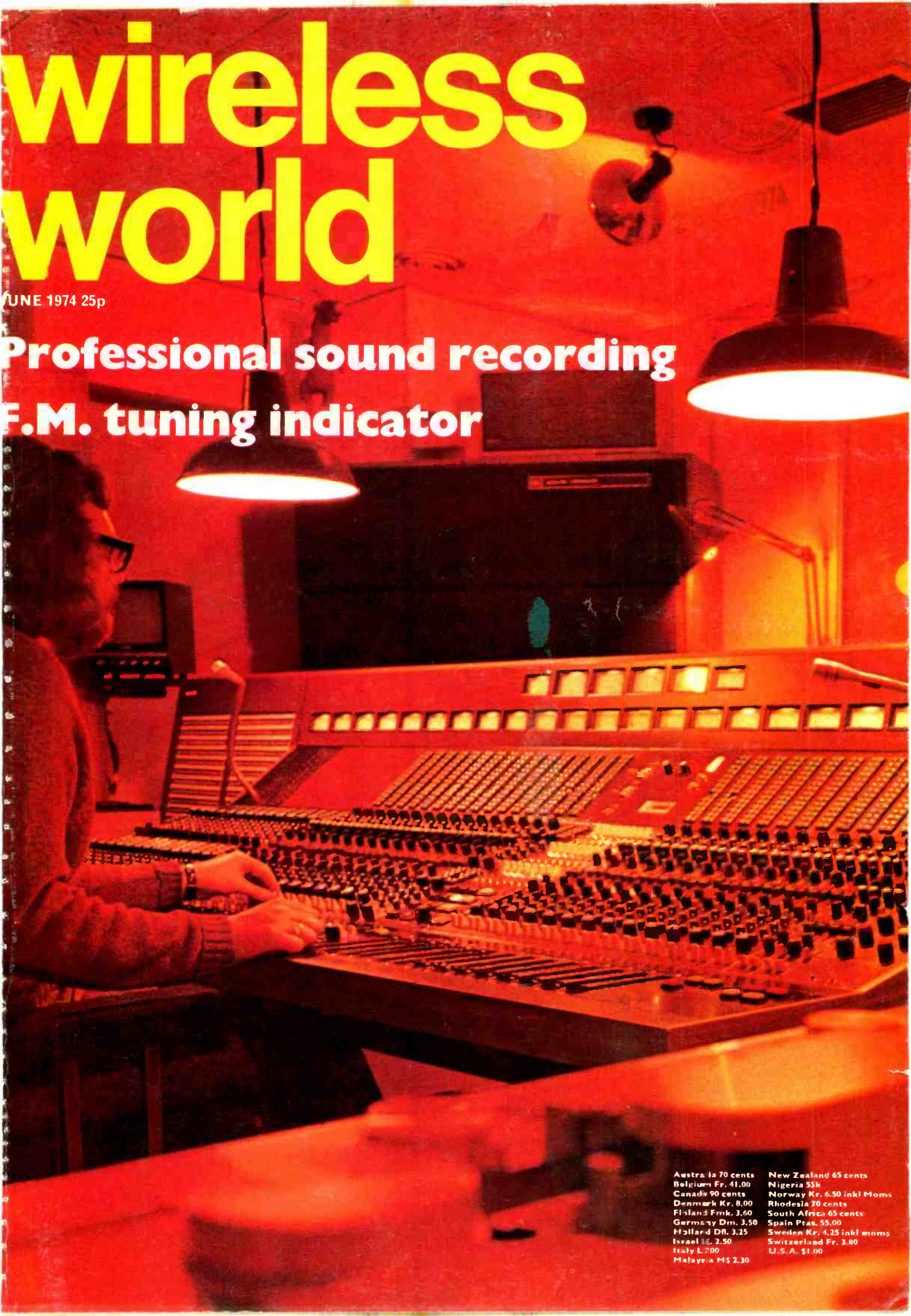
wireless world

JUNE 1974 25p

Professional sound recording

F.M. tuning indicator



Australia 70 cents
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New Zealand 65 cents
Nigeria 55k
Norway Kr. 6.50 inkl Moms
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BRADLEY services

Don't call us! We'll call you!

We know how easily sophisticated instruments can drift imperceptibly away from standard. So, after we've repaired, calibrated and returned your equipment to you, we make a note to remind you when a periodic check or recalibration should be carried out.

Jogging the memory is just one of the little, extra details that help to make up the Bradley Repair and Calibration Service; but, of course we need to hear from you in the first instance.

R & C is a separate division of Bradley Electronics with its own 20,000 sq. ft. factory next door to the main London works. We've been rejuvenating instruments for more than 20 years, during which time we've handled virtually every type and make in common use – from simple meters to complicated systems. We will tackle anything in the frequency range DC to 18 GHz and return it to you ready to plug in.

If you need authenticated performance in addition to our normal guarantee, our Standards Laboratory is approved by the British Calibration Service. It will supply calibration certificates for AC, DC and RF measurements. And our standards, of course, are directly traceable to the NPL and the National Bureau of Standards.

And just to add the finishing touch, we will collect and deliver anywhere in mainland Britain.

BRADLEY electronics

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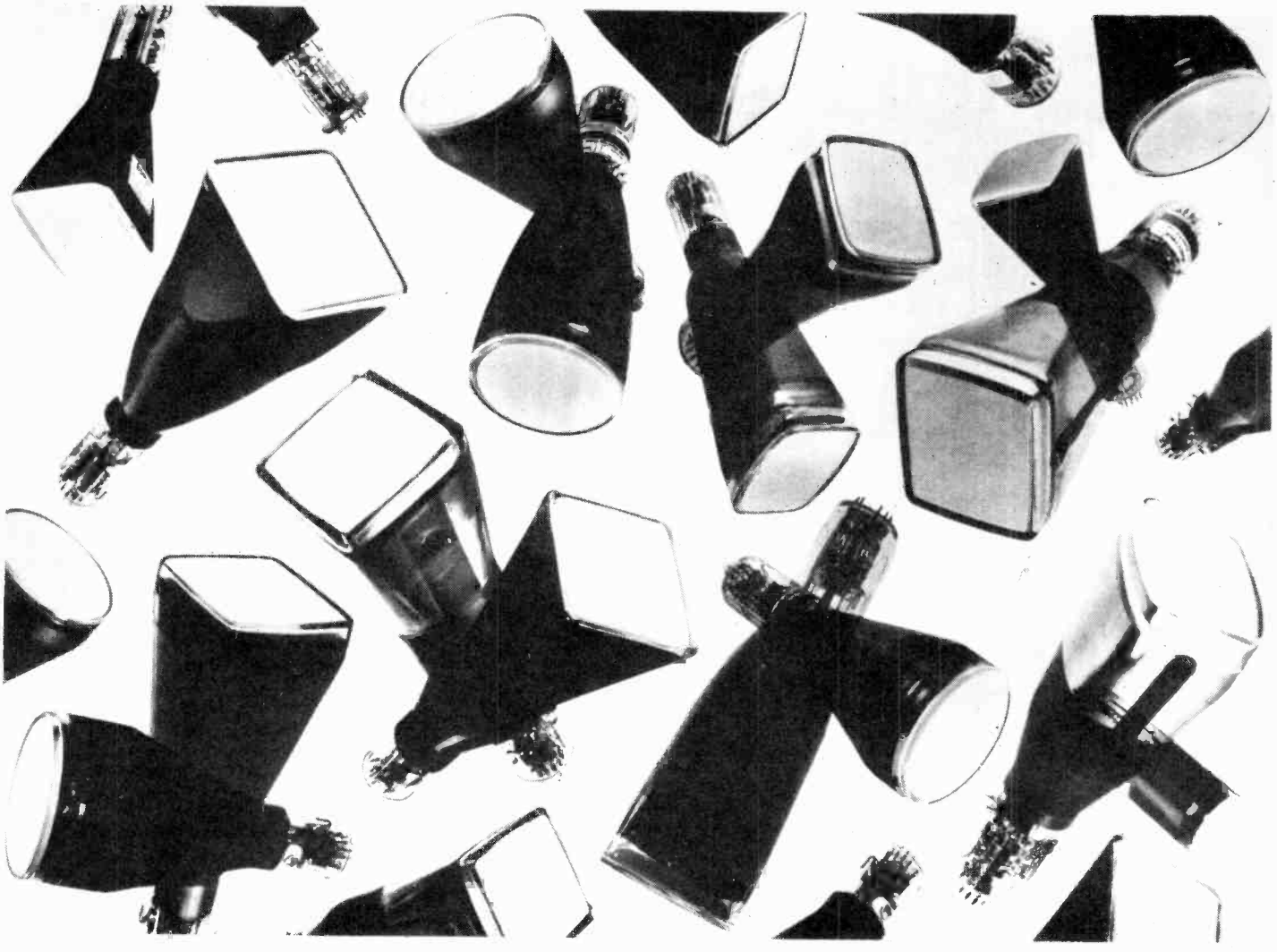
Telephone: 01-450 7811 Telex: 25583

WW—001 FOR FURTHER DETAILS



The many faces of BRIMAR

reveal the biggest current range of oscilloscope tubes in Europe.

Whenever it's a matter of designing or making an oscilloscope, remember one essential fact. Brimar have a complete range of tubes for operation up to 75/100MHz bandwidth. Many with ex-stock delivery.

The fact is: the current Brimar range of tubes is the largest in Europe — with as many as twenty-five different versions to choose from.

Brimar are continually revising and updating their range to meet the demands of the market. The latest additions are the D10-230 and D10-240 (4″ compact flat-faced tubes) and the D16-100 (XY plotter)

The quality of Brimar tubes is unquestionably good. Improve your scope — telephone or write for full or abridged data and prices 01-804 1201

TYPES TO ASK FOR:		
D3-130	D13-51	D14-172
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D7-201	D13-600	D14-200
D10-210	D13-601	D14-210
D10-230	D13-610	D16-100
D10-240	D14-150	SE4D
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D13-33	D14-171	SE5F
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BRIMAR

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Mollison Avenue,
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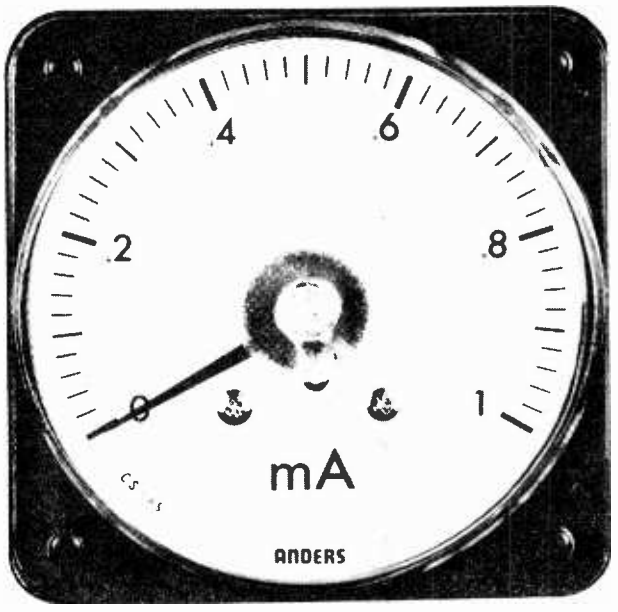
WW—006 FOR FURTHER DETAILS

ANDERS MEANS METERS...

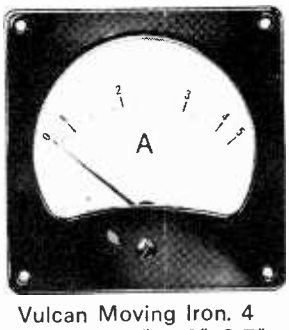
OXFORD LONG SCALE 250°

- **Now available, long scale meter to satisfy budgetary requirements for low cost equipment.**
- Models CS65 and CS85 with scale lengths of 6″ and 7·75″
- OEM quantity prices extremely competitive
- 500μA upwards, DC or AC rectified
- Shadow-free dial—easy to read scale

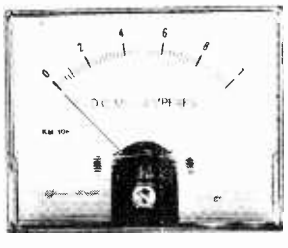


Anders provide what is probably the largest range of meters available from a single source in Europe: MC/MI, dynamometer, vibrating reed, electrostatic, etc. in over 100 case styles and sizes, a few of which are shown below.

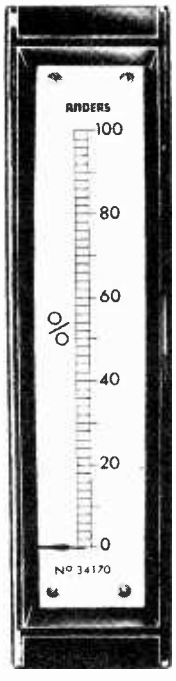
Popular models and ranges are stocked in depth while a specially equipped instrument department enables swift production of non-standard ranges and scales, to suit individual customer requirements, in large or small quantities.



Vulcan Moving Iron. 4 models, 1·5″, 1·8″, 2·7″, 3·7″ scales. Voltmeters, ammeters and motor starting meters.

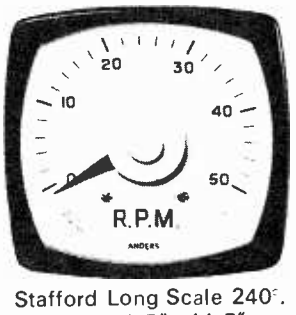


Kestrel Clear Front. 7 models, 1·3″—5·25″ scales. DC moving coil, AC moving coil rectified, AC moving iron.

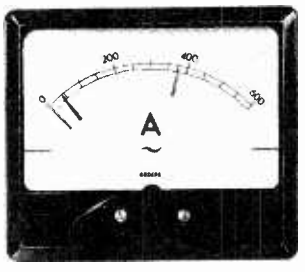


Profile 350 edgewise 4·3″ scale.
DC moving coil and AC moving coil rectified.
Horizontal or vertical mounting.

Models KE1 and KE2 Miniature Edgewise Meters. Nominal scale lengths 1.2″ and 2″. Available in sensitivities from 50 microamps Moving Coil.



Stafford Long Scale 240°. 6 models, 3·5″—11·5″ scales. DC moving coil, AC moving coil rectified, AC moving iron. Also 98° scale.



Solicontroller Moving Coil Relay. DC moving coil and AC moving coil rectified. 1 or 2 adjustable alarm controls.

Lancaster Long Scale 240°. 2 models, 4″, 5·5″ scales. DC moving coil and AC moving coil rectified.

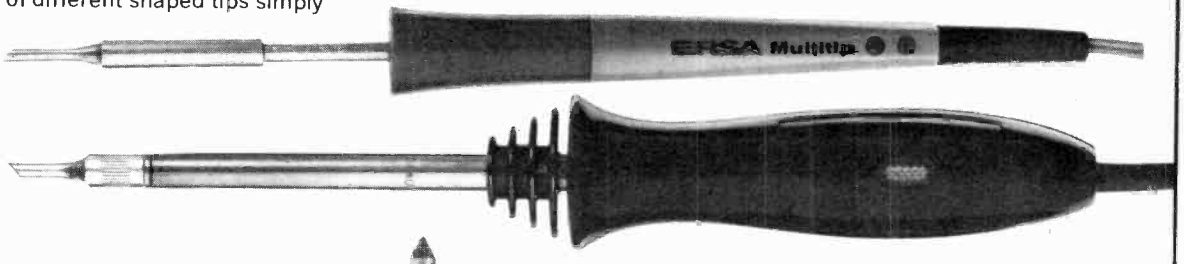
ANDERS ELECTRONICS LIMITED 48/56 Bayham Place, Bayham Street, London, N.W.1. Telephone 01-387 9092.

Manufacturers and distributors of Electrical Measuring Instruments. Sole U.K. distributors of FRAHM Resonant Reed Frequency Meters and Tachometers. Manufacturers of purpose built electrical and electronic equipment to customers' requirements.

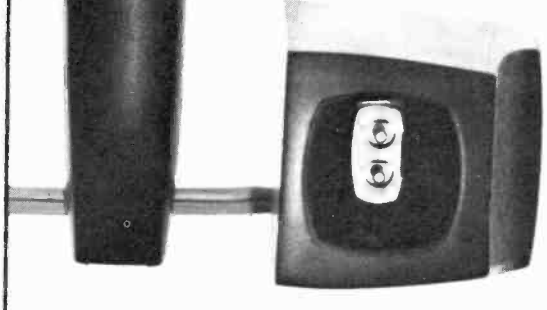
WW—007 FOR FURTHER DETAILS

The Greenwood guide to professional soldering.

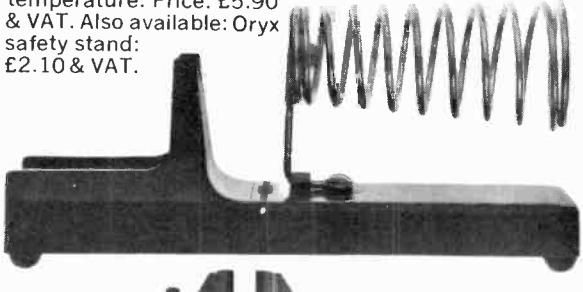
The Ersa Multitip. A top-quality iron that's ultra-light, offering reliability so necessary to achieve constant production flow. A range of different shaped tips simply push onto the stem of the iron. It has the unique advantage that you can change the element in seconds. Price: £3.20 & VAT.



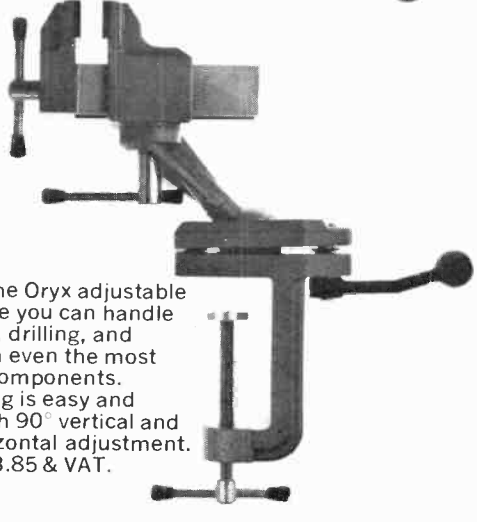
The Iso-Tip. A safe, high-powered iron which works anywhere without a mains lead. The breakthrough? Nickel Cadmium cells that are re-chargeable. (A charging stand is included for 240v or 115v A.C.) Each charge gives at least 60 soldering joints. Weight? Only 6oz. Price: £10.70 & VAT.



The Oryx 50. A temperature controlled mains soldering iron. (Temperature control within ± 2%.) Adjustment (200°–400°C) can be made whilst iron is operating using the same tip. Light, compact and easy to handle. A large 50W element loading gives rapid heating and high performance with constant tip temperature. Price: £5.90 & VAT. Also available: Oryx safety stand: £2.10 & VAT.

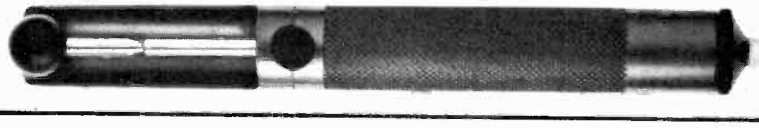


The Ersa Sprint. Unique – it heats up to maximum temperature in only 10 seconds, and is the lightest gun on the UK market. Ideal for the service-man. With its lightweight (only 7oz.) and compact construction, it can be manoeuvred in even the most awkward areas. Price: £5.95 & VAT.



With the Oryx adjustable bench vice you can handle soldering, drilling, and cutting on even the most delicate components. Positioning is easy and quick, with 90° vertical and 360° horizontal adjustment. Price: £13.85 & VAT.

Oryx SR3A desoldering tool. Ideal where components are tightly grouped. Instantly removes unwanted solder from printed circuits etc. Accurate, reliable, speedy, and safe. Price: £4.50 & VAT.



Greenwood Electronics offer a range of highly advanced products specifically for professional soldering applications.

For more detailed information about the comprehensive Greenwood range, send us the coupon today.

Please send me more details about the Greenwood range of soldering equipment.

Name _____

Address _____

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WWI

Greenwood Electronics

21 Germain Street, Chesham, Bucks, HP5 1LL
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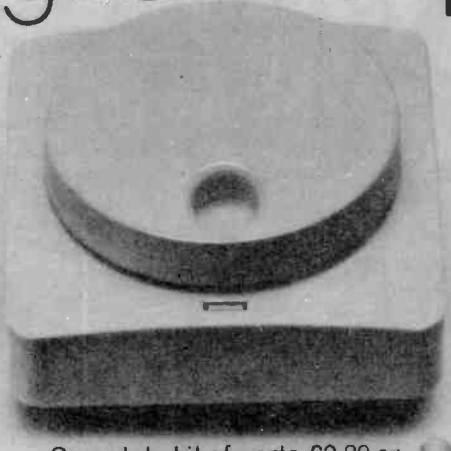
WW—008 FOR FURTHER DETAILS

Cool lighting **for hot parties.**

Velvet dim to full brightness at a touch of the finger. Off/on and infinitely variable.

Beta light glow makes switch easy to find in the dark and consumes no current.

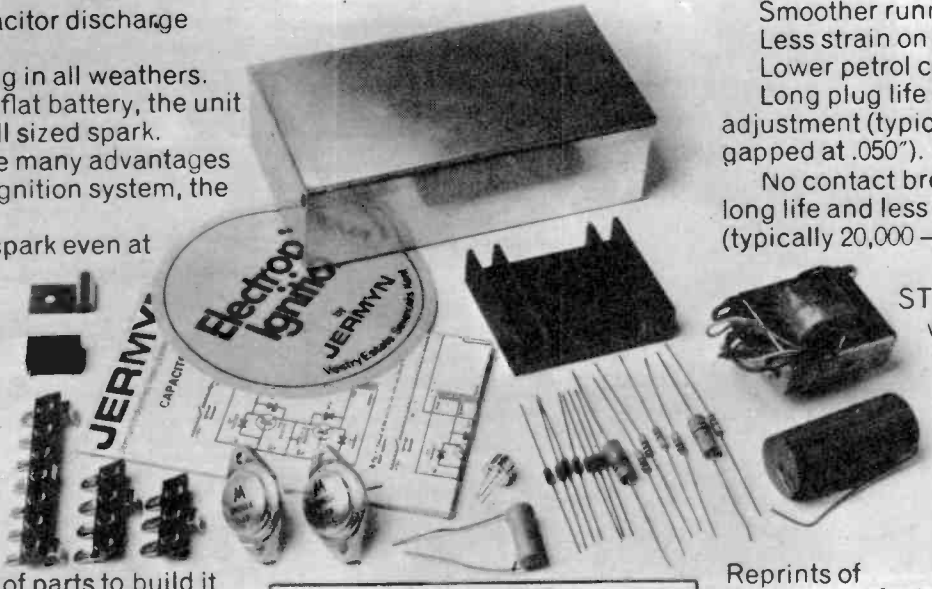


Economical too!
As the light is progressively dimmed, so the current consumption drops – think of it as an electric tap. 300 watt capacity, straight replacement for standard light switch.

Complete kit of parts £2.80 or made up £2.90

Hot Ignition for cold mornings.

The Jermyn capacitor discharge ignition system.
Instant starting in all weathers. Even with a near flat battery, the unit will produce a full sized spark.
Just one of the many advantages of an electronic ignition system, the others are:
High energy spark even at maximum revs.



Smoother running.
Less strain on battery and starter.
Lower petrol consumption.
Long plug life with infrequent adjustment (typically 20,000 miles, gapped at .050").
No contact breaker arcing giving long life and less adjustment (typically 20,000 – 25,000 miles)

STATE + or – earth when ordering.

Complete set of parts to build it yourself for only £7.75, as described in Practical Wireless and fully approved by the author.

Save 55p
Buy both for £10.00

Reprints of the two part feature are available at 25p.

To Jermyn Industries, 154 Vestry Estate, Sevenoaks, Kent. **All Prices Exclusive of VAT.**
Please despatch return of post ..... light dimmer kit ..... light dimmer .....
Ignition Kits ..... + or – earth ..... £10 pair, Enclose cheque or postal order.
BLOCK CAPITALS
NAME.....
ADDRESS.....
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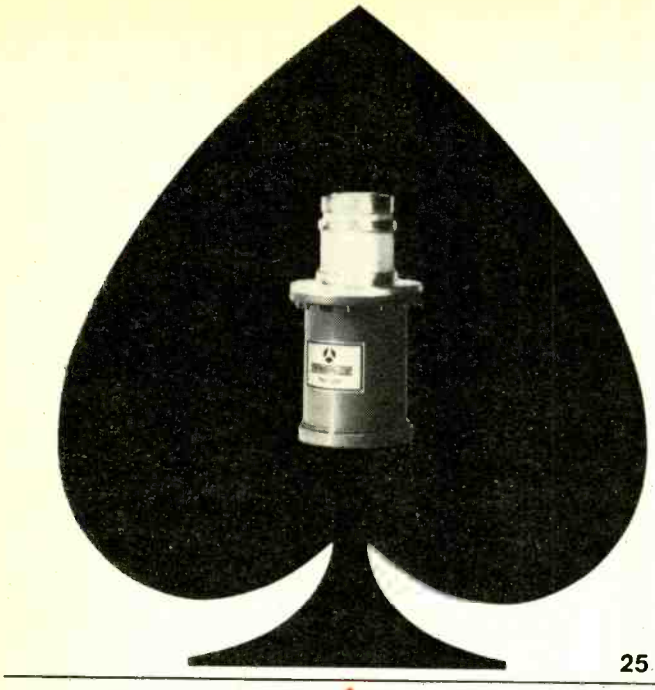
JERMYN

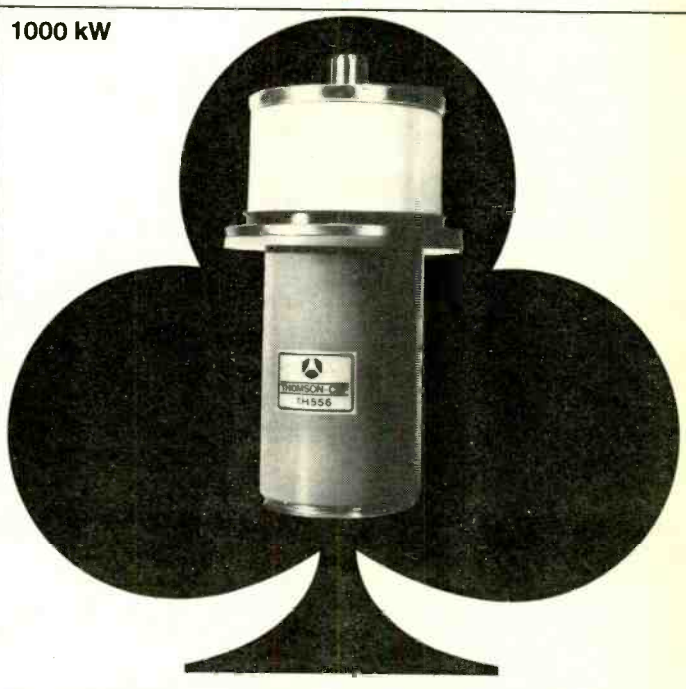
WW—009 FOR FURTHER DETAILS



25 kW

100 kW

250 kW



1000 kW

From 25 kW up to one megawatt...

... four RF-heating aces, every one a winner!

Annoucing a whole new deal for RF-heating – a new generation of rugged metal/ceramic triodes, especially designed for this application. Incorporation both the latest progress in vapour-phase anode cooling – **Hypervapotron*** – and our revolutionary advance in grid technology – **Pyrobloc***, these four tubes represent today's state-of-the-art in power grid triodes. In various standard single-tube or multi-tube installations, they deliver anywhere from 20 kW up to 2 MW of CW RF power for industrial thermal treatment. These four new tubes are the latest addition to our full line of triodes, for economical and reliable induction or dielectric-loss heating. For more details on them or any of our other tubes, contact us directly or just circle the appropriate number on the Readers' Service Card.

* Registered trade mark

THOMSON-CSF

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2034

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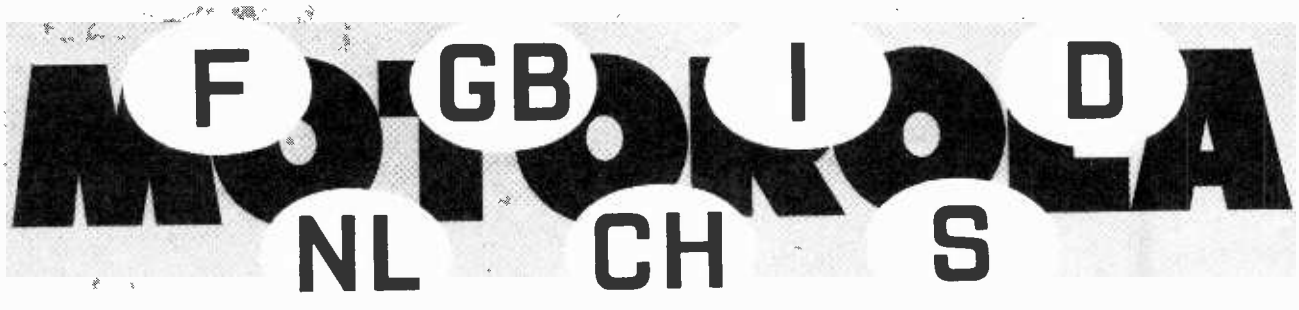
Designed in Europe.

Computer aided design operation in Geneva.

Made in Europe.

Manufacturing plants at Toulouse and East Kilbride...



Distributed throughout Europe.

8 Motorola marketing companies, 36 distributorships.

With Motorola, European industry can enjoy direct access to the full breadth of experience and expertise of a semiconductor manufacturer completely committed to the European market.

Motorola's all-embracing computerised IC design centre at Geneva covers MOS, Linear and Digital ICs. And there's a direct data link between Geneva and all Motorola European factories and marketing companies.

Manufacture is based at East Kilbride in Scotland and Toulouse in France. Both factories are equipped with diffusion facilities—and concentrate primarily on RF power, MECL, MOS, discrete power devices and linear ICs.

Motorola has its marketing companies in most European countries with sales offices in many principal cities—in addition to a complete network of 36 distributors.

This investment in technical skill, design and productive capacity enables Motorola to maintain a close technical dialogue with the advanced industries of Europe—computer, communications, industrial, consumer and automotive.

MOTOROLA Semiconductors

Motorola Semiconductors Ltd.,
York House, Empire Way, Wembley. Tel: 01-902 8836.

WW—011 FOR FURTHER DETAILS

The one you can't ignore!

Remote control unit (optional)

Our picture illustrates some of the U-type JVC VCR features. They are not the only ones that matter.

For instance. You can use any colour or monochrome receiver or monitor to view your recordings. Automatically repeat or return to a scene of interest. And the picture is always locked in colour before it is displayed.

Such excellent features, in fact, that you ought not to buy a video cassette recorder until you've seen the complete specification of the JVC machine. **And it is available now.**

In addition to the CR 6000E $\frac{3}{4}$" U-type recorder/player there is the CR 5000E for playback only. CR 6000E, price from £749 ; CR 5000E, from £664 (prices exclude VAT).

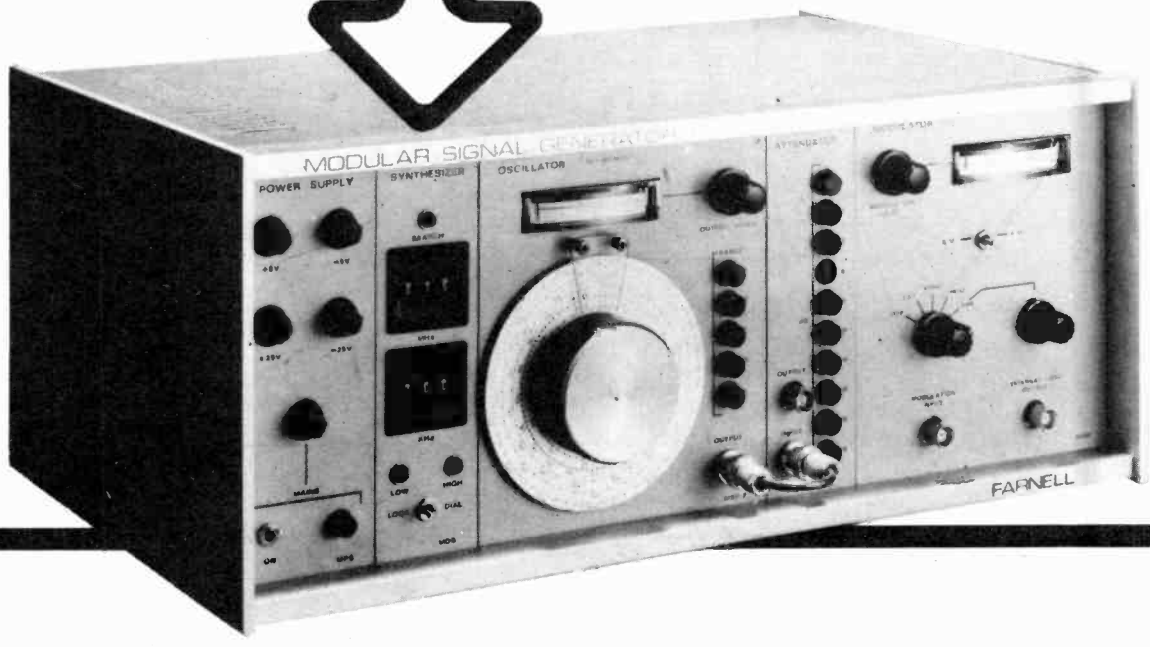
We'd like to tell you more. Telephone Bell & Howell's Video Systems Division on 01-902 8812 or write to Bell & Howell A-V Ltd., Freepost, Wembley, Middlesex, HA0 1BR (no stamp required).

BELL & HOWELL

JVC U VCR

WW—012 FOR FURTHER DETAILS

Thanks to this new module . . .



. . . we can offer an accurate and drift-free phase-lock synthesized signal generator for around £800

The Farnell range of modular signal generators now includes synthesized models, M1/ADM and M2/ADM, to cover frequency ranges of 100kHz to 12MHz and 10MHz to 108MHz respectively.

Frequency is controlled by a six decade bank of thumbwheel switches to an accuracy of ± 5PPM. The oscillator automatically chooses the correct range and seeks the required frequency, a search lamp extinguishing when it has found it. And there the frequency will stay with crystal accuracy and stability until an alternative is selected. A 1kHz frequency change takes only milliseconds and a change as wide as 10MHz to 100MHz (which involves four range changes) is completed in about five seconds.

Like all Farnell r.f. signal generators and sweepers, there is facility for remote programming via TTL compatible BCD 1248 inputs through a rear connector.

Narrowband sweep application.
The M1/ADM is an excellent narrowband sweeper ideal for setting up receiver filters or discriminator circuits on an individual or production line basis.

Centre frequency is controlled with crystal accuracy and stability by the digital synthesizer module while the frequency modulator unit is used to provide sweep. Full a.m./f.m. modulation facilities are available after alignment tests.

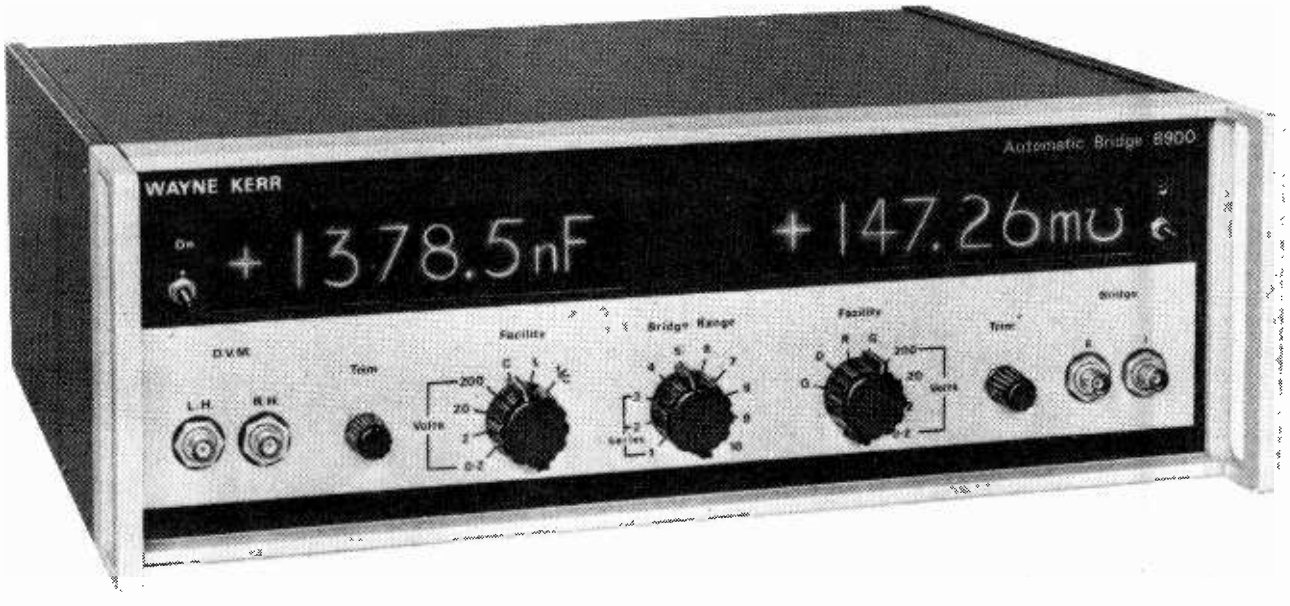
For details of all Farnell r.f. test equipment contact:-

FARNELL INSTRUMENTS LIMITED,
TELECOMMUNICATIONS DIVISION,
SANDBECK WAY, WETHERBY,
LS22 4DH. YORKSHIRE.
TEL: 0937 3541, TELEX 557294
LONDON OFFICE TEL : 01-802 5359

Farnell

WW—013 FOR FURTHER DETAILS

New automatic digital bridge from Wayne Kerr



Wayne Kerr's new B900 is one of the best value-for-money bridges in the world.

It is universal, has a wide range, and gives immediate digital readout of resistive and reactive terms–simultaneously.

On all ten ranges, for every type of measurement available, the displays provide a complete indication of the numerical value (up to 19999), polarity, decimal points and units–automatically and in half a second.

Direct measurements of Q, dissipation and dc volts.
2, 3, & 4–terminal. Automatic lead compensation.
4–Quadrant: +ve or −ve C, L, 1/C, G and R.
Overall coverage:

10μΩ	– 200MΩ	1nH	– 20 kH
0.001pF	– 20,000μF	10p℧	– 200℧

Accuracy: 0.1% (10Ω–200MΩ), 0.3% (10mΩ–10Ω) in all quadrants. Frequency: 1kHz Outputs: Analog and TTL.

For more information phone Bognor (02433) 25811, or fill in the coupon.

WAYNE KERR
A member of the Wilmot Breeden group.

Please send me details of the B900.

For the attention of Mr_____

Company name and address_____

_____

_____

_____

WW—June

Post to Wayne Kerr, Durban Road, Bognor Regis, Sussex PO22 9RL

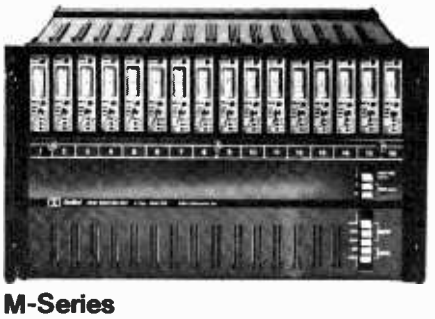
WW—015 FOR FURTHER DETAILS

There is a Dolby noise reduction unit for every professional application

Professional Recording and Transmission Applications

360
The Dolby 360 is a basic single-channel A-type noise reduction unit for encoding or decoding. This unit is normally used in a fixed mode such as in disc cutting or landline sending or receiving; the operating mode is manually selected.

361
The Dolby 361 is similar to the 360, providing a single channel of A-type noise reduction, but with relay switching of operating mode and tape recorder connections. The changeover can be controlled automatically by the recorder.



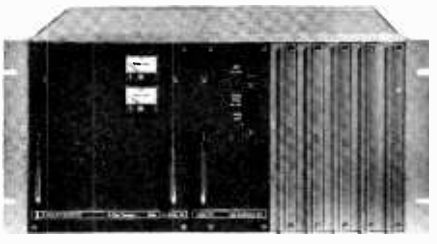
M-Series
The Dolby M16 A-type unit is designed specifically for professional multi-track recording, and incorporates 16 channels of noise reduction in a compact chassis only 10½ inches high. The similar M8 is an 8-track version, and the M8X allows simple extension of the M16 for 24-track use.

Motion Picture Industry

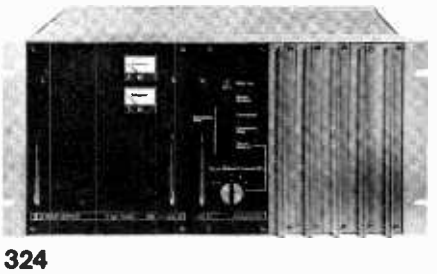
364
The Dolby 364 Cinema Noise Reduction Unit is intended primarily for use with Dolby A-type encoded optical sound-tracks. The 364 also includes a standard 'Academy' filter for conventional tracks, a clean-up circuit for old or worn prints, and provision for playback of magnetic sound-tracks with or without Dolby system encoding.

E2
The Dolby E2 Cinema Equalizer is a companion unit to the 364, and has been specifically designed to solve the response equalization problems of cinemas. Used with the 364 and Dolbyized optical sound-tracks, the E2 enables most cinemas to achieve modern sound reproduction standards without replacement of existing equipment.

Professional Encoders for Consumer Media

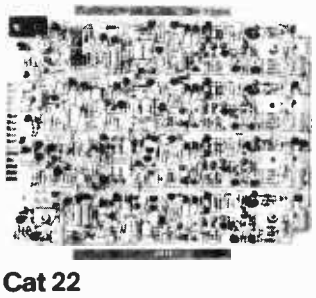


320
The Dolby 320 Duplication Processor is a professional quality unit with B-type (consumer) noise reduction characteristics. The unit is used for encoding duplication master tapes in the high-speed duplication of Dolbyized cassettes, cartridges, and open-reel tapes. The 320 is a two-channel unit.



324
The 324 Broadcast Encoder allows broadcast stations to encode stereo FM broadcasts with the Dolby B-type characteristic. The unit provides for an optional reduction of high frequency pre-emphasis, reducing the need for high frequency compression, and thus allowing a significant additional improvement of reception quality.

Noise Reduction Module



Cat 22
The Dolby noise reduction module, Cat 22, is the basic functional unit employed in all A-type equipment. The Cat 22 is available as a spare or in quantity to OEM users for factory installation. A half-speed version of the module (Cat 40) is also available.

Test Set (A-type)

Cat 35
The Dolby NRM Test Set, Cat 35, permits rapid verification of performance of Cat 22 Noise Reduction Modules without their removal or the need for additional test equipment.

Dolby™

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COMMUNICATIONS CONTACT

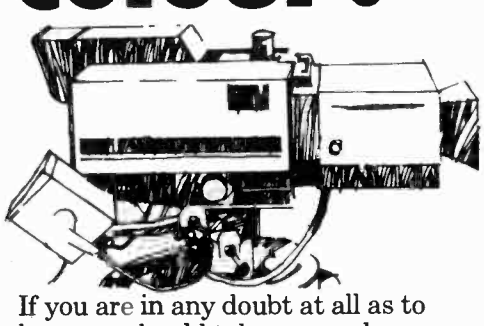
4 PAGES of news from Mullard

If you come to Brighton for the Communications 74 Exhibition, contact us at Mullard on stand 80/81. You will be very welcome. Contact us anyway whenever you need components for telecoms, broadcasting, radar and navaids.

We have unique resources for their development and production, and have devoted literally millions of pounds to meeting the component needs of manufacturers of communications equipment.

Some of our products are well-established favourites, others are at the forefront of current technology. Some are made on an extremely large scale, some are customer specials. Please let u know of your own particular requirement.

Tubing up for colour?



If you are in any doubt at all as to how you should tube your colour television cameras, remember that a pretty convincing case can be made for Plumbicon* tubes.

Reliability is a major reason. Millions of burning hours are being clocked up by the 2,000 or so tubes which have been put into broadcast service in the UK. Programme companies are reporting lives of well over five . . . six . . . and seven thousand hours. In telecine equipment lives of over ten thousand hours are not uncommon.

Continual development, also, has kept the Plumbicon tube out in front. The 1¼-inch tube has been supplemented by high resolution 1-inch tubes with and without light bias. And types are available with response in the red region extended to approximate more closely to the human eye. Also, there are now ⅝-inch tubes and tubes with increased performance to volume ratios are being developed.

Altogether there are 36 Plumbicon tubes in the Mullard range. All are summarised in a wall-chart. Use reader enquiry service no. 100 and a copy will be sent to you.

*Registered trademark for television camera tubes.

ZENERS just the way you want them.

You can get Mullard 400mW and 1W Zener selected for voltage and other parameters t meet your own exact specifications. Voltag can be within 1% if you want them that wa

Quantities of up to 2,000 can be supplied with fast delivery through the Mullard SOSWIFT Service. Bulk selections over 2,000 pieces can be made to negotiat delivery times through the SELECT 61, 79 88 Services.

400-milliwatt types.

BZY88: DO-7 glass encapsulation 3·0 to 36V.

SOSWIFT Service and SELECT 88 Bulk Selection Service.

BZX79: DO-35 miniature glass encapsulati 4·7 to 75V.

SELECT 79 BULK Selection Service.

1-watt types.

BZX61: DO-15 plastic encapsulation 7·5 to 75V.

SOSWIFT Service and SELECT 61 Bulk Selection Service.

Please use reader enquiry service no.101. for data on all the above types.

Mullard Communications Contact

DON'T 'MAKE DO' WHEN CHOOSING CORES FOR SWITCHED MODE POWER SUPPLIES

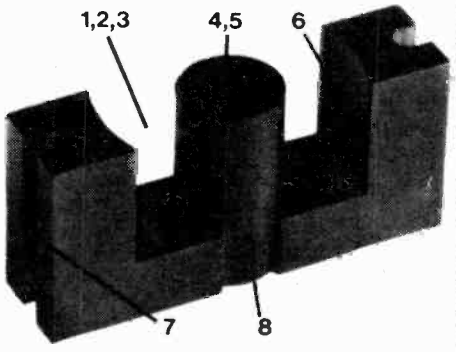
You can 'make do' when choosing ferrite cores for switched mode power supplies for telecommunications equipment. But you don't have to any more. Mullard have thoroughly investigated this field of application and are introducing a new range of cores specially designed for switched mode power supplies.

Insulation and safety, the special stresses imposed by switched mode operation, winding economics, modes of circuit failure, mechanical specifications and BSI requirements . . . all have been given extremely careful consideration.

The resulting range of purpose-built cores are made of a new ferrite material, Ferroxcube A16. Unlike most other ferrite materials, it may be used at temperatures of up to 100°C and even beyond without saturation occurring. Also, its resistivity is high and effective total core losses in switched mode inverter transformers–that is at high flux densities and at frequencies in the region of 25kHz–are low.

The shape of the new cores has also been specifically tailored for switched mode power supplies. It is in effect that of a pot core with the sides cut away to allow 'lead out' space for copper strip and multiple windings. The pot-core-like outer limbs partially shroud the centre limb and prevent excessive field radiation. Also, the winding window is long enough to meet double insulation requirements, in particular, insulation requirements IEC65 and BS415, and to keep leakage inductance within acceptable limits.

Purpose designed cores



1. Ample lead-out space
2. Generous space for lead-out separation
3. Optimised for minimum leakage inductance
4. Round section for snug winding
5. Minimum circumference for winding economy
6. Partial shrouding of centre limb
7. Grooved for clamping
8. Purpose designed shape

The centre limb cross-section is circular and is of the minimum area for switched mode applications. This keeps winding turn length, and hence eddy current losses in the copper, to the minimum. At the same time, there is no bowing of the windings which causes the increased leakage inductance experienced with rectangular section cores.

The new cores are used in pairs, and grooves in their outer limbs allow them to be clamped together and mounted with two lengths of standard metric studding. The studding can be extended to carry a board for mounting rectifiers, thus keeping connections to the shortest possible length.

There are four sizes of core and all are intended for use in switched mode power supplies operating at frequencies above the audio range, for instance at 25kHz. They may be used in units where the input is derived from rectified mains or from d.c. supplies such as batteries, and are suitable for designs covering a wide range of d.c. outputs.

When used in 25kHz push-pull circuits at the unfavourable end of the application spectrum (supplying low voltage, 5V, output) the cores are rated for the maximum transformer temperature of 100°C as follows: type FX3720 for 50W supplies, type FX3730 100W, type FX3740 200W, and type FX3750 for 500W supplies. Coil formers will be made available for use with all types.

An application note is available which not only simplifies transformer design but helps to save time, money and trouble elsewhere in the circuit. For a free copy and data on all four cores please write to Dept. C.I.H., Ref. CPS/C20, Mullard Ltd., New Road, Mitcham, Surrey CR4 4XY.

UHF/MICROWAVE PHASE LOCKED OSCILLATOR

Customer options offered.

A u.h.f./microwave phase-locked oscillator with a number of customer options is being announced by Mullard. It features extremely high stability and freedom from spurious signals and unwanted harmonics, and has a basic output of 0·5 to 1W at 0·9 to 1·5GHz.

All the merits of lumped, distributed, three-dimensional and microwave integrated circuit technologies are combined in its design. The result is an extremely compact, lightweight and reliable unit.

It can be supplied with an integral reference oscillator having a stability of ±0·0005%. Alternatively, an external oscillator can be provided which has a stability of up to 1 part in 10^8 per year.

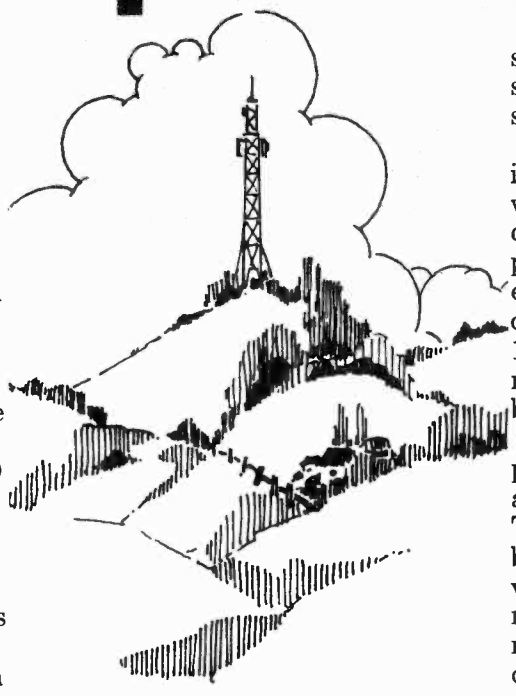
Provision can be made for the acceptance of either frequency or phase modulating signals. The unit can therefore be used as a completely self-contained and very effective transmitter or as a stable local oscillator for microwave link satellite communications and radar systems.

Among other options available are output circuits giving outputs from 300MHz to 36GHz in c.w. or pulsed systems, and amplifiers providing outputs of up to 10W.

Use reader enquiry service no. 102 for a leaflet giving further information.

TV Transposer service calls for super components

Transmitters which are unmanned, and for part of the year possibly inaccessible, obviously call for outstanding components. This is particularly the case with TV transposer stations. Here, transistors and tubes must be not only highly reliable, but extremely stable and linear.



Ultra-linear triodes.
Mullard tubes for transposer service are ceramic-metal triodes specially designed for the job. Types YD1300 and YD1302 are of planar electrode construction and are intended for 25 and 50W operation in band IV and V combined vision and sound transposer transmitters. Linearity is of a very high order and the inter-modulation distortion is better than 55dB in a 3-tone test.

A triode in the higher output category is the YD1336 (developed from the YD1332). It is of cylindrical electrode construction and offers outputs of 100 to 200W. Linearity standards are similar to those of the smaller tubes and cross-talk is low.

With these special triodes it is possible to design some transmitters with semiconductor devices in all stages except the power amplifier and so enhance reliability and reduce size.

High performance transistors.
Mullard transistors for transposer service are unique in being designed, specified and guaranteed for this special application.

The d.c. safe operating area is exceptionally large compared with earlier types, making for completely safe operation at high powers in class A and ensuring extremely low intermodulation distortion. Furthermore, they are 100% individually tested for inter-modulation in the manner prescribed by transposer manufacturers.

An advanced diffusion process is employed in which arsenic is used as an emitter dopant. This allows the depth of diffusion to be very accurately controlled and a very thin base is obtained giving a minimum f_T of 2GHz. The maintenance of high performance over long life is assisted by the employment of a sophisticated gold metallisation system.

At 860MHz the most powerful member of the Mullard transposer transistor family, the BLX98, has a power gain of typically 5·0dB, giving a minimum output of 3·5W with intermodulation distortion better than 60dB.

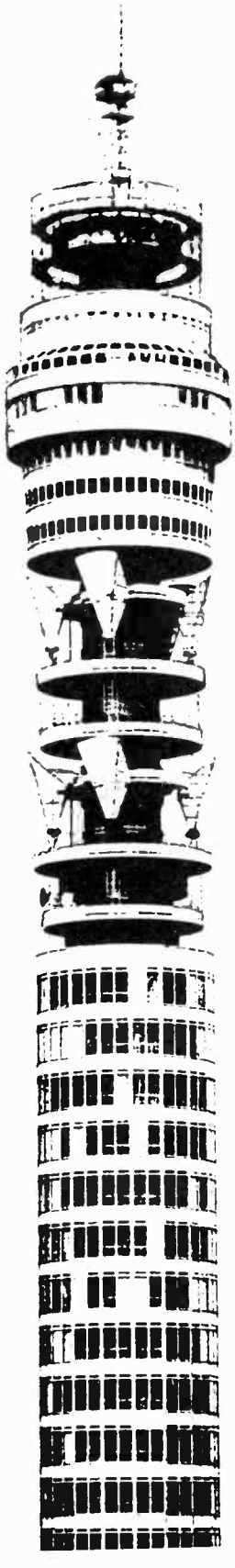
Simpler Gigahertz amplifiers with advanced transistor

The Mullard 551BFY/A transistor is of particular interest to designers of u.h.f. and microwave repeater stations. It is an n-p-n silicon device with a noise figure of 4·0dB at 2GHz and a power gain of 8dB.

Broadband amplifiers with centre frequencies of up to 2 or 3GHz can be designed relatively easily by taking advantage of the high gain of the 551BFY/A. And with it microwave repeaters can be made to operate on a 'straight-through' basis, there being no need for conversion down to an intermediate frequency.

In radar systems, too, and ultra high-speed data communications systems operating at gigahertz bit rates the 551BFY/A is an extremely attractive device. An interesting military application is in electronic warfare countermeasures where it can replace travelling wave tubes in octave band amplifiers.

The typical transition frequency of the 551BFY/A (at f=500MHz) is 5GHz. V_{CBO} max. is 20V, and I_C max. 25mA. Total permissible power dissipation up to ambient temperatures of 60°C is 300mW. A miniature ceramic encapsulation is used which is compatible with strip-line and microstrip circuits.



MORE MULLARD TTL TO TOUGH POST OFFICE SPEC

Mullard have recently gained approval for a further four TTL integrated circuits to the tough Post Office D3000 Class A Specification. This brings the total number of Mullard TTL devices approved and provisionally approved to D3000 to twenty-two, the widest range being offered by any company. The addition of a further eleven types to the range is being considered. Mullard were the first company to supply standard TTL to D3000 and have been doing so since last year.

The specification includes important overstress and endurance tests with exacting internal inspection requirements. It assures an extremely high standard of reliability and long life performance, and users can look forward to a component life of forty years with cumulative failures not greater than 2 per-cent.

The devices are being supplied to Post Office contractors and will be offered to other equipment manufacturers who are concerned with very high standards of reliability. All are functionally equivalent to types in the well-known FJ (74) series, and will be used by the Post Office in switching and digital transmission equipment. Encapsulation is ceramic 14- and 16-lead dual-in-line.

Contact Column

SUB-SYSTEMS PAY OFF

The discrete component is far from dead, and in the world of communications never will be. But as technology advances, many equipment manufacturers are finding it to their advantage to buy in sub-systems, assemblies and modules of various kinds from Mullard. In this way they are saving on design staff and design time, and similarly effecting savings in production time and costs.

Even large manufacturers with considerable resources frequently prefer to buy in sub-systems. The items they require may involve stripline and similar technologies which they cannot call on in-house. Sub-systems do, in fact, frequently demand an expertise which is peculiar to the component manufacturer. The solid-state processes required in the fabrication of thin film modules is another case in point.

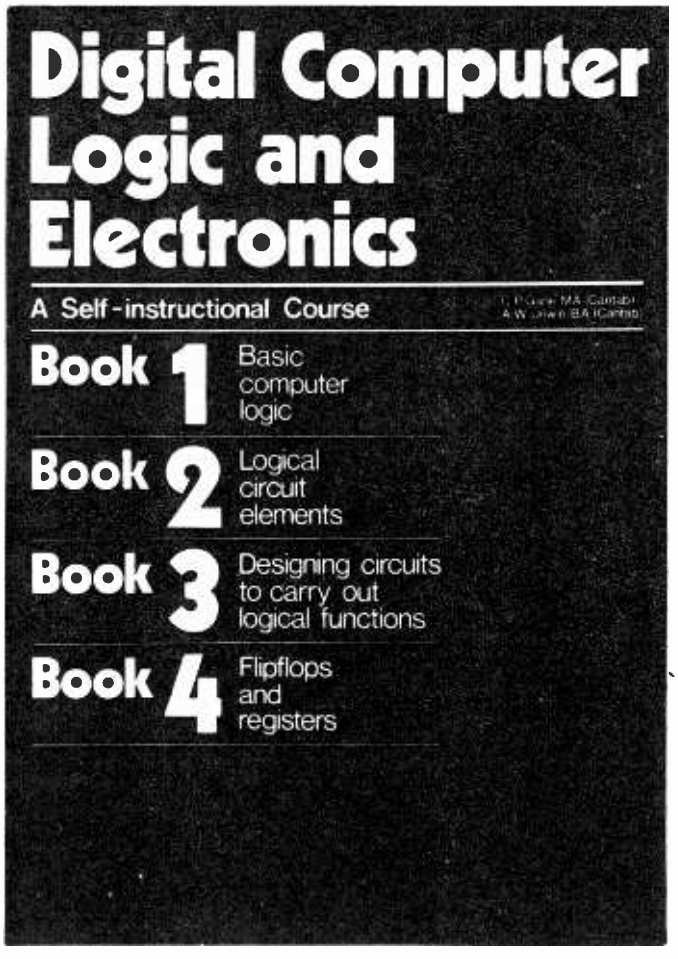
Often an assembly not only demands the same fabrication technology as the discrete component, but is virtually an extension of it. A good example is the range of tuneable cavities which Mullard supply for use with television transmitter tetrodes. The cost of the equipment manufacturer making such cavities himself would be extremely high.

Equally important is the enhanced performance which can be obtained with bought-in sub-systems and assemblies. In some instances, such as the Mullard u.h.f. broadband amplifier modules, the performance would be extremely difficult to obtain with a conventional assemblage of discrete components.

Equipment manufacturers can find out whether a sub-system approach is likely to be advantageous for their own projects by outlining their requirements to Mullard. An individual assessment can then be offered.

by 'Electron'

Join the Digital Revolution



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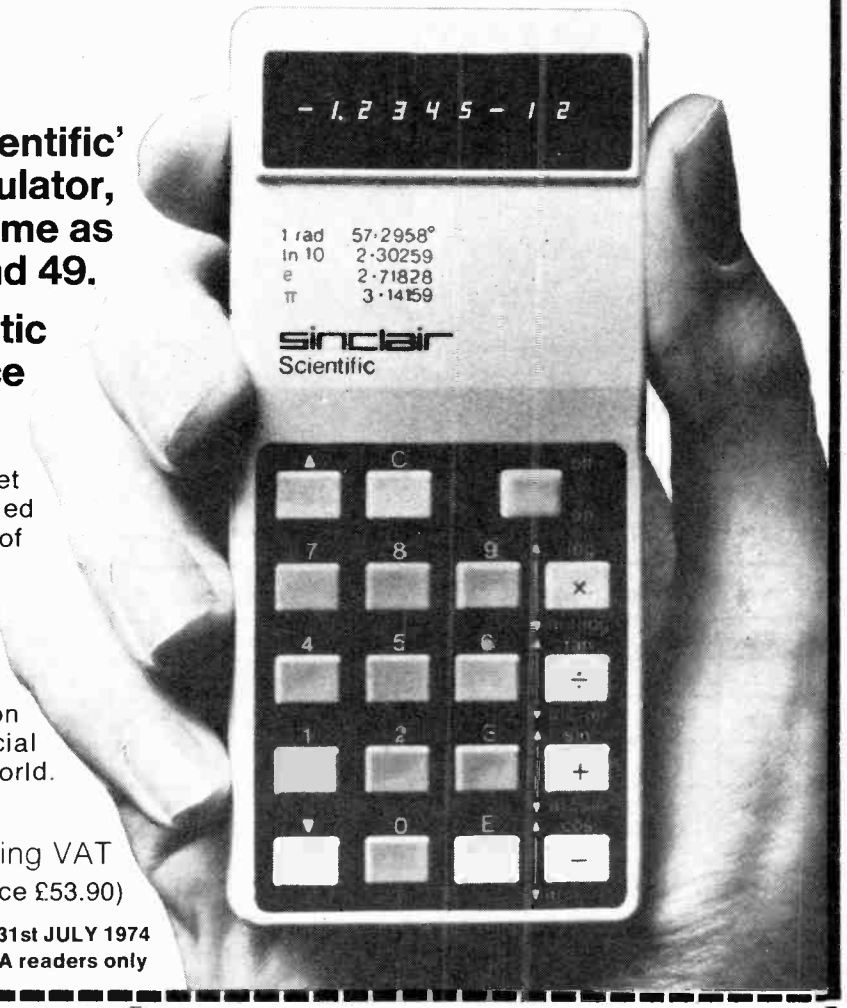

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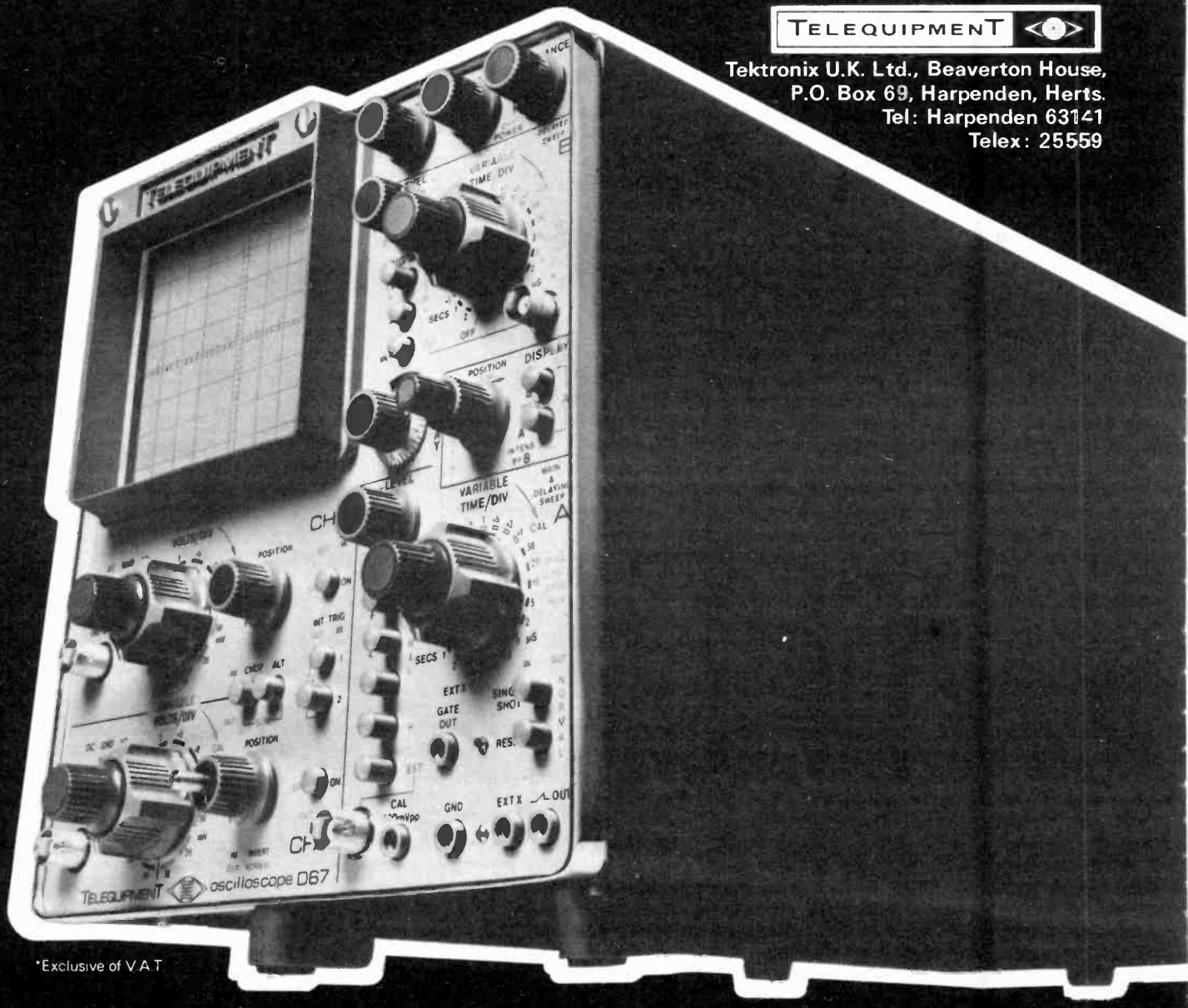

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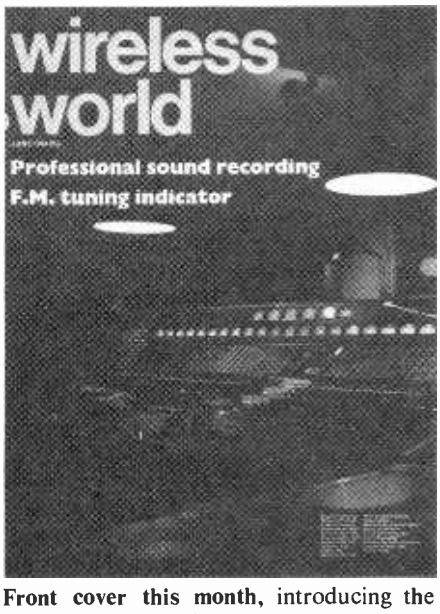
SIXTY-FOURTH YEAR OF PUBLICATION



Front cover this month, introducing the article on professional sound recording, shows the control room at Kingsway Recorders. The custom-built mixing console has 30 input channels, with full monitoring and mixing facilities for 24-track recording.

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IN OUR NEXT ISSUE

(published July 17)

Digital tuning aid. An integrated circuit design to assist in the tuning of keyboard instruments.

Electronic ignition. A comparative analysis of techniques used in car ignition systems.

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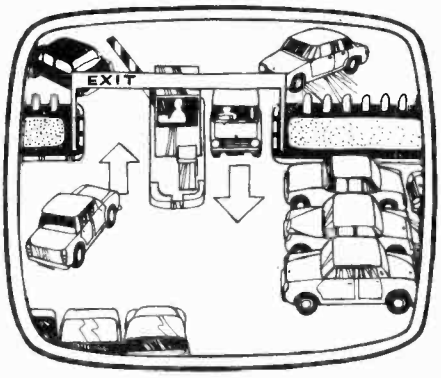

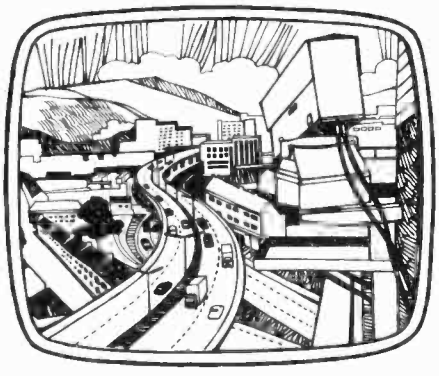

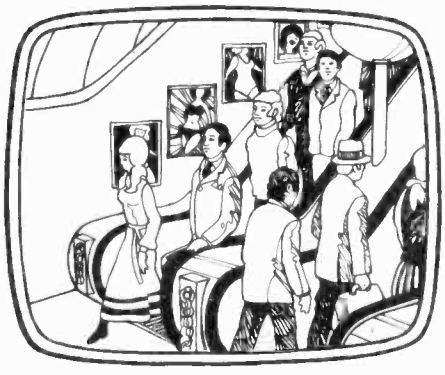

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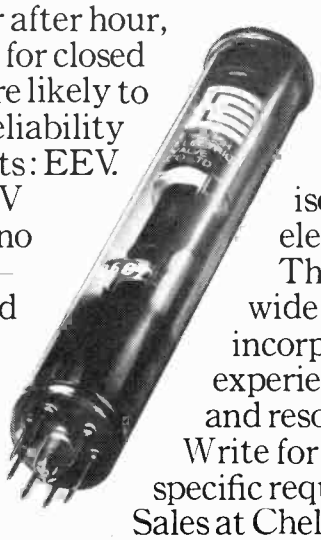

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Alienated music

Electronics has had a much more profound effect on music than just the wider dissemination it has made possible through broadcasting and records. It has introduced an element of artificiality, which separates the composer/performer from the listener more so than in previous centuries. In traditional music-making the instrumentalist has direct control not only of the selection of notes but of the energy which creates the sounds (e.g. by bowing or blowing). This direct control makes possible a marvellously subtle communication, through the performer, between the soul of the composer and the soul of the listener. When this direct control is removed the music becomes alienated from both the performer (interpreting the composer) and the listener. The first stage of alienation, not very great, occurs when a p.a. system is used to amplify musical sounds—an additional source of energy is introduced between performer and listener. The second stage is when the p.a. microphone is replaced by a specialized transducer attached to an instrument, as in the electric guitar. A third stage is the replacement of the mechanical generation of sound by electronic generation, as in electronic organs and synthesizers. The fourth stage of alienation is the removal of the immediacy of the live performance: the human instrumentalist is abolished and the composer of electronic music puts electrical waveforms onto magnetic tape, to be played to the listener at some later time.

Many of these new arts of music making have been accepted into our culture. Composers using electronic processing in "serious" music, such as Stockhausen, are considered respectable, if a little odd, by the musical world; electronic music studios and courses have been introduced by universities and colleges of music; and the electric guitar and sound synthesizer have become common instruments in pop music. Nonetheless, some music lovers regard these techniques as abominations, while many admit to an inability to respond to the sounds produced. It is perhaps no accident that electronic music is often used to induce atmospheres that are strange, remote, cold or "cerebral" in films and broadcast programmes—typically in science fiction material. The reaction against alienated music is probably due to a natural conservatism in our aesthetic responses. It takes a very long time, and perhaps a biological evolutionary process, for certain sounds—timbres, harmonies, textures, etc.—to become meaningful to us. Conditioned as we are to sounds pitched in certain scales, we find it difficult to accept as musical the unpitched sounds which electronic generators are capable of producing. Stravinsky's *Rite of Spring,* now over sixty years old, is still considered advanced music by many people. Some of the most successful electronic organs are those which use digitally stored waveforms of the notes of pipe organs.

Nevertheless, the new musical techniques made possible by electronics cannot be rejected or ignored. They are part of our lives already. It may be that alienated music truly expresses the alienation of man from his fellows in a highly industrialized society (the result of the division of labour and other technological changes). If this is so it may prove to be a genuine, and indeed inevitable, development of traditional music.

Electronic telephone exchanges

A review of techniques

by M. T. Hills
Department of Electrical Engineering Science, University of Essex

An introduction is given to modern telephone exchanges currently being installed or in an advanced stage of development in Britain today. This article deals with the requirements of an exchange which has to fit into the existing, predominantly electromechanical network and describes how some of the functions may be usefully performed by electronics. A later article will deal with the development of computer-controlled exchanges.

One of the most important facts about the modern telephone system is the massive size of financial investment and expenditure that it involves. The British Post Office has an investment of over £3,300 million in the telephone service of which £450 million consists of telephone exchange equipment. Current expenditure on replacing old exchanges and installing new ones is in excess of £200 million a year. When a telephone exchange is installed it is designed to have a life of between 20–30 years and there are still many exchanges in the United Kingdom which were installed before the second world war and are still giving good service. Hence the majority of telephone exchanges are based on technology developed 20 or more years ago. New systems are being developed based on modern technology and there is a gradual introduction of them both here and abroad. They will, however, represent only a small proportion of the total until nearly the end of this century.

This article outlines some of the types of modern exchange design that are currently being manufactured or under advanced development and, in particular, those systems which use electronics in some form. It will come as a shock to many engineers who work in fields outside telephony that, with few exceptions, there are not yet any completely electronic public exchanges in service or even being developed. Although electronic techniques are taking an increasing role in the control of modern exchanges, the actual switch is still an electromechanical device such as a cross-bar switch or reed-relay (both described in more detail later). The only exceptions are those exchanges which switch the speech signals in digital form using pulse code modulation (p.c.m.).

The retention of electromechanical devices for analogue switches occurs because, as yet, no electronic component has been developed which can match the performance of a pair of mechanically operated contacts for the functions of a two-way switch with low on and high off resistance, good bandwidth and high power handling capacity, together with low noise and economy.

Hence for some time to come these new exchanges will only be a small proportion of the network and when they are introduced they must work with the old, existing network. An immense amount of development effort over the years has gone into the design of the older systems and, for all their shortcomings, they do provide a very low-cost solution to the switching problem.

Requirements of an automatic exchange

The telephone system starts with the subscriber's instruments in his home or his office. Each subscriber has his own pair of wires which connect him to the local telephone exchange. Sometimes, when the subscribers are on a party line, two of them share a pair of wires. If the instruments are located in an office then there are frequently private telephone exchanges in the office which permit a large number of subscribers to share a smaller number of exchange lines as well as providing interconnection within the office.

In the UK there are more than 6,000 local exchanges ranging in size from less than 100 lines to 20,000 or more. Apart from less than 50 manual exchanges still existing, all these local exchanges are fully automatic. When the telephone is not in use there is a capacitor in series with a bell across the line. This means that the exchange can send an a.c. signal to ring the bell. In order to make a call, the handset is taken off the instrument and this operates a switch which completes a d.c. path across the line which in turn operates a relay in the local exchange and starts the setting-up process.

The exchange returns dialling tone to the subscriber and he may then dial his required number. This consists of a series of short break pulses on the line, the number of pulses being equal to the number dialled and occurring at ten impulses a second. Each series of pulses is separated by an inter-digit pause of at least 400ms; this minimum is guaranteed by the mechanical construction of the dial and is mainly the time taken to pull the dial round to a new starting position. The line conditions are shown in Fig. 1.

This is a relatively slow but highly economic method of signalling. Push-button telephones have been developed and are in limited use. These signal the required number by means of a pair of tones as shown in Fig. 2. This provides a much faster method of signalling but at an increased cost for the subscriber's instrument as well as at the exchange. As will be seen later, the majority of equipment in the UK operates at dial-pulse speed and therefore little is gained by having a faster input. The advantages of push buttons can be obtained, however, with the modern development of m.o.s. integrated circuits which fit inside the telephone instrument and remember the sequence of digits keyed and then convert them to dial pulses. In this case the telephone exchange is "unaware"

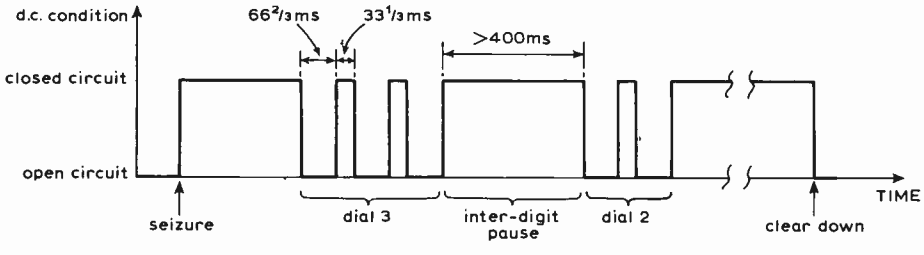


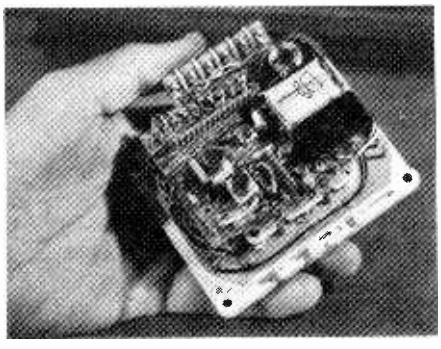
Fig. 1 Signalling conditions from a dial telephone.

of the fact that a push-button telephone has been used.

At the exchange the equipment must respond to the dialled code and connect the caller either to a subscriber on the same exchange or else to a trunk line leading to the required exchange. With 6,000 local exchanges, it is obviously not possible to have trunk lines between each and every exchange and it is necessary to provide trunk switching exchanges. In the case of a large city such as London where there are around 300 local exchanges a number of intermediate exchanges have been installed as shown in Fig. 3. In the London area each exchange either has a direct connection to every other exchange or else via one or another of the intermediate exchanges.

For long-distance calls on the subscriber trunk dialling (s.t.d.) network the country is divided into 450 areas, each of which is served by a trunk exchange called a group switching centre (g.s.c.). Each local exchange within this area has access to the appropriate g.s.c. If a call from one local exchange is to another local exchange within the same trunk area, but for which a direct route does not exist, then it may be completed via the g.s.c. There are a large number of routes radiating from each group switching centre to other group switching centres and this permits calls from the local exchange in one area to be routed to a local exchange in another area. The majority of long-distance calls made may be completed by going through not more than three group switching centres. There are, however, some group switching centres which cannot be reached directly or via an intermediate group switching centre, and in these cases, until recently, the call would have to be set up by an operator who knew the required routine. At the present time a new trunk transit network is being introduced which will ultimately consist of about 30 exchanges to which all group switching centres will be connected. When completed this new network will permit fully automatic dialling from any exchange to any exchange within the UK. This hierarchical routing pattern is shown in Fig. 4. A similar scheme is being developed internationally so that eventually there will be fully automatic dialling between all countries of the world. Considerable progress has in fact been made and it is now possible in many parts of England for subscribers to dial their calls to a significant proportion of Europe and to North America as well.

The "Keyphone", a self-contained push-button telephone using m.o.s. integrated circuits, is a direct replacement for the rotary-dial telephone (GEC Telecommunications Ltd.).



Electronic unit, employing large scale m.o.s. integrated circuits for converting push-button signals to decadic pulses, complete with push-button assembly (GEC Telecommunications Ltd.).

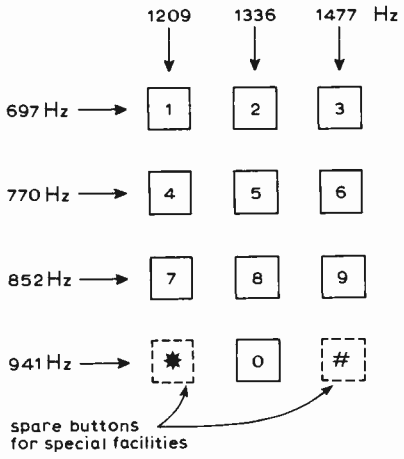


Fig. 2 Layout and frequency code for a push-button telephone.

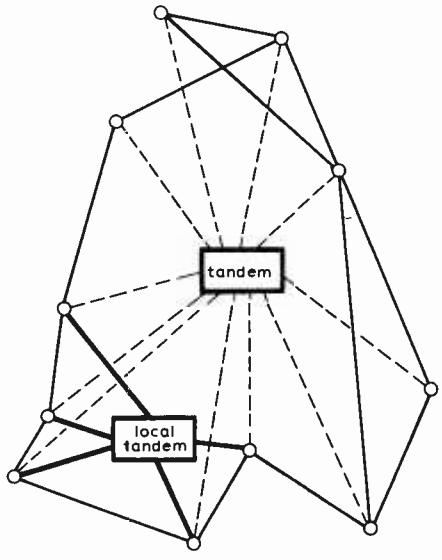


Fig.3 (right) Use of main and local tandems in areas such as London.

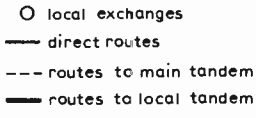
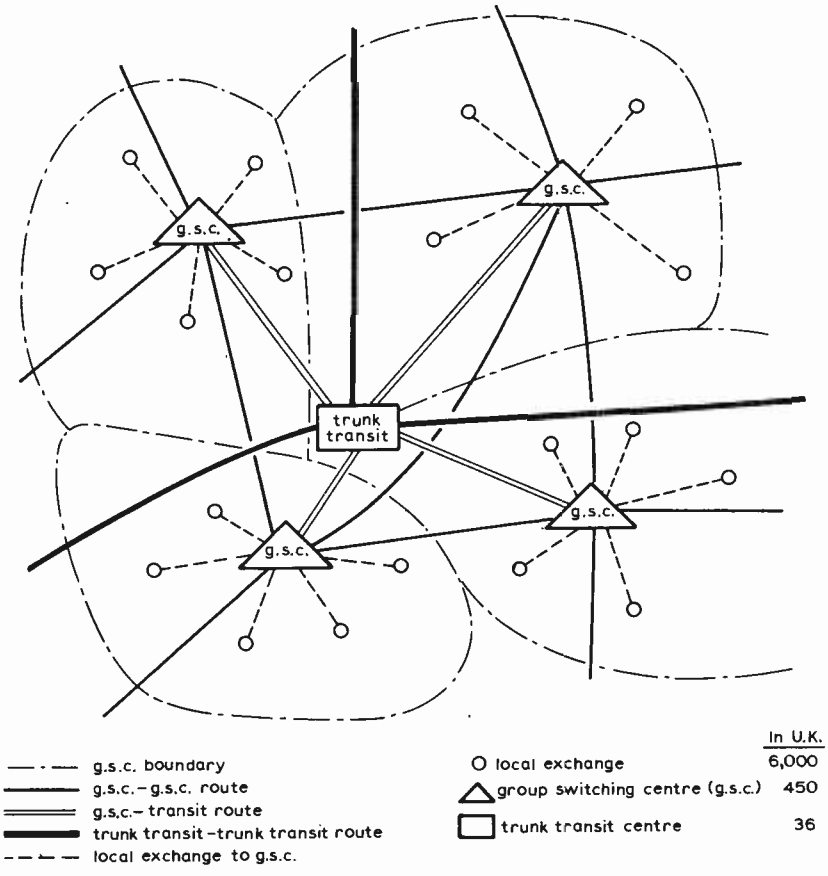


Fig.4 (below) Hierarchical routing of telephone calls.



In order to achieve automatic dialling the telephone exchanges must perform the following functions.

1. Detect calling condition.
2. Receive the dialled information.
3. If a local call, then set up the path to the required subscriber and, if he is free, send him ringing current; if busy then send the "busy" tone to the calling subscriber.
4. If the call is for another exchange then the subscriber must be connected to a suitable outgoing trunk circuit and any dialled information forwarded to the other exchanges en route.
5. The exchange must make sure that the calling subscriber is charged for his call.
6. The exchange must monitor both subscribers to detect when either clears down in order that charging may cease and that the equipment is released.

A telephone exchange consists of three basic functions:

- A switch to connect subscribers together or to trunk lines.
- Signalling equipment to pass information between exchanges.
- Control system to act upon the signalling information and operate the switch accordingly.

The rest of this article outlines some of the ways in which these functions are performed and explains how electronics is being used to improve their performance and reduce their cost.

The Strowger system

Over 90% of the UK telephone exchanges uses the Strowger system. This is named after the American who first invented it and is based on a mechanical switch which can be stepped in two dimensions as shown in Fig. 5. There are 100 sets of contacts arranged in ten levels of ten contacts each. The switch wiper is controlled by two solenoids, one of which will step the wipers up to a particular level while the other will step the wiper around to a particular set of contacts within that level.

The mechanism is operated directly from the dial pulses and these are directed to the appropriate solenoid by means of a relay circuit. A simple 100-line exchange may be built with these devices whereby the first digit steps up the wiper and the second one positions it to the appropriate subscriber.

