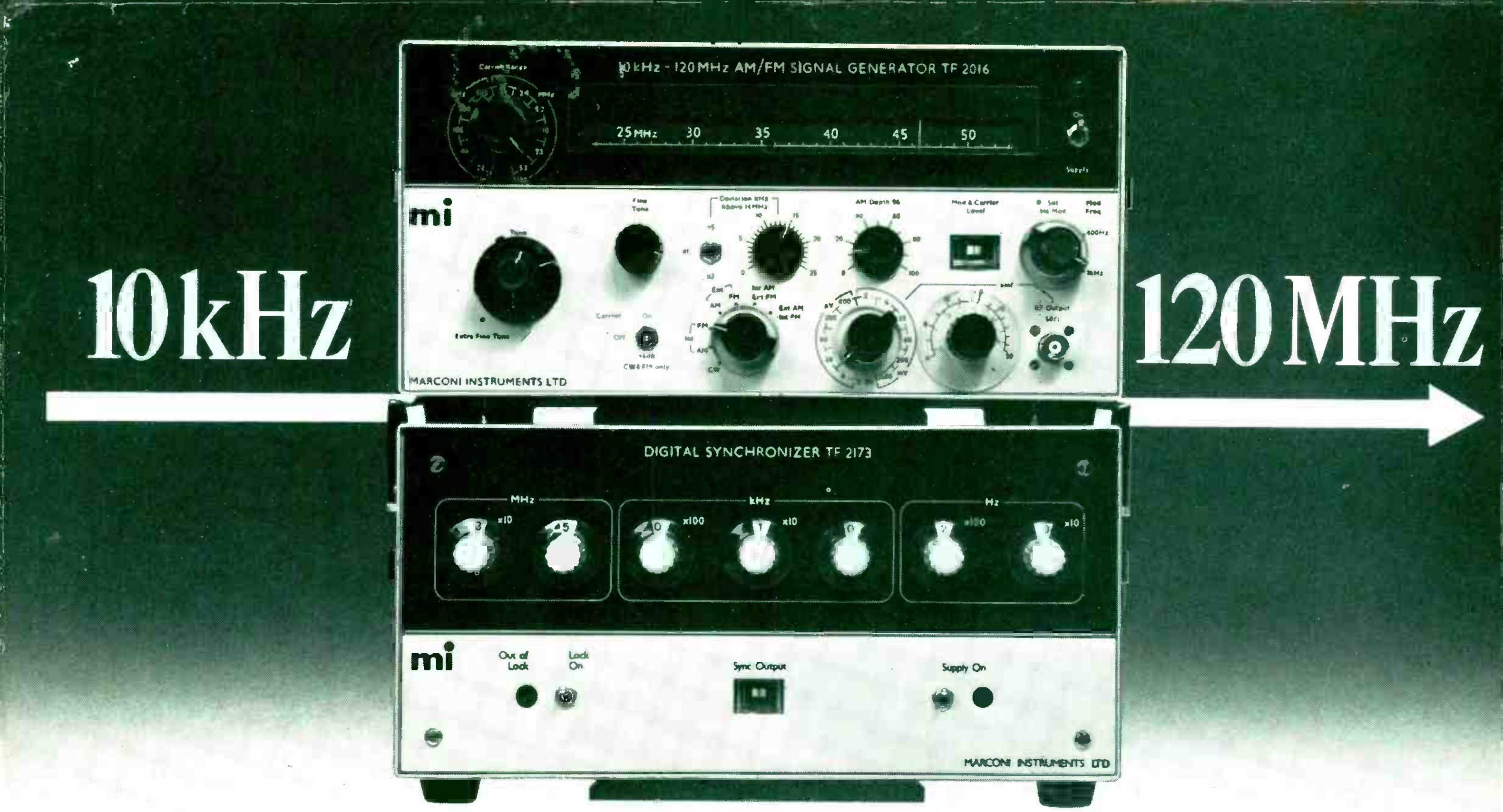
wireless world

OCTOBER 1978 40p

Electronic organ
Relativity and time signals
Oscilloscope storage unit

Australia $A1.25
Canada $1.75
Denmark Kr. 11.00
Germany Dm. 4.00
Greece Dr. 47.00
Holland Dfl. 4.50
Italy L. 1100
New Zealand $NZ 1.50
Norway Kr. 11.00 incl. moms
Singapore M $3.25
Spain Ptas. 80.00
U.S.A. $1.65



The mi Signal Generator for vlf·lf·mf·hf·vhf bands

AM/FM Signal Generator TF 2016 is a general purpose instrument for receiver testing. Its facility for battery operation and its rugged construction make it ideal for field as well as factory use.

TF 2016 will deliver up to 4 V e.m.f. and yet has a leakage level that is so low that even receivers with a sensitivity of 0.1 μV can be tested without ambiguity. And the **total** output level accuracy of ±1 dB ensures confidence every time.

Fundamental frequency generation is used over the entire frequency range thus ensuring the total absence of non-harmonics. The good tuning discrimination makes narrow band receiver testing quick and easy.

Amplitude modulation up to 100% modulation depth and frequency modulation up to 75 kHz deviation are available using the internal 400 Hz and 1 kHz oscillators. External modulation can be applied and, if required, internal a.m. and external f.m., or internal f.m. and external a.m., can be applied simultaneously.

A version of TF 2016 will shortly be available equipped with a 150 Hz preset pilot tone f.m. for use on Clansman receivers.

Pulse Modulator, TF 2169, may be fitted to the signal generator to provide pulsed r.f. for radar i.f. testing. IF probes can be supplied to help tuning to receivers fitted with battery economizer circuits. Alternative output level calibration plates, matching pads, attenuators and r.f. fuse units are included in the wide range of optional accessories.

Digital Synchronizer

The addition of this clip-on unit (as shown in our photograph) converts the TF 2016 into a synthesizer. It provides a stability of ±1 part in 10^6 and allows the frequency to be set in 10 Hz steps.

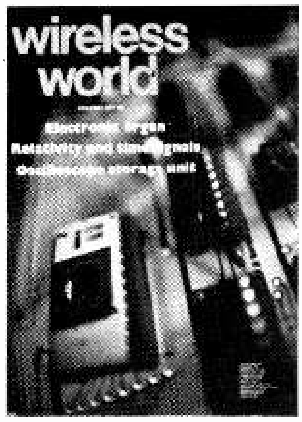
Full information gladly supplied on request.

mi MARCONI INSTRUMENTS

Marconi Instruments Limited · Longacres · St. Albans · Hertfordshire · England AL4 0JN · Tel: (0727) 59292 · Telex: 23350
Marconi Electronics Inc · 100 Stonehurst Court · Northvale · New Jersey 07647 **USA** · Tel: (201) 767-7250 · Twx: 710-991-9752
Marconi Instruments · 32 avenue des Ecoles · 91600 Savigny-Sur-Orge · **France** · Tél: 996.03.86. · Télex: 600541.F
Marconi Messtechnik GmbH · 8000 München 21 Jörgstrasse 74 · **West Germany** · Tel: (089) 58 20 41 · Telex: 5 212642

A GEC-Marconi Electronics Company

WW—001 FOR FURTHER DETAILS



Front cover shows part of an ITT equipment for programming microprocessors (itself a form of m.p.u.).
Photograph by Paul Brierley

IN OUR NEXT ISSUE

***Character rounding* for the W.W. teletext decoder. An additional board to improve the appearance of displayed characters.**

***Reduce wideband noise* in tape recording by 30dB with i.c. compander that uses pre-emphasis to reduce pumping effect. (D. L. Harrison)**

***Breadboard survey.* This article explains how various breadboard systems are constructed and used. A number of commercial types are described and compared in terms of flexibility, ease of assembly and cost.**

Current issue price 40p, back issues (if available) 50p, at Retail and Trade Counter, Paris Garden, London SE1. Available on microfilm please contact editor.
By post, current issue 55p, back issues (if available) 50p, order and payments to Room 11, Dorset House, London SE1 9LU.
Editorial & Advertising offices: Dorset House, Stamford Street, London SE1 9LU.
Telephones: Editorial 01-261 8620. Advertising 01-261 8339.
Telegrams/Telex: Wiworld Bisnespres 25137 BISPRS G. Cables: Ethaworld, London SE1.
Subscription rates: 1 year, £7.00 UK and $23.40 overseas ($24 USA and Canada).
Student rate: 1 year, £3.50 UK and £4.50 overseas ($11.70 USA and Canada).
Distribution: 40 Bowling Green Lane, London EC1R ONE. Telephone 01-837 3636.
Subscriptions: Oakfield House, Perrymount Road, Haywards Heath, Sussex. RH16 3DH. Telephone 0444 59188. Please notify a change of address.
USA mailing agents: Expediters of the Printed Word Ltd, 527 Madison Avenue, Suite 1217, New York, NY 10022, 2nd-class postage paid at New York.
IPC Business Press Ltd. 1978
ISSN 0043 6062

wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

OCTOBER 1978 vol 84 N 1514

43 **Electronic voting**

44 **Relativity and time signals**
by L. Essen

46 **Digital Pal coder**
by O. J. Downing & J. E. Tully

47 **Negative feedback and non-linearity**
by Cathode Ray

51 **Add-on oscilloscope waveform store**
by R. H. Fastner

57 **Letters to the Editor**
Discriminative metal detector
Preparation for WARC '79
Tri-state logic

61 **Capacitance meter**
by K. Holford

67 **Digital picture coding**
by D. Webster

71 **News of the month**
ARI in the grave?
White Paper on broadcasting
Teletext aids the deaf

75 **Frequency synthesizers — 2**
by R. Thompson

79 **Electronic organ tone system**
by A. D. Ryder

84 **American audio**
by J. Dinsdale & G. Tillett

89 **World of amateur radio**

90 **Circuit ideas**

92 **Developments in cassette recorders**
by B. Lane

96 **New products**

98 **Sidebands**
by Mixer

Why your next sine-square wave oscillator should be a Farnell function generator!

Inexpensive, yet without compromise to performance, facilities or engineering standards, our FG3 is simply today's best buy in the function generator market.
At £110 U.K. (ex.VAT) it costs less than most sine/square wave oscillators and boasts many features normally available only in more sophisticated instruments.

★ Frequency range 0.02Hz to 200kHz—easily extendible down to 0.002Hz

★ 100mV to 12V pk-pk from main output with SINE, SQUARE or TRIANGLE selectable

★ Additional constant level outputs—TTL, triangle and sweep ramp

★ Internal and external SWEEP facility. Linear or logarithmic

★ Audioband covered in one sweep

★ Sweep speed 8mS for 1:1000 variation. Extendible by external capacitor

★ Sweep width adjustable

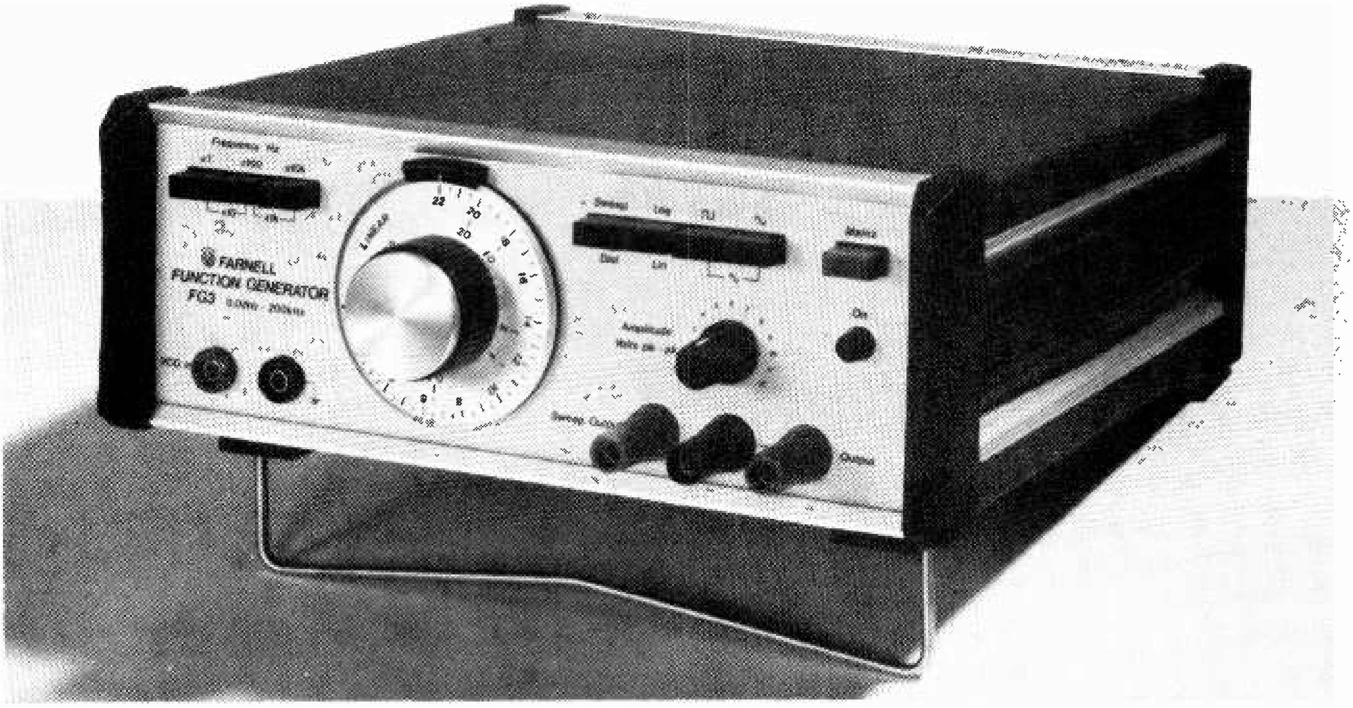
★ Low distortion

★ VCO input also allows f.m. mode

★ Mains operated (dual standard 95-130 or 190-260 a.c.)—no costly batteries to replace. Fully stabilised power supply

★ Short-circuit proof outputs

So if you are thinking of buying a sine/square wave oscillator, remember, you'll get a whole lot more for your money from our function generator! *Send for details NOW!*



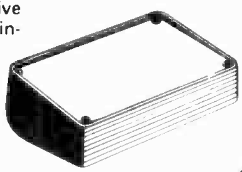
FARNELL INSTRUMENTS LIMITED · SANDBECK WAY · WETHERBY · WEST YORKSHIRE LS22 4DH TEL 0937 63541 or 01-864 7433 & 7434 · TELEX 557294 FARIST G

WW—081 FOR FURTHER DETAILS

BIMCONSOLES
BIMBOXES
BIMBOARDS
BIMDRILLS
BIMDICATORS

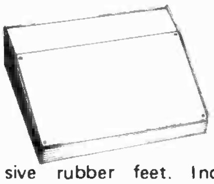
MINI DESK BIMCONSOLES

Moulded in Orange, Blue, Black or Grey ABS and incorporating guides on all sides for holding 1.5mm thick pcb's. 1mm Grey Aluminium panel sits recessed into front of console and held by screws running into integral brass bushes. Stand-off bosses in base for supporting small sub-assemblies etc. 4 self adhesive rubber feet also included.



BIM1005 (161x96x58mm) £2.12*
BIM1006 (215x130x75mm) £2.94*

LOW PROFILE BIMCONSOLES

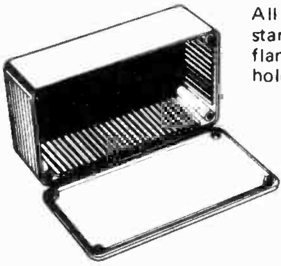


1mm Grey Aluminium panel sits recessed into front of console base, which is moulded in Orange, Blue, Black or Grey ABS and sits on 4 self adhesive rubber feet. Incorporating guides for holding 1.5mm thick pcb, the base also has stand-off bosses for supporting small sub-assemblies etc. and ventilation slots. Front panel is held by 4 screws which run into integral brass bushes.

BIM6005 (143x105x55.5[31.5] mm) £2.32*
BIM6006 (143x170x55.5[31.5] mm) £3.08*
BIM6007 (214x170x82[31.5] mm) £4.12*

ABS & DIECAST BIMBOXES

5 sizes, in either ABS or Diecast Aluminium
ABS moulded in Orange, Blue, Grey or Black
Diecast Aluminium available in Grey Hammertone or Natural



All boxes incorporate guides on all sides for holding 1.5mm thick pcb's and stand-off bosses in base for supporting small sub-assemblies etc. Close fitting flanged lids held by screws running into integral brass bushes (ABS) or tapped holes (Diecast).

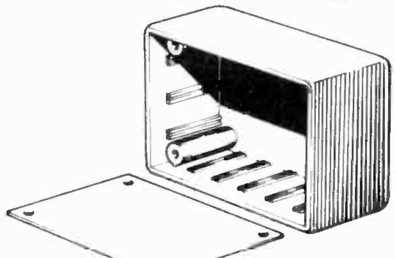
	ABS		Diecast	Hammertone	Natural
(100x50x25mm)	BIM2002/12	£0.95*	BIM5002/12	£1.20*	£0.97*
(112x62x31mm)	BIM2003/13	£1.05*	BIM5003/13	£1.50*	£1.20*
(120x65x40mm)	BIM2004/14	£1.15*	BIM5004/14	£1.86*	£1.49*
(150x80x50mm)	BIM2005/15	£1.30*	BIM5005/15	£2.38*	£1.91*
(190x110x60mm)	BIM2006/16	£2.04*	BIM5006/16	£3.41*	£2.85*

Also available in Grey Polystyrene (112x61x31mm) with no slots and self tapping screws BIM2007/17 £0.88*

MULTI-PURPOSE BIMBOXES

Moulded in Orange, Blue, Black or Grey ABS with 1mm thick Grey aluminium recessed front cover which is retained by 4 screws running into integral brass bushes. 1.5mm pcb guides are incorporated on all sides and as with all ABS boxes they are 85°C rated. 4 self adhesive rubber feet also included.

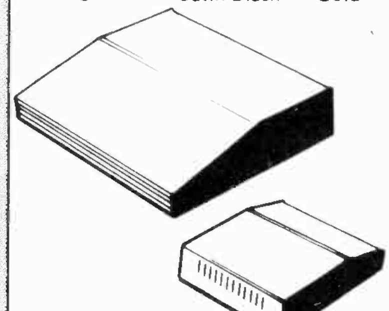
BIM 4003 (85x56x28.5mm) £1.24*
BIM 4004 (111x71x41.5mm) £1.56*
BIM 4005 (161x96x52.5mm) £2.08*



ALL METAL BIMCONSOLES

All aluminium, 2 piece desk consoles with either 15° or 30° sloping fronts, sit on 4 self-adhesive non slip rubber feet. Ventilation slots in base and rear panels permit efficient cooling.

Colour Code	Top Panel	Base
A	Off White	Blue
B	Sand	Green
C	Satin Black	Gold



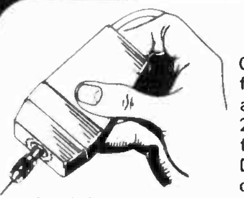
15° Sloping Panel

BIM7151 (102x140x51[28] mm) £ 9.43*
BIM7152 (165x140x51[28] mm) £10.43*
BIM7153 (165x216x51[28] mm) £11.42*
BIM7154 (165x211x76[33] mm) £12.39*
BIM7155 (254x211x76[33] mm) £13.66*
BIM7156 (254x287x76[33] mm) £14.65*
BIM7157 (356x211x76[33] mm) £15.80*
BIM7158 (356x287x76[33] mm) £16.78*

30° Sloping Panel

BIM7301 (102x140x76[28] mm) £ 9.43*
BIM7302 (165x140x76[28] mm) £10.43*
BIM7303 (165x183x102[28] mm) £11.42*
BIM7304 (254x140x76[28] mm) £12.39*
BIM7305 (254x183x102[28] mm) £13.66*
BIM7306 (254x259x102[28] mm) £14.65*
BIM7307 (356x183x102[28] mm) £15.80*
BIM7308 (356x259x102[28] mm) £16.78*

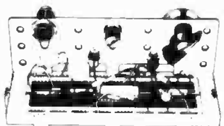
MAINS BIMDRILL

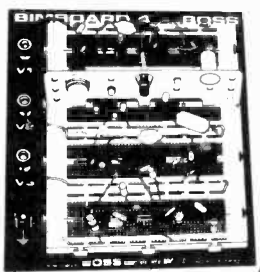


Operates directly from 220-240Vac and supplied with 2 metres long cable fitted with 2 pin DIN plug. Will drill brass, steel and aluminium as well as pcb's etc. Has integral biased-off switch and accepts tools with 1,2 and 3.2mm dia shanks £9.72*
Accessory Kit including 1mm, 2mm, .125" twist drills, 5 burrs and 2.4mm collet £2.20*

DIL COMPATIBLE BIMBOARDS

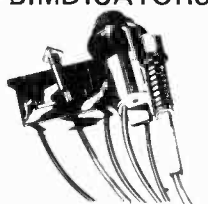
Bimboards accept all sizes of DIL packages as well as resistors, diodes, capacitors and LED's etc. They have integral Bus Strips running up each side for carrying Vcc and ground as well as Component Support Brackets for holding lamps, fuses and switches etc. Available as either single or multiple units, the latter mounted on 1.5mm thick, matt black aluminium back plates which stand on non slip rubber feet and have 4 screw terminals for incoming power.
Bimboard 1 contains 500 individual sockets whereas the multiple units containing 2, 3 or 4 Bimboards incorporate 1,100, 1,650 or 2,200 individual sockets, all arranged on a 2.5mm(0.1") matrix.





Bimboard 1 £ 9.72* Bimboard 2 £22.68*
Bimboard 3 £32.40* Bimboard 4 £42.12*

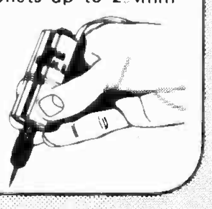
BIMDICATORS



Remember we are also one of Europe's largest manufacturers of Filament, Neon and LED indicators. Send for our BIMDICATOR DATA

12 VOLT BIMDRILLS

2 small but powerful 12V dc drills, easily held in hand or used with lathe/stand adaptor. Both drills have integral on/off switches and 1 metre long cable.
Mini Bimdrill with 2 collets up to 2.4mm capacity £7.56*
Major Bimdrill with 3 collets up to 3mm capacity £12.96*
Mains to 12 Volts adaptor, lathe, stand and accessory kits also available, details on request.



BOSS
INDUSTRIAL MOULDINGS LIMITED

2 Herne Hill Road, London SE24 0AU
Telephone: 01-737 2383
Telex: 919693 Answer Back 'LITZEN G'
Cables & Telegrams: 'LITZEN LONDON SE24'

*All quoted prices are 1 off and include Postage, Packing and VAT. Terms are strictly cash with order unless you have authorised BOSS account. For individual data sheets on all BOSS products send stamped, self addressed envelope

In future, recording the present will be a thing of the past.

What's past is past. And said to be best forgotten.

But it's fundamental to the very existence of communications recording to be able to replay a selected portion of tape to find out what was said by who, to whom . . . and when. And 'when' can be vital.

Equally vital, particularly in emergencies when every second counts, is the ability to obtain such replay access rapidly, precisely, automatically. With absolute certainty—and without time-consuming multiple knob-twiddling aided by guesswork.

Racal-Thermionic has recognized this need and produced TIMESEARCH—designed specifically for its ICR range of multi-channel communications recorders—and providing just these facilities.

TIMESEARCH can generate a coded time reference signal of crystal accuracy and index it onto the tape. It can read and display that signal. It can search a tape at high speed for a pre-selected time signal and automatically initiate replay at that time.

In communications recording, the future becomes the present; the present becomes the past. And when you need to recall the past with precision, you need TIMESEARCH.

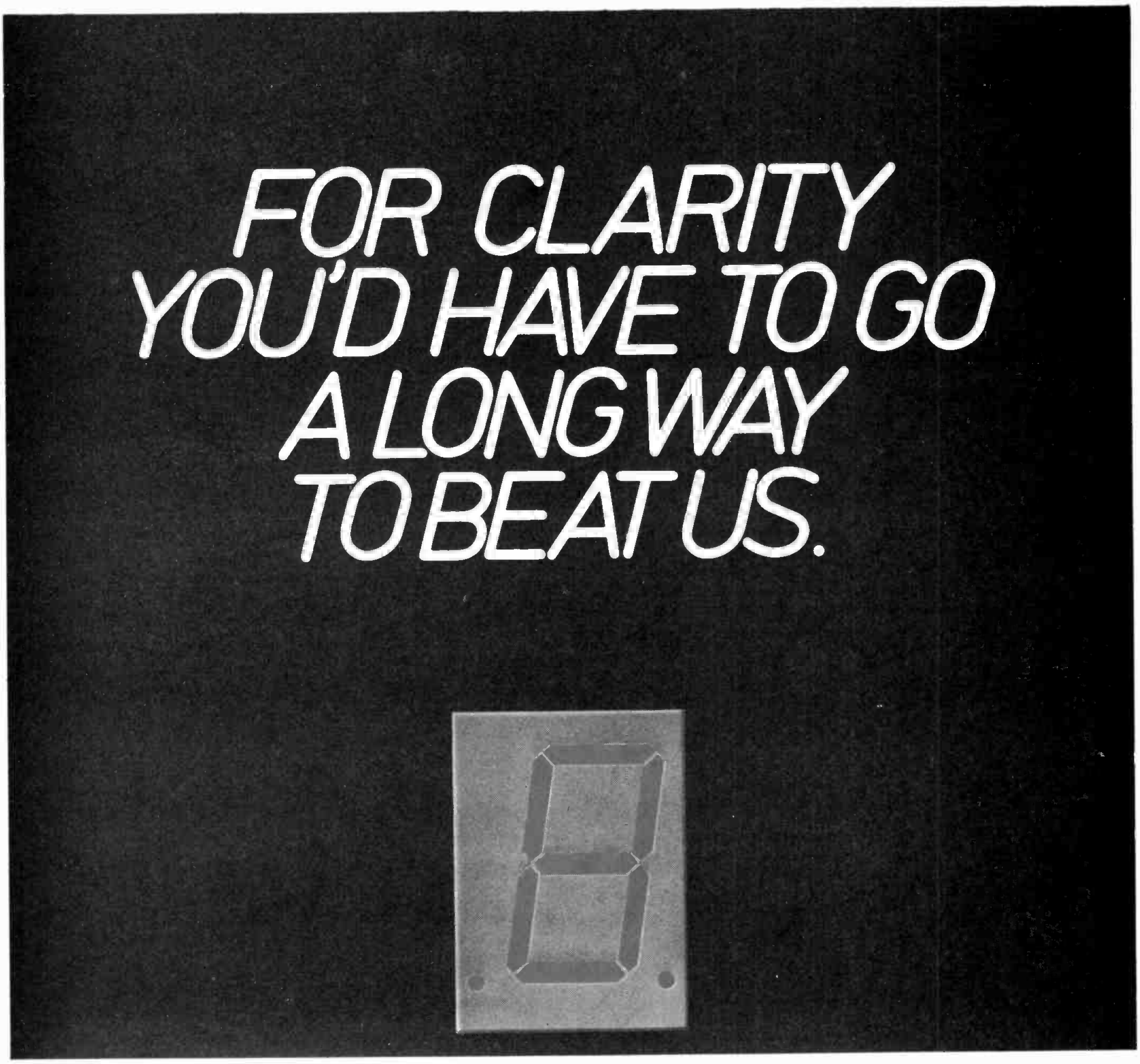
And for providing precise time signals every 10 seconds for recording onto magnetic tape: the International Timing Unit.

Racal-Thermionic the recording people

Racal-Thermionic Limited, Hardley Industrial Estate, Hythe, Southampton, SO4 6ZH, England. Telephone 0703 843265. Telex 47600

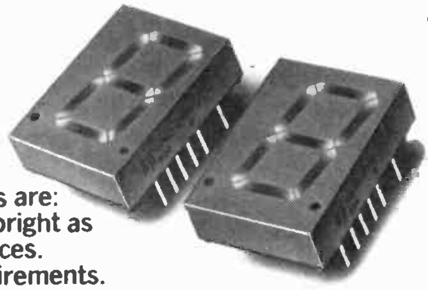
RACAL

WW—017 FOR FURTHER DETAILS



Hewlett-Packard's HDSP-3400 series display.

The readability of the HDSP-3400 series is excellent—designed for viewing distances of up to 33 feet. Even in bright ambients the clarity is remarkable. They replace existing 0.6" and 0.8" displays and are fully compatible with them.



Significant features are:
* Nearly twice as bright as competitive devices.
* Low power requirements. Single Ga AsP chip per segment.
* Categorised for luminous intensity, assuring uniformity of light output.
* Grey packaging for optimum contrast.
* Overflow digit device available.
* Low cost. 100 + £1.36.

For full details of why you'd have to go a long way to beat the HDSP-3400 series return the coupon.

HEWLETT hp PACKARD

To Crellon Electronics Ltd., 380 Bath Road, Slough, Berks. SL1 6JE.
Tel: Burnham (06286) 4434. Telex: 847 571.

Please send me full data
on the Hewlett-Packard HDSP-3400 Series

Name ______________________

Company ______________________

Address ______________________

____

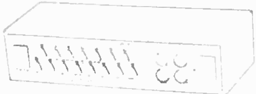
Tel. ______________________

WW10/78

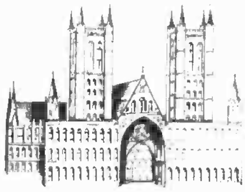
WW—014 FOR FURTHER DETAILS

MAPLIN

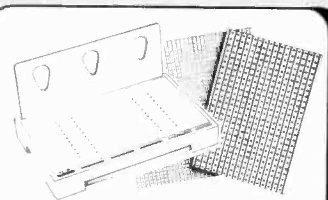
everything for the modern D.I.Y. electronics enthusiast and more.



THE 'DRUMSETTE' RHYTHM GENERATOR
Organists, pianists, guitarists . . . an automatic drum set to accompany you! Nine highly realistic instruments play fifteen different rhythms. Fifteen rhythm-select touch switches and a touch plate for stop/start without rhythm change gives absolute ease of operation. Build it yourself for under £65 including smart teak-effect cabinet. See it and hear it in our shop! Send for full construction details now. MES49, price 25p.

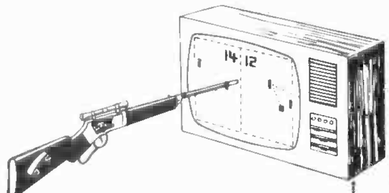


REVERBERATION SYSTEMS
High quality spring line driver module uses 4 integrated circuits and two transistors. Built and tested circuit board with wiring instructions for spring line. X885G, price £6.00. Power supply to suit drive module costs around £2.50 and construction details are in catalogue, or ask for leaflet MES24. Mechanical spring lines: Short line (XL08J) £4.49; Long line (X884F) £10.39. (All prices include V.A.T. and p. & p.)

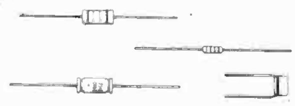


BOARDS AND PCB's
Pages 59 to 61 of our catalogue show you our range of Veroboards and S-Decs or if you prefer to make your own pcb's a range of etching systems including the novel etch-in-a-bag system, plus printed circuit transfers for the professional finish to your boards.

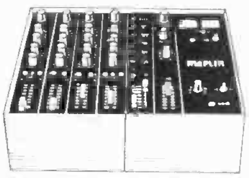
9-CHANNEL RADIO CONTROL SYSTEM. A comprehensive model control system, featuring nine independent fully proportional channels achieved by a design using very few components thus keeping the cost to a minimum. Full construction details in our booklet (XF03D) price £1.20.



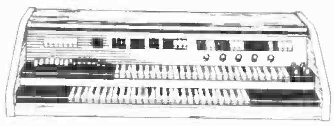
T.V. GAME
A fascinating TV game kit that plays football, tennis, squash and practice for only £21.59. Reprint of construction details 25p. Add on rifle kit only £10.60. (All prices include V.A.T. and p.&p.).



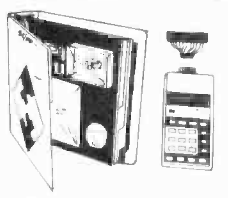
MASSIVE RANGE OF COMPONENTS
For instance the capacitor section in our catalogue includes non-polarised electrolytics and our resistor section includes even 1% tolerance types. Get our fascinating catalogue now — you won't regret it.



AUDIO MIXER
A superb stereo audio mixer. It can be equipped with up to 16 input modules of your choice and its performance matches that of the very best tape-recorders and hi-fi equipment. It meets the requirements of professional recording studios, FM radio stations, concert halls and theatres. Full construction details in our catalogue. A component schedule is available on request.



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



MICROPROCESSOR
Build a mini-computer with our microprocessor kit. Features: 46 different instruction types; 256 bytes of read/write memory (more are easily added), micro-processor can address up to 65,536 8 bit-bytes. Complete kit for use with teletype etc. (XB91Y). £74.10.
20-key keyboard for use with above (in place of teletype) (XB92A). £71.11. Both kits with detailed instruction books. See our newsletter for details of additional RAM's, tri-state interfacing chips, number-cruncher and standard cassette tape-recorder interface to store your programmes. (All prices include V.A.T. and p. & p.).

Our bi-monthly newsletter keeps you up to date with latest guaranteed prices – our latest special offers – details of new projects and new lines. Send 30p for the next six issues (5p discount voucher with each copy).

Look inside for our 4-page special pull out featuring the New 79-80 catalogue

POST THIS COUPON NOW FOR YOUR COPY OF OUR 1977 CATALOGUE PRICE 60p

Please rush me a copy of your 216 page catalogue
I enclose 60p, but understand that if I am not completely satisfied I may return the catalogue to you within 14 days and have my 60p refunded immediately.

NAME ____________________

ADDRESS ____________________

____

MAPLIN ELECTRONIC SUPPLIES
P.O. BOX 3 RAYLEIGH ESSEX SS6 8LR
Telephone: Southend (0702) 715155
Shop: 284, London Road, Westcliff-on-Sea, Essex
(Closed on Monday) Telephone Southend (0702) 715157

WW — 011 FOR FURTHER DETAILS

WW10

The Ultimate Multi-mate

What other DMM offers all this for £127?

It's easy to see why Philips new PM 2517 digital multimeter is called The Ultimate Multi-mate. No other DMM comes anywhere near its combination of laboratory performance and handy form - for such a handy price. Take a look at some of the features it packs in.

Full 4-digit display giving higher resolution than 3½ digits for 80% of measurements. Parameter readout, too.

Choice of LED or LCD display - choose the one that suits you, the price is the same. Mains unit supplied free with LED version.

Autoranging with manual override. Average auto response time less than two seconds.

True RMS rather than "average" detection. The Ultimate Multi-mate measures non-sinewave AC signals more accurately.

High accuracy - necessary to make full use of those four digits. An impressive 0.2% of reading ±0.05% of scale on d.c. volts.

Current to 10A via a separate input is standard, not optional, on the PM 2517.

Overload protection that is so comprehensive you have to try very hard to do any damage, even with mains and TV booster voltages.

Small and sturdy construction makes this DMM ideal for bench or field work.

Ergonomic design allows it to work in any position without fuss or fumble.

Low-cost temperature option makes possible measurement from —60 to +200°C.

Data hold option means that in tricky situations you can "freeze" measurements for increased operator safety and convenience.

Built to international standards - you name them and the PM 2517 meets them. But what else would you expect from an international company like Philips?

The Ultimate Multi-mate is available from Wessex Electronics Ltd., 114 - 116 North Street, Downend, Bristol BS16 5SE. Tel: (0272) 571404; Rank Radio International, Watton Road, Ware, Herts. (Tel: Ware 3966); and Philips Service Centres ('phone 01-686-0505 for the address of your nearest branch).

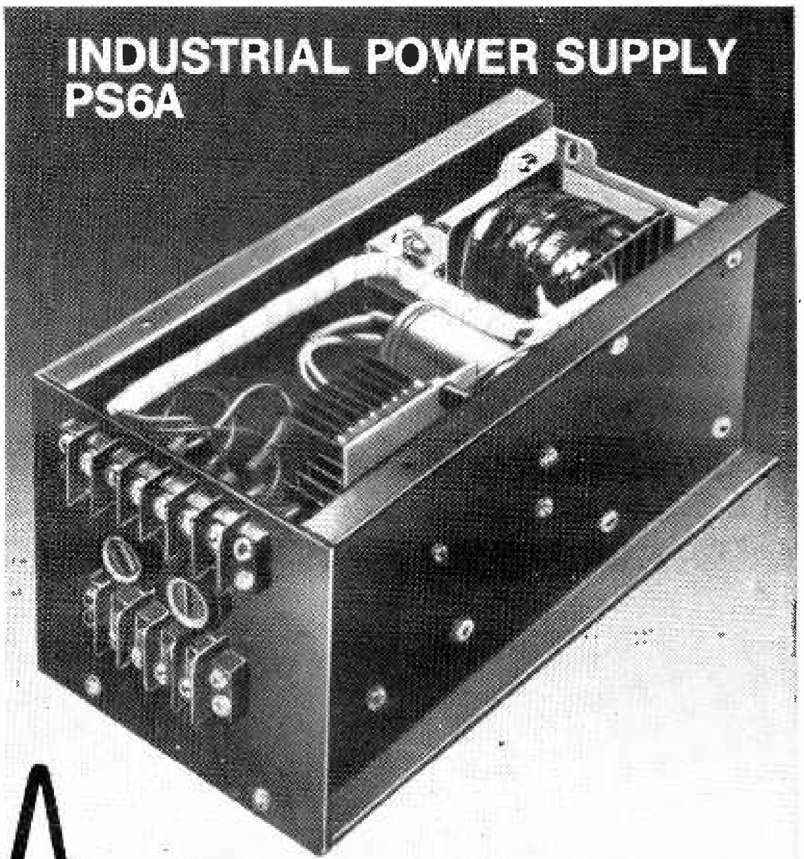
It can also be purchased from the U.K. marketing organisation -

Pye Unicam Ltd
Philips Electronic Instruments Dept
York Street Cambridge, England CB1 2PX
Tel Cambridge (0223) 58866 Telex. 817331

PHILIPS **Test & Measuring Instruments**

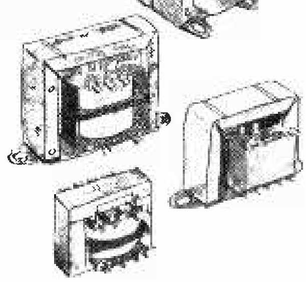
PHILIPS

- **Reasonably priced at £40**
- **24V. D.C. Unregulated 6A**
- **12V. D.C. Regulated 1A Thermally protected with automatic recovery**
- **Mains powered 110-120V. A.C. or 220-240V. A.C.**

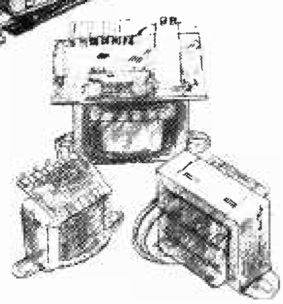


Bulgin Electronics
One of the Bulgin Group of Companies Soundex Ltd
Park Lane, Broxbourne, Herts. Tel: Hoddesdon 64455

WW—94 FOR FURTHER DETAILS



there are Transformers and . . .



We have been established for over twenty years and are proud of the reputation earned for the design and manufacture of high quality transformers, and other wound components.

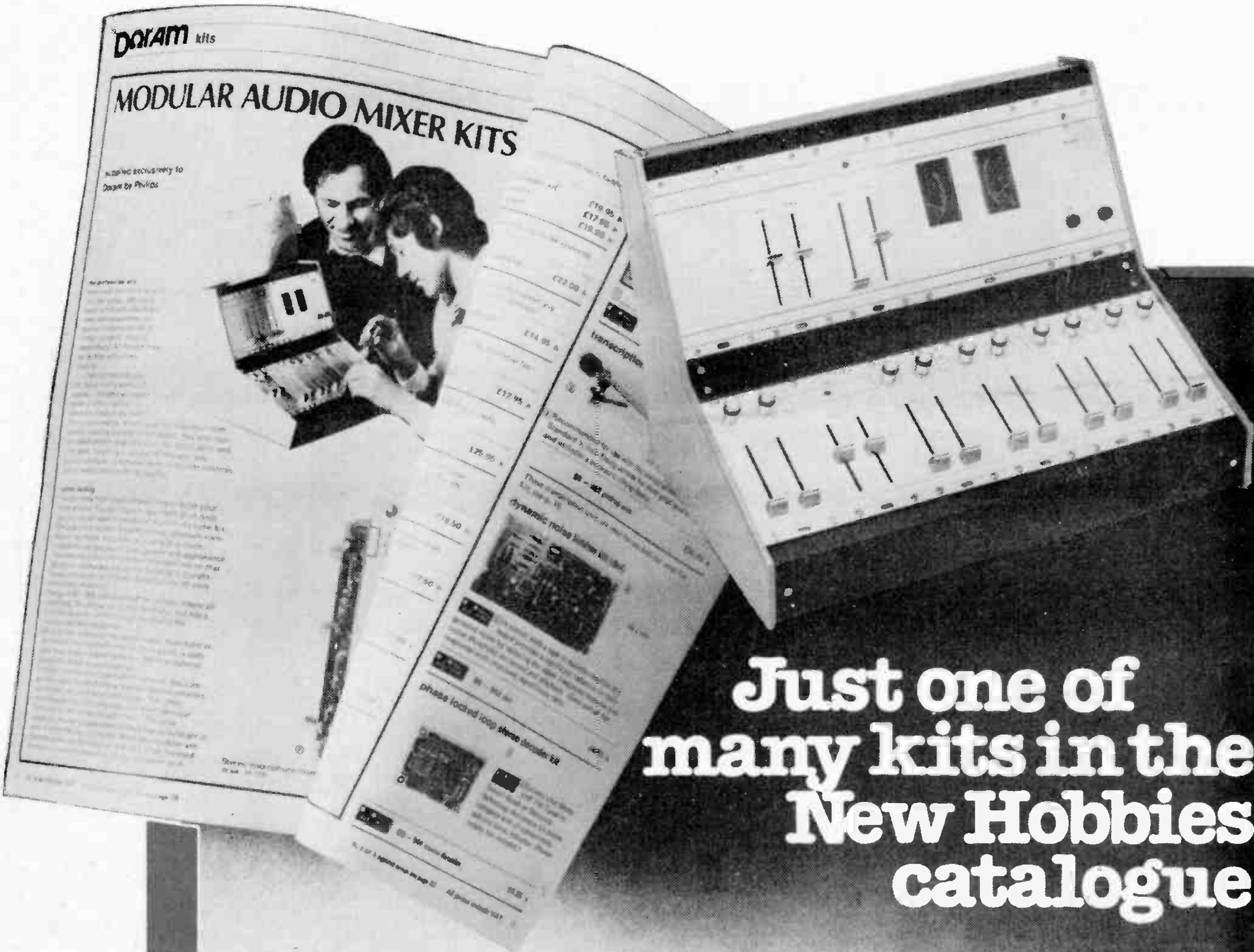
Our design team is available to give their personal attention to customers' technical requirements.

Development and pre-production samples can be supplied by our prompt prototype service.

Drake Transformers

DRAKE TRANSFORMERS LIMITED
South Green Works
Kennel Lane, Billericay, Essex CM11 2SP
Telephone Billericay (02774) 51155
Telex 99426 (prefix message DRAKE)

WW—059 FOR FURTHER DETAILS



Just one of many kits in the New Hobbies catalogue

The new Doram Electronic Hobbies Catalogue is packed full of new exciting merchandise including

MICRO PROCESSOR BASED KITS.

ELECTRONIC KITS FOR ALL THE FAMILY

ELECTRONIC TOOLS AND BOOKS

AUDIO & CAR ACCESSORIES ETC.

Send for your copy now.
(AVAILABLE LATE SEPT)

Overseas customers (except for N. Ireland)— 60p including despatch by Air (or all-up post).

Doram Electronics Ltd
P.O. Box TR8
Wellington Road Estate
Wellington Bridge
Leeds LS12 2UF

Doram

ELECTRONIC HOBBIES CATALOGUE

Name..............................

Address...........................

....

Please send my FREE Hobbies Catalogue. I enclose 25p. contribution to p. & p.

Doram Electronics Ltd
P.O. Box TR8
Wellington Road Estate,
Wellington Bridge,
Leeds LS12 2UF

Stop with Beridox. Go with Fuji.

Fuji are internationally recognised experts at coating film with high-quality, high-resolution emulsions for the world's top movie and still cameras. Now Fuji are applying this technology to producing top-quality tape for all types of video systems.

Beridox for stop-motion

When it comes to stop-motion performance, Fuji ¾" Beridox video cassettes are outstanding, with a stop-motion life of 60 minutes or more. Especially developed to out-perform CrO_2 coatings, Beridox tape results in sharper images, improved colour performance, superb resistance to image deterioration from repeated playbacks, and minimal head wear. And Beridox video cassettes are ideal for use with any make of U-format machine on the market, including portables.

Fuji, the all-size video-tape experts

Beridox U-format is just one Fuji tape product. They also make other types of video tapes, from the 2" quad to the new VHS ½" size. There's the professional 1" V611, with its outstanding resolution and standard-equipment capability. The ½" V600, compatible with all EIAJ CP-504 and CP-507 helical-scan VTRs. And the ½" Beridox tape V621 for high-density-type helical-scan units. Plus Fuji high band H701 for 4-head video machines. There's also a Fuji tape for the Sony Beta-Format machines.

For more information about Fuji Beridox and other Fuji video tapes, use the enquiry service to obtain literature from Bell & Howell. Remember – stop with Beridox. Go with Fuji.

Fuji tape for use with...

...portable and mains machines prior to EIJI high density, including EIAJ1 low density, (e.g. JVC PV4500), and mains machines, KV350, SU700, etc.
Portable and mains EIAJ high density format (e.g. JVC PV4800, Sony AV3420CE, National Panasonic NV3850).
A-format cartridge. National Panasonic NV5120, 5130, Hitachi/Shibaden SV630.
1" VTRs. All IVC 600, 700, 800, 900.
EV310CE. EV320CE. Ampex 5803, 7903, 7950, 7803.
All U-format machines including JVC, CR6000, CP5060, CR6060, CR8300, Sony VP1210, VP1230, VO1810, VO1830, 'O2850, NEC PBC7505, PVC8207, PVC8307, National V9210, 9200, NV9500.
-format portable machines JVC CR4400, Sony VO3800.

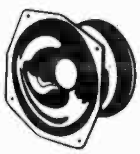
Bell & Howell A-V Ltd., Alperton House, Bridgewater Road, Wembley, Middx. HA0 1EG.

BELL & HOWELL

WW—089 FOR FURTHER DETAILS

WILMSLOW AUDIO
The firm for Speakers

HI-FI DRIVE UNITS



Audax HD12.9 D25	£7.50
Audax HD13 D34H	£12.50
Audax HD20 B25H4	£14.65
Audax HD20 B25J4	£12.25
Audax HD11 P25EBC	£7.25
Baker Superb	£22.50
Castle 8RS/DD	£12.35
Chartwell CE205 8 bass, matched pairs only pairs	59.90
Coles 4001	£6.25
Coles 3000	£6.25
Celestion HF1300 II	£8.25
Celestion HF2000	£9.75
Dalesford D10 tweeter	£8.25
Dalesford D20/105 4	£10.95
Dalesford D30/110 5	£10.95
Dalesford D50/153 6½	£11.95
Dalesford D50/200 8	£11.95
Dalesford D70/250 10	£24.95
Dalesford D100/310 12	£34.95
Decca London	£41.25
Decca CO/1000/8	£8.95
Decca DK30	£27.50
E.M.I. type 350 4 ohm	£9.25
E.M.I. 14A/770 14 x 9	£12.50
E.M.I. 8 x 5 d/c 10 watt	£3.95
Isophon KK10/8	£8.25
Isophon KK8/8	£7.50
Jordan Watts Module	£17.95
Jordan 50mm Unit	£22.50
Jordan CB Crossover	£22.50
KEF T27	£8.50
KEF B110	£10.95
KEF B200	£11.95
KEF B139	£24.95
KEF DN13	£4.95
KEF DN12	£7.25
KEF DN22 pair	£36.00
Lowther PM6	£49.95
Lowther PM6 MKI	£52.00
Lowther PM7	£86.50
Peerless DT10HFC	£9.75
Peerless KO10DT	£8.95
Peerless KO40MRF	£11.75
Radford BD25 II	£26.95
Radford MD9	£14.50
Radford MD6	£17.95
Radford FN8/FN831	£19.95
Richard Allan CG8T	£9.95
Richard Allan CG12T Super	£22.45
Richard Allan HP8B	£15.50
Richard Allan LP8B	£10.35
Richard Allan HP12B	£25.25
Richard Allan DT20	£7.25
Richard Allan DT30	£7.45
Seas HO86	£8.75
Shackman Electrostatic C/W polar network & X/O pair	£112.00
Tannoy HPD 295A	£91.50

PA GROUP & DISCO UNITS

Tannoy HPD 315A	£102.95
Tannoy HPD 385A	£119.95
Baker Group 25	£13.00
Baker Group 35	£14.50
Baker Group 50/12	£21.00
Baker Group 50/15	£25.75
Celestion G12M	£13.50
Celestion G12H	£17.95
Celestion G18C	£41.95
Celestion G12/75 (alum. dome)	£22.50
Celestion G12/75 (d/cone)	£24.50
Celestion G12M/50 (cambric edge)	£16.95
Celestion G15/100 (alum dome)	£32.50
Celestion MH1000	£13.50
Celestion Powercell 12 /100	£45.95
Celestion Powercell 15 /100	£47.50
Celestion Powercell 15 /125	£51.95
Fane Pop 40	£10.95
Fane Pop 50H	£12.50
Fane Pop 75	£16.95
Fane Pop 65	£19.95
Fane Pop 80	£21.95
Fane Pop 100	£35.95
Fane J44 horn	£6.50
Fane J104 horn	£13.75
Fane J73 horn	£9.75
Fane Guitar 80L	£19.75
Fane Guitar 80B	£19.95
Fane Disco 80	£21.50
Fane PA80	£19.50
Fane Bass 85	£29.95
Fane Crescendo 12A	£42.95
Fane Crescendo 12B	£44.95
Fane Crescendo 15/100	£54.95
Fane Crescendo 15/125	£64.95
Fane Crescendo 18	£75.95
Fane 920 II Horn	£45.95
Fane HPX1/HPX2	£2.50
Fane PH50	£6.50
Goodmans 8PA	£3.95
Goodmans 12P	£16.95
Goodmans 12PD	£19.95
Goodmans 12PG	£19.50
Goodmans 18P	£39.95
Goodmans 50HX	£18.95
McKenzie Forte 12	£22.95
Motorola Piezo Horn	£8.50
Richard Allan HD8T	£14.50
Richard Allan HD10T	£15.75
Richard Allan HD12T	£20.95
Richard Allan HD15	£36.95
Richard Allan HD15T	£37.95

WILMSLOW AUDIO
KITS FOR MAGAZINE DESIGNS etc.

Kits include drive units, crossovers, BAF/Long fibre wool, etc. for pair of speakers.
Carriage £3.50

Practical Hifi & Audio PRO9-TL (Rogers)	£118.00
Felt panels for PRO9-TL	£5.50 + £1.50 p&p
Hifi Answers Monitor (Rogers)	£129.00
Hifi News State of the Art (Atkinson)	£161.00
Popular Hifi Mini Monitor (Colloms)	£63.00
Popular Hifi Round Sound (Stephens) including complete cabinet kit	£68.00
Popular Hifi (Jordan)	£91.00
Practical Hifi & Audio Monitor (Giles)	£119.00
Practical Hifi & Audio Triangle (Giles)	£86.00
Practical Hifi & Audio BSC3 (Rogers)	£60.00
Practical Hifi Mini Triangle (Giles)	£99.00
Hifi News Tabor (Jones)	£59.75
Hifi News Tabor (with H4 bass units)	£65.00
Wireless World T.L./KEF (Bailey)	£112.00
Wireless World T.L./Radford (Bailey)	£154.00

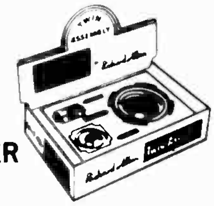
SMART BADGES FREE WITH ALL ABOVE KITS (TO GIVE THAT PROFESSIONAL TOUCH TO DIY SPEAKERS!)

Send 3 x 7p stamps for reprints/construction details of any of above designs.

CARRIAGE & INSURANCE

Tweeters/Crossovers	40p each
Speakers up to 10	75p each
Speakers 12	£1.25 each
Speakers 15	£2.00 each
Speakers 18	£2.95 each
Speaker Kits	£2.50 pair
Mag. design kits	£3.50 pair

SPEAKER KITS



Prices per pair. Carriage £2.50.

Dalesford System 1	£52.90
Dalesford System 2	£55.75
Dalesford System 3	£101.75
Dalesford System 4	£108.00
Dalesford System 5	£139.00
Dalesford System 6	£93.00
Eagle SK210	£15.00
Eagle SK215	£29.00
Eagle SK320	£37.00
Eagle SK325	£67.00
Eagle SK335	£91.00
Goodmans DIN20	£31.50
Goodmans Mezzo Twinkit	£51.95
Kef Kit I	£59.50
Lowther PM6 Kit	£91.75
Lowther PM6 MKI Kit	£96.50
Module	£39.90
Peerless 1060	£71.95
Peerless 1070	£122.00
Peerless 1120	£139.00
Peerless 2050	£49.95
Peerless 2060	£65.95
Radford Studio 90	£154.00
Radford Monitor 270	£208.00
Radford Studio 270	£275.00
Radford Studio 360	£390.00
RamKit 50 (makes Ram 100)	£69.95
Richard Allan Twin Assembly	£33.00
Richard Allan Triple 8	£51.00
Richard Allan Triple 12	£62.00
Richard Allan Super Triple	£73.00
Richard Allan RA8	£46.50
Richard Allan RA82	£74.00
Richard Allan RA82L	£79.95
Seas Mini	£17.90
Seas 203	£35.50
Seas 302	£43.90
Seas 303	£73.90
Seas 503	£119.90
Wharfedale Denton 2XP	£26.95
Wharfedale Linton 3XP	£41.95
Wharfedale Glendale 3XP	£56.95

Everything in stock for the speaker constructor!
BAF, long fibre wool, foam, crossovers, felt panels, components, etc.
Large selection of grille fabrics.
(Send 15p in stamps for fabric samples)
(Prices correct at 1/8/78)

SWIFT OF WILMSLOW
The firm for Hi-Fi
5 Swan Street,
Wilmslow, Cheshire.

Send 15p stamp for free 38 page catalogue 'Choosing a Speaker'

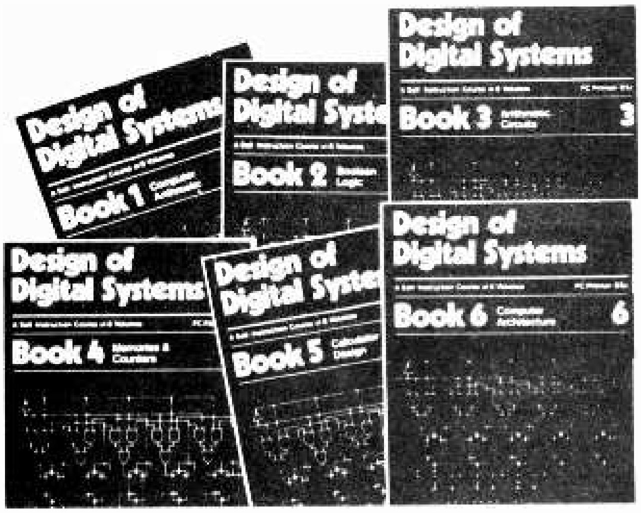
Telephone: Speakers, Mail Order and Export: Wilmslow 29599 Hi-Fi: Wilmslow 26213

Lightning service on telephoned credit card orders!

WILMSLOW AUDIO
The firm for Speakers
Swan Works, Bank Square,
Wilmslow, Cheshire.

Understanding Digital Electronics

New teach-yourself courses



In the years ahead the products of digital electronics technology will play an important part in your life. Calculators and digital watches are already commonplace. Tomorrow a digital display could show your vehicle speed and petrol consumption, you could be calling people by entering their name into a telephone which would automatically look up their number and dial it for you.

These courses were written by experts in electronics and learning systems so that you could teach yourself the theory and application of digital logic. Learning by self-instruction has the advantages of being faster and more thorough than classroom learning. You work at your own pace and must respond by answering questions on each new piece of information before proceeding.

After completing these courses you will have broadened your career prospects and increased your fundamental understanding of the rapidly changing technological world around you.

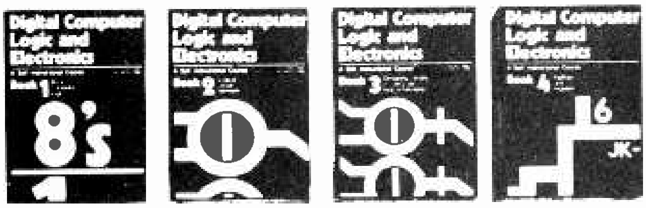
The six volumes of Design of Digital Systems cost only:	**£8.10**	+ 90p post & packing
And the four volumes of Digital Computer Logic and Electronics cost only:	**£4.60**	
But if you buy both courses, the total cost is only:	**£12.00**	+ £1 post & packing

Price includes surface mail anywhere in the world — Airmail extra.

Design of Digital Systems is written for the engineer seeking to learn more about digital electronics. Its six volumes — each A4 size — are packed with information, diagrams and questions designed to lead you step-by-step through number systems and Boolean algebra to memories, counters and simple arithmetic circuits, and finally to a complete understanding of the design and operation of calculators and computers.

The contents of Design of Digital Systems include:

Book 1 Octal, hexadecimal and binary number systems, conversion between number systems, representation of negative numbers, complementary systems, binary multiplication and division.
Book 2 OR and AND functions, logic gates, NOT, exclusive OR, NAND, NOR and exclusive-NOR functions, multiple input gates, truth tables, De Morgans Laws, canonical forms, logic conventions, Karnaugh mapping, three-state and wired logic.
Book 3 Half adders and full adders, subtractors, serial and parallel adders, processors and arithmetic logic units (ALUs), multiplication and division systems.
Book 4 Flip flops, shift registers, asynchronous and synchronous counters, ring, Johnson and exclusive-OR feedback counters, random access memories (RAMs) and read only memories (ROMs).
Book 5 Structure of calculators, keyboard encoding, decoding display data, register systems, control unit, program ROM, address decoding, instruction sets, instruction decoding, control program structure.
Book 6 Central processing unit (CPU), memory organisation, character representation, program storage, address modes, input output systems, program interrupts, interrupt priorities, programming, assemblers, computers, executive programs, operating systems and time sharing.



Digital Computer Logic and Electronics is designed for the beginner. No mathematical knowledge other than simple arithmetic is assumed, though the student should have an aptitude for logical thought. It consists of four volumes — each A4 size — and serves as an introduction to the subject of digital electronics. Everyone can learn from it — designer, executive, scientist, student, engineer.

Contents include: Binary, octal and decimal number systems, conversion between number systems, AND, OR, NOR and NAND gates and inverters, Boolean algebra and truth tables, De Morgans Laws, design of logic circuits using NOR gates, R-S and J-K flip flops, binary counters, shift registers and half adders.

CAMBRIDGE LEARNING ENTERPRISES, UNIT 31, RIVERMILL SITE FREEPOST, ST. IVES, HUNTINGDON, CAMBS. PE17 4BR, ENGLAND TELEPHONE: ST. IVES (0480) 67446

PROPRIETORS: DATRIDGE LTD. REG. OFFICE: RIVERMILL LODGE, ST. IVES REGD. IN ENGLAND No 1328762

Flow Charts & Algorithms

HELP YOU PRESENT safety procedures, government legislation, office procedures, teaching materials and computer programs by means of YES and NO answers to questions.

THE ALGORITHM WRITER'S GUIDE explains how to define the questions, put them in the best order and draw the flow chart, with numerous examples shown. All that students require is an aptitude for logical thought. Size A5, 130 pages. This book is a MUST for those with things to say.

£2.95 + 45p post & packing by surface mail anywhere in the world. Airmail extra.

GUARANTEE
If you are not entirely satisfied your money will be refunded.

Cambridge Learning Enterprises, Unit 31, Freepost Rivermill Site, St. Ives, Huntingdon, Cambs, PE17 4BR England

Please send me the following books
... sets Digital Computer Logic & Electronics @ £5.50, p&p included
... sets Design of Digital Systems @ £9.00, p&p included
... Combined sets @ £13.00, p&p included
... The Algorithm Writer's Guide @ £3.40, p&p included

Name

Address

I enclose a cheque/PO payable to Cambridge Learning Enterprises for £
Please charge my Access/Barclaycard/Visa/Eurocard/Mastercharge/Interbank account number
Signature ... deleted as appropriate
Telephone orders from credit card holders accepted on 0480-67446 (ansafone). Overseas customers should send a bank draft in sterling drawn on a London Bank.
WW31

AVO. You'll never meet a better meter

Nobody makes a more impressive range of analogue meters for the professional than Avo.

And within this impressive range is a series of smaller meters which can be picked up with a thumb and forefinger and slipped into a pocket for those applications where simple portability is a crucial factor.

These are the Models 71 and 73 Multimeters, the electronic EM272, the electrician's "Multiminor" MM5, the 300 and 1200 Clampmeters and the LM4 Lightmeter.

These instruments may be smaller than the rest, but they're equally big in quality, accuracy and reliability.

Otherwise we'd never call them Avo.

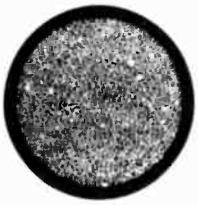
Get in touch today and we'll let you have the full facts.

AVO LIMITED
Archcliffe Road, Dover, Kent, CT17 9EN.
Telephone: 0304 202620 Telex: 96283

WW—110 FOR FURTHER DETAILS

THORN Thorn Measurement & Components Division

seen from the professional angle



the 201 is something quite personal...

The M 201 Hypercardioid moving coil microphone is designed for recording or broadcasting. The M 201 offers excellent separation characteristics in extreme accousticai conditions.

Specifications:
Frequency Response: 40-18000 Hz. Output Level at 1 kHz: 0,14 mV/μ bar ≙ -56 dbm (0 dbm ≙ 1 mW/10 dynes/cm2). EIA Sensitivity Rating: -149 dbm. Hum Pickup Level: 5 μ V/5 μ Tesla (50 Hz). Polar Pattern: Hypercardioid. Output Impedance: 200 Ω. Load Impedance: > 1000 Ω. Connections: M 201 N (C) = Cannon XLR-3-50 T or Switchcraft: 2+3 = 200 Ω, 1 = ground. M 201 N = 3-pin DIN plug T 3262: 1+3 = 200 Ω. 2 = ground. M 201 N (6) = 6 pin Tuchel.
Dimensions: length 6", shaft Ø 0,95".
Weight: 8,60 oz.

BEYER DYNAMIC (GB) LIMITED
1 Clair Road, Haywards Heath, Sussex.
Tel: Haywards Heath 51003

WW—084 FOR FURTHER DETAILS

WW—078 FOR FURTHER DETAILS

The catch was never quite as simple. Verospeed can supply a swell catch, and a push-release catch, for use on cabinets, cases and containers — both neat and postive, and ideal for applications demanding corrosion resistance and anti-vibration.
And we can get these to you, or any other of the items contained in our Autumn '78 catalogue, fast. Phone us your order by 3 pm, and we'll promise to post it today; or if you haven't got our catalogue, just ask and we'll send it.

VEROSPEED
Barton Park Industrial Estate,
Eastleigh, Hampshire SO5 5RR
Tel: (0703) 618525

WW—053 FOR FURTHER DETAILS

KGM TV CAMERAS

the big choice

Type 130 is a compact 2/3 inch camera with an unusually high specification for a camera of this size. It is a sturdy, reliable camera of great versatility.

Type 113 is an extremely rugged camera designed for critical applications of a very wide nature. Resolution is better than 800 lines.

Type 118 is a day and night camera based on Type 113 but with many unique features to enhance its performance in difficult light conditions.

KGM cameras and monitors are backed by KGM's many years' experience of designing and building CCTV equipment for large industrial users and leading public authorities. *Send for your data sheets now.*

KGM ELECTRONICS LIMITED

Clock Tower Road, Isleworth, Middlesex TW7 6DU
Tel: 01-568 0151. Telex: 934120

WW—095 FOR FURTHER DETAILS

A ONCE ONLY FANTASTIC OFFER

THE AMAZING sanwa

LCD-900

First in the world using LCD scale

Down! from £83.86

TO £59.95 INCL. VAT

BUY NOW

+ £1.62 P.&P. & INS.

WHILE STOCKS LAST

Just send your Cheque or P.O. to

QUALITY ELECTRONICS LTD.
24 HIGH STREET, LYDD, KENT TN29 9AJ
(TEL. 0679 20252)

OR TELEPHONE US YOUR ACCESS NO.

WW—093 FOR FURTHER DETAILS

FANTASTIC GOLDRING SAVINGS

GOLDRING G103 Belt Drive Turntable

Famous name turntable slashed to near half price. Complete with plinth, cover and leads. Accepts any standard cartridge (not included)

FULL 12 MONTH GUARANTEE

OUR PRICE £26.95

R.R.P. £54 (p/p & Ins £2.50)

SAVE OVER £24

Build your own GOLDRING CK2 Belt Drive Turntable

Beautifully engineered unit from the famous Goldring company, comes complete with instructions and all necessary parts. Ready to incorporate into your design plinth and cover. The pleasure of assembling your own deck.
(Plinth, cover and cartridge not included).
Usually sold for £54.95 with plinth and cover.

