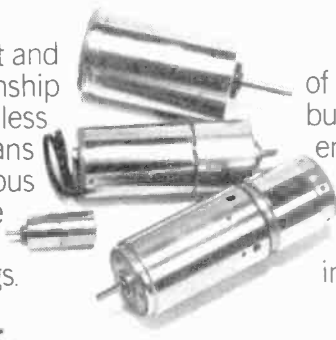
Well, it's a point of view, particularly if you're a high-fidelity sound fan and happen to live in America. All those thousands of Citizens' Band outfits seem to be causing their share of problems to the FCC and to the users of audio gear, according to a leader in the latest *The Audio Amateur* published in the States. It isn't just the CB transceiver itself, but the fact that a beefy great linear amplifier is often tied on the end of it, so that one's chat about the World Series or Grandma's leg will get through, come what may. If the Citizens simply annoyed each other, some would say 'serve 'em right', but all too often, it seems, they become a sort of permanent alternative programme in a lot of audio amplifiers. Presumably the signal is detected by sensitive and non-linear front ends.

The FCC, says the leader, have recently said that the situation is now out of control and that they are unable even to monitor activity on the band. They have also stopped asking CB operators to pay for a licence. So, since it appears that no paid licence is needed and no monitoring or control can be carried out, there is very little to stop anyone from doing anything. I don't know how you feel about that, but it scares me to death. The *TAA* leader writer concludes that unless the FCC can do something to control CB ". . . they had better review the feasibility of CB itself."

I wouldn't like to knock CB too much on this score, because I have no personal experience of it. Perhaps some of our American readers could comment on the above.

Precision Performance Servomotors

Escap instrument servomotors start fast and continue to lead the field. But such championship qualities are only part of the story. Unique ironless rotors ensure low inertia. Minimal friction means exceptionally low starting voltages. Precious metal commutators and brushes guarantee unsurpassed stamina – as do their self lubricating bearings.

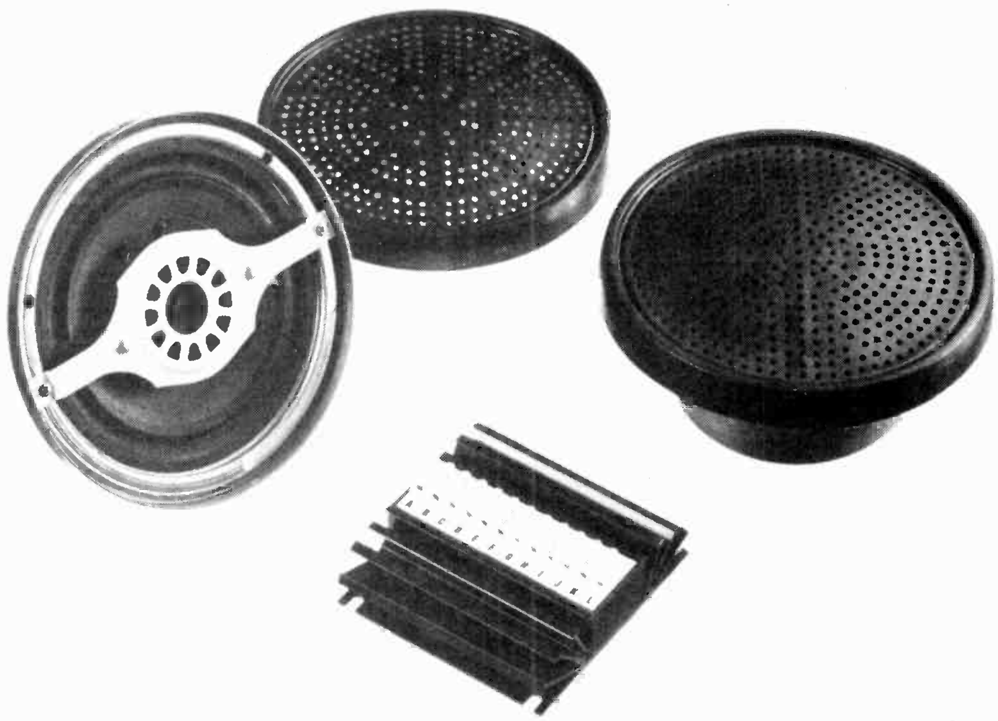


These are but a few of the definable qualities of Portescap's miniature precision servomotors – built by Swiss craftsmen for the professional engineer.

Your product can be a winner too if you team up with Portescap. So be quick off the mark and circle the reply number, for more information.

Portescap

Portescap (U.K.) Limited, 204 Elgar Road, Reading, RG2 0DD.
Tel: Reading (0734) 861485/6/7/8. Telex: 847661.



DIY SPEAKER KITS

15-WATT KIT IN CHASSIS FORM

When you are looking for a good speaker, why not build your own from this kit. It's the unit which we supply with the enclosures illustrated below Size 13 · 8" (approx.) woofer (EMI),tweeter, and matching crossover components Power handling capacity 15 watts rms. 30 watts peak.

£17.00 PER STEREO PAIR + P & P £3.40

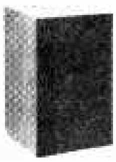
EASY-TO-BUILD WITH ENCLOSURE

Specially designed by RT-VC for cost-conscious hi-fi enthusiasts, these kits incorporate two teak-simulate enclosures, two EMI 13" · 8" (approx.) woofers, two tweeters and a pair of matching crossovers. Easily constructed, using a few basic tools. Supplied complete with an easy-to-follow circuit diagram, and crossover components. Input 15 watts rms. 30 watts peak, each unit. Cabinet size 20 · 11" · 9½" (approx.).

£25.50 PER STEREO PAIR + p & p £5.50

COMPACT' FOR TOP VALUE

How about this for incredible bookshelf value from RT-VC! A pair of high efficiency units for only £7.50 – just what you need for low-power amplifiers. These infinite baffle enclosures come to you ready mitred and professionally finished. Each cabinet measures 12" · 9" · 5" (approx.) deep, and is in wood simulate. Complete with two 8" (approx.) speakers for max. power handling of 7 watts.



£7.50 per stereo pair + p & p £1.70

SPEAKERS Two models – Duo IIb, teak veneer, 12 watts rms, 24 watts peak, 18½" · 13½" · 7¼" (approx.).

★£34 PER PAIR + p & p £6.50

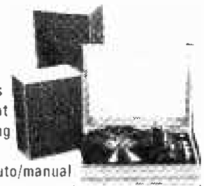
Duo III, 20 watts rms, 40 watts peak, 27" · 13" · 11½" (approx.)

★£52 PER PAIR + p & p £7.50

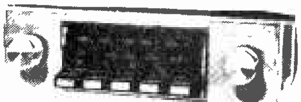
EASY TO BUILD RECORD PLAYER KIT

Ideally suited for the constructor who requires a complete stereo unit at a budget price, comprising ready assembled stereo amp. module, Garrard auto/manual deck with cueing device, pre-cut and finished cabinet work. Output 4 watts per channel, phones socket and record / replay socket

£26.95 p & p £4.05



CAR RADIO KIT



Complete with speaker, baffle and fixing strip. The Tourist IV for the experienced constructor only. The Tourist IV has five push buttons, four medium band and one for long wave band. The tuning scale is illuminated and attractive small aluminium control knobs are used for manual tuning and volume control. The modern style fascia has been designed to blend with most car interiors and the finished radio will slot into a standard car radio aperture. Size approx. 7" · 2" · 4¼". Power Supply Nominal 12 volts positive or negative earth (altered internally) Power Output 4 watts into 4 ohms.

MOTOR TOP 10 AWARD

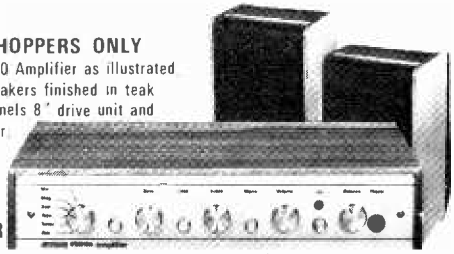
£12.50 + p & p £1.50

PERSONAL SHOPPERS ONLY

Viscount IV 20 x 20 Amplifier as illustrated plus 1 pair of speakers finished in teak with melamine panels 8" drive unit and 3¼" approx tweeter 22" 13" 10¾" size approx.

£45.00

SPECIAL OFFER



illustrated 20 x 20 WATT STEREO AMPLIFIER ★

Superb Viscount IV unit in teak-finished cabinet. Silver fascia with aluminium rotary controls and pushbuttons, red mains indicator and stereo jack socket Function switch for mic. magnetic and crystal pick-ups, tape, tuner, and auxiliary Rear panel features two mains outlets, DIN speaker and input sockets, plus fuse. 20 + 20 watts rms. 40 + 40 watts peak.

£29.90 + p & p £2.10

FREE 'Limited Period' A Free 4 Channel Stereo Adaptor to all purchasers of the Viscount Amplifier. Available separately £3.95 + p & p £1.00

SPECIAL OFFER For example Duo speaker system II or III Viscount Amplifier, MP60 type turntable complete

DEDUCT 10% (Mail order only (Not on postage)) DEDUCT 15% (Personal Shoppers only)

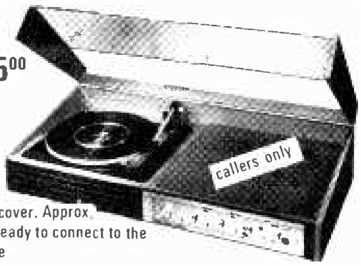
★ on complete stereo systems using ★ starred Products

PERSONAL SHOPPERS ONLY

PLINTH & COVER BSR OR GARRARD TEAK FINISH	£4.95
GOODMAN 5" approx., 7 watt bass speaker	£2.70
AM. FM. TUNER P C B with Mullard L P. 1186, 1185 1181 modules	£9.50
CROWN 5 push button car radio, LW MW 12v Pos. neg earth 5watts output, tone control complete with speaker and fixing kit, in dash type	£15.95
STEREO CASSETTE TAPE PLAYER Negative earth only, 3 watts per channel output	£16.50
AM. FM. STEREO MULTIPLEX CAR RADIO/cassette player in dash fixing Negative earth 5 watts output	£36.00
I.C. Stereo 8 Track to Cassette adaptor converts, any 8 track player to cassette player.	£18.95
GLOBAL Spherical speaker 8 ohms 5 watts	£3.50
100K Multiturn Varicap tuning pots 6 for	£1.00
HEAVY DUTY FIBRE GLASS COPPER CLAD BOARD 27" x 17 x 1/16" Approx. per sheet only	£1.90
DECCA DC1000 Stereo Cassette Record deck P.C.B. complete with switch oscillator coils and tape-heads and circuit diagrams	£2.95

VISCOUNT COMBI £65.00

For personal shoppers only, this unit comprises: The 20 · 20 Viscount amplifier BSR MP60 Type turntable housed in an attractive teak finished console with smoked acrylic cover. Approx 30¼" · 14½" · 7½" complete ready to connect to the speaker system of your choice



BSR TURNTABLES

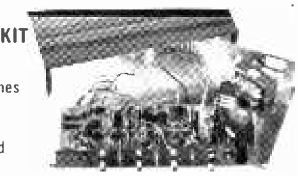
BSR MP60 TYPE Single play record player (Chassis form) £15.95 less cartridge. P & P £2.00

BSR automatic record player deck (Chassis form) with cueing device and stereo ceramic head. £9.95 P & P £2.00

Cartridges to suit above ACOS MAGNETIC STEREO ...... £4.95 CERAMIC STEREO £1.95

TURNTABLE illus. Popular BSR MP 60 type, complete with magnetic cartridge, diamond stylus, and de luxe plinth and cover. Ready wired ★ £29 + p & p £4.50

30 x 30 WATT AMPLIFIER KIT



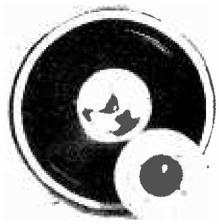
Specially designed by R T-VC for the experienced constructor, this kit comes complete in every detail. Same facilities as Viscount IV amplifier. Chassis is ready punched, drilled and formed Cabinet is finished in teak veneer. Silver fascia and easy-to-handle aluminium knobs.

Output 30 + 30 watts rms, 60+60 peak. £29.00 + p & p £2.10

DECCA 20 WATTS STEREO SPEAKER

This matching loudspeaker system is hand made, kit comprises of two 8" diameter approx. base drive unit, with heavy die cast chassis laminated cones with rolled P.V.C surrounds, two 3½" diameter approx domed tweeters comp with crossover networks

£20.00 £4.00 p & p stereo pair



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PORTABLE MONO DISCO

with built-in pre-amplifiers

Here's the big-value portable disco console from RT-VC! It features a pair of BSR MP 60 type auto-return, single play professional series record decks. Plus all the controls and features you need to give fabulous disco performances. Simply connects into your existing slave or external amplifier.

p & p £6.50 £64.00

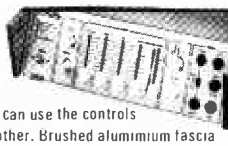
35-WATT MONO DISCO AMP

£27.50 + p & p £2.50

Size approx 13⅝" 5¼" 6¾"

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.

100 WATT MONO DISCO AMP



Size approx. 14" · 4" · 10¾". Sloping facia,you can use the controls without fuss or bother. Brushed aluminium fascia and rotary controls. Five smooth acting, vertically mounted slide controls – master volume, tape level, mic level, deck level, PLUS INTER-DECK FADER for perfect graduated change from record deck No. 1 to No. 2, or vice versa. Pre-fade level control (PFL) lets YOU hear next disc before fading it in. VU meter monitors output level. Output 100 watts RMS 200 watts peak.

£65.00 p & p £4.00

PRACTICE GUITAR AMPLIFIER WITH BUILT-IN SPEAKER

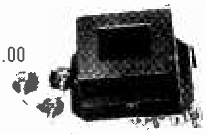
This budget practice amplifier, has been specially designed for the amateur, who requires a quality self-contained unit with all facilities. 2 inputs – 1 for mic or guitar, the 2nd for record player or cassette deck, it also can be used for cine-sound amplification. 2 volume controls, 1 for each input, also base and treble controls. Power output with internal speaker, 10 watts RMS, with remote speaker (not supplied) 20 watts RMS. Size approx. 17" + 9" · 11.

£32.50 + p & p £3.00

HOME 8 TRACK CARTRIDGE PLAYER

Automatically switches programmes monitored by indicators with manual override track selection. This unit will match with the Unisound modules and is compatable with the Viscount IV amplifier with Sim teak cabinet. approx 9 · 8 · 3¼. p & p £1.50 £14.60

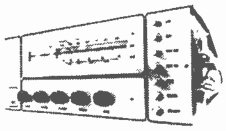
4 x 4 STEREO AMP KIT £14.50 P & P £2.00



For the experienced constructor who wants to design his own stereo. Kit includes all necessary components including constructors manual. Plus Pair of easy to build 4 watt speakers in kit form, with teak simulate finish cabinets 12 x 9 x 5 approx.

PYE STEREO GRAM CHASSIS

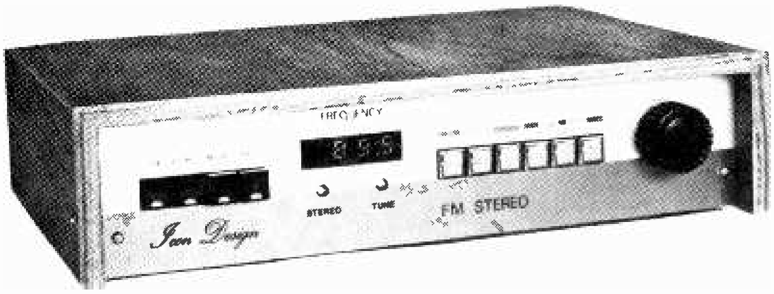
(Complete with circuit diagrams)



Complete ready to install Wave bands LM, VHF STEREO, VHF MONO Controls for tuning volume, balance, bass and treble. Power output 7 watts R M S per channel 14 watts peak 8 ohms 2" · 8" approx chassis speakers and BSR auto record player deck

PERSONAL SHOPPERS ONLY £35.00

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



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

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

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

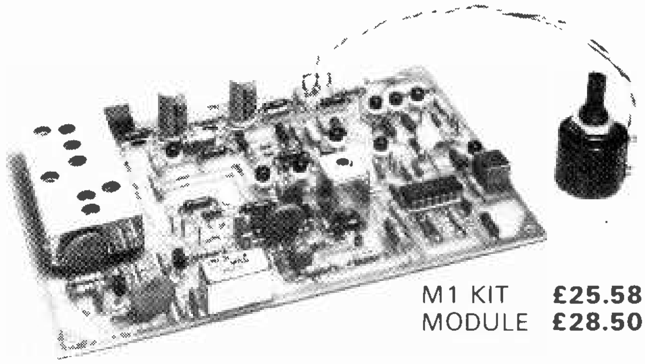
Good stereo reception is assured by the use of a phase locked decoder with full 'birdie' and spurious output filtering.

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

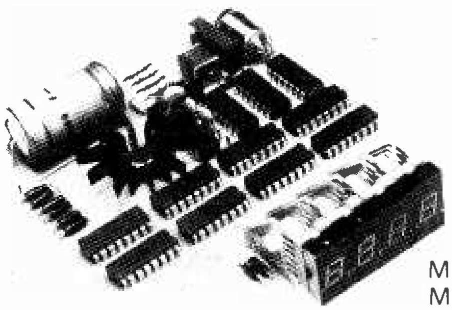
	Tuner	Kit
T1 PUSH-BUTTON VERSION	**£110.00**	**£98.47**
T2 TOUCH TUNED	**£115.00**	**£101.31**
T3 DIGITAL (AS SHOWN)	**£139.00**	**£132.14**

MAIN RECEIVER MODULE M1

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



M1 KIT **£25.58**
MODULE **£28.50**



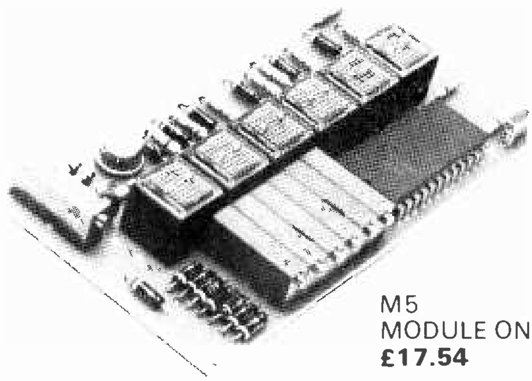
M6
MODULE ONLY
£44.40

DIGITAL FREQUENCY METER M6

We are very proud of this one We don't have to say it's the best, as far as we know it's the only one! On a board less than 4" square is all the electronics of a stable counter with i.f. offset (added) and a stabilized power supply! With the aid of a small daughter board (not shown) which fits neatly into the above module (M1), the exact station frequency is displayed to the nearest 0.1 MHz. It's a tuning scale 20" long with accurate calibrations every 0 1"! You get the transformer, daughter board (ready wired in), polarized filter, and a list of station frequencies. What more do you want?

TOUCH TUNE MODULE M5

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



M5
MODULE ONLY
£17.54

OTHER MODULES etc.