Since subscribers are using their telephones only a small part of the time, it is uneconomic to provide selectors for each subscriber. This is avoided in most systems by providing each subscriber with a uni-selector, which is a one-dimensional switch as shown in Fig. 6. When the subscriber's line relay operates, this initiates a search by the uni-selector to find a free first selector. In this way a large number of subscribers may share a far smaller number of first selectors, as shown in Fig. 7.

For greater than 100 lines, two or more selectors are needed for each conversation. In this case the first selector is stepped up by the first dialled digit; it then steps around automatically searching for a free second selector which will respond to the next digit. When the dialled code corresponds to an outgoing route, the selector searches over the trunk circuits and connects the call to the first free one.

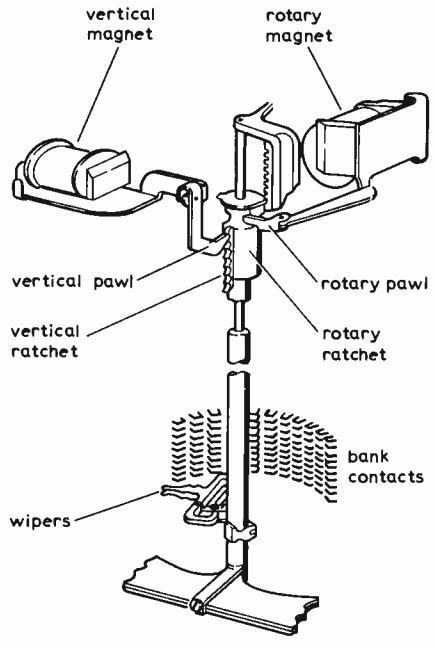


Fig. 5 Strowger two-motion selector mechanism.

The Strowger system is slow since it actually works at dial-pulse speed. Consequently the use of push-button telephones will not save any time since the tones would have to be converted to dial pulses. Strowger is bulky and needs a considerable amount of maintenance, but it is very economic.

Many other techniques to mechanically position selectors have been developed throughout the world. These were individual motors or, in some cases, common rotary power with electromagnetic clutches to move the selectors to the required position.

Modern electromechanical systems

Cross-bar systems. An essential feature of the Strowger system is that each selector has its own set of control relays and its own operating mechanism. This leads to a very reliable system philosophy since a fault in any one selector will cause little disruption of the complete system. An alternative approach to the Strowger system, which was developed in the late 1930s, is based on the cross-bar switch, Fig. 8. This consists of an array of switches which may be operated on a co-ordinate basis by means of solenoids arranged along the vertical and horizontal axes. This means that a connection may be made in a much shorter time than the average time taken to position a selector. One cross-bar switch will now handle the calls for a number of subscribers and consequently some form of common control is necessary.

A switching system is normally arranged in ranks of switches as shown in Fig. 9. In order to set up the suitable path the common control must operate a number of individual switches so that a calling subscriber is first connected to a free link, which has access to a switch which connects it to the digit reception equipment. In this type of common control system it is necessary to provide equipment to receive and store the dialled information, and this is called a register.

The sequence of operation of this type of exchange is

1. When a subscriber initiates a calling condition, this operates his line relay which sends a signal to the common control.

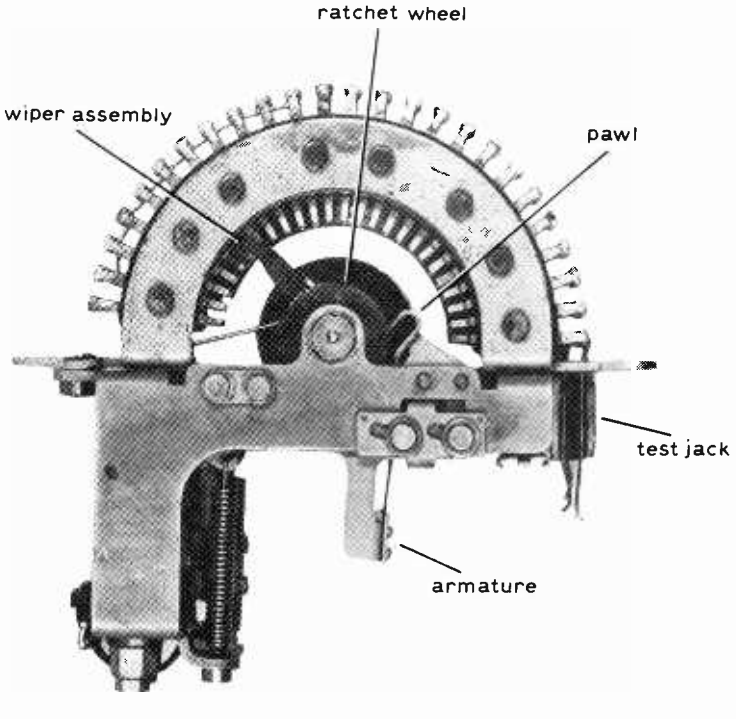


Fig. 6 Uniselector mechanism (Post Office).

2. The common control detects the calling condition and finds a free transmission bridge and free register. It then operates the switches in order to set up a path between the subscriber and the selected transmission bridge and the transmission bridge to the selected register.

3. The register will then receive the dialled digits and, when enough digits have been received to decide upon the routing, the register sends a signal to the common control.

4. When a common control selects a signal from the register it will find a free path to the required subscriber or to required trunk circuit. It will then set up the path, and, if it is an internal call, test the state of the called subscriber. If busy, then the common control will operate a relay in the transmission bridge to send the appropriate tone back to the calling subscriber. If the called subscriber is free a relay is operated in the transmission bridge to send ringing current.

5. The systems are usually arranged so that when a subscriber clears down, the path associated with that subscriber is automatically released.

It may be seen that the common control can only set up or complete one call at a time. However, it will only take a fraction of a second to do this and therefore one common control can service a fairly large exchange. For the largest exchanges there would be a number of common controls in order to provide the traffic capacity.

The fact that a common control is used means that the exchange system has a greater liability to being made totally inoperative in the event of a fault within the common control. In a public exchange this usually implies that a certain amount of duplication and redundancy is provided for in these common controls. The development of cross-bar systems has reached the stage

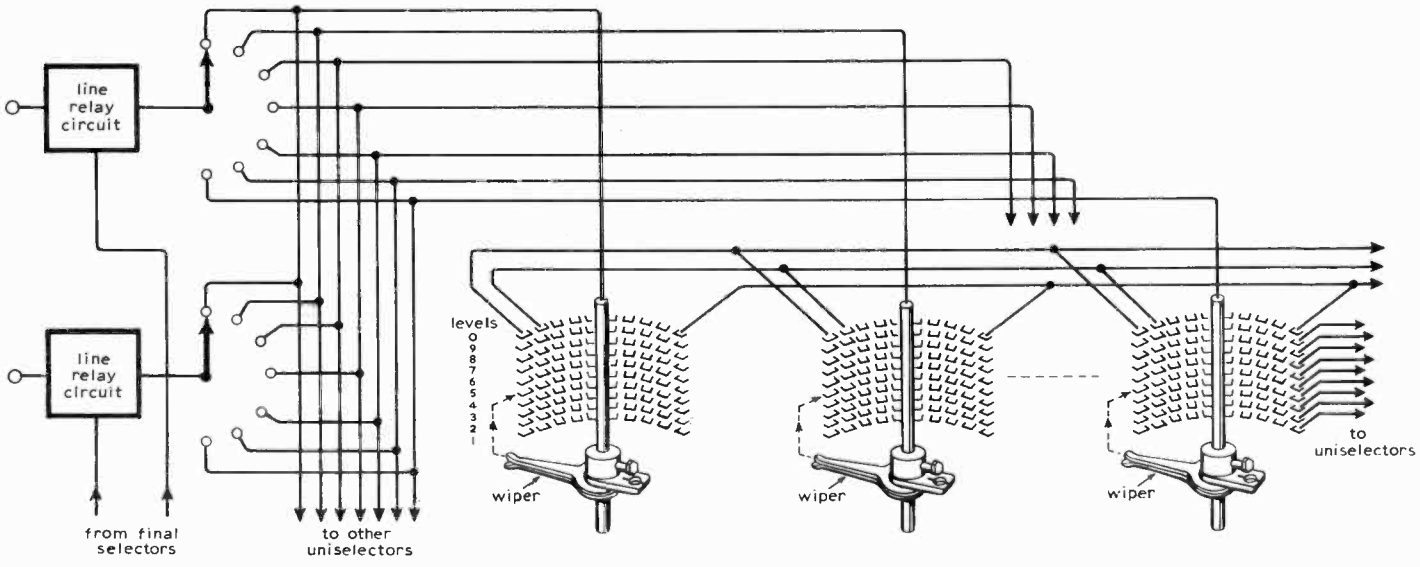


Fig. 7 Simplified diagram of a 100-line exchange.

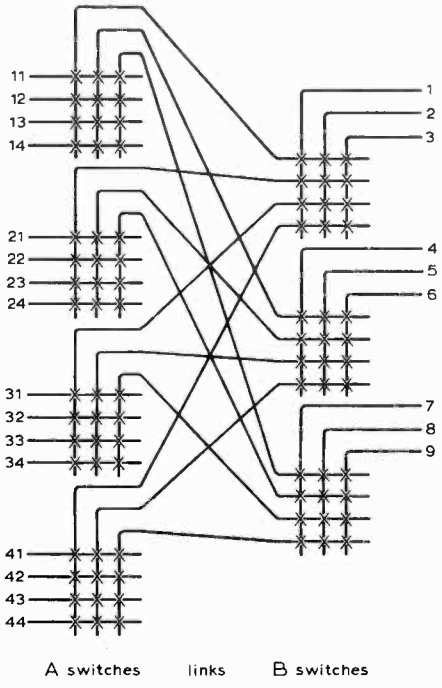


Fig. 9 Use of small co-ordinate arrays of switches to make larger switches.

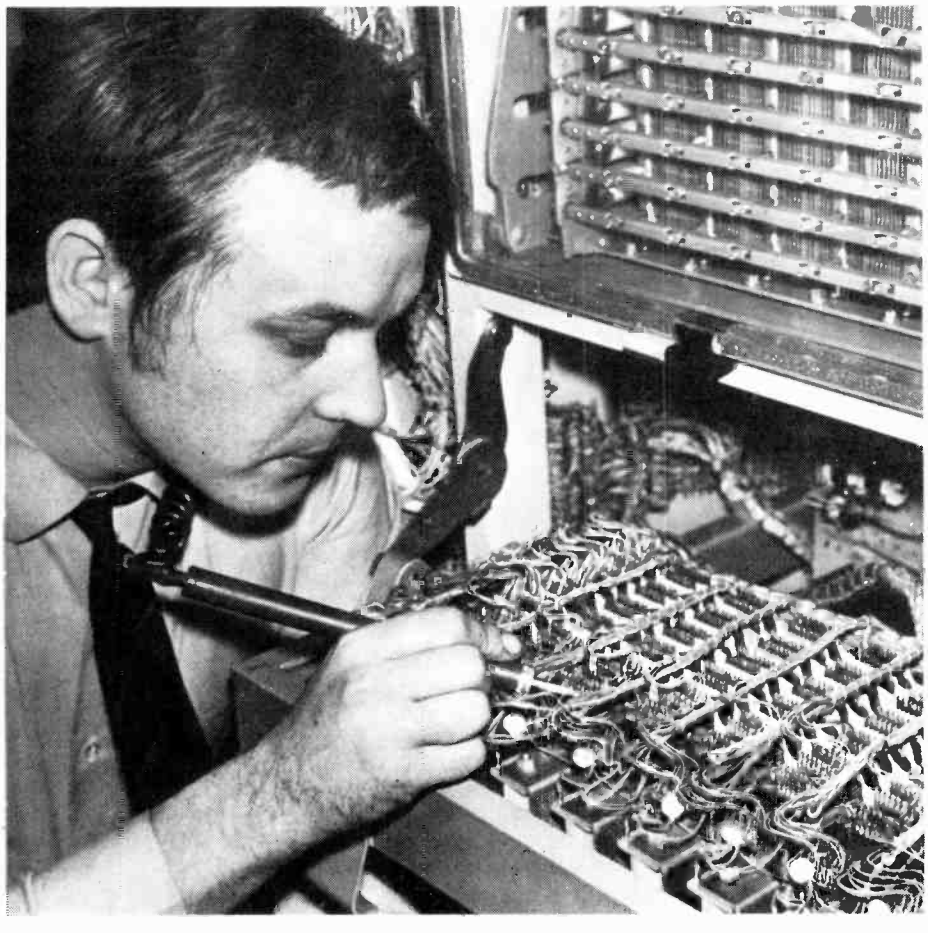


Fig. 8 Working on a cross-bar switch (GEC Telecommunications Ltd.).

where they achieve the same level of reliability as the dispersed control Strowger system. The major advantages of a cross-bar system are that they require far less maintenance and operate much faster than the Strowger system.

There are a number of cross-bar exchanges in the UK and they are used for all larger new exchanges and for the new trunk exchanges. However, the majority of telephone exchanges are in fact extensions of existing exchanges, and this implies that the only economic course of action is to extend them with the same technology as they were originally built, i.e. Strowger.

Reed-relay systems. More recently cross-bar-type systems have been constructed using matrices of reed relays. This type of relay consists of a pair of soft iron contacts encapsulated in a glass envelope which is filled with some inert gas (Fig. 10). When these contacts are placed within a magnetic field the soft iron magnetizes and they attract each other to make a connection. In practice a number of these inserts may be placed within a single coil to provide simultaneous switching of four or more paths.

One of the major advantages of reed-relay systems is that their speed of operation is very much faster than that of cross-bar systems. For instance, a reed relay may make contact within a few milliseconds from the energization of its coil. The typical cross-bar system will take several hundred milliseconds. Another major advantage is that the reliability of the contacts is very much higher than for a cross-bar system since the contacts are totally encapsulated.

Reed-relay systems have similar structures to cross-bar systems but take advantage of the greater flexibility of matrix size that is possible with reed relays. Also they are more amenable to some form of electronic control since their coils need less power to operate than do cross-bar switches.

In the UK, reed-relay systems are being installed and over the past few years over 400 small exchanges (up to 2000 lines) called TXE2 have been built. Plans have now been agreed to use a reed-relay system called TXE4 for the large exchanges and these will be introduced in quantity from about 1976.

Electronic systems

Electronic switches. Electronics has always seemed an attractive candidate for switches in view of the small size and easy controllability of transistors. Early experiments in the UK led to the use of an experimental time division multiplex exchange, the principle of which is shown in Fig. 11. In this system each subscriber is connected to a common highway by means of a transistor switch. To connect two subscribers together, the common control has merely to open the two switches at the same time for a short period. So long as the sampling rate is greater than twice the highest audio frequency transmitted, time division may be used so that a number of pairs of subscribers can use the same highway.

Since this is effectively utilizing pulse amplitude modulation, it is necessary to provide low-pass filters to band limit the signal prior to sampling and to reconstruct the signal after it has passed through the highway. Because of the power loss involved in sampling some form of amplification is usually necessary and this complicates the simplified picture shown in the diagram. In the experimental system developed in the UK there are 100 time slots on a highway, which permits a maximum of 50 simultaneous conversations since a time slot is needed for each direction of conversation. This obviously only caters for a very limited exchange size, and in a larger system it is necessary to have several highways and switches between the highways to interconnect subscribers who are connected to different highways. In practice a large exchange would need several stages of switching and this resulted in practice in rather poor transmission quality. A further problem was the necessity to continue working with existing telephone instruments which need d.c. current to activate them and which need very large ringing currents for their bells. This meant that relays were needed in each subscriber's line unit to provide these conditions since they could not be handled by the transistors and therefore increased the cost of the system.

This type of system has not been found to be very satisfactory for public local exchanges although some private exchanges have been developed on this principle.

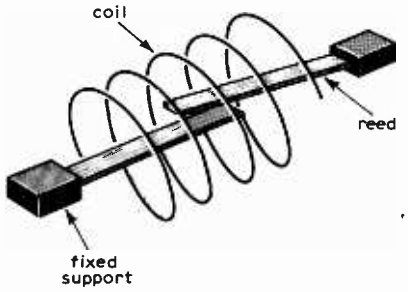


Fig. 10 Principle of operation of a reed relay.

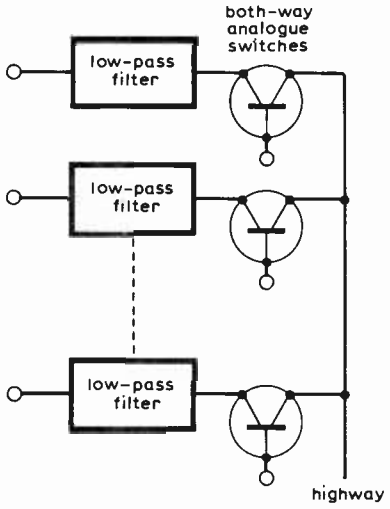


Fig. 11 Much simplified diagram of time division multiplex switch.

Recently there has been an increased interest in the use of solid-state switches in matrices similar to cross-bar or reed-relay systems, without the use of time division.

There will be a very important role for electronic switches in the trunk exchanges of the future. This is a result of the development of pulse-code modulation (p.c.m.) for inter-exchange transmission systems. In a p.c.m. system the signals are converted to digital form by means of an analogue-to-digital converter. The digit streams corresponding to the large number of independent conversations are then time divided on to a high-speed digital link. At the other end of the link the digits are converted back by a digital-to-analogue converter. The advantages of p.c.m. are that a larger number of speech channels may be provided down an existing pair of wires at lower cost. When a number of p.c.m. trunk systems are connected to the same trunk exchange it becomes feasible to switch the speech channels in digital form through the exchange. This will save the cost of converting the signal back to analogue, switching it in analogue form and then reconverting it to digital for the outgoing route. Since the signal is in digital form it is straightforward to switch this by conventional means without any of the transmission impairment that is involved in pulse amplitude modulation. Also, since this is a trunk exchange, there are no problems of ringing current or d.c. feed since these functions are provided by conventional local exchanges.

In the UK there are at present two experimental p.c.m. exchanges in public service. In the future, as the number of p.c.m. transmission systems is increased, there will be development of p.c.m. exchanges. It is unlikely, however, that there will be any significant number of this type of exchange before 1980.

Therefore today, with very few exceptions, all modern telephone exchanges use some form of electromechanical switch. These are based either on reed relays or miniaturized cross-bar switches as well as the more conventional designs. However, electronics has found an increasing use on the control side of exchange systems.

Electronic control. Electronic sub-systems have been gradually introduced into exchange systems over the past 20 to 30 years. Until recently the main application was for what are called register-translators. These are equipments designed to provide for a uniform numbering scheme within a large city such as London and also for subscriber trunk dialling. From the user's point of view it is obviously desirable that the code he has to dial to obtain another subscriber is the same regardless of where he dials it. In practice this aim is relaxed slightly, in that a shorter version of a dialled code is usually used for local calls whereas the full version is used for s.t.d. In fact, the long-term international aim is that with the addition of a country code the same number will be valid anywhere in the world.

In a large city such as London it may be seen from Fig. 3 that the route taken to reach a particular exchange is highly dependent upon the originating exchange. In the

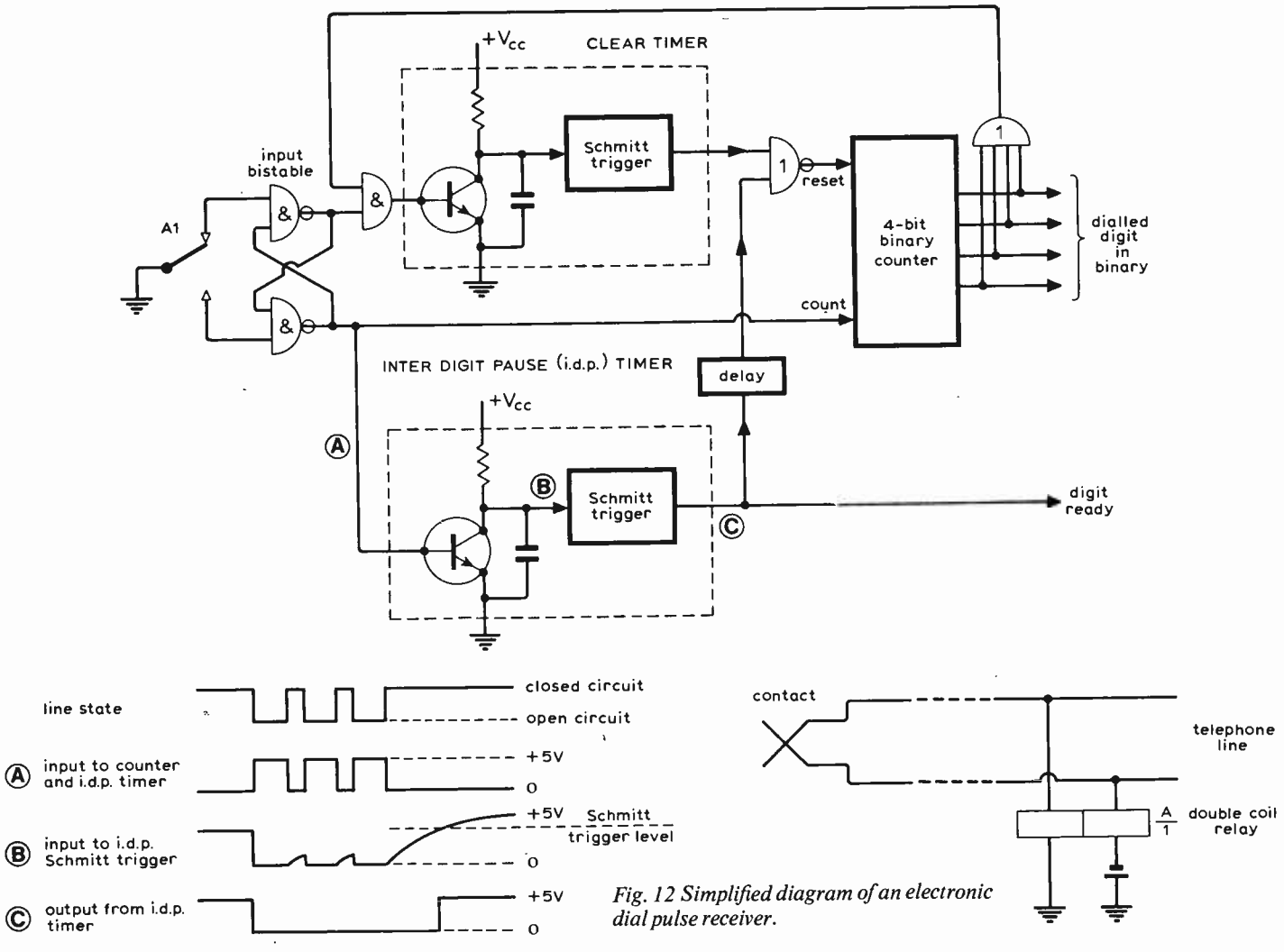


Fig. 12 Simplified diagram of an electronic dial pulse receiver.

London area each subscriber is allocated a three-digit code, indicating the exchange, followed by a four-digit code indicating the subscriber's number on that exchange. In order to provide the necessary routing, equipment is needed in each exchange which will store the three-code digits and then apply to an internal "look-up" table to find the particular routing to the required exchange. This route is set up by pulsing out up to six routing digits which will connect the subscriber to the appropriate outgoing trunk line and route him through a tandem exchange if necessary. While this routing is occurring the subscriber will be continuing to dial and the four-digit numerical portion of the number must be stored until the routing is finished. The numerical portion must then be regenerated to operate the remote exchange.

Early equipment to provide this function was based on two motion selectors and uniselectors together with relay control. However, this function is a natural candidate for electronics since a large amount of storage is necessary for each call in the process of being set up and "look-up" tables are needed. One popular system is based upon the use of magnetic drums which store dialled information together with the "look-up" tables. One drum contains enough storage and equipment to service 48 calls simultaneously.

Similar equipment is needed at the group switching centre in order to provide s.t.d. facilities. In addition this equipment will also determine the call charge and set a relay in the trunk circuit to send meter pulses back to the subscriber at the appropriate rate.

One simple example of how electronic circuits may be used is shown in Fig. 12, which is a simplified diagram of an electronic dial pulse receiver. This takes as its input a relay contact which is operated by the short pulses generated by the dial mechanism, and the output is a four-bit binary number giving the dialled digit. This type of circuit could be used as an input to an electronic register translator.

The operation of the circuit is as follows. The contacts, A1, of the line relay follow the dial contacts and the state of line is converted into logic levels by an input bistable circuit. One output from this bistable is fed to a four-bit binary counter which steps each time a break pulse occurs. Each time the line goes open-circuit the transistor in the inter-digit pause timer conducts and discharges the capacitor. When the line goes closed-circuit, this transistor is cut off and the timing capacitor charges. Provided a further break pulse occurs within 100ms, the capacitor is discharged again and the voltage across it never reaches the trigger level of the Schmitt circuit. However, if the line remains made for longer than 100ms then the Schmitt circuit will trigger and indicate that the dialled digit has been received. The output from the counter may then be strobed into the next part of the system and the counter reset.

If the line remains open-circuit for longer than 200ms the clear timer will generate an output and reset the counter.

Acknowledgement. I am grateful to Mr N. Horton who developed the circuit upon which Fig. 12 is based.

(To be continued)

Frequency allocations wallchart

A wallchart showing frequency allocations for the UK and Europe is the subject of a special offer made by coupon in this issue. Designed by *Wireless World* and printed in colour, the chart covers the electromagnetic spectrum from 3kHz to 300GHz. It is scaled on eight logarithmic bands containing 15 main categories of transmissions identified by colours. All the important spot frequencies are marked, as well as "special interest" frequencies. The special-offer price, available only to readers of *Wireless World*, is 30p including VAT, postage and packing. Normal price is 80p including VAT, postage and packing. See advertisement page a68 for details of how to order the wallchart.

News of the Month

Motorway menace reduced

Reliable and relatively cheap instruments for measuring atmospheric visibility on motorways have been developed at the Atomic Energy Authority's Harwell research centre. The Visirange visibility meter is designed as an aid for routine traffic control, whilst the Visiplan system records visibility at selected points for pre-construction route planning.

Both instruments operate by measuring the loss of contrast in an illuminated target when viewed from a distance, and they differ mainly in their optical path lengths and in the type of output signal which they give. In both, the target consists of a brightly lit strip, bounded on both sides by black edges. Images of the dark and light parts of this target are projected onto a pair of photo-electric detectors in the receiver. The presence of fog in the light path between the target and the receiver decreases the contrast between the dark and light parts of the target and the difference in output from the two detectors is reduced. Measurement of this differential can be related to meteorological visibility.

The Visirange meter is a low cost instrument particularly suited to routine measurement of visibility levels over the range 1 kilometre to 5 metres or less. The optical path length is only 2 metres, allowing the target and the receiver to be mounted in the same integral frame. The output of the instrument can be used to raise alarm signals at preset levels, to relay information to the police or to bring appropriate speed limit signs into automatic operation.

The Visiplan fog recording service is operated by Harwell and is designed to provide a long-term record of visibility conditions at key points along the prospective motorway route so that, during the planning stage, due account can be taken of fog incidence. To cover the increased range of visibility required in this application—10 kilometres down to 50 metres—the instrument is in two parts with the target section sited about 50 metres from the receiver. The output of the instrument is fed to an automatic recorder.

Prototype of the new Bedford heavy-truck range undergoing ride and vibration tests on the "road simulator" at the National Engineering Laboratory, Scotland. A computer is used to pin-point peak areas of vibration within the truck.

Link scheme success for schools

The National Electronics Council Link Scheme for schools has been functioning now for nearly two years. During that time the co-ordinator has established about a hundred links. The success of a particular link has depended to a large extent on the enthusiasm of both parties involved. In some cases, apart from the occasional technical enquiry by telephone, little assistance has been asked for. In other links, however, the teacher has fully utilized the offer of help by involving the engineer in advising and even supervising pupils undertaking projects.

With the increased interest in electronics at CSE and A-levels, there is now an even greater requirement for experienced and enthusiastic engineers from industry, research establishments and higher educational institutions to offer help to their local schools. Apart from improving the general education background of all pupils at school, it will eventually lead to an improvement in the basic knowledge of new recruits to the electronics industry.

Consequently any offer of assistance will be gratefully received by the co-ordinator of the scheme, Mr P. D. Noakes, Department of Electrical Engineering Science, University of Essex, Wivenhoe Park, Colchester CO4 3SO.

Television Society awards

The Royal Television Society's gold medal for outstanding contributions to television was awarded to Dr Walter Bruch by Prince Philip at the Society's annual ball on May 28. Dr Bruch, inventor of the PAL system, is chief of basic television research at AEG Telefunken, Germany. I. J. Shelley, BBC, and N. W. White, Marconi Instruments, received the Geoffrey Parr award for their work on the design and development of automatic monitoring and control equipment for unattended transmitters. The John Logie Baird travelling scholarship was awarded to Peter J. Best, a post-graduate student at the University of Manchester Institute of Science and Technology, who is at present doing research in medical electronics for his Ph.D. degree.

Dr Jacob Bronowski received the Society's silver medal for his series of television programmes "The Ascent of Man" which he wrote and presented. (Some of the photographs in Dr Bronowski's book based on this series are by Paul Brierley, who frequently provides front-cover photographs for *Wireless World*.)

Stereo radio for Scotland

The BBC network of stereo sound distribution circuits has been extended to central Scotland, making it possible to broadcast in stereo from the v.h.f. radio transmitters

Some of the equipment installed in the Radio Clyde control room, Glasgow. The tape machine shown is supplied by Bias Electronics who can also provide a version which gives a delay of 8 seconds at 7½ i.p.s. This facility is useful for monitoring and editing live "phone-in" programmes as necessary.

serving the areas around the main stations at Forfar, Kirk o'Shotts and Ashkirk. Most Radio 2 and Radio 3 programmes and some Radio 1 (when on v.h.f. using the Radio 2 transmitters) and Radio Scotland programmes are produced in stereo.

Scottish stereophonic transmitters

	R1/2	R3	R Scotland
Kirk o'Shotts	89.9	92.1	94.3
Ashkirk	89.1	91.3	93.5
Ayr*	88.7	90.9	93.1
Campbeltown	88.6	90.8	93.0
Forfar	88.3	90.5	92.7
Lochgilphead	88.3	90.5	92.7
Milburn Muir*	88.8	91.0	93.2
Perth	89.0	91.2	93.4
Pitlochry	89.2	91.4	93.6
Rosneath	89.2	91.4	93.6
Toward	88.5	90.7	92.9

*New stations opening during 1974.

Quadraphony—experimental broadcast

To enable those who are interested to hear a number of recent BBC quadraphonic recordings, there will be an experimental broadcast from 12.05 a.m. to 1 a.m. on the early morning of Saturday, July 6. Two groups of stereo transmitters will be used, Radio 2 carrying the left and right front signals, with Radio 3 carrying the left and right rear signals. To take full advantage of the quadraphonic transmission, listeners will require two complete stereophonic receivers, one of which should be tuned to Radio 2, feeding the front speakers; a second stereo receiver tuned to Radio 3 should be connected to the rear speakers. It is realized that very few listeners will have two stereophonic receivers, but it is possible that in some cases friends and neighbours might wish to pool their resources. No alteration in the loudspeaker wiring of a stereo system is required. The rear left signal will be transmitted through the conventional right channel.

In the absence of a second stereo receiver some interesting, though not representative, results could be obtained by using a mono v.h.f. receiver to provide the rear information; alternatively a medium wave portable could be used, although the results will then be even less representative.

V.h.f. transmitters which are not yet equipped for stereophony will carry the experimental programme in mono. While the two v.h.f. networks are carrying the special programme, "Night Ride" will continue on 1500 and 247 metres.

The special programme will include a variety of different musical items as well as some drama and outside broadcast material. The BBC would be grateful for reports from listeners who are able to hear this experimental broadcast.

It must be emphasized that there is no possibility of a regular quadraphonic service on the basis of two separate transmitter networks, but the BBC will continue its investigations into the possibility of a system to provide quadraphonic programmes from a single transmitter, without degrading the results obtained by those with mono or stereo receivers.

Safety on the Tees

Teesport, destined to become one of the major oil terminals in the UK, is to be made safer with the installation of a hydrographic survey system to the already thriving port in the North East of England which will, in the near future, handle many more large tankers when the oil from the giant Ekofisk field is piped ashore just south of the River Tees.

The system will enable sounding charts to be produced within hours of a survey instead of days using conventional methods, and also enable dredgers to be deployed more efficiently.

Fitted on board the survey launch will be a data logger, an echosounder and navigation aids. The data logger records depth, position fixing and time information on cassettes of magnetic tape. On completion of the survey the magnetic tapes are taken ashore and fed into a processor which converts the recordings into a sounding chart using a flat bed plotter. The system, known as Hydroplot, will be supplied by Marconi Space and Defence Systems Ltd.

Electronic Component Show '75

The 24th international London Electronic Component Show, is to be held May 13–16, 1975 at Olympia, London. Three main exhibition halls at Olympia will provide a stage for the latest developments and products in the electronics and associated industries. The show is sponsored by the Radio and Electronic Component Manufacturers' Federation.

The next Instrument Electronics and Automation Exhibition, which alternated annually with the Component Show at Olympia, will be held at Birmingham's new £20m National Exhibition Centre.

Future telecoms challenge

A recent study has given some indication of the electronic components that will be needed by Post Office equipment makers during the 1970s. Requirements for active components are likely to rise from about £45m in 1974 to £120m in 1978. A similar growth in passive components is also expected. This is due to a radical change in manufacturing techniques resulting from the decision to replace electromechanical Strowger equipment in telephone exchanges by electronic equipment. Instead of purchasing and processing raw materials like steel, copper, textiles and plastics the emphasis will shift to the assembly of bought-in electronic components.

As a pointer to the level of growth, the Post Office last year added nearly a million new exchange line connections to the network, whereas it took about 40 years to reach the first million. Strowger equipment should be completely replaced by the 1990s.

With the aim of developing and planning Britain's telecommunications services of the future with greater effectiveness, the Post Office is regrouping part of its research and development resources into a new department. The department—Telecommunications Systems Strategy—is to create an overall strategy for the co-ordinated

development of new telecommunications systems, with the aim of securing the best and most economic service.

Fall in TV deliveries

Deliveries to UK distributors of UK-made colour television receivers reached 600,000 in the first four months of 1974, representing a 10% fall compared with the same period of 1973, according to the latest statistics compiled by the British Radio Equipment Manufacturers' Association. UK-made monochrome TV deliveries during January to April 1974 were 208,000, compared with 371,000 for the first four months of 1973, a fall of 44%. These figures apply to deliveries made to specialist, rental and relay companies and exclude imported deliveries.

Water Music

COMBINING sheer vulgarity with radio is the Binatone "Little John" for use in the toilet. Set incorporates a loo-roll holder and has an output of 500mW from a $2\frac{1}{4}$in, 8-ohm speaker. Powered by a 9V battery with space for a spare in case caught short, this novel radio is available in three colours. These are: pink, ivory or mustard. Set tunes over the medium wave only, and is fitted with a ferrite rod aerial. The receiver costs £5.75 and is available from J. Parkar and Co (London) Ltd, Parkar House, Beresford Avenue, Wembley, Middlesex. (Tel: 01-903 5211).

Quadraphonics news— UD-4 to be launched

Nippon Columbia Co Ltd have announced completion of development of their QMX disc record for surround-sound reproduction. The finalized system, called UD-4, will be marketed late this summer in Japan and is planned for release in Europe toward the year end. UD-4 records, as well as studio and playback equipment, will be available from Nippon Columbia. Fifty records will be released this year.

The system, which can be viewed as combining the merits of the two-channel matrix approach with those of the discrete technique, was briefly described in our Berlin report (pages 543/4 November 1973 issue) and we plan to describe the system in more detail in a later issue. To summarize, UD-4 records are "four-way" records. They can be played in mono without directional anomalies; they can be played on conventional stereo players; they can be played in the two-channel surround-sound mode with a relatively simple matrix decoder; and with addition of a suitable pickup and demodulator (also fitted with a CD-4 facility) to recover the carrier-channel information and effectively provide a "discrete" performance. As we have remarked before, it is an elegant system and one that, at least, ". . . might make the future of CD-4 less certain" (*Letters*, March 1973 page 118).

Incidentally, as a bonus, Nippon Columbia should be able to claim that theirs is the only equipment that will play all current quadraphonic disc recordings, making such claims by competitors void!

The system was demonstrated to the trade for the first time in the UK by Nippon Columbia and Johnsons of Hendon at the May radio shows.

Meanwhile, introduction of CD-4 records is being accelerated this year. At May 1st the total number of CD-4 records was 501, with 129 American titles and 372 Japanese titles. Announcing plans to release a further 50 records at a recent CD-4 "up-date" organized by RCA, WEA and Matsushita, RCA said a new vinyl record compound had been developed—an improved one over that reported in the September 1972 issue, page 424—that provides "exceptional wear characteristics, superior audio properties and a high degree of stability under varying mould conditions". They are now seeking collaboration with chemical suppliers with a view to further cost-reducing improvements. It was also disclosed that a new "CD-4" integrated circuit had been produced that is incorporated into a new (June) line of RCA CD-4 players in the USA. (This is in addition to two Signetics chips already developed, one for the Victor Company of Japan and one for National Panasonic/Quadracast Systems.)

RCA claim they can now extend playing time to 28min and achieve baseband levels to within 1dB of conventional records.

More records with side sound images are being made by RCA (the latest Frank Zappa recording for instance) but sitting a little off-centre at the recent demonstration showed how unstable these were, appearing to come from the back corner speakers if one was nearest to them. One obvious consequence of this is that sound sources panned around 360°—presumably at constant speed—appear to linger at speakers, followed by a quick jump between them (especially noticeable with the Hugo Montenegro rotating carousel effect). It is often difficult to say exactly where a sound image is supposed to be.

It became clear that various companies are at the prototype stage in working to produce ceramic cartridges capable of recovering the high frequencies on carrier-channel records. At the same time a new Shibata stylus was announced that will sell at $2 in Japan on an o.e.m. basis. This stylus, titanium bonded for improved strength of adhesion and resistance to corrosion, weighs less than half of the current iron-bonded type. These two developments are evidently aimed at securing penetration of carrier-system reproduction equipment at the low-cost end of the market.

A new, simplified, cutter system will be available from the Victor Company in September with various improvements that include changed cutter dimensions (e.g. back angle from 45° to 35°), and adoption of two Neutrex systems instead of one. This last-mentioned move is claimed to improve difference-signal response to −3.3dB (from −6dB) at 10kHz and reduce distortion of this signal to 1% from 5 to 12kHz, previously 4 to 5% for comparison (levels are not quoted). This mark 2 version will cost $40,000, as opposed to $60,000 for mark 1.

Satellite launcher guidance

The Ariane programme, aimed at developing a European satellite launcher capable of placing a 750kg geo-stationary satellite in orbit by 1980, is expected to extend over a seven-year period with subsequent production envisaged at two launches per year. The inertial guidance sensing for the satellite launcher is to be supplied by Ferranti.

The sensor chosen is a two-box system. One box contains the inertial platform and the second contains the control, computing and power supply circuitry necessary for operation of the inertial platforms plus the appropriate circuitry needed to provide signals to and from an interface module and for telemetry.

The inertial platform consists of a central instrument cluster isolated from the vehicle angular motion by gimbals. The instrument cluster consists of three single-axis gyroscopes and three single-axis accelerometers. Vehicle acceleration is measured by the three accelerometers along three mutually perpendicular fixed axes. A digital computer then uses this information to calculate instantaneous vehicle velocity and position, and generate the steering demands necessary to achieve the required orbit.

Briefly

Motorola in Warrington. Plans have been announced by Motorola Electronics for a major manufacturing and engineering facility for its communications systems products at Warrington in NW England.

Mini-film on resistors. "METAL FILM RESISTORS" is a new 16mm seven-minute colour film, dealing with the manufacture of metal-film linear resistors. It is available on loan from the Mullard film library.

Next IEE president. Mr J. H. H. Merriman, CB, OBE, Msc, Board Member for Technology and Senior Post Office Development Director, will take office as President of the Institute of Electrical Engineers on October 1, 1974.

Sensitive f.m. tuning indicator

Simple to use indicator with one lamp

by J. A. Skingley
Plessey Company Ltd, Swindon

Based on the indicator circuit used in the f.m. tuner design published in the April and May issues, this circuit is suitable for connection to other tuners. The circuit uses a third transistor connected to a long-tailed pair to feed a single l.e.d. that has maximum brightness when in-tune: a simpler system than the two-lamp kind.

The need to provide a sensitive indication of the state of tune is apparent to anyone who has tried to tune-in an f.m. set without this facility. There are usually three points associated with each station where an audio output is obtained, these corresponding to the three slopes of the S-curve of the detector. The outer two of these are usually distorted but are frequently mistaken for the correct tuning position, especially on cheaper sets. Having found the centre of these, it is difficult to determine the exact point of tune; the sound amplitude or bandwidth being of much less help than in the case of a medium-wave receiver. The increase in stereo broadcasting heightens the need for accurate tuning if the full advantage of this mode of reception is to be obtained.

The main problem of providing a tuning aid with an f.m. receiver is that there is no voltage or current available, as in an a.m. receiver, that can be monitored and maximized to give the correct tuning point. The amplitude information has been eliminated by the limiting i.f. amplifier, so that the only available voltage at the detector is a function of the tuning error. This does not pass through a maximum but linearly traverses a voltage range, the centre of which is the correct tuning point. Early methods of using this consisted of a centre-zero moving-coil meter connected between this varying voltage and a reference point. The meter was then adjusted to its centre for correct tuning.

The method of Fig. 1 similarly uses a reference voltage, but this time a long-tailed pair of transistors is used as a comparator, two light-emitting diode indicators being used to show balance and hence the correct tuning point. In this case, adjustment is made until the two lamps are of equal brightness.

The disadvantage of both of the above methods is that their method of use needs to be re-learned, as neither relies on adjustment to a maximum indication which is the traditional mode of tuning indication and one which is therefore readily understood by the non-technical user.

The circuit of Fig. 2 overcomes this disadvantage by providing a maximum indication at the correct tuning point and by using only a single lamp. Here, a third transistor has been added to the long-tailed pair and it is this which is used to drive the lamp. The operation is as follows.

If the input voltage is equal to the reference voltage, i.e. at the correct tune point, and assuming that the volt drop through R_1 and R_2 is negligible, then all three transistors will conduct equally because the matched devices will have equal base-emitter voltages. The tail current, determined by R_3 and the reference voltage, will therefore be split equally three ways. If the input voltage is raised above that of the reference then Tr_1 will conduct more and Tr_2 less, as in a normal long-tailed pair. The common emitter voltage will rise, since the V_{BE} of Tr_3 will decrease with its current. The base-emitter voltage of Tr_2 will also decrease, as its base voltage rises by only half of the input voltage rise, while its emitter must follow the other two. Therefore the current in Tr_2 falls and the lamp dims.

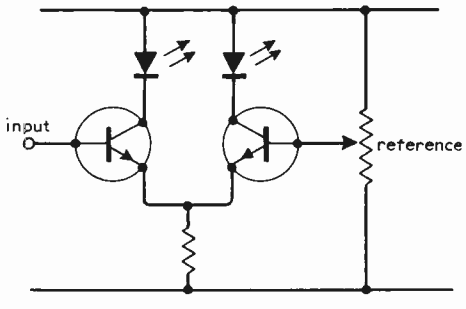


Fig. 1. Conventional two-lamp indicator requires adjustment of receiver tuning for equal brightness.

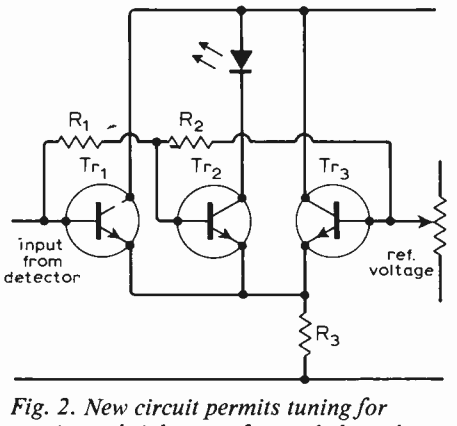


Fig. 2. New circuit permits tuning for maximum brightness of a single lamp by addition of a third transistor.

Because the circuit is symmetrical the same thing happens when the input is reduced, this being the equivalent to increasing the reference voltage while keeping the input fixed. Thus the lamp is at maximum brilliance when the input equals the reference voltage, i.e. when the set is tuned.

The circuit as it stands has two disadvantages. Firstly, because three transistors conduct equally at balance, three times the lamp current is consumed by the circuit. Secondly, the value of R_1 and R_2 must be low and this will present an excessive load to the detector output.

Both of these criticisms are overcome in the circuit of Fig. 3 which operates on the same basic principle. Input impedance is increased by Tr_4 and Tr_5. Current through these is determined by the base-emitter voltage of Tr_1 and Tr_3 and resistors R_5 and R_7 respectively. This current is virtually constant over the normal range of indication. Resistors R_4 and R_6, which also carry this fixed current, drop V_{BE} of Tr_1 and Tr_3 by about 60 mV below that of Tr_2, thus ensuring that these devices conduct only one tenth of the current of Tr_2 when the circuit is balanced. This technique is only possible because of the well-matched base-emitter voltages of the integrated transistors. Most of the tail current is thus passed to the lamp and the supply current minimized. Transistors Tr_1 or Tr_3 pass the tail current direct to the supply line when the set is out of tune and the circuit unbalanced.

The circuit of Fig. 4 shows the method

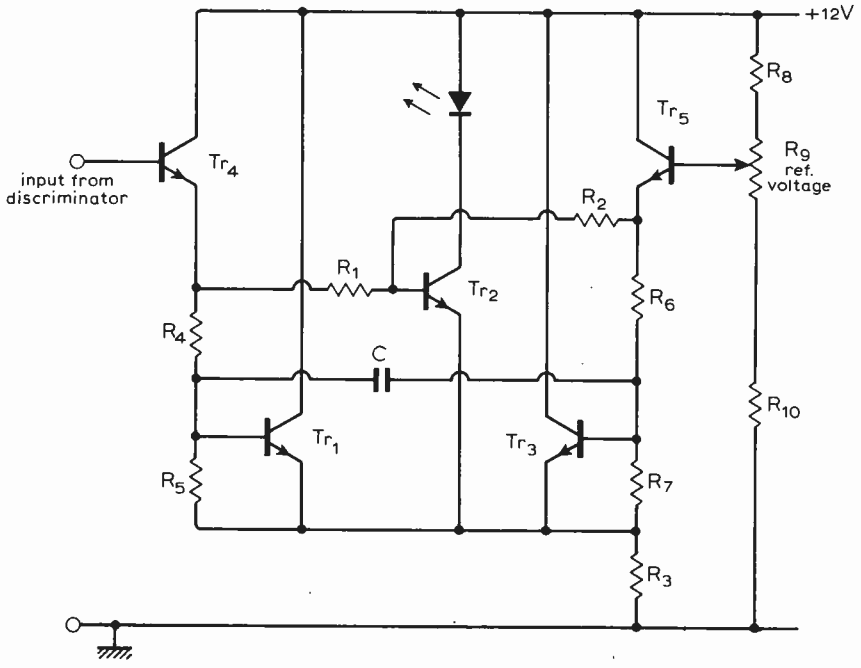


Fig. 3. Additional components reduce current drain of Tr_1 and Tr_3 by an order of magnitude and increase input impedance. (Transistors are integrated.)

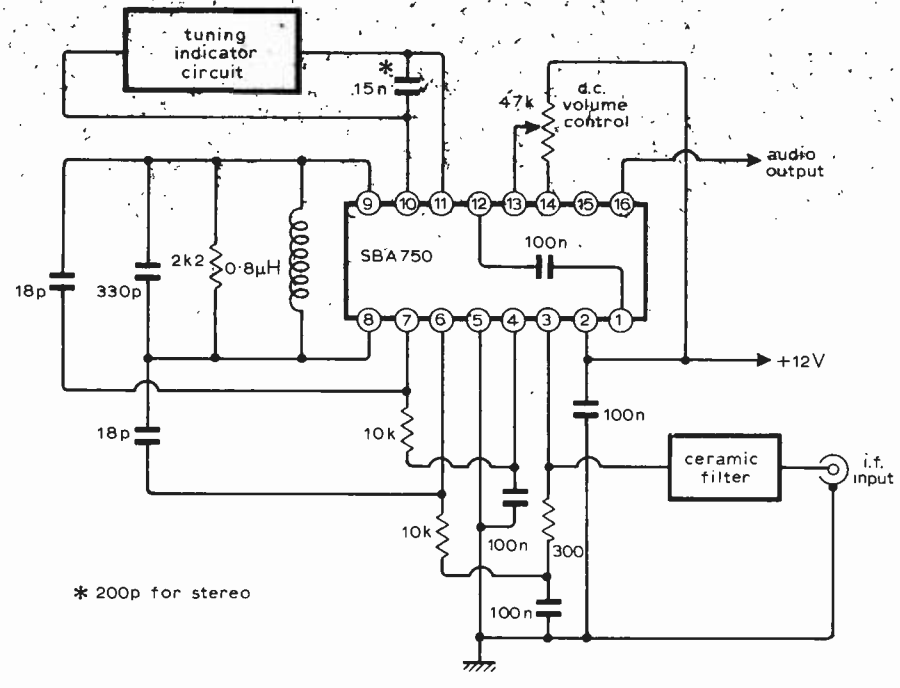


Fig. 4. Used with the SBA750 i.c., the reference can be dispensed with as the output is differential.

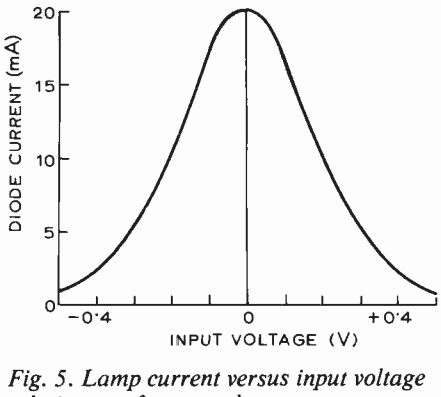
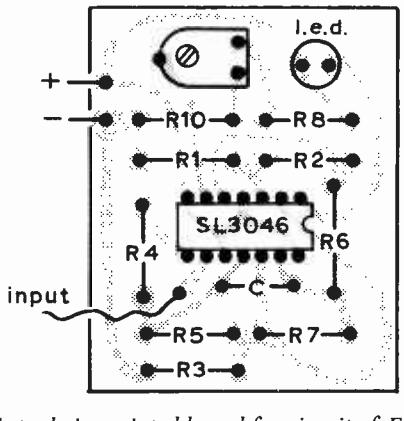


Fig. 5. Lamp current versus input voltage relative to reference voltage.



Actual-size printed board for circuit of Fig. 3, and pin connections for the i.c.

of connection to the SBA750 limiting i.f. amplifier and detector. The bias available from pins 10 and 11 is about 8V, causing a tail current of 25mA, thus supplying about 20mA to the l.e.d. These pins are the detector output and since this is differential, the reference can be eliminated. Instead, pins 10 and 11 may be directly connected to the bases of Tr_4 and Tr_5 of Fig. 3.

If this indicator is being added to an existing receiver, a check should be made that the power supply can deliver the extra current. If a dropping resistor is used in the supply, it is better to connect the indicator to the unregulated end of this.

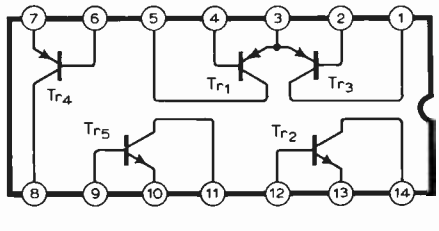
The device used is the Plessey SL3046 five-transistor array, a plastics-cased version of the SL3045. These devices, in common with all integrated circuits, have a substrate connection which must be connected to a voltage more negative than that which any other part of the array can ever reach. Usually the negative supply rail is the most convenient and safe place. In this case, however, to save on the number of pins, the substrate is internally connected to one of the emitters. This transistor is therefore used for Tr_2.

Fig. 5 shows a plot of lamp current against input voltage relative to the reference voltage. This reference is normally made variable and adjusted during alignment of the receiver for maximum brilliance at the correct tuning point. The circuit is unaffected by the presence of audio on the detector output, but this may be filtered first if desired.

In action the indicator is easy to use giving a very clear, sensitive indication of the correct tuning point within a few millivolts and is much easier to set than the two-lamp system. In addition, despite the slightly higher transistor costs, the saving of one lamp makes this circuit cheaper and is a good example of the effective use of integrated transistor arrays.

Components

R_1, R_2	470Ω	10%
R_3	270Ω	10%
R_4, R_6	100Ω	10%
R_5, R_7	680Ω	10%
R_8	3.3kΩ	10%
R_9	1kΩ pre-set	
R_{10}	6.8kΩ	
C	0.1μF	
transistors	SL3046	
l.e.d.	5082-4403	



Tape recording and the law

How reliable are magnetic recordings as evidence?

by Hugh D. Ford

Some countries accept magnetic recordings as evidence in their courts of law; others do not accept them. This article reviews some of the problems of detecting recordings which have been tampered with, and in particular the problem of detecting copies of recordings. The author concludes that while some forms of tampering can be detected others cannot be detected, with the result that magnetic recordings should be treated with great caution in evidence.

Before examining the possible methods of detecting edits or other forms of tampering with the intelligence of recordings it is necessary to consider the methods by which recordings presented in courts of law are made. To an audio engineer the first thing that comes to mind is a recording made in a proper studio under ideal conditions and using first-class equipment —I have never heard of such a recording being challenged in court.

In practice I have come across a few recordings made using Nagra IIIs and Nagra SNN recorders. However, in my experience, the common equipment standard is something like a pocket dictating machine being carried up and down the main shopping street in a briefcase full of rattling keys, rustling papers and anything else that one can think of that makes a random background noise! There are of course some recordings that reach a reasonable amateur standard, but the normal quality is poor with unintelligible speech in at least some parts and excessive background noise which more often than not has a wide frequency spectrum and a large dynamic range.

The law about tapes

At the time of writing the English law allows magnetic recordings as evidence in courts of law, provided that two conditions are observed:

1. Either a tape must be an original recording, or there must be some good reason why the original cannot be produced in court.

2. The continuity of handling of a tape must be fully accounted for from the time of the recording to the time of production of a recording in court.

These two essential requirements originate from the law about the use of photographic evidence and do provide a certain amount of protection against the use of edited recordings or other forms of tampering. However, in practice it is the continuity of handling that bears great weight in court—and this factor depends upon witnesses, who may not be above suspicion, telling the truth.

This is where the "expert witness" comes on the scene and is faced with the problems of deciding whether or not a recording is in fact an original recording, and in either case whether the recording has been altered in any material way. He may also be faced with other problems such as assisting with making a written transcript of very poor recordings, providing "cleaned-up" versions of the original tape for replaying to the jury, and most important, advising upon the shortcomings of any recording methods that may have been used.

The latter problem is in my opinion extremely important if proper justice is to be done because there are circumstances where the likelihood of tampering with a recording is remote but the method of making a recording can produce deceptive results. For instance, a relatively clear recording was made of the conversation between one alleged culprit and a policeman armed with the recorder and sitting in the back of a car with him. The other alleged culprit was driving the car and said that he did not hear the conversation in the back of the car and did not know what was happening—if he had known he would probably have been found guilty of bribery.

If this recording had been replayed in court without any technical advice the jury would have been convinced that the conversation was clear and would have been heard by all the persons in the car. But an explanation in court of the function of automatic gain controls and microphone characteristics convinced the jury that the conversation might well not have been heard by the driver; on this evidence he was found not guilty.

Magnetic recordings are not yet very common in the English courts of law, and those that do appear have usually been made by amateurs in tape recording. However, while magnetic tape is used by the British police as an aide memoire, there is a movement towards using magnetic recordings for interviewing suspects and for recording their statements. It is my opinion that considerable care must be taken if this procedure is to be adopted, for while we are blessed with a relatively honest police force there are criminals within the police who might be tempted to tamper with evidence.

The final legal aspect is the likely penalty for tampering with magnetically recorded evidence. At the moment the production of falsified evidence is treated as perjury, which carries fairly severe penalties. Consideration is, however, being given to the possibility of treating the production of falsified magnetic tapes as forgery, which attracts far more severe penalties because the act of forgery is essentially premeditated.

The problem of tape copies

The assumption that copies can be detected gives a degree of protection against edited tapes being produced, as it eliminates the conventional method of editing with a razor blade and splicing tape.

But—can we detect a well-made copy?

Let us first consider what we would expect to find if we were presented with a recording which has been made using a new tape on a battery operated recorder, equipped with the usual automatic gain control. Fig. 1 shows that pattern of events which is typical; the magnetic tape has a non-magnetic leader and trailer attached by factory-made splices which are of standard lengths and colours. The noise level replayed from the tape both before and after the recorded section should correspond to the bulk erase noise for the particular tape type, and the recorded section will start with a recorded click when the recorder was switched on and terminate with a double recorded click when the recorder was switched off. The recorded signal level will not exceed a

certain limit and will be consistent throughout the recorded section. The recording will not contain any underlying tones such as power supply hum, or contain any clicks of an electrical nature.

At first sight it may appear to be easy to make a copy tape which will comply with this format; however one must also take into account the circumstances of any given recording.

Provided that a recording sounds as if it is complete in these respects, we are forced to use the following lines of investigation:

1. Do the start and stop patterns align with the recorder used?
2. Are the recorded noise levels right?
3. Does the recording contain hum or other recorded tones?
4. Are the recorded levels right? Is the bias frequency right?
5. Is the recorded format that of the original recorder?
6. Does the tape contain recorded electrical clicks or other signs of interference?

Start and stop patterns

With the exception of some high quality studio recorders, all recorders leave a click pattern recorded on the tape when the machine is started or stopped in the record mode; this pattern differs to a great extent from one type of recorder to another or can therefore be used to identify a particular type of machine.

The stop pattern is of particular importance as this gives a clear indication of the mechanical spacing between the record and erase heads of the particular machine. Furthermore, the tape noise around the stop pattern is of particular interest because the noise in the gap between the record and erase heads is bias erase noise, and the noise after the erase head is bulk erase noise if the tape in question has not previously been used.

Using various techniques it is an easy matter to determine the start and stop waveforms, and to determine from the last-mentioned the record/erase head spacing. The actual shape of the stop waveform is also significant because it varies not only from one recorder to another but also gives some indication of the type of erase head used (such as single or double head-gaps). The type of start waveform is somewhat more difficult to analyse, but here it is possible to compare the waveform with a typical start waveform of the type of recorder alleged to have been used for the original recording.

Are the noise levels right?

When analysing a tape recording for originality we are concerned with a number of different noise levels: these are the bulk erase noise of the tape used, the bias erase noise (which is the noise level from tape when it has been passed over the record and/or erase heads of the recording machine alleged to have been used and when it is in the record mode but without any audio input signal), and finally the recorded background noise throughout the audible recording.

The relation between bulk erase noise and bias erase noise is fundamental to the analysis of recordings and should be clearly understood. The bulk erase noise level is the noise level commonly found to exist on new and unused tapes and it is consistent to fairly close limits within a tape type. Bulk erase noise is the tape noise resulting from passing a tape in an open magnetic circuit through a saturating alternating current magnetic field which is slowly reduced to zero intensity. These conditions are met by the common types of tape bulk eraser which erase tapes out of contact with the ferromagnetic circuit. Bulk erase noise is always less than bias erase noise, which is added by passing a tape through a slowly decreasing alternating current magnetic field in a closed magnetic circuit. Such a condition is met when a tape is in contact with the erase or the record heads of a tape recorder set to the record mode and without any audio input signal.

In practice the tape recorder may also add further noise but for the purposes of this article the total measured noise resulting from the tape being recorded with no audio signal input will still be called bias erase noise; but it is important to note that this bias erase noise will vary in level from one recorder to another. It is also useful to note that the bias erase noise introduced by a recorder is normally at virtually the same level when the tape has passed over both the record and erase heads and when it has passed over either head alone.

Depending upon the alleged history of a recording, it is necessary to decide upon the significant points for analysis, but rather surprisingly the "unused" section of a tape is an extremely important part. As I have already said, it is no easy matter to make a tape copy with the correct stopping conditions, and one way to eliminate this problem is to copy a tape in its entirety and subsequently to remove the bias erase noise after the "off" click of the original recording. At first sight it would appear to be virtually impossible to bulk erase a tape up to the point precisely coincident with the "off" click; there is in fact a very simple way in which this may be done, but it may leave a "footprint".

All parts of a tape which should contain bulk erase noise should have a graphical recording of the noise level made throughout their length, using a replay machine with the correct replay head width and a good replay amplifier with an adequate margin in signal-to-noise ratio. The use of other replay track widths may also give valuable results. The resulting plots of tape noise should naturally be consistent in level and exhibit a tape noise level which agrees with the bulk erase noise of the tape type. It is then vital to look in further detail, and it is my practice to do several third-octave spectrum analyses along the length of the "unused" section of a tape and to make sure that they are consistent.

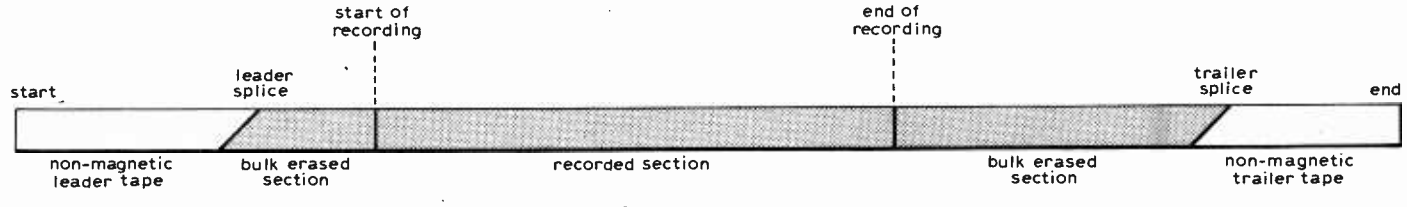


Fig. 1. Expected tape format for new tape on a battery recorder.

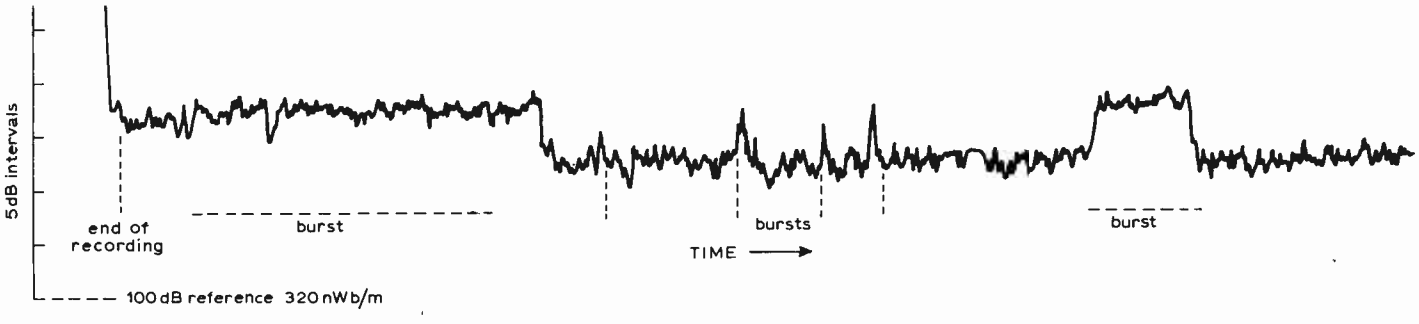


Fig. 2. Tone bursts revealed as the result of narrow band analysis.

Any inconsistency must be investigated in further detail and Fig. 2 shows what could be found—periodic bursts of 30Hz tone along unused tape!

While a defect in a recording such as this is completely inaudible at the normal tape speed, it is clearly audible at higher tape speeds. Therefore a wise precaution is always to replay tapes throughout their length at both higher and lower tape speeds than the nominal speed.

This leads to the problem of determining the noise level between the "off" clicks of the record and erase heads; at the correct tape speed this gap occupies a very short time, with the result that measurement of the noise level may be virtually impossible even when using a high speed level recorder. However, operation at a lower tape speed will normally solve this problem so that the expected bias/erase noise can be checked. Another method that is useful for investigating the noise level near large amplitude signals is to run the tape backwards so that the section of tape of interest occurs before the large amplitude signal, thus avoiding saturation of the measuring equipment.

The background noise level within the recorded section of a tape should also be checked throughout the recording by making a continuous recording of level with a high-speed pen recorder, and using a lowered tape speed to investigate any sections where there are any short term drops in level.

Hum or tones within the recording

At first sight it would appear that a recording which has been made with a battery operated recorder away from the public electricity supply should not contain 50Hz hum—this however may not be the case. In fact many recorders use capstan servo systems which operate by using tachometers in conjunction with various forms of frequency comparison, and it is not uncommon for tones from these systems to be recorded at very low level on to tape.

Because of this low level any analysis requires the use of very narrow band filters which must also have a wide dynamic range so that they do not overload during heavily modulated passages of the audio recording. However, there is a limit to the minimum bandwidth that can be used because of the inherent wow and flutter in any recording, which may put originally constant frequencies out of the filter bandwidth.

A further matter which always warrants investigation is any mains frequency hum within a recording, but this line of attack must be approached with great caution as it is all too easy to come to incorrect conclusions about the characteristics of the recorded hum. For instance, a change in hum level coincident with a phase change in hum may be regarded with great suspicion: however, a little thought shows that this can be a result of perfectly normal circumstances, such as the total recorded hum being caused by a number of hum sources and one of them being switched off. Cyclic changes in recorded hum level are a slightly different matter and can be the result of adding hum when copying a recording which already contains hum; but here again there are quite innocent origins which must be considered.

Recorded levels and bias frequency

The analysis of the recorded level in terms of a standard reference level is best carried out by means of a high-speed level recorder. From such results it is possible to note any sudden changes in level which do not correlate with the conditions of the alleged original recording. In particular, any breaks in the recording where the noise level approaches either bias erase noise or bulk erase noise become clear so that further investigation can follow.

Normally it is quite clear from listening tests whether any automatic gain control has been used during the recording, but a combination of a level recording and listening tests is certain to decide if this is the case.

Where it is apparent that an automatic gain control has been in use the peak recorded levels should be consistent if adequate record gain was available at the time of recording, and this matter can be readily confirmed, if necessary by simulating the alleged original conditions and making sound level measurements.

Finally, there is the matter of the recorder's bias frequency, and while I have seldom found this to be a useful matter to investigate it is worthwhile to attempt to extract the frequency of the recorded bias waveform by running at lower tape speeds. Should it be possible to determine the bias frequency, which is unusual where the recording speed was less than 19 cm/s, this may be used as a further check upon the authenticity of a recording. Furthermore, the bias frequency should be sensibly constant throughout a particular recording if it was made with a single machine without breaks.

The recorded format

The recorded track width and the possible presence of a pilot tone track (as used for synchronous film recording) is one of the more obvious factors that may be confirmed, but only to reasonable accuracy without using destructive methods of investigation.

The safest method is to use a magnetic tape viewer which is a commercially available item and consists of a suspension of ferromagnetic particles contained behind a very thin non-ferrous diaphragm.

A more accurate method is to apply a mixture of carbonyl iron and a rapidly evaporating liquid (which must not be a solvent) to the tape coating. This then leaves a deposit of carbonyl iron particles aligned with the recorded flux on the surface of the tape and shows the precise location of the recorded tracks. However, caution is necessary to ensure that the tape coating is not damaged, and some visible marking may be left on the tape.

Clicks and other interference

As any recording engineer is well aware, there are two sources of audible clicks: those from electrical interference and those associated with poor editing. So far as tape copies are concerned, either of these may occur; and there is a third form of click that may be introduced at the stage of either the original recording or that of the copy. This is an audible click that is associated with sudden variations of level together with the use of poor automatic gain control or limiter time constants.

During the analysis of any form of audible click it is vital that the replayed risetime should correspond to the original recorded risetime; hence the correct replay equalization time constants must be used and the replay azimuth must be as near as possible correct. The last-mentioned factor implies that the minimum available track width should be used for replaying the tape, consistent with a reasonable signal-to-noise ratio.

It is then possible to photograph the risetime of the recorded click with a good degree of accuracy, and should the risetime be outside the bandwidth of the original recorder this would be a grave cause for suspicion. For this type of analysis it is, of course, vital that the original recording should be used, because any attempts to define click risetimes from copy tapes are meaningless.

Other matters giving cause for suspicion are highly asymmetrical click waveforms which cannot form a part of music or speech (which has a worst-case asymmetry in the order of 8 dB), and click waveforms which form single cycles of a frequency which is alien to the adjacent waveform.

It may, however, be surprising that even 90° splices made with a magnetized razor blade give a slow waveform in comparison with normal music or speech waveforms.

The genuine(?) original tape

The previous tests give a reasonably good chance of detecting a copy tape, but I am sure that someone with a knowledge of these and other techniques could produce a copy that would pass as an original unless it were subjected to an extremely time consuming examination which would not normally be financed by the courts of justice.

The conventional professional form of editing implies splicing a tape, and such a slice involves about 12mm of splicing tape which has a good chance of being observed visually. Hence the common methods of editing require that a copy tape be made, and there is a good chance of detecting such a copy.

Assuming that professional editing methods cannot be used, one resorts to amateur editing methods, which, when they do not employ splicing, are concerned with starting and stopping the recorder at appropriate times. If this has been done without any precautions, substantial clicks will be left on the tape at any points where the recorder has been switched into or out of the record mode. Such clicks can be readily analysed and are obvious signs of tampering; however, this form of editing can be easily accomplished without leaving recorded clicks on the tape. This is done by using the pause control which is fitted to many recorders. The desired editing point is marked on the tape with a wax pencil and the tape is moved by hand a few

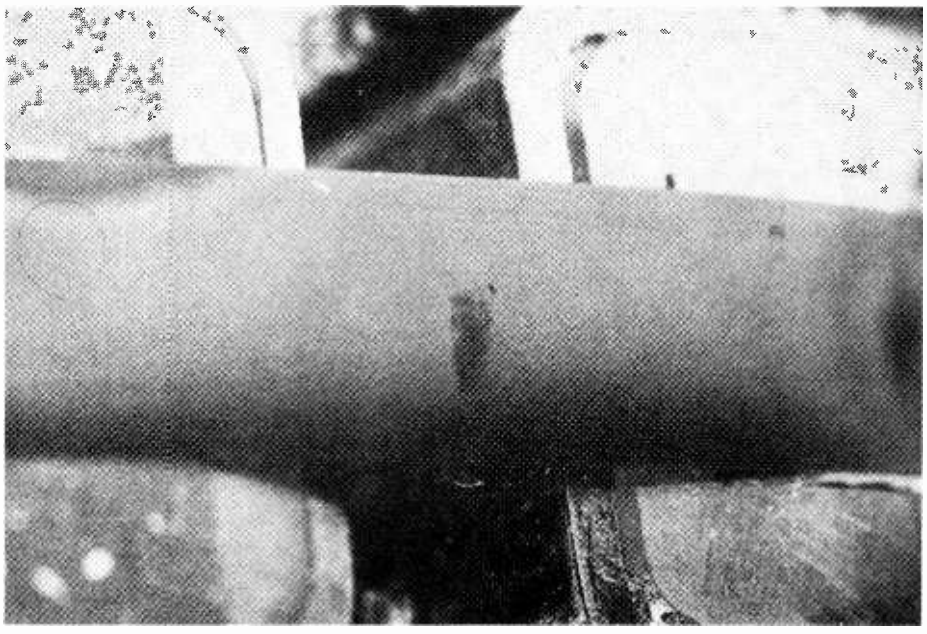


Fig. 3. Editing mark found on tape used as evidence in a criminal court case.

centimetres in the forward direction; the recorder is then put into the record mode and the pause condition and the tape is rewound by hand to the desired editing point, with the result that the clicks produced when the machine was switched to record are erased. The recording is then started by releasing the pause control, which with many recorders gives a remarkably fast start time of the order of only a few milliseconds.

If this type of editing is carefully done it can be extremely difficult, if not impossible, to detect. As with other types of editing the clue lies in any variations of recorded level, noise or tones, at the editing point. Furthermore, it is wise to make a careful inspection of both sides of the tape at any point where editing is suspected, as well as observing the recorded tracks with a tape viewer or carbonyl iron suspension. Fig. 3 shows the result of the inspection of a tape which was involved in criminal proceedings. It was found that the location of this editing mark with respect to the defects in the recording bore a precise relationship to the spacing between the heads of the recorder which was known to have been used.

Other forms of deception that may be used are the removal of parts of a recording by erasure, simply switching the recorder on and off, and, finally, the loss of complete reels of recorded tape, which, while it is not exactly in the province of engineering, provides a very effective form of editing.

Overall it is necessary to treat each particular recording on its own merits, and to devise checking methods that are appropriate to each case. However, while carefully made copies of an original tape may be used for limited investigation, it is vital to check every parameter on the alleged original recording because any copying process must essentially produce some degradation of the recorded "quality".

Generally one's own ears provide the most powerful tool for investigating recordings, and any points that sound wrong or in any way suspicious should then be subjected to detailed analysis by other means. Even then there may be endless argument about the interpretation of results, the classic case being the apparently truncated word which sounds wrong. This can be the subject of every form of analysis including oscillograms and spectrograms (voice prints), the sole effect of which is to produce a heated debate between speech experts, who will fail to agree whether or not the decay rate of the waveform is natural but agree that identical results could be produced by a 45° splice in the tape.

Should tape be used in evidence?

It is my opinion that magnetic recordings should never be considered as being reliable evidence, because I am convinced that it is not very difficult to produce edited recordings that will pass the most stringent tests without edits being located. This opinion is supported by all the engineers with whom I have worked in this field, and is further supported by the only experimental trials that have to my knowledge been undertaken in this field.

In the light of this knowledge I hope that those countries that have so far not arrived at the stage of accepting magnetic recordings as evidence in courts of law will take the precaution of rejecting magnetic recordings as a reliable form of evidence.

Unfortunately, many countries have accepted magnetic recordings as evidence in courts, with the result that police forces and other official bodies are tempted to make use of magnetic recordings for obtaining evidence and for recording interviews with suspects. Where such use of tape cannot be avoided it is important that recordings should be made under controlled conditions, and in particular that every effort should be made to make the investigation into the authenticity of such recordings a straightforward operation.

The methods outlined above are by no means a complete summary of the techniques that I have found to be useful, but do present the major methods that should be considered for use on any recording. Individual recordings which have been made on various types of recorder will dictate the use of other methods, with the result that it is essential to treat each tape on its own merits.

Finally, I emphasize that no claim is made that edited tapes can be detected. Some can, but I and my colleagues are firmly of the opinion that it is currently impossible to detect some edits.

This article is a version shortened by the author of a paper he presented to the Audio Engineering Society convention in Copenhagen, March 1974. It is printed here by kind permission of the *J.A.E.S.* in which the full paper will be found, vol. 22, no. 4, May 1974.

Research Notes

Magnetism and the weather

The Appleton Laboratory (once the Radio Research Station) at Slough has found a correlation between temperature and rainfall and the sunspot cycle. This has set research workers looking into historical records of things which are affected by the weather, such as crop yields. From these it emerges that there is, in addition to the familiar 11-year cycle, a longer cycle of 180 years.

This is just one of many pieces of evidence that the weather, in both the long and the short term, is influenced by magnetic storms and local changes in the earth's field.

Geological records also suggest that on the many past occasions when there has been a complete reversal of the earth's magnetic polarity there have simultaneously been great changes in flora and fauna. Could this be because unusual solar activity produced unusual climates?

Photoelectric leaf sensor

Crops such as lettuce, sugar-beet, turnips and cabbages are farmed by sowing an excess of seeds close together in rows and thinning-out after germination. Thinning-out by hand is a tedious job, so various mechanical thinning-out techniques have been developed. The simplest of these just chops out unwanted plants at regular intervals, without regard to how many plants are actually left, but the more sophisticated detect the presence of plants and adjust the thinning-out procedure accordingly, to achieve optimum spacing of the crop.

Plant sensing has been attempted, for example, by means of mechanical sensors, by using a probe to detect plants by measuring their electrical resistance, and by a light-ray and photo detector which senses the presence of a plant when the light is interrupted. These sensing techniques work well under ideal conditions but are affected by rain, mud and dust, stones, or uneven soil surface. A more reliable way of detecting plants has been developed by the National Institute for Agricultural Engineering. It depends on the fact that green leaves strongly reflect infra-red light at a wavelength of longer than 700 nanometres, whereas soil does not. By comparing the reflectance of the ground at infra-red with the reflectance of visible light it is possible to sense the presence of small seedlings accurately.

The sensing arrangements consist of a tungsten-halogen lamp, lens system, ground-scanning arrangement with oscillating mirrors, filters for separating the visible and infra-red, light detectors, amplifiers, and a "sunlight compensatory amplifier" which corrects for ambient light. The light detectors in the NIAE prototype equipment are Plessey OPT1A integrating light detectors which include a photodiode, an m.o.s. transistor, and an amplifier. The photodiode is given a "charge" of reverse bias: light makes the diode conduct and reduce the bias.

With this apparatus it is possible to scan a row of seedlings at three mph, detecting cabbage, lettuce and sugar beet at the cotyledon stage (leaf area 200sq mm or over) with 99% accuracy.

Better cryogenic power cables

Some proposals for low-loss underground power cables involve the use of superconductive elements and liquid-helium cooling. It may not be necessary to go to such extremities. Work at Heriot-Watt University at Edinburgh has shown that liquid-nitrogen cooling to about $-180°C$ improves the qualities of ordinary paper insulation so much that the cost of a cable could be significantly reduced. A design study for a cable 58cm in diameter overall, including thermal insulation and sheathing, suggests that a pair of cables could carry 5000 MW at 500kV d.c. The trench needed to lay the cable would be only 1.5 metres wide and deep.

Sky-wave radar to track hurricanes?

Over-the-horizon radar, using frequencies in the h.f. band which are reflected by the ionosphere, is used both for military purposes and for ionospheric research. As far as ionospheric research is concerned, only a modest aerial is required, since the object is merely to see whether signals come back on a particular frequency and so assess the state of the ionosphere as a reflector. For military purposes—keeping an eye on activity thousands of kilometres away—sharp directivity is required and at wavelengths of, say, 10 metres this calls for a huge array of aerials. Such an array may be too expensive for civil purposes.

In recent years Prof. E. D. R. Shearman of Birmingham University has been experimenting to adapt the radio astronomy technique of aperture synthesis to sky-wave radar. (This depends on the fact that if the source or target persists for a long time the same directivity as a huge aerial array can be obtained by combining measurements taken with a fixed and a moving aerial, the moving aerial being shifted to a number of different positions and measurements made at each.)

Promising results have now been obtained. The aerials used were three-element Yagis, the frequency was 32MHz and the maximum separation was 300 metres—the length of a section of disused British Rail track at R.R.E., Defford. A complete set of measurements took about 4 minutes and the beamwidth after synthesis was some 2 degrees. The receiver used was a twin-channel Wadley loop superhet.

With such a modest set-up it should be possible to detect large waves at sea. Doppler shifts in the returned echoes give some indication of the speed and direction of the waves and hence allow deductions to be made about the wind. A sky-wave radar station of this type, placed in a hurricane-prone area such as the coast of Bangladesh, might give early warning of an impending disaster. It is true, of course, that weather satellites report cloud systems associated with hurricanes, but sky-wave radar is more precise and cheaper.

Electron guns for rainmaking?

"Cloud seeding" makes rain by dropping particles of silver iodine or solid carbon monoxide into clouds from aircraft. Enough experience has been accumulated to prove that it can be made to work. But it is expensive. Dr F. Winterburg of the Desert Research Institute, Nevada, proposes using electrons fired into the clouds instead. The obvious problem is the very limited range of even a high-voltage electron beam in air. Dr Winterburg thinks this can be overcome by firing a rapid succession of high-energy electron pulses along the same path, so that the heating and thinning of the air by expansion would enable successive pulses to penetrate further.

Laser gas-leak detectors

Leaks of natural gas from buried pipelines can be detected by means of a helium-neon laser. An instrument for this purpose, made by International Research and Development, was demonstrated recently at the Electro-Optics Exhibition at Brighton. Detection depends on the fact that methane is strongly absorbent of light at the 3.39μm laser wavelength. Concentrations to 10 p.p.m. are detected.

Videophone aids disgruntled consumers

Rediffusion has been demonstrating how a videophone can be used in local government. The new Tyne-Wear authority used one to connect itself to housewives who wanted to complain about goods purchased which were unsatisfactory in some way. The video link carries four displays —the two speakers, the goods, and a spare, and the idea is to enable the local government official to combine efficiency with an effective human contact.

Letters to the Editor

Engineers and technicians

Ref. your editorial in the April issue and in particular your remarks concerning the UKAPE fight against employers who classify engineers with the mass of technicians and other manual workers. I also refer to your statement that three years' training to B.Sc. standard makes one undisputedly superior!

Might I, a humble technician, being typical of the main subscribers to *W.W.*, offer the following observations.

Marconi was just one of many unqualified people who fought against jeering professionals to lay the foundation of our trade. Most of today's innovations are the result of years of experience, not a B.Sc. The HNC/C&G students also seem to be wasting time in five years' or more study when a superior B.Sc. is obtained in three! Closing the door of CEI a few years back does not make us overnight morons.

Finally, why not browse through *W.W.* situations vacant and see how many companies ask for HNC/C&G; also how many class them as engineers and pay accordingly!

Alan Perry,
Hillingdon,
Middlesex.

Horn loudspeaker design

I read with great interest Mr Dinsdale's first article on horn loudspeakers in the March issue and much appreciated the historical survey given by the author. The later part of the article dealing with horn theory was, however, slightly confusing, not only the obvious lack of correspondence between Fig. 2 and the text accompanying it but more so the statements made under "Loading the rear of the loudspeaker motor". It is hard to believe that the difference in loads presented to the diaphragm between positive and negative excursions should be of major importance. The air load on a diaphragm is the pressure difference across it and, assuming sinusoidal or near sinusoidal pressure variations on both sides, the net difference is the same irrespective of direction of movement, only a change of sign taking place. The pressure on either side of the diaphragm may have any instantaneous value as long as the variations are periodic.

The effect of loading the rear of the loudspeaker with a closed chamber is best seen from the expression for the mechanical impedance at the throat:

$$Z_{MT} = R_{MT} + j\frac{1}{\omega \cdot C_{MT}}$$

The reactance should clearly be termed a negative compliance; thus the positive compliance presented by the diaphragm suspension in parallel with the compliance of the closed chamber can be made to cancel the throat reactance at all frequencies above the cut-off frequency, not only at cut-off. From a loading point of view a closed chamber is superior to a mid-range horn. A compound horn design must rely on the stiffness of the diaphragm suspension to load it at low frequencies.

Tore Hevreng,
Lidingö,
Sweden.

The author replies:

I am sorry that my article has confused Mr Hevreng. Fig. 2 was intended to illustrate the non-linearity of the adiabatic p-v relationship for air, as I tried to explain in the accompanying text. It is clear from Fig. 2 that the change in volume resulting from a compressive stress is less than that resulting from an equal expansive stress, and this does indeed give rise to serious distortion at the throat of a horn, where pressures can be very high.

For example, Fig. 9 (in part 2 of the article, May issue) indicates that when operated at a level of 1 watt/sq.cm at the throat, a horn will give distortion levels of nearly 2% at the cut-off frequency, and 20% at ten times this frequency, due to the non-linear p-v relationship. At lower power levels of course the distortion becomes insignificant.

I am grateful to Mr Hevreng and a number of readers for pointing out an oversight on my part, that the reactance of the closed compression chamber used by some designers to load the rear of the loudspeaker is capacitive while the reactive component of the throat impedance is inductive. The compliances of the diaphragm suspension and the closed chamber can, of course, be arranged to cancel the throat reactance at all frequencies above cut-off, but examination of Fig. 1 shows that for the exponential and hyperbolic horns this reactance becomes significant only at frequencies near to cut-off.

Finally, the loudspeaker should never be allowed to rely merely on the stiffness of the diaphragm suspension to load it at low frequencies; as I indicate in part 2 of the article the signal bandwidth should be limited electrically (preferably by active filters at low level, rather than by passive crossover networks between power amplifier and loudspeakers), so that the horn is not driven at frequencies below cut-off. If this is done, it is my experience that horns in which the unloaded side of the diaphragm is allowed to radiate give a better performance than those with a compression chamber.