ONLY £16.95
(+ p.p & Ins. £1.75)

ALL PRICES INC. VAT

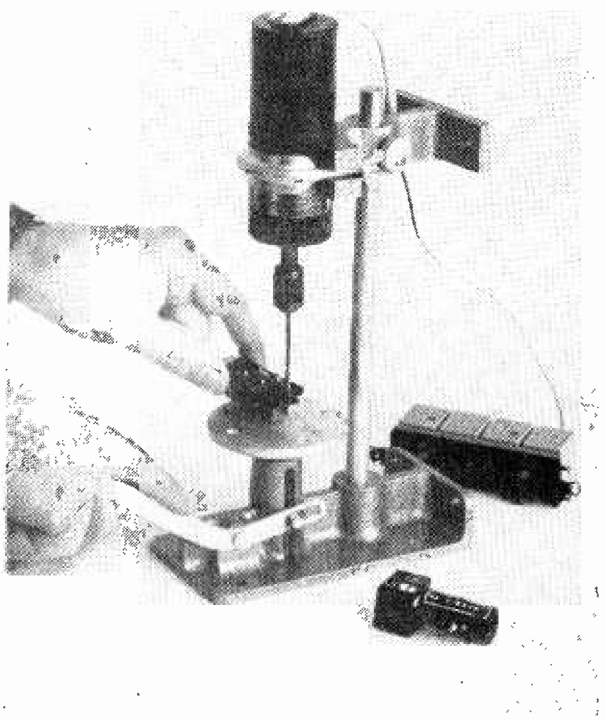
Call in or send cheque, P.O, M.O, Access, Barclaycard, Diners Club or American Express Number.

Sonic Sound Audio
248/250 TOTTENHAM COURT ROAD, LONDON W1. TEL: 01-637 1908

WW—097 FOR FURTHER DETAILS

A. D. BAYLISS & SON LTD.

Behind this name there's a lot of real POWER!



Illustrated right is a **TITAN DRILL**

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

TITAN DRILL & STAND — **£21.45** + 8% VAT = £23 17 + £1 P&P

TITAN DRILL ONLY — **£9.79** + 8% VAT = £10 57 + 35p P&P

RELIANT DRILL & STAND — **£18.44** + 8% VAT = £19 92 + £1 P&P

RELIANT DRILL ONLY — **£6.34** + 8% VAT = £6 85 + 35p P&P

TITAN MINI DRILL KIT Drill Plus 20 Tools — **£16.25** + 8% VAT = £17 55 + 50p P&P

RELIANT MINI DRILL KIT Drill Plus 20 Tools — **£13.20** + 8% VAT = £14 26 + 50p P&P

TRANSFORMER UNIT — **£9.40** + 8% VAT = £10 15 + 75p P&P

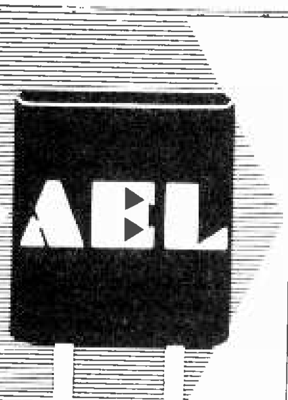
These are examples of the extensive range of power tools designed to meet the needs of development engineers laboratory workers model makers and others requiring small precision production aids
To back up the power tools Expo offer a comprehensive selection of Drills Grinding Points and other tools
SEND STAMP for full details to main distributors

A. D. BAYLISS & SON LTD., Pfera Works, Redmarley, Glos. GL19 3JU

Stockists Richards Electric, Gloucester, Hoopers of Ledbury Hobbs of Ledbury D&D Models Hereford Bertella Gloucester. J Power Services & Co Ltd, Worcester

WW—022 FOR FURTHER DETAILS

QUARTZ CRYSTALS —FAST!



AEL

AEL CRYSTALS LIMITED
Gatwick House, Horley Surrey, England RH6 9SU
Telephone: Horley (02934) 5353 Telex: 87116 (Aerocon Horley)
Cables: Aerocon Telex Horley

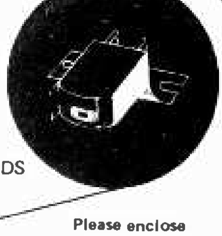
WW—020 FOR FURTHER DETAILS

HAVE YOU DONE IT LATELY!

Fit a new tape head and transform the performance of your tape recorder

MONOLITH
THE MONOLITH ELECTRONICS CO LTD

QUALITY
REEL TO REEL
AND CASSETTE TAPE HEADS



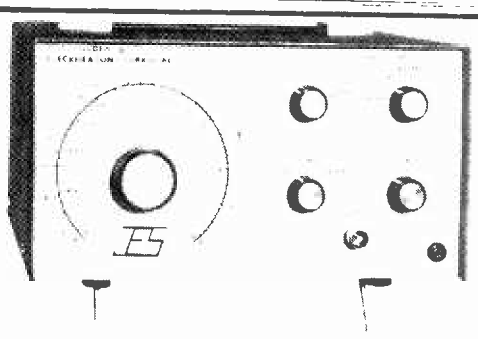
Full Catalogue 25p

Please enclose 20p P&P with order

B24—RP stereo cassette glass/ferrite record/playback £9.84
B12—01 mono cass. playbk. £1.60 B24—01 stereo cass. playbk. £2.80
A28—05 stereo 8tk cartridge £1.80 E12—09 stereo/mono cass. erase £1.80

5/7 Church St, Crewkerne, Som. Tel. (0460) 74321

WW—070 FOR FURTHER DETAILS



JES AUDIO INSTRUMENTATION

Illustrated the Si453 Audio Oscillator

SPECIAL FEATURES:

- ★ very low distortion content less than 0 03%
- ★ an output conforming to RIAA recording characteristic
- ★ battery operation for no ripple or hum loop
- ★ square wave output of fast rise time

£70.00

also available

Si451 Millivoltmeter
★ 20 ranges also with variable control permitting easy reading of **relative** frequency response **£70.00**

Si452 Distortion Measuring Unit
★ low cost distortion measurement down to 0 01% with comprehensive facilities including L F cut switch, etc **£56.00**

ALL PRICES PLUS VAT

J. E. SUGDEN & CO. LTD., CARR STREET, CLECKHEATON, W. YORKS. BD19 5LA. Tel. 0274-872501

WW—057 FOR FURTHER DETAILS

I GET ALL IC'S from here

OSTS new from ambit® international

Ambit stoppress....news on items available.....KV1210: triple AM tuning diode with 2-9v bias only £2.75.....DT1200 Digital frequency readout module ...... 911223 ultra low THD/IMD mpx decoder module £9.95.......944378 'Hyperfi' mpx decoder with post decoder muting and pilot cancel £19.95...... VMOS

COUNTER ATTRACTIONS:

From previous advertisements, we trust you all now know that the OSTS supplies only the very best quality parts, and that buying from the OSTS you may construct your circuit in total confidence that the parts will not let you down - so this month we feature a couple of really excellent products that will shortly feature as "standards"

ICM7207	A frequency counter crystal contolled gating and timing IC	£4.95
ICM7208	A seven decade counter for use with the 7207	£14.95
ICM7217	Four decade presettable counter/timer with carry out & LED drive	£9.50

25p and an SAE brings you a photocopy of a feature article describing a 500MHz counter using the 7207/8 and 11C90 ECL prescalar for around £60.

Please note that OSTS prices exclude VAT at 8% throughout this side of the page. Most ambit *items are at 12½% except those marked *. Please keep orders separately totalled, although a single combined payment, and 25p postage charge, will be sufficient.*

CD4000 CMOS

4000	17p	4059	563p	4522	149p
4001	17p	4060	115p	4527	157p
4002	17p	4063	109p	4528	102p
4006	109p	4066	53p	4529	141p
4007	18p	4067	400p	4530	90p
4008	80p	4068	25p	4531	141p
4009	58p	4069	20p	4532	125p
4010	58p	4070	20p	4534	614p
4011	17p	4071	20p	4536	380p
4012	17p	4072	20p	4538	150p
4013	55p	4073	20p	4539	110p
4016	52p	4075	20p	4541	141p
4017	80p	4076	90p	4543	174p
4018	80p	4077	20p	4549	399p
4019	60p	4078	20p	4553	440p
4020	93p	4081	20p	4554	153p
4021	82p	4082	20p	4556	77p
4022	90p	4085	82p	4557	386p
4023	17p	4086	82p	4558	117p
4024	76p	4089	150p	4559	388p
4025	17p	4093	50p	4560	218p
4026	180p	4094	190p	4561	65p
4027	55p	4096	105p	4562	530p
4028	72p	4097	372p	4566	159p
4029	100p	4098	110p	4568	281p
4030	58p	4099	122p	4569	303p
4031	250p	4160	90p	4572	25p
4032	100p	4161	90p	4580	600p
4033	145p	4162	90p	4581	319p
4034	200p	4163	90p	4582	164p
4035	120p	4174	104p	4583	84p
4036	250p	4175	95p	4584	63p
4037	100p	4194	95p	4585	100p
4038	105p	4501	23p		
4039	250p	4502	91p		
4040	83p	4503	69p		
4041	90p	4506	51p		
4042	85p	4507	55p		
4043	85p	4508	248p		
4044	80p	4510	99p		
4045	150p	4511	149p		
4046	130p	4512	98p		
4047	99p	4513	206p		
4048	60p	4514	260p		
4049	55p	4515	300p		
4050	55p	4516	125p		
4051	65p	4517	382p		
4052	65p	4518	103p		
4053	65p	4519	57p		
4054	120p	4520	109p		
4055	135p	4521	236p		

Micromarket

6800 series		8216	£2.25	2114	£10
6800P	£13	8224	£4	2708	£10.55
6820P	£6	8228	£5.25	**Development**	
6850P	£6.75	8251	£8	MEK6800	£220
6810P	£4	8255	£5.40	TK80	£306
6852	£15	**MEMORIES**		AMI, Signetics,	
8080 series		2102	£1.70	TI, Intersil,	
8080	£16	2112	£3.40	Harris etc. OA	
8212		2513	£7.54		
		4027	£5.78		

Voltage Regs

NEW LOW PRICES

7800 series UC TO220 package 1A	all 95p
7900 series UC TO220 package 1A	all £1
78MUC series TO220 package ½A	all 90p
78LCP series TO92 100mA	all 35p
L200 up to 3A/adjustable V&A	195p
78MGT2C ½amp adjustable volts	175p
79MGT2C ½amp adjustable volts	175p
723C precision controller	65p

MAINS FILTERS FOR NOISE/RFI etc

1 amp in IEC connector	£4.83
5 amp in 'wire in' case	£3.87
NE550A	73p

LINEARS non-consumer

BIMOS		LM324N	71p
CA3130E	84p	LM339N	66p
CA3130T	90p	LM348N	186p
CA3140E	35p	LM3900N	60p
CA3140T	72p	709HC to5	64p
CA3160E	90p	709PC dil	36p
CA3160T	99p	710HC to5	65p
Op amps		710PC dil	59p
LM301AH	67p	723CN	65p
LM301AN	30p	741CH to5	66p
LM308H	121p	741CN 8dil	27p
LM308N	97p	747CN	70p
LM318H	279p	748CN	36p
LM318N	224p	NE531T	120p
		NE531N	105p

OPTO 7 seg displays

0.43" High Efficiency HP:

5082- 7650	red CA	233p
5082- 7653	red CC	
5082- 7660	yellow CA	
5082- 7663	yellow CC	
5082- 7670	green CA	
5082- 7673	green CC	

0.3" Standard HP

5082- 7730	red CA	147p
5082- 7740	red CC	

0.5" Fairchild

FND500	red CC	150p
FND507	red CA	150p

TTL:Standard AND LP SchottkY

All prices listed in pence *

	'N'	'LSN'		'N'	'LSN'		'N'	'LSN'		'N'	'LSN'
7400	13	20	7455	35	24	74126	57	44	74185	134	
7401	13	20	7460	17		74128	74		74188	275	
7402	14	20	7463			74132	73	78	74190	115	92
7403	14	20	7470	28		74133		29	74191		
7404	14	24	7472	28		74136		40	74192	105	180
7405	18	26	7473	32		74138		60	74193	105	180
7406	38		7474	27	38	74139		60	74194	105	187
7407	38		7475	38	40	74141	56		74195	95	137
7408	17	24	7476	37		74142	265		74196	99	110
7409	17	24	7478			74143	312		74197	85	110
7410	15	24	7480	48		74144	312		74198	150	
7411	20	24	7481	86		74145	65		74199	160	
7412	17	24	7482	69		74147	175		74248		90
7413	30	52	7483A			74148	109		74251		90
7414	51	130	7484	97		74150	99		74253		105
7415		24	7485	104	99	74151	64	84	74257		108
7416	30		7486		40	74153	64	54	74279		52
7417	30		7489	205		74154	96		74283		120
7420	16	24	7490	33	90	74155	54	110	74290		90
7421	29	24	7491	76	110	74156	80	110	74295		120
7422	24	24	7492	38	78	74157	67	55	74298		100
7423	27		7493	32	99	74158		60	74258		110
7425	27		7494	78		74159	210		74260		26
7426	36	27	7495A	65	99	74160	82	130	74365		49
7427	27	29	7496	58	120	74161	92	78	74366		49
7428	35	32	7497	185		74162	92	130	74367		43
7430	17	24	74100	119		74163	92	78	74368		49
7432	25	24	74104	63		74164	104		74375		60
7433	40	32	74105	62		74165	105		74379		130
7437	40	24	74107	32	38	74166			74399		150
7438	33	24	74109	63	38	74167	20		74445		92
7440	17	24	74110	54		74168			74447		90
7441	74		74111	68		74169		200	74490		140
7442	70	99	74112	88		74170	230	200	74668		110
7443	115		74113		38	74172	625				
7444	112		74114		38	74173	170				
7445	94		74116	198		74174	87	120			
7446	94		74118	83		74175	87	110			
7447	82		74119	119		74176	75				
7448	56	99	74120	115		74177	78				
7449		99	74121	25		74180	85				
7450	17		74122	46		74181	165	350			
7451	17	24	74123	48		74182	160				
7453	17		74124			74183		210			
7454	17	24	74125	38	44	74184	135				

ICM7217 count & display £9.50
ICM7207 clock pulse IC £4.95
ICM7208 count & display £14.95
ICL7106CP LCD DVM IC £9.55
KIT £24.80
LED DVM with ICL7107 £20.65

MISCELLENY

NE555	30p
NE556	78p
NE558	180p
LM3909	72p
11C90DC	1400p
8629 divide by 100 to 150MHz	4.20p
95H90DC 320MHz divide by ten	7.80p

Ambit overspill

the remainder of the column is not OSTS

Varicap diodes VAT 12.5%.........

BA102	30p
BA121	32p
ITT210	30p
BB105B	40p
BB104B	45p
5xBB104B	200p
MVAM2	148p
MVAM115	105p
MVAM125	105p
matching to a max of 6 diodes per diode (1%)	25p
KV1210	275p

PIN & switching VAT 12.5%.........

BA479 pin	35p
tda1061 pi-network attenuator	95p
BA182 bandswitch diode	21p
10 for	150p

Requests for the next issue of the catalogue now being "booked" for despatch immediately it is ready (about November). Please send 45p to reserve a copy.

From the World's leading radio innovation source:

New this month, the DT1200 AM/FM/Time digital readout module in a fully screened enclose for panel mounting. A frequency counter with 10.7MHz offset for FM and 455kHz offset for AM, plus a quartz based digital clock function - including an mpx beacon and fine tuning indication. Single 12v 350mA rail operation, only £45.00 for all this!

Moving Coil Meters

Ambit offers a very wide range of low cost meters, together with the unique 'Meter Made' scale system for professional grade scale customizing:

Series	Scale Area	illumination	cost*
900	14x31mm	internal 12v	250p
920	30x50mm	from behind	275p
930	36x63mm	internal 12v	375p
940 twin	35x45mm	from behind	350p
950	55x45mm	from behind	300p

Stock movement 200uA/750Ω. The 930 series is 5% linear, others are 77uA at 50% FSD. These and many others available in quantity for OEMs *SAE for full scale details please. (Not in cat.)*

Radio; Audio; Comms ICs:

Only the very best quality - and only types we have used in our own laboratory tests

Radio frequency + mixers + oscillator(s)		
TDA1062	DC to VHF front end system	1.95
TDA1083/ULN2204	am/fm/audio in one IC	1.95
TDA1090/ULN2242	am/fm hifi tuner system	3.35
HA1197	LF/30MHz am receiver system	1.40
CA3123E/uA720	LF/30MHz linear system	1.40
TBA651	LF/30MHz linear system	1.81
SD6000	DMOS RF/Mixer pair	3.75
IF amplifiers		
CA3089E/KB4402	famous FM IF system	1.94
HA1137W/K	4420 as 3089 + deviation mute	2.20
CA3189E	update with deviation mute	2.75
TBA120a/SN76660N	FM if and detector	0.75
TBA120S	hi gain version TBA120	1.00
MC1350P	agc IF amp	1.20
MC1330P	synch AM dembdulator	1.35
MC1495L	precision 4 quad multiplier	6.86*
MC1496P	popular double balanced mixer	1.25
Communications circuits		
KB4406	differential amplifier	0.50
KB4412	2 bal.mixers/agc/gain/doub. conv	2.55
KB4413	am/fm/ssb det. AGC, ANL, mute	2.75
KB4417	3mV mic processor preamp	2.55
KB4423	FM noise blanker system	2.55
Audio preamps		
LM381	stereo high gain/low THD	1.81
LM1303	stereo audio optimized OA	0.99
TDA1054	high quality with alc option	1.95
KB4417	see above	
Audio Power amps		
TBA810AS	7W RMS overload protected	1.09
TDA2002	8W/2Ω in pentawatt package	1.95
TDA2020	15W RMS hifi power dc coupled	2.99
TCA940	10W higher voltage 810	1.80
ULN2283	1W 2.5 to 12 v supply capability	1.00
LM380N8	1W power	1.00
LM380N14	2.5W power	1.00
HA1370	HiFi 15w in easy heatsink pack	2.99
Stereo Decoder Devices		
MC1310/KB4400	original pll decoder	2.20
CA3090AQ	RCA's pll decoder	3.25
uA758	Buffered version of 1310	2.20
LM1307/uA707	non pll type	1.55
HA1196	advanced adj.sep pll low thd	3.95
HA11223	newpilot cancel low thd/imd	4.35

All ambit decoders are supplied with the LED beacon of your choice. Please state colour.

Discrete semiconductors

Some of the biggest stocks of specialist MOS and FET transistors for radio in the UK.

BF900	80p*	40673	55p*	40822	43p*
40823	51p*	MEM680	75p*	BF256S	34p*

Most types for most RF circuitry, inc. new UHF T package types etc. See price list.....

Hitachi VMOS 100W power devices:

Start saving now for the biggest breakthrough in power transistor technology yet. Ambit has the new Hitachi VMOS data (£1) and by the time you read this, we should have received our first stock order. But they aren't cheap.

DISCRETE LEDS - the best value of all:

LED size:	2.5x5mm	5mm dia	clip
RED	17p	14p	2p
YELLOW	20p	15p	2p
GREEN	20p	16p	2p

10% disc for 10 off, 25% discount per 100

Switch Systems: Check our combinations!

A very wide selection of BOTH Alps SUB series units, (Schadow/AB/Oreor compatible) & the miniature Dialistat units. Available in DIY systems for maximum flexibility and low cost.

And Finally

Further details of these, and many more of the wonders of the world of wireless in the new Ambit catalogue - with magazine supplement. 45p inc pp etc.
Phone (0277) 216029/227050 9am-7pm
callers welcome anytime

Coils & Filters by TOKO

After a period of relative price stability, please note that some prices are increased - as a direct result of the failure of £ versus stronger trading currencies. (Mainly Yen)

7 & 10mm IFTs for AM/FM - 1000s es

455/470kHz	most types of appcns	30p
10.7MHz		33p

Short wave Coils sets
Now two ranges of impedance/coupling ea 33p

TV video and sound IFs/detectors

Another new range in 10mm	33p
6MHz ceramic IF sound filter	80p

Molded VHF coils full catalogue 15p
Ultra stable coils for 30 - 200MHz from 20p

Chokes - biggest range/biggest stocks
Most E12 values ex stock, any to order

BA series	1uH to 1mH	16p
7RB series	100uH to 33mH	19p
10RB series	33mH to 120mH	33p

FM IF FILTERS ceramic and linear phase

CFSE/SFE10.7	stereo ceramic IF 10.7MHz filters in 5 groups	50p
CFSB10.7	mono/roofing IF filter	50p
BBR3125N	4pole linear pahe 10.7MHz	150p
BBR3132A	6pole linear phase 10.7MHz	250p

MPX pilot tone filters for 19 & 38kHz

BLR3107N	Stereo 4k7 impedance	215p
BLR2007	Stereo 3k3 impedance	220p
BLR3152	Mono 4k7 impedance	100p
BLR3157	Mono 4k7/3k0 imp	100p

AM/FM/SSB IF FILTERS

MFL series 2.4kHz ssb /455kHz carrier	1195p
MFH series 4/5/7kHz BW on 455kHz	195p
MFK series 7/9kHz BW on 455kHz	165p
LFY455D 12kHz 4 ele ladder on 455kHz	125p
CFM2455 6kHz micro mechanical	65p
SFD455/470kHz murata IF filter	85p
CFT455B/C 6/8kHz min + 2IFTs	60p
CFU470C 6kHz on 470kHz	65p

Ratio Detectors for FM/NBFM

1A651/7 455kHz ratio det	135p
KAN1508/9 10.7MHz ratio detector	66p
94ACS15106/7 10.7MHz ratio detector	66p

Quadrature detectors for CA3089E etc

KACSK586HM	single	33p
KACS34342/3	double	66p

Polyvaricon tuning capacitors + trimmers

2A20ST7 2x266pF AM	95p
CY22217Z 2x335p AM 2x20pF FM	175p
CY23217PX 2x335pF AM 3x20pF FM (2 trimmers)	245p

Tuner Modules

From the biggest and best range................

TUNERHEADS for 88-108MHz band 2 (varicap)

EF5803	6 cct, 3 MOSFETs, amp. osc.	19.75
EF5801	6 cct, 2 MOSFETs, osc op	17.45
EF5600	5cct, MOSFET RF, by TOKO	14.95
EF5400	4cct balanced mixer/pin agc	9.75
EC3302	3cct FET input miniature	8.25

TUNERSETS by LARSHOLT (head+IF)

7252	Dual MOS head/low dist IF	26.50
7253	FET head, mpx decoder inc	26.50

IF AMPLIFIERS all with deviation mute, agc, afc, meter drives etc

7020	HiGain dual ceramic filter	6.95
7030	Mos preamp, linear phase filter	10.95
7130	2 mos preamps, 3 lpfilters	16.25
NBFM1	455/470kHz NBFM module	9.95

MPX decoders, all with pilot tone filters and buffer amplifiers for min 300mV RMS

92310	1310 based system	6.95
93090	3090AQ based system	8.85
91196	HA1196 based + birdy filter	1299
911968	HA1196 based + birdy filter + 2 x LM380 audio monitor amps	16.45
911223	HA11223 based system	12.50

AM RADIO

91197	The original MW/LW varicap tuner with electronic switch	11.85
9122	The uniband tuner module	13.22

AM FM RADIO UNITS

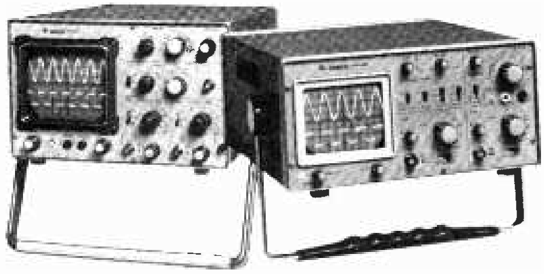
71083	Using TDA1083, provides a complete MW/LW/FM portable radio chassis for clock radio etc	12.95
710830	Drive/dial system for 71083	1.75

SPECIALS: TUNERHEADs in the range 40-200MHz to special order
The EF5803 and EF5400 are available to cover bands in the region described. The costs depend on quantity and actual mods required to cover the desired band. Max coverage approx. 20% of centre frequency selected. Also, please allow 3-5 weeks delivery for these items.

2 Gresham Road, Brentwood, Essex.

Stay ahead-follow this sign

GOULD ADVANCE INSTRUMENTS HAVE A WORLDWIDE REPUTATION. BUT THEY NEED NOT COST YOU THE EARTH.



OS245A AND OS250B OSCILLOSCOPES

Two dual trace oscilloscopes, with sensitivity of 5mV/div., and 2mV/cm respectively. The OS250B offers variable trigger level with or without bright line. The OS245A has a bandwidth of 10MHz, the OS250B offers 15MHz. Fully portable, these are the ideal instruments for servicing, educational and general purpose applications.

ALPHA III DIGITAL MULTIMETER

A tough, attractive, 3½ digit multimeter with 25 ranges and a basic accuracy of ±0.2%. A bright red LED display gives a clear reading even in high ambient light conditions, and yet power consumption is low enough for extensive field applications.

A purpose built CMOS chip incorporates all analogue and digital circuitry, giving a low component count and increased reliability.

TC 320 TIMER COUNTER

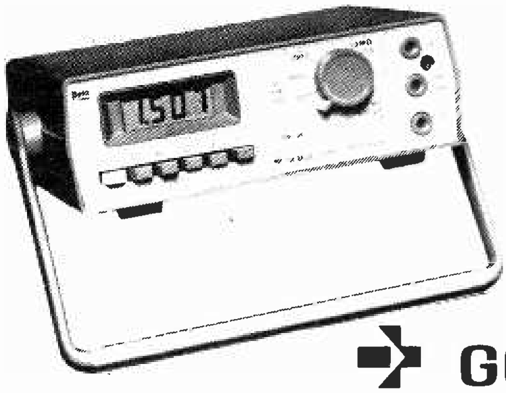
This new, tough, 5-digit unit has an operating frequency of 35MHz. Plated through hole PCB construction keeps the component count down, for exceptional reliability. Frequency measurements up to at least 35MHz can be easily read from the clear 7-segment display. The TC320 offers outstanding performance – including "disciplined" triggering – at a remarkably modest price.

BETA DIGITAL MULTIMETER

A general-purpose multimeter, offering 29 ranges, including temperature (optional), and a basic accuracy figure of ±0.2%. A clear, 3½ digit Liquid Crystal Display, 0.5" high, gives a high-contrast read-out. Fully portable, with a minimum of 300 hours' battery life, the Beta has already established a reputation for accuracy and reliability.

For details of any of these instruments and the Gould Advance 2 year guarantee, write or phone today.

Gould Instruments Division,
Roebuck Road, Hainault, Essex IG6 3UE.
Telephone: 01-500 1000 Telex: 263785.



GOULD

WW—058 FOR FURTHER DETAILS

wireless world

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

Deputy Editor:
PHILIP DARRINGTON
Phone 01-261 8435

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

Projects Editor:
MIKE SAGIN
Phone: 01-261 8429

Communications Editor:
RAY ASHMORE, B.Sc., G8KYY
Phone 01-261 8043

News Editor:
JOHN DWYER
Phone 01-261 8620

Drawing Office Manager:
ROGER GOODMAN

Production:
D. R. BRAY

Advertisement Controller:
G. BENTON ROWELL

Advertisement Manager:
BOB NIBBS
Phone 01-261 8622

DAVID KITCHENER
Phone 01-261 8037

Classified Manager:
BRIAN DURRANT
Phone 01-261 8508 or 01-261 8423

BARRY LEARY *(Classified Advertisements)*
Phone 01-261 8508

JOHN GIBBON *(Make-up and copy)*
Phone 01-261 8353

Publishing Director:
GORDON HENDERSON

Electronic voting

AS ANOTHER general election draws near many people in electronics will be reflecting on the antiquated system we now use for electing our representatives in parliament and how it could be transformed by modern technology. It seems extraordinary in an age of computers, data transmission and all the techniques described in our recent articles "The paperless revolution" (July and August issues) that we are still voting with bits of paper marked with crosses dropped into tin boxes. And it is particularly bad that the ordinary citizen is restricted to this crude instrument of democracy while those who seek to persuade him of the rightness of their policies and their fitness to govern have at their disposal all the resources, the subtlety and power of modern mass communications including of course the electronic medium of television. It is a one-sided arrangement more appropriate to oligarchy than true democracy. But with two-way electronic information systems such as viewdata about to come into operation the means are now available to make a change.

There is no point, of course, in setting up a straightforward electronic equivalent of the ballot-box system. That would be nothing more than trivial gadgeteering. What we need to do is to exploit the immediacy, flexibility and information bit-rate of the two-way electronic system to redress the balance in favour of the citizen and give him a more direct say in decisions, in the manner of ancient Greek democracy, rather than leave these decisions entirely to so-called representatives whom he chooses at infrequent intervals, often hastily, while bemused and emotionally disturbed by electioneering propaganda. Two centuries ago Rousseau pointed out "The commands of the leaders may pass for the general will if the people, being free to oppose, does not do so." *(The Social Contract)*, and Tom Paine added later "There ought to be a method of ascertaining public opinion, to find out what the sense of a nation is and to be governed by it." *(The Rights of Man)*. They would be glad to know that the technical means are now available to make referendums quickly and easily. With two-way information systems it is possible to have a national vote on any policy or issue at any time. And this would not be restricted to simple binary decisions but could easily allow a range of choices which could be voted for in order of preference.

A correspondent, Stephen Frost, has suggested a complete scheme for such voting based on the regional viewdata computers soon to be established round the UK and using public polling booths, rather like public telephones, containing computer terminals. (It could be a long time before there is a viewdata terminal in every home.) Voters would be identified and authenticated by coded cards rather like credit cards which, to ensure only one vote per person, would be read by the terminals before allowing votes, made by push-button, to be entered. Frost suggests that the secrecy of the ballot could be maintained and "rigging" avoided by arranging that the computer would not record who had voted and how. Nonetheless there is a danger of abuse here if the system came under the control of an unscrupulous government. Another weakness, pointed out by Frost, is that voting could be done by people other than the rightful owners of the cards. In some cases they could be genuine proxies, but in others they could have obtained and used the cards unlawfully. It remains to be seen if such drawbacks could be overcome.

Of course, the electronic referendum would make the traditional Member of Parliament redundant. In our present version of democracy, in which he is no longer basically a personal representative of a group of people but a mere counter rigidly controlled for parliamentary voting purposes by a party machine, this would be no great loss.

Relativity and time signals

"The theory is so rigidly held that young scientists dare not openly express their doubts"

by **L. Essen,** D.Sc., C.Eng., F.R.S.

Perhaps best known for his quartz ring clock — which revealed variations in the earth's rotation — L. Essen's main activity during his 44 years with NPL was the measurement of frequency and time, "but with sidelines" he admits. He built the first caesium clock in 1955, later used with the US Naval Observatory to define the atomic second. One of his early sidelines was a determination of the velocity of light by cavity resonator which showed Michelson's value to be 17 km/s too low. (Which illustrates a peculiarity of Nobel prizes — Michelson got one, Essen didn't.)

He's always been interested in relativity, and repeated the Michelson-Morley experiment with quartz crystal in 1937 and with radio waves in 1955, when he first pointed out a basic error in the theory. "No one has attempted to refute my arguments," Dr Essen told us, "but I was warned that if I persisted I was likely to spoil my career prospects."

ONE OF THE EARLIEST applications of radio was the transmission of time signals as an aid to sea navigation and today signals are used to synchronise atomic time throughout the world for navigational and other purposes. The comparison of distant clocks by radio is now a precise and well known technique. This was not the case in 1905 when Einstein published his famous paper on relativity and there is some excuse for the mistakes he made in the thought-experiments which he described in order to determine the relative rates of two identical clocks in uniform relative motion. But there is no excuse for their repetition in current literature.

The mistakes have been exposed in published criticisms[1] of the theory but the criticisms have been almost completely ignored; and the continued acceptance and teaching of relativity hinders the development of a rational extension of electromagnetic theory. It could be argued that the truth will eventually prevail but history teaches us that when a false view of nature has become firmly established it may persist for decades or even centuries. We cannot afford to wait that long. The energy reserves are dwindling rapidly and if there is to be a scientific breakthrough to solve the crisis it will possibly be in worthwhile therefore making another attempt to weaken the strangehold of relativity by explaining the basic mistakes in still greater detail.

Measurement of time and the comparison of clocks

The passage of time is measured by counting the number of repetitions of some regular periodic event such as the revolution of the earth, the swings of a pendulum, the vibrations of a piece of quartz, or the radio waves emitted by an atom. Whichever event is chosen the result of the count is converted for convenience into one-second ticks which are then counted on a clock dial and expressed as hours and minutes.

"The general public is misled into believing that science is a mysterious subject which can be understood by only a few exceptionally gifted mathematicians."

The only way of comparing distant clocks is to transmit the ticks by radio so that at each station there are two clock dials, one counting the ticks from the local clock, and the other the ticks from the distant clock. In practice a continuous count may not be necessary because the result may be known approximately from experience or may be given by a coded message on the transmission, but the principle remains the same. The relative rates of the clocks are found by comparing the rates at which the readings on the two dials increase, and the complication of synchronizing the two clocks before the start of the measurement does not arise.

Einstein's prediction

Einstein predicts, to use his own words, that "the time marked by the moving clock, viewed in the stationary system, is slow by ... ... $\frac{1}{2}(v/c)^2$ second per second", where v is the relative velocity between clocks, and c is the velocity of light. In practical terms the only meaning that can be attached to this rather vaguely worded statement is that the reading on the clock dial recording the ticks from the distant moving clock increases more slowly, by $\frac{1}{2}(v/c)^2$ s/s than the reading on the dial recording the ticks from the local clock. According to Einstein's relativity postulate either of the clocks can be regarded as the moving one and the full prediction is therefore

clock B, viewed at A, goes slower than clock A by $\frac{1}{2}(v/c)^2$ s/s—(1)

clock A, viewed at B, goes slower than clock B by $\frac{1}{2}(v/c)^2$ s/s—(2)

This result is not logically impossible but it has an important consequence which does not appear to have been appreciated by Einstein or subsequent writers on the subject. More ticks are transmitted than are received and this process continues indefinitely whether the clocks are approaching or receding from each other, the effect being proportional to v^2. This loss of ticks is inexplicable but it is inherent in Einstein's prediction. However being unaware of the consequence, relativitists, including Einstein, later make the more reasonable assumption that all the transmitted ticks arrive at the other clock in the course of the measurement. They thus unknowingly make two contradictory assumptions and naturally they obtain paradoxical results.

Einstein's prediction contains no mention of the ordinary Doppler effect, which is proportional to v/c. This is eliminated by Einstein's definition of time – a point which is not discussed by relativitists. The measurements will in practice include the term for the Doppler effect but for simplicity the prediction is given here exactly as Einstein gave it.

The clock paradox

Einstein described the following thought experiment. Two identical clocks, A and B say, are side by side. One of them B moves in a straight line at uniform velocity away from A to a point x. Einstein states that, in accordance with his result (1), B will be slow compared with A. Now this is not in accordance with (1), the phrase "viewed at A" having been omitted. The clock B continues to travel in a number of straight line paths until it arrives back at A, when it will be found to read less than A.

Einstein calls the result peculiar but gives no explanation.

The paradox is not immediately obvious because Einstein gives only half of the result. Although accelerations must be applied to obtain the round trip, no correction is made for them and they are not even mentioned. As far as the experiment is concerned the clocks are in uniform relative motion and either clock can be taken as the moving one. The full result is

clock B goes slower than clock A by $\frac{1}{2}(v/c)^2$ s/s
clock A goes slower than clock B by $\frac{1}{2}(v/c)^2$ s/s

which is obviously paradoxical.

There is no problem if the experiment is carried out correctly. The ticks from B are received on a dial at the position of A; and another dial travels with B to receive the ticks from A. At the end of the experiment the dials will record the result (1) and (2) as they must do since a thought experiment cannot give a result that contradicts the initial postulates.

Consequences of Einstein's mistake

The paradox result follows from a simple "experimental" error but it was accepted by Einstein and has been accepted by relativists ever since and it is important to consider the consequences. It is based on the assumption that no ticks are lost. This assumption is reasonable but it contradicts the prediction (1) and (2). By accepting the result they thus reject the relativity theory. They still accept the existence of the second-order time contraction but it is now a real physical effect just as in the Lorentz theory from which Einstein started.

Introduction of gravitation and acceleration

In 1918 Einstein published a paper[3] which took the form of a discussion between a relativist and a critic. The relativist admits that the paradox result contradicts his initial postulates.

"Students are told that the theory must be accepted although they cannot expect to understand it. They are encouraged right at the beginning of their careers to forsake science in favour of dogma."

He then describes a thought experiment in which gravitational fields are switched on and off at different points of the path of the moving clock as it makes a round trip; and concludes that the result obtained earlier by assuming that acceleration has no effect is due to the gravitational fields. It is not surprising that this paper with its damaging admission, its irrational assumptions and its "experimental" mistakes is seldom mentioned in the literature. Many writers on relativity nevertheless advance a similar argument. They conceal the paradox, as Einstein did, by giving only one half of the result, and justify this by pointing out that the two clocks are not symmetrical, overlooking the fact that they have made them symmetrical, as far as the experiment is concerned, by assuming that accelerations have no effect. Without this assumption they would not be able to obtain any result at all. Vague suggestions are then made that the result is due to the accelerations.

Does it matter?

It has been explained how Einstein, in the course of his paper, rejects the relativity postulate and returns to the Lorentz theory, which is still found to be useful. It might be asked therefore whether the mistakes are important. I suggest that they are immensely important. Students are told that the theory must be accepted although they cannot expect to understand it. They are encouraged right at the beginning of their careers to forsake science in favour of dogma. The general public are misled into believing that science is a mysterious subject which can be understood by only a few exceptionally gifted mathematicians. Since the time of Einstein and of one of his most ardent supporters Eddington there has been a great increase in anti-rational thought and mysticism. The theory is so rigidly held that young scientists who have any regard for their careers dare not openly express their doubts.

Experimental checks

It is often claimed that the special theory of relativity has been confirmed by experiment. In fact no experiment has been carried out in which symmetrical measurements have been taken at each of two stations moving relatively to each other with the required high velocity; and there has therefore been no check at all on the relativity aspect of the theory, which is of course its essence. Any checks that have been made can only relate to the Lorentz theory to which Einstein returns by accepting the paradox result. Moreover even with this limited interpretation the checks are always far from convincing.

This is true for example of a recent experiment[4] in which four atomic clocks were compared with similar clocks at an observatory after they had travelled round the world in both an eastward and westward direction. It was claimed that the result provided an unambiguous resolution of the clock paradox. Now the paradox result was deduced, mistakenly, from the special theory which was concerned only with uniform relative velocity, but the results predicted for this experiment were based on gravitational and kinematic effects. It does not seem therefore to have any connection with the clock paradox, as described by Einstein. The untreated results given in the paper indicate that the average clock lost 132ns (nanoseconds or 10^{-9}s) for the eastward journey and gained 134ns for the westward journey, but since the difference between individual clocks was as much as 300ns little, if any, significance can be attached to these average values. The authors do not use all the results and apply a statistical analysis, details of which are not given, to those they do use. They conclude that the average clock loses 59ns on the eastward flight and gains 273ns on the westward flight in close agreement with the predicted values. These criticisms were rejected by *Nature* but subsequently published elsewhere[5].

"... the continued acceptance and teaching of relativity hinders the development of a rational extension of electromagnetic theory."

A hope for the future?

There are fortunately a few writers who are breaking with tradition and developing new ideas which may be fruitful. In this country there are two small volumes[6] by H. Aspden and in France R. L. Vallee has published[7] a theory of energy which appears to be gaining in spite of much opposition. A society, the S.E.P.E.D. has been formed for the promotion of his ideas. One important conclusion he reaches is that space contains an unlimited amount of high frequency energy which could possibly be extracted and used with safety and efficiency.

References

1. Einstein, A. 1905 Translation in The Principle of Relativity, Methuen, London, 1923.
2. Essen, L. The special theory of relativity — a critical analysis. Oxford science research paper 5, Clarendon Press, Oxford, 1971.
   Essen, L. Einstein's special theory of relativity. *Proc. Royal Institution*, vol. 45, page 141. 1972.
3. Einstein, A. *Naturwissenschaften*, vol. 48. 1918, p.697.
4. Hafele, J. C. and Keating, R. E. *Science*, vol. 177, 1972, pp166-8.
5. Essen, L. *Creation Research Quarterly*, vol. 14, 1977, p.46.
6. Aspden, H. Physics without Einstein, Sabberton Publications, Southampton, 1969.
   Aspden, H. Modern Aether Science, Sabberton Publications, Southampton, 1972.
7. Vallee, R. L. L'energie electromagnetique, materielle et gravitationelle. Masson et cie, 1971. Refer to S.E.P.E.D. 16 Bis rue de Jouffroy 75017 Paris.

Digital PAL coder

Binary inputs produce composite PAL signals for primary or complementary colours, black and white.

by O. J. Downing, Ph.D., **& J. E. Tully,** M.Sc., Postgraduate School of Electrical & Electronic Engineering, University of Bradford.

The increasing use of television as a display medium for digital signals has stimulated the present design of a PAL coder capable of accepting binary R(ed), G(reen) and B(lue) input signals and of producing a composite PAL video output corresponding to the relevant primary or complementary colour, black or white.

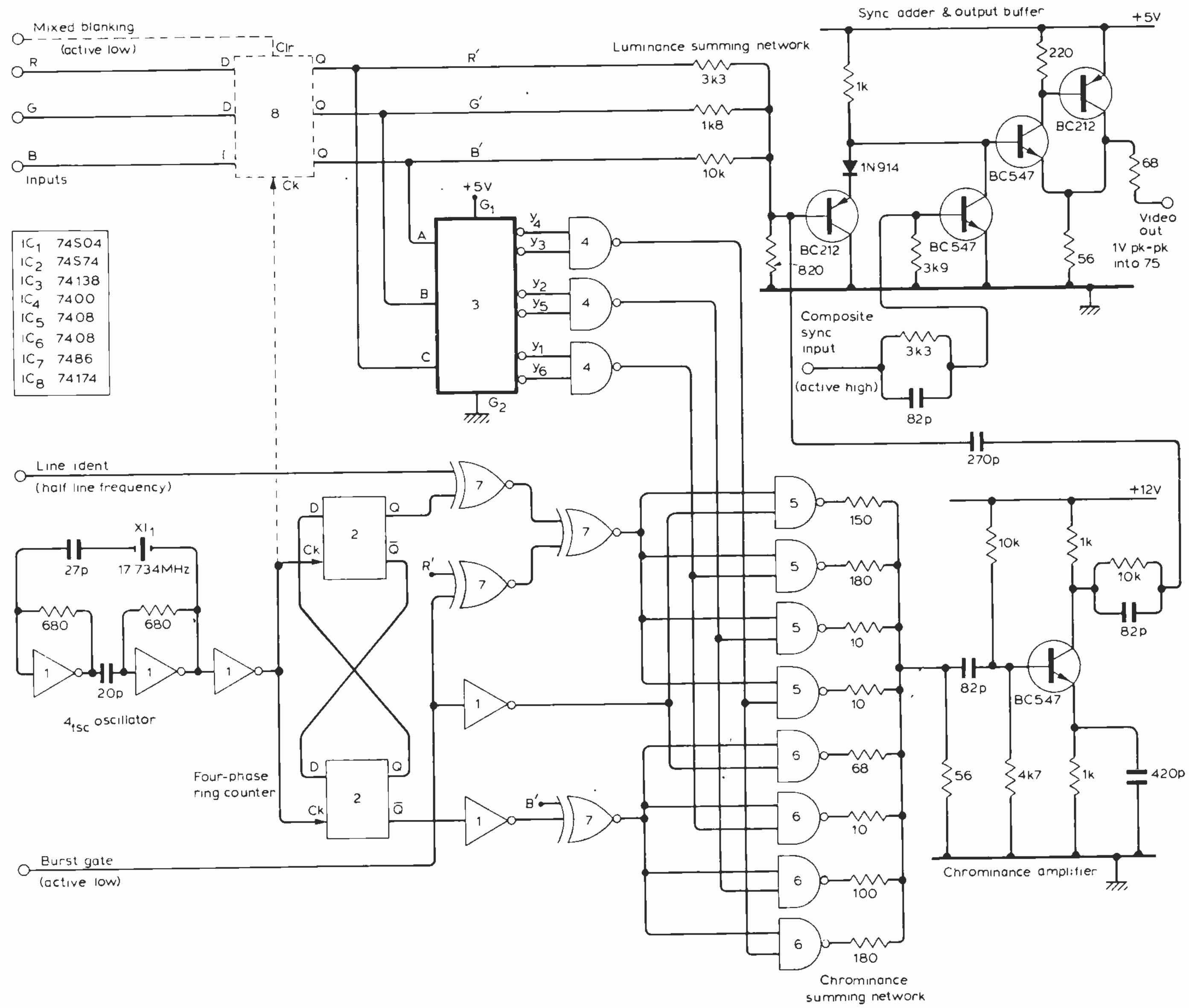
A QUICK GLANCE at the PAL equation suggests that the chrominance part of the video signal can be obtained by adding colour subcarrier frequency (f_{sc}) sinusoidal and co-sinusoidal components, of suitable amplitudes, to the luminance signal. In this design these are obtained by counting a $4 \times f_{sc}$ clock signal IC_1 with a four-phase ring counter, IC_2, to give square-wave subcarrier phases of −90°, 0°, 90° and 180°.

It is found, firstly, that the phases of the sine and cosine components, i.e. + or −, are controlled by the values of B and R respectively during active line (the phase of the sine term must be complemented during burst). And secondly that the amplitudes of these components are the same for each colour and its complement, thus requiring a total of three different amplitudes. The phases of the sine, cosine terms are selected using exclusive-NOR gates, IC_7, one of which complements the cosine component from line-to-line to give phase-alternation. The relevant amplitudes are obtained by switching weighted currents into a low-resistance node via 3-8 line decoder IC_3. The luminance component is obtained in a similar way direct from the R, G and B signals.

The nearest 10% tolerance resistors to the theoretical values were used in the prototype and gave well-defined primary and complementary colours; alternative selections of resistor values could be used to provide an alternative set of colours.

The input latch shown in broken lines is optional but provides a convenient means of blanking and de-skewing the inputs, and of presenting defined logic levels to the luminance scanning network. The use of this latch and a fairly wideband chrominance amplifier also minimizes colour fringing at vertical edges and obviates the need for luminance "delay". □

Chrominance signal is obtained by counting 4 × subcarrier-frequency clock signal and four-phase ring counter.



Negative feedback and non-linearity

Exploring the fallacy that n.f.b. reduces all harmonics equally

by 'Cathode Ray'

MR M. G. SALEM has recently called attention (in the July issue, pp. 59-60) to the fallacy, apparently not yet extinct, of supposing that negative feedback reduces all distortion harmonics equally, by the same factor as it reduces the gain of the amplifier to which it is applied. In doing so he mentioned, in effect, that I had put an explosive charge under this particular fallacy quite a long time ago – actually April 1961 under the above title, repeated as Chapter 19 in *Essays in Electronics*. Having myself forgotten doing so, I feel confident that few other than Mr Salem are so familiar with the said work that the following revised version of it will be greeted with widespread cries of protest against excessive repetition.

Undoubtedly the first thing to learn about negative feedback is that it is never so simple as it looks. Superficial study gives one the impression that it reduces undesirable things such as distortion of all kinds and noise, mains hum, etc., dividing them by (1-*AB*) or (1 + *AB*), depending on the conventions adopted. Also that the input and output impedances of the amplifier to which it is applied are either decreased or increased – in the same ratio? The truth is that, even if such complications as phase shifts are excluded, none of these things is necessarily so. The effects on impedance will *not* be in the same ratio. In general, noise reduction won't be, either. Some kinds can even be increased by negative feedback. In simple cases the reducing effect on distortion is more dependable, but even there one can easily go wrong, as in the example Mr Salem pointed out. That example concerned non-linearity distortion, the effect of which is to introduce signal frequencies (harmonics and intermodulation) not present in the original. Reducing non-linearity is usually the main object of negative feedback, because that causes the most objectionable kind of distortion. No amplifier with any claim to be suitable for high-quality sound reproduction would be without negative feedback.

So let us start with a reminder of how it is commonly said to reduce non-linearity distortion. Fig. 1(a) shows an amplifier with an *A*-fold voltage gain. For every millivolt (say) applied to the input it gives *A* millivolts out. To simplify things later, we assume that the amplifier is a phase-reversing one, as indicated by the gain being shown as −*A*. Now feed back a fraction *B* of this output, as at (b). The voltage fed back is thus −*AB*. From the point of view of the input terminals of the amplifier the −*AB* fed back is in opposition to the signal required between those terminals (= 1). The signal needed between XX to maintain the amplifier signal level as before is therefore 1 + *AB*, of which the + *AB* offsets the −*AB* fed back, leaving a net input of 1*.

Fig. 1 thus shows that negative feedback reduces the overall or gross gain of the amplifier from *A* to *A*/(1 + *AB*) – often denoted by *A'*. At this point all the books mention that if the design makes *AB* so much larger than 1 that 1 can by comparison be neglected, *A'* becomes (as near as makes no matter) 1/*B*. The great significance of this is that *B* usually depends solely on something like a potential divider that is perfectly linear, so the non-linearities involved in *A* are more or less removed. These and other advantages are paid for by the extra amplification needed to make *AB* very much larger than 1 and at the same time to ensure enough net input.

We now switch attention to the distortion created inside the amplifier by its non-linearity. It can be considered as if due to an additional input, say *d* millivolts; or, hopefully, microvolts. At first we might suppose that because applying negative feedback reduces the gain from *A* to 1/(1 + *AB*) then the legitimate signal and the distortion would both be reduced in the same ratio, so the percentage distortion would be unchanged. However, comparing (a) and (b) in Fig. 1 we see that the signal level inside the amplifier, and therefore the amount of distortion, is the same in both cases, whereas the gross signal input is much greater in (b). Therefore distortion as a percentage of the signal has been reduced by feedback in the same ratio as the gain.

That is the point at which writer or reader (or both) tend to suppose that this important feedback law has been duly established and they can go on to something else. As an optional extra it may have been noted that if the gain of the amplifier is assumed to be (near enough) the same at all audio frequencies – as of course it ought to be – then the distortion harmonics and intermodulation products are all equally reduced by negative feedback.

But before hurrying on let us consider precisely what we have been meaning by *A*. We defined it – or, to be fair to you, *I* defined it – as the number of signal millivolts received at the output (Fig. 1(a)) for every millivolt applied at the input. But I didn't insist on millivolts, or on any particular signal level. The same *A* was assumed to hold good for the (presumably) much lower level of the distortion. In other words, *A* was assumed to be linear. That being so, it wasn't very clever to use it in a calcula-

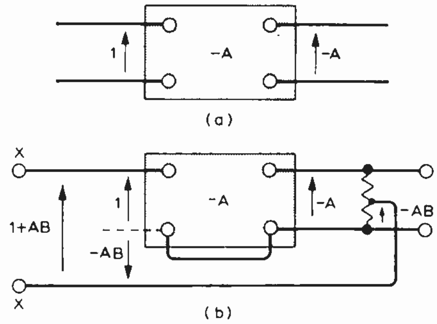


Fig. 1. *(a) represents an amplifier without feedback, and (b) the same amplifier with feedback, a fraction B of the output voltage being tapped off and returned to the input. In this case the amplifier is a phase-reversing one, so its voltage gain is shown as −A. The voltage fed back is therefore in opposition to the input voltage, which has to be increased accordingly; i.e., the feedback is negative.*

*If no assumption is made about the polarity of the amplifier output being negative with regard to the input, the gain being called just *A*, then the gross input works out as 1 − *AB*. This is correct for positive feedback, but for negative feedback either the amplifier or the feedback arrangement has to be phase-reversing, represented by making the value of either *A* or *B* negative, thus cancelling out the minus and giving 1 + *AB* as in Fig. 1(b). As we are considering only negative feedback, it seems rather pedantic and unnecessarily confusing to have to remember to use a double negative every time. In practice there are only (usually) two frequencies at which *AB* is simple plus or minus; for all the rest one has to consider other phase angles than 0 and 180 , using 'complex' algebra. But it is a *very* simple recap we are having, with a view to making just one point, not an exhaustive treatise on negative feedback.

tion concerning amplifier non-linearity. True, we guarded against complete absurdity by making the signal voltage in the amplifier the same in both Fig. 1 diagrams. But if the non-linearity is considerable, so that the distortion is a significant part of the total output, that safeguard isn't good enough. For, when the feedback is applied and reduces the distortion, the total output will be different.

The correct procedure, now that an element of doubt has been found to exist in the basis of the argument, would be to embark on a comprehensive and rigorous mathematical analysis that would cover every case. But you know me too well to expect that. Anyway, the higher the level of maths the greater the risk of going wrong or of the truth being obscured. (Mathematicians, don't bother to write to me on this, for I shall decline to answer.)

The 'line' in 'linearity' is the graph of output against input. These come in two kinds. One of them could be plotted by connecting a calibrated signal generator to the input of the amplifier and varying the signal strength there while measuring the corresponding peak or r.m.s. voltages at the output. It might look something like Fig. 2. There would

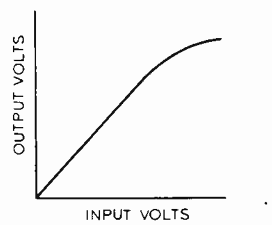


Fig. 2. *This is one kind of output/input graph, in which the voltages are peak or r.m.s. values.*

be no point in reversing the connections with the idea of extending the curve into the negative region, for its shape would necessarily be the same in reverse. The other kind, which is the one we are going to study, is seen by substituting the Y plates of a cathode ray oscilloscope for the output voltmeter, and connecting the X plates (with suitable distortionless amplification) across the input. The positive and negative half-cycles obviously swing the curve in both directions from the origin as their *instantaneous* values are shown on the screen, and their shapes are not necessarily the same.

A perfectly linear amplifier would yield a perfectly straight 'curve', as in Fig. 3(a). In the case of a power amplifier this would merely show it was being uneconomically under-driven. In a commercial world it is necessary to work up to some distortion, even though it be limited to less than 0.1%. Most amplifiers, so long as they are not over-driven, tend to show curves of two main shapes (or combinations of both), as in Fig. 3(b) and (c). The first has a

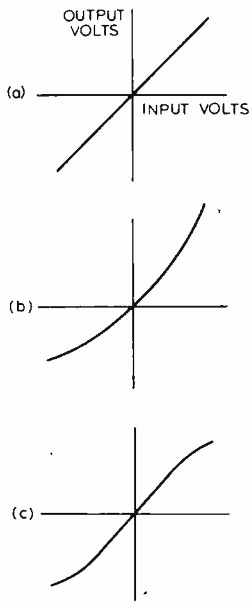


Fig. 3. *In this kind of output/input graph, instantaneous voltages are plotted. (a) is a linear (distortionless) characteristic; (b) and (c) are non-linear curves, representing respectively second and third order distortion.*

square-law term in its output/input equation, which generates a second harmonic of the signal, and second-order intermodulation. The second has a cubic term and generates third-order distortion, which sounds worse.

Now *A* (being output/input) is represented in these Fig. 3 diagrams by the slope of the curve. In (a) the slope is the same throughout, so *A* is constant and (assuming, as we usually can, that *B* is likewise) there need be no question as to exactly what 1 + *AB* means. But in such a situation there is no need for feedback! In (b) and (c), *A* is varying all the time, so one doesn't know what figure to insert for it when using the formula. We can say that Fig. 3(b) indicates a smaller *A* at the negative peaks than at the positive, so presumably the negative part of the curve is straightened out less by negative feedback than the positive part, but the effect on the distortion is difficult to assess without a large-scale mathematical operation. Let us see what we can do without that.

In order to find out whether the harmonic structure of the distortion (as distinct from its amount) is affected by feedback there should be no need to consider any particular practical amplifier. That is just as well, because it would be quite tricky to represent typical crossover distortion mathematically. A single transistor is easier, because it does have a Fig. 3-type graph that is a good approximation to an exponential curve, and (with suitable assumptions) the corresponding array of harmonics in the output can be derived as a basis for calculation. But why bother? Things will be much easier and clearer if (at least for a trial) we assume we have a hypothetical amplifier with a pure square-law characteristic, like Fig. 3(b), and plotted quantitatively as Fig. 4, using the equation.

$$v_o = 100v_i + 1000v_i^2$$

where v_o is the instantaneous output voltage and v_i the sinusoidal input voltage. This gives the amplifier a gain of 100 as regards the fundamental.

A simple calculation shows that with a peak v_i of 0.04V the $1000v_i^2$ term causes 20% second-harmonic distortion. We can do it graphically by drawing a straight line joining the tips of the curve, noting how far up the v_o axis it comes (1.6V in this case) and lowering the line half the distance. It is then the linear part of the characteristic responsible for the fundamental, shown (dotted) as a pure sine wave in Fig.5 (a) The actual amplifier curve I have plotted in Fig. 4 is 0.8V lower at zero v_i and 0.8V higher at posititve and negative peaks. The points can be transferred to Fig. 5(a), and when joined up by the full line show what comes out of the amplifier when 0.04V peak is put in. The difference between this and the fundamental has been plotted below, (b), and is clearly a second harmonic. Both Fig. 4 and Fig. 5 show that its peak value is 0.8V, which in relation to the fundamental's 4V is 20%.

Anyone with the most elementary knowledge of the differential calculus will realize that the easiest way of finding the slope (which is *A*) at any point on the Fig. 4 curve is to differentiate its equation, thus:

$$A = \frac{dv_o}{dv_i} = 100 + 2000v_i$$

So at zero v_i it is 100, which is what one would expect, since an input confined to very small values of v_i would yield neligible distortion, and 100 is the slope of the fundamental line, corresponding to an amplification of 100. At the

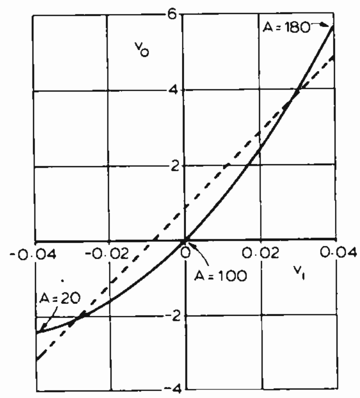


Fig. 4. *The full line is a graph of the Fig. 3 (b) type. The broken line shows its fundamental part; the vertical difference between the two represents second-harmonic distortion, as shown in Fig. 5.*

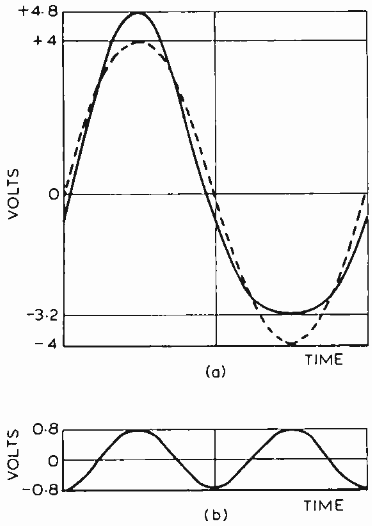


Fig. 5. *The full line in (a) shows the output waveform of an amplifier with the characteristic shown in Fig. 4, when the input is a pure sine wave. The broken line is the fundamental part, corresponding again to Fig. 4. The difference between the two, shown by itself at (b), is the second harmonic.*

positive peak it is 100 + 80 = 180 and at the negative peak it is 100 − 80 = 20. So 20% distortion, which is not as horrible as you might expect, if it is all second harmonic, is associated here with a no less than 9 to 1 variation in amplification over each cycle of signal. We can hardly be surprised, then, if we find that negative feedback doesn't work entirely according to plan.

Perhaps the best way of seeing how it does work is to plot a with-feedback curve to compare with Fig. 4, which can be done by making a table to calculate some points. Remember, the voltage fed back at any point is equal to Bv_o, and this added to v_i gives v'_i, the with-feedback input needed.

To make it easy to compare the two curves, the v' scale of the new one should be the v_i scale of the old multiplied by as many times as v'_i must be greater than v_i to maintain the same output. A convenient figure for this, which is also reasonable for feedback practice, is 10. $(1 + AB)$ being 10, AB is 9 and B is 0.09.

(1) v_i	(2) v_o	(3) $0.09v_o$	(4) v'_i
0.01	1.1	0.099	0.109
0.014	1.596	0.1436	0.1576
0.02	2.4	0.216	0.236
0.03	3.9	0.351	0.381
0.04	5.6	0.504	0.544
−0.01	−0.9	−0.081	−0.091
−0.02	−1.6	−0.144	−0.164
−0.03	−2.1	−0.189	−0.219
−0.04	−2.4	−0.216	−0.256

Column (1) contains a selection of points covering the peak-to-peak swing of v_i. Column (2) contains the corresponding output voltages calculated from the equation, which were needed for plotting Fig. 4. Column (3) shows the voltages fed back, equal to $0.09v_o$. Lastly column (4), which is got by adding (3) to (1), shows the input required at XX in Fig. 1(b) to maintain the same output (2) as before.

Plotting Fig. 6 from columns (2) and (4) we are at once impressed by the success of negative feedback in straightening out the amplifier curve. It is now hardly distinguishable from a straight line, especially on the positive side.

Becoming a little more critical, we note that we need considerably more than 10 times the former peak input; to be exact, 13.6 times. But 10 was calculated on the basis of $A = 100$, whereas we have already noted on Fig. 4 that A varies from 100 to 180 during the positive half-cycle, and if we calculate the average multiplier for this range of values of A we find that it is 13.6. Rather than find fault here we might thank feedback for raising the positive fundamental peak output from 4V with 20% distortion to 5.5V with about 1½% distortion.

On the other hand any satisfaction that might at first be derived from seeing that the input needed for the negative peak has been increased only 6.4 times is damped by the unfortunate accompanying fact that the fundamental negative peak has been reduced from 4V to about 2.5V. And of course a 5.5V positive peak is no good with a 2.5V negative peak – unless use of the amplifier is confined to rather unusual waveforms.

It seems, then, that if at least our original 4V peak sine-wave output is to be maintained it will be necessary to bring up the negative input, as we would be able to do, seeing that we were prepared to find at least ±0.4V. To see what we get we shall have to extend our plots in the negative direction. If we proceed to calculate column (2) we find that beyond $v_i = -0.05$V a complication sets in; increasing $-v_i$ reduces $-v_o$, making the curve bend up. This is because the curve is derived from the equation for A, which makes A negative if v_i is more negative than −0.05V.

In a real amplifier, however, the de-

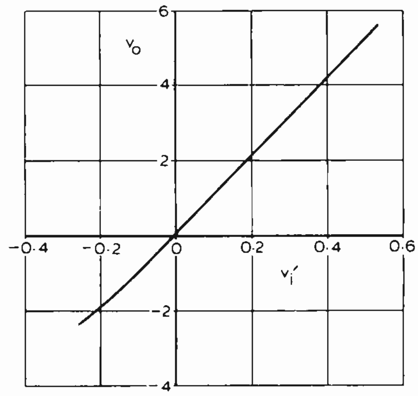


Fig. 6. *This, for comparison with Fig. 4, is the result of reducing the small-signal gain A-fold by negative feedback and correspondingly increasing the external input (v′) to yield the same net input (v_i) as before.*

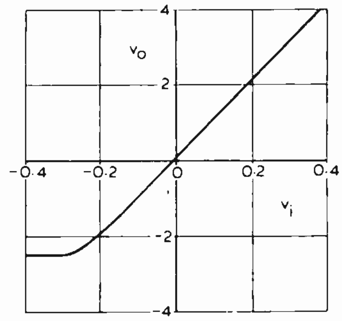


Fig. 7. *The result of further adjusting the input v_i to ±0.4V. Audibly, the result would be worse than without feedback (Fig. 4), and the output less.*

cline of its gain to zero during the signal cycle is normally due to the cutting off of one or more transistors. In the usual push-pull configuration – in which distortion is largely third-order – the gain recovers as the signal goes more negative; indeed, if the biasing is correct it shouldn't fall off in the first place. But we are considering a square-law amplifier, to which the nearest practical approximation is a single-ended type, which cuts off altogether if the signal goes too negative. So a realistic procedure will be to continue the curve horizontally to the left:

v_i	v_o	$0.09v_o$	v'_i
−0.05	−2.5	−0.225	−0.275
−0.06	−2.5	−0.225	−0.285
−0.07	−2.5	−0.225	−0.295

At this rate it is obviously going to take us a long time to reach $v'_i = -0.4$, but we now have enough information to omit the intermediate stages and boldly write

$$v'_i = -0.4;\ v_o = 2.5$$

Continuing beyond our original ±0.4V (to match the ±0.04V in Fig. 4) is clearly not going to make the picture any prettier, so in Fig. 7 I have kept within those limits. Now we see the truth about negative feedback, and it doesn't look as good as we may have supposed. And if anyone is thinking I've fiddled it by arbitrarily departing from the simple quadratic equation at the negative end, I invite him to stick to the equation. The result will be even more ghastly than Fig. 7.