M2 Stereo decoder	**£7.60**	kit **£6.22**
M3 Push button 'M5'	**£15.95**	kit **£14.70**
M4 Power supply ..	**£6.30**	kit **£5.90**
SL1310 decoder IC ..	**£1.95**	
TBA750 f m. i f ..	**£1.55**	
20v regulator IC	**£1.50**	
LP1186 front-end	**£7.75**	
Filter, SFJ10 7MA ...	**£1.55**	
7 segment L.E D (c/a) ...	**£1.99**	
Descriptive booklet .	**£0.50**	(£1 00 export)

ALL PRICES + 12.5% VAT

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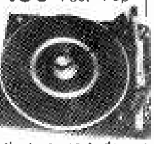
Purton, WILTS
SN5 9DG

RETURN OF POST MAIL ORDER SERVICE

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



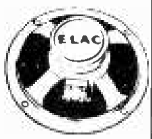
Plays 12" 10" or 7" records. Auto or Manual A high quality unit backed by BSR reliability with 12 months guarantee A C 200/250V
Size 13½-11¼in 3 speeds
Above motor board 3¾in
Below motor board 2½in
with STEREO and MONO CARTRIDGE
B S R SINGLE PLAYER similar to above with stereo cartridge and cueing device,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

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

HEAVY METAL PLINTHS
With P V C Cover Cut out for most B S R or Garrard decks Silver grey finish **£6.50** Post £1 50
Model "A" Size 12½ x 14¾ x 7½in
Model "B" Size 16 x 13¾ x 7in **£7.50.**
Extra large plinth & cover, teak wood base Size 20"×17½"×9" **£19.5[illegible]** [illegible]allers only

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

ELAC HI-FI SPEAKER 8in. TWIN CONE



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

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

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

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board Size 10½ x 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 **35p.** D P **60p.** STEREO L/S **85p.** D P **£1.** Edge 5K S P Transistor **45p.**

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

TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.**
TOGGLE SWITCHES S P **30p.** D P S T **40p.** D P D T **50p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS GP91 **£1.50.** GP93 **£2.50.**
SONOTONE stereo **£2.00.** **SHURE** M75 ECS **£8.**

E.M.I. 13½ x 8in. SPEAKER SALE!
With tweeter and crossover 10 watt
State 3 or 8 ohm
As illustrated
£7.95 Post 45p

Ditto
15 watts
8 ohm
£10.50
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With tweeter and crossover
20 watt
Bass res 25 c p s
Flux = 11,000 gauss
4 or 8 or 15 ohm 20 to 20,000 c p s
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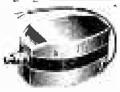
Bookshelf Cabinet **£8.50**
Teak finish For EMI 13 x 8 speakers Post £1 00

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



BLANK ALUMINIUM CHASSIS. 6 x 4—**70p;** 8 x 6—**90p;** 10 x 7—**£1.15;** 12 x 8—**£1.35;** 14 x 9—**£1.50;** 16 x 6—**£1.45;** 16 x 10—**£1.70.** **ANGLE ALI.** 6 x ¾ x ¾in—**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.**
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VARICAP FM TUNER HEAD with circuit & connections **£4.95.**

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

R.C.S. 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

R.C.S. POWER PACK KIT
12 VOLT, 750mA Complete with printed circuit board and assembly instructions
£3.35 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
Full instructions supplied Details S A E
£1.45 Post 30p

RCS DRILL SPEED CONTROLLER/LIGHT DIMMER KIT. Easy to build kit Will control up to 500 watts AC mains.
£3.25 Post 35p

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp Inputs for high, medium or low imp per channel, with volume control and P C Board Can be ganged to make multi-way stereo mixers
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MAINS TRANSFORMERS
ALL POST 50p

250-0-250V 70mA 6 5V, 2A	£3.45
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GENERAL PURPOSE LOW VOLTAGE Tapped outputs at 2 amp 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25-and 30V **£5.30.** 1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£5.30.** 2 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£8.50.** 3 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£11.00.** 5 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60 **£14.50.** 12V 100mA **£1.** 9V 1 amp **£1.** 12V 300mA, **£1.** 12V 750mA, **£1.** 10V, 30V, 40V 2 amp, **£2.75.** 20V, 3 amp, **£2.45.** 40V, 2 amp, **£2.95.** 30V 5A and 34V 2ACT **£3.45.** 0 5 8 10 16V ½ amp, **£1.95.** 20V ½ amp, **£1.75.** 20V, 1 amp, **£2.20.** 20V 3 amp **£2.50.** 20-0-20V 1 amp **£2.95.** 30V 1½ amp, **£2.75;** 20V, 40V, 60V or 20-0-20V 1 amp **£3.50.** 30-0-30V 3 amp **£7.** 2 × 18V 6 amp **£11.00.**
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13 × 10 × 6in
50 to 14,000 cps
8 watts rms 8 ohms
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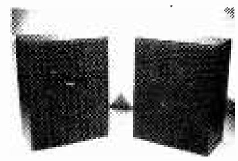
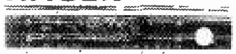


KUBA-KOPENHAGEN STEREO



TUNER-AMPLIFIER CHASSIS AM-FM 5+5 WATT
This Continental 4-band radiogram chassis uses first class quality components throughout Features Large facia panel with 7 push buttons for medium long, short VHF-FM AFC phono mains on-off 4-rotary controls tuning volume tone balance Facia size 17 × 4½ inches Chassis size 17 × 4½ × 5½ inches DIN-connector sockets for tape record/playback, loudspeakers phono pick-up external FM-AM aerials Automatic stereo beacon light Built-in ferrite rod aerial for medium/longwave A C 240V mains Circuit supplied
Above speakers are suitable **£33.50** Post £1 50

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HIGH STABILITY. ½W 2% 10 ohms to 6 meg **12p.**
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WIRE-WOUND RESISTORS 5 watt 10 watt 15 watt 10 ohms to 100K **12p** each

BAKER MAJOR 12" £15.00
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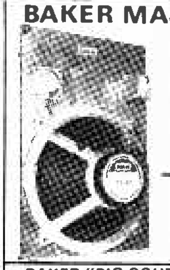

30-14,500 c/s, 12in double cone woofer and tweeter cone together with a BAKER ceramic magnet assembly having a flux density of 14,000 gauss and a total flux of 145,000 Maxwells Bass resonance 40 c/s Rated 25W NOTE 4 or 8 or 16 ohms must be stated
Module kit 30-17 000 c/s with tweeter crossover baffle and instructions **£19.00** Post £1 60 each
Please state 4 or 8 or 16 ohms

BAKER "BIG-SOUND" SPEAKERS. Post £1 00 each

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

BAKER LOUDSPEAKER, 12 INCH, 60 WATT, GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER FULL RANGE PROFESSIONAL QUALITY RESPONSE 30-16,000 CPS MASSIVE CERAMIC MAGNET WITH ALUMINIUM PRESENCE CENTRE DOME **£21.00** Post £1 60

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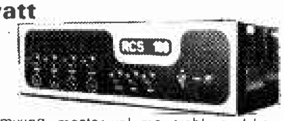
For 6½in speaker and tweeter 12x8x6in **£5.80** Post 75p
Many other cabinets in stock Phone your requirements

R.C.S. 100 watt VALVE AMPLIFIER CHASSIS



Four inputs Four way mixing, master volume treble and bass controls Suits all speakers This professional quality amplifier chassis is suitable for all groups, disco, P A , where high quality power is required 5 speaker outputs A/C mains operated Slave output socket. Produced by demand for a quality valve amplifier 100V line output to order Send for leaflet
Suitable carrying cab **£16.50** Price **£85** carr £2 50

SPEAKER COVERING MATERIALS. Samples Large S A E
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft
Horn Tweeters 2-16kc/s, 10W 8 ohm or 16 ohm **£3.60**
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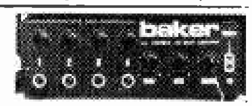
LOUDSPEAKERS P.M. 3 OHM 7x4in **£1.50;** 6½in **£1.80;** 8x5in, **£1.90;** 8in **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in 2¾in 35 ohm 3in 25 ohm 2½in 3in 5x3in, 7x4in 8 ohm, 2½in 3in 3½in 5in, 15 ohm, 3½in dia, 6x4in 7x4in 5x3in 3 ohm, 2½in 2⅝in, 3½in, 5in dia **£1.60 each.**
PHILIPS LOUDSPEAKER, 8in, 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in diameter 4W **£2.50.** 10in diameter 5W **£2.95;**
12in diameter 6W **£3.50.** 3/8/15 ohms, please state
PIEZO ELECTRIC HORN TWEETER. Handles up to 100 watts No crossover required **£7.95.**

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

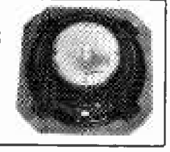
BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised
Ideal for Groups, Disco and P A 4 inputs speech and music 4 way mixing Output 4 8/16 ohms a c Mains Separate treble and bass controls Master volume control
Guaranteed Details S A E **£72** £1 50 carr
NEW MODEL MAJOR—50 watt 4 input 2 vol Treble and bass Ideal disco amplifier **£49** Carr £1

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

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



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

ELECTRO MAGNETIC PENDULUM MECHANISM
1 5V d c operation over 300 hours continuous on SP2 battery fully adjustable swing and speed Ideal displays teaching electro magnetism or for metronome strobe etc
95p Post 30p

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

RADIO COMPONENT SPECIALISTS
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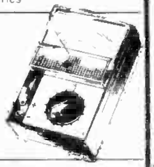
SERVICE TRADING CO

RELAYS

Wide range of AC and DC relays available from stock. Phone or write in your enquiries.

WHY PAY MORE?!



MULTI RANGE METER. A.C. volts 2.5-500. D.C. volts 2.5-500 (Sensitivity 2000 Ω/V D.C. & A.C.) D.C. current 0/1/10/100 mA. Ohms range. Sturdy compact moving coil instrument with 21 ranges, dimensions 120 × 80 × 44mm. Weight 0.32 kg. SERVICE TRADING CO. Price **£5.50**. Incl. leads and battery. Post 50p. (Total price inc. VAT & Post **£6.48**.)

TRIAC

Raytheon tag symmetrical Triac. Type Tag 250/500v. 10 amp 500 piv. Glass passivated plastic triac. Swiss precision product for long term reliability **£1.25**. P&P 10p (inclusive of date and application sheet). Suitable Diac **20p**.

0 to 60 MINUTES CLOCKWORK TIMER.

Double pole 15 amp 230AC. Contacts (no dial) **£1.50**. P&P 30p.

GALVANOMETER.

50 micro mirror galvo. Calibrated 50-0-50 and 0-100. Mfg. by Griffin & George Ltd. Offered at fraction of maker's price, in original ministry packing **£12.00**, p&p 60p.

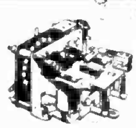
CONTACTOR

Mfg. by Hendrey Relays, type C2839 220/250 AC ops. Contact 4C/0 at 20 amp at 440 volts AC, price **£6.00**. P&P 75p.

230 VOLT AC FAN ASSEMBLY

[illegible] **£3.95**. P&P [illegible]

21-WAY SELECTOR SWITCH with reset coil



The ingenious electro mechanical device can be switched up to 21 positions and can be reset from any position by energising the reset coil 230/240v A.C. operation. Unit is mounted on strong chassis. Complete with cover. Price **£5.50**. P&P 75p.

VORTEX BLOWER AND VACUUM UNIT

[illegible] These units are ex-equipment but have had minimum use. Fully tested prior to despatch. Price **£12** + £1.50 P&P. Suitable transformer for 230/240v a.c. **£6** + £1 P&P.

CENTRIFUGAL BLOWER

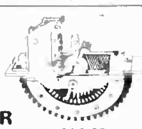
Mfg. by Smiths Industries 230/240v a.c. Miniature Model Series SE/200. Size 95mm x 82mm x 82mm. Aperture 38mm x 31mm. 12 c.f.m. £2.75. Post 50p. Mfg. by Fracmo 115/230V a.c. 2800/3400 r.p.m. Fan type aperture 3" x 2½" VBL4/L Price £12. Post £1. Also available extremely powerful blower mfg. by Fracmo.

NI-CAD BATTERIES

[illegible]

Postage 30p per unit.

UNISELECTOR SWITCH



4 bank 25 way 75 ohm coil 36-48v D.C. operation. Ex **new** equipment **£4.25**, P&P 75p. Total price inc. VAT **£5.40**.

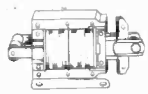
MINIATURE UNISELECTOR

12v 11 way 4 bank (3 non-bridging 1 homing) **£2.50**. P&P 35p.

MICRO SWITCHES

As illustrated but fitted with 1" Lever. 10 for **£2.00**.
Sub-miniature Burgess type V 4T 1. 10 for **£2.50**. 50 for **£10.00**, post paid.
Sub-miniature Honeywell roller M.S. type 3 115M 9061. 10 for **£2.50**, post paid.
LEVER OPERATED 20 amp c/o. Mfg. by Unimax USA. 10 for **£4.00** plus 50p P&P (min. order 10).

NEW HEAVY DUTY SOLENOID



Mfg. by Magnetic Devices 240v A.C. operation approx. 20lb pull at 1.25". Price **£7.00**. P&P 75p.
Similar to above approx. 10lb pull **£3.50**. P&P 60p.

230-250 VOLT A.C. SOLENOID

Similar in appearance to illustration. Approximately 1½lb pull. Size of feet 1⅝ × 13 16". Price **£1.00**. Post 25p.

24 VOLT D.C. SOLENOIDS

UNIT containing **1 heavy duty solenoid approx. 25 lb. pull** at 1 in. travel, 2 solenoids of approx. 1 lb. pull at ½ in. travel, 6 solenoids of approx. 4 oz. pull at ¼ in. travel. Plus 1 24V D.C. 1 heavy duty 1 make relay. Price **£3.00**. Post £1.00. **ABSOLUTE BARGAIN.**

240 A.C. SOLENOID OPERATED FLUID VALVE

Rated 1 p.s.i. will handle up to 7 p.s.i. Forged brass body, stainless steel core and spring, ⅜ in. b.s.p. inlet/outlet. Precision made. British mfg. PRICE **£2.75**. Post 50p. new original packing.

VARIABLE VOLTAGE TRANSFORMERS

Carriage extra — INPUT 230 v. A.C. 50/60

OUTPUT VARIABLE 0/260v. A.C.

BRAND NEW. All types.

200W (1 Amp) fitted A/C volt meter	£11.50
0.5 KVA (Max. 2½ Amp)	£14.00
1 KVA (Max. 5 Amp)	£18.00
2 KVA (Max. 10 Amp)	£30.00
3 KVA (Max. 15 Amp)	£38.00
4 KVA (Max. 20 Amp)	£60.00

LT TRANSFORMERS

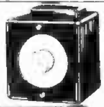
0-12v/24v at 1 amp	£2.50 p&p 50p
0-15v at 1 amp + 0-15v at 1 amp (30v 1 amp)	£2.50 p&p 50p
25-0-25v at 2½ amp	£4.50 p&p 75p
0-12v/24v 10 amp	£12.35 p&p £1.50
0-4v/6v/24v/32v at 12 amp	£13.00 p&p £1.50
0-12v at 20 amp or 0-24v at 10 amp	£12.40 p&p £1.50
0-6v/12v/17v/18v/20v at 20 amp	£14.00 p&p £1.50
0-6v/12v at 20 amp	£11.85 p&p £1.00

Other types in stock, phone in enquiries.

300 V.A. ISOLATING TRANSFORMER

115/230 screened primary, two separate or 115v for 115 or 230v. Secondary two 115v at 150 V.A. each for 115 or 230v output. Can be used in series or parallel connections. Fully tropicalised. Length 13.5cm, width 11cm, weight 15lbs. Special price **£6.00**, carr. £1.00.

RODENE UNISET TYPE 71 TIMER



0-60 sec. 230v AC operation incorporating a lapsed time indicator and repeat facilities. A precision motorised timer ideal for process timing, photography, welding, mixing etc. Price **£6.00** p&p 60p.

STROBE! STROBE! STROBE!

HY-LIGHT STROBE KIT Mk. IV

Latest type Xenon white light tube. Solid state timing and triggering circuit. 230/240 volt A.C. operation. Speed adjustable 1-20 f.p.s. Designed for large rooms, halls, etc. Light output greater than many (so called 4 Joule) strobes. Price **£18.00**. Post 75p. Specially designed case and reflector for Hy-Light **£8.25**. Post £1.00.

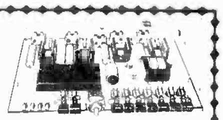
ULTRA VIOLET BLACK LIGHT FLUORESCENT TUBES

4ft. 40 watt £7.00 (callers only) **2ft. 20 watt £5.00**. Post 60p. (For use in stan bi-pin fittings) MINI **12in. 8 watt £1.75**. Post 25p. **9in. 6 watt £1.40**. **6in. 4 watt £1.40**. Post 25p. Complete ballast unit. Either 6", 9" or 12" tube 230V A.C. op. **£3.50** plus p&p 40p. Also available for 12V D.C. op. **£3.50** plus p&p 40p.

XENON FLASH GUN TUBES

Range of Xenon tubes available from stock. S.A.E. for full details.

SQUAD LIGHT

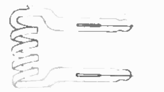


A new conception in light control. Four channels each capable of handling 750 watts of spotlights, floodlights or dozens of small mains lamps. Seven programs all speed controlled plus flash modulation, effectively giving 14 different displays. Makes sound-to-light obsolete. Completely electrically and mechanically noise free.
Price only **£60.00**
Post 75p. S.A.E. (Foolscap) for further details.

RELAYS

Wide range of AC and DC relays available from stock. Phone or write in your enquiries.

FT3



High intensity multi turn voltage neon glow discharge flash tube. Design for ignition timing etc. **£1.50** P&P 25p. 3 for **£3.00** P&P 50p.

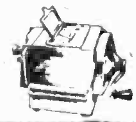
RESET COUNTER

[illegible] **£1.75** [illegible] **£1.50** [illegible]

BIG INCH

Tiny precision built 3 rpm USA motor size only 1 × 1. 100 volt AC op. supplied with resistor for 230 volt AC price **£2.00** P&P 20p. 4 for **£5.00** post paid.

INSULATION TESTERS (NEW)



Test to I.E.E. spec. Rugged metal construction suitable for bench or field work, constant speed clutch. Size L 8 in. W 4 in. H 6 in., weight 6 lb.
500 VOLTS 500 megohms **£40.00** Post 80p
1000 VOLTS 1000 megohms **£46.00** Post 80p
SAE for leaflet.

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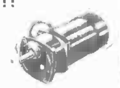
ACCOUNT CUSTOMERS MIN. ORDER £10.00

GEARED MOTORS

100 R.P.M. 115 lbs. ins.!!



115 lb. ins. 110 volt 50Hz 2.8 amp single phase split capacitor motor. Immense power. Continuously rated. Totally enclosed. Fan cooled. In line gearbox. Length 250mm. Dia. 135mm. Spindle Dia. 15.5mm. Length 145mm. ex-equipment tested **£12.00**. Post £1.50. Suitable transformer 230/240 volt **£8.00**. Post 75p.

15 R.P.M.

Type SD48 15 r.p.m. 80 lb. ins. Input 100/120 volt A.C. Length incl. gearbox 270mm. Height 135mm. Width 150mm. Shaft drive 16mm. Weight 8.5 Kilos. BRAND NEW. Price **£10.00**, carr. £1.00. Suitable transformer for use on 220/240 volt A.C. **£6.00**. Post 50p.

BODINE TYPE N.C.I. GEARED MOTOR

(Type 1) 71 r.p.m. torque 10 lb. in. **Reversible** 1/70th h.p. cycle 38 amp. This U.S.A. motor is offered in as new condition. Input voltage of motor 115v **A.C.** Supplied complete with transformer for **230/240v A.C. input.** Price type **£6.25**. Post 75p or less transformer **£3.75**. Post 65p.
(Type 3) 71 r.p.m. 230 Volt A.C. Continuously rated. Non reversible **£6.50**. Post 75p.