J. Dinsdale.

Colour separation overlay

I was most interested to see Gwilym Dann's article on colour separation overlay in the April issue. Mr Dann rightly points out the two major technical imperfections: the problems of rimming and tearing. However he offers little to solve these difficulties and perpetuates an "old wives' tale" which needs to be consigned to oblivion.

Rimming (the halo caused by scattered light from the backing) can only be removed by spatial separation of the backing and subject, but its effects can often be mitigated by using yellow as a key signal. Mr Dann's dismissal of yellow hardly stands up to argument. Flesh tones have minimal chroma content and even the most golden of blond hair produces a surprisingly small (negative) B−Y output (easily checked on a vectorscope). Moreover if a B−Y signal has been derived as a key signal, yellow, the complement of blue, must inevitably be available. Indeed on most colour separation overlay units the datum line can be wound from peak positive B−Y to peak negative B−Y, thus giving blue or yellow keying.

The use of a yellow backing of course gives rise to precisely the same rimming effect but the halo is now a yellow one and not blue—this is frequently far more acceptable. Yellow also has the advantage that filters for projected light backings have a very high transmission factor. Projected blue backings demand very high lamp intensities because of the dense filters needed.

Thus the rather old-fashioned arguments against yellow keying really have no foundation and indeed present practice is to use yellow or blue, depending on prevailing circumstances.

The other problem of "tearing" (a "sparkle" effect produced by the switch jittering on noise if the key transitions are not clearly defined) could perhaps be helped by electronic means. If each transition of the keying signal about a datum level is used to trigger a retriggerable monostable of perhaps 250–300ns period and the "delayed" edge of the output pulse is used to toggle the overlay switch, much of the very high frequency jittering could be removed at the expense of a harder margin and a keying outline shift (that can be removed by retiming sources). An alternative (or addition) may be to add some hysteresis to the switch. To my knowledge neither technique has been investigated.

Yet another approach may be to scrap the idea of linear signals in the keying chain and to provide a variable gamma amplifier that would stretch certain parts of key signal preferentially, increasing its slope at the datum level.

Chris Woolf,
North Ferriby,
Yorks.

Editor's note: In Mr Dann's article the diagrams above captions Fig. 1 and Fig. 6 were accidentally transposed. Apologies for this error.

The author replies:

I do not, as Mr Woolf suggests, dismiss the

use of yellow as a backing for he is undoubtedly right in his reference to the advantages of this colour where the backing is produced by projected light. I think, however, that he has been fortunate with his blondes.

I do not believe that better performance of colour separation overlay depends on improvements in the electronics but rather from improved techniques in the way in which it is deployed as a process.

Mr Woolf says I dream of a wide future but I am sure he will agree that it is a splendid way to dream.

Gwilym Dann.

Electrostatic forces on pickups

I would like to communicate to those of your readers interested in high-fidelity disc reproduction a slightly alarming observation I have made in this field.

I recently installed some high-quality disc reproduction equipment in my home (Linn Sondek deck, SME arm, Shure V15 type III cartridge). The deck, like most others on the market, is available with a plinth and hinged plastic dust cover. This dust cover, as with any plastic article, is liable to become electrostatically charged. If the equipment is used with the dust cover closed the arm will become charged by electrostatic induction, hence there will be a force attracting the arm towards the cover. The fact that the arm is metallic and earthed will clearly improve the charging rather than hinder it. Since the area of the arm on the stylus side of the pivot is greater than on the counterbalance side there will be a net upward force exerted on the stylus end of the arm. Clearly this force will upset the delicate balancing which provides the tracking force necessary for correct operation of the cartridge.

I tested these ideas by placing the arm in a playing position (stylus protector in place), closing the dust cover and then stroking it with my hand. The arm pivoted upwards abruptly, hit the cover and rebounded back on to the turntable; the stylus protector proved to be a wise precaution. Although I do not make a practice of stroking the dust cover whilst I play records it is clear that there will always be some residual charge on the cover, especially in the dry atmosphere of the modern centrally heated house.

Further tests were carried out using the Shure test record TTR 110 to determine whether playing with the dust cover closed had any adverse effect on the tracking. Such an effect was indeed observed.

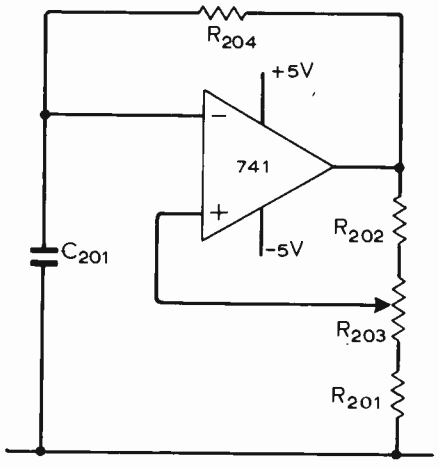
I do not know whether or not this effect is well known amongst the hi-fi cognoscenti, but it certainly is not well documented. The obvious solution of playing records with the dust cover raised has many obvious disadvantages. For example, when using very low tracking forces made possible by modern equipment, a strong draught is enough to cause the pickup arm to skate across a record; a more amusing and rather more expensive example of the dangers of raising the dust cover was furnished by a friend of mine: whilst he was playing a badly warped record his cat became convinced that such rapid bobbing up and down as that exhibited by the pickup arm could only be made by something edible. The cat pounced, with disastrous results.

In a more serious vein it would be interesting to hear of any solutions that other readers may think of to this problem.

M. P. Hide,
Godalming,
Surrey.

Electronic piano design

May I suggest an improvement to G. Cowie's electronic piano (March–May issues)? My experience of his *RC* relaxation oscillators has been that they are potentially extremely stable, but suffer from variations in contact resistance of the pre-set.



The problem can be minimized by a simple rearrangement of components as shown in the diagram. Any change in contact resistance is to be compared with the input resistance of the 741, not R_{204}. Since the input resistance of a 741 is typically $1M\Omega$ an increase in stability greater than an order of magnitude can be expected.

The formula for frequency of oscillation should be

$$f \approx \frac{R_1 + R_2}{4 C_1 R_1 R_1}$$ and not as published.

M. Walne,
Brighouse,
Yorks.

Plug-in p.c. boards

I must register my wholehearted agreement with R. N. Goodman (Letters, April issue) concerning the reliability of edge connectors. I have myself had much trouble with integral "plated" connectors, and I am by no means alone at I.S.V.R. in this respect. We also have found that boards fitted with male connectors offer much greater reliability, especially in circuit development work, where they can withstand repeated connection and disconnection without deterioration.

The type of connectors used are made by Varelco and distributed by Vero Electronics, and these cost an insignificant amount compared to the cost of the board contents. More widespread use of male board connectors is to be encouraged.

J. R. Watkinson,
Institute of Sound and Vibration Research,
Southampton.

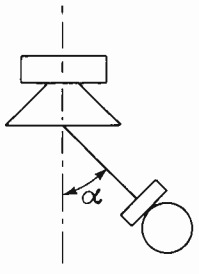
Doppler in loudspeakers

James Moir is to be congratulated on his article on Doppler distortion (April issue) which clarified the somewhat muddled picture left by the "Doppler" versus "no Doppler" debate hitherto. There are, however, a few practical points missed by the author that might help readers wanting to measure this much debated distortion.

I feel I ought to point out that the formula for the Doppler frequency shift, as stated by Mr Moir, applies only to the case when the observer is in motion, the Doppler shift being the result of the number of cycles received per second altering. The correct formula for the Doppler frequency shift applicable to loudspeakers, where the alteration of wavelength is the cause of the frequency shift, is

$$f_o = f_s \left(\frac{1}{1 \pm \frac{V \cos\alpha}{c}} \right)$$

It is customary when measuring loudspeaker parameters to place the microphone at a distance of one metre, on the tweeter axis, since both microphones and loudspeakers tend to get directional at high frequencies. The special nature of Doppler distortion, however, necessitates a change in procedure. As can be seen from the formula, the frequency shift is dependent on the angle the measuring microphone makes with the axis of the loudspeaker (see diagram).



The effect of off-axis placement is to reduce the deviation of the h.f. carrier, and, as Mr Moir points out, this has no effect on the frequencies of the sidebands, although it reduces their apparent level. This indicates that the microphone should be placed on the axis of the loudspeaker unit radiating the modulating (l.f.) signal, if an unambiguous reading is to be obtained.

Finally, on the subject of musical test signals, it would be interesting to know whether a particular *composer* affects the distortion readings! One might find the end of the third movement of Widor's 9th symphony for organ throwing a few speakers off their balance!

Paal Rasmussen,
London, S.W.7.

The author replies:

I would thank Mr Rasmussen for his remarks about Doppler distortion and suggest that he and any others interested

might like to look at a previous contribution of mine[1] in which I dealt with the effect of off-axis measurement on the extent of Doppler distortion.

In the plane of the diaphragm, Doppler distortion should vanish and in the open air conditions under which we measure the performance of loudspeakers we found it to be at least 20 dB lower than on-axis. Indeed, in the early stages of the investigation, I used this effect as one of the checks that we were measuring the components due to Doppler and not those due to amplitude dependent distortions that appear as sidebands at the same frequencies as the Doppler components.

It is worth noting that the on-axis focusing that occurs with the Doppler components is due to an entirely different mechanism to that causing focusing of the primary speaker output signal. The Doppler components fall to zero in the plane of the cone because in this plane there is no variation in the distance between the microphone and loudspeaker diaphragm during a cycle of the lower frequency. Focusing of the primary signal output occurs due to the phase cancellation that arises from the use of a radiator that is several wavelengths in diameter at the frequency of measurement.

With speaker enclosures of normal dimensions the effect of measuring on the axis of the low frequency unit or on the axis of the tweeter is not very significant because the angular difference is small when the measuring microphone is at 1 metre from the face of the enclosure. When the low frequency and high frequency units are widely spaced it could be significant.

The frequency spectrum of the music being produced has a very significant effect on the extent of the Doppler distortion that is introduced by a wide range loudspeaker. Harwood of the BBC Research Department published some data on this in a paper in the *Journal of the Audio Engineering Society* for November 1972, a reference that I regret that I omitted from the contribution to *Wireless World*. There is further data on the same subject in a paper of mine "The Measurement of Loudspeaker Efficiency" available as an Audio Engineering Society Reprint A1.

James Moir.

1. Doppler Distortion in Loudspeakers by J. Moir. *Hi-Fi News*, Jan. 1967.

Neutron radiography

I read with considerable interest your "Research Notes" article in the April issue. As you only mentioned the West German usage of the process it may be that you are not aware that here at Harwell we are very much engaged in the practical applications of neutron radiography.

The Harwell Neutron Radiography Service has been in existence for a number of years and is available on a "commercial" basis to industry. Most of our work at present is in the examination of radioactive assemblies by the "indirect" process you describe but we radiograph a large variety of non-active objects, to take advantage of the contrast differences or special properties of neutron radiography.

You make the point about hydrogen atoms interacting with neutrons and this opens up many possibilities of imaging hydrocarbons within dense or metal objects. The classic "gimmick" example of this is a piece of string radiographed inside a lead block, but non-destructive tests of explosive devices, the position of "O" rings in an assembly, or the gas bubbles in a carbon-fibre epoxy-resin mixture within a metal case are all practical examples of the same property. Other materials which show up clearly on a neutron radiograph are cadmium, boron and lithium.

I think, however, that I would like to correct an impression which may be left by the final paragraph of your notes. Exposure times are indeed quite short—but only if reactor sources are used for the generation of the neutron beam. At Harwell a two-minute exposure is quite typical, but for non-reactor neutron radiographs the exposure times tend to be very extended.

T. J. M. Robertson,
Atomic Energy Research Establishment,
Harwell,
Berks.

Sound radio compression

Although neither erudite nor technical, I find myself in complete agreement with your correspondent on the subject of compression on m.f. broadcasting (Letters, April).

Several years ago I wrote to the BBC on this subject and received a reply which, as far as I remember, gave congestion on the m.f. band as the reason, suggesting that I went over to v.h.f. reception, which, of course, was the answer.

Like Mr Higham, I find this form of distortion particularly offensive and distressing and would sooner put up with some interference than be obliged to permanently endure listening to a signal which has been deliberately tampered with in this grotesque manner.

In my opinion the transmission quality from the Brookmans Park station was better on the day it opened than it is now.

D. W. Hammond,
Woodford Green,
Essex.

Referring to Mr Higham's letter in the April issue, I have found when visiting broadcast studios that compressors there are usually adjusted to operate slightly all the time. This is so that the operators "can see the meter kicking". Thus even the v.h.f. service suffers a little, quite apart from the compression introduced in any recording process.

I would be pleased to hear from any of your readers who have made a satisfactory expander to counteract this compression, perhaps similar to that in *Wireless World* of December 1968 (p. 472). I hesitate to construct that model now as with i.cs and l.e.ds there must be an easier way.

M. D. Bass,
South Croydon,
Surrey.

Soldering-iron leakage

Mr Sproxton's letter in your March issue prompts me to recall my own experience when, for the first time, I entered upon the field of calculator construction and assembled an Advance calculator, as described in *Wireless World*.

Heeding the dire warning in the instructions against using any but the more effectively earthed soldering iron, I thought to check mine. I found, to my horror, that a simple ohmmeter test between the bit and the earth pin on the mains connector showed a wholly unacceptable value. I forget what it was (all this was over a year ago), but for the purpose of this letter, I have again measured it and find that it is between 3 and 10 ohms. The reason, as I discovered when I made the first measurement, is that the earth wire is connected to the pin on the linkage mechanism operated by the thermostat. Thus it is a sliding or rolling contact, and it is not surprising, therefore, that it is of a high resistance and variable. Pretty well any value between the limits noted may be obtained by bodily flexing the iron.

I returned the iron to the manufacturers, thinking I was doing them a favour by pointing out that the iron seemed wholly unsuitable for applications where the slightest leakage could do harm and asking for the iron to be effectively earthed. Far from expressing any appreciation of my action, or even regret at having produced what I consider to be a defective iron (let alone putting it right), they sought to justify themselves by quoting approval by (inter alia) many Government departments. They did, however, say that later models had been modified—little consolation to possessors of their earlier versions. I bought another iron (an Antex Model C), which showed a resistance of 0.14 ohms between the earth pin and the heated rod on which the bit slips. With this I have successfully constructed three calculators and I now use the Antex for all transistor work, reserving the more powerful, but rather suspect, earlier one for kettles and other less sensitive apparatus.

I hope this information will help Mr Sproxton in his correspondence with manufacturers of soldering irons and trust that he has better luck than I have had. I am sorry I am unable to answer the question he asks, but I suspect the complete answer is not quite as simple as a mere figure for d.c. resistance between the bit and the earth pin.

C. E. H. Benson,
Weston-under-Redcastle,
Shrewsbury.

Laser wirephoto system

A report on the design and development of a wirephoto transceiver to be used by Associated Press news agency

As part of the trend towards more efficient usage of telephone links, telephone companies are encouraging a changeover from high quality analogue lines to digital links. Professor W. Schreiber of Massachusetts Institute of Technology has developed a wirephoto transmitter-receiver and digital picture processor which meets this requirement.

A method of transmitting colour pictures over telephone lines has been recently described in *Wireless World*.[1] However, although the processing of colour pictures was novel, the basic mechanism of the transmitter, receiver and the continuing use of analogue signals over the telephone link were fairly conventional. The limitations of such techniques are becoming more obvious with time since the necessary high quality audio links (800Hz to 18kHz for the colour transmitter) are expensive to establish and maintain.

It would seem that the new digital links being offered by telephone companies are a solution to some of these problems, since no special alignment is necessary to accommodate extreme bandwidth, making it possible to provide temporary service over the ordinary local telephone distribution network, quickly and at low cost. With the increasing availability of digital wired links, the digital encoding of picture information makes economic sense. Quite recently the American news agency Associated Press commissioned a development project for a new telephoto transmitter/receiver and digital picture processor which would meet the needs of the future. This project was assigned to the Electronics Research Laboratory of the Massachusetts Institute of Technology and was directed by Professor William F. Schreiber. The results of his work was the laser scanning, dry silver facsimile system and a separate digital picture processor described below and in two papers published by MIT.[2,3]

Selection of scanning/writing system

In developing a new facsimile machine advantage could be taken of the opportunity to seek ways of improving the picture quality over existing systems. Since the transmitter more often than not scans a continuous tone photograph, there is a natural tendency to choose a photosensitive writing process. An additional advantage of such a choice is that the scanning and writing systems may be made to perform the dual function.

Of the types of photosensitive papers available, dry silver paper seemed to be most suited since it was capable of producing pictures of the desired quality and uses a very simple heat treatment for picture development. The scanner/writer selected was a low-power helium-neon laser, for the basic reason that it was reliable, cheap and, since it could be directly modulated, eliminated the need for a separate modulator. Feedback control of the laser brightness also achieves a consistent control of the paper exposure. From this starting point, several subsequent development decisions are possible concerning the method of scanning. Those selected were a flat-bed scanner offering a simple, low-cost paper drive, a galvanometer-driven mirror for horizontal scanning, continuous paper motion for vertical scanning and oven processing of the paper.

The final system designed for use by newspaper agencies handles both the input photographs and output paper as a continuous web, 11in wide and of any length. The scanning density is 100 lines per inch, per minute and to meet existing telephoto transmission standards the transmission signal is double-sideband amplitude modulation. Processing to a digital form is accomplished by a separate analogue-to-digital converter contained within a signal processing computer to be described later. Better resolution and higher scanning speeds are possible where other applications are considered.

Since the tone scale of the output picture was considered to be the most important single aspect of picture quality, control of the tone scale was provided by ensuring stable processing of the exposed paper. In addition a locally generated step wedge is printed at the beginning of every picture and a non-linear amplifier operates on the receiver input signal to produce the required photo transfer characteristic.

The optical system

The optical system is based on a 1mW modulatable He-Ne laser. The power output is more than adequate to expose the 3M type 7771 dry silver paper, the only disadvantage being that the spectrum of light is such that a panchromatic paper is required, resulting in the need to expose and process in darkness. Colour picture transmission would require an alternative light source. The laser selected is cheap and already in commercial production. A

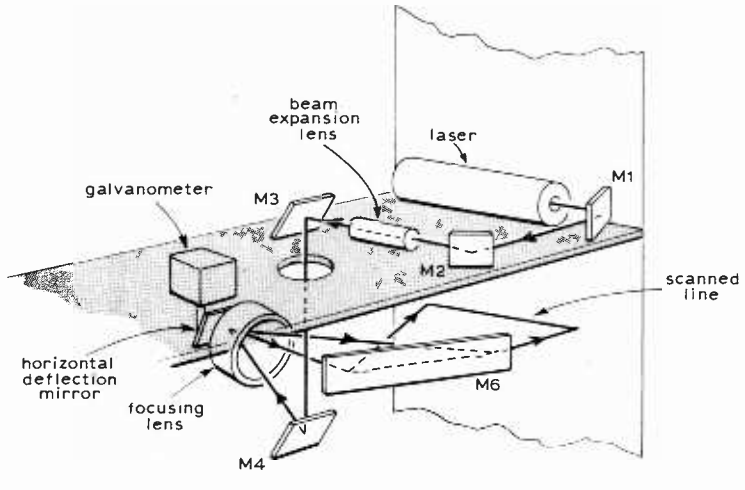


Fig. 1. Mechanical layout of the optical scanner.

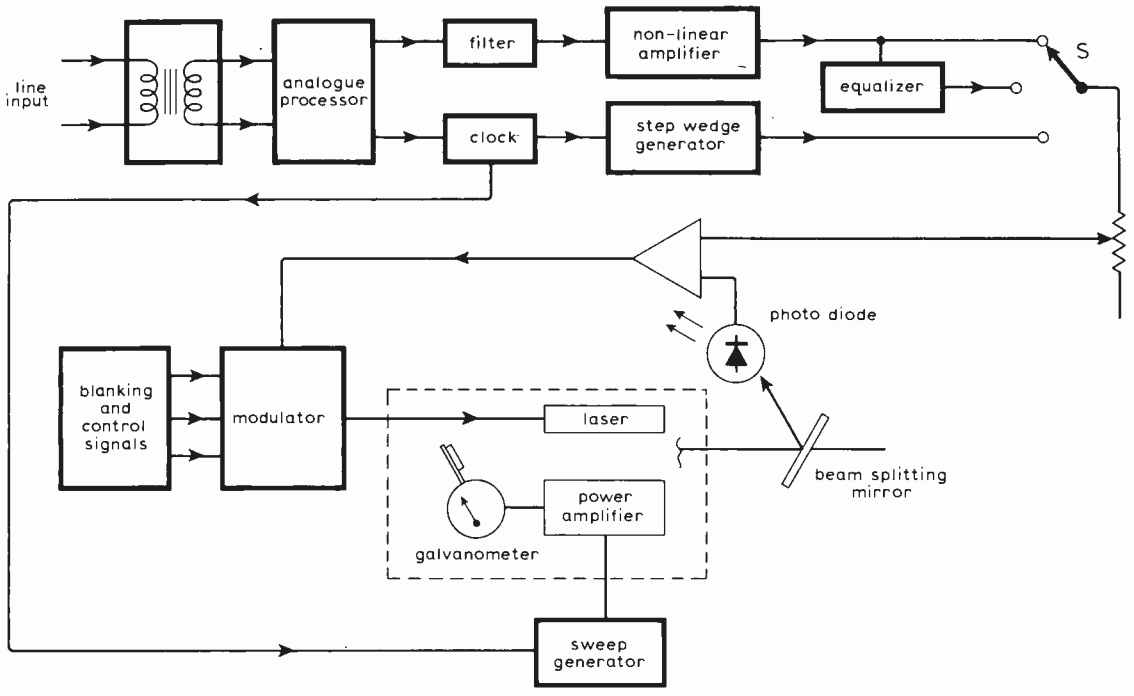


Fig. 2. Block diagram of the wirephoto receiver.

useful feature of the final design takes into account potentially unstable lasers. Thus the modulation characteristic need have neither a linear nor a stable modulation characteristic since the optical feedback system adequately accommodates such problems. The minimum modulation ratio of 30:1, more preferably 100:1, is met by the device selected since current in the plasma can be reduced to a point where the laser action ceases, but the plasma is still stable. This helps to ensure that low light levels do not result in the feedback loop turning the system off accidentally. Fig.1 shows the disposition of the laser and the other elements of the optical system. A heavy, stable platform carries the laser on top, and along one edge is the vertical paper drive. The light beam produced by the laser is deflected by two fixed mirrors to a beam expansion lens. From here the beam is reflected via a periscope below the platform and into a focusing lens. Behind the lens is a movable mirror attached to the armature of a galvanometer. This mirror re-directs the beam back through the focusing lens onto a long, diagonally disposed folding mirror, which reflects the beam onto the paper surface. Rotation of the galvanometer mirror produces horizontal scanning of the light beam. The lower periscope mirror is set to one side of the focusing lens, allowing the full useful angular coverage of the lens to be used and permitting a short optical path length. By design of the lens to produce a flat field at infinity focus, the beam is automatically brought to focus along a straight line, one focal length distant from the lens. Tangent correction is built into the galvanometer such that it moves the focused spot at a constant velocity when driven by a linear ramp.

The dry silver paper selected has several advantages, the first of which is the simple development process. This consists of the application of heat for a specified period of time and at a specified temperature. Such a process eliminates the replenishment of developers and cleaning operations. The paper is sufficiently sensitive to be adequately exposed by a low power laser. Finally, using such a system, the galvanometer mirror and paper feed are the only moving parts, thus significantly contributing to the mechanical reliability.

The successful development of the paper is dependent upon the relationship between the temperature applied and the length of time of processing. A trade-off, one against the other, can be effected without a distortion of the density-log-exposure (D log E) curve. Several methods of heating were tried including hot air, hot liquid, hydrocarbons and heated rollers. The most satisfactory appears to be a hot air oven with a heated section one inch long. The paper is made to traverse the oven at one inch per minute, matching the paper drive speed of the receiver.

Prototype receiver circuitry

Signals from line, conforming to normal standards, enter the analogue processor (Fig.2). This is very similar in design to a conventional receiver and serves the purpose of demodulating the incoming signal and feeding the baseband video to a filter and a synchronizing pulse to the receiver clock. This pulse appears at the beginning of the first line of each image.

Following the filter, the signal is routed into a non-linear amplifier and equalizer, the purpose of which is to compensate for the paper transfer characteristic. The synchronizing pulse starts the clock, which then provides timing signals for the sweep generator and the step wedge generator. The switch *S* operates to connect the wedge generator first to the modulator and then to the equalizer output for the incoming signal. The comparator amplifier which drives the modulator forms part of a feedback loop which includes the optical system. A photodetector diode receives a small fraction of the light from the scanning beam, via a beam splitting mirror. The signal thus produced is compared with the incoming signal and the amplifier produces an output corresponding to the input video minus the feedback signal. The sweep generator which produces the deflection drives a power amplifier, which in turn supplies the galvanometer.

Digital picture processing

As the system stands, it merely represents a direct replacement for conventional wirephoto transceivers utilizing d.s.b. modulation. Since one of the main objects is to eliminate the use of high grade analogue telephone circuits, an investigation is being undertaken at MIT to provide analogue-to-digital conversion, additional processing of the picture prior to transmission and, on reception, d-to-a conversion. The objective the designers are working towards is a system whereby, after digitizing, the picture is stored in a computer memory for subsequent display on a television screen. An editor can select and then edit by cropping, enlargement or reduction, vary the contrast, combine pictures and add or superimpose captions. The stored result can then be transmitted without additional photographic work being undertaken.

A laboratory model of this system has been developed using a PDP-9 computer which will accept pictures from the Associated Press network, or a local analogue transmitter, a 12,000 picture element/second c.r.t. scanner, magnetic tape or Dectape, and store the result on disc. Pictures stored on the disc can be re-transmitted or displayed on a television screen using a full frame semiconductor store. Editing facilities have been developed and the addition of captions realized by storing them as ASCII (American Standard Code for

Information Interchange) characters, processing them to video at the time of transmission.

These operations are controlled by a supervisory programme providing an interactive display. Commands are displayed as video information prior to being initiated, giving unskilled operators the opportunity to check.

The second stage of development uses a PDP-11 computer with input and output facilities for US or European signal standards. In addition, digital signals up to 56kB/s can be accepted and produced. A second installation will be provided at the New York AP offices and test transmissions undertaken over the Bell System digital data system between Boston and New York.

The television display full-frame semiconductor memory supports the picture on a 256 × 256 matrix, assigning four bits to each picture element. Picture enhancement can be achieved by three types of real-time processing. The first is the addition of pseudo-random noise, the second, linear interpolation to a 512 × 512 matrix and the third a non-linear transformation of the signal antilog combined with a correction for the brightness characteristic of the TV tube.

Cropping is achieved by the superimposition of a rectangle of arbitrary size and shape on the display. When selection of the picture area is complete the computer can be commanded to scale the picture to appropriate dimensions for transmission.

References

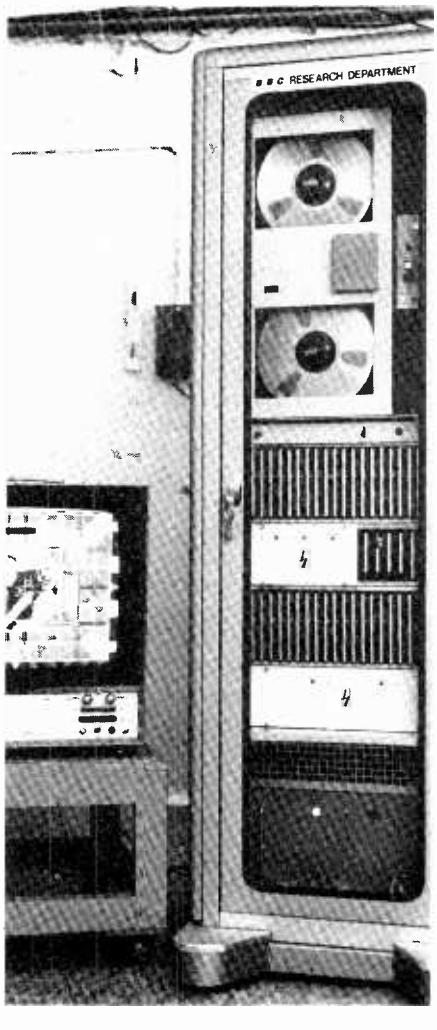
1. Smith, J. H. "Colour telephoto system," *Wireless World*, May 1973, pp.214–219.
2. Schreiber, William F. "Laser/dry facsimile system" presented at 3rd Annual TAPPI Reprography Conference, Boston, Mass., USA, September 30–October 3, 1973.
3. Schreiber, W. F. and Troxel, D. E. "Digital Wirephoto System," MIT Research Lab. of Electronics, USA, November 30, 1973.

Digital television recording

Engineers at the BBC Research Department have built an experimental machine for recording colour television signals in digital form. It uses a standard instrumentation tape transport and the information describing the 8-bit digital signal is divided amongst 42 parallel tracks along the 1-inch tape.

Most of the signal processing is carried out on 42 identical printed circuit boards. The machine may be locked to an external clock, timing and skew correction being carried out automatically. A system which detects and conceals most of the disturbances resulting from tape dropouts has been designed with the particular characteristics of digital magnetic recording in view.

The recorder is intended for use as a research tool in the development of improved methods of error detection and correction, and to ascertain whether a number of possible techniques for reducing television bit rate may be safely applied several times in succession during the history of a signal. Earlier work by the BBC team in this field included a digital stereo sound recorder (see *Wireless World*, September 1972, pp 432–435).



Experimental BBC digital television recorder showing the display of a test card.

Horn loudspeaker design—3

Conclusion of design theories with the details of two horns for construction

by J. Dinsdale, M.A., M.Sc. *Cranfield Unit for Precision Engineering*

The two designs which follow are specific examples derived from the design data and tables provided in parts one and two of this series. Guidelines for construction are given, although it is intended that the constructor devise his own variations, using the design data, to suit his particular requirements.

Much has been written about the best methods of constructing loudspeaker enclosures, especially regarding rigidity and the prevention of resonances and leaks, and as far as the horn is concerned, these points are equally important. The horn enclosure has to stand up to considerable acoustic stress, and any shortcomings in its manufacture are liable to cause more serious aural distress than would be the case with some other enclosures.

Ideally, the horn should be cast in circular section, but this form of construction is only practical with small middle and high frequency horns. The technique best adopted by the home constructor is to cast in plaster-of-Paris using a plywood mould and reinforcements as necessary. The calculated profile should be set out using plywood templates held in place by stringers, which will be buried within the casting itself as "reinforcement". It is also a good plan to provide a $\frac{1}{2}$in panel at the throat end for mounting the loudspeaker, and a further panel surrounding the mouth which will help in securing the complete horn assembly and fixing any decorative cloth finish.

Bass horns are almost invariably constructed of flat panels cut so as to approximate to the correct flare profile. Plywood, chipboard or blockboard are satisfactory, either $\frac{3}{4}$ or $\frac{1}{2}$in thick. Composite sand-filled panels consisting of two thin walls of $\frac{1}{8}$in plywood spaced $\frac{3}{4}$ or 1in apart and filled with dry sand provide extremely rigid resonance-free enclosures. Great care should be taken to prevent any particles of sand, sawdust, etc. from entering the speech-coil gap of the loudspeaker; a recent demonstration mounted by the author at St. Albans was spoiled by distortion caused by a minute particle of wood in one of the treble loudspeakers. Care must also be taken to ensure that the sand is dry, otherwise the wood panels will rot. It is advisable to bake the sand on shallow trays in an oven to ensure that all moisture is removed. After filling, a few minutes of organ music will help the sand to settle down ready for "topping-up".

The wooden panels should be fixed together using wood-screws and with a liberal application of a liquid glue along all mating faces. This not only adds strength, but also makes all the joints air-tight. Further strength should be provided by triangular corner fillets and "glue-blocks" placed at intervals along the longer joints. In addition, smaller reflecting plates should be placed at the outside of all sharp corners to "ease" the wavefronts around bends, and to help preserve the steady exponential increase in horn area, as indicated in Fig. 10. Manufacturing tolerances should not exceed $\pm\frac{1}{16}$in at the throat but errors of $\frac{1}{2}$in at the mouth of the bass horn are unlikely to have any noticeable effect on the performance. It is worth bearing in mind that the velocity of sound, on which all design calculations are ultimately based, itself varies by as much as 5% at climatic extremes.

A vital detail is to ensure that the loudspeakers can be fitted and removed easily, maintaining an overall air-tight construction by means of thin rubber gaskets if necessary. It should of course be remembered that the highest pressures occur at the throat, and the greatest effort to ensure rigidity and absence of leaks should be made in this area. As the cross-sectional area of the horn increases, it is a good plan to fit longitudinal stiffening panels, made of $\frac{1}{4}$in plywood, across the centre of the horn, thereby converting the horn into two symmetrical adjacent ducts. This reduces air turbulence effects at bends and makes the bends themselves less critical in addition to providing extra cross-bracing between panels that might otherwise resonate. It is worth fitting longitudinal stiffeners for the final 25% of each bass horn.

Unlike the majority of loudspeaker enclosures, there is no need to provide any sound absorbent material within the enclosure itself (except within the compression chamber, if fitted, which may be lined with acoustic wadding, long-hair wool, etc., to absorb high frequency sound). The interior of the horn should have all sharp edges removed with sandpaper and all internal corners filled with putty or a similar setting plastic compound and smoothed down by means of a finger. This practice, which is not mandatory, also has the effect of sealing any remaining air leaks. The whole interior surface should be treated with a thick coat of gloss paint.

Design of a "mini-horn"

The intention of the mini-horn is to provide as many as possible of the benefits of horn-loading within an enclosure which is sufficiently small for use in a small living room, where the overall size is of course especially important when a quadraphonic or even a stereophonic installation is under consideration. The room for which this particular mini-horn was originally designed imposed limitations of 20in as the maximum intrusion into the room, and an overall height of 4ft; fortunately, corner positioning was acceptable.

It was clear that only one loudspeaker could be used, and after some thought, the Eagle FR65 was chosen. This is a co-axial twin-cone loudspeaker in which the inner (tweeter) cone is itself shaped as a small horn. This subsidiary cone will handle the extreme top of the frequency range and beam it out axially through the treble horn. The loudspeaker has a nominal diameter of 6·5in, a frequency range of 35 to 18,000Hz and power handling capacity of 10 watts. It is clear that, since top frequencies will be dealt with by the tweeter cone, the bass horn need only cover 3 octaves, i.e. from 70Hz to 560Hz, and the middle-frequency horn can take over at (say) 500Hz. This middle-frequency horn will be most efficient for 4 octaves, i.e. up to about 8kHz, at which point the tweeter cone will already be taking over. The complete frequency spectrum will therefore be:

Bass horn	70Hz to 550Hz
Middle horn	500Hz to 8000Hz
Top horn (tweeter cone)	8kHz upwards

The other design consideration at this stage is the power handling capacity. A bass power of 0·3 watts at a distortion level of up to 1% was decided.

Bass horn

In order to derive the greatest benefit from corner-positioning, the mouth of the bass horn should be at floor level and should stretch horizontally from wall to wall. A mouth consisting of a quadrant of a circle of 19in radius was considered, giving a horizontal arc of 2·48ft. Examination of Table 3 (Part 2) shows a minimum mouth area of 2·56 sq.ft for a horn capable of reproducing down to 70Hz, and dimensions of 2·48ft × 1·03ft (29·7in × 12·5in) were therefore chosen for the bass horn. Table 7 suggests a throat area of 0·048 sq.ft (i.e. 45 sq.cm) and Fig. 9 indicates that for 1% distortion at 7 times the cut-off frequency (i.e. 490Hz) the power at the throat will be 0·007 watts/sq. cm, giving 0·3 watts total, which is the specified value.

Table 9 shows that the bass horn will have a length of 6·18ft (exponential contour) or 5·24ft (tractrix contour). It was decided to adopt the tractrix so as to give

a shorter overall length, and the complete contour has been constructed in Fig. 12.

Treble horn

The treble horn will load the front of the loudspeaker, commencing at the nominal diaphragm area of 23 sq.in, which is thus the throat area for this horn. The lowest frequency to be handled is 500Hz, and from Table 4 the mouth area is 130·7 sq. in, which may conveniently be realized as 10·1in × 12·9in. Table 10 now gives the horn length as 4·42in.

It is also possible to adopt a circular format for this horn, in which case the mouth diameter will be 12·9in or alternatively some degree of horizontal directivity may be introduced by adopting an aspect ratio of 2·5:1 (larger dimension horizontal). In this event the mouth dimensions become 18·08in × 7·23in, and the flare contours should be arranged to give the appropriate expansion (see Fig. 13).

Integration and complete design

Radiation at the throats of the mid-frequency and bass horns will be in anti-phase, since these horns load the front and back respectively of the single loudspeaker. Since the mouths of both horns will be in the same vertical plane, the combined length should be an *odd* number of half-wavelengths at the crossover frequency to ensure that radiation from both mouths is in phase at this frequency. The total length is 5·24ft plus 0·37ft, i.e. 5·61ft. At 500Hz this length corresponds closely to five half-wavelengths as shown by Table 11. This design thus includes a satisfactory combination of horns.

The cavity which couples the rear of the loudspeaker diaphragm with the throat of the bass horn should now be designed to cut off radiation from the bass horn at 550Hz.

$$V = cS_t/2\pi f$$

where V = cavity volume, S_t = throat area,

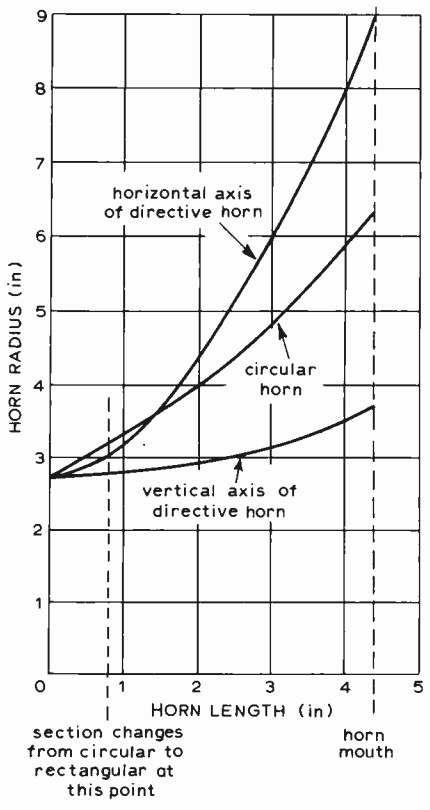


Fig. 13. Flare contour for the treble section of the mini-horn.

f = cut-off frequency, whence V = 27·23 cu.in. The volume taken up by the magnet, etc, of the loudspeaker is approximately 21 cu.in (obtained by direct measurement) and thus the overall cavity volume will be some 48 cu.in. The parameters of the mini-horn have been summarized in Table 12.

Finally, the bass horn should be folded into a suitable shape, and the two horns integrated together. In view of the limited space available and the desire for simplicity,

Table 12
Summary of mini-horn parameters

Bass horn	
Frequency range	70Hz to 550Hz
Driver unit	Eagle FR65
Position	Corner
Mouth area	2·57 sq.ft
Throat area	0·048 sq.ft
Contour	Tractrix
Length	5·24ft
Cavity volume	48 cu.in (including 21 cu.in loudspeaker volume)
Treble horn	
Frequency range	500Hz upwards
Driver unit	Eagle FR65
Mouth area	130·7 sq.in
Throat area	23 sq.in
Contour	Exponential
Length	4·42in

a design with only one major fold may be adopted, shown in Fig. 14(b) (*overpage*). The mouth of the bass horn is at the bottom of the enclosure between the two walls, making contact with the floor. The mouth of the mid-horn is placed immediately above this, in the same plane, leading back to the loudspeaker itself. The loudspeaker is mounted on a small baffle board which supports the middle-frequency horn at the front and the cavity coupling to the throat of the bass horn at the rear. The bass horn bends vertically upwards almost immediately after the throat to a point some 4ft high at which it doubles back on itself down the corner of the room to form the mouth. The cross sectional area may conveniently be made trapezoidal, but the design shown will not preserve "plane-ness" of wavefronts around the bends. Fig. 14(b) (*overpage*) illustrates the general arrangement only, as readers may well wish to make modifications for personal reasons. The material used should be ¾in chipboard, etc, except the side and front panels of ½in plywood.

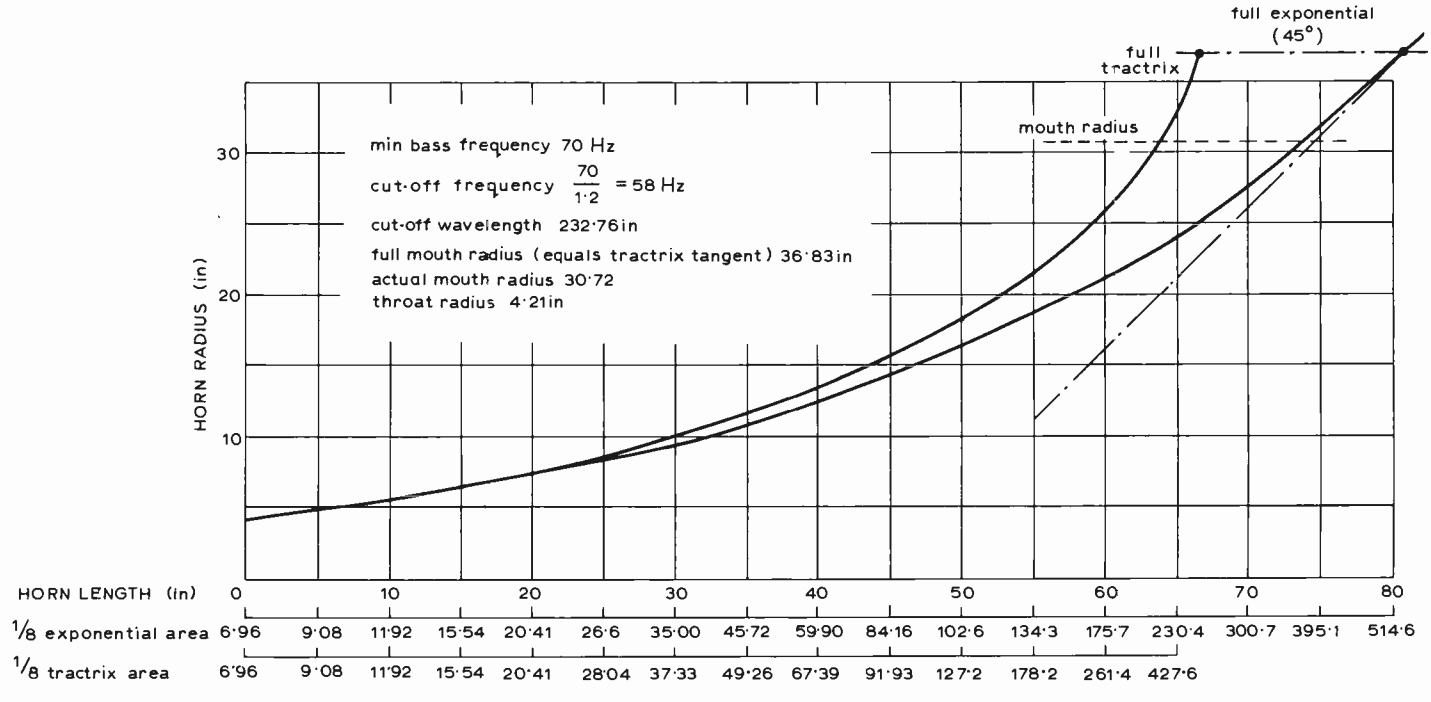


Fig. 12. Flare contour for the bass section of the mini-horn.

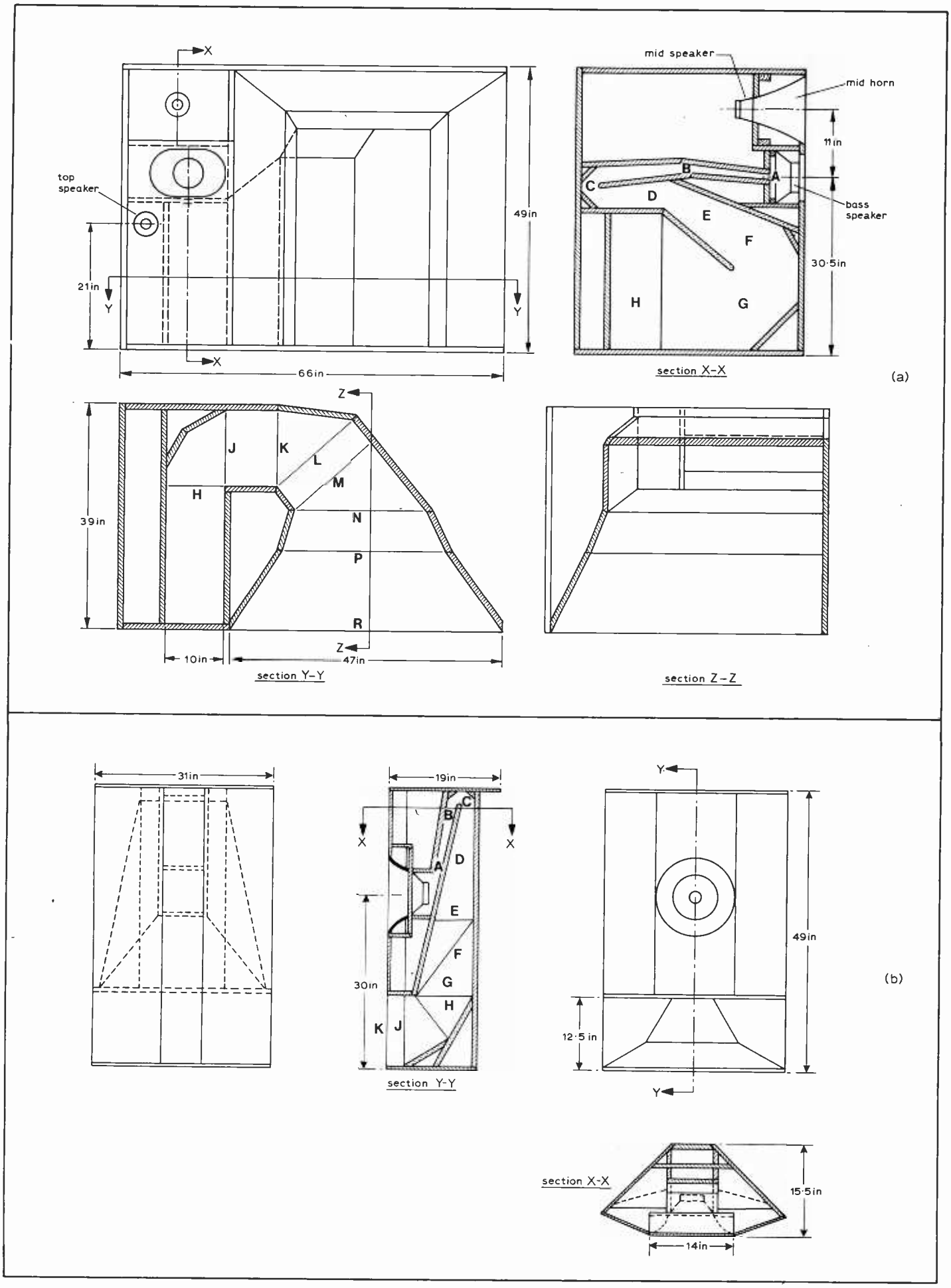


Fig. 14 (a) Suggested realization of the no-compromise horn (b) suggested realization of the mini-horn. Cross sectional details for the mini bass horn are given in Table 14 and for the no-compromise bass horn in Table 15.

Design of a no-compromise horn

Following the many qualifications already stated in this article, it must be clear that "no-compromise" is in itself a misnomer —horn design consists largely of making the most effective compromises between conflicting requirements. However, this design is aimed at the situation where the best possible practice can be followed without being unduly hampered by limitations of either size or position. Nevertheless, it would be somewhat pointless to design an enclosure which cannot be built without professional tools, facilities and materials, so the design has been conducted with a large living room (or small hall) in mind, and directed towards the competent do-it-yourself enthusiast.

In order to cover a wide frequency range, a three-horn design has been adopted, using three separate loudspeaker units.

Bass Horn	40Hz to 440Hz
Mid-frequency Horn	400Hz to 3·8Hz
Treble Horn	3·5Hz to 20Hz

A total acoustic power handling capacity of 1W at a distortion level up to 2% has been chosen as being more than adequate for the situation envisaged. A wall-mounting design is adopted, using a tractrix bass horn, to simplify the eventual positioning of the system. (Of course, there is no reason why a design intended for wall-mounting should not be placed in a corner but it is not recommended that corner designs be placed against a wall.)

The choice of loudspeaker drive units is not straightforward; there are many commercial units worth using in horns, although individual designers inevitably have their own favourites. For this design it was decided to use:

Horn	Unit	Power(W)	Frequency Range (Hz)	Diaphragm Area (Nominal sq.in)
Bass	KEF B139	30	20–1k	42
Middle	KEF B110	15	30–5k	13
Treble	KEF T27	6	3k–30k	1·5

Bass horn

The mouth area for a minimum frequency of 40Hz is given in Table 2 as 15·73 sq.ft, realized as 47in by 48in. The diaphragm area of the B139 loudspeaker is approximately 42 sq.in (the diaphragm is oval in shape) which corresponds closely with the 8in speaker of Table 7. This table gives a recommended throat area for the bass horn of 0·073 sq.ft (68 sq.cm). The highest frequency to be handled by this horn will be 440Hz, i.e. 11 times the cut-off frequency. Fig. 9 shows that for 2% distortion at 11 times the cut-off frequency, the throat will handle 0·01 watts/sq.cm, which for a mouth area of 68 sq.cm gives 0·68 watts total power. The length of the bass horn, from Table 8, is 13·1ft using the tractrix contour, and this curve may be constructed to a suitable scale in the same way as that produced for the mini-horn. The form of the tractrix should commence with a throat radius equivalent to four times the chosen throat area (eight times in the case of the corner horn) and terminate at a mouth radius giving a perimeter equal to the cut-off wavelength. The area at a series of points along the horn (e.g. every 6in) may be obtained by reading the radius from the graph and taking one quarter of the corresponding area.

Middle horn

Attention should now be directed to the mid-frequency horn. The cut-off frequency of 400Hz, together with the area of the chosen loudspeaker (13 sq.in) result in a mouth area of 203·6 sq.in, a throat area of 13·75 sq.in and a length of 8·78in (exponential contour). Again the contour should be constructed to a suitable scale (which may be 1:1 for the mid-frequency and treble horns). Since the throat areas of the middle and treble horns are made equal to their respective loudspeaker diaphragm areas, there is no problem regarding air overload distortion—one could do little if there were.

Treble horn

In view of the throat area of 1·5 sq.in for this horn, it is suggested that a mouth area of (say) 30 sq.in is adopted, giving an exponential length of 1·1in.

However, at these frequencies it is quite acceptable to mount the loudspeaker directly onto a flat baffle board without any horn.

Integration and complete design

The three loudspeaker drive units should drive their respective horns in phase. Initially it will be assumed that, whereas the middle and treble horns must load the front of the loudspeakers (to avoid diffraction effects caused by the frame and magnet assembly at the rear), the bass horn will in fact load the rear of the loudspeaker. This implies that the bass loudspeaker must be connected in anti-phase to the middle and treble loudspeakers. If examination of the behaviour of the bass and middle horns at their mutual crossover point reveals that the radiation is in anti-phase, the bass horn can be arranged to load the front of its loudspeaker, which will then have to be connected in phase with the other two. In fact the total length of the bass and middle horns is 13·8ft and Table 11 shows that this is nearly equivalent to an even number of half-wavelengths at 400Hz, the crossover frequency. The bass loudspeaker may therefore be reversed so that the horn loads the front of the diaphragm; this will also make the design of the acoustic cavity much simpler.

The cavity between the bass loudspeaker and its horn should be designed to give a cut-off frequency of 440Hz. Applying the aforementioned formula gives a volume of 51 cu.in. There is no real need to employ a similar cavity at the crossover between the middle and treble horns; the fact that these horns are not folded, together with their large throats, reduces distortion at high frequencies to negligible proportions.

Finally, the three horns must be combined into a composite enclosure. As with the mini-horn there are many ways of achieving this, and it would be invidious to specify a particular design to the exclusion of all others. However, certain basic rules apply, and the following suggestions may be of value.

The rectangular mouth of the bass horn should be placed at floor level, with the mouths of the middle and treble horns placed above it, in the same plane. If the back-to-front depth of the complete structure is at a premium, the middle and treble horns may be mounted on top of the complete folded bass horn, giving a very high cabinet. If, however, height is at a premium, then the bass horn may be folded behind the middle and top horns, thus minimizing the overall height but increasing the width. This latter approach is shown in Fig. 14(a), and the complete design of the no-compromise horn is summarized in Table 13. Material used for construction is 1in blockboard, plywood, etc, and all joints should be screwed and glued to make them airtight.

When converting from a basic parameter design, as described in this section, to complete working drawings, the temptation is often to press on rapidly and adopt certain compromises. Unfortunately, the final construction is a "once only" event, and horn structures cannot easily be modified if major audio deficiencies (e.g. resonances or "holes" in the frequency spectrum) become apparent during listening tests. It

Table 13
Summary of no-compromise horn parameters

Bass horn	
Frequency range	40Hz to 440Hz
Driver unit	KEF B139
Position	Wall
Mouth area	15·73 sq.ft
Throat area	0·073 sq.ft
Contour	Tractrix
Length	13·1ft
Cavity volume	51 cu.in (directly at front of loudspeaker)
Middle horn	
Frequency range	400Hz to 3·8kHz
Driver unit	KEF B110
Mouth area	203·6 sq.in
Throat area	13·75 sq.in
Contour	Exponential
Length	8·78in
Treble horn	
Frequency range	3·5kHz upwards
Driver unit	KEF T27
Mouth area	30 sq.in
Throat area	1·5 sq. in
Contour	Exponential
Length	1·1in

Table 14
Cross section details for the mini bass horn

Sec.	Length (in)	Area (sq.in)	Realized (in)
A	0	7·0	1
B	10	11·9	1·7
C	15	15·5	2·2
D	25	28	4
E	35	49	7
F	40	67	complex section
G	45	92	
H	50	127	
J	60	261	26 x 10 high
K	63	370	29.7 x 12.5 high

Table 15
Cross section details for the no-compromise bass horn

Sec.	Length (in)	Area (sq.in)	Realized (in)
A	0	10·6	1·06
B	15	17·0	1·7
C	30	27·8	2·78
D	40	38·0	3·8
E	50	54·0	5·4
F	60	75·0	7·5
G	75	122	12·2
H	94	230	23
J	104	316	13·5 × 23 high
K	113	426	13·5 × 31·5 high
L	120	540	17 × 31·5 high
M	125	630	17 × 37 high
N	132	790	21 × 37 high
P	139	1125	28 × 40 high
R	153	2265	47 × 48 high

is therefore strongly recommended that the final design takes place over an extended period, with several alternative approaches being worked on simultaneously until one of them emerges as the right solution for the parameters and overall concept in mind.

The three loudspeaker units must be connected via suitable filters so that each handles frequencies only within its appropriate pass-band. The simplest way of achieving this is by means of passive crossover networks at the output of the power amplifier. However, this method reduces the beneficial effects of electromagnetic damping of the loudspeaker movement afforded by the low output impedance of the amplifier, and a better method is to use three separate power amplifiers whose inputs are fed via active high and low pass filters, as outlined in Part 2.

It is well-worth experimenting over an extended listening period until the optimum bandwidth and sensitivity of each horn has been realized, paying particular attention to the crossover points.

Conclusions

This article has taken the form of a critical review of work which took place largely between 20 and 50 years ago. The author of such reviews benefits from hindsight, but inevitably loses much of the excitement and impact of the original work. I have been in contact with many individuals who were personally involved with the development of horns, in both amateur and professional capacities; I thank them all for their advice and comments, and hope that I have done justice to their suggestions.

In spite of the obvious disadvantages of large size and high cost, and the difficulties of realizing an adequate design, the exponential horn loudspeaker still has many enthusiastic users, the present author among them. The clear advantages conferred by the horn in terms of presence, clear bass, low distortion and sheer realism, combine to make horn enthusiasts redouble their efforts to design a better horn rather than to adopt an alternative type of enclosure.

It will be clear to readers of this article that, with the possible exception of straight horns of circular section constructed in a very stiff material, the simple horns described here can only approximate to the ideal performance offered by this genre of reproducer. Although the pioneer development work was conducted between 50 and 70 years ago, engineers are continuously designing new horns and investigating different aspects of their performance, often with the aid of computers to construct a mathematical model for the analysis of conditions in a practical horn (38, 39). It must be emphasized again that first-class results may be obtained by following the basic design data and constructional advice given in this article. Loudspeakers in general, and horns in particular, are controversial subjects, and I have no doubt that many will wish to challenge some of the statements I have made. I hope that this article, together with any discussion, will stimulate many audio enthusiasts to design and make their own horns, and to write about the results so that all may benefit from their findings.

Finally, I acknowledge with thanks the helpful advice given by Mr Gilbert Telfer, whose experience of the design and manufacture of horns has been a constant encouragement.

JACK DINSDALE was educated at Trinity College, Cambridge and later at Cranfield. After a craft apprenticeship in mechanical engineering he joined the Elliott Automation Group where for nine years he was concerned with missile guidance, digital computer design and latterly with on-line applications of computers to industrial and military control systems. Mr Dinsdale is now Principal Research Engineer with the Cranfield Unit for Precision Engineering, a commercial department of the post-graduate Cranfield Institute of Technology, engaged in the design and manufacture of high precision machine systems for industry. He is responsible for all aspects of electronics, automation and computing.
Mr Dinsdale is married and has three sons. His spare time activities include sound reproduction, music-making and horticulture.

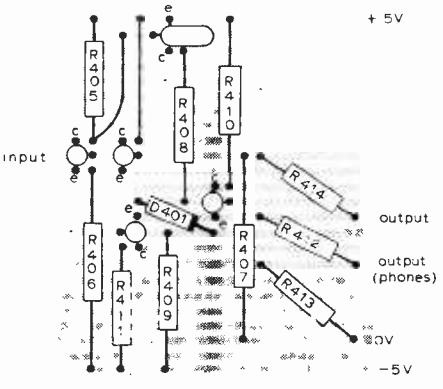
Electronic piano design

To help potential constructors of the electronic piano design (March, April and May issues) gauge its tonal qualities, the designer, Geoff Cowie, will provide recordings of its sounds on cassette, for £1. Send remittance c/o the *Wireless World* editorial office.

Alan Douglas, a supplier of keyboards for the design, tells us he can provide key-switches that incorporate the necessary modification described in the April issue. The gold-clad phosphor-bronze contacts (not gold-plated as suggested in the articles) are precisely aligned at the assembly stage to be normally closed instead of normally open. This unusual arrangement is to achieve touch-sensitive key action with the minimum of circuit complexity. The keyswitches, together with a robust, lightweight (magnesium alloy) C-C keyboard, are available for less than £32, including VAT, from Alan Douglas, 4 Lees Barn Road, Radcliffe-on-Trent, Notts.

We regret that various errors occurred in the headphone amplifier circuit board (Fig. 17). A revised wiring diagram accompanies this note.

For the oscillator circuit of Fig. 6, the modified form of Mr Walne's (see Letters, this issue) is recommended. Note that adequate tuning range may not be obtained if the pre-set resistor ends are connected together as suggested in Fig. 14.



The value of R_{502} (Fig. 3) was omitted from the parts list—it should be 1kΩ. Optional capacitor C_{402}, added across R_{402} as shown in Fig. 16, was 0.01μF in the original design; its inclusion and value is a matter of personal taste. Capacitor C_{401} (Fig. 7) should be 50μF, as listed, and not 5μF.

An alternative to the OC203 transistor specified for Tr_{403} is 2N3705. Diode type 1N914 or similar can be substituted for the OA200 diodes.

In the oscillator parts list there should, of course, be twelve 10- and 15-kΩ resistors (and not two) and in the key circuit list R_1 was incorrectly given; it should be 1.8kΩ.

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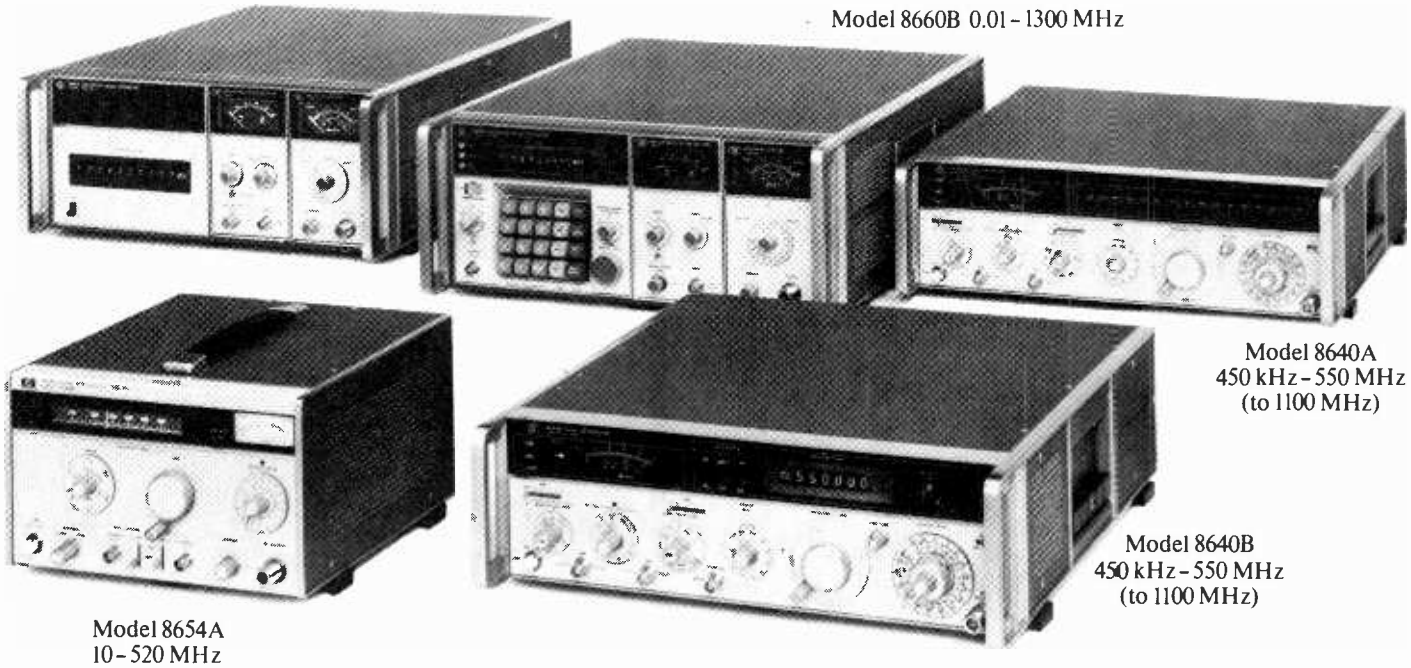

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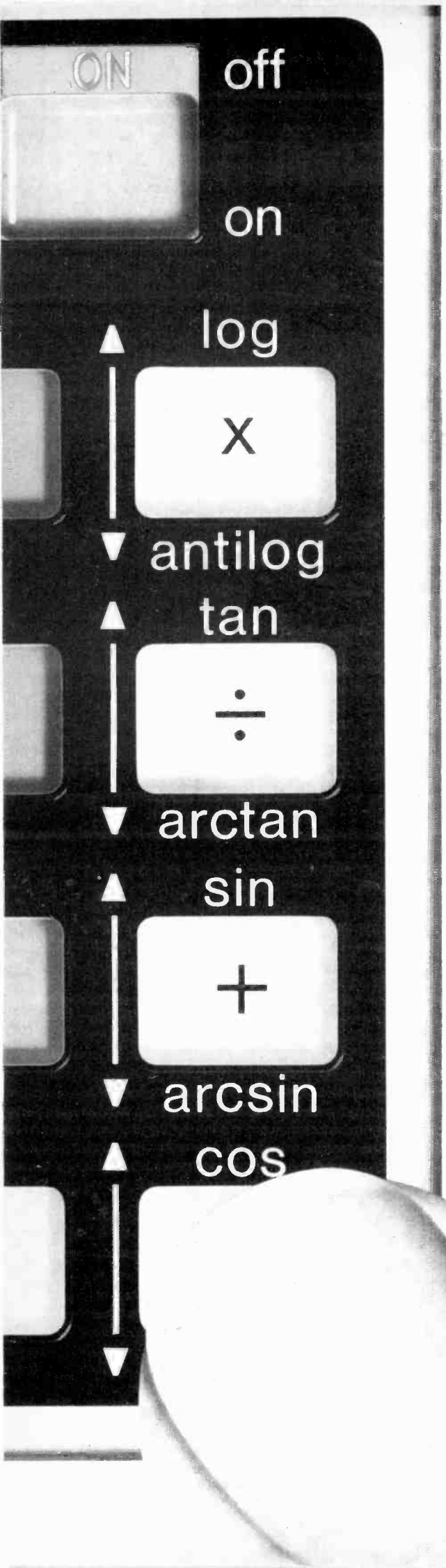

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Radio interference —a review

International standardization of measurement and limits: methods of investigation and suppression

by A. S. McLachlan, J. H. Ainley and R. J. Harry

Directorate of Radio Technology, Ministry of Posts and Telecommunications

Dealing with radio interference is, perhaps, one of the less well-known aspects of radio engineering and yet it is one of considerable importance. It has a direct bearing on the enjoyment by many millions of listeners and and viewers of sound and television broadcasting; it is an important factor in the provision of accurate telegraphic and intelligible telephonic communication; and it can be a matter of life and death in connection with the radio aids upon which aircraft and ships rely for safe navigation.

Interference with a radio signal can be caused by radio-frequency energy coming from natural or man-made sources. The former include thunderstorms, charged precipitation and other natural phenomena and there is nothing that can be done to eliminate these sources of interference. Their effect can only be ameliorated by attention to the design of the radio system concerned, by providing an adequate transmitted signal strength to over-ride reasonable levels of noise and by carefully designing the receiving system to make the best use of the available signal.

It is with man-made interference that this article is primarily concerned and its sources can be divided into four classes:

(i) Interference from other radio systems operating on the same frequency channel; this can generally only be eliminated or minimized by careful frequency assignment planning to provide adequate geographical separation or time sharing between co-channel stations. This aspect of interference is a subject on its own and is not covered by the present article.

(ii) Interference from spurious out-of-hand radiation produced by radio equipment used for communication purposes. This type of interference can be caused by both transmitting and receiving equipment and can affect other, quite unrelated, radio systems.

(iii) Interference caused by electric equipment in which radio-frequency energy is deliberately generated for heating purposes, e.g. diathermy, plastics welding and cooking equipment.

(iv) Interference caused by electric equipment of many different kinds in which radio-frequency energy is an unwanted by-product and plays no part in the proper functioning of the equipment, e.g. motor car ignition systems, electric motors and switching devices.

The abatement of radio interference is partly a social, partly an economic and partly an engineering problem. In a society in which economic considerations were secondary to social conscience, equipment and appliances could be designed from the outset so that however they were used they would not cause radio interference. In a practical society, however, a policy such as this would impose unacceptable restrictions on the design of equipment, leading, in many cases, to costs which would be prohibitive. Compromise is thus necessary and equipment is generally suppressed to a degree which, in "normal" use, will not cause "harmful" interference to receivers of "reasonable" quality in "good" working conditions with suitable aerial systems in areas of "adequate" field strength. To define these various terms objectively and precisely is difficult and it has been the concern of various national and international bodies over the years to arrive at fair and economic solutions, so that the burden of responsibility is shared equitably by the equipment manufacturers and the providers of radio systems. In all of these considerations it is of paramount importance to ensure that suppression measures applied in no way render any item of equipment less safe or less able to perform the function for which it is intended.

Regulatory powers

In the United Kingdom, until the passing of the Wireless Telegraphy Act 1949,[1] the abatement of interference was on an entirely voluntary basis. The Post Office, as the licensing authority at that time, had set up and operated a country-wide radio interference service with specialised headquarters and laboratory facilities in London. The object of this service was to deal with specific cases of interference to sound and, later, television broadcasting reception and to give advice and guidance on technical problems as they arose. Broadcasting organizations and various branches of the electrical and radio industry co-operated in the study of radio interference problems and the overall effort was co-ordinated primarily in appropriate committees set up by the Institution of Electrical Engineers and the British Standards Institution.

Under the 1949 Act the Postmaster General was empowered, after due consultation with an advisory committee set up for this purpose, to make regulations concerning the manufacture and/or use of specific items of electric equipment which might cause undue radio interference.

Up to the present time a number of regulations[2] have been made covering electric appliances the use of which has been shown by experience to give rise to the most frequent complaints of interference. They lay down limits to be met when the level of interference is measured in a stated manner using measuring equipment of specified essential characteristics. The introduction of regulations in the U.K., by encouraging manufacturers to suppress equipment and appliances at the time of manufacture, has been a contributory cause of the fall in complaints of interference from a peak of 170,000 in 1955 to around 57,000 per annum at the present time.

When, in 1969, the office of the Postmaster General was abolished and the Post Office became a Public Corporation, responsibility for spectrum management in the United Kingdom, including the control of radio interference, became the responsibility of the newly-created Minister of Posts and Telecommunications. The headquarters organization and the development laboratory from the Post Office were incorporated into the establishment of the new Ministry. However, it was not considered practicable for the Ministry to take over the field organization dealing with the interference complaints from the general public. Clearly the Post Office, with its extensive country-wide engineering organization, was in a better position to carry on with this work. Consequently field engineers of the Post Office continue to undertake the investigation of day-to-day complaints, acting now as agents of the Minister. The Ministry, for its part, takes an active role in the work of national and international committees dealing with interference problems and, on the basis that prevention is better than cure, assists manufacturers of a wide range of apparatus to meet the requirements of regulations and standards by giving advice on suppression techniques.

International aspects

There is another and perhaps less obvious aspect of radio interference suppression. This is its effect on trade between countries. Different requirements in legislation on radio interference suppression in different

countries, while allowing electric goods to flow in one direction, may make it difficult for them to move in another direction. This constitutes a technical barrier to trade and it is one of the objects of the major trading countries of the world to eliminate such barriers. International standardization of the methods of measurement and limits for radio interference is the means of achieving this aim. The need for such standardization has long been recognized, and since the mid-1930s the U.K. has participated in the work of the International Special Committee on Radio Interference (C.I.S.P.R.) which operates under the aegis of the International Electrotechnical Commission (I.E.C.). The aims of the C.I.S.P.R. are the establishment of internationally agreed methods of measurement and limits of radio interference. To a large extent these aims have been achieved with the realization of agreed specifications for interference measuring receivers for the frequency range from 10kHz to 1000MHz[3] and recommendations for methods of measurement and limits for a wide range of appliances and equipment. A specification for a measuring receiver and recommendations for a method of measurement and limits for the frequency range 1 to 18GHz have now been agreed in the C.I.S.P.R. but these have not yet been published. Limits of interference and methods of measurement laid down in U.K. Regulations and British Standards[4] are in most cases in close agreement with C.I.S.P.R. Recommendations.

Within the Common Market the need for harmonization of interference legislation is recognized and directives setting limits on the interference generated by a wide range of electric equipment are likely to be introduced in the near future[7] as part of the E.E.C's programme designed to eliminate technical barriers to trade. They relate to equipment such as domestic appliances, radio and television receivers, semiconductor control devices and fluorescent light fittings. Goods manufactured in one member state and certified as conforming to the technical provisions of the relevant directive will be acceptable for marketing in all other member states. The technical provisions will be based on C.I.S.P.R. recommendations.

In June 1972, before the U.K. became a member of E.E.C., the Community adopted a directive relating to the suppression of radio interference from ignition systems on certain petrol-engined vehicles. Under this directive new vehicles which conform to its technical provisions will have a certificate to that effect. These technical provisions include the limits of interference contained in C.I.S.P.R. Recommendation 18/2 which were also adopted by the Economic Commission for Europe (E.C.E.) of the United Nations in its Regulation 10 (Uniform provisions concerning the approval of vehicles with regard to radio interference suppression). The U.K. accepted E.C.E. Regulation No. 10 in 1969, and is making its observance by vehicle manufacturers mandatory on and after 1 April 1974. Vehicles which conform to it will bear an approval mark. At a later date when type approval to the E.E.C. standard[6] (which is similar for all practical

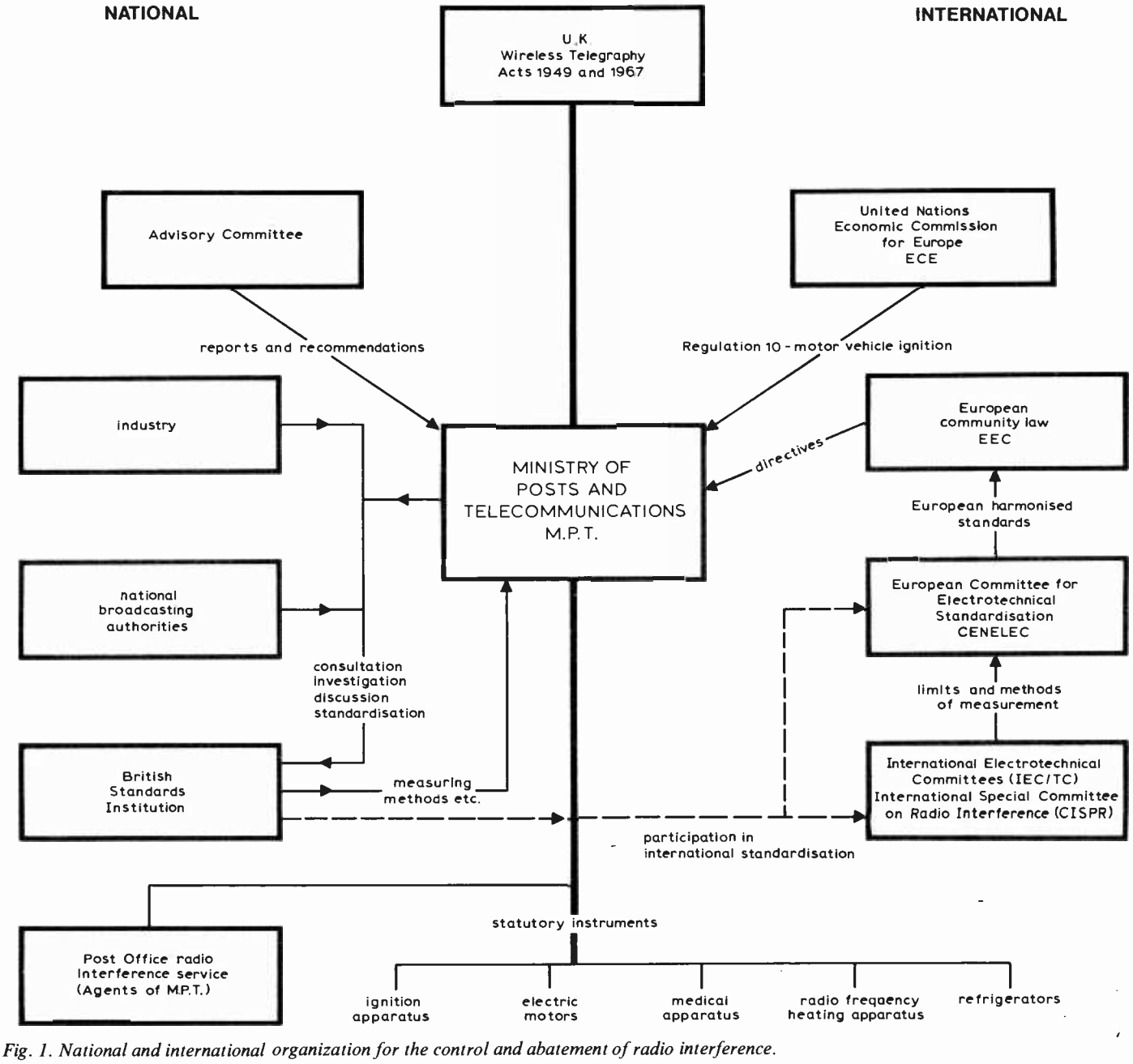

Fig. 1. National and international organization for the control and abatement of radio interference.

purposes) becomes mandatory, the E.E.C. approval mark will be replaced by the certificate. In order to obtain the appropriate E.E.C. or E.C.E. approval for a specific type of vehicle the manufacturer must submit a sample vehicle for test. In the U.K. the M.P.T. has set up a testing station and acts as the test authority on behalf of the Department of the Environment which is responsible for the issue of approvals. When obtained, this approval enables the manufacturer to export his vehicles to other countries in Europe which have accepted the scheme, without separate, national, approval being required. The provisions of C.I.S.P.R. Recommendation 18/2 mentioned above are now embodied in a U.K. Statutory Instrument[2] made under the Wireless Telegraphy Act 1949.

The present national and international arrangements which have evolved as regards control and abatement of radio interference are shown in Fig. 1.

Investigating interference complaints

The large majority of complaints dealt with by the radio interference service investigators in the field are complaints from members of the public of interference with reception of sound or television broadcasting. However, with the rapid growth of mobile radio services in recent years, a small but significant number now arise within this service. The rise and fall of interference complaints is shown in Fig. 2.

In the earliest days of broadcasting, interference to sound radio reception resulted mainly from oscillation in other receivers, and the work of investigation officers consisted mostly of persuading listeners to refrain from advancing the reaction control too far. This problem disappeared as superheterodyne receivers came into general use, but the rapid growth in popularity both of sound broadcasting and the use of electricity in homes and factories resulted in increased interference caused by electric appliances. The Radio Interference Service expanded to meet these problems and by 1939 the field staff totalled some 250 men who in that year investigated about 48,000 complaints of interference to sound radio and 100 to television. During the 1939–45 war broadcasting services were drastically reduced and only a skeleton interference staff was maintained, but from 1947, when television broadcasting was resumed, the pre-war trends continued and the number of complaints of interference increased more rapidly than before. A peak was reached in 1955 when about 500 men were involved and a total of almost 170,000 complaints were investigated, about two-thirds of which related to television. Since that time, despite the continuing growth of broadcasting services and the increasing numbers of radio and television receivers and electric appliances in use, the number of interference complaints has progressively fallen. Although the complexity of some interference problems has increased, it has nevertheless been possible to reduce the staff required and, to deal with approximately 69,270 complaints in 1972, of which 86.3% related to television, about 330 investigation officers were employed.

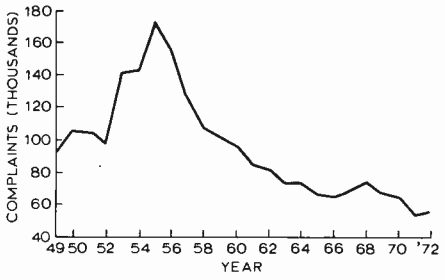

Fig. 2. The rise and fall of interference complaints.

There have been three main reasons for this reduction in the number of complaints. The first is that the coverage given by television broadcasting stations has been improved to provide adequate field strength in many areas where formerly low field strength was a prime factor in interference complaints. Secondly, there is a continuing change-over from v.h.f. to u.h.f. television reception, which is less subject to interference from the more common sources and in general requires the use of more efficient antenna systems which help to give better protection from interference. Thirdly, substantial improvements have resulted from the introduction of the statutory regulations relating to interference from certain classes of electric apparatus, and from the voluntary compliance by manufacturers of apparatus with British Standards containing radio interference limits. One example is that the majority of manufacturers of appliances such as food mixers, hair dryers, and portable tools have voluntarily fitted suppressors to their products.

One of the functions of the M.P.T. headquarters unit is the collection and dissemination of information. Statistics derived from reports by Post Office field staff are analysed to measure the effectiveness of regulations and to identify new sources of interference as they make their effect felt. Periodically, bulletins are prepared for issue to the field staff giving useful information on new forms of interference or new methods of suppression or other information which will assist the investigation officers in their daily work. Often the experience of one officer, reported in a bulletin, will be of practical value to others.

The first step in investigating a complaint from a listener or viewer is to examine the receiving installation to verify that the signal field strength available is adequate, that an antenna suiting the situation is provided, and that the receiver is in good working order and properly adjusted. It may be noted in Table 1, which shows in condensed form the 1972 statistics of interference complaints, that in about one-third of the complaints investigated these conditions were not met.

The interference officer has at his disposal equipment to demonstrate to the owner of an unsatisfactory installation the effect of putting his house in order, at least in those situations where the signal is adequate. This includes a telescopic mast and antenna, to demonstrate the effect of an efficient antenna, and a small portable television receiver for use if the complainant's receiver is suspected of being faulty.

When the receiver is found to be in good order the investigator will proceed to observe the effect of the interference. This may be more easily said than done, for interference is often of an intermittent nature and it may be some time before it makes its presence apparent. There are no set rules of procedure from now on; a brief observation of the interference may be sufficient to indicate, to the investigator with a wealth of experience, the probable cause of the trouble, and perhaps even to locate the source without the use of other special equipment. For instance, short bursts of interference to both sound and vision on a television receiver might be characteristic of a sewing machine in use nearby and a few enquiries at neighbouring houses may quickly identify the source.

However, if the simple approach does not produce the desired result it is necessary to resort to more scientific means, and a number of special interference tracing receivers are available to the investigating officer. Separate models are available for the l.f./m.f., the v.h.f. and the u.h.f. bands re-

TABLE 1
SIMPLIFIED 1972 STATISTICS OF INTERFERENCE COMPLAINTS

Sources	No. of complaints per service					Approximate % of all complaints
	Sound		Television		Private mobile radio	
	l.f./m.f.	v.h.f.	v.h.f.	u.h.f.		
Inadequate signal	57	36	874	1001	6	3.00
Inadequate antenna	637	436	5867	2735	43	14.00
Receiver faults or maladjustments	611	594	6499	3945	208	17.00
Contact devices	1170	250	7528	791	16	14.00
Radio transmitters in U.K.	220	256	2053	979	435	6.00
Broadcast receiver radiation	323	14	1485	1472	23	5.00
Electric motors	275	83	2585	178	15	4.00
Overhead powerlines	86	14	2324	65	15	4.00
Discharge lamps and signs	301	25	1001	63	3	2.00
Industrial and medical r.f. heating equipment	18	10	728	74	22	1.00
Identified sources other than those above	582	154	3294	857	103	7.00
Unidentified	1561	357	9527	2043	324	20.00

spectively, together with a light-weight readily portable combined v.h.f./u.h.f. model for general use. All the receivers have directional antennae so that they may be used to take rough bearings on interference sources, together with facilities for measuring field strength. These two facilities, in the capable hands of an experienced officer, will usually lead to identification of the source of the interference, provided of course that the interference remains on for a long enough period.

Where it is immediately practicable the investigating officer will demonstrate how the interference can be cleared by means of suppressors or filters, and may supply and fit these components provided that the complainant or the owner of the offending apparatus agrees to bear the cost. In some cases, however, the co-operation of a manufacturer may have to be sought, for instance in providing additional screening in an appliance to reduce radiation.

Suppression of interference

Basically, radio frequency interference can be generated in two ways: by switching an electric current on or off, or by means of an oscillator. The transient change of current when a switch is operated contains components the magnitudes of which depend upon many factors such as current switched, the instant of switching in relation to the alternating current cycle (if the supply is a.c.), the capacitance of the wiring across the switch contacts, and dirtiness or bounce in the switch contacts (either of which may cause a single operation of the switch to give rise to multiple interruptions of the current). Resonances in the circuits connected to the switch may cause some frequencies to predominate in the interference produced.

If the switch is a simple on-off device each operation will generate interference in the form of a "click" and this may not be very serious; however, continuous switching operations occur in, for example, commutator motors, motor car ignition systems, dimmer or speed control devices and gas discharge lamps. Such devices will generate continuous broadband interference which is characterized by the presence of high amplitude, short risetime pulses having a repetition rate which is dependent on the switching rate. There are also many multiple switching devices in use nowadays, such as lift controls and automatic washing machine programmers which generate a succession of broadband disturbances in more or less rapid succession. This is generally referred to as discontinuous interference.

The second type of interference generator is the device in which radio frequency energy is deliberately generated by means of an oscillator. Examples are industrial, scientific, medical, or cooking equipment and radio receivers of the superheterodyne type. The r.f. energy produced ranges from many kilowatts in some industrial r.f. heaters to a few milliwatts in a small radio receiver, but both can be serious sources of interference.