That is quite bad enough, for on analysing Fig. 7* I find that the fundamental output is only just over 3V peak, compared with 4V in Fig. 4 (a power reduction of 44%) and in exchange for our 20% second-harmonic distortion we have received the following mixed bag:

Harmonic	Percentage
2	13.2
3	7.4
4	3.3
5	1.24
6	0.16
7	0.83

*By the method described in M. G. Scroggie's *Radio & Electronic Laboratory Handbook*, 8th edition, Sec. 11.10.

plus undetermined amounts of higher harmonics which, judging from the sharpness of the bend in Fig. 7 and the magnitude of the 7th harmonic, are likely to be very significant aurally if not numerically. It is true that the total harmonic distortion, found by taking the square root of the sum of the squares of the above lot, is only 15.6% But if anyone thinks this is an improvement on the 20% without feedback he oughtn't to be let out alone in the hif-fi market. He would be an easy prey to the merchants, whose motive in quoting t.h.d. figures is only too clear to those who have compared actual sound reproduction with the harmonics present. Though opinions of authorities differ as to the factors by which harmonics higher than the second should be multiplied to give some idea of their relative unpleasantness, the most conservative suggest (without necessarily admitting that it is adequate) a weighting factor equal to half the harmonic order. For instance, the 0.83% 7th harmonic would have to be multiplied by 3½, raising it to 2.9%. D. E. L. Shorter of the BBC considered the square of this factor not excessive. That would raise the 7th-harmonic figure for comparison with the second to over 10%.

At this point a red herring labelled 'intermodulation' is almost certain to be seen crossing our path. But if any benefit is to be derived from the time you have so self-sacrificingly spent in following me thus far, I advise that we refrain from spending any more in chasing after it. No doubt we know that the products of intermodulation, being in general not musically related to the tones present in the original sounds, are more objectionable than at least the lower harmonics, which are; but it doesn't follow that one must insist on intermodulation data and refuse harmonics as worthless substitutes. For, when measured under comparable conditions, harmonic percentages are more or less proportional to intermodulation percentages, so can be used as comparative indexes of intermodulation, easier to measure. And anyway, in this case we are getting the higher harmonics, which are discordant in their own right.

Another possible red herring is one that isn't nearly as fresh as it is often made out to be by means of new-fangled terms such as transient intermodulation distortion and slewing-rate distortion. It is in fact many years old, and although it too is an undesirable product of ill-designed negative feedback it also is an avoidable one, not directly related to the present subject.

Getting back to our uneasy contemplation of Fig. 7, we see that there is nothing for it but to reduce the input signal until the sharp bend is cleared; say ± 0.25V peak. The output, which by then is nearly all fundamental, is barely 2.5V, or less than 40% of the power we got in Fig. 4, admittedly with lots of second harmonic too. But if we reduce the fundamental without feedback to the same level, the second harmonic comes down to 12½%, which on paper is certainly not hi-fi, but wouldn't greatly offend as many listeners as you might think.

It is now time to sum up:

(1) The common belief that negative feedback reduces non-linearity distortion in the same ratio as it reduces amplification is strictly true only if there is no non-linearity to reduce.

(2) However, provided that the original non-linearity is not so bad that the slope of the output/input curve (which is the amplification) falls seriously below the nominal value at any point within the maximum signal amplitude, the common belief is fair enough.

(3) It follows from (1) and (2) that any idea that one can sling an amplifier together any old how and pull it straight with liberal supplies of negative feedback is unsound — even apart from the practical difficulties of this treatment.

(4) While negative feedback works like a charm on amplifiers with *moderate* non-linearity, run well within their capability, it doesn't necessarily increase the amount of power that can be drawn; on the contrary, it may reduce it.

(5) In any case, once the signal amplitude runs past the nearly-undistorted limits, it abruptly becomes very distorted, not only as regards quantity but even more as regards quality. In other words, even a moderately overloaded amplifier sounds a lot worse with feedback than without.

(6) The fact that hi-fi fans insist, especially in America, on vast numbers of output watts being available, in spite of the surprisingly small *average* power needed for even quite loud reproduction, is thus explained.

(7) The fact that demonstrations of 'hi-fi', unless conducted by masters of the art, are usually such painful experiences, is also explained. The demonstrator so often doesn't reckon that he is doing his job if the output falls below the maximum rating.

Except by dividing signal voltages by 10 in order to be more appropriate for modern transistors than were those in the valve version of 1961, and writing a new introduction on Fig. 1, I have followed much the same lines as in the original and have arrived at the same conclusions. Present readers will no doubt be thinking I ought to have reduced the distortion figures by a factor of at least 10 to be more in accord with present-day amplifiers. But it must be remembered that, with the larger amounts of feedback now used, its effects on overloading can be even worse than are shown here, intentionally exaggerated though they were to get the message across. This has been dramatically confirmed as recently as the July 1978 issue, where on p.57 James Moir showed a curve which clearly illustrates my very point — that distortion without feedback is, at a certain output level, suddenly and vastly overtaken by distortion with feedback.

I hope that, by confining the no-feedback distortion to only one harmonic, I have left no room for the fallacy that all distortion harmonics are necessarily reduced by negative feedback in the same ratio as the gain – or even at all, since we have seen that many harmonics can actually be created by feedback that were not there without it. □

LITERATURE RECEIVED

Video display unit ZIP-64 from Data Dynamics is said to offer low cost with high performance. A leaflet can be had from Data Dynamics at Data House, Springfield Road, Hayes, Middlesex WW412

P.r.o.m. programming equipment made by Data I/O and a large list of p.r.o.m.s from twenty suppliers is presented in a leaflet from Microsystem Services, Duke Street, High Wycombe, Bucks. WW413

Illuminated push switches illustrated and described in 28-page catalogue from Licon, Norway Road, Hilsea Industrial Estate, Portsmouth PO3 5HT WW414

Power supplies and components for use with equipment vulnerable to transients and poor line regulation and in conditions where a supply must not be broken are all described in the Topaz catalogue from Euro Electronic Instruments Ltd, Shirley House, 27 Camden Road, London NW1 1YE WW415

Single-board computers in the Intel iSBC range of o.e.m. equipment have been summarized by Rapid Recall in a pocket guide, obtainable from Rapid Recall at 9 Betterton Street, Drury Lane, London WW416

Turntables from Collaro are updated and described in leaflets from Magnavox Electronics Company Ltd, By-pass Road, Barking, Essex 1G11 0TF WW417

Picoammeter from Keithley, Model 480, is discussed in general and specified in a brochure from Keithley Instruments Ltd, 1 Boulton Road, Reading RG2 0NL . WW418

"DC Motors, Speed Controls, Servo Systems" is the title of a 500-page handbook from Electrocraft. It is available at £3 from Unimatic Engineers Ltd, Granville Road Works, 122 Granville Road, Cricklewood, London NW2 2LN.

Audio kits from Powertran are illustrated, described and priced in a catalogue obtainable from Powertran Electronics, Portway Industrial Estate, Andover, Hants SP10 3NN. WW designs offered include the Linsley Hood cassette deck, Nelson-Jones f.m. tuner, Stuart tape recorder and Linsley Hood audio oscillator WW419

Add-on oscilloscope waveform store — 1

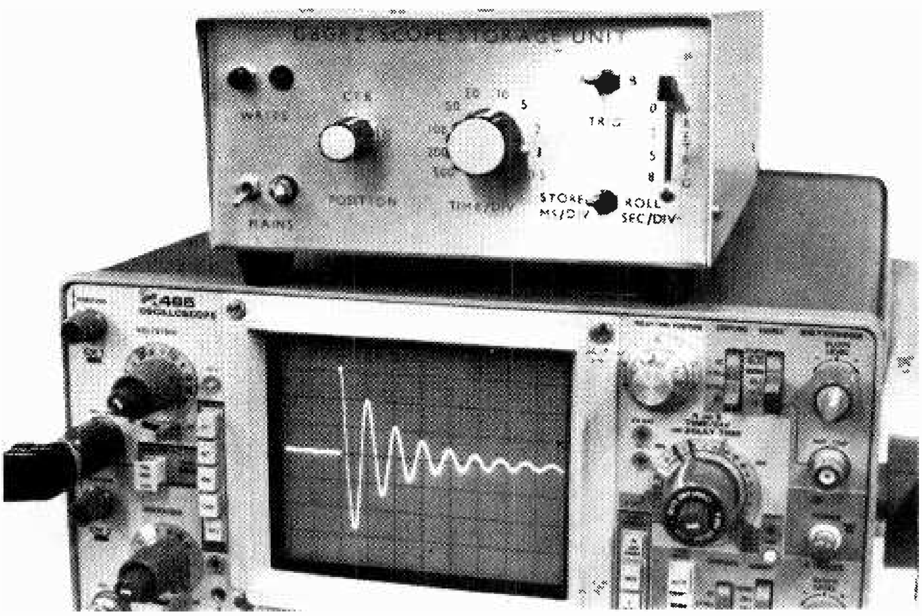
Digital unit for audio waveform storage and display using a dual-channel oscilloscope

by R. D. Fastner

The instrument described here employs digital storage techniques to allow an ordinary dual-channel oscilloscope to function as a storage type. The input signal to the oscilloscope is extracted, converted to digital form, stored, converted back to the analogue form and displayed on the oscilloscope screen. A useful feature is that the waveform before the trigger pulse can be displayed. Circuitry is included to remove the "steps" in the waveform which would ordinarily be the result of a sampling process. Interfacing with the oscilloscope is not dealt with in detail, since requirements vary with facilities existing already.

THIS IS a mains-powered instrument designed to give a storage facility to a non-storage oscilloscope. The instrument consists of an analogue-to-digital converter, 8000 bits (1000 × 8) of memory, a digital-to-analogue converter and a step eliminator, which converts the normal step output of the d.a.c. to straight lines. This greatly improves the presentation of stored waveforms with few samples. There is also some control circuitry to control the read/write, sync. and blank functions. A crystal oscillator is used for simplicity and stability, and its frequency is divided down in a 1, 2, 5 sequence to give 10 time/division ranges. There is also a roll mode of operation which gives an extra nine time/division ranges below that of the normal storage mode. A useful pretrigger function enables the unit to store the waveform leading up to and away from the trigger point – a mode which is not possible with normal c.r.t. storage. An advantage of this system of storage is that the waveform may be expanded and analysed after being stored.

Since the unit may be used to store digital waveforms with fast transitions a tracking a-d converter was rejected because of its slow full-scale slew rate. The successive-approximation type used will reach any level in a maximum time of 2% of a division, assuming the input changes state during the first of the two samples. On the other hand, the slew time of the tracking type of converter depends on the input levels, and has a maximum time of 2^n clock pulses. Reduction of this time can be accomplished by increasing the clock frequency when the difference between input and digital output is greater than a specified amount. The frequency can then be reduced when the difference between the levels has been reduced. There is the disadvantage, in this mode of operation, that more complex circuitry is needed to detect the levels at which the higher speed clock is gated in and out.



The storage unit in use, displaying a test waveform.

Random-access memory i.cs were rejected as storage elements in favour of shift registers, because the register's sequential operation suited the circuit operation. One disadvantage of r.a.ms is the need for address lines, which results in more components and greater complication in p.c.b. layout. Another is the increased complexity of the circuitry, especially regarding roll and pretrigger functions.

Analogue-to-digital converter

Analogue input waveforms are converted to 8-bit binary form to provide 256 discrete levels on conversion back to analogue form for display. The converter, shown in Fig. 2, is in action continuously, whether the instrument is reading or writing. It uses three integrated circuits to perform its major functions: a MC14559 c.m.o.s. successive-approximation register (not the locmos version, which has a higher propagation delay); a MC1408-L8 bipolar, 8-bit digital-to-analogue converter; and MC1407 bipolar a-d control circuit, which is a wideband amplifier and comparator. Transistor Tr_1 shifts vol-

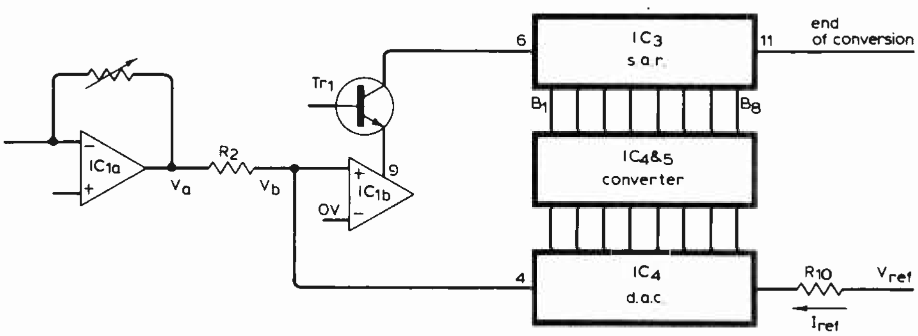


Fig. 1. Block diagram of the input circuit and d-a converter.

tage levels from the bipolar 5V of the MC1407 (IC_1) to c.m.o.s. 15V for IC_3 and, similarly, the eight buffers in $IC_{2,5}$ shift levels back to 5V for the bipolar MC1408-L8 – IC_4.

Operation. In essence, the converter is an analogue-digital-analogue feedback loop. The block diagram of Fig. 1 shows the input amplifier, IC_{1a}, whose output is taken to a voltage comparator, IC_{1b}. Via the level shifter, Tr_1, the comparator controls the successive-approximation register, IC_3, which is clocked. The digital outputs of the s.a.r. are buffered and applied to the digital-to-analogue converter, IC_4, whose output is then taken back to the comparator. The loop circulates until the two comparator inputs are zero.

Assume that, in Fig. 2, the s.a.r. is reset, with B1 to B8 low: IC_4, the d-a converter in the a-d loop, is drawing no current via its output pin 4. Also assume some positive output, V_a, from IC_1, pin 12. The comparator sees a positive voltage, V_b, on its non-inverting input, IC_1, pin 5; its output, pin 9, is high. Transistor Tr_1, the 5V-15V level shifter, is off and its collector is high. This high voltage is fed into the s.a.r. D input, IC_3, pin 6 which, on receipt of the first clock input, enables B1, the most significant bit, which appears on IC_3, pin 4, to be set. When the m.s.b. goes high, it is converted down to the 5V level and is fed into IC_4, pin 5. IC_4 now draws $I_{ref}/2$, and V_b, the voltage at the comparator input is now $V_a - I_{ref}/2 \times R_2$. If this voltage is positive, the comparator output will be high; if negative, the output will be low.

If it is high, the next clock pulse sets IC_3, pin 3, which is bit 2, high. This causes IC_4 to draw $I_{ref}/2 + I_{ref}/4$, hence the current corresponding to each bit is half that for the previous one. Now, $V_b = V_a - (I_{ref}/2 + I_{ref}/4 \times R_2)$ and is again compared as before. This time, if V_b is negative, the comparator output is low and the next clock pulse simultaneously resets B2 and sets B3. The output of IC_3 draws $I_{ref}/2 + I_{ref}/8 \times R_2$ and again the *IR* product is subtracted from V_a and the result compared. This sequence is continued for all eight bits, each being generated, added to the previous bit, compared and reset or remaining set to keep $V_b = 0$. At the end of the sequence, IC_3, pin 11, which is "end of conversion" (e.o.c.), goes high and is used to

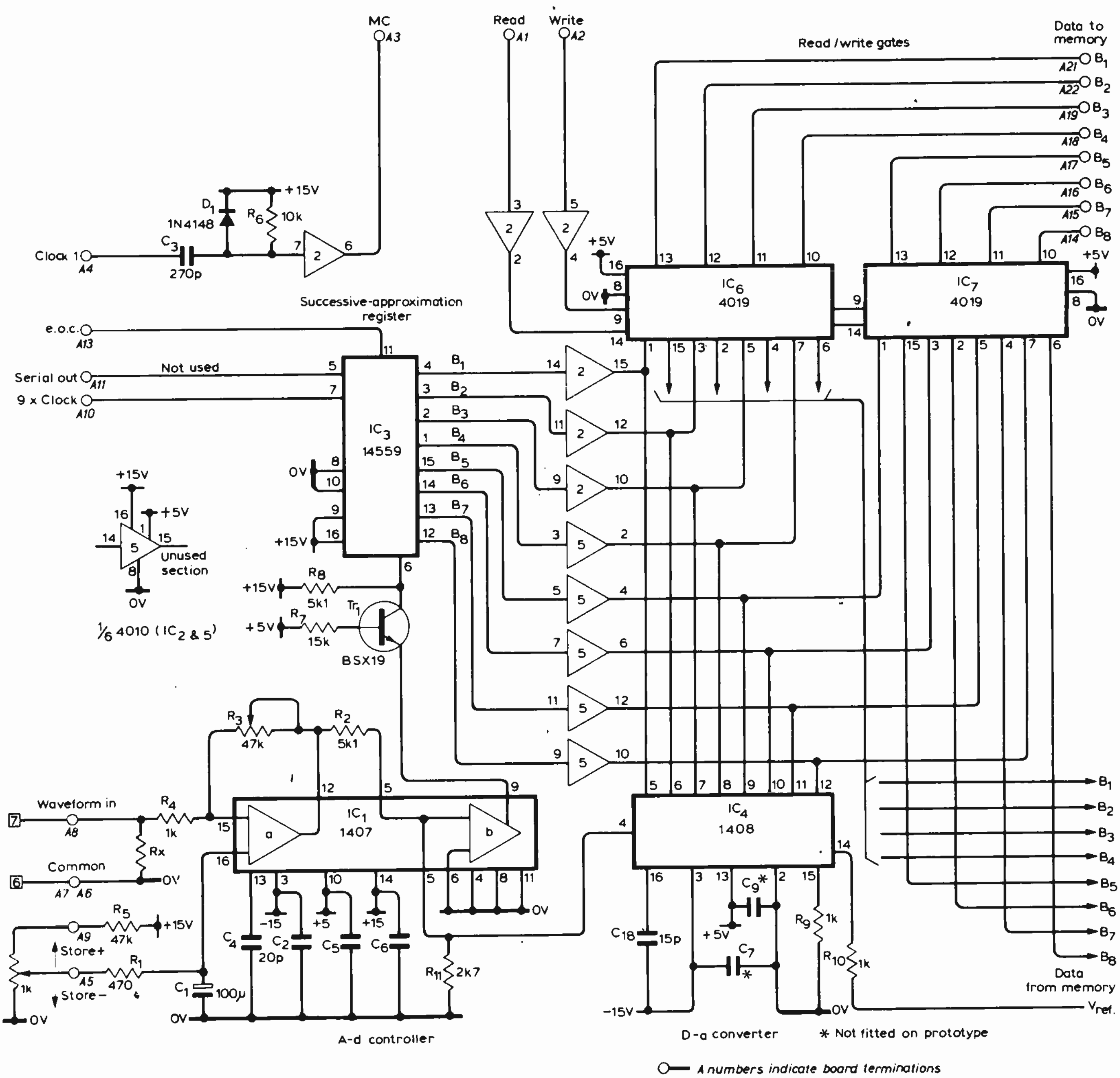


Fig. 2. Circuit of the a-d converter. The gates in $IC_{6,7}$ are controlled by the read/write circuitry and connect the digitised input to the memory or the output of the memory to its input for re-circulation.

generate a pulse, which sets a flip-flop and strobes the data into memory by means of a write pulse and $IC_{6,7}$. The complete sequence is nine clock cycles long, the e.o.c. being half a cycle wide.

Memory

Sixteen NE2528, dual 250-bit, c.m.o.s. shift registers are used for the memory, operated from +5V and −8V (no 0V). The data is clocked through by a modified end of conversion (e.o.c.) pulse generated by the a-d converter.

Since the memory is, in effect, eight large shift registers, as seen in Fig. 3, all that is required for operation is a clock and some read/write gating. Two 4019 and-or gates, seen in Fig. 2, are used for this gating, controlled by the read and write inputs. The latter enables the gates from the a.d.c. to the memory input, whilst the latter inhibits the gates from the memory output to input. When the unit is in a 'write' condition, the first bistable in the memory acts as a latch, eliminating the need for separate latches.

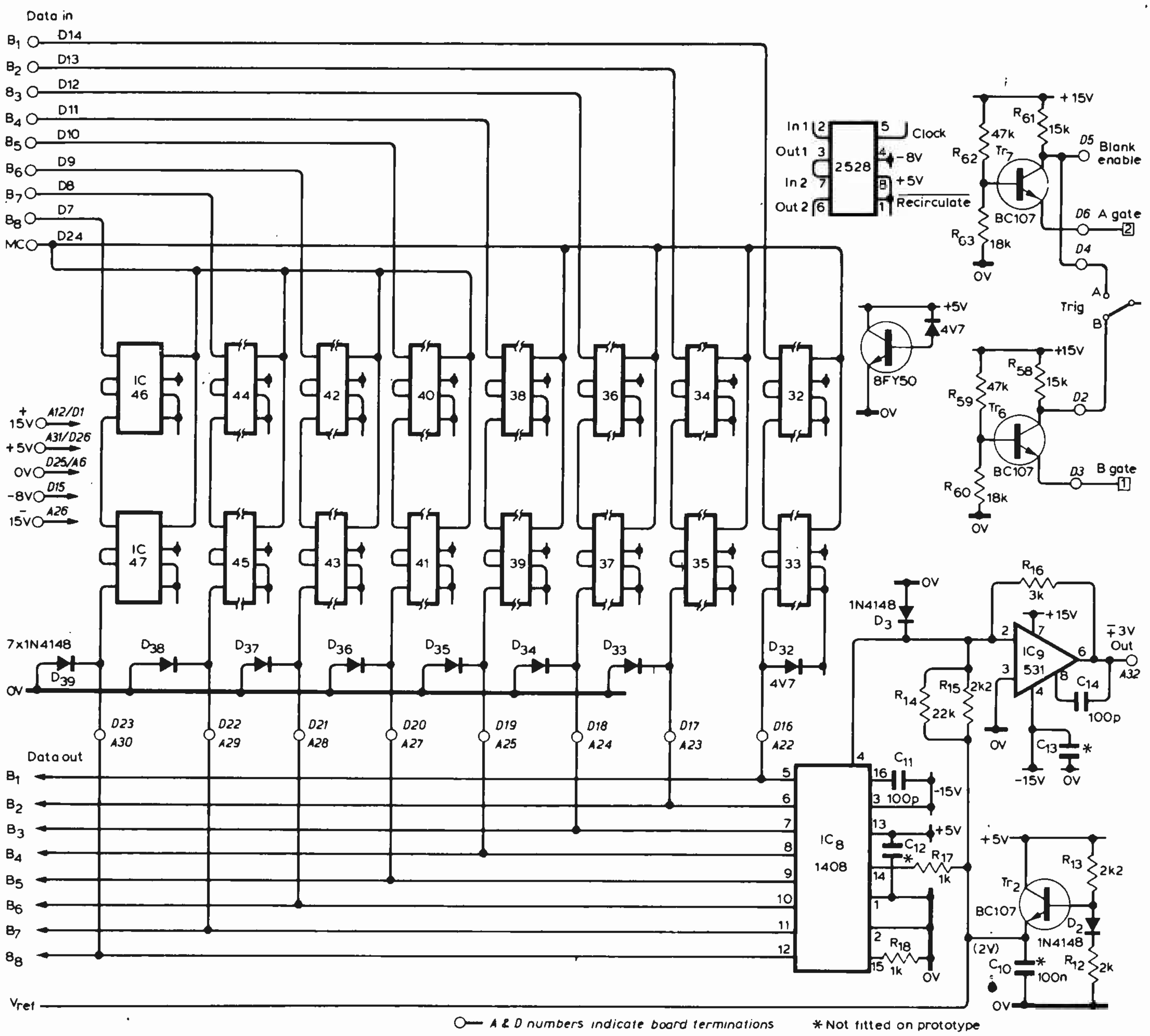
The NE2528 shift registers require a high clock pulse width of not less than 200ns and a low pulse width of not greater than 100μs; if the clock pulse is low for longer than 100μs data is lost, but it may stay high indefinitely. For this reason, R_6 and C_3 in Fig. 2 are required to form a pulse generating circuit, whose function is to limit with width of the clock pulse to approximately 3μs when on low clock rates. Omission of these components results in the stored waveform deteriorating as the memory i.cs warm up.

Fig. 3. Circuit of the memory and d-a converter. IC_9 provides the output for the step eliminator of Fig. 5.

Outputs $B_{2\text{-}8}$ are clamped by 1N4148 diodes to prevent them forcibly switching on the d.a.c. inputs. Output B_1 is clamped by a 7.4V zener diode from +5V because it was found that if this input went 0.7V negative, the output appeared to have "crossover distortion." Several d.a.c. chips were tested and all showed this distortion. No mention of this phenomenon was found in the specifications of the d.a.c. chip.

D-a converter

A second MC1408-L8 i.c., IC_8, is used for the d-a conversion as shown in Fig. 3. Since the device has a constant current-output it is followed by a current-to-voltage converter, IC_9. The inputs to the d.a.c. are taken from the outputs of the memory. A positive current corresponding to B_1 is fed into the output of the d.a.c. via R_{14} and R_{15}, causing the output of IC_9 to become



bipolar. If B_1 were presented to $IC_{8/9}$, pin 4 would draw $I_{ref}/2 = V_{ref}/R_{17} \times \frac{1}{2} = 2V/1k \times \frac{1}{2} = 1mA$. R_{14} and R_{15} in parallel equal approximately 2kΩ. R_{14}, the "select-on-test" resistor, is chosen so that with B_1 only the final output from the unit is 0V; i.e., it is an offset adjustment. R_{14} and R_{15} are connected to V_{ref} and, assuming their combined value is 2kΩ, supply the 1mA to IC_8, pin 4. As IC_9 input is a virtual earth, $IR_{16} = 0$ and therefore the output will be 0V. The voltage output from the circuit ranges from:

$$-IR_{14}R_{15}R_{16} = -V_{ref}R_{16}/R_{14}R_{15} = -3V$$

to

$$-I_{d.a.c.(max)} + IR_{14}R_{15}R_{16} = 2.97$$

or about ±3V.

The characteristics of the d.a.c. are such that the m.s.b. current switch is the fastest to operate and the least signficant bit is the slowest, with the intermediate bit-switching times increasing with decreasing significance. the transition B_1 off – $B_{2\text{-}8}$ on, to $B_{2\text{-}8}$ off – B_1 on, results in some period of time when B_1 has switched on but $B_{2\text{-}8}$ (or any combination) have not switched off. During this short period of time all eight bits appear to be on and the output of the d.a.c. tries to draw maximum current, resulting in a negative-going spike. Diode D_3, a 1N4148 or similar, is included in the circuit to "fill in" this spike. If this diode is omitted IC_9 output would try to follow the spike and a positive glitch would appear at the output.

The reference voltage generator is basically a potential divider buffered by an emitter follower Tr_2. The 1N4148 diode is included for thermal stabilisation.

Clock

A 1.8 MHz crystal oscillator, seen in Fig. 4, is used to generate the maximum clock frequency required, which is nine times the maximum sample rate. This is divided down under control of the time/division switch, S_{5a}, to give a nine times clock output for each of the normal store mode ranges. As the output is fed only to the s.a.r. the whole circuit is operated from a +15V supply. MC14510 decade counters are used for the first two stages, $IC_{20\text{-}21}$, and a CD 4029 binary/decade counter, IC_{22}, for the third.

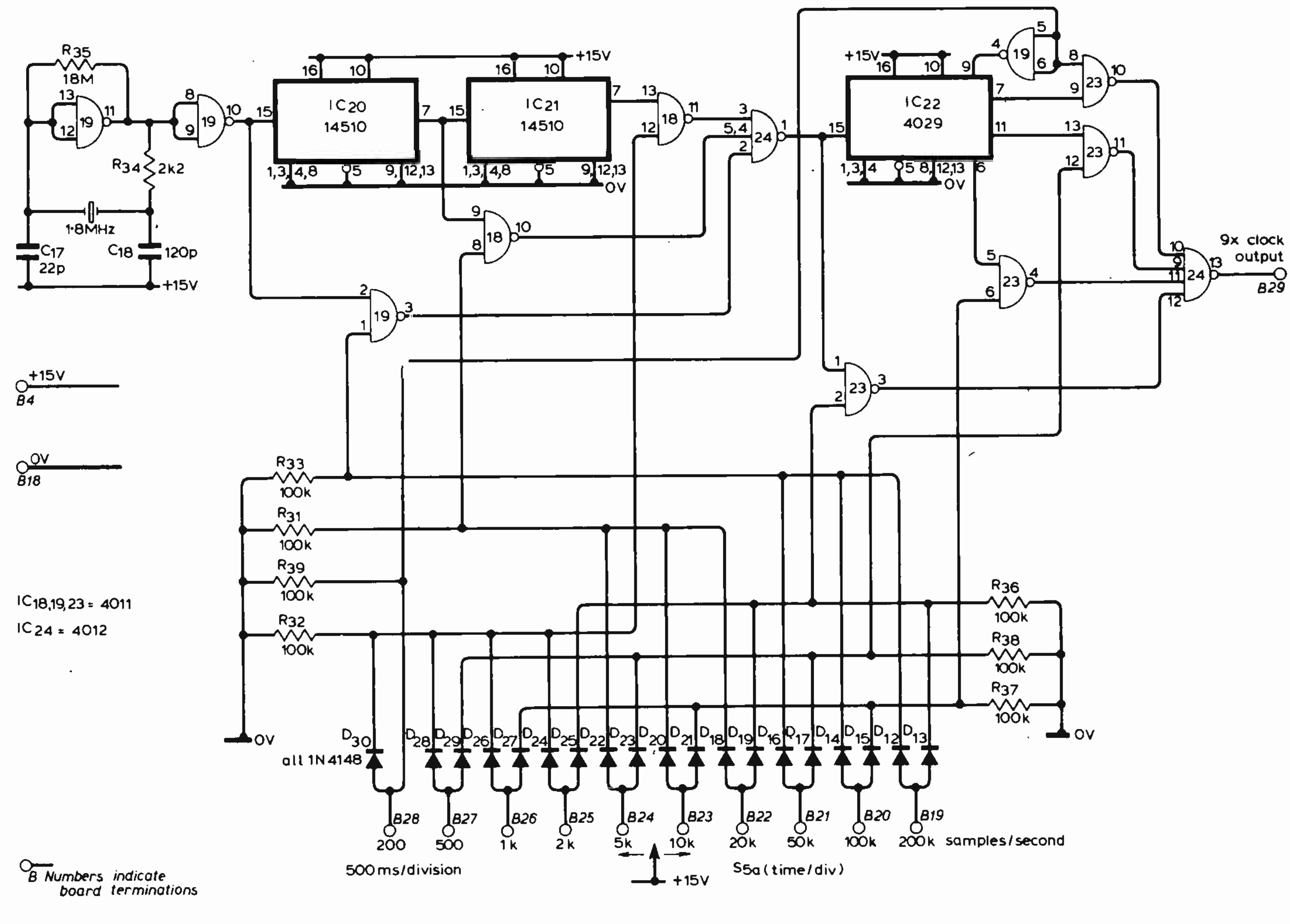
The output from the crystal oscillator is divided down by gating it into, or around, counters as required. Gates are operated in pairs and are enabled from the time/div. switch by diode logic. Ranges above 0.5s/div. use decade counters in the first two stages and a binary counter in the last. Binary outputs 1 and 2 are used to give divisions of 2 and 4 respectively. The 0.5s/div. range is derived in a similar manner, except that the third counter is operated in the decade mode and the output is taken from the terminal count. If starting of the oscillator is unreliable the 18 megohm resistor in the circuit may be reduced to 10 megohms. This resistor sets the bias level at the input of the nand gate.

Step eliminator

The function of this circuit, shown in Fig.5, is to convert the normal step output of the d-a converter to something more presentable. It consists of a differential amplifier, followed by a sample-and-hold circuit and an integrator. The output is taken from the integrator, IC_{29}, via an inverting buffer, IC_{28}. The integrator time constants are selected by the time/div. switch.

Assuming the input and output of the circuit are at 0V, the differential amplifier IC_{25} will also be at 0V and, when the 4016 analogue gate IC_{26} is strobed, the storage capacitor C_{28} will also be at 0V. When the strobe pulse is removed, the 4016 gate is disabled and has an impedance of several megohms. The voltage stored by C_{28} is buffered by IC_{27}, a LM301 voltage follower, and fed to the input of the integrator, which will remain at 0V by virtue of the virtual earth configuration.

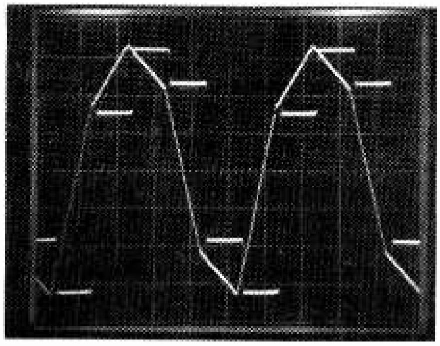
Fig. 4. Crystal oscillator and dividers, with gating for selection of final clock frequency.



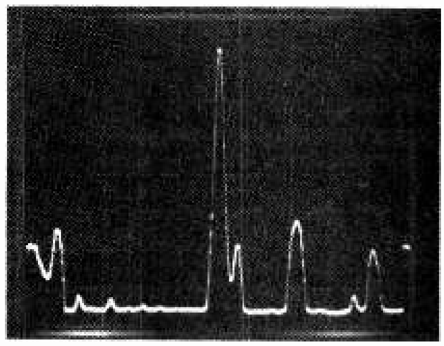
If an input step of 2V is now received, the output from IC_{25} will go to −2V, since it has unity gain. After approximately 2.5μs, which is the time allowed for settling, IC_{26} is strobed by a 0.5μs pulse, the storage capacitor being charged to −2V, and is fed via IC_{27} to the integrator, which is made to perform a positive-going ramp at a rate determined by the −2V and the timing components $R_{50\text{-}52}$ and $C_{31\text{-}40}$. Since the storage capacitor imposes a heavy load whilst charging, a reservoir capacitor, C_{24}, is connected from the output of IC_{25} to 0V to supply the current during the strobe time.

The integrator output voltage is shown simply in Fig. 6. Input current I_{in} = fed-back current $-I_F = V_{in}/R$. $V_c = Q_c/C$ and $Q_c = I_F t$, therefore $V_c = -I_F t/C$. But $I_F = V_{in}/R$, so $V_c = -V_c = -V_{in}t/CR$. CR is chosen to equal the same period t, so that $V_0 = -V_{in}$ by the end of the sample period, and therefore the integrator output = +2V.

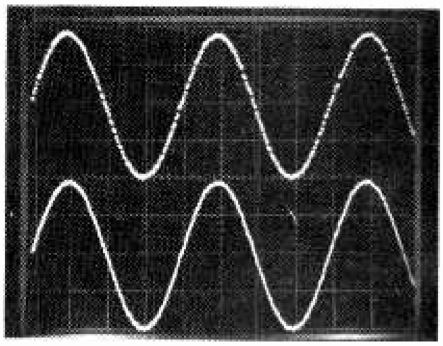
If the second sample is also +2V, the output of IC_{25} will be (+2) − (+2) = 0V, i.e. there will be no difference between the two inputs. After the next strobe, 0V will be presented to the integrator input and, since $I_{in} = 0$, I_F must also be zero, and the output will remain at +2V. A third sample of −1V will make IC_{25} output (=2) − (−1) = +3V. This, when fed to the integrator, will cause it to fall linearly by 3V from +2V, resulting in a



The action of the step eliminator, using a waveform with a fewer number of steps than normally seen to illustrate the effect. The result of inaccuracy in the choice of integrator capacitors can be seen. Frequency in was 40kHz at 200 kHz sampling rate. Oscilloscope sweep 20μs/div., storage unit speed 2ms/div.



Pre-trigger of 5 divisions (graticule very faint). Large pulse is trigger.



Typical trace at 100 samples per cycle of the input.

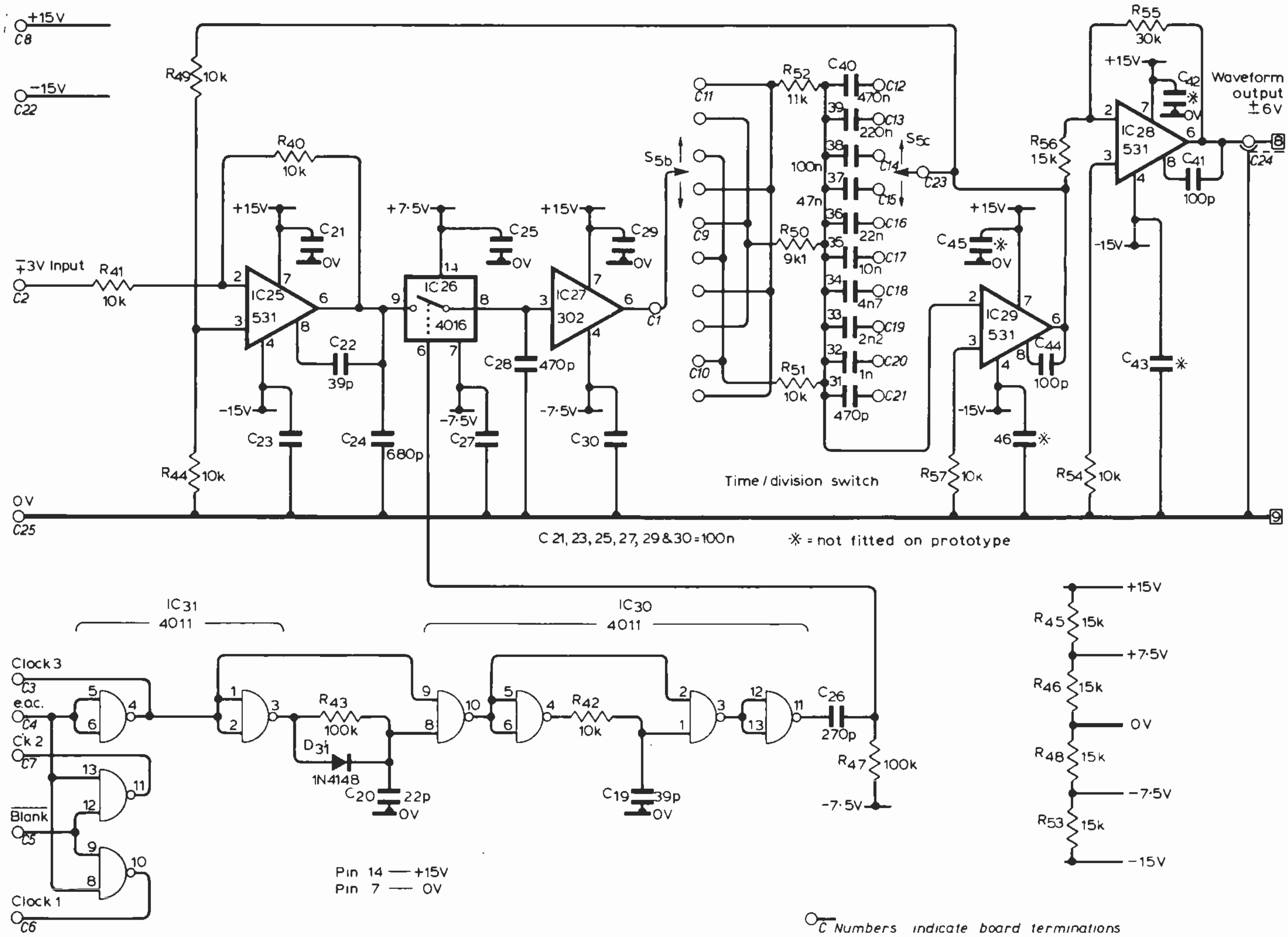


Fig. 5. Step eliminator and output amplifier. The faster ranges of the integrator should have close-tolerance capacitors to achieve the correct slopes.

voltage of −1V by the next strobe pulse. Photograph 1 shows the resulting effect, the slight errors in levels being due to the timing components not being selected for the correct time constants.

The input to the analogue gate is limited to slightly less than the supply voltage to the device. For the bipolar inputs required by the integrator, IC_{26} is operated from a ±7.5V supply. Thus, for safety, the input is limited to ±6V. This, in turn, limits the d.a.c. and integrator outputs to ±3V since, if both were at opposite extremes, the resulting output from IC_{25} would be ±6V.

Strobe pulse generation. The circuit, $IC_{30\text{-}31}$, consists of a positive transition detector, following an inverter, which gives a positive transition approximately 2.5μs after the negative-going edge of the e.o.c. pulse. This delay

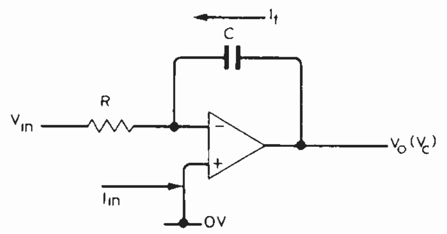


Fig. 6. Derivation of the integrator output voltage.

is required to allow for the data to emerge from the memory, the d.a.c. to settle and to allow the output of IC_{25} to charge C_{24} after the step input. The first positive transition detector is followed by a second one which gives a low going 0.5μs pulse after the positive going edge of the previous stage. Level shifting of the 0 to +15V pulse to −7.5V to +7.5V to be compatible with the gate IC_{26} is by capacitive coupling in C_{26} with a pull down to −7.5V by means of R_{47}. For use with oscilloscopes with 8 divisions horizontally the 1.8MHz crystal, which gives 1,000 samples in 10 divisions at 0.5ms/div., may be replaced with one of 2.25MHz or 1.125MHz. The former gives 1,000 samples in 8 div. at 0.5ms/div. and the latter 1,000 samples in 8 div. at 1ms/div. The higher of the two may be too high for the a-d converter to operate reliably, and the lower reduces the unit time/div. ranges to 9. The time constants of the step eliminator will need to be reduced from 5 to 4μs, 10 to 8μs and 20 to 16μs and their decades (330 + 69, 680 + 120pF, 1500 + 100pF used with 10kΩ).

Printed circuit boards

A set of four double sided p.c.bs is available, at £14.00, including postage and packing, from M. R. Sagin at 23 Keyes Road, London N.W.2.

Mobile radio users campaign for more frequencies

FOR THE FIRST TIME in its twenty-five-year history, the Mobile Radio Users' Association (MRUA) is mobilising its membership to begin battle for the allocation of more frequencies for mobile radio. Warren Taylor, head of the MRUA, believes that, because the number of UK companies now switching to mobile radio is rising annually by more than fifteen per cent, the direct industrial and economic benefits from mobile radio could be tripled in the next five years. "Unless the whole business grinds to a halt in the next eighteen months," he says.

The results of a number of independent surveys, which have estimated that private mobile radio systems currently in use by British industrial and commercial organisations are providing direct savings in the region of £200 million each year, give an idea of what these economic benefits could be.

MRUA members, who include organisations ranging from multinationals like Shell and IBM to local mini-cab operators throughout the country, met in Bristol during July for the first "Freedom of the Air" Conference, to begin to build an international claim for more frequencies.

The Conference Bulletin, released in August, said that it was unanimously agreed that any restrictions, because of lack of frequencies, in the use of mobile radio would seriously affect the competitiveness of British industry. It said, "The UK economy requires free and unfettered use of enough spectrum to cope with industry's demand until the 21st century. The mobile industry had to succeed in deterring Governments (nationally and internationally) from increasing use of spectrum by broadcasting. It was essential that the broadcasting authorities give up duplicated and wasteful use of Bands I, II and III. These would provide enough spectrum to secure industry's use for the next decade".

It was put to the Home Office that the Users' Association might better handle the problems of users where frequency congestion and interference occurred. The Home Office said that it would consider this and reply shortly. It was unanimously agreed that the Home Office, the Department of Trade and Industry and other Government Agencies should be asked to agree in writing to the extension of the spectrum for industries needs in the field of mobile radio communication.

In addition, according to the Bulletin, the radio manufacturers agreed to assist the users in strengthening the lobby for national and international recognition of the importance of mobile radio in industry. The Officers and the Committee of the Users' Association were asked to attack the inertia and apathy of the Government in not recognising the importance of mobile radio to their industrial strategy.

One result of the Conference was that it was decided by the Committee to expand the Users' Association by appointing a Technical Consultant and a permanent Secretariat and to seek more help from all manufacturers and users.

The really important date for the MRUA will come in 1979 when the WARC is held in Geneva. About this, Mr Taylor said before the Conference, "We are determined that our representatives at the World Conference will be in the strongest possible position to make a greater claim for more frequencies for private mobile radio use than has so far been proposed. Our research has shown quite clearly that even ten per cent annual growth in the use of mobile radio in this country will shortly exhaust available channels."

British Post Office telecommunications compare unfavourably with overseas — Government White Paper

THE GOVERNMENT'S White Paper on the Post Office, published in July, agrees with the Carter Committee that efficiency in the British Telecommunications service appears to compare unfavourably with some of the highest standards attained overseas. "There is, indeed, much to be achieved in improving the quality and efficiency of the basic telephone service and of data communications links for industry and commerce."

To improve this situation the paper suggests that "the basic aim must be to achieve reduction in real unit costs through increased utilisation of existing assets and through more efficient methods of working with new equipment." The Government has agreed with the Post Office that it would be reasonable, taking 1977-78 as a base, to look for a general reduction in the real unit cost of the telecommunications services of some five per cent per annum over the five years to 1982-83.

The Government has also encouraged the Post Office to move as rapidly as possible towards the next generation of equipment, including computer-controlled exchanges integrated with economical systems of transmission. All of these developments are being brought together in the System X programme, intended for introduction in Britain in the early 1980's (see News, p51 Sept. '77, and p72 June '78), and the Post Office is giving this programme the highest priority.

The paper also referred to another White Paper on the Nationalised Industries, which envisaged that the industries would select a number of key performance and service indicators, including historic series and valid international comparisons, and publish them prominently in their annual reports. The Post Office paper then suggested that it was important that the Post Office, as a monopoly, should demonstrate to the public that it was using its vast resources efficiently to provide the best possible service at the lowest prices. Relevant information is now being compiled by the Post Office, who intend to make a start on this in their forthcoming annual report, and the Government is welcoming their decision to publish, each quarter, the key national and regional statistics on telecommunications performance.

LETTERS TO THE EDITOR

PREPARATION FOR WARC 1979

Your comment in the July issue (page 47) on the Home Office Radio Regulatory Department's publication "Preparation for the World Administrative Radio Conference 1979" omitted to emphasise that the proposals discussed in the report are stated to be still "tentative." (The word is repeated several times in the document.) There is a promise that the UK's formal submission might be published in the spring of 1979.

That admission that our national stance is not yet finalised may give some hope to those who believe that the summary does not, as it states, "represent a balanced . . . plan for all frequency bands." But the time left for a true comparative evaluation of the relative value, to the nation, of alternative uses of specific parts of the spectrum is now terribly short. One may, therefore, doubt whether this or any government can now assess that balance in time.

Referring only to the mobile radio use of frequencies, the Home Office offical view (that an additional 70-90MHz will be required below 600MHz to satisfy the demand for civil land mobile services up to the end of the century) is not supported in their proposals by any firm plan to make it available unless Bands I and III are given up by the broadcasting service. On the one hand, several contributors suggested the 70-90MHz should be more than 100MHz. On the other hand, the broadcasters submit that they not only want to keep Bands I and III but also to extend Band III and to extend Band II at the expense of mobile radio.

When does the nation have a chance to choose between double coverage on radio and television and fuel and cost saving? Do even our representatives in Parliament have a debate planned on this issue so vital to our future? Which will we go for at WARC?

Perhaps the root cause of the absence of any analysis of such issues is the tendency for politicians to take the easy way out by reacting to the most powerful lobby, and then only on those issues which the voting public can fully comprehend. Thus, there are no unbiased and accepted, economic and sociological value analysis criteria for spectrum usage, and no careful weighing of conflicting use proposals. Yet, unlike other natural resources to be managed, there will be no new spectrum 'finds' to ameliorate wastage.

J. W. Carlton
Pye Telecommunications Ltd
Cambridge

DISCRIMINATIVE METAL DETECTOR

The problem of distinguishing between ferrous and non-ferrous metal (July issue, p.43) is not quite as straightforward as it looks. To the search coil of a metal detector a piece of iron looks like a combination of two things: first, a loosely coupled 'short-circuited turn', since it conducts and loads the circuit, and secondly an iron core, since it has permeability which tends to increase the effective inductance of the coil. These effects oppose one another so the response of a detector to a piece of iron depends on their relative strengths. A detector operating at 100kHz or more is likely to 'see' iron more clearly by its conductance than its permeability, in which case it is not distinguishable from non-ferrous metal.

The present generation of metal detectors of the kind used by 'treasure hunters' attempts to solve this problem by means of a much lower operating frequency. Frequencies down to about 1kHz are in fact used. The permeability of a piece of iron is effectively greater and usually predominates over the conductance.

Working at audio frequency rather than a low radio frequency brings an additional bonus. At 100kHz, skin effect restricts current flow to the outside layer of metal, and all pieces of metal tend to look similar, if they are the same size and shape. At audio frequency current penetration is much greater; a piece of silver paper the size of a coin is 'seen' by the search coil as an object of lower Q. In the more sophisticated type of 'discriminator' detector this difference in Q is translated to a distinctive difference in the way the detector responds, and the 'treasure hunter' combing a holiday beach for coins can then avoid the time-wasting process of digging up endless ice cream wrappers etc.

There is, however, a continuing problem in the shape of the 'ring-pull' from a can of beer. This is aluminium and high-Q. A detector set to ignore it will also ignore valuable objects such as low-carat gold rings!

George Wareham
London WC2

Dr Macario's article on a metal detector (July issue) does not give the inductance of the search coil or the tuning capacitance but refers to Mr Waddington's, which I looked up. There the inductance is again not given so I assumed a diameter of 6 inches and a length of ½inch, and, using Nagaoka's constant, found an inductance of 680μH which with 500pF tunes to 250kHz, not 120kHz as stated by the author.

I wound the coil on a disc cut with a pocket knife from scrap polystyrene and the measured inductance agreed with the calculated. I then worked out the resonant frequency of the 625kHz oscillator and I found that it does not tune to 625kHz.

I have built several coils and cannot make the oscillator run anywhere near 125kHz except by adding about 2000pF.

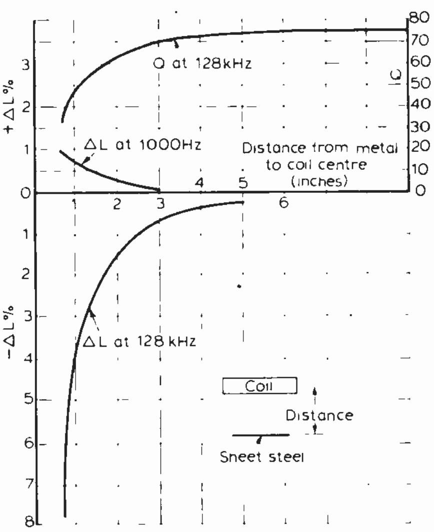
I used two different coils in the 625kHz oscillator. Mine runs at 750kHz.

The Waddington detector does have Home Office approval so it must work at the correct frequency.

The Macario oscillator has a lot of drive and a rough calculation indicates an r.f. voltage much larger than the supply voltage which is not possible with protective diodes on the c.m.o.s. input. The actual oscillator has a poor waveform because the tuned circuit is driven hard into the diodes. I could not deduce the actual oscillator frequency so I increased the capacitance to about 2400pF giving 130kHz.

All this has nothing to do with the point I originally intended to make, which is that I cannot see how the Macario detector can tell the difference between ferrous and non-ferrous metals. Over many years I have used a Q meter to measure r.f. coils mounted on a ferrous or non-ferrous chassis and I have always found the inductance is reduced by the proximity of any metal except, of course, dust iron or ferrite. The reason is that steel, which has magnetic properties increasing inductance at low audio frequencies, is a conductor and the eddy currents reduce the effective inductance. Which effect is more important depends on conductivity thickness and frequency.

The accompanying graph shows the change in inductance when a thin steel sheet (5½in x 3in, from a Polaroid film pack) is moved near the coil. Measurements of inductance were done both at 1000Hz and 128kHz. At 1000Hz the inductance increases slightly but at 128kHz there is a large change in the opposite direction. I have tried rusty steel. One piece increased the inductance, the rest decreased it.



My friends in the Chemistry Department cannot predict which oxide will be formed because it depends on the available water and oxygen. Most of the oxides will be non-magnetic but some magnetite might be formed and the remaining iron could be so divided that the eddy currents would be reduced. This would increase the inductance.

At 1000Hz it would be possible to make a detector to discriminate between ferrous and non-ferrous metals but not at r.f. using the beat frequency method of the Macario detector.

Another point concerns "pulling." When two oscillators work at nearly the same frequency one pulls the frequency of the other and they lock unless they are completely separate. In this case they are on the same circuit board and I am surprised to see that they can be adjusted to within a fraction of a Hz of one another. I built the Macario oscillator and set it up to give a Lissajous figure to check for locking. With 9 volts peak-to-peak from a signal generator (Marconi TF867) the exposed output lead (about 3 inches and a croc clip) was 4 inches at the nearest point from the oscillator. It locked over a range of about 12Hz.

Whether it locks on the complete detector will depend on the precise layout. If C_{14} and its wiring goes within a few inches of the 9-volt 120kHz reference from IC_7-point B, for example, it will lock.

There is other evidence for locking. When I removed the signal generator to avoid locking it was almost impossible to keep the Lissajous figure stationary because hand capacitance causes a shift of several hertz. After bringing the figure to rest, removal of the hand causes the figure to rotate. The oscillators should be in a screened box, not a plastic box.

If the two oscillators are free-running and the l.e.d. display is stationary this implies an oscillator stability and an accuracy of adjustment of a part in a million, which seems unlikely in a portable oscillator on the end of pole. Although I have not built the complete detector I am reasonably certain that the oscillators are not free-running but are in fact phase locked, not by design but by accident.

One last point, an l.e.d. display is almost invisible in sunlight.

M. D. Samain
Electrical Engineering Department
University of Salford

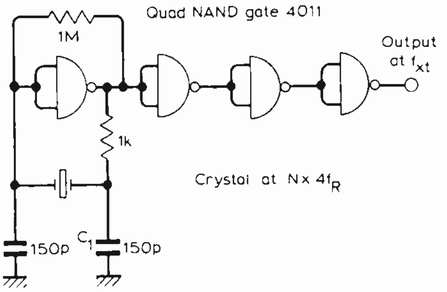
Dr Macario replies:
The letter by M. D. Samain is of importance as it outlines points which have been raised by a considerable number of other readers following my article in the July issue. Actually, the article was originally entitled "A different metal detector"; the word "discriminative" came in later, but as Mr Samain points out this is a much more complicated matter than just one word in a title allows. I did make it clear in the text that "the potential to differentiate exists . . .", and I would be interested to hear of any comprehensive reference on the effects of various small metal objects in the vicinity of a search coil. I did make a brief reference search at the time but without success.

I had also made a few simple tests at 85kHz and noted the following:
1. Small solid brass/iron objects can be discriminated as theory suggests.
2. Large metal objects, such as Samain uses, cause a lowering of inductance due to eddy currents.
3. Small metal objects with holes such as washers act as a shorted turn and are not necessarily discriminated.
4. The orientation of a flat object with respect to the plane of the coil can alter the above findings.

I will return to the idea of using a lower frequency later.

The next point is that of not showing the coil inductance and tuning capacitance. The coil shown in the photograph in the article was a Waddington coil provided by a colleague and was simply tuned to 125kHz and/or 85kHz for test purposes. The capacitance C_1 used had to be much larger than that given by Waddington. The sensitivity of a metal detector may well depend on the number of the turns in the coil, rather than its inductance being matched to a particular tuning capacitor, and this is another area of useful investigation. The only data available to us at the present time is Waddington's.

The choice of inductance, tuning capacitance and frequency also affects the best ratio of feedback capacitors C_3:C_4:C_5. As the frequency is lowered they should all be made correspondingly larger. Then increase C_1 to obtain a good sinewave at the oscillator input. An excellent sinewave of about 2V peak-to-peak is available. A square wave



occurs at all other outputs except at the input of C_3.

Although the voltage swings of the two oscillators are large, in fact equal to the supply, the current is very small, and locking of the two oscillators is minimal. This is partly due to the use of a double sided p.c. board (which is always good practice when dealing with r.f. circuits) while all the components are inserted tight to the board. The board size shown in the article is, however, about the smallest one can use in practice. The circuit is also balanced and therefore the supply current remains constant for all phases. Actually, the circuit does just show a tendency to lock within the nearest Hz. This is useful in a way, because the display has a chance to settle down. Two improvements are: (1) put 10kΩ between points A and A^1, (2) place the earphone outlet between Q and $\bar{Q}$ of either 4013 output in series with 22kΩ.

This brings me to my main point which is that, like Mr Samain, I am extremely doubtful of the long term practicality of building an LC oscillator of very high stability with the inductor being waved around at the end of a pole. I did discuss this briefly in the article and put forward some ideas for experimentation. However, let us look at the question of going to a lower frequency again. If, for example, a detected object which caused a 10Hz change in frequency at 100kHz, only caused a 1Hz change at 10kHz, the sensitivity problem is not solved. However, if the change was 2Hz because there were more turns on the coil etc., then an improvement would result. As I said earlier, some information in this area is needed – at least by me.

Finally, the detector described is sensitive in theory to a change in frequency of ¼Hz in one second. This sensitivity can be increased by making the reference oscillator frequency $4f_R$ a multiple of this frequency, i.e. $N \times 4f_R$. For example, using a coil at 30kHz requires $4f_R$= 120kHz. Making this a crystal oscillator running at 1.920MHz makes the detector eight times more sensitive (and also to variations of the search coil). A suitable crystal oscillator (stable to within 1Hz) is shown in Fig. 1. This uses a quad NAND 4011) or quad NOR (4001) device as already available in my detector, and replaces the reference oscillator. The frequency is set by adjusting capacitor C_1.

R. C. V. Macario
University College of Swansea

BICYCLE DYNAMOS

The "Circuit Idea" of Mr B. J. Pollard in the June issue entitled "Standby battery for dynamo lighting" gives a quite remarkable idea of the common bicycle dynamo.

These devices are variable-speed single phase alternators with rotating permanent-magnet field systems, output being taken from a stationary coil system. The output rating is typically 6 volts 0.5 amp.

The stator generated e.m.f. is basically proportional to the speed of rotation of the field, as is also the frequency of the generated e.m.f. When the road speed of the bicycle increases, the voltage applied to the lamps and the current through them hence tends to rise.

The complete dynamo lighting set is however designed so that the main factor controlling the magnitude of the alternator output current is, at speeds above say 8 m.p.h. or so, the inductive reactance of the stator circuit. When generated e.m.f. and frequency increase, so does the reactance. The terminal voltage of the alternator is arranged to rise only to 7-7.5 volts on load even at 30 m.p.h.

Forty years ago the Philips concern designed a new cycle dynamo with an 8-pole rotating magnet, an excellent effort, and published an article about it in the *Philips Technical Review* which explained the principles of design involved. Since then I would have thought that nobody could be in doubt about cycle dynamos. Those curious should measure the *open-circuit* output voltage with an Avometer while riding the bicycle at various speeds on the road.

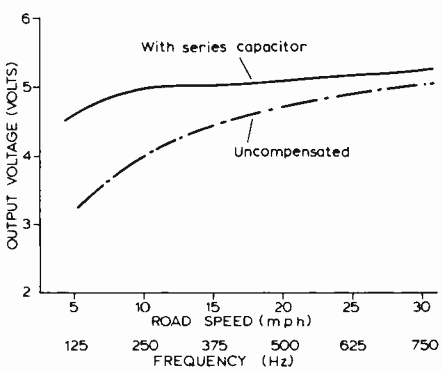
Mr Pollard says that the typical output of "a bicycle dynamo" is "around 4.5V r.m.s." The usual reason for low output voltage is that investigation by an inexperienced person has reduced the magnetism of the rotating field magnet. To bring the output voltage up by putting series capacitance in the output circuit, thus vitiating the voltage regulation built into the original design, is quite absurd.

P. Short
University of Newcastle-upon-Tyne

Mr Pollard replies:
I wonder if Mr Short rides a bicycle with a dynamo, as I do, or better still, has taken the trouble to notice the almost uniformly poor efficiency of dynamo-driven cycle lighting, particularly at city-centre speeds of around 10 m.p.h.

I have owned two bicycle dynamos, both manufactured by H. Miller & Co. of Motherwell. The first, purchased 18 years ago, produced an output which rose inexorably with increasing speed and regularly burnt out the tail lamp at speeds of over 20 m.p.h. The second, purchased a year ago, is much better behaved. Its rated output seems a little uncertain: the instruction book quotes 5 volts 3.6 watts, while on the dynamo itself is stamped just "6V". The lamps supplied are 6V 0.5A and 6V 0.04A.

The actual output voltage of this second model (into the correct load), measured with an Avo at various road speeds is shown in the accompanying graph and compared with that obtained when the series capacitor is in



circuit. The capacitor produces a marked improvement in the voltage regulation at speeds above 3 m.p.h. and its use does not seem to me, therefore, to be "absurd" at all.

I have never dismantled either dynamo, but I carried out some measurements on the "modern" version – with the bicycle stationary I might add! – and the results are summarised below. The dynamo source impedance (i.e. the stator impedance) at any particular frequency is somewhat dependent on the current used to measure it, and the figures given are for a 35mA drive which is only 6% of the normal output current, but nevertheless serves to illustrate that this dynamo is not quite as simple as Mr Short would like to believe.

Frequency (Hz)	Equiv speed road (m.p.h.)	R^*_{ac} Ω	L (mH)	Z (Ω)	φ	O/c Output (V)
125	5	4	8	7.5	55	8
250	10	6.5	6.5	12	60	13
375	15	8	6	16.5	60	17.5
500	20	8.5	5.5	20.5	65	21
750	30	11.5	5	26	65	28

$^*R_{dc} = 2.5\,\Omega$

Varying the position of the rotor did not significantly affect any of these measurements.

There is a good deal of loss resistance in series with the winding inductance; furthermore, both the open-circuit output voltage and the internal impedance modulus ("Z") are almost precisely proportional to $(\text{frequency})^{0.7}$

I find the index of proportionality of 0.7 instead of the expected unity rather puzzling. I wonder if any of your readers have an explanation for this?

Brian Pollard
Coventry

ELECTRET RADIATION DOSEMETER

The report in the June issue News of the Month (p.45) concerning the electret detector as a personal dosemeter and alarm described what may be a device of value to those engaged in work with radioactive materials. However, some of the terms employed are confusing since they are not, to my knowledge, used in English-speaking countries. The "stylodosimeter" presumably refers to a quartz fibre electrometer and "flowmeters" to dose rate measuring instruments. The reference to radioactive contamination is surely misleading; the device appears to measure radiation exposure, a totally different and not necessarily related quantity.

The triggering threshold range quoted for the device (1-40 rem) makes it rather insensitive compared with those currently employed and this could well prove a limitation to its use for dose control at the low levels presently achieved.

With regard to the general tone of the report and the suggestion that the use of the device will reveal any official cover-ups of radiation exposure, it should be pointed out that there are strict legal limitations on radiation doses received by workers. The exposures of all workers are recorded and there has, for a long time, been a clear legal requirement for these records to be freely available for inspection by the employee concerned. The measurements on which these records are based are required to be made by Government-approved laboratories.

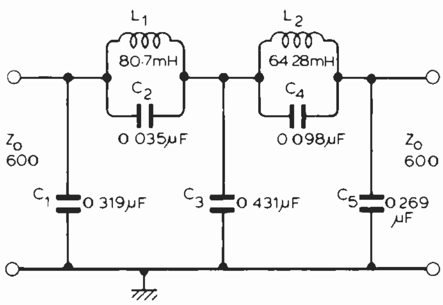
In these circumstances it is difficult to see what purpose would be served by illegal acts of concealment and I believe that it would be difficult to find an informed critic of the nuclear industry who would seriously think otherwise. There may be genuinely felt concern about a nuclear future in some quarters but dose concealment is not a significant factor in this in the United Kingdom.

G. C. Meggitt
UK Atomic Energy Authority
Safety and Reliability Directorate
Warrington

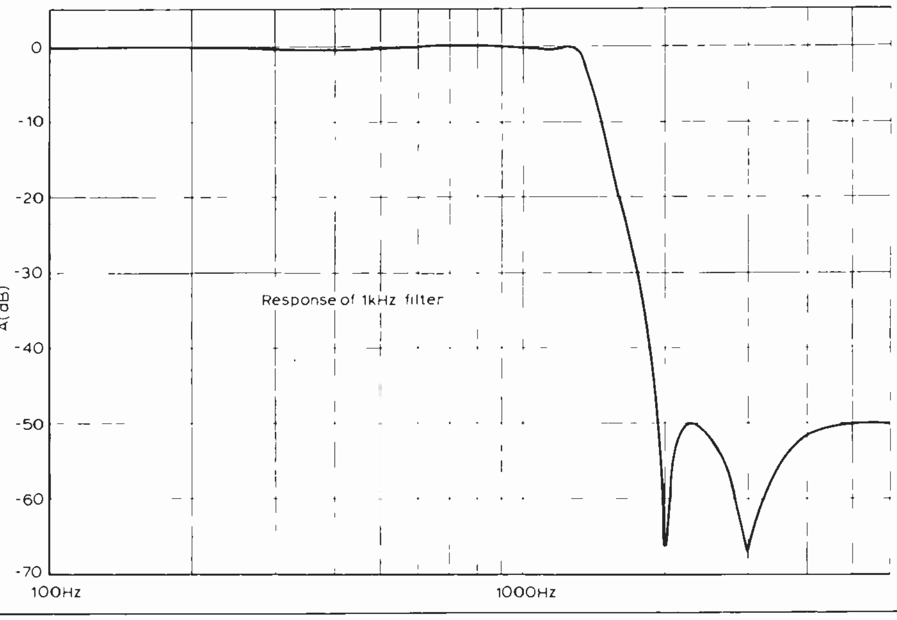
1kHz SOURCE CLEANING FILTER

In your July issue J. Vanderkooy and S. P. Lipshitz underlined the difficulty of generating a sufficiently pure sinewave for measuring the distortion of modern amplifiers.

A frequently used method of obtaining a pure waveform is to employ low-pass filters to remove unwanted harmonics from the oscillator output but this is very expensive if a wide range of frequencies is of interest. Readers who are satisfied with a spot check made at 1kHz only may be interested in a 5th-order Cauer low-pass filter designed for this purpose (see accompanying diagrams).