A.E.G. WATER PUMP

[illegible] **£15** [illegible]

CITENCO

FHP Motor type C 7333 15 220/240v a.c. 19 rpm reversible motor, torque 14.5 kg. Gear ratio 144:1. Brand new incl. capacitor, our price **£14.25** + £1.25 p&p.

REVERSIBLE MOTOR 230V A.C.

General Electric 230v A.C. 1,600 r.p.m. 0.25 amp. Complete with anti vibration mounting bracket and capacitor. O.A. size 111mm x 95mm. Spindle 5/16" dia. 20mm long. Ex-equipment tested. **£3.00**. Post 50p.

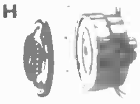
A.E.I. MOTOR

AEI 1/12 hp continuous rated, reversible motor 100/120v A.C. 50/60 cycle 2850 r.p.m. Flange fixing dia 4", length 4", shaft 1" × 5/16". Price **£3.25**. P&P 75p.

METERS NEW 90mm Diameter

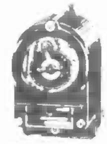
Type: 65CS D.C. mc. 2, 5, 10, 20, 50 amp **£3.00**. 100 amp **£3.25**. **Type: 62T2 A.C.** M.I. 1, 10, 50 amp **£3.00**. 0-150 Volt A.C. M.I. **£3.25** and 300 Volt A.C. R.M.C. **£3.00** P&P 30p.

BENDIX MAGNETIC CLUTCH



Superb example of electro-mechanics. Main body in two sections. Coil section is fixed and has ⅝" sleeve. The drive section rotating on the outer perimeter. When engaged the transmission is extremely powerful. Diameter 1½". Total width 1¼". 24V D.C. op. Price **£3.50** plus p&p 45p.

TIME SWITCH



Horstmann Type V Mk II Time Switch 200/250 volt A.C. Two on two off every 24 hours at any manually pre-set time 30 amp contacts. 36-hour spring reserve in case of power failure. Day omitting device. Fitted in heavy high impact case with glass observation window. Built to highest Electricity Board spec. Individually tested. Price **£7.75**. Post 50p. (Total inc. VAT £8.91)

SANGAMO WESTERN type S251 200/250 V a.c. 2 on 2 off every 24 hours. 20 amps contacts with override switch, diameter 4" × 3". Price **£6.00** p&p 50p.

A.C. MAINS TIMER UNIT

Based on an electric clock with 25 amp single-pole switch which can be preset for any period up to 12 hrs. ahead to switch on for any length of time from 10 mins. to 6 hrs. then switch off. An additional 60 min. audible timer is also incorporated. Ideal for Tape Recorders, Lights, Electric Blankets etc. Attractive satin copper finish. Size 135 mm × 130 mm × 60 mm. Price **£2.25**. Post 40p. (Total inc. VAT & Post **£2.87**).

POWER RHEOSTATS

New ceramic construction, vitreous enamel embedded winding, heavy duty brush assembly, continuously rated.

25 WATT		£1.90
50 WATT	£2.40	100 WATT
£3.70		
Black Silver Skirted knob	22p ea.	

600 WATT DIMMER SWITCH

Easily fitted. Fully guaranteed by makers. Will control up to 600w of lighting except fluorescent at mains voltage. Complete with simple instructions **£3.95**. Post 25p. 1000 watt model **£5.60**. Post 25p. 2000 watt model **£9.75**. Post 40p.

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NEW PRODUCTS!

NRDC-AMBISONIC 45J

SURROUND SOUND DECODER

The **first ever** kit specially produced by Integrex for this British NRDC backed surround sound system which is the result of 7 years' research by the Ambisonic team. W.W. July, Aug. and Sept. '77.

The unit is designed to decode not only 45J but virtually all other 'quadrophonic' systems (Not CD4), including the new BBC Matrix H.10 input selections.

The decoder is linear throughout and does not rely on listener fatiguing logic enhancement techniques. Both 2 or 3 input signals and 4 or 6 output signals are provided in this most versatile unit. Complete with mains power, wooden cabinet, panel, knobs, etc.

Complete kit, including licence fee £45.00 + VAT

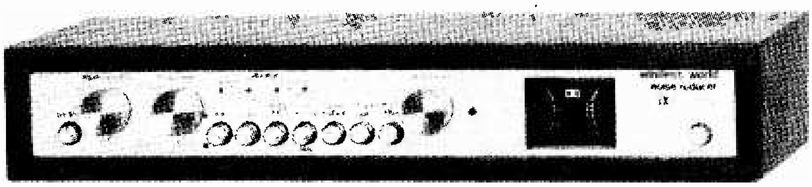
INTRUDER 1 RADAR ALARM

With Home Office Type approval.

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

Wireless World Dolby(TM) noise reducer

Trademark of Dolby Laboratories Inc.



Typical performance

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

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

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

Dynamic Range >90db

30mV sensitivity.

Featuring

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

Complete Kit **PRICE: £39.90**+VAT

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

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

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

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

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

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

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

Buy it with Access — EUROCARD — BARCLAYCARD — master charge

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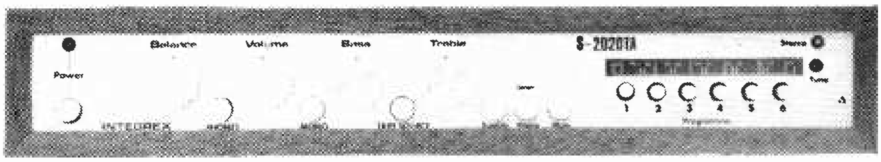
INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET



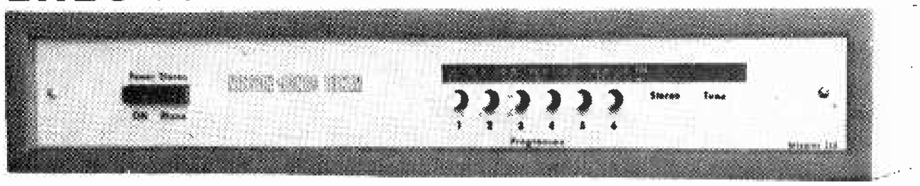
A high-quality push-button FM Varicap Stereo Tuner combined with a 24W r.m.s. per channel Stereo Amplifier.

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

PRICE: £58.95 + VAT

NELSON-JONES STEREO FM TUNER KIT

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

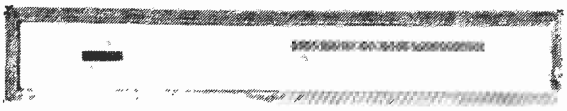


Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75μV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

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

STEREO MODULE TUNER KIT

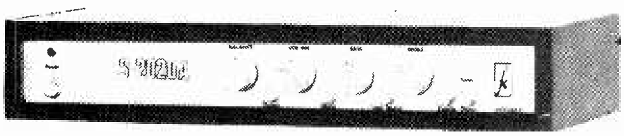


Sens. 30dB S/N mono @ 1.2μV
THD typically 0.3%
Tuning range 88—104MHz
LED sig. strength and stereo indicator

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

PRICE: Stereo £31.95 + VAT

S-2020A AMPLIFIER KIT



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

Power 'on/off' FET transient protection.

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

PRICE: £33.95 + VAT

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

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

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

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Over a century ago we provided the raw material for producing that distinctive Aussie sound. Today we're still giving the world the benefits of British sound technology by producing the ultimate in hi-fi loudspeaker quality.

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From the small compact bookshelf speaker up to the big Ditton 66, whatever you choose you get the ultimate in speaker experience with Celestion.

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Regd. office Dorset House, Stamford Street, London SE1 9LU

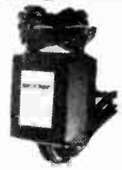
MICRO AMPLIFIER & MICROPHONE

Ex behind the ear hearing aids complete with volume control **£2.16**, and microphone.

VEEDER-ROOT COUNTER

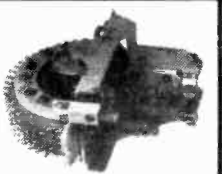
6 Digit 230-250v cycle operated, not resettable also needs perspex or similar panel over the wheels **£1.62**.

PP3/PP9 REPLACEMENT MAINS UNIT



Japanese made in plastic container with leads size 2" x 1½" x 1½" this is ideal to power a calculator or radio, it has a full wave rectified and smoothed output of 9 volts suitable for a loading of up to 100mA **£2.53**.

UNISELECTORS



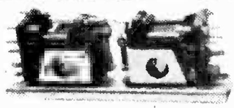
These are pulse operated switches as used in automatic telephone switchboards etc. A 24v pulse moves the switch through one switch way all we have are of the 25 switch full wiper type the following sizes are in stock

3 bank	**£4.80** + 37p	3 bank & Homer	**£5.40**
4 bank	**£5.94** +	5 bank	**£7.02**
8 bank	**£9.72** +	10 bank	**£10.80**
12 bank	**£12.96** +		

MOTORISED DISCO SWITCHES

With six 10 amp changeover switches. Multi adjustable 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

LATCHING RELAY



by Guardian Electric mains operated it is in fact two relays mounted on a metal base plate. The relays being mounted in such a way to ensure that when one closes the other opens and vice versa thus when closed relay A would remain locked until manually released or electrically released by energising relay B. Each relay has 2 sets of 10 amp changeover contacts. Should be ideal for burglar alarms and similar applications **£2.11**.

24 HOUR MOTOR

beautifully made by Sangamo. This is 200-240v mains driven motor with gear box together in one housing size approx 1¾" dia by 1¾" deep. It you are contemplating making a 24 hour switch with a lot of on offs then this is obviously the motor **Price £1.89**.

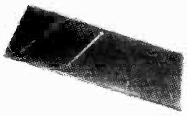
4 POLE MOTOR

Carefully balanced fitted with belt drive pulley for tape recorders, etc. Normal mains working speed 1,250 rmp **£2.12**.

HUMIDITY SWITCH

American made by Ranco their type No J11. The action of this device depends upon the dampness causing a membrane to stretch and trigger a sensitive microswitch adjustable by a screw. Quite sensitive — breathing on it for instance will switch it on. Micro 3 amp at 250v AC. Overall size of the device approx 3⅛" long 1" wide and 1⅛" deep **65p**.

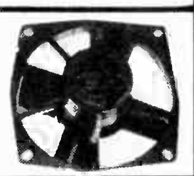
RECTANGULAR HOT PLATE



Aluminium panel with ridged top and angled underneath to strengthen it. This is approx 10" x 4½" of flat plate. Beneath please is 100w element and sensor switch which will maintain the surface of the plate just too hot to touch. With leads and tags. This is ideal if you are making up a food warmer or for an airing cupboard etc. **Price £1.03**.

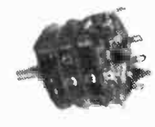
FOR NORMAL 230/240 50Hz MAINS

EXTRACTOR FAN



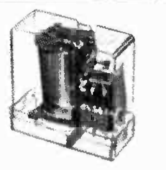
Ex computers — made by Woods of Colchester ideal for fixing through panel — reasonably quiet running — very powerful 2500 rpm. Choice of two sizes 5" or 6½" dia **£4.43**.

ROTARY WAFER SWITCH



—wiper contacts 3 way 8 poles 5 amp rating break before make — ¼" diameter 1" long spindle, slotted for knob screw, made by Plessey **Price £1.08**.

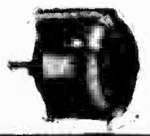
PERSPEX ENCLOSED 12 VOLT RELAY



with 10 amp changeover contacts size approx 2" x 1" x 2½" in case **£1.08**.

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 1350 revs., including starting capacitor

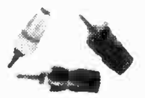


(1) Ref. No. KLZ 20 50-4 230 volts 50HZ **£6.30**.
(2) Ref. No. KLZ 32 50-4 230 volts 50HZ **£7.28**.
(3) Ref. same as above 115 volts 50HZ **£3.30**.
(4) Ref. same as above 110 volts 60HZ **£3.30**.

HONEYWELL P.B. MICROSWITCH

1-2 or 3 10 amp 250v change over microswitch thro panel mounting by cock nuts 1" dia black knob 1 switch **40p**, 2 switch **55p**, 3 switch **70p**.

INSULATED TERMINALS

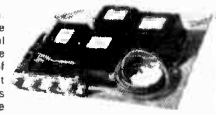


Well made with metal panel insulators — screw down to trap wire or insert 4mm plug into top — **15p** each, following colours available: red, blue, yellow & green.

EDGE MOUNTING MOVING COIL METER

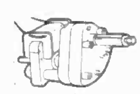
100VA fsd. Size 3" x 2". Sealed D.B. made for G.P.O. new and unused **£3.60**.

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 anyone, in easy-to-assemble modular form and complete with a pair of Goodmans speakers this should 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

SPIT MOTOR WITH CARTER GEAR BOX



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 barbeque or to drive a tumbler for stone polishing, in fact, there are no ends to its uses. Normal mains operation **£3.25** including POST & VAT

THIS MONTH'S SNIP

Breakdown Parcel — four unused, made for compution units containing most useful components, and these components, unlike those from most computons panel, have easily usable length. The transistors for instance have leads over 1" long — the diodes have approx ½" leads

TERMS

Cash with order. Prices includes VAT and carriage unless stated but orders under £6 must add 50p to off-set packing, etc. **01-688 1833**.

BULK ENQUIRIES WELCOMED

IT'S FREE!

Our monthly Advance Advertising Bargains List gives details of bargains arriving or just arrived — often bargains which sell out before our advertisement can appear — It's an interesting list and it's free—just send S.A.E. Below are a few of the Bargains still available from previous lists.

Nearly Sold out. Car Starter Charger kits — we have been able to get a few more of the rectifiers which made this kit possible at a very low-price but had to pay more for these and with the increased postal charges, price of this is now £7.95. It is still a bargain, however, and it is interesting to note the various uses to which our customers have put this kit. One wrote in to say that he started his old Bentley with it, apparently it was almost impossible to turn over by hand but started quite quickly with our car starter. Another customer writes to say that fitted on to his electric lawn mower, the battery of which had worn out, he now uses the car starter to drive the mower instead of the battery. We like to hear about the uses found for our various kits and welcome hints and suggestions from customers.

Automatic Telephone Exchange, this takes standard GPO instruments which can dial each other, up to 75 telephones can be interconnected. Believed to be in good working order in fact it was working until removed recently from a Bank by the builders doing alterations. The exchange which is floor standing is full of relays and uniselector switches and has a separate power units supply for the 50v AC bells and the DC for speech. Price of this exchange is £250, carriage at cost, telephones are not included in this price but are available prices £3 + 24p or new style £5 + 40p.

Tubes for Rigonda 6" TV's. Limited quantity of these are available, used but tested and guaranteed o.k. Price £7.50 + 94p. Post £1.50 + 18p.

Power Units for Rigonda 6" T.V. Again not new but tested and guaranteed price £3.50 + 44p. Post 40p + 4p.

Fan Motor, mains operated, this is totally enclosed and therefore suitable for extracting dusty or corrosive vapours, good maker, specifications as follows 1300 rpm, 240v s, 50hz, 7W. Spindle is threaded to take the fan blade, no doubt could be adapted £1.50 + 12p. Post 60p + 5p.

12v Battery Motor. Delco, as used for blower heaters, fans, etc. This is very powerful but quite compact, size 3" long x 2¾" dia. with central fixing flange and ¼" spindle, this is a series wound motor so it will also work off AC and can be made reversible by bringing out the internal brush connections to a d.p. changeover switch. Price £2.00 + 16p. Post 50p + 4p.

"C" Core Transformer, primary tapped 115v, 200v, 240v primary screen to separate tag and 4 secondaries (1) is 50-0-50v @ 9A (2) 17volts 7A (3) 17 volts 7A (4) 20 volts @ 1A. It will be seen that by interconnecting it could be made to give 50v-0-50v at 900mA, a useful transformer for high power amplifiers, etc. Ex-equipment but guaranteed perfect £3.75 + 28p. Post £1.00 + 8p. The makers price of this is over £10.

Professional Scotch Tape on 10½" spool (these having the normal ¼" spindle). We understand that this spool is standard for most popular professional reel to reel tape recorders. This is first-class tape normally priced at over £9 per reel. We have limited number, brand new and unused. Price £4.50 + 36p. Post 50p + 5p.

EX G.P.O. Telephones. We have recently had to replace our stocks of these and like everything else the prices are up so we take this opportunity of revising our prices. Three types are available — standard desk model, this is the one with internal bell and dial, price £3.00 + 16p, post 80p + 7p. Model 3 has no dial but internal bell price £2.00 + 16p. Post £1.20 + 9p.

Sundries available. 50v transformer for ringing GPO type bells, price £2.00 + 16p. Post 40p + 3p. Twin connecting wire for telephones 100 metre coil price £5.00 + 40p post 80p + 7p. Bakelite cased bells, so you can hear telephone when you are not in same room, price £2.50 + 20p. Post 50p + 4p.

Kymograph Brodie Starling, motor gear box type. This is a mains operated unit very solidly constructed in heavy cast iron case. It seems to be basicly a motor with a variable speed gear box. The output speeds are quoted in mm per minute, on 9" diameter cylinder but the drive which is fitted to the device is normal ½" spindle and the speeds are selected by a knob on the front dial through which the knob rotates, is calibrated as follows 2, 4, 8, 16, 32, 64, 128, 256, 512, 1024. We are not at all sure to what purpose these machines were normally put and would welcome any information about them from readers. We have only a few price £17.50 + £1.40. Post £1.60 + 14p.

Interrupted Beam Switch Kit. This has been recently re-arranged and is suitable for operation by a normal light beam or an infra red beam. The kit consists photo electric cell, 2 transistors, relay and all the necessary resistors and condensers together with mounting board and tag strip. This is both useful and educational, price £2.00 + 16p. Post 50p + 4p.

Mains Klaxton, main operated. These make a terrific noise and would frighten away any intruder or they could be used to scare birds or in works to signal starting, stopping times and tea breaks, etc. These are actually motorised and have a funnel shaped trumpet. Price £6.50 + 32p. Post 50p + 4p.

110 rev. per minute Motor. This is essentially an induction motor fitted with gear box and output drive spindle. Works off our normal 50hz mains and motor is 240v wound despite the fact that the unit was made in America. Useful for dozens of applications, stone polishing, etc. Price £3 + 24p. Post 50p + 4p.

Insulated Sheeting. Often referred to SRBP paxolin or bakelite, this is a very hard material similar to formica, it is made from resin impregnated paper highly compressed. We have this available in large sheets, from very thin to very thick and will cut to your specification. Sold by weight and cuts, price per kilo £2 + 16p, plus 50p per cut carriage at cost. Or we stock this in small pieces approx ⅛" thick in size as below

Size			Size	
6 x 2	18p + 2p		6 x 6	54p + 4p
12 x 2	30p + 2p		12 x 6	90p + 8p
6 x 2½	22p + 2p		6 x 8	66p + 5p
12 x 2½	42p + 4p		12 x 8	£1.20 + 10p
6 x 4½	36p + 2p		12 x 12	£1.60 + 12p
12 x 4½	72p + 6p			

Tufnol Sheeting. Similar to the above but instead of paper, fibre, cloth or linen is used. This means the finished sheet is extremely tough and unlikely to break even under abnormal strain conditions. Should also be used where a lot of holes have to be punched or drilled in a small space. Supplied to your size and thickness. Price per kilo £10 + 80p, cutting charge 50p per piece extra, carriage at cost.