There are four basic ways of combating interference:

(i) in oscillating devices, by arranging that the frequency of the oscillation is one which does not interfere with radio services in the vicinity;

(ii) by enclosing the offending device in a screened enclosure which does not allow the r.f. energy to escape;

(iii) in switching devices, by introducing, capacitive, inductive or resistive components to reduce the r.f. content of the current transients;

(iv) in some cases by modifying the receiving equipment.

Examples of each of these methods will be discussed.

Industrial, scientific, medical and cooking equipment is required to operate at a wide variety of frequencies to suit various applications, and a number of small frequency bands have been set aside, by international agreement, for this purpose. These are known as "free radiation" bands and there is no restriction on the radiation permitted in these bands. Other services must keep clear or put up with interference. However, in some cases the internationally agreed bands may not fit in with national frequency planning. For example, the i.s.m. (industrial, scientific, medical) frequency 40.68MHz is rather close to the frequency of 41.5MHz used for the sound carrier associated with the lowest v.h.f. television channel of the 405-line system used in this country, and is a potential source of interference to channel 1 viewers. To avoid this particular form of interference 40.68MHz is not used as a free radiation frequency in this country. Instead a system of zoning is used in which the i.s.m. equipment is assigned a working frequency in a television channel which is not in use in the area in which the equipment is installed. Thus, for areas where channel 1 is not used the i.s.m. equipment is allocated 42 ± 0.08MHz; where channel 1 is used the operating frequency is 49 ± 0.98 or 56 ± 0.112MHz. In both cases the radiation is limited to 1V/m at 30m from the boundary of the premises in which the equipment is installed. At frequencies other than the operating frequency the radiation is limited to a much lower level, 30μV/m at 30m from the boundary of the premises being a typical level in the v.h.f. bands.

Another type of interference which was at one time prevalent in the Peterborough area (and came to be known as the "Peterborough effect") occurred when I.T.A. transmissions commenced from Mendlesham on channel 11. Peterborough is at extreme range from Mendlesham and the signals were rather weak. At the same time, receivers in the Peterborough area tuned to the local B.B.C. station on channel 5 produced interference at the second harmonic of the local oscillator frequency of 101.40 ± 0.3MHz right in the middle of the Mendlesham signal and many hundreds of cases of interference occurred. The solution in these cases was to re-tune the intermediate frequency amplifiers in the receivers to a slightly different frequency so that the beating oscillator frequency no longer interfered with the I.T.A. signal. This operation was an extensive one carried out with the co-operation of receiver manufacturers and a number of teams of investigation officers drafted temporarily into the area from other parts of the country. The problem ceased to exist later when a closer I.T.A. transmitter came into operation. In planning the u.h.f. television service care was taken to avoid as far as possible using at the same station pairs of channels which would give rise to this type of interference.

To keep interference to a minimum in the small number of locations where the harmonics of oscillators of v.h.f. receivers are near the frequency of the vision carrier of a u.h.f. channel, limits of oscillator radiation and immunity are prescribed for television receivers.[4]

Enclosing the source within an earthed screen to prevent the radiation of interference is a measure that can sometimes be applied. For example, some industrial and medical equipments can be treated in this way. In the case of microwave ovens, these have to be fully screened to avoid danger to the operator, and linked switches must be provided to cut off the r.f. energy when the door is opened. Careful screening can also be applied in radio receivers to prevent direct radiation of the beating oscillator frequency. However, in this case it may still be possible for some energy to escape via the antenna. Generally speaking, screening is an expensive method of avoiding interference and is only used where there are compelling reasons for it.

The suppression of switching devices,[8] whether of the single-operation type or repetitive, is essentially the introduction of components which will slow down the transient current changes to limit the power generated at radio frequencies and filtering elements to attenuate r.f. energy transmitted along, and to damp down any resonances in, the associated wiring.

At radio frequencies capacitors behave

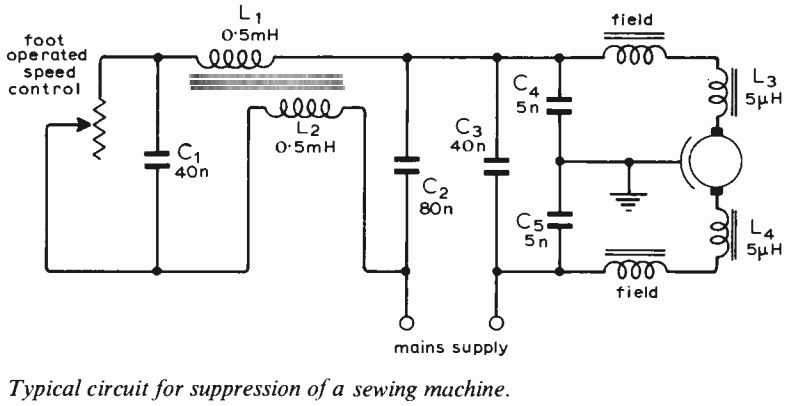

Fig. 3. Typical circuit for suppression of a sewing machine.

electrically as series tuned circuits, the inductance being that of the foil windings, or plates, and connecting leads. Capacitors must therefore be chosen to have a low impedance throughout the frequency range to be suppressed. Inductors behave electrically as parallel tuned circuits, the capacitance being that of the inductor windings. Inductors must therefore be chosen to have a high impedance throughout the frequency range to be suppressed. To meet these requirements it is generally necessary to have one set of suppression components for the l.f. and m.f. sound broadcast bands and another set for the v.h.f. sound broadcast and television bands.

Experience will usually suggest the best form of suppression for a particular equipment but some trial and error must be used to find the optimum values for the components. In many devices the housing of the necessary components in a confined space presents a difficult design problem, and great care must be taken in the choice of components. In particular, some of the capacitors used must be capable of withstanding the continuous application of mains voltage and associated large voltage spikes.

An example of the suppression applied to a sewing machine is shown in Fig. 3. C_1, C_2 and L_1, L_2 suppress the clicks from the foot operated speed control. C_3, C_4 and C_5 suppress the l.f. and m.f. interference from the motor and the small 5μH chokes L_3, L_4 are fitted close to the brushes to suppress v.h.f. interference.

A measure which may be effective in cases where suppression at the source presents difficulties is the introduction of filtering in the aerial lead of the affected receiving equipment. For example, when receiving a wanted signal of normal strength, a very strong signal on some other frequency applied to the input terminals of a receiver may cause blocking or cross modulation or some other non-linear effect which will interfere with reception of the wanted signal. A suitable filter will often solve this problem. *(To be concluded.)*

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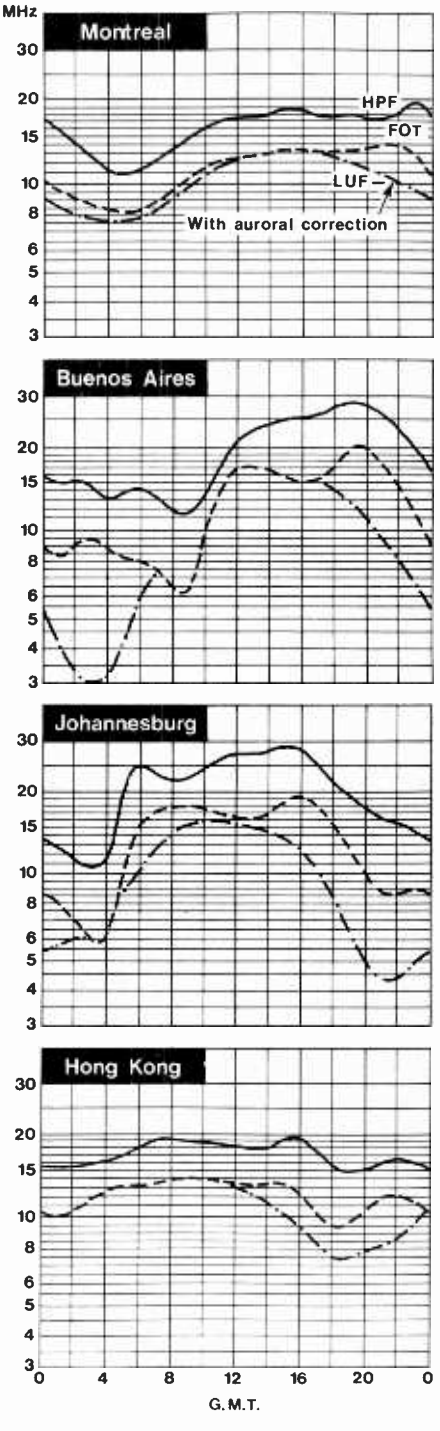
HF predictions for June

Ionospheric Index IF2

	1972	1973	1974
January	58	41	7
February	78	46	12
March	100	41	27
April	90	13	19
May	90	43	10
June	82	37	8
July	94	32	7
August	96	25	6
September	83	40	5
October	80	26	4
November	56	8	3
December	49	4	2

April 1974 onwards are forecast values. Data supplied by Science Research Council, Appleton Laboratory, Slough.



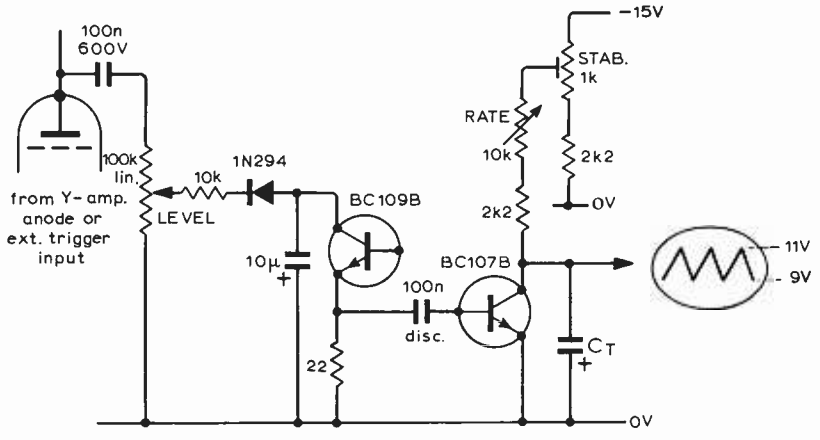
Circuit Ideas

Timebase circuit

Advantages of this simple timebase circuit include fast flyback time due to the negative resistance operation of the transistors in the breakdown region, option of slower sweep rates by increasing C_T at will, and pin-point stability adjustment found only in costly 'scopes. Old oscilloscopes which have only a synchronized free-running timebase can be easily modified using this cheap circuit.

The right part of the circuit consists of the timing capacitor and rate charging resistor and when the breakdown voltage of the reverse-biased BC107B (about 9 to 11 volts) is reached, the capacitor is quickly discharged. When the voltage falls by about two volts, the transistor assumes its high resistance state and the capacitor charges up again, so that in this free-running mode, a two-volt saw-tooth wave is available, the frequency being controlled by the rate control. When the 1kΩ stability control is moved downwards, the circuit gives no output and it can then be triggered by synchronizing or trigger pulses obtained from the left part of the circuit. In the figure, the Y output is used via a level control to generate pulses using a similarly reverse-biased BC109B and the 22Ω resistor. These pulses can trigger the breakdown of the BC107B into conduction and initiate the sawtooth.

K. Padmanabhan,
Madras.



Simple code-operated switch or combination lock

The circuit is of a five-number combination lock costing under £1.50 and using five integrated circuits.

Six set/reset bistable circuits are formed by cross-coupling two two-input NAND gates. A 0-V input is needed to change the state of these. Five are used for the combination and the sixth prevents circuit operation by a number in incorrect sequence. (Simplified NAND symbols.)

The states of the bistable outputs after switch-on are indicated by H (high) and L (low) and this is the "reset" state. Each bistable circuit must be changed to the "set" state, in turn, from left to right by the combination, as selected by a 12-way rotary switch and the number entered by a push-button.

If any bistable circuit, except B1, is set while the preceding one is still reset, one of the 7401 open collector NAND gates goes low due to both of its inputs being high and this sets B6, which holds the other five in the reset state until the circuit is switched off.

When B5 is set, the then low output is inverted and switches on Tr_1 which operates the reed relay. The other output of B5 cannot be used to operate Tr_1 directly because then a 0-V input on 5 alone would operate the relay.

At switch-on B1 to B6 are reset by C_1, which then charges via R_4 in 100ms and the circuit is ready for operation. Resistor R_3 discharges C_1 after switch-off.

For use in a car an extra "hold-on" contact across Tr_1 emitter-collector is advisable to prevent faulty operation from electrical noise.

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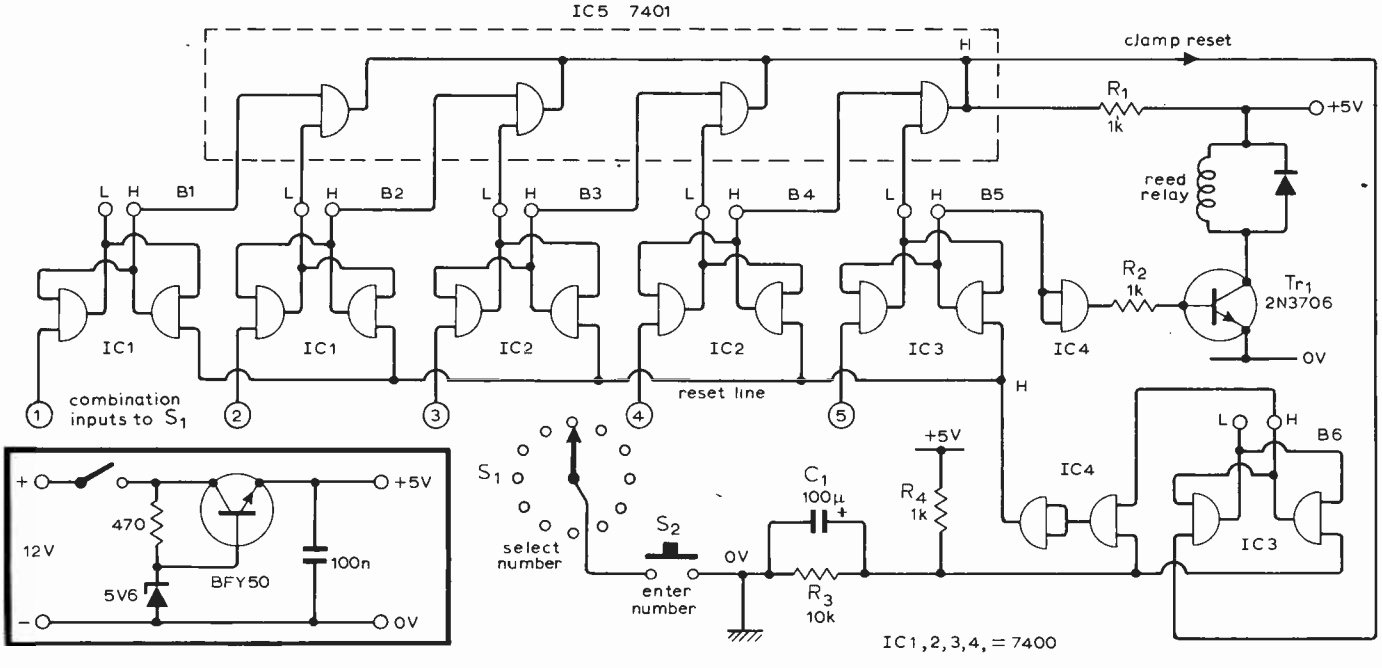
Banbury,
Oxon.



Negative resistor

The following circuit possesses the advantage over other negative resistance devices that it is suitable for both a.c. and d.c. applications, and thus more nearly approximates to the "missing" fourth impedance in phasor diagrams. As such, educationists and others may find it useful.

The op-amp is used in the non-inverting configuration where the voltage gain is $A = 1+(R_F/R_A)$.

The voltage (relative to 0V) presented to the non-inverting input is $-IR_N$ where I is the current flowing through the device from A to B and therefore the output voltage (relative to 0V) is $-IR_N[1+(R_F/R_A)]$. Consequently the voltage between terminals A and B is

$$V_{AB} = -IR_N\left(1+\frac{R_F}{R_A}\right) + IR_N = \frac{-IR_NR_F}{R_A}$$

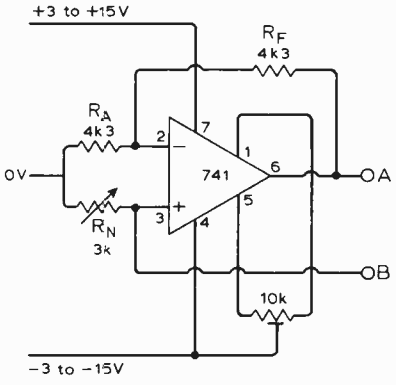
Therefore the impedance Z between A and B is

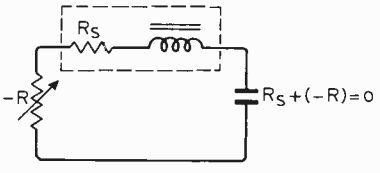
$$Z = \frac{V_{AB}}{I} = \frac{-R_NR_F}{R_A}$$

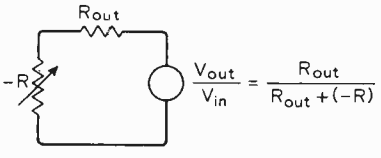
It must be noted that the amplifier earth floats with respect to both output terminals. Consequently a floating power supply is required and this must, of course, be symmetrical with respect to 0V. For use as a d.c. negative resistor the offset voltage of the amplifier must be cancelled by adjusting the 100-kΩ potentiometer. In practice the negative resistor is limited by the op-amp in terms of maximum output voltage and current and operating frequency, although the circuit shown is a good low-frequency approximation. The value of the negative resistor may be varied by adjusting R_N or R_F/R_A or both.

The circuit has been used successfully to cause LC circuits to oscillate at sub-audio frequencies using large, low-efficiency inductors and capacitors of the order of 0.1 to 1μF by cancelling out the inductor series resistance (middle circuit), and also as a two terminal amplifier (bottom circuit). Being a d.c. negative resistor it also works in the more obvious demonstration of putting it in series with a larger positive resistor R_P and finding the resistance as measured with an ohmmeter to be the difference $R_P+(-R)$. No doubt teachers and lecturers will find many other applications. There is no reason why complex impedances should not be substituted for R_N, giving possibilities of negative capacitance and inductance.

David A. B. Miller,
Perth.

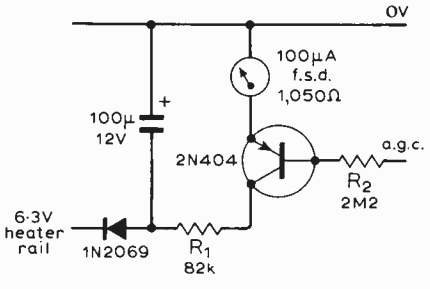






Simple S-meter

It was found necessary to repair a home-built, valved, communications receiver, which had suffered transport damage to the S-meter. The original circuit used a 1mA f.s.d. meter, connected in a bridge circuit, involving the screen currents of the i.f. valves. This simplified circuit, draws a very small current from the a.g.c. rail in the receiver to drive an emitter follower,



which supplies current to an S or tuning meter. The negative voltage required to power the emitter follower is obtained very simply by half-wave rectification of the 6·3V heater rail in the receiver. The circuit fits easily on a small piece of circuit board, which itself can be supported by the terminal posts on the back of the meter.

Resistor R_1 should be chosen so that with the transistor saturated the current in the meter gives f.s.d. Resistor R_2 should be chosen to give about 0·95 of f.s.d. in the meter on a very strong local signal. The circuit used a 100μA f.s.d. meter, but with changes to R_1 and R_2, it could probably use a 1_mA f.s.d. meter. As the transistor is practically in a base-open-circuit condition, a transistor with sufficient $V_{CEO\,max}$ rating should be chosen.

M. J. Shoobridge,
Alicante, Spain.

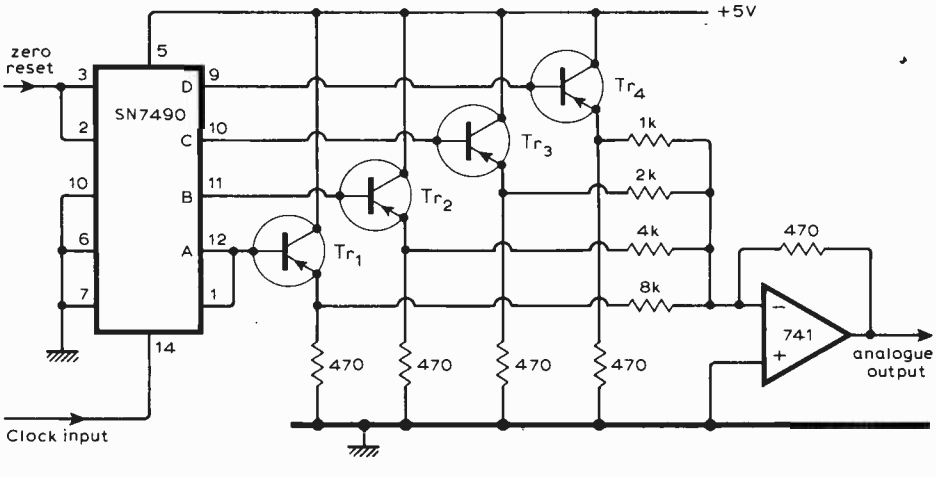
Simple digital to analogue converter

Transistors Tr_1 to Tr_4 are either saturated or cut off by the outputs of the 7490 b.c.d. counter. By simply adding portions of the emitter voltages in the ratios 1:2:4:8 for the DCBA outputs the analogue output can be obtained. Summing is performed by the 741 op-amp.

A converter with a 1 in 100 output definition may be made by using a second similar circuit with its clock input connected to the D output of the first circuit. The new summing resistors which are also connected to the inverting input of the 741 are then 10k, 20k, 40k and 80kΩ for the D′, C′, B′ and A′ outputs.

Such a circuit has been used for a simple two-digit d.v.m. with the transistors suitably matched for V_{CEsat} and using 1% summing resistors.

D. James,
Worthing, Sussex.



World of Amateur Radio

Band scan

Not all amateurs anticipate that we may soon be reaching the end of sunspot cycle No. 20. T. J. Cohen, W4UMF and Paul Lintz suggest in *CQ* that the present cycle may not end until after 1975 and possibly as late as mid-1977. They also believe, as the result of a detailed analysis of past cycles, that there may be relatively low solar activity for at least 40 years, with smoothed sunspot numbers reaching only about 50 in Cycle 21 and not going above 100 until about 2015AD. But past experience suggests that long-term sunspot prediction is highly speculative.

Certainly an unpredicted burst of solar activity in early May resulted in a sudden and quite dramatic increase in m.u.f. with 21MHz open for trans-Atlantic contacts late in the evening, and the band sounding like the long period of high solar activity in 1972. This coincided with the appearance of a remarkable variety of special prefixes in connection with the ITU Telecommunications Day events.

Moonbounce contacts between Peter Blair, G3LTF near Chelmsford and VK2AMW near Sydney on 432MHz would appear to establish a new e-m-e (earth-moon-earth) mode amateur record. The Chelmsford station has 750 watts and a 15-ft dish while VK2AMW uses 500 watts and a 30-ft dish. MT4578 transistors were used in the first stages of both the receivers.

French amateurs are no longer able to use 1215–1220MHz and 1260–1300MHz —this unfortunately includes the 1296 to 1298MHz portion favoured for international working. They have also suffered restrictions on other u.h.f. bands including the withdrawal of 433 to 434.5MHz.

Repeater pros and cons

The debate about f.m. and f.m. repeaters continues to attract lively interest, although it is now virtually certain that several more 144MHz f.m. repeaters will soon be in operation in the UK. Apart from those already reported as in the planning stage, the UK FM Group (Northern) is hoping to establish a repeater near Barnsley and the Central Scotland Group has plans for a linear repeater. The RSGB is trying to encourage groups to consider establishing repeaters for 70cm and 23cm rather than 144MHz. The Home Office (formerly MPT) is believed to be concerned at the use of repeaters by fixed rather than mobile stations.

Operation of the GB3PI repeater has underlined the problems of the "phantom bleeper" who "accesses" the repeater with the correct tone blip and then immediately closes down; another problem is that of the long contact through the repeater by stations that could communicate directly —an indication of how a repeater channel tends to concentrate operation to a limited number of frequencies.

From South Africa comes the similar complaint that some f.m. transceivers are equipped only for the "national calling frequency" of 145.5MHz with the result that this has become a "national talking frequency".

But the most bitter comments on the widespread adoption of simple f.m. gear in conjunction with repeaters are those of Bob Cooper, W5KHT who claims that 144MHz operators in the United States have virtually abandoned interest in long-distance "tropo" contacts in favour of local f.m. operation: "The spirit of v.h.f./u.h.f. exploration may be dying—if it is the tombstone should have a 19-inch whip antenna prominently affixed to the top". He suggests that although there may always be a handful of dedicated enthusiasts who will pursue meteors, moonbounce and long-haul tropo working it needs more than a handful to take full advantage of a good tropo opening: "We have become too channelised with two-metre f.m. transceivers on the local repeater channel and then complain the band is never open anymore," he suggests.

Amateur television topics

In World of Amateur Radio in April 1972 a report was made of a new look being given to mechanical systems of television by Chris Long in Australia. One outcome of this report of 48-line television on 1.8MHz was that a number of enthusiasts in the UK began to share his interest in reviving low-definition TV. Mr D. B. Pitt (1 Burnwood Drive, Wollaton, Nottingham NG8 2DJ) had already been experimenting with 30-line mechanical TV but as a result of correspondence with Chris Long it was soon decided to try and standardise work on 32 lines and multiples of this figure—and Chris Long has since experimented on 32, 64, 128, 256, 512 and even 1028 lines (although presumably not using mechanical systems only). His efforts have included outside-broadcasts using home-made portable equipment.

In the latest issue of *CQ-TV* D. B. Pitt reports that there are now about 30 people in the UK experimenting with low-definition TV and that encouragement has come from Mr H. J. Barton-Chapple. But he considers that the standard of results achieved here remains low in comparison with that of tapes produced in Australia. He is seeking more support from technically expert enthusiasts to help raise the standard, although he emphasises that one of the attractions of low-definition TV is that participation is possible at a simple technical level and at low cost.

Slow-scan TV continues to attract increasing interest in the UK and this may be accelerated by the recent decision of the Home Office to permit ssTV transmissions on the 3.5MHz band and by the recent successes in exchanging ssTV pictures with Continental amateurs on 144MHz.

The 1974 Convention of the British Amateur Television Club is to be held outside London, at the Benn Memorial Hall at Rugby on Saturday, September 28. The venue is just off the M1 Motorway and near the Rugby Midland main line railway station.

La poste clandestine

An obituary of Robert Perton, F31Q, in *Radio-REF* reveals that this French amateur, licensed in 1937, after the collapse of France in 1940, returned from military service and set about constructing a clandestine radio transmitter which was used for communication with Britain for more than a year. In order to disrupt the monitoring services it is claimed that F3IQ also constructed an interference generator which he installed a few yards from the local d/f service and which was brought into operation at the times the transmitter was on the air. It is also suggested that when members of the monitoring service brought equipment to him for repair he made this work last for 35 days.

The death has also occurred of Norman Turner, G4NT, managing director of Ernest Turner Electrical Instruments Ltd of High Wycombe and president of the Chiltern Amateur Radio Club. An early enthusiast for amateur mobile operation, he also had a regular schedule lasting over a number of years with an amateur in Barbados.

In brief

Another North-west Amateur Radio Convention is to be held as a two-day event at Lancaster University from September 14 to 15. . . . XV5AA to XV5AC in Vietnam are now being permitted to communicate with other amateurs. . . . The American Electronic Industries Association has published a set of standards for the commercial manufacture of amateur radio aerials. . . . The FCC has raised the basic fee for American amateur licences from $9 to $10. . . . Canada has registered a strong objection to the FCC proposals to put Citizen's Band operation into 224 to 225MHz. . . . ARRL has opposed the FCC suggestion of a new Emergency Medical Paging service between 449.8 to 450MHz and suggests instead 445.8 to 456MHz. . . . FCC are proposing a common emergency frequency for Alaska of 4383.8kHz to allow amateur stations to intercommunicate with other services.

PAT HAWKER, G3VA

Clutter-free radar for cars

Conclusion: frequency measurement and application

by J. Shefer, R. J. Klensch, G. Kaplan and H. C. Johnson

RCA Laboratories, New Jersey

As described in last month's section on quantization there have been two different approaches to frequency measurement designed and tested for the automotive radar. One uses the rate of zero crossings counting technique and the other uses the average period measurement technique. Both techniques will be described although most of the experimental effort has been concentrated on the conventional counting technique.

Video circuits and signal processing

Following pre-amplification and the 10kHz band pass filter is a high-level amplifier/clipper which clips signals about 2 or 3dB above the background level. The conventional counter consists of a one-shot circuit that is triggered by the clipped input signal. The duration of the one-shot "on" time is as long as possible, consistent with the maximum input signal frequency of 200kHz. Making the "on" time as long as possible gives the most noise immunity possible since this particular one-shot cannot be retriggered during its "on" time. If the output of the one-shot is integrated then a voltage proportional to its range is obtained. Likewise, if the one-shot is made to drive a meter movement, the deflection will be proportional to range. Such a meter has been connected and calibrated to read 100 metres at full scale.

In a collision avoidance system more than just the range to the car in front is needed. Some velocity data must be used in conjunction with the range so that a decision can be made to slow down or continue. Velocity data is obtained from a Doppler speed sensor. By integrating the output pulse train of the Doppler unit a voltage proportional to velocity is developed, which is displayed on a second meter, calibrated in miles-per-hour with a full scale of 100m.p.h. Combining the two signals (range and velocity) in a variable threshold device, it is possible to sound an alarm whenever the vehicle gets too close to the car in front for the speed being maintained. One car length for each 10m.p.h. of velocity is an example for a typical alarm setting, which may be set to any desired value.

There exists one other useful bit of information in determining the presence of a hazard. It is the closing velocity between the two vehicles in question. Knowing the closing velocity as well as the range between vehicles and one's own velocity, it is possible to further optimize the condition for giving the danger signal. In the experimental radar, the alarm is sounded and the brakes are applied when

$$R \leq (k_1 v + k_2 dR/dt) \quad \ldots\ldots (4)$$

where R is the distance between vehicles, v is the velocity of the following vehicle, dR/dt is the closing velocity between the two vehicles, k_1 is the factor mentioned earlier, such as one car length per 10m.p.h. or 0·5 metres/m.p.h. and k_2 is a factor, determined by trial and error to be in the region between 1 and 3 metres/m.p.h.

If the closing velocity, dR/dt were not available, eq. (4) would reduce to $R \leq k_1 V$ for the alarm to be given. The constant k_1 would have to be made large enough to allow a safe stop for the situation of a car closing on a parked car. However, for the condition of the two moving vehicles (one following the other) the system would then appear to be overconservative. By adding the dR/dt factor, the system recognizes closing velocity and thereby allow k_1 to be made smaller, the assumption being that the car in front cannot come to a sudden stop but must decelerate. This deceleration would appear as an increase in closing velocity which would cause the following car to also decelerate so both cars would then stop safely.

It should be noted that provisions can easily be made for the driver to reset, by the "flick of a switch", constants k_1 and k_2 in accordance with prevailing weather and road conditions.

The closing rate, dR/dt, can be derived either by differentiating the range voltage, R, or by obtaining the Doppler shift directly from the video signal. As seen from Fig. 9, if a switched up-down counter is used, synchronous with the triangular modulation, f_m, a count proportional to the Doppler shift can be obtained.

The first of these methods was used in the experimental model, using a capacitor-driven operational amplifier with resistive negative feedback. A third meter, calibrated in m.p.h., displays the negative (receding) or positive (approaching) closing rates, and the alarm circuit utilizes dR/dt according to eq. (4).

The processing system which eliminates the quantization effects is outlined in Fig. 13. There are several main blocks shown in this figure. The first block selects a suitable portion of the difference frequency waveform to use for the measurement. It is important that the phase reversal portions (shown in Fig. 8) not be included within the measurement because of the quantization effects that are caused by the phase reversals occurring near the peaks and valleys of the triangular modulation waveform. A suitable portion of the difference frequency waveform must always fall between these peaks and valleys. It is also desirable to utilize a large fraction of the difference frequency waveform so that the measurement will be reliable and the effects of noise are averaged. Therefore, we want to use a sampling of the waveform that consists of at least a minimum duration interval for reliable processing and noise immunity but is not too large so that the phase reversal portions of the waveform are not excluded.

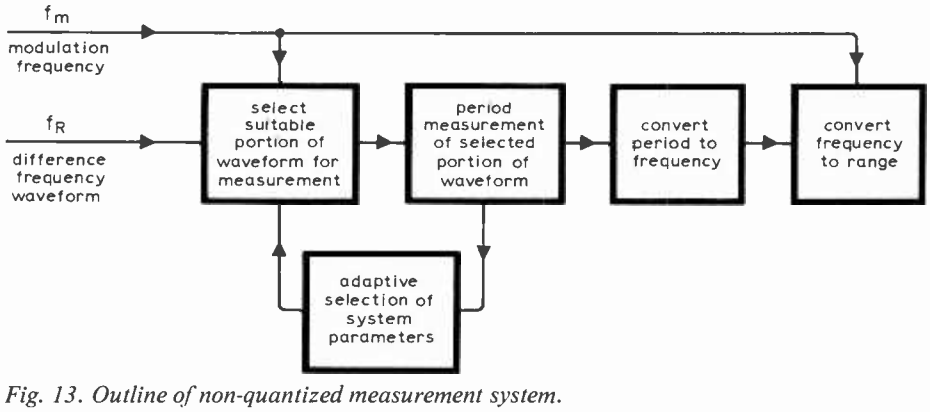


Fig. 13. Outline of non-quantized measurement system.

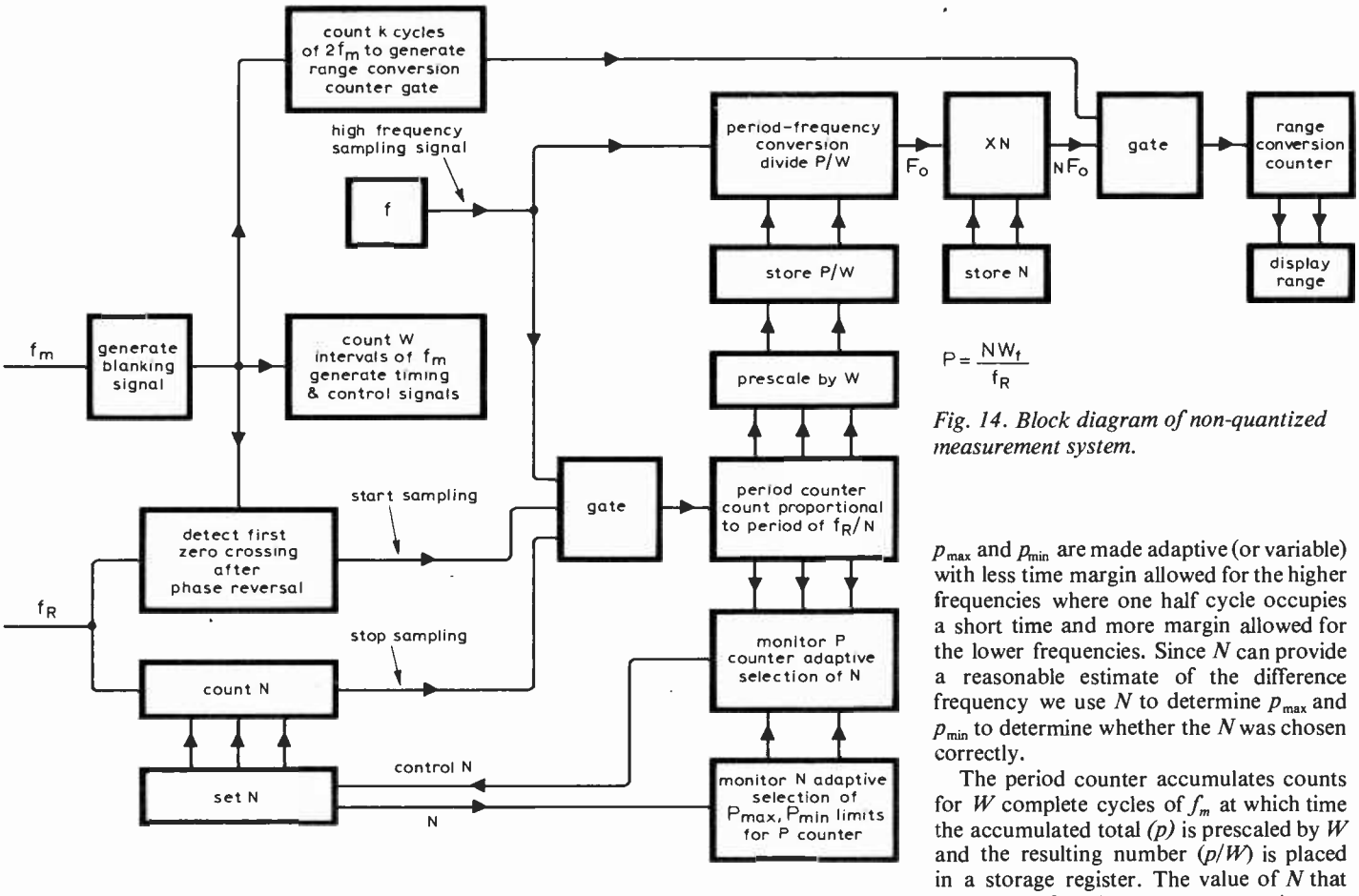


Fig. 14. Block diagram of non-quantized measurement system.

The difference frequency is not constrained to stay within a narrow range but will vary (perhaps over a 20: 1 ratio or more). Therefore, to best accommodate the wide dynamic range of difference frequencies, the measurement system is an adaptive one. That is, the system's parameters are allowed to change as the difference frequency changes in a way which achieves the "goal" of selecting a suitable portion of the waveform for processing. A decision to change the measurement parameters is made by monitoring the period measurement and taking appropriate action to adjust the measurement parameters. This will be more fully described below. As shown in Fig. 13, the next steps are to convert the period measurement to a frequency and then to a range. A more detailed system diagram is shown in Fig. 14.

Inputs to the processor are the difference frequency waveform and the triangular modulation waveform of frequency f_m. From the triangular modulation waveform, a pulse train, of frequency $2f_m$ and called the blanking signal, is generated with a pulse occurring at the peaks and valleys of the modulation waveform.

The period measurement begins by detecting the first zero crossing of the difference frequency waveform that occurs after the end of a blanking signal pulse. This insures that the phase reversal of the difference frequency waveform is completed before the measurement begins. At the time of this zero crossing, a high-frequency pulse train of frequency f pulses per second is gated into a counter called the period counter. After N additional zero crossings (half cycles) of the difference frequency waveform have occurred, the gate is closed and the counter stops incrementing. The process is repeated after the next blanking signal occurs and continues for a total of $2W$ blanking pulses. At this time the count (p) in the period counter is given by (5)

$$p = \frac{WNf}{f_R} \quad \ldots\ldots\ldots\ldots \quad (5)$$

For reliable measurements, N must be chosen correctly. If N is too large, the sampling interval can extend beyond the next blanking signal into the phase reversal region, while if N is too small, the measurement will not be accurate because useful information is discarded. By monitoring the period counter outputs, we can determine the average sampling time. If the sampling time is too small, then the processor increases N for the next measurement, if the sampling time is too long, then N will be decreased for the next measurement. Basically we monitor the period counter, compare its contents with two limits, p_{max} and p_{min}, and have the processor always adjusting N to maintain the period counter output between these limits.

The time of the first zero crossing of the difference frequency may vary by up to one half cycle of the difference frequency. Therefore, in choosing p_{max}, a safety margin must be allowed for, with the safety margin being larger for the low frequencies. Because the difference frequency varies (in frequency) over a wide range, a safety margin that is adequate for the lower frequencies is excessive for the higher frequencies. To make better use of the difference frequency waveform, the limits p_{max} and p_{min} are made adaptive (or variable) with less time margin allowed for the higher frequencies where one half cycle occupies a short time and more margin allowed for the lower frequencies. Since N can provide a reasonable estimate of the difference frequency we use N to determine p_{max} and p_{min} to determine whether the N was chosen correctly.

The period counter accumulates counts for W complete cycles of f_m at which time the accumulated total (p) is prescaled by W and the resulting number (p/W) is placed in a storage register. The value of N that was used for the measurement is also stored. If a change to a new value for N is made, the counters are reset and a new period measurement is started.

The processor now begins to convert the period measurement to a frequency. As shown in Fig. 14, the first step in this conversion is to strobe the scaled (p/W) count into a pre-setable centre operating in the down count mode. The clock input to the counter is the same high-frequency sampling pulse train used to measure the period. The output from this period conversion counter is a pulse train of frequency f_0 where

$$f_0 = \frac{f}{p/W} = \frac{f_R}{N}$$

The output frequency (f_0) is then fed into a circuit which generates N output pulses for each input pulse. The new output frequency (Nf_0) is then equal to f_R.

By using the same pulse train (f) to generate counts in the period counter and then to convert the measured period to a frequency, we have made the frequency stability of the sampling pulse train relatively unimportant.

So far we have measured the period of the difference frequency waveform excluding the phase reversal portions and have converted this period measurement into a pulse train of the same frequency as the input frequency. However, by excluding the phase reversal region from the measurements, we insure that the output frequency is not subject to the coarse quantization effect that arises with conventional processing. A conversion of frequency to range is made by first generating a time gate of

duration $K/2f_m$ and then gating the output frequency Nf_0 into the range conversion counter. The range conversion counter has a count of $(4\Delta FK/c)R$ accumulated and by setting $4\Delta FK/c$ equal to a convenient number such as 10, each count equals 0·1 metres. A display is easily driven if the range conversion counter is arranged as a cascade of decode counters. Note that by generating a range conversion gate from f_m, any variation or drift in f_m is automatically compensated for in the range measurement.

The processor just described does not require any accurate clocks within the processing system. Frequency variations in the high-frequency sampling pulse train are compensated for by using the same pulse train for period measurements and period-to-frequency conversion. Also variations in f_m are compensated for by using f_m to generate the range conversion counter time gate.

Automatic collision avoidance braking

The automatic braking system in the experimental radar is fairly rudimentary at the moment in that once the alarm is given, the brake pedal is automatically depressed by a force that increases linearly with time to maximum pressure, until the alarm is removed. The force is then removed linearly with time. Developing the force necessary to apply the brakes was accomplished by using a vacuum-operated piston. The piston pulls the pedal via a spring in series with a flexible cable that goes through the bulkhead and connects to the brake pedal. This allows the driver to override or augment the braking if necessary. The valve that allows the engine's vacuum system to evacuate the chamber of the piston is driven by electrical signals derived from the signal processor when an alarm is given.

A proportional braking system is currently under consideration where the brakes will be applied according to the severity of the danger situation; the pedal force P will then be

$$P = k_p[K_1 v + k_2(dR/dt) - R]$$

where k_p is a constant, adjusted to the car's braking and accelerating dynamics, and has the dimensions of force/metre.

Experimental tests

The experimental system uses an RCA transferred electron oscillator power source. Antennas are modified and scaled versions of the RCA hand-held radar. An efficient doubler circuit in microstrip was developed at RCA Laboratories, as well as the various video circuits for amplification, filtering and processing. Other r.f. components were purchased as standard catalogue items.

The components of the experimental system include the Doppler speed sensor and the active radar power supply which operates from the 12-volt car battery. The maximum power drain is 20W. The reflector is completely passive and therefore needs no power.

The experimental set-up on the test vehicle is shown in Photos 3 and 4. Although the active radar and passive reflector are slightly larger than an American licence plate, scaling to higher frequencies would decrease the size to that of a licence plate. The registration numbers can then be imprinted on the protective antenna covers (glassfibre) and the units can be mounted in the space reserved for licence plates. Alternatively, the active radar can be mounted behind a plastic grille.

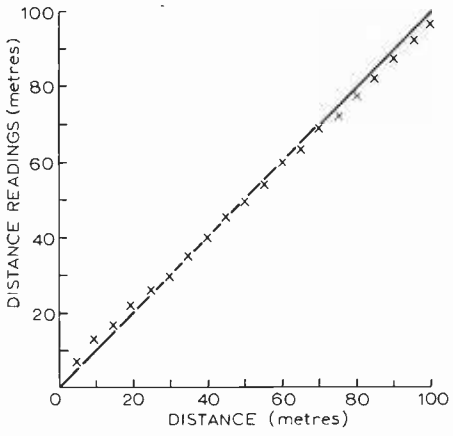


Fig. 15. Accuracy of distance measurements.

The experimental collision avoidance radar has been extensively tested on RCA Laboratories' grounds and adjoining highways. Although not specifically "ruggedized" for highway use, the system has not failed from vibrations or adverse climatic conditions. It was not affected by rain appreciably, nor was the performance noticeably degraded by applying a layer of mud and road dirt to the antenna covers.

The distance measurements were quite repeatable and of adequate accuracy. Fig. 15 shows measurements of distance readings on the display meter versus actual distances (using the zero crossings counting technique). Errors can be reduced further by using a more linear meter movement although the quantization limitation is still present.

Experimental tests were concerned with determining whether the new processor would not be subject to the coarse quantization effects that previously occurred. The radar and processor were mounted on a car which was situated 40 metres from the harmonic reflector. Then the car was slowly moved in 0·1-metre increments a total of 1·5 metres. At each point a reading on a digital display was noted (the display itself had a quantization of 0·1 metres). The experimental parameters of the system were f_m = 2·2kHz and ΔF = 22MHz. For these parameters, the quantization error with the zero crossing processing previously used was about 1·7 metres. Results of the experiment using the new processing

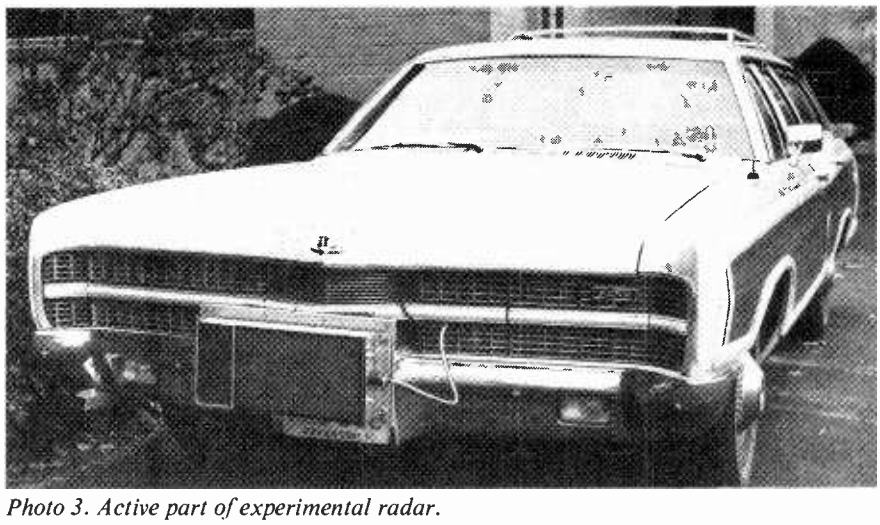


Photo 3. Active part of experimental radar.

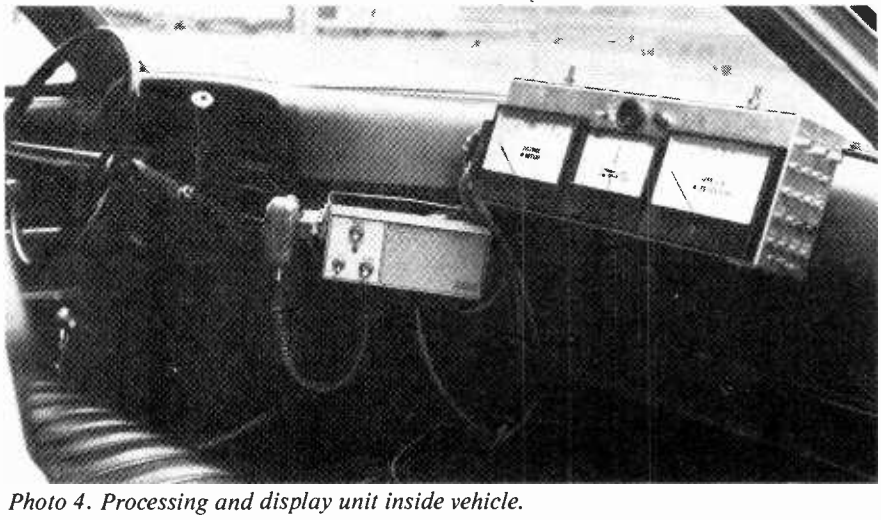


Photo 4. Processing and display unit inside vehicle.

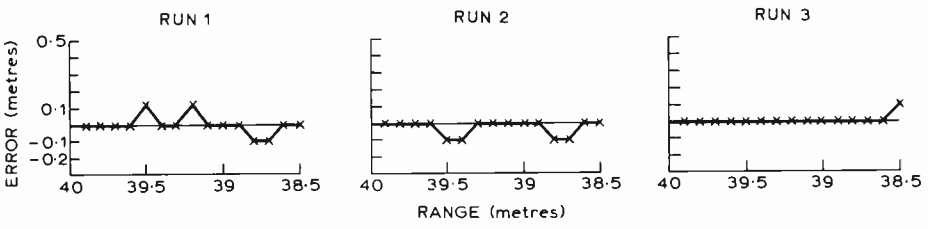


Fig. 16. Experimental results with non-quantized processing.

technique are shown in Fig. 16. Note that the quantization has been reduced to 0·1 metres (basically the display limitation). Therefore, the new technique does eliminate the coarse quantization effect.

Modes of operation

Several different modes of utilizing the collision avoidance radar can be discerned. In a semi-automatic mode, the radar will sound and flash an alarm whenever warranted; taking action will be left to the driver, who may choose to slow down, change lanes, or ignore the warning for any reason.

In another mode of operation, the brakes can be applied automatically, either immediately the alarm is sounded, or with delayed action, giving the driver a chance to act first. If the driver fails to act, the system will provide a last-minute "panic" stop that will at least moderate the collision impact.

In yet another mode, the collision avoidance radar can be integrated with a cruise control system, providing completely "foot off" operation.

It is also possible to "tag" specifically identified collision hazards located on or off the highway, such as bridge abutments, construction barriers or trees. A reflector mounted on such an obstacle will stop a car approaching it within a predetermined angle, but will not influence a car travelling in a safe lane.

Reflectors can also be placed at wrong-way entrances to one-way streets or highway exit ramps to prevent inadvertent entry.

Cost and cost effectiveness

The system lends itself very well to integration using printed-circuit techniques throughout. The passive reflector, which in general use will have to be mounted by law on the back of every vehicle (similar to requirements of red tail-lights), can be produced inexpensively on one printed-circuit board. The active radar is more complex, but not more than a.m./f.m. radios currently used in cars.

To make the radar "cost effective", its cost must be less than the damage involved in the rear-end collisions which have been prevented through its use, on the average. We have mentioned an estimate of $10 billion in "societal cost" per year due to rear-end collisons. This comes to $100 per car per year, which amounts to a substantial sum over a vehicle's lifetime. A radar with a capability of preventing or moderating even a fraction of the rear-end collision damage might become quite an attractive proposition.

Acknowledgements

The harmonic radar effort has drawn on the talents and skills of diverse RCA groups. The authors are grateful to Harold Staras, who held the whole project together and provided ideas and encouragement at every turn; to L. Schiff for many fruitful discussions; to W. C. Wilkinson, O. M. Woodward and Z. L. White who designed and constructed the antennas; to L. S. Napoli, J. J. Hughes and J. Rosen who developed the microstrip doubler circuit; A. Presser who designed the local oscillator doubler; and to R. Burgen and T. Nolan who helped build and road-test the system and A. Ritzie who constructed the new processor and aided in the testing.

Books Received

Japanese Radio, Record and Tape Player Schematic/Servicing Manual by Homer Davidson has information on most of the Japanese equipment available today. Full circuit diagrams along with photographs of the various pieces of equipment are given. This is supplemented with a systematic guide to the servicing including general "symptom and cause" charts. Part lists with part numbers are given and replacement details where applicable. The book ends with a list of major importers with addresses. Price £1·90. Pp. 228. Foulsham-Tab Ltd, Yeovil Road, Slough, Bucks.

Robotics by John F. Young will be useful to people concerned with or just interested in robots. After a general chapter on robots describing different types and their uses the book deals with specific aspects of robotics in detail. Robot senses, simulating human senses as well as those for detecting radio or ultrasonic waves are discussed. Muscles of the robot, robot stability, mobility and limbs, robot vision, hearing and speech are all dealt with in detail. The final chapter is devoted to the future of robots pointing out the economic and social consequences. Price £6. Pp. 303. Butterworth Group, 88 Kingsway, London WC2B 6AB.

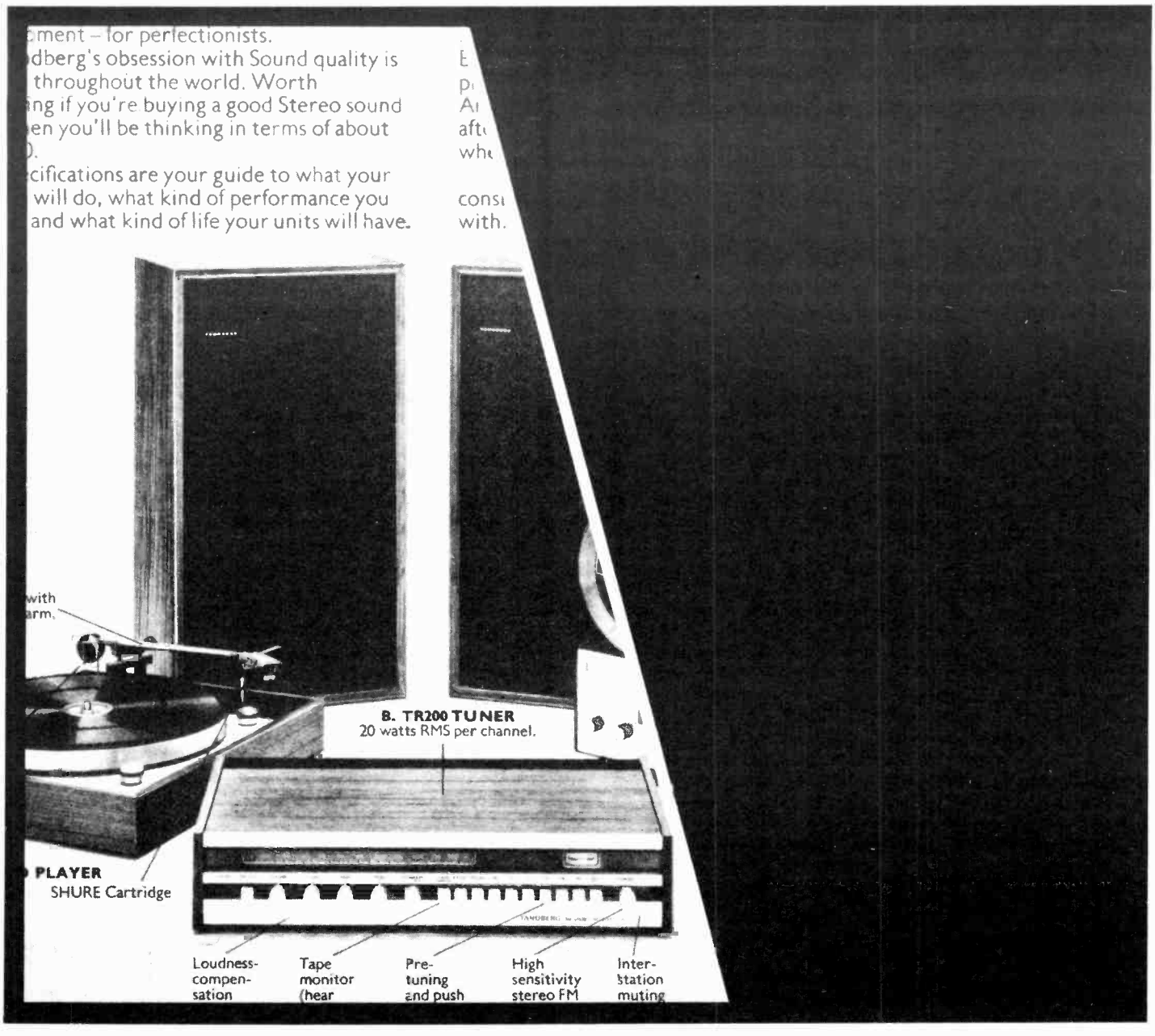
Component Performance and Systems Applications of Surface Acoustic Wave Devices I.E.E. Conference Publication 109. This book is a result of a specialist seminar organized by the I.E.E. in association with two working groups of the I.E.E.E., which was held from the 25th to 28th September, 1973. Two major interconnected themes are covered (a) component performance of existing surface acoustic wave devices, and (b) present and future systems applications of s.a.w. devices. The book covers eight sessions each having a different chairman. Materials and fabrication, acoustic subsystems, programmable devices, filters, radar application of s.a.w., digital signal processing, communication systems and air traffic control applications are all dealt with. The book concludes with a summary of chairman's remarks and a final discussion. Price £11 (special price to I.E.E. members on application to publisher with membership number). Pp. 372. Publication Sales Department, Institution of Electrical Engineers, Station House, 70 Nightingale Road, Hitchin, Herts SG5 1RJ.

ITV Guide to Independent Television 1974 contains detailed information on more than 200 existing or proposed IBA transmitting stations. It describes the work of the authority and the associated programme companies. One section covers technical operations with details on recent developments in television as well as the planning and building of a transmitter. There is also a chapter on factors affecting reception and how it may be improved, together with maps for each main u.h.f. transmitter. In addition to technical information the book has separate chapters on each category of programme. These include planning, audience research and advertising control. Price 90p. Pp. 240. Independent Television Publications Ltd, 247 Tottenham Court Road, London W1P 0AU.

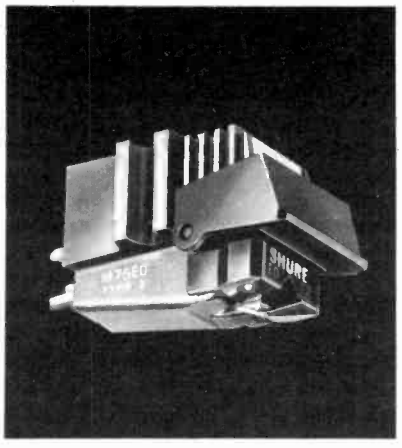
101 TV Troubles by Art Margolis. The book is divided into 15 chapters, each of them being concerned with one type of symptom. All the relevant circuitry is described and then causes for the fault in question are suggested along with the possible remedies. As well as basic television faults all the main colour faults are analysed together with circuit diagrams and theory. Price £1·40. Pp. 218. Foulsham-Tab Ltd, Yeovil Road, Slough, Bucks.

How to listen to the world—9th edition, produced in association with the BBC. The purpose of this book is to enable the reader to obtain the best results from his radio or television receiver. Several chapters deal with problems encountered by an international broadcasting station and other articles are devoted to topics of general interest, including "Operating a DX station" and "Listening to Music". A new section in the book is an International Buyer's Guide giving information on numerous items of audio and communications equipment. Price £1·90. Pp. 168. Fountain Press Model & Allied Publications Ltd, Book Division, Station Road, King's Langley, Herts.

Problems in Electronics, by J. Auvray and M. Fourrier, provides a large number of exercises and calculations involving passive and active components covering frequencies from l.f. to u.h.f. There are also chapters on logic circuits, filters and circuit synthesis. All problems are accompanied with detailed solutions and are based on real circuits. Price £6. Pp. 430. Pergamon Press Ltd, Headington Hill Hall, Oxford OX3 0BW.



How to read a hi-fi advert



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The Sinclair Cambridge... no other calculator is so powerful and so compact.

Complete kit–£24·95!

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The Cambridge – new from Sinclair
The Cambridge is a new electronic calculator from Sinclair, Europe's largest calculator manufacturer. It offers the power to handle complex calculations, in a compact, reliable package. No other calculator can approach the specification below at anything like the price – and by building it yourself you can save a further £5·50!

Truly pocket-sized
With all its calculating capability, the Cambridge still measures just $4\frac{1}{2}''$ x 2″ x $\frac{11}{16}''$. That means you can carry the Cambridge wherever you go without inconvenience – it fits in your pocket with barely a bulge. It runs on U16- type batteries which gives weeks of life before replacement.

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All parts are supplied – all you need provide is a soldering iron and a pair of cutters. Complete step-by-step instructions are provided, and our service department will back you throughout if you've any queries or problems.

Total cost? Just £27·45!
The Sinclair Cambridge kit is supplied to you direct from the manufacturer. Ready assembled, it costs £32·95 – so you're saving £5·50! Of course we'll be happy to supply you with one ready-assembled if you prefer – it's still far and away the best calculator value on the market.

Features of the Sinclair Cambridge

- Uniquely handy package. $4\frac{1}{2}''$ x 2″ x $\frac{11}{16}''$, weight $3\frac{1}{2}$ oz.
- Standard keyboard. All you need for complex calculations.
- Clear-last-entry feature.
- Fully-floating decimal point.
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- Four operators (+, —, x, ÷), with constant on all four.
- Constant acts as last entry in a calculation.
- Constant and algebraic logic combine to act as a limited memory, allowing complex calculations on a calculator costing less than £30.
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- Clear, bright 8-digit display.
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A complete kit!

The kit comes to you packaged in a heavy-duty polystyrene container. It contains all you need to assemble your Sinclair Cambridge. Assembly time is about 3 hours.

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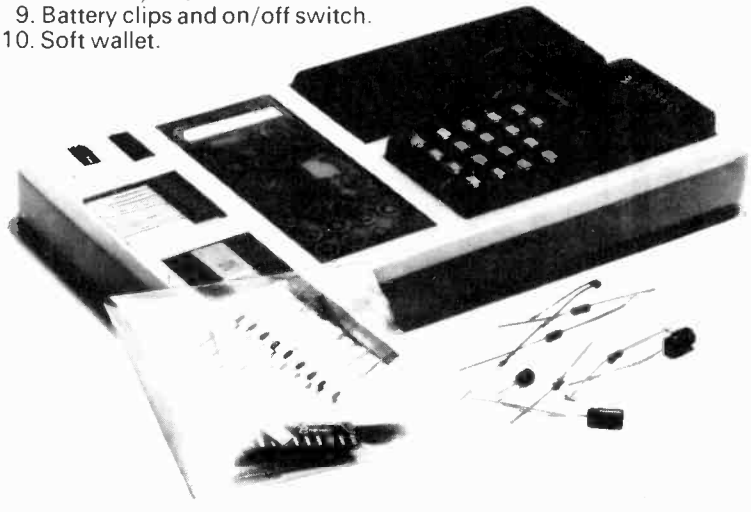
3. Interface chip.
4. Thick-film resistor pack.
5. Case mouldings, with buttons, window and light-up display in position.
6. Printed circuit board.
7. Keyboard panel.
8. Electronic components pack (diodes, resistors, capacitors, transistor).
9. Battery clips and on/off switch.
10. Soft wallet.



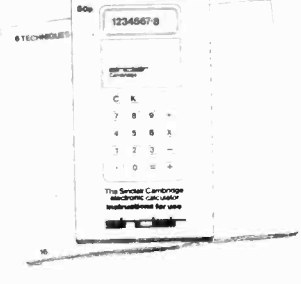
Actual size!

4½in long x 2in wide x 11/16in deep

This valuable book – free!

If you just use your Sinclair Cambridge for routine arithmetic – for shopping, conversions, percentages, accounting, tallying, and so on – then you'll get more than your money's worth.

But if you want to get even more out of it, you can go one step further and learn how to unlock the full potential of this piece of electronic technology.



How ? It's all explained in this unique booklet, written by a leading calculator design consultant. In its fact-packed 32 pages it explains, step by step, how you can use the Sinclair Cambridge to carry out complex calculations

Why only Sinclair can make you this offer

The reason's simple : only Sinclair – Europe's largest electronic calculator manufacturer – have the necessary combination of skills and scale.

Sinclair Radionics are the makers of the Executive – the smallest electronic calculator in the world. In spite of being one of the more expensive of the small calculators, it was a runaway best-seller. The experience gained on the Executive has enabled us to design and produce the Cambridge at this remarkably low price.

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It seemed only logical to combine the knowledge of do-it-yourself kits with the knowledge of small calculator technology.

And *you* benefit !

Take advantage of this money-back, no-risks offer today

The Sinclair Cambridge is fully guaranteed. Return your kit within 10 days, and we'll refund your money without question. All parts are tested and checked before despatch – and we guarantee a correctly-assembled calculator for one year.

Simply fill in the preferential order form below and slip it in the post today.

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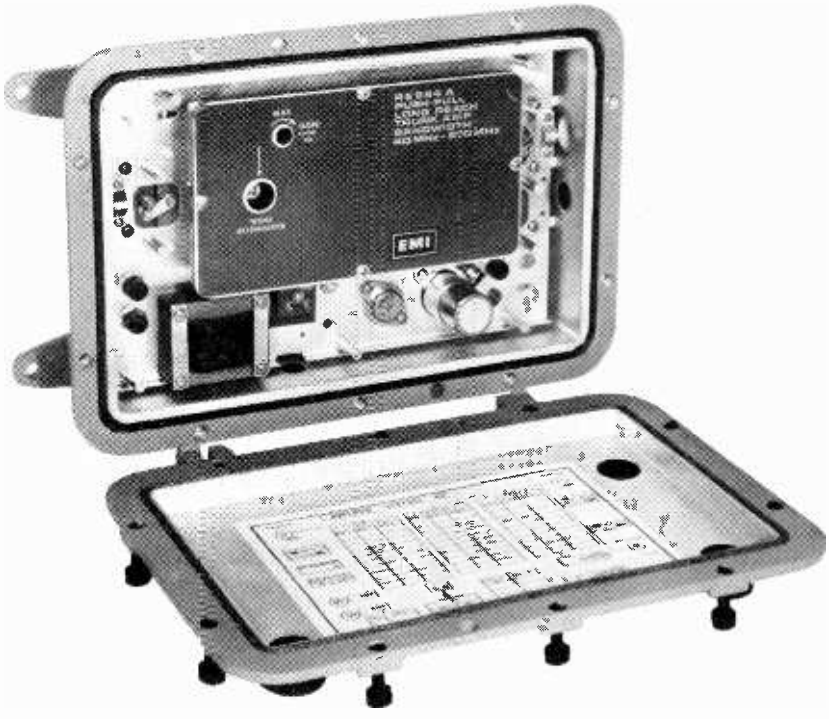

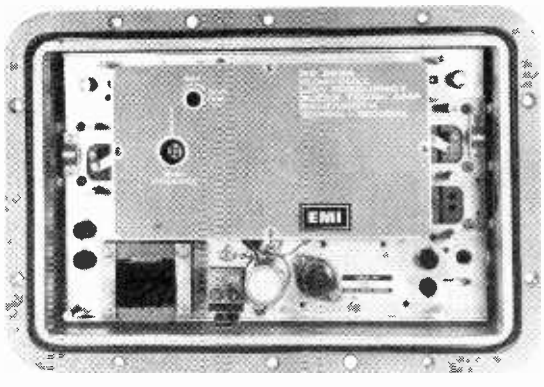

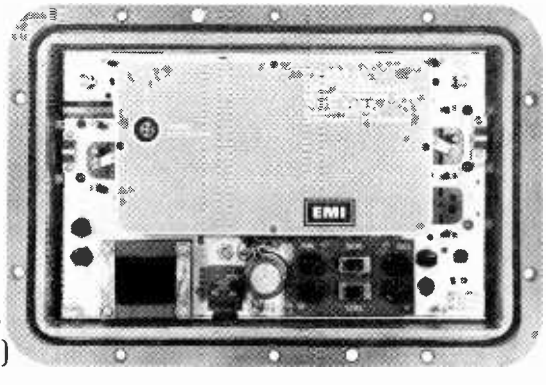

EMI Colorline is now available with two new competitively-priced long-reach trunk amplifiers for systems with trunk routes up to 35.5 km. The RE984 Amplifier (40-270MHz) is designed for systems requiring a large number of units in cascade. The RE993 Long-reach Low Frequency Amplifier (30-120 MHz) is for Supertrunk lines, and operates on a limited band-width to achieve even longer reach. Automatic gain (ALSC) versions of both amplifiers are also available. Another new device is the EMI outlet plate (complying with the recommendations of IEC 169-2) for Colorline or other cable television systems.

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Programming the "Scientific"

A four-function calculator chip re-programmed

by Nigel H. Searle, Ph.D.

Sinclair Radionics Ltd

When considering new products, a calculator manufacturer is constantly faced with the problem of whether to buy a standard chip from a semiconductor house, or to design a new chip. In the former case, he will be faced with the prospect of competing head-on with other manufacturers using the same chip, whose calculators will therefore have the same functional characteristics as his own. In the latter case, he will have a unique product, but there are risks involved. Until recently, a custom calculator chip design has meant a substantial investment of both cash and man-power in a product which takes almost 12 months to come to a rapidly changing market; and it has been a step into unknown areas of new semiconductor process rules, production yields, and so on. Custom designs will continue, though, as long as the technology is developing at its present pace. However, there is now an alternative, which involves re-programming a standard chip to radically alter the capabilities of the end product—the calculator. The resultant chip will be as easy to produce as the standard device from which it has been developed so there are no unknown quantities with respect to the validity of the overall design or production yields. Furthermore, the design effort and cost are considerably less; so also is the total development time, allowing the calculator manufacturer the luxury of having only to meet the market's requirements 6 months ahead instead of 12.

A brief description of the structure of a calculator chip will help in the understanding of what is involved in re-programming it. For this purpose, it is necessary to consider only the three main parts of that structure—the random access memory (RAM), the processor or arithmetic unit, and the read-only memory (ROM).

The RAM is the dynamic data storage medium. Typically it is organised into 4-bit groups, each capable of storing a binary-coded decimal (BCD) digit. The 4-bit groups may themselves be organised into registers each of perhaps 12 or 16 digits. A 12-digit register would be suitable for an 8-digit calculator, and a 16-digit register for a 12-digit machine, the extra digits in each case being used to store information about the position of the decimal point, the sign of the number in the register, and so on.

The processor is capable of operating upon the data in the RAM and altering it. For example, it may take two digits from the RAM, add them, and store the result in the RAM location from which one of the two digits came. Often the processor will also set a bit of RAM, which could be one of several bits separate from the main register-structured RAM, to state "1" or state "0" depending upon whether the addition of two digits caused a carry or not, i.e. whether they totalled more or less than ten. The processor is controlled by instructions from the ROM which is split into words each of a fixed length, typically from 7 to 15 bits, and each containing a member of the instruction set.

In addition to instructions which tell the processor to operate on data in the RAM, there will also be instructions which control the sequence in which instructions from the ROM are executed. For example, an instruction may cause the processor to transfer control not to the next instruction in the ROM (which is always the default option) but to an entirely different location, if the carry bit is set. In considering the suitability of a particular calculator chip for re-programming, the following factors are amongst those which must be taken into account:

RAM size

Is the amount of RAM sufficient for the application? If, for example, a calculator is to have two memory registers and is to be capable of handling 8 digit numbers than at least 32 digits (128 bits) are required in the RAM, since in addition to the memory requirements there is also the register containing the number being displayed and the register which contains the previous result while a new number is being entered. Most calculator chips for simple four-function calculators have a RAM organised into three registers, and four registers if the chip is aimed at the four-function-with-memory market.

RAM organisation

Any register structure which is imposed by the instruction set on the RAM will inevitably prove to be a restriction in certain situations. A RAM of 64 digits which can effectively only be used as four 16-digit registers is potentially less useful than one which can also be used as eight 8-digit registers. Also, unless there are separate registers which are broken down into single bits rather than 4-bit groups, then it is important that the bits within the 4-bit digit groups of the main RAM can be directly addressed.

ROM size

Of course, it is important that the overall ROM size should be sufficient to contain the instruction sequences necessary to carry out all the keyboard functions of the calculator. A short ROM word length implies a restricted instruction set, which may be limiting, whereas a long ROM word is associated with a wide range of instructions, any one of which causes a fairly complex operation to be performed by the processor (for example, the addition of two registers rather than just two digits). A long ROM word may have been appropriate for the original calculator application but could well be inefficient for a different machine because the full power of the long instructions would not be utilised.

Subroutines

If the basic instructions of the instruction set operate only on digits from the RAM then it is important that at least one level of subroutine is available so that sets of instructions can be written to operate on whole registers and be called by the various algorithms for the keyboard functions. If the calculator is to have scientific functions, such as logarithms and trigonometric functions, available from the keyboard, then another level of subroutine is needed—this time a higher level—so that the sequence of instructions to perform a multiplication, for example, can be used by the more complex scientific functions.

Sinclair Scientific

The Sinclair Scientific is a 12-function calculator (+, −, ×, ÷, log, antilog, sin, cos, tan, arcsin, arccos, arctan), with a 5-digit mantissa and 2-digit exponent. It was developed by re-programming a chip which was originally designed with

Cont. on page 206

Pulse modulators

by J. Carruthers, J. H. Evans, J. Kinsler and P. Williams *Paisley College of Technology*

An introduction to direct and coded modulation systems for pulse trains. Circuits of pulse amplitude, code, duration and position modulators are covered in Circards 15.

Systems using amplitude modulation, frequency modulation and phase modulation use a sinusoidal carrier which has one of its characteristics—amplitude, frequency or phase—varied under the control of an analogue signal of message $x(t)$. In pulse modulation systems the carrier may be considered to be a periodic, rectangular pulse train $c(t)$ as shown in Fig. 1. The pulse train has an amplitude A_c, a pulse width τ_c and a fundamental frequency $f_c = 1/T_c$.

Amplitude, width or position (in time) of the carrier pulses may be varied as a function of the lower-frequency analogue signal waveform to produce pulse modulation, p.a.m., pulse width (duration) modulation, p.d.m., or pulse position modulation, p.p.m. For all practical applications of pulse modulation, the analogue modulating signal should be band-limited with a suitable filter so that it contains a reasonably well-defined upper frequency component f_m which is the highest significant frequency in the modulating waveform.

Each pulse in a modulated carrier pulse train $y(t)$ contains one sample of information regarding the "instantaneous" value of the modulating signal $x(t)$. The sampling theorem states that all the information in $x(t)$ will be preserved if the samples are evenly spaced and occur at a rate that is not less than $2f_m$. In practice the sampling rate normally exceeds this minimum value by a factor of at least about 1.2.

Pulse amplitude modulation may be considered to be the process of changing the amplitude of a periodic rectangular carrier pulse train in synchronism with, and in proportion to, the instantaneous variations of the modulating analogue signal. Using a sinewave as an example of the modulating signal the p.a.m. waveform shown in Fig. 2 is obtained. The basic form of a pulse amplitude modulator is shown in Fig. 3.

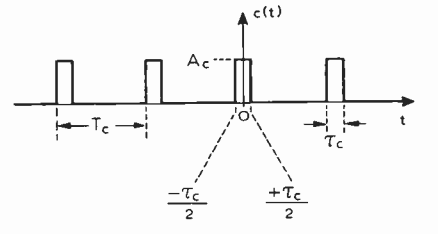
The unmodulated carrier pulse train shown in Fig. 1 has a Fourier series representation

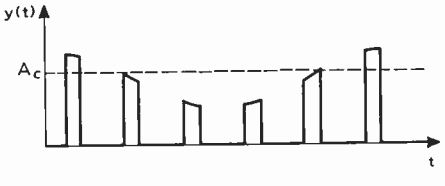
$$c(t)=\frac{A_c\tau_c}{T_c}\left[1+2\sum_{n=1}^{\infty}\left\{\frac{\sin(\omega_n\tau_c/2)}{\omega_n\tau_c/2}\right\}\cos\omega_n t\right]$$

where $\omega_n = 2_n/\tau_c$ and $_n = 1, 2, 3 \ldots \infty$.

With a sinusoidal modulating signal of $A \sin \omega t$, the amplitude of the pulses become $A_c(1 + m_A . \sin \omega t)$ where m_A is the modulation index A/A_c which must be < 1 to avoid overmodulation of the pulse train.

The p.a.m. wave shown in Fig. 2 may be considered either as a sinewave amplitude modulating the pulse train, or as the unmodulated carrier sampling the amplitude function $A_c(1 + m_A \sin \omega t)$ over an interval of τ, at a rate equal to the p.r.f. of the pulse train, f_c. The frequency spectrum of the p.a.m. signal may be seen conceptually by considering initially that of the unmodulated carrier which will contain a d.c. component and a theoretically infinite series of sinusoids at f_c, $2f_c$, $3f_c$, etc, which have diminishing amplitude with increasing frequency.





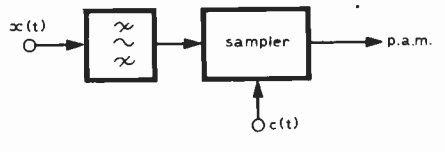


Fig. 1. Carrier pulse nomenclature.

Fig. 2. A p.a.m. waveform—a modulated pulse or a sampled input signal.

Fig. 3. The basic pulse-amplitude modulator.

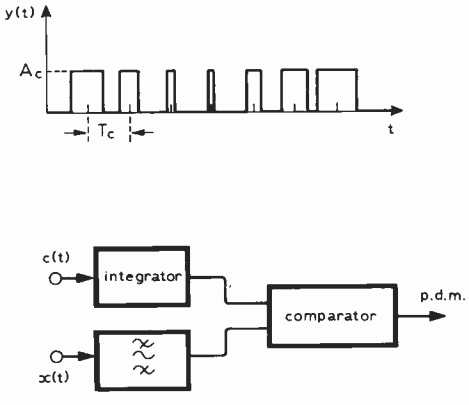


Fig. 4 (top). In this example of p.d.m., both edges are shifted, modulating the pulse symmetrically.

Fig. 5. The input signal x(t) *varies the threshold of a triangular pulse from the integrator to produce p.d.m.*

The amplitude modulation will produce a lower sideband and an upper sideband to each of the carrier components f_c, $2f_c$, etc and a component at the original modulating frequency or band of frequencies. This latter component will have an amplitude of $A_c m_A \tau/T_c$ and may be recovered by passing the p.a.m. wave through a low-pass filter, which also passes the d.c. component. P.a.m. signals are required to preserve the *shape* of the modulated pulses and therefore suffer from the same signal-to-noise ratio restrictions as a.m. but with a transmission bandwidth requirement of approximately $3/\tau_c$ Hz. Consequently p.a.m. is more commonly used as a part of the signal processing in other systems than as a system in its own right.

Pulse duration modulation may be considered as the process of changing the width of the pulses in a periodic, rectangular carrier pulse train in synchronism with, and in proportion to, the instantaneous variations of the modulating analogue signal. In p.d.m., either the leading edges or the trailing edges or both edges of the carrier pulse train may be shifted in time due to the modulation. Fig. 4 shows an example of a p.d.m. wave where both edges have been shifted and

the time interval between the centres of successive pulses remains fixed at T_c. With a sinusoidal modulating signal the unmodulated puise width τ_c becomes $(1 + m_w \sin\omega t)$ where m_w is the modulation index τ_m/τ_c which must be <1 as the pulses cannot have a negative width, τ_m being the maximum deviation of the pulse width from its unmodulated value τ_c.

The p.d.m. wave contains a d.c. component, the original modulating frequencies and the harmonic series of carrier frequencies each of which has an infinite number of sideband pairs associated with it. In practice, not more than about three of these sideband pairs has significant amplitude so the original analogue signal may be recovered by passing the p.d.m. wave through a low-pass filter provided the carrier pulse train has a sufficiently high p.r.f. compared with f_m. The signal-to-noise ratio obtainable with p.d.m. is greater than that obtainable with p.a.m. due to the use of a wider transmission bandwidth, the improvement being similar to that of phase modulation compared with amplitude modulation. One form of pulse duration modulator is shown in Fig. 5.

Pulse position modulation may be considered to be the process of varying the position in time of the pulses in a periodic, rectangular, carrier pulse train in synchronism with, and in proportion to, the instantaneous variations of the modulating analogue signal. These modulated pulses cannot be advanced in time so that they may be considered as being displaced continuously in time with respect to the positions in time where the unmodulated

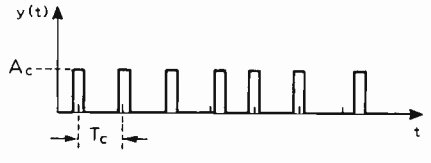


Fig. 6. Pulse-position modulation.

pulses would have occurred as indicated in Fig. 6. Pulse position modulation can be produced by generating a p.d.m. signal and feeding it into a monostable multivibrator. Figs 7 & 8 show two methods of generating a p.p.m. signal by using a pulse train $p(t)$ having a normal leading or trailing edge with a negative-or-positive slope ramp. The method of Fig. 8 avoids the need to generate a p.a.m. signal as part of the process.

With a sinusoidal modulating signal the "instantaneous" position of the pulses in time may be represented by $z(t) = f_c t + m_p \sin\omega t$ where m_p is the modulation index T_m/T_c, T_m being the peak deviation of pulses from their unmodulated position. The p.p.m. signal may be converted back to p.d.m. or p.a.m. to recover the modulating signal by means of a low-pass filter. Because noise has less effect on the position of pulses compared with its effect on the amplitude or edges of pulses, p.p.m. can provide a better signal-to-noise ratio than either p.a.m. or p.d.m.

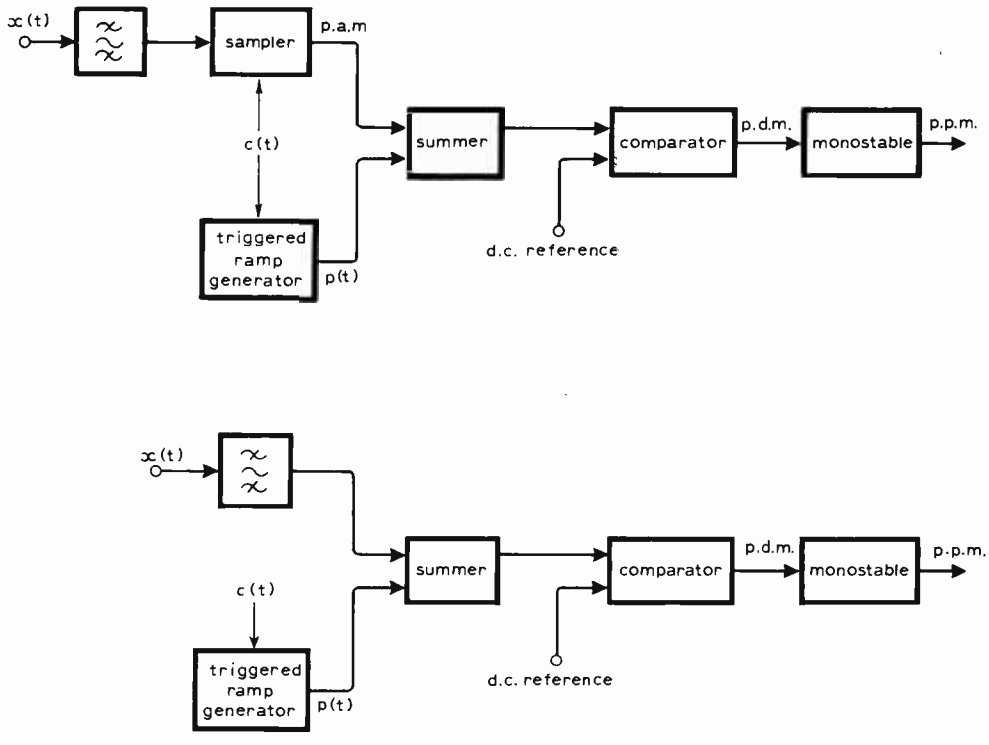


Fig. 7 (top). A pulse-position modulator.
Fig. 8. The p.a.m. is dispensed with in this system.

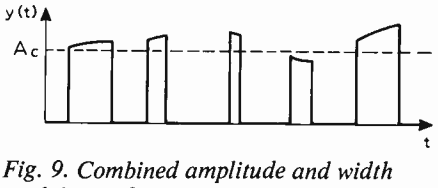


Fig. 9. Combined amplitude and width modulation for two information channels.

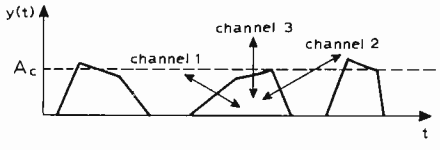


Fig. 10. Three-channel operation.