L1 253 turns 28 swg 35mm VINKOR LA1211
L1-C2 Tune to 3kHz
L2 226 turns 28 swg 35mm VINKOR LA1211
L2-C4 Tune to 2kHz



Economy of design has been achieved by carefully positioning the peaks of attenuation so they coincide with the second and third harmonics. In this way a "50dB" filter may be made to attenuate both these frequencies by 65dB, and all higher harmonics by at least 50dB.

J. A. Hardcastle, G3JIR
Huyton
Liverpool

SPELLING FOR TECHNICAL JARGON

I have read with growing frustration the correspondence in your journal on the spelling of programme, or is it program?

It will obviously come as a great surprise to all your correspondents that the OED (surely the final arbiter in any dispute between English and American) clearly states that the form 'programme' was a reintroduction from French in the 18th and 19th centuries. It has since ousted the preferred form 'program' which was the correct English prior to this. It also displaced the alternative, and presumably more etymologically-correct, form 'programma' — a straight transcription from Greek.

It seems that there was (and still is) a misplaced snobbery in the attribution of foreign characteristics to English words without good reason. Surely few of the proponents of the 'me' version are habitual recipients of telegrammes or readers of circuit diagrammes.

Technical jargon necessarily contains many newly-invented words of dubious pedigree, and it is a mistake to attempt to make them conform to inappropriate grammatical rules. The correct form of spelling and pronunciation is that which is accepted in this context, otherwise the purpose of jargon — clear communication — is negated. Even so, dual standards will and do occur. I wonder if an uninformed reader of your journal would be able to deduce a single clear definition of 1K. Is it 1000 or 1024? It depends on context although it is not unknown for both meanings to be used within a single article. 2.4% is not a large tolerance in a resistor, but if one is dealing with integers it is beyond the pale. For the informed reader there is little chance of serious error in this particular case.

A language is a living entity; it would be a serious disservice to English to try and fossilise it like a fly in amber (elektron in Greek – but that is another rabbit).

J. E. Chester
Wavertree
Liverpool

Editor's note: By current convention, the lower-case letter 'k' (abbreviation for 'kilo' in SI units of course) stands for 1000, while the upper-case form 'K' has been adopted for 1024 ($= 2^{10}$).

DIVIDE-BY-THREE CIRCUIT

With regard to the letter from Mr D. Stuart Smith (August issue), I feel it must be pointed out that his claim that his novel divide-by-three circuit produces an accurate unity mark/space ratio is misleading. In fact, this will only be true if the input waveform itself has a unity mark/space ratio.

As Mr Stuart Smith shows in his waveform diagrams, the exclusive OR function results in the transitions in the output of Q_2 being alternately synchronous with the positive and negative edges of the input signal. Therefore the mark/space ratio of the output must be proportional to that of the input.

Of course, one could take steps to ensure unity mark/space ratio of the input waveform but that, in principle, is the same as using a conventional divide-by-three and modifying the output, as in Mr Eaton's original Circuit Idea (June issue).

K. Clayson
Merstham
Surrey

TRI-STATE DEVICES IN LOGIC SYSTEMS

Messrs. Catt, Davidson and Walton in "Interconnections of Logic Elements" (June issue, page 62) made the following statement: "Any function which is possible with tri-state devices can be more easily implemented with open collector t.t.l. Tri-state is an unfortunate development caused by the misunderstanding of the requirements for transmission line driving."

By definition open collector devices require a collector load which would take the form of resistors on the bus, introducing more components, and more complexity. Catastrophic power dissipation caused by progressive collapse of tri-state devices is only partially relevant as most m.o.s. devices have current limited outputs preventing such failure. Surely all the design engineers of bus orientated microprocessors by Motorola, Intel, Texas, Zilog, etc., could not have misunderstood line driving requirements?

B. A. Hutchinson
Department of Electrical & Electronic Engineering
University of Newcastle upon Tyne

The authors reply:
Mr Hutchinson quotes two sentences from the article in which the following statements are made:
1. Open collector t.t.l. is a superior replacement for tri-state t.t.l. in all applications in which the latter is used.
2. Tri-state t.t.l. is an unfortunate development.
3. Tri-state t.t.l. is a product of the same wrong-thinking which originally led to t.t.l., *viz.* a basic misunderstanding of how to model the interconnection between logic gates.

Mr Hutchinson appears to be taking issue with (1) and (2) but he gives no reasoned argument for dismissing the discussion leading to (3).

His objection to (1) seems to be based on the assertion that tri-state t.t.l. requires considerably more components to implement a particular bus arrangement because of pull-up resistors. This argument is presumably based on the idea that each open-collector gate requires its own pull-up resistor. This is not so. Pull-ups are only required at each end of the bus connections (i.e. two places) where they serve as terminations matched to the characteristic impedance of the bus lines. These resistors would normally take the form of d.i.ps and hence represent small overhead in terms of cost, failure modes, etc.

Mr Hutchinson goes on to discuss protection of m.o.s. tri-state outputs against catastrophic failure. He may be correct. Our article, however, is concerned with t.t.l. and its variants and it was not our intention to make any assertions concerning m.o.s.; this would require a separate article. In the case of tri-state t.t.l., I have two communications from semiconductor manufacturers stating that the failure mode we described does exist.

His final argument, a variation on the theme of "So many people cannot be wrong," hardly requires an answer. Fortunately correctness or incorrectness is based, not on a democratic consensus, but on reasoned argument and experiment. We are prepared to demonstrate the validity of our conclusions before any scientific or engineering audience which Mr Hutchinson cares to assemble.

I. Catt, M. F. Davidson and D. S. Walton

MPU CONNECTOR PIN STANDARDIZATION

In my work at this laboratory on microprocessor development I have come across a pressing need for the professional standardisation of pin connections for Eurocard *indirect connectors*. I know from my contact with a number of organisations and companies that the need is urgent and that some initiative would be welcomed. Consequently, I have drawn up a framework for a proposal for standardisation which I am circulating to all interested parties for comment and suggestions. In brief, it is that the 96-way indirect connector should have rows *a* and *c* assigned standard functions and that row *b* be reserved for non-standard use. I am asking for preferences and suggestions from professional microprocessor users for the allocation of pin numbers to microprocessor address, data and control lines, serving principally the Intel 8080, 8085, 8086; Zilog Z80, Z8000; Motorola M6800, 6802, 6809, MOS Technology 65XX, which I see to be the most widely used devices and ones likely to afford most benefit when used with Eurocard and double Eurocard size boards under a standardisation scheme.

Would interested readers please write to me as soon as possible giving their views? I will then, in consultation with my professional colleagues, draw up a proposed standard, which I will distribute for approval, and, subsequently will submit to the relevant institutions (IEE, BSI, etc).

I believe the matter to be in need of urgent action (if we are to avoid the emergence of an unsatisfactory standard as has occurred in the USA with the S-100 bus). For this reason I will try to avoid a discussion of any but the most important aspects of the definition of the standard.

Paul L. Borrill
Mullard Space Science Laboratory
University College London
Holmbury St Mary
Dorking, Surrey

RADIO FROM 1917

Readers of your journal may be interested to know of the recent donation to the IEE Library by John Scott-Taggart O.B.E., M.C., F.I.E.E., of some seventy books on early radio, radar and electronics. These works, which valuably augment the Institution's already strong historical collections, are from both British and foreign publishers and date from 1917. A list of the books is available for those interested from the IEE Library.

John Gurnsey
Librarian
Institution of Electrical Engineers
London WC2

NOSTALGIA CORNER

It was good to learn from Mr E. J. Williams (Letters, August) that the record music sessions at RAF Yatesbury c. 1942 are still remembered with pleasure. Of course one could go on reminiscing indefinitely, but I do feel it should be added that also on the teaching staff at No. 9 'Radio' (actually r.d.f., now radar) School at Yatesbury was the now world-famous Arthur C. Clarke. He was distinguished from the other three Clark(e)s on the camp by the forename 'Spaceship', notwithstanding that this was before even the V2 gave a hint of things to come. It was, of course, Spaceship Clarke who in this journal back in 1945 first envisaged the use of geostationary satellites for worldwide broadcasting of television, now normal practice.

M. G. Scroggie
Bexhill
Sussex

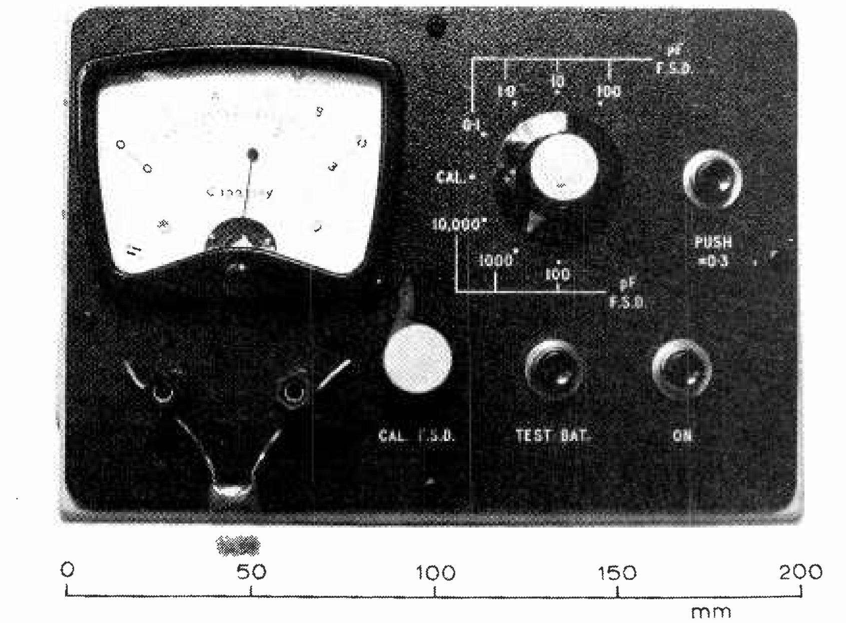
Capacitance meter

Measurement of capacitance in the 1pF-100μF range by the diode-pump principle.

by K. Holford, M.I.E.R.E., Philips Research Laboratories, Redhill.

A direct reading capacitance meter is described which has no balance controls to adjust. The range covered is from 1 pF to 100 μF with an accuracy of about 0.5 pF plus 3%. The lowest range is 0-30 pF. The indicator is a 100 μA meter.

The circuit requires a 9V supply and is intended to be portable. The electronics are simple, one integrated circuit and five small transistors.



THE BULK of commercial capacitor measuring equipment is based upon the use of sinusoidal voltages with bridges. For investigating the quality of capacitors this is fine. But where just a simple capacitor size selection is involved the process is elaborate. The balancing tedium is reduced with automatic equipment, but this is expensive.

The capacitor is, of course, a component for storing charge, $C = Q/V$, (farads, amp-seconds and volts respectively) and it is possible to make direct measurement of stored charge per applied volt (farads) rather than use the capacitor's reactance which derives from charge modulation brought about by applying a sinusoidal voltage. Indeed, equipments are now appearing based upon this concept, such as injecting a constant current into the capacitor and measuring the time it takes to achieve a predetermined voltage. The larger the capacitor the longer the time, in a direct proportional relationship.

The equipment is well suited to the measurement of large capacitors which can be difficult to measure by the reactance technique. It can be built using digital techniques including a clock for the time measurement. Other techniques can also lead to the design of simple equipment.

If an upper limit for the capacitor size is set at about 100μF and a 100μA meter is suitable as a display, the capacitors can be measured using a repetitive charging technique which involves applying only a few volts to the capacitor, the value of which can be read from the meter in terms of the current flow. Even a capacitor as small as 30 pF will produce a 100 μA reading, provided the charge repetition is made high enough, in this case about 1 MHz.

The scale of the meter is linear and there is no need of special calibration. A wide range of capacitors can be catered for by making use of a few widely spaced frequencies and by altering the meter sensitivity using shunts. Readily achievable measurement errors are about 3% plus 0.5pF. Capacitors can be matched as accurately as the meter can be read, say to within 1% with a reasonable size of meter.

The basic circuit is that of the diode pump [1] and is shown in Fig 1, where the charging and discharging of the capacitor is accomplished with a square wave drive voltage. The charge and discharge currents are separated by diodes, so that only one of these flows through the meter. The circuit description is simplified by assuming the square wave has its lower level at 0V and upper at +V. When the voltage moves from 0V to +V the capacitor charges round the loop including diode D_1 and the meter.

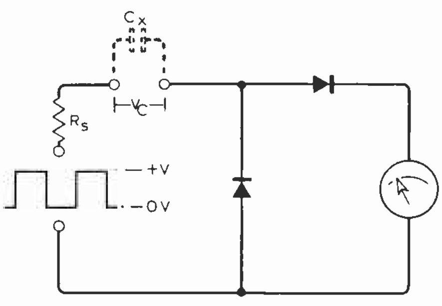


Fig. 1. Diode pump principle

The diode D_2 is nonconducting. It is intended that the capacitor obtains a substantially complete charge during this time. When the square wave returns to 0V the capacitor can discharge round the loop including D_2, with D_1 being nonconducting. The square wave input can be looked upon as a short circuit at this time since any current flow does not change the input voltage.

Thus, the meter has only the charging current flowing through it and the nature of a moving coil meter is to average the current flow. Current flow multiplied by time is charge and the current is therefore a measure of the size of the capacitor. It only remains to apply a suitable scale factor to allow for the number of volts being used and the number of times per second the capacitor is being charged. A capacitor able to deliver or absorb a current flow of one amp for one second while showing only a voltage change of one volt has a capacity of one farad.

By making the number of charges per second large the instrument will measure small capacitors. The large capacitors are charged less times per second in order to keep the current down to a manageable amount. But not so low as to cause excessive meter pointer jitter.

With capacitors as large as 100 μF the meter sensitivity had to be reduced to a full scale reading of about 2mA in order to comply.

The objective of the design is to have a linear scale and so the voltage change across the capacitor during charging and discharging must be independent of the particular size of capacitor being measured. Thus, a doubling in capacitor size must result in twice the charge. The resistance shown as R_s in Fig. 1 must be small enough to ensure that even the largest capacitor can be charged to within a small percentage of completion within the time allowed by the square wave. The choice of square wave frequency is a matter for design and calibration and will be returned to later. But first some of the characteristics which are not of prime importance.

The square wave, for instance, need not be particularly square or have an equal mark-space ratio. But it should move between well defined voltage levels and have a flat top and bottom of sufficient extent to allow for substantially a full charge and discharge of the capacitor; 1% loss of charge voltage means a 1% low current reading. The square wave may have some ringing, say after changing from one level to the other, but must settle before the capacitor charge is complete to avoid over charging. The single polarity nature of the applied voltage will not be conducive to a mini-charge-discharge process during the ring unless the ring amplitude is very large. Finally the direct voltage associated with a square wave is not very important. Any d.c. is blocked by the capacitor after the first charge and plays no part in subsequent measurement. The d.c. level may need to be kept small however, to enable low voltage rated capacitors to be measured.

Improved circuit

The circuit of Fig. 1 has the disadvantage that the meter is in the capacitor charging circuit and its series resistance or inductance could affect the accuracy of a measurement, particularly at high frequencies with small capacitors. The diode feeding the meter can be replaced with the emitter-base junction of a transistor and the meter transferred to the collector circuit, as shown in Fig. 2.

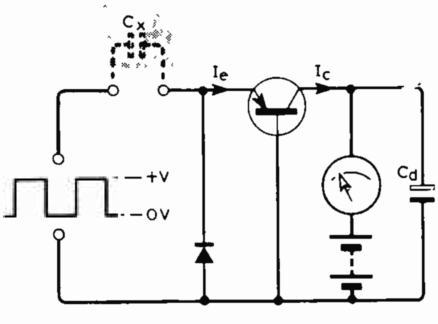


Fig. 2. Transistor isolates the meter circuit from the capacitance

Collector current is not quite equal to emitter current but with modern, high h_{FE} transistors the difference is small and easily taken out in calibration:

$$I_c = I_e h_{FE}/(1+h_{FE}).$$

For instance if h_{FE} is only 49 with collector current is only 2% less than the emitter and if h_{FE} changes 10% with temperature the calibration error is a mere 0.2%. Clearly there are more important matters.

In Fig. 2 the collector is decoupled with C_d which avoids effects due to meter coil inductance and Miller/Blumlein feedback reducing the transistor frequency response.

Also the circuit is tolerant of appreciable meter series resistance which means that the shunts which control the meter sensitivity can be made from convenient value resistors, as in Fig.3.

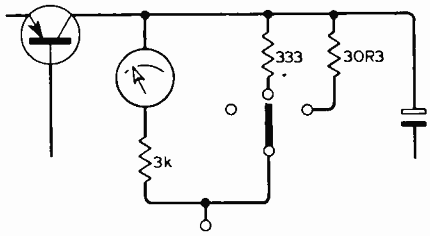


Fig. 3. Meter sensitivity switching. Tolerance to meter resistance allows the use of shunts of reasonable values – in this case chosen to give 0.1, 1.0 and 10mA.

The electrolytic decoupling capacitor C_d needs a low leakage if the equipment is to be of the highest possible accuracy. For instance, if this were 2μA and the meter 100μA, then 2% of the meter reading may be time-dependent as the capacitor polarises. It is not difficult to find selected tantalum capacitors with a leakage current below 0.5μA in the size required.

Square wave voltage. Referring again to Fig. 1 it can be seen that the voltage drop across the diode D_1 reduces the amount of the square wave voltage applied to the capacitor and that across D_2 allows voltage to remain on the capacitor when it should ideally be discharged. However, as long as the required *voltage change* occurs across the capacitor, the measurement will be accurate and the square wave voltage can be increased to allow for the diodes. A voltage increase of 1 volt for the two silicon diodes is about correct since, if the equipment is being designed to be accurate, the capacitor must be substantially fully charged and discharged, and so the voltage increase required is that corresponding to a small diode current.

Another concern is that the voltage used to charge the capacitor shall be large enough to swamp any change in diode voltage with temperature. For indoor use the equipment is not likely to be subject to great temperature change and an allowance of ±20°C will be more than enough. Such a temperature range would cause a diode voltage change of about ±40 mV for each diode. Thus a square wave voltage of 4V pk-pk, plus another 1 volt for the diodes, should keep the effect of this upon calibration to 1% per diode. This 5 volts can be provided by a 9V transistor radio battery and is also small enough not to exceed the rating of most electrolytics. Thus the equipment should have a wide application.

Square wave source resistance. The square wave generator must be able to supply an adequate current to charge and discharge the capacitor in the time available, and this imposes constraints on the allowable source resistance. Assuming, in Fig. 1, that all the resistance can be lumped as R_s, the charge law is:

$$V_c = V_s(1-e^{-t/CR_s}) \quad \ldots (1)$$

With an infinite charging time the term e^{-t/CR_s} goes to zero and the capacitor voltage V_c attains the voltage V_s. With a time t equal to $4CR_s$ the term accounts for a 2% loss of charge. The capacitor will also not discharge by 2%. Thus compared to an infinite charging time there will be 4% less charge change and 4% lower current reading on the meter. If C is reduced the error reduces, but the error is not linear and cannot therefore be compensated by simply increasing the voltage.

The equation can be used to examine whether R_s is likely to be a cause of error in a completed equipment since the error with an increase in C or R_s grows rapidly; 2.7 times for a factor two increase in C and 7 times if C is increased four times.

The current flow through the meter in Fig. 1 is given by:

$$I = CVf \quad \ldots (2)$$

where I is in amps if C is in farads, V in volts and f is the number of charges per second.

Assuming a 30 pF capacitor and a full scale reading of 100 μA, together with an effective square wave voltage of 4 volts, the frequency f works out to be 833kHz. For a 100 μf capacitor the meter sensitivity must be reduced to avoid an absurdly low frequency. For 2mA the frequency required is 4 Hz, which is near to the lowest useable because of the need to smooth out needle jitter and still have a reasonable response time.

From equations 2 and 1 it can be shown that a large I causes most difficulty with ensuring that the capacitor can be charged/discharged in the time available. If the values of I and V are made the same for each range the problem is much the same on all ranges. For instance the frequency must be decreased by a factor 10 each time the capacitor range is increased by a factor 10 and so the charge time constant CR_s, equation 2, always has the same relationship to t, i.e. t/CR_s is fixed. In other words, the charge error is the same fractional amount on each range at the same meter reading, irrespective of the size of capacitor being measured, unless the meter sensitivity is changed. More current flows if t is kept fixed and C is increased but t/CR_s is reduced (negative power) and the error increases.

In the equipment to be described the meter sensitivity is reduced to its lowest of 1.666 mA on the 100 μF range and so this range is chosen as an example of error due to inadequate charge time. The other ranges use 5 times less current and from equations 1 and 2 the error can be expected to be e^5 times less and will be negligible unless the 100 μF range is very poor.

From the equation 2 the average current required to charge a 100 μF capacitor once per second with an effective 4V supply is $I_{av} \times 10^{-4}$A. Since the meter is shunted to read 1.666mA, the frequency needs to be $1.666/10^{-4} \times 4) = 4.17$ Hz, which has a half-cycle time of 0.12 seconds.

This range is for electrolytics which often have a tolerance of −20% +50% and precision measurement is not usually required. Thus a time of 4 CR_s was deemed acceptable and means a 4% error at full scale, with less error at lower readings. From $4CR_s = 0.12$ it can be calculated that R_s should not be more than 300 ohms and it will be seen later that the design achieves 330 ohms.

THE author, Ken Holford, is a principal engineer with Philips (previously Mullard) Research Laboratories and has been involved in circuit design for about 20 years. His electrical engineering started just after the 1939-1945 war, when equipment was in short supply. Power supply failures were common, your own generator a luxurious necessity, and a permit required for a new electric motor. He joined a Midland engineering company rewinding and redesigning equipment, often war surplus having the wrong voltage rating. He obtained an HNC from evening studies and moved to the research and development lab. of a motor vehicle component manufacturer.

Having an interest in electronics he joined Mullard and studied semiconductor circuit design. By 1960 such knowledge was in great demand and he teamed up with colleagues to lecture other Mullard engineers, extending this activity to many surrounding colleges. He was a contributor to the book "Reference Manual of Transistor Circuit Design" (1960) which was produced in thousands by Mullard at that time.

More recently, in September, 1972, he wrote a "Doppler with-sense" microwave article for *Wireless World*. He designed the Mullard microwave vehicle detector of the automatic portable traffic signals used at road-work sites in the UK.

The capacity meter was a hobby project.

Square wave generator. The square wave voltage should be well defined in amplitude and change little in magnitude with temperature – an f.e.t. output stage is ideal. The LOCMOS integrated circuits have this type of output and the hex. inverter HEF4049 in particular has six stages, of which some can be connected in parallel to get a lower output resistance. Measurements on a few samples of these showed that a single stage had a typical output resistance of 1kΩ and thus three in parallel would achieve, or nearly achieve, the target of 300 ohms. The connexion is shown in Fig. 4 and the square wave frequency is controlled by a single C and R and is easily changed to permit a number of different frequencies. Five of the stages are used and the sixth is put to a use which will be seen later.

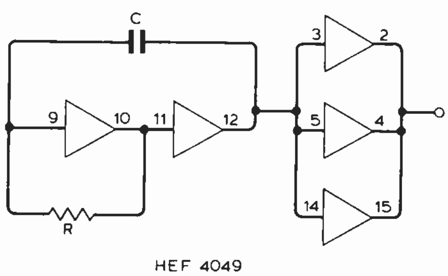


Fig. 4. Five of the six inverters in the HEF 4049 i.c. used to generate square waves.

This does the job although, due to the input stage not being of the high gain op-amp type with an accurate threshold at half supply voltage the square wave mark/space ratio is up to 20% different from unity. The circuit produces a respectable square wave at frequencies up to 1 MHz, as shown in Fig 5.

Earlier, the designer had considered using a modern f.e.t. op.-amp., such as the RCA CA3130, but this did not have the frequency response to produce a satisfactory square wave at 1 MHz. It would also need an output stage buffer. The 555 was also a possibility but a need for two timing resistors was a disadvantage. No doubt other i.cs could be found to do a similar job, or perhaps better. But as this circuit proved adequate and, as time was not unlimited, the design was frozen.

In a battery-powered measuring equipment used casually, the greatest loss of battery power is caused by the instrument being inadvertently left on. One way of avoiding this is to dispense with the normal switch and have a push button which activates the circuit for a

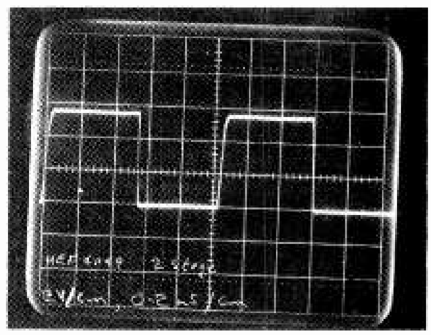
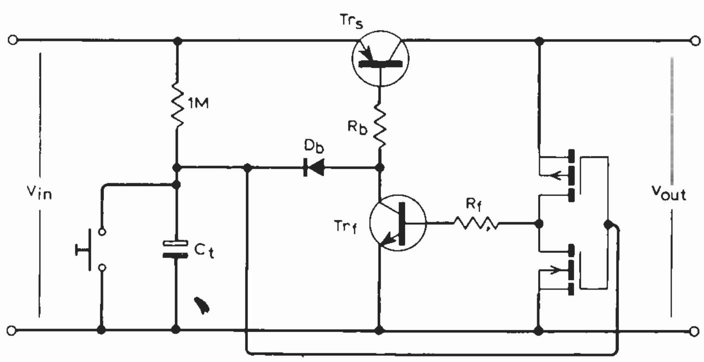


Fig. 5. Output waveform of circuit of Fig. 4. Oscilloscope sensitivity 2V/cm, timebase speed 200ns/cm. In this case timing resistor was 4.7kΩ and capacitor 68pF.

Fig. 6. Power supply switching and timing circuit. Inverter is part of HEF 4049.



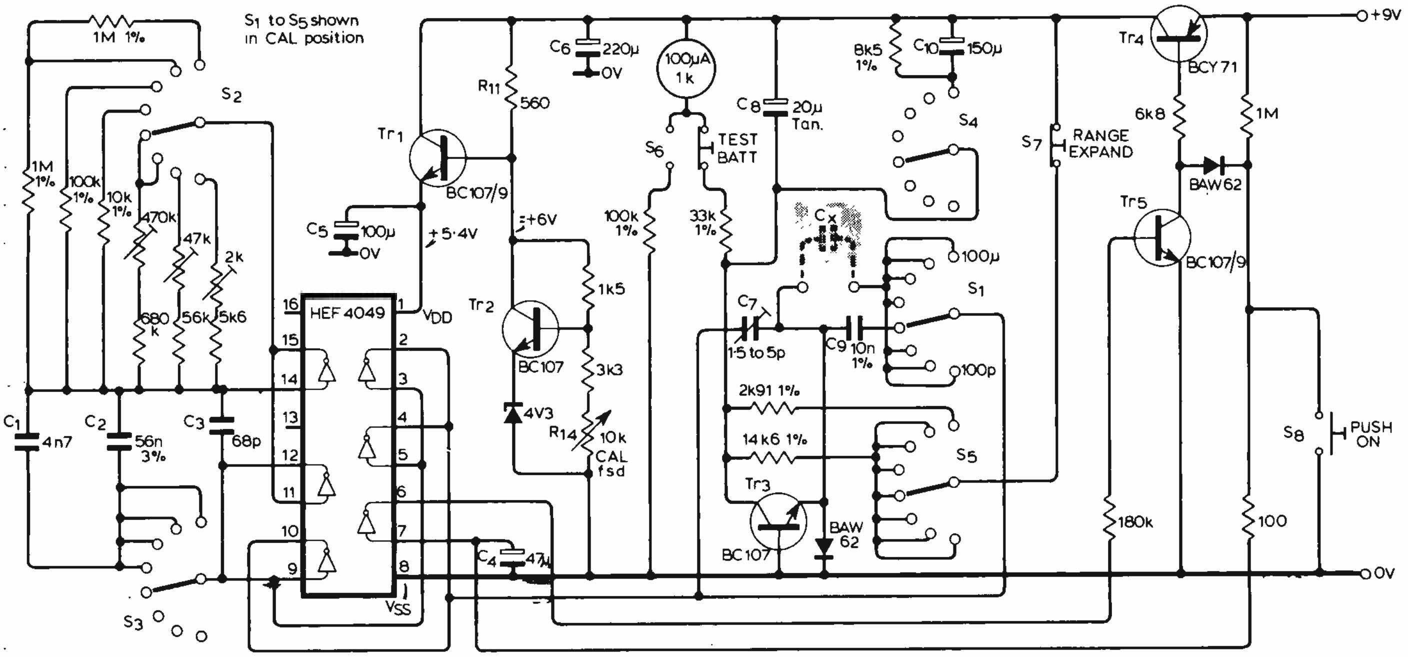


Fig. 7. Complete circuit diagram. Capacitor C_8 should not exhibit more than 1μA leakage and the voltage supply must not fall below 7A.

fixed time. If more time is required the button can be re-pressed to extend the period. The use of f.e.ts makes this easy. A measurement can easily be completed in 15 seconds and a timer was made for 30 seconds. One of the LOCMOS stages was used for this and the basic principle is shown in Fig. 6.

Normally C_t is charged and the output voltage of the circuit is zero because the series transistor is off. Pressing the push discharges C_t and turns on the series transistor T_s by allowing current to flow through R_b and D_b. The input voltage V_{in} is then applied to the f.e.t. inverter T_i, the gates of which are now low and their centre at substantially supply line voltage. This centre supplies votage to T_f base and T_f in turn supplies transistor T_s. Upon release of the push the capacitor starts to recharge and when the voltage gets to about half the V_{out} supply voltage the supply to R_f is reduced and the circuit shuts down. Since C_t remains charged in the off condition it is kept well polarised and the leakage current should be low. Any leakage is not significant in affecting battery life, only timing.

Complete circuit

The complete circuit is shown in Fig. 7 and has seven capacitor ranges increasing from 100 pF to 100 μF for a full-scale meter reading. On one further position a 1% tolerance capacitor is switched in so that the 100 μA calibration can be checked and rest if necessary. A push button will remove a meter shunt so that any range can be expanded from 0-100 to 0-30. Thus, except for capacitors of less than 10 pF, no capacitor need be measured such that the reading is below 0.3 of full scale. The meter is scaled 0-30 and 0-100.

Before describing the complete circuit further it is worth listing the functions of the various switches which have been numbered for this purpose.

S_1 Connects a calibration capacitor across terminals and disconnects the unknown.

S_2 Selects the frequency timing resistor for the square wave.

S_3 Selects one of two timing capacitors for the square wave.

S_4 Changes the meter shunt and the size of smoothing capacitor on the 100 μF range.

S_5 Selects the value of the meter shunt which will be removed when the range expansion button is pressed. This is different on the 100 μF range to that on the others.

Note that S_1 to S_5 are 1-pole, 8-way switches.

S_6 Battery test single-pole, changeover push button.

S_7 Range-expand single-pole, normally-closed push button.

S_8 "Switch-on" single-pole, normally-open push button.

Most of the circuit will be recognised from the previous description. Tr_4 is the series switch, turned on by Tr_5, which itself is turned on by the output at terminal 6 of the hex. inverter when the push button S_8 discharges C_4.

The voltage supplied to the hex. inverter controls the magnitude of the square wave and in turn the magnitude of the meter current reading for a given capacitor size. The method of setting the calibration is to adjust this voltage by R_{14}.

The regulator, Tr_1 and Tr_2 is simple but sufficient because of the use of a built-in precision capacitor which enables the calibration to be checked and reset if necessary. Tr_1 is an emitter follower which transfers the voltage from Tr_2 collector which, in turn, is set by R_{14}. Only about 0.6V is lost across R_{11} when the battery voltage is low in order to conserve battery life.

The oscillator frequency is determined by the value of R and C selected by S_2 and S_3. On the four highest capacity ranges the resistors should have a tolerance of 1% and, as can be seen, are fixed. Calibration is made correct using the CAL control using a precision capacitor in the test position. Afterwards the voltage at terminal 1 of the i.c. should be measured and, if it is not 5.4V ±0.2V, the capacitor C_2 is probably not quite correct. If voltage is high, the battery life will be shortened, since at design centre a minimum voltage of 7V is recommended and the battery starts with 9V.

On the other ranges, the value of the timing resistor is adjustable and so each range can be set as accurately as the standards available for calibration. The CAL range and the 0.01μF range are common, so setting the CAL using the instrument's own internal standard should be sufficient. On the 100 pF range, the trimmer C_7 across the measuring terminals will need adjustment — best done with the range expand in use. The best setting was found to be that which caused a reading of 0.3 pF with nothing being measured. The measuring error was then not more than 0.5 pF anywhere on the range. With no C_7 the error was 2pF.

The battery timer is set for about thirty seconds, depending a little on leakage currents. This can be extended if required, or the push button omitted and a normal on-off switch used. The advantage of the push button is that battery life can be more than 12 months with the equipment in casual use.

Reference

1. A thorough explanation of the circuit is given in "The diode-transistor pump," by D.E. O'N. Waddington, *Wi: eless World*, July 1966, p.338.

From factory floor to R+D

The Sullivan reputation for quality and accuracy is known and respected in electrical standards laboratories throughout the industry. But Sullivan also make some instruments that are just as much at home on the factory floor as on the laboratory bench. This is typified by the Megohmmeter T2900–a portable d.c. instrument designed for the measurement of high value discrete resistors and the insulation resistance of non-conductive materials, motors, cables etc. The T2900 can provide test voltages up to 1000V d.c.

The instrument also has a current measuring facility inherent in its operation; currents as low as 1 pico-ampere may be indicated.

Indeed, the Megohmmeter can provide accuraute results, clearly and at temperatures of up to 50°C. Get in touch with us today for the full facts on the Sullivan Megohmmeter T2900.

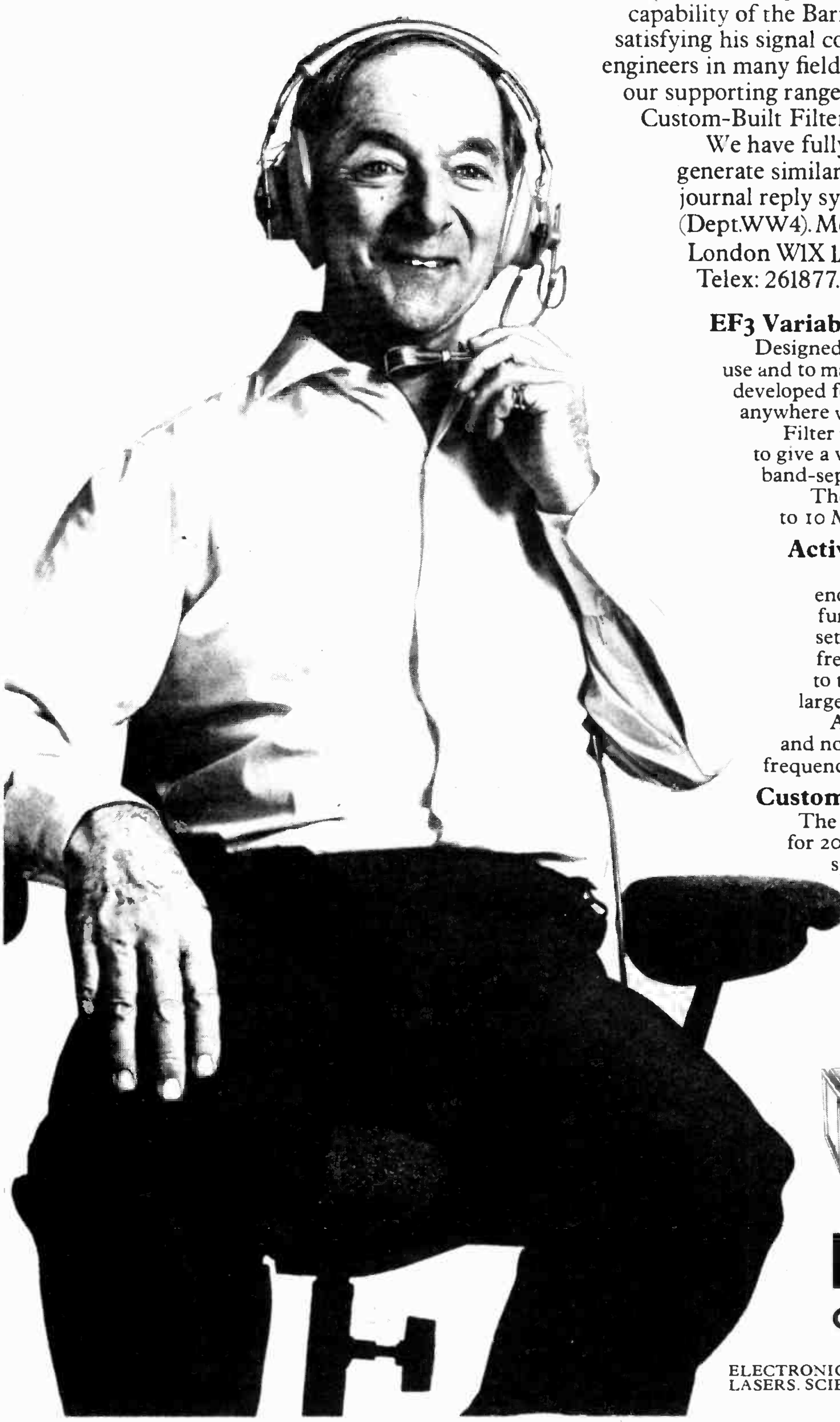
H.W. Sullivan Limited Archcliffe Road, Dover, Kent CT17 9EN Tel: 0304 202620 Telex: 96283

THORN Thorn Measurement & Components Division

Sullivan

WW—121 FOR FURTHER DETAILS

At the end of the test session the communications engineer sang the praises of our filters.



"What performance" he said, referring to the capability of the Barr & Stroud EF3 Filter System in satisfying his signal conditioning needs. He and other engineers in many fields are equally complimentary about our supporting range of Active Filter Modules and our Custom-Built Filter Service.

We have fully descriptive literature which will generate similar enthusiasm in yourself. Use the journal reply system or call us, Barr & Stroud Limited, (Dept.WW4). Melrose House, 4-6 Savile Row, London W1X 1AF. Telephone: 01-437 9652. Telex: 261877.

EF3 Variable Filter System

Designed on a modular basis to give flexibility in use and to match your budget. A plug-in system developed for use in labs., test departments, anywhere where signal conditioning is required.

Filter units can be used separately or combined to give a wide variety of functions from low-pass to band-separate.

The current pass-band capacity is from d.c. to 10 MHz.

Active Filter Modules

The ready-to-use convenience of small, encapsulated filter units, each with a basic function. No filter knowledge required to set up for specific characteristic or cut-off frequency. These filters are equally suited to the one-off lab. application and the large quantity production requirement.

Available in low-pass, high-pass, universal and notch designs with a range of cut-off frequencies and attenuation rates.

Custom-Built Filters

The basis of our filter activity, this service has for 20 years provided solutions to customers specific requirements. Based on in-house computer facilities and an extensive programme library we can design and manufacture the filters not provided in our standard range.

Designs can be passive or active with cut-off rates up to several hundred dB per octave in a frequency range up to around 70 MHz.

Barr & Stroud
adds to your resources

ELECTRONIC FILTERS. OPTICAL FILTERS. FIBRE OPTICS. LASERS. SCIENTIFIC AND MEDICAL INSTRUMENTATION.

Digital picture coding

When widespread use of digital video signal transmission comes about the techniques to allow realistic bit rates should be available

by **David Webster,** M.Sc.,M.I.E.E.E.

Of the many methods that are available for reducing the transmission bit rates of the digital video signals it is very difficult to say that one technique is best. In general techniques that use a frame memory give better results than those that do not. It was once the case that the degree of improvement could not be justified because of the high cost of a suitable memory. But in the past few years the advent of m.o.s. l.s.i. shift registers and other devices has gone a long way to enable frame memory techniques to be used.

Predictive coding techniques are normally superior to sub-sampling and conditional replenishment techniques and need little, if any, extra hardware. Fortunately transmission errors can be handled by the careful choice of predictors and forced up-dating. Transform coding techniques look promising for the future. They have good transmission error immunity and are capable of large reductions in bit rates. Their drawback is their need for much hardware and the fast signal processing required in their operation.

CONTRASTING SHARPLY with the rapidly expanding use of digital transmission techniques in the world's telephone networks, the transmission of television signals has been an almost exclusively analogue process. As the television signal is often transported from studio to transmitter site by the same transmission network as used for the more humble telephone signal, it seems logical to investigate the digital encoding of television signals. In recent years some interest has been shown in video telephones and again it seems logical to integrate such a service into the ever more digitally orientated telephone transmission network.

Digital techniques offer important advantages in the transmission of video signals, particularly for long distance transmission. The signal impairment brought about by long distance transmission of a digital signal is much less than that experienced by an analogue signal. Additionally when a television signal is sent from one country to another there is the problem of standards conversion. Standards conversion of a digital signal is much easier to achieve than that of an analogue signal.

The conversion of an analogue signal into a digital format involves two processes, sampling and quantization.

Sampling involves measuring the amplitude of the analogue signal at regular time intervals. Nyquist showed that the theoretical minimum sampling frequency is twice the bandwidth of the analogue signal. In practice the sampling frequency must be slightly greater than the theoretical minimum, due to imperfections in the sampling pulses and filters. When a video signal is being sampled the sample points are often called picture elements or pels. Thus each line of a television picture can be represented by a number of pels.

Quantizing involves converting the sampled value into a binary number which is used to represent that value. The binary number can then be transmitted, in a serial fashion, as a digital signal. When a telephony signal is being quantized it is normal to use a non-uniform relationship between the incoming signal level and the binary number derived from it (in speech small amplitudes are much more common than large amplitudes). The relationship between the incoming signal level and the resulting binary number representing it is the companding law, Fig. 1.

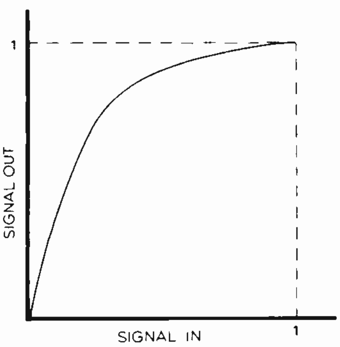


Fig 1. *In speech small amplitudes are more common than large amplitudes – one reason for using a non-linear companding law between incoming signal level and the binary number representing it in telephony.*

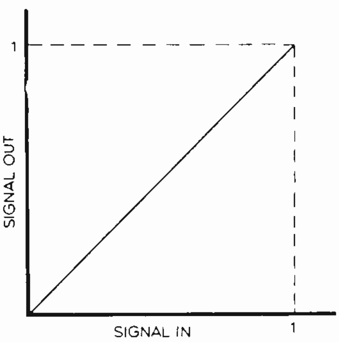


Fig 2. *Linear companding law is more appropriate for television signals. Maximum signal level has been normalized to unity.*

In a normal television signal there are just as many high signal levels as there are low signal levels and so it is normal to use a straight line relationship for the companding law, Fig. 2. Good results can be achieved by using eight bits to represent each pel.

As an example of the digital transmission rate required, consider the British 625-line system. This has an analogue transmission bandwidth of 5.5MHz and a practical sampling rate is 13MHz. Thus, by representing each pel by an eight-bit binary number the digital transmission rate is 13 x 8 = 104Mbit/s. Equipment to handle such a large transmission rate is available but the cost of transmission is very high. There is thus a considerable amount of interest being currently shown in techniques that can reduce this transmission rate, while of course maintaining picture quality.

Basis of transmission rate reduction

The techniques that have been applied to reducing digital transmission rates fall into two main categories. The first category involves reducing the amount of redundancy that is present in all video signals. The second involves the examination of those characteristics of the eye that can be exploited in fooling it into believing that it is seeing a much better quality picture than it actually is.

Consider a typical television picture. Normally there will be some object, probably in motion, set against a stationary background. The background is not changing and thus conveys no new information from frame to frame. Also large areas of moving objects can have very little detail (try and observe detail in a moving object) and so there is little new information displayed in each progressive frame. Thus the major part of a typical television frame is much the same as the previous frame. This represents a very considerable amount of redundancy, which if it can be reduced would result in the requirement for a considerably reduced transmission rate.

Around moving edges and when the scene displayed is suddenly changed there is very little redundancy and at first sight this would appear to present major problems in any attempt to reduce transmission rates. However, it is in these areas that certain characteristics of the eye can be exploited to great advantage.

The eye is very tolerant to the blurring of moving objects. This is very evident from a television picture. The camera integrates the picture over a period of 1/25th of a second and so any object that has undergone appreciable movement during this period must then be represented by a blurred image. This may be a fundamental property of the eye or a property arrived at through prolonged conditioning; either way, the fact remains that the viewer does tolerate a significant reduction in resolution.

The eye is very tolerant to inaccuracies in the presentation of sharp edges. Fig. 3 shows three transitions in video signal level that the eye will accept as sharp edges. In a similar way

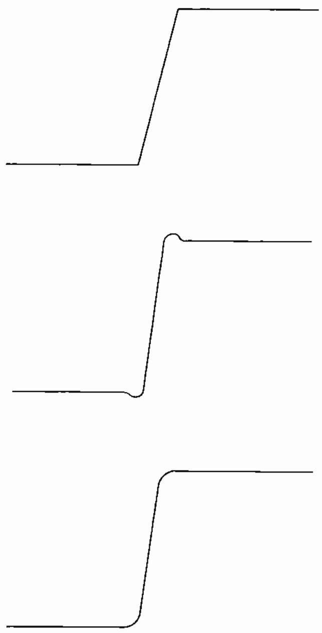


Fig. 3. *Human eye is very tolerant to innacuracies in sharp-edged scenes – all three transitions appear as sharp edges.*

the effect of a glitch is much less objectionable to the eye when it is close to a sharp edge in the picture, Fig. 4. From this it can be deduced that inaccuracies in the reception of the video signal representing a sharp edge in the picture are not too serious. And if the edge is the boundary of a moving area, its accurate representation is even less important.

Another property of the eye that can be exploited is that when the scene displayed on a television suddenly

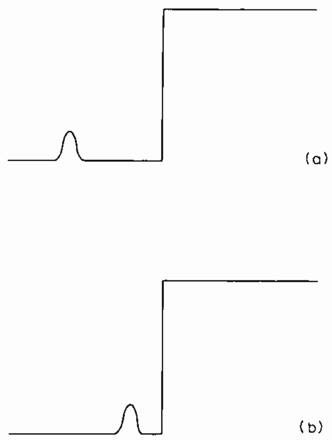


Fig. 4. *The "glitch" is much less objectionable to the eye when close to a sharp edge.*

changes, the eye only gradually begins to perceive the detail portrayed in the new picture. At first all that is noticed is the outline shape of the object in the new scene and it is only later that the detail is noticed. This process can take a significant fraction of a second and in this time several frames can be displayed.

Spatial and temporal sub-sampling

One technique that exploits the effects mentioned above is spatial and temporal sub-sampling. The equipment involved in converting the analogue signal into a digital signal, prior to transmission, detects moving areas and misses out some pels. After transmission and before converting to an analogue signal again, values are derived for the missing pels by interpolation from the two surrounding pels. This is spatial sub-sampling and exploits the allowable loss in definition in moving areas of a picture.

In stationary areas or in slowly moving areas certain pels can again be missed out prior to transmission. Before the signal is converted back into an analogue form the value from the previous frame of the missing pel can be inserted. This is temporal sub-sampling and removes some of the statistical redundancy in the signal.

To carry out spatial and temporal sub-sampling a decision has to be made as to whether a pel is in a stationary or a moving section to the picture. One method of doing this is to derive a difference level between the pel under consideration and the equivalent pel in the previous frame. If this difference is larger than a set level the pel is said to be part of a moving area. This requires a memory capable of storing all of the data from the previous frame.

Because there can be large differences in the same pel between frames even in stationary areas, because of noise, it is usual to decide on an area basis if there has been significant movement or not.

Much work has been carried out on sub-sampling techniques for video telephone signals. This has shown that 2:1 sub-sampling, i.e. halving the transmission rate, can give acceptable results but the quality deteriorates rapidly if coarser sub-sampling is attempted. Although the quality obtained is acceptable for video telephones it would be difficult to achieve good transmission rate reduction and still maintain the quality of broadcast standard television.

Conditional replenishment

A technique that makes use of the great similarity between consecutive frames is conditional replenishment. The difference in the value of the same pel in consecutive frames will be very small except in areas of the picture containing moving objects and even in these areas it is possible that only the pels around the boundary of the object will be experiencing significant changes.

If frame memories are provided at the transmitter and the receiver then only the values of those pels that have changed between frames need be transmitted. To enable the receiver's frame memory to track the signal successfully, the memory location of the change must also be transmitted. To economize on the amount of transmission capacity required for specifying the position of the changed pel, it is normal to decide on an area basis if a significant change has taken place or not. Then only the memory location of the area need be transmitted.

As there is a wide range in the rate of change of a television picture, the rate of information transmission will vary widely unless special techniques are employed to even out the flow. This can be achieved by means of a buffer memory. Information relating to changes enters the buffer as and when it occurs and leaves the buffer at a constant rate. To accommodate large changes in the picture content a very large buffer is required, however, buffering introduces a delay in the transmission process and it is the length of an acceptable delay that limits the size of the buffer that can be used.

To prevent the buffer overflowing it is necessary to increase the difference value, deemed to represent a significant difference between frames, as the buffer fills up. During very active periods the changed pels can be sub-sampled and interpolation used at the receiver for the non-transmitted pels. These techniques lead to a loss of resolution, but as they are only used during periods of rapid change in the picture the effect is tolerable.

The conditional replenishment technique is useful in applications where the picture is not constantly in a state of rapid change and so it is more applicable to video telephone use than to broadcast television. Video telephones show almost exclusively the human head and so the video telephone picture experiences much less in the way of rapid change than that observed on broadcast television.

Predictive coding

High correlation between a pel and its neighbours in space and time is the basis of predictive coding. A prediction is made for the pel from the neighbouring pels. This prediction takes the form

$$P_0 = \sum_{i=1}^{n} a_i P_i,$$

where P_0 is the predicted value of the pel, the set of P_i are the values of the neighbouring pels and the set of a_i are normalized constants.

The difference signal, P-P_0 where P is the acutal value of the pel, is derived and it is this difference signal that is actually transmitted. With an appropriate choice for the set of a_i the difference signal should be small. It is then possible to represent the difference signal with fewer bits, but still with the same resolution as the original signal. If large difference signals are occasionally encountered they can be catered for by using a non-linear companding law. Small increments for small signal levels and large increments for large signal levels. Large difference signals are associated with steps in the original signal level and inaccuracies in the representation of such steps go unnoticed by the eye.

Differential p.c.m.

The simplest predictive coding technique is differential pulse code modulation (d.p.c.m.). An implementation of this is shown in fig. 5. The input to the transmitter is an eight-bit p.c.m. representation of a pel, from which is subtracted the same value as the receivers representation of the previous pel in an eight-bit p.c.m. format. The

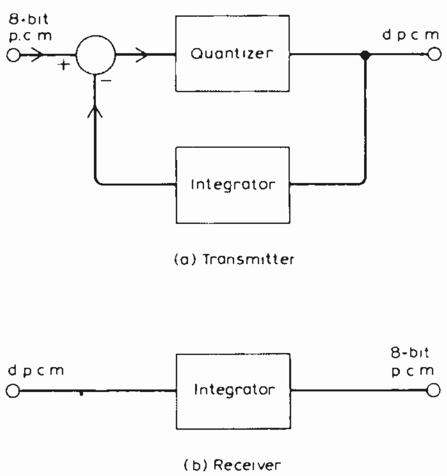


Fig. 5. *In predictive coding, a prediction of a picture element is made from its neighbours and the difference between this and the actual value transmitted.*

resultant difference signal is passed through a quantizer with a non-linear companding law and then transmitted. At the receiver the incoming difference signal is integrated and the original signal restored.

Differential p.c.m. makes use of the previous pel for the determination of a difference signal and it thus makes use of the horizontal correlation in the picture.

Field predictive coders

There are many reasons why the exploitation of the horizontal correlation is preferable to the vertical correlation. In a non-interlace system access to the vertically adjacent pel requires the storage of one picture line. With the more common 2:1 interlace system this becomes a field minus a line of storage. If in a 2:1 interlace system the vertically adjacent pel in the same field is used as the predictor, requiring one line of storage, the vertical correlation is significantly less than the horizontal correlation as the vertical pel is now two lines away.

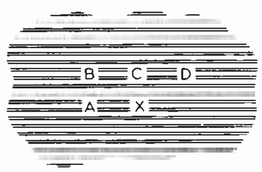


Fig. 6. *Simple predictive codings can be improved in various ways. In predicting the X pel, elements can either be averaged, e.g. $(A+D)/2$, or based on differences between lines, such as $A+(C-B)$.*

A predictive scheme that makes use of horizontal correlation can give a good quality representation, but unfortunately it does have problems in handling sharp vertical or diagonal edges in the picture. Such a predictive scheme produces blurring at these edges. In attempting to overcome this "edge busyness" the vertical correlation in the picture can be exploited as well as the horizontal. This is because vertically adjacent pels can give a prediction of edges in the picture.

Consider Fig. 6 which shows some pels in the same field. X represents the pel that is currently being predicted, A is the previous pel in the same line, and B, C and D are pels in the previous line. One form of prediction that can be made is the average of pel A and one or more of B, C and D. This is "averaged" prediction. Alternatively the prediction can be the sum of A and a normalized difference between two of the pels in the previous line. This is "planar" prediction. Average predictors such as $(A+D)/2$ and the planar predictors such as $A+(C-B)$ both give an improvement over the simple d.p.c.m. scheme which uses only A as the predictor.

Further reading
Transmission and Display of Pictorial Information, by D. E. Pearson. Pentech Press, London, 1975.
Principles of Pulse Code Modulation, by K. W. Caatermole. Illiffe Books, 1969.
Picture coding, by W. F. Schrieber, *Proc, I.EEE*, vol, 55, 1976, pp320-30.
Detail perception after scene changes in television image presentation, by A. J. Seyler & Z. L. Budrikis, *I.EEE Trans*, vol. IT-11, 1965, pp 31.
Telvision coding using two-dimensional spatial prediction, by D. J. Conner, R. F. W. Pease & W. G. Scholes, *B.S.T.J.*, vol. 50, 1971, pp. 1049-61.
Exchange of spatial and temporal resolution in television coding, by R. F. W. Pease & J. O. Limb, *B.S.T.J.*, vol. 50, 1971, pp. 191-9.
Visual encoding system with conditional picture-element replenishment, by F. W. Mounts, *B.S.T.J.*, vol. 48, 1969.
Transmitting television as clusters of frame-to-frame differences, by J. C. Candy, M. A. Franks, B. G. Haskell & F. W. Mounts, *B.S.T.J.*, vol. 50, 1971, pp. 1889-17.
Frame-to-Frame coding of television pictures using two-dimensional fourier transforms, by B. G. Haskell, *IEEE Trans.* vol. IT-20, 1974, pp. 119-20.
Simple interframe coder for video telephony, by J. O. Limb and R. F. W. Pease, *B.S.T.J.*, vol. 50, 1971, pp. 1877-88.
Low-bit rate interframe coder for videotelephony by B. G. Haskell & R. L. Schmidt, *B.S.T.J.*, vol. 54, 1975, pp. 1475-95.
Interframe transform coding methods, by J. A. Roese, A. Habibi, W. K. Pratt & G. S. Robinson, *IEEE 1975 Communications Conference*, vol. 2, pp. 23.17-23.21.

Frame predictive coders

A further improvement in performance can be achieved by using pels from the previous frame in the predictor. This improvement is due to the high correlation between frames. But to exploit such predictors frame memories are required.

Comparison of predictive coders

As the number of pels used to create a predictor increases the predictor provides a better and better estimate of the pel. With a very good predictor the difference between the predictor and the actual value of the pel becomes very small and so the difference signal can be transmitted with very few bits. With an appropriate choice of frame predictor, excellent quality can be achieved by means of a three-bit difference signal for each pal.

Unfortunately complicated predictors require complicated equipment to produce them. This is particularly true of frame predictors which, of course, require frame memories.

Problems arise with predictive coders when there is a transmission error. The receiver integrates the incoming difference signals and so any transmission error is incorporated into all signals emanating from the receiver. Fortunately it is possible to choose a predictor which causes the effect of transmission errors to diminish as time progresses. Average predictors are better in this respect than planar predictors.

One technique often used to eliminate accumulated errors at the receiver is "forced updating." Every so often a line is transmitted in its original p.c.m. format rather than its difference format. This of course requires the use of small buffer memories to allow constant transmission rates.

Transform coding

In transform coding a mathematical transform of an image is made. It is the transform coefficients that are quantized and transmitted. At the receiver the inverse transform is carried out, allowing the original image to be reconstructed.

Many of the changes between frames of a television picture can be represented by simple translations of an object. If these translations remain constant over many frames, the frame difference will be very similar over many frames.

The Fourier transform of a time-shifted signal differs from the original signal by a phase shift $\omega\Delta t$. Thus the two-dimensional Fourier transform of a frame difference will be very similar to that of the previous frame difference transform except for a phase difference $\omega_x\Delta x + \omega_y\Delta y$. Thus for transmission only Δx and Δy need be sent plus information relating to those regions of the picture that are not in true translation.

The Fourier transform is not the only transform that can be used for coding purposes and the cosine transform in particular looks very promising.

Theoretically transform coding techniques are capable of excellent results. In the future it may be possible to transmit signals with the equivalent of 1 bit/pel. The technique shows excellent immunity to the effects of transmission errors.

Unfortunately transform coders require several frame memories to implement them and the amount of signal processing involved is at present very difficult to do in real time. □

V.h.f.-only aircraft fly out of control

During the recent French air-traffic control dispute, aircraft normally flying to and over-flying France and Spain were permitted by the Civil Aviation Authority (CAA) to use a route, designated the 'Spanish Track', which passed over part of the Atlantic Ocean between Lands End and Madrid. Normally only aircraft equipped with h.f. radio, and consequently capable of maintaining contact with the air traffic control centres, are allowed over the Atlantic Ocean: v.h.f.-only aircraft are usually restricted to the overland routes. However, because of the holdups resulting from the dispute, the special Atlantic route was available for both types of aircraft. This was a dispensation of a rule in the normal procedures which said that v.h.f.-only aircraft could not fly over the Atlantic.

A warning was given to the operators of the v.h.f.-only aircraft that, due to the lack of communication with Shanwick Oceanic, who control the Atlantic Ocean traffic, normal air traffic control service would not be available over a major portion of the route. Instead, control service to these flights was limited to basic separation provided by the clearance to enter the Shanwick flight information region. The operators were also warned that normal air traffic control action in the event of emergencies might not be practical.

Fortunately many of the aircraft using the route were originally designed for Atlantic crossings and did in fact have h.f. radio as well as v.h.f. radio. However, the use of the route by undiscriminated aircraft proved to be far from satisfactory, and one week later the CAA issued the following statement: "The CAA has decided that in the event of the reintroduction of the Spanish Track, airline operators will be required to be equipped with h.f. radio. There is nothing basically unsafe in the arrangements made for flights using the Spanish Track provided that all concerned strictly comply with the detailed procedures. This has led to a detailed review of the arrangements and it has become evident that the degree of non-compliance was such as to give rise to difficulties in the management of the air traffic flow."

Shanwick Oceanic, at Prestwick in Scotland, normally use a teleprinter link to their transmitter and receiver station in Ballygreen, Southern Ireland, for all of their air traffic control communications. Atlantic flights on the American side of the ocean are controlled by Gander in Newfoundland, Canada.

Aircraft which normally fly trans-atlantic require navigational equipment in addition to h.f. radio if they are to fly at heights above 27,500 feet. The Spanish Track flight path, which incidentally may still be used by h.f.-equipped aircraft in the event of further air-traffic control disputes, uses height levels from 24,000 to 27,000 feet.

UK headquarters for Japanese-owned broadcast company

SONY BROADCAST BV, the subsidiary of Sony Corporation of Tokyo, formed on January 2 of this year, is to have new headquarters in Basingstoke. The decision to use a UK-base to handle marketing operations for Europe, the Middle East and Africa was made a few months ago, but a spokesman for the company could give no reason for the move, other than that they preferred to operate from the UK. The old headquarters, in Vianen, Holland, are to retain their distribution facilities for the company.

In addition to a marketing division, the Basingstoke headquarters will house research laboratories, sales administration and customer training. A separate building near the headquarters will provide warehousing, special projects and quality assurance facilities, and spare parts stocks to supplement Sony's service centre in Antwerp.

Mr Howard Steele, Managing Director of Sony Broadcast, and ex-Director of Engineering for the IBA, said of the move, "The spearhead of our marketing operations from Basingstoke will be Sony Broadcast's range of equipment for electronic news gathering, studio and field production requirements. The equipment has been subjected to rigorous testing over recent months by a number of broadcasting organisations and has met with universal approval. We are particularly gratified by the way in which our range of U-matic high-band recorders has been received, with general acceptance of third generation recordings for on-air use."

The full address of the new headquarters is City Wall House, Basing View, Basingstoke, Hampshire RG21 2LA.

NEWS OF THE MONTH

Responses to Government White Paper on broadcasting

ON THE DAY FOLLOWING the publication of the White Paper* on broadcasting, Lady Plowden, the Chairman of the IBA, said that it was "a major disappointment" that the Paper had decided that the fourth channel should go to the Open Broadcasting Authority (OBA). While the Paper suggested that a unique opportunity would be missed if the fourth channel was not used for innovative programming, the IBA considered that it was only necessary to look at the awards won by ITV programmes to see new innovative programming of quality. "New talent does not magically arise because there is a new organisation," said Lady Plowden. "Television does not produce innovative programmes in limbo."

The IBA believe that the White Paper's proposal reflects a failure to understand the practicalities of running a tv network, and that a fourth channel service integrated with ITV, under the IBA's control, would give the public a more effective service, more quickly and more economically.

The White Paper lays on the IBA fresh responsibilities in the coming years. These include the extension of local radio — which will also be effected by the BBC, the equipping of transmitters for the fourth television channel, and the development of pay-television and community services by cable. The IBA welcome these proposals, according to an IBA publication.

On the subject of Independent Local Radio (ILR), the publication says that the IBA will be co-operating with the Home Office and the BBC on a proposed working party to settle the assignment of frequencies, and they hope to get ahead quickly with the acquisition of sites and planning permissions for the ILR areas. It continued by saying that the IBA's engineering division is ready to undertake the expansion of ILR and the building and operation of transmitter networks for the fourth channel, and this may well involve heavy concentration on Wales, where, according to the White Paper, a Welsh language service is to be given priority.

It also welcomes the Government's indication that the IBA would not be excluded from any international discussions on the subject of future satellite broadcasting.

The White Paper says that the IBA has spent some £5 million on the engineering work needed to put the fourth channel on the air, and the Government has agreed with the Annan Committee that, in order to keep the cost to a minimum and to avoid unnecessary delay, the IBA should be responsible for engineering the channel and its transmission. The Paper says, "The IBA estimates that to provide a network of transmitters for the fourth channel with a population coverage of 80 per cent of the population in each of the existing ITV franchise areas would cost some £14.5 million (at current prices) over four and a half years. The aim will be, however (as for the existing u.h.f. tv services), to extend the coverage to just over 99 per cent of the population of the UK. This would cost an additional £13.5 million and take a further four and a half years. The OBA will reimburse the IBA for the cost of engineering and transmitting the fourth channel service, but the Government will be prepared, if necessary, to make loans to the IBA for the engineering work."

Engineering requirements for the fourth channel will include new transmitters and distribution links between studios and the transmitters. Most of the IBA's aerials have sufficient bandwidths for four channels so these are not expected to present much of a problem.

* Broadcasting, presented to Parliament in July 1978.

Com-Com's view

The Community Communications Group (Com-Com) deplores the Government's rejection of a local broadcasting authority, and instead proposes a 'Community Broadcasting Agency'. They believe that attending to local communications needs should be a higher priority in the 1980s than expanding national network broadcasting. "Nevertheless," says a Com-Com report, "if a fourth u.h.f. tv channel is to be allocated, Com-Com is in favour of an Open Broadcasting Authority along the lines proposed in the White Paper."

The Group members propose that the 'Agency' be established, along the lines of the Cooperative Development Agency Act of May 1978. Its functions, briefly, would be to look after small communities, perhaps no larger than a group of residents in a block of flats or a town of 100,000 people in the case of local radio, issuing licences, and taking responsibility for hospital and university broadcasting and cable radio and tv transmissions. It would also represent the interests of community broadcasting at a national level, for example in the assignment of frequencies, and make development grants available to groups wishing to establish stations. More importantly, the Agency would be financed from a variety of sources, structured as non-profit-distributing entities and owned and operated by the communities they served. □

Government grant of £4.5m to foreign-owned UK company

THE MINISTER OF STATE at the Department of Industry, Mr Alan Williams, announced recently that the Government was making a grant of £4.5m to Mullard Ltd, who are owned by the Dutch company N.V. Philips' Gloeilampenfabrieken. This grant, provided under Section 7 of the Industry Act 1972, has enabled Mullard to launch a £24m, three year investment plan, known as Project Vanguard, to modernize the manufacturing facilities at the company's tube assembly plant at Durham, and to establish a new 20in 90° tube production line at their Simonstone plant.

The investments at Simonstone and Durham will total £13.1m and £7.8m respectively. Further investments of £2.4m and £0.9m will be made at Philips Washington, which makes the neck components for the tubes, and at Crossens, where the incorporated magnetic components are produced, respectively.