24 Hour Time Switches with 3 on/offs. Continental made, these are a precision clock, having 3 on/offs, will no doubt find many uses especially with the ever increasing prices for fuel for heating, etc. Switch is rated at 13 amps. Additional on/off triggers can be fitted to this block to a max. of 5; we hope to have these triggers available very shortly. Price of clock with on/offs £7.50 + 45p. Post 60p + 5p.

Cables less than ½ price — all Volex CC — P.V.C. covered flat except singles made to B.S.S.

Size	Type	Price 100 metres	Carriage
1.5mm	Single	£2.50 + 20p	£1.00 + 8p
1.5mm	Twin	£4.50 + 36p	£1.50 + 12p
1.5mm	3 Core & Earth	£6.00 + 48p	£2.00 + 16p
4mm	Single double ins	£6.00 + 48p	£2.00 + 16p
4mm	Twin	£8.50 + 72p	£2.50 + 20p
4mm	Three core & Earth	£10.00 + 80p	£3.00 + 24p
6mm	Single	£8.00 + 64p	£2.50 + 20p
6mm	Twin and Earth	£20.00 + £1.60	£4.00 + 32p
16mm	Twin and Earth	£51.00 + £4.08	£6.00 + 48p

Electricised Bargain. Fused outlets suitable for clocks, fans, heaters, etc. while bakelite standard 13A fuse easily renewable, price 15p + 1.5p minimum quantity of ten. Post on ten 30p + 2p.

FM Tuner Unit with stereo decoder with pointer and pointer scale and drive. L.E.D. indicator shows optimum tune position uses 10 transistors and 12 diodes 6v d.c. or through resistor. Price £14.00 + £1.75.

FM Tuner Unit to suit Unilex and most other amplifiers, operates off 12volt or through series resistor, complete with dial, pointer and drive spindle, this is a very good performer, price £8.00 + £1.00.

AM/FM Tuner, this is again 12v unit but if used with the Unilex or similar amplifier then its power supply can be used with series resistor. Fitted with clear easy to read scale, pointer and spindle. Suitable for use with the decoder mentioned. Price £9.75 + £1.25.

Decoder, suitable to work with the above tuners, price £8.25 + £1.04.

300mA Battery Eliminator, plugs into 13 amp socket and has output which can be varied between the 6, 7.5 and 9 volts. Also detachable lead with 4 in 1 plug. Fitted with fuse and cut out meets B.S.S. covering this type of device. Price £3.70 + 46p.

Push Button Switches, each a 4 pole changeover switch mounted on a strip complete with grey oblong knob. These are suitable for most types of radios or instruments, the length of front panel required for the 4 switch is approx 2¾" plus a further 1" behind the panel for the mechanism. Two switch 90p + 11p. 3 switch £1.30 + 16p. 3 switch but 4 knob, 4th knob being off £1.50 + 15p. 4 switch £1.75 + 21p.

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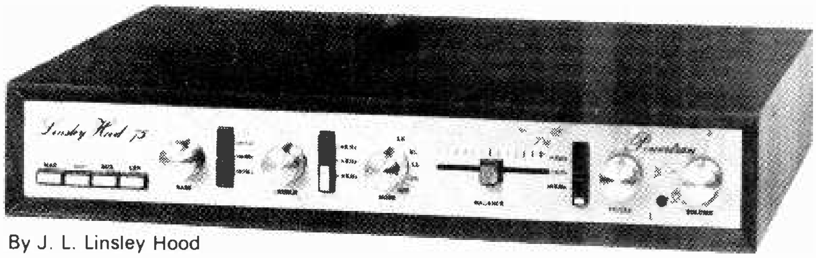
POWERTRAN ELECTRONICS

INCORPORATING AMBIENTACOUSTICS

HI-FI NEWS 75W/CHANNEL AMPLIFIER



By J. L. Linsley Hood

In Hi-Fi News there was published by Mr Linsley-Hood a series of four articles (November, 1972-February, 1973) and a subsequent follow-up article (April, 1974) on a design for an amplifier of exceptional performance which has as its principal feature an ability to supply from a direct coupled fully protected output stage, power in excess of 75 watts whilst maintaining distortion at less than 0 01% even at very low power levels The power amplifier is complemented by a pre-amplifier based on a discrete component operational amplifier referred to as the Liniac which is employed in the two most critical points of the system, namely the equalization stage and tone control stage, positions where most conventional designs run out of gain at the extremes of the frequency spectrum Unusual features of the design are the variable transition frequencies of the tone controls and the variable slope of the scratch filter. There is a choice of four inputs, two equalized and two linear, each having independently adjustable signal level The attractive slimline unit pictured has been made practical by highly compact PCBs and a specially designed Toroidal transformer

Pack	Price
1. Fibreglass printed-circuit board for power amp	£1.15
2. Set of resistors, capacitors, pre-sets for power amp	£2.5:
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	£1.9C
6. Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7. Set of low noise, high gain semiconductors for pre-amp	£2.40
8. Set of potentiometers (including mains switch)	£3.50
9. Set of 4 push-button switches, rotary mode switch	£5.40
10. Toroidal transformer complete with magnetic screen/housing primary: 0 117-234 V; secondaries: 33-0-33 V, 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	£5.40
13. Set of miscellaneous parts including DIN skts, mains input skt, fuse holder, inter-connecting cable, control knobs	£6.20
14. Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc	£8.20
15. Handbook (free with complete kit)	£0.30
16. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

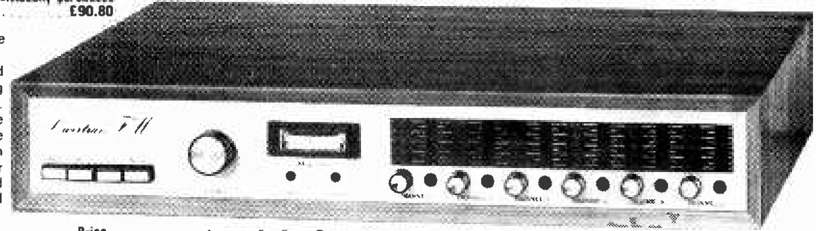
2 each of packs 1-7 inclusive are required for complete stereo system. Total cost of individually purchased packs £90.80

FREE TEAK CASE WITH FULL KITS

KIT PRICE ONLY **£79.80**

WIRELESS WORLD FM TUNER

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley Hood 75W Amplifier, this kit provides the perfect match The Wireless World (Skingley and Thompson — April, May 1974) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a.m. rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push button pre-selection Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator For long term stability metal oxide resistors are used throughout



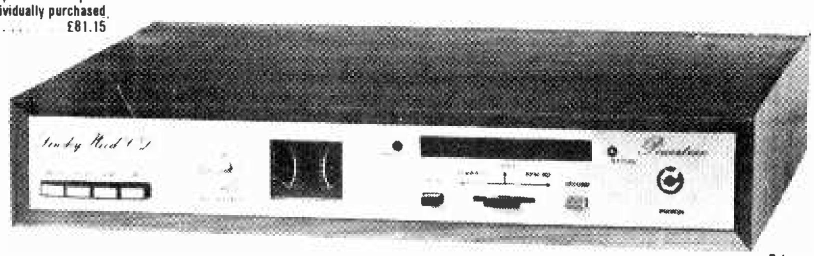
Pack	Price
1. Fibreglass printed board for front end IF strip, demodulator, AFC and mute circuits	£2.15
2. Set of metal oxide resistors, thermistor, capacitors, cermet preset for mounting on pack 1	£4.80
3. Set of transistors, diodes, LED, integrated circuits for mounting on pack 1	£5.25
4. Pre-aligned front end module, coil assembly, three section ceramic filter	£8.50
5. Fibreglass printed circuit board for stereo decoder	£1.10
6. Set of metal oxide resistors, capacitors, cermet preset for decoder	£2.60
7. Set of transistors LED, integrated circuit for decoder	£2.90
8. Set of components for channel selector switch module including fibreglass printed circuit board, push-button switches, knobs, LEDs, preset adjusters etc.	£9.40
9. Function switch, 10 turn tuning potentiometer, knobs	£5.80
10. Frequency meter, meter drive components, fibreglass printed circuit board	£10.35
11. Toroidal transformer with electrostatic screen. Primary: 0-117V 234V	£4.90
12. Set of capacitors, rectifiers, voltage regulator for power supply	£2.10
13. Set of miscellaneous parts, including sockets, fuse holder, fuses, inter-connecting wire, etc.	£2.05
14. Set of metal work parts including silk screen printed facia panel, acrylic silk screen printed tuning indicator panel insert, internal screen, fixing parts, etc.	£8.30
15. Construction notes (free with complete kit)	£0.25
16. Teak cabinet 10.3" x 12.7" x 3.1"	£10.70

One each of packs 1-16 inclusive are required for complete stereo FM tuner. Total cost of individually purchased packs £81.15

FREE TEAK CASE WITH FULL KITS

KIT PRICE only **£70.20**

LINSLEY-HOOD CASSETTE DECK



Published in Wireless World (May, June, August 1976) by Mr Linsley-Hood, this design, although straightforward and relatively low cost nevertheless provides a very high standard of performance To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Push button switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier

Pack	Price
1. Stereo PCB (accommodates 2 rep. amps, 2 rec. amps, 2 meter amps, bias/erase osc, relay)	£3.35
2. Stereo set of capitors, M.O. resistors, potentiometers for above	£9.80
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB, all components for solenoid, speed control circuits	£3.80
6. Goldring Lenco mechanism as specified.	£21.95
7. Function switch, knobs	£1.90
8. Dual VU meter with illuminating lamp	£8.70
9. Toroidal transformer with E.S. screen prim. 0-117V, 234V, Sec. 15V	£4.90
10. Set of capacitors, rectifiers, I.C. voltage regulator for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts, including sockets, fuse holder, fuses, interconnecting wire, etc.	£3.40
12. Set of metalwork including silk screened facia panel, internal screen, fixing parts, etc.	£7.10
13. Construction notes	£0.25
14. Teak cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for compete stereo cassette deck. Total cost of individually purchased packs £90.05

SPECIAL PRICE FOR COMPLETE KITS £85.90

PRICE STABILITY

Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until October 31st, 1977, provided that this month's advertisement is quoted with your order E&OE VAT rate changes excluded

All components are brand new first grade full specification devices. All resistors (except where stated) are low noise carbon film types. All printed circuit boards are fibre-glass, drilled, roller tinned and supplied with circuit diagrams and construction layouts.

Value Added Tax not included in prices.

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TTL BULK USERS

Please note we have purchased a distributor s entire stock and can offer the following items in substantial quantities at half current 1000 up prices

7416N	7441AN	7470	7495J	74151N
7417N	7443J	7476N	7495N	74153N
7420N	7445N	7480N	7410N	74155N
7423N	7445J	7482N	74105N	74155J
7423J	7446AN	7483	74107J	74156N
7430J	7446N	7485N	74107N	74180N
7437J	7448N	7485J	74126J	74180J
7437N	7453N	7491AN	74145J	74181N
7440N	7454N	7494J	74150N	74182N
7441AJ	7460N	7494N	74151J	74182J
				9601N

Also: 7401. 7403. 7410. 7430. 7451. 7474.

PHONE FOR QUOTATION

NIXIE TUBES

ITT GN4 Red-Standard numerals 0-9 Complete with ceramic base for PCB mounting 1 08" dia × 1 38" high plus ½" base depth inc pins Operating voltage 170v DC min Complete data and connections supplied Brand new **£1.50.** p & p 20p 10 off £1 00 each 100 or more 85p each p & p 40p any quantity
ITT 5870F Special Offer **95p.** p &p 20p

ROTARY STUD SWITCH

PLESSEY. 30 way, 2 bank Single pole Contacts 1 amp 240v AC/DC 005Ω res Make before break Stop infinitely adjustable allowing for any desired arc of travel Ideal for instrument and model switching Size 2⅛" dia overall × 2⅛" deep plus 1⅝" × ¼" dia spindle **£2.25.** p & p 20p **5 off £1.95 each.** p & p 40p

UNI-SELECTOR

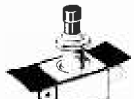
240v AC or DC operation Split 30-way double bank contacts Overall size approx 2¾" dia × 2½" deep Brand new Bargain at **£4.50.** p & p 65p

TRANSFORMERS

DAVENSET AUTO
2KVA continuously rated Tapped for any voltage from 5 260v in steps of 5v With an isolated winding of 0-5-10v at 8½ amps this transformer is an extremely useful buy Push-on connections Size 8" × 5¼" × 6½" A really robust job Bargain at **£23.50.** Carr £3 00
750VA continuously rated Tapped as above with 0-5-10V isolated winding of 5 amps (Same connections Size 4½" × 3¾" × 4¾" Also bargain at **£12.50.** Carr £2 00
GOODYEAR 1KVa auto transformer 0-110-115-120-200-220 240v Fully shrouded Terminal block connections Size 5" × 4¼" × 5½" plus block Cannot be bettered at **£13.95.** p & p £1 50

ISOLATING TYPES

Pri 10-0-200-220-240v Sec 3-9 27v at 9 amps 17-0-17 at 250 m a 0-17 at 250 m a **£7.95.** p & p £1 00
TORROIDAL
Pri 15-0-210-240v Sec 140v at 35 m/a 31v at 500 m/a c t 10v at 1 9 amps Scr Size 3½" dia × 1½" **£3.95** p & p 30p
MINIATURE
Pri 240V Sec 6v at ½ amp Size 1¾" × 1½" × 1¼" Ideal as power supply base for models radios, cassettes etc **£1.50** ea p & p 20p 6 off £1 00 ea p & p 45p

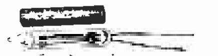


Press on/off Single hole fixing SP/ST Size 1⅛" × ⅞" Stud extends ½" Rated 1 amp at 240v 2½ amps at 125v Price for 5 (min qty) **£1.75** p & p 30p 10 or more 30p each p & p 40p

REED SWITCHES

Glass encaps N/o contacts Glass length 1⅛" dia ⅛" overall length 1⅞" 10 off £1 00 p & p 25p **100 off £8.00,** p & p free **1000 off £68.00,** p & p free

SYLVANIA SWITCH

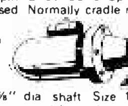


Complete with magnet Contacts N/C 3 amp Vacuum sealed 1¼" × ¼" dia

10 for £2.50
50 for £11.00
100 for £18.00
Plus 50p p & p any quantity

MOTORS

RANCO 1/6 H.P. 1425 rpm 240v 50Hz Split phase ½" × 3" long shaft Unused Normally cradle mounted but offered without



1/8 H.P. reversible geared motor 220/240v 50 Hz 1 Ph cap start cont rating Gearing 5 1 Final drive approx 280 rpm ⅜" dia shaft Size 14" inc gearbox × 5½" dia plus cap and base New Robust **£23.95,** carr £3 00
ACADEX shaded pole motor Open frame 230v 50 Hz Double ended 5/32" dia spindle each 1¼" long Ideal for fans models etc Size 1¾" × 2⅜" × 1⅜" deep plus spindles **£1.50** p & p 45p
CROUZET shaded pole motor Open frame 115/230v 50 Hz 1425 rpm Size 2½" × 2¾" × 1⅛" deep plus ¼" long × 5/32" dia spindle **£3.50** p & p 62p
PAPST MOTORS. Noted for advanced design and superb construction Rotating diecast outer body acts as flywheel and eliminates wow and flutter 50 Hz capacitor start

MODEL HSKZ 32 80 6/12 220v Dual speed tape deck motor 500/1000 rpm 12 mm drive shaft gives tape speeds of 9 53/19 05 cm/sec (3¾/7½ ins/sec) respectively Size approx 5½" dia × 3½" plus 1⅜" spindle. **£16.50.** p & p £1 10
MODEL RO 32 65-4 Dual voltage 125/250v Size 2⅞" × 3⅛" Spindle 5/16" dia **£12.50.** p & p £1 10
MODEL HSZ 20 25 2 Basically 42v but can be operated from mains with additional capacitor A magnificent small motor Size 1⅞" × 2⅜" Spindle 5/16" dia **£5.95.** p & p 45p

SOLENOIDS 240V A.C.

MAGNETIC DEVICES LTD (No 1) has 20lb pull for 50% duty 1½" travel push or pull Shackle both ends Size 1¾" wide × 3⅛" high × 4" long plus 3" arm travel **£6.75** plus p & p £1 00

(No 2) has 2lb pull continuously rated ¼" travel Size 1½" × 1½" h × 2¼" plus travel **£1.80,** 30p p & p
PYE ETHER LTD Thrust operates through spring loaded hinged lever giving a 1lb pull or push Complete with mounting bracket and push on connections Size overall inc bracket 2½"w × 3"h × 3½" long **£2.25** p & p 45p

RELAYS

Octal base 2 C O 6 amp contacts Following voltages 6v 12v 230v A C 12v 24v 48v 110v D C all **£1.25** each plus base **15p** postage and packing 15p 11-pin 3 C/O 6 amp contacts 48v 115v A C 24v 48v 110v D C all at **£1.50** each base **15p** plus 15p p & p

PRESSURE SWITCH

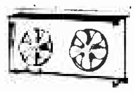
BY TEDDINGTON CONTROLS Adjustable 1 to 2 lbs/sq in SPDT Rated 15 amps 250v A C **£1.95,** p & p 25p

SODECO PRINTING IMPULSE COUNTER.

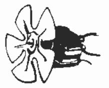
Model PN 217 24v D C BRAND NEW 1st channel 6 digit decimal counter 2nd channel date and time register Supplied in original maker s packing complete with instruction manual **£87.50,** p & p £1 00

FANS

DUAL EXTRACTOR FAN.

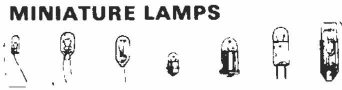


240v 50 Hz Two thick stack shaded pole motors make this a highly efficient unit producing a powerful airflow Mounted in heavy steel frame each has five element 6½" blades Size 22½" × 14" × 5½" deep **£8.95,** carr £2 75



SINGLE FAN with motor similar to above Very useful in home and workshop Remember last summer Keep cool this year **Only £3.95.** p & p 65p

MINIATURE LAMPS



A B C D E F G

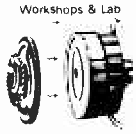
Type	Size (Dia)	Volt/Curr	Type	Size (Dia)	Volt/Curr
A	3MM	5 6V 60 MA	0	3MM	2-5V 360 MA
B	4MM	4V 250 MA			5-6 60 MA
		5V 60 MA	E	4MM	6V 200 MA
		12V 40 MA			6 3 200 MA
		12V 100 MA			14V 40 MA
		14V 75 MA	F	4MM	2 7V 60 MA
		28V 40 MA			12V 160 MA
C	5MM	28V 40 MA			14V 80 MA
G					

Small telephone jack type 6 or 24V
Price Types A-F £4 00 for 25 50 and upwards **13p** each Type G **45p** each p & p 20p per order

BENDIX MAGNETIC CLUTCH

Superb example of electro-mechanics Main body in two sections coil section fixed with ⅛" sleeve drive section rotating on outer perimeter Uniting plate has ⅜" ID bearing concentric with main section and 18-tooth cog wheel Extremely powerful transmission 24V D C 240 m/a **£3.75** plus p & p 40p

Dozens of uses in Home. Farm. Workshops & Lab



PCB EDGE CONNECTOR

CINCH 15" pitch 27 way but designed with adjustable fixing endplates enabling connector to be cut and used in any length desired **15p,** p & p 15p **10 off £4.00,** p & p 30p

MEM LIMIT SWITCH

Snap action 5 amps at 240 410 A C size base 3⅜" × 1⅞" × 1⅞" plus heavy duty roller plunger 1½" ext or 1" when compressed Very robust for tireless operation weatherproof Price **£2.20** plus p & p 40p

JABSCO (ITT) ROTARY PUMP

Self-priming Works from electric drill or suitably powered motor for ¼" drive shaft ½" hose connections Throughput 2 3 galls per min at 2400 rpm Dozens of uses in home and workshop Giveaway at **£2.75,** p & p 20p

---

RADIO AND TV SPARES ALL COMPONENTS BRAND NEW. CASH WITH ORDER ONLY. P & P 35np. ALL PRICES INCLUDE VAT. AT 12½% CARRIAGE ON TUBES £1.25 EXTRA

MAIL ORDER ONLY. NO CALLERS.