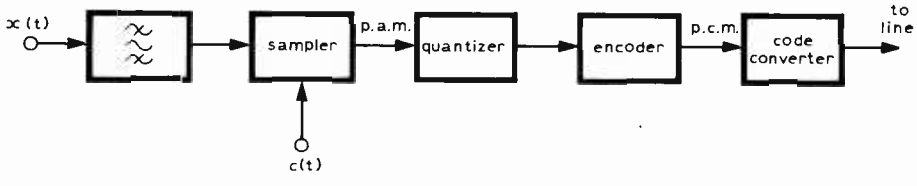


Fig. 11. A pulse-code modulator.

Sometimes it is useful to convey two modulating signals on the same pulse train without resorting to more complex time-division multiplexing techniques. For example, it is possible to first pulse-width modulate a pulse train with one signal and then pulse-amplitude modulate the p.d.m. wave with a second signal, the resulting p.d.m.-p.a.m. wave appearing like that shown in Fig. 9. Three signals may be made to modulate the same pulse train by using one source to vary the slope of the leading edge, one source to modulate the slope of the trailing edge and a third source to modulate the amplitude of the resulting pulses, as indicated in Fig. 10.

In pulse code modulation the analogue signal to be encoded is band-limited and passed to a sampling gate to produce p.a.m. The p.a.m. signal can have any instantaneous value within its allowed dynamic range and these variations are converted to a finite number of allowed levels by a quantizer. This process introduces an error into the signal, producing quantization noise which places a fundamental limit on the achievable signal-to-noise ratio. Each quantized p.a.m. sample is then encoded into a group of binary pulses to produce the p.c.m. signal. The number of pulses in each code group is determined by the number of allowed levels in the quantization scheme. For example, speech that has been band-limited to 0.3 to 3.4kHz and sampled at a rate of 8kHz is commonly represented by a 128-level quantization scheme so that a 7-bit code group is required since $128 = 2^7$.

To avoid transmission of the d.c. component in the binary coded pulses the p.c.m. signal is often converted to a bipolar form. Because only the presence or absence of a pulse, rather than its shape, needs to be determined at the decoder a transmission bandwidth of only

about $1/\tau_c$ is sufficient, where τ_c is the width of a pulse within a code group. The binary signals can be identically regenerated during transmission, so the overall signal-to-noise ratio obtainable with p.c.m. is much greater than that with the modulation methods already discussed.

With speech signals a further improvement is obtained by compressing its dynamic range at the encoder and expanding it at the decoder, a process known as companding. The basic processing in a p.c.m. transmitter is shown in Fig. 11 and that for a time-division multiplexed p.c.m. transmitter in Fig. 12.

Delta modulation (Δm), or differential p.c.m., does not transmit pulses related to the instantaneous value of the modulating signal at a sampling instant, but uses a one-bit code to convey information about the rate of change of the modulating signal between successive samples. The greater the rate of change of the analogue modulating signal the greater is the repetition rate of the output pulses.

The basic form of a delta modulator is shown in Fig. 13, where the pulse modulator transmits pulses from the pulse source to the integrator with one polarity if the comparator output is negative and with opposite polarity if the comparator output is positive. Thus the output from the integrator is a stepped waveform that "oscillates" about the continuous input signal waveform $x(t)$, and always attempts to keep this difference at a small value.

As a delta modulator transmits information about the rate of change of the analogue signal, an overload condition can be reached if the analogue signal changes too rapidly for the successive pulses, of fixed amplitude, to follow the change. The modulating signal can be recovered by feeding the delta modulated signal into an integrator followed by a low-pass filter. Although only a 1-bit code is used in delta modulation, the sampling or pulse rate has a minimum value that is higher than that required by the sampling theorem for p.c.m. For similar performance delta modulation generally needs a wider bandwidth than p.c.m. and the signal-to-noise ratio decreases with increasing frequency. However, the circuitry required in the encoder and the decoder is much simpler than for p.c.m.

Titles of cards in Series 15 are

Pulse amplitude modulator with precision limiter
IC pulse duration modulator
Pulse amplitude modulator with shunt gate
Pulse duration and position modulation using 555
Variable slope modulator
Pulse modulation using 555 timer
Pulse amplitude and duration modulator in c.m.o.s.
DC motor control using p.d.m.
Delta modulators
DC amplifier for p.d.m.
Pulse position modulator
Pulse code modulator

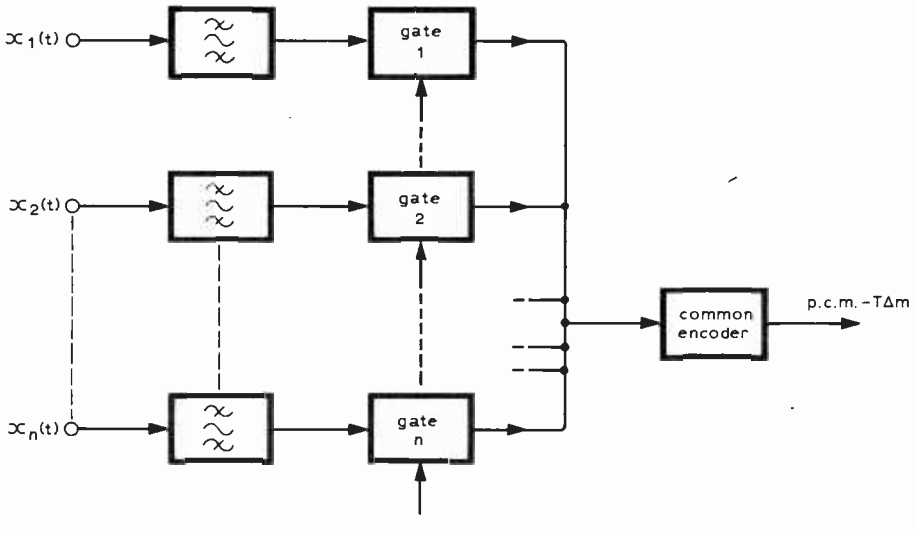


Fig. 12. Multi-channel operation in p.c.m. using time-division multiplex.

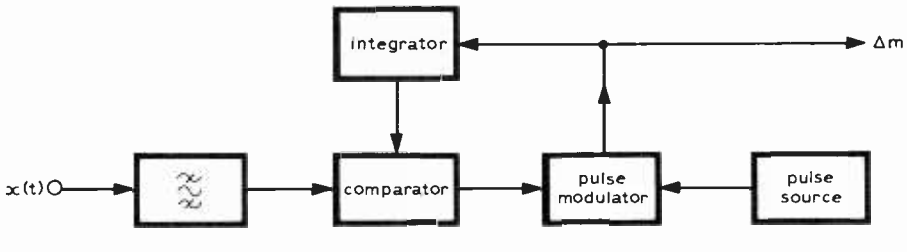
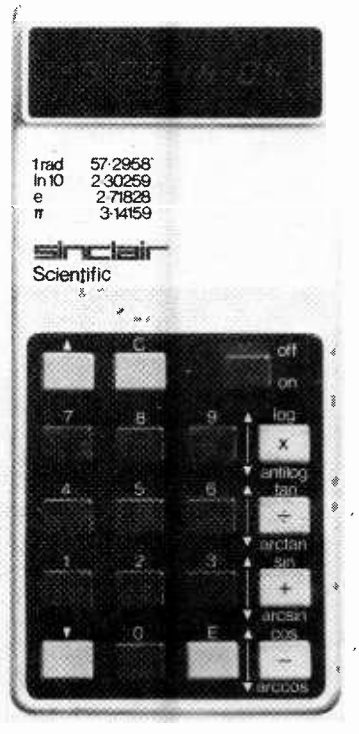


Fig. 13. The basic delta modulator.

Programming the "Scientific" (cont.)



The Sinclair Scientific calculator. The four function keys each fulfil a dual function, selected by the keys at top left and bottom left.

the simple 4-function calculator market in mind. It was important that, although the RAM structure was essentially a 3-register structure, it could be subdivided into more than three registers for some of the scientific functions.

The scientific functions needed only two levels of subroutine, since the basic instructions in the instruction set were capable of operating on entire registers. The chip had no subroutine structure at all in fact, but it did have available a number of single RAM bits which could be used to identify return addresses in place of the programme counter stack normally associated with a subroutine facility.

The use of scientific notation and of Polish logic, which is the only consistent method of problem entry for a scientific calculator, had the side benefit of making more ROM space available for arithmetic algorithms.

Even so, the ROM space remaining for the scientific functions was extremely limited. This problem was overcome by some radically different and very compact algorithms for the logarithmic and trigonometric functions. Again, the instruction set had to be appropriate to the particular algorithms used.

Readers of Wireless World can obtain the Scientific calculator at a special discount price. See page a21 for details of the offer.

New Products

Pan pot

A pan pot manufactured by Allen and Heath Ltd incorporates four potentiometers mounted at 90° on a steel chassis. The potentiometers have a linear 10kΩ carbon track with silvered contacts rotating through 85°. The joystick, which also moves through 85°, is mechanically connected to the potentiometers by two sliding hoops bisecting each other. The joystick bush in the centre of the chassis requires a hole $\frac{11}{16}$in in diameter for mounting and the top of the chassis has two recessed holes for mounting in an instrument. Each unit is supplied with an application sheet detailing circuitry for use in various control circuits. Allen and Heath Ltd, Pembroke House, Campsbourne Road, Hornsey, London N.8.
WW 302 for further details

Polyester film capacitors

General Instrument has announced a new series of polyester film capacitors, registered under the trade-mark Crystal-Cap. The capacitors, which are designed for by-pass and coupling applications, combine small size with reliability. The Crystal-Cap construction uses a self-sealing dielectric film material to form its own case which provides the small size. Terminal wires are inserted under heat and pressure at each sealed end to contact the active foils. The operating temperature of the capacitors is −50 to +85°C at the full rated working voltage. The capacitance range is 0.001 to 1μF with surge voltage ratings from 50 to 600V d.c.w. General Instrument Europe S.p.A., 20149 Milano, Plaza Amendola 9, Italy.
WW 301 for further details

Pulse generator

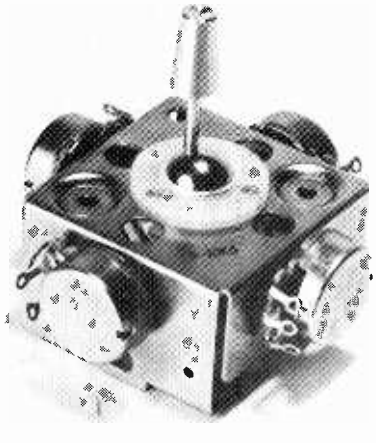
The 502 pulse generator features a frequency range of 1Hz to 10MHz with continuous adjustment in seven switched ranges, a variable pulse width in seven switched ranges from 50ns to 1s and an impedance switch for selecting either a high impedance output, giving 3V into 1kΩ for use with t.t.l. systems or a low impedance output, giving 5V at 50Ω for use with other logic systems. A function switch selects square waves or pulses, single shot/burst, or external trigger. An external trigger polarity switch selects either the positive or negative edge of the input waveform to trigger the generator. The 502 has a battery or mains option, with a l.e.d. indicator which goes off when the battery voltage drops below 7V or acts as an on-off indicator in the mains version. Price £58 + Vat (£8 extra for the mains option). Child Instruments Ltd, 1a Duke Street, Manchester Square, London W1M 6HQ.
WW 303 for further details

Powerful power-pack

Farnell have announced a power supply designated the H30/100. The d.c. stabilized supply, which is suitable for application such as driving magnetic coils, has 0 to 30V and 0 to 100A available, with automatic changeover modes of constant voltage or constant current. The unit employs pre-regulation techniques to minimize power dissipation in the series regulator, and provides load and line regulation figures of 0.01% with ripple being less than 1mV r.m.s. The dimensions are 10½in high by 19in wide by 21in deep. The unit is designed for rack mounting and weighs 190lbs. Forced air cooling is employed and a thermal overload trip is incorporated. Other facilities provided are remote sensing, remote programming and the ability to operate in a series or parallel mode. Farnell Instruments Ltd, Sandbeck Way, Wetherby LS22 4DH.
WW 304 for further details

Temperature indicators

Self-adhesive Hermet temperature indicators combine an accuracy of ±1% with a cost as low as 3.7p per unit. The range includes 41 separate temperature ratings from 40°C to 260°C and labels are available in a multiple-increment pack,



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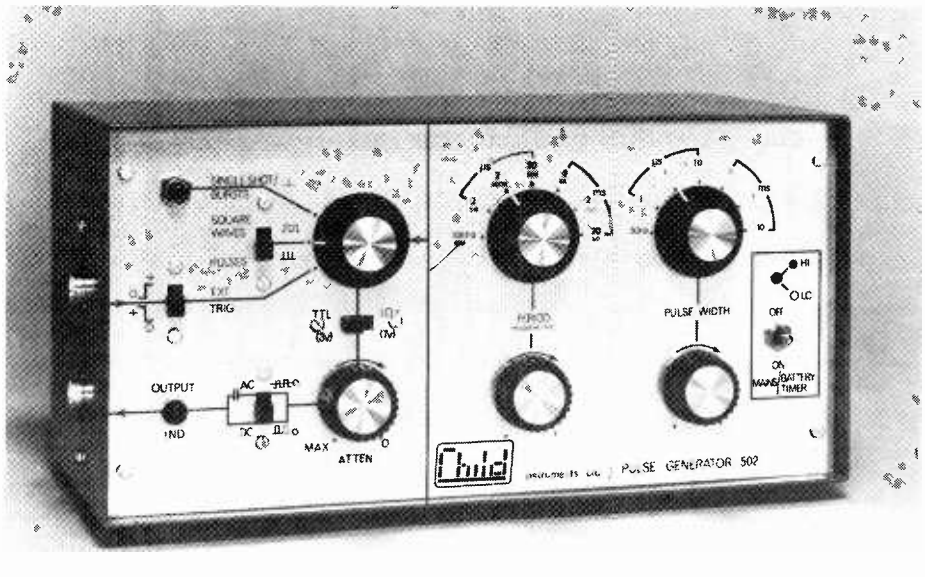


WW303

five increments to one label, or in single-increment tabs. When subjected to their rated temperature the indicators turn from silver to black, the chemical change being viewed through a plastic window. The self-adhesive indicators can be fixed on to most clean, dry surfaces after which they can be submerged in many water or oil-based liquids without impairing their accuracy. A. Levermore & Co Ltd, 40–44 The Broadway, London SW19 1SQ.
WW 305 for further details

Non-linear filter

The voltage controlled low pass non-linear filter, model 1PVC-1 (patent pending) is a general-purpose device providing attenuation above the corner frequency. The circuit can filter without introducing phase shift either inside or outside the pass band and exhibits improved attenuation of noise spikes. The corner frequency is set, by an external control voltage and/or capacitance change, from d.c. to 20kHz. The device, which is input and output short-circuit proof, requires a supply voltage of $\pm 15V$ $\pm 0.5V$. The electrical characteristics at an ambient temperature of 25°C are: an input to output offset voltage of 200mV typical, an input bias current of 2nA maximum, an input resistance from d.c. to 100kHz of 3.3kΩ typical, with a voltage gain of unity and an output voltage swing into a load > 15kΩ of $\pm 13V$ typical. Non-Linear Filters, P.O. Box 338, Trumbull, Ct 06611, U.S.A.
WW 306 for further details

Electrolytic capacitors

Indel 70 is a range of electrolytic capacitors designed for industrial applications. The electrolyte is inert and semi-dry, which, combined with the anode purity of 99.99%, gives a low leakage current and a shelf life of at least three years. The leakage current is $0.006\ CV + 4\mu A$ at 20°C within 5 minutes where C is in μF and V is in volts. The capacitors are non-inductively wound and incorporate screw terminals embedded in a glass-filled nylon deck which minimizes equivalent series resistance. The range is available from 68μF to 250,000μF with tolerances of −10% and +50% at a temperature of 20°C ±5°C and at 50 or 60Hz. The voltage range is 6.3 to 500V d.c. and the operating temperature range is −40 to +70°C. Advance Filmcap Ltd, Rhosymedre, Wrexham, Denbighshire.
WW 307 for further details

Display tube for calculators

The latest addition to the Mullard range of Pandicon numerical indicators, type YM1500/12, is designed for use in desk calculators or similar applications where space is limited. The display can present twelve orange-red numerals, 7.6mm high, with decimal points and commas. The characters are the seven segment type with a decade pitch of 6.35mm. An anode to cathode voltage of 160V is necessary for ignition with a peak anode current of 14mA. Mullard Ltd, Mullard House, Torrington Place, London WC1E 7HE.
WW 309 for further details

Digital capacitance meter

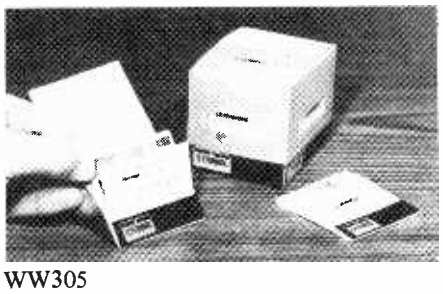
The model 275 capacitance meter provides automatic capacitance and dissipation measurements with an accuracy of 0.1% plus one digit. This is displayed on a readout of $3\frac{1}{2}$ digits with a decimal point. The instrument's electronics are solid state, mounted on a single p.c. board. A companion comparator for rapid hi-in-lo sorting and provisions for an external d.c. bias supply are both available. The model 275 uses a test frequency of 1kHz but a frequency of 100Hz is available in a model 278. Other options include a test voltage of 1V r.m.s. instead of 0.5V peak, and an added lower capacitance range of 19.99 picofarads. Tranchant Electronics (UK) Ltd, Tranchant House, 100a High Street, Hampton, Middlesex.
WW 308 for further details

Circular connector

A low cost miniature connector has been developed by Viking Industries Ltd. To eliminate the use of multi-component parts, the insulator, coupling ring and connector housing are moulded as a single unit from a polycarbonate material. The plug is locked into the socket by locking tabs; squeezing the finger grips on the coupling ring deflects the locking tabs and releases the plug. The connectors are rated at 5A with a dielectric withstanding voltage of 1500V r.m.s. maximum at sea level. In an operating temperature range of −55 to +125°C the insulation resistance is 5×10^3 MΩ minimum. Viking Industries (UK) Ltd, Barton Industrial Estate, Faldo Road, Barton-le-Clay, Bedfordshire.
WW 311 for further details

Rotary reed switch

A range of lightweight rotary reed switches suitable for use in hazardous atmospheres is now available in the UK. The ten-position switch will mount on p.c. boards but can be factory/field modified to suit customer specifications. The reed is operated by a permanent magnet, two magnets being used to provide a two-pole switch. A minimum electrical life of 5×10^6 cycles at 7W maximum d.c. resistive load is specified for each switch. Maximum switching current is 0.25A and a typical breakdown voltage is 250



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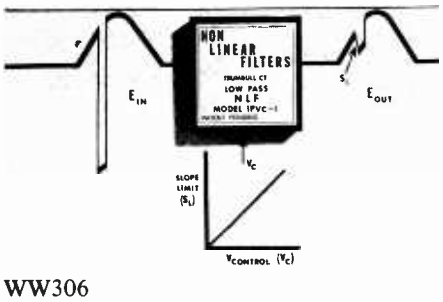

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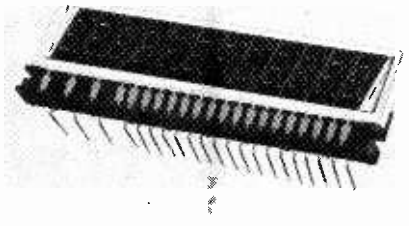


WW309

volts r.m.s. Maximum contact resistance is 200 milli-ohms and minimum insulation resistance is 1×10^6 ohms. B & R Relays Ltd, Temple Fields, Harlow, Essex CM20 2BG.
WW 310 for further details

Autoranging d.m.m.

A specification guarantee for one year is given with the model 168 multimeter from Keithley Instruments Ltd. The autoranging meter measures a.c./d.c. voltage from 0.1mV per digit to 1000V (500 a.c.), a.c./d.c. current from 0.1 to 1A and resistance from 0.1 ohm per digit to 20MΩ. The display is a $3\frac{1}{2}$ digit l.e.d. type which gives details of range, polarity, value and function. A field-installable battery pack (model 1688) can provide six hours of continuous operation before recharging which takes nine hours. Keithley Instruments Ltd, 1 Boulton Road, Reading RG2 0NL.
WW 312 for further details

Zero pressure connector

A new Amphenol 224 series of p.c.b. connectors features a patented system of cantilevered beam contacts that require zero insertion force. The two rows of contacts are opened and closed by a quarter-turn of an activating rod so boards can be inserted or removed with zero force. The connectors have 38 contact positions with solderless wrap terminations. Polarizing keys fit into unused contact positions and are used for top insertion applications. The contacts are gold-plated and have current and voltage ratings of 3.0A and 600V a.c. r.m.s. respectively, with an insulation resistance of 5000MΩ minimum. Amphenol Ltd, Thanet Way, Whitstable, Kent CT5 3JF.
WW 315 for further details

Low-profile socket

A low-profile socket with a "kink" on the contact tails retains the socket in a $\frac{1}{16}$in board prior to soldering. The socket, which snaps into position, is available with either 14 or 16 contacts. There is a 0.2in standoff between the insulator and the p.c. board for circuit clearance and flux cleaning. The recommended mounting holes are 0.035in ±0.002in diameter to ensure the snap-in and retention features. The socket utilizes a glass-filled thermoplastic and the contacts are beryllium copper with either gold or tin plating. Rastra Electronics Ltd, 275 King Street, Hammersmith, London W6.
WW 313 for further details

Conductive paint

This is a paint which becomes electrically conductive when dry and which can be brushed, rolled or sprayed. It finds application in screening and heating, possessing a resistance of 1.5, 20 or 100 ohms per square when applied to a thickness of 60g/sq.m. Adwel Industries Ltd. Power Road, Chiswick, London W4 5PZ.
WW323 for further details

Power supply

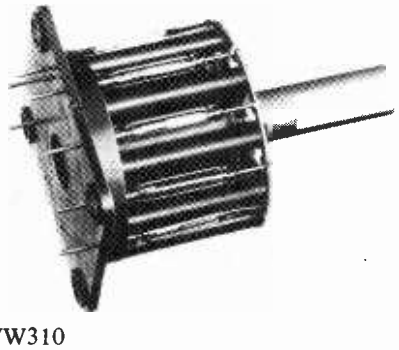
The latest addition to the Zirkon range of p.c.b. mounting power supplies is the type PZA3-05-60. This unit requires 240V a.c. +10% −23%, 48 to 450Hz, and will deliver 30W at 5V. The output current is 6A at 5V derated to 5A at 6V. Output ripple is 5mV r.m.s., 20mV p.p. The overall efficiency is 70% and the transient response time is less than 100μs. The supply has an adjustable constant-current overload limiter, auto thermal derating and t.t.l. compatible shut down. Any number of units may be used in current sharing parallel operation. Zirkon Electronics Ltd, Baystrait House, Biggleswade, Bedfordshire.
WW 314 for further details

Digital phase meter

The digital and analogue indication of phase angle between signals in the range 2Hz to 200kHz is the function of Type 2971 Digital Phasemeter. Analogue presentation of phase angle in radians is provided by a meter, the digital display giving the result in either radians or degrees, together with an indication of lead or lag. The signals may be in the range 10mV to 15V and need not be of the same amplitude. Positive or negative triggering can be selected. No tuning is necessary. B & K Laboratories Ltd, Cross Lances Road, Hounslow, Middlesex.
WW316 for further details

Low-cost oscilloscope

The recently-noted trend towards sensibly-specified and priced instruments is continued in the Advance OS140 and OS240 oscilloscopes. The two are single (OS140) and dual trace 40cm tube versions to the same specification, which is basically for a 10MHz, 5mV/div instrument. The timebase covers speeds between 200ns/div to 1s/div or more, and free-runs in the absence of trigger. Comprehensive trigger control is provided and, in the case of the OS240, a true *x-y* facility is obtained by the use of one of the vertical deflection amplifiers as a horizontal amplifier.



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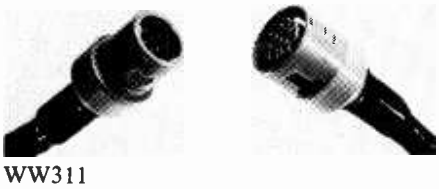

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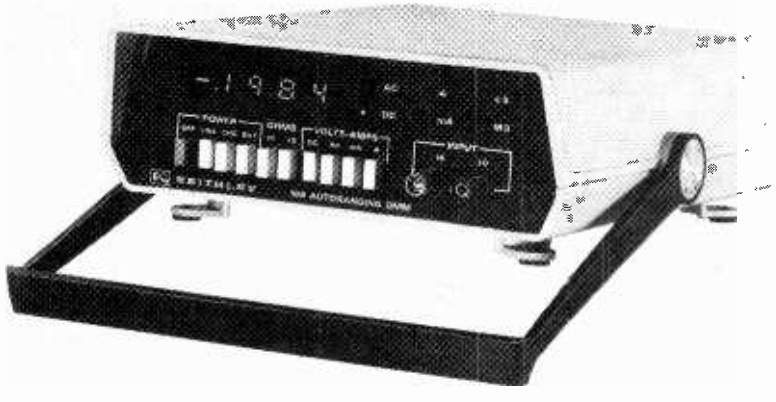


WW312

Chopped or alternate beam-switching modes are selected by the sweep-speed switch. The instruments are designed to occupy the minimum of bench space, being 132 × 270 × 31mm in size and around 5kg in weight. Advance Electronics Ltd, Instrument Division, Roebuck Road, Hainault, Essex.
WW324 for further details

Printed-board connector

An addition to the range of Ernie connectors is the 160-way two-part unit, intended for the inter-connection of printed-circuit boards. Made in glass-filled polycarbonate, the connector is 9in long, the triple-spring contacts being staggered. The socket contacts are in tinned bronze, plated with rolled-on gold, and the plugs are electro-plated in gold, current rating being 7A at a contact resistance of 12mΩ. Insertion and withdrawal forces are 18kp and 10kp respectively. Radiatron Components Ltd, 76 Crown Road, Twickenham, Middlesex.
WW325 for further details

Trimmer potentiometers

The RVR10 cermet trimmer is 10mm in diameter and is rated at 0.5W at 40°C. The cermet track affords infinite resolution and a temperature coefficient of ±250 p.p.m./°C throughout the range of 100 ohms to 1 megohm. Pin spacing is on a 0.1in grid and there is an integral dust cover. These units are made by Hakuto and distributed by Guest Distribution, Redlands, Coulsdon, Surrey at 16p in quantities of 500.
WW317 for further details

R.f. connector

Intended for applications in which the cable outer must be insulated from chassis earth, the Amphenol 31–010 BNC connector possesses a moulded plastic body and is provided with an extra pin for connexion to the r.f. earth. It is interchangeable dimensionally with the standard UG-1094/U connector and will fit a similar mounting hole. Amphenol Ltd, Thanet Way, Whitstable, Kent.
WW318 for further details

Digital voltmeter

A direct-voltage only instrument, the 1045 digital voltmeter from Datron is claimed to exhibit errors of 0.01% of reading ±0.005% of full-scale ±μ1V, holding this performance for six months at room temperatures without recalibration. After this period, the instrument is stable to within 0.01% of reading per year. The 1045 is a 4½-digit unit with a most sensitive range of 0–10mV, an input impedance of 10,000MΩ and a specially-developed integrated circuit input stage providing current and voltage drifts of 2pA/°C and 0.3μV/°C. Common-mode rejection ratio is 140dB. Datron Electronics Ltd, Meteor Close, Norwich Airport Industrial Estate, Norwich, Norfolk.
WW319 for further details

DIY pulse delays

A 75Ω pulse delay unit, UN068, has been produced by Matthey principally with the TV broadcast engineer in mind.

Consisting of two encapsulated modules enclosed in a metal box having BNC connectors, the device can be wired to produce delays from 5ns to 4500ns in steps of 5ns or 100ns. Matthey Printed Products Ltd, William Clowes Street, Burslem, Stoke-on-Trent ST6 3AT.
WW320 for further details

Solid State Devices

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

Opto-coupler

A further addition to the Motorola range of opto-couplers is the 4N25, a high-voltage version of the 4N26. Minimum isolation voltage of the 4N25 is 2500V with an isolation resistance of 10^{11} ohms. The device, which is in a six-pin dual-in-line package, features a frequency response of 300kHz typical, a d.c. current transfer ratio of 60% and a 2.8μs typical switching time. The price, for 100-up quantities, is 95p each.
WW 350 for further details **GDS**

Low cost triac

The General Electric triac, type SC136 costs 37p each in 100-up quantities and is rated at 3A, with 200 or 400V options. The 400V version will withstand the surge current from a tungsten lamp load of up to 720W at mains voltage. The device will also switch to a conducting state automatically without damage, should the breakover voltage in either direction be exceeded. A minimum commutating dv/dt of 5V/sec, and a non-repetitive peak current capability of 30A for one cycle of the mains supply is offered by the device.
WW351 for further details **Jermyn**

Dual transistors

A range of dual silicon n-p-n transistors called the NKT 6000 series offer four devices in a six-lead TO-5 package. The four devices have matched gains, matched base-emitter voltages and have an h_{FE} ratio of 0.83 to 1.2. The NKT 6001, 3, 5 and 10 have base-emitter voltages matched to within 1, 3, 5 and 10 millivolts respectively.
WW 352 for further details **Newmarket**

80A thyristors

The 81RM series from International Rectifier feature 80A at 100 to 1000V thyristors which are rated for use up to 10kHz or with 200A/μs repetitive di/dt. The series has a peak surge current capability of 1640A and a fusing I^2t of 13,500 A^2s. Maximum turn-off time with reverse voltage is 20μs. The devices are available with flexible leads or flag connectors to Jedec TO-94 and TO-83 respectively.
WW 353 for further details **International Rectifier**

L.e.d. linear indicator

F.R. Electronics have introduced a range of d.i.l. packaged linear l.e.d. arrays designed to mount end-to-end without loss of centre-to-centre spacing. Each "cursor" comprises ten l.e.ds mounted in line on 0.1in. centres under a flat, or lensed, coloured window. Red, green or yellow types are available as standard at a price of £2.10 for one-off.
WW 354 for further details **F.R. Electronics**

Pulse transistor

The PH 1175 power pulse transistor will produce a 175W, 1μs pulse at 1090MHz with a 10% duty factor at 8dB of gain and at V_{CC} of 50V. The device, which is constructed using the patented Auromet process developed by Power Hybrids, features the wide metal fingers (fishbone) geometry inherent in overlay structures, and emitter ballasting. The transistor is internally matched for broadband and d.m.e./t.a.c.a.n. applications with input and output impedances of $4 + j\,7.5$ and $3 - j4$ respectively, at 1090MHz.
WW 355 for further details **Impectron**

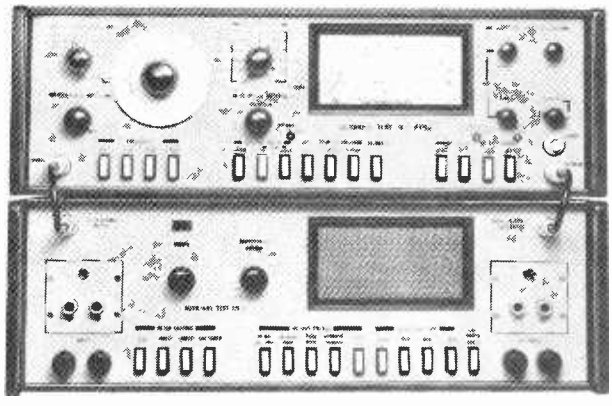
Infra-red-sensitive photo-cell

A new range of high-speed, infra-red-sensitive photoconductive cells with a peak spectral response at 700nm have been introduced by Photain Controls Ltd. There are five cells in the range with direct voltage ratings from 150V to 300V, power dissipation of 50mW–150mW, dark resistance 50Mohms–400Mohms and resistance at 10 lux of 5–10kohms and 50–100kohms. All the cells will operate from −20 to +65°C and have a rise time of 10ms and a decay time of 6ms at 100 lux.
WW357 for further details **Photain**

Suppliers

F.R. Electronics Ltd, Wimborne, Dorset BH21 2BJ.
Newmarket Transistors Ltd, Exning Road, Newmarket, Suffolk.
GDS Sales Ltd, Michaelmas House, Salt Hill, Bath Road, Slough, Berks.
International Rectifier, Hurst Green, Oxted, Surrey RH8 9BB.
Impectron Ltd, Impectron House, 23–31 King Street, London W3 9LH.
Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
Photain Controls Ltd, Randalls Road, Leatherhead, Surrey.

Audio Test Set



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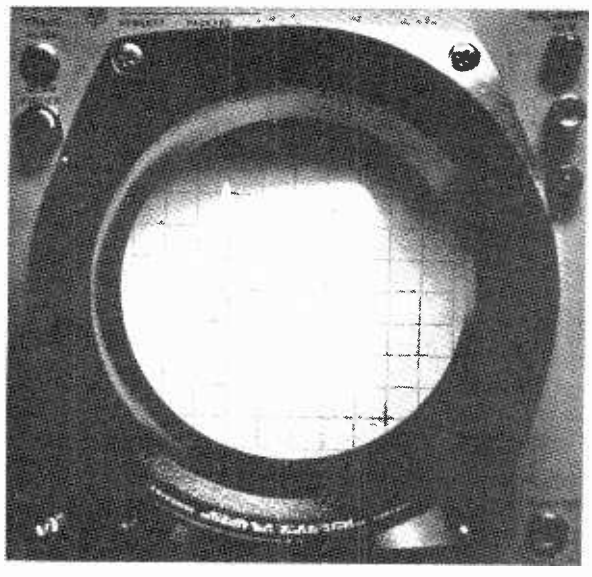

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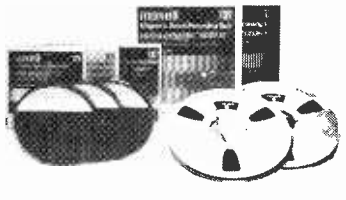

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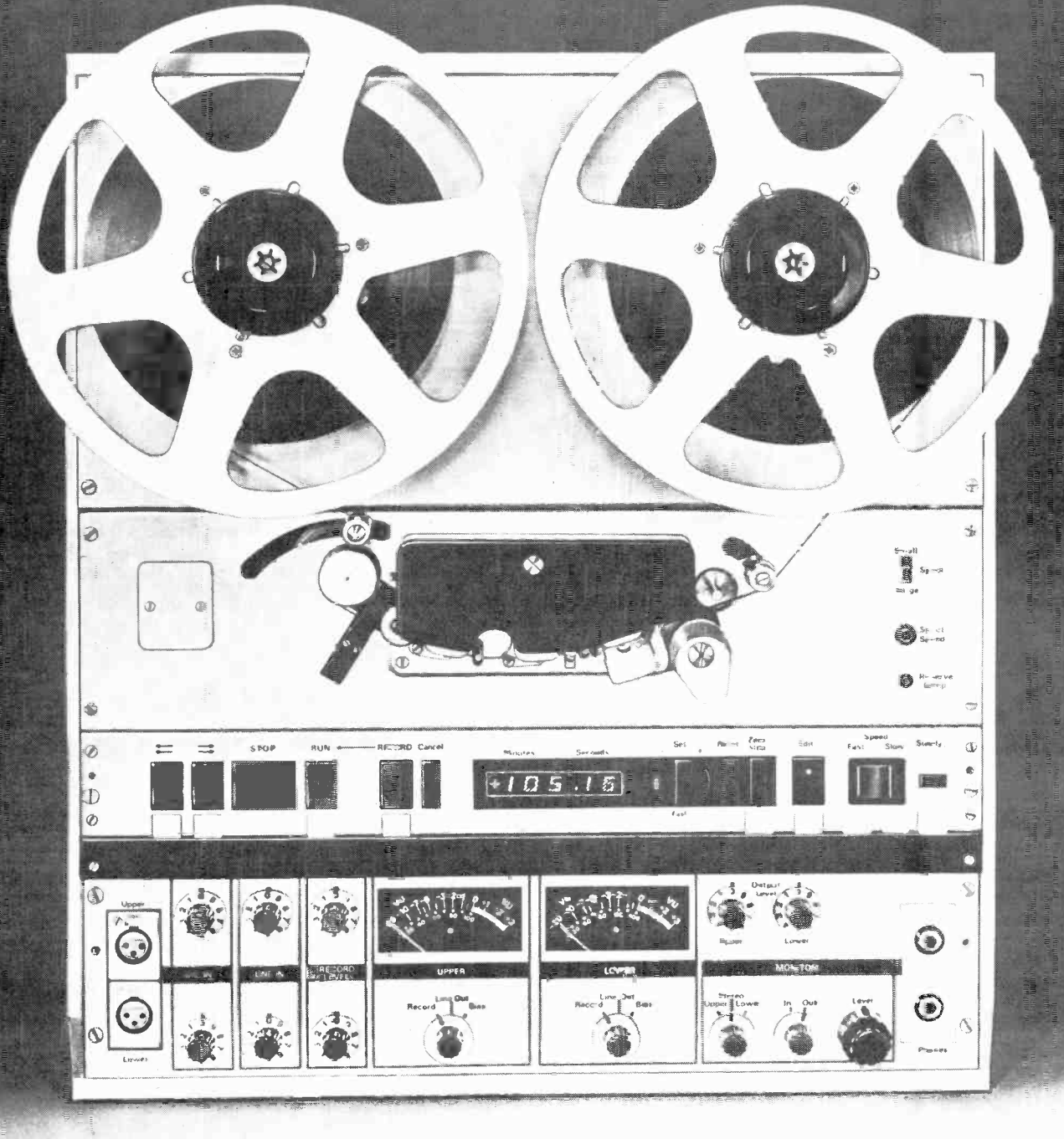


Professional sound recording

A view into the present and future commercial recording industry, its techniques, equipment, development and capabilities.

by W. E. Anderton

Assistant editor, Wireless World

It's hard to accept the fact that music and commercialism go hand in hand, but this commercialism has led to the vast industry involved with sound recording. The resources available to development engineers made possible through the growth of pop music over the last two decades plus new demands made on equipment from discerning recording engineers and artists has led to a snowballing situation of more money, better performance and more facilities. The complexities of recording have built up at such an incredible rate that it has become necessary to stop and take a look at the industry as a whole, to ask why or if complexity is necessary and how simplification is possible. The aim of this feature is, therefore, to provide a unified view of the developing recording industry, to show how demands from engineers and artists have led to changing techniques of recording and to reveal the influence this has had and will have on equipment performance and the facilities deemed necessary to produce a sound recording of the highest quality.

An idea of the resources necessary to equip a large sound studio is provided by a contract recently received by Ruper Neve and Company to supply six recording consoles to the world-wide operations of EMI. The consoles have a total value of over £250,000.

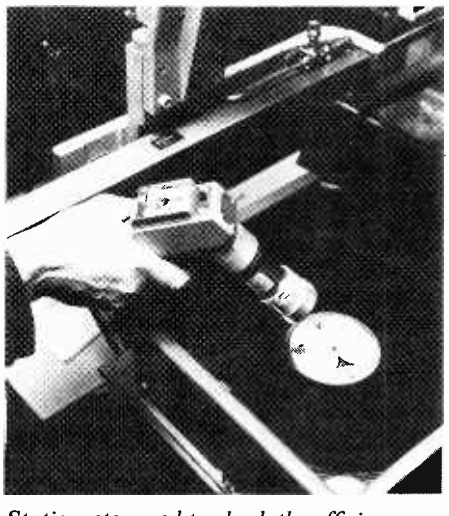
The main reason for the growth in equipment cost has been the development of multitrack recording from two-track to four to 16 and now 24 tracks with 32 just around the corner. The pop world has been the main force behind this, where the final product is more dependent on intermediate electronic processing than the original sound. So that this processing can be performed with the most flexible control over the finished product, it is necessary to separate the information to be recorded as much as possible. Close miking techniques can provide a multitrack tape with one instrument or sound source per track with good separation and all easily accessible for processing.

Commercialism again plays a major part in this type of facility being commonplace. If a recording artist appears at a studio and asks for 24-track facilities—whether they are in fact necessary or not—and they are not available, then he will take his money elsewhere. Fortunately, this demand and supply situation has not meant that performance of equipment has suffered. Specifications of professional equipment are not questioned; it's the use of this equipment and the reasons for its development which must be examined.

Future possibilities are staggering. As the cost of mini digital computers falls to around one-fifteenth the cost of a comprehensive mixing desk alone, there will be nothing to prevent the use of on-line computers in studios capable of being programmed to accept input from a control potentiometer and converting this to any desired control instruction. Digital equipment will become more and more a part of the recording process and in fact is already appearing in the form of automatic mixing facilities and digital delay lines.

Capabilities offered by many new devices almost point to the redundancy of the recording artist. One such device manufactured by EMS works out the fundamental frequency of an input signal and converts this to a related d.c. voltage of the particular input. Feed this together with another output voltage proportional to the input waveform average amplitude into a voltage controlled synthesizer programmed to produce the waveform characteristic of *any* predetermined instrument and the result is whatever instrument the producer cares to record, not what was played originally. Rather a far-fetched idea but indicative of the control now offered by instrumentation over signal processing.

Again, the point is that this type of facility is well within the capabilities of circuit design—it's the use of the final product which is questionable.



Static meter used to check the efficiency of an ioising device for removing trimmed waste from vinyl pressings at the Hayes production plant of EMI records.

Multichannel recording

The essence of recording 16, 24 or even 32 tracks simultaneously is to treat the recording stage as simply an information gathering process, concentrating purely on achieving a good signal-to-noise ratio on each tape track and not considering balance at all. If 32 microphone signals are to be condensed to a 16-track tape, some mixing will be involved but the extent of such mixing will be minimal. Certain economic and practical advantages then follow. Since obtaining an effective sound balance may be time consuming, deferring this process to separate mix down (final mixing of the multitrack tape to the stereo or quad master) sessions is more economical since the musicians do not have to be paid for repeated replays. The process of overdubbing is now also possible in which some parts of the music are recorded separately, musicians being fed with the already recorded sound via headphones.

One necessity demanded by this system of recording is the monitoring of sound during recording to provide an estimate of how the final stereo or quadrophonic mix will sound. An independent mixer must be provided having as many inputs as there are tracks and as many outputs as there are monitoring loudspeakers. During the recording, a trial balance may be achieved on the monitor and for this reason stepped level controls are often provided to facilitate logging. Where the overdub technique is employed, the input to the monitor mixing matrix consists partly of pre-recorded signal and partly of console output.

Since the multitrack technique presupposes a substantial degree of separation between musicians, a further essential provision is the "foldback" mixer or cue mixer to provide performers with a headphone signal enabling them to keep in time.

The process of mixing the signals from the master multitrack tape is performed either with the same console or in busy studios in a tape mixing room having a console adapted specifically to this purpose.

The work of building up a good mix is

lengthy and tedious, being a process of trial and error dependent to a large extent on the engineer's memory and endurance.

For this reason, attempts are being made to provide the tools for time saving, ease and greater accuracy of operation. The automated mix down process is simply one in which the controls on the console are linked with voltage controlled devices and provision is made for the logging of the settings of these controls in digitally coded form. The digital code may be recorded on one of the tracks of the multitrack master tape, thus ensuring an accurate synchronized store of information relating control operations to the programme. By re-running the recording, individual operations may be modified by means of an updating facility.

The type of facilities available from a 16 track mixing desk would be as follows: 24 input channels each having line and microphone inputs with comprehensive equalization and faders on each channel; eight output mixing groups (each group provides a combination of sub-mixes) with remix facilities plus eight output tie lines for 16-track recording; four limiter/compressors with linking of control lines for stereo or quadraphonic operation; four equalizer units terminated on a patch panel; four reverberation groups (send and return) with pan pots and group selectors on the return lines; four foldback or cue groups; a four-speaker monitor system with 16-track playback to the monitor matrix; four studio playback outputs, up to 21 VU meters and pre-fade listen available on all input channels (this facility allows the operator to monitor a particular input or group prior to feeding it to the main output) plus patching and talkback facilities with pan potentiometers on all input channels and monitor tracks.

If this list were extended appropriately to cater for 24-track recording, it's obvious that the amount of control required when all input channels are in use calls for the automation facility—not to replace or devalue the status of the recording engineer but to provide a useful memory store of all level settings and their position in time.

Automation

To reiterate, an automatic mixing facility will encompass the simultaneous recording on spare tracks of the master tape of digital control data derived from the analogue signals being handled by the mixing desk. On replay, the control data resets the desk levels to produce the previously achieved audio mix. The system must be capable of being easily updated if necessary.

Control of faders can be achieved by one of two systems[1] (although it is believed that a completely different system will shortly appear in the UK of which no details are available at present). The first is a servo controlled conventional fader operated either manually, or positioned by a motor powered by a small servo amplifier. Two inputs to the servo amplifier would be a control voltage and the other a feedback control voltage to stabilize the servo system. The main advantages of this system are low noise and obvious operation as the fader knobs physically move in sympathy with the data input to the servo amplifier. Mechanical complexity and the need for a power amplifier requiring relatively high current tend to offset the advantages.

A second system uses voltage controlled amplifiers as the faders themselves. Frowned upon in the past for their poor stability and noise performance, v.c.as are now available with low inherent noise, low distortion and high gain. An indicating system must be provided if the v.c.a. is to be used as a practical fader so that the effective position of the fader can be easily read at any time. Light-emitting diodes can be included to indicate the control voltage and hence the effective slider position. The advantages of the v.c.a. are low cost, low current requirements, a high level of stability and a low level of complexity.

New Neve console at the BBC Television Centre, studio 3.

The v.c.a. circuit may not itself be complex, but the control unit must be. The fader control voltages are multiplexed and converted into a digital signal for recording on spare tracks. The control unit must then decode replayed signals, convert them back to analogue form by sample and hold circuits and provide adequate timing facilities. Some form of error correcting code must also be supplied as sound recorders use tape of inferior quality compared with computer tape, in that a higher level of dropout can usually be tolerated.

It will be some time before automatic mixing facilities become a common sight in recording studios. One possible problem may be the use of different methods for coding and decoding the control signals on different desks. This would mean that a tape recorder using one facility must have its final mix prepared using the same facility and cannot be taken to another studio for the final mix down as sometimes occurs.

Multitrack audio in video recording

Recording a video programme and the associated audio signal on separate machines has the advantage that the audio tape can be handled by sound engineers using multitrack facilities, until it is ready to be dubbed back on the edited video tape. The television industry has been slow to adopt this technique although the film industry has used it for a number of years. Problems in synchronizing separate video and audio recorders have only recently been solved by the use of an 80-bit digital code generated 30 times a second (for a 60Hz field rate) known as the SMPTE code.[2] The main concern of the code is to provide a means of gaining some increase in quality and flexibility of the audio portion of the programme by standardization of synchronizing codes and allowing electronic editing to be applied to the audio tape.

It was necessary to develop the facility for audio tape recorders to use the code in a manner similar to that handled on v.t.rs. The audio machines could then also be used in conjunction with the automated editing systems for post production work. As a result, a synchronizer code reader is necessary which will compare code signals on a frame-by-frame basis and then generate an error signal to the d.c. capstan servo that is a function of the difference between any source of master code (v.t.r.) and the audio tape recorder.

The code reader has two functions, the first being to demodulate and decode the slave (audio recorder) serial time code, the second to display the slave or master codes for manual parking of the slave and master machines. The reader's ability to read code from 1/5 to 40 times play speed makes it a useful tool in the "search" mode. The synchronizer contains the necessary circuitry for providing a control voltage to the audio tape recorder capstan servo circuitry.

Noise

The development of multitrack recording has resulted in the necessity to use a noise reduction system to code the original recorded tracks and decode during the final

mix down of a master tape. The noise build up involved in processing a 24-track tape for stereo is approximately 10dB. The four-band compressor-expander processor used by the Dolby A noise reduction system is now almost a standard compact fitment for a professional sound recording studio although two American systems, DBX and Burwen, are now available in this country. Over 8,000 recording tracks are equipped with A-type units.

An exciting development in the use of a noise reduction system for discs is taking place at the moment. In America, records have already been produced processed with the DBX system. The disc processing system is an extension of that used for professional tape noise reduction, involving broadband compression during recording and expansion during playback but with the frequency weighting of the r.m.s. level-sensing circuit set to cope with disc noise —including rumble, high level pops and clicks as well as tape hiss from the master tapes. Using the DBX,[3] it is possible to achieve a dynamic range of around 100dB, about 30dB better than is at present accepted. Production variations are also open to record companies using this system: either getting more music on a record without degrading the normal signal to noise ratio, or putting a 12in l.p's worth of recording onto a ten inch disc with no loss in quality but with a 30% saving in precious vinyl, or using the system to overcome the high surface noise inherent in discs pressed using cheaper and inferior plastic compounds.

A commercial decoder has been introduced, available in the States for $200, and it is hoped that a consumer version will soon be marketed at about $100. The only apparent problem with the system is that processed discs are not compatible with reproduction when no decoder is available. It is therefore unlikely that the system will ever be universally accepted even though the results seem quite remarkable. The Decca Recording Company in this country is at present evaluating the system.

A further development over the last two years has been the application of the Dolby noise reduction system to optical sound tracks. Initial research by Dolby Laboratories[4] showed that much of the poor quality of the optical sound track could be due to the way in which it was used, rather than to any inherent defect in the optical recording principle itself. An investigation showed that wide-range, high-fidelity optical sound-tracks can be made, the sole significant problem being the resultant relatively high noise level, which increases with the use of the print.

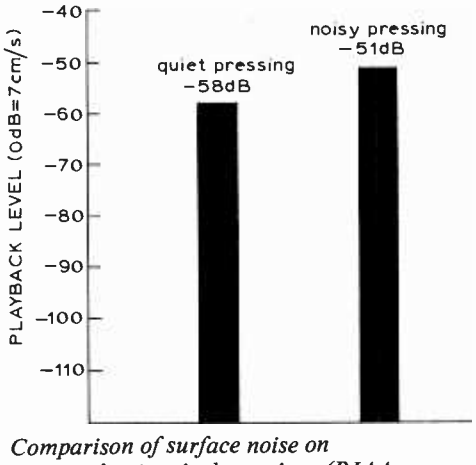
A considerable amount of treble cut is applied when optical sound-tracks are played back in the theatre. This high frequency roll-off, set by the American Academy (of Motion Picture Arts and Sciences) Standard Electrical Characteristics first published in 1938, effects an attenuation of at least 20dB at 9kHz. "Each characteristic was arrived at by listening to a variety of studio release product in a number of theatres. . . ." Films were made to match the theatres, and the theatres made to match the films, resulting in the conclusion it is wrong to accept that the Academy characteristic was derived to create the best compromise between noise reduction and high frequency response.

The practical consequence was found by Dolby Laboratories to be that "if a theatre has a flat playback frequency response, optical sound-tracks recorded and reproduced with the Dolby system will exhibit an improved frequency response, decreased distortion, and a lower noise level. The same sound track is, however, compatible in a conventional theatre". Further investigations took into account limitations such as theatre loudspeaker performance and suggested an acoustical response approximately 6 to 8dB down at 8kHz.

A Dolby noise reduction unit was consequently designed specifically for motion picture reproduction. Units of this type are being installed in theatres only after acoustical measurement of each auditorium has established the equalization or loudspeaker modification required to ensure that the frequency response of the entire system, including the theatre acoustics, will be as uniform as possible.

This table compares some of the common characteristics of a total recording system from microphone to disc. These are only intended to provide the order of magnitude of specifications of a typical professional system. The parameters shown are not necessarily the most important for the assessment of an individual piece of equipment.

	Condenser pressure gradient microphone	Multi-channel sound mixing console	Channel control amplifier	Noise reduction unit	Multi-channel tape recorder (15 ips)	Disc cutter and associated amplifiers
Frequency response	30Hz–16kHz ± 2dB	20Hz–20kHz ± 1dB	15Hz–20kHz ± 0.5dB	30Hz–20kHz ± 1dB (record/replay)	60Hz–15kHz ± 1dB	40Hz–16kHz ± 1dB
Sensitivity	2mV/dyne/cm²	Adjustable between −80dBm and +10dBm		0dBm line in and out	Max input +22dBm	Recorded level settable in steps up to +8dB
Distortion	0.5% at 128dB SPL	T.H.D. at 20dBm into 600 from any output 0.075%	mic. input +20dBm and 1kHz is 0.01%	0.2% from 40Hz – 20kHz at +8dBm	1% max (NAB)	0.3% at 1kHz (cutter drive)
Noise reduction				10dB from 30Hz to 5kHz rising to 15dB at 15kHz		
Noise level	Self-noise −17dB ref. 2 × 10 $^{-4}$dyne/cm²	−80dBm residual output noise	−125dBm equiv. input noise		62dB (s/n) (NAB)	Better than 70dB (signal to rumble)



Comparison of surface noise on quiet and noisy vinyl pressings (RIAA playback, "A" weighted scale, unmodulated groove).

More mobiles

Large mobile recording units with comprehensive multitrack facilities and costing upwards of £60,000 seem to be springing up left, right and centre. The only major limitations involved with mobile recording are the amount of space available for equipment and the acoustics of the unit for monitoring purposes. Sound proofing is not necessarily as great a problem as it may seem, especially if the internal acoustics can be made just right. Most units are used for recording onto a multitrack master but the final mix is usually done in more spacious studio surroundings. For £400 a day (plus tape) it is possible to have the use of a mobile unit containing 24-track console and record facilities, microphones, monitor loudspeakers, noise reduction, echo, limiter/compressors, equalizers, c.c.t.v., plus engineers, bathroom, toilet and kitchen sink.

If all this seems to be lacking in value, the main purpose is to supply full multi-track capabilities together with attendant equalization and remix facilities. A growing need which the mobile fulfils is to provide these sort of facilities in the relaxed atmosphere of music making in a country house or even in the open air.

A major constraint on the achievement of normal control room conditions is the geometry of the vehicle, whose width constriction is at 2.5m. With typical monitoring loudspeakers, this means an average distance of 1.8m between speaker cones and an optimum listening distance to the monitor engineer of 2.5 to 3m.

Control console design varies little from current studio practice except in the need to

conserve space. Auxiliary facilities are located in vertical panels mounted against the side of the vehicle to conserve space, but multi-track recorders are unavoidably of the standard studio construction and therefore occupy considerable floor space. Communication facilities must be more comprehensive than those provided in the average studio so some system of closed circuit cable television should be included.

While mentioning the increasing number of mobile units in operation, it's worth noting another small industry within an industry which has recently developed as the result of commercial demand. Commercial radio advertising known as "spots" has meant the use of studios specifically making their bread and butter from producing spot recordings. To make a compromise between the type of sound quality normally expected from a pocket transistor radio and that obtained with a high quality receiving system, spots are often recorded with bass and treble emphasis. The recordings are monitored by the normal studio monitor loudspeakers as well as by much smaller versions simulating transistor radio capabilities.

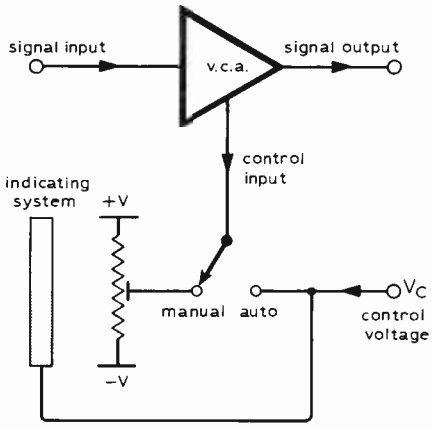
P.c.m. and quad—the future

Efforts are being made to improve the performance of recording systems, but the present performance is so close to the theoretical limits of the magnetic recording medium that it has become necessary to develop a new recording system in order to break through this theoretical barrier. The choice is either to employ a recording medium basically different from the magnetic system, or to use the conventional medium with some modulation method not affected by the limitations of recording analogue audio signals on magnetic tape. A system adaptable for sound recording which has attracted great attention in recent years as an excellent transmission medium is that of pulse code modulation.

Digital systems for recording developed by the BBC and by Nippon Columbia have been described in *Wireless World*[5, 6]. Conventional audio magnetic recorders have a more than adequate signal to noise ratio for digital recording but the frequency band is insufficient and timing jitter is too large. These problems are overcome if a helical-scan video tape recorder is used as a wide frequency-band recorder, and if a synchronization system is used in combination with a buffer memory to provide high timing accuracy.

An error correcting system is of vital importance with a digital recording system. Dropout from magnetic tapes is usually caused by dust, or peeling or unevenness of the magnetic coating. Conventional audio recorders are not significantly affected by the dropout phenomenon, but a p.c.m. recorder would be seriously affected because the recording area for each bit of information is very small. A very small dropout causes a code error and the physical result is a clicking noise sounding like a scratched record.

One method of error correction and detection involves judging the presence or absence of the check pulse in each binary word, another involves watching the level of the reproduced f.m. signal to detect whether or not the dropout causes lowering of level. Although these methods are indirect, most errors can be successfully detected.



Simplified voltage controlled amplifier fader.

Recording by p.c.m. is never accompanied by the type of noise related to magnetic recording characteristics such as modulation noise. This is because the p.c.m. signal is composed of a binary pulse stream and decoding the signals involves only the presence or absence of pulses. Most of the noise in a p.c.m. recorder is "quantization noise" generated when analogue signals are converted into digital codes.

A further advantage offered by the p.c.m. recording process is minimum and constant phase difference between channels when multichannel signals are recorded on magnetic tape. Wow and flutter can be eliminated through the use of a pulsed-oscillator synchronous system and a buffer memory which account for any timing variations arising in the tape transport.

An almost universal cry of dissent against the future use of digital equipment is the fallacious one of high cost. It is well within the limits of modern technology to produce a completely digital studio barring input and output devices (microphones, preamplifiers and loudspeakers). The technique of multiplex scanning used to read information from the large number of channels often now involved in a recording session means that the number of control devices can be reduced with a corresponding reduction in cost. One equalizer unit can be programmed to cope with all channels no matter how many they may be. As each channel is scanned, the equalizers' characteristics are adjusted according to preset control, to provide the correct equalization for that particular channel. This could equally well apply to limiters, compressors, reverberation and so on.

To back this claim for cost practicality, it appears that the BBC will soon be confronted with the question of updating their sound studio equipment with either standard analogue systems, analogue systems with facilities for the use of digital ancillaries or completely digital equipment. It seems likely that the first fully digital sound studio will be in productive use within the next six years.

It was intended at this point to comment on the trends towards quadraphonic recording but so much could be and has been said in support or against the various coding systems and recording techniques, that nothing more of value can be said at this point in time. Although all of the larger commercial recording studies have made allowance for the addition of quadraphonic facilities as required, very few have met demands from customer musicians for these facilities to be employed. It will, therefore, be a long time before there are many high quality quadraphonic recordings for sale.

Deafness

A final observation which was made during the preparation of this article was the controversy over the sound pressure levels which are likely to cause damage to hearing. Monitoring levels in studio control rooms are often painfully consistently loud when dealing with pop music. It became clear that there were two reactions to the situation, either to overstate the problem or to dismiss it as being non-existent. Although a deaf recording engineer has yet to be found there must be many who do not realize the gradual effect of continued exposure to sound at high levels. Even though it may not be vital for everyone to possess sensitive hearing extending above 16kHz, it must surely be an asset to anyone earning his living by judging and controlling sound quality. A sensible recommendation made in a paper compiled by the Association of Professional Recording Studios is that in studios where listening levels above 90dB are to be found, facilities should be made available to staff members being subjected to these levels for regular audiometric tests to be carried out by a qualified audiologist.

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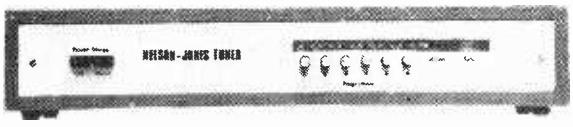

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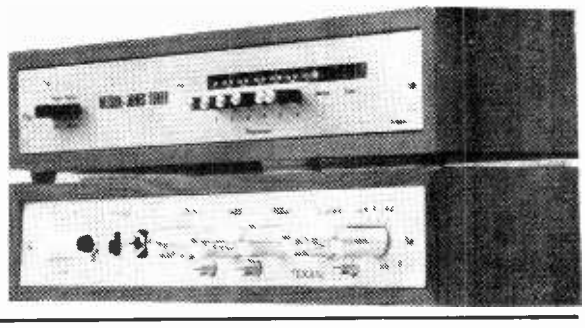
IC STABILISED and S/C protected power supply.
CABINET double veneered against warp.

The Nelson-Jones Tuner has **all** of these features and many more, and more importantly the design is fully **proven** not just with a few prototypes but with many thousands of working tuners spread across the world.

Typ. Specn: 20 dB quieting 0.75uV. Image rejection —70dB.I.F. Rejection —85 dB

Basic tuner module prices start as low as **£11.40**, with **complete** kits starting at **£24·95** (mono) + PP 50p. and of course all components are available separately.
Our low cost **alignment service** is available to customers without access to a signal generator. Please send large SAE for our latest price lists which detail all of the many options and special low prices for complete kits. All our other products remain available.
PORTUS AND HAYWOOD PHASE LOCKED DECODER (W.W. Sept. '70). Still the lowest distortion P.L. decoder available. THD typically 0.05% (at Nelson-Jones Tuner O/P level)! Supplied complete with Red LED.
Price **£6.50** when bought with a **complete** N-J tuner kit or **£7.68** if bought separately (P.P. 19p.)
PLEASE NOTE. Existing tuners are readily convertible and kits/parts are available for this purpose.
TEXAN AMPLIFIER. We have designed the tuner case and metalwork to match the Texan amplifier (see photograph). Complete designer approved Texan kits are available at **£28·50** plus p.p 50p including Teak Sleeve.

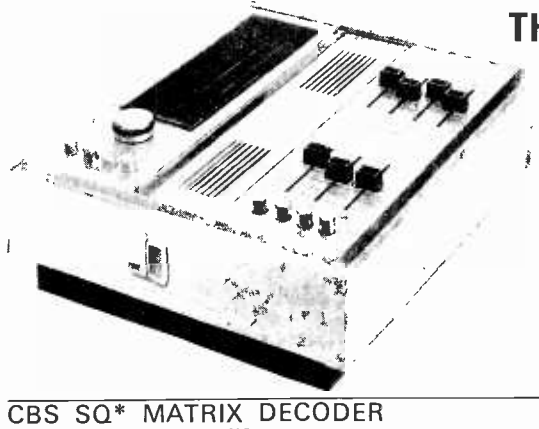


NEW LOW COST STEREO TUNER

No alignment required. Mullard LP1186 front end module used with Ceramic IF and IC amplifier. Push button tuning (6 position) with **Interstation Mute,** restricted range **AFC,** single LED tuning indicator, phase locked IC decoder, and complete metalwork and veneered cabinet. Complete with IC regulated PSU and full assembly instructions. (Mechanically identical to N-J Tuner.)

TYP. SPECIFICATION
2μV for 30dB S/N
Image rejection 40dB
IF rejection 65dB

PRICE: Complete Mono kit **£22.40** Complete Stereo kit **£26.82** p.p. 60p.



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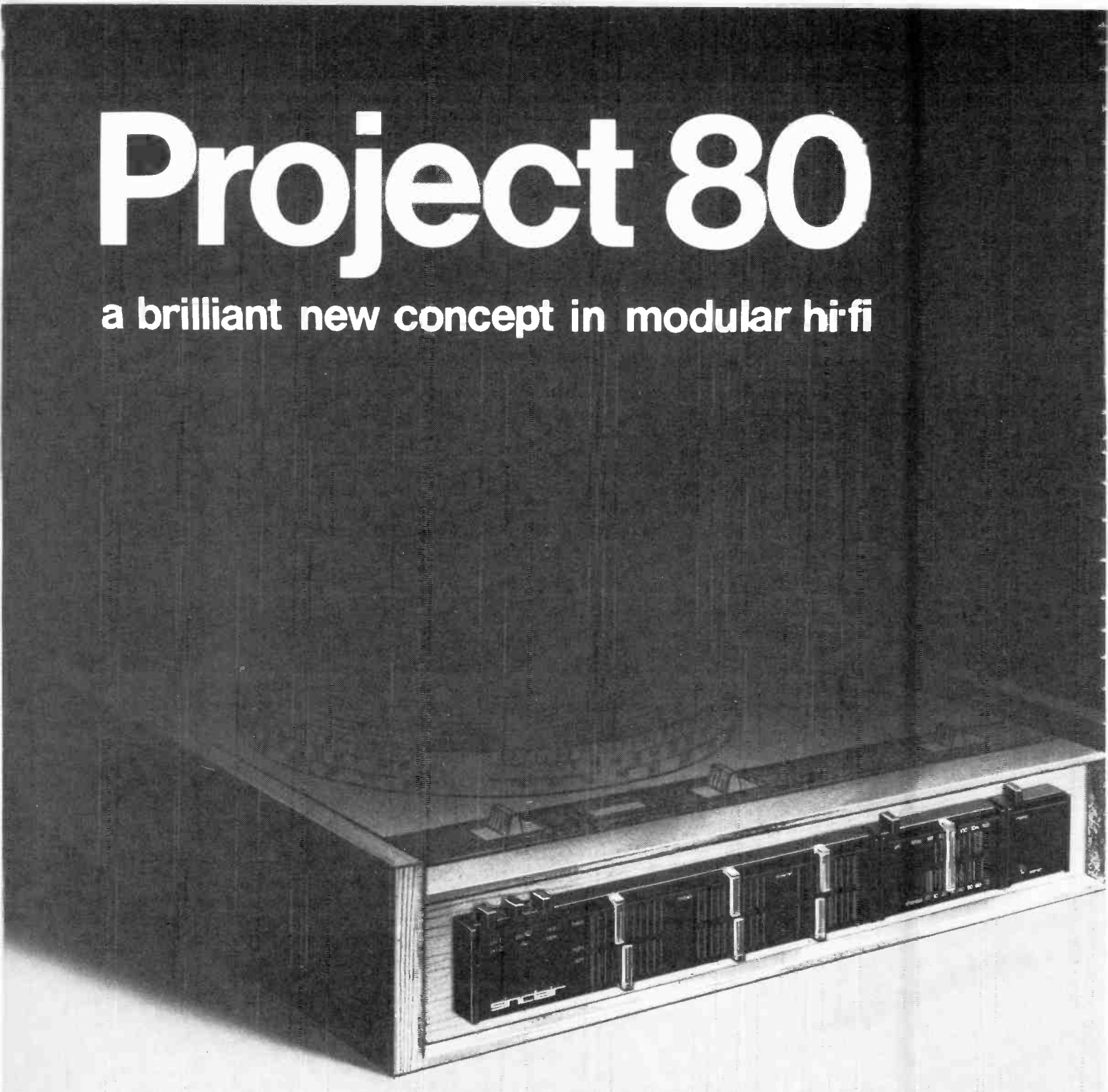
Project 80

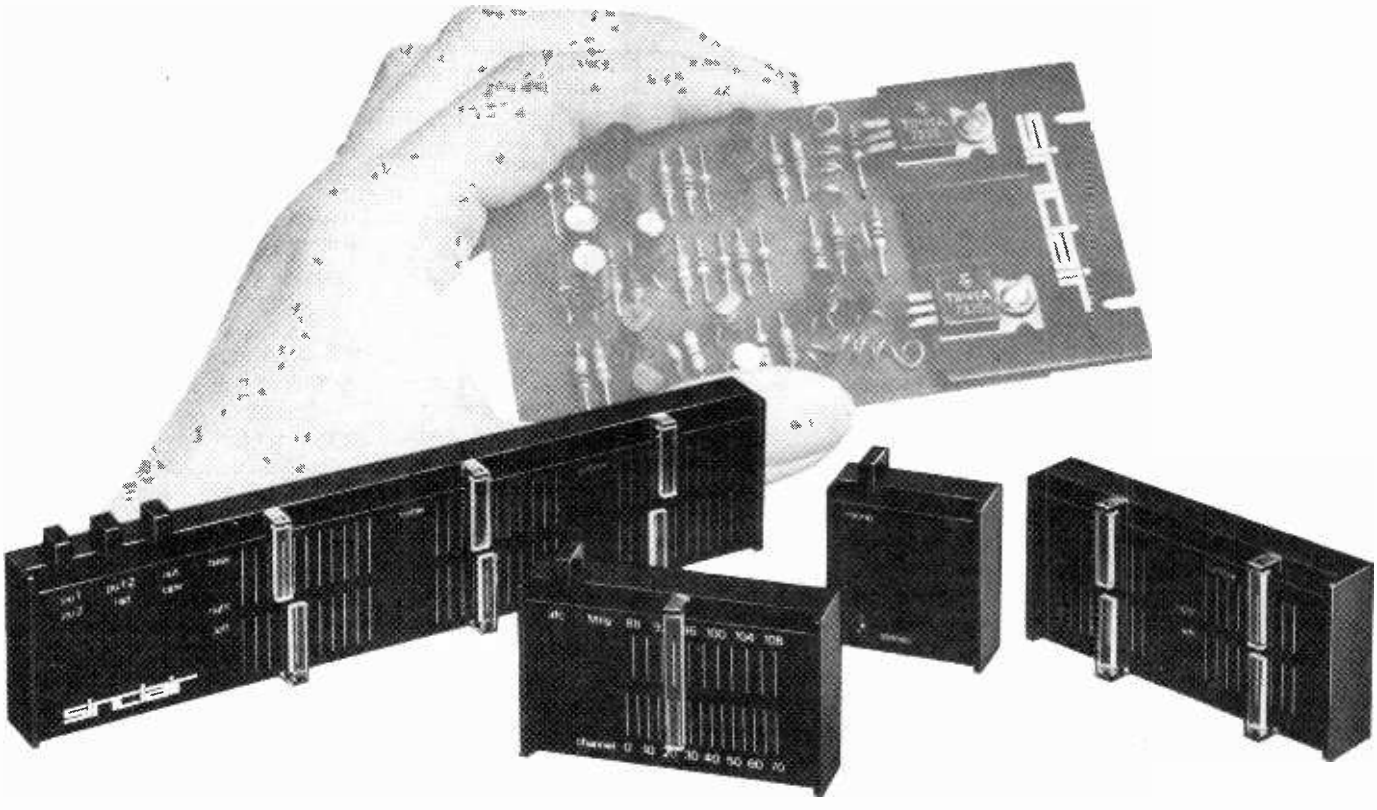
a brilliant new concept in modular hi-fi



Project 80 is going to be the ultimate in modular hi-fi construction for a very long time to come. It combines the qualities most demanded of any modern domestic system – good circuitry, reliability and fine performance – with other features to be found nowhere else in the world. For example, *compactness* – Project 80 control units are $\frac{3}{4}$" deep × 2" high, and each one is completely self-contained. *Elegance* – all of Sinclair's design leadership has been concentrated on producing designs of outstanding functional elegance unsurpassed for styling and simplicity. *Flexibility* – the size and styling of Project 80 modules makes them the most versatile units ever. Combine them how you will, where you will, the Project 80 System of your choice gives you the best.

sinclair

Sinclair Project 80



technically the world's most advanced

Project 80 gives you choice from a range of 9 different modules for combining in a variety of ways to suit your requirements. The Stereo 80 is a versatile pre-amp control unit designed to meet all domestic hi-fi requirements including tape monitoring, high sensitivity magnetic cartridge input, and of course, individual slide controls on each channel for precise output matching. By separating the F.M. tuner and stereo decoder, useful economies can be effected where stereo radio reception is not needed. Two power amplifiers – Z.40 (18 watts RMS continuous into 4 ohms using 35V) and Z.60 (25 watts RMS continuous into 8 ohms using 50V) are available with choice of 3 different power supply units. The PZ.8 with its virtually indestructible circuitry is particularly recommended. For the final word in system building, the Active Filter Unit puts the finishing touch of quality to what are easily the world's most technically advanced hi-fi modules. Any further units likely to be added to Project 80 range will be compatible with those already available.

Stereo 80 Control Unit Size – 260 × 50 × 20mm (10¼ × 2 × ¾ins) Finish – Black with white indicators and transparent sliders Inputs – Magnetic pick-up 3mV RIAA corrected: Ceramic pick-up 350mV Radio 100mV; Tape 30mV Signal/noise ratio – 60db Frequency range – 20Hz to 15KHz ±1dB; 10Hz to 25KHz ±3dB Power requirements – 20 to 35 volts Outputs – 100mV + AB monitoring for tape Controls – Press button tape radio and P.U. Sliders on each channel for volume bass treble R.R.P. (add £1·19 V.A.T.) **£11.95**

Project 80 FM Tuner Size – 85 × 50 × 20mm (3½ × 2 × ¾ins) Tuning range Dual varicap – 87·5 to 108MHz Detector – I.C. balanced coincidence One I.C. equal to 26 transistors Distortion – 0·2% at 1KHz for 30% modulation 4 pole ceramic filter in I.F. section Aerial impedance – 75 Ω or 240-300 Ω Sensitivity – 5 microvolts for 30dB S/N ratio Output – 300mV for 30% modulation Power requirements – 25 to 35 volts R.R.P. (add £1·19 V.A.T.) **£11.95**

Project 80 Stereo Decoder Size – 47 × 50 × 20mm (1⅞ × 2 × ¾ins) One 19 transistor I.C. Channel separation greater than 30dB Power requirements – 25V Output 150mV per channel R.R.P. (add 74p V.A.T.) **£7.45**

Active Filter Unit Separate controls on each channel. Size – 108 × 50 × 20mm (4¼ × 2 × ¾ins) Voltage gain – minus 0·2dB Frequency response – 40Hz to 22KHz controls minimum Distortion – at 1KHz – 0·03% using 30V supply H.F. cut off (scratch) – 22 KHz to 5·5KHz, 12dB/oct. slope L.F. cut off (rumble) – 28dB at 20Hz, 9dB/oct. slope R.R.P. (add 69p V.A.T.) **£6.95**

Z.40 Power Amplifier Size – 55 × 80 × 20mm (2⅛ × 3⅛ × ¾ins) 9 transistors Input sensitivity – 100mV Output 18 watts RMS continuous into 4 Ω (35V) Frequency response – 30Hz-100KHz ±3dB S/N ratio – 64dB Distortion – at 10 watts into 8 Ω less than 0·1% Power requirements – 12 to 35 volts; built-in protection against overload R.R.P. (add 54p V.A.T.) **£5.40**

Z.60 Power Amplifier Size – 55 × 98 × 15mm (2⅛ × 3¾ × ¾ins) 12 transistors Input sensitivity – 100-250mV Output – 25 watts RMS continuous into 8 Ω (50V). Distortion – typically 0·03% Frequency response – 15Hz to more than 200KHz ±3dB S/N ratio – better than 70dB Built-in protection against transient overload and short circuiting Load impedance – 4 Ω min. safe on open circuit R.R.P. (add 69p V.A.T.) **£6.95**

Power Supply Units PZ.8 Stabilised. Re-entrant current limiting makes damage from overload or even direct shorting impossible. Normal working voltage (adjustable) 50V. R.R.P. £7·98 + 79p V.A.T. Without mains transformer PZ.6 35V. stabilised R.R.P. £7·98 + 79p V.A.T. PZ.5 30V unstabilised R.R.P. £4·98 + 49p V.A.T.

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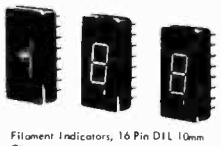

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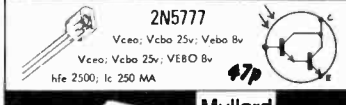

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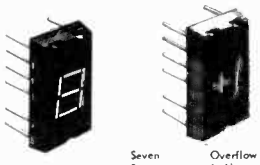

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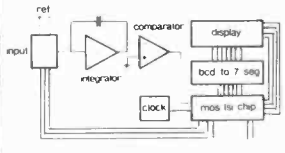

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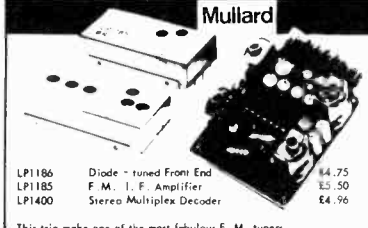

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AC176	15p	BC109	12p	BC268	15p	BF185	28p	D40N3	61p	ZTX303	14p	2N3710	11p
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								OC44	14p	2N1711	26p	2N5295	53p
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								OC71	14p	2N1893	52½p	2N5449	16p
								OC72	14p	2N2218	22p	2N5457	47p
								OC75	15p	2N2219	39p	2N5458	44p
								OC76	27p	2N2646	55p	2N5459	44p
								OC81	14p	2N2894	99p	2N5485	53p
								OC83	25p	2N2904	33p	2N5777	49p
								OC170	28p	2N2905	31p	2N6068	45p
								OC171	33p	2N2924	16p	2N6069	52p
								OCP71	£1.57	2N2925	18p	2N6070	58p
								ORP12	66p	2N2926G	10p	2N6071	63p
								TIP29	54p	2N3053	19p	2N6073	68p
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								TIP31A	68p	2N3055	52p	2N6076	16½p
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50v			106F	46p	2N4441	87p
60v	MCR103	44p				
100v	MCR104	49p	106A	48p		
200v	MCR120	51p	106B	53p	2N4442	£1.06
400v			106D	67p	2N4443	£1.45
600v			106M	£1.50	2N4444	£2.09

REGULATORS

	100mA (TO-39)	500mA * (TO-3)	500mA * (SOT-32)	1A (TO-220)
5V	TBA625A	L005T1 (MVR5V)	L129 TDA1405	7805UC
	£1.30	£1.65	£1.65	£2.42
12V	TBA625B	L036T1 (MVR12V)	L130 TDA1412	7812UC
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15V	TBA625C	L037T1 (MVR15V)	L131 TDA1415	7815UC
	£1.30	£1.65	£1.65	£2.42

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V	1A		3A		6A		12A	
50	IN4001	6½p	IN5400	15½p			BYX61 - 50	£3.21
100	IN4002	7½p	IN5401	16½p			BYX61 -100	£3.48
200	IN4003	9p	IN5402	17½p	BYZ13	58p	BYX61 -200	£3.76
400	IN4004	9p	IN5404	22p	BYZ12	66p	BYX61 -400	£4.29
600	IN4005	11p	IN5406	26p	BYZ11	73p	BYX62 -600	£4.29
800	IN4006	13½p	IN5407	28p	BYZ10	85p		
1000	IN4007	16½p	IN5408	31p				

TRIACS

	4A	
25v	2N6068	45p
50v	2N6069	52p
100v	2N6070	58p
200v	2N6071	63p
400v	2N6073	68p
600v	2N6075	£1.49

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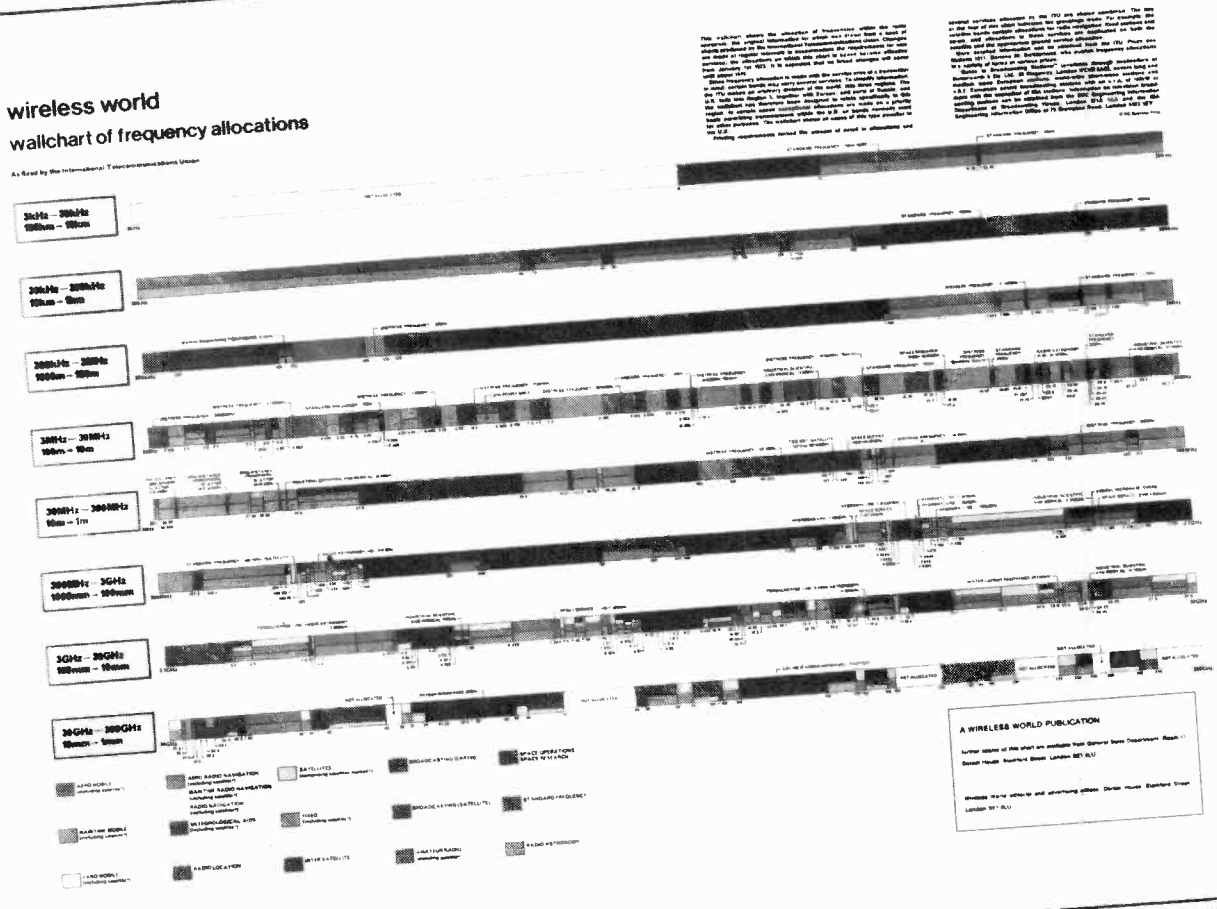

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The wallchart shows the allocation of frequencies within the radio spectrum ranging from 3kHz to 300 GHz and is scaled on 8 logarithmic bands containing 15 main categories of transmissions which are identified by colours. All the important spot frequencies and 'special interest' frequencies are marked. The information is taken from the International Telecommunications Union and has been condensed into easily read chart form. Measures 2'11"×1'11".

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HIOKI Model 720X VOM

A versatile, accurate measuring instrument. 20,000 opv. 0/5/25/100/500/1000V DC. 0/10/50/250/1000V AC. 0–50uA/250mA. 0–20k/2 Megohms.

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MODEL PL436

20,000 opv DC. 8000 opv AC. Mirror scale ·6/3/12/30/120/600V DC. 3/30/120/600V DC. 50/600uA/60/600mA. 10/100K/1 Meg/10 Meg Ohm. –20 to +46dB.

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U4323 MULTIMETER

20,000opv. Simple unit with audio/IF oscillator. Suitable for general receiver tuning. Ranges: 0.5/2.5/10/50/250/500/1000V DC. 2.5/10/15/250/500/1000V AC. 0.05/0.5/5/50/500mA DC. Resistance: x 10, x 100, x 1,000, x 10.000 (50Ω, 500Ω, 5kΩ, 50kΩ centre scale) Battery operated. Size: 160 x 97 x 40mm. Supplied in carrying case complete with test leads.

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MODEL HIOKI 730X

30,000 opv. Overload protection. 6/30/60/300/600/1200V DC. 12/60/120/600/1200V AC. 60/μA/30mA/300mA. 2K/200K/2 Meg Ohm. –10 to · 63 dB.

OUR PRICE £7.50 P&P 15p.

MODEL TE300

30,000opv. Mirror scale. Overload protection. 0/0.6/3/15/60/300/1200V DC. 0/6/30/120/600/1200V AC. 0/30uA/6mA/60mA/300mA/600mA. 0/8k/80k/800k/8 Meg ohms. –20 to +63dB.

OUR PRICE £7.50 P&P 15p

U4324 MULTIMETER

High sensitivity, overload protected. 20,000opv. Ranges: 0.6/1.2/3/12/30/60/120/600/1200V DC. 3/6/15/60/150/300/600/900V AC. Current: 0.06/0.6/6/60/600mA/3A DC. 0.3/3/30/300mA/3A AC. Resistence: 25/500 ohms/0.5/5/50/500k ohms/5 Mohms. Decibels: –10 to +12dB. Size 167 x 98 x 63mm. Supplied complete with test leads, spare diode and instructions.