In answer to a written parliamentary question from Mr Doug Hoyle MP, Mr Williams said, "By specialising in the production of 20in and 22in tubes, Mullard will be well placed to meet the growing demand within the EEC for tube sizes below 26in. The Government has consistently stated its determination to maintain a viable colour television tube making capacity in the UK. In order to assist this major investment programme, the Government reaffirms its support for the Radio Industry Council initiative of October 1977 under which the UK set-makers agreed to increase their use of UK made tubes, in particular the 22in tube. The Government is taking steps both to enable UK set-makers to increase their proportion of 22in tubes made in the UK up to 75% by 1980 and to monitor systematically the achievement of this objective."

Project Vanguard is aimed at providing an enhanced and expanding range of tubes and ancillary components which will prove fully competitive both technically and economically in the 1979 market environment. At the same time it will contribute towards job security at the four plants involved. The project will also aim at increasing Mullard's share of the UK tube market from around half in 1978 to over two-thirds in 1981, both figures being based on a total market of 1.8m tv sets. By 1981, therefore, two out of every three tv sets made in the UK could be equipped with a British-made tube.

Mullard, who, following the closure of the Thorn plant at Skelmersdale in 1977, are the UK's only tv tube manufacturer, plan to achieve an increase in exports and a reduction in tube imports, thereby contributing significantly to the national balance of payments.

In answer to a query about the award of grants to foreign-owned companies, a spokesman for the Department of Industry said that, under the Industry Act 1972, all companies based in the UK, whether they are foreign-owned or not, are treated the same. □

Teletext aids the deaf

THE BBC AND THE IBA are both researching the possibility of using teletext to provide optional subtitling on television screens to enable the deaf and hard-of-hearing to benefit more fully from television programmes.

The BBC are working with Leicester Polytechnic to find a way of using a computer to transcribe the output from a palantype shorthand-writing machine into normal English at speeds in excess of 200 words per minute. If they succeed, the system could be used on the BBC's Ceefax service, and would allow deaf people to follow all the programmes while those who are not so afflicted would not have to see the subtitles on their screens. The work was described recently by Mr Lyndon Thomas of Leicester Polytechnic at a seminar held by the National Deaf Children's Society in London.

Similar work by the IBA is being carried out jointly with the Independent Television Companies Association (ITCA), supporting a research project at Southampton University. Their work is expected to cost over £50,000 and is aimed at providing optional subtitling for the deaf by means of the Oracle teletext system. The project, which will probably take three years, is being carried out under the supervision of Dr Alan Newell of Southampton University.

Both the BBC and the IBA have recognised that conventional techniques of producing subtitles are expensive and time-consuming and palantype machines, of the sort used by Mr Jack Ashley, MP in the House of Commons, could greatly increase the speed of subtitling.

Mr Ashley, having become profoundly deaf, found that the brief notes that colleagues wrote for him were less than adequate for him to take an active part in the House, because he needed to know word-for-word what was being said in the speeches. The palantype machine he used enabled him to see a display of a written version of the words being spoken. It used a form of shorthand because it was impossible for his typist, who acted as his ears and fed the machine with the contents of the speech, to record the words, letter-for-letter, real time. Unfortunately, the machine output was also in this coded phonetic form, where the words were split into syllables, and one could only read it quickly after a long period of training.

Research work had already been carried out at the National Physical Laboratory to translate palantype outputs into standard spelling, but this used a large and expensive computer and had to remember 75,000 words and how to spell them in both English and palantype. Mr Newell thought that a small portable electronic processing unit was capable of performing the task if one did not go to great lengths to spell each word correctly, and so he set out designing one at Southampton. Two such units were built and tested in the House of Commons by Jack Ashley by February 1977. The displays were not in true English but in a form which was relatively easy to learn. Since then improvements have been made to the accuracy of the spelling.

The problem with subtitling is that it can take one person about 30 times the length of a programme to produce a subtitled version of that programme. It is hoped that subtitling of the palantype form will overcome this problem. "It has become clear," said the IBA, "that before a regular service of optional subtitling can be introduced, much needs to be known about the human factors involved and suitable operational equipment." They hope that ITV will be able to start transmitting some programmes with experimental subtitles for deaf viewers during the next 12 months. However, before viewers will be able to take advantage of this form of subtitling, it will be necessary for them to have teletext decoders in their tv receivers.

Ref. 'Palantype Transcription Units' by Alan Newell, 'Palantype in the office' by Geoff Hayward, *Hearing*, journal of the Royal National Institute for the Deaf, May/June 1978.

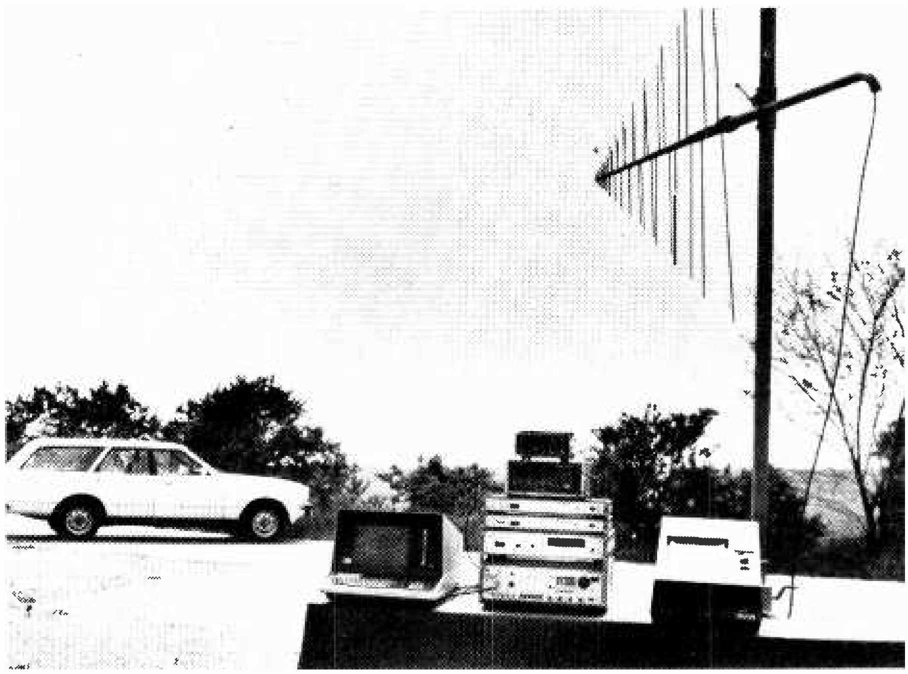
A cerebral palsied child using a pointer fixed to a headcap to type a message on the keyboard of an experimental computer-assisted communications system, designed by Bell Laboratories and the Telephone Pioneers of America.

Few alternative modes of communication are available today for people with severe speech and muscle impairments, and most of these limit vocabulary. This experimental minicomputer-based keyboard system is claimed to go a long way towards overcoming this. Using the system, a disabled person can compose messages by simply pressing large buttons on an oversized portable keyboard. The buttons are recessed in one inch diameter, well-separated holes. The message typed by the person appears on a video screen and may be supplied on hard copy at the press of two more buttons. To reduce the amount of typing, the computer stores abbreviations fpr words, word endings and phrases which it can automatically recognize and write out. Bell Laboratories have preprogrammed a standard list of these electronic abbreviations and is preparing instructions explaining how a person can add others.

Home Office comments on NEC c.b. report

THE HOME SECRETARY, The Rt. Hon. Merlyn Rees MP, has replied, in a letter, to the National Electronics Council's report on c.b. radio (see page 38, August) forwarded to him by HRH The Duke of Kent, Chairman of the NEC. According to the *National Electronics Review*, July-August 1978, the Home Secretary said that they (the Home Office) would certainly take the NEC's views on board, but that if they did not feel, on balance, that a c.b. should be introduced, the conclusion was one which was not lightly arrived at and was not simply the product of cautious, over-bureaucratic thinking. They were quite prepared to keep an open mind on the issue. While welcoming the report's recognition that it would not be appropriate to introduce c.b. in the country on 27MHz, the Secretary said that the pressure on the v.h.f. and u.h.f. bands was such that they must be satisfied that its use for c.b. could be justified in the face of competing claims for other mobile services. The letter continued by saying that the other area where the Home Office still had misgivings was in relation to the control of possible misuses of the facility and the need to minimize the risk of interference to other services. According to the letter, to regulate c.b. radio in the way the NEC report suggested would require a considerable increase in manpower. There would also be expenditure complications and the undesirability of an army of regulatory officials.

Robert Bosch GmbH has recently acquired a computer-controlled v.h.f./u.h.f. test assembly to hunt down sources of radio interference in car parts such as ignition systems, electric motors and generators, and in film cameras and emergency generator units. The assembly, which was supplied by Rhode & Schwarz, uses a receiver, type ESU 2, capable of measuring frequency over a range of 25 to 1000 MHz in compliance with VDE guidelines 0875, 0877 and 0879, CISPR publications 2, 4, 12, 13 and 14, and European Community directives. It has a voltage range of -10 to +120 dB (μV) over the frequency range and can measure two-port transfer constants from −90 to +40 dB. A Tektronix 4051 desktop computer is employed and evaluates the test results and presents them in graphic and tabular form on a video display. The computer results may also be recorded on a tektronix hard copy unit, type 4631. Other equipment used in the assembly include a frequency controller, type EZK, two code converters type PCW, all from Rhode & Schwarz, a digital voltmeter and a frequency counter.



Is ARI in the grave?

A STORY IN THE German journal *Funkschau* recently reminded *Wireless World* of the traffic information service, ARI (automotive road information), which was being tested in the UK about two years ago. (See p47, Dec. 76 issue.) The story gave some indication of how the countries who have ARI seem to take it for granted, and how some countries are almost slaves to the service, while others are still not sure that they want it at all. "We Germans in the central country of Europe which is well provided with ARI often do not know that this kind of traffic communication radio is either still rejected in other parts of Europe or is just being discussed or tested. Even progressive Switzerland is still debating (the last time was at the end of December last year), when representatives of the general management of the PTT, the Radio Society, the Automobile Clubs, the Accident Advisory Centres and the Police authorities were all of the opinion that a communication radio similar to ARI would be useful, especially when, in choosing the system, the tendencies of neighbouring countries are considered. . . . In this country it does not often happen, but in other countries from time to time there are splendid street maps which indicate precisely in which part of a street UKW stations can be heard", said a translation of the story. So, what did happen after the one month test in the UK two years ago? *Wireless World* has been finding out.

The test was carried out by the London Broadcasting Company, LBC, using the Blaupunkt ARI system from 19th October to the 18th November 1976. ARI decoding equipment was fitted to thirty journalists', police, and other public representatives' vehicles to help them tune to radio LBC on 93MHz v.h.f./f.m. or 261m medium wave whenever traffic information was broadcast. Of these thirty people, only 26 replied to the questionnaire. However, a spokesman for Robert Bosch Limited, who own Blaupunkt Radio, said that these 26 people included two IBA officials, the Minister for Industry, the shadow Minister for Transport, a leader of the GLC, AA and RAC representatives, a visiting Ambassador, a dozen motoring journalists, and representatives from a chauffeur hire firm and two motor companies, including Ford. "Of these participants, all but the IBA officials, who could not comment because it would prejudice IBA policy, said that the test was a success," said the spokesman. Twenty-two of these considered that the system required wide scale testing or nationwide introduction.

An analysis of the questionnaire response by the participants is in our possession but is too large to be dealt with in detail here.

After the results of this experiment were announced, four radio companies, LBC in London, BRMB in Birmingham, Piccadilly in Manchester and Clyde in Scotland, asked the IBA to apply to the Home Office for a wide scale test for a period of six to twelve months. The IBA did so in May 1977. The Department of Transport, who had set up a working party to study area broadcasting of traffic information, refused them permission because they wished to wait for a report from the Traffic Road Research Laboratory (TRRL). The working party included four BBC representatives, five people from the TRRL, four Home Office representatives, two policemen and one IBA official. The AA and the RAC were not represented.

Some of the pro-ARI people we spoke to said that the TRRL committee, who they say have been studying the BBC Carfax system (see p28, Jan 78), on submitting their report to the Home Office, considered that the ARI test would not be helpful in their work. A TRRL spokesman, when asked about this, said that the TRRL do not get involved in technical matters but are more likely to look at whether telling drivers of problems on particular roads would be of any benefit to them. The TRRL is responsible to the Departments of the Environment and Transport.

According to a Bosch spokesman, at least six local radio companies, supported by the Society of Motor Manufacturers and Traders, who represent the British motor industry, are now pressing for another test to coincide with the Motor Show at the NEC, Birmingham, in October this year. The Bosch spokesman said that Metro Sound, a Newcastle station, had got all the commercial stations to agree to ARI being 'pressed ahead' and that they had asked the IBA to approach the Home Office again. This they had not done. However the pro-ARIs believe that the IBA have been deterred by comments in the recent Government White Paper on broadcasting, and are unlikely to take the initiative to apply. The only proviso now, they say, is if the Government asks the IBA to conduct tests.

A member of the IBA information service confirmed that they would not press for further tests unless asked by the Department of Transport and said that, while they were not convinced of the worth of the BBC's Carfax, they were convinced that local radio had a part to play in traffic assistance. However, they had no strong feelings about the ARI system either.

This brings to mind one point raised by Bosch; that is, that Germany and Austria, when trying to decide whether to have ARI, asked the question "do we need traffic information". This was their big issue and finding the answer cost them a lot of money. In the UK the Department of Transport do not have to ask this question, we have been transmitting road reports for many years. "What we need now," say the pro-ARIs, "is to get it to the people in the correct way."

News in Brief

Within the framework of Telecom 79, the third **World Telecommunication Exhibition** which will take place in Geneva from 20 to 26 Sept. 1979, the ITU is organising the first World Telecommunications and Electronics Book Fair. This will be the first ITU event to feature exclusively books and publications on the subject of telecommunications.

AMI Microsystems Ltd, of Swindon, have reached an agreement in principle, for the merger of Millennium into a wholly-owned subsidiary of AMI. The transaction is subject to the negotiation of mutually satisfactory agreements and to the final approval by both Boards of Directors and Millennium shareholders. Millennium is a supplier of microprocessor support products.

Vapour ignition hazards can be controlled — HSE

THE MAIN PROPOSAL in a Health and Safety Executive (HSE) report[1], published in August, said that the IBA's (Radio Forth's) transmitter at Barns Farm on the Forth estuary should be moved three kilometres away from a proposed Shell plant at nearby Braefoot Bay, because of the risk of radio frequency sparks igniting concentrations of vapour at the plant. The plant would be storing liquefied butane and propane and would be linked by pipeline to other plants at St Fergus, Aberdeenshire and Moss Morran, Fife (see p43, Dec. '77 issue).

Mr John Locke, Director of the HSE, said in a letter to the Secretary of State for Scotland, "It is the view of the HSE that if the recommendations outlined in the report are fully implemented the risk of radio frequency sparks igniting flammable concentrations of vapour would be insignificant. This being so we see no reason why objection need be raised to the proposed developments at Braefoot Bay and Moss Morran on the grounds of hazards from radio transmission."

Giving an indication of the probability of ignition due to radio interference the report says, "Prevention of large scale vapour releases is an integral part of plant design and operation and the probability of such releases occurring will be reduced to an acceptably low level as a result of the hazard audit which will be carried out during the design and construction stages of the operation. Radio frequency transmissions will not cause releases to occur and will not ignite releases of flammable vapour even if both are present together unless some third factor, that is the release of radio frequency transmission power as a spark, also occurs." Such an event was considered to be very remote especially if practical safeguards were implemented.

The report says that by using the latest available information on the British Standard on such hazards, calculations indicate that radio frequency sparks capable of igniting vapour would not occur on the majority of structures proposed at Moss Morran and Braefoot Bay. "The possible exception to this would be some pipes which would cross a road at Braefoot Bay," it says. However, it points out that an assessment based on the same criteria, but using gas ignition values derived by the German researcher Herr Dr. Bittner, indicates that there would still be a possibility of r.f. sparks capable of igniting vapours at both plants, and although moving the Barns Farm transmitter would again remove any r.f. risk from Braefoot Bay a problem could remain at the Esso Moss Morran plant.

To verify the theoretical assessments, and control any other problems which might be revealed, the report proposed other conditions. These were that comprehensive tests should be conducted at the proposed sites during erection to determine induced power levels in site structures and that safeguards should be installed on any plant where these tests confirm the need. Where the possibility of the existence of flammable vapour in the atmosphere cannot be completely ruled out, the report recommends permanent bonding, screening and earthing and the use of special maintenance procedures.

In making its assessment, the HSE considered a number of matters raised by objectors to the proposed developments. These included the effect of amateur radio transmissions on the overall assessment, the use of medium and high frequency radios by merchant vessels in the Forth estuary, and the presence of high-power naval radar.

It was concluded that the effect of amateur radio transmissions on the overall assessment was negligible. Fortunately, at the most sensitive frequency for sparks, the amateur's transmitter power is restricted to 10W d.c. input or 27W p.e.p. output. Also, at this frequency, maximum aerial gains are approximately 5dB, because any additional gain would require large structures which are normally impracticable for radio amateurs. Typical peak effective radiated power (p.e.r.p.) levels at both ends of the amateur scale were quoted as 85W for the 1.8 to 2MHz band and 25200W for the 144 to 146MHz band. A total of 111 amateurs, located within 16km of the plants, were considered in the report, and the expected field strengths in each band were calculated and modified to take account of the number of transmissions, the amount of power normally used and the directional properties of the transmissions.

Similar calculations were made for commercial transmitters, naval shore-based transmitters, RAF transmitters and shipboard transmitters. The field strengths formed the basis of the calculations for the margins of the safety and the final results gave values for the combined effects of these transmissions for ethylene, alkanes and hydrogen. Some v.h.f. and u.h.f. transmitters used by the Scottish Development Department, RAF Pitreavie and Turnhouse airport, and an experimental radar transmitter at Burntisland were ignored in the calculations. The reasons given were that the radio transmitters were considered to have low powers outside the sensitive h.f. band and the radar beamed down the Forth estuary rather than across the sites.

According to the report, sparks may be formed when two conductors at different potentials touch each other. This might happen in practice when maintenance or construction work takes place. Mobile cranes have been singled out as worst case unintentional receiving structures, although these are not normally permitted to work in classified areas unless special precautions are taken. Another example is scaffolding which might, by itself or in conjunction with adjacent structures, form aerial loops in which r.f. currents could be induced.

Precautions include the connecting of flanged joints in pipes were there is any likelihood of a loss of conductivity across them, the connection of large structures which are either closer than 50mm or are not otherwise electrically connected, and the r.f. earthing of structures to minimize potential differences at ground level. R.f. earthing provides ground paths for r.f. currents, which might otherwise circulate through extensive portions of the plant, and breaks up possible resonances in long pipe runs. The manner in which structural parts are connected to earth is important because earth leads which are of a significant proportion of a quarter of a wavelength begin to assume high impedances and this presents a limitation on the effective application of the earthing techniques. The Executive's Working Group considered that screening would be a practical safeguard for limited use on the sites. It was envisaged that close steel meshing would provide useful attenuation of radio waves because if wires were fractured, currents would flow in the many other paths provided by the meshing without causing a spark.

Two more reports[2,3] were published at the same time as the above report. One[2] is the report of a working group, chaired by the HSE, who have been examining r.f. hazards at two plants, at St Fergus in Scotland, arising from anticipated levels of low frequency electromagnetic radiation from the Royal Naval Wireless Transmitter Station at nearby Crimond. Unfortunately, the group was unable to arrive at a positive conclusion mainly because the results of recent researches in this country and in Germany had given widely differing results. Since the report, the HSE has proposed a programme of further tests. The second report[3] was prepared by the HSE after a request from Mr Tony Benn, the Secretary of State for Energy, for assistance in considering an application by Shell for a pipeline construction authorization. The authorization was for two gas pipelines from St Fergus to Moss Morran, Fife, and St Fergus to Boddam, Peterhead. The report said that the level of risks presented by the pipelines would not be sufficient to justify the HSE objecting to their construction on health and safety grounds.

1. Assessment of the Hazard from Radio Frequency Ignition at the Shell and Esso Sites at Braefoot Bay and Moss Morran, Fife.
2. Report of a Working Group on Radio Ignition Hazards at St Fergus, Scotland.
3. A Safety Evaluation of the Proposed St Fergus to Moss Morran natural gas liquids and St Fergus to Boddam gas pipelines.

News in Brief

The **1979 Montreux International Television Symposium** and Technical Exhibition is to be held from May 27 to June 1. There will be two sessions, one devoted to progress in systems design or technology and the other to equipment innovations.

Park Air Electronics Ltd has signed an exclusive sales agreement with Comco, Coral Gables communications company, of Miami, Florida. Comco, who will represent PAE in the USA, Central and South American markets, are major suppliers of v.h.f. ground-to-air communications equipment and have extensive dealer and distribution networks in the Americas.

Hy-Gain Corporation, manufacturer of amateur aerials, has been purchased by Telex Corporation, and resumed manufacturing. The original firm ran into financial problems due to the erratic demand in the USA for citizen's band equipment.

The Electronic Components Division of Ferranti Ltd has become **Ferranti Electronics Ltd.** Correspondence should now be addressed to the new company and contracts and orders previously placed with the Electronic Components Division will be managed on behalf of Ferranti Ltd by Ferranti Electronics Ltd as will all future contracts and orders. There will be no change in company contracts.

Frequency synthesizers — 2

The generation of wanted frequencies from other frequencies

by R. Thompson, M.I.E.E.

Part 1 of this article described circuits which generate wanted frequencies from other frequencies using frequency addition and multiplication. This second part describes circuits for a third method, that of frequency division. It also introduces prescalers and explains how they can be used to extend the frequency range of frequency division circuits.

FREQUENCY DIVISION, even at frequencies up to 1GHz, is now almost exclusively carried out by circuits based on the digital binary counter. Alternative methods such as synchronising subharmonic oscillators or tuned regenerative loops have been outdated by the low cost of digital integrated circuits.

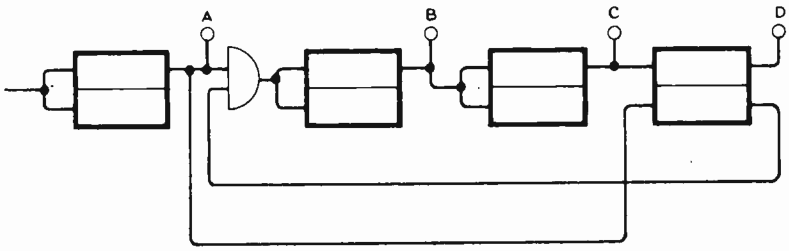
Simple cascading of binary counting elements provide division ratios of 2^N, where N is the number of elements. Generally, however, the division ratios required in synthesizers will not be a 2^N number, in which case the binary counters must be modified. The modifications normally involve the use of feedback loops which either cause binary elements to change state or inhibit clocking pulses. For instance, a divide-by-10 function is obtained with four binary circuits. These would count from 0 to 15, resetting to 0 on the 16th clock input if connected in simple cascade. After 8 counts, however, the last stage changes from 0 to 1 and this change in state can be used to bypass stages 2 and 3. Only two pulses are therefore required to return the counter to all zeros. The arrangement and logic table for this circuit are shown in Fig. 10.

A very common requirement in synthesizers is for a divider which can be readily varied by switches or control logic. Normally the approach to this requirement is to use standard counting blocks, 2^N or 10, in conjunction with either recognition or presetting logic. These arrangements are shown in Fig. 11. In (a), the setting switches programme the recognition circuits to the required division number. The counter then starts at zero and counts up to the required number, the recognition circuits produce an output pulse and this is used to reset the counter to zero. In (b), the required number is preset into the counter, which then counts down to zero. This produces an output pulse which again presets the counter. Alternatively, the "nines complement" of the number may be preset and the counter counted up to all nines.

A problem of frequent concern with dividers is the time delay introduced by the logic elements. These can accumulate to very significant times when many elements are cascaded. Synchronous counters avoid this accumulation by clocking all stages with the same pulse, as shown in Fig. 12. Arrangement (a) is a ripple-through counter where clocking is effected by the change of state of the previous stage. In arrangement (b) all stages are clocked in parallel with the clock pulses, the pulses being gated by the state of all "previous" stages. This achieves the same counting action as (b) but with almost synchronous output changes.

When operating in the synchronous mode, differential delays throughout a logic circuit are reduced. This makes the logic processing easier because the changes occur at defined times. It does not, however, increase counting speed, on the contrary it slows it down since time must be allowed for gates to be set between clock pulses.

Variable divider circuits are typically three times slower than straightforward counters because terminal states have to be detected and the counter reset once every count cycle. This resetting action must be completed between input clock pulses in order that no input pulse is missed. One method of exten-



Count	0	1	2	3	4	5	6	7	8	9	10
A	0	1	0	1	0	1	0	1	0	1	0
B	0	0	1	1	0	0	1	1	0	0	0
C	0	0	0	0	1	1	1	1	0	0	0
D	0	0	0	0	0	0	0	0	1	1	0

Fig. 10. *Circuit and logic table for a digital binary counter which can be used to provide frequency division. See text.*

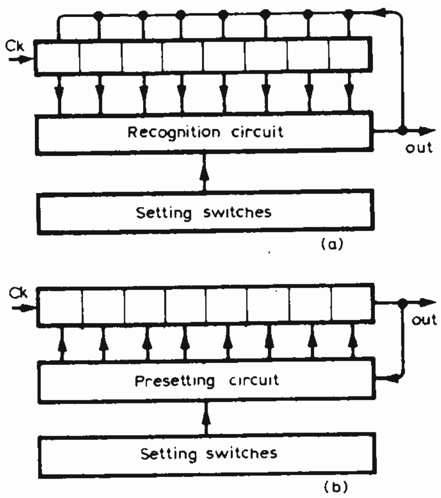


Fig. 11. *Dividers whose division ratios can be varied by switches or control logic. In (a) the setting switches programme the recognition circuits to the required division number and the counter starts at zero and counts up to the required number. In (b) the required number is preset into the counter, which then counts down to zero. This produces an output which presets the counter.*

ding the frequency range of the variable divider is to use an "early decode" circuit, as in Fig. 13(a). The counter is preset and commences counting, in this case downwards, in the normal manner. The most significant stage reaches zero first, followed by the next most significant and so on until all but the least significant are at zero. All of these zeros are gated together with a signal from the least significant stage whose signal is taken not from the zero but from some higher state such as 2. The early decode gate therefore produces an output two clock pulses before the counter would have reached all zeros. The next clock pulse can now trigger the early decode bistable whose output resets all counter stages and the final clock pulse of the counting cycle resets the bistable releasing the reset from the counter. At this stage the counter is ready to start counting from the reset state at the next clock pulse. This particular arrangement allows a full clock cycle for the counters to reset; obviously the decoding could be made even earlier to provide longer resetting times. Earlier decoding would require further bi-stables in the decoder circuit to count off the clock pulses missed while the main counter was resetting.

Another method of extending the frequency range is to use a higher speed divider ahead of the main variable divider. This "prescaler" could be a fixed divider as shown in Fig. 13(b). Since the maximum frequency to be handled by the variable divider is reduced by a factor P, say, the arrangement has the disadvantage that changing the variable division ratio by one now changes the overall division ratio by P. This can be overcome by using a prescaler providing two alternative division ratios.

Figure 13(c) shows the arrangement for such a variable modulus prescaler. If the A and the N counters were connected in cascade, we would have a counter with a least significant digit (l.s.d.) equal to that of the l.s.d. of A and, with the clock input applied to A, the maximum input frequency would be set by the speed of the A counter. With a variable modulus prescaler the output of the prescaler is tapped up the variable counter, splitting it into A and N as shown.

With a prescaler division ratio of P, the l.s.d. of N represents division increments of P. The purpose of having an alternative prescaler ratio greater than P, that is (P + M), is to count off the digits in the required division ratio which are less significant than P. These digits are of course those in A whose l.s.d. will represent increments in M.

The count cycle starts with A-plus-N set to the required division number and the prescaler set to divide-by-(P + M) such that the prescaler produces an output after every (P + M) input pulse. This decrements the N counter by one, registering P pulses, and also decrements the A counter, registering M pulses. The total change in A and N therefore directly indicates the total input count. When the A counter reaches zero, that is after trhe required number of M decrements, it switches the prescaler to a division ratio of P. Although the A counter stops, the N counter continues to decrement until it too reaches zero. When this occurs an output pulse is generated which is also used to reset the A and N counters.

It can be seen that the significance of the l.s.d. of the variable divider is set by the difference of two division ratios. The maximum input frequency, however, is increased by the smaller of the two prescaler division ratios. For instance, if the prescaler ratios are 10 and 11, a ten times extension of frequency can be obtained with no alteration to the l.s.d. significance.

The prescaler will only work when the number set in A is less than that in N. Since the A count can only be decremented by (P + M) input pulses the N counter must always be able to correctly register the P portion as part of the total count.

We can derive the ratio of input and output frequencies for the variable modulus divider quite easily, as follows:

Input pulses to decrement A to zero = (P + M)A

Count in N when A reaches zero = N − A

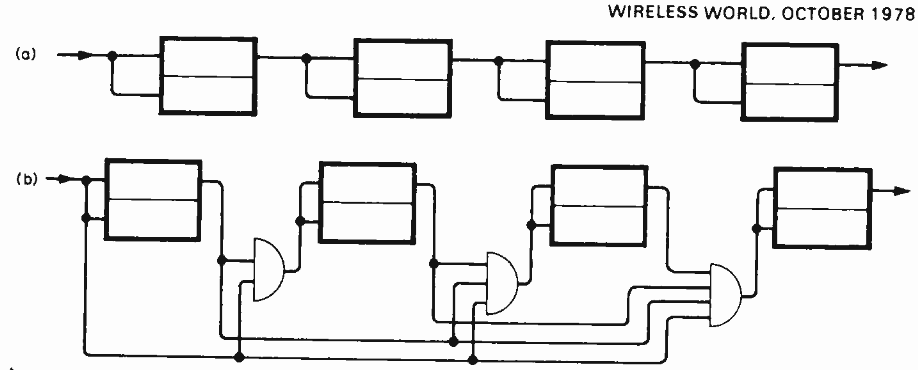
Number of further inputs for N to reach zero = (N − A)P

Therefore the total count in one cycle = (P + M)A + (N − A)P

= MA + NP

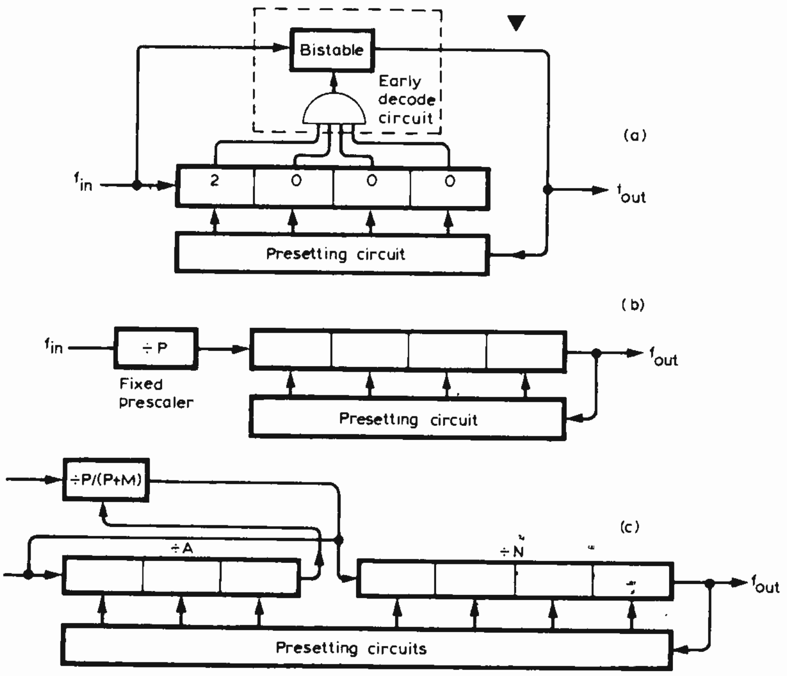
and $f_{out} = f_{in}(MA + NP)$

Where very-high-speed working is required it may be necessary to use the "early decode" technique described earlier to provide time for the A and N counters to be reset.



▲ **Fig. 12.** *Synchronous counters avoid the accumulation of time delays by clocking each stage with the same pulse. (a) is a non-synchronous ripple-through counter where clocking is effected by the change of state of the previous stage. In (b), which is synchronous, all stages are clocked in parallel with the clock pulses, which are gated by the state of all previous stages.*

Fig. 13. *Arrangements for extending the frequency range of variable dividers. (a) uses an 'early decode' circuit, and (b) employs a prescaler. See text. Arrangement (c) is a variable-modulus prescaler which provides two alternative division ratios.* ▼



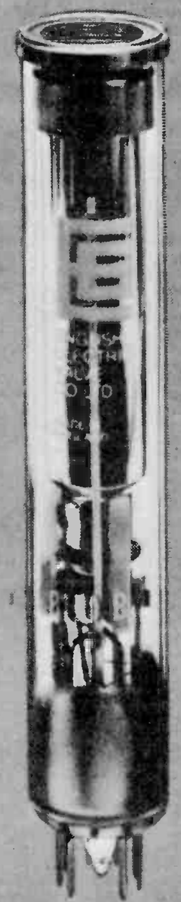
Night and day, these are the ones.

Darkness

EEV Ebsicon

The CCTV photoconductive tube from EEV using the silicon intensifier target principle which extends sensitivity into very low-light ranges.
The Ebsicon makes CCTV operation possible in hitherto 'impossible' situations. TV reading of X-ray fluoroscopic images is a typical example.

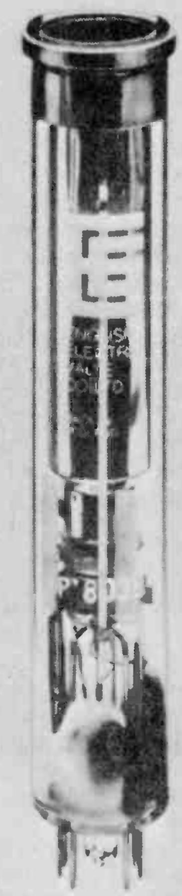
Low-light levels



EEV Sidicon

Where conditions are moderately difficult EEV's new high sensitivity Sidicon is ideal. It is available in three quality grades, has excellent 'blooming' characteristics and precision silicon diode array target.

Normal light levels



EEV Vidicon

Unbeatable for reliability, the EEV Vidicon is electrostatically or magnetically focused, has separate or integral mesh and a range of photo-surfaces based on antimony trisulphide.

No matter what your working conditions are, contact us at Chelmsford to find out more.

EEV

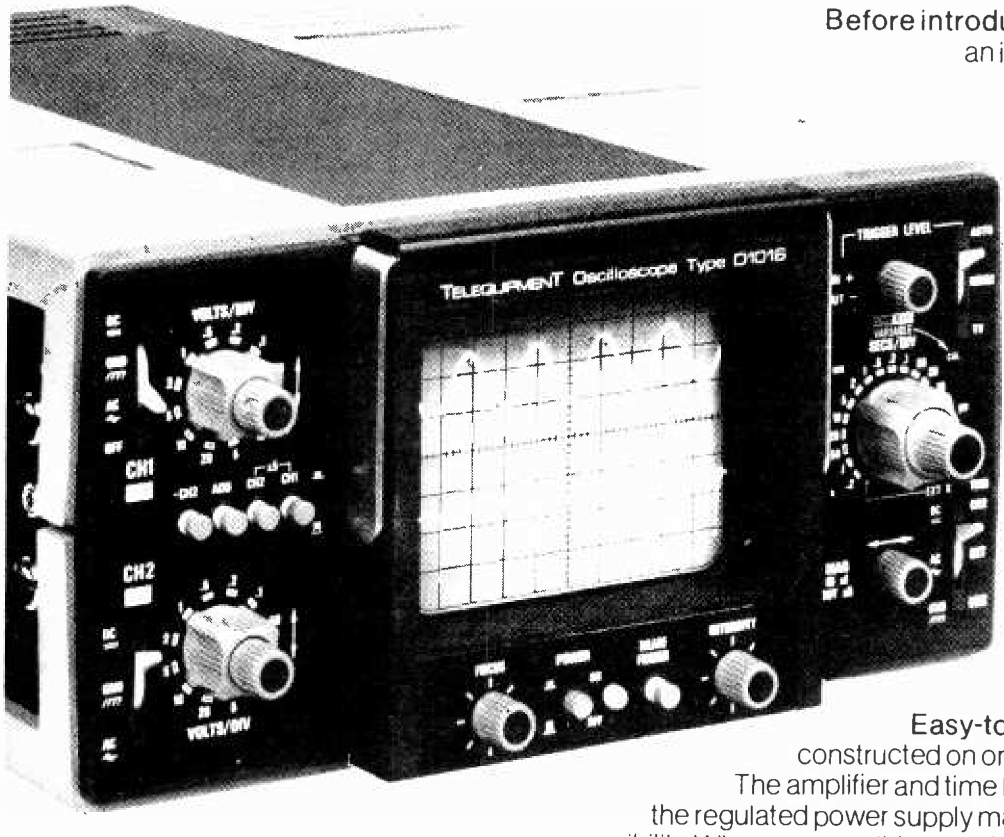
S 6029

ENGLISH ELECTRIC VALVE CO LTD, CHELMSFORD, ESSEX CM1 2QU. TEL (0245) 61777. TELEX 99103. GRAMS ENELECTICO CHELMSFORD
A MEMBER OF THE GEC GROUP

WW—076 FOR FURTHER DETAILS

It had to happen... the NEW 1000 series

a new generation of easy-to-use, economy line scopes offering the flexibility that you the customer demanded and from who else but Telequipment, world leaders in low cost scopes.



Before introducing the 1000 series, we conducted an intensive market survey throughout Europe, the results of which were analysed by our engineering and marketing teams; from this a definite set of parameters emerged. These have all been embodied in our new 1000 series.

A choice of bandwidth: 10 or 15MHz, 5mV sensitivity at full bandwidth and 1mV sensitivity at 4MHz and a choice of modes; Algebraic Add, true X–Y, and X5 gain switching; remember we told you it was flexible.

Easy-to-use: this it certainly is; note the minimum number of controls on the front panel, probably less than any other competitive scope available and, of course, all colour coded for easy reference.

Easy-to-read: note the five inch CRT.

Easy-to-service: primary circuits are constructed on only three boards in a "u" configuration. The amplifier and time base boards pivot around the regulated power supply making for excellent accessibility. Wherever possible, standard commercial components have been utilised throughout, simplifying acquisition.

Lightweight: only 8kg (approx. 17.5lb).

Reliable: here we have called on our many years' experience in the manufacture of low cost scopes. Components are rated in excess of their required values. Automatic insertion and testing reduces human errors. Flow soldering ensures maximum reliability of soldered joints.

Low cost: just check our price list and remember there is a lot more to cost than just the price.

We made it happen,
so if you would like to know the full spec.,
send for our colour leaflet.

See it at
EPG
Runcorn 3rd 4th Oct.
Southampton 24th 25th Oct.
London 10th 11th 12th Oct.

TELEQUIPMENT

Tektronix UK Ltd., PO Box 69, Coldharbour Lane, Harpenden, Herts.
Tel: 05827 63141. Telex: 25559. Regional Offices: Dublin 500979. Livingston 32766.
Maidenhead 71555. Manchester 061-224 0446
Also available from Electroplan Ltd., PO Box 19, Orchard Road, Royston, Herts
Tel: Royston 41171

WW — 112 FOR FURTHER DETAILS

Electronic organ tone system

Modular design uses sine wave synthesis to produce a high quality pipe organ sound

by **A. D. Ryder,** M.A., Ph.D., F.I.E.E.

ALTHOUGH ORGANS take many forms, the pipe organ is generally the standard by which others are judged. The main role of electronics is to provide an acceptable replica of a pipe organ at a fraction of the cost. This electronic organ tone system design differs from many commercial instruments by using a harmonic-synthesis approach. It provides for a full-size two-manual organ with 61 keys on each manual, and 32 on the pedals, which may be played polyphonically. Several variations and additions are possible including comprehensive coupling. Keying is by d.c., and only one contact per key is needed. The design is suitable for modernising an existing instrument or for a new console. Shorter keyboards may of course be used, with some saving in components. The pedal department is based on a 16ft pitch and the manual departments are on an 8ft pitch. Apart from a multiple frequency-divider, all components are general purpose types, and the basic system is condensed onto 19 boards which can be housed in a standard 17in rack. Component cost for the basic system is around £450 and optional coupling circuits add about £65.

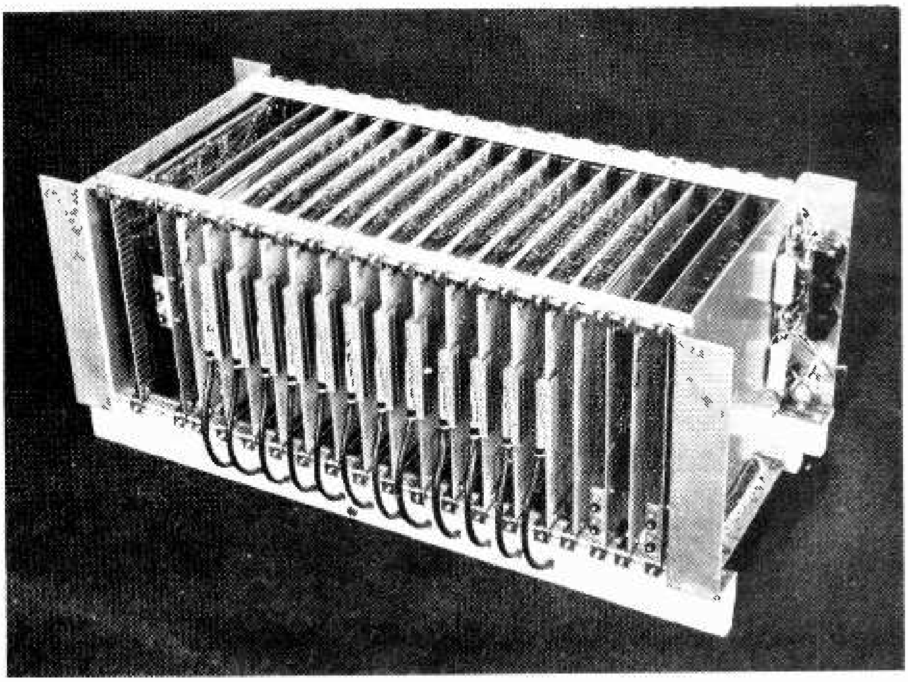


Fig. 1. *Assembled system in a 17in rack. The illustration does not show the mains transformer which is mounted separately. Twelve connectors are used to bring in the key signals to the front of the gate cards.*

Introduction

If the playing tones for an electronic organ are to be derived from a common source, rather than from individual oscillators, there are two main methods of producing the different waveforms required for stops of different tone colours. A harmonically rich waveform, such as a sawtooth, may be selectively filtered, or individual harmonics as sine waves, may be combined in different proportions. A practical substitute for a sawtooth is the staircase waveform obtained by mixing square waves in octave pitches, thus filling in the even harmonics, and this method is currently popular because square waves are easily generated and manipulated. The second method, known as sine wave addition, was used in the original Compton and Hammond designs based on electro-mechanical generators. In principle, any required waveform can be produced by either method, but in practice there is a significant difference because of the frequency range needed for a four or five octave keyboard. If a sawtooth of constant amplitude is fed to a filter, the output will vary with frequency, in both waveform and amplitude. However, with the sine-addition method, in its simplest form, these factors remain constant. Neither of these is ideal, but the second is closer to a pipe organ stop. Variations in tone-colour and loudness often represent the main restriction of an instrument which uses subtractive filtering. The sine wave addition technique was primarily adopted because the problems of achieving a musically satisfactory result by the filter method appeared very considerable.

In the basic system, seven sine wave pitches of ratios 1, 2, 3, 4, 5, 6 and 8 are provided for each manual and for the pedal, the pedal pitches being set an octave lower, starting at 32.7Hz. Different stops or tone-colours are directly produced by different combinations of harmonics. The harmonic spectrum can be widened by coupling, or by providing additional waveforms. There is a total of 154 keys, and, although the harmonics do not extend beyond about 10kHz, there are more than seven tone-gates per key if provision is made for upward coupling. Much of the design effort has been directed to minimising the space required, and the complexity of interconnection for the large number of gates.

Frequency generation

All of the frequencies are derived from one master frequency of about 1MHz, which is controlled by a crystal with a variable offset. This gives approximately 1% tuning above and below standard pitch so that the organ may be tuned to another instrument. The master frequency is fed to a multiple divider which provides 12 reference frequencies closely approximating an equal-tempered scale. All of the playing frequencies, 300 in all, are derived from these references. The use of a common frequency source is practically convenient and economical, but it cannot give the effect of different ranks of pipes, slightly out of tune, sounding together as a chorus. This effect is most closely reproduced by instruments which use a separate oscillator for each note of each stop. However, the present design does allow for a "quasi-chorus" effect, which is described later. The playing frequencies are generated and gated as square waves which are then filtered into sine waves with approximately 4% harmonic content. The filtering takes place before the mixing process, and does not affect balance.

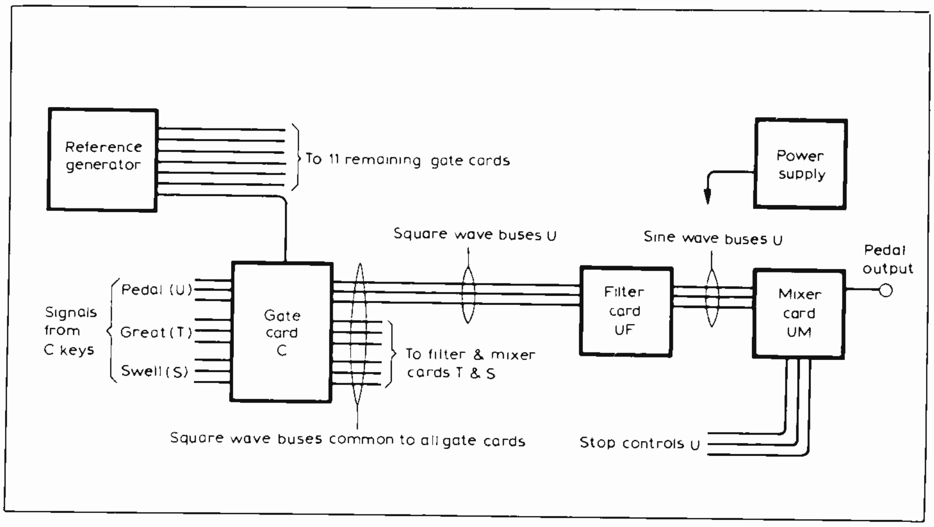


Fig. 2. *Block diagram of basic system which comprises 12 gate cards, 3 filter cards, and 3 mixer cards. If the coupling circuits are used they are interposed between the key signals and the gate cards.*

Voicing and regulation

In organ terminology, voicing is the adjustment of the sound quality of a pipe, and regulation is the adjustment of loudness. Each pipe is adjusted to build up the stop of which it forms part. In the most advanced sine wave organs, complex wiring and mixing circuits allow the amplitude of each harmonic to be independently adjustable note by note for each stop, so that voicing and regulation are similar to a pipe organ. In the present design, there is only one signal line for each harmonic pitch of each keyboard, so that each harmonic combination can easily be set up, but has to suffice for the whole keyboard. As already mentioned, a constant amplitude is not satisfactory, therefore each harmonic is independently pre-regulated by choosing appropriate resistor values. The level is set, note by note, to give an aurally satisfactory balance over the frequency range. With this method, combinations of harmonics also tend to be balanced and free from major variations of loudness or tone quality. It is possible to vary the relative strength of any chosen harmonic for different notes by using RC combinations at the mixing stage so that the built-in regulation can be modified for better voicing of a particular stop.

Harmonic accuracy

In some older sine wave organs, harmonics were borrowed from higher notes. For example, the 3rd harmonic for C1 (note C of the lowest octave) would be taken from the generator for G2, the 5th harmonic from E3, and so on. Apart from the octaves, the equal tempered scale does not provide true harmonics. The frequency of G2 is close to 3 × C1, but E3 differs by nearly 1% from 5 × C1. An error such as that of E3 would probably produce a rough tone, but a more serious objection to borrowing is that it detracts from the richness of chord sounds by eliminating some of the frequencies which should be present. In the present design each harmonic is generated in relation to its own fundamental from the same reference.

Starting transients

An organ pipe may take a few tens of ms to speak fully, and some types sound harmonics before the fundamental. To simulate such pipes it is necessary to control the build-up of each harmonic independently, note by note. In a sine wave system this is not difficult, but requires a number of keying circuits which are individually adjusted for each stop.

This design uses a common keying circuit for all harmonics together. The attack is graded so that, within limits, high notes speak faster than low notes.

Coupling

Coupling is not very common in electronic organs and, if offered, may be limited and expensive. In pipe organs however, coupling is nearly always used to connect more pipes to each key. This can enhance the sound and extend the variety of registration (combination of stops) available. Couplers may be local or interdepartmental. The action of the first kind is to couple each key to a higher or lower note of the same keyboard. The most common is an octave coupler, which causes key CK1 to sound C2 as well as C1, DK1 to sound D2 and D1, and so on. Others are the sub-octave, and the super-octave which is two octaves higher. A drawback of local coupling is the missing notes. If, for example, CK1 is pressed there is the addition of C3 but no more sound at C2 level.

The most common interdepartmental coupler is the great-to-pedal, which makes the great manual playable from the pedals and simultaneously with any stops drawn on the pedal organ. This coupler works only one way so that the pedal department is not connected to the great manual. Usually, a full set of upward couplers is available which, for a two-manual organ, would consist of great-to-pedal, swell-to-pedal, and swell-to-great. Couplings such as swell octave-to-pedal are also used as well as a unison-off coupler, actually an un-coupler, which allows the octave, or a coupled department, to be sounded alone.

For an electronic organ, couplers offer similar advantages. In a sine wave instrument, coupling the octave and/or the twelfth locally or from another department, also provides a means of broadening the harmonic spectrum. Although the present design can be used without couplers, suitable circuits will be described which can be added to the basic system. For coupling purposes, the manual departments each have 68 keying inputs, extending up to GK6, and the pedal has 44, up to GK4. The swell-octave provides the pedal with stops at a 4ft pitch, i.e. two octaves above normal.

A special feature is that the relative strength of the coupled note, or of the unison, may be adjusted so that, for example, the degree of brilliance added by the octave may be varied. Also, if the octave is used at reduced strength, the missing note effect is mitigated because when the octave key is played it makes an additional contribution at its own pitch level.

Other options

The coupling system and the quasi-chorus effect are options particularly associated with this design, but other additions are possible and some practical circuits will be described. Arrangements for volume control are optional but, if orthodox practice is followed, only the swell department will be controlled by the swell pedal and the loudness of the other departments will be determined by the selection of stops provided. To avoid electrical noise the volume pedals should work on d.c.,

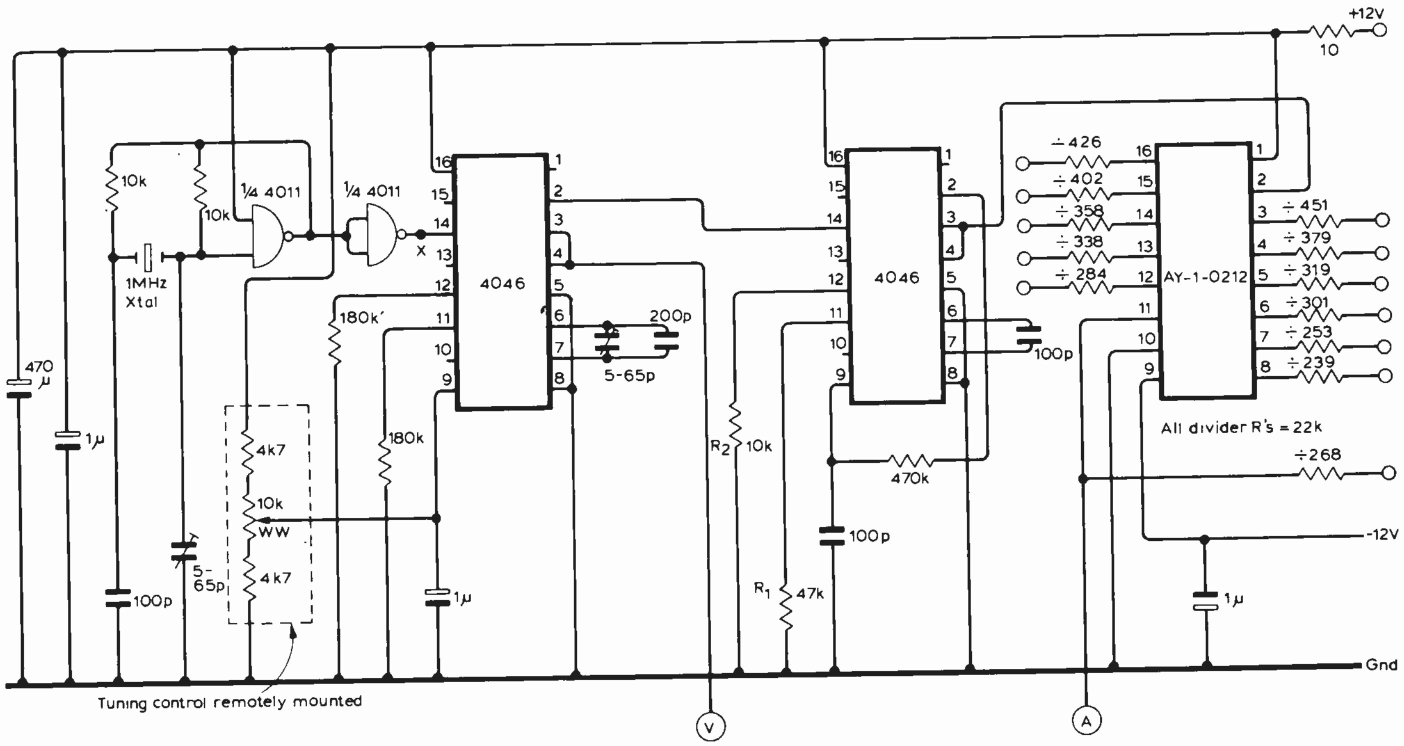
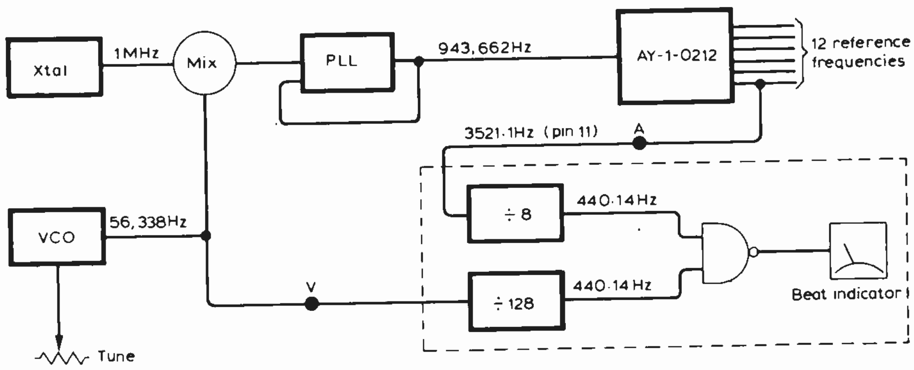


Fig. 4. *Tunable reference generator circuit. The 2k2Ω and 4k7Ω resistors, R_1 and R_2 should be 2%. For fixed tuning the two 4046 i.cs and associated components are omitted and the 1MHz signal at point X is taken directly to pin 2 of the AY-1-0212.*



rather than directly on the signal. Vibrato, frequency-modulation, may be applied to the generators to affect all departments together or, by using an external modulated delay device, to an individual department. Tremulant, amplitude-modulation, may be applied selectively to a single department. Chiff, starting transients, can be introduced but are restricted because all of the harmonics are keyed together. A noise busbar can be provided for adding to stop mixtures of each department. The keying envelope can be given a long decay, sustain, which can be graded over the keyboard, but the inherent attack rate is not fast enough to simulate a piano sound.

In pipe organ practice, pistons or press-buttons are often provided to bring in pre-selected stop combinations. This facility can be achieved using a c.m.o.s. memory.

Although it is not intended to deal with power amplifiers, an electronic organ provides a fairly severe test for loudspeakers, therefore a suggested design using an active crossover will be described. The ability to regulate each harmonic independently allows compensation for irregularities in loudspeaker response and this is especially useful in the region below 100Hz.

Mechanical description

To reduce interconnections, the circuits are assembled on plug-in cards which ease construction, testing and setting-up. The printed circuit boards are the same size as general purpose boards on the market so that both types can be used in the same assembly. Edge connections are mainly straight buses, and a motherboard is not necessary. The card size of 8in × 6½in can accept 59 edge connections at 0.1in spacing, and in the basic form the design uses 19 cards of four types. Gate cards; these are specially designed and 12 are required. Filter cards; also specially designed, one per department. Mixing cards; one per department, constructed using plug-in Veroboard. Oscillator card; assembled on one plug-in Veroboard, with some space for additional circuits. The photograph in Fig. 1 shows the rack containing the basic system. There is space for a 20th card which can be used for further options. The power supply components are mounted on one of the side panels, and the mains transformer is mounted separately. Due to space limitation the coupling circuits cannot fit into the main rack, but can be assembled on a large Veroboard mounted horizontally below. It is possible to add a second set of cards to provide three more independent departments which could be coupled to the keyboards and would allow a third manual to be used. The harmonic range can be extended, and there are possibilities for independent treatment of keying and differential tuning. The descriptions to follow will show how the elements of the system may be adapted to meet various requirements.

Fig. 3. *Tunable reference generator system for providing frequencies shown in lower part of table 2. The standardising circuit in the dotted area has frequencies shown for zero beat. This circuit may be omitted.*

Circuit nomenclature

The octaves of each keyboard are numbered from the bottom so that the lowest key is CK1 and the next is C'K1, followed by DK1, D'K1 and so on up to BK1. The next octave starts at CK2. Apostrophes are used for sharp signs. On a 61-note manual, the highest key is CK6, starting the sixth octave, and on a 32-note pedalboard, the highest is GK3, about halfway up the third octave. The fundamental frequencies for the manual departments range from C 65.4 to C 2,093Hz, and from C 32.7 to G 196Hz for the pedal. For the notes C and their harmonics, there are six keying signals from each manual and three from the pedals, but for other notes there are fewer. The gate card design provides 16 keying inputs for use with couplers as previously described. The three departments are called pedal — U, great — T, and swell — S, so on any gate card the keying inputs run from UK1 to UK4, TK1 to TK6, and SK1 to SK6. On cards G' to B, the highest numbers are not used, so they have 13 inputs only.

The length of an open organ pipe sounding note C at 65.4Hz is about 8ft, and a pipe sounding twice this frequency is about 4ft and so on. Table 1 shows some of the lengths, intervals and typical names used. Descriptions in the text will use harmonic numbers unless otherwise stated.

Table 1

Harmonic No.	Footage	Interval	Typical name
1	8	—	Principal
1½	5⅓	5th	Quint
2	4	(8th)	Octave
3	2⅔	12th	Nazard
4	2	15th	Fifteenth
5	1⅗	17th	Tierce
6	1⅓	19th	Larigot
7	1¹⁄₇	Flat 21st	Septime
8	1	22nd	Used in
10	⅘	24th	mixtures,
12	⅔	26th	also higher
16	½	29th	pitches

Pedal pitches are usually set an octave lower, starting at 16ft. The quint is not a harmonic but, if used with the fundamental, it can produce a sub-octave effect due to the subjective difference tone. Each pipe has its own spectrum of harmonics in addition to the pitch sounded.

Table 3. Frequencies relating to Fig. 3 for a tuning range of 1% either side of a zero beat frequency.

Deviation	Divider input kHz	V.c.o. output kHz	Beat frequency Hz
+1.0%	953.1	46.9	78.1
+0.8%	951.2	48.8	62.5
+0.6%	949.3	50.7	46.8
+0.4%	947.4	52.6	31.3
+0.2%	945.5	54.5	15.6
0	943.7	56.3	0
−0.2%	941.8	58.2	15.6
−0.4%	939.9	60.1	31.3
−0.6%	938.0	62.0	46.8
−0.8%	936.1	63.9	62.5
−1.0%	934.2	65.8	78.1

Table 2. Two possible sequences of reference frequencies from the divider.

	Input frequency 1MHz												
Pin	—	3	16	15	4	14	13	5	6	12	11	7	8
Note	C	C'	D	D'	E	F	F'	G	G'	A	A'	B	C
Hz	2093	2218	2350	2490	2637	2794	2960	3136	3322	3520	3729	3951	4186
Pin	3	16	15	4	14	13	5	6	12	11	7	8	—
	Input frequency 943.7kHz												

Circuit description

A block diagram is show in Fig. 2. The 25 or so frequencies generated on each gate card have their mean values tied to the one incoming reference, but the complete card may be frequency-modulated independently of the reference. The locally generated frequencies are selectively switched onto the outgoing square-wave buses under control of the key signals via a keying matrix. For example, depressing CK1 on the great, assuming the unison coupler is on, will cause the C card to output 65.4Hz on the T1 square-wave bus, twice this frequency on the T2 bus, and so on. The three sets of buses are shared by all 12 gate cards, though each uses a different reference, and is wired to different keys.

Each departmental set of square-wave buses connects to a filter card which feeds a group of sine-wave buses to the mixer for that department. The mixer card carries a virtual earth mixing amplifier and switching circuits for connecting different combinations of harmonics to the mixer. The strength of each harmonic, and thus tone-colour and loudness of each combination or stop, is determined by a resistor or an RC circuit as already mentioned.

An octave adjustment by wire link is provided on the gate cards to allow some freedom in the design of the reference generator. The G.I.M. AY-1-

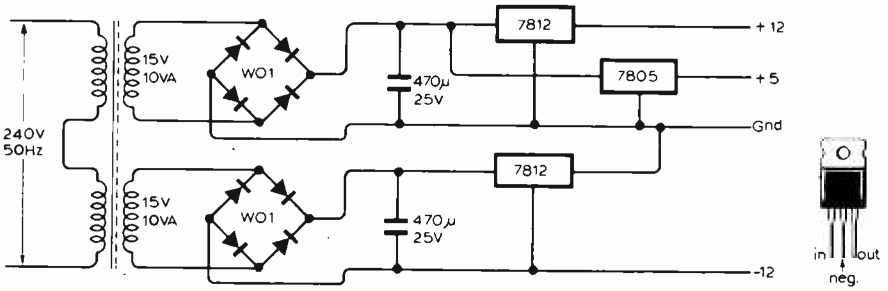


Fig. 5. *Power supply.*

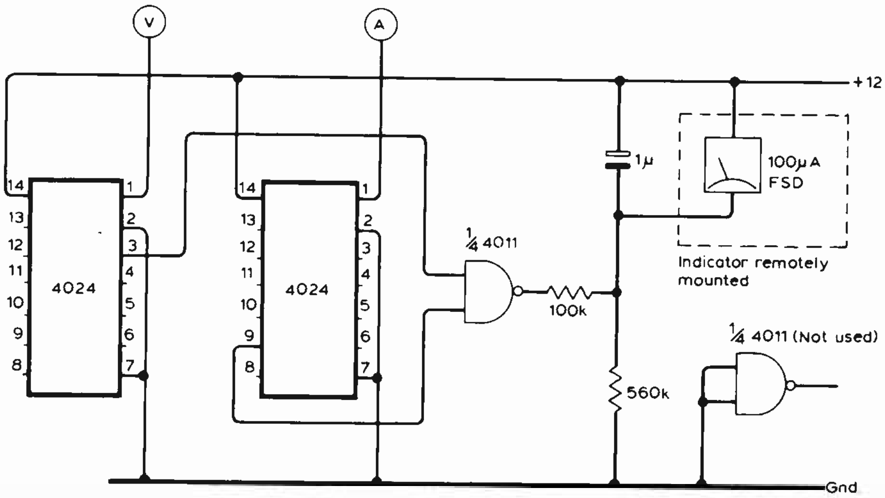


Fig. 6. *Tuning standardising circuit. The two resistors can be altered to suit different meter movements.*

0212 divider gives 12 whole-number divisions of its input frequency in the ratio of $\sqrt[12]{2}$, about 1.059, which is that required for an equal-tempered chromatic scale. As shown in table 2, if the input is 1MHz, the outputs range from C' 2218Hz to C 4186Hz, and if the input is a semitone lower at 943.7kHz, the outputs range from C 2093 to B 3915Hz. Appropriate routing of the outputs and the octave adjustments allows either frequency to be used or a number of others.

A tunable reference generator system is shown in Fig. 3. The frequency at one semitone below 1MHz is derived using a v.c.o. together with a mixer, and is recovered by a p.l.l. Instability of the v.c.o. has only a second-order effect, and it allows a ±1% tuning range for adjusting the organ to another instrument. The tuning control may be scaled with a frequency counter at the p.11. output, and table 3 shows the relevant frequencies.

At various points in the tuning range there will be a more or less simple whole-number ratio between the v.c.o. output frequency and its difference from 1MHz. The system in Fig. 3 exploits a convenient numerical coincidence and allows the tuning to be set up precisely to the crystal. Pin 11 of the divider, shown as the A reference, gives 1/268 of its input frequency, and this is the same as 1/16 of the v.c.o. frequency when the deviation from standard pitch (A is 440Hz, A reference is 3520Hz) is only +0.03%. This condition can be detected using a visual beat indicator as shown. The sensitivity, as table 3 indicates, is about 0.8Hz beat rate for 0.01% deviation. Because of the whole-number divisions, the AY-1-0212 can produce a theoretically correct frequency on only one output at a time, but if the pin 11 output is set 0.03% high, all outputs will be within 0.1%, which is sufficient for most purposes.