PHD COMPONENTS DEPT 3, UNIT 7, CENTENARY ESTATE, JEFFERIES ROAD, ENFIELD, MIDDX. 01-805 4060. TELEX 261295.

MULTISECTION CAPACITORS

Description	
400-400/350	3 00
200-200-150-50/300	2 50
1000-2000/35	80p
600/300	1.90
600/250	1.55
200-300/350	2.05
1000-1000/40	1.00
2500-2500/30	1.30
300-300/300	2 25
200-200-75-25/350	2 40
100-300-100-16/275	1.60
150-100-100-100-150/320	2.60
150-150-100/350	1.50
175-100-100	2 35
220/100	32p
2500-2500/63	1.70
700/200	1 30
400/350	1.55

DROPPER SECTIONS 16p each

MAINS DROPPERS

Pye 11062	75p
Pye 11009	1.20
BRC Mono 1400	80p
BRC Mono 1500	75p
BRC Colour 3000/3500	75p
BRC Colour 8000	75p
BRC Colour 8500	75p
Phillips G8	50p
Phillips 210 (with link)	55p
Phillips 210	65p
RRI Mono 141	75p
RRI Mono 161	80p
GEC 27840	75p
GEC 2000	75p
Phillips G9	35p

DIODES

		OA81	11p	BA102	24p	BAX13	5p
AA113	14p	OA85	11p	BA130	35p	BAX16	6p
AA116	14p	OA90	6p	BA145	16p	BAY38	10p
AA117	14p	OA91	6p	BA148	16p	IN4148	4p
AA119	8p	OA95	6p	BA154	12p	BY206	30p
OA47	6p	OA202	11p	BA155	15p		
OA79	6p	BA100	14p	BA164	17p		

RECTIFIERS

BY100	21p	IN4001	4p
BY126	15p	IN4002	5p
BY127	15p	IN4003	6p
BY133	22p	IN4004	7p
BY182	2 00	IN4005	8p
BY238	40p	IN4006	9p
BYX10	14p	IN4007	10p

TUNER

ELC1043/05 5.50 each

CRYSTAL

4 43 MHz 1.90 each

THYRISTORS

2N4443	1 20
TV106	1 80
BR101	45p
BRY39	45p
BR100	35p

Bridge Rectifiers

BY164	50p
BY179	65p

High Voltage

TV20 1 90 each

INTEGRATED CIRCUITS

MC1307P	1.50	SL901B	5.00
MC1310P	2.50	SL917B	7 00
TAA350	1 90	SN76003ND	1.70
TAA550	50p	SN76013N	1.80
TAA630S	4 00	SN76013N07	1 80
TBA120S	1 50	SN76013ND	1 60
TBA120SQ	1.50	SN76023N	1 85
TBA520Q	3 00	SN76023ND	1.60
TBA530Q	2 50	SN76033N	2 75
TBA540Q	3.00	SN76665N	2.50
TBA550Q	4.00	CA3065	2.50
TBA560CQ	4 00	MC1358P	2 50
TBA750Q	2.20	MC1327P	2.00
TBA800	1.60	MC1327PQ	2 50
TBA920Q	4.00	MC1330P	1 50
TBA990Q	4 00	MC1351P	1 20
SN76003N	2.75	MC1352P	1.60

TRANSISTORS

		AF121	30p	BC142	29p	BC237	15p	BF118	25p	BF274	15p		
AC107	33p	AF124	23p	BC143	34p	BC238	11p	BF121	24p	BF336	34p		
AC126	23p	AF125	23p	BC147	12p	BC251A	16p	BF152	30p	BF337	34p		
AC127	30p	AF125	23p	BC148	11p	BC301	32p	BF154	30p	BF338	34p		
AC12701	50p	AF127	23p	BC149	13p	BC303	59p	BF157	30p	BF458	59p		
AC128	23p	AF139	34p	BC153	19p	BC307	11p	BF158	24p	BFX29	29p		
AC12801	50p	AF178	53p	BC154	19p	BC308	9p	BF163	24p	BFX84	24p		
AC141	24p	AF179	55p	BC157	14p	BC327	12p	BF167	24p	BFX85	25p		
AC141K	40p	AF180	53p	BC158	12p	BC328	12p	BF173	24p	BFX88	23p		
AC142	24p	AF181	49p	BC159	14p	BC337	15p	BF177	29p	BFX89	30p		
AC142K	25p	AF186	39p	BC171	14p	BC547	12p	BF178	32p	BFY50	22p		
AC153	23p	AF239	39p	BC172	13p	BD115	64p	BF179	32p	BFY51	22p		
AC176	24p	AL102	1.05	BC178	21p	BD116	60p	BF180	34p	BFY52	22p		
AC17601	50p	AU107	1.05	BC179	19p	BD124	79p	BF181	32p	BU105/01	1.90		
AC187	23p	AU110	1.85	BC182L	10p	BD131	44p	BF182	43p	BU105/02	1.90		
AC187K	24p	AU113	2.20	BC182LB	10p	BD132	49p	BF183	43p	BU105/04	2.50		
AC188	24p	BC107	10p	BC183L	10p	BD133	49p	BF184	25p	BU108	3.00		
AC188K	40p	BC108	10p	BC183LB	10p	BD134	49p	BF185	25p	BU126	2 90		
AC193K	29p	BC109	10p	BC184L	10p	BD135	39p	BF194	14p	BU204	1.90		
AC194K	31p	BC113	12p	BC186	24p	BD136	45p	BF195	14p	BU205	1.90		
AD140	45p	BC114	19p	BC187	26p	BD137	47p	BF196	14p	BU206	1.90		
AD142	50p	BC115	19p	BC203	15p	BD138	49p	BF197	14p	BU208	3 00		
AD143	50p	BC116	19p	BC204	15p	BD139	80p	BF198	19p	MJE340	65p		
AD145	50p	BC117	19p	BC205	15p	BD144	2 10	BF199	24p	MJE520	80p		
AD149	1.00	BC118	28p	BC206	15p	BD155	74p	BF200	34p	AF126	1.10		
AD161	45p	BC119	28p	BC207	15p	BD157	74p	BF240	19p	MJE3055	73p		
AD162	45p	BC125	21p	BC208	11p	BD183	55p	BF241	21p	MPSU05	65p		
AF114	50p	BC126	19p	BC209	15p	BD235	74p	BF256LC	44p	MPSU55	1.25		
AF115	23p	BC136	19p	BC212L	11p	BD237	74p	BF257	48p	R2008B	3.00		
AF116	23p	BC137	19p	BC213L	11p	BD238	74p	BF258	65p	R2009	3.00		
AF117	19p	BC138	19p	BC214L	11p	BDX32	2.50	BF271	15p	R2010B	3.00		
AF118	48p	BC139	19p	BC225	15p	BF115	19p	BF273	15p	TIP31A	60p		
										TIP32A	60p		

REPLACEMENT COMPONENTS

Aerial Isolators	1 00 each
Lopt Korting	10.00 each
BRC 3500 Cutouts	1.60 each

VALVES

		PCL82	75p
DY86/87	50p	PCL84	1 00
DY802	50p	PCL85	90p
ECC82	50p	PCL86	90p
EF80	45p	PFL200	85p
EF183	46p	PL36	90p
EF184	46p	PL84	70p
EH90	90p	PL504	1 20
PCC89	1 20	PL508	2 00
PCC189	1 60	PL509	3.00
PCF80	75p	PL519	3.00
PCF86	1 50	PY500A	1 90
PCF801	60p	PY800	65p
PCF802	1 50	PL802	4.00

EHT TRIPLERS (Priced each)

BRC950	2.65	Pye CT205	5.50
BRC1400	2.65	Pye 731	8.25
BRC1500 (17")	2 65	Decca 2030	6 60
BRC1500 (24")	3.00	GEC 2028	7 10
BRC3500	6 60	GEC 2110	7 10
BRC8000	2 90	ITT CVC5	6.60
BRC8500	5 50	RRI 111/174	10.00
BRC9000	7 75	RRI A823	7 70
Decca CS190	7.10	Korting 90°	7 10
Phillips G8	7 30	Tanberg	7 10

MARCONI VALVE VOLTMETER
TF428B **£15** ea

EX-MINISTRY GENERATOR 0-20KHZ
Sinewave output. Metered. 600 Ohms. 240V Input. Size 16x10x9" deep. **£22.50** each

EX-MINISTRY MARCONI 0-6WATTS
Multi Range, Multi Impedance POWER METERS. **£30** each.

EDWARDS HIGH VACUUM PUMPS
Type 1SC30 @ **£55** each
Type ES35 @ **£40** each
Carriage £2.75

MARCONI TF675F WIDE RANGE PULSE GENERATOR
+/— variable outputs up to 50V. Optional delay. Small compact unit. **£18** ea.

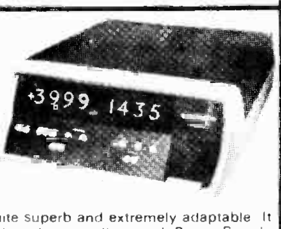
ROYAL INVERTORS manufactured USA. 28V DC Input. Output 115V AC 400HZ up to 24KVA. Brand new. Crated **£12.50** ea.

MARCONI NOISE GENERATOR TF987/1
4 Ranges 0-5; 0-10; 0-15; 0-30. Due to large purchases now priced at **£15** ea.

TRIPODS WITH PAN AND TILT HEAD
Will take 75lb. load
£32.50 each

TEKTRONIX OSCILLOSCOPE type 502. High gain. Limited bandwidth **£250** each.
EX-MINISTRY X BAND SPECTRUM ANALYSER CT152 (Marconi TF1035) 8.5GHZ to 9.7 GHZ. Power input 115/250V 45-650HZ. Pan-climatic. **£120** each.
J.A.C. ELECTRONICS FREQUENCY METER type 331. HZ to 3 GHZ. In and Out. Prices from **£75 to £200** each.
MARCONI SIGNAL GENERATORS. Freq. range 10-470MHZ. Type TF801B/3/S. **£150** each. TF801D/1/S **£260** each.
MARCONI FM/AM SIGNAL GENERATOR TF2002. One only **£1250.**
FM/AM SIGNAL GENERATOR type AN/USM16. 10 to 420MHZ. Limited quantity **£300** ea.
MUIRHEAD DECADE OSCILLATOR D890A. **£75** each.
MUIRHEAD FREQUENCY ANALYSER D699A. **£50.**
SCHOMANDL FREQUENCY METER FD1 with FDM1. **£75** each.
HEWLETT PACKARD Oscilloscope type 175A DC-50MHZ Double Beam **£200**, with delay amplifier **£230.**
BRUEL & KJOER Automatic Vibration Exciter type 1016. 5HZ to 10KHZ. **£125** each.
AIRMEC WAVE ANALYSER type 248. **£40** each.
FLANN SIGNAL SOURCE 1.2 to 5 GHZ type PCL/PA. **£75.**
RHODE & SCHWARZ ADMITTANCE METER BN3511. As new **£65.**
POLARAD RECEIVER Model FIM-B2. Complete 1-10GHZ **£375.**
MARCONI OSCILLATOR TF1101. 20HZ-20KHZ. Nice condition. Special price **£50.**
MARCONI Wide Range Oscillator TF1370. Freq. range 10HZ to 10MHZ. Sine Wave 10HZ to 100KHZ. Square Wave. High outputs up to 31.6V. Fantastic value at **£90** ea.
MARCONI ADAPTOR TM6113 for TF2700. TF1313. TF8668B **£20** ea.
AIRMEC 4 trace scope. Type 279. Large screen **£95.**
MARCONI TF142F DISTORTION FACTOR METER giving percentage distortion on a directly calibrated dial and includes any spurious components up to 30KHZ **£29.50** ea.
MARCONI PORTABLE FREQUENCY METER TF1026/11. 100 to 160MHZ. Very fine condition **£25.**
DECCA NAVIGATOR DISPLAY UNIT. Very impressive **£12.50** ea.
COURTENAY MAJOR Mk. 2. 250 joules. 5 outputs. Can be combined — 1250 joules. No heads. **£30.**
AIRMEC MODULATION METER 210 £75.
HILGER & WATTS SPECTROMETER H1170 **£200.**
RHODES & SCHWARZ Tunable Indicating Amplifier UBM **£75**
TEKTRONIX 180A Time Making Generator **£55**
S.E. Labs Oscilloscope Type 102 **£220**
RHODES & SCHWARZ POWER METER. BNRD-BN 2412/50 **£50**
MARCONI RF POWER METER. TF1020A/1 75 ohm **£65**
I.C. TESTER by **SCHLUMBERGER.** Model TCL232 — tests 741, 709, etc. Dual in lines, flat packs or TOs **£50**
SPECTRUM ANALYSER by **NELSON ROSS.** Plug-in for TEKTRONIX Oscilloscopes 561/506, etc. Freq. 0-500KHZ Model 023 **£200**
SOLARTRON CD1212 SB 40 meg **£85.** DB 24 meg twice **£120.** Many other types available
Ex-Ministry OSCILLOSCOPE. CT436 Double beam DC 6MHZ **£95** ea.

DATA LOGGER by DYNAMCO



These are BRAND NEW — not finished — DATA LOGGERS BY **DYNAMCO.** They are completed but for the plug-in boards. The case with hinged lid is quite superb and extremely adaptable. It contains as well as the mother board an equally superb Power Supply with the following voltages +28V. +15V. +5V (2.5A) — this supply is crowbar protected. −5V. −14V. −20V. −24V. −48V and other supplies including auto 110V. This unit supplied in its original cardboard box complete with original manual and must be of serious interest to the professional constructor and anyone considering the construction of a micro processor system. Unit size 7½" high x 19" wide x 23" deep.
Price **£45** each. Carriage £2.50

PICK-A-PACK — 50 PENCE A POUND

From Our "Pick-A-Pack" area weigh up your own components. No restrictions on what you take

EX-DYNAMCO Oscilloscopes INVERTORS 30V Input 6KV Output. Size 2" x 4½" x 1½". Complete with circuit £10 each. P&P £1

MINIATURE — OXLEY PATCH PANELS — BRAND NEW **EX-DYNAMCO.** 10 x 10 complete with pins **£8** each. P&P 50p

★TELEPHONES. Post Office style 746. Black or two-tone **£6.50** ea. Modern style 706. Black or two tone grey **£4.50** ea. P&P 75p each. Old black style **£1.50** ea. P&P £1
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PL802† 1.80*
PY33 0.68*
PY81† 0.72*
PY82 0.45*
PY83 0.60*
PY88† 0.68*
PY500A† 1.36*
PY800/81† 0.72*
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QQV03-10† 1.60
QQV03-20A† 8.50*
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QQZ03-20A 27.50
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QV03-12 3.00
QV04-7 2.50
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7H7 1.00*
7R7 1.50*
7S7 2.25*
7Y4 0.75*

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12AT7† 0.45*
12AU6 0.50*
12AU7† 0.45*
12AV6 0.60*
12AV7 2.84*
12AX7† 0.45*
12AY7† 0.82*
12B4A† 1.00*
12BA6 0.50*
12BE6 0.60*
12BH7† 0.60*
12BY7† 0.80*
12E1 4.00
12E14 19.80
13E1 43.55
19H4 16.88
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30C15 1.20*
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30F5 1.00*
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30FL14 1.28*
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30L15 1.32*
30L17 1.32*
30P4 0.92*
30P19 0.92*
30PL1 1.32*
30PL13 1.44*
30PL14 1.68*
30PL15 1.44*
35W4 0.60*
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75B1 3.15
75C1 1.55
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85A2 1.50
90AG 7.26
90AV 7.16
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90CG 5.74
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805 20.00
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931A 12.24

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5814A 2.60*
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5842 6.90
5876A 9.38
5879 3.16*
5886 10.50
5963 1.87*
5965 2.20*
6005 3.65*
6021 4.46
6057 5.95
6058 4.56
6059 4.00
6061 4.25
6062 3.75
6063 3.65
6064 5.60
6067 6.08
6072 3.77
6080† 3.40*
6097A + B + C 40.00
6146A 4.27
6146B 4.65
6159 6.00
6189 6.08
6201 4.71
6442 15.00
6883B 4.93
6973 2.61
7025† 1.20
7551 3.65
7586 6.79
7587 12.54
7609 28.75
7868 2.93*
7895 7.48
8005 25.00*
8068 5.50
8122 33.15
8136 1.54
8417 3.40
18042 5.17
18045 5.57

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

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2AP1* 8.50
2BP1* 9.00
3BP1 6.00
3DP1* 5.00
3EG1* 7.00
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3JP7* 10.00
3KP1* 15.00
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VCR139A* 8.00
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* = Surplus
VAT 8%

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7400 0.20
7401 0.20
7402 0.20
7403 0.20
7404 0.26
7405 0.23
7406 0.55
7407 0.55
7408 0.28
7409 0.28
7410 0.20
7412 0.26
7413 0.45
7416 0.40
7417 0.40
7420 0.20

7422 0.25
7423 0.35
7425 0.35
7427 0.35
7428 0.50
7430 0.20
7432 0.36
7433 0.37
7437 0.42
7438 0.37
7440 0.22
7441AN 0.92
7442 0.78
7447AN 1.20
7450 0.20
7451 0.20

7453 0.20
7454 0.20
7460 0.20
7470 0.35
7472 0.36
7473 0.36
7474 0.40
7475 0.59
7476 0.42
7480 0.60
7482 0.85
7483 1.00
7484 1.00
7486 0.40
7490 0.52
7491AN 0.85

7492 0.60
7493 0.70
7494 0.80
7495 0.80
7496 0.90
7497 3.67
74100 1.75
74107 0.45
74109 0.86
74110 0.57
74111 0.86
74116 1.89
74118 0.95
74119 2.00
74120 1.10
74121 0.45
74122 0.60
74123 1.00

74125 0.80
74126 0.80
74128 0.80
74132 0.80
74136 0.68
74141 0.85
74142 3.00
74143 3.00
74144 3.00
74145 1.00
74147 2.45
74148 2.00
74150 1.75
74151 0.90
74154 2.00
74155 0.90
74156 0.90
74157 0.90

74159 2.50
74170 2.60
74172 5.00
74173 1.75
74174 1.57
74175 1.00
74176 1.10
74178 1.65
74179 1.65
74180 1.65
74190 1.48
74191 1.48
74192 1.25
74193 1.25
74194 1.25
74195 1.10
74196 1.20
74197 1.00

74198 2.25
74199 2.25
76013N 1.75*
TAA570 2.30*
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TBA480Q 1.84*
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TBA560CQ 3.22*
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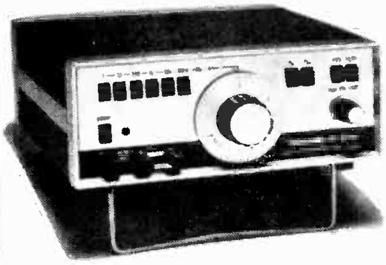

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£115 Also independently 10V from 600Ω fixed level. Variable d.c. off-set.

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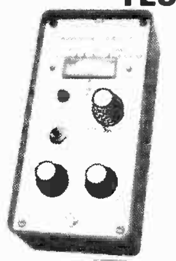

This compact unit facilitates the rapid checking of junction transistors (NPN or PNP), indicating a fault in either junction, excess leakage current PLUS a spot-check of d.c. current-gain.