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U435 MULTIMETER

20,000opv. Overload protected. Ranges: 75mV/2.5/10/25/100/250/500/1000V DC. 2.5/10/25/100/250/500/1000V AC. Current: 50uA/1/5/25/100mA/0.5/2.5A DC. 5/25/100mA/0.5/2.5A AC. Resistance: 0.3/3/30/300k ohms. Size: 205 x 110 x 84mm. Supplied complete with leads, crocodile clips and steel carrying case.

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U91 Clamp VOLT AMMETER

For measuring AC voltage and current without breaking circuit. Ranges: 300/600V AC. Current: 10/25/100/250/500A. Accuracy 4%. Size 283 x 94 x 36mm. Complete with carrying case, leads and fuses.

OUR PRICE £10.50 P&P 20p

TMK MODEL TW50K

46 ranges, mirror scale. 50k/V DC 50k/V AC. DC Volts: 0.125/0.25/1.25/2.5/5/10/25/50/125/250/500/1000. AC Volts 1.5/3/5/10/25/50/125/250/500/1000. DC current 25/50uA/2.5/5/25/50/250/500mA/5/10A. Resistence: 10k/100k/1 Meg/10 Meg ohms. –20 to +81.5dB.

OUR PRICE £12.50 P&P 17p

U4312 MULTIMETER

extremely sturdy instrument for general electrical use. 667opv. 0/0.3/1.5/7.5/30/60/150/300/600/900V DC & 75mV. 0/0.3/1.5/7.5/30/60/150/300/600/900V AC. 0/300uA/1.5/6/15/150/60/600mA/1/1.5/6A DC. 0/1.5/6/15/60/150/600mA/1.5/6A AC. 0/200/3k/30k ohms. DC accuracy 1%. AC 1.5%. Knife edge pointer, mirror scale. Complete with sturdy metal carrying case, leads and instructions.

OUR PRICE £9.75 P&P 25p

MODEL 500

30,000 opv with overload protection. Mirror scale. 0/0.5/2.5/10/25/100/250/500/1000V DC. 0/2.5/10/25/100/250/500/1000V AC. 0/50uA/5/50/500mA. 12A DC. 0/60k/6 meg/60 megohms.

OUR PRICE £13.95 Carr. paid
Leather case for above £1.75

HIOKI 750X VOLT-OHM-MILLIAMETER

43 ranges: 0–0.3/0.6/1.5/3/6/12/30/60/150/300/600/1,200V DC. 0–3/6/15/30/60/120/300/600/1,200V AC. Current: 0–30/60uA/1.5/3/15/30/150/300mA/6/12A. Resistence: 0–3/300k/3/30Mohms. Decibels: –10 to +17dB. Output:–0–3/6/15/30/60/120/300V. Accuracy ± 3% DC, ± 4% AC. Sensitivity: 50,000 opv DC, 5,000 opv AC. 4 inch meter. Built in protection. Size: 57 x 102 x 153mm.

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HIOKI MODEL 700X

100,000opv. Overload protection. Mirror scale. 0.3/0.6/1.2/1.5/3/6/12/30/60/120/300/600/1200V DC. 1.5/3/6/12/30/60/150/300/600/1200V AC. 15/30uA/3/6/30/60/150/500mA/6/12A DC. 2k/200k/2M/20MOhms. –20 to +63dB.

OUR PRICE £14.95 P&P20p

Model HT100B4 MULTIMETER

Overload protected, shock proof circuits. 9.5uA Meter with mirror scale. Sensitivity 100kV. Polarity change switch. Ranges: 0.5/2.5/1-/50/250/500/1,000 Volts DC. 2.5/10/50/250/1,000 Volts AC. DC resistence' 0–20/200k/2/20 Meg. ohms. DC current:– 10/250uA/2.5/25/250 mA/10A. AC current:–0–10A. –20 to +62dB. Operates from 2 x 1.5V batteries. Size: 180 x 134 x 79mm.

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MODEL AS.100D VOM

100,000 opv. Mirror scale. Built-in meter protection. 0/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600V AC. 0/10μA/6/60/300mA/12 Amp. 0/2K/200K/2 M/200 Meg Ohm. – 20 to · 17 dB

OUR PRICE £17.50 P&P 20p.

TMK 100K LAB TESTER

100,000opv. 6½" scale. Buzzer short circuit check. Sensitivity 100,000 opv DC. 5k/V AC DC Volts: 0.5/2.5/10/50/250/1000V AC. 3/10/50/250/500/1000V DC. current 10/100uA/10/10/100/500mA/2.5/10A. Resistence: 1k/10k/100k/10 Meg/100 Meg ohms. Decibels: –10 to +49dB. Plastic case with carrying handle. Size: 190 x 172 x 99mm.

OUR PRICE £19.95 P&P 25p

370WTR MULTIMETER

Features AC current ranges. 20,000opv. 0/0.5/2.5/10/50/250/500/1000V DC. 0/2.5/10/50/250/500/1000V AC. 0/50uA/1/10/100mA/1/10A DC. 0/100mA/1/10A AC. 0/5k/50k/500k/5 Meg/50 Meg. Decibels: –20 to +62dB.

OUR PRICE £19.95 P&P 25p

KAMODEN 72.200 Multitester

High sensitivity tester. 200,000 opv Overload protected. Mirror scale. Ranges:–0/.6/.3/3/30/120/600/1200V DC. 0/3/12/60/300/11200 V AC. 0/6uA/1.2mA/120mA/600mA/12A DC 0/12A AC. –20 to +63dB. 0/2k/200k/2 Meg/200 Megohms.

OUR PRICE £22.50 P&P 30p

U4317 MULTIMETER

High sensitivity instrument for field and laboratory work. Knife edge pointer, 86mm. mirror scale. Ranges: 100mV/0.5/2.5/10/25/50/100/250/500/1000 V DC. 0.5/2.5/10/25/50/100/250/500/1000V AC. Current: 50uA/0.5/1/5/10/50/250mA/1/5A DC. 0.25/0.5/1/5/10/50/250mA/1/5A AC. Resistance: 0.5/10/100/200 ohms/1/3/30/300k ohms. Decibels: –5 to +10dB Battery operated. Size: 210 x 115 x 90mm. Supplied in carrying case complete with leads.

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MODEL U4311 Sub-standard Multi-range Volt-Ammeter

Sensitivity 330 Ohms/Volt AC and DC. Accuracy 0.5% DC. 1% AC. Scale length: 165mm. 0/300/750uA/1.5/3/7.5/15/30/75/150/300/750mA/1.5/3/7.5A DC. 0/75/150/300/750mV/1.5/3/7.5/15/30/75/150/300/750V DC. 0/750mV/1.5/3 /7.5/15/30/75/150/300/750V AC. Automatic cut out device. Supplied complete with test leads, manual and test certificates.

OUR PRICE £49.00 P&P 50p

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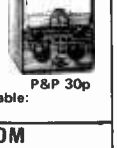
28 ranges. DC volts 1.5–1500V. AC volts 1.5–1500V. Resistance up to 1000 Megohms, 200/240V AC operation. Complete with probe and instructions.



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Additional probes available: RF £2.12, HV £2.50

MODEL AF.105 VOM

50,000 opv. Mirror scale. Meter protection. 0/3/3/12/60/120/300/600/1200V DC. 0/6/30/120/300/600/1200V DC. 0/30μA/6/60/300 mA/12 Amp. 0/10K/1m/10m/100 Meg Ohms.– 20 to · 17 dB.

OUR PRICE £12.50 P&P 20p.

LB3 TRANSISTOR TESTER

Tests ICO and B. PNP/NPN. Operates from 9V battery. Instructions supplied.

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LB4 TRANSISTOR TESTER

Tests PNP or NPN transistors. Audio indication. Operates on two 1.5V batteries. Complete with instructions etc.

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U4341 Multimeter & Transistor Tester

27 ranges. 16,700opv. Overload protected. Ranges: 0.3/1.5/6/30/60/150/300/900V DC. 1.5/7.5/30/150/300/750V AC. Current: 0.06/0.6/6/60/600mA DC. 0.3/3/30/300mA AC. Resistance: 0.06/0.6/2/6/20/60/200k ohms/2 Mohms. Battery operated. Supplied complete with probes, leads and steel carrying case. Size: 115 x 215 x 90mm.

OUR PRICE £10.50 P&P 20p

S100TR MULTIMETER TRANSISTOR TESTER

100,000opv. Mirror scale. Overload protection. 0/0.12/0.6/3/12/30/120/600V DC. 0/6/30/120/600V AC. 0/12/600uA/12/300mA/6/12A DC 0/10k/1 Meg/100 Meg. –20 to +50dB. 0.01–0.2 MFD Transistor tester measures Alpha, Beta and ICO. Complete with instructions, batteries and leads.

OUR PRICE £19.95 P&P 25p

KAMODEN HMG500 insulation resistance tester

Range 0–1,000 Megohms, 500V. Battery operated. Wide range clear meter 4"x 4¾". Complete with deluxe carrying case, batteries and instructions.

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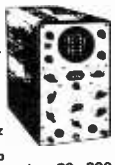
For display of pulsed and periodic waveforms in electronic circuits. VERT. AMP. Bandwidth: 10MHz. Sensitivity at 100kHz VRMS/mm: 0.1–25; HOR. AMP. Bandwidth: 500kHz. Sensitivity ay 100kHz VRMS/mm: 0.3–25 Preset triggered sweep 1–3000usec. Free running 20–200 kHz in nine ranges. Calibrator pips. 220 x 360 x 430mm. 115–230V AC.



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5 MHz pass band. Separate Y1 and Y2 amplifiers. Rectangular 5" x 4" CRT. Calibrated triggered sweep from 0.2usec. to 100 milli-sec/cm. Free running time base, 50Hz–1MHz. Built-in time base Calibrator and amplitude Calibrator. Supplied complete with all accessories and instruction manual.

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A new portable bridge offering excellent range and accuracy at low cost. Resistance: 6 ranges: 0.1 ohm-11.1 megohm ± 1% Inductance: 6 ranges: 1 microhenry-111 henries ± 2% Capacity: 6 ranges: 10pf-1110 mfd ± 2% Turns Ratio: 6 ranges: 1:1/1000-1:11100 ± 1% Bridge Voltage at 1.000cps. Operated from 9-volt battery 100 microamp meter indication. Size 7⅞" x 5" x 2"

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5 ranges, 400kHz to 30 MHz. An inexpensive instrument for the handy-man. Operates on 9V battery. Wide easy to read scale. 800kHz modulation. Size: 149 x 149 x 92mm. Complete with instructions and leads.

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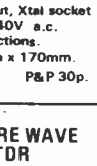
MODEL TE20 RF SIGNAL GENERATOR

Six bands. 120kHz–260MHz. Dual output RF terminals. Separate variable audio output. Accuracy ± 2%. Audio output to 8V. Power requirements: 105–125V, 220–240V AC. Size: 193 x 265 x 150mm. Complete with test leads etc.

OUR PRICE £17.50 P&P 40p

TE-20D RF SIGNAL GENERATOR

Accurate wide range signal generator covering 120 kHz-500 MHz on 6 bands. Directly calibrated. Variable R.F. attenuator audio output, Xtal socket for calibration. 220/240V a.c. Brand new with instructions. Size 140mm x 215mm x 170mm.



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TE22 SINE SQUARE WAVE AUDIO GENERATOR

Sine 20cps to 200kHz on 4 bands. Square 20 cps to 30 kHz. Output impedence 5000 Ohms. 200/250V AC operation. Supplied brand new guaranteed, with instruction manual and leads.

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All transistorised compact fully portable. AF sine-wave 18Hz to 220 kHz. AF square wave 18Hz to 100k Hz. Output Square/Sine wave 10V. P-P RF 100kHz to 200MHz. Output 1V maximum. 220/240V AC operation. Complete with instructions and leads.

OUR PRICE £37.50 P&P 50p

Also see previous page

MODEL MG100 SINE SQUARE WAVE AUDIO GENERATOR

Range 19-220,000Hz Sine Wave 19–100,000 Hz Square Wave. Output Sine or Square wave 10v. P. to P. Size 180 x 90 x 90mm. Operation 220/240v. A.C.

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PS200 Regulated POWER SUPPLY UNIT

Solid state. Variable output 5–20V DC up to 2 Amp. Independent meters to monitor voltage and current. Output 220/240V AC. Size: 190 x 136 x 98mm.

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MW 1–8 80x80mm **£6.90** P&P 15p

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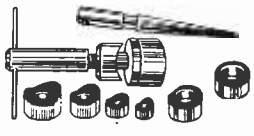

Carefully machined top grade steel. Contains 1/2", 5/8", 3/4", 1" and 1 1/8" punches complete with gripper and accessories.

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Features 24 hour alarm setting, on/off and auto alarm 'sleep' switch. Illuminated rotary dial with hours, minutes and seconds. Automatically turns off radio, TV, light etc. and with auto-switching will turn on again when required. 240V AC operation. Switch rating 250V–3 Amp.

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complete with printed circuit mounting board.

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LH02S STERED HEADPHONES

Light weight headphones with padded ear pieces. 4/16 ohms 20–20,000Hz. Complete with 6' lead and plug.

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TE1018 Deluxe Mono High Impedence Headset.

Sensitive magnetic headset with soft ear pads. Impedence 2,600 ohms (600 ohms DC). Frequency response: 200–4,000Hz.

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Low cost with excellent response. Foam rubber earcups. Adjustable headband. 8 ohms impedence. Frequency response 25Hz–18kHz. Complete with cable and stereo jack plug.

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6 transistor high quality tuner. Size only 153 x 101 x 63mm 3 IF stages. Double tuned discriminator. Ample output to feed most amplifiers. Operates on 9V battery. Covers 88–108MHz. Ready built, ready for use. Fantastic value for money.

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6 transistor high quality unit– 3 IF stages and double tuned discriminator. For use with most amplifiers. Covers 88–108MHz. Powered by 9V battery.

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P & P 25p plus VAT.

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AMPLIFIER

Amplifier output 8 watts per channel RMS. Distortion less than 0·06%. Silicon transistors. Two pick-up plus radio and tape inputs, tape output and scratch filter. Excellent Value.

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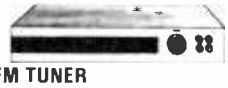

FM TUNER

Excellent selectivity and sensitivity. Twin dual-varicap tuning. 4 pole ceramic filter. 19 transistor stereo demodulator giving 40 dB separation. Distortion 0·2% output. Fantastic Value.

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Project 805	£26.95
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5 Microphone inputs each with individual gain controls enabling complete mixing facilities. Battery operated. Size: 235 x 127 x 76mm. Inputs: Mics. 3 x 3mV 50k; 2 x 3mV 600 ohms. Phono. Mag. 4mV 50k; Phono Ceramic 100mV 1 Meg. Output 250mV 100k.

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AF80 0.5W mic. amplifier	£4.22
AF305 Intercom	£9.52
AF310 Mono amplifier	£5.91
AT5 Automatic light control	£2.58
AT25 Window wiper robot	£5.82
AT30 Photo cell switch unit	£5.70
AT50 400W triac light dimmer/speed control	£4.80
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AE6 Monostable multi-vibrator	93p
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TYPE	5	10	25
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TYPE	Each	5	10
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1mA	£3.65	VU Meter	£3.90
5mA	£3.65		
10mA	£3.65		
50mA	£3.65		
100mA	£3.65		
500mA	£3.65		
1A DC	£3.65		
5A DC	£3.65		
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100uA	£4.50	300V AC	£4.45
500uA	£4.30	VU Meter	£4.90
50-0-50uA	£4.50		
100-0-100uA	£4.45		
1mA	£4.30		
1A DC	£4.30		
5A DC	£4.30		
20V DC	£4.30		
50V DC	£4.30		
300V DC	£4.30		

EDGWISE MODEL PE70
Size: 90 x 34mm

50uA	£4.15
100uA	£4.10
200uA	£4.05
500uA	£3.90
50-0-50uA	£4.10
100-0-100uA	£4.05
1mA	£3.85
300V AC	£3.95
VU Meter	£4.30

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50-0-50uA	£7.90	300V DC	£7.60
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1-0-1mA	£7.60	5V/50V DC	£8.60
1A DC	£7.60	5V/15V DC	£8.60
5A DC	£7.60	1/5A DC	£8.60
5V DC	£7.60	1A/15A DC	£8.60
10V DC	£7.60		
15V DC	£7.60		

CLEAR PLASTIC MODEL MR 85P
Size: 120 x 110mm

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100uA	£5.40	15V AC	£5.30
200uA	£5.35	300V AC	£5.30
500uA	£5.25	S Meter 1mA	£5.20
50-0-50uA	£5.40	VU Meter	£5.55
100-0-100uA	£5.35	1A AC	* £5.20
500-0-500uA	£5.20	5A AC	* £5.20
1mA	£5.20	10A AC	* £5.20
1-0-1mA	£5.20	20A AC	* £5.20
5mA	£5.20	30A AC	* £5.20
10mA	£5.20		
50mA	£5.20		
100mA	£5.20		
500mA	£5.20		
1A DC	£5.20		
5A DC	£5.20		
15A DC	£5.20		
30A DC	£5.40		
10V DC	£5.20		
20V DC	£5.20		
50V DC	£5.20		
150V DC	£5.20		

CLEAR PLASTIC MODEL SD830
Size: 110 x 83mm

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100uA	£4.25	20V DC	£4 10
200uA	£4.20	50V DC	£4.10
500uA	£4.15	300V DC	£4.10
50-0-50uA	£4.25	15V AC	£4.20
100-0-100uA	£4.20	300V AC	£4 20
1mA	£4.10	VU Meter	£4.40
5mA	£4.10		
10mA	£4.10		
50mA	£4.10		
100mA	£4.10		
500mA	£4.10		
1A DC	£4.10		
5A DC	£4.10		
10A DC	£4.10		
5V DC	£4.10		

CLEAR PLASTIC MODEL MR 45P
Size: 50 x 50mm

50uA	£3 20	300V AC	£3 05
100uA	£3 15	S Meter 1mA	£2 95
200uA	£3.10	VU Meter	£3 40
500uA	£3 00	1A AC	* £2 95
50-0-50uA	£3 15	5A AC	* £2 95
100-0-100uA	£3 10	10A AC	* £2 95
500-0-500uA	£2.95	20A AC	* £2 95
1mA	£2.95	30A AC	* £2.95
5mA	£2 95		
10mA	£2.95		
50mA	£2.95		
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CLEAR PLASTIC MODEL MR 38P
Size: 42 x 42mm

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100uA	£3.05	50V DC	£2 80
200uA	£3.00	100V DC	£2 80
500uA	£2.85	150V DC	£2 80
50-0-50uA	£3 05	300V DC	£2.85
100-0-100uA	£3.00	500V DC	£2.85
500-0-500uA	£2.80	750V DC	£2.90
1mA	£2.80	15V AC	£2.90
1-0-1mA	£2.80	50V AC	£2.90
2mA	£2.80	150V AC	£2.90
5mA	£2.80	300V AC	£2 90
10mA	£2.80	500V AC	£3.00
20mA	£2.80	S Meter 1mA	£2.80
50mA	£2.80	VU Meter	£3.20
100mA	£2.80		
150mA	£2.80		
200mA	£2.80		
300mA	£2.80		
500mA	£2.80		
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10A DC	£2.80		
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Size: 59 x 46mm

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100uA	£3.45	20V DC	£3.30
200uA	£3.40	50V DC	£3.30
500uA	£3.35	300V DC	£3.30
50-0-50uA	£3.45	15V AC	£3.45
100-0-100uA	£3.40	300V AC	£3 45
1mA	£3.30	VU Meter	£3.65
5mA	£3.30		
10mA	£3.30		
50mA	£3.30		
100mA	£3.30		
500mA	£3.30		
1A DC	£3.30		
5A DC	£3.30		
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Size: 86 x 78mm

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500uA	£3.75	150V AC	£3.80
50-0-50uA	£3.85	300V AC	£3.90
100-0-100uA	£3.80	500V AC	£3.80
500-0-500uA	£3.70	S Meter 1mA	£4 10
1mA	£3.70	VU Meter	£3.70
1-0-1mA	£3.70	1A AC	* £3.70
5mA	£3 70	5A AC	* £3.70
10mA	£3 70	10A AC	* £3.70
50mA	£3 70	20A AC	* £3.70
100mA	£3.70	30A AC	* £3.70
500mA	£3 70	50mA AC	* £3.70
1A DC	£3.70	100mA AC	* £3.70
5A DC	£3.70	200mA AC	* £3.70
10A DC	£3 70	500mA AC	* £3.70
15A DC	£3.70		
20A DC	£3.80		
30A DC	£3 85		
50A DC	£4.05		
5V DC	£3 70		
10V DC	£3.70		
15V DC	£3.70		
20V DC	£3.70		
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Size: 80 x 80mm

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50-0-50uA	£4.45	5A AC	* £3.30
100-0-100uA	£4.40	10A AC	* £3.30
1mA	£4 20	20A AC	* £3.30
1A DC	£4 20	30A AC	* £3.30
5A DC	£4.20		
20V DC	£4.20		
50V DC	£4.20		
300V DC	£4.20		
300V AC	£4.30		
VU Meter	£4.70		

CLEAR PLASTIC MODEL MR 52P
Size: 60 x 60mm

50uA	£3 70	S Meter 1mA	£3.30
100uA	£3.50	VU Meter	£3.80
500uA	£3.35	1A AC	* £3.30
50-0-50uA	£3.50	5A AC	* £3.30
100-0-100uA	£3.45	10A AC	* £3.30
1mA	£3.30	20A AC	* £3.30
5mA	£3.30	30A AC	* £3.30
10mA	£3.30		
50mA	£3.30		
100mA	£3.30		
500mA	£3.30		
1A DC	£3.30		
5A DC	£3.30		
10V DC	£3 30		
20V DC	£3.30		
50V DC	£3.30		
300V DC	£3.30		
15V AC	£3.40		
300V AC	£3.40		

BAKELITE MODEL MR 65 Size: 80 x 80mm

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500uA	£3.65	150V AC	* £3.60
50-0-50uA	£3.95	300V AC	* £3.60
100-0-100uA	£3.90	500V AC	* £3.60
500-0-500uA	£3.60	VU Meter	£4.10
1mA	£3.60	1A AC	* £3.60
1-0-1mA	£3.60	5A AC	* £3.60
5mA	£3.60	10A AC	* £3.60
10mA	£3.60	20A AC	* £3.60
50mA	£3.60	30A AC	* £3.60
100mA	£3.60	50A DC	* £3.60
500mA	£3.60	5V DC	* £3.60
1A DC	£3.60	10V DC	* £3.60
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A1065	£1·25	ECH42	0·75	EY88	0·40	PL84	0·40	TT21	4·20	UL84	0·40	1T4	0·30
AR8	0·50	ECH81	0·30	EZ40	0·50	PL504	0·75	U25	0·85	UY41	0·45	1X2A	0·60
ATP4	0·50	ECH83	0·45	EZ41	0·75	PL508	1·00	U26	0·85	UY85	0·35	1X2B	0·60
B12H	3·00	ECH84	0·45	EZ80	0·28	PL509	1·20	U27	0·60	VR105/30	0·40	2K25	8·00
CY31	0·50	ECL80	0·50	EZ81	0·27	PL802	0·95	U191	0·75	X66	0·50	3A4	0·50
DAF96	0·50	ECL82	0·35	GY501	0·70	PY33	0·63	U801	0·80	VR150/30	0·40	3D6	0·40
DF96	0·50	ECL83	0·70	GZ34	0·65	PY80	0·40	UABC80	0·40	Z800U	2·00	3S4	0·40
DK96	0·60	ECL86	0·40	GZ37	1·00	PY81	0·35	UAF42	0·60				
DL92	0·40	EF36	0·65	KT66	2·50	PY82	0·35	UBC41	0·60				
DL96	0·60	EF37A	1·00	KT88	2·90	PY83	0·40	UBF80	0·40				
DM70	0·60	EF40	0·62	MH4	0·75	PY88	0·45	UBF89	0·40				
DY86/87	0·35	EF41	0·65	ML6	0·50	PY500	1·00	UBL1	0·70				
DY802	0·35	EF80	0·25	OA2	0·40	PY800	0·45	UBL21	0·70				
E88CC	0·70	EF83	1·10	OAF70	0·55	PY801	0·45	UCC85	0·45				
E92CC	0·55	EF85	0·35	OB2	0·40	QV03-12	0·50	UCF80	0·70				
E88CC/01	1·15	EF86	0·30	PABC80	0·40	QQVO3-10	1·25	UCH42	0·75				
E180CC	0·65	EF89	0·27	PC97	0·45	QQVO6-40A	8·00	UCH81	0·40				
E182CC	1·25	EF91	0·37	PCF82	0·35	R19	0·60	UCL82	0·35				
EA50	0·25	EF92	0·50	PCF84	0·60	SC1/400	2·50	UCL83	0·65				
EABC80	0·38	EF95	0·35	PCF86	0·60	SC1/600	4·50	UF41	0·65				
EAF42	0·55	EF183	0·30	PCF200	0·75	SP61	0·70	UF80	0·35				
EB91	0·20	EF184	0·31	PCF201	0·75	SU4	0·60	UF85	0·40				
EBC33	0·75	EFL200	0·60	PCF801	0·55			UF89	0·40				
EBC41	0·65	EL34	0·60	PCF802	0·50			UL41	0·60				
EBF80	0·40	EL36	0·50	PCF805	0·90								
EBF83	0·40	EL41	0·75	PCF	0·65								
EBF89	0·30	EL81	0·55	PCF808	0·85								
EC52	0·35	EL82	0·55	PCH200	0·80								
EC93	0·60	EL84	0·26	PCL81	0·60								
ECC81	0·35	EL85	0·44	PCL82	0·40								
ECC82	0·33	EL86	0·38	PCL83	0·65								
ECC83	0·33	EL90	0·45	PCL84	0·45								
ECC84	0·30	EL504	0·70	PCL86	0·50								
ECC85	0·38	EM31	0·60	PCL805	0·60								
ECC86	0·80	EM80	0·45	PFL200	0·70								
ECC88	0·40	EM84	0·35	PL36	0·60								
ECC189	0·65	EM87	0·70	PL38	0·65								
ECF80	0·35	EY51	0·40	PL81	0·50								
ECF82	0·35	EY81	0·40	PL82	0·45								
ECF801	0·60	EY86	0·40	PL83	0·45								

VAT 10% EXTRA

	£		£		£		£		£		£		£
Z801U	2·00	3V4	0·70	5Z3	0·80	6BR7	1·00	6K7	0·45				
Z803U	1·35	5B/254M	5·00	5Z4	0·80	6BW6	0·90	6K7G	0·30				
Z900T	1·20	5B/255M	3·20	5Z4GT	0·45	6BW7	0·90	6K8GT	0·50				
1A3	0·45	5R4GY	0·80	6AB7	0·50	6C4	0·35	6K25	0·75				
1L4	0·20	5U4G	0·40	6AC7	0·50	6C6	0·40	6L6	1·50				
1R5	0·40	5V4G	0·50	6AH6	0·60	6CB6	0·40	6L7G	0·40				
1S4	0·30	5Y3GT	0·45	6AK5	0·40	6CH6	1·40	6Q7G	0·45				
1S5	0·30	5Y4G	0·40	6AK8	0·38	6CL6	0·65	6SA7	0·45				
				6AL5	0·25	6D6	0·40	6SA7GT	0·30				
				6AL5W	0·50	6EA8	0·70	6SC7GT	0·30				
				6AM6	0·37	6F7	1·00	6SG7	0·45	19G6	6·60	866A	1·10
				6AN8	0·65	6FSG	0·50	6SJ7	0·50	19H4	7·00	931A	5·80
				6AQ5	0·45	6F23	0·90	6SJ7GT	0·30	20P3	0·75	954	0·50
				6AQ5W	0·65	6F32	0·50	6SK7	0·50	20P4	1·00	955	0·40
				6AS6	0·50	6F33	3·25	6SK7G	0·45	25L6GT	0·60	956	0·30
				6AT6	0·45	6H6	0·30	6SL7GT	0·45	30C15	1·00	957	0·40
				6AU6	0·30	6J4WA	1·00	6SN7GT	0·45	30C17	1·00	1629	0·50
				6AX4GT	0·75	6J5	0·65	6SQ7	0·50	30C18	0·90	2051	0·80
				6AX5GT	0·80	6J5GT	0·45	6V6G	0·15	30F5	1·00	5933	3·00
				6B7	0·60	6J6	0·30	6V6GT	0·45	30FL1	0·80	6057	0·60
				6BE6	0·32	6J6W	0·45	6X4	0·40	30FL12	1·05	6060	0·60
				6BG6G	0·70	6J7	0·45	6X5G	0·40	30FL14	0·85	6064	0·50
				6BJ6	0·55	6J7G	0·40	6X5GT	0·45			6065	0·70
				6BQ7A	0·55	6K6GT	0·75	6Y6G	0·80			6080	2·20
								6Z4	0·50			6146	2·00
								6-30L2	0·90			8020	4·00
								7B7	0·70			9001	0·30
								7Y4	0·75			9002	0·50
								9D6	0·40			9003	0·55
								11E2	5·00			9004	0·30
								11E3	6·00			9006	0·30
								12A6	0·30			**C.R. TUBES**	
								12AT6	0·40			DG7-5	12·00
								12AT7	0·35	30L15	0·95	DG13-2	18·00
								12AU7	0·33	30L17	0·95	DG13-34	12·00
								12AV6	0·50	30P12	0·95	MW13-3515	00·00
								12AX7	0·33	30P19	0·95	VCR139A	8·00
								12BA6	0·40	30PL1	0·95	3BP1	4·00
								12BE6	0·50	30PL13	1·10	88D	9·00
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								12C8	0·45	35L6GT	0·75	88L	9·00
								12E1	3·00	35W4	0·50	**SPECIAL VALVES**	
								12K5	1·00	35Z4GT	0·70	CV2339	45·00
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								12K8GT	0·60	50CD6G	1·10	K301	7·00
								12Q7GT	0·40	75	0·70	K305	11·00
								12SA7GT	0·50	76	0·60	K308	14·50
								12SC7	0·50	78	0·55	K337	14·50
								12SJ7	0·45	80	0·60	KRN2A	6·00
								12Y4	0·30	723A/B	7·50	V246A/1K	
								12SG7	0·45	803	5·50		28·00
								14S7	0·80	805	12·00	3J/92/E	35·00
								19AQ5	0·50	807	0·60	725A	22·50
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AC128	AF127	BF167	NKT222	OC70	1N38A	2N3391
AC176	AF139	BF185	OA5	OC73	1N43	2N3730
ACY18	AF178	BFY51	OA47	OC78	1N70	2N3731
ACY19	AF186	BFY52	OA70	OC78D	1N277	2N3819
ACY20	AFZ12	BFY90	OA71	OC81	1N415C	2N4038
ACY28	ASY26	BSY27	OA73	OC82	1N4148	2N4058
ACY39	ASY27	BSY38	OA79	OC82D	2N456A	2N4061
ACY40	ASY28	BSY95A	OA91	OC82DM	2N708	2N4785
AD149	BC108	BYZ16	OA200	OC83	2N918	2N5295
AD161	BC118	CRS1/10	OA202	OC139	2N1304	3N128
AD162	BC119	CRS1/20	OAZ200	OC140	2N1305	3N154
ADZ11	BC136	CRS1/30	OC22	OC170	2N1307	3N159
ADZ12	BC137	CRS1/40	OC22	OC172	2N1309	2S303
AF114	BC148A	CRS3/10	OC26	OC200	2N2062	404
AF115	BC172	CRS3/20	OC28	OC206	2N2147	2082
AF116	BC172A	CRS3/30	OC29	SX754	2N2411	40250
AF117	BC212A	CRS3/40	OC39	ZR11	2N2989	40251
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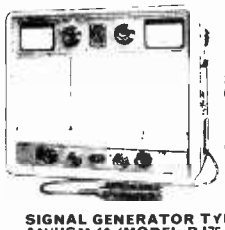
MANY OTHERS IN STOCK including integrated circuits, C.R.T. and special valves. Minimum Mail Order £1. U.K. POSTAGE £1—£2 17p, over £4 free. C.O.D. 25p extra.



MARCONI TF 867 SIGNAL GENERATOR
Range: 15KHz to 30MHz. Output 0.4μV to 4V at 13 or 75 ohms. Impedance with termination (supplied). Built in crystal check facility with handbook. **£125** including carr.

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A precision HF/VHF signal generator embodying facilities seldom found or contained in one instrument, namely outputs of **CW/AM/PM and swept carrier,** in the frequency range **10 to 440 MHz.** Some of the features of the instrument are: **AUTOMATIC FREQUENCY STABILISATION** (locks output signal to selected frequency), **AUTOMATIC LEVEL CONTROL** (holds output constant ±1db **INTERPOLATION OSCILLATION** (for precise tuning between crystal check points) **MARKERS** (for S.F.M.)
BRIEF SPECIFICATION: Frequency 10 to 440MHz, RF output 0.224V at 50 ohms. Modes of operation CW-HI, CW, CW (calibrated and stabilised), AM-400Hz and 1kHz and external, FM-400Hz and 1kHz and external 0.75 kHzdev., S.F.M.—x1, x10, x100, 0-75, 750 & 7500kHz dev. resp., P.M.—50 to 5000 pps at 1 to 30μsec. width int. or ext., 150 to 5000Hz rep rate, 3 meters for; mod. and dev., frequency discrimination pulse level output. With manual. Complete specification and price on application.

500/250W MEDIUM WAVE BROADCAST TRANSMITTERS. Price and details on application.

M.O. for ET 4336 TX (see description in previous issues) **£8·50.** P. & P. **£1·50.**

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SCHLUMBERGER B 1200 99db UHF ATTENUATOR. £55·00

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PLESSEY PR 524 DUAL DIVERSITY RECEIVER. Solid state, six pre-selected channels with motorised tuning, automatic receiver selection and indication. Complete with FSK terminal unit and spare coils for turret tuners. All housed in table top cabinet. **£100·00**

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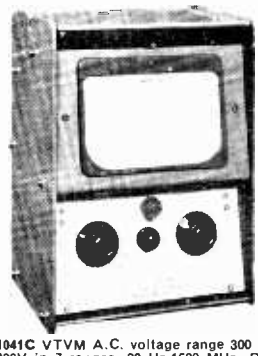
TF 1102 AMPLITUDE MODULATOR Amplitude modulates at up to 80% the C.W. or F.M. output of any signal generator with a frequency range of 100kHz to 500MHz. Input waveforms to the modulator may be: sine, square, pulse or picture at any level up to H1 impedance, Mod level monitored on panel meter. **£40·00**

Open 9-12.30, 1.30-5.30 p.m. except Thursday 9-1 p.m.



TF1041C VTVM A.C. voltage range 300 MV to 300V in 7 ranges, 20 Hz-1500 MHz. D.C. voltage ranges 300 MV 1000V in 8 ranges. D.C. resistance 50 ohms to 500 ohms. Price **£62·50.**
TF 1041B. Spec. as for 1041C. **£52·50.**

HEWLETT—PACKARD
185A 800 MHz SAMPLING OSCILLOSCOPE WITH 188A DUAL TRACE PLUG-IN. Full spec. and P.O.A.
175A 50MHz Oscilloscope.
5248 COUNTER FREQUENCY MEASUREMENT: 10Hz to 10.1MH2. Accuracy : 1 count. Automatic positioning of decimal point. Period measurement: 0-10kHz, reads in seconds, milliseconds or microseconds, decimal point automatically positioned. Display on 6 neon lamp decades and 2 meters. Complete with manual and following plug-ins: **525A** 10 to 100MHz. **525B** 100 to 220MHz. **526A** video amplifier. Price on application.
616B SHF SIGNAL GENERATOR. Freq. range 1.75GHz-4.2GHz, Mod.: F.M., C.W. Pulse and Ext. A.M., output 0.1uV-200mW. Price on application.

PLEASE ADD 10% VAT TO ALL ORDERS

TF 1258A VHF SPECTRUM ANALYSER for analysis and measurement of Radar Equipment. Frequency range 190 to 230MHz with crystal check points. Sweep width 0·5 to 5MHz, output pulse delay (a) 85-175 μSec, (b) 0·7-1·4 mSec with ×1 and ×2 multiplier and ÷2, ×1, ×2 multiplier. Output 2μV to 20mV with ×10 multiplier. **£200.**

TF 1370 R-C OSCILLATOR, SQUARE AND SINE WAVE. Freq: Sinewave 10Hz-10MHz, squarewave 10Hz-100kHz. Direct output: sinewave: 0-31.6V rms., 10Hz-1MHz, squarewave: 0-73.2pp 10Hz-100kHz. Attenuator range: −50dB to +10dB. Impedance: 75, 100, 600Ω. Price upon application

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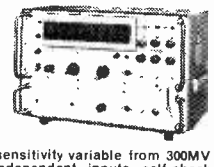
TF 1400S DOUBLE PULSE GENERATOR WITH TM 6600/S SECONDARY PULSE UNIT. For testing radar, nucleonics, 'scopes, counters, filters etc. **SPEC. TF 1400S.** Rep. freq. 10Hz to 100kHz, pulse width 0·1 to 100μ sec., delay −1·5 to +3000μ sec., rise time 30N sec. **SPEC. TM 6600/S.** As for TF1400S except pulse width 0·5 to 25μ sec., delay 0 to +300μ sec. **£230.**

TF 526B OSCILLATOR AND DETECTOR UNIT £50·00.

TF 1226B, TF1225A, TF 577A. WHITE NOISE TEST SET £185·00. Full spec. on request.

BEST PRICES PAID FOR TEST AND COMMUNICATION EQUIPMENT. Single items or quantities. Private or Industrial.

RACAL UNIVERSAL COUNTER/TIMER SA550 (CT488)
8 digit In-line read-out. Facilities include: direct frequency measurement up to 100MHz; pulse, period, ratio, time interval and totalising measurements. Input sensitivity variable from 300MV to 9V, three independent inputs, self-check etc. Full spec. on request. **£145.**



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RCA ET **4336** also modified version of increased output to 700w.
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AR88 SPARES. We hold the largest stock in U.K. Write for list.

R.F. METER 0-8 amp. 2½" (U.S.A.) **£1·80** P. & P. 15p. ..

29/41FT. AERIALS each consisting of ten 3ft., ¾in. dia. tubular screw-in sections. 11ft. (6-section) whip aerial with adaptor to fit the 7in. rod, insulated base, stay plate and stay assemblies, pegs, reamer, hammer, etc. Absolutely brand new and complete ready to erect, in canvas bag. **£7·50** new or **£4·50** slightly used. Carriage **£1·50.**

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50 line AUTOMATIC PRIVATE TELEPHONE SWITCHBOARD

Price of each of the above on application.

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EnCase ENVIRONMENTAL HOUSING

A cleverly designed protected polycarbonate enclosure: weatherproof, hoseproof and damp and dust protecting. Its high impact strength will withstand rough handling. The seven sizes can interconnect and any case will extend vertically or horizontally or both, while maintaining full protection. Send for new catalogue.

Encase includes chassis, retaining screws, cover, gasket and cover-retaining screws; also includes P. & P. and VAT. Many extras available, incl. hinges, etc.

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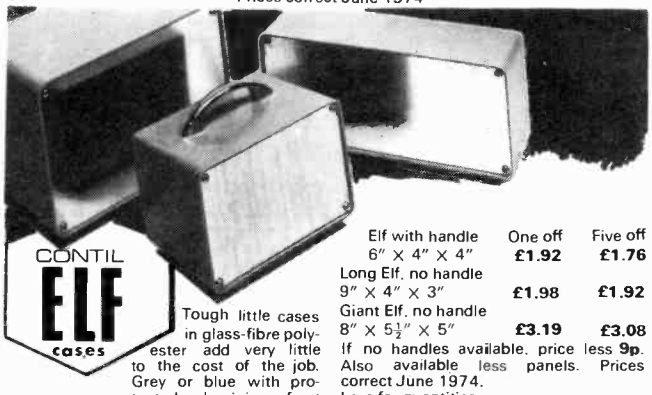
ENG	22″ × 15″ × 7″	**£21.18**

Prices correct June 1974



CONTIL ELF cases

Tough little cases in glass-fibre polyester add very little to the cost of the job. Grey or blue with protected aluminium front panel (16 s.w.g.).

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Elf with handle 6″ × 4″ × 4″	**£1.92**	**£1.76**
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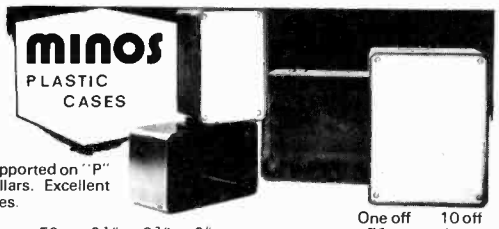
If no handles available, price less **9p**. Also available less panels. Prices correct June 1974. Less for quantities. Prices include feet, P. & P. and VAT.

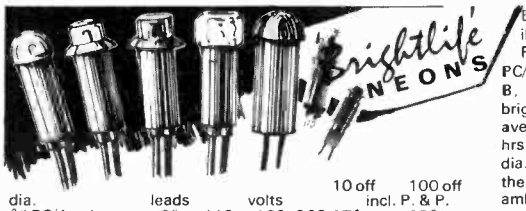
MINOS PLASTIC CASES



A smart miniature case in tough, rigid, high-gloss black ABS. Front panels in either aluminium or white PVC/Steel. Built-in slots for PC cards, dividers, or screens. Chassis or PC boards can be supported on "P" clips for internal pillars. Excellent as encapsulation boxes.

	One off	10 off
M2 65mm × 100mm × 50mm 2½″ × 3¾″ × 2″	**51p**	**45p**
M3 100mm × 130mm × 50mm 3¾″ × 5″ × 2″	**67p**	**58p**

Prices include P. & P. and VAT. Less for quantities. Also available without panel and screws. Prices correct June 1974. Minimum order £1

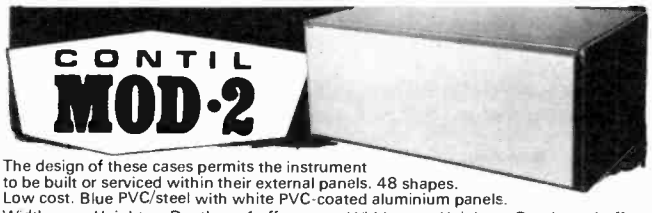


Brightlife neons, illustrated are PC/A or C, PC/F, PC/G or I, PP/A or B, Q & S, are brighter and give an average of 25,000 hrs life. The 0·5″ dia. are red or white, the 0·375″ are red, amber or white: these have three cap shapes and all may be supplied for 115, 240V or the PP neons in 110, 240 and 440V, with 6″ or 30″ leads.

dia.	leads	volts	10 off incl. P. & P.	100 off incl. P. & P.
½″ PC/A to I	6″	110 or 160–260	**17½p**	**16½p**
½″ PC/A to I	30″	110 or 160–260	**19½p**	**18½p**
½″ PP/A	6″	110 or 160–260	**17½p**	**16½p**
½″ PP/A	30″	110 or 160–260	**19½p**	**18½p**
Q type	none	110 or 160–260	**29p**	**27p**
S type	none	—	**23p**	**21p**

Add 10% VAT. Min. quantity each type ten off. Send for details in new catalogue. Prices Correct June 1974.

CONTIL MOD·2



The design of these cases permits the instrument to be built or serviced within their external panels. 48 shapes. Low cost. Blue PVC/steel with white PVC-coated aluminium panels.

	Width	Height	Depth	1 off		Width	Height	Depth	1 off
A	4·5″	3″	6·5″	**£3.60**	M	4·5″	3″	13″	**£4.44**
B	4·5″	7″	6·5″	**£4.44**	N	4·5″	7″	13″	**£5.44**
C	4·5″	10″	6·5″	**£4.91**	O	4·5″	10″	13″	**£6.91**
D	9″	3″	6·5″	**£4.91**	P	9″	3″	13″	**£5.44**
E	9″	7″	6·5″	**£5.44**	Q	9″	7″	13″	**£6.91**
F	9″	10″	6·5″	**£6.28**	R	9″	10″	13″	**£8.41**
G	13″	3″	6·5″	**£5.44**	S	13″	3″	13″	**£6.91**
H	13″	7″	6·5″	**£6.28**	T	13″	7″	13″	**£8.41**
I	13″	10″	6·5″	**£6.91**	U	13″	10″	13″	**£10.20**
J	18″	3″	6·5″	**£6.28**	V	18″	3″	13″	**£8.41**
K	18″	7″	6·5″	**£8.41**	W	18″	7″	13″	**£10.20**
L	18″	10″	6·5″	**£10.20**	X	18″	10″	13″	**£12.21**

Woodgrain D @ **£5.44**, E & G @ **£6.28**, H @ **£6.91**.
Prices include screws, rubber feet, one or two chassis according to size, and P. & P. and VAT.
Prices correct June 1974.

WEST HYDE

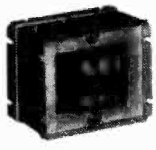
WEST HYDE DEVELOPMENTS Ltd, Ryefield Cres., Northwood Hills, Northwood, Middx HA6 1NN.
Tel: Northwood 24941/26732 *Write or 'phone for new free catalogue.* Telex: 923231

WW—104 FOR FURTHER DETAILS

TRANSFORMERS

SAFETY MAINS ISOLATING TRANSFORMERS
Pri 120/240V Sec 120/240V Centre Tapped & Screened

Ref. No.	VA (Watts)	Weight lb	Weight oz	Size cm.	£	P & P p
07	20	1	8	7·0× 7·0× 6·0	2·55	30
149	60	3	12	9·9× 7·7× 8·6	3·79	36
150	100	5	8	9·9× 8·9× 8·6	4·17	52
151	200	8	0	12·1× 9·3×10·2	7·09	52
152	250	13	12	12·1×11·8×10·2	9·25	67
153	350	15	0	14·0×10·8×11·8	12·32	82
154	500	19	8	14·0×13·4×11·8	17·87	*
155	750	29	0	17·2×14·0×14·0	24·31	*
156	1000	38	0	17·2×16·6×14·0	29·87	*
158	2000	60	0	21·6×15·3×18·1	49·25	*
159	3000	85	0	23·5×17·8×19·7	76·53	*
160	6000	78	0	35·0×20·4×29·3	125·89	*



AUTO TRANSFORMERS

Ref. No.	VA (Watts)	Weight lb	Weight oz	Size cm.	Auto Taps	£	P & P p
113	20	1	0	5·8× 5·1× 4·5	0-115-210-240	1·34	22
64	75	2	4	7·0× 6·7 ×6·1	0-115-210-240	2·64	36
4	150	3	4	8·9× 7·7× 7·7	0-115-200-220-240	3·18	36
66	300	6	4	9·9× 9·6× 8·6	" "	6·19	52
67	500	12	8	12·1×11·2×10·2	" "	9·20	67
84	1000	19	8	14·0×13·4×14·3	" "	16·71	82
93	1500	30	4	14·0×15·9×14·3	" "	24·19	*
95	2000	32	0	17·2×16·6×14·0	" "	31·57	*
73	3000	40	0	21·6×13·4×18·1	" "	39·17	*

CASED AUTO TRANSFORMERS
115V 500VA cased transformer, with mains lead and two 115V outlet sockets, £9·49. P & P 67p. A 20 Watt version. £2·02. P & P 22p.

LOW VOLTAGE TRANSFORMERS
PRIMARY 200-250 VOLTS 12 AND/OR 24 VOLT RANGE

Ref. No.	Amps. 12V	Amps. 24V	Weight lb	Weight oz	Size cm.	Secondary Windings	£	P & P p
111	0·5	0·25		8	4·8× 2·9× 3·5	0-12V at 0·25A×2	1·34	22
213	1·0	0·5	1	4	6·1× 5·8× 4·8	0-12V at 0·5A×2	1·58	22
71	2	1	1	12	7·0× 6·4× 6·1	0-12V at 1A×2	2·09	22
18	4	2	2	12	8·3× 7·7× 7·0	0-12V at 2A×2	2·95	36
70	6	3	3	8	8·9× 8·0× 7·7	0-12V at 3A×2	3·52	42
108	8	4	5	8	9·9× 8·9× 8·6	0-12V at 4A×2	3·96	52
72	10	5	6	4	9·9× 9·6× 8·6	0-12V at 5A×2	4·67	52
116	12	6	6	12	9·9×10·2×8·6	0-12V at 5A×2	5·61	52
17	16	8	8	12	12·1× 9·9×10·2	0-12V at 8A×2	7·22	52
115	20	10	18	8	14·0× 9·6×11·8	0-12V at 10A×2	9·20	67
187	30	15	15	8	14·0×12·1×11·8	0-12V at 15A×2	16·94	82
226	60	30	32	0	17·2×15·3×14·0	0-12V at 30A×2	31·28	*

30 VOLT RANGE

Ref No.	Amps.	Weight lb	Weight oz	Size cm.	Secondary Taps	£	P & P p
112	0·5	1	4	6·1× 5·8× 4·8	0-12-15-20-24-30V	1·58	22
79	1·0	2	4	7·0× 6·7× 6·1	" "	2·11	36
3	2·0	3	4	8·9× 7·7× 7·7	" "	3·18	36
20	3·0	4	8	9·9× 8·3× 8·6	" "	3·96	42
21	4·0	6	4	9·9× 9·6× 8·6	" "	4·67	52
51	5·0	6	12	12·1× 8·6×10·2	" "	5·83	52
117	6·0	8	0	12·1× 9·3×10·2	" "	6·94	52
88	8·0	12	0	12·1×11·8×10·2	" "	9·00	67
89	10·0	13	12	14·0×10·2×11·8	" "	11·36	67

50 VOLT RANGE

Ref. No.	Amps.	Weight lb	Weight oz	Size cm.	Secondary Taps	£	P & P p
102	0·5	1	12	7·0× 6·4× 6·1	0-19-25-33-40-50V	2·09	30
103	1·0	2	12	8·3× 7·4× 7·0	" "	3·08	36
104	2·0	5	8	9·9× 8·9× 8·6	" "	4·26	42
105	3·0	6	12	9·9×10·2× 8·6	" "	5·79	52
106	4·0	10	0	12·1×10·5×10·2	" "	7·69	* 52
107	6·0	12	0	14·0×10·2×11·8	" "	11·38	67
118	8·0	18	0	14·0×12·7×11·8	" "	12·40	97
119	10·0	25	0	17·2×12·7×14·0	" "	18·62	*

60 VOLT RANGE

Ref. No.	Amps.	Weight lb	Weight oz	Size cm.		£	P & P p
124	0·5	2	4	7·0× 6·7× 6·1	0-24-30-40-48-60V	2·12	36
126	1·0	3	4	8·9× 7·7× 7·7	" "	2·97	36
127	2·0	6	4	9·9× 9·6× 8·6	" "	4·67	42
125	3·0	8	12	12·1× 9·9×10·2	" "	7·11	52
123	4·0	13	12	12·1×11·8×10·2	" "	9·20	67
40	5·0	12	00	14·0×10·2×11·8	" "	10·83	67
120	6·0	15	8	14·0×12·1×11·8	" "	13·35	82
121	8·0	25	00	14·0×14·7×11·8	" "	15·01	*
122	10·0	25	0	17·2×12·7×14·0	" "	22·10	*
189	12·0	29	00	17·2×14·0×14·0	" "	24·74	*

MINIATURE TRANSFORMERS WITH SCREENS

Ref. No.	MA	Weight lb	Weight oz	Size cm.	VOLTS	£	P & P p
238	200		2	2·8×2·6×2·0	3-0-3	1·44	10
212	1A 1A	1	4	6·1×5·8×4·8	0-6 0-6	1·67	22
13	100		4	3·9×2·6×2·9	9-0-9	1·23	10
235	330, 330		4	4·8×2·9×3·5	0-9, 0-9	1·67	10
207	500, 500	1	00	6·1×5·4×4·8	0-8-9, 0-8-9	2·23	22
208	1A, 1A	1	12	7·0×6·4×6·1	0-8-9, 0-8-9	3·00	30
236	200, 200		4	4·8×2·9×3·5	0-15, 0-15	1·67	10
214	300, 300	1	4	6·1×5·8×4·8	0-20, 0-20	1·76	22
221	700 (D.C.)	1	8	7·0×6·1×6·1	20-12-0-12-20	1·55	30
206	1A, 1A	2	12	8·3×7·7×7·0	0-15-20, 0-15-20	4·05	38
203	500, 500	2	4	8·3×7·0×7·0	0-15-27, 0-15-27	3·10	38
204	1A, 1A	3	4	8·9×7·7×7·7	0-15-27, 0-15-27	3·15	38

BATTERY CHARGER TYPES
PRIMARY 200-250 VOLT (Secondary 2V, 6V, 12V)

Ref. No.	Amps.	Weight lb	Weight oz	Size cm.		£	P & P p
45	1·5	1	8	7·0× 6·1× 6·1	Please note, these units do not include rectifiers	1·61	30
5	4·0	3	4	8·9× 7·7× 7·7		2·93	42
86	6·0	6	4	9·9× 9·6× 8·6		4·40	52
146	8·0	6	12	9·9×10·2× 8·6		5·02	52
50	12·5	12	0	14·0×10·2×11·8		7·53	67

*Carriage via B.R.S.

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AVOMETERS • ELECTROSIL RESISTORS

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SERVOMEX type AC7—30 amps. **£35** ea.
Carriage £1·50

AMERICAN SWEEP GENERATOR type 452. Covers from 5 to 100 MHZ. Has built in display and 101 DB Push Button RF Attenuator in one DB steps, plus Calibrated Marker Generator covering 5 to 100 MHZ continuous. American Government Contract, so quality is high. Supplied for 240V 50 HZ operation with plugs and leads. Size 13½ × 9½ × 19in. Price **£70** each. Carriage £1·50.

AMERICAN SWEEP GENERATOR type TRM 3 15 to 400 MHZ. **£300.**

AMERICAN POWER UNITS STANDARD 230V 50 HZ Input 28V 40 AMP OUTPUT. Size 22 × 16 × 9in. Supplied in original transit case **£25.**

AMERICAN AM GENERATOR type 497. 4 to 400 MHZ. Supplied with leads, etc., for 240V 50 HZ operation **£35.**

12″ LONG PERSISTANCE TUBES
Ideal for SSTV; educational purposes. Type 12DP7A. Connections, voltages etc. Brand New Boxed **£7·50** each including carriage and VAT.

SPECIAL 40 MHZ SCOPE SOLARTRON CD1212 ONLY £50. Has to be a snag. There is—no plug—in Y amps available. TB-100 nanosecs per cm. to 5 secs. per cm. In 24 calibrated ranges. 20 nanosecs per cm. with times 5 expansion. 5″ flat faced tube. Trace locator. 0-2 microsec. signal delay. Built in calibrator. 1 KHZ square wave. 200 micro volts to 100 volts in 18 calibrated ranges. Tube sensitivity 3 V/CM MAIN FRAM Y AMP boosts this to better than 200mV per cm. at 40 MHZ. 240V. 50 HZ input. Complete with full manual including plug-in circuits. Come and see one working or Carriage £1·50.

SINGLE TRACE 40 MHZ PLUG-INS for CD1212 oscilloscopes now available at £25 ea. P. & P. 75p.

***STILL at £42·50**
Solartron CD 711S.2 Double Beam Oscilloscope DC—9 mc/s; 3 mv/cm; trigger delay; crystal calibrator; 4″ flat faced tube. In good working condition. Carr. **£1·50.**

SOLARTRON CD 523 Single Beam Oscilloscope 3db at 10 MHZ; 1mV max sensitivity. DC coupled down to 1 vol. 4in. flat faced PDA tube. TB from 1 secs. per cm. to 0·1 microsecs. per cm. plus times 5 expansion **£50.**

MARCONI TF 195M-0/40 KHZ Sine Wave Generator 0/40 Volts output Metered. These must go **£7·25.**

MARCONI TF 801B. AM SIGNAL GENERATOR. 12 to 470 MHZ. In good working condition **£90.**

MARCONI TF 938 (CT44). Absorption Wattmeter 10mW to 6 Watts. Input impedance 2·5 ohms to 20K ohms. Freq. response flat at 20KHZ. Calibrated in volts and dbs. 5in. mirror backed meter **£7·50** ea. P. & P. 75p.

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MARCONI TF 428C. Measures AC 100MV to 150V 20HZ to 15 MHZ. Measures DC 40MV to 300V. Complete with probe. Standard 240V operation **£12·50** each.

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MARCONI VVM TF 1300. Measures AC 50MV to 100V, 20 HZ to 300 MHZ, DC 100MV to 300V. Ohms 50 to 5 Meg Ohm. In fine condition **£18** each.

E.H.T. TRANSFORMERS, e.g. 5KV at 0.125 Amps and others. All 240 volts input.

BRAND NEW AMERICAN HIGH VOLTAGE CAPACITORS. 0·15mfd 120kV working. **£20** each. Carriage at cost.

MODERN TELEPHONES type 706. Two tone grey. **£3·75** ea. Two-tone green **£3·75** ea. Black **£3·75** ea. P. & P. 25p ea.

Ideal **EXTENSION** Telephones with standard GPO type dial, bell and lead coding. **£1·75** ea. P. & P. 25p.

All telephones complete with bell and dial.

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MORGANITE Special Brand new, 2·5; 10; 100; 250; 500K; 1 in. sealed, **17p** ea.

BERCO 2½ Watt. Brand new, 5; 10; 50; 250; ohms; 1; 2·5; 10; 25; 50K at **15p** ea.

STANDARD 2 meg. log pots. Current type **15p** ea.

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ALMA precision resistors 200K; 400K; 497K; 998K; 1 meg—0·1% **27p** ea.; 3·25k, 5·6k, 13k-0·1% **20p** ea.

CAPACITORS. Brand New. 10,000mfd 50V 60p ea. P & P 15p.

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TRIMMER PACK, 2 Twin 50/200 pf ceramic; 2 Twin 10/60 pf ceramic; 2 min strips with 4 preset 5/20 pf on each; 3 air spaced preset 30/100 pf on ceramic base. ALL BRAND NEW **25p** the LOT. P. & P. 10p.

ROTARY SWITCH PACK—6 Brand New switches (1 ceramic; 1-4 pole 2 way etc.), **50p.** P. & P. 20p.

FLAT FACED 4″ Twin Beam Tube. Type CV2193. (Cossor 89D). Green Trace Brand New. **£4** each. P & P 37p.

C.R.T.'s 5″ type CV1385/ACR13. Brand new with spec. sheet. **63p** ea. P. & P. 35p.

TUBE type VCR138 **£2** ea. P. & P. 37p. Numetal shields **60p** ea.

BASES for CV1385 or VCR138 **20p** ea. P. & P. 15p.

GRATICULES. 12 cm. by 14 cm. in High Quality plastic. **15p** each. P. & P. 5p.

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ELECTROSTATIC VOLTMETERS from 0–300 Volts to 0–10KV. S.A.E. with your requirements.

FIBRE GLASS PRINTED CIRCUIT BOARD. Brand new. Single sided up to 2½″ wide × 15″ **1p** per sq. in. Larger pieces **1p** per sq. in. Double sided. Any size **1p** per sq. in. Postage 10p per order.

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METERS by SIFAM type M 42. 25–0–25 micro amp. Scaled 25–0–25 green; 250–0–250 red; linear. As new. **£3·50** ea. P. & P. 37p.

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OTHER BLOCK PAPER CAPACITORS AVAILABLE. S.A.E. with requirements.

PHOTOCELL equivalent OCP 71, **13p** ea.

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From As New to well used condition. Price from **£275** (Main frame).

TEKTRONIX 502A OSCILLOSCOPES

Brand New. Guaranteed.
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Type 175A. Dual 50MHz **£275** each.

5 VOLT ½ AMP LOGIC (I.C's) POWER SUPPLY
Standard Mains Input. **£2·75** each.
P. & P. 25p.

MAKE YOUR SINGLE BEAM SCOPE INTO A DOUBLE WITH OUR NEW LOW PRICED SOLID STATE SWITCH.
2 HZ to 8 MHZ. Hook up a 9 volt battery and connect to your scope and have two traces for ONLY **£5·50.** P. & P. 25p.
STILL AVAILABLE our 20 MHZ version at **£9·25.** P. & P. 25p.

20HZ to 200KHZ SINE AND SQUARE WAVE GENERATOR

In four ranges. Wien bridge oscillator thermistor stabilised. Separate independent sine and square wave amplitude controls. 3V max sine, 6V max square outputs. Completely assembled P.C. Board, ready to use. 9 to 12V supply required. **£7·85** each. P & P 25p. Sine Wave only **£5·85** each. P & P 25p.

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12V to 1·5 KV 2MA. Size 1½ x 2½ x 4in. Multi tapped secondary and output level control makes possible large range of voltage and current output combinations without modification. Very flexible unit at **£2·95** each. P. & P. 25p.

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5 MHZ to 150 MHZ (Useful harmonics up to 1·5 GMZ) up to 15 MHZ sweep width. Only 3 controls, preset RF level, sweep width and frequency. Ideal for 10·7 or TV IF alignment, filters, receivers. Can be used with any general purpose scope. Full instructions supplied. Connect 6·3V AC and use within minutes of receiving.
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TRANSISTORS

Type	Price	Type	Price	Type	Price (£)	Type	Price (£)	Type	Price (£)
AC107	0·35	BC148	0·12	BF125	0·25	BU205	1·98	2N3794	0·20
AC117	0·24	BC149	0·14	BF127	0·30	BU207	3·00	2N3819	0·35
AC126	0·25	BC152	0·25	BF158	0·25	BU208	3·15	2N3823	1·45
AC127	0·25	BC153	0·20	BF159	0·27	BU209	2·55	2N3904	0·16
AC128	0·25	BC154	0·20	BF160	0·22	CRS1/40	0·45	2N3905	0·18
AC141K	0·27	BC157	0·15	BF161	0·45	CRS3/40	0·55	2N3906	0·15
AC142K	0·19	BC158	0·13	BF163	0·45	ME6002	0·17	2N4036	0·52
AC154	0·20	BC159	0·15	BF167	0·25	ME8001	0·18	2N4046	0·35
AC176	0·25	BC167B	0·15	BF173	0·25	MJE340	0·68	2N4289	0·20
AC187	0·25	BC168B	0·13	BF177	0·30	MJE341	0·72	2N4291	0·18
AC188	0·25	BC169C	0·13	BF178	0·33	MJE370	0·65	2N4292	0·20
AC193K	0·30	BC170	0·15	BF179	0·33	MJE520	0·85	2N5296	0·37
AC194K	0·32	BC171	0·15	BF180	0·35	MJE521	0·95	2N5298	0·38
ACY39	0·68	BC172	0·14	BF181	0·33	MJE2955	1·20	2N5457	0·30
AD140	0·50	BC173	0·20	BF183	0·44	MJE3055	0·74	2N5458	0·35
AD142	0·52	BC176	0·22	BF184	0·26	MPF102	0·40	2N6027	0·65
AD149	0·50	BC177	0·20	BF185	0·26	OC28	0·65		
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AF239	0·40	BC261	0·28	BF256	0·45	OC171	0·30		
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AL102	1·10	BC300	0·58	BF258	0·66	R2008B	2·05		
AL103	1·10	BC303	0·60	BF259	0·93	R2010B	2·10		
AU103	1·40	BC308	0·10	BF263	0·70	TIP31A	0·65		
AU110	1·10	BC309	0·15	BF337	0·35	TIP32A	0·67		
BC107	0·12	BC360	0·95	BF596	0·70	TIS43	0·30		
BC108	0·12	BCY33	0·36	BFT43	0·55	2N706	0·12		
BC108B	0·13	BD115	0·65	BFW10	0·55	2N706A	0·15		
BC109	0·13	BD123	0·98	BFX29	0·30	2N916	0·20		
BC109C	0·14	BD124	0·80	BFX30	0·35	2N918	0·42		
BC113	0·13	BD131	0·45	BFX84	0·25	2N1304	0·21		
BC114	0·20	BD132	0·50	BFX85	0·26	2N1305	0·21		
BC115	0·20	BD135	0·40	BFX88	0·24	2N2646	0·53		
BC116	0·20	BD136	0·46	BFY50	0·25	2N2904	0·22		
BC117	0·20	BD137	0·48	BFY51	0·23	2N2904A	0·26		
BC125	0·22	BD138	0·50	BFY52	0·23	2N2905	0·72		
BC126	0·20	BD139	0·55	BFY90	0·70	2N2926G	0·13		
BC132	0·15	BD140	0·62	BPX25	1·65	2N2926Y	0·12		
BC134	0·20	BD234	0·75	BPX29	1·60	2N3019	0·75		
BC135	0·15	BDX18	1·45	BPX52	1·90	2N3053	0·21		
BC136	0·20	BDX32	2·55	BRY39	0·40	2N3054	0·55		
BC137	0·20	BDY18	1·78	BSY54	0·50	2N3055	0·60		
BC138	0·20	BDY20	0·99	BSY56	0·80	2N3391A	0·23		
BC142	0·30	BFI15	0·20	BT106	0·99	2N3706	0·10		
BC143	0·35	BFI21	0·25	BU105/02	1·95	2N3771	1·70		
BC147B	0·13	BFI23	0·28	BU108	3·25	2N3772	1·90		
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THYRISTORS, TRIACS AND TRIACS WITH TRIGGER

IF	VRM: 50V	100V	200V	400V	600V
1·6A	20/—/—	23/26/27	25/28/30	35/38/40	45/52/55
3A	—/—/—	—/28/30	—/34/36	—/50/52	—/66/70
4A	26/—/—	30/—/—	38/—/—	60/—/—	75/—/—
6A	29/—/—	33/44/46	42/56/58	68/80/84	80/100/105
8A	32/—/—	38/50/52	47/64/67	75/92/97	90/114/120
10A	36/—/—	42/60/63	51/74/78	84/104/109	100/128/134
16A	—/—/—	—/82/90	—/88/95	—/132/140	—/175/185

Notes: All prices are in pence per unit. First price in each group is thyristor, second is triac, third is triac with trigger. Encapsulation depends on current rating and device type. Connection data supplied with each device. Quantity enquiries welcomed.

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400mW 3·0-33V. **12p** each.
1W 3·3-100V **18p** each.

MINIATURE BRIDGE RECTIFIERS

PIV	2A	4A	6A
50V	0·35	0·38	0·43
100V	0·38	0·43	0·49
200V	0·41	0·48	0·60
400V	0·45	0·60	0·71

INTEGRATED CIRCUITS

Type	Price (£)	Type	Price (£)
CA3065	1·90	TBA530Q	1·98
MCI310P	2·94	TBA540	2·20
MCI351P	0·75	TBA540Q	2·21
MCI358PQ	1·80	TBA550Q	3·29
MC3051P	0·58	TBA560C	2·71
TAA300	1·46	TBA570	1·17
TAA320	0·94	TBA673	1·80
TAA350	1·54	TBA700	1·90
TAA450	1·85	TBA720Q	2·20
TAA570	1·39	TBA750Q	1·54
TAA550	0·49	TBA800	1·75
TAA630Q	3·29	TBA920Q	3·29
TAA700	3·30	TBA990	3·29
TAA840	1·64	TBA990Q	3·29
TAD100	1·42	TCA270Q	3·30
TBA240A	0·88	SL917B	3·80
TBA480Q	1·24	PA263	1·63
TBA520Q	2·72	ZN414	1·25
TBA530	1·98	MFC4060A	0·70

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¼W Iskra high stability carbon film—very low noise—capless construction. ¼W Mullard CR25 carbon film—very small body size 7·5 x 2·5 mm. ¼W 2% ELECTROSIL TR5.

Power watts	Tolerance	Range	Values available	Price 1–99	Price 100+
¼	5%	4·7Ω–2·2MΩ	E24	1.3p	1·1p
¼	10%	3·3MΩ–10MΩ	E12	1.3p	1·1p
½	2%	10Ω–1MΩ	E24	3·5p	3p
½	10%	1Ω–3·9Ω	E12	1.3p	1·1p
¼	5%	4·7Ω–1MΩ	E12	1.3p	1·1p
4	10%	1Ω–10Ω	E12	8p	7p

Quantity price applies for any selection. Ignore fractions on total order.

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0·5 watt 5% Iskra resistors 5 off each value 4·7Ω to 1MΩ.
E12 pack 325 resistors **£2·40**. E24 pack 650 resistors **£4·70**.

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Carbon track 5kΩ to 2MΩ, log or linear (log ¼W, lin ¼W).
Single, **14p**. Dual gang (stereo), **49p**. Single D.P. switch, **28p**.

SKELETON PRESET POTENTIOMETERS

Linear: 100, 250, 500Ω and decades to 5MΩ. Horizontal or vertical P.C. mounting (0·1 matrix).
Sub-miniature 0·1W, **5p** each. Miniature 0·25W, **7p** each.

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The GDI is the world's first semiconductor that can convert a concentration of gas or smoke into an electrical signal. The sensor decreases its electrical resistance when it absorbs deoxidizing or combustible gases such as hydrogen, carbon monoxide, methane, propane, alcohol, North Sea gas, as well as carbon-dust containing air or smoke. This decrease is usually large enough to be utilized without amplification. Full details and circuits are supplied with each detector.
Detector GDI, **£2**. Kit of parts for mains operated detector including GDI but excluding case, **£5.60**. Suitable case **£1.50**. Kit of parts for 12 or 24V battery operation, including GDI and P.C. Board, **£7.70**. As above for PP9 battery **£6.90**. NOTE: The battery operated kits incorporate our patented circuit to minimise battery-drain typically 90mA for 24V.

PRINTED BOARD MARKER 97p

Draw the planned circuit on to a copper laminate board with the P.C. Pen, allow to dry, and immerse the board in the etchant. On removal the circuit remains in high relief.

MULLARD POLYESTER CAPACITORS C296 SERIES

400V: 0·001μF, 0·0015μF, 0·0022μF, 0·0033μF, 0·0047μF, **3p**. 0·0068μF, 0·01μF, 0·015μF, 0·022μF, 0·033μF, **3½p**. 0·047μF, 0·068μF, 0·1μF, **5p**. 0·15μF, **6p**. 0·22μF, **7½p**. 0·33μF, **11p**. 0·47μF, **13p**.
160V: 0·01μF, 0·015μF, 0·022μF, 0·033μF, 0·047μF, 0·068μF, **3p**. 0·1μF, **3½p**. 0·15μF, **4½p**. 0·22μF, **5p**. 0·33μF, **6p**. 0·47μF, **7½p**. 0·68μF, **11p**. 1·0μF, **13p**.

MULLARD POLYESTER CAPACITORS C280 SERIES

250V P.C. mounting: 0·01μF, 0·015μF, 0·022μF, **3p**. 0·033μF, 0·047μF, 0·068μF. **3½p**. 0·1μF, **4p**. 0·15μF, 0·22μF, **5p**. 0·33μF, **6½p**. 0·47μF, **8½p**. 0·68μF, **11p**. 1·0μF, **13p**. 1·5μF, **20p**. 2·2μF, **24p**.

MYLAR FILM CAPACITORS 100V
0·001μF, 0·002μF, 0·005μF, 0·01μF, 0·02μF, **3p**. 0·04μF, 0·05μF. 0·068μF, 0·1μF. **4p**.

CERAMIC DISC CAPACITORS
100pF to 10,000pF, **2p** each.

ELECTROLYTIC CAPACITORS—MULLARD 015/6/7

(μF/v) 1/63, 1·5/63, 2·2/63, 3·3/63, 4·7/63, 6·8/40, 6·8/63, 10/25, 10/63, 15/16, 15/40, 15/63, 22/10, 22/25, 22/63, 33/6·3, 33/16, 33/40, 47/4, 47/10, 47/25, 47/40, 68/6·3, 68/16, 100/4, 100/10, 100/25, 150/6·3, 150/16, 220/4, 220/6·3, 220/16, 330/4, **6p**. 47/63, 100/40, 150/25, 220/25, 330/10, 470/6·3, **7p**. 68/63, 150/40, 220/40, 330/16, 1000/4, **10p**. 470/10, 680/6·3, **11p**. 100/63, 150/63, 220/63, 1000/10, **12p**. 470/25, 680/16, 1500/6·3, **13p**. 470/40, 680/25, 1000/16, 1500/10, 2200/6·3, **18p**. 330/63, 680/40, 1000/25, 1500/16, 2200/10, 3300/6·3, 4700/4, **21p**.

SOLID TANTALUM BEAD CAPACITORS 12p

0·1μF	35V	2·2μF	35V	22μF	16V
0·22μF	35V	4·7μF	35V	33μF	10V
0·47μF	35V	6·8μF	25V	47μF	6·3V
1·0μF	35V	10μF	25V	100μF	3V

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	0·1	0·15
2½ x 3¾	24p	20p
2½ x 5	28p	28p
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3¾ x 5	32p	32p
17 x 2½	85p	67p
17 x 3¾	120p	108p
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Pkt. 50 pins	20p	20p

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2 pin, 3 pin, 5 pin 180°, 5 pin 240°, 6 pin, 7 pin
Plug 12p. Socket 8p.
4 way screened cable, **25p**/metre.
6 way screened cable, **30p**/metre.

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2N457A	1·35	2N4037	0·42	BC147	0·12	BF246	0·43
2N490	3·16	2N4058	0·16	BC148	0·13	BF247	0·23
2N491	3·58	2N4059	0·09	BC149	0·12	BF254	0·16
2N492	3·99	2N4060	0·11	BC153	0·18	BF255	0·17
2N493	4·20	2N4061	0·11	BC154	0·18	BF257	0·46
2N696	0·15	2N4062	0·11	BC157	0·14	BF258	0·59
2N697	0·15	2N4126	0·20	BC158	0·13	BF259	0·55
2N698	0·25	2N4289	0·13	BC159	0·14	BFS21A	2·30
2N699	0·29	2N4919	0·84	BC160	0·37	BFS28	0·92
2N706	0·16	2N4920	0·98	BC167B	0·13	BFS61	0·27
2N706A	0·18	2N4921	0·73	BC168B	0·13	BFS98	0·20
2N708	0·14	2N4922	0·84	BC168C	0·11	BFX29	0·30
2N709	0·38	2N4923	0·83	BC169B	0·13	BFX30	0·25
2N711	0·30	2N5172	0·12	BC169C	0·13	BFX44	0·33
2N718	0·21	2N5174	0·22	BC170	0·11	BFX63	2·48
2N718A	0·49	2N5175	0·26	BC171	0·13	BFX68	0·30
2N720	0·50	2N5176	0·32	BC172	0·11	BFX84	0·24
2N721	0·55	2N5190	0·92	BC182	0·12	BFX85	0·30
2N914	0·22	2N5191	0·95	BC182L	0·12	BFX87	0·28
2N916	0·41	2N5192	1·24	BC183	0·09	BFX88	0·25
2N918	0·47	2N5195	1·46	BC183L	0·09	BFX89	0·45
2N929	0·30	2N5245	0·43	BC184	0·11	BFY18	0·35
2N1302	0·19	2N5457	0·49	BC184L	0·11	BFY19	0·35
2N1303	0·19	2N5458	0·45	BC186	0·25	BFY20	0·50
2N1304	0·24	2N5459	0·49	BC187	0·27	BFY29	0·40
2N1305	0·24	40361	0·48	BC207	0·12	BFY50	0·23
2N1306	0·31	40362	0·50	BC208	0·11	BFY51	0·19
2N1307	0·22	40363	0·61	BC212K	0·10	BFY52	0·21
2N1308	0·25	40389	0·46	BC212L	0·16	BFY53	0·16
2N1309	0·36	40394	0·56	BC214L	0·21	BFY90	0·60
2N1671	1·44	40395	0·65	BC237	0·09	BRY39	0·48
2N1671A	1·54	40406	0·44	BC238	0·09	BU104	1·42
2N1671B	1·72	40407	0·33	BC239	0·09	BU105	2·25
2N1671C	4·32	40408	0·50	BC251	0·20	C106A	0·46
2N1711	0·45	40409	0·52	BC252	0·18	C106B	0·55
2N1907	5·50	40410	0·52	BC253	0·23	C106D	0·65
2N2102	0·50	40411	2·25	BC257	0·09	C106E	0·43
2N2147	0·70	40414	3·55	BC258	0·09	CA3020A	1·80
2N2148	0·94	40430	0·85	BC259	0·13	CA3046	0·70
2N2160	0·60	40583	0·23	BC261	0·20	CA3048	2·11
2N2192	0·40	40601	0·67	BC262	0·18	CA3089E	1·96
2N2192A	0·40	40602	0·46	BC263	0·23	CA30900	4·23
2N2913	0·40	40603	0·53	BC300	2·12	LM301A	0·48
2N2193A	0·61	40604	0·56	BC301	0·34	LM304A	2·03
2N2194	0·73	40636	1·10	BC302	0·29	LM309K	1·88
2N2194A	0·30	40669	1·00	BC303	0·54	LM702C	0·75
2N2218A	0·60	40673	0·70	BC307	0·10	LM709T099	0·48
2N2219	0·45	AC107	0·25	BC307A	0·10	8DIL	0·38
2N2219A	0·60	AC113	0·16	BC308	0·09	14DIL	0·33
2N2220	0·45	AC117	0·20	BC308A	0·12	LM723C	0·75
2N2221	0·41	AC126	0·25	BC308B	0·09	LM741T099	0·40
2N2221A	0·40	AC127	0·25	BC309	0·10	8DIL	0·46
2N2222	0·40	AC128	0·25	BC309A	0·10	14DIL	0·38
2N2222A	0·50	AC151V	0·14	BC309B	0·10	LM747	1·00
2N2368	0·31	AC152V	0·17	BC237	0·21	LM74880IL	0·60
2N2369	0·37	AC153	0·25	BC238	0·19	14DIL	0·73
2N2369	0·41	AC153K	0·25	BC337	0·19	MC1303p	1·26
2N2646	0·77	AC154	0·20	BC338	0·19	MC131D	2·92
2N2647	1·12	AC176	0·18	BC30	0·43	MC1458CP1	0·79
2N2904	0·55	AC176K	0·25	BCY31	0·52	MJ480	0·90
2N2904A	0·70	AC187K	0·23	BCY32	1·15	MJ481	1·14
2N2905	0·48	AC188K	0·34	BCY33	0·34	MJ490	0·98
2N2905A	0·50	ACY18	0·24	BCY34	0·37	MJ491	1·38
2N2906	0·31	ACY19	0·27	BCY38	0·53	MJE340	0·42
2N2906A	0·37	ACY20	0·22	BCY39	1·05	MJE2955	1·12
2N2907	0·40	ACY21	0·26	BCY40	0·87	MJE3055	0·68
2N2907A	0·45	ACY28	0·20	BCY42	0·15	MP8111	0·32
2N2926	0·11	ACY30	0·42	BCY58	0·21	MP8112	0·40
2N3053	0·32	AD142	0·50	BCY59	0·22	MP8113	0·47
2N3054	0·60	AD143	0·45	BCY70	0·17	MPF102	0·39
2N3055	0·75	AD149V	0·66	BCY71	0·22	MPSA05	0·25
2N3390	0·26	AD150	0·63	BCY72	0·13	MPSA06	0·26
2N3391	0·23	AD161	0·45	BD87	3·54	MPSA55	0·26
2N3391A	0·29	AD162	0·45	BD88	2·42	MPSA56	0·27
2N3392	0·13	AD161 }	pr	BD89	0·97	NE555V	0·90
2N3393	0·13	AD162 }	1·05	BD115	0·75	NE560	4·48
2N3394	0·13	AF109R	0·40	BD116	0·75	NE561	4·48
2N3402	0·18	AF115	0·24	BD121	0·75	NE565A	4·48
2N3403	0·19	AF116	0·25	BD123	0·32	OC23	0·56
2N3440	0·59	AF117	0·20	BD124	0·67	OC28	0·76
2N3441	0·97	AF118	0·50	BD131	0·40	OC35	0·60
2N3442	1·69	AF124	0·24	BD132	0·50	OC42	0·35
2N3414	0·10	AF125	0·20	BD135	0·43	OC45	0·32
2N3415	0·10	AF126	0·19	BD136	0·49	OC71	0·12
2N3416	0·15	AF127	0·20	BD137	0·55	OC72	0·13
2N3417	0·21	AF139	0·39	BD138	0·63	OC81	0·20
2N3638	0·15	AF170	0·25	BD139	0·71	OC83	0·20
2N3638A	0·15	AF172	0·25	BD140	0·87	ORP12	0·50
2N3639	0·27	AF178	0·55	BDY20	1·05	SC350	1·68
2N3641	0·17	AF179	0·65	BF115	0·25	SC360	1·46
2N3702	0·11	AF180	0·50	BF116	0·23	SC40D	1·89
2N3703	0·12	AF186	0·40	BF117	0·43	SC410	1·32
2N3704	0·14	AF200	0·35	BF119	0·58	SC45D	1·89
2N3705	0·12	AF239	0·51	BF121	0·25	SC460	1·96
2N3706	0·09	AF240	0·72	BF123	0·27	SC50D	2·60
2N3707	0·13	AF279	0·54	BF125	0·25	SC51D	2·39
2N3708	0·70	AF280	0·54	BF152	0·20	SL414A	1·80
2N3709	0·11	AL102	0·75	BF153	0·21	SL623	4·59
2N3710	0·12	AL103	0·70	BF154	0·16	TAA263	0·70
2N3711	0·11	BC107	0·16	BF158	0·23	TAA350	2·10
2N3712	0·96	BC108	0·15	BF159	0·27	TAA621	2·83
2N3713	1·20	BC109	0·19	BF160	0·23	TAA661B	1·32
2N3714	1·33	BC113	0·13	BF161	0·42	TAD100	1·50
2N3715	1·50	BC115	0·15	BF163	0·32	Filter	0·70
2N3716	1·80	BC116	0·15	BF166	0·32	TBA271	0·64
2N3771	2·20	BC116A	0·18	BF167	0·21	TBA641B	2·25
2N3772	1·80	BC117	0·21	BF173	0·24	TBA800	1·50
2N3773	2·65	BC118	0·11	BF177	0·29	TBA810	1·50
2N3779	3·15	BC119	0·29	BF178	0·35	TIL209	0·35
2N3790	2·40	BC121	0·23	BF179	0·43	TIP29A	0·49
2N3791	2·35	BC125	0·15	BF180	0·35	TIP30A	0·58
2N3792	2·69	BC126	0·20	BF181	0·34	TIP31A	0·62
2N3794	0·10	BC132	0·30	BF182	0·40	TIP32A	0·74
2N3819	0·37	BC134	0·11	BF183	0·40	TIP33A	1·01
2N3820	0·38	BC135	0·11	BF184	0·30	TIP34A	1·51
2N3823	1·42	BC136	0·15	BF185	0·17	TIP35A	2·90
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2N3904	0·27	BC141	0·29	BF197	0·15	TIP2955	0·93
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2N1304	22p	2N5457	36p
2N1613	20p	2S001	3·00
2N1671	1·00	2S026	8·90
2N2147	75p	2S303	70p
2N2160	69p	40250	45p
2N2926	10p	40361	45p
2N3053	20p	40362	40p
2N3054	45p	40408	50p
2N3055	45p	40486	75p
2N3440	50p	40636	1·00
2N3442	1·10	40430	85p
2N3525	80p		
2N3614	59p		
2N3702	11p		

TRIACS

Stnd. mounting with accessories

3 AMP RANGE

Type	P.I.V.	1-11 Price Each
SC35A	100v	80p
SC35B	200v	85p
SC35D	400v	90p
SC35E	500v	£1·20

6 AMP RANGE

SC40A	100v	90p
SC40B	200v	95p
SC40D	400v	£1·20
SC40E	500v	£1·50

10 AMP RANGE

SC45A	100v	£1·05
SC45B	200v	£1·15
SC45D	400v	£1·45
SC45E	500v	£1·85

15 AMP RANGE

SC50A	100v	£1·45
SC50B	200v	£1·65
SC50D	400v	£1·95
SC50E	500v	£2·25

TRIACS Additional Types

40430	TRIAC (T066)	85p
40669	TRIAC (Plastic)	90p
40486	TRIAC (T05)	75p

3 Amp T048

15 Amp T048

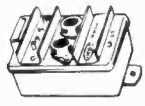
SILICON CONTROLLED RECTIFIERS

Type	1-11
ONE AMP (T05) P.I.V.	
CRS 1/05AF	50v 30p
CRS 1/10AF	100v 30p
CRS 1/20AF	200v 35p
CRS 1/40AF	400v 45p
CRS 1/60AF	600v 55p
THREE AMP (T048)	
CRS 3/05AF	50v 40p
CRS 3/10AF	100v 40p
CRS 3/20AF	200v 45p
CRS 3/40AF	400v 55p
CRS 3/60AF	600v 65p
FIVE AMP	
CRS 5/400	400v 60p
SEVEN AMP (T048)	
CRS 7/100	100v 60p
CRS 7/200	200v 67p
CRS 7/400	400v 85p
CRS 7/600	600v 95p
SIXTEEN AMP (T043)	
CRS 16/100	100v 70p
CRS 16/200	200v 75p
CRS 16/400	400v 85p
CRS 16/600	600v £1·10

EASY TO BUILD KITS BY AMTROM

—EVERYTHING SUPPLIED

Model No.		
310	Radio control receiver	3·29
300	4-channel R/C transmitter	6·61
345	Superhet R/C receiver	6·61
65	Simple transistor tester	1·66
115	8 watt Amplifier	4·50
120	12 watt amplifier	4·73
125	Stereo control unit	6·61
130	Mono control unit	4·16
605	Power supply for 115	5·31
610	Power supply for 120	5·31
615	Power supply for 2 x 120	6·64
230	AM/FM aerial amplifier	3·29
240	Auto packing light	6·90
275	Mic. preamplifier	6·98
570S	LF generator 10Hz-1mHz	21·45
575S	Sq. wave generator 20Hz-20Khz	19·77
590	SWR meter	9·47
630	STAB Power supply 6-12v 0·25-0-1A	9·24
690	DC motor speed Gov.	3·31
700	Electronic Chaffinch	7·92
760	Acoustic switch	12·57
780	Metal Detector (electronics only)	10·91
790	Capacitive Burglar alarm	7·92
835	Guitar preamp.	4·99
840	Delay car alarm	6·99
875	CAP. Discharge Ignition for car engine (-Ve Earth)	13·99
80	Scope Calibrator	2·65
255	Level indicator	6·98
525	120-160mHz VHF timer	11·31
715	Photo cell switch	8·97
795	Electronic continuity tester	4·97
860	Photo timer	15·51
235	Acoustic Alarm for driver	8·61
465	Quartz XTAL checker	9·90
220	Signal Injector	2·30
390	Vox	15·50
432	Testakit	19·30
670	Buffer Battery Charger	6·55
885	Capacitive Contact Alarm	6·25
850	Electronic Keyer	18·75
820	Electronic Digital Clock	58·50



ALL KITS OFFERED SUBJECT TO STOCK AVAILABILITY
Prices correct at time of preparation. Subject to change without notice.