The circuit in Fig. 4 uses c.m.o.s. devices so the inputs of unused sections should be connected to a supply rail. The 10MΩ resistor sets the d.c. working point, the 10kΩ resistor gives some control of loop gain, and the trimmer capacitor allows some frequency adjustment. The first 4046 p.l.l. is not used in a loop, but forms the v.c.o. and mixer. Mixing is achieved by using the pin 2 phase comparator of the i.c. which exclusively-ORs its v.c.o. signal output with the 1MHz signal at point X. An output is generated at the difference frequency along with other frequencies. The v.c.o. frequency is controlled by the voltage at pin 9, and the working range is set by two 100pF capacitors, a trimmer, and the 180kΩ resistors. The trimmer should be set so that the v.c.o. frequency at pin 4 is 56.3kHz with the tuning control in the centre position. With an R_1:R_2 ratio of 1:1 as shown, the frequency swing available should exceed that shown in table 3, and only the trimmer should need adjustment.

The second p.l.l. is used conventionally so that when its v.c.o. output frequency coincides with the incoming signal, the output of the phase comparator at pin 2 contains a d.c. component dependent on the relative phase. This output is fed back to pin 9 via a low-pass filter to hold the loop in lock. The p.l.l. is set up initially with the loop opened and pin 9 fed from a variable direct voltage. The required mid-frequency of 943.7kHz should be obtained with pin 9 at the middle of the range, between +4 and +6V. Because this frequency is near the device limit, it may be necessary to vary R_1 slightly. After this adjustment the frequency range in table 3 should be well inside the control range of about 0 to 10V on pin 9. All p.l.l. settings should be finally checked using the permanent power supply shown in Fig. 5.

Component summary for basic system

	No.
P.c.b. E01 (special design)	12
P.c.b. E02 (special design)	3
Veroboards (code 09-0091D)	4
Mains transformer 15-0-15V 20VA	1
Bridge rectifier (e.g. W01)	1
Regulators, +12, +5, −12V	3
AY-1-0212 (GIM) multiple divider	1
4011 quad NAND	1
4016 quad switch	9
4024 7-stage counter	36
4046 phase-lock loop	14
4520 2 × 4-stage counter	24
741 op-amp	25
Transistors (e.g. Mullard BC548C)	1250
Diodes (e.g. 1N4148)	280
Crystal 1MHz	1
Edge connector, 59-way plus key position	19
Edge connector, 24-way plus key position	12
Tantalum bead capacitors, 1µF/35V	400
Ceramic capacitors, 100pf 2%	41
Trimmers 5-65pF	14
Filter capacitors	156
Other capacitors	25
Resistors ½-watt	2100

The list includes 4 × 741 and 9 × 4016 for mixing and stop switching.

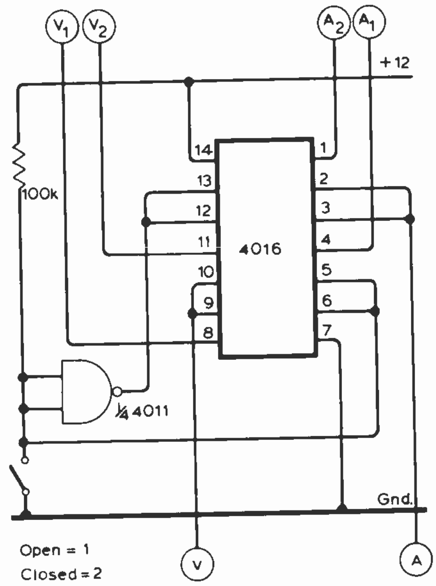


Fig. 7. *Change-over switch.*

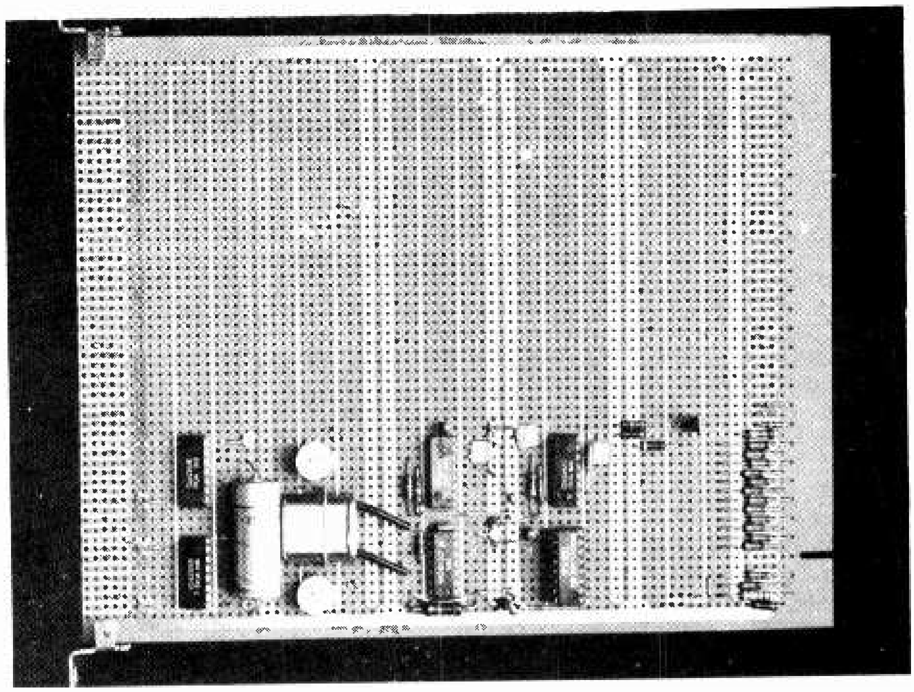


Fig. 8. *Prototype master oscillator including the standardising circuit. Space is available for additional functions.*

The locked output of the second p.l.l. also drives the divider. An optional standardising circuit is shown in Fig. 6. The first 4024 divides the v.c.o. frequency by 128, and the second 4024 divides the A reference by 8. A 4011 acts as a comparator so that when its inputs are in antiphase the output is high, and when in phase, the output is low for half of each cycle. Indicator calibration is

continued on page 91

American audio

Reports on the Consumer Electronics Show, Chicago, and High Fidelity Show, Atlanta

by Jack Dinsdale and George Tillett

ONCE AGAIN the venue for Chicago's Consumer Electronics Show in May this year was the McCormick Place exhibition centre and the adjacent McCormick Inn. But there was a further display of so-called "esoteric high fidelity" exhibits at the nearby Pick Congress Hotel, and it was this that provided the greatest interest for me.

The largest area was in McCormick Place itself, which accounted for 132 hi-fi exhibits at Mall and Lobby levels and in 34 sound rooms; 300 radio, audio compact and tape equipment exhibits; 100 personal calculator and watch manufacturers; 75 television and video systems; some 200 autosound, citizens' band and telephone accessories, and another 75 exhibits by trade associations and magazines. In nearby McCormick Inn, hi-fi exhibitors were using 71 sound rooms and over 60 hospitality suites. A number of manufacturers had taken space in two or even all three of the locations.

Two trends emerged strongly from the exhibition: the proliferation of extremely high quality equipment, often from small specialist companies, and an increasingly "systems" approach to the subject of sound reproduction. It is now being realised that a complete sound reproducing system must contain a signal source (tape, cassette, radio tuner or disc replay system), amplifying means, and loudspeakers or headphones. In the past, too little attention has been given to the matching and interface connections (both electrical and mechanical) between these items, and the result has often been that a complete system consisting of well-matched, middle-priced components can sound better than a similar system made up from top quality units throughout but with little thought given to the problem of matching.

Amplifiers

With the current emphasis on the subjective "sound" of amplifiers, there were examples shown of a range of circuitry for both signal and power amplifiers, aimed at improving the realism (musicality?) of the sound. A number of manufacturers were using thermionic devices as their active elements. The question whether to call them "valves" or "tubes" has been ingeniously resolved by the expression "vacuum state." The majority of mainstream amplifiers, especially those marketed by companies offering complete audio packages, made use of conventional circuitry and provided fairly conventional "hi-fi" sound (i.e. not particularly musical). However, the specialist amplifier manufacturers are now becoming aware of the principal audio shortcomings of so many amplifiers, and are taking effective steps to reduce the effects of transient distortion, premature operation of protection circuitry, and overloading of disc-input stages through insufficient headroom (an overload factor of 35 to 40dB appears to be necessary).

Power amplifiers were available with several ingenious circuit configurations designed to minimise distortion, for example Sony's pulse width modulation (class D), Hitcahi's use of m.o.s.f.e.t. output devices, and several variations on the class AB theme. The specified figures for distortion, frequency response, and signal/noise level are now so good as to be almost meaningless, and yet subtle subjective differences can still be detected under certain listening conditions. It is likely that further studies of transient effects and psychoacoustics will be necessary to identify and eliminate these remaining imperfections.

A particularly interesting development was the increasing use of "biamplification," whereby the hitherto conventional passive crossover network interposed between the output of a single power amplifier and the loudspeakers is replaced by an active electronic crossover operating at small signal level, generally after the preamplifier, and feeding separate power amplifiers for bass, middle and top. A number of companies, including Series 20 and Audio Research, were offering electronic crossover units, while others were marketing split loudspeaker systems complete with electronic crossover and individual power amplifiers for each loudspeaker. A well-engineered system of this sort can exhibit audible advantages in terms of reduced intermodulation distortion, and although the cost of four or six power amplifiers will clearly be higher than the more conventional two amplifiers (one per channel) it is worth remembering that in general the power handling capability of each biamplifier will be lower, thus offsetting at least some of the extra cost. Furthermore, the bass amplifiers can use l.f. transistors in a well-protected circuit, while the mid and top amplifiers, although requiring h.f. transistors, are not required to handle such high power levels.

Pre-amplifiers and processors

Advanced pre-amplifiers claiming to offer audibly lower distortion than conventional units were being shown by David Hafler, Marcof and Audio Research. A growing number of companies and magazines in the USA are starting to extol the virtues of moving-coil pickups, and at Chicago there were several pre-pre-amplifiers which accommodated with varying degrees of success the challenge of achieving the correct cartridge loading, adequate dynamic range, signal/noise ratio, and frequency response with minimal distortion.

There were several interesting developments in the field of "audio processing." One of these, the Digital Time Delay System by Audio Pulse, provides successive, attenuated, time delayed outputs to be played via a second amplifier through loudspeakers behind the listener, thus simulating concert hall acoustics in a living room. The original signals are sampled at 250kHz, and components below 8kHz are then delayed by amounts from 8 to 94ms by means of digital shift registers before being fed to the rear loudspeakers. The Audio Pulse system can also be used to provide attenuated reverberation effects from 0.2 to 1.2 seconds. One of the most impressive demonstrations of the whole exhibition was by R. G. Dynamics, whose Dynamic Signal Processors act as expanders to recreate the full dynamic range of music, normally lost in the recording process. By concentrating on the psychological effects on the listener, and employing low noise low distortion circuitry, R. G. have produced a device which restores up to 16dB of dynamics and thus brings music to life in an effortless and remarkably realistic way which does not pall even after prolonged listening (via the superb Dahlquist DQ10 loudspeakers). Indeed, switching the Dynamic Processor out of circuit left one with a very flat and uninteresting sound altogether.

Although there was much discussion on digital recording and replay, there appeared to be no actual hardware on demonstration. An enquiry on the Philips stand regarding that company's recently-announced opto-electronic digital system (August issue, p.39) resulted in a statement that it would be "at least three years" before hardware would be available.

Tuners

Major developments are taking place in tuner circuitry, especially in the areas of digitial waveform synthesis and advanced electronic frequency display. Lux, Mitsubishi and Sony were exhibiting tuners in which the local oscillator frequency is controlled by a binary-divided crystal-controlled oscillator as part of a phase-locked-loop system to ensure continuous positive locking of the phase of the local oscillator to that of the transmitted carrier. This gives extremely accurate tuning with automatic frequency stepping in 200kHz intervals. A further innovation by Mitsubishi was to cancel the 19kHz stereo pilot tone not by a filter (which would inevitably affect the audio signal) but by the addition of a further 19kHz signal identical in amplitude to the pilot tobe but in exact anti-phase to it. Many tuners incorporated digital (l.e.d.) frequency display, and also microprocessor memory facilities for up to seven preselected stations.

Loudspeakers

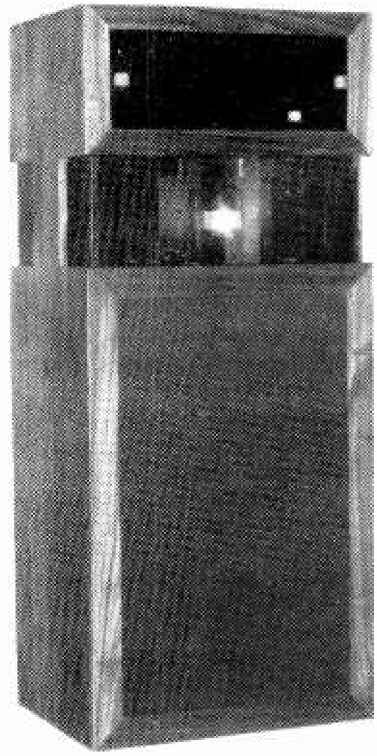
Developments in loudspeakers continue to offer the greatest degree of invention. Listening to the wide range of loudspeakers at Chicago illustrated without doubt that these, together with the listening room and placing, contribute by far the greatest colouration to the subjective "sound" of a system. There is little agreement at present over the ideal driver, and so one could listen to moving-coil units, electrostatics, the Motorola piezoelectric tweeter (previously usable only above 3kHz, although a mid-frequency drive from 2kHz is now available) and most esoteric of all, the Plasmatronic Hill type 1 plasma driver, which claimed to provide exceptional clarity of reproduction (zero colouration and laser-like phase coherence) from 700Hz to above the limit of audibility, and operated via a biamping system with a 12-inch subwoofer and 5-inch/mid-range unit. The plasma driver requires "topping-up" with helium "available in cylinders from your local welding supply company" every 300 hours listening time, and the cost of this is claimed not to exceed 30 to 40 cents per hour.

There was little unanimity of agreement over the acoustic loading of even conventional moving-coil drivers, which were housed in so-called infinite baffles, an assortment of ported enclosures, and even folded horns were in evidence. For those living in very small apartments, ADS (Analog & Digital Systems Inc) and Adcom (Braun) were demonstrating extremely small, almost pocket-sized, loudspeakers, the latter offering a frequency range of 50Hz to 25kHz from only 6¾ × 4¼ × 4⅜ inches. The sound from these minute units sounded rather constricted alongside the larger units, but in certain situations they would undoubtedly hold their own.

The full-range multiple horns by Frazier, Beta and Technics showed again the effortless way in which this particular type of very efficient loading can deal with a wide range of musical signals, although the difficulties of avoiding colouration were also evident (see however the footnote to this report).

Of particular interest were the unusual loading techniques employed by Qysonic, who utilised the interference of elliptical wavefronts coupled with a laminar-flow vent port arrangement in a cabinet only 8in deep, the minimum diffraction approach by Avid, and the use by Electrovoice in their Interface range of loudspeakers of electronic equalising (active crossovers again) to provide a better bass response than the unaided enclosure could give.

Two very realistic-sounding systems were those by Design Acoustics and Janis. The former were showing their uniquely-shaped dodecahedron loudspeaker some 22 inches in diameter containing ten separate drive units, together with a range of conventional reactangular cabinets for those who could not accept the dodecahedron into their decor. The units provide a close approximation to essentially hemispherical wavefronts and a very high ratio of reverberant to direct sound. Janis were showing their "ultimate sub-woofer," only 22 × 22 × 18in, which provides a response wihin 1dB from 30 to 100Hz (it is only 2dB down at 25Hz). The unit contains a slot-loaded 15in driver with a 4in dia. speech coil, which is mounted facing upward. Because of the non-directional nature of frequencies below about 150Hz the sub-woofer can be placed anywhere in the listening room, and one unit will normally cope with the bass of two or four channels. Inevitably, the unit must be driven via a biamplifier system. At Chicago the Janis subwoofer was augmenting the bass of two Quad electrostatics to provide one of the most natural, almost ethereal, sound of the entire show. To listen to this loudspeaker was to appreciate the inadequacy and naivety of statements such as "only 6dB down at 30Hz," and also to experience perhaps more so than from any other loudspeaker, the sheer bass power produced by a symphony orchestra.



The Plasmatronic loudspeaker system, showing light produced by the high frequency plasma driver mounted just above the large bass unit.

Accessories

Among a plethora of audio gadgets, goodies and gimmicks, one of the most remarkable and potentially useful was the Discofilm record cleaning process, to be marketed shortly by Audiogroome division of Empire Scientific Corp. (better known for their pickups and turntables). Discofilm consists of a clear, treacle-like substance that one pours crudely over old or dirty vinyl records, using a plastic "spreader" to ensure that the complete playing surface is covered. After the "goo" has dried (in 30-40 minutes) the complete film is peeled away, using a small strip of sticky tape to grip it initially, and the manufacturers claim that all dust and dirt particles, including deposits of former so-called cleaners, will be removed, leaving the disc cleaner (and hence quieter) than when new. Only time will confirm the effectiveness (or otherwise) of this new product, but to one with a record collection started in the mid-1950s when standards of cleanliness were not (nor needed to be) as high as today, the Discofilm could be the answer to a prayer.

After a tentative start in the early 1970s, direct cut discs have clearly arrived, and at Chicago most demonstration rooms had at least one of these discs available with which to display the full glory of their wares. (Paradoxically, the extreme dynamic and frequency ranges cut into these discs can be a mixed blessing, and some manufacturers would be better advised to confine their demonstration discs to conventional pressings.) Although the quality varies considerably, there is no doubt that the very best of the direct cut discs convey a remarkably lifelike quality through those systems able to do justice to them.

It is always instructive to examine what auxiliary components are in use by exhibitors; for example, what is the most favoured pickup used by exhibitors of (say) amplifiers or loudspeakers. At Chicago, the Shure V15/IV and Stanton 681EEE cartridges were much in evidence, both giving a very clean undistorted sound quality, although not in the writer's opinion as natural-sounding as the best moving-coil designs. The up-market loudspeaker most in evidence was the Dahlquist DQ-10, and although it has been accused of having a slightly harsh "top," listening evidence at Chicago indicated that this impression could have been caused by problems elsewhere in the system or by non-optimum matching.

Jack Dinsdale

BY A COINCIDENCE, the Institute of High Fidelity in the USA, yielding to internal pressures, decided to stage a high fidelity show in Atlanta, just three weeks before the Chicago CES. This had about 200 exhibitors, many of whom attended both events. The following notes are a selection of the most interesting items I saw at both of these shows.

Big news in the tape world is the introduction of the new pure metal or "metal film" tapes which use fine iron particles instead of oxides. Efficiency can be as much as 7dB higher with lower distortion, improved signal-to-noise ratio and less high frequency saturation. Tape heads have to be redesigned and bias current increased but at least three companies were demonstrating modified cassette decks with the new tapes. They were JVC, Nakamichi and Tandberg – the last-named using a 3M tape called "Metafine" which will apparently be made in two versions, one requiring 70μs equalization. Nakamichi were using a modified Model 1000 studio cassette deck and comparisions were being made with a Revox open-reel machine which were most impressive. Nakamichi were also demonstrating a machine equipped with both Dolby and Telcon (Telefunken) noise reduction systems. As the last mentioned gives 20dB of noise reduction, its use by Nakamichi might well start a trend . . .

It has long been taken for granted that the Philips cassette licence precludes the marketing of decks having a 3¾in/s speed. Well, either this assumption is incorrect or a separate agreement has been negotiated because B.I.C.-Avnet introduced three models, all using 3¾in/s speeds in addition to the standard 1⅞in/s. The top model has a monitor head and the response at the higher speed is claimed to be within ±3dB up to 22kHz. Playing time is of course cut in half: no doubt the next step will be to redesign the C.120 cassette – maybe for metal tapes!

At the moment Marantz seem to have won the receiver power race with their new Model 2600, which delivers 400 watts per channel! Like its smaller(!) brother, the 270-watt Model 2500, this new model uses a heat sink tunnel with a small fan and among the features is a quartz frequency standard, an oscilloscope display and a special low distortion (t.i.m.) circuit. A number of frequency synthesized f.m. tuners and receivers were to be seen, some using complete synthesis like the Sherwood MPU model, while others featured manual tuning with a display. The Sherwood tuner displays the station's call letters as well as the frequency and it has an auto-scan plus preset switches for four stations. Nakamichi's 730 receiver is another sophisticated unit and it uses a motor-driven 4-gang capacitor controlled by touch sensors. Another motor operates the volume control – also, like the rest of the functions, being operated by touch sensors. An optional remote control unit employing a pulse operated infra-red system can function up to 45 feet away. Dynaco's Model 2501 f.m. tuner has no less than six tuned stages in the varactor front-end. When the tuning knob is touched the station read-out is displayed, but as soon as the hand is removed the display becomes a clock!

One of the most interesting amplifiers on show was Threshold's Stasis 1, a "feedforward" model using a separate amplifier for error nulling. Unlike other feedforward designs, the error nulling section is connected directly to the load. It is claimed that near perfect operating parameters are achieved because the distortion of the current source amplifier, which handles the energy, is divided down by the high damping factor of a "stasis" section and becomes nearly unmeasurable up to actual clipping. Power output of this admittedly prototype unit was 300 watts into 4 ohms with a rated t.h.d. of less than 0.002%. Threshold were also showing an all-cascode class A amplifier which has a 1 kilowatt power supply. The output stage uses a dynamic biasing circuit which is claimed to track the bias voltage to maintain constant class A operation under all conditions.

At both the Atlanta and Chicago Shows an overwhelming variety of loudspeakers was seen and heard, ranging from tiny shoebox models to super-large systems like the Infinity Quantum Reference which stands over 6 feet high and 4 feet wide. It is best described as a semi-line source with two vertical arrays of flat electromagnetic induction speakers reinforced by a smaller line at the rear. The bass driver is a 15-inch dynamic type which uses the Watkins dual speech coil.

The full-range electrostatic systems were demonstrated, one from Acoustat and the other from Dayton-Wright, while Beveridge had an even larger e.s.l. panel augmented by a dynamic bass unit. But perhaps the most interesting systems was the Plasmatronic, dealt with by Jack Dinsdale above. It was designed by a laser physicist and the plasma driver is something like an enlarged Ionophone. Jack Dinsdale mentioned the need for topping it up with helium. As the poet said: "What's come to perfection, perishes" and I well remember having to change the quartz tube on my Ionophone loudspeaker every few weeks . . .

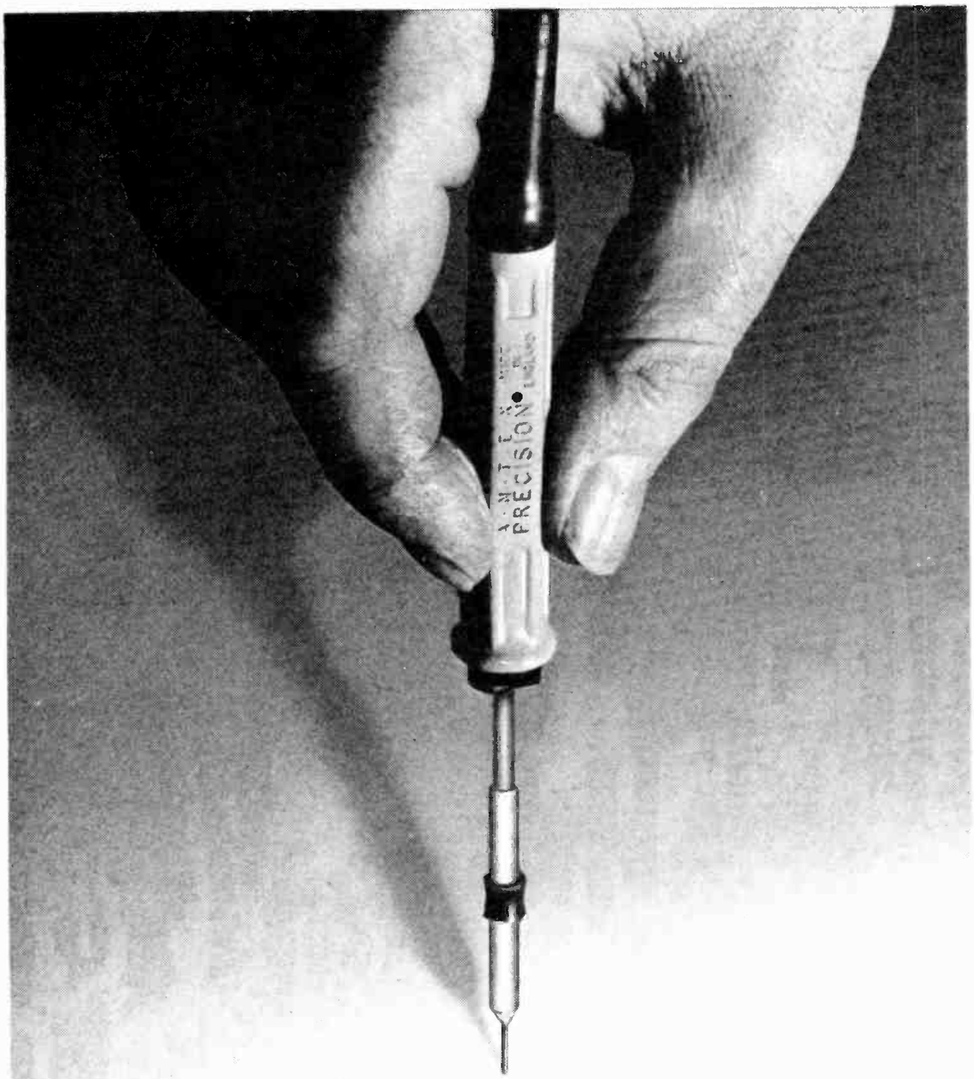
Another fascinating loudspeaker was the Barcus-Berry glass diaphragm system which consisted of a sheet of glass measuring about 7 by 5 inches and mounted in a small box. A transducer – probably a piezo type – is fixed to the glass at the rear and a crossover is mounted in the box as the unit is sold as an add-on tweeter. But the curious thing is this: radiation is almost omnidirectional and response extends to well above 30kHz . . .

In brief

A new firm, Nagatronics, introduced a ribbon pickpup (anyone remember the Ferranti?) . . . DBX were demonstrating a "bass synthesizer" which created low frequency harmonics from a fundamental: it is called a "Boom Box" . . . Optonica had a turntable which uses a laser to count the grooves on the record for programming with the aid of a microprocessor . . . Dolby were demonstrating a system which could use the f.m. station's 19kHz pilot tone to switch on the decoder in the listener's receiver . . . One company was showing a small breathalyser unit which used red, green and amber l.e.ds to indicate alcoholic content of a person's breath. Not far away, a salesman at another stand was demonstrating battery indicators consisting of a figure of W. C. Fields with a red nose that lights up. A pity the two companies did not get together!

Finally, a few words about television: projected sales of colour tv in the USA for 1978 vary between 8 and 9 million, units, while monochrome forecasts are around the 5 million mark – both slightly less than last year's figures. The last few months have seen increased activity in projection tv and Advent is now faced with competition from several Japanese manufacturers. Sharp introduced a two-piece system with three projection tubes, using a 72-inch (diagonal) screen. Among the features are a built-in crosshatch pattern generator, electronic channel selection and an ultrasonic remote control. The audio section uses a pair of six-inch loudspeakers. Price will be in the $3000 range. GE's new W1000 uses a different approach, and here a specially developed 13-inch two-gun tube rear-projects the picture to a 1000 square inch plastic Fresnel lens screen. (Translated, this works out to 45 inches, diagonally). There are two mirrors plus a three-element coated plastic lens. Price is about $2800. Other models from Mitsubishi, Panasonic, Quasar and Sony are two-unit systems with separate screens.

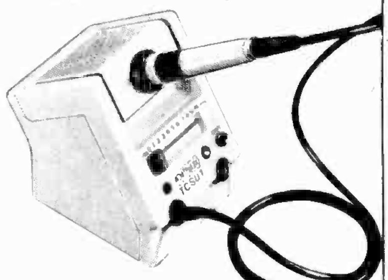
George Tillett



pin-point quickly & efficiently with ANTEX soldering irons

You can now combine fingertip accuracy with strict temperature control (within 2%) at the 0.6mm tip of a miniature soldering iron by using the soldering station shown with one of the 24volt irons.
The exceptionally fast recovery time of a miniature iron of 40watts at the chosen temperature ensures a short exposure or dwell time. If your requirements are less demanding, one of our ordinary miniature or general purpose soldering irons or kits may suit better.
All our soldering equipment is made in England to strict local and international standards of safety.
Our name for reliability is spreading from all over Europe to the U.S.A., to Japan and to most other countries.

Model TCSU1 Soldering Station



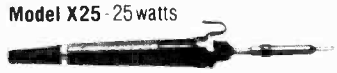
CTC 35watt –

The TCSU1 soldering station with either the XTC 50watt – 24/26volt soldering iron or the CTC 35watt – soldering iron for pin point precision and exceptionally fast recovery time.
We have put at least twice as much power into irons which are already well known for good recovery time. The temperature control stops them from over-heating; the 'fail-safe' electronic circuit provides protection even if the thermocouple fails.
TCSU1 soldering station **£52.65**. XTC and CTC irons **£14.85** inclusive of VAT and P&P

Model CX - 17 watts

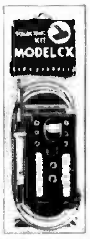
a miniature iron with the element enclosed first in a ceramic shaft, then in a stainless steel. Virtually leak free. Only 7½" long. Fitted with a 3/32" bit.
£4.15 inclusive of VAT and P&P. Range of 5 other bits available from ¼" down to 3/64"

Model X25 - 25watts



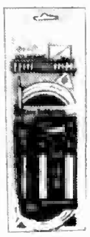
A general purpose iron also with a ceramic and steel shaft to give you toughness combined with near-perfect insulation. Fitted with 1/8" bit and priced at **£4.15** inclusive of VAT and P&P. Range of 4 other bits available

Model SK3 Kit



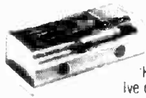
Contains both the model CX230 soldering iron and the stand ST3. Priced at **£5.99** inclusive of VAT and P&P. It makes an excellent present for the radio amateur, modelmaker or hobbyist.

Model SK4 Kit



With the model X25/240 general purpose iron and the ST3 stand, this kit is a must for every toolkit in the home. Priced at **£5.99** inclusive of VAT and P&P.

Model SK1 Kit



This kit contains a 15watt miniature soldering iron, complete with 2 spare bits, a coil of solder, a heat sink and a booklet 'How to solder'. Priced at **£6.48** inclusive of VAT and P&P

Model MLX Kit

The soldering iron in this kit can be operated from any ordinary car battery. It is fitted with 15 feet flexible cable and battery clips. Packed in a strong plastic envelope it can be left in a car, a boat or a caravan ready for soldering in the field.

Price **£4.83** inclusive of VAT and P&P

Please send the following ....
....
Please send me the Antex colour brochure .... ☐
I enclose cheque/P.O./Giro No. 258 1000
Name ....
Address ....
....
....
Antex Ltd. Freepost, Plymouth PL1 1BR
Tel. 0752 67377 W.W.10.78

ANTEX

Mayflower House, Armada Way, Plymouth, Devon Tel: 0752 67377/8 Telex: 45296

Model 178

Now . . . the next generation of bench DMMs!

Two New Keithley Models offer uncompromising performance and outstanding value!

- Accuracy 3½'s can't match 0.04% + 1 digit on dc volts and ohms
- Large, bright, 20,000-count LED display that's quick and easy to read.
- Convenient bench size that won't get "lost" yet doesn't crowd.
- Exceptional reliability.

Model 178 offers functions and ranges for most measurement needs 100μV to 1200V dc, 100μV to 1000V ac, 0·1Ω to 20MΩ.
Model 179 is a full-function, multi-feature model offering the same advantages as the 178. Plus **TRMS** AC; 10μV Sensitivity; Hi and Lo Ohms; AC and DC Current Yet it's still half the price you'd expect. Only £199.

Both models feature designed-in reliability

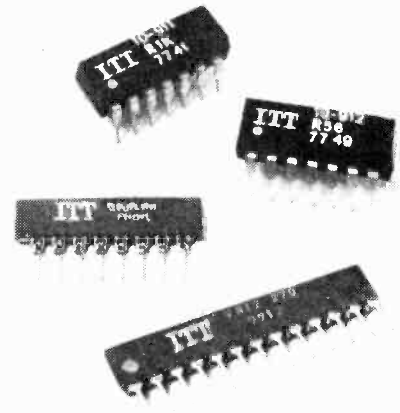
Rugged circuits use a minimum of parts — high quality, off-the-shelf parts — carefully assembled and tested by Keithley.
Outstanding overload protection and rugged mechanical design keep both units going even after severe abuse. One-year accuracy specifications minimise recalibration costs.
A battery option, user installable, gets you off "line" for critical measurements or for field use.

For complete specifications on the 178 and 179, call Keithley Instruments, 1 Boulton Road, Reading. Phone 0734 861287

KEITHLEY
The measurement engineers.

WW—038 FOR FURTHER DETAILS

Thick Film resistor networks by ITT -of course



A wide range of low-cost Single-in-line and Dual-in-line resistor networks in standard circuit configurations are available from ITT on short delivery. Each resistor network is backed by many years' experience of thick film technology, and made to exacting specifications. Typical applications include pull-up resistors and line termination for TTL, ECL and CMOS logic.

S.I.L. units are ruggedly constructed in two basic package heights (8.55mm and 5mm) with 3 to 20 leads, giving designers the maximum flexibility to cater for various power-dissipation and board-density demands.

D.I.L. resistor networks from ITT are available in 14-pin and 16-pin transfer moulded packages.
In both styles resistor values are available up to 10MΩ with standard tolerances as close as 1%.
Custom designed networks are also available, offering a cost effective solution to many board-space problems. For more information on standard or non-standard ITT resistor networks, contact:

ITT Components Group Europe
RESISTOR DIVISION,
South Denes, Great Yarmouth, Norfolk NR30 3PX
Tel: 0493 56122. Telex: 97421.

Components ITT

WORLD OF AMATEUR RADIO

The new RAE

The City & Guilds of London Institute has issued a list of 40 "sample items" of the new multi-choice Radio Amateurs' Examination to be introduced next May, together with a breakdown of how the papers will be composed. The first part (1 hour) will consist of 35 items: 66% on licensing conditions, 34% on transmitter interference. The second part (1¾ hours) will include 60 items: 8% operating practices and procedures; 18% electrical theory; 12% semiconductors; 15% radio receivers; 13% transmitters; 24% propagation, and aerials; and 10% measurement. Valves no longer form part of the syllabus, despite their continued use by the majority of amateurs.

My first impression is that the adoption of multiple choice has not meant any lowering of the technical or regulatory standard; if anything the reverse. Candidates who have not carefully prepared for the exam will need to be extremely lucky gamblers to pick enough winners to scrape through.

More questionable is whether the authorities recognise sufficiently that amateur radio is a form of "self-training" and that this is defeated by erecting a formidable barrier at the outset or to insist that newcomers should, for instance, be able to handle calculations in microcoulombs. The main result of a stiff RAE is surely to increase the demand for a Citizens' Band. Those of us who acquired amateur licences before the days of the RAE were fortunate indeed!

Machine-telegraphy and data

A number of readers have commented on the "Revolutionise amateur radio?" item in the July issue. Some of these have made the valid point that gaining experience in various modes such as h.f./r.t.t.y., high-speed data on v.h.f., the use of terrestrial and space repeaters and so on is all part of useful self-training, and should be encouraged. For example, it is argued that with so many Service and commercial users now on r.t.t.y. rather than manual c.w., amateur experience and understanding of this could be as important today as were his skills on manual c.w. in 1939. Robin Addie, G8LT, makes this point strongly.

Well, yes. Most of us would agree that these various modes can and do form an interesting and rewarding part of the hobby. My main reservation is that some of them are tending to be oversold to newcomers who are led to believe that digital non-return-to-zero transmissions (i.e. Morse) is now technically out-dated. A recent writer in *Break-in*, for example, argued that as the Services now place more emphasis on machine – than manual – telegraphy, this proves that r.t.t.y. is a better system than c.w. and that amateurs should cease learning Morse!

Norman Sedgewick, G8WV, in *Short-wave Magazine* takes the diametrically opposed view that in r.t.t.y. "amateurs are perpetuating an out-dated system which was used professionally as a stop-gap until the development of fully synchronous error-correcting systems and the completely different approach of Piccolo."

Peter Martinez, G3PLX, while recognising the limitations of basic h.f. r.t.t.y., is exploring ways in which microprocessors could be used by amateurs to implement fully synchronous techniques such as forward error correction, duplex ARQ (automatic repetition of errors). He has already made considerable progress and would be interested to hear from others working along such lines. His address is 11 Marchwood Court, Broadsands Drive, Gosport, Hants (Gosport 21563).

A general appeal to r.t.t.y. enthusiasts is that they recognise the high interference-potential of this mode and keep contacts reasonably short, remembering that the recent French move towards "exclusive" r.t.t.y. allocations was rejected by IARU Region 1.

Need for Novice licence?

Trevor Tugwell of the Stevenage & District Amateur Radio Society feels that the progressive development of amateur radio should be encouraged. However, he points out that geostationary OSCAR satellites could virtually "destroy" the present Class A licence, since it would open the way for regular long-distance operation by those holding Class B licences. This, he believes, would "reduce to a trickle" those prepared to learn Morse.

He feels that the only way to retain interest in h.f. operation would be by stressing the technical merits of c.w. and by pressing the Home Office to introduce "novice" h.f. licences akin to those in many other countries, based on, say, a 5w.p.m. code test, and providing facilities for low-power operation within segments of the 3.5, 21 and 28 MHz bands. This would provide a useful stepping-stone between Class B and Class A licences. One could go further and suggest in addition a simplified form of RAE for novices.

Around the bands

The RSGB has protested that a pulsed Syledis location system being used by oil companies at several locations in the UK is causing widespread interference to amateurs. Centred on 432.5MHz (a "secondary" allocation to amateurs) it is causing interference over several MHz and it is argued that such a system need not have been put in a popular amateur band.

The 10GHz beacons on Alderney (GB3ALD) and Isle of Wight (GB3IOW) are back on the air. Beacon stations in the Faeroes Islands (OY6VHF on 144.885MHz and OY6UHF on 432.885MHz) have been heard as far away as Hamburg. A 50.5MHz beacon station on Cyprus (5B4CY) began operation in May and has been received at good strength in the UK.

The Home Office has agreed that fascimile transmissions will be permitted in the 3.5 to 3.8MHz band provided that bandwidth does not exceed that of telephony signals. It has also agreed to issue licences for a further series of repeater stations (Phase 3) and agreed in principle to an r.t.t.y. repeater.

July saw several Sporadic E openings extending up to 144MHz and resulted in what are believed to be the first contacts on 144MHz between Greece and the UK.

In brief

Dr John Allaway, G3FKM, a former president of RSGB, is the Society's first honorary h.f. manager. There are now managers for h.f., v.h.f. and microwaves . . . . The Swiss PTT is to issue a special stamp in Autumn 1979 to mark the 50th anniversary of the formation of USKA, the Swiss national amateur radio society. There are some 2,000 amateurs in Switzerland . . . . Russian amateurs sent out over 2-million QSL cards during 1977 and received some 1.5-million . . . . The first all-OSCAR award has been issued to W2BXA . . . . Microwave stations in the UK are being urged to use horizontal polarisation as the standard . . . . The Intruder Watch, founded by the RSGB in 1957, is this year celebrating its 21st anniversary; it has spread world-wide with some 30 countries now participating . . . . The RSGB expects to run two centres for the December RAE at London and Derby . . . . "Narrow bandwidth television association" is the new name of the former "Low definition television association". Aim remains the encouragement of highest possible quality moving television pictures within the audio bandwidth (or bandwidth of an audio tape recorder) . . . . By April 1978, US amateur operator licences totalled 337,959, up 11% in a year.

PAT HAWKER, G3VA

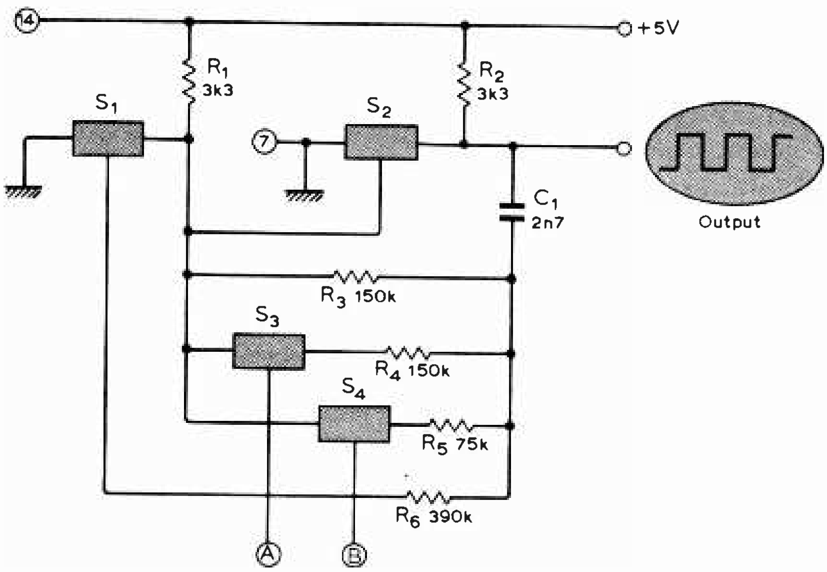
CIRCUIT IDEAS

Programmable oscillator

AN I.C. OSCILLATOR produces a range of output frequencies which are programmable using the two digital inputs. The circuit, which has a number of applications such as a multitone alarm or variable frequency clock for a digital system, is based on a single 4016 c.m.o.s. quad bilateral-switch i.c. Switches S_1 and S_2 are used as invertors together with R_3, R_6 and C_1, to form an astable multivibrator. Frequency variation is achieved by opening either S_3 or S_4 or both, with control inputs A and B. This connects R_4 and R_5 in parallel with R_3 which changes the time constant of the multivibrator, and hence its frequency. With the components shown, output frequencies of 2, 4, 6 and 8kHz are available. By changing the capacitor and resistor values, higher or lower frequencies can also be achieved.

Frequency modulation is possible by feeding a varying digital signal into the control inputs. Also, by the addition of a second 4016 and four extra resistors in parallel with R_3, the number of output frequencies available can be raised to 64.

D. Turner,
Plymouth,
Devon.

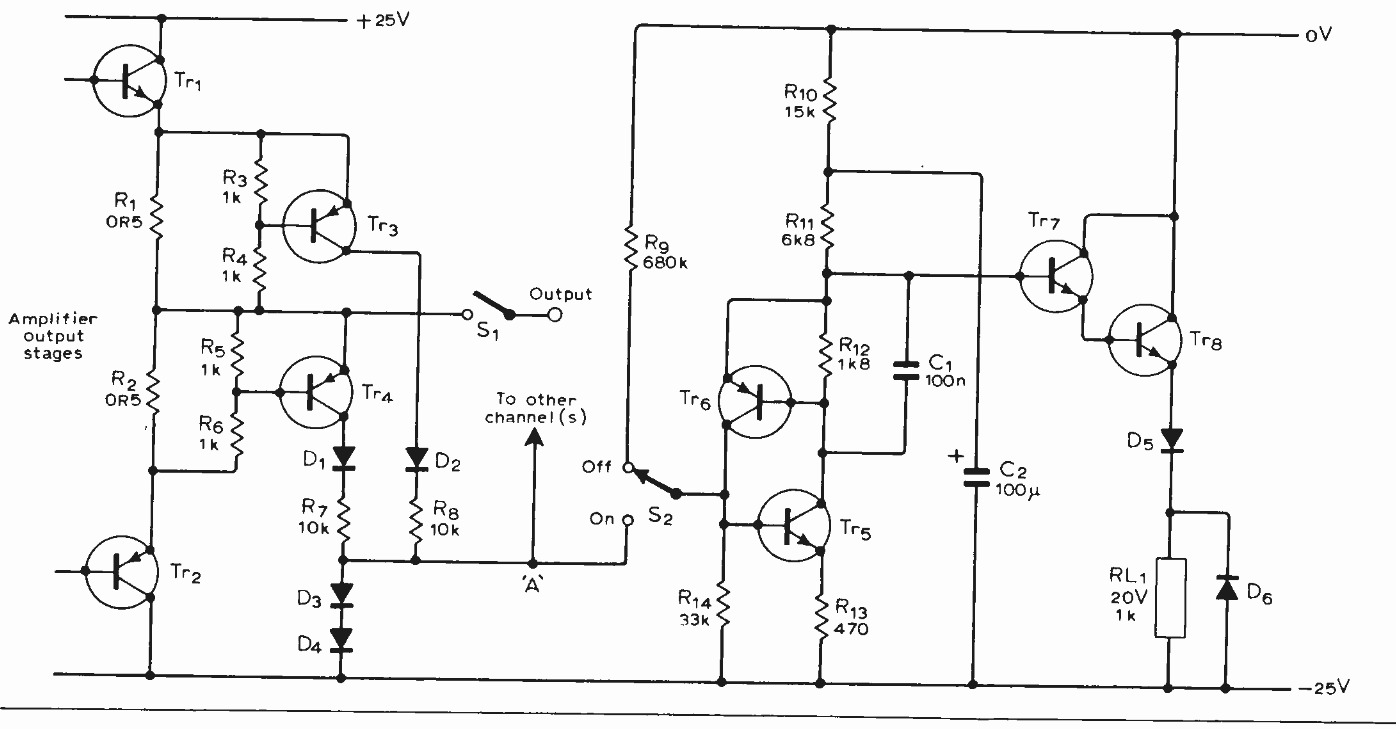


Overload protection and transient elimination

THIS CIRCUIT is suitable for use with d.c. coupled audio power amplifiers, and combines protection against current overloads with delayed switch-on for the elimination of output transients. Transistor Tr_5 is initially turned off, and C_2 charges via R_{10}. After a delay of about 1.5s the relay switches on which closes S_1 and connects the load to the amplifier. If a large current flows in Tr_1 or Tr_2 of the amplifier output stage, Tr_3 or Tr_4 will turn on. This turns on Tr_5 and the relay switches off. The circuit is reset by switching off the amplifier until the supply has dropped to a few volts, and Tr_5/Tr_6 are no longer saturated.

Capacitor C_1 reduces the susceptibility to spurious operation, and D_5,D_6 provide protection for Tr_7 and Tr_8. Point A is a virtual earth summing junction so other amplifier channels can be accommodated. The circuit can also be modified for different supply voltages, overload currents and delay times.

T. J. Moulsley,
Barton-le-Clay,
Bedford.



continued from page 83

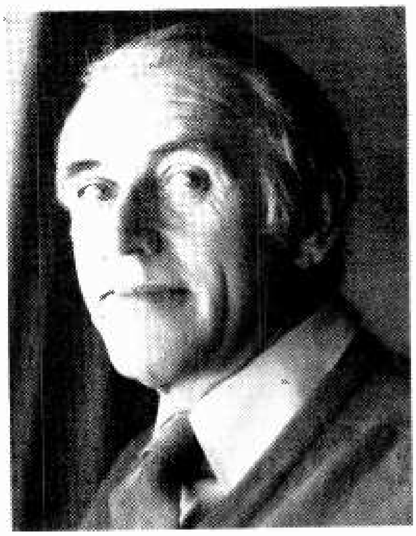
unimportant, and a different meter movement can be accommodated by changing the resistors.This indicator and tuning control may be remotely mounted.

If two sets of gate cards are used in an expanded system, it is possible to drive both sets from the circuit in Fig. 4 by changing the output resistors from 22kΩ to 10kΩ. This does not prevent the two sets from being independently frequency-modulated, but it does restrict them to the same tuning. To permit independent tuning the complete circuit of Fig. 4 should be duplicated beyond point X, which gives two sets of references from the crystal. The standardising circuit can be made switchable, and to avoid long a.c. leads a 4016 switch may be used as shown in Fig. 7.

The power-supply components are mounted on one side of the rack, which serves as a heat-sink for the regulators, see Fig. 1. The reference generator card uses a Veroboard as shown in the prototype assembly in Fig. 8. Edge-connection details are shown in Fig. 9. For the reference generator, positions 3 to 15, omitting 7, are reference outputs, position 16 is tuning and 17 is for the indicator.

For testing it is convenient to start with the crystal oscillator. The various frequency adjustments have already been referred to. If a frequency counter is not available an oscilloscope with a calibrated timebase can be used to measure the beat frequencies in table 2. If the crystal trimmer is set to mid range, the crystal should be very close to 1MHz. Supply currents for the prototype were +25 and −6mA.

David Ryder read Natural Sciences at Cambridge, but his career has been mainly in engineering. After a short spell in an instrumentation laboratory, he worked in the lift-manufacturing industry, and in the last few years has been concerned in the development of machine-tool controls. A lifelong interest in piano-playing, and a growing appreciation of the music of J. S. Bach led him recently to take up the organ. He says, "It is not surprising that an instrument with 600 years of development behind it can be an inexhaustible study, my organ lessons have been a first-class investment".



A 15 min cassette recording of the prototype is available for £2.00 c.w.o. A set of 15 special printed circuit boards (12 × E01, 3 × E02) is also available for £117.32 c.w.o. Both items are post free in the UK, and delivery is about 2 weeks and 4 weeks respectively.

Purchasers of these will also receive supplementary component and procurement details. Hiykon Ltd, Woodside Croft, Ladybridge Lane, Heaton, Bolton, BL1 5ED.

To be continued

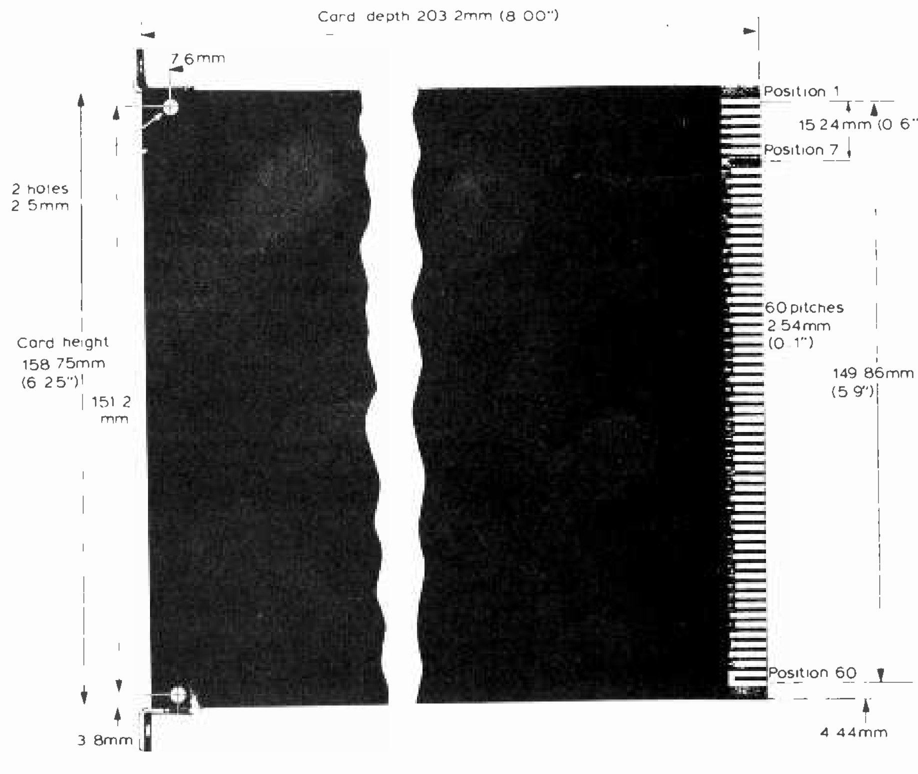


Fig. 9. *Standard edge connections looking onto the copper side. The slot occupies position 7, and connections 59/60 are both ground. On cards requiring +12V, this is supplied via connections 1 and 2. The special cards E01 and E02 have 2.5mm fixing holes as shown.*

Corrections

Tunable audio equalizer. The photograph shown in Martin Thomas's design for a tunable audio equalizer in the September issue was of David Russell, author of Trends in microprocessors (who says for "single-chip microprocessor" read single chip microcomputer). "No disrespect intended" responds Dr Thomas "but I hope that the article with my photo doesn't turn out to be about a UFO detector, electronic personal vibrator or a remote-controlled plant waterer, to name but a few diabolical probabilities!"

Apologies to both authors, and to readers for other errors in that article. In Fig. 3 the bottom end of R_5 should be disconnected from earth and connected to IC_5 output. The right-hand side of the expression for bandpass centre frequency on page 59 should have been within a square-root sign. An oblique stroke should appear in the $s^2\omega_0^2$ term in the transfer function beneath to read s^2/ω_0^2. And in the state-variable filter box on page 62, *HPinput* should have appeared as *HP/input*.

Loudspeaker system design. In Fig. 13 of Siegfried Linkwitz' article (June), the bottom end of the 34.8kΩ resistor at the inverting input of the lower-left op-amp should connect to the other channel, and not to earth as shown. In Fig. 18 the square-root sign should not extend over the term including frequencies. Mr Linkwitz adds "the B110 is connected out of phase relative to the T27 and B139 because of a 180 phase difference between the channels in Fig 13." And that "741 op-amps should not be used in the buffer and tweeter stages if more than 2V peak is required from the tweeter channel to drive the power amplifier into clipping. Instead, faster and wider badwidth amplifiers are recommended to avoid potential s.i.d." Finally, on page 53 of the May issue, centre column, for 85dB read 95dB.

Developments in cassette recorders

New materials and techniques for magnetic tape recording

by Basil Lane

MODERN hi-fi systems now usually include a cassette recorder and because of the popularity of these machines there is a continuing pressure on designers and manufacturers to come up with improvements at annual intervals. Many of the so-called improvements seen in the past few years have, in reality, been no more than tidying up the sloppy designs of previous years. At times it has seemed that those employed to design cassette recorders have just come straight out of university and are not aware of the lessons learned from other branches of audio design!

Analogue recording is as old as recording itself and the limitations of the system have always been painfully obvious. Neglecting the future promised by the application of digital techniques to audio recording, there is still a surprising amount of "steam" left in this technique. This year, quite large steps have been taken with the introduction of pure iron particle tapes and the necessary changes to the designs of the cassette recorders produced to accept this tape.

The significance of the design changes lies in the large increase of coercivity in the new tape. For example, where existing high coercivity tapes are specified at about 500 oersted, the later generation of pure iron particle tapes have coercivities in the region of 1000 oersted. A bar to the introduction of tapes of this type in the domestic recording field has been that the existing generation of machines cannot provide the high magnetic fields required to satisfactorily record and erase tapes above 500 Oe. Two factors have been dominant: first is the design of the record head, which requires that flux saturation is avoided while providing good short wavelength resolution; the second is that the record head amplifier should be able to accommodate the additional drive conditions imposed without suffering from signal limiting.

At the time of the introduction of CrO_2 tapes and the subsequent cobalt modified ferric oxide equivalents, both these parameters emerged as being of great importance. The limitations of the ferrite heads in use at the time had not been fully appreciated: neither had the requirement for an adequate dynamic range in the drive amplifier. Often record amplifiers had to produce a large amount of pre-emphasis to compensate for the shortcomings of the replay head above 2kHz. The result would either be distortion due to core saturation in the head or distortion due to limiting in the drive amplifier.

Tape heads

The use of a single head for record and playback purposes has tended to add to the designer's difficulties and it is understandable that most of the modern top performance machines have now adopted the practice of having separate record and replay heads.

Because of the high values of gap flux now required to effectively magnetise a tape, great care has to be taken over the magnetic properties of the material and also the physical constraints of the core with respect to the saturation flux level at the pole tips. In selecting the material, the designer starts with the obvious magnetic and electrical properties and then considers such aspects as the hardness, the porosity (relevant in the case of moulded ferrites), and the wear characteristics using the various types of tape available.

Table 1 shows some of the parameters for the most popular materials and the latest ones which are now being adopted by some manufacturers. These fall into three typical groups, being based on the ferrites which are derived from magnetic oxide powder compounds, metal alloys used in a laminated form, such as the Permalloys, and a third type which is a pure metal alloy powder called Sen-Alloy. This has been applied in other fields since 1937, but only recently has been adopted for tape heads.

Where recording is the prime requirements, the saturation flux density, resistivity and Curie temperature of the core material are of the greatest importance. Since tape materials with high coercivities are now being developed, large leakage flux fields are needed in the head gap area. These will be easier to obtain using core materials with high saturation, since the pole tip design to produce the necessary sharp field gradient which enables high density recording necessarily involves small gap dimensions.

Although some ferrites are capable of displaying quite high saturation flux densities, from Table 1 Sen-Alloy and Permalloy offer the best. What militates against Permalloy is that, in the harder

Table 1. *Magnetic and physical properties of record head materials.*

magnetic and physical properties table

	Polycrystalline ferrites Mn-Zn-Fe-O			Single crystal ferrites	Permalloy		Sen-alloy	
	41M	60M	71M	Mn-Zn-Fe-O	Standard Fe-Mi	Hard Fe-M-Mb-Ti	Standard Fe-Al-Si	SCA Fe-Al-Si-Ti
Permeability (μ)								
@ 10kHz, 10m0e	20000	15000	5000		5000		13000	10,500
@ 1MHz	2000	2500	2500					
@ 5MHz	400	300	900					
Flux density (B_{10}) gauss	3300	4500	5000	4080	6300	5050	9000	8000
Coercive Force (H_c) oersted	0.03	0.03	0.05	0.04	0.01	0.015	0.022	0.03
Sat. Flux Density (B_S) gauss	3800	5000	5500	4700	7200	5800	10500	8700
Curie temp. (T_c) °C	110	150	200	240	350	250	500	500
Resistivity (ρ) Ω.cm	>10	>1	>1	5	60	80	80	85
Hardness H_v kg/cm^2	650	650	650	640	120	200	500	590
Thermal expansion coeff. 1/°C ∝ × 10[7])	110	120	130					
Average grain size μm	50	50	50					25
Porosity (P) %	0.05	0.05	0.05					
Density (d) gm/cc	5.1	5.1	5.1	5.15	8.62	8.7	7.0	7.0
Wear rate μm/1000hr.	1	1	1	3	2	2	2	1

form, saturation flux figures are only marginally better than the ferrites normally used (these are compounds containing between 60% and 70% manganese oxide), and are much more difficult to manufacture because of the need for thin laminations to keep the core resistance high. Sen-Alloy therefore comes out with distinct advantages, except that it has always proved to be a very difficult material to work. Recently, both Matsushita and Yamaha have developed manufacturing processes which seem to have not only solved the problem of its extreme brittleness, which made machining almost impossible, but also improved the basic magnetic characteristics.

For replay heads, a narrow and extremely accurate gap is essential, suggesting that the material used for the core should be easily machined. Permeability, which affects the head sensitivity,, should be high, as also should be the resistivity, the hardness and the quality of the surface finish. Within the audio band permeability can vary considerably for the materials listed. Ferrites have a relatively slow decline in permeability over the audio range, while Permalloy and similar laminated metal cores display much more disastrous drops from 50,000 at 100Hz to about 5,000 at 10kHz. Although Sen-Alloy shows quite a large drop over the audio band, at 10kHz the figure is significantly higher than some ferrites and much higher than laminated metal.

To illustrate some of the problems in head design, three examples follow, using typical data as listed in Table 2 and Fig. 1. This is an illustration of the contours of equal magnetising force (H) around the gap of a recording head. Units used in these examples are the old c.g.s. system, which has unfortunately persisted in the magnetic materials industry. Initially, it is to be assumed that the tape to be recorded is a CrO_2 type, having a typical coercivity of 500 oersted.

The ideal critical zone marked in Fig. 1 indicates a region where the recording field should be of the same value as the tape coercivity. The zone is actually a band of variable width, due to the addition of the time-variable flux caused by the presence of the audio signal. The length of the critical zone is thus dependent upon the relative values of bias and signal levels which are determined solely by tape coating parameters.

Assuming a saturation flux density (B_s) for head 1 of 5500 gauss, the maximum value of magnetising force in the gap (H_g), will be

$$B_s = H_g = 5500 \text{ oersted}$$

assuming that the gap is air or of a similar permeability. (In c.g.s. units, permeability in air is unity).

At this point reference should be made to Fig. 1. This has been devised from original papers by Westmijze[1], Hoagland[2], and Camras[3] and is based on the assumption that where the fringing field is calculated at distances greater than 0.4 times the gap length the field pattern is cylindrical. The near field pattern is drawn using the data provided by Westmijze[1]. In simpified form, if the gap field H_g is normalised to unity, then the far field strength (H_c) will be given by:

$$H_c = \frac{s}{\pi d}$$

where d is the coating thickness of the tape. In Fig. 1 the scale of dimensions is given, for simplicity, by the ratio *y/s* where *y* is the distance along the *y*, *y'* axis and *s* is the gap length.

The value of H_c can now be calculated, assuming the ideal critical field will lie on a radius where $y = d$. Thus, for example 1, the maximum field available in the critical zone where the tape thickness is 6μm will be 364 oersted. In practice, the coating will experience a zone of higher field strength, but this is much closer to the gap where the contours curve considerably, causing distortion of the signal and a reduction in the short wavelength (maximum output level).

If the gap is widened, as in the example given for head 2, although the same value of H_g previals the location of the 364 oersted curve has moved further away from the gap to a radius of 29μm from the gap centre. Since the practical zone width will also have been increased, recording resolution at short wavelengths will suffer due to bias erasure. To obtain the correct 500 oersted contour for the tape thickness of 6μm, the level of H_g should be adjusted down to a value of only 1570 oersted, well within the limits of the maximum flux density for the core material selected. Clearly head I cannot produce the bias fields suitable for low distortion recording on tapes above about 360 oersted and this helps to explain the dilemma of the designer who is forced to adopt a narrow gap configuration in cases where the head is used both for record and replay.

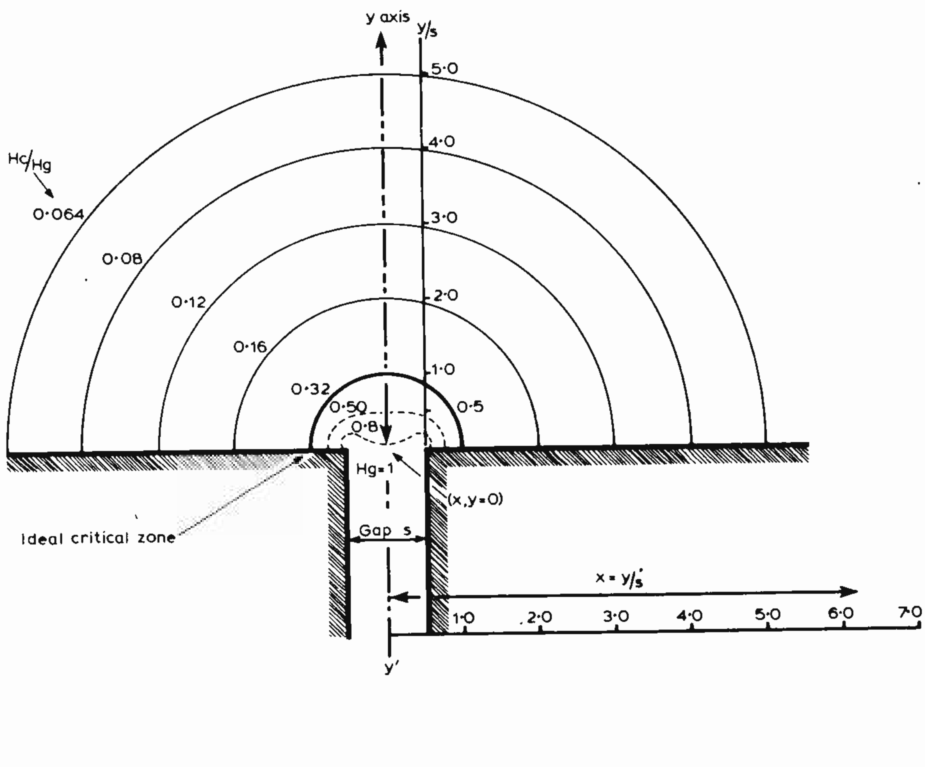
However, the same core material will not only adequately cope with CrO_2 tapes with a coercivity of 500 oersted when used with a design having a gap length of 6μm, but is also capable of operating correctly with 6μm coatings having coercivities up to 1590 oersted! In this example a ferrite with a typically median value of B_s has been selected deliberately, to illustrate a worst case condition.

If the narrow gap version is selected, but this time using Sendust as a core material, the value of B_s rises to 10,500 which now permits a maximum value of magnetising force in the ideal critical zone of 696 oersted – well above that required for CrO_2 tape, but insufficient for correctly operating the new pure iron tapes. Nevertheless, as has been demonstrated in the first two

Table 2. *Examples of parameters for three hypothetical heads.*

Parameter	*Head 1*	*Head 2*	*Head 3*
Core material	Ferrite	Ferrite	Sendust
Core permeability (10kHz)μ	5000	5000	11000
Core length (l_2)	10mm	10mm	10mm
Gap and core cross-sectional area (*A*)	$6\times10^{-7}m^2$	$6\times10^{-7}m^2$	$6\times10^{-7}m^2$
Saturation flux density (B_s)	5500	5500	5500
Gap length (l_g)	$1.25\times10^{-6}m$	$6\times10^{-6}m$	$1.25\times10^{-6}m$

Fig. 1. *Contours of the relative value of equal magnetising force (H) around a record head.*



cases, a simple and small increase in the gap length up to about 2µm will allow the correct conditions to be obtained.