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Pri 230v sec tapped 40-41-42-48-49-50v very conservatively rated at 10 amps and 60v 100M/A. Size 9x7x6ins **£17.50,** carr £3

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Ex-equipment, perfect condition. Metal shrouded table top connections. Pri 200-250v in 5v steps. Sec 240v 10 amps **£35,** carr £4. Pri 200-250v in 10v steps Sec tapped 90-100-110-120v 7.5 amps **£19.50,** carr £3. Pri 200-240v in 10v steps Sec tapped 90-100-110-120v 4.5 amps **£12.50,** carr £2. Partridge Pri 110-115-200-220-240-250 Sec 240v 13 amps open type terminal connections **£40,** carr £4

GARDNERS ISOLATION TRANSFORMERS
New, fraction of maker's price. Open type top connections. Pri. 220-240v Sec. 240v 6amps **£22.50,** carr. £3. Open type cable lead connections. Pri. 200-220-240v. Sec. 240v 700 watts **£10,** carr. £2. Pri 110-200-220-240v sec 240v 3 amps built in metal case **£15,** carr £2.

WODEN 3000 WATT AUTO TRANSFORMERS
Ex equipment, perfect condition. Tapped 105 - 115 - 125 - 135 - 200 - 215 - 230 - 245 - 260v Open type terminal block connections **£22.50,** carr. £2 Can be supplied in metal case with two American 2/3 pin flush mounting sockets. 3 core 240v mains lead. Carrying handle **£37.50,** carr. £3

AUTO TRANSFORMERS FOR AMERICAN EQUIPMENT
240/110v 80-3000 Watts, fitted with 2-3 pin sockets and 3 core mains lead. Send sae for price list. We have England's largest selection of American electrical accessories. 2-3 pin plugs recessed and surface type, 2-3 sockets, multi-way adaptors, 2-3 pin grounding adaptors. Cable type sockets. Extension cords 240v. Edison screw type light bulbs. Industrial plugs and sockets. Let us know your requirements.

HEAVY DUTY L.T. TRANSFORMERS BY FAMOUS MAKERS
Pri 110-240v sec tapped 15-20-25-30v 30 amps **£18.50,** carr £3. C core type 12 inch flying leads Pri 415v SP sec 27v 1500 watts. Connected to 240v. 15v 55 amps can be obtained. Open frame type terminal connections **£35,** carr £5. Pri 240v sec 12v 30 amps twice will give 12v 60 amps or 24v 30 amps **£23,** carr £2. Enclosed type terminal connections. Pri 240v sec taped 6-12v 12v 20 amps **£10.95,** carr £2. 20v 20 amps **£12,** carr £2. Open type table top connections.

"C" CORE TYPES ALL PRIMARIES 220-240v
No. 1 Sec. 18-0-18v No 1 8-0-18v 12A **£10,** carr £2. No. 2 Sec. tapped 22-25-28v 5A and 16v 1A twice, 10v 1A twice, 26v 2.5A, 23v 1A, 6.3v 2A 145-0-145v 200m/A, separate windings **£6,** carr £1. No 3 Tapped 29-31-32v 15A and 23-24-26v 5A and 14-15-17v 5A **£12,** carr £2. No 4 Sec. tapped 27-28-30-39v 10A **£12,** carr. £2. No. 5 Sec. tapped 10-21v 5A and 1-3v 5A, the following outputs can be obtained 1-3-10-11-13-21-22-24v. 5A **£4,** carr. £1. No. 6 Sec. tapped 1-3v. 1.1A and 10-30v 1.1A **£2.50,** pp 75p. No 7 Sec. tapped 20-22V 1.5A **£2,** pp 75p. No. 8 33v 11 amps **£6.50,** carr £1.50

GEC L.T. TRANSFORMERS ALL PRIMARIES 220-240v
G.P.O. spec. Sec tapped 59-61-63-65-67-69v 10A **£10,** carr £2. Sec tapped 58-63-69-74v 3A **£4.50,** pp 75p. Both types terminal block connections

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New and boxed Pri. 220-240v Sec 29.5 875 m/a twice conservatively rated **£3.00** p.p 75p. Pri. 220-240v Sec. 504v 375 M/A 50v 125 M/A 6.3v 4.5A 6.3v 3A **£6.00,** carr. £1.50 Pri. 200-240v sec 11.6v 3.5A **£2.00,** p.p 75p.

REDCLIFFE 'C' CORE CHOKES
20H 180 M/A **£3.50,** p.p. £1.25 0.7H 250 M/A **£1,** p.p. 50p 50H 25 M/A **£1,** p.p 50p. 20H 75 M/A, £1.50, p.p 50p.

L.T. TRANSFORMERS
By famous makers. Fraction of maker's price. All primaries 220-240v open type No 1 Sec. 26v 10A Top panel connections **£5.75,** pp £1. No. 2 Sec. 43v 3A Wire end connections **£3.75,** pp 75p. No 3 33v 5A and 18-0-18v 1A Wire connections **£3.75,** pp 75p. No 4: 30v 5.5A and 12v 2.2A **£5.50,** pp £1. No 5: Sec 14v 5A, 14v 2.5A, 12v 10A, 8v 10A, 24v 750m/A, separate windings **£10,** carr. £2. No. 6: 26v 5A, 16v 4A, 25v 2A, separate windings **£8.50,** pp £1. Potted types. No. 7: Sec tapped 24-30-32v 2A **£3,** pp 75p. No. 8 Sec 2-0-2v 24A, high voltage insulation **£5.50,** carr £1. No 9 Sec. 6.6v 6A, 6.6v 6A, 5v 6A, separate windings. The following outputs can be obtained. 6.6v 6A, 6v 6.6A, 5v 6A, 13v 6A and 5v 6A, 6.6v 12A and 5v 6A, 11.6v 6A and 6.6v 6A, 18.2v 6A **£5.95,** carr. £1. No 10 24-0-24v 470m/A and 4.5 1A and 150v 15m/A, separate windings **£2.50,** pp 75p. No 11: Sec 4.2v 1A **£1.25,** pp 50p. No. 12: Sec 50v 1A and 140v 195m/A and 6.3v at 1.25A **£3.50,** pp £1. No 13 Sec. 6v 1A twice **£2,** pp 50p. No. 14 Sec 24v 1A, 24v 750m/A **£3,** pp 50p. No 15 Sec. 9v 2A and 9v 1A, open type **£2.50,** pp 50p. No. 15 Sec 35v 5A, 200v 100m/A, 30v 100m/A, separate windings **£7.50,** carr. £1.50

HT TRANS BY FAMOUS MAKER ALL PRIMARIES 240v. OPEN TYPE TAG CONNECTIONS
Sec 350-0-350v 120m/A 6.3v CT4A 5v. 2A **£3.95,** pp 75p. 300-0-300v, 150m/A 6.3v. CT 4A 5-6.3V 2A **£3.95,** pp 75p. 300-0-300v, 100m/A, 6.3v 3.5A 5v 2A **£3.50,** pp 75p 250-0-250v 80m/A 6.3v, 3.5A 6.3v 1A 5v 2A Fully shrouded 500-0-500v 200m/A **£4.50,** carr £1

H.T. TRANSFORMERS BY FAMOUS MAKERS
Fraction of original prices
ALL PRIMARIES 220-240v
Potted types No 1 408-200-0-200-408v 408v taps 165m/A, 200v taps 500m/A £5.50, carr £1.50 No 2 Sec. 330-0-330v 200m/A, 6.3v 6.6A, 5v 3A **£4.75,** carr £1.25 No 3 350-0-350v 200m/A, 6.3v 6.6A, 5v 3A **£4.95,** carr £1.25. No. 4 300v 37m/A twice 4v 1A, 4v 0.3A, 4kv DC wkg. **£3,** pp 75p. No. 4 Sec 630-0-630v 105m/A, 5v 4A, 5v 2A **£4.95,** carr £1.25

AC WKG BLOCK CAPACITORS BY FAMOUS MANUFACTURERS

MFD	Volts	Price
0.25	1500vAC	**50p**
0.75	440vAC	**50p**
1	470vAC	**60p**
1.25	360vAC	**65p**
2	400vAC	**75p**
2.4	360vAC	**75p**
2.5	360vAC	**75p**
2.7 + 0.1	700vAC	**£1.25**
3	440vAC	**£1.00**
3.5	250vAC	**£1.00**
4	250vAC	**£1.00**
5	360vAC	**£1.25**
5	440vAC	**£1.50**
7.2	440vAC	**£1.50**
8.4	250vAC	**£1.00**
15	250vAC	**£1.75**

PP up to 2.5MFD **25p,** 2.7 to 15MFD **50p** + 8% on total.

OIL FILLED BLOCK CAPACITORS
TCC: 8mfd 800v DC wkg **£1,** pp 35p. 1mfd 2000v DC wkg. **75p,** pp 35p. 1 mfd 1500v DC wkg **60p,** pp 25p. 1 mfd 1000v DC wkg. **55p,** pp 25p. 1 mfd 600v DC wkg. **30p,** pp 15p. 2 mfd 200v DC wkg. Three for **50p,** pp 35p. **Dubilier:** 8 mfd 350v DC wkg. **50p,** pp 35p. 4mfd 1250v DC wkg. **£1,** pp 35p. 2mfd 750v DC wkg. **50p,** pp 25p. 2mfd 600v DC wkg. **40p,** pp 25p. 0.1 mfd 10kv DC wkg 3kv RMS **£2,** pp 75p. 0.1mfd 3000v DC wkg. **75p,** pp 25p. **Hunts:** 1 mfd 350v DC wkg. 2 mfd 200v DC wkg., either type, three for **50p,** pp 25p. American types 4+4+4+2+1 mid 600v DC wkg. **£3,** pp 75p. 8+8+4mfd 650v DC wkg. **£3,** pp 75p. 6+4+3mfd 400v DC wkg, **£2,** pp 75p. 7mfd 600v DC wkg **75p,** pp 35p. 6mfd 600v DC wkg **60p,** pp 25p. 4mfd 600v DC wkg **50p,** pp 25p. **TMC Special Offer:** 2mfd 100v DC wkg. Cartons of 12 **£1,** pp 50p. 50mfd 150v DC wkg **£1,** pp 25p. **AC Wkg Types** 15mfd 330v AC **£1.50;** 6mfd 300v AC **75p;** 4mfd 400v AC **75p;** 4mfd tubular 250v AC **60p.**

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AC240v BLOWERS
Ex computer equipment. Perfect condition. Robustly housed on metal frame. Overall size 11 x 7 x 7in. Air outlet size 4 x 3ins. Motor spec. 1,300 rpm. Cont. rated. Cap. start included with motor. Quiet running. **£4.50,** carr £1

HT SMOOTHING CHOKES
Parmeko potted type 4.5H 280 m/A, 5H 200m/A, 10H 180m/A **£2,** pp 75p. 50H 25m/A, 15H 75m/A **£1,** pp 50p. Gardners 15H 180m/A **£3,** pp £1. 10H 300msA **£4,** pp £1. 100H 20m/A **£1,** pp 50p. C core types, 0.7H 250m/A **£1,** pp 50p. 70H 10m/A **£1,** pp 50p. 20H 75m/A **£1.75,** pp 50p. Potted swinging type 5H 40m/A-4H 250m/A **£2,** pp 75p. **L.T. CHOKES:** 4.8m/H 10A **£4,** pp £1. 150 m/H 3A **£3,** pp £1. Potted type 100m/H 2A **£4,** pp £1. 13m/H 15A **£1.50,** pp 50p. Open swinging type 60m/H 2A-180 m/H 0.2A

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PYE UHF LINKS (WESTMINSTER TYPE 470). 2 only. **£250.00 each.**

COSSOR CDU110 Scopes with CAM111B (Fet) Plug-ins, Dual-Beam. 5MV to 20V. 25MHz Basic Frame. Modern Rectangular Display. **£200.000.**

PYE PF2FMH Hand Portables, High-Band FM, 3-ch., less rechargeable batteries. **£65.00.**

CHART RECORDERS, Honeywell Model Y15301. 110V 50Hz, takes 12" chart paper, 30-90-270 ins per hour, brand new, boxed, **£100.00 each** (2 only)

ITT AM5 STARPHONE MOBILES, Low Band AM, as new, less speakers. **£100.00 each.**

BARGAIN PACK OF LOW VOLTAGE ELECTROLYTICS, Up to 50V working. Seatronics manufacture, approx 100. **£1.50 per pack** + 12½% VAT

MULLARD 85A2 85V STABILISER VALVES (brand new). **70p each or 2 for £1.20.**

TOOLS FOR THE ELECTRONIC ENTHUSIAST
BY DRAPER, SPIRALUX, etc AND A GOOD RANGE OF WELLER SOLDERING EQUIP. IN STOCK
SAE FOR LISTS

ALL BELOW +8% VAT

MAINS TRANSFORMERS. TYPE 60/2, mains input 200 - 210 - 220 - 230 - 240 - 250V AC. Output 0 - 20 - 40 - 60V at 2A, in Metal and Plastic case, approx. 7½ × 4½ × 4, fully fused (ideal for PSU). **£3.00 each.**

MAINS TRANSFORMERS. TYPE 15/300. 240V input, 15V at 300mA output, **£1.50 each.**

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TRANSISTORS
BFY51, 4 for 60p
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BC108, 4 for 50p
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BC148 (NPN SILICON), **4 for 50p**
BC158 (PNP SILICON), **4 for 50p**
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BNC PLUGS (ex-equip), **5 for £1.50**
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SO239 Sockets (PTFE), brand new (4 hole fixing type), **50p each or 5 for £2.25**

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BINOCULAR LENSES, 2¼" dia. × 6" Focal length, good quality Achromats, but rejected because of small scratch or chip at edges. **£1.25 each** (or **2 for £2.00.**

Min. 5pf AIRSPACE TRIMMERS, approx. ⅜" square, **3 for 50p.**

CALIBRATOR XTALS 100KHz + 1MHz IN ONE 10-X CAN, **£1.00 each.**

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VIDEO PCB (AG58314) **£5.00**

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6,800mfd at 25V (brand new), **50p each.**

SLOW MOTION MOTORS, 120V 50Hz 1RPM, size approx. 2" dia. 1½" deep, with ⅛" spindle, **60p each** or **2 for £1.00.**

6BW6 VALVES (BRAND NEW), **85p each or 2 for £1.50.**

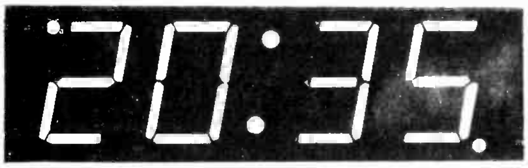
SUB-MINIATURE ROTARY SWITCHES, 4 × 5 way make contacts, size approx. ¾" dia. 1" deep, 3/16" spindle, **50p each.**

MULTICORE SOLDER
Size 5, Savbit, 18swg in Alloy dispenser, **32p.**
Size C1SAV18 Savbit, 18swg **56p.**
½kg (1 1lb), 60/40, 20 swg on Plastic Reel, **£3.00.**
Alusol Aluminium Solder 1-metre coil **40p.**
Large Reel **£2.75.**

Pye Cambridge Low-Band AM Boot-Mount Radio-telephones, set only (less control equip.), **£27.50 each.**

WW—097 FOR FURTHER DETAILS

TIME FOR WIRELESS?



The MA1012 LED digital clock module is a full 12/24 hour format clock unit, operating from 50/60Hz mains and offering a host of features: Hours, minutes display in bright 0.5" LEDs, with optional seconds, sleep and snooze alarms, fast and slow setting, PM indicator, switched output for radio, but the most important feature is the non-multiplexed directly driven display. This means no RFI, so the MA1012 is ideal for use in any type of radio/tuner etc. The neat fitting means it can be slotted into many existing cabinets/chassis - only 1.75 x 3.75 x 0.7 " total!! £9.45 per module - isolating mains transformer £1.50 (8% vat) Two modules and two transformers for £20.00 + 8% VAT.

AMBIT announce a new addition to the catalogue - information on TOKO's new ceramic ladder filters, 2.4kHz SSB filters etc. HF coils, new flat faced low cost panel meters. Catalogue 45p.

DETECKNOWLEDGEY

Metal locator principles and practise, including some of the facts that the manufacturers of £100+ metal locators wouldn't like you to know !! £1.00

The Bionic Ferret 4000 – A little detector technology of our own. The VCO based metal locator for the electronics constructor, including platsic moldings for housings of electronics and search coil, tubing etc. Can be set up using just a test meter. 'All in' price £34.26 inc PP and 8% VAT.

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COMPONENTS ETC:

As usual, Ambit offers a comprehensive range of components and modules for wireless, including over 300,000 types of signal inductors for just about every conceivable RF signal application from 5kHz to 300MHz.

SEMICONDUCTORS

CA3089E	FM IF	1.94
KB4402	FMIF	1.94
HA1137W	FM IF	2.20
TBA120	FM IF	0.75
TBA120S	FM IF	1.00
SN76660N	FM IF	0.75
uA720	AM radio	1.40
CA3123E	AM radio	1.40
HA1197	AM radio	1.40
TBA651	AM radio	1.40
MC1350	agc gain	1.00
uA753	FM gain	1.80
LM1496	Bal mix	1.25
MC1310P	mpx dec.	2.20
CA3090AQ	mpx dec.	4.35
HA1196	mpx dec.	4.20
LM380N	2w AF	1.00
LM381	st. pream.	1.81
tda2020	15w AF	2.99
tca940e	10w AF	1.80
tba810as	7w AF	1.08
LM301an	op amp	0.39*
CA3130T	mos oa	0.85*
uA741	op amp	0.34*
LM3900	op amps	0.68*
7805uc	5v/1A	1.55*
tda1412	12v/.6A	0.95*
78M20uc	20v/.5A	1.20*
78M24uc	24v/.5A	1.20*
uA723cn	variable	0.80*
NE550a	variable	0.80*
TAA550b	32v ref.	0.50*
icl8038cc	sig gen	4.50*
NE555v	timer	0.70*
NE566v	vco	2.50*
NE567v	tone dec.	2.50*
NE560B	hf pll	3.50*
NE561B	hf pll	3.50*
NE565k	lf pll	2.50*
MC1312	quad	1.50
11C90	650MHz	14.00*
ZTX107	50v/.3W	0.14
ZTX108	30v/.3W	0.14
ZTX109	30v/.3W	0.14

BC413	lo noise	0.18
40238	shld.RF	0.25*
BF224	.6GHz RF	0.22
BF274	.7GHz	0.18
ZTX212	50v/.3W	0.17
ZTX213	30v/.3W	0.16
ZTX214	30v/.3W	0.17
ZTX451	60v/1W	0.18
ZTX551	60v/1W	0.18
BD515	45v/10W	0.27
BD516	45v/10W	0.30
BD535	60v/50W	0.52
BD536	60v/50W	0.53
BD609	80v/90W	0.70
BD610	80v/90W	1.20
BF256	1GHz jfet	0.34
E176	p ch. swt.	0.38
MEM614	(40822)	0.38*
MEM616	(40673)	0.57*
MEM680	lo noise	0.75*
BA102	vhf varic.	0.30
BA121		0.30
BB104	dual varic	0.45
BB105	uhf varic	0.40
mvam2	dual am	1.48
mvam115	15v/AM	1.05
mvam125	25v am	0.90

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10mm

AM IFts with cap.	0.30
FM IFts with cap.	0.33
eg	
YHCS11098AC2	0.30
YHCS12374AC2	0.30
YHCS11100AC2	0.30
KACSK586HM	0.33
7mm IFs for RC	0.33
CFS10.7 ceramic	0.50
BLR3107N mpx	1.90
BBR3132 6pole fm	2.25
MFL 2.4kHz/455	9.95
MFHT 4/5/7kHz	1.95
MFK 7/9kHz	1.65

Modules/tunerheads

EC3302U 3 varicap FM	£7.50
EF5600U 5 varicap FM	£12.95
NT3302UG 3 gang FM	£7.50
EF5800 6 varicap FM	£14.00
EF5801(5800+osc op)	£17.50
8319 4varicap mos mix	£11.45
7252 fm tunerset	£26.50
7253 stereo tunerset	£26.50
7020 cer. filt. fm if	£6.95
7030 linear phase if	£10.95
NBFM1 kit for 455-470kHz nbfm if filter/amp/detector for +12v	£5.95
92310 mpx decoder	£6.95
91196 mpx decoder &birdy filter	£12.99
93090 mpx decder.	£8.36
91197 mw/lw tuner	£11.35
7122 3 varicap am tuner for MW (or LW) kit	£9.00
810k complete TBA810AS module kit	£3.00
940k as above with tca 940E (both kits inc heatsink)	£3.95

NB All our audio ICs are "short circuit" protected as defined by the manufacturer All our mpx decoders are provided with TOKO mpx notch filters. All our FM IF modules use the improved mute version HA1137W.