EXCLUSIVE—SPECIAL OFFERS!

MW/LW CAR RADIO + or — Earth with speakers and fixings. £6·50 carr/packg 30p.
8 TRACK CAR STEREO (— Earth) with speakers, In pods and fixings £12·50 carr/packg 40p.
PORTABLE BATTERY CASSETTE TAPE PLAYER £7·25
CAR LIGHTER PLUG and ADAPTOR for all cassette and radio 6/7½/9 volt output (state width) £1·95 each.
ROTEL STEREOPHONES RH630 £6·80; RH700 £10·25; RH430 £4·14.
AKAI GXC40
Stereo cassette recorder £59·95 carr/packg 50p.
Pair Akai ADM microphones £6·95 carr/packg 20p
WEIN WS00 BATTERY/MAINS CASSETTE RECORDER £12·75
PORTABLE CASSETTE TAPE
Player—for car or carry around. £7·25 carr/packg 20p.

HANIMAX BC808 POCKET CALCULATOR WITH % KEY £28·95.
HANIMAX BC811M Memory Version £33·75
STEREO COMPACT RECORD PLAYER 2×7 watts. Complete with speakers (List £54·50) Price £39·95 Plus free pair of stereo phones.

NEW RANGES

BRIDGE RECTIFIERS

FEATURES SMALL SIZE AND LOW COST. Sizes are approximate.

250M/A QUARTER AMP

B025/05	50 PIV	16p
B025/10	100 PIV	18p

¼ x ¼ x ¼" dia.

½ AMP 1-11 Pricing

Type	P.I.V.	Price ea.
B05/05	50v	20p
B05/10	100v	22p
B05/20	200v	23p
B05/40	400v	25p
B05/60	600v	27p

½H x ½L x ⅜" dia.

1 AMP P.I.V.

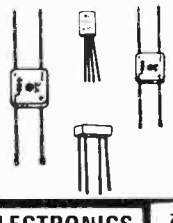
B1/05	50v	25p
B1/10	100v	25p
B1/20	200v	28p
B1/60	600v	30p

½H x ½L x ⅜" dia.

1 AMP P.I.V.

W005	50v	29p
W01	100v	30p
W02	200v	32p
W06	600v	35p

¾ x ¾" Tubular



2 AMPS P.I.V.

B2/05	50v	35p
B2/10	100v	40p
B2/20	200v	45p
B2/60	600v	50p
B2/100	1000v	55p

½H x ½L x ⅜" dia.

4 AMPS P.I.V.

B4/100	100v	55p
B4/200	200v	59p
B4/400	400v	65p
B4/600	600v	75p
B4/800	800v	£1·00

½H x ½L x ⅜" dia.

6 AMPS P.I.V.

B6/05	50v	65p
B6/10	100v	70p
B6/20	200v	80p
B6/40	400v	90p
B6/6x0	600v	£1·00

½H x ½L x ⅜" dia.

All prices correct at time of press 10% VAT to be added to all orders (UK only) Export & UK Manufacturers/ Colleges supplied. E.&O.E.

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All types of Transistors Rectifiers—Bridges SCR's—Triacs Integrated Circuits F.E.T.—Light Devices

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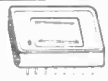
TBA800 5 WATT IC
Suitable alternative to SL403D 5/30 volt operated. 8/16 OHM 5 watt output. With circuits and data £1·50. Complete with printed circuit boards and components £2·75.

Sinclair IC12
with circuits and data. 6 watt IC with printed circuit board. 28 volt. operated. £2·00

ZN414 IC
Integrated circuit radio as featured by many magazines (P.W Jan. 73 Reprint Ref. No. 19 for 10p). £1·20.

STROBE TUBE ZFT4A. Suitable for Dec. '73 Pract. Electronics £3·00
ST2 (D32) DIAC 25p
CRS1/40 SCR 45p
ZFT4 £3·00
ZFT8 £3·50

Ultrasonic Transducers
Operate at 40Khz up to 100 yds. Ideal remote switching and signalling. Complete with data transmitter and receiver new I.C circuits. Per pair £5·90. TA960 with socket £1·80



3015F 7 SEG.
I.C. size complete with data price £1·70 each (digital clock circuits ref. No. 31, 15p).

TIL209 LED 24p ea. 22p ea. per 10

BUILD YOURSELF A POCKET CALCULATOR

A complete kit, packaged in a polystyrene container and taking about 3 hours to assemble—that's the Sinclair Cambridge pocket calculator from Henry's. Some of the many features include interface chip, thick-film resistor pack, printed circuit board, electronic components pack. Size 4¾" long x 2" wide x ⅝" deep.
Free of charge with the kit for the more advanced technologist is a 32-page booklet explaining how to calculate Logs, Tangents, Sines etc.

Price £19·95 + VAT Also available assembled ready to use £22·50 + VAT.

LIVING SOUND LOW NOISE TOP QUALITY CASSETTES MADE BY EMI TAPES LTD TO INTERNATIONAL STANDARDS ESPECIALLY FOR HENRY'S. ALL POST PAID LESS THAN ½ REC. PRICES. COMPLETE WITH LIBRARY CASES.

	3 for	6 for	10 for	25 for
C 60	£1·10	£1·98	£3·00	£7·40
C 90	£1·46	£2·80	£4·60	£11·25
C 120	£1·80	£3·45	£5·50	£13·45

Quantity and trade enquiries invited.

LEARN A LANGUAGE—complete with phrase book. German—French—Spanish—Italian £1·36 per course. £5 for any 4.

A SELECTION OF INTERESTING ITEMS

3025	Compact transistor tester	£6·95 p & p 15p
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D1203	Teleamp. with PU coil	£4·95 p & p 20p
LL1	Door intercomm. and chime	£8·40 p & p 25p
US50	Ultrasonic Switch transmitter/receiver	£12·75
1 Kw Dimmer/controller		£3·00 p & p 10p
9" Twin spring unit	For	£3·30 p & p 15p
16" Twin spring unit	Reverbs	£6·85 p & p 25p
VHF 105 Aircraft Band Convertor		£4·50 p & p 15p
B2005 4 Ch. mic. mixer		£4·20 p & p 15p
B2004 2 ch. Stereo mixer		£6·75 p & p 15p
PK3 kit. Etch your own printed circuits		£1·95 p & p 20p.
C3041	1-250 MHz	£4·25
C3043	50H 1-300 MHz	£5·75

Henry's RADIO LIMITED
EDGWARE ROAD, W2

ELECTRONICS FOR EVERY PURPOSE
See facing page for addresses

ZENER DIODES
400 m/w BZY88/BZX83. From 3·3 volt—33 volts 10p each.
1·3 watts 5% Miniature Tubulars IN4700 series. From 3·3 volt—33 volt 18p each.
10 watts. Stnd. Mounting. ZS series 6·8 volts—100 volts 5% 40p each.

SILICON RECTIFIERS
1 amp series IN4001 to IN4007. From 6p ea
1·5 amp PL4001 to PL4007 from 8p ea
3 amp PL7001/IN5400 From 14p ea
Send for full list 36.

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Hi Fi and Transistors – Up to date Brochures on request

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Due to rapid price changes, shortages of paper and raw materials, all prices in the existing catalogues no longer apply. Call or phone for latest prices. A new catalogue will be available for Aug/Sept. 1974.

You pay less VAT with Henry's Low Prices

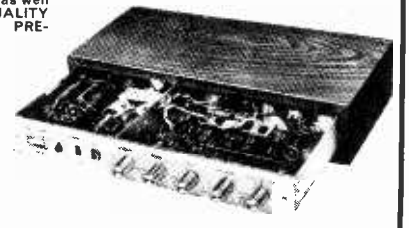
Now built and used by thousands of satisfied customers. Features slim design overall size in cabinet 15¼" x 2¾" x 6¾" 6-IC's, 10 transistors, stabilisers Gardners low field transformer. Fibre Glass PC Panel, complete chassis work. Now available built and tested as well as in kit form. HIGH QUALITY AND STABILITY ARE PRE-DOMINATE FEATURES — DEVELOPED BY TEXAS ENGINEERS FOR PERFORMANCE, RELIABILITY ANDEASE OF CONSTRUCTION FACILITIES.

On/off switch indicator, headphones socket, separate treble, bass, volume and balance controls, scratch and rumble filters, mono/stereo switch. Input selector: Mag. P.U., Radio Tuner, Aux. Can be altered for Mic., Tape, Tape-head, etc. Constructional details Ref. No. 21 **30p.** Distributed by Henry's throughout UK.

FREE — Teak cabinet with complete kit.

BUILD THE TEXAN

20 + 20WATT IC STEREO AMPLIFIER
As featured by *Practical Wireless* 1972



Kit Price £28·50 (+VAT+50p carr/packing) or built and tested **£35·00** (+VAT+50p carr/packing), as illustrated.

BUILD THE NEW HENELEC STEREO FM TUNER

A completely new high stability stereo FM tuner. Features variable capacity diode tuning, stabiliser power supply, IC Decoder, high gain low noise. IF stages, LED indicators. Tuning meter, AFC, eas to construct and use. Mains operated. Slim modern design with fibre glass PC, teak cabinet etc. Available as a kit to build or ready built. Overall size 8" x 2¾"×6¾". Produced to give high performance with a realistic price. (Parts list and constructional details Ref. No. 5 30p.) Henry's are sole distributors UK and Europe.

Kit price
£21·00 (+VAT)
OR BUILT AND TESTED **£24·95** (+VAT)

EARN YOURSELF EASY MONEY, WITH PORTABLE DISCO EQUIPMENT

DISCO MINI A complete portable disco, fitted mixer/preamp, 2 decks all facilities **£98·50**
As above but with Slider Controls **£118·50**
100 watt amplifier for above **£49·50**
SDLS100 100 watt mixer/amplifier with slider controls **£89·00**
R50 50 watt mixer/amplifier **£49·50**
R100 100 watt mixer/amplifier **£57·50**
DISCO AMP 100 watt mixer/amplifier **£73·00**
NORTHCOURT
400, 40 watt Mixer Amplifier **£37·50**
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DISCO MIXER/PREAMPLIFIERS (OP for up to 6-100 watt amplifiers)
SDLI (rotary controls) **£49·50**
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DISCO VOX (slider controls) the complete disco preamp **£72·00**
DJ100 100 watt power amplifier for above **£49·50**
DJ30L Mk II 3 channel, 3 kW sound to light **£41 25**
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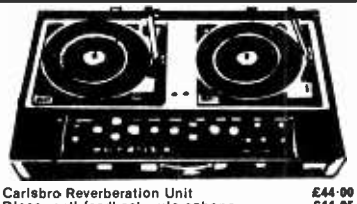
DJ DISCLITE As 30L/II +Variable speed flashes **£54·00**



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150 watt QI cassette wheel projector **£50·00**
Spare Effects and Liquid cassettes large range of patterns **£6·00**
6in. Liquid wheels **£5·50**. Various Cassettes **£6·00**
Mini spot bank fitted 3 lamps **£12·95**
Auto Trilite (mini with flashers) **£17·00**
Bubblemaker with 1 gall. Liquid **£22·50**
Mixer/Misc/Speakers/Lighting UK's largest range. **FREE** stock list ref. No. 18 on request.
AKG/RESLO/DJ/CARLSBRO/EAGLE Mics, Stands, Mixers, Cabinets, Chassis and complete Speaker Systems. Megaphones, Turntables, Public Address Components.

LOW COST HI-FI SPEAKERS

SPECIAL OFFERS
EMI 13" x 8"—full range speakers (post 20p each or 30p pair)
*150TC—8 ohms Twin Cone 10 watt **£2·20** each or **£4·00** pair.
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350 20 watt C/o Tweeters 8 or 15 ohms **£7·80** ea.
* Polished wood cabinet **£4·60** post 35p.

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20-2	8"	30 watt	**£24·50** pair
20-3	8"	40 watt	**£35·95** pair
LINTON 2		20 watt	**£18·30** pair
GLENDALE 3		30 watt	**£32·95** pair
DOVEDALE 3		50 watt	**£51·50** pair
KEF KK2			**£55·00** pair
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TEST EQUIPMENT

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(carr. etc. 30p)

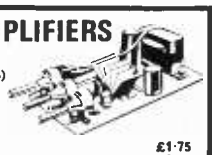
ITI-2	20K/V Slimline deluxe with case	**£5·95**
	20K/Volt Slimline	**£6·75**
TLH33D	2K/Volt Robust with case	**£7·50**
U4323	+IF 8AF·OSC	**£7·00**
AF105	50K/Volt	**£12·50**
U4313	20K/Volt AC current. Steel case	**£10·50**
U4341	Plus Built in transistor tester	**£10·50**
Model 500 30K/Volt (case **£2.25**)		**£11·75**

OTHER EQUIPMENT

SE250B	Pocket Signal Injector	2·25 carr. 15p
TE15	Grid Dip meter 440kHz-280mHz	16·50 carr. 30p
TE40	AC Millivoltmeter 1·2mHz	19·75 carr. 35p
TE65	28 Range valve voltmeter	22·50 carr. 40p
TE20D	120kHz-500mHz RF Generator	18·95 carr. 40p
TE22D	20Hz-200kHz Audio Generator	19·95 carr. 40p
SE350A	Deluxe Signal Tracer	12·95 carr. 20p
SE400	Volts/ohms/R-C sub./RF field/RF gen.	15·50 carr. 20p

MINIATURE AMPLIFIERS

AMPLIFIERS (carr. etc. 20p)



4-300, 0·3 watt 9 volt	**£1·75**
104, 1 watt 9 volt	**£3·10**
304, 3 watt 9 volt	**£3·95**
555, 3 watt 12 volt	**£4·10**
E1208, 5 watt 12 volt	**£5·10**
608, 10 watt 24 volt	**£4·95**
410, 10 watt 28 volt	**£4·95**
E1206, 30 watt 45 volt	**£9·75**
E1210, 2½ + 2½ watts 12 volt	**£8·25**
RE500, 5 watt IC mains operated Amplifier with controls	**£6·30**
SAC14, 7 + 7 watt Stereo with controls	**£11·75**
SAC13, 15 + 15 watt Stereo with controls	**£14·95**
SP40-5 2Z40/Stereo 80/P25	**£25·00**
SP40-6 2Z40/Stereo 80/P26	**£27·75**
SP60 2Z60/Stereo 80/P28	**£30·45**
Transformer PZB	**£3.95**

NEW SINCLAIR PROJECT 80

Stereo Pre-Amplifier	**£11·95**
Audio Filter Unit	**£6·95**
2Z40 15 watt Amplifier	**£5·45**
2Z60 25 watt Amplifier	**£6·95**
PZ5 Mod. for 1 on 2 Z40	**£4·98**
PZ6 Mod. (S Tab) 1 on 2 Z40	**£7·98**
PZ8 Mod. (S Tab) 1 on 2 Z60	**£7·98**
TRANSFORMER FOR PZ8	**£3·95**
NEW FM TUNER STEREO DECODER	**£11·95** **£7·45**

All items post paid.

SPECIAL PURCHASES

UHF TV TUNERS CHANNELS 21 TO 64
Brand new transistorised geared tuners for 625 line Receiver IF output. **£2·50** post 20p.

All types offered subject to availability. Price correct at time of procf. E. & O. E. Subject to change without notice. 10% VAT to be added to all orders. Export Supplied.

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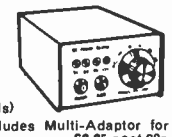
FIBRE OPTICS

0·01 diam. Mono Filament **£5·50** per 100 metre reel.
0·13 diam. 64 Fibres Sheathed. **£1·00** per metre.
SPRAYS 15mm. diam. Mares Tails. **£9·50**

POWER SUPPLIES FOR EVERY PURPOSE

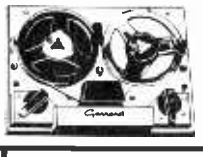
(All cased unless stated chassis)



470C 6/7½/9 volt 300 MA (includes Multi-Adaptor for Tape Recorders, etc.)	**£2·25** post 20p
Car Lighter Voltage Adaptors 300mA (State voltage 6v, 7½v, 9v)	**£1·95** ea. post 25p
SC202 3/6/7½/9 volt 400mA	**£4·25** carr. 30p
HC244R Stabilised version	**£5·50** carr. 30p
P500 9 volt 500mA	**£3·20** post 20p
P11 24 volt 500mA (chassis)	**£2·90** post 20p
P15 26/28 volt 1 amp (chassis)	**£2·90** post 20p
P1080 12v 1 amp (chassis)	**£4·70** post 20p
P1081 45v 0·9 amp (chassis)	**£7·80** post 20p
P12 4½-12 volt 0·4-1 amp	**£7·15** post 30p
SE101A 3/6/9/12 volt 1 amp (Stab.)	**£12·75** post 25p
RP164 6/7½/9/12 1 amp (Stab.)	**£13·45** post 30p

GARRARD BATTERY TAPE DECK

GARRARD 2 speed 9 volt tape decks. Fitted record/play and oscillator/Erase heads. Wind and rewind controls. Takes up to 4" spools. Brand new complete with head circuits. **£9·50** carr. 30p.



TOP QUALITY SLIDER CONTROLS

60mm stroke high quality controls complete with knobs (post etc., 15p any quantity).
Singles Log and Lin 5K, 10K, 22K, 50K, 100K, 250K, 500K, 1 Meg, **45p** each.
Ganged Log and Lin 10K, 22K, 50K, 100K, 250K, **65p** each. (Quantity discounts available.) Complete with knobs.

MARRIOT TAPE HEADS

4 TRACK MONO or 2 TRACK STEREO. '17' High Impedance **£2·50**. '18' Medium Impedance **£3·50**. '36' **£5·00**. R730/E73 2 track mono Record/Erase, low imp. **75p** pair. Erase Heads for '17', '18' and '36' **£1·00**. '63' 2 track mono HI imp. **£1·75**. '43' Erase Head for '63' 75p. (Post etc., 15p any quantity.)

NEW REVOLUTIONARY SUPER TESTER 680R

The complete testing system

Volts AC=11 ranges from 2V to 2500V
Volts DC=13 ranges from 100mV to 2KV
Amp DC=12 ranges from 500A to 10A
Amp AC=10 ranges from 200μA to 5A
Ohms=6 ranges from one tenth of Ohm to 100MΩ
Reactance=1 range from 0 to 10MΩ
Capacity=6 ranges from 0 to 500pF and from 0 to 0·5μF and from 0 to 50·000pF
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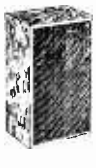

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C10	15	Assorted Pots & Pre-Sets	0·55
C11	5	Jack Sockets 3 × 3·5m Standard Switch Type 2 ×	0·55
C12	40	Paper Condensers preferred types mixed valued	0·55
C13	20	Electrolytics Trans. types	0·55
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets etc.	0·55
C15	4	Mains Slide Switches, 2 Amp	0·55
C16	20	Assorted Tag Strips & Panels	0·55
C17	10	Assorted Control Knobs	0·55
C18	4	Rotary Wave Change Switches	0·55
C19	3	Relays 6-24V Operating	0·55
C20	4	Sheets Copper Laminate approx. 10" × 7"	0·55

PLUGS AND SOCKETS

SOCKETS

PS 35 DIN	2 Pin (Speaker)	0·06
PS 36 DIN	3 Pin	0·10
PS 37 DIN	5 Pin 180°	0·10
PS 38 DIN	5 Pin 240°	0·10
PS 39	Jack 2·5mm Switched	0·09
PS 40	Jack 3·5mm Switched	0·10
PS 41	Jack ¼" Switched	0·17
PS 42	Jack Stereo Switched	0·26
PS 43	Phono Single	0·06
PS 44	Phono Double	0·10
PS 45	Car Aerial	0·09
PS 46	Co-Axial Surface	0·09
PS 47	Co-Axial Flush	0·14

INLINE SOCKETS

PS 21	D.I.N. 2 Pin (Speaker)	0·13
PS 22	D.I.N. 3 Pin	0·17
PS 23	D.I.N. 5 Pin 180°	0·17
PS 24	D.I.N. 5 Pin 240°	0·17
PS 25	Jack 2·5mm Plastic	0·10
PS 26	Jack 3·5mm Plastic	0·12
PS 27	Jack ¼" Plastic	0·24
PS 28	Jack ¼" Screened	0·28
PS 29	Jack Stereo Plastic	0·22
PS 30	Jack Stereo Screened	0·32
PS 31	Phono Screened	0·14
PS 32	Car Aerial	0·15
PS 33	Co-Axial	0·17

PLUGS

PS 1	D.I.N. 2 Pin (Speaker)	0·11
PS 2	D.I.N. 3 Pin	0·12
PS 3	D.I.N. 4 Pin	0·15
PS 4	D.I.N. 5 Pin 180°	0·14
PS 5	D.I.N. 5 Pin 240°	0·15
PS 6	D.I.N. 6 Pin	0·15
PS 7	D.I.N. 7 Pin	0·15
PS 8	Jack 2·5mm Screened	0·10
PS 9	Jack 3·5mm Plastic	0·09
PS 10	Jack 3·5mm Screened	0·12
PS 11	Jack ¼" Plastic	0·13
PS 12	Jack ¼" Screened	0·18
PS 13	Jack Stereo Screened	0·29
PS 14	Phono	0·06
PS 15	Car Aerial	0·15
PS 16	Co-Axial	0·10

CABLES

CP 1	Single Lapped Screen	0·06
CP 2	Twin Common Screen	0·08
CP 3	Stereo Screened	0·08
CP 4	Four Core Common Screen	0·23
PC 5	Four Core Individually Screened	0·30
CP 6	Microphone Fully Braided Cable	0·10
CP 7	Three Core Mains Cable	0·07
CP 8	Twin Oval Mains Cable	0·06
CP 9	Speaker Cable	0·04
CP 10	Low Loss Co-Axial	0·10

CARBON POTENTIOMETERS

Log and Lin
4·7K, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M

VC 1	Single Less Switch	0·14
VC 2	Single D.P. Switch	0·26
VC 3	Tandem Less Switch	0·44
VC 4	1K Lin Less Switch	0·14
VC 5	100K Log anti-Log	0·14

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Type	Amps	Price	P ★ P
MT50/½	½	£1·93	30p
MT50/1	1	£2·42	35p
MT50/2	2	£3·30	40p

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Model No.		Price
UK65	Simple transistor tester	£ 1·88
UK145	Amplifier 1·5W	£ 4·37
UK220	Signal Injector	£ 3·13
UK230	AM/FM Antenna Amplifier	£ 3·88
UK275	Mike Pre-amplifier	£ 8·3
UK300	4-channel Radio Control Transmitter	£ 7·85
UK310	Radio Control Receiver	£ 3·93
UK325	'GCX2' Channel splitting unit 1,000 & 2,000 Hz	£ 9·44
UK330	'GCX2' Channel splitting unit 1,500 & 2,500 Hz	£ 9·44
UK000	Superhetrodyne Radio Control Receiver	£ 7·85
UK525	VHF Tuner 120 to 160 MHz	£14·93
UK555	Radio Control Field Strength Meter	£12·74
UK705	Windscreen Wiper timer	£ 8·98
UK710	4-Channel AF mixer	£14·68
UK780	Electronics Unit for Metal Detector	£12·74
UK835	Guitar pre-amplifier	£ 5·67
UK875	Capacitive Discharge Electronic Ignition for Internal Combustion Engines	£17·41

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7" E.P. 18¾" × 7" × 8". (50 records) £2·10
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Holds 12. 10" × 3¾" × 5". Lock & Handle £1·30

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Holds 14. 13" × 5" × 6". Lock & Handle. £1·95
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COLOURS: Red, Black and Tan—Please state preference.

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ACOS GP96-1. 100mV at 1cm/sec	£2·65
TTC J-2005. Crystal/Hi Output	95p
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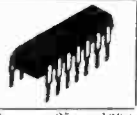
74 Series T.T.L. I.C'S



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	1	25	100+
SN7400	0·18	0·17	0·16
SN7401	0·18	0·17	0·16
SN7402	0·18	0·17	0·16
SN7403	0·18	0·17	0·16
SN7404	0·18	0·17	0·16
SN7405	0·18	0·17	0·16
SN7406	0·39	0·34	0·31
SN7407	0·39	0·34	0·31
SN7408	0·20	0·19	0·18
SN7409	0·20	0·19	0·18
SN7410	0·18	9·17	0·16
SN7411	0·28	0·27	0·26
SN7412	0·35	0·34	0·31
SN7413	0·32	0·31	0·30
SN7416	0·48	0·44	0·42
SN7417	0·48	0·44	0·42
SN7420	0·18	0·17	0·16
SN7422	0·55	0·53	0·50
SN7423	0·55	0·53	0·50
SN7425	0·55	0·53	0·50
SN7426	0·50	0·46	0·44
SN7427	0·50	0·46	0·44
SN7428	0·55	0·53	0·50
SN7430	0·18	0·17	0·16
SN7432	0·50	0·46	0·44
SN7433	0·75	0·73	0·70
SN7437	0·70	0·68	0·65
SN7438	0·70	0·68	0·65
SN7440	0·18	0·17	0·16
SN7441	0·74	0·71	0·64
SN7442	0·64	0·71	0·64
SN7443	£1·20	£1·15	£1·10
SN7444	£1·20	£1·15	£1·10
SN7445	£1·98	£1·95	£1·90
SN7446	£1·20	£1·15	£1·10
SN7447	£1·10	£1·07	£1·05
SN7448	£1·10	£1·07	£1·05
SN7450	0·18	0·17	0·16

	1	25	10+1
SN7451	0·18	0·17	0·16
SN7453	0·18	0·17	0·16
SN7454	0·18	0·17	0·16
SN7460	0·18	0·17	0·16
SN7470	0·32	0·29	0·27
SN7472	0·32	0·29	0·27
SN7473	0·41	0·39	0·35
SN7474	0·41	0·39	0·35
SN7475	0·50	0·48	0·46
SN7476	0·44	0·43	0·42
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SN7485	£3·50	£3·40	£3·30
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SN7492	0·74	0·71	0·64
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SN7494	0·85	0·82	0·75
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SN74100	£1·50	£1·45	£1·40
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SN74156	£1·50	£1·45	£1·35
SN74157	£2·00	£1·90	£1·80
SN74160	£2·10	£2·00	£1·90
SN74161	£2·10	£2·00	£1·90
SN74162	£4·40	£4·15	£3·85
SN74163	£4·40	£4·15	£3·85
SN74164	£2·20	£2·10	£2·00
SN74165	£2·20	£2·10	£2·00
SN74166	£3·20	£3·10	£3·00
SN74174	£2·50	£2·40	£2·30
SN74175	£1·75	£1·65	£1·55
SN74176	£1·85	£1·75	£1·65
SN74177	£1·85	£1·75	£1·65
SN74180	£1·50	£1·40	£1·30
SN74181	£5·00	£4·50	£4·00
SN74182	£2·00	£1·90	£1·75
SN74184	£3·20	£3·10	£3·00
SN74190	£2·15	£2·10	£2·00
SN74191	£2·15	£2·10	£2·00
SN74192	£2·15	£2·10	£2·00
SN74193	£2·15	£2·10	£2·00
SN74194	£2·98	£2·86	£2·75
SN74195	£2·00	£1·95	£1·90
SN74196	£1·95	£1·90	£1·85
SN74197	£1·95	£1·90	£1·85
SN74198	£5·00	£4·75	£4·50
SN74199	£5·00	£4·75	£4·50

Devices may be mixed to qualify for quantity price. (TTL 74 Series only) data is available for the above series of I.C.'s in book form. Price 35p

NOW WE GIVE YOU 50w PEAK (25w R.M.S.) *PLUS* THERMAL PROTECTION! The NEW AL60 Hi-Fi Audio Amplifier FOR ONLY £3.95

- Max Heat Sink temp. 90°C.
- Frequency Response 20Hz to 100KHz
- 0·1% Distortion
- Distortion better than 1% at 1KHz
- Supply voltage 10-35 volts
- Thermal Feedback
- Latest Design Improvements
- Load—3, 4, 8 or 16 ohms
- Signal to noise ratio 80dB
- Overall size 63mm × 105mm . . 13mm

Especially designed to a strict specification. Only the finest components have been used and the latest solid state circuitry incorporated in this powerful little amplifier which should satisfy the most critical A.F. enthusiast.

FULLY BUILT—TESTED and GUARANTEED

STABILISED POWER MODULE SPM80 £3·25

AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including: Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which include Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No.	Contents	Price
UIC00	12 + 7400	0·55
UIC01	12 × 7401	0·55
UIC02	12 × 7402	0·55
UIC03	12 × 7403	0·55
UIC04	12 × 7404	0·55
UIC05	12 × 7405	0·55
UIC06	8 × 7406	0·55
UIC07	8 × 7407	0·55
UIC10	12 × 7410	0·55
UIC20	12 × 7420	0·55
UIC30	12 × 7430	0·55
UIC40	12 × 7440	0·55
UIC41	5 × 7441	0·55
UIC42	5 × 7442	0·55
UIC43	5 × 7443	0·55
UIC44	5 × 7444	0·55
UIC45	5 × 7445	0·55
UIC46	5 × 7446	0·55
UIC48	5 × 7448	0·55
UIC50	12 × 7450	0·55
UIC51	12 × 7451	0·55
UIC53	12 × 7453	0·55
UIC54	12 × 7454	0·55
UIC60	12 × 7460	0·55
UIC70	8 × 7470	0·55
UIC72	8 × 7472	0·55
UIC73	8 × 7473	0·55
UIC74	8 × 7474	0·55
UIC76	8 × 7476	0·55
UIC80	5 × 7480	0·55
UIC81	5 × 7481	0·55
UIC82	5 × 7482	0·55
UIC83	5 × 7483	0·55
UIC86	5 × 7486	0·55
UIC90	5 × 7490	0·55
UIC91	5 × 7491	0·55
UIC92	5 × 7492	0·55
UIC93	5 × 7493	0·55
UIC94	5 × 7494	0·55
UIC95	5 × 7495	0·55
UIC96	5 × 7496	0·55
UIC100	5 × 74100	0·55
UIC121	5 × 74121	0·55
UIC141	5 × 74141	0·55
UIC151	5 × 74151	0·55
UIC154	5 × 74154	0·55
UIC193	5 × 74193	0·55
UIC199	5 × 74199	0·55
UICXI	25 Assorted 74's	1·55

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz–20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
All input voltages are for an output of 250mV.		Input overload	+26dB
Tape and P.U. inputs equalised to RIAA curve		Supply	+35 volts at 20mA
within ±1dB from 20Hz to 20kHz.		Dimensions	292 × 82 × 35 mm

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £25.30 FREE p.&p

only £13·15

LINEAR I.C.'s—FULL SPEC.

Type No.	Case		1	25	100+
72702	DIL	14	0·50	0·48	0·45
72709	DIL	14	0·35	0·33	0·30
72710	DIL	14	0·45	0·43	0·40
72741	DIL	14	0·40	0·38	0·35
72741C	TO-5	8	0·45	0·43	0·40
72741P	DIL	8	0·38	0·36	0·34
72748P	DIL	8	0·38	0·36	0·34
SL201C	TO-5	8	0·50	0·45	0·40
SL701C	TO-5	8	0·50	0·45	0·40
SL702C	TO-5	8	0·50	0·45	0·40
TAA263	TO-72	4	0·80	0·70	0·60
TAA293	TO-74	10	£1·00	0·95	0·90
TAA350A	TO-5	10	£1·85	£1·80	£1·70
μA703C	TO-5	8	0·28	0·26	0·24
μA709C	TO-5	8	0·35	0·32	0·30
μA711	TO-5	10	0·45	0·43	0·40
ZN414	TO-18	4	£1·20	—	—

DTL 930 SERIES LOGIC I.C's

Type	1	25	100+
BP930	0·15	0·14	0·13
BP932	0·16	0·15	0·14
BP933	0·16	0·15	0·14
BP935	0·16	0·15	0·14
BP936	0·16	0·15	0·14
BP944	0·16	0·15	0·14
BP945	0·30	0·28	0·25
BP946	0·15	0·14	0·13
BP948	0·30	0·28	0·25
BP951	0·70	0·65	0·60
BP962	0·15	0·14	0·13
BP9093	0·45	0·43	0·40
BP9094	0·45	0·43	0·40
BP9097	0·45	0·43	0·40
BP9099	0·45	0·43	0·40

DUAL-IN-LINE SOCKETS

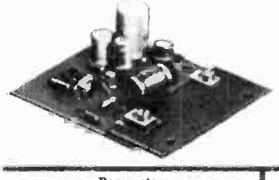
14 & 16 Lead Sockets for use with DUAL-IN-LINE I.C's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1–24	25–99	100up
TSO 14 pin type	33p	30p	27p
TSO 16	38p	35p	32p
TSO 24 pin type	75p	70p	68p
BPS 8 pin type	15p	13p	11p
LOW COST No.			
BPS 14	16p	14p	12p
BPS 16	17p	15p	13p

NUMERICAL INDICATOR TUBES

Type	Description	
3015F	Minitron 7 Segment Indicator	£1·50
MAN 3M	L.E.D. 7 Segment Display 0.127" High Characters	£1·90
CD 66	Side Viewing 'Nixie Type' Tube 16 mm.	£1·87
GR 116	Side Viewing 'Nixie Type' Tube 13 mm.	£1·70

AL10/AL20/AL30 AUDIO AMPLIFIER MODULES



The AL10, AL20 and AL30 units are similar in their appearance and in their general specification. However, careful selection of the plastic power device has resulted in a range of output powers from 3 to 10 watts R.M.S.
The versatility of their design makes them ideal for use in record players, tape recorders, stereo amplifiers and cassette and cartridge tape players in the car and at home.

Parameter	Conditions	Performance
HARMONIC DISTORTION	Po 3 WATTS f 1KHz	0·25%
LOAD IMPEDANCE	—	8–16Ω
INPUT IMPEDANCE	f 1KHz	100 kΩ
FREQUENCY RESPONSE ± 3dB	Po 2 WATTS	50 Hz–25KHz
SENSITIVITY for RATED O/P	Vs 25V, RL 8Ω f 1KHz	75mV. RMS
DIMENSIONS	—	3" × 2½" × 1"

The above table relates to the AL10, AL20 and AL30 modules. The following table outlines the differences in their working conditions.

Parameter	AL10	AL20	AL30
Maximum Supply Voltage	25	30	30
Power output for 2% T.H.D. (RL 8Ω f 1 KHz)	3 watts RMS Min.	5 watts RMS Min.	10 watts RMS Min.
PRICE	£2·20	£2·50	£3·3

3 TERMINAL POSITIVE VOLTAGE REGULATORS

To3 Plastic Encapsulation O/P 1·5 Amps.

μA7805	5V (Equiv. to MVR5V)	£1·76
μA7812	12V (Equiv. to MVR12V)	£1·76

BI-PAK

CATALOGUE & LISTS

Send S.A.E. and 10p

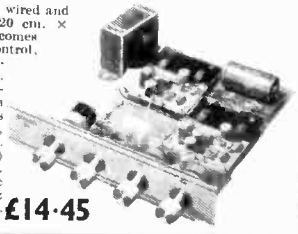
TEAK VENEERED CABINETS for:

STEREO 20
TC 20. £3.95 p&p 30p
MK 50 KIT
TC 100. £6.50 p&p 30p

E.M.I. LEK 350 Loudspeaker System Enclosure kit in teak veneer, including speakers. Rec. retail price £45.50 per pr. OUR SPECIAL PRICE £35.50 per pair P. & P. £1. ONLY WHILE STOCKS LAST!

The STEREO 20

The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm. × 14 cm. × 5·5 cm. This compact unit comes complete with on/off switch volume control, balance, bass and treble controls. Transformer, Power supply and Power amps. Attractively printed front panel and matching control knobs. The 'Stereo 20 has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet. Output power 20w peak. Input 1 (Cer.) 300mV into 1M. Freq. res. 25Hz–25kHz. Input 2 (Aux.) 4mV into 30K. Harmonic distortion. Bass control ±12dB at 60Hz typically 0·25% at 1 watt. Treble control ±14dB at 14kHz.



£14·45

FRONT PANEL, 4 knobs. Headphone Socket, on/off switch and neon for PA100/MK50. FPK100 **£2.95.**

TRANSFORMERS

T461 (Use with AL10) **£1·88** P. & P. 15p.
T838 (Use with AL20) **£1·93** P. & P. 15p.
BMT80 (Use with AL30 & AL50) **£2·15** P. & P. 25p

POWER SUPPLIES

PS 12. (Use with AL10 & AL20) **88p**
SPM 80. (Use with also AL30 & AL50) **£3·25**

PA 12. PRE-AMPLIFIER SPECIFICATION

The PA 12 pre-amplifier has been designed to match into most budget stereo systems. It is compatible with the AL 10, AL 20 and AL 30 audio power amplifiers and it can be supplied from their associated power supplies. There are two stereo inputs, one has been designed for use with *Ceramic cartridge while the auxiliary input will suit most †Magnetic cartridges. Full details are given in the specification table. The four controls are, from left to right: Volume and on/off switch, balance, bass and treble. Size 152mm × 84mm × 35mm

PRICE £4·35

Frequency response— 20Hz–50KHz (—3dB
Bass control ± 12dB at 60H
Treble control— ±14dB at 14KHz
*Input 1. Impedance 1 Meg. ohm Sensitivity 300mV
†Input 2. Impedance 30 K ohms Sensitivity 4mV

FRONT PANELS FP12 with knobs £1·20

All prices inclusive of V.A.T. Giro No. 388 - 7006
Please send all orders direct to warehouse and despatch department

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Guaranteed Satisfaction or Money Back

HART ELECTRONICS

AUDIO KITS

F.M. TUNER
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Cost of tuner chassis (no case) is **£22** for mono, **£25·45** for stereo. Metal case **£2·55.** An extended wooden case to fit tuner and amplifier will be offered shortly.

BAILEY/BURROWS/QUILTER PRE AMP.
The best engineered kit available of the combined best of three pre-amp designs. This is the kit with no wiring to the controls, switches or inputs. A complete and sophisticated 5 input signal processing stage for any power amplifier requiring up to 1½v input for only **£20·50.** Front end only **£10·44.** Tone control only **£11·41.**

BAILEY 30 WATT POWER AMPS.
Our best selling power amplifier, you can't better its performance or the quality of the kit and at only **£9·88** per channel, it's amazing value for money.

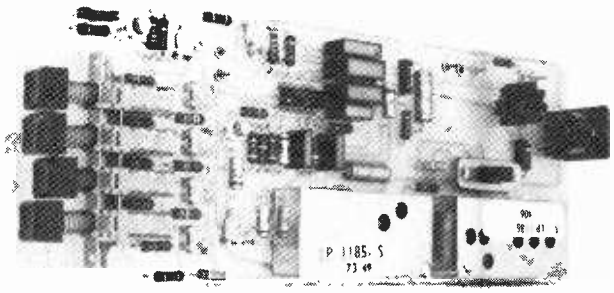
DIGITAL MULTIMETER
Our first venture into instruments and by the way it's selling it won't be long before we're offering others. It is of course unique as it measures DC and AC volts, resistance, capacitance, period, time and frequency. Not bad for **£65's** worth of parts.

STUART TAPE CIRCUITS
Our printed circuits and components offer the easy way to convert any suitable quality deck into a very high quality Stereo Tape unit. Input and output levels suit Bailey pre amp.
Total cost varies but around **£35** is all you need. We can offer tape heads as well if you want new ones.
All above kits have fibreglass PCB's. Prices exclude VAT but P&P is included.
Further information is in our lists **FREE** if you send us a 9 in. × 4 in. S.A.E.

REPRINTS
Post free, no VAT.
Bailey 30W **18p.**

STUART TAPE RECORDER
All 3 articles under one cover **30p.**

BAILY/BURROWS/QUILTER
Preamp circuits, layouts and assembly notes **15p.**



FM Tuner

SPRING BARGAIN SALE

Of brand new components at trade prices. Unit prices are shown, quantity prices by negotiation.

Capacitors

50.	C437AR/A4000. 4000/2·5. Mullard	20p
400.	C428AR/F80. 80/25. Mullard	22p
60.	2500µf 70v. CCL	80p
25.	C431 BR H1600. 1600/64. Mullard	77p
30.	2500µf 25v. Plessey	35p
40.	C432 FR/H2000. 2000/64. Mullard	£1·00

Miscellaneous

90.	50DN 0400 A100 Heatsink. Marston	60p
100.	10DN 0400 C1 SX Heatsink. Black anod.	48p
1.	CRT DPM9-11. Mullard	£15·00
1.	CRT 3AZP 31. Ei-el	£15·00
1.	CRT 10MW4A.	£5·00
1.	CRT 10FP4A. RCA	£5·00
2.	CRT SE14/70. EMI	£12·00
2.	Monitor. BD851. Marconi	£5·00
20.	T 502. Eagle 2 in. Vernier Dial	£1·12
300.	79/840. 3way Phono soc. Carr	05p
350.	79/844. 5way Phono soc. Carr	06p
100.	SW 1587. 3 × 3PCO. Push button sw.	15p
200.	4P 3W. Rotary switch	18p
200.	6P 5W. Rotary switch	30p
1.	PE Gemini FM Turner. AMC	£12·00
2.	FM Turner Front end. Guest	£4·00
1.	Deram loudspeaker. Decca	£12·00

Also others too numerous to mention, please send for full list.

Penylan Mill, Oswestry, Salop

Personal callers are always welcome, but please note we are closed all day Saturday

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E.H.T. POWERUNIT. 110/240v. 50Hz giving 5 K.V. at 50 m/a. METERED OUTPUT. **£17·50.**

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11 x 3¾ x 1/16 in. **12p** sheet. 5 for **50p.**
10 x 4 x 1/16 in. **12p** sheet. 5 for **50p.**
10¾ x 5¾ x 1/16 in. **15p** sheet. 4 for **50p.**
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Offcut pack (smallest 4 × 2 in.) **50p** 300 sq. in.
P&P single sheet **4p.** Bargain packs **20p**

TELEPHONE DIALS (New) £1 ea.

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EXTENSION TELEPHONES (Type 706) Various Colours **£3·50.** P.P. 25p. Excellent condition.
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HIGH VACUUM DIFFUSION PUMPS (Metrovac 093C). New condition. **£40.** P.P. £2. **A.E.I. P10. ION Pump Control Units. £17·50.**

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BULK COMPONENT OFFER. Resistors/Capacitors. All types and values. All new modern components. Over 500 pieces **£2.** (Trial order 100pcs. 50p.) We are confident you will re-order.

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250W. ISOLATION TRANSFORMER. 240v. **£3·25.** P.P. 50p.

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2300W. STEP-DOWN TRANSFORMER. (Double wound.) 240v.-117v. 50 HZ. **£22·50.** P.P. £2.

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3 digit 12v. (Rotary Reset) 2¼ × 1¼ × 1¼ in. **£1** each.
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6 core (6 colours) 3 screened, 14/0048. **18p.** yd. 100 yds. **£12·50.**
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8 cores. 7/·mm. bonded side by side in ribbon form.

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2 Pole Change-over **45p.**

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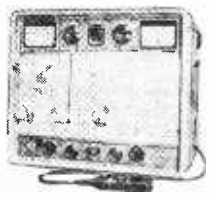
ROMFORD 44473 **RM7 9DD**



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AVO MULTIMETER Model 8X (Panclimatic). **£32.** Cases. prods and leads extra.

CT. 373 TEST SET. Oscillator: 17c/s–170kc/s ±1%. ±1c/s at ambient temp. 0°C–45°C. Distortion Meter: Freq. range: 20c/s to 20kc/s. distortion range: 10%. 30%. 100% f.s.d. 0.5% readable. Signal input: approx. 500mV to 130V basic range. 250mV to 1300V extreme limits. Full spec. on request. **£98.**

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AVO CT 160 VALVE TESTER. As above but in portable valise form. **£65.**
Viewing by appointment only.

Inland V.A.T. add 10%. Prices include P. & P. ***Carriage extra for overseas orders. Please phone 01-540 9534***

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Type	Pc	VCBO	FT MHz	Price
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BD107 (SNPN)	11·5w	64	100	63p
2N711B/2G106 (SPNP)	150mw	18	120/150 Tot. Sw. Time 275 NS	43p
2N985 (GPNP)	300mw	15	Tot. Sw. Time 115 NS	95p
2N1304 (GPNP)	150mw	30	6	15p
2N1309 (GPNP)	150mw	30	15	30p
2N1046 (GPNP)	50w	100	20	£2·50
2N1146A (GPNP)	90w	70	15	45p
2N1542 (G)	106w	100	0·35	50p
2N1547 (G)	106w	100	0·35	75p
2N1557 (G)	106w	40	0·35	50p
2N1908 (GPNP)	150w	130	20	£6·00
2N2080 (G)	170w	70	0·2	£1·10
2N2082 (G)	170w	40	0·2	£1·10
2N2405 (SNPN)	1w	120	120	55p
2N3054 (SNPN)	29w	90	1·2	40p
2N3055 (SNPN)	115w	100		45p
2N3375 (SNPN)	11·6w	65	500	£3·46
2N4427 (SNPN)	3·5w	40	700	52p
2N5322 (SNPN)	10w	65	325	50p

Type	Price	Type	Price	Type	Price
2N301A/OC22	50p	OC83	25p	RAS310AF	25p
ASZ16/OC26	25p	GET110/NKT303	20p	STC Wire End	
OC35	40p	OC702	10p	400PIV1A	4 for 50p
OC42	40p	OA5	20p	IN3193	13p
OC71	12p	OA10	25p	IN3194	14p
CV7006/OC72	20p	OA81	20p	IN3255	20p
OC75	25p	RAS508AF	25p		

RCA PHOTOMULTIPLIER C31005B
Checked and tested.....**£37·50**

BRIDGE RECTIFIERS
1B40KO5 50v 4a.....**95p**

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GEX541B1P2 .....**£6·88**
GEX541B1P1 .....**£3·50**
GEX541D2P1 .....**£3·50**
GEX541NB1P1F...**£6·00**
GEX541HP3F .....**£6·00**
SX751N1B1P1F ...**£6·00**

INTEGRATED CIRCUITS
MC3544 ....**£1·10**
MC353G .....**£2·00**
MC358AG .....**£5·00**
MC365G .....**£5·00**
CA3020 .....**93p**
CA3021 .....**£1·15**
CA3028A **97p**
CA3038A .....**£2·14**
CA3055 .....**£1·24**
CA3085 .....**78p**
CD4035AE .....**£1·91**
CD4017AE .....**£3·86**
CD4047AD **£3.86**

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GE2N1774 200v. 5a.**£1·20**
CR1-021C 20v. 1a. ..**25p**
CR10-101B 100v. 10a.....**£1·00**
CR10-021 10a..... **£1·00**
CR10-40B 10a..... **£1·00**
CR10-051 10a..... **£1·00**
CR10-017 10a..... **£1·00**
BTX 92 1200R 16a 1200v.....**£2·85**
STC 3/40 400v. 3a....**50p**

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Edwards High Vacuum "Speedivac" model VSK1B range 25-760 torr contact ratings 250v. 5a. volume 4·2 cu. cm. max. working pressure 15lb/sq. in. gauge net weight 17 ozs.....**£6·20**
Belling Delay hand reset L415.....**£1·10**
Stackpole min. rocker 125v. 10a. 250v. 5a.....**20p**
Tippalite Rocker 12v.....**60p**
Securex 5000 press button 250v. ac..**£1·20**

DIGITAL COUNTERS
Veeder Root Mech. Reset 4 dig. **50p**

STABILIZED POWER SUPPLIES
Advance PM47 0-15v.....**£18.50**

RELAYS
Varley Min. 700Ω 12v.....**50p**
Siemens Min. 12/15v.....**50p**
Magnetic Dev. Type 596E.....**£2·00**
BR Type M51 240v.....**65p**

KEYBOARDS
ICT Numerical.....**£3·50** carr. 35p
ICL Alpha Verifier (PN7035130)....**£27·50** carr. £1·00

ELECTROACOUSTIC UNIT
6 watt (peak) Amplifier 240v. AC, with inputs for Radio, Tape Recorder, freq. response 80-12,500Hz, bass and treble controls, 2 speakers. Dimensions 265 x 235 x 580 mm. Net weight 10Kg. Ideal for education seminars etc. **£12·00** incl. carr.

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McMurdo Red Range. Plug RP24.....**56p**
McMurdo Red Range. SKT RS32.....**90p**
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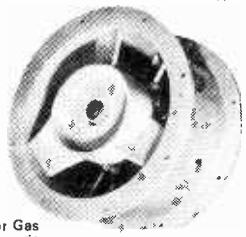

Airmax Type M1/Y3954 (3 blades) Cast Aluminium alloy impeller & casing (corresponds to current type 3965 7½") 230v. 1ph 50c 2900rpm Class "A" insulation 425cfm free air weight 9½lbs. incl. p.p. **£21·00.**

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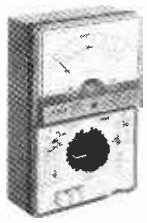

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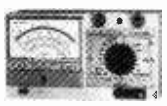

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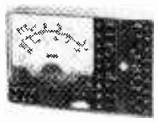

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POWER SUPPLY UNIT PN-12A: 230V a.c. input 50-60c/s, 513V and 1025V at 420m/A o/put. With 2 smoothing chokes 9H, 2 Capacitors, 10Mfd 1500V and 10Mfd 600V. Filament transformer 230V a.c. input. 4 Rectifying valves type 5Z3. 2 × 5V windings at 3Amps each and 5V at 6Amp and 4V at 0·25Amps. Mounted on steel base 19in. W × 11in. H × 14in. D. (All connections at the rear.) Excellent cond. **£8·50** each, Carr. £2.

MODULATOR UNIT: 50 watt, part of BC-640, complete with 2 × 811 valves, microphone and modulator transformers etc. **£7·50** each, Carr. £2·00.

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AN/ARC-27 TRANSMITTER/RECEIVER (FOR EXPORT ONLY): Frequency 225-400 mc. 1750 channels 100 Kc apart with 18 preset channels. Modulation: am. Power output 9 watts. Receiver is superheterodyne. Max. output 2 watts. Antenna: 50 ohm impedance. Power requirements 24v d.c. Complete transmitter with operating cables, control box, headphones, microphone. Price **£250·00** each secondhand, excellent condition.
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AZ41	0·60	EABC80		ECH35	1·25	EF183	0·30	EZ81	0·29	OB2	0·40	PEN45DD		PY83	0·38	UCH81	0·40	3V4	0·70	6BX6	0·40	6X4	0·40	30C17	1·10	6080	2·25
CBL31	1·00		0·38	ECH42	1·00	EF184	0·35	EZ90	0·40	OZ4	0·45		0·75	PY500	1·00	UCL82	0·35	5R4GY	0·80	6CD6G	1·30	6X5GT	0·45	30C18	0·90	6146	2·00
CL33	1·50	EAF42	0·75	ECH81	0·30	EH90	0·55	GY501	0·80	PC86	0·60	PFL200	0·65	PY801	0·50	UCL83	0·70	5U4G	0·40	6CH6	1·40	7B6	0·75	30F5	1·10	**TUBES**	
CY31	0·50	EAF8010	0·50	ECH83	0·45	EL33	1·75	GZ30	0·45	PC88	0·60	PL36	0·63	SP41	3·00	UF41	0·75	5V4G	0·50	6E5	1·00	7B7	0·70	30FL1	0·80	2AP1	4·00
DAF91	0·30	EBC33	1·00	ECH84	0·45	EL34	0·60	GZ32	0·50	PC900	0·48	PL38	1·25	SP61	0·75	UF89	0·40	5Y3GT	0·45	6F23	1·05	7C5	1·30	30FL14	0·90	3BP1	3·50
DAF96	0·50	EBC41	0·75	ECL80	0·55	EL37	2·50	GZ34	0·65	PCC84	0·40	PL81	0·50	T41	1·00	UL41	0·85	5Z4G	0·45	6J5G	0·45	7C6	0·75	30L15	1·05	3DP1A	3·50
DCC90	1·35	EBC81	0·33	ECL82	0·35	EL41	0·90	H63	0·90	PCC89	0·50	PL82	0·45	U25	0·85	UL84	0·43	6/30L2	0·90	6J5GT	0·45	7H7	0·70	30L17	0·95	3EG1	10·00
DF91	0·30	EBC83	0·33	ECL86	0·40	EL42	0·90	HL41DD		PCC189	0·60	PL83	0·45	U26	0·85	UY41	0·48	6AL5	0·25	6J7GT	0·45	7S7	2·25	30P12	1·05	3FP7	1·50
DF96	0·50	EBF80	0·40	ECLL800		EL84	0·28		0·70	PCF80	0·40	PL84	0·40	U191	0·75	UY85	0·40	6AQ5	0·45	6K6GT	0·75	7Y4	0·75	30P19	1·00	3GP1	3·50
DK91	0·45	EBF89	0·32		3·20	EL91	0·50	HN309	1·50	PCF86	0·60	PL500	0·80	U404	0·70	VP4B	1·25	6AS7	0·85	6K7GT	0·35	12AC6	0·70	30P4	1·00	3GP7	3·50
DK92	0·70	EBL31	1·50	EF37A	1·20	EL95	0·40	KT61	1·75	PCF802	0·50	PL504	0·80	U801	0·80	VR75/30		6AT6	0·45	6K8GT	0·50	12AD6	0·65	30PL13	1·20	5BP1	5·00
DK96	0·60	EC92	1·00	EF39	1·20	EL360	1·25	KT66	2·50	PCF805	0·90	PL508	0·90	UABC80	0·48		0·40	6AU6	0·30	6P25	1·75	12AE6	0·65	30PL14	1·25	5CP1	5·00
DL92	0·40	ECC81	0·40	EF41	0·65	ELL80	1·25	KT81	(7C5)	PCF806	0·75	PL509	1·55	UAF42	0·75	VR105/30		6AV6	0·45	6Q7GT	0·50	12AT6	0·40	35L6GT	0·75	5FP7	3·00
DL94	0·48	ECC82	0·33	EF80	0·25	EM80	0·45		1·30	PCF808	0·90	PL801	1·00	UBC41	0·40		0·40	6BA6	0·28	6S7M	0·45	12AT7	0·40	35W4	0·50	88D	10·00
DL96	0·55	ECC83	0·33	EF85	0·35	EM81	0·60	KT88	2·90	PCL82	0·35	PL802	0·95	UCH42	0·75	VR150/30		6BE6	0·35	6S7GT	0·30	12AU6	0·45	35Z3	0·75	CV429	22·00
DM70	0·60	ECC85	0·40	EF86	0·30	EM84	0·35	KTW61	1·00	PCL83	0·66	PY32	0·63	UBF80	0·40		0·40	6BH6	0·75	6S7GT	0·48	12AU7	0·33	35Z4GT	0·70	CV960	8·00
DM160	0·60	ECC88	0·40	EF89	0·28	EY51	0·40	KTW62	1·00	PCL84	0·45	PY33	0·63	UBF89	0·40	Y63	1·50	6BJ6	0·55	6SN7GT		12AX7	0·33	50C5	0·60	DG7-6	10·00
DY86/7	0·36	ECF80	0·35	EF91	0·37	EY86	0·40	KTW63	1·00	PCL85	0·60	PY81/800		UCC85	0·45	1R5	0·45	6BQ7A	0·55		0·48	12BA6	0·45	50CD6G		VCR138	8·00
		ECF82	0·40	EF92	0·50	EZ40	0·75	N78	2·75	PCL86	0·45		0·50			1S5	0·30	6BR7	1·00	6U4GT	0·75	12BE6	0·50		1·20	VCR139A	
		ECF801	0·40	EF93	0·25	EZ41	0·75									1T4	0·30	6BW6	0·90	6U5G	0·75	12BH7	0·50	80	0·60		8·00

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1N21	0·17	2N708	0·15	2N3709	0·10	AF116	0·25	BF195	0·13	CR83-40		GJ7M	0·50	NKT128		NKT403		OA95	0·07	OC26	0·40	OC71	0·15	OC84	0·30	ORP60	0·45
1N23	0·35	2N1302	0·18	2N3710	0·11	AF117	0·20	BF196	0·15		0·55	KS100A	0·20		0·45		0·70	OA200	0·08	OC28	0·70	OC72	0·25	OC123	1·10	ORP61	0·48
1N4001	0·06	2N1303	0·18	2N3711	0·11	AF139	0·33	BF197	0·15	C810B	3·50	MAT101		NKT211		NKT404		OA202	0·10	OC29	0·65	OC73	0·50	OC139	0·40	SX640	0·75
1N4002	0·07	2N1304	0·22	2N3819	0·35	AFZ12	1·50	BFS61	0·25	CV102	0·25		0·25		0·25		0·60	OA210	0·20	OC30	0·40	OC74	0·30	OC140	0·65	SX642	0·60
1N4003	0·08	2N1305	0·22	2N4286	0·15	BC107	0·12	BFS98	0·25	CV103	0·18	MAT120		NKT213		NKT7130	0·30	OA211	0·35	OC35	0·55	OC75	0·30	OC141	0·80	SX643	0·75
1N4004	0·08	2N1306	0·28	2N4289	0·15	BC108	0·12	BFY50	0·20	CV253	1·00		0·20		0·25	OA5	0·60	OAZ202	0·45	OC36	0·65	OC76	0·30	OC169	0·20	ZS21	0·30
1N4005	0·08	2N1307	0·28	AC126	0·25	BC109	0·12	BFY51	0·20	CV2154	2·00	MAT121		NKT2140	24	OA6	0·12	OAZ2100	0·40	OC41	0·35	OC77	0·55	OC170	0·25	ZS22	0·25
1N4006	0·12	2N1308	0·28	AC127	0·25	BC115	0·20	BFY52	0·20	CV2155	2·00		0·25	NKT216		OA7	0·20	OAZ2110	0·40	OC42	0·40	OC78	0·25	OC171	0·30	ZS170	0·10
18111	0·25	2N1307	0·28	AC128	0·20	BC116	0·20	BTY79/		CV2158	3·50	MJE3700	0·68		0·40	OA9	0·20	OAZ2420	0·15	OC43	0·70	OC78D	0·25	OC200	0·55	ZS178	0·40
18131	0·13	2N2147	0·75	AC176	0·25	BC117	0·21	100R	0·75	CV2159	3·50	MJE5200	0·85	NKT217		OA10	0·40	OAZ2440	0·25	OC44	0·18	OC79	0·30	OC201	0·80	ZS271	0·18
18132	0·13	2N2218	0·23	AC187	0·20	BC169	0·14	BY100	0·15	DD006	0·15	MJE2955			0·45	OA47	0·08	OAZ2460	0·15	OC44M	0·17	OC81	0·28	OC202	0·90	ZT21	0·25
18132	0·13	2N2444	1·99	AC188	0·20	BCY34	0·45	BY126	0·14	DD006	0·25		1·10	NKT218		OA70	0·10	OC16	1·00	OC45	0·18	OC81D	0·25	OC203	0·55	ZTX107	0·12
2G220	0·63	2N2646	0·50	ACY17	0·35	BD121	1·00	BY127	0·15	GET1020	0·50	MJE3055			1·13	OA71	0·20	OC16T	1·00	OC45M	0·18	OC81M	0·20	OC204	0·65	ZTX108	0·10
2G301	0·40	2N2926	0·10	AD140	0·50	BD123	1·00	BZY88		GET1030	0·40		0·75	NKT301		OA79	0·10	OC19	0·50	OC46	0·27	OC81DM		OC205	1·00	ZTX300	0·14
2G302	0·40	2N3702	0·11	AD149	0·50	BF115	0·22	Series	0·10	GET1160	0·85	MPF102			0·65	OA81	0·10	OC20	2·00	OC57	0·60		0·18	OC206	1·10	ZTX3040	0·25
2N696	0·15	2N3703	0·12	AD161	0·39	BF173	0·28	CR81/05		GET5750	0·40		0·40	NKT304		OA85	0·15	OC22	1·00	OC58	0·60	OC81Z	0·45	OC207	1·00	ZTX5000	0·15
2N697	0·15	2N3704	0·14	AD162	0·39	BF180	0·35		0·30	GEX66	1·25	MPF103	0·36		0·75	OA86	0·15	OC23	1·25	OC59	0·60	OC82	0·28	OCP70	0·50	ZTX5030	0·16
2N706	0·10	2N3705	0·15	AF114	0·25	BF181	0·35	CR81-40		GEX541		MPF104		NKT401		OA90	0·07	OC24	1·10	OC66	0·50	OC82D	0·25	OCP71	1·00	ZTX5310	0·25
2N706A	0·12	2N3707	0·13	AF115	0·25	BF194	0·13		0·45		0·75		0·35		0·75	OA91	0·07	OC25	0·40	OC70	0·18	OC83	0·25	ORP12	0·55		

Industrial Valves

1B3GT		5Z3		12E1		815		5726/		6923		CV28		CV404		CV2325		CV4043		E180F		GXU2		ME1403		Q8108/45	
1B24		5Z4G		12E14		828		6AL5W		6939		CV31		CV415		CV2361		CV4044		E181CC		GXU3		ME1404		Q8150/15	
1B35A		3B28		13D1		829B		5727/				CV45		CV416		CV2466		CV4046		E182CC		GXU4		ME1500		Q8150/30	
1B63A		3B29		13E1		830B		2D21W		7193		CV53		CV417		CV2516		CV4048		E186F		GXU50		ME1501		Q8150/36	
1B35A		3C22		6AF4A		28D7		860		7203		CV73		CV428		CV2519		CV4053		E188CC						Q8150/40	
1B63A		3C23		6AK5		29C1		866		7360		CV74		CV434		CV2520		CV4056		EA50		KT66		OA2		Q8150/45	
1N21		3C24/24G		6AM5		53KU		866A		7586		CV85		CV447		CV2522		CV4059		EA52		KT67		OA3		Q8150/80	
1N21B		3C45		6AM6		75B1		866E		5802		CV118		CV449		CV2721		CV4060		EA76		KT88				Q81200	
1N23B		3CX100A5		6AN5		75C1		827A		5814		CV121		CV466		CV2901		CV4062		ECC35				OA4G		Q81202	
1N23CR		3E29		6AN8		75C1		827A		8013		CV124		CV468		CV2901		CV4063		ECF804		M8079				Q81203	
1X2A		3J/121E		6AR5		83A1		881R		5823		CV128		CV488		CV3929		CV4064		EF50		M8080		OB2		Q81205	
1X2B		3J/160E		6AS6		85A1		891R		5840		CV131		CV491		CV3986		CV4079		EF54		M8081		OB3		QU37	
		3J/170E		6AU4GTA		85A2				5963		CV132		CV492		CV3988		CV4501		EF55		M8082		OD3		QV03-12	
2A3		3Q/150E		6AU5GT		90AG		954		5965		CV133		CV493		CV3991		CV4502		EF804		M8083		OG3		QV04-7	
2AS15		3Q/195E		6AU6		90AV		955				CV135		CV717		CV3998		CV4503		EFP60		M8091		OZ4		QV05-25	
2C26A		3S4		6AV5GTA		90C1		956		6005/		CV136		CV808		CV4001		CV4504		EL91		M8096		OZ4A		QV06-20	
2C34		3V/340B		6AW8A		90CG		957		6AQ5W		CV137		CV1072		CV4002		CV4507		EN30		M8097				QY3-125A	
2C39A		3V/390A		6AX5GT		90CV				9005		CV138		CV1076		CV4003		CV4508		EN31		M8098		OT15		QY4-250A	
2C43		3V/390B		6BA8A		95A1		1625		9006		CV140		CV1092		CV4004		CV5060		EN32		M8100				QY4-400A	
2D21				6BK4		100TH				6021		CV144		CV1219		CV4005		CV6004		EN91		M8136		QA2400			
2D21W		4-125A		6BK7A		150B2		2050		6057		CV160		CV1343		CV4006		CV6008		ESU74		M8137		QA2403		R10	
2E26		4-250A		6BL7GTA		150B3		2050W		6058		CV173		CV1475		CV400.		CV6045		ESU76		M8140		QA2404		R17	
2J31		4-400A		6BN6		150C1		2051		12201A		CV187		CV1476		CV4005		DA30		ESU77		M8141		QA2406		R18	
2J33		4B32		6BR7		150C2				6059		CV188		CV1477		CV4009		DA41		F6057		M8142		QA2407		S11E12	
2J50		4C35		6BS7		150C3		4003A		6060		CV190		CV1478		CV4010		DA42		F6060		M8144		QB3/300		S130	
2J54		4CX250B		6BX7GT		150C4		4212D or E		6063		CV220		CV1794		CV4011		DA100		F6061		M8149		QB3-5-750		S130P	
2J56A		4E27		6BZ6		250TH		4242A		6064		CV261		CV1480		CV4012		DET22		F6063		M8157		QB4-1100		STV280/40	
2K25		4J50		6CB6		328		4313C		6065		CV273		CV1481		CV4013		E55L		FX219		M8161		QF41		STV280/80	
2K26		4J52		6CH6		329		4328A		6067		CV284		CV1482		CV4014		E80CC		FX225		M8162		QF45		SU41	
2K28		4J52A		6CL6		631-P1		4687		6072		CV286		CV1787		CV4015		E80FC		FX227		M8163		QQV02-6		SU42	
2K45		4J53		6CW4		705A		5544		6073		CV287		CV1832		CV4016		E80F		G1/371K		M8167		QQV03-10			
2X2A		4X150A		6DK6		715A		5545		6074		CV315		CV1833		CV4017		E80L		G120/1B		M8179		QQV03-20		TD03-10	
		4X150D		6DQ6B		715B				6080		CV329		CV1835		CV4018		E80T		G150/2B		M8190		QQV03-20		TT15	
3A/107A		4X250B		6EA8		723A/B		5642		6097C		CV337		CV1994		CV4019		E81CC		G180/2M		M8196		QQV03-20A		TT21	
3A/108A				6F33		725A		5644		B890		CV342		CV2000		CV4020		E81L		G240/2D		M8204		QQV04-15		TTR31MR	
3A/109B		5B/251M		6H6(metal)				5651		B8156		CV345		CV2131		CV4022		E82CC		G400/1K		M8212		QQV06-40		TZ40	
3A/109B		5B/252M		6K7GT		801		5670		BT5		CV354		CV2154		CV4023		E83CC		GN4		M8214		QQV06-40A			
3A/110A		5B/254M		6U8A		803		5672		BT45		CV359		CV2155		CV4024		E83F		GT1C		M8223		Q8702/0		U17	
3A/110B		5B/255M		6V6GT		805		5676		BT79		CV360		CV2160		CV4025		E88CC		GTR120W		M8224		Q8752/0		U19	
3A/146J		5B/256M				807		5687		BT83		CV371		CV2179		CV4028		E90CC		GTR150MS		M8225		Q8754/0		U27	
3A/167M		5B/257M		11E3		808		5696		C1C		CV372		CV2235		CV4033		E90L		GU18		M8232		Q8756/0		VL8631	
3A5		5C22		11E13		811		5702		C1K		CV378		CV2237		CV4035		E91H		GU20/21		M8237		Q883/3			
3B/240M		5D21		12AY7		811A		5718		CAA322		CV391		CV2238		CV4038		E92CC		GU50		M8245		Q892/10		Z300T	
3B/241M		5R4GY		12B4A		812A		5719		CV5		CV395		CV2253		CV4039		E180CC		GXU1		ME1400		Q895/10		Z759	
3B24		5U4GB		12BY7A		813		5725/		CV25		CV397		CV2289		CV4040						ME1401		Q8105/45		Z803U	
								6AS6W		6807		CV26															

Integrated Circuits

7400	0·20	7410	0·20	7420	0·20	7430	0·20	7437	0·45	7447	0·90	7476	0·45	74107	0·51	74157	1·09
7401	0·20	7411	0·23	7422	0·28	7432	0·37	7438	0·43	7448	0·90	7480	0·80	74110	0·57	74170	2·88
7402	0·20	7412	0·28	7423	0·40	7433	0·43	7440	0·20	7450	0·20	7482	0·87	74111	0·86	74174	1·80
7403	0·20	7413	0·30	7425	0·37	7437	0·37	7441AN	0·85	7451	0·20	7483	1·26	74118	1·00	74175	1·29
7404	0·20	7416	0·30	7427	0·37	7438	0·43	7442	0·85	7453	0·20	7484	1·00	74119	1·92	74176	1·44
7405	0·20	7417	0·30	7428	0·43	7440	0·20	7450	0·20	7454	0·20	7486	1·50	74121	0·57	74190	2·30
7406	0·40	7420	0·20	7430	0·20	7442	0·37	7451	0·20	7460	0·20	7490	0·75	74122	0·80	74191	2·30
7407	0·40	7422	0·28	7432	0·37	7443	0·48	7453	0·20	7470	0·33	7491AN	1·10	74123	1·44	74192	2·30
7408	0·25	7423	0·40	7433	0·43	7445	0·59	7454	0·20	7472	0·38	7492	0·75	74141	1·00	74193	2·30
7409	0·33	7425	0·37					7460	0·20	7473	0·44	7493	0·75	74145	1·44	74194	1·72
		7427	0·37					7470	0·33	7474	0·48	7494	0·85	74150	2·30	74195	1·44
		7428	0·43					7472	0·38	7475	0·59	7495	0·85	74151	1·15	74196	1·58
		7430	0·20					7473	0·44	74100	2·16	7496	1·00	74154	2·30	74197	1·58
		7432	0·37					7474	0·48	74104	0·45	7497	4·32	74155	1·15	74198	3·16
		7433	0·43					7475	0·59	74105	0·45	74100	2·16	74156	1·15	74199	2·88

LOW PROFILE SOCKETS

14 pin DIL, 15p.
16 pin, DIL, 17p.

Stockists of English Electric, Ferranti, M.O. Valve Co., Mullard, S.T.C.

FROM 1ST APRIL ALL ORDERS SUBJECT TO V.A.T. AT APPLICABLE RATE. THIS MUST BE ADDED TO TOTAL ORDER PRICE INCLUDING POSTAGE.
Terms of Business: Mon. to Sat. Open to callers 9 a.m. to 5 p.m. Closed Sat. 1 p.m. to 3 p.m. Express postage 5p. for one valve; 1p each additional valve. Express postage: 3p for one transistor, and 1p for each additional. Over 10 post free. All orders over £5 post free. Valves tested and released to A.R.B. specification if required. (Full valve availability list on request, S.A.E.) Prices correct when going to press.

STEREO IC DECODER

HIGH PERFORMANCE PHASE LOCKED LOOP
(as in 'W.W.' July '72)

MOTOROLA MC1310P EX STOCK DELIVERY

SPECIFICATION

Separation: 40dB 50Hz-15kHz.
I/P level: 560mV rms
Input impedance: 50kΩ.
Distortion: 0·3%
O/P level: 485mV rms per channel.
Power requirements: 8-16V at 16mA
Will drive up to 75mA stereo 'on' lamp or LED.

KIT COMPRISES FIBREGLASS PCB (Roller tinned), Resistors, I.C., Capacitors, Preset Potm. & Comprehensive Instructions — **ONLY £3·98** — **WHY PAY MORE?** post free.

LIGHT EMITTING DIODE Suitable as stereo 'on' indicator for above — **RED 29p** **GREEN 59p**

MC1310P only £3·15 plus p.p. 6p

NOTE
As the supplier of the first MC1310P decoder kit, of which we have sold literally thousands, our customers can benefit from our wide experience.

V.A.T.
Please add V.A.T. at 10% to all prices

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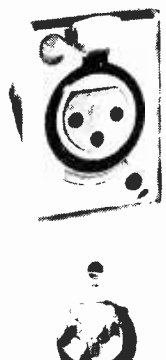
WW—111 FOR FURTHER DETAILS



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Broadcast pattern jackfields, jackcords, plugs and jacks
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Pot cores in a wide range of useful sizes:
Double Aperture Cores:
Ring Cores

TRANSISTORS

Very wide range of types is shown together with grouped and tabulated specifications for each one. Outlines are illustrated, and there is a full range of supporting hardware. Also near-equivalent tables are given.

I.C.s

Here too a wide range of TTL types are shown, together with linear and special purpose types. Over 60 circuit and connection diagrams as well as much other useful information is included.

MINITRON DIGITAL INDICATORS

3015F Seven segment filament, compatible with standard logic modules. 0–9 and decimal point: 9mm characters in 16 lead DIL. **£1·20**
Suitable 8CD decoder driver 7447 **£1·15**
3015G showing + or — & 1 & dec. pt. **£1·20**

CAPACITORS
POLYESTER C.280

Radial leads for P.C.B. mounting. Working voltage 250V d.c.
0·01, 0·015, 0·022, 0·033, 0·047 ea. **3p**
0·068, 0·1, 0·15 ea. **4p**
0·22, **5p**; 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1·0, **14p**; 1·5, **21p**; 2·2, **24p**

TANTALUM BEAD

0·1, 0·22, 0·47, 1·0 mF/35V ea. **13p**
2·2/16V, 2·2/35V, 4·7/16V, 10/6·3V ea. **13p**
4·7/35V, 10/16V, 22/6·3V ea. **16p**
10/25V, 22/16V, 47/6·3V, 100/3V ea. **18p**

POLYCARBONATE

Type B32540 Working Voltage—250V d.c.
Values in mF: 0·0047; 0·006B; 0·0082; 0·1; 0·012; 0·015 ea. **3p**
0·018; 0·022; 0·027; 0·033; 0·039; 0·047; 0·056; 0·068; 0·082; 0·1 ea. **4p**

Working voltage 100V d.c.
0.1; 0.12; 0.15 **4p**; 0.18 **5p**; 0.22 **6p**
0.27 **7p**; 0.33 **8p**; 0.39; 0.47 **9p**
0.56 **12p**; 0.68 **13p**

SILVERED MICA

Working voltage 500V d.c.
Values in pFs—2·2 to 820 in 32 stages ea. **6p**
1000, 1500 **7p**; 1800 **8p**; 2200 **10p**; 2700, 3600 **12p**; 4700, 5000 **15p**; 6800 **20p**; 8200, 10,000 **25p**

CERAMIC DISC

1000pF/500, 2000/500, 5000/500, 0·01mF/50, 0·02mF/50, 0·1mF/3—each **2p**; 0·05mF/50V—**3p**

CERAMIC PLATE

In a range of 26 values from 22 to 6800pF/50V d.c., each **2p**

POTENTIOMETERS

ROTARY, CARBON TRACK. *Double wipers for good contact and long working life*
P.20 SINGLE linear 100ohms to 2·2megohms ea. **14p**
P.20 SINGLE log. 4·7Kohms to 2·2megohms ea. **14p**
JP.20 DUAL GANG lin. 4·7Kohms to 2·2megohms ea. **48p**
JP.20 DUAL GANG log. 4·7Kohms to 2·2megohms ea. **48p**
JP.20 DUAL GANG Log/antilog 10K, 22K, 47K, 1 megohm only ea. **48p**
JP.20 DUAL GANG antilog 10K only **48p**
2A DP mains switch for any of above **14p** extra.
Decades of 10, 22 and 47 only available in ranges above.
Skeleton Carbon Presets Type PR, horizontal or vertical **6p** each.

SLIDER

Linear or log, 4·7K to 1 meg, in all popular values ea. **30p**
Escutcheon plates, black, white or light grey ea. **10p**
Control knobs, blk/wht/red/yel/grn/blue/dk. grey/lt grey ea. **7p**

JACKS AND PLUGS

SOCKETS
2 circuit unswitched S1/SS **12p**
2 circuit 2 break contacts S1/BB **15p**
3 circuit unswitched (Not GPO) S3/SSS **17p**
3 circuit with 3 break contacts S3/BBB **20p**
2 circuit with chrome nut and black/white/red/green or grey unswitched S5/SS **16p**
with 2 break contacts S5/BB **20p**
Miniature 3.5mm 2 circuit, (black) 2 break contacts S6/BB **9p**

PLUGS
2 circuit screened top entry P1 **24p**
side entry SEP1 **36p**
Line socket mono 231 **40p**
Line socket stereo 244 **45p**
3 circuit unscreened, black/grey/white P4 **46p**
2 circuit, unscreened, black/white/red/black/green/grey P2 **18p**
3 circuit screen top entry P3 **53p**
side entry SEP3 **55p**
Miniature 3·5mm 2 circuit screened P5 **13p**
Miniature 3·5mm 2 circuit unscreened various colours P6 **10p**

INSULATED SCREW TERMINALS

In moulded polypropylene, with nickel plate on brass. With insulating set, washers, tag and nuts. 15A/250V in black/brown/red/yellow/green/blue/grey/white. Type TP.1 ea. **14p**

DIN CONNECTORS

2 way loudspeaker	**Socket 10p**	**Plug 12p**
3 way audio	**Socket 10p**	**Plug 12p**
5 way audio 180°	**Socket 12p**	**Plug 15p**
5 way audio 240°	**Socket 12p**	**Plug 15p**
6 way audio	**Socket 13p**	**Plug 15p**

RESISTORS

Code	Watts	Ohms	1 to 9	10 to 99 (see note below)	100 up
C	1/3	4·7–470K	1·3	1·1	0·9 nett
C	1/2	4·7–10M	1·3	1·1	0·9 nett
C	3/4	4·7–10M	1·5	1·2	0·9 nett
C	1	4·7–10M	3·2	2·5	1·9 nett
MO	1/2	10–1M	4	3·3	2·3 nett
WW	1	0·22–3·9Ω	9	9	8
WW	3	1–10K	7	7	6
WW	7	1–10K	9	9	8

Codes:
C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TR5, ultra low noise.
WW = wire wound, Plessey.
Values: All E12 except C ¼W, C ½W, and MO ¼W.
E12: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.
Tolerances:
5% except WW 10% ±0·05Ω below 10Ω and MO ¼W 2%.
Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions of one penny on total value of resistor order.) Prices for 100 up in units of 100 only.

ZENER DIODES

Full range E24 values: 400mW: 2·7V to 36V, **14p** each: 1W: 6·8V to 82V, **21p** each: 1·5W: 4·7V to 75V, 48p each. Clip to increase 1·5W rating to 3 watts (type 266F), **5p.**
20W 7·5V to 75V **69p** each

VEROBOARD

Copper clad 0·1 matrix—2·5 X 3·75 ins. **27p**; 3·75 X 3·75 ins.—**30p**; 2·5 X 5 ins.—**30p**; 3·75 X 5 ins.—**33p**. Copper clad 0·15 in. matrix 2·5 X 3·75 ins.—**20p**; 3·75 X 3·75 ins.—**30p**; 2·5 X 5 ins.—**30p**; 3·75 X 5 ins.—**36p**.
Vero spot face cutter (any matrix) **43p**.
0·040 pins (for 0·1 matrix) per 100—**35p**.
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CATALOGUE 7

SECOND PRINTING

112 pages, thousands of items, illustrations, diagrams, much useful technical information. The 2nd printing of this catalogue has been updated as much as possible on prices. It still costs only 25p post free and still includes a refund voucher for 25p for spending when ordering goods list value £5 or more.

COVERS & HEATSINKS

Many types including:
T03 Transistor cover, clip-on **7p**
HEATSINK
Type 6WI Extruded aluminium 1° C/W, undrilled **60p**
drilled 2 X T03 **78p**

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All for ¼" shafts in a very wide range of types from utilitarian to modern solid aluminium

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Unsurpassed for "breadboard work" can be used indefinitely without deterioration. Components just push into plug holes and connect automatically. Slot for control panel. 70 holes **£1·98**

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For more advanced work with 208 contacts in 38 rows. Will take one 16 lead carrier. **£3·63.** (Carriers supplied separately.)

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6 ft strip **66p**
25 mtr. reel **£7·15**

ELECTROLYTIC CAPACITORS
Axial Lead

qF	3V	6·3V	10V	16V	25V	40V	63V	100V
0·47	—	—	—	—	—	—	11p	8p
1·0	—	—	—	—	—	11p	—	8p
2·2	—	—	—	—	11p	—	8p	9p
4·7	—	—	—	11p	—	8p	9p	8p
10	—	—	—	—	8p	9p	8p	8p
22	—	—	8p	—	9p	8p	8p	10p
47	8p	—	9p	8p	8p	8p	10p	13p
100	9p	8p	8p	8p	9p	10p	12p	19p
220	8p	8p	9p	10p	10p	11p	17p	28p
470	9p	10p	10p	11p	13p	17p	24p	45p
1,000	11p	13p	13p	17p	20p	25p	41p	—
2,200	15p	18p	23p	26p	37p	41p	—	—
4,700	26p	30p	39p	44p	58p	—	—	—
10,000	42p	46p	—	—	—	—	—	—

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MARCONI Type TF144H STANDARD SIGNAL GENERATOR

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Full specification available on request

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4000–50 MHz DUAL TRACE OSCILLOSCOPE

5mV/cm Sensitivity. 10ns/cm to 2s/cm Timebase. Calibrated Sweep. Gated Trigger.

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Price only **99p** each plus 16p p&p

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Fully tested and checked, guaranteed 12 months with one free calibration.

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Test Set no 1 panclimatic Avo similar to specification as model 9. **£73.00**

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Ever-ready case enables the meter to be used whilst in its case £5

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Sperry Floating Head J101 Memory System
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WIDE RANGE OF SPARES FOR THE FOLLOWING COMPUTERS ICI 1500, ICL 1900, SYSTEM 4, 4100, 803, AMPEX, etc.