Admittedly these examples are crude, as the core design used has a uniform cross section which would certainly not be the case for a practical head. In addition, no attempt has been made to allow for design devices which alter the distribution of the fringing flux, or to take account of core losses, or even to calculate using the more practical figures of B_{max} for the core, instead of the more readily obtained saturation figures. As a first order approximation, the examples do serve to clearly demonstrate the marginal magnetic properties of ferrites when used as a narrow gap audio record head, even when dealing with contemporary CrO_2 tapes. They also indicate that Sendust is clearly superior, even to the extent that this material comes close to having the desired properties permitting narrow gap heads to be fabricated for the next generation of magnetic tape.

It is interesting to note that Tandberg, who are among the first to produce a cassette recorder for pure iron particle tape, have chosen to use a ferrite head for recording, having a gap of 5µm. (See appendix). This machine, the TCD340A, has other novel features which will be described later.

Yamaha and Matsushita have published details of Sendust heads which could record high coercivity tapes and because of the obvious value of this material to designers, some details are offered here.

Sendust audio frequency heads

Sendust or Sen-alloy comprises a combination of about 84% iron (Fe); 9.7% silicon (Si and 5.8% aluminium (Al). It was first used in 1932 by Professor Matsumoto as a core material for r.f. coils. In its original form it was a powder compressed with a binding material to form a solid. As such it was far from ideal for tape head cores and it was not until about 1972 that methods were developed for producing a form suitable for video head applications.[4].

Since the alloy is both brittle and hard, it is difficult to machine and so casting techniques have been developed to produce extremely accurate core forms [5,6]. In the methods adopted by Yamaha and Matsushita, long core sections are produced which then only require slicing. Machining is made easier with the addition of small percentages of rare earth elements such as titanium (Ti), yttrium (Y), or cerium (Ce). Matsushita head cores, for example, contain 0.5% Ti. Inevitably, these additions do modify the magnetic performance, as shown in Table 1.

The manufacturing process used by Matsushita starts with melting the alloy components at a temperature of 1440°C in an argon atmosphere and then, in the same atmosphere, pouring the melt into moulds. Pressure is then quickly applied to between 500 kg/cm² and 1000 kg/cm², followed by a rapid quench. This method is called squeeze casting and is said to produce improved magnetic properties due to the elimination of inclusions. It does, however, have the disadvantage that a 10hr annealing is required to restore the permeability. The Yamaha process is more involved, but does seem to offer some advantages in the better magnetic properties of their material. The alloy is produced from high purity raw materials and contains no rare earth additions. Comparisons of the B-H and relative permeability curves of Sendust with and without additives are given in Figs 2 and 3.

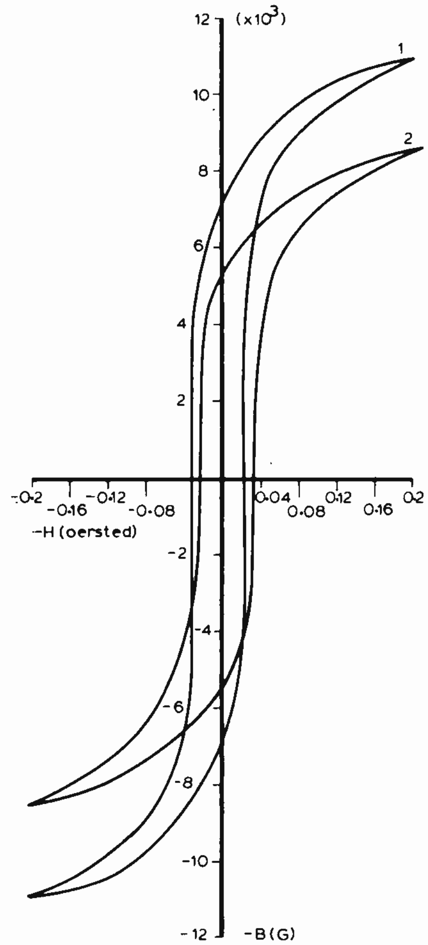


Fig. 2. The B-H magnetic characteristic for (1) pure Sendust; (2) Sendust with added titanium and zirconium.

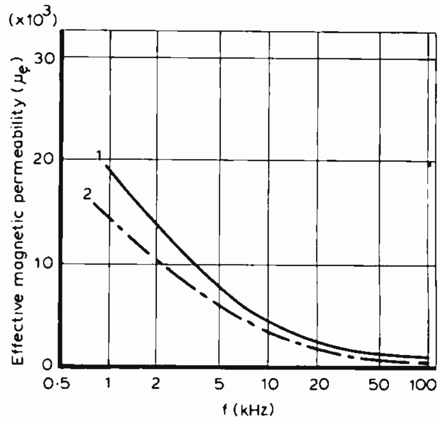


Fig. 3. *Effective permeability plotted against frequency for (1) pure Sendust; (2) Sendust with added zirconium and titanium.*

The melt is made in a vacuum of 10^{-5}torr and, in the same vacuum, is poured into capsules which are then rotated at 18000 r.p.m. From these, the Sendust is poured into graphite moulds and allowed to cool. The centrifuging produces an isotropic crystalline solid, formed into core shapes of very precise dimensions.

As with most other head designs, the cores are fitted into Permalloy cases, with the core tips showing through a window. Because the wear rate of these two materials is different, which could lead to later recording losses, Yamaha then coat a thin film of Sendust over the entire front face, using a vacuum plasma deposition process. This ensures a uniform surface with a high resistance to wear.

Table 3. *Characteristics of the Hall element used in the Hitachi record head.*

Specifications of the Hitachi Hall element

Size of element	1.4µm thick 0.2mm wide 1mm long	InSb thin films
Product sensitivity	37mV/mA. kgauss	
Output	4.0mV	10 gauss field, bias 11.2mA
Noise	0.56µV(r.m.s.)	bias 11.2mA, 100Hz-10kHz
S/n ratio	77 dB	4.0mV, 0.56µV
Resistivity	$1.2\times10^{-2}\Omega$.cm	
Temperature coefficient of output	−1.6%/deg.	0-50°C

Alternative tape head technology

Until recently the most practical technique for converting fluctuations in a magnetic field into a varying electric signal has been electromagnetic induction. However, probably as a result of a very complete analysis of methods undertaken by M. Camras some years ago, the Hall effect suggested itself as a practical alternative for magnetic recording. This is named after E. H. Hall, who in 1879 discovered that if a current carrying conductor is fixed in a transverse magnetic field the moving electrons are forced to one side (Fig. 4). This creates a potential difference between the edges of the conductor that is directly proportional to the flux density B, the value of the current flowing, I, and the density of the moving charges in the conductor.

Thus

$$V_H = \frac{K_H I.H}{T}$$

Where V_H = the Hall voltage, H is the field strength, T is the thickness of material through which H passes and K_H represents the Hall coefficient of the material given by

$$K_H \frac{1}{ne}$$

where n = number of charge carriers and e = the charge per carrier.

Clearly, K_H will be large when the number of charge carriers is small, but in a metal, there are very large numbers of carriers, so the Hall voltage will be small. This suggests the use of some semiconductor materials, those proving most suitable being germanium and indium antimonide (InSb), the latter having a value of K_H of 30,000.

These encouraging figures suggest that a practical replay head can be made which offers a number of advantages over normal heads. First, because the Hall voltage is dependent upon H, the head is flux sensitive, rather than being sensitive to the rate of change of flux as in conventional heads. This should improve low frequency reproduction and make it possible to transduce signals down to d.c. Second, because the electrical element is a straight conductor, the circuit will be purely resistive and an improved transient performance is obtained.

Although the principles of the Hall element suggest that a replay head without magnetic materials could be produced, two difficulties lay in that path. At the flux levels available from the recorded magnetic tape (approximately 200mM/mm at low frequencies) output levels from the element would be low and the signal to noise ratio would suffer. Also, the need to establish a connection on the edge that would be in contact with the tape would create engineering difficulties. Methods which use alternative points of connection simply reduce sensitivity.

In fact, the simplest method is to use a conventional core assembly with the Hall element placed in a rear gap of the magnetic circuit. Fig. 5 shows an actual record-play head produced by Hitachi for their new D7500 cassette deck. Table 3 gives details of the Hall element used. The InSb element is laid as thin film directly onto one of the ferrite core pole pieces, thus making it possible to fabricate an extremely thin element to give a high sensitivity. In addition, Hitachi apply a heat treatment which is said to improve the Hall coefficient.

Record amplifier improvements

The limitations of magnetic tapes and record heads for casssette recorders have all too often led to the practice of attempting to compensate for declining short wavelength flux on the tape, either by reducing the bias to below the optimum level or by applying high levels of pre-emphasis in the record amplifier. Because the head preamplifier also generally performs the function of record equalisation, problems of slew rate limiting and intermodulation tend to arise. In addition, signals with large high frequency energy (made worse by companders such as Dolby B) may suffer from limiting due to the small overload margin available from the devices and the supply voltage normally used.

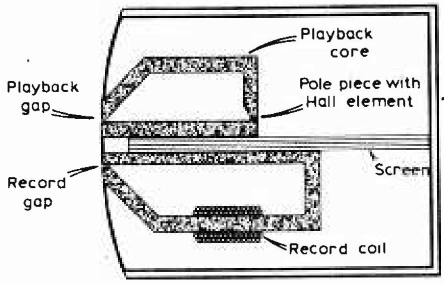


Fig. 4 *Construction of the Hitachi D7500 cassette record-replay head.*

Tandberg have come up with a different approach which seems to eliminate many of the difficulties. They start by separating the functions of pre-emphasis from the function of driving the head cores (Fig. 6). Since the equalisation amplifier then only has to operate at small signal voltages, the effects of intermodulation and slew rate limiting are reduced. In addition, the buffering of the bias oscillator from the equalisation amplifier by the drive amplifier has considerably reduced the interactive effects that can sometimes occur.

Finally, the idea of using a "constant current resistor" to provide the source for head current has been rejected in favour of a transformer used as a constant current load for the final stage. Rejection of the bias tending to feed back into the drive amplifier is obtained by an LC filter between the output stage and the point injection of the bias signal. This combination has been the subject of a recent world-wide patent application by Tandberg and is called the Actilinear recording system.

Appendix

At a recent conference to launch Tandberg's 1978 cassette recorders, additional information provided by Herman Lia, Tandberg's designer, was produced which is of considerable elegance. A simple formula which encompasses the graphical solutions used here may be quickly used to establish first order criteria for far fringing fields.

$$B_c = \frac{\mu_0 \pi d H_c}{s}$$

where μ_0 = 1 (c.g.s. units), d = thickness of tape coating, H_c = tape coercivity, s = gap length and B_c = core flux density. The core flux density will equal the gap flux density, thus equating to H_g used in the body of this article. Using data supplied by 3M (UK), who have developed the Metafine 4 pure iron tape, and a ferrite core material having a maximum operating flux density of 4000 gauss, the following design results were obtained.

$$d = 4\mu\text{m}, H_c = 1050, B_c = 4000$$

$$s = \frac{\mu_0 \pi d H_c}{B_c}$$

$$= \frac{3.142 \times 4 \times 1050}{4000}$$

$$= 3.29\mu\text{m}$$

By allowing a margin for future developments, and setting the gap length at 5μm, the maximum value of H_c for coating thicknesses from 4μm to 6μm is 1060 to 1590 Oe, thus offering considerable margins of safety.

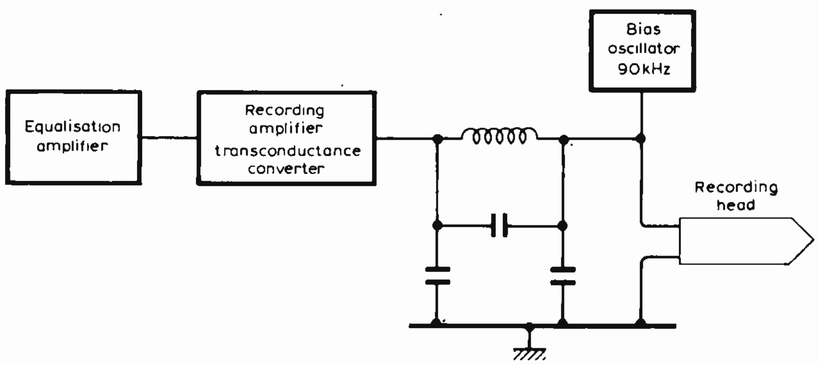
They also suggest that by taking the saturation flux density figures for core materials, Sendust looks better than it really is. This is because the B-H curve for Sendust shows a considerably larger ration for B_{max} versus B_{sat} than ferrites, thus reducing the total working range of the material.

Clearly wide gap heads are necessary with existing materials, but Tandberg are working with Trondheim University to optimise an "amorphous" magnetic material which will permit gap lengths down to the 1μm region. This suggests a working flux density of at least 13,300 gauss in the core material.

I am indebted to Tor Sivertson and Herman Lia for this additional information and to Herman Lia for the elegantly simple formula given above.

1. *Philips Res. Report.* 8, R2i4, 1953 pp. 1161-183.
2. Hoagland, A. S. "Digital Magnetic Recording" pub. John Wiley & Sons pp. 90-97.
3. U.S. Patent 2,628, 285 1953.
4. NHK Laboratories note, Serial No. 154, July 1972.
5. *I.E.E.E. Trans/Mag.* Sept. 1977, vol. Mag 13, No 5, pp. 1473.
6. Internal document issued by Yamaha, Japan.

Fig. 5. *Block diagram of the Tandberg Actilinear recording amplifier*



(a)

NEW PRODUCTS

Digital multimeter

A portable instrument, the Jugoslav-made Iskra Digimer 10 is a 3½ digit multi-function, digital meter providing for measurements of alternating and direct voltage, alternating and direct current, and resistance. Automatic polarity indication is provided and the unit is powered by rechargeable batteries which last for eight hours. The display is a 7-segment type, 7.62mm high. Ranges are: voltage (alternating and direct) 200mV to 2000V full-scale; current (a.c. and d.c.) 20μA to 2A; resistance 0.1Ω to 20mΩ. Iskra Ltd, Redlands, Coulsdon, Surrey CR3 2HT.
WW304

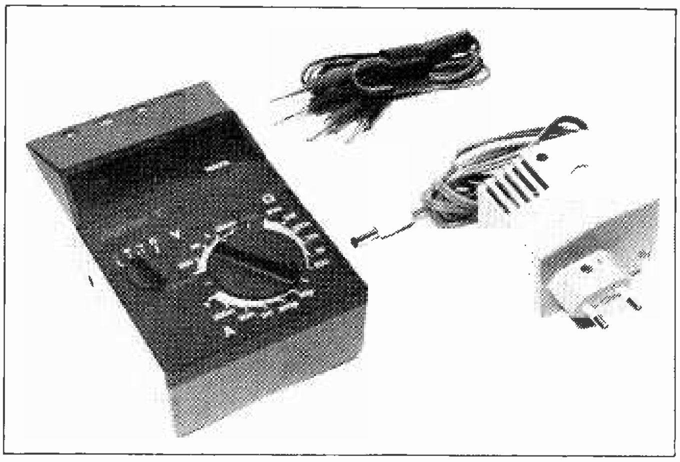
Power supply

A power source intended mainly for use with prototype mixed linear and digital integrated circuitry, the TOPS2 can also be economically used to power microprocessors. The outputs are 5V at 5A and 15V at 1A, positive and negative, although they may be adjusted about these levels. Overvoltage protection is provided for the 5V output, while the 'linear' outputs have overcurrent protection: autoreset is present on all three. Overload is indicated. Farnell Instruments Ltd, Sandbeck Way, Wetherby, Yorkshire LS22 4DH.
WW302

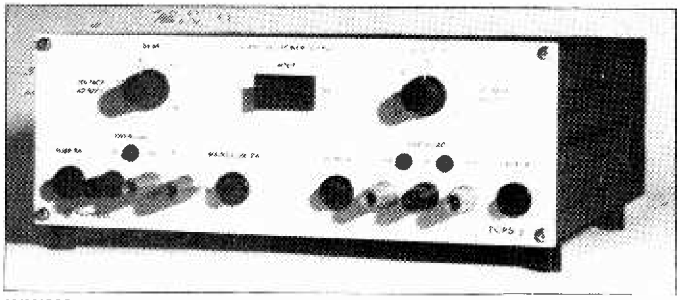
Transistor sockets

Sockets for power transistors in TO-3 or TO-66 cans are announced by Astralux. The

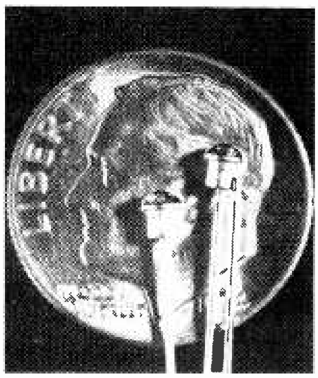
sockets are made from glass-filled diallyl phthalate, and contacts are of either beryllium copper or brass, gold or tin-plated. Current rating is up to 10A, with a 30A version also available, and one or two ground straps of tin-plated brass are provided. Astralux Dynamics Ltd, Brightlingsea, Colchester, Essex CO7 OSW.
WW303



WW304



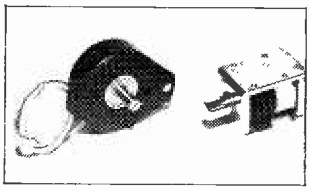
WW302



WW313

Wide angle l.e.d.

The Opcon OSL-1 and OSL-1S are one-lead and two-lead l.e.d.s which offer a viewing angle of 180° and are claimed to be the smallest devices commercially available. Both versions have a typical luminous intensity of 1.1mCd with a forward current of 15mA. Norbain Optoelectronics Division, Norbain House, Arkwright Road, Reading, Berkshire RG2 OLT.
WW313



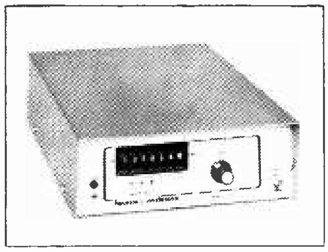
Solenoids

Freedom from mechanical noise and the necessity for end stops are claimed for rotary and linear solenoids made by Roxburgh Electronics. Maximum effort is exerted at the beginning of the stroke and the armature is stopped by electromagnetic braking.

The rotary type will work at voltages from 6 to 48V over a rotary excursion of 20°, 30° or 45°: moments of rotary inertia range from 3.8×10^{-3} to 870×10^{-3}gr/cm/s^2. No axial movement is exerted. The linear variety accept supplies of 6-100V, maximum torques, as in the rotary type, varying between 0.15kg to 0.95kg for the smallest version to 1.5kg-3.6kg in the largest model. Roxburgh Electronics Ltd, 22 Winchelsea Road, Rye, East Sussex TN31 7BR.
WW315

Frequency synthesizer

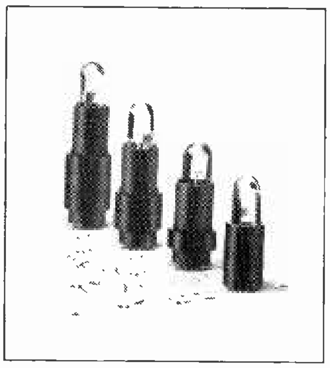
The model S1-107 can synthesize frequencies from 0.1Hz to 16MHz with a resolution of 5½ digits. An



internal reference oscillator provides a stability of ± 10 p.p.m. in the temperature range 0 to 50°C. Circuit optons include external b.c.d. programming, and ± 1 p.p.m. refreence oscillator. The unit measures 216 × 81 × 229mm. Syntest Corporation, 169 Millham Street, Marlboro, Mass. 01752, U.S.A.
WW311

Variable-height l.e.d.s

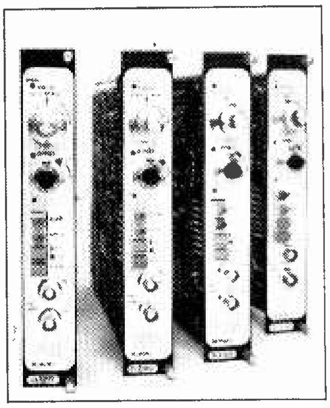
Printed-circuit board mounting l.e.d.s by Marl can be adjusted in height above the board by the insertion of extender sections,



which fit directly to the base of the l.e.d. and which have flow-soldering contracts. The l.e.d.s themselves are the PC201 series and are obtainable in red, amber and green. Marl Associates Ltd, The Ellers, Ulverston, Cumbria LA12 OAA.
WW301

Waveform memory

This is a memory module for the Datalab 2000 series of waveform recorders. Analogue waveforms are applied to the input of the module, he DL2005, digitized and stored in a 40K memory, from



which it can be read, converted back to analogue form and displayed or used as computer input. Maximum sampling rate is 2MHz. Input amplifier gain is step variable to provide for inputs of between 100mV and 5V full scale, with a 'fill-in' control, and the preamplifier output is presented at the front panel. An offset control reduces the effect of superimposed direct voltage. Data Laboratories Ltd, 28 Wates Way, Mitcham, Surrey CR4 4HR.
WW309

Phase meter

A direct meter display of phase difference between two signals is presented by the Prosser PSI A200 analogue phase meter. A taut-band meter is used, with a scale calibrated from 0-180, and lights indicate which of the two inputs is leading. A switch increases display sensitivity to 18

and an output of the phase information is provided for external use. Input amplitudes between 50mVpk and 5Vpk are recommended, though in the frequency range 10Hz to 100kHz, an input of 5mV will operate the instrument. Inputs must be symmetrical for maximum accuracy in measurement, but slight distortions are acceptable. Prosser Scientific Instruments Ltd, Lady Lane Industrial Estate, Hadleigh, Ipswich IP7 6DQ.
WW307

Counter i.c.s

The eight-digit i.c.s, from Intersil, called universal counters, can function as a frequency counter, period counter, frequency ratio counter, and a time interval counter. The devices are designed to display frequency in kHz and time in µs with a decimal point output and leading zeros blanked. The ICM 7216 and ICK7226 are housed in 28 pin and 40 pin packages respectively, but the last mentioned device offers additional accumulation times and b.c.d. outputs. The only external components required are a 10MHz crystal, switches, tuning capacitors and an eight digit l.e.d. display. Intersil Inc., 8 Tessa Road, Reading, Berkshire RG1 8NS.
WW312

Pulse generators

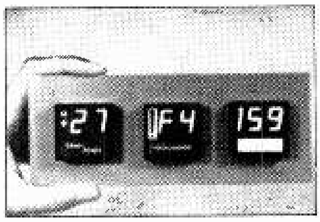
A pulse transition time of less than 0.1ns is exhibited by the AVK series of pulse generators made by the Canadian firm of Avtech, who say that it is particularly intended for use with fast logic devices, going on to say that they think it might be the fastest solid-state pulse generator available commercially. The unit requires a trigger of between 2 and 5 volts, producing either 5V fixed-amplitude or 0-15V variable outputs, depending on model, polarity being fixed by the user. Width is either 1-50ns or 4-100ns, input trigger being either 0-20kHz at 100ns output or 0-1MHz at 1ns output. The generators are distributed by Lyons Instruments Ltd, Hoddesdon, Herts.
WW306

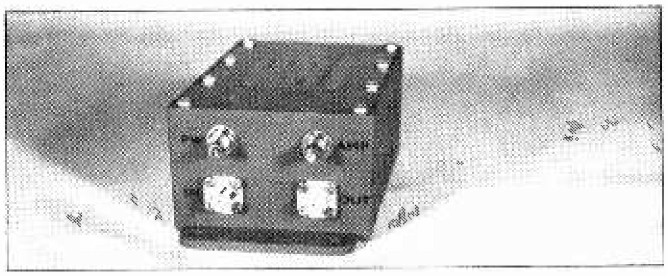
Pyrometer

The portable pyrometer by Oryx is intended to provide an accurate indication of soldering iron temperature in the range 200-450°C. The unit needs no power supply and has a detachable thermocouple probe with a non-burn lead of neoprene. Greenwood Electronics, Portman Road, Reading, Berkshire RG3 1NE.
WW314

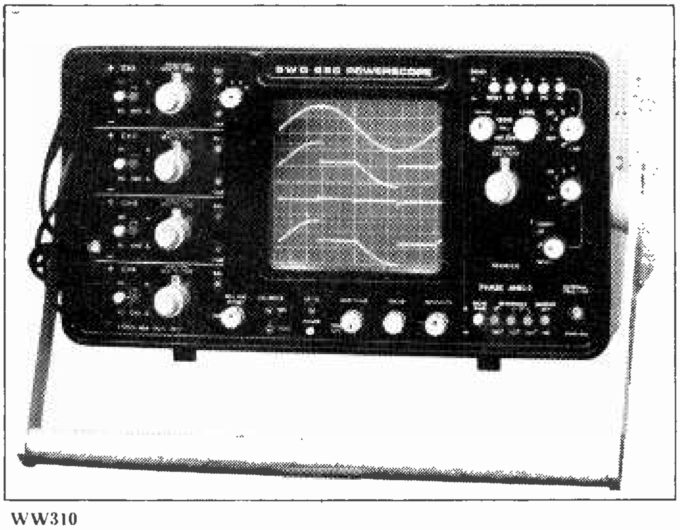
Alphanumeric indicators

Eight-bit coded inputs can be used to illuminate alphanumeric displays or as alarm identification in an area about the size of a pilot lamp. The displays are 2½ digit, programmable indicators, incorporating in different versions 8-bit decoders, a 25MHz counter, an 8-channel failure surveillance unit with alarm, or a 2-digit display with sense for use with shaft encoders, the decoder providing linearization of a non-linear signal. Sufficient output power is obtainable to drive a relay. Centrelco S.A., CH-1211 Geneve 26, Case Postale 241, Switzerland.
WW308

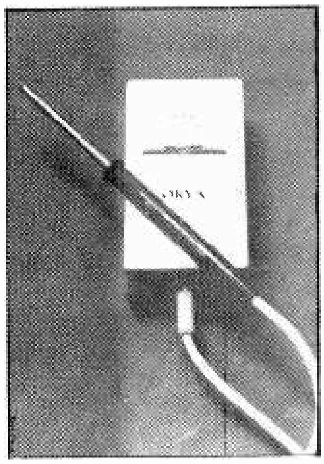




WW306



WW310



WW305

Conductive coating

The use of plastic cases for electronic equipment is convenient but affords no protection against radiated interference and no possibility of earthing. A conductive coating, which can be brushed, sprayed or screened, is made by Metex in America and named Xecote. It consists of a thermoplastic resin binder with a suspension of metallic particles and will adhere to most plastic surfaces, a primer being needed for very smooth parts. Xecote dries in air in around two hours and is fully cured in 24. Finish is matt black, which can be used as an undercoat for a normal paint. Components Division, MCP Electronics Ltd, Alperton, Wembley, Middlesex HAO 4PE.
WW305

Oscilloscope for power

Voltage, current, phase and time are the important quantities in measurements at power frequencies, between 25 and around 2000Hz. An oscilloscope by the Australian BWD company, the 880 Powerscope, is intended for workers in power engineering and is said by the makers to be particularly useful for measurements on devices such as thyristors, triacs and magnetic amplifiers. Four channels are provided on a 10cm square screen, the ranges coping with voltages from 0.1 to 1000V, current up to 100A, time from 100ns to 100s and phase. The frequency of the majority of supplies is measured by a phase-lock loop and the instrument measures phase by the provision of a pulse in 1° steps, which can be used either to trigger the timebase or as a bright-up marker. The unit is said to have been designed with the safety aspect in mind, since it is likely to be used at high voltages. BWD Electronics Pty Ltd, Miles Street, Mulgrave, Victoria 3170, Australia.
WW310

Who? Me?

The leisured, microprocessed society of the '90s, in which the mere utterance of the word 'work' will mean cancellation of one's annual holiday in the nearest factory, can't come too quickly for the average A-level school leaver, if a recent essay competition in the *Guardian* is any guide. Most of the essayists – school leavers and their teacher-advisers – are of the opinion that a career in industry is, if anything, slightly less attractive than a life stretch at the Scrubs, and intend to devote their attention to finding alternative ways of scraping an existence.

What a refreshing attitude! They're not going to be forced into anything they don't like, these youngsters. Any suggestion of being made to perform "boring" tasks in exchange for their daily bread is obviously going to be met by an offended stare. They're absolutely right, of course; why on earth should anyone who has been freely provided with an education up to the rarified atmosphere of A levels be required to spend his time doing anything but medicine and law? There are, after all, masses of ill-educated, dull, unimaginative and probably dirty work-persons available who are only too happy to do the necessary, mundane, productive work (sorry! – a slip of the pen) to keep the bright young minds supplied with life's necessities.

One of the prize-winning essayists makes the valuable point that no industrial talent scout has thought fit to approach him and attempt to entice him into any particular dark mill, satanic or otherwise. I do so sympathize with this kind of predicament. I suffered from that same lack of interest in me, as an asset to an employer: it even became necessary to find out for myself about my prospective career and eventually I came to realize that I was going to have to abase myself and apply for a job. The R.A.F. showed every sign of being interested in me, to the point of insistence, but that only lasted a short time and doesn't count.

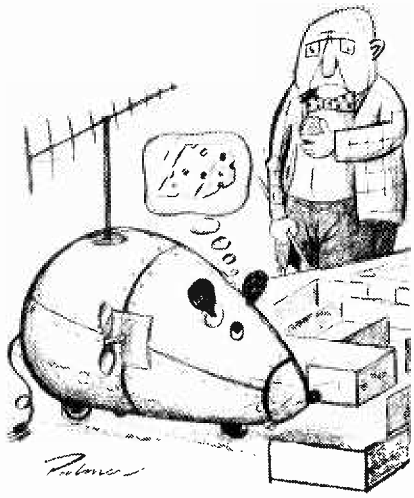
So, to all school-leavers, I would say: stick to your principles — and for heaven's sake don't give anyone the impression that you're alive, or they'll get you into a job, sooner or later.

Tricky Mickey

Well, it's happened. We've been to the brink before – heard the rustlings in the snake pit several times and once or twice our collective toes have been over the edge, but I can now reveal, as they say, that our collective lid has thoroughly and irretrievably flipped.

It's all the fault of these infernal computer contraptions. I've complained before that I have trouble finding out what they all do, and it seems now that the sooner I learn to keep my mouth shut, the better. I should explain myself, and I can do no better than

SIDEBANDS by Mixer



to quote from a press handout lately received. "New York, June ... Entries have been received from approximately 6,000 engineers worldwide, for the first running of the "Amazing Micro Mouse Maze Contest" sponsored by both Spectrum Magazine of the Institute of Electrical and Electronic Engineers, IEEE, and Computer Magazine." It goes on to explain that the robot creatures have to negotiate a maze without remote control and with no wires. They don't have to look like mice, apparently, which is just as well because they aren't allowed to fly or jump over the walls.

Six thousand engineers! One hopes, assumes even, that the research and development needed to build these distracted rodents will be done in time not otherwise occupied by gainful employment. The thought of some vital project grinding to a halt because the lab. is ankle-deep in panic-stricken beasts is one I, for one, don't care to contemplate. Last year, we are told, 54 people entered, but only six official mice (lovely phrase, that!) made it to the starting gate because the other 48 couldn't be made to work. I dare say they were being fed on the kind of cheese that comes in aluminium foil and were suffering from short-circuited guidance mechanisms.

Sight and sound

London Bridge, far from falling down, is being rebuilt. The station, that is. It's now a mass of bright yellow girders, brown tiles and natty little yellow cabins for the ticket collectors to lurk in. When it's finished, it will probably look very nice indeed — they've even given the bit where the trains come in a lick of paint. There is a brand-new public address system too, and that's where I stop being quite so delighted. Straining to hear where the Epsom Downs train was, last evening, all I could catch was the usual, grotesque Bill and Ben double-talk, like Stanley Unwin with a head cold, translated into Urdu and articulated through a roll of roof insulation.

It must be very difficult, in a great echoing vault like a main-line station, to provide a decent p.a. service, what with the noise of locos and the vast area it is necessary to cover, but it must surely be possible to design something that is at least intelligible. I did notice that the lady announcer was a sight more readable than the man, who mumbled, so maybe a course of training in microphone technique would be a help.

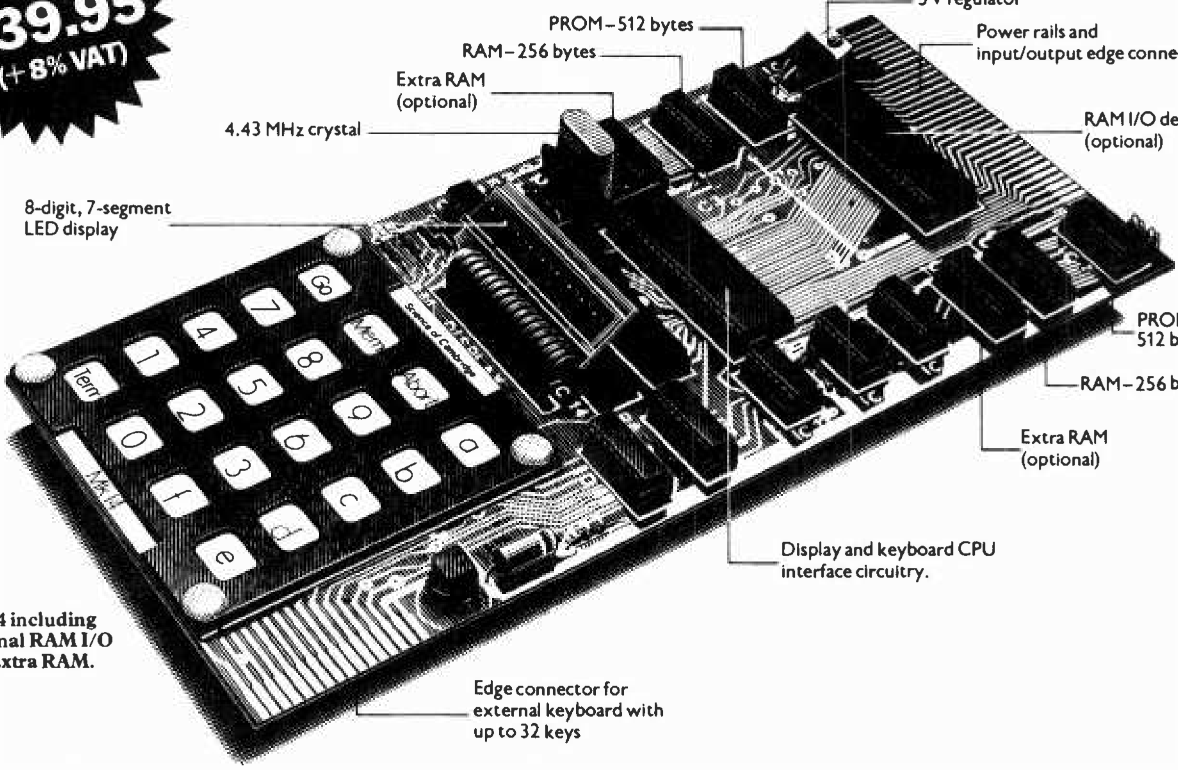
But it seems to me that sound is perhaps not the best way of letting passengers know that the 17.38 to Epsom Downs has just become the 18.12 to Brighton, calling at every tenth sleeper on the way. There is already a good deal of racket in there and, unless the threshold of pain is to be approached, it is difficult to see how an audio message can be certain of competing successfully. So why not sprinkle a few v.d.u.s about the platform, as they do in airport lounges, so that those of us who can read run less risk of ending up in Brighton when our slippers are warming in Croydon? I dare say the words are already forming on the chairman's lips — something to do with cost and the likelihood of disgruntled Celtic supporters potting at the displays with empties. It isn't my job to sort out details like that, however — I just get the ideas.

Series of events

When Free Grid, of fond memory, was writing this page, it was a poor month indeed when he didn't have a gentle poke at the technical language we use. I can't pretend the same easy familiarity with Latin and Greek displayed by my predecessor (the classics master at my old school would be very happy to confirm that) but I am tempted to join in this programme/program argument, if only because it strikes me as almost unbelievably idiotic. The Concise Oxford prefers the mme spelling, and that is good enough for me. It may be inconsistent with diagram and all the others, but who's talking about consistency? The argument seems to be that a computer programme is somehow different from any other kind of programme and should therefore look different: this is sophistry and is unworthy. Computers are confusing enough without inventing difficulties. In any case, does anyone seriously mean that either spelling is difficult to understand?

From Science of Cambridge: the new MK 14. Simplest, most advanced, most flexible microcomputer – in kit form.

only £39.95 (+8% VAT)



MK 14 including optional RAM I/O and Extra RAM.

The MK 14 is a complete microcomputer with a keyboard, a display, 8 x 512-byte pre-programmed PROMs, and a 256-byte RAM programmable through the keyboard.

As such the MK 14 can handle dozens of user-written programs through the hexadecimal keyboard.

Yet in kit form, the MK 14 costs only £39.95 (+£3.20 VAT, and p&p).

More memory—and peripherals!

Optional extras include:

1. Extra RAM – 256 bytes.
2. 16-line RAM I/O device (allowed for on the PCB) giving further 128 bytes of RAM.
3. Low-cost cassette interface module – which means you can use ordinary tape cassettes/ recorder for storage of data and programs.
4. Revised monitor, to get the most from the cassette interface module. It consists of 2 replacement PROMs, pre-programmed with sub-routines for the interface, offset calculations and single step, and single-operation data entry.
5. PROM programmer and blank PROMs to set up your own pre-programmed dedicated applications.

All are available now to owners of MK 14.

A valuable tool—and a training aid

As a computer, it handles operations of all types – from complex games to digital alarm clock functioning, from basic maths to a pulse delay chain. Programs are in the Manual, together with instructions for creating your own genuinely valuable programs. And, of course, it's a superb education and training aid – providing an ideal introduction to computer technology.

SPECIFICATIONS

●Hexadecimal keyboard ● 8-digit, 7-segment LED display ● 8 x 512 PROM, containing monitor program and interface instructions ●256 bytes of RAM ● 4 MHz crystal ● 5 V regulator ● Single 8 V power supply ● Space available for extra 256-byte RAM and 16 port I/O ● Edge connector access to all data lines and I/O ports

Free Manual

Every MK 14 kit includes a Manual which deals with procedures from soldering techniques to interfacing with complex external equipment. It includes 20 sample programs including math routines (square root, etc), digital alarm clock, single-step, music box, mastermind and moon landing games, self-replication, general purpose sequencing, etc.

Designed for fast, easy assembly

The MK 14 can be assembled by anyone with a fine-tip soldering iron and a few hours' spare time, using the illustrated step-by-step instructions provided.

How to get your MK 14

Getting your MK 14 kit is easy. Just fill in the coupon below, and post it to us today, with a cheque or PO made payable to Science of Cambridge. And, of course, it comes to you with a comprehensive guarantee. If for any reason, you're not completely satisfied with your MK 14, return it to us within 14 days for a full cash refund.

Science of Cambridge Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN. Telephone: Cambridge (0223) 311488

To: Science of Cambridge Ltd, 6 Kings Parade, Cambridge, Cambs., CB2 1SN.

Please send me the following, plus details of other peripherals:

☐ MK 14 Standard Microcomputer Kit @ £43.55 (inc 40p p&p.)
☐ Extra RAM @ £3.88 (inc p&p.)
☐ RAM I/O device @ £8.42 (inc p&p.)

I enclose cheque/money order/PO for £________ (indicate total amount.)

Name ________________

Address (please print) ________________

____

____

____

WW/10

Allow 21 days for delivery.

Science of Cambridge

WW—123 FOR FURTHER DETAILS

ELECTRONIC INSTRUMENTS EXHIBITIONS

Join us at our current events

In 1978, we're holding EPG Exhibitions at Runcorn, London and Southampton.

Visit these exhibitions in order to keep pace with all the latest developments in electronic test and measurement instrumentation.

The Electronic Promotion Group is an alliance of over 60 manufacturers of professional grade electronic instruments who have staged these highly successful exhibitions each year since 1966. This year there are even more exhibitors than ever before, represented by professional engineers who will be happy to discuss and demonstrate the latest innovations in professional electronic instrumentation.

Keep up to date with the electronics industry by joining us at one of our current events. Just complete and post the coupon for your free tickets and visitor brochure.

EPG's CURRENT EVENTS will be held at:

RUNCORN
EUROCREST HOTEL
3-4 October 1978

LONDON
BLOOMSBURY CENTRE HOTEL
10-12 October 1978
Opening times 09.30-17.30 (17.00 last day)

SOUTHAMPTON
POST HOUSE HOTEL
24-25 October 1978

To Peter H. Lowndes, Public Relations Division, Industrial and Trade Fairs Limited, Radcliffe House, Blenheim Court, Solihull, West Midlands B91 2BG.
Telephone 021-705 6707.

Please send me ________ free tickets and visitor information for the EPG Exhibitions.

NAME ____________

POSITION ____________

COMPANY ____________

ADDRESS ____________

W.W.

TOPS THE PACK!

ACE

ACE MAILTRONIX LTD
Dept. WW, Tootal Street
Wakefield, W. Yorkshire WF1 5JR

COMPONENTS — Now over 1,000 types in stock!
KITS — See the new range of low-cost 'ELEKITS'.
MODULES — New ready-built functions.
SERVICE — 1st Class same day despatch.
QUALITY — All guaranteed products.
PRICES — Many reductions!
MAGAZINE PROJECTS — Trouble-free!

I enclose 30p*, please send catalogue.

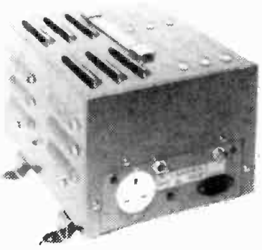
Name ____________

Address ____________

*Refundable with future orders over £5.00.

SINE WAVE INVERTERS

120-300 VA. 50/60 Hz



HIGH QUALITY YET ATTRACTIVELY PRICED A.C. POWER SUPPLIES FOR MOBILE, INDUSTRIAL, COMMUNICATIONS, MARINE AND MANY OTHER USES

★ Ruggedly built in welded steel cases
★ Stabilised low distortion output
★ Closely controlled frequency
★ Full overload and short-circuit protection
★ Battery protection by low voltage warning and automatic cut-out
★ Automatic standby and remote options

SERIES A: 12/24 V DC.IP. 240, 220 or 115V. AC. O.P.

CARACAL ENGINEERING

42-44 SHORTMEAD ST., BIGGLESWADE, BEDS. Tel: 0767-81361

---

we wondered why....

The B.B.C., British Rail, B.A.C., Decca Acoustics, Institute of Sound and Vibration Research, I.C.L., Post Office Telecommunications, Philips Research, U.K. Atomic Energy Authority, and many Universities were among our customers.

Maybe they liked the competitive prices of our modules, or the fact that all modules have a frequency response from 20Hz to 22kHz −0.2dB, a slewing rate of 8 volts per microsecond, input sensitivity of 0dB (0.775V), a damping factor greater than 400 to 1kHz and a total harmonic distortion less than 0.055% at 1kHz.

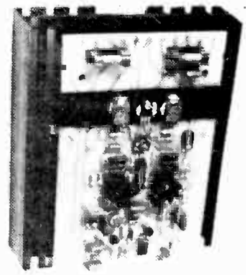
Or could it be that they went for the reliability and the comprehensive protection circuitry. Then there's the full 2 year guarantee which accompanies our range of modules.

OR PERHAPS .... THEY JUST LIKED THE SOUND OF US!

J.P.S. 60 : 60 Watt.
J.P.S. 100 : 100 Watt.
J.P.S. 150 : 150 Watt.

Power supplies available to suit all modules. Send for further information on our range of pre amplifier modules. JPS products are now stocked at the distributors shown below. Further information on all products available direct from JPS Associates or via reader reply service.

All modules are made in the United Kingdom.



J.P.S. ASSOCIATES
(ASTONKILN LTD.)
BELMONT HOUSE
STEELE ROAD
PARK ROYAL
LONDON NW10 7AR
Tel: 01-961 1274/5

DENMARK
T.S. RADIO
Bakkegardsvej 36
3300 Frederiksvaerk,
Denmark.
Tel. (03) 12 07 39
Mr. Ole Juul-Moller.

BELGIUM
Tiensestraat 260
3000 Leuven, Belgium
Tel (016) 234554

ENGLAND Midlands
CROXFORD CUSTOM EQUIP
64 London Road,
Leicester
Tel 0533 538465
Mr. Phil Croxford

ENGLAND West
SEVERNSIDE AUDIO & LTG
29 The Promenade
Gloucester Road,
Bristol BS7 8TZ.
Tel. 0272 41666
Mr. Peter Hannay.

ENGLAND South
R.E.W. AUDIO VISUAL
126 Charing Cross Road,
London,
W.C.2.
Tel 01 836 2372
Mr. John Cowan

SCOTLAND
ATMOSPHERE LTG. & SOUND
57 Nelson Street,
Aberdeen,
Scotland
Tel 0224 572905
Mr. Keith Main.

WW—037 FOR FURTHER DETAILS

PERSONAL COMPUTER WORLD SHOW

21-23 September 1978
West Centre Hotel
Lillie Road London SW6

Featuring Microcomputers for small businesses, microcomputers in education and the home.

Competition Best homebrew system, best software, best school and home applications.

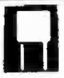
Attractions PCW Microchess championship. Computer controlled model railway. Leslie Solomon and his voice-controlled microcomputer. Innovators corner.

Conference 3 day-long seminars on microcomputers in business, education, home computing.

Show open daily 10.00—19.00 (17.00 Saturday) Admission £1.00

For further information ring Will Martin 01-486 1951

NEW COMPONENTS — SPECIAL PRICES



CERAMIC CAPACITORS EDPU 63 V

Stock Values PF

4.7; 10; 12; 15; 18; 22; 27; 33; 39; 47; 56; 82; 100; 120; 150; 180; 220; 270; 330; 390; 470; 560; 680; 820; 1000/2200; 3300; 4700; 10,000.

4.7— 1000pf	.04
2200pf	.045
3300pf	.06
4700pf	.06
10,000	.04

CERAMIC CAPACITORS 5Mm Pitch 250V
Stock Values (pf)

15; 47; 56; 100; 1000; 1500; 2200; 2700; 3300; 4700; 5600; 6800; 8200; 10,000. **.03 each**

POLYPROPYLENE RADIAL LEAD
Cylindrical Plastic Case. PCM 5mm. 2½% Tolerance — 100pf; 220pf; 330pf; 470pf. 630V 680pf; 1000pf; 1500pf; 2200pf; 3300pf; 4700pf;. 160V. Size 7x12.5mm. Price .08 ea.

NOISE SUPPRESSION CAPACITORS 250v AC

0.015	.13
0.022	.13
0.033	.14
0.047	.15
0.068	.16
0.1	.18
0.15	.24
0.22	.32

PCM 15mm
.15 .22 22.5mm

POLYESTER RADIAL

B	REDUCED		.047	.035
U	100V	10%	.068	.03
L	.0022	.03	.1	.0415
K	.0047	.03	.22	.04
STOCK	.01	.03	.47	.08
	.022	.035	.68	.085

TANTALUM BEAD

			10—6.3	.08
.1	35V	.10	10—16	.10
.15	35V	.10	10—25	.16
.22	35V	.10	10—35	.16
.33	35V	.10	15—16	.14
.47	35V	.10	15—25	.12
.68	35V	.10	22—10	.11
1	35V	.10	22—16	.18
1.5	35V	.10	22—35	.20
2.2	16V	.10	33—10	.18
2.2	35V	.11	47—6.3	.16
3.3	16V	.10	47—10	.16
4.7	10V	.10	47—16	.20
4.7	25V	.11	68—3V	.16
4.7	35V	.125	100—6.3	.20
6.8	35V	.125	100—10	.40
			220—3V	.20

SPECIAL THIS MONTH

AXIAL LEAD MONOLYTHIC CERAMICS .01 x 7R 10%
.06 each
POTENTIOMETER 16Mm
with switch and knob
Miniature 200K Log **.30p**

ELECTROLYTICS AXIAL

470—25 **10p** 1000—63 **45p**
1000—40 **20p** 2200—40 **60p**

INDUSTRIAL DISTRIBUTOR

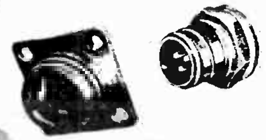
C.W.O. V.A.T. Included
P. & P. 20p — Overseas extra

GREENWAY ELECTRONIC COMPONENTS (EAST GRINSTEAD) LTD., MAIL ORDER DEPT.
62 Maypole Road, Ashurst Wood, East Grinstead, Sx. RH19 3RB
Tel. 034-282 3712

WW—109 FOR FURTHER DETAILS

CONNECTORS

CANNON PAINTON BELLING LEE PLESSEY GREENPAR AMPHENOL



1,000s in stock from:

Servo and Electronic Sales

SERVO AND ELECTRONIC SALES LTD.
24 HIGH STREET, LYDD, KENT TN29 9AJ
TELEPHONE: LYDD (0679) 20252 TELEX: 965265 A8 SERVOE G

sanwa *from:* **Quality Electronics Limited**
At above address

WW—052 FOR FURTHER DETAILS

SINCLAIR PRODUCTS★
Microvision tv in stock £200. PDM35 digital multimeter £27.25. Main adaptor £3.24, padded case £3.25. 30kv probe £18.36. DM235 p.o.a. Cambridge programmable calculator £13.15. Prog library £2.95.

S-DECS AND T-DECS★
S-DeC £3.39, T-DeC £4.44, u-DeCA £4.52, u-DeCB £6.73, 16 dil or 10T05 adaptors with sockets £2.14.

CONTINENTAL SPECIALITIES PRODUCTS★
EXP300 £6.21, EXP350 £3.40, EXP600 £6.80, EXP650 £3.89, EXP4B £2.48, PB6 £9.94, PB100 £12.74, LM1 £30.99, LP1 £33.48, LP2 £19.44.

TV GAMES KITS
Send sae for free data. Tank battle chip plus kit £13.95. Stunt cycle chip plus kit £12.50. AY-3-8600 plus kit £12.50. AY-3-8500 plus kit £8.95. Rifle kit £4.95.

MAINS TRANSFORMERS
6-0-6V 100ma 79p, 1½a £2.35, 6.3V 1½a £1.89, 9-0-9V 75ma 79p, 1a £1.99, 2a £2.60 12-0-12V 50ma 79p, 100ma 90p, 1a £2.49, 13V ½a 95p. 15-0-15V 1a £2.79, 30-0-30V 1a £3.59.

BATTERY ELIMINATOR BARGAINS
3-way model 6/7½/9V 300ma £3.30. **100ma radio models** with press-stud connectors 9V £2.85, 6V £2.85, 4½ V £2.85, 9V+9Z £4.50, 6V+6V £4.50, 4½+4½ V £4.50. **Cassette recorder mains unit** 7½V with 5 pin din plug £2.85.

JC12, JC20 and JC40 AMPLIFIERS
A range of integrated circuit audio amplifiers with free data and printed circuits. JC12 6 watts £1.60, JC20 10 watts £2.95, JC40 20 watts £3.95. Send sae for data.

PRINTED CIRCUIT MATERIALS
50 sq ins pcb 40p, 1 lb FeC1 £1.05, dalo pens 73p, laminate cutter 75p, small drill bit 20p.

BATTERY ELIMINATOR KITS
Send sae for free data. **100ma radio types** with press-stud connectors 4½V £1.80, 6V £1.80, 9V £1.80, 4½+4½V £2.50, 6+6V £2.50, 9+9V £2.50. **Transistor stabilised 8-way types** for low hum 3/4½/6/7½/9/12/15/18V. 100ma £3.20, 1 amp £6.40. **Heavy duty 13-way types** 4½/6/7/8½/11/13/14/17/21/25/28/34/42V, 1 amp £4.65, 2 amp £7.25. **Stabilised power kits** 2-18V 100ma £3.60, 2-30V1A £6.95, 2-30V 2A £10.95. **Car convertor kit** input 12V dc output 6/7½/9V 1A stabilised £1.95.

BI-PAK AUDIO MODULES
Send sae for data. S450, S450 tuner £23.51, AI60 £4.86, PA100 £16.71, SPM80 £4.47, BMT80 £5.95, MK60 £38.74, Stereo 30 £20.12.

SWANLEY ELECTRONICS
Dept. WW, 32 Goldsel Road, Swanley, Kent
Mail order only. Postage 30p extra. Prices include VAT. Official orders welcome.

THE NEWBEAR COMPUTING STORE

The Bear announces its new store at:

2 GATLEY ROAD, CHEADLE, CHESHIRE
Tel. 061-491 0134

Callers welcome, mail order to Newbury

PETITEVID V.D.U. KIT, £85
110 to 1200 baud V24, 64 CH x 16 line scrolling, all on 8 x4 P.C.B. Needs T.V. set UHF modulator and ASC11 keyboard

BOOKS

		P&P
Computer designs. 77-68 a 6800 Microcomputer	£7.50	50
Spare diagram set for 77-68	£1.50	50
WB-1 a TTL Microcomputer	£6.50	50
Spare diagram set for WB-1	£1.00	50
Zilog. Z-80 Technical Manual	£4.00	50
Z-80 PIO Manual	£2.50	50
Z-80 Programming Manual	£4.00	75
Motorola. Understanding Microprocessors	£2.75	30
M6800 Microprocessor Programming Manual	£4.50	50
M6800 Applications Manual	£9.50	1 00
M.O.S. Technology. KIM 1 User Manual	£5.00	75
6500 Programming Manual	£5.00	75
6500 Hardware Manual	£5.00	75
Adam Osbourne. Introduction to Microcomputers		
Vol 0 Beginners Book	£5.95	50
Vol. 1 Basic Concepts	£5.95	50
Vol. 2 Some Real Products	£11.95	1 00
8080 Programming for Logic Design	£5.95	50
6800 Programming for Logic Design	£5.95	50
Some Common Basic Programs	£9.95	.50
Payroll with Cost Accounting in Basic	£9.95	1 00
Sybex. Microprocessors	£8.00	50
Microprocessor Interfacing Techniques C207	£8.00	50
Scelbi. '8080' Software Gourmet Guide Cookbook	£7.95	50
'6800' Software Gourmet Guide Cookbook	£7.95	50
The Scelbi Byte Primer	£9.95	1 00
What to Do After you Hit Return	£7.00	75
PCC Reference Book on Home Computers	£4.95	50
Instant Basic	£4.95	75
My Computer Likes Me	£1.65	30
Games with a Pocket Calculator	£1.75	30
Games, Tricks & Puzzles for a Hand Calculator	£2.45	30
Best of Creative Computing Vol 1	£6.95	75
Best of Creative Computing Vol 2	£6.95	75
Hobby Computers are here	£3.99	50
Best of Byte	£8.95	75
101 Basic Computer Games	£5.50	75
The Home Computer Revolution	£3.45	50
Computer Lib	£5.95	75
The first book of Kim	£7.00	50

Hardware Components Section

MEMORIES

2102-1	£1.25	4027 (250ns)	£4.50
2102L-1	£1.35	2114 (450ns)	£10.00
2112	£3.04	4116 (250ns)	£19.00
2513	£6.50	2708 (450ns)	£10.50

SPECIAL MOTOROLA MICROCOMPUTING ICs

MC6800P	£9.26	SWATBUG	£16.00
MC6820P	£4.63	MC6830L7	£11.33
MC6850P	£8.00	MC8602P	£2.88
MC6810AP	£3.61	MC14536P	£3.69
		MC3459	£2.00

ZILOG MICROPROCESSORS

Z-80 CPU 2 5MHz	£15.50	Z-80A CPU	£20.50
Z-80 PIO PS	£10.00	Z-80A P10	£11.55
Z-80 CTC PS	£10.00	Z-80A CTC	£11.55

MICROPROCESSORS

SC/MP Mk II £10.30 6502 £14.93 8080 £6.00

INTERFACING ICs / BUFFERS

SFF96364	£16.20	VDU	81LS95	£1.30
MC1488P	£1.40		81LS96	£1.30
MC1489P	£1.40		81LS97	£1.30
75150P	£1.30	For V24,	81LS98	£1.30
75150N	£1.20	RS232C	8T26	£1.84
75154	£2.50		8T95	£1.60
4N33	£1.95		8T97	£1.60
AY-5-1013	£5.40		74367	£1.30
6402	£4.50			

LOW POWER SCHOTTKY TTL PRICE LIST

74LS00	.18	74LS30	.26	74LS109	.38
74LS01	.21	74LS32	.24	74LS112	.38
74LS02	.21	74LS33	.40	74LS113	.38
74LS03	.21	74LS37	.30	74LS114	.38
74LS04	.26	74LS38	.30	74LS125	.50
74LS05	.26	74LS40	.27	74LS126	.50
74LS08	.21	74LS42	.88	74LS132	.85
74LS09	.21	74LS47	.96	74LS136	.38
74LS10	.21	74LS48	.96	74LS138	.65
74LS11	.26	74LS51	.21	74LS139	.65
74LS12	.21	74LS54	.21	74LS151	.96
74LS13	.55	74LS55	.21	74LS153	.58
74LS14	£1.26	74LS73	.34	74LS154	£1.45
74LS15	.21	74LS74	.38	74LS155	£1.05
74LS20	.21	74LS75	.55	74LS156	£1.05
74LS21	.26	74LS76	.34	74LS157	.60
74LS22	.21	74LS78	.34	74LS158	.65
74LS26	.31	74LS83	£1.05	74LS160	£1.22
74LS27	.21	74LS86	.38	etc —	
74LS28	.40	74LS107	.38		

NEW RANGE OF LOW COST S100 8K RAM BOARDS, PCBs, ETC . . . PLEASE SEND FOR LATEST LIST.

BEAR BAGS (Kits)

1	77-68 components and edge connectors	£49.50
2	77-68 Led s and switches	£14.95
3	77-68 Power Supply	£17.95
4	77-68 19 5a Rack and Backplane	£27.70
5	77-68 4K Ram P C B and components	£75.00
6	77-68 Mon 1 P C B and components	£50.70
7	4K Ram Exorciser P C B and components	£71.50
8	8K Ram Exorciser P C B and components	£160.00
9	Petitevid V D U Kit	£85.00
10	Kansas City Cassette Interface	£18.95
11	U H F modulator	£4.50
12	77-68 VDU PCB and Components	£69.90
15	Promverter	£8.50

Available direct from us or from your local Bear Bag Stockist (dealer enquiries welcome)

VIM 1
The new 6502 based micro from Synertek fully assembled and tested **£199.00** +8% VAT.
Carriage £1.00 send for Data Sheet

PRINTED CIRCUIT BOARDS

CPU	£10.00
4K RAM	£10.00
Soft Monitor	£10.00
V D U /Keyboard interface	£10.00
ROM Monitor	T.B.A.
Veroboard 8 x 8	£4.10
Veroboard backplane 8 x 17	£4.30
Hexadecimal Keyboards	£11.25
FND 500 7 segment display	£1.05
Decoder chip	£2.45
ASCII Keyboard (unencoded)	£27.50
Keyboard assembled and tested	£86.00
Keyboard case	£20.33

Goods are normally shipped within 24 hours, subject to availability. Barclaycard & Access. VAT at 8% for Hardware Components. 30p postage and packing unless otherwise stated. Cheques to be made out to "The Newbear Computing Store". Send for an up-to-date catalogue to The Newbear Computing Store, 7 Bone Lane, Newbury 0635-49223. Callers are welcome Monday to Saturday 9.00 a.m.-5.30 p.m., but please ring to let us know when you are calling.

DRAKE Radio Shack Ltd

DRAKE SSR-1
GENERAL COVERAGE RECEIVER
0.5-30MHZ 30 BANDS
10KHZ READOUT

£149.85 ACCESS OR BARCLAYCARD
Details 15p stamps or 4 I.R C Foreign

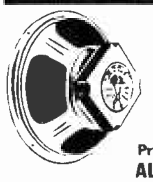
AS WELL AS DRAKE EQUIPMENT, WE ARE THE DIRECT IMPORTERS OF HAL RTTY AND MICROPROCESSORS ATLAS, NYE MORSE KEYS, PRESTEL VHF/UHF PROFESSIONAL FIELD STRENGTH METERS HAM RADIO CIR ASTRO 200 HY-GAIN CDR ROTORS HUSTLER OMEGA-T SYSTEMS MFJ FILTERS AND SPEECH PROCESSORS SUPEREX WE ALSO STOCK SHURE MICROPHONES YAESU MICROWAVE MODULES, SOLID STATE MODULES, ICOM, COPAL CLOCKS G-WHIPS BANTEX MOSLEY DAIWA ASAHI JAYBEAM DECCA AND THE USUAL ACCESSORIES—COAX, CONNECTORS INSULATORS, VALVES, Etc

We are situated just around the corner from West Hampstead Underground Station (Bakerloo line) A few minutes walk away is West Hampstead Midland Region station and West End Lane on the Broad Street Line We are on the following Bus Routes 28, 59, 159 Hours of opening are 9-5 Monday to Friday Closed for Lunch 1-2 Saturday we are open 9-12 30 only World wide exports

DRAKE ★ SALES ★ SERVICE

RADIO SHACK LTD.
188 BROADHURST GARDENS, LONDON NW6 3AY
Giro Account No. 588 7151. Telephone: 01-624 7174. Cables: Radio Shack London, N.W.6. Telex: 23718

Sonic HI-FI DISCOUNT CENTRES



DISCOUNT SPEAKERS

Guarantees:
TITAN 5 years
FANE Lifetime
OTHERS 1 year

Prices correct at 18.7.78
ALL PRICES INC. VAT

Please state Imp reqd

HI-FI TYPES	List/Value £	Sonic Price £
5 FANE 501 Mid or Full range	Sp Price	4.95
8 A F Model 80 Dual Cone	Sp Price	5.95
8 A F Model 83 Dual Cone	Sp Price	6.95
FANE 8 808T Dual Cone	Sp Price	3.95
WHARFEDALE LINTON 3XP kit Pr	60 70	43.95
10 DENTON 2XP KIT Pair	39 15	26.95
10 GLENDALE 3XP KIT	82 44	58.95
8 FANE MODE ONE KIT	Sp Price Pair	19.99
AF FRI KIT	Sp Price Pair	14.95
10 ELAC Model 10RM 10-15w	Sp Price	3.85

CABINETS (TEAK VENEERED)
20 x 11½ x 9½ Suitable for Mode 1 or FRI kits and Models 80 83 or 808T Spkrs Limited number **6.95 ea.**

GROUP/DISCO TYPES

12 TITAN T12/145R 45w	15 00	10.95
12 TITAN T12/60A 60w	22 50	12.95
12 TITAN T12/100A 100w	36 00	22.95
12 CELESTION G12M	16 50	12.99
12 CELESTION G12H 30w	22 00	16.95
12 CELESTION G1250 50w	25 75	18.95
12 GOODMANS 12 PD	Sp Price	21.95
12 GOODMANS 12 PG	Sp Price	18.95
12 FANE 'SPECIALIST' P A 80	27 95	18.95
12 FANE 'SPECIALIST DISCO 80	29 95	19.95
12 FANE 'SPECIALIST DISCO 100	31 95	21.95
12 FANE 'SPECIALIST' GUITAR 80L	27 95	18.95
12 FANE SPECIALIST' GUITAR 100L	28 95	19.95
12 FANE SPECIALIST GUITAR 80B	28 95	19.95
12 FANE CRESCENDO 12A	59 95	41.95
12 FANE CRESCENDO 12L	62 95	39.95
12 FANE CRESCENDO 12 BASS	59 54	39.95
12 FANE CRESCENDO 12/150 150w	89 95	59.95
15 TITAN T15/60 60w	26 00	17.95
15 TITAN T15/70 70w	28 00	19.95
15 TITAN T15/100 100w	41 00	29.95

GROUP/DISCO TYPES (continued)

15 FANE 'SPECIALIST' BASS 85	39 95	29.95
15 FANE 'SPECIALIST' BASS 100	42 00	31.50
15 GOODMANS 15P	Sp Price	23.95
15 FANE CRESCENDO/15	76 89	51.95
15 FANE CRESCENDO BASS	79 95	51.95
15 FANE CRESCENDO 15/100LT	74 69	51.95
15 FANE CRESCENDO 15/160 160w	99 75	72.95
15 FANE CRESCENDO COLOSSUS 200w	113 40	72.95
18 TITAN T18/100 100w	51.00	38.95
18 GOODMANS 18P	Sp Price	39.95
18 CELESTION G18C	53 00	41.95
18 FANE CRESCENDO 18a	106 95	72.95
18 FANE CRESCENDO BASS	94.75	59.95
18 FANE 'COLOSSUS' 200w	120 75	75.00

PLEASE STATE IMPEDANCE

HORN UNITS (Carr 85p)

CELESTION MH1000 25w	17 00	13.75
FANE 910 MK II 50w	17 75	10.99
FANE 920 100w	62.95	44.50
FANE 144 30 50w	7 95	4.95
FANE 173 50w	11.75	7.95
FANE J104 50 70w	16 95	10.95

HIGH POWER 'CROSS-OVERS'

FANE HPX1R or HPX2R Carr 35p 3.25 **2.25**

ADD-ON HIGH FREQUENCY UNITS

F A L 'Add-on Carr £1	51 84	35.95
TITAN T1H 70w Carr £1	33 00	23.95
TITAN TS2H 100w Carr £1	33.00	23.95
TITAN T2H Carr £1	39 00	26.95

EXTRA SPECIAL MAIL ORDER OFFER

TITAN TA/50A 50w AMPLIFIER

High sensitivity multi purpose, three ind controlled inputs, Controls Bass, Treble Presence.
Robust, well styled compact cabinet Black Vynide covered Attractive Black/Silver Fascia 12 months Guarantee Carr £1 **£39.95**

PAIR FANE POP 15 12" SPEAKERS

Suitable for use with above when wired in series and housed in sealed cabinet **£9.95**
SUITABLE TWIN SPEAKER CABINET **£11.95**

Also for personal shoppers only
Amps, T'tables, Jingle Machines, Disco Consoles, Lighting, Cabinets. Credit terms available Orders over £20.
Phone orders accepted from Access & Barclaycard holders.