Others: (from gen. price list)

FX1115 ferrite beads	10/25p
FR1 mw/lw ferrite rod	£0.90
Min. foil trimmers by Dau:	
5/10/20pF swing 7.5	0.18
33/42pF swing 7.5	0.26
60pF swing 10mm dia	0.24
22turn 100k diode law trimpots for varicaps	0.45
1000pF feedthrus	0.05
10000uF/63v	1.15
Chokes 1uH to 124mH	OA.

VAT is extra at 12.5% except where otherwise shown. Postage now 25p per order please. Catalogue 45p inc pp & vat. Please send an SAE with all enquiries (a5 or larger size please) Price list free with an SAE (a5 size)

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WW — 108 FOR FURTHER DETAILS

TRANSFORMERS

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VAT 8%

MAINS ISOLATING

PRI 120/240V SEC 120/240V Centre Tapped and Screened

Ref.	VA (Watts)	£	P&P
07★	20	4.40	79
149	60	6.20	.96
150	100	7.13	1 14
151	200	11.16	1.50
152	250	12.79	1.84
153	350	16.28	1.84
154	500	19.15	2.15
155	750	29.06	OA
156	1000	37.20	OA*
157	1500	45.60	OA
158	2000	54.80	OA
159	3000	79.05	OA

★115 or 240 sec only

12 and/or 24-VOLT

Separate 12v windings Pri 220-240 Volts

Ref	Amps 12v	Amps 24v	£	P&P
111	0.5	0.25	2.20	.43
213	1.0	0.5	2.64	.78
71	2	1	3.41	.78
18	4	2	4.03	.96
70	6	3	5.35	.96
108	8	4	6.98	1 14
72	10	5	7.67	1 14
116	12	6	8.99	1.32
17	16	8	10.38	1.32
115	20	10	13.18	2.08
187	30	15	17.05	2.08
226	60	30	26.82	OA

50 VOLT RANGE

Primary 220-240V
SEC. TAPS 0-19-25-33-40-50V
VOLTAGES AVAILABLE
6, 7, 8, 10, 14, 15, 17, 19, 21, 25, 31, 33, 40, 50V, or 25-0-25V

Ref.	Amps	£	P&P
102	0.5	3.41	78
103	1.0	4.57	96
104	2.0	6.98	1 14
105	3.0	8.45	1.32
106	4.0	10.70	1.50
107	6.0	14.62	1.64
118	8.0	17.05	2.08
119	10.0	21.70	OA

30 VOLT RANGE

Primary 220-240v
SEC. TAPS 0-12-15-20-25-30v
VOLTAGES AVAILABLE
3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 15-0-15V

Ref.	Amps	£	P&P
112	0.5	2.64	.78
79	1.0	3.57	.96
3	2.0	5.27	.96
20	3.0	6.20	1.14
21	4.0	7.44	1.14
51	5.0	8.37	1.32
117	6.0	9.92	1.45
88	8.0	11.73	1 64
89	10.0	13.33	1.84

60 VOLT RANGE

Primary 220-240V
SEC TAPS 0-24-30-40-48-60V
VOLTAGES AVAILABLE
6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V or 24-0-24V or 30-0-30V

Ref.	Amps	£	P&P
124	0.5	3.88	.96
126	1.0	5.58	.96
127	2.0	7.60	1.14
125	3.0	10.54	1.32
123	4.0	12.23	1.84
40	5.0	13.95	1.64
120	6.0	15.66	1.84
121	8.0	20.15	OA
122	10.0	24.03	OA
189	12.0	27.13	OA

AUTO TRANSFORMERS

Ref.	VA Watts	TAPS	£	P&P
113	20	0-115-210-240v	2.48	.71
64	75	0-115-210-240v	3.95	.96
4	150	0-115-210-220-240v	5.35	96
66	300	.. ..	7.75	1.14
67	500	.. ..	10.99	1.64
84	1000	.. ..	18.76	2.08
93	1500	.. ..	23.28	OA
95	2000	.. ..	34.82	OA
73	3000	.. ..	48.00	OA

SCREENED MINIATURES Primary 240v

Ref.	mA	Volts	£	P&P
238	200	3-0-3	1.99	.55
212	1A, 1A	0-6, 0-6	2.85	.78
13	100	9-0-9	2.14	.38
235	330, 330	0-9, 0-9	1.99	.38
207	500, 500	0-8-9, 0-8-9	2.59	.71
208	1A, 1A	0-8-9, 0-8-9	3.53	.78
236	200, 200	0-15, 0-15	1.99	.38
214	300, 300	0-20, 0-20	2.56	.78
221	700 (DC)	20-12-0-12-20	3.41	.78
206	1A, 1A	0-15-20, 0-15-20	4.63	.96
203	500, 500	0-15-27, 0-15-27	3.99	96
204	1A, 1A	0-15-27, 0-15-27	5.39	.96
S112	500	0-12-15-20-24-30	2.64	.78

HIGH VOLTAGE

MAINS ISOLATING
Pri 200/220 or 400/440
Sec 100/120 or 200/240

VA	Ref.	£	P&P
60	243	5.89	1.32
350	247	14.11	1.84
1000	250	35.65	OA
2000	252	54.25	OA

CASED AUTO. TRANSFORMERS

240V cable input. USA 2-pin outlets

20VA	£4.96	P&P .96	Ref.	113W
75VA	£6.03	P&P 1.14	Ref.	64W
150VA	£8.48	P&P 1.14	Ref.	4W
300VA	£12.53	P&P 1.45	Ref.	66W
500VA	£15.73	P&P 1 64	Ref	67W
750VA	£18.55	P&P 1.76	Ref.	83W
1000VA	£22.68	OA	Ref.	84W
2000VA	£37.65	OA	Ref.	95W

DECS SOLDERLESS BREADBOARDING

S Dec 70 contacts	£1.98
T Dec 208 contacts	£3.38
U Dec 'A' IC's etc.	£3.99
U Dec 'B' IC's etc.	£6.99

VAT 8% P&P 40p

BRIDGE RECTIFIERS

200v	2A	45p
400v	2A	55p
200v	4A	65p
400v	4A	80p
400v	6A	£1.00
500v	10A★	£2.35

P&P 29p. VAT 12½%
★VAT 8%

HIGH QUALITY MODULES

10 watt RMS Amplifier	£3.66
25 watt RMS Amplifier	£4.57
125 watt RMS Amplifier	£15.95*
Pre-Amp for 3-5-10w	£6.95
Pre Amp for 25w	£13.88
Power Supplies for 3-5-10w	£1.35
Power Supplies for 25w	£3.76
Transformer for 5-10w	£2.41
Transformer for 25w (one module)	£4.79
P&P Amps/Pre-Amps/Power Supplies	40p
P&P Transformers	96p

VAT 12½% *VAT 8%

METERS

AVO8	£68.95
AVO71	£28.00
AVO73	£37.80
AVOMM5	£21.94
WEE MEGGER	£55.05
AVO TT169 in-circuits transistor tester	£26.00
U4315	£14.95

Avo Cases and Accessories
P&P £1.50. VAT 8%

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Complete chassis, inc. 7+7w r.m.s. amps, pre-amp, power supply, front panel, knobs (needs mains trans.). **£19.05.** Mains trans. **£2.45.** Teak veneered cab. **£5.25.** P&P £1.02. VAT 12½%

TI MINI-MULTIMETER

DC-1000V. AC-1000V
AC/DC-1000Ω/V
DC-100mA. Res — 150K
Bargain at **£5.30**
VAT 8% P&P 62p

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128. 3, 4.5, 7.5, 9, 12v 500mA. £5.32
STABILISED 3, 6, 7.5, 9v at 400mA £5.95
3300. 6, 7.5, 9v at 300mA plugs direct into 13A socket (fused) £3.30
P&P 70p. VAT 12½%

STEREO F.M. TUNER

4 Pre-selected stations
Switched AFC
Supply 20-35v 90Ma Max.
£21.63. P&P 40p. VAT 12½%

ANTEX SOLDERING IRONS

15W **£3.75.** 18W **£3.75.** 25W **£3.40**
Soldering iron kit **£5.15**
Stand for above **£1.40.** P&P 46p. VAT 8%

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Operating Voltage 20/45v
ONLY **£2.85** P&P 36p
VAT 12½%

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PANEL METERS AND SEMICONDUCTOR STOCKISTS. AUDIO ACCESSORIES & BARGAIN PAKS. SAVE POSTAGE. CALLERS WELCOME (MON.-FRI.) OR SEND 15p STAMP FOR LISTS
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TELEPHONE: 01-488 3316/8
NEAREST TUBE STATIONS: ALDGATE & LIVERPOOL ST.

WW—077 FOR FURTHER DETAILS

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7400	16p	74109	89p
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74LS00	30p	74112	96p
7401	18p	74116	200p
7402	18p	74118	84p
7403	18p	74120	120p
7404	23p	74121	32p
74H04	36p	74122	54p
7405	25p	74123	76p
7406	43p	74125	73p
7407	43p	74126	70p
7408	25p	74128	75p
7409	27p	74132	70p
7410	18p	74136	75p
74H10	28p	74141	75p
7411	24p	74142	320p
7412	25p	74145	90p
7413	36p	74147	190p
7414	75p	74148	160p
7416	33p	74150	140p
7417	36p	74151	72p
7420	18p	74153	85p
7421	40p	74154	150p
7422	22p	74155	90p
7423	37p	74156	90p
7425	30p	74157	90p
7427	37p	74158	140p
7428	36p	74159	190p
7430	18p	74160	120p
7432	36p	74161	120p
7437	36p	74162	120p
7438	36p	74163	120p
7440	19p	74164	120p
7441	75p	74165	220p
7442	70p	74166	160p
7443	140p	74167	340p
7444	140p	74170	250p
7445	120p	74172	720p
7446	100p	74173	160p
7447	85p	74174	120p
7448	80p	74175	85p
7450	18p	74176	120p
7451	20p	74177	120p
7453	20p	74179	160p
7454	18p	74180	110p
7460	18p	74181	298p
7470	36p	74182	82p
7472	30p	74185	150p
7473	34p	74186	920p
7474	34p	74190	160p
7475	45p	74191	160p
7476	36p	74192	120p
7480	50p	74193	160p
7481	95p	74194	120p
7482	90p	74195	95p
7483	90p	74196	120p
7484	110p	74197	120p
7485	120p	74198	250p
7486	34p	74199	250p
7489	320p	74221	160p
7490	40p	74251	140p
7491	85p	74265	90p
7492	55p	74278	290p
7493	40p	74279	140p
7494	90p	74283	190p
7495	70p	74290	150p
7496	84p	74293	150p
7497	340p	74298	200p
74100	120p	74365	150p
74104	65p	74366	150p
74105	65p	74390	200p
74107	36p	74393	225p

C-MOS I.Cs

CD4000AE	20p
CD4001AE	20p
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CD4006AE	95p
CD4007AE	20p
CD4009AE	61p
CD4011AE	20p
CD4012A	20p
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
CD4040AE	120p
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
CD4073AE	30p
CD4081AE	21p
CD4082AE	27p
CD4093AE	95p
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 DTLs

930	36p
936	40p
946	40p
955	60p
962	36p
963	40p

MEMORIES

1702 EPROM	1000p
2102 RAM	200p
2104 RAM	1000p
2107 RAM	1000p
2112 RAM	450p
2513 ROM	900p
2602 RAM	250p
X887 ROM	1600p
AY-5-1013	600p

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
CA3140	BIMOS —	8 pin DIL	100p
CA3160	Int Comp	8 pin DIL	110p
LM318N	High speed	8 pin DIL	200p
LM324N	Quad Op Amp	14 pin DIL	120p
NE531V	High slew rate	8 pin DIL	140p
3900	Quad Op Amp	14 pin DIL	70p
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	36p
776	Programable Op Amp	TO-5	140p

LINEAR I.C.s

*AY-1-0212	Tone Generator	16 pin DIL	600p
*CA3028A	Diff Cascade Amp	TO5	95p
*CA3046	5 Transistor Array	14 pin DIL	80p
*CA3048	Quad Low Noise Amp	16 pin DIL	200p
*CA3053	Diff Cascade Amp	TO5	70p
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
ICL8038CC	VCO Fun Gen	14 pin DIL	340p
LM339N	Vol Quad Comparator	14 pin DIL	200p
LM377N	Dual 2W Aud Amp	14 pin DIL	175p
*LM380	2W Audio Amp	14 pin DIL	99p
*LM381	Stereo Preamp	14 pin DIL	175p
*LM389N	Aud Amp +3 Trs Array	18 pin DIL	160p
*M252	Rhythm Generator	16 pin DIL	800p
*MC1310P	FM Stereo Dec	14 pin DIL	190p
*MC1351P	Lim Det Aud Preamp	14 pin DIL	97p
MC1495L	Multiplier	14 pin DIL	450p
*MC1496L	Bal Mod Demod	14 pin DIL	100p
*MC3340P	Electronic Attenuator	8 pin DIL	160p
*MC3360P	¼W Audio Amp	8 pin DIL	160p
*MFC4000B	1/4W Audio Amp	PCB	120p
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
*SP8515	Prescaler 450MHz ÷ 10	16 pin DIL	675p
*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 QIL	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	90p	ORP12	85p
OCP71	120p	ORP60	90p
2N5777	45p	ORP61	90p

LEDS

		0.2" Red	18p
TIL209 Red	16p	Green	20p
TIL211 Green	25p	Yellow	36p
TIL32 Infrared	75p	Tri-state Red/Green/Off	160p

SEVEN SEGMENT DISPLAYS

3015F	190p	FND 500 Red	130p
DL704 Red/Green	140p	FND 507 Red	130p
DL707 Red/Green	140p	TIL 321 Red	130p
DL747 Red/Green	225p	TIL 322 Red	130p

Drivers: 75491 **84p**; 75492 **96p**, 9368/9374 **200p**

TRANSISTORS

AC125	25p	BFX88	30p
AC126	20p	BFY50	22p
AC127	20p	BFY51	22p
AC128	18p	BFY52	22p
AC141	20p	BFY90	120p
AC142	20p	BRY39	45p
AC176	20p	BSX19	20p
AC187	20p	BSX20	20p
AC187K	25p	*BU105	140p
AC188	20p	BU108	250p
AC188K	25p	*MJE340	65p
AD149	49p	MJ481	175p
AD161	45p	MJ491	200p
AD162	45p	MJ2501	225p
AF114	20p	MJ2955	120p
AF115	20p	MJE2955	130p
AF116	20p	MJ3001	225p
AF117	20p	MJE3055	70p
AF127	25p	*MPSA06	30p
AF139	43p	*MPSA12	50p
AF239	48p	*MPSA56	32p
BC107 B	9p	*MPSU06	62p
BC108 B	9p	*MPSU56	78p
BC109 B	10p	OC28	120p
BC109C	12p	OC35	90p
*BC117	22p	OC36	90p
*BC147	9p	*OC71	20p
*BC148	9p	*R2008B	200p
*BC149C	10p	*R2010B	200p
*BC157	11p	*TIP29A	40p
*BC158	10p	*TIP29C	55p
*BC159	11p	*TIP30A	48p
*BC169C	12p	*TIP30C	60p
*BC172	11p	TIP31A	52p
BC177	18p	TIP31C	52p
BC178	17p	TIP32A	58p
BC179	18p	TIP32C	82p
*BC182	12p	TIP33A	90p
*BC183	12p	TIP33C	115p
*BC184	13p	TIP34A	115p
BC187	30p	TIP34C	160p
*BC212	11p	TIP35A	225p
*BC213	10p	TIP35C	290p
*BC214	14p	TIP36A	270p
BC461	36p	TIP36C	340p
BC478	30p	TIP41A	65p
BCY70	18p	TIP41B	70p
BCY71	22p	TIP41C	78p
BD124	130p	TIP42A	70p
BD131	63p	TIP42B	76p
BD132	65p	TIP42C	82p
*BD135	48p	TIP2955	78p
*BD136	50p	*TIS93	30p
*BD139	52p	*ZTX108	10p
*BD140	58p	*ZTX300	13p
BDY56	200p	*ZTX500	15p
BF115	22p	*ZTX502	18p
BF167	23p	2N457A	190p
BF170	23p	2N697	22p
BF173	25p	2N698	45p
BF177	26p	2N706	20p
BF178	28p	2N708	20p
BF179	33p	2N918	40p
BF180	33p	2N930	18p
BF184	22p	2N1131	18p
*BF194	10p	2N1132	18p
*BF195	9p	2N1304	70p
*BF196	14p	2N1305	70p
*BF197	15p	2N1306	75p
BF200	32p	2N1307	75p
BF257	32p	2N1308	50p
BF258	36p	2N1309	50p
BF259	45p	2N1613	25p
BF337	30p	2N1711	25p
*BFR39	30p	2N1893	30p
*BFR40	30p	2N2102	55p
*BFR41	30p	2N2219	20p
*BFR79	30p	2N2222	20p
*BFR80	30p	2N2369	14p
BFR81	30p	2N2484	30p
*BFR88	30p	2N2904 A	25p
BFX30	34p	2N2905 A	25p
BFX84	30p	2N2906 A	24p
BFX85	30p	*2N2926R	7p
BFX86	30p	*2N2926B	7p
BFX87	30p	*2N2926O	10p

*2N2926Y	12p
*2N2926G	12p
2N3053	22p
2N3054	65p
2N3055	65p
2N3439	67p
2N3442	140p
*2N3565	30p
*2N3702	12p
*2N3703	12p
*2N3704	12p
*2N3705	12p
*2N3706	12p
*2N3707	12p
*2N3708	12p
*2N3709	12p
2N3773	250p
2N3866	90p
*2N3903	18p
*2N3904	16p
*2N3905	20p
*2N3906	16p
*2N4058	15p
*2N4059	10p
*2N4060	13p
*2N4123	22p
*2N4124	22p
*2N4125	22p
*2N4126	22p
*2N4289	20p
*2N4401	27p
*2N4403	27p
2N4427	90p
*2N5089	27p
2N5296	55p
*2N5401	50p
2N6034	160p
2N6107	55p
2N6247	190p
(Comp to 2N3055)	
2N6254	130p
2N6292	65p
40360	40p
40361	45p
40362	45p
40364	120p
40409	65p
40410	65p
40411	300p
40636	130p
40594	88p
40595	97p
40871	80p
40872	84p