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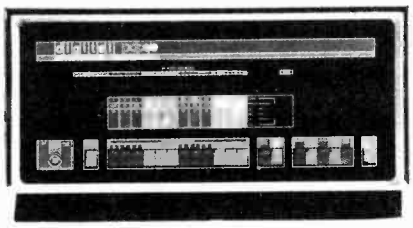

PDP8E 12K Processor complete with
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Data Dynamics BRPE 114 Punch (110 cps)
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Rack-mounted in double cabinet

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PDP8I 8K Processor
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Models S110 and R82C. 17 char. per sec. Rebuilt, available from stock. **£45.**

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ICT KEYBOARDS

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Magnetic Tape Transporters AMPEX TM4, TM2, TM7, FR300, IBM 7330, POTTER. From **£89.00.**

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Photo-electric Readers for all colour paper tapes up to 1 in.
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Available with full warranty.
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Data Entry, parallel to 11 columns. Print speed 5 lines per second. **PRICE £85-00.**

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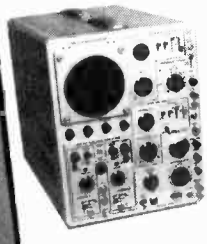

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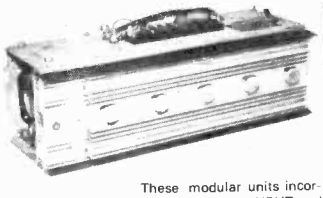

These modular units incorporate overload protection on both INPUT and OUTPUT. Load regulation of 1% or better. Low ripple and fast response time. Input voltage 120–130 50 Hz. Available in the following types:

6 Volt 8 Amp	£12·00	12 Volt 12 Amp	£22·00
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PRECISION A.C. MILLIVOLTMETER VF 252 BY SOLARTRON

£75

* 1% Accuracy on all ranges
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★ With 4 independent inputs ★ 3 digits plus polarity ★ range switching without breaking current measuring circuit ★ High input impedance on voltage ★ low input impedance on current.

Frequency Range 300Hz–500Hz on volts. Measures 0.01mV–600VDC. 1nA–999mA current. 1mV–600VAC, 100nA–999mA. NEW CONDITION IN MANUFACTURER'S ORIGINAL PACKING

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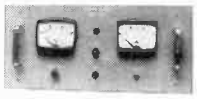
Power Supplies



28V 20A £39·50
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VARIABLE VOLTAGE HIGH CURRENT HIGH STABILITY HIGH RELIABILITY

These power supplies were designed for continuous operation in computer equipment. Manufactured to highest engineering standard for long-term reliability and stability. Independent voltage and current meters. Core Transformer
Manufacturers' price probably in excess of £200.

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These machines, originally ex-computer, are multi-track recording units, ideal for data storage. Record and Replay Heads encased in one common unit. Low resistance heads. Frequency response approximately 0 Kc/s to 50 Kc/s. Bit density 557 b.p.i. ½ in., 10½ in. spools. 230 V to 380V. Capstan motor speed 1,500 r.p.m. 48 V DC rewind motors complete with vacuum assembly. Finished in brush aluminium and matt black. Size 27 in. X 26 in. X 8 in. Weight 90 lbs. Price **£89·50.**

PRICE £35

RCA 301 TAPE DECK MODEL 381

Technical Data. ½" wide Magnetic Tape. Power supplies: Input 208-230V AC 60 c/s. Single phase Magnetic recording head, read/write and erase. Seven channels each head. Speed 30"/sec. forward or reverse, 90"/sec. during rewind. The recording density of 333 characters per inch is maintained, thus giving the nominal read and write rate of 10,000 characters per second. Maximum diameter of 8" tape reel. Accommodates 1200ft. of Magnetic Tape, which gives a minimum of 1,150ft. available for recording.

Potentiometers

TEN TURN 3600° ROTATION

Res Ohms	Linearity Per cent	Manufacturers	Model	Price
100	0·5	Beckman	A.S.	£2·00
200	0·5	Beckman	A	£2·00
500	0·1	Beckman	S	£2·50
500	1·0	Relcon	HEL107-10	£2·25
1K		Relcon	HEL0710	£2·25
2K	0·5	Beckman	SA1101	£3·00
2K	0·25	Beckman	7216	£3·00
2K		Reliance	GPM15	£2·00
2K		General Controls	GPA15/4	£2·00
5K		Relcon	07-10	£2·50
5K		Colvern	CLR2503	£3·00
10K	0·1	Beckman X	A	£3·50
15K		Colvern	CLR2402	£3·00
25K	0·5	Helipot	SAJ337	£3·00
29K	0·05	Beckman	SA1244	£4·50
30K	0·1	Beckman	A.88	£3·50
30K	0·5	Beckman	SA1692	£3·00
50K		Reliance	07-10	£2·25
50K			07-5	£2·25
50K	0·5	Beckman	A	£3·00
100K	0·1	Beckman	A	£3·50
100K		Colvern	2501	£2·25
298K	0·1	Beckman	8A3902	£3·50
300K	0·1	Beckman	A	£3·50

THREE TURN 780° ROTATION

25Ω	Beckman	Type C	£2·25
100/100	Beckman	Type C	£3·00
300	Beckman	9303	£2·25
1K	Fox	PX2/H3	£2·25
10K 0·5	Beckman	C.ss.	£2·25
20K/20K 0·1	Beckman	C.S.	£3·00
10K/10K 0·1	Beckman	C	£3·00
50K 0·5	Beckman	C.S.	£1·75

FIFTEEN TURN 5400° ROTATION

25K/25K	Beckman B	10 watts	£6·50
46K/46K	Beckman B	10 watts	£6·50

WANDEL & GOLTERMANN

Distortion Measuring Set VZM-1 for colour t.v. 625 lines PAL. **£750.**
Distortion Measuring Set VZM-2 556KHz-12MHz. **£250.**
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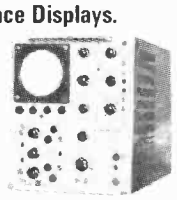
Voltage & Level Meter 10KHz-14MHz TFPM 43 measuring range 8v-40uv (+20–86dB). **£339.**
Selective Level Oscillator 10KHz-14MHz TFPS 42. **£349.**

Solartron C.T.484 oscilloscope. DC–40 MHz. 3% accuracy. Dual Trace Displays.



TIME BASE. 100 nanosecs/cm—5 secs/cm or continuously variable up to 12 secs/cm. Sweep expansion x 5. Accuracy: ± 3%.
X AMPLIFIER. Bandwidth: D.C.—150 Kc/s. Sensitivity: 200 mV/cm and 1 V/cm. Input Impedance: 1 M.ohm 40 pF.
INTERNAL CALIBRATOR. Accuracy: ± 3%.
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WIDE BAND Y AMPLIFIER PLUG ALSO AVAILABLE. Bandwidth: D.C.—40 Mc/s. Rise Time: 8 nanosecs. Sensitivity: 50 mV/cm—50V/cm. Input Impedance: 1 m.ohm 22pF. Measuring Accuracy: ± 5% direct, ± 3% with calibrator. P.O.A.

£149.50

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K.G.M. Type 3015F 7 Segment display showing figures 0–9 plus decimal point. Character pf 9mm height. In 16 DIL case.
NEW LOW PRICE £1·25
SN7447N BCD Decoder Driver **£1·00.**

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£10·50

Clamp-on Voltammeter is used for measurements of AC voltages and currents without breaking circuits.
Specification
Measurement ranges:—Current 10–25–100–250–500 Amps. Voltage 300, 600 V. Accuracy 4%. Scale length 60mm. Overall dimensions 283×94×36mm. Weight 1·5 lbs.

Stop Press

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These boards are basically a multi-pole multi-throw switch device consisting of a X-Y Matrix with two contact decks in the Z Plane running at 90 degrees to each other. Contact is made by either, shorting or plugging in pins. Ideal for prototype work, etc. Boards available in 2 planes. 24 × 50 **£29.** 20 × 11 **£15.**

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Please note: all instruments offered are second-hand and tested and guaranteed 12 months unless otherwise stated.

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Amperclamp
For measuring a.c. currents from 250mA to 500 amps.
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For transistors and diodes.
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E.H.T. PROBE Extends D.C. voltage to 25,000v. **£5.95.**

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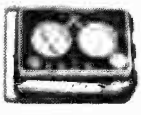

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FOUR INTERNATIONAL PATENTS — SENSITIVITY 20,000 Ohms per Volt
10 FIELDS OF MEASUREMENT
AND 80 RANGES. ACCURACY 1% in D.C. 2% in A.C.
OUTSTANDING FEATURES:
20,000 Ohm per Volt sensitivity ● Fully screened against external magnetic fields ● Scale width and small case dimensions (128 x 95 x 32mm) ● Accuracy and stability (1% in D.C., 2% in A.C.) of indicated reading ● Simplicity and ease of use and readability ● Full ranges of accessories ● 1000 times overload ● Printed circuit board is removable without de-soldering ● More ranges than any other meter. VOLTS A.C. = 11 ranges: 2–10–50–250–1000–2500. Volts and **4–20–100–500 and 2000 Volts.** VOLTS D.C. = 13 ranges: 100mV–2V–10–50–200–500–1000 **Volts 200 mV-4V-20-100-400 and 2000 Volts** AMP D.C. = 12 ranges: 50μA-500μA-5 mA-50 mA-500 mA-50 Amp and 100μA-1 mA-10 mA-100 mA-1 Amp and 10 Amp. AMP. A.C. = 10 ranges: 250μA-2.5 mA-25 mA-250 mA-2.5 Amp and 500μA-5mA-50 mA-500 mA-5 Amp. OHMS REACTANCE = 6 ranges: **x1-x10-x100-x1000-x0.000 and Low Ohms.** DETECTOR = 1 range: from 0 to 10 Megaohms. FREQUENCY = 2 ranges: from 0 to 500 and from 0 to 5000 Hz. V. OUTPUT VOLTAGE = 9 ranges: 10-50-250-1000-2500 V and **20-100-500-2000 Volts.** DECIBELS = 10 ranges: from −24 to +70 db. CAPACITY = 6 ranges: from 0 to 50,000 and from 0 to 500,000 pF using the mains and from 0 to 20, from 0 to 200, from 0 to 2,000 and from 0 to 20,000 Micro farad using the incorporated 3 Volts battery.
Bold figures indicate depress button.

£18.50 with shockproof case

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METERS PROBES, ETC.

AC/DC MULTI-METER

With taut band suspension movement. Sensitivity 20,000 ohms per volt on DC and 4,000 ohms per volt on AC.
Technical Data:
0.06-0.6-6-60-600mA-3 Amps DC. 0.3-3-30-300mA-3 Amps AC. 0.6-1.2-3-12-30-60-120-600 DC. 1200 Volts. 3-6-15-60-150-1300-600-900 Volts AC. 45 to 20,000 Hz.
500Ω. 5-50-500kΩ resistance. Decibel range −10 to +12dB. Accuracy (% of F.S.D.):—DC and resistance measurements ±2.5. Price with test leads and storage case **£8.00** **POST FREE**

AMPERTEST 690

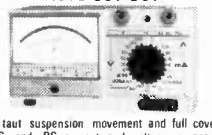
NEW CLAMP TYPE AMMETER

With unique self-locking meter system retains reading until released, enabling engineer to obtain accurate results after testing inaccessible places etc.

Designed for use in one hand, measures without breaking the circuit. It has six current ranges from 3A to 600A f.s.d. with the first division at 100mA, a 10-to-1 current transformer supplied with the instrument provides ranges from 300mA to 60A f.s.d. with the first division at 10mA. Two a.c. voltage ranges of 250V and 600V f.s.d. are provided.

£39.50 **POST FREE**
inc. leather case

MULTIMETER WITH FULLY AUTO CUT-OUT



With taut suspension movement and full coverage of AC and DC current and voltage ranges. The instrument incorporates all facilities needed for field and laboratory measurements. Knife edge pointer and 86mm long mirror scale allow the high inherent accuracy of the instrument to be utilized in full. The movements and circuits are fully protected by transistorized triggering circuit.
Scale length: 86mm D.C. current ranges: 50μA, 0.5, 1, 5, 10, 50, 250mA 1, 5 Amps. A.C. current ranges: 0.25, 0.5, 1, 5, 10, 50, 250mA, 1, 5 Amps. D.C. voltage ranges: 100mV, 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. A.C. voltage ranges: 0.5, 2.5, 10, 25, 50, 100, 250, 500, 1000V. Transmission level: −5 to +10db. Resistance ranges 0.5, 200; mid-scale reading 13 10Ω–3kΩ; mid-scale reading 200Ω, 100Ω, 30kΩ; mid-scale reading 2000Ω, 1kΩ–300kΩ mid-scale reading 20kΩ. Accuracy, % of F.S.D.: D.C. ranges — 1.5 A.C. ranges — 2.5. Sensitivity: D.C. ranges, 20,000Ω/V. A.C. ranges, 4,000Ω/V for all ranges except 2.5V and 10V. 1000Ω/V for 10V range 200Ω/V for 2.5V range. Batteries required: 2 dry cells 1.5V for automatic cut-out, 1 dry cell 1.5V for resistance range. Overall dimensions: 210 x 115 x 90mm. in carrying case, complete with test leads.

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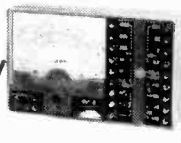

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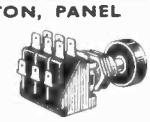

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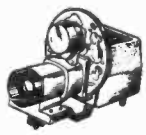

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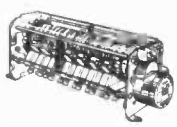

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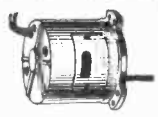

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Advertisement accepted up to 12 noon Tuesday, July 2nd, for the July issue subject to space being available.

THE POLYTECHNIC OF NORTH LONDON
Holloway Road, N.7.
DEPARTMENT OF PHYSICS

LABORATORY TECHNICIAN
Grade 5
(ELECTRONICS TECHNICIAN)

There is a vacancy for an electronics technician in the physics department of the Polytechnic of North London. The work is mainly concerned with the maintenance and servicing of electronic measuring instruments.

Applicants must have an appropriate Higher National Certificate or equivalent qualification and a minimum of seven years' technical experience, including a wide knowledge of electronic servicing.

Salary scale: £2,181 per annum rising by annual increments to a maximum of £2,556 per annum (inclusive of London Weighting allowance).

Applications to: The Head of the Physics Department, The Polytechnic of North London, Holloway, London, N7 8DB. [3828

COUNTY COUNCIL OF ESSEX
North-East Essex Technical College & School of Art
Electrical Engineering Department

Chief Laboratory Technician

is required. Applicants must have good experience in the maintenance and construction of electronic equipment, some of it in a supervisory capacity.

Salary, technicians' scale T.5, £1,926-£2,235 p.a., starting point according to qualifications and experience.

Five-day 37-hour week, permanent superannuable post.

Request application form, quoting ref. T.121, from the Principal, North-East Essex Technical College & School of Art, Sheepen Road, Colchester, Essex C03 3LL. Closing date 21st June, 1974. [3829

UNIVERSITY OF SUSSEX
SCHOOL OF APPLIED SCIENCES

ELECTRONICS ENGINEER
(Technician Grade V)

There is a vacancy for an experienced electronics engineer to be responsible for the servicing of equipment within the Materials Science Division. Duties also include some development work on projects associated with the research programmes being carried out in the Laboratories.

In the near future, it is anticipated that the successful candidate will have the opportunity of becoming fully involved in the operation of the University's Electron Microscopy Service Suite for which additional training (if necessary) would be given.

Salary on scale **£1881-£2241** per annum.

Applications giving full details of age, qualifications and experience should be sent to the Laboratory Superintendent, School of Applied Sciences, University of Sussex, Brighton BN1 9QT.

[3762

Electronic Technician

Within our Group Engineering Department at St. Albans we have an increasing design and development work load, due to the continuing modernisation of existing factory facilities together with a programme of expansion of our production capacity throughout the United Kingdom.

The post requires a man who can interpret the engineer's requirements to construct and test electronic inspection and control equipment. This may be in the form of bottle inspection machines or control panels for furnaces. A knowledge of good wiring practice for both electric and electronic currents is required.

The successful applicant will from time to time assist in installing equipment at Group factories throughout the U.K. The post will suit an electrical tradesman who has obtained ONC or similar qualifications in electronics. It would also be helpful to have working knowledge of small bore pipework.

The appointment will involve some travel to our factory site within the British Isles. The post offers excellent conditions, interesting work and opportunities for promotion within the Group.

Please apply in the first instance to :—

Mr. A. Raine Howe,
Design and Development Engineer,
Research & Development Centre,
Valley Road Industrial Estate,
Porters Wood, St. Albans, Herts. [3784

UNITED GLASS

EXCITING OPPORTUNITY FOR A YOUNG MAN INTERESTED IN C.C.T.V.

Six months ago we set up our T.V. studio and are now looking for a young man to join our Video production team. He will assist the Studio Engineer in the operation, maintenance and development of a 3-camera colour C.C.T.V. system, incorporating telecine and U-matic videocassette copying facilities. Some knowledge of T.V. theory is essential and any experience in servicing VTR's and cameras would be useful.
You'll be given every opportunity to learn about colour C.C.T.V. – including day release. The salary will be according to age and experience plus L.V's.

If you're interested and want to know more
Telephone Peter Makosz on 01-499 0031
or write
HAMBRO LIFE ASSURANCE
7 Old Park Lane, London W1Y 3LJ.

3822

RADIO OPERATORS JOIN THE POST OFFICE FROM AGE 19

A job in the Post Office Maritime Service is the key to an interesting career, whether you have recently qualified and are looking for a shore-based job, or are seagoing and wish to swallow the anchor. A progressive future in the Post Office could be yours if you hold a General Certificate in Radiocommunications, issued by the Ministry of Posts and Telecommunications, or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic.

Starting pay at age 19 is £1,567 a year, including contributions to a compulsory pension scheme, with an additional allowance averaging £300 for shift duties. After two years', satisfactory service your pay becomes £2,054, rising to a maximum of £2,622 at age 25 years. If you are over 19 years of age your salary is dependent upon age at entry.

There are opportunities for further promotion to positions with a basic salary of £3,475 and prospects for advancement into Senior Management.

For further information, write to the Inspector of Wireless Telegraphy (L524), MRSD/ET17, Room 643, Armour House, St. Martin's-le-Grand, London EC1A 1AR.

Post Office Telecommunications

Electronic Technicians

WALLSGRAVE HOSPITAL

Two Electronic Technicians are required for the Electronics Department dealing with the maintenance of a wide variety of electronic and electro medical apparatus.

Applicants must possess H.N.C., H.N.D., or O.N.C. in electronics or equivalent City and Guilds Certificate.

General diagnostic maintenance experience in the electronic field is necessary. Training in maintenance of specialised hospital equipment will be given. Salary scale from £1,719 to £2,211 p.a. Additional payments are made if overtime is required. Applications stating age, qualification and experience, together with the names of two referees should be sent to the Group Engineer, Coventry Area Health Authority, P.O. Box 92, The Birches, Tamworth Road, Keresley End, Coventry.

3820

COVENTRY
Area Health Authority

Video Circuitry Design Engineer –Canada

In just 12 years our client has grown into an internationally recognised leader in the field of television broadcast equipment. We seek a specialist who can join their research and development laboratory as a Project Engineer, in their modern manufacturing facility in Montreal, Canada.

This is an opportunity for you to join a company which has shown its ability to grow in an expanding market, and you will have had at least 3 years' experience in creative linear circuit design, with a full understanding of professional broadcast equipment. This career position offers outstanding prospects for personal development in a young country with an expanding economy. Excellent salary and benefits, with all reasonable relocation expenses paid.

Contact Stuart Tait
(quoting reference DC/19/6)
Lansdowne Recruitment Limited,
Design House, The Mall, London W5 5LS.
Tel. 01-579 6585.

lansdowne Recruitment Limited

3824

TEXAS INSTRUMENTS'

aggressive thrust into the **CONSUMER ELECTRONICS MARKET** with its rapidly expanding range of power semi-conductors, has resulted in opportunities for creative and energetic engineers. These engineers, when appointed, will join a team of technologists from many different disciplines, based in Bedford, responsible for the development and production of high voltage transistors (up to 2.2KV) and other power semi-conductors to serve the TV deflection market world-wide. It is expected that the significant advances in technology which have already taken place and the further advances expected from this highly qualified and prolific team, will soon begin to impact in other market areas.
The work is demanding, exciting and rewarding.

SENIOR APPLICATIONS ENGINEER

This position requires an engineer with a high level of personal drive coupled with at least 3 years' experience in semi-conductor television design.
The major part of the work will be involved with the power stages in television—power supplies, deflection and associated control circuits. This is a splendid opportunity for a creative mind to develop new system design concepts which provide cost effectiveness and/or technical improvement in the end equipment and which will often involve the creation of a new generation of semi-conductor products.
Another aspect of the work will involve customer contact to determine specifications and device operating conditions and maintain close liaison with the development and characterization groups in TI to advise on current product suitability and play an active role in determining future products.
The present scope of the work covers TV design world-wide and there will be every opportunity to branch out into other fields.
On joining the company, the successful applicant will be working alongside first-class applications engineers in many fields including MOS, Opto, Bipolar digital and linear IC's and there will be every opportunity for cross fertilization of ideas from the various disciplines.
Salary is in the range of £2,500–£3,500 but could be higher for outstanding candidate.

CHARACTERIZATION ENGINEER

To be responsible for all aspects of the characterization function for power semi-conductors, including those being currently developed to serve the TV deflection and other similar markets.
This will include the instigation and control of characterization programs, and based on these programs the preparation of product specifications and reports to demonstrate the product's capabilities and promote them in the market. Development of measurement techniques to meet customer requirements and the interpretation of these into production tests to guarantee the required operating characteristics. The implementation of product evaluation programs on engineering and development samples to assess their operating characteristics and ratings against required specifications. The establishing of product recurrent evaluation programs.
Close liaison with other disciplines such as product marketing and product engineering will be essential.
The person appointed will be qualified to degree level in either electronic engineering or physics and would preferably have 2 years' semi-conductor experience, though the right person with a general electronic engineering background will be considered.
Salary is in the range of £2,000–£3,000 but could be higher for outstanding candidate.

PRODUCT DEVELOPMENT ENGINEER/SENIOR ENGINEER

Required for the development of new high voltage transistors and other power semi-conductors for the consumer and other markets.
Responsibility covers all aspects of development from translation of market or application requirements into specifications and device designs, to the ultimate introduction of new devices into the market place.
New devices are characterized under operational conditions which often involves the development of new measurement techniques. TI is a forerunner in this field and some of the latest equipment is available for this work.
Close liaison with engineers from other disciplines such as applications is essential. A degree of involvement with customers is also required for introduction of new devices and resolution of operational problems.
The appointee will be qualified to degree level in Physics or Electrical Engineering and will have at least 2 years' experience in semi-conductors, but above all he will have a creative and agile mind.
Salary is in the range of £2,000–£3,000 but could be higher for outstanding candidate.

A full range of benefits include:

* **FREE PRIVATE MEDICAL PLAN**
* **FINANCIAL HELP WITH RELOCATION**
* **EXCELLENT WORKING CONDITIONS**
* **GENUINE PROMOTION OPPORTUNITIES**
* **SUBSIDIZED CAFETERIA**

Please write or telephone (reversing charges) Patrick Fitzgerald, Ext. 3490.

TEXAS INSTRUMENTS LTD
Manton Lane Bedford
Telephone Bedford 67466

3795

Take off with the Leaders in T.V. Broadcast Equipment.

Pye TVT design and manufacture an extensive range of TV equipment which is used in all points of broadcasting networks all over the world. At the moment we have appointments at all levels of seniority for:

INSTALLATION AND COMMISSIONING ENGINEERS
PLANNING ENGINEERS
PLANNING DRAUGHTSMEN

Work will involve the planning, installation and commissioning of equipment for contracts both in the UK and overseas. You'll be based in Cambridge but, Installation and Commissioning engineers especially, could be asked to tackle assignments abroad for periods of up to six months.

But it's not only you that will take off – so will your career. Pye TVT are leaders and intend to stay so. One of the ways of doing this is by paying the best people competitive salaries and encouraging advancement. We offer, among many fringe benefits, a pension with life assurance; and will pay overseas allowances in addition to removal expenses.

In return we require a high degree of technical competence and practical ability with present generation monochrome and colour TV transmitter and studio equipment.

Please write giving brief outline of your career to date to:

Mrs J. A. Macnab – Personnel Manager

Pye TVT Limited
P O Box 41 Coldhams Lane
Cambridge CB1 3JU

A member of the Pye of Cambridge Group

3831

Radio/Audio/TV Engineer

The Littlewoods Organisation is one of the largest and fastest-growing retail organisations in the U.K. and is also one of the country's leaders in domestic radio, audio and T.V. retailing. High standards of production quality are essential for merchandise included in our Mail Order catalogues and, with the continuing expansion of our activities, we need to fill a particularly interesting vacancy in our Liverpool headquarters.

We require a suitably-qualified technologist to maintain these standards, by acting as Quality Controller to ensure that samples of goods we receive from manufacturers meet with our value, safety and performance requirements.

The work involves direct personal contact with our suppliers and the development of engineering modifications to merchandise when these are necessary to allow our standards to be met. It also involves maintenance of the high technical standards of our repair workshops. Some travelling will be necessary.

Applicants will be educated to degree level, or at least to HNC standard in Electronic Engineering; at least 3 years' experience in domestic electronic equipment manufacture – including design and production – is desirable.

The Company offers an excellent salary, together with a generous relocation allowance, if required.

To apply, please write giving details of yourself and your career to: Appointments Manager, Littlewoods, JM Centre, Old Hall Street, Liverpool X.

Littlewoods

3803

RADIALL
MICROWAVE COMPONENTS LTD.

Salesman/ Sales Engineer

We are seeking a man experienced in selling to the electronics industry to successfully sell our range of coaxial and multipin connectors and high frequency components in the Midlands and Northern Home Counties.

An attractive salary, company car, expenses and excellent prospects will be offered to the successful candidate.

Please write in confidence to:
S. W. Marsh, General Manager
Radiall Microwave Components Ltd.
Romar House, the Causeway
Staines, Middlesex

3814

Ground Radio Technicians

Step out into an exciting new world and a high tax-free salary

International Aeradio in conjunction with Lockheed Aircraft International are jointly engaged on a wide range of civil aviation and communications contracts in the Arabian Gulf and can offer Ground Radio Technicians highly rewarding opportunities in two areas of activity.

One covers the maintenance of transmitters, receivers and aerial systems of HF point-to-point links using SSB/ISB and FSK techniques and calls for a good knowledge of radio systems using multiplex techniques in VHF, UHF and SHF bands. The other requires experience in the maintenance of Ground/Air communication systems and Radio Navigational Aid equipment such as NDB, ILS, TACAN and CADF.

These are unaccompanied positions earning a salary of £3,617 p.a. tax-free plus a gratuity of £800 p.a. for a $2\frac{1}{2}$-year contract; generous leave including free return flights to London each six months, free bachelor accommodation and non-contributory sickness schemes.

IAL

LOCKHEED

Telephone or write for an application form to: The Recruitment Officer, Ref: GRT/WW, International Aeradio Ltd., Aeradio House, Hayes Road, Southall, Middx. Tel 01-571 0678.

3832

Test/Commissioning Engineers

Are you in an ever deepening rut?

Why not join a progressive Company engaged in the production of sophisticated equipment for use in the Graphic Arts Industry?

This is interesting work in the field of Digital Electro/Optical Phototypesetting. Advanced digital display technology is used in conjunction with Digital Computing Techniques. Test and Commissioning Engineers of all grades are required for our rapidly expanding production programme. We offer good salaries, excellent terms and conditions of employment, but most of all an exciting working environment.

Ring 01-205 0123—ask for Maurice Alberts. He will tell you more.

LINOTYPE-PAUL LTD.,
Kingsbury Works,
Kingsbury Road,
London NW9 8UT.

1971 1974

3801

Electronics Appointments Register

We know of more good jobs than are printed on this page.

Even if you scour the Sits Vac columns you won't find all the good jobs to fit your qualifications. Because the best jobs aren't always advertised.

More and more companies are using the Electronics Appointments Register to find qualified men and women.

Join one of our Registers and soon you could be on a short list for a better job. Our confidential service costs you nothing.

Send in the coupon—we'll mail you by return.

G A R Graduate Appointments Register

Please send me details of how to enrol on one of your Appointment Registers.

Name _____

Address _____

_____ ww9

Age limits 20-45.

Post to G.A.R. 76 Dean Street London W.1. 01-734 6536

3796

Just one technician's opinion of his future with us.

David joined Marconi Communication Systems Ltd. in 1968 and has been in the Repair and Calibration Section for 12 months. He is currently studying for his City & Guilds Telecommunication Technician certificate on a day release basis. His work is varied and interesting and consists of checking and maintaining the performance of complex electronic test equipment used to test and develop the Company's products.

If you have some experience of modern circuitry and fault finding, why not find out more about a job alongside David ? If you have C & G or ONC so much the better. There are also opportunities for people with experience in computers for our Automatic Test Department. We can offer good salaries and all the career opportunities that exist in a large Company together with generous removal expenses where necessary. The positions are based in Chelmsford, so why not clip the coupon and send it now to Gordon Short, Technical Recruitment Officer, Marconi Communication Systems Ltd., New Street, Chelmsford, Essex. Telephone Chelmsford 53221. Ext. 592.

"... I consider that the ever increasing knowledge that I am acquiring is the basis of an interesting and rewarding career".

David Orves Age 22
Calibration Technician.

Name_____

Address_____

Marconi Communication Systems
A GEC-Marconi Electronics Company

100 IN HONOUR OF THE CENTENARY OF THE BIRTH OF GUGLIELMO MARCONI 1874 1974

3825

VOICE OF KENYA

MAINTENANCE ENGINEER

(Broadcast Transmitter)

Required by the Ministry of Information and Broadcasting to introduce a revised maintenance system and assist in its implementation; to instruct staff and compile a maintenance instruction manual; to give occasional lectures on maintenance to engineering trainees.

Candidates 30-50 years, must hold a degree or diploma in Engineering with extensive practical experience in organising and undertaking maintenance of sound transmission equipment, medium wave, short wave and VHF transmitters. Experience as an Instructor in maintenance techniques would be an advantage.

Salary in the range £3,020 to £3,340 p.a. which includes an allowance, normally tax free, of £1,210 to £1,380 p.a. Terminal gratuity 25 per cent. For a married man with two children paying tax at the standard rate the total emoluments described above, including gratuity, approximate to a gross (i.e. before tax) UK return of £5,150 to £5,350 and for a single man £4,950 to £5,200. Other benefits include:—Subsidised Accommodation, Education Allowances; Holiday Visit Passages; Free Family Passages; Appointment Grant £100/£200; 30 month tour.

The post described is partly financed by Britain's programme of aid to the developing countries administered by the Overseas Development Administration of the Foreign and Commonwealth Office.

For further particulars you should apply, giving brief details of experience to:

crown agents

M Division, 4 Millbank, London SW1P 3JD, quoting reference number M2K/730923/WF. [3779

CIRCUIT DEVELOPMENT ENGINEERS
TELEVISION SYSTEMS
SALARY RANGE £7,000 (OPEN)

The Grass Valley Group, Inc. (USA), a leading manufacturer of television line and terminal equipment, has immediate openings for highly qualified circuit development engineers Specifically, we are looking for creative and resourceful people who are capable of carrying ideas through to completed products. Applicants are expected to be familiar with the latest solid state devices and techniques, and preferably should have experience in the design of video switching systems, video processing systems, and possibly digital video systems. Some experience in television studio operations and techniques is also desirable. Educational requirements are a C.E. or a B.Sc. in electronic engineering. A minimum of five years' design experience is required.

If you are interested in a challenging and rewarding career with an expanding company, please airmail a resume of your educational and technical background, work experience, and personal history to William L. Rorden, Chief Engineer, The Grass Valley Group, Inc., P.O. Box 1114, Grass Valley, California 95945, USA. Resumes need not be formal; however, we are interested in learning as much about you and your experience as possible. Immediate consideration will be given and response made to suitable applicants, with a view toward arranging personal interviews in London in early 1974. All resumes will be treated in confidence. References will be required at or prior to the time of interview.

Grass Valley is a small town located in the foothills of the Sierra Nevada mountains in northern California, adjacent to summer resort and ski areas, and 2 1/2 hours from San Francisco.

THE GRASS VALLEY GROUP, INC.

3611

ELECTRO-OPTIC SALES

Owing to continued expansion, there is a vacancy for a technically qualified man (physicist or engineer) aged 26/36 to be based on our London Office as an outside sales representative. We are a well known firm of Engineers and Instrument Makers with a wide range of products.

The man we are seeking will have the ability to express himself clearly and to get on with people. He will have experience in electronics and preferably will have an interest in optics. He should have commercial sense and be willing to travel frequently in the UK. He will live within range of London, north of the Thames, and be expected to cover an area which will include the Midlands, but nothing south of the Thames.

The work is exceptionally interesting and the position progressive. Specialised training can be given.

Write, marking envelope "Personal" to:

Director,
Barr & Stroud Ltd.,
Kinnaird House,
1 Pall Mall East,
London SW1Y 5AU.

[3758

TELEVISION SERVICE ENGINEERS, INSTALLATION ENGINEERS, C.C.T.V. ENGINEERS, AUDIO-VISUAL ENGINEERS AND CABLE INSTALLERS

are urgently required to cope with our rapidly increasing business in hotels, banks and industrial premises in London and the South East. If you are experienced in any of these fields, we will welcome you with open arms. If you are a television enthusiast with sound technical knowledge but without previous experience in the industry, we can probably find a place for you. Salaries start at about £2,000. Fringe benefits include, private use of Company estate car, bonus scheme, lunch allowance, pension and life assurance schemes, staff status.

TELEVISION SYSTEMS & RESEARCH LIMITED
Southern Regional Office, Market Road, Richmond, Surrey. Telephone 01-560 3246

[3773

Electronics Engineers up to £5000

Many jobs which would suit you down to the ground – either in the U.K. or overseas – are never advertised. Yet it will cost you nothing whatever to give yourself the opportunity to be considered for them.
Join the Lansdowne Appointments Register – used by hundreds of employers to select electronics engineers. You have nothing to lose, everything to gain – and it's all conducted in strict confidence. So post the coupon – find out exactly how you can make use of a service which is all the more valuable for being free!

To: Stuart Tait, Lansdowne Appointments Register, Design House, The Mall, London W5 5LS. Tel: 01-579 6585 (anytime – 24 hour answering service).

Please send me further details.

Name.....
Age (20-45 only) .....
Address.....
.....
..... WW 19/6

lansdowne Appointments Register 97

HACKER RADIO LTD

MANUFACTURERS OF RADIO AND AUDIO EQUIPMENT OF OUTSTANDING QUALITY

An opportunity occurs in our Development Department for a

RADIO ENGINEER

to be responsible for the design and development of advanced domestic broadcast receivers.

The successful applicant for the post will have had previous experience in this field and will possess HNC or equivalent qualifications.

We also require for our Development Department a competent

DESIGN DRAUGHTSMAN

who will be engaged primarily upon detailed work in connection with radio chassis and associated assemblies, but who will also find himself playing the role of mechanical trouble-shooter upon occasions.

Both positions offer attractive salaries plus an excellent contributory pension and life assurance scheme, and the chosen applicants will be directly responsible to the Technical Director.

Please write, giving full details of experience and qualifications, to:

The Technical Director,
Hacker Radio Ltd.,
Norreys Drive, Cox Green, Maidenhead, Berks., SL6 4BP

[3791

Foreign and Commonwealth Office

Telecommunications Technicians

. . . at Hanslope Park, Milton Keynes, for work on various receivers and associated test equipment, recorders, telephone and teleprinter equipment, electronic ancillary equipment (some using analogue and digital techniques), voice frequency telegraph and other specialized equipment.

Candidates must have ONC or equivalent in electrical/electronic subjects and have served an apprenticeship or had equivalent training.

Starting salary £1,745 (at 21)–£1,937 (at 23)–£2,365 (at 28 or over on entry); scale maximum £2,587. Prospects of promotion up to £3,761. Non-contributory pension scheme.

For full details and an application form (to be returned by July 5, 1974), write to Civil Service Commission, Alencon Link, Basingstoke, Hants RG21 1JB, or telephone BASINGSTOKE 29222 ext 500 or LONDON 01-839 1992 (24-hour answering service). Please quote T/8651.

[3811]

Southern Television

have vacancies for **ELECTRONIC ENGINEERS** at their Southampton Studios.

1st year Engineers are required in Telecine and other Operational Departments.

QUALIFICATIONS should be to ONC or Final City and Guilds Telecommunications level.

SALARY—1st year Engineer £2,055 rising by annual increments to £3,007 after 6 years.

Excellent Pension, Accident Insurance and Life Assurance Schemes in operation.

Apply in writing to:
The Personnel Administrator,
Southern Television Ltd,
Northam, Southampton SO9 4YQ

SOUTHERN INDEPENDENT TELEVISION 3793

Assistant Editor electronics

An English subsidiary of a Dutch scientific and technical development and publishing company requires an assistant editor for a monthly magazine on electronics, the first English language issue of which is to be published later this year. Applicants should have a sound knowledge of electronics and an ability to write lucidly on that subject. Previous journalistic experience is not essential but would be an advantage as would a knowledge of the German language

The Dutch company already publishes similar magazines in Holland and West Germany with an aggregate monthly circulation of 115,000. The successful applicant will have the opportunity to assist in the technical development of the proposed magazine on attractive terms and conditions of employment. The location of the company's offices has not yet been decided but is likely to be in the London, Leeds or Birmingham areas

Applications with career details should be addressed to R P G Lewis, A C A., Kidsons, Columbia House, 69 Aldwych, London WC2B 4DY

3823

JOHN KING require
NEW WORTHING SHOP
Senior Technical Salesman for Hi-Fi, Tape Department. Terrific scope, superb facilities. Full details in confidence to
JOHN KING
71 East Street, Brighton. Tel: 25918/27674.
[3688

TAPE ENGINEER
Able to operate and maintain tape duplication and recording equipment. London area.
Money no object for right person.
Apply:
ITA, 5 Pratt St., NW1. Tel: 01-485 6162.
[3799

RADIO OFFICERS

Do you have PMG I, PMG II, MPT 2 years operating experience?

Possession of one of these qualifies you for consideration for a Radio Officer post with composite signals organisation.

On satisfactory completion of a 7-month specialist training course, successful applicants are paid on a scale rising to £3,096 pa; commencing salary according to age—25 years and over £2,245 pa. During training salary also by age, 25 years and over £1,724 pa with free accommodation.

The future holds good opportunities for established status, service overseas and promotion.

Training courses commence at intervals throughout the year. Earliest possible application advised.

Applications only from British-born UK residents up to 35 years of age (40 years if exceptionally well qualified) will be considered.

Full details from:

Recruitment Officer,
Government Communications Headquarters,
Room A/1105, Priors Road, Oakley,
Cheltenham, Glos GL52 5AJ
Telephone Cheltenham 21491 Ext 2270

[92

OPTICAL FIBRE COMMUNICATIONS

Communication by optical fibres is a rapidly expanding new technology which is being widely taken up by industry. The Laser research group at Southampton, comprising some 15 research workers has been engaged in this field for some years with support from Science Research Council, industry and elsewhere. We have already announced world records for low transmission loss and high bandwidth in our fibres and wish to expand the present research team. Applications are therefore invited for a number of research fellowships, including a Pirelli Fellowship, at salaries linked to the scale for Lecturers. Persons with an interest in any aspect of the subject are eligible. Vacancies also exist for research students and a technician. Applications giving details of education, experience and the names of two referees should be sent to the Deputy Secretary's Section (Ext. 2400),

The University, Southampton SO9 5NH. Please quote reference number: 231/R/WW. [3775

ELECTRONIC VACANCIES

Engineers

Draughtsmen ● Designers

Service and Test Engineers

Technicians ● Technical Authors

Sales Engineers

£1,600-£5,000 pa

Permanent or Contract

Phone MICHAEL NORTH
01-388 0918
MALLA TECHNICAL STAFF LIMITED
334 Euston Rd., London NW1 3BG
195

ASSISTANCE

needed in the construction of automatic vision testing equipment. Experience desirable in construction and testing of TTL/CMOS circuitry at prototype level. Salary up to £1,839 p.a. (incl. L.A.) depending on qualifications. ONC or equivalent essential, HNC desirable.

Applications to Professor R. A. Weale, Institute of Ophthalmology, Judd Street, London, WC1H 9QS, by 30th June, 1974. [3783

MEDICAL UNIT,
UNIVERSITY COLLEGE HOSPITAL MEDICAL SCHOOL,
University Street, London, WC1E 6JJ

MEDICAL ELECTRONICS TECHNICIAN

to work in teaching hospital of Medical School as part of a team evaluating drugs in man under laboratory and clinical conditions.

The successful applicant would operate and maintain a wide range of electronic monitoring equipment and will be encouraged to pursue interest in the design field. An interest in computer techniques would be an advantage.

The post would suit a graduate or person with industrial experience. Salary in the range £1,440-£2,222 plus London Weighting.

Apply to the Secretary quoting Reference CP/2.

[3788

Test Engineers for telecom equipment -Haverhill

Have you experience of testing electronic equipment? If you have, then join the world's leading company in this field, where expansion is constant, and opportunity is waiting for you in the pleasant surroundings of Haverhill, Suffolk right now.

Your job will entail testing VHF or UHF radio telecommunications equipment to very high standards. An indication of the importance placed on these positions, and the rewards you can derive, is that the thoroughness of testing procedures is at the root of Pye Telecom's rise to worldwide leadership in this field.

Technical qualifications will be welcome but are by no means as important as practical experience. Relocation assistance is available and there is a possibility of local authority housing. Your application form will be in the post immediately on receipt of your brief letter addressed to Mrs. C. Dawe.

Pye Telecommunications Ltd
Colne Valley Road, Haverhill, Suffolk
Tel: Haverhill 4422

A member of the Pye of Cambridge Group

3794

THE POLYTECHNIC OF NORTH LONDON
Holloway, N7 8DB

Department of Chemistry

TECHNICIAN GRADE 5

required for work in the research laboratories. A knowledge of modern instrumentation and the ability to undertake some construction and maintenance work is required.

Applicants should have City and Guilds Advanced Certificate, HNC or equivalent qualification.

Salary Scale: £2,181 rising by annual increments to a maximum of £2,556 per annum (inclusive of London Weighting allowance).

For further details and application forms please apply to:

Head of Department of Chemistry
The Polytechnic of North London
Holloway Road
London N7 8DB

[3805

City of Glasgow Police

WIRELESS TECHNICIAN (£1,809–£2,040)

The City of Glasgow Police, Wireless Branch, requires an experienced Wireless Technician to install and maintain a wide range of interesting equipment.

A City and Guilds Certificate in Telecommunications would be an advantage, but emphasis will be on the applicant's ability and experience.

This is a secure, superannuated position and the successful candidate is offered scope, variety and responsibility with the prospect of a steadily developing career in a demanding and even expanding field.

Applicants must be in possession of a current driving licence.

Conditions of Service include a 37-hour week, 18 days annual holiday plus nine public holidays and a sickness scheme.

Written applications should be submitted to The Chief Constable, City of Glasgow Police, 21 St Andrew's Street, Glasgow G1 5PA. [3778

The Polytechnic of Central London

Department of Communication Studies

STUDIO ENGINEER

£2,460–£2,790

for the Media Workshop which consists of two Radio studios and one monochrome television studio. The Workshop exists to teach broadcasting techniques as a part of a course in media studies and is therefore equipped to a higher standard than is usual with Educational Television studios. Applicants who will be responsible to the Technical Manager for the operation and maintenance of vision and sound apparatus, should have had practical experience within Radio and TV Studios or have a theoretical knowledge of sound and vision circuitry. Qualifications to HNC or C&G Final level an advantage but not essential.

Application form from The Establishment Officer, 309 Regent Street, London, W1R 8AL. 01-580 2020 Ext. 212. [3786

Grampian

Grampian, leaders in the field of industrial sound systems require additional staff as Systems Planners, who will be responsible for the detailed planning of industrial sound systems to meet specific customers' requirements, and for the progressing of these systems through to installation.
Applicants should possess a sound, basic knowledge of electronics. Experience with solid-state audio equipment, particularly professional or industrial, would be an advantage. These positions offer excellent job security, competitive salaries, and pension and life assurance schemes.

Tel. Mr. Turner on
01-894 9141
Or write for application form to:
Grampian Reproducers Limited,
The Hanworth Trading Estate, Feltham, Middlesex TW13 6EJ 3757

ITN

Have the following vacancies:

1) SUPERVISORY ENGINEER for Sound Maintenance
Duties include the supervision of the Sound Maintenance Section, which covers the maintenance, installation and modification of sound equipment involved with television transmission, film sound recording and allied film equipment.

2) SOUND TECHNICIAN
Duties include operation of magnetic and optical sound recording equipment, tape and disc replay machines in the Studios and Dubbing Control Rooms, and normal sound duties in the Studios, including some boom operating.

3) ENGINEER—RADIO LINKS
Duties include the operation and maintenance of microwave outside broadcast links and radio telephone equipment. He would work with the ITN News Outside Broadcast Unit and flexibility in working hours and willingness to travel in the course of his work are essential requirements.

Subsidised staff restaurant. Four weeks holiday. Staff Pension Scheme. Free Life Insurance.
Tel. 01-637 3144 3767

FOREIGN AND COMMONWEALTH OFFICE

COMMUNICATIONS OFFICERS

APPLICATIONS ARE INVITED TO FILL IN THE TELECOMMUNICATIONS BRANCH OF H.M. DIPLOMATIC SERVICE.

Members of the Telecommunications Branch serve in more than 60 diplomatic missions overseas and also in the UK.

Applicants should be skilled in the operations of HF radio communication equipment and be competent at sending and receiving the Morse code. They should produce evidence of a sound knowledge of radio and electronic theory, eg MPT/PMG Grade I or equivalent City and Guilds certificates.

Successful candidates will receive training on specialised equipment before taking up overseas appointments.

Further particulars may be obtained from:

Communications Administration Department
Foreign and Commonwealth Office
Hanslope Park
MILTON KEYNES
MK19 7BH [3813

UNIVERSITY OF NOTTINGHAM
LANGUAGE CENTRE

Recording Studio Technician

To be responsible for studio, off-air and other language recording work, editing, maintenance of Sound Archives and supervision of an open Library of Recordings.

Applicants should have experience of recording and editing to high standards.

Typing ability would be an advantage, and knowledge of one or more of the following languages would be desirable but not essential: French, German, Russian, Spanish.

Pleasant working conditions in a secure post. Salary on Grade 2B **£1,524-£1,794** per annum. Apply by letter, quoting qualifications and previous experience, to the Staff Appointments Officer, University of Nottingham, University Park, Nottingham, NG7 2RD. Closing date—28th June, 1974. [3766

Are your ears big enough~

to pick up the sound of £2,500 per year?

We are looking for young people with finely tuned ears to the technical world of audio and hi-fi who know what is going on in the marketing fields as well. This ability coupled with experience of technical writing or publications work could secure them a post with our group of leading hi-fi publications.

Write to the Group Editor, Clement Brown, at Haymarket Publications, Gillow House, 5 Winsley Street, London W1.

3768

IMPERIAL COLLEGE

ELECTRONICS TECHNICIAN

(Grade 5)

required for electronics workshop to work on the maintenance of electrical and electronic equipment. Digital experience preferred with qualifications to at least ONC standard. 9 a.m. to 5.30 p.m. 5-day week. Four weeks holiday plus generous leave at Christmas and Easter. This is a contract appointment with good prospects continuation. Starting salary on scale £2,182 to £2,557 including London weighting.

Please apply to: Mr. T. W. Dickinson, Physics Department, Imperial College, London, S.W.7, or ring 01-589 5111, extension 2336. [3808

Opportunities in the

ELECTRONICS FIELD

Men with analogue or digital qualifications/ experience seeking higher paid posts in: TEST—SERVICE—DESIGN—SALES

Phone: Mike Gernat 01-629 7306
NEWMAN APPOINTMENTS
360 Oxford St., W.1. 3760

ANTARCTICA

Graduate ELECTRONIC ENGINEER or PHYSICIST

required for research and development in surface and airborne radio-echo sounding of glaciers. A pulsed radar is used in an aircraft flying over the ice sheet to measure the ice thickness. The same instrument used on the surface can measure the velocity of glacier flow.

Candidates should have experience in the design and construction of advanced electronic circuitry and must be prepared to work in the Antarctic for periods of four months. The successful candidate will be based at the Survey's Glaciological Section in Cambridge. In appropriate cases research findings may be submitted for a higher degree.

Salary: £1,793 to £2,889 per annum.

Please apply to:

THE ESTABLISHMENTS OFFICER
BRITISH ANTARCTIC SURVEY
30 GILLINGHAM STREET, LONDON, SW1V 1HY

Telephone: (01) 834 3687 [3790

KIRKLEES AREA HEALTH AUTHORITY
Huddersfield District
Appointment of

Electronic & Biomedical Equipment Technician

Salary scale £1,719-£2,211 p.a.
(Medical Physics Technician III)

This is a newly established post offering wide scope and opportunity in the creation of an electronics maintenance service. The successful applicant will be responsible to the District Engineer for the maintenance of a variety of electronic and biomedical equipment throughout the hospitals in the District. Applicants should have served not less than 3 years as a Medical Physics Technician V or IV or have had seven years comparable technical experience and have obtained an ONC, HNC or HND in electronics or an appropriate science degree or an equivalent qualification. In addition they should have wide experience of electronic equipment and the safety aspects involved.

Application form and job description available from the Area Personnel Officer, Kirklees Area Health Authority, St. Luke's House, Crosland Moor, Huddersfield, HD4 5RH

Closing date for receipt of applications: 26th June, 1974. [3789

COLOUR TELEVISION ENGINEER

We are a busy major international advertising agency working on household-name clients. To assist in the operation and maintenance of a growing colour-television installation we require a further television engineer. A sound basic knowledge of television is necessary together with operational experience of broadcast or closed-circuit television equipment. Experience in the operation and maintenance of a Rank Cintel Twin Lens Flying Spot Scanner would be particularly advantageous.

Excellent working conditions, five-day week, four weeks holiday, contributory pension scheme, free membership of BUPA.

Salary negotiable.

Applications to: **Colin Forster, TV & Film Service Manager, Leo Burnett Ltd, 48 St Martin's Lane, London WC2. Tel. 01-836 2424.** [3771

TECHNICAL SUPPORT ENGINEER

Domestic Tape Recording Equipment

The impending launch of a world famous range of domestic cassette recorders in the U.K. has created an unusually interesting opportunity for a suitably experienced engineer.

In this position you will be responsible to the National Service Manager for:
✳ Provision of technical support to the marketing organisation, including resolution of technical problems in the field.
✳ Bench servicing (with potential capability to supervise technicians who will be recruited as the business grows). ✳ Spares inventory control. ✳ Organising and conducting training courses for dealer service personnel.

You must have appropriate technical experience in the domestic tape recording field and ideally you should be qualified to HNC level. You must live in or be willing to move to an area within convenient travelling distance to Greenford, Middlesex.

The Company is well established and highly diversified and can offer you a challenging position in an informal, yet professional working environment, with ample scope to develop your career. There will be a good starting salary with a full range of employee benefits. (Ref. A8990/WW)

REPLIES will be forwarded direct, unopened and in confidence to the client unless addressed to our Security Manager listing companies to which they may not be sent. They should include comprehensive career details, not refer to previous correspondence with PA and quote the reference on the envelope.

PA ADVERTISING LIMITED,
2 Albert Gate, London SW1X 7JU. Telephone: 01-235 6060

3797

NORTHAMPTON BOROUGH COUNCIL

Engineering Department
AREA TRAFFIC CONTROL

A comprehensive Area Traffic Control Scheme is being designed for the expanding town of Northampton. The system will comprise a computer control centre connected by data transmission links to on-street traffic signal equipment.

The Scheme has now reached a critical stage and the first contract is to be let for the computer and data transmission system.

Design work is proceeding on specifications for traffic signal control, special vehicle detection and closed circuit television equipment.

The following specialist staff are required to join an enthusiastic team to be responsible for the successful implementation and operation of the Scheme. All posts are on the Council's permanent establishment.

Engineering Assistant (Systems—Hardware)

£1926–£2820

for the specification, design, implementation and operation of electronic equipment associated with the Scheme. Applicants should have a degree in electrical engineering or a directly relevant discipline and have at least one year's experience of one or more of the following: digital electronic techniques, data transmission, computer hardware.

Technician (Hardware)

£1644–£2535

Applicants should possess at least ONC in electrical engineering or an equivalent qualification and should have experience in the testing, commissioning or prototype construction of light electronic equipment. Familiarity with digital integrated circuits, electronic techniques and/or modern traffic control equipment is required.

Starting salaries will be commensurate with experience and qualifications. Assistance with housing and removal expenses, temporary lodging or travelling allowance in approved cases.

Further details and application forms from Chief Executive (Personnel), Guildhall, Northampton NN1 1DE.

This advertisement appears after consultation with the Local Government Staff Commission for England. Other factors being equal, preference will be given to serving local government officers.

3759

CHELSEA COLLEGE
University of London

TECHNICAL SUPERVISOR

of

AUDIO VISUAL SERVICE UNIT
GRADE 7

Applications are invited for the post of Technical Supervisor of the Audio-Visual Service Unit. The person appointed will be responsible to the Director of the Centre for Science Education for the provision of audio-visual services to the College and the supervision of the Audio-Visual Service Unit.

Candidates should be capable organisers and have wide experience of the use of audio-visual techniques, with particular expertise in photography. A sound knowledge of electronics would be an advantage. Salary scale: £2,992-£3,376 per annum (including London Allowance). Further details and application forms from the Personnel Office (WW), Chelsea College, Manresa Road, London SW3 6LX. Closing date 26th June, 1974. [3817

THE CITY UNIVERSITY

Department of Electrical and Electronic Engineering

LABORATORY TECHNICIAN
Grade 4

Applicants are required, preferably with experience in Opto-Electronics. Duties will be related to the Laser Group and some assistance in the Electrical Machines Laboratory. Possession of ONC/equivalent desirable.

LABORATORY TECHNICIAN
Grade 3

Applicants are required to have Electronics background, to assist in various Research groups and Final Year Teaching Laboratories.

Salary scales:
(1) £1,848-£2,163 plus £175 London Allowance.
(2) £1,650-£1,920 plus £175 London Allowance.

Application by letter quoting Ref. EED/74 to Personnel Officer at The City University, St. John Street, London EC1V 4PB by 28th June, 1974. [3819

Nigerian Telecommunications Engineer

The Shell-BP Petroleum Development Company of Nigeria Limited has a vacancy for a qualified Nigerian Telecommunications Engineer.

You should be academically qualified at C.E.I. Chartered Engineer level, be eligible for membership of the Nigerian Society of Engineers or hold any other qualifications acceptable to the Council of Registered Engineers of Nigeria. You must have a minimum of 5 years' total practical experience in at least two of the following:

(*a*) Multi-channel fixed communications systems
(*b*) Telemetry
(*c*) Mobile radio systems

If you are a Nigerian National returning to your country this year and are interested in this position, please telephone Pauline Ford on 01-934 2493 or write, giving details of age, qualifications and experience, to:—

Shell International Petroleum Company Limited,
Recruitment Division, (GM), PNEL/41,
Shell Centre, London SE1 7NA.

3800

The Hatfield Polytechnic

TECHNICIAN

for Psychological Laboratory

for maintenance and construction of a variety of electronic and other equipment. The person appointed will work with a Senior Technician. Applicants should preferably hold an appropriate intermediate or National Certificate, or City and Guilds qualification, but this is not essential.

Salary scale: £1,242-£1,644 per annum.

Application form and further details from: The Staffing Officer, The Hatfield Polytechnic, P.O. Box 109, Hatfield, Herts.

Quote ref.: 542. [3806

THE POLYTECHNIC OF NORTH LONDON
Holloway Road, N7 8DB.

DEPARTMENT OF ELECTRONIC AND COMMUNICATIONS ENGINEERING

LABORATORY TECHNICIAN GRADE 4

Applications are invited from candidates who are suitably qualified Electronics Technicians. Experience in microwave/radar technology would be an advantage.

This is a Laboratory Technician Grade 4 appointment with prospects of promotion for a man showing initiative. Five day week totalling 35 hours.

Salary scale: £2,022 rising by annual increments to £2,337 per annum (including London Weighting). Write stating age, experience and qualifications to the Establishment Officer, The Polytechnic of North London, Holloway Road, N7 8DB.

Enquiries to Mr. S. A. Elliott, 607 6767 Extn. 289.

[3761

Electronic Gauging Engineer

Within our Group Engineering Department at St. Albans we have an increasing design and development work load, due to the continuing modernisation of existing factory facilities together with a programme of expansion of our production capacity throughout the United Kingdom.

An electronic engineer is required to assist the Senior Electronic Gauging Engineer in the application of electronics and electronic machines for the inspection of glass bottles. The post requires a good knowledge of optics, electronics, logic and pneumatics and it would be helpful to have some knowledge of telemetry, high frequency oscillators or video circuitry.

The engineer will be expected to assist in the evaluation, development and testing under production conditions of commercially available equipment and to design, develop, procure, install and commission special inspection equipment not commercially available.

He will be expected to have a degree, HND or HNC in electronics and it would be helpful to have some knowledge of control theory.

The appointment will involve some travel to our factory sites within the British Isles. The post offers excellent conditions, interesting work and opportunities for promotion within the Group.

Please apply in the first instance to:—

Mr. A. Raine Howe,
Design and Development Engineer,
Research & Development Centre,
Valley Road Industrial Estate,
Porters Wood, St. Albans, Herts. [3785

UNITED GLASS

TECHNICIANS AND ENGINEERS FOR ST. ALBANS AND LUTON

QUALIFIED OR NOT!

OPPORTUNITIES for challenging work on testing and calibrating valve and solid-state electronic measuring equipments embracing all frequencies up to u.h.f. in Production, Service and Calibration departments.

APPLICATIONS are invited from people of all ages with experience or formal training in electronics and from Ex-Services technicians.

HIGHLY COMPETITIVE SALARIES, negotiable and backed by valuable fringe benefits. Overtime normally available.

GENEROUS RE-LOCATION EXPENSES available in most instances.

CONDITIONS excellent; free life assurance, pension schemes, canteen, social club.
37½ hour, 5-day, working week.

WRITE or phone for application forms quoting reference WW

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MARCONI INSTRUMENTS LTD,
Longacres, St. Albans, Herts
Tel: St. Albans 59292
Luton Airport, Luton, Beds
Tel: Luton 33866

A GEC-Marconi Electronics Company

THE QUEEN'S AWARD TO INDUSTRY 1971

94

ASGOTECHNIC LTD.

require

ELECTRONIC TECHNICIANS

For their MARINE SERVICE DIVISION. Vacancies are available at most major ports throughout the United Kingdom and Eire. The positions are of responsibility and involve the engineer in the Service, Repair and Installation of Marine Navigational and Control equipment. Practical ability and experience are the prime requisites and applications are invited from such suitably qualified engineers.

A basic commencing salary of £2,250 plus profit participation (which should bring the first year's earnings up to a minimum of £3,000) and full expenses will apply. A Cortina car, contributory pension scheme, free life insurance and group membership of B.U.P.A. are also included.

Applications to—
Mr. Ashurst or Mr. Gorman,
Asgotechnic Ltd,
Freepost, Macclesfield,
Cheshire SK10 2YF.

Telephone: (0625) 32363 or
Telex: 667636 Asgomacc

[3777

PROJECT ENGINEER
(MOBILE RADIO)

Salary Rising to £3,336 (currently under review)

An experienced Engineer is required to undertake responsibility for the planning and implementation of mobile radio systems.
He will work in the Communications Planning Section of the Telecommunications Department and should be qualified to degree or graduate membership of IEE or IERE.
Experience must include work at professional level in equipment or systems design at VHF and UHF, with knowledge of radio propagation theory, multi-base station operation and control system functioning. Familiarity with multi-channel microwave systems and digital control techniques would be an advantage.

Applications, quoting reference WW A706 and giving brief details of qualifications and experience, to:

Senior Personnel Officer (Headquarters and Marketing), West Midlands Gas, Wharf Lane, Solihull, Warwickshire B91 2JP.

WEST MIDLANDS GAS

38081

UNIVERSITY OF SURREY
TELEVISION SERVICE

The Television Service provides facilities for teaching and research, both in the Studio and with mobile equipment, throughout the University. There is a comprehensively equipped control room with IVC editing VTRs. and plumbicon studio cameras.

SENIOR ENGINEER (T6) £2370-£2874

Candidates should have HNC Electronics, BBC Grade C or similar qualification, and experience in television engineering.

ENGINEER (T4) £1848-£2163

Candidates should have ONC Electronics or City and Guilds Radio and TV Servicing, and television servicing experience. Applications immediately on forms obtainable from:

Assistant Secretary (Personnel), University of Surrey, Guildford or Tel: Guildford 71281, Ext. 452.

[3827

NATIONAL AUDIO VISUAL AIDS CENTRE

TECHNICIAN

required for
EXPERIMENTAL DEVELOPMENT UNIT
at the
National Audio Visual Aids Centre.

Duties will include technical evaluation of optical, mechanical and electronic equipment used in schools.

Details and form of application from: Head, Experimental Development Unit, National Audio Visual Aids Centre, 254/6 Belsize Road, London NW6 4BT. [3826

SITUATIONS VACANT

COMPETENT Colour T/V Service Engineer. Good salary efficient man. Assistance accommodation, Devon Market Town. Box No. WW 3766.

DEPARTMENT of Nuclear Physics, University of Oxford, has a vacancy for an electronics technician to join a small group developing a computer-based system for collection and analysis of nuclear data. HNC or equivalent qualification is appropriate. Ability to work on own initiative is needed. Special area of interest is the development of integrated circuit assemblies within a Camac specification. Salary within a range from £1,848 rising to £2,382. Approximately eight weeks' paid leave per year. Write to T. L. Green, Nuclear Physics Laboratory, Keble Road, Oxford, mentioning reference A159. [3781

FREELANCE Design Engineer required, short range A.M. Telemetry equipment. Own staff informed. Box No. WW 3817.

HI-FI AUDIO ENGINEERS. We require experienced Junior and Seniors and will pay top rates to get them. Tell us about your abilities. 01-437 4607. [19

LEEDS City Council, Department of Education. City of Leeds College of Music Cookridge Street, Leeds, LS2 8BH. Workshop Technician T1/2/3, £672-£1,644. Salary according to age and qualifications. The person appointed will be expected to assist with the maintenance and repair of the College instruments and equipment in general, but primary responsibility will be for electronic equipment, e.g. tape recorders, amplifiers, etc. Application forms and further details from the Registrar of the College, to whom they should be returned as soon as possible. [3802

LONDON BOROUGH OF BRENT. WILLESDEN COLLEGE OF TECHNOLOGY, Denzil Road, London, NW10 2XD. Department of Electrical Engineering Vacancies from September 1, 1974 LECTURERS I: (1) To teach both theory and practice on City and Guilds Radio/TV Electronics Technician and Mechanics courses. Applicants should be well qualified and with appropriate industrial experience; (2) To teach on City and Guilds Telecommunications and Electrical Technician courses. Applicants should be well qualified with experience in the Radio/Electronic industry; (3) To teach Mathematics on ONC/HNC and City and Guilds Technician courses. Applicants should be University Graduates, preferably with some industrial experience. Salary (under review): Non-graduates £1,778-£2,803; Graduates £1,940-£2,965. Further details and application forms may be obtained from the Registrar, to be returned within two weeks. [3782

MANAGEMENT opportunity for good Closed Circuit TV Sales Engineer, with wide knowledge of installation work and equipment. Good basic, bonus and car, new housing available. Aged over 28, mobile and personable. Please write with full details. Box No. W.W. 3763.

MEDICAL PHYSICS DEPARTMENT, PLYMOUTH GENERAL HOSPITAL. ELECTRONICS TECHNICIAN required to work on a varied and interesting range of biomedical tasks in an expanding well-equipped maintenance and development laboratory at Freedom Fields Hospital, Plymouth. The person appointed will join a small team responsible (to the Chartered Electronics Engineer) for the successful operation of a wide range of patient-orientated equipment. Development, construction and testing of special-purpose equipment is undertaken and safety and purchase decisions are made on new equipment. Some travel in South Devon and in Cornwall necessitates a current driving licence. Relevant experience is desirable and the minimum qualification is ONC (or equivalent). The appointment will be in either of the following grades, depending on experience. (Salary scales are under review).

Medical Physics Technician IV—£1,530-£1,953 p.a.
Medical Physics Technician III—£1,719-£2,211 p.a.

Further details of the work may be obtained from Mr. L. R. Jenkin, Telephone PLYMOUTH 68080, Ext. 369.

Application forms from the Hospital Secretary, North Friary House, Greenbank Terrace, Plymouth, PL4 8QQ. [3774

QUALIFIED Colour T.V. Engineers and Audio Engineers reuired urgently to join a rapidly expanding company. Good conditions and best rates of pay. Apply to: Mr. R. Jones, Roy Newton Ltd., Oldbury Road Ind. Est., West Bromwich. Staffs. Tel. 021-553 6521. [3772

YOUNG ELECTRONICS TECHNICIAN required for the construction, testing and servicing of electronic equipment at our works in N.W.1. Very varied work. Qualifications: ONC or C&G or ex-apprentice or similar desirable. Excellent opportunity for right person with a small expanding company. Please write for an application form to: Young Electronics Ltd., 54 Lawford Road, London, NW5 2LN. [3816

Classifieds continued on p. 116

AMPEX

Ampex requires broadcast television engineers for the following vacancies in a fast expanding international systems operation

1) Mobile systems engineer
2) Studio systems engineer
3) Systems proposal engineer

These vacancies cover the design, manufacture and control of mobile and studio contracts, also proposal writing in response to tenders and enquiries

QUALIFICATIONS REQUIRED

Experience in colour broadcasting television industry. A formal qualification would be an advantage, as would a second language and international experience, but are not essential

We are interested in hearing from people starting their careers as well as those with a proven successful background in this industry

The group is based in Reading. International travel will be involved. A good salary with attractive employee benefits is available to the right candidates

Please write, including a résumé, or asking for details to:

The Personnel Manager, Ampex Great Britain Limited, Acre Road, Reading, Berkshire
Telephone Reading 85200 [3769

Grampian

DEVELOPMENT ENGINEERS

Grampian, leaders in the field of industrial sound systems, manufacture a wide range of electronic and electro-acoustic equipment, including a recently introduced modular series incorporating solid state audio switching and priority control. Part of the Telephone Rentals group, Grampian have a rapidly expanding commitment to supply systems based on this equipment, and consequently have the following vacancies.

Development Engineers required for work on new projects to expand the existing ranges. A degree, HND, or equivalent in electronics preferred. Experience with analogue circuitry or electro-acoustic devices would be a distinct advantage. These positions offer excellent job security, competitive salaries and pension and life assurance schemes.

Tel. Mr. Turner on 01-894 9141

Or write for application form to:

Grampian Reproducers Limited,
The Hanworth Trading Estate, Feltham, Middlesex TW13 6EJ 3764

Manweb
ELECTRICITY

Require at Chester

Instrument Inspector

A Technician is required for duties at the Communications Workshop of the Chief Engineer's Technical Department at New Crane Street, Chester.

The duties include:

i) Construction of prototype equipment.
ii) Testing and approval of new equipment.
iii) Maintenance and repair of the following equipment:
  (a) Computers, data transmission and associated line interface equipment.
  (b) Telegraph data printers and signalling equipment.
  (c) Automatic telephone switching equipment.
  (d) vf supervisory signalling equipment.
  (e) vhf radio base station equipment and controls and mobile equipments.
  (f) Measuring equipment and instruments.

A recognized engineering apprenticeship is required. Experience of fault-finding and repair of radio equipment is essential, together with experience with one other of the equipment categories mentioned above.

Salary for a 40-hour, 5-day week will be £31.54, plus service increments.

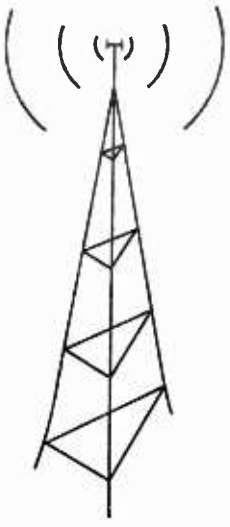
A bonus scheme is in operation enabling the successful applicant to earn up to a further 33⅓% of basic salary.

Applications, giving full details, should be sent to the Secretary (Personnel), Manweb, Head Office, Sealand Road, Chester CH1 4LR, within 14 days. [3812

APPTS Contd.

Are You Interested In

Radio, T.V. or Electronics



and have some knowledge or practical experience in any of these fields

then the Metropolitan Police may have a job for you as a Radio Technician

we offer
Good pay
Excellent prospects
Secure employment
4 weeks holiday
Day release

Phone our Engineer Mr. H. G. Fielding on 01-653 6681, during office hours, to arrange an informal interview, or write to Metropolitan Police, Telecommunications Dept., Room 1627, New Scotland Yard, Victoria Street, London SW1H 0BG.

3804

COURSES

The Polytechnic of North London

3 year full-time course for student with 2 "A" levels, ONC or equivalent to become

Chartered Electronic and Radio Engineers

This modern course in electronics and communications engineering, starting in October 1974, prepares students for entry into the Institution of Electronic and Radio Engineers and the Institution of Electrical Engineers.

Details from: The Department of Electronic & Communications Engineering, The Polytechnic of North London, Holloway, London N7 8DB.

3695

GLASGOW COLLEGE OF TECHNOLOGY

All who hold (or expect to hold) a good HNC or HND in Electrical and Electronic Engineering are invited to enrol for the course leading to

B.Sc. in
ELECTRICAL ENGINEERING
(C.N.A.A.)
BY PART-TIME STUDY

This course is the first of its kind to be offered in Scotland, and provides a new opportunity to obtain a degree without giving up employment.

Further details and an application form may be obtained from:
The Academic Registrar,
Glasgow College of Technology (Ref: D),
North Hanover Place,
Glasgow G4 0BA
Tel. 041-332 7090

The college is readily accessible by road or rail. [3830

ARTICLES WANTED

TOP PRICES PAID

for semiconductor and component redundant or excess inventories

P.R.S. ELECTRONICS

126 Headstone Road
Harrow, Middlesex
Tel: 01-965 6864

[34

ELECTRO-TECH COMPONENTS LTD.

Are buyers of all types of electronic components and equipment. They will be pleased to view clearance stocks anywhere in Great Britain at one or two days notice
and negotiate on the spot!

ELECTRO-TECH
COMPONENTS LTD.
315/317 Edgware Road, London, W.2
Tel: 01-723 5667. 01-402 5580

[37

TAPE RECORDING

RECORDS MADE TO ORDER

DEMO DISCS MASTERS FOR RECORD COMPANIES	VINYLITE PRESSINGS

Single discs. 1-20. Mono or Stereo. delivery 4 days from your tapes. Quantity runs 25 to 1,000 records PRESSED IN VINYLITE IN OUR OWN PLANT. Delivery 3-4 weeks. Sleeves/Labels. Finest quality NEUMANN STEREO/Mono Lathes. We cut for many Studios UK/OVERSEAS. SAE list.

DEROY RECORDS
PO Box 3, Hawk Street, Carnforth, Lancs.
Tel. 2273

[82

Classifieds continued from p. 115

ARTICLES FOR SALE

AARVAK ELECTRONICS, 3-channel sound-light converters, from £18. Strobes, £25. Rainbow Strobes, £132.—12A Bruce Grove, N17 6RA. 01-808 9096. [23

BUILD IT in a DEWBOX quality plastic cabinet 2 in. x 2½ in. x any length. D.E.W. Ltd. (W.), Ringwood Rd., Fernwood, Dorset. S.A.E. for leaflet. Write now—Right now. [76

BECKMAN time/freuency measuring system model 5571,0-156 M/hz, 2 part in 10 fits any transducer, seven units, digital printout, Cost £3,000, reasonable offers. Honeywell 530 x y recorder complete, and type 153 electronic recorder, offers. Marconi Standard Signal Generator TF867 £100. Buyers collect. Telephone Sedgley 73465. or QTHR. [3780

COLOUR, UHF and TV SPARES. Colour and UHF lists available on request. New Philips G6 single standard convergence panels complete, incl. 16 controls, coils, P.B. switches, leads, etc. and circuit data £3.75, or with yoke £5.00, P/P 30p. New Colour Scan Coils, Mullard or Plessey plus convergence yoke and blue lateral, £10.00, P/P 40. Mullard AT1025/05 Convergence Yoke, £2.50, P/P 25p. Mullard or Plessey Blue Laterals, £1.25, P/P 10p. BRC 3000 type Scan Coils, £4.00, P/P 40p. Delay Lines DL20, £3.50, DL1E, DL1, £1.50, P/P 25p. Lum. Delay Lines, 50p, P/P 15p. EHT Colour Quadrupler for Bush Murphy CTV 25 111/174 series, £8.25, P/P 25p. EHT Colour Tripler ITT TH25/1TH suitable most sets, £2.00, P/P 25p. KB CVC1 Dual Stand. convergence panels complete incl. 22 controls, £3.75, P/P 35p. CRT Base Panel, £1.75, P/P 15p. Makers Colour surplus/salvaged Philips G8 panels part complete: Decoder incl. I/C, £2.50, IF incl. 5 modules, £2.50, T. Base, £1.00, P/P 25p. CRT base, 75p, P/P 15p. GEC 2040 panels, Decoder, £3.50, T. Base, £1.00, RGB and Sound, £1.00, P/P 25p. Pye CT70 Colour LOPT assembly incl. EHT output and Focus Control, £3.50, P/P 35p. B9D valve bases 10p, P/P 6p. VARICAP TUNERS. UHF ELC 1043 NEW, £4.50, Philips VHF for Band 1 and 3, £2.85 incl. data. Salvaged VHF and UHF Varicap tuners, £1.50, P/P 25p. UHF TUNERS NEW, Transistorised, £2.85 or incl. slow motion drive, £3.85. 4 position and 6 pos. push-button transistd., £4.95.

Classifieds continued on p. 118

We've got prices to put power in your profits

TOSHIBA Valves

Type	Goods Price (p)
DY87	30.0
DY802	30.0
ECC82	28.0
EF80	29.5
EF183	34.5
EF184	34.5
EH90	31.5
PC900	24.5
PCC89	40.0
PCC189	41.0
PCF80	31.5
PCF86	39.0
PCF801	42.0
PCF802	40.0
PCL82	39.0
PCL84	34.0
PCL85	39.5
PCL86	41.0
PFL200	55.5
PL36	55.5
PL84	25.0
PL504	60.5
PL508	67.0
PY88	35.5
PY800	29.0

Semi-Conductors

Type	Goods Price	Type	Goods Price	Type	Goods Price	Type	Goods Price
AC127	17p	AF 118	50p	BC 154	22p	BF 195	15p
AC 128	15p	AF 139	42p	BC 157	12p	BF 196	20p
AC 141K	30p	AF 178	45p	BC 158	10p	BF 197	17p
AC 142K	30p	AF 180	45p	BC 159	14p	BF 200	25p
AC 151	20p	AF 181	45p	BC 173	18p	BF 218	30p
AC 154	18p	AF 239	45p	BC 178B	20p	BF 224	35p
AC 155	18p	BA 145	14p	BC 182L	12p	BF 258	40p
AC 156	20p	BC 107	11p	BC 183L	12p	BF 337	35p
AC 176	22p	BC 108	11p	BC 187	28p	BFY 50	22p
AC 187	19p	BC 109	12p	BC 214L	15p	BFY 52	20p
AC 187K	30p	BC 113	25p	BD 124	70p	BSY 52	35p
AC 188K	30p	BC 116	25p	BD 131	45p	BY 126	11p
AD 142	45p	BC 117	20p	BD 132	45p	BY 127	12p
AD 149	40p	BC 125	25p	BF 115	20p	E.1222	30p
AD 161	38p	BC 132	25p	BF 160	20p	IN 60	05p
AD 162	38p	BC 135	20p	BF 167	20p	OA 202	7.5p
AF 114	24p	BC 137	25p	BF 173	25p	OC 71	15p
AF 115	23p	BC 138	40p	BF 178	35p	BU 105/02	£2.40
AF 116	23p	BC 142	26p	BF 179	40p	2SC1172B	£2.40
AF 117	23p	BC 143	30p	BF 180	35p	R2008B	£2.00
		BC 147A	08p	BF 181	35p	R2010B	£2.00
		BC 148	08p	BF 184	21p	BU 108	£2.10
		BC 149	12p	BF 185	21p	BT 106	£1.40
		BC 153	20p	BF 194	15p	MJE 340	45p

EHT RECTIFIER TRAY ASSEMBLIES

Type	Goods Price	Type	Goods Price
ITH Decca Col.	£4.50	11TAM Philips G8	£4.50
ITN GEC/Sobell	£4.50	TCQ Pye/Ekco	£3.50
2TQ 1400 + 950 Mk II	£1.85	11 TAQ ITT/KB	£4.50
2TAK 1500 5 Stick	£2.00	3 TCU BRC 3000	£5.00
2DAF 1500 3 Stick	£1.85	11 TAZ GEC 2010	£5.35
2HD 950 3 Stick	£1.70	**12 MONTHS GUARANTEE**	

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Type	Goods Price
19" A49/191X	48.00
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22" A56/120X	53.25

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ADVANCE SIGNAL GENERATOR C2/H Push-button selectivity ..... £30·00

ADVANCE AUDIO GENERATOR Model HI 15Hz-50HKz ..... £20·00

MARCONI SIGNAL GENERATOR Type TF801A 10-30MHz ..... £40·00

MARCONI VALVE VOLTMETER Type TF428C 0-300 volt D.C. £28.00

AIRMEC SIGNAL GENERATOR Type 201 30KHz-30MHz ..... £75·00

WAYNE KERR VHF FREQUENCY STANDARD, 12 channel ..... £20·00

WAYNE KERR A321 WAVEFORM ANALYSER, 1Hz-1200Hz ..... £30·00

PYE ELECTROSTATIC GALVANOMETER, 0-20kV. mains ..... £15·00

BRIT. PHYS. LABS. CZ960 COMPONENT COMPARATOR ..... £40·00

BRIT. PHYS. LABS. CZ457/3 COMPONENT COMPARATOR, with Automator UNIT CZU457/2 ..... £65·00

TEKTRONIX OSCILLOSCOPE Type 524D DC-10MHz ..... £70·00

TEKTRONIX 524AD OSCILLOSCOPE ..... £100·00

NAGARD DOUBLE-PULSE GENERATOR Type 5002A.O. 1Hz-1MHz ..... £65·00

AIRMEC MODULATION METER Type 210 3-300MHz ..... £100·00

MARCONI SIGNAL GENERATOR Type TF144G 85KHz-25MHz ..... £25·00

MARCONI SIGNAL GENERATOR Type TF867/2 15KHz-30MHz ..... £100·00

AIRMEC SIGNAL GENERATOR, Type 201A 30KHz-30MHz ..... £125·00

AIRMEC 853 WAVE ANALYSER 30KHz-30MHz ..... £50·00

AIRMEC BRIDGE HETERODYNE DETECTOR Type 775 ..... £65·00

HEWLETT-PACKARD UHF SIGNAL GENERATOR Type 614A 800-2300MHz ..... £175·00

MARCONI SIGNAL GENERATOR TF762B 300-600MHz ..... £50·00

MARCONI VIDEO OSCILLATOR TF885/A 0-12MHz ..... £45·00

ROHDE & SCHWARZ DIAGRAPH BN3561 30-300MHz ..... £300·00

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AIRMEC 252 SIGNAL GENERATOR, 30Hz-300kHz ..... £35·00

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GRESHAM LION WAVEFORM GENERATOR, 625 line staircase ..... £25·00

GRESHAM LION WAVEFORM GENERATOR, 405 line staircase ..... £15·00

GRESHAM LION COMPOSITE WAVEFORM GENERATOR, 405/525/625 sine, square, pulse, bar ..... £50·00

MARCONI TF1673, 100dB STEP ATTENUATOR ..... £20·00

MARCONI TF1289, VSWR INDICATOR £50·00

MARCONI TF1237, NOISE GENERATOR £50·00

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RACK VENTILATION UNITS, 19 in., incorporating mains blower, carriage 50p £5·50

SAVAGE 500watt PA amp., contains 12 x KT88s, no details, offers.

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PSU, as above but 190-280V at 500mA preset, stab., plus 6.3V at 5A twice, mains input, carriage £1.50 ..... £5·00

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MAINS ISOLATING TRANSFORMERS, (ex equipment), in metal cases totally enclosed tapped mains input, 110 240V, etc. Output, 240V at 3A +12V at 0.5A, carriage £1 £10·00

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33 WAY ISEP plugs only 20p

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PABST FANS, TYPE 1200, 110/127V, with suitable start capacitor carriage 50p .. £2·00

MULLARD TUBULAR CERAMIC CAPACITORS, 1-18pF, new boxed, per 100, carriage 50p ..... £10·00

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20-0-20V at 1.5A, 60p each (carriage 30p) 2 for £1

13-0-13V at 100mA. 40p each (carriage 30p) 3 for £1

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Classifieds continued from p. 116

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01-807 3719. (Closed Thursday.) [33

CONSTRUCTION AIDS—Screws, nuts, spacers etc., in small quantities. Aluminium panels punched to spec. or plain sheet supplied. Fascia panels etched aluminium to individual requirements. Printed circuit boards—masters, negatives and board, one-off or small numbers. Send 6p for list. Ramar Constructor Services, 29 Shelbourne Road, Stratford on Avon, Warwks. [28

COLOUR Decoder, new complete solid state unit comprising; mains regulated P.U., sync. sep., chrominance, filter-delay and luminance modules, circuit. £16. Also new aligned Nelson Jones Tuner, £7. Both £21, ring 0223-870834 after 6. [3770

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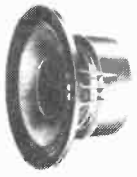

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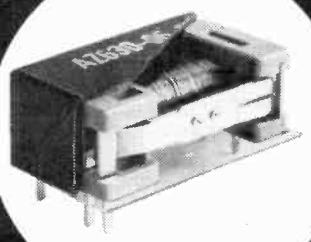

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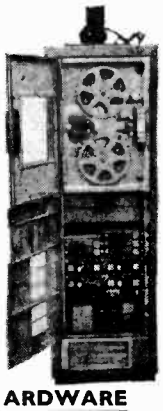

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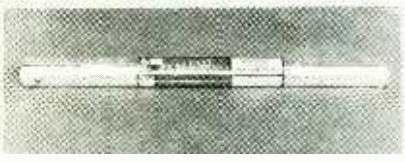
Extrusol and Multipure.

EXTRUSOL Extruded Bars and MULTI-PURE Cast Bars are made from specially processed ultra high purity solder. EXTRUSOL bars and pellets are protected by plastic film from the moment they are made to the moment they are used. And MULTI-PURE bars are probably the smoothest and brightest solder bars you will ever see.



Ersin Multicore Savbit.

This cored solder has countless uses. For instance, it avoids erosion of copper plating and wires as well as prolonging the life of soldering iron bits.

Liquid Fluxes.

We have a whole family of them, so you're bound to find the right one for your job. One of our latest is Activated RESIN 366 flux, exceptionally fast but non-corrosive and non-conductive.

Right, those are the products. Now for the advice. And we can't really say any more than: if you've a soldering problem or question, call us. We really do have all the answers and the widest range of test equipment.

ROSIN BASE

ERSIN Flux No.	Type	Solids Content w/w	Specifications
0360	non-activated	38%	MIL-F-14256D Type R; DTD 599A DIN 8527 F-SW 31
5381	mildly activated Chloride and Bromide free	25%	MIL-F-14256D Type RMA. DTD 599A
304D 304W	mildly activated Halide Free	10% 25%	DIN 8527 Type F-SW 32 DTD 599A
PC.21A	activated	38%	DTD 599A; DIN 8527, F-SW 26
PC.25	activated	25%	DTD 599A; DIN 8527, F-SW 26
366	activated (extra fast)	38%	Meet DIN 8511 Type F-SW 26 and pass DTD 599A Corrosion Test
366A-25	activated (extra fast)	25%	
ORGANIC ACID			
PC.101 PC.112	water base solvent base, fast drying	12% 9.5%	Water soluble residues must be removed after soldering.
INORGANIC ACID			
ARAX	water base extremely active	40%	Used with most "very difficult to solder" metals. Not for electronics assembly joints.

Solderability Test Instrument.

Already used by major electronic companies throughout the world, this novel instrument saves production costs by controlling solderability of component leads which, unlike a printed circuit, cannot be assessed by a simple "immersion and inspection" test.

Multicore Soldering Chemicals.

We make a complete, compatible range to assist in soldering processes. They clean, protect and preserve.

For full information on these or any other Multicore products, please write on your company's letterhead direct to:

Multicore Solders Limited, Maylands Avenue, Hemel Hempstead, Hertfordshire HP2 7EP.
Tel: Hemel Hempstead 3636. Telex: 82363.