FETs

*BF244B	36p
*BF256B	70p
*MPF102	40p
*MPF103	40p
*MPF104	40p
*MPF105	40p
*2N3819	25p
*2N3820	50p
2N3823	57p
*2N5457	40p
*2N5458	40p
*2N5459	40p
*2N5485	40p

MOSFETs

3N128	96p
3N140	95p
3N141	95p
3N187	180p
40603	63p
40673	63p

UJTs

*TIS43	34p
2N2160	120p
2N2646	45p
*2N4871	54p

DIODES

***SIGNAL**

OA47	9p
OA81	20p
OA85	20p
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

ZENER

2.7V to 33V*

*400mW	9p
*1W	18p

BRIDGE RECTIFIERS

*1A 50V	25p
*1A 100V	27p
*1A 200V	30p
*1A 400V	32p
*1A 600V	36p
*2A 50V	30p
*2A 100V	35p
*2A 200V	40p
*2A 400V	45p
*3A 200V	60p
*3A 600V	72p
*4A 100V	84p
*4A 400V	90p
6A 50V	90p
6A 100V	96p
6A 200V	108p
6A 400V	120p
10A 400V	270p
25A 400V	400p

TRIACS

Plastic

Amp	Volts	
3	400	85p
6	400	99p
6	500	107p
10	400	120p
10	500	140p
15	400	160p
15	500	180p
40430		130p
40669		130p
DIAC		
BR100		30p

HEATSINK

For TO-220 Vol. Regs and Transistors 17 C/W **25p**

VOLTAGE REGULATORS — FIXED — PLASTIC

1 Amp Positive			1 Amp Negative		
5V	7805	140p	5V	7905	200p
12V	7812	140p	12V	7912	200p
15V	7815	140p	15V	7915	200p
18V	7818	140p	18V	7918	200p
24V	7824	140p	24V	7924	200p

LM309K 1 Amp 5V TO3 **140p** LM323K 3A 5V **700p**
LM309H 100mA 5V TO5 **75p**
TBA625B 12V 0.5A TO5 **120p**

VARIABLE VOLTAGE REGULATOR
723 2V to 37V 150mA 14 pin DIL **45p**

DUAL VOLTAGE REGULATOR
1468 ±15V 100mA 16 pin DIL **300p**.
(Adjustable by resistors from ± 8V to ± 20V)

SCR-THYRISTORS

1A 50V	TO5	70p	C106D 4A/400V	Plastic	63p
1A100V	TO5	80p	*MCR101		
1A400V	TO5	90p	0.5A/15V	TO-92	25p
3A400V	Stud	100p	2N3525		
7A100V	TO5+HS	84p	5A/400V	TO-66	120p
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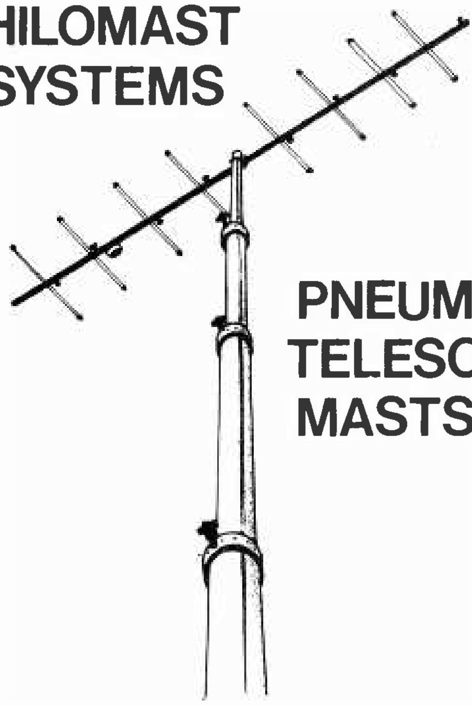

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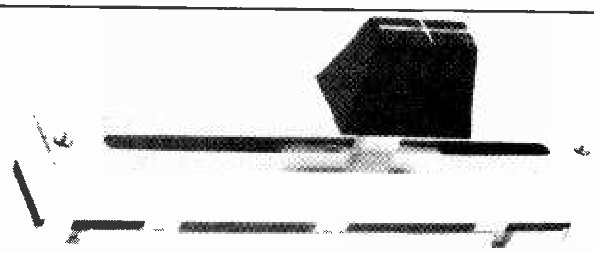

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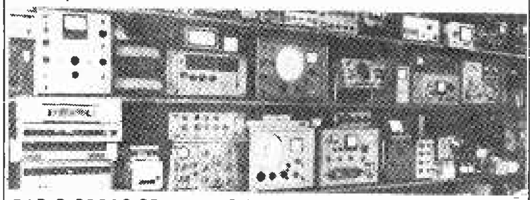

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EABC80	0.40
EAF42	0.70
EB91	0.30
EBC33	1.00
EBC41	0.75
EBF80	0.45
EBF83	0.45
EBF89	0.40
EC52	0.40
ECC81	0.45
ECC82	0.40
ECC83	0.40
ECC84	0.35
ECC85	0.45
ECC86	1.25
ECC88	0.55
ECC189	0.80
ECF80	0.45
ECF82	0.45
ECF801	0.75
ECH81	0.45
ECH84	0.50
ECL80	0.60
ECL82	0.40
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ECL86	0.55
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EF37A	1.60
EF39	1.00
EF40	0.70
EF41	0.75
EF80	0.35
EF83	1.50
EF85	0.45
EF86	0.45
EF89	0.35
EF91	0.65
EF92	0.75
EF95	0.45
EF183	0.40
EF184	0.40
EF804	2.00
EFL200	0.75
EH90	0.60
EL32	0.60
EL34	0.80
EL35	0.60
EL37	3.00
EL41	0.80
EL81	0.60

Type	Price
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KT88	4.50
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PC88	0.65
PC92	0.65
PCC84	0.45
PCC85	0.50
PCC89	0.55
PCC189	0.65
PCF82	0.40
PCF84	0.65
PCF86	0.65
PCF201	0.90
PCF801	0.55
PCF802	0.55
PCF805	1.10
PCF806	0.85
PCF808	1.00
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PCL81	0.60
PCL82	0.45
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	2.00
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PY33	0.60
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PY83	0.50
PY88	0.50
PY500	1.10
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U26	0.85
U27	1.00
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U801	0.80
UABC80	0.50
UAF42	0.75
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	0.75
UF80	0.40
UF85	0.50
UF89	0.50
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UL84	0.50
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6AB7	0.60
6AC7	0.60
6AH6	0.75
6AK5	0.45
6AK8	0.40
6AL5	0.30
6AL5W	0.65
6AM5	1.60
6AM6	0.65
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6AQ5	0.50
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6AT6	0.65
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6AV6	0.50
6AX4GT	0.80
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6B7	0.75
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6BR7	2.30
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6SG7	0.60
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6SK7	0.60
6SL7GT	0.55
6SN7GT	0.55
6SQ7	0.65
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12AT7	0.45
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1629	0.70
2051	1.00
5763	1.60
5933	3.00
6057	0.85
6060	0.85
6064	0.85
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6F8G	0.75
6F12	0.65
6F17	1.00
6F33	4.20
6H6	0.45
6J4WA	1.75
6J5	0.75
6J5GT	0.55
6J6	0.35
6J7	0.70
6J7G	0.50
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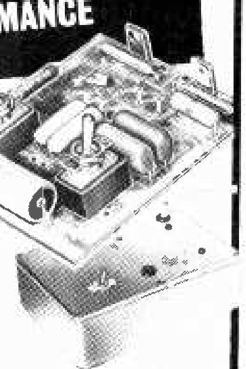

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Facts » Profits

The first of our standard reference books to be published using our new computer-based information system is the second edition of "INSTRUMENT MANUFACTURERS United Kingdom 1977/1978 (eurolec 52)." Its 320 pages provide detailed background information on around 500 companies whose *main* activities are the manufacture in the UK of industrial instruments and systems. It costs £12.00 + 95p post and packing.

Also produced using the new accurate system is its valuable companion - the respected "ELECTRONIC MANUFACTURERS United Kingdom 2nd edition 1977/1978 (eurolec 53)" This covers around 800 companies whose *main* activities are the manufacture in the UK of electronic products, including capital equipment, consumer goods, and components. It costs £16.00 + £1.20 UK post and packing

Produced at the end of last year our fat "ELECTRONIC COMPONENTS ON OFFER IN THE UK (eurolec 50)" has proven very popular. Its 520 pages give sound background information on manufacturers, importers and distributors.

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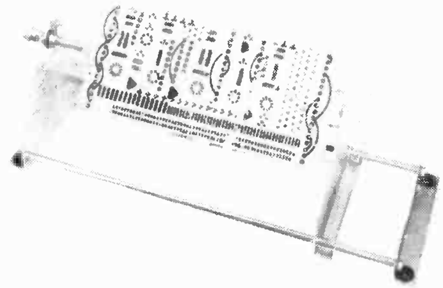

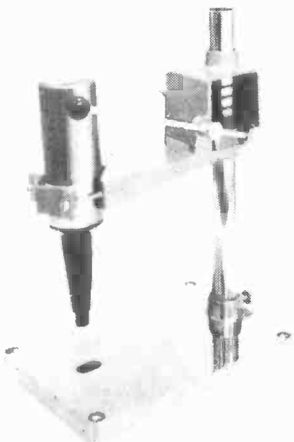

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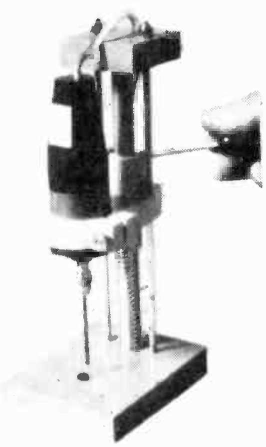

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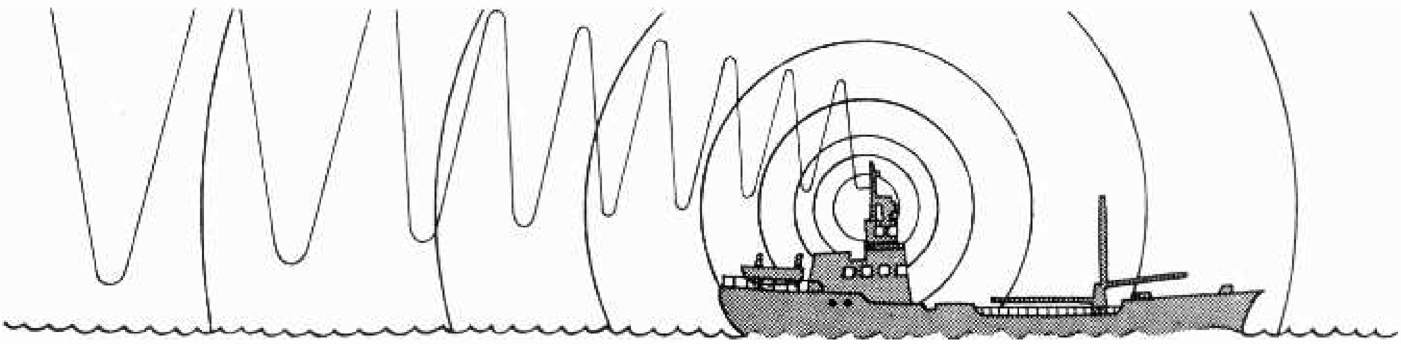
PHONE: Eddie Farrell on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.



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Post Office Telecommunications

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Application forms and further particulars are available, by postcard request please, from The Personnel Manager (AVT1), The Open University, PO Box 75, Walton Hall, Milton Keynes MK7 6AL, or by telephone from Milton Keynes 63868. 7431

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Application form and job description available from Central Personnel Office, St. James's University Hospital, Beckett Street, Leeds LS9 7TF. Tel: (0532) 33144 ext. 730.

Closing date for receipt of completed forms: Thursday, 25th August, 1977.

(7471)

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TELEVISION SERVICE

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Applicants should be professional television engineers with experience of operations and maintenance of colour television origination and recording equipment. Work will be at Service's studio centre, the colour mobile unit and at Medical School. Normal colour vision is a requirement for this post.

Salary on scale £2904-£4811 with appropriate placing.

Further particulars from The Secretary, The University, Aberdeen, with whom applications (2 copies) should be lodged by 26 August, 1977.

(7446)

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(7441)

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(7451)

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BOSCH

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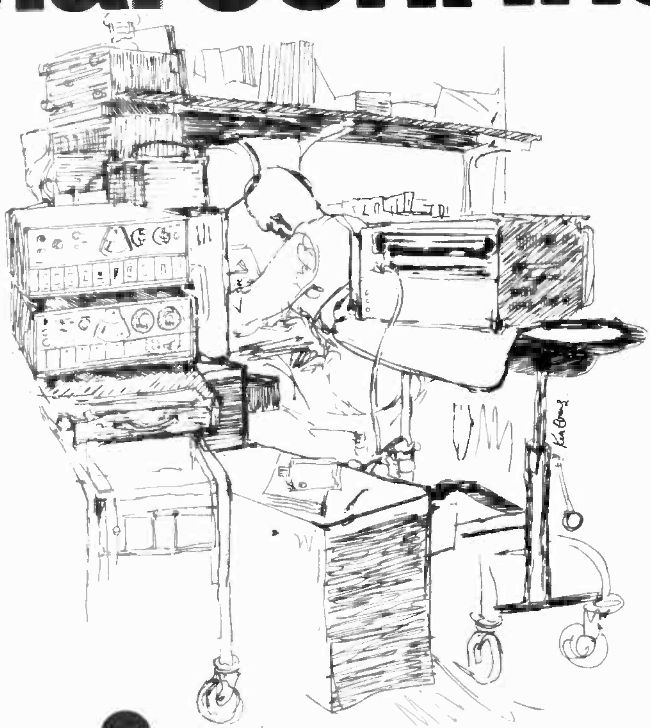

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(7435)

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(7473)

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Applications are invited from experienced and qualified people to teach subjects in the communication engineering course. The successful applicant would have experience in microwave systems with emphasis on baseband equipment (telephony and data), transmission, reception, and repeater stations and/or experience in broadcast systems with emphasis on sound studio equipment and low and medium power broadcast transmitters.

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Applications in duplicate should include particulars of age, nationality, marital status, family if any, qualifications, experience, present post and the names and addresses of three referees from whom confiential enquiries can be made. Further information will be forwarded to all applicants. Applications are required by **30 September, 1977** and should be sent to the Registrar, The Papua New Guinea University of Technology, P O Box 793, Lae, Papua New Guinea. A copy of the application should be sent to the Association of Commonwealth Universities (Appts.), 36 Gordon Square, London WC1H 0PF, from whom general information can be obtained.

(7427)

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Department of Economics and Social Studies

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Application forms and details from the Establishment Officer, The Polytechnic, Wolverhampton.

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(7445)

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Salary £2334 p.a. x. £111 to £2889 p.a. plus 12½% Shift Allowance and appropriate Pay Supplement.

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(7470)

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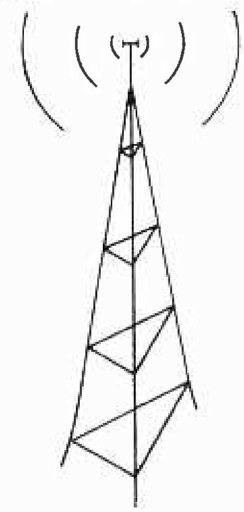

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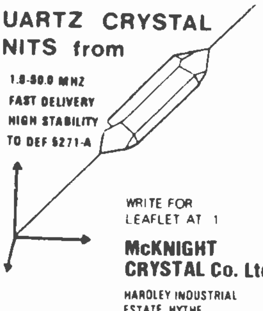

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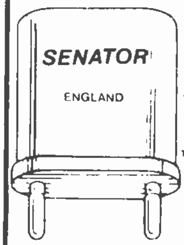

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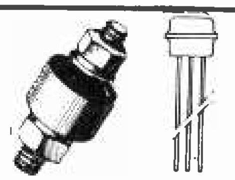

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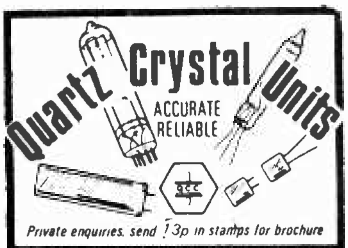

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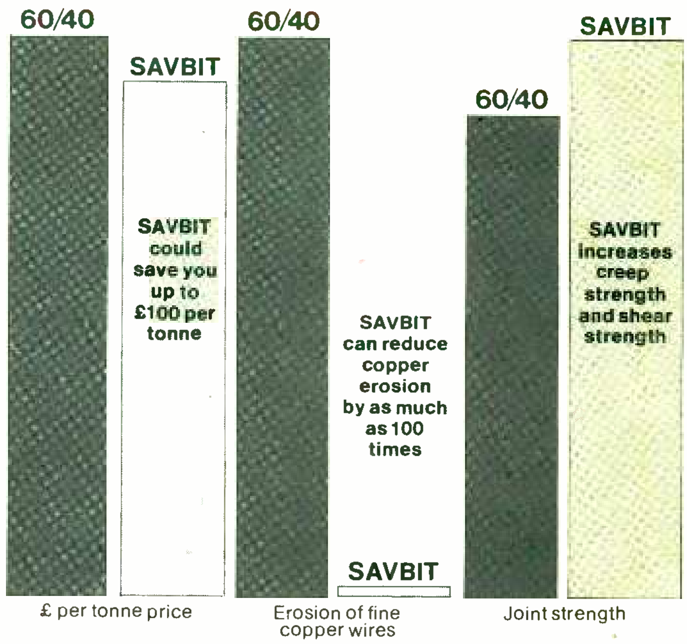
As this diagram shows,* compared with a 60/40 alloy, Savbit can reduce the dissolution of copper by as much as 100 times. Yet wetting rate, flow, conductivity and capillary force are almost identical – with creep strength and shear strength actually increased.

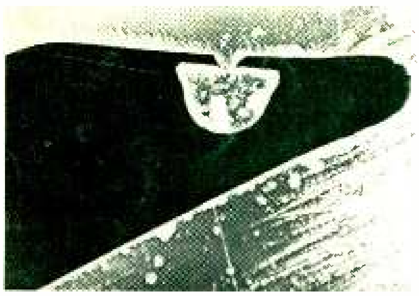
*(Indicative of product advantages only; not to scale)



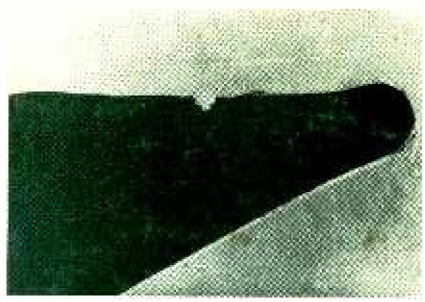
...and more

Some people think Savbit alloy is only usable with plain copper soldering iron bits, but this isn't true.

As these photographs illustrate dramatically, Savbit also saves significantly on the cost of iron-plated soldering iron bits, which have a copper core. This is exposed through cracks in the plating.



Cracked iron-plated bit, after 40,000 simulated operations using 60/40 Solder.



Cracked iron-plated bit, after 40,000 simulated operations using SAVBIT Solder.

Add this advantage to the increased reliability and joint quality Savbit offers, and you'll understand why more and more 60/40 users are making the change – and profiting. The Ministry of Defence have given a special new Approval No. DTD 900/4535A for Savbit alloy with ERSIN 362 flux to be used in lieu of Solders to B.S. 219 and B.S. 441.

ERSIN Multicore

For full information on Savbit or any other Multicore products, please write on your company's letterhead direct to:

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