403 SAUCHIEHALL ST., GLASGOW
Tel: 041-332 0700
Add £1 carr on Hi-Fi spkrs or kits £1 25 (12 Spkrs) £1 50 (15), £2 50 (18)

WW—016 FOR FURTHER DETAILS

NEW STYLING

NRDC-AMBISONIC UHJ

SURROUND SOUND DECODER

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

Complete kit, including licence fee **£45.00** + VAT
or ready built and tested **£61.50** + VAT

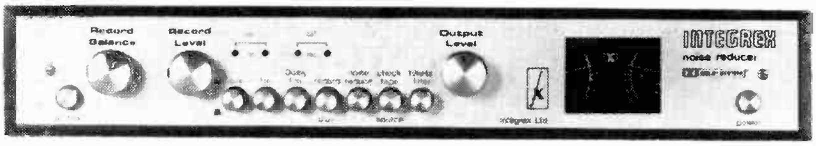
INTRUDER 1 RADAR ALARM

With Home Office Type approval
As in "Wireless World", designed by Mike Hosking, 240V ac mains operated and disguised as a hardbacked book. Detection range up to 30 feet.

Complete exclusive designer approved kit **£46.00** + VAT
or ready built and tested, **£54.00** + VAT

Wireless World Dolby(TM) noise reducer

Trademark of Dolby Laboratories Inc.



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

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

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

Dynamic Range >90db

30mV sensitivity.

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

Complete Kit **PRICE: £39.90**+VAT

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

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

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

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

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

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

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

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

Buy it with Access
EUROCARD
BARCLAYCARD
master charge

INTEGREX LTD.

Please send SAE for complete lists and specifications
Portwood Industrial Estate, Church Gresley,
Burton-on-Trent, Staffs DE11 9PT
Burton-on-Trent (0283) 215432 Telex 377106

INTEGREX

S-2020TA STEREO TUNER/AMPLIFIER KIT

SOLID MAHOGANY CABINET

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

Brief Spec. Amplifier Low field Toroidal transformer, Mag, input, Tape In/Out facility (for noise reduction unit, etc.), THD less than 0.1% at 20W into 8 ohms. Power on/off FET transient protection. All sockets, fuses, etc., are PC mounted for ease of assembly. Tuner section uses 3302 FET module requiring no RF alignment, ceramic IF, INTERSTATION MUTE, and phase-locked IC stereo decoder. LED tuning and stereo indicators. Tuning range 88—104MHz. 30dB mono S/N @ 1.2µV. THD 0.3%. Pre-decoder 'birdy' filter. **PRICE: £58.95**+VAT

NELSON-JONES MK. I STEREO FM TUNER KIT

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

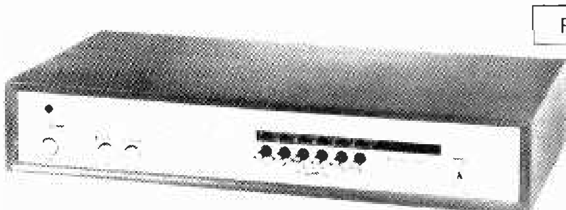
Brief Spec. Tuning range 88—104MHz. 20dB mono quieting @ 0.75µV. Image rejection — 70dB. IF rejection — 85dB. THD typically 0.4%.
IC stabilized PSU and LED tuning indicators. Push-button tuning and AFC unit. Choice of either mono or stereo with a choice of stereo decoders.

Compare this spec. with tuners costing twice the price.

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

Please send for details of the Nelson-Jones Mk. II Kit as in this month's W.W.

STEREO MODULE TUNER KIT



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

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

PRICE: Stereo £31.95+VAT

S-2020A AMPLIFIER KIT

Developed in our laboratories from the highly successful "TEXAN" design. PC mounting potentiometers, switches, sockets and fuses are used for ease of assembly and to minimize wiring Power 'on/off' FET transient protection.

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

PRICE: £33.95+VAT

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

BASIC NELSON-JONES TUNER KIT	£14.28+VAT	**PHASE-LOCKED IC DECODER KIT**	£4.47+VAT
BASIC MODULE TUNER KIT (stereo)	£16.75+VAT	**PUSH-BUTTON UNIT**	£5.00+VAT
PORTUS-HAYWOOD PHASE-LOCKED STEREO DECODER KIT			£8.00+VAT

TRANSISTORISED 3cm RADAR AMPLIFIER SWITCH: with 24v waveguide switch, .9 x .4cm ins. with crystal CV.2355 and spark gap VX.1046. **£16.20** + £1.00 post.

TRANSISTORISED VIDEO INDICATOR (used with above amplifier): 1½" C.R.T. **£10.80** + £1.00 post.

INSULATION TEST SET 0 to 10 KV, negative earth, with Ionisation Amplifier, 100/230 Volts. AC **£45.90**, carr. £3.00.

RACAL RA-17 RECEIVER 500KHz—30mHz. s/hand, good condition, **£365.00** (including VAT 12½%).

AVO TRANSISTOR ANALYSER CT.446: £37.80, carr. £2.20.

MARCONI FREQUENCY METER 1026/4: 2000-4000mHz 'as new' condition. **£32.40** or secondhand condition **£24.30.**

1026/2: 100-160mHz £32.40 'as new' or s/hand **£24.30.** Carriage for all type £2.00.

BURGLAR ALARM BELL: 6-8v. d.c. **£3.24** + £1.60 post.
TELEPRINTER TYPE 7B: Pageprinter 24v. d.c. power supply, speed 50 bauds per min. S/hand cond. (excellent), no parts broken **£21.60,** carriage £3.50.
AUTO TRANSFORMER: 230v. 50c/s, 1000 watts. Mounted in strong steel case 5" x 6½" x 7". Bitumen impregnated. **£12.96,** carr. £2.00.
CRYSTAL TEST SET TYPE 193: Used for checking crystals in freq. range 3,000-10,000kHz. Mains 230v 50hz. Measures crystal current under oscillatory conditions and the equivalent resistance. Crystal freq. can be tested in conjunction with a freq. meter. **£27.00,** carr. £2.00.
ELECTROLYTIC CAPACITOR REFORMING UNIT NO. 1. 230v a.c. input 0-100mfd 6 to 450 volts in 10 ranges complete with leads and plus. **£15.00.** Carriage £3.00.
FIELD FLUID SAMPLING SET TYPE TP/SKP/10,000 with thermal control milliporer oil sampling kit. **£125.00.** Carriage £4.00.
RING TOROIDAL DUST CORES: Size 2½" outside, 1¾" inside, 5/16" thick. Box of two **£1.10** + 30p post.
ROTARY INVERTERS TYPE PE-218E: Input 24-28v. d.c. 80 amps, 4,800rpm. Output 115v. a.c. 13 amp 400c/s. 1Ph. P.F.9 **£21.60** + **£3.00** carr.
R.F. POWER RADIATION METER CT.477. Covering X, S and L bands, **£125.00.** Carriage £4.00.
RECTIFIER UNIT: 200-250v. a.c. input, 24v. d.c. at 26 amps output continuous rating. **£37.80,** carr. £5.00.
MARCONI SIGNAL GENERATOR 801/DS: 10-480mHz. **£318.60.**
ROTARY CONVERTER: 24 volts d.c. input, 230 volts, 100 watts output. **£27.50,** carriage £4.00.

RADIO TELETYPE TERMINAL SET SG1A 115 volts a.c. **£17.50,** carriage £3.00.
TELEGRAPH DISTORTION TEST SET (TYPES 5CBV and 5BV) 230v. a.c. **£25.00,** carriage £3.00.
RESONATOR PERFORMANCE CT.424 8.5 to 9.0 kmc/s 3 cm. **£75.00,** post £2.00.
ALUMINIUM TRIPOD (extra strong) will support 50lb. Extends to 56in. **£10.00,** carriage £3.00.
INVERTER 24 volts d.c. input 400 cycles 1pH 6600 r.p.m. 200 volts peak. **£7.50,** £1.50 post.
OXYGEN BOTTLE 1800lb. w.p. **£10.00,** carriage £3.00.
NOISE SOURCE UNIT with CV.1881 noise source mount. Produces thermal noise 15.5dB 200/250 a.c. **£75.00.**
LOW SPEED TAPE COMPARATOR (Datronic) ⅝" tape. **£45.00,** £5 carr.
ADDO 1" TAPE REPRODUCER: £65.00, carriage £5.00.
MUIRHEAD D514 T.M.S.: 12v. d.c. or 100-250v. a.c. volts input. Range 100-40.000Hz. **£15.00,** carriage £4.00.
AUTOTUTOR MARK II: (Viewer Training Aid) 230v. a.c. Designed for use in intrinsic programming method, info stored on microfilm and projected through optical system onto viewing screen. **£120.00.**
AVO VALVE TESTER & CHARACTERISTIC METER: £75.00, carr. £5.00.
RANK FLUTTER METER TYPE 1740: £65.00, carr. £4.00.
MICROMETER CONDENSER TYPE C.689: 0-8.5uuF precision variable condenser, **£35.00,** post £2.00.
KROHN-KITE OSCILLATOR MODEL 440A: .001cps-100kc push-button selectors, square or sine wave output. **£45.00,** carriage £5.00.
MUIRHEAD DECADE OSCILLATOR TYPE 890D: £85.00, carr. £5.00.
ELLIOT COMPUTER 308 complete with all manuals, leads, etc. 4 teleprinters, Creed model 75, and associated readers with power supply, battery charger and standby battery, £750.00 (weight approx. 2 tons).

BARGAIN MAPS

Large stocks of unused U.S.A.F. surplus maps, weather charts, etc. including:—

ONC-E1 — U.K. in full and part N.W. Europe. Scale 1:1,000,000.
JNC-9N — N. Europe, U.K., Scandinavia. Scale 1:2,000,000.
JN-21N — Europe (Mediterranean). Scale 1:2,000,000.
SIZE: 58" x 42", colour. Many others. Please send S.A.E. for list.
Price each 70p (inc. p + p)
25 x Maps (either same type OR assorted) **£10.00** + £1.00 p + p.
10 x Maps (either same type OR assorted) **£6.00** (inc. p + p).

Above prices include VAT at 8% (except where stated)
Carriage quotes given are for 50-mile radius of Herts.

Visit our new shop in Ware High Street (old A10) opposite Church. 100s of individual bargains for callers. If you wish to collect any of the above items please telephone prior to calling to avoid disappointment.

W. MILLS

3 & 3a BALDOCK STREET, WARE, HERTS. SG12 9DT
WARE 66312 (STD 0920)

The only thing to match our Sales Service is our After-Sales Service

When you get your test equipment serviced or maintained by the London Instrument Repair Centre, you get the same top quality work that made the instrument in the first place–and backed by a full year's warranty too.
Contact the address below for your nearest centre.

LIRC LONDON INSTRUMENT REPAIR CENTRE

The service organisation of:

AVO MEGGER Sullivan Taylor

Archcliffe Road, Dover, Kent. Telephone: 0304-202620

Thorn Measurement & Components Division

WW—119 FOR FURTHER DETAILS

reprints

If you are interested in a particular article/special Feature or advertisement published in this issue of

WIRELESS WORLD

why not take advantage of our reprint service.

Reprints can be secured at reasonable cost to your own specifications providing an attractive and valuable addition to your promotional material. *(Minimum order 250.)*

For further details contact
Brian Bannister, IPC Electrical-Electronic Press Ltd. Phone 01-261 8046 or simply complete and return the form below.

To Brian Bannister, Reprints Department
Dorset House, Stamford Street
London SE1 9LU

I am interested in .... copies of the article/advertisement headed .... featured in
WIRELESS WORLD
on page(s) .... in the issue dated ....

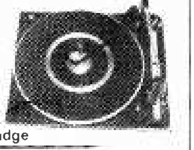
Please send me full details of your reprint service by return of post.

Name ....
Company ....
Address ....
.... Tel. No. ....


Celestion

U.K. RETURN OF POST MAIL ORDER SERVICE, ALSO WORLDWIDE EXPORT SERVICE

BSR HI-FI AUTOCHANGER STEREO AND MONO £21.50 Post £1



Plays 12, 10 or 7 records Auto or Manual. A high quality unit backed by BSR reliability with 12 months' guarantee A C 200/250V. Size 13½-11¼in 3 speeds. Above motor board 3¾in. Below motor board 2½in with Sonotone V100 magnetic cartridge

BSR P128/MP60 with magnetic cartridge. Balanced arm Cueing device Bias Compensator **£24.50.** Post £1

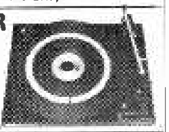
NEW BSR SINGLE PLAYER £19.95
Model P182 3-speeds flared aluminium turntable Post £1
S shaped arm, cueing device, stereo ceramic cartridge

B S R Budget Autochanger with stereo cartridge, plays all size records **£12.95**

HEAVY METAL PLINTHS

With P V C Cover. Cut out for most BSR or Garrard decks. Silver grey finish **£6.50** Post £1 50
Model 'A' Size 12½ x 14¾ x 7½in
Model 'B' Size 16 x 13¾ x 7in **£7.50**
Extra large plinth & cover teak wood base Size 20 x 17½ x 9in **£18.50.** Shop callers only

BSR SINGLE PLAYER

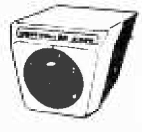


Ideal replacement or disco deck with cueing device and stereo ceramic cartridge. 3 speeds. Large turntable, modern design
£17.50 Post £1

GARRARD AP76 SINGLE RECORD PLAYER £27.50 Post £1
3-speed balanced arm, semi-transcription unit

GARRARD BUDGET AUTOCHANGER £14.95 Post £1
3-speed, stereo cartridge

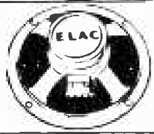
SMITH'S CLOCKWORK 15 AMP TIME SWITCH
0-6 HOURS £3.30 Post 35p



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

TEAKWOOD LOUDSPEAKER GRILLES will easily fit to baffle board. Size 10½ x 7⅞in—**45p.**

ELAC HI-FI SPEAKER 8in. TWIN CONE



Large ceramic magnet 50-16,000 c/s
Bass resonance 40 c/s
8 ohm impedance
10 watts RMS **£5.95** Post 35p

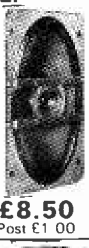
VOLUME CONTROLS

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

80 Ohm Coax 8p yd.
FRINGE LOW LOSS **15p** yd
Ideal 625 and colour
PLUGS **10p.** SOCKETS **10p.**
LINE SOCKETS **18p.**
OUTLET BOXES **50p.**
300 ohm FEEDER **5p** yd

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

E.M.I. 13½ x 8in. SPEAKER SALE!



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

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

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

Suitable Bookshelf Cabinet £8.50
Teak finish For EMI 13 x 8 speakers Post £1 00

THE "INSTANT" BULK TAPE ERASER

Suitable for cassettes, and all sizes of tape reels A.C. mains 200/250V. Leaflet S.A.E
Will also demagnetise small tools **£4.95** Post 50p
Head Demagnetiser **£4.75.**

RELAYS. 12V D C **95p.** 6V D C **85p.** 240V A C. **95p.**
BLANK ALUMINIUM CHASSIS. 6 x 4—**95p;** 8 x 6—**£1.40;** 10 x 7—**£1.55;** 12 x 8—**£1.70;** 14 x 9—**£1.90;** 16 x 6—**£1.85;** 16 x 10—**£2.20.** **ANGLE ALI.** 6 x ¾ x ¾in—**15p.**
ALUMINIUM PANELS. 6 x 4—**24p;** 8 x 6—**38p;** 14 x 3—**40p;** 10 x 7—**54p;** 12 x 8—**70p;** 12 x 5—**44p;** 16 x 6—**70p;** 14 x 9—**94p;** 12 x 12—**£1;** 16 x 10—**£1.16.**
ALI BOXES IN STOCK. MANY SIZES
VARICAP FM TUNER HEAD with circuit & connections **£4.95.** Some technical knowledge required
TAG STRIP 28-way **12p.**
TAPE OSCILLATOR COIL. Valve type, **35p.**
BRIDGE RECTIFIER 200V PIV ½ amp **50p.** 8 amp **£2.50.**
TOGGLE SWITCHES S P **30p.** D P S T **40p.** D.P D T **50p.**
MANY OTHER TOGGLES IN STOCK
PICK-UP CARTRIDGES ACOS, GP91 **£1.50.** GP95 **£2.50.**
SONOTONE stereo **£2.00.** **ADASTRA** magnetic **£5.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p ea.**

R.C.S. SOUND TO LIGHT KIT Mk. 2

Kit of parts to build a 3 channel sound to light unit 1,000 watts per channel. Suitable for home use. Easy to build. Full instructions supplied. Cabinet **£4.** Will operate from 200MV to 100 watt signal. **£17** Post 35p

R.C.S. LOW VOLTAGE STABILISED POWER PACK KITS

All parts and instructions with Zener diode, printed circuit rectifiers and double wound mains transformer. Input 200/240V a c. Output voltages available, 6 or 7 5 or 9 or 12V d c up to 100mA or less. Size 3 x 2½ x 1½in. Please state voltage required **£2.95** Post 45p

R.C.S. POWER PACK KIT

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

R.C.S. "MINOR" 10 watt AMPLIFIER KIT

This kit is suitable for record players, guitars, tape playback, electronic instruments or small P A. systems. Two versions available. Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel, input 100mV, size 9½ x 3 x 2in approx S A E. details. Full instructions supplied. A.C mains powered

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

R.C.S. STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and P C. Board **£2.95**
Can be ganged to make multi-way stereo mixers Post 35p

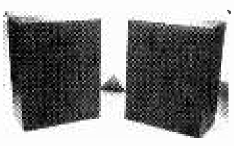
MAINS TRANSFORMERS ALL POST 75p

250-0-250V 70mA, 6 5V 2A	£3.45
250-0-250V 80mA 6 3V 3 5A 6 3V 1A	£4.60
350-0-350V 80mA 6 3V 3 5A 6 3V 1A	£5.80
300-0-300V 120mA 2×6 3V 2A C T, 5V 2A	£8.50
220V 45mA 6 3V 2A	£1.75
HEATED TRANS 6 3V ½ amp	£1.00
Ditto 3 amp	£1.75
GENERAL PURPOSE LOW VOLTAGE Tapped outputs	
2 amp 3 4 5 6 8 9 10, 12 15 18 25 and 30V	£5.30
1 amp 6 8 10 12 16 18 20 24, 30 36, 40 48 60	£5.30
2 amp 6 8 10 12 16 18 20 24 30, 36, 40, 48 60	£8.50
3 amp 6 8, 10 12 16 18, 20 24 30, 36 40 48 60	£11.00
5 amp 6 8 10 12 16 18, 20, 24 30 36 40 48 60	£14.50

12V, 100mA	£1.00	20V 40V 60V 1 amp	£3.50
12V, 750mA	£1.30	12V 300mA	£1.00
10-0-10V 2amp	£2.45	10V 30V 40V 2 amp	£2.75
30V 5 amp and 17V-0-17V,		40V, 2 amp	£2.95
2 amp	£3.45	20V 1 amp	£2.20
0 5, 8 10, 16V, ½ amp	£1.95	20V-0-20V 1 amp	£2.95
9V, 3 amp	£2.75	30V-0-30V 2 amp	£7.00
24V 3 amp + 48V ½ amp	£3.50	2 of 18V 6 amp each	£9.00
30V, 2 amp	£3.00	12 0-12V 2 amp	£2.95
30V 1½ amp	£2.75	9V ¼ amp	£1.30

AUTO TRANSFORMERS 115V to 230V or 230V to 115V 150W **£5.00**
250W **£6.00.** 400W **£7.00** 500W **£8.00**
FULL WAVE BRIDGE CHARGER RECTIFIERS
6 or 12V outputs 2 amp **75p.** 4 amp **£1.25**
CHARGER TRANSFORMERS 1½ amp **£3.50**
4 amp **£6.80**
12V 1½ amp Half Wave Selenium Rectifier **25p**

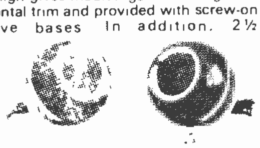
COMPACT SPEAKERS



Teak or White
13 × 10 × 6in approx.
50 to 14,000 cps
10 watts rms 4 ohms.
£16 pair Post £1 30

EXTENSION SPEAKERS £3.95 ea.

These little marvels of modern sound reproduction are ideally suited for today's domestic audio set-up. Two of these smart spheres, each with 5 watt deep throated ceramic magnets, will produce superb stereo reproduction. The globe shaped cases in high gloss mouldings of red or green, are finished with chrome frontal trim and provided with screw-on rubber inset protective bases. In addition, 2½ metres of strong lead already fitted with phono plug is supplied
Full Range Frequency Response
Impedance 8 ohms
Power Peak 5 watts



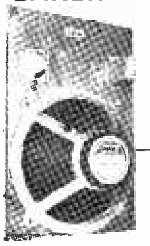
LOW VOLTAGE ELECTROLYTICS
1, 2, 4 5, 8, 16, 25, 30, 50, 100, 200mF 15V **10p.**
500mF 12V **15p;** 25V **20p;** 50V **30p;**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 420mF/500V **£1.30.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
3900mF 100V **£1.60.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 6V **25p;** 12V **42p;** 35V **85p.** 5600mF/76V **£1.75**
MANY OTHER ELECTROLYTICS IN STOCK

SHORT WAVE 100pF air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, 50pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0 01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0.1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0.001 to 0.05 **12p;** 0 1 **15p;** 0 25 **25p;** 0.47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 385 + 385pF **50p;** 500pF standard **75p.**
365 + 365 + 25 + 25pF. Slow motion drive **65p.**
120pF **TWIN GANG, 50p;** 365pF **TWIN GANG, 50p.**
NEON PANEL INDICATORS 250V. Amber or red **30p.**
RESISTORS. 10Ω to 10M. ¼W, ½W, 1W, 20% **2p;** 2W **10p.**
HIGH STABILITY. ½W 2% 10 ohms to 1 meg, **12p.**
Ditto 5% Preferred values 10 ohms to 10 meg, **5p.**

ELECTRO MAGNETIC PENDULUM MECHANISM
1 5V d c operation over 300 hours continuous on SP2 battery, fully adjustable swing and speed. Ideal displays, teaching electro magnetism or for metronome, strobe, etc. **95p** Post 30p

BAKER MAJOR 12" £16.88

Post £1.00



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

Module kit, 30-17,000 c/s with tweeter, crossover, baffle and instructions **£20.52** Post £1.60 each
Please state 4 or 8 or 16 ohms

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

'Group 25'	'Group 35'	'Group 50/15'
12in 30W **£12.96**	12in 40W **£15.12**	15in 75W **£28.08**
4 or 8 or 16 ohm	4 or 8 or 16 ohm	8 or 16 ohm

BAKER LOUDSPEAKER, 12 INCH. 60 WATT.
GROUP 50/12, 4 OR 8 OR 16 OHM HIGH POWER
FULL RANGE PROFESSIONAL QUALITY
RESPONSE 30-16,000 CPS **£22.68**
MASSIVE CERAMIC MAGNET Post £1 60
WITH ALUMINIUM PRESENCE CENTRE DOME

TEAK VENEERED HI-FI SPEAKERS AND CABINETS
For 12in or 10in speaker 20x13x12in **£14.50** Post £2
For 13x8in. or 8in speaker **£8.50** Post £1
For 6½in speaker and tweeter 12x8x6in **£5.95** Post 75p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S A.E
LOUDSPEAKER CABINET WADDING 18in wide **20p** ft.

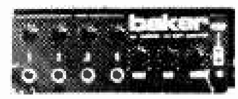
R.C.S. 100 watt VALVE AMPLIFIER CHASSIS

Four inputs. Four way mixing, master volume, treble and bass controls. Suits all speakers. This professional quality amplifier chassis is suitable for all groups, disco, P.A., where high quality power is required. 5 speaker outputs. A/C mains operated. Slave output socket. Produced by demand for a quality valve amplifier. 100V line output to order. Send for leaflet.
Suitable carrying cab **£16.50** Price **£99** carr £2.50

Horn tweeters 2-16kc/s 10W 8 ohm or 16 ohm **£3.60.**
Audax Tweeters 3-18kc/s 50W 8 ohm **£7.50.**
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS P.M. 3 OHM 7x4in. **£1.50;** 6½in, **£1.80;** 8x5in **£1.90;** 8in., **£1.95.**
SPECIAL OFFER: 80 ohm 2¼in, 2¾in, 35 ohm, 3in., 25 ohm, 2½in, 3in, 5x3in., 7x4in, 8 ohm, 2½in, 3in, 3½in., 5in, 15 ohm, 3½in dia, 6x4in., 7x4in., 5x3in., 3 ohm 2½in, 2⅝in, 3½in, 5in dia **£1.50 each.**
PHILIPS LOUDSPEAKER, 8in, 4 ohms, 4 watts, **£1.95**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in diameter 4W **£2.50.** 10in diameter 5W **£2.95;** 12in. diameter 6W **£3.50.** 3/8/15 ohms, please state
MOTOROLA PIEZO ELECTRIC HORN TWEETER. £7.95
Handles up to 100 watts. No crossover required.

BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ x 4¾ x 2in. **£1.50**

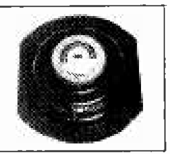
BAKER 150 WATT PROFESSIONAL MIXER AMPLIFIER



All purpose transistorised. Ideal for Groups, Disco and P A. 4 inputs speech and music. 4 way mixing. Output 4 8/16 ohms. a.c Mains. Separate treble and bass controls. Master volume control. Guaranteed. Details S.A.E **£85** £1 50 carr

LOW VOLTAGE POWER PACK for MODELS
Ready made. Famous make. Will supply 10 volts at 400mA. With terminals and mains lead.

GOODMANS COMPACT 12-INCH BASS WOOFER



Standard 12in diameter fixing with cut sides 12 x 10. 14 000 Gauss magnet. 20 watts R M S. 4 ohm imp. Bass resonance = 30 c.p s. Frequency response 30-8000 c p s.
£9.95 each Post £1

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

MONO PRE-AMPLIFIER. Mains operated solid state pre-amplifier unit designed to complement amplifiers without low level phono and tape input stages. This free-standing cabinet incorporates circuitry for automatic R I A A equalisation on magnetic phono input and N A B equalisation for tape heads. Power ON/OFF, PHONO/TAPE switches and pilot lamp are on the front panel, phono socket input and output are rear located.

£4.50 each or £8 pair. Post 50p

RADIO COMPONENT SPECIALISTS

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

Radio Books and Components Lists 20p. (Minimum posting charge 30p.) Cash prices include VAT. (We accept Access or Barclaycard. Phone your Order) Tel. 01-684 1665

VALVES

Minimum Order £1.00

VALVES VAT PLEASE ADD 12½%

	£
A1065	1.25
AR8	0.60
ARP3	0.60
ATP4	0.50
B12H	3.00
CY31	0.50
DAF96	0.60
DET22	19.50
DF96	0.60
DK96	0.80
DH76	0.40
DL92	0.50
DY86/87	0.55
DY802	0.55
E55L	7.50
E88 CC/01	1.30
E180CC	1.30
E180E	6.00
E182CC	3.50
EA76	2.00
EABC80	0.50
EB91	0.40
EBC33	0.50
EBF80	0.50
EBF83	0.50
EBF89	0.50
EC52	0.40
ECC81	0.55
ECC82	0.50
ECC83	1.15
ECC84	0.45
ECC85	0.50
ECC86	1.25
ECC88	0.60
ECC189	0.80
ECF80	0.50
ECF82	0.45
ECF801	0.75
ECH34	0.95
ECH35	1.50
ECH42	0.85
ECH81	0.45
ECH84	0.95
ECL80	0.60
ECL82	0.55
ECL83	1.20
ECL85	0.65
ECL86	0.55
EF37A	1.50
EF39	2.90
EF40	0.70
EF41	0.75
EF80	0.40
EF83	1.50
EF85	0.45
EF86	0.55
EF91	0.65
EF92	0.75
EF95	0.45
EF183	0.65
EF184	1.60
EF804	2.00
EFL200	0.75
EH90	0.60
EL32	0.60
EL34	2.20
EL37	3.00
EL41	0.80

EL81	1.05
EL82	0.60
EL84	0.60
EL86	0.70
EL90	1.30
EL91	1.60
EL95	0.70
EL504	0.80
EL802	1.50
EL822	3.00
EM31	0.75
EM80	0.60
EM81	0.60
EM84	0.40
EM87	1.00
EY51	0.45
EY81	0.45
EY86/87	0.55
EY38	0.55
EZ80	0.45
EZ81	0.60
GY501	0.90
GZ32	0.65
GZ33	3.50
GZ34	2.00
GZ37	2.50
KT66	4.00
KT88	5.75
MH4	1.00
ML6	1.00
OA2	0.55
OB2	0.60
PABC80	0.40
PC85	0.50
PC86	0.85
PC88	0.75
PC900	1.25
PCC84	0.45
PCC89	0.55
PCC189	0.65
PCF80	0.80
PCF82	0.40
PCF84	0.65
PCF86	0.65
PCF200	0.90
PCF201	0.80
PCF801	0.55
PCF802	0.65
PCF805	1.80
PCF806	0.85
PCF808	1.80
PCH200	0.80
PCL81	0.60
PCL82	0.65
PCL84	0.70
PCL86	0.70
PCL805/85	0.75
PD500	2.25
PFL200	1.35
PL36	0.80
PL81	0.75
PL82	0.50
PL83	0.50
PL84	0.65
PL504	1.40
PL508	1.30
PL509	2.40
PL802	2.80
PLL80	1.80

PY33	0.60
PY80	0.60
PY81/800	0.55
PY82	0.45
PY83	0.50
PY88	0.65
PY500	1.35
PY859	5.75
PY801	0.60
QQV03-10	2.50
QQV03-12	2.50
QQV06-40A	14.00
QV03-12	2.00
SC1/400	4.00
SC1/600	4.00
SP61	0.85
TT21	7.50
U25	1.00
U26	0.85
U27	1.00
U191	0.75
U281	0.50
U301	0.50
U801	0.80
UABC80	0.60
UAF42	0.65
UBF80	0.55
UBF89	0.50
UBL1	1.00
UBL21	0.75
UCC84	0.60
UCC85	0.50
UCF80	0.80
UCH81	0.60
UCL82	0.75
UF41	0.80
UF80	0.45
UF85	0.40
UL41	0.75
UL84	0.75
UM80	0.60
UM84	0.40
UY82	0.55
UY85	0.50
VR105/30	1.80
VR150/30	1.25
Z66	075
X61M	1.50
Z800U	3.00
Z801U	3.50
Z900T	1.50
1A3	0.60
1L4	0.30
1R5	0.55
1S4	0.40
1S5	0.40
1T4	0.40
1U4	0.60
1X2B	1.10
2D21	0.55
2K25	11.00
2X2	0.80
3A4	0.60
3D6	0.40
3D21	20.00
3E29	5.50
3S4	0.50
3V4	0.85
5B/254M	6.50

5B/255M	6.50
5B/258M	6.50
5R4GY	1.10
5U4G	0.95
5V4G	0.65
5Y3GT	0.65
5Z3	1.00
5Z4G	0.70
5Z4GT	0.75
6AB7	0.60
6AC7	0.60
6AH6	0.70
6AK5	0.55
6AK8	0.40
6AL5	0.40
6AL5D	0.65
6AM5	1.60
6AM6	0.65
6AN8	0.85
6AQ5	1.30
6AQ5W	0.85
6AS6	0.80
6AT6	0.75
6AU6	0.40
6AV6	0.50
6AX4GT	0.80
6AX5GT	1.00
6B7	0.75
6BA6	0.40
6BE6	0.50
6BG6G	1.00
6BJ6	1.10
6BQ7A	0.60
6BR7	2.30
6BW6	2.80
6BW7	1.00
6C4	0.40
6C6	0.55
6CH6	3.00
6CL6	0.75
6CY5	0.90
6D6	0.50
6EA8	0.80
6F6GB	0.90
6F8G	0.75
6F12	0.65
6F14	0.80
6F15	0.60
6F17	1.00
6F24	0.90
6F33	4.20
6M6	4.20
6J4WA	1.75
6J5	0.75
6J5GT	0.55
6J6	0.50
6J7	0.75
6J7G	0.50
6K7	0.70
6K7G	0.35
6K8GT	0.55

6L6M	1.90
6L6GT	0.90
6L7G	0.65
6L18	0.60
6LD20	0.50
6Q7G	0.70
6SA7	0.55
6SG7	0.75
6SJ7	0.70
6SJ7GT	0.50
6SK7	0.60
6SL7GT	0.75
6SN7GT	0.75
6SQ7	0.75
6V6GT	0.75
6X4	0.60
6X5GT	0.55
6Y6G	0.95
6Z4	0.65
6-30L2	0.90
7B7	0.80
7V4	0.80
9D2	0.60
9D6	0.75
10C2	0.60
10F18	0.60
10P13	0.60
11E2	11.00
12A6	0.60
12AT6	0.45
12AT7	0.55
12AU7	0.50
12AV6	0.70
12AX7	0.50
12BA6	0.50
12BE6	0.60
12BM7	0.60
12C8	0.55
12E1	4.25
1215GT	0.40
12K7GT	0.60
12K8GT	0.70
12Q7GT	0.50
12SC7	0.55
12SH7	0.70
12SJ7	0.55
12SQ7	0.55
12Y4	0.40
13D6	0.60
14S7	1.00
19AQ5	0.75
19G3	10.00
19G6	6.00
19H5	17.00
20D1	0.60
20F2	0.60
20L1	1.00
20P1	0.40
20P3	0.60
20P4	1.10
20P5	1.00

25L6GT	0.80
25Z4G	0.70
30C15	1.00
30C17	1.10
30C18	see PCF805
30F5	1.00
30F12	1.20
30FL12	1.20
30FL14	1.00
30L15	1.00
30L17	1.00
30P12	1.00
30PL1	1.00
30PL13	1.10
30PL14	1.10
35L6GT	0.80
35W4	0.60
35Z4GT	0.70
50C5	0.70
50CD6G	1.20
75	1.00
75C1	0.80
76	0.80
78	0.75
80	0.75
85A2	2.20
723A/B	11.00
803	6.00
805	18.00
807	1.00
813	10.50
8298	11.00
832A	4.50
866A	2.80
931A	6.00
954	0.50
955	0.50
956	0.50
957	0.90
1625	1.00
1629	0.70
2051	1.00
5763	2.00
5842	5.50
5933	3.00
6057	0.85
6060	0.85
6064	0.85
6065	1.20
6067	1.00
6080	3.50
6146	3.80
6146B	4.20
6360	2.00
8020	5.50

POSTAGE: £1-£2 20p; £2-£3 30p, £3-£5 40p; £5-£10 60p; over £10 free

VIDECON TUBE TYPE P863B
English Electric—£20

MARCONI SIGNAL GENERATORS

TF 2400/1 Frequency Converter up to 510MHz.
MODULATION METER 210A. 2.5-300MHz. AM 0-100%FMD+100kHz in 4 ranges. **AIRMEC VHF WAVE ANALYSER 248** Freq from 5MHz to 300MHz
TF 801 D/1/S SIGNAL GENERATOR. Range 10-485MHz in 5 ranges R F. output 0 1 V-1V. Source C M 50Ω output impedance. Internal modulation at 1KHz at up to 90%
TF 995 A/1 or A/2 or A/2M or A5 SIGNAL GENERATORS. Very high class AM/FM 1 5MHz to 220MHZ Detailed spec and price on application.
TF 995/3S with additional amplifier to give extra high output between 1.5 and 6 Mc/s
HIGH FREQUENCY SPECTRUM ANALYSER. MARCONI TYPE 1094A/S Basic Freq range 3 to 30 Mc/s and with LF unit from 100Hz to 3 MHz Measures relative amplitudes up to 60dB.
TF1041 B VALVE MULTIMETER. DC voltage from 300mV to 1.000V AC voltage from 300mV to 300V at up to 1.000MHz.

WHITE NOISE TEST SET. The instrument consists of two units, a Marconi Noise Generator Type TF 2091 and Noise Receiver Type TF 2092 Measures noise and intermodulation on wide band multichannel telephone systems Suitable for 12 channel to 2.700 channel system

MARCONI TF 887 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 CT478; CT479; QT480 Signal Generators frequency from 1 3kMS up to 11kHz output up to 1mV CW and imp. mod.

LEVEL OSCILLATOR TYPE REL 3W29. Frequency from 0 3 to 1200Kc/s. Mod. ext output from +16dB to −60dB. impedance output 75. 140. 600 ohms.

36' AERIAL MASTS consisting of 6 sections 6 8 × 2¼ dia Complete with all accessories to erect and instal
AVO CT 160 VALVE TESTER
LOW RESISTANCE HEADPHONES TYPE CLB £1.50. 40p postage VAT 12½%
AR88 D & LF SPARES. We hold the largest stock in UK. Write for list

TELEPHONE TYPE "J" tropicalised
10 LINE MAGNETO SWITCHBOARDS
CABLE LAYING APPARATUS No. 11. New production P.O A

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

VALVES AND TRANSISTORS

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

RHODE & SCHWARZ

Z-g DIAGRAPH TYPE 2DU 30-420MHz 50Ω Model type ZDD. Frequency 300-2400MHz. Directly measures multiterminal networks, phase shift, phase angle with complementary POWER SIGNAL GENERATOR TYPE SMLM high freq resolution, internal external mod up to 3v out

OSCILLOSCOPES (NEW PRODUCTION)
SCOPEX 4S-6, 6MHz Single Beam. 10mV sensitivity. Display — 6 cm x 8 cm Weight 4 5kg.
SCOPEX 4D-10A, 10MHz Dual Trace. 10mV sensitivity Display — 6 cm x 8 cm Weight 6kg.
DARTON D12, 15MHz Dual Trace 1mV sensitivity. Display — 8 cm x 10 cm Weight 7 8kg
SIGNAL GENERATOR H.P. MODEL 680C. High power, stable and high accuracy Frequency 10 to 480MHz Modulation level 0 to 95% at carrier levels 0 5V. output level continuously from 0 1μV into a 50 ohm. Maximum output 1V

FOR EXPORT ONLY
Mullard C11, High power installation 1000W
Technical details and prices available on request

TEKTRONIX OSCILLOSCOPES

545A. Bandwidth 0C to 30MHz
570 CHARACTERISTIC CURVE TRACE
DANA EXACT FUNCTION GENERATOR MODEL 121. Frequency range 0 2Hz to 2MHz (7 ranges), voltage controlled to 10V sweep generator 1ms to 10 sec
TEXSCAN ELECTRONIC SYSTEM ANALYZER MODEL 9990. Frequency range 10MHz to 300MHz with market controls.
FURZEHILL SENSITIVE VALVE VOLTMETER TYPE V200A full scale from 10mV to 1000V in 6 steps with output amplifier
TRAINING SET for Radio Operators with 10 key terminals and control frequency and volume
EDDYSTONE COMMUNICATIONS RECEIVER MODEL 730/1A 730/4. Frequency from 500kc/s to 28Mc/s.
HIGH VACUUM VARIABLE CAPACITORS — ceramic envelope — UC 1000A/20/150=VMMHC 1000 60-1000μF, 20kv-150A RF max=27MHz
TEST SET FT2 for testing Transceivers A40, A41, A42 and CPRC26
UNIVERSAL WIRELESS TRAINING SET No 1 Mk 2 YA 8316 to train 32 operators simultaneously on key and phone Complete installation consists of 3 kits packed in 3 special transit cases
HARNESS "A" & "B" CONTROL UNITS "A" "R" "J1" "J2," Microphones No 5, 6, 7 connectors, frames carrier sets etc.

VAT FOR TEST EQUIPMENT
PLEASE ADD **8%**

COLOMOR
(ELECTRONICS LTD.)
170 Goldhawk Rd., London, W.12
Tel. 01-743 0899
Open Monday to Friday
9-12.30, 1.30-5.30 p.m.

MARCONI TEST EQUIPMENT

MARCONI TF1064B/5 VHF Signal Generator
TF455E Wave analyser. New **£135**
TF1101 RC oscillators. **£65**
TF1099 20MHz sweep generators
TF1041B & C. VT Voltmeters
TF1102 Amplitude modulator. 500MHz
TF1020A Power meter. 100W. 250MHz. **£85**
TF1152A/1 Power meter. 25W. 500MHz. **£75**
TF890A/1 RF test set. **£425**
TF801B/3S Signal generator. **£175**
TF1417 200MHz counter (imperfect).
TF1400 Pulse generator
TF675F Pulse generator
TF1370 Wide-range RC oscillator **£125**
TF2904 Colour gain delay test set
TF1058 UHF/SHF signal generator
TF995A/4. AM/FM signal generator
TF1066 AM/FM signal generator.

ZENITH 8 AMP VARIACS. £28.50 (carr. 150p)

ADVANCE CONSTANT VOLTAGE TRANSFORMERS
Input 190-260V AC Output constant 220 Volts. 250W. £25 (£2 carriage)

POLARAD TYPE TSA. SPECTRUM ANALYSER. C/w type STU/2M plug-in unit covering from 950 to 4500 MHz

EVER-READY NICKEL CADMIUM BATTERIES
Size 'F' 6 A.H. 1.24 Volts. £2.75 (post 25p)

POWER SUPPLIES

ADVANCE PM51 0-30V @ 5 Amps **£36**
ADVANCE PMA20 0-7V @ 20 Amps **£39**
Both brand new, boxed, with book
APT 10459/11. 10-15V @ 7.5A **£25**
APT 10459/13. 24V (var) 5A **£25**
(All items + £1 carr.)

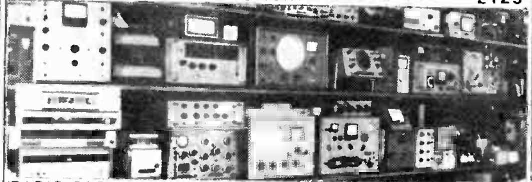
BECKMAN TURNS COUNTER DIALS
Miniature type (22mm diam.) Counting up to 15 turn 'Helipots'. Brand new with mounting instructions. Only **£2.50 each**

Wandel & Gotterman Equipment
Level Meter 0.2-1600KHz
Level Oscillator 0.2-1600KHz
Level Transmitter .3-1350 KHz
Carrier Frequency Level Meter

P. F. RALFE ELECTRONICS

10 CHAPEL STREET, LONDON, NW1
TEL: 01-723 8753

TEST EQUIPMENT
LEADER TV FM Sweep and marker generator
ADVANCE HR100 X-Y Recorder. £105.00
HEWLETT-PACKARD 302A Wave-Analyser.
RACAL type 801R. 100mHZ digital frequency meter
TEXSCAN X-Y oscilloscope. 9-inch CRT.
TELETYPE ASR33 now in stock
SOLARTRON 1420.2 digital voltmeter. 6 ranges to 1KV
AIRMEC 254 High-power oscillator/amplifier
BOONTON 80 Signal generator. 2-400MHz **£105**
BOONTON 230A RF Power Amplifier **£325**
BPL Capacitance decade (5) CD133. 100pf-1uF **£45**
GERTSCH Frequency meter and deviation meter. 20-1000MHz **£250**
HEWLETT PACKARD 693D sweep oscillator **£350**
DERRITRON Digital Wheatstone Bridge **£110**
MUIRHEAD K-134-A Battery op. wave analyser
PYE EHT scalamp voltmeter 0-40KV **£125**



RADIO CORPS PB1 pulse & bar generator **£45**
SIEMENS Level oscillator 12-160KHz
SCHOMANDL type FD1 frequency meter **£125**
Bruel & Kjoer type 3301 Automatic Frequency Response Recorder 200Hz-20KHz
MUIRHEAD-PAMETRADA D489EM Wave Analyser
TEKTRONIX 555 scope with plug-ins types CA (2 off), 21 and 22
TEKTRONIX 545 main frames. £210. Choice of plug-in units extra
TEKTRONIX 585A oscilloscope with '82' P.I. DC-80MHz
TEKTRONIX type 180A Time-mark generator **£110**
TELEQUIPMENT D53 Oscilloscope
TEKTRONIX 556. 50MHz Oscilloscope

NOTICE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry our three months' guarantee. Calibration and certificates can be arranged at cost. Overseas enquiries welcome. Prices quoted are subject to an additional 8% VAT

ROHDE & SCHWARZ EQUIPMENT

HUZ Field Strength Meter. 47-225MHz
AMF TV Demodulator 55-90MHz
Selective UHF v/meter, bands 4&5. USVF
Selectomat. RF Voltmeter. USWV BN 15221 £450
Standard attenuator. 0-100db 0-300 mHz DPR
UHF Sig. gen. type SDR 0.3-1 GHz £750
UHF Signal generator type SCH. £175
UHF Test receiver type USVD. £325
POLYSKOP SWOB I

PYE-LING VIBRATORS
3 ohm coil. Overall dimensions 9 x 6½ x 6½ cms. Each £5.25. (25p P&P)

TEXTRONIX TYPE 561A OSCILLOSCOPES
Supplied in first-class condition complete with types 3A1 and 3B3 plug-in units. DC-10MHz double-beam 10mV/div. Calibrated sweep delay and single-shot. Time-base 0.5us/div. £350.00.

'CENTAUR' INSTRUMENT COOLING FANS
Made by Rotron Holland. These are very high quality, quiet running fans, specially designed for the cooling of all types of electronic equipment. Measures 4.5x4 5x1 5 115V AC. 11 Watts. The list price of these is over £10 each. We have a quantity available brand new for only **£4.50 each**

500V TRANSISTORISED INSULATION TESTER
Lightweight, small size (13x7x4cms). Reads insulation from 0 2-100MΩ at 500V pressure. Runs from standard 9V PP3. Brand new **£16.50**

TELEVISION MONITORS
Phillips studio quality precision colour monitors and Pye monochrome 405/525/625 lines

PACE ELECTRONICS VARIPLOTTER
Type 1100E **£175**

MUIRHEAD DECADE OSCILLATORS type 890A.
1Hz-110kHz in four decade ranges. Scope monitored output for high accuracy of frequency. Excellent generator.

WW820 FOR FURTHER DETAILS

WW—056 FOR FURTHER DETAILS

WW—067 FOR FURTHER DETAILS

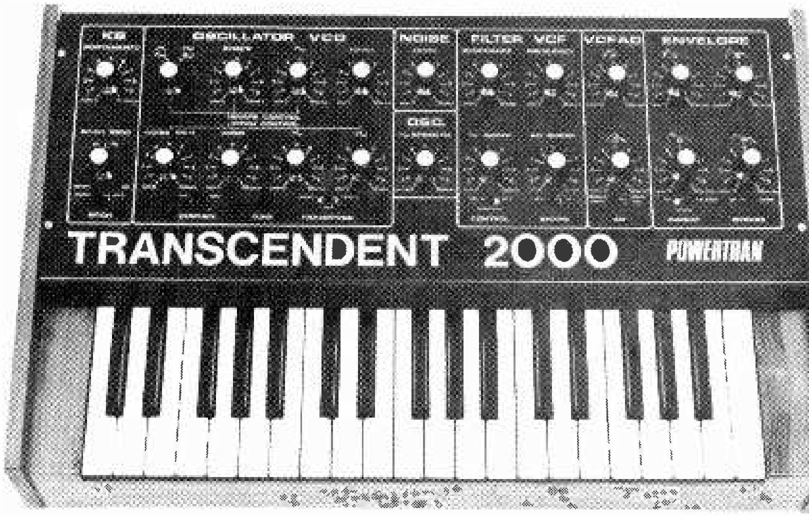
AUDIO KITS OF DISTINCTION FROM POWERTRAN

NEW!

TRANSCENDENT 2000

SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International (July, August 1978)



Live performance synthesizer designed by consultant Tim Orr (formerly synthesizer designer for EMS Ltd) and featured as a constructional article in Electronics Today International, the TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down with portamento, pitch bending, a VCO with shape modulation, a versatile VCF with both low and high pass outputs and a separate dynamic sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator and a new pitch detector amongst its many features

Kit includes fully finished metalwork, solid teak cabinet, filter sweep pedal and really is complete — right down to the last nut and bolt. Virtually everything is on one circuit board and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

INTRODUCTORY OFFER

£172!

Due to the fantastic success of the launching of this superb new kit we are able to continue the Special Introductory Offer of £172 for complete kit

INTERNATIONAL POWERSLAVE 200 + 200 watt AMPLIFIER

As featured in Electronics Today International

400W rms continuous — 800W peak!
0.03% THD at FULL power!
PLUS all the following features too!

- ★ Each channel totally independent with its own stabilised power supply driven by custom designed TOROIDAL transformers!
- ★ Inherent reliability — monster heat sinks for cool running at the hottest venues — electronic open and short circuit protection!
- ★ Ultra low feedback (an incredible low 14dB overall!), super high slewing rate (20V/μs), 200W rms continuous to 4 ohm from EACH channel, input sensitivity 0 775V (0dB)
- ★ Professional quality components, sturdy 19 rack mounting chassis complete with sleeve and feet for free standing work too
- ★ Easy to build — plenty of working space with ready access to all components, minimal wiring, extensive instruction suitable for both experienced constructors and newcomers to electronics
- ★ Value for money — quality and performance comparable with ready-built amplifiers costing over £600!

Pack		Price
1.	Fibre glass printed circuit board for power amp	£4.20
2.	Set of capacitors, metal oxide resistors, thermistor, cormet pre-sets for power amp	£6.40
3.	Set of semiconductors for power and with mounting hardware, cooling tabs	£27.60
4.	Pair of monster black drilled heat sinks, transistor mounting bracket	£6.90
5.	Toroidal transformer, Primary 0-117V-234V, Secondaries 42-0-42V, 0-15V, 0-15V, Electrostatic screen	£17.50
6.	Set of all parts for stabilized power supply including fibre glass printed circuit board, mounting bracket, semiconductors, resistors, capacitors, etc	£18.90
7A.	Set of all parts for buffer/overdrive unit including fibre glass printed circuit board, semiconductors, resistors, capacitors, controls — required for PSI 4001 only	£3.80
7B.	Set of parts for peak power meter including professional quality meter, fibre glass printed circuit board, components, controls — required for PSI 4002 only	£8.50
8.	Set of all miscellaneous parts including sockets, illum. mains switches, fuse holders, fuses, cut-outs, cable, etc	£12.10
9.	Cabinet, including chassis, anodised silver on black panels, fixing parts, etc. Please state whether Slave or Studio model required	£25.50
10.	Handbook £0.50 or free on request when ordering any of above packs.	

2 each of packs 1-7 (A or B), 1 each 8, 9 and 10 are required for complete 200 + 200W professional amplifier.

Total cost of individually purchased packs — PS1 4001 £208.20; PS1 4002 £217.60

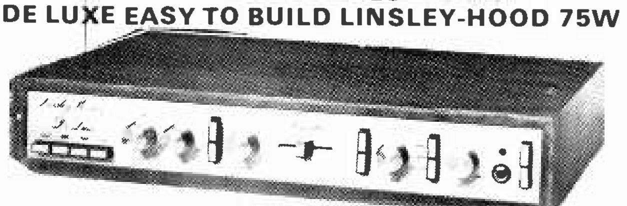
PSI 4001 SLAVE MODEL

PSI 4002 STUDIO MODEL

SPECIAL PRICES FOR COMPLETE KITS!

PS1 4001 — £187.50
PS1 4002 — £196.90

DE LUXE EASY TO BUILD LINSLEY-HOOD 75W AMPLIFIER



AVAILABLE AS SEPARATE PACKS
PRICES IN OUR FREE CATALOGUE

SPECIAL PRICE FOR COMPLETE KIT £99.30

The standard model of our kit for Mr Linsley-Hood s 75 watt design has for a long time offered exceptional performance at a very modest cost with high quality high power ready-built units of comparable quality generally being over three times the price

Features of the amplifier include very low distortion (less than 0 01%) 75W rms per channel power output rumble filter variable slope scratch filter variable transition frequency tone controls tape monitoring facilities and individually adjustable inputs This model is based on 5 circuit boards which not having the controls mounted on them can if desired be effectively used separately in high performance audio systems not based on our metalwork

Our new De Luxe model uses 14 boards which interconnect with gold plated contacts and are designed to have the potentiometers and switches mounted upon them This system almost eliminates internal wiring making installation after their assembly delightfully straightforward and as each board can be easily removed in seconds from the chassis checking and maintenance is so simple that even newcomers to electronics will be able to cope competently with the kit Additional features of our new model are inclusion of the latest circuit improvements generously sized heat sinks for heavy duty use [illegible]pical climates and metal oxide resistors throughout for long term stability and reliability

Pack		Price
1.	Fibreglass printed circuit board for power amp	£1.15
2.	Set of resistors, capacitors, pre-sets for power amp	£2.50
3.	Set of semiconductors for power amp	£6.50
4.	Pair of 2 drilled, finned heat sinks	£1.10
5.	Fibreglass printed-circuit board for pre-amp	£1.90
6.	Set of low noise resistors, capacitors, pre-sets for pre-amp	£4.10
7.	Set of low noise, high gain semiconductors for pre-amp	£2.40
8.	Set of potentiometers (including mains switch)	£3.50
9.	Set of 4 push-button switches, rotary mode switch	£5.40
10.	Toroidal transformer complete with magnetic screen/ housing primary: 0 117-234 V: secondaries: 33-0-33 V, 25-0-25 V	£12.95
11.	Fibreglass printed-circuit board for power supply	£0.85
12.	Set of resistors, capacitors, secondary fuses, semiconductors for power supply	£5.40
13.	Set of miscellaneous parts including DIN skts., mains input skt., fuse holder, interconnecting cable, control knobs	£6.20
14.	Set of metalwork parts including silk screen printed fascia panel and all brackets, fixing parts, etc.	£8.20
15.	Handbook	£0.30
16.	High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70

2 each of packs 1-7, 1 each of packs 8-16 inclusive are required for complete stereo amplifier. Total cost of individually purchased packs £92.80

PACK PRICES FOR STANDARD KIT

STANDARD LINSLEY-HOOD 75W AMPLIFIER

SPECIAL PRICE FOR COMPLETE KIT £79.80

KENYA HOLLAND JAMAICA UNITED ARAB EMIRATES FALKLAND ISLANDS PORTUGAL GUYANA INDIA GREECE JORDAN UNITED STATES OF AMERICA YUGOSLAVIA ASCENSION ISLAND

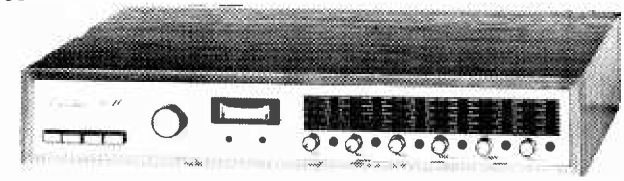
EIRE GRENADA SAUDI ARABIA NEW ZEALAND NORWAY SINGAPORE ICELAND SWEDEN MALAYA INDONESIA BRAZIL SWITZERLAND ZAMBIA GIBRALTAR CHILE SPAIN

MUSCAT & OMAN FRANCE DENMARK GAMBIA AUSTRALIA HONG KONG NAURU GERMANY TUNISIA LUXEMBOURG NIGERIA FINLAND SOUTH AFRICA CZECHOSLOVAKIA AUSTRIA

Designed in response to demand for a tuner to complement the world-wide acclaimed Linsley-Hood 75W Amplifier, this kit provides the perfect match. The Wireless World (Skingley and Thompson) published original circuit has been developed further for inclusion into this outstanding slimline unit and features a pre-aligned front end module, excellent a m rejection and temperature compensated varicap tuning, which may be controlled either continuously or by push-button pre-selection. Frequencies are indicated by a frequency meter and sliding LED indicators, attached to each channel selector pre-set. The PLL stereo decoder incorporates active filters for "birdy" suppression and power is supplied via a toroidal transformer and integrated regulator. For long term stability metal oxide resistors are used throughout

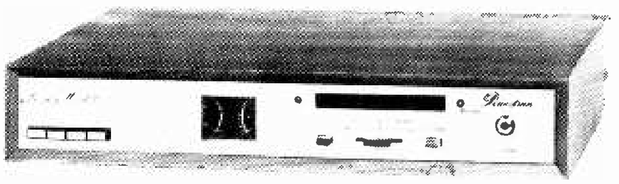
AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

WIRELESS WORLD FM TUNER



SPECIAL PRICE FOR COMPLETE KIT **£70.20**

LINSLEY-HOOD CASSETTE DECK



SPECIAL PRICE FOR COMPLETE KIT **£79.60**

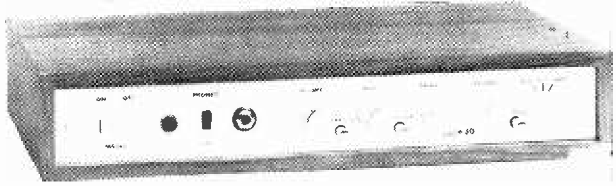
Pack	Price
1. Stereo PCB (accommodates 2 rep. amps. 2 meter amps. bias/erase osc. relay)	£3.35
2. Stereo set of capacitors. M.O. resistors. potentiometers for above	£7.95
3. Stereo set of semiconductors for above	£8.50
4. Miniature relay with socket	£2.90
5. PCB. all components for solenoid. speed control circuits	£3.80
6. Goldring-Lenco mechanism as specified	£18.50
7. Function switch. knobs	£1.90
8. Dual VU meter with illuminating lamp	£6.95
9. Toroidal transformer with E.S. screen prim. 0-117V. 234V. Sec. 15V	£4.90
10 Set of capacitors. rectifiers. I.C. voltage regulator P.C.B. for power supply (Powertran design)	£2.80
11. Set of miscellaneous parts. including sockets. fuse holder. fuses. interconnecting wire. etc	£3.40
12. Set of metalwork including silk screened fascia panel. internal screen. fixing parts. etc	£7.10
13. Construction notes	£0.25
14. High Quality Teak Veneer cabinet 18.3" x 12.7" x 3.1"	£10.70

One each of packs 1-14 inclusive are required for complete stereo cassette deck. Total cost of individually purchased packs £83.00

Matsushita WY 436 AZ head (optional extra) . £4.50 (free with compete kit)

Published in Wireless World (May, June, August 1976) by Mr Linsley-Hood, this design, although straightforward and relatively low cost, nevertheless provides a very high standard of performance. To permit circuit optimization separate record and replay amplifiers are used, the latter using a discrete component front-end designed such that the noise level is below that of the tape background. Pushbutton switches are used to provide a choice of equalization time constants, a choice of bias levels and also an option of using an additional pre-amplifier for microphone use. The mechanism used is the Goldring-Lenco CRV, a unit distinguished in its robustness and ease of operation. Speed control and automatic cassette ejection are both implemented by electronic circuitry. This unit which is powered by a toroidal transformer and uses metal oxide resistors throughout offers an excellent match for the Wireless World Tuner and the Linsley-Hood 75 Watt Amplifier. Circuit changes as published in February, 1978, follow-up article are included in the kit AT NO EXTRA COST! A higher performance head (Matsushita WY 436 AZ head as recommended in the follow-up article) is offered as an optional extra but this will be automatically supplied FREE OF CHARGE with all orders for complete kits!

T20+20 AND T30+30 20W, 30W AMPLIFIERS



Designed by Texas engineers and described in Practical Wireless the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements the slimline T20+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and rumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel

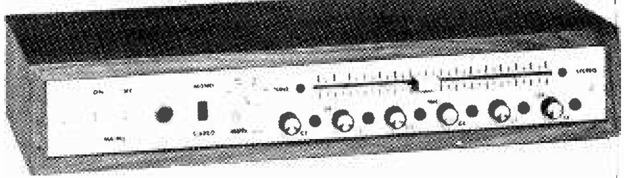
SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE **£33.10**

T30+30 KIT PRICE **£38.40**

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

WWII TUNER

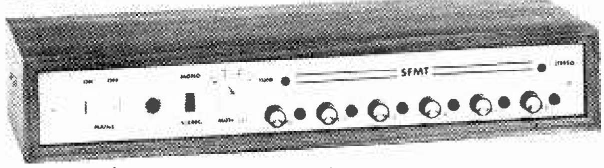


SPECIAL PRICE FOR COMPLETE KIT **£47.70**

AVAILABLE AS SEPARATE PACKS — PRICES IN OUR FREE CATALOGUE

Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT **£35.90**

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

Wireless World Designs: Full kits are not available for the projects below but PCBs and component sets are stocked. Further details of these and other packs are in our Free Catalogue

30W Bailey Amplifier

BAIL Pk 1	F/Glass PCB	£1.00
BAIL Pk 2	Resistors Capacitors	£2.35
BAIL Pk 3	Semiconductors	£4.70

Regulated Power Supply for Bailey Amplifier

60VS Pk 1	F Glass PCB	£0.85
60VS Pk 2	Resistors, Capacitors	£2.20
60VS Pk 3	Semiconductors	£3.10
60VS Pk 6A	Toroidal transformer	£8.80

Linsley-Hood Low Distortion Oscillator.

LDO Pk 1	Fibreglass PCB	£1.65
LDO Pk 2	M O Resistors capacitors	£2.60
LDO Pk 3	Semiconductors	£3.90

Stuart Tape Recorder

TRRP Pk 1	Replay Amp F G PCB (stereo)	£1.30
TRRC Pk 1	Record Amp F G PCB (stereo)	£1.70
TROS Pk 1	Bias Erase F G PCB (stereo)	£1.20

E. F. Taylor Pre-Amplifier

EFTP Pk 1	Fibreglass PCB (stereo)	£1.45
EFTP Pk 2	M O Res caps (stereo)	£3.20
EFTP Pk 3	Semiconductors (stereo)	£4.20

NEW! Improved stereo decoder (as described in April 1978 W W.) F/Glass PCB, M O Res, Caps, Cermet pre-sets, IC, IC socket. **£6.30**

SQ QUADRAPHONIC DECODERS

These state-of-the-art circuits described by CBS are offered as kits of superior quality with close tolerance capacitors metal oxide resistors and Fibreglass PCBs designed for edge connector insertion. Further information on these kits is given in our FREE CATALOGUE

M1 Basic matrix decoder	£5.90
L1 Full logic decoder	£17.20
L2A Full logic decoder with variable blend	£22.60
L3A As L2A but with high performance discrete component front end	£30.10
(or with carbon film resistors)	£25.90
SQM1 30 Decoder complete with 30W rear channel amplifiers. Complete kit matches T30+30 amplifier	£40.75

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U K customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London

Value Added Tax not included in prices
UK Carriage FREE

PRICE STABILITY: Order with confidence! Irrespective of any price changes we will honour all prices in this advertisement until October 31st, 1978, if this month's advertisement is mentioned with your order. Errors and VAT rate changes excluded.

U.K. ORDERS: Subject to 12½% surcharge for VAT (i e add ⅛ to the price). No charge is made for carriage* or current rate if charged

SECURICOR DELIVERY: For this optional service (U K mainland only) add £2 50 (VAT inclusive) per kit

SALES COUNTER: If you prefer to collect your kit from the factory call at Sales Counter (at rear of factory). Open 9 a m -4 30 p m Monday-Thursday

QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned and supplied with circuit diagrams and construction layouts

FOR FURTHER INFORMATION PLEASE WRITE OR TELEPHONE FOR OUR **FREE CATALOGUE**

DEPT. WW10

POWERTRAN ELECTRONICS

PORTWAY INDUSTRIAL ESTATE ANDOVER
ANDOVER HANTS SP10 3NN (0264) 64455

NEW GUINEA ISRAEL GUERNSEY CYPRUS BELGIUM UGANDA BRUNEI TRINIDAD SOUTH WEST AFRICA ITALY JAVA SIERRA LEONE WINDWARD ISLANDS CANADA MALTA

Electronic Brokers Ltd

The Test Equipment People

Calibrated & Guaranteed 12 Months

Visit us at the EPG Exhibitions at:
Bloomsbury Centre Hotel, London, 10th, 11th and 12th October, 1978
Post House Hotel, Southampton, 25th and 26th October, 1978

AC Voltmeters & Electronic Multimeters

ADVANCE
VM77E Transistorised Voltmeter 10Hz-6Mz 1mV-300V I/P Z 10M Ohms £130.00

AIRMEC
301A RF Valve Voltmeter 100Hz-900MHz 300µV-300V ... £330.00

BOONTON
91H RF Valve Voltmeter 20KHz-1200MHz 100µV-300V . £415.00

BRADLEY
112RF Millivoltmeter 3mV-300mV. 1-300MHz. Battery operated £375.00

BRUEL & KJAER
2409 Electronic Voltmeter 2Hz-200KHz 10mV-1000V True RMS . £245.00

FLUKE
883AB AC/DC Differential Voltmeter 1mV-1100V 20H -100KHz £975.00

FLUKE
931B True RMS Differential Voltmeter 10Hz-1MHz 0 01V-1100Vr m s £1,050.00

HEWLETT PACKARD
400F AC Voltmeter 20Hz-4MHz 100µV-300V £235.00
411A RF Millivoltmeter 500KHz-1GHz. 10mV-10V £395.00

PHILIPS
PM.2503 Electronic Multimeter AC/DC Voltage and Current £90.00

ROHDE & SCHWARZ
U.R.V. RF Voltmeter 1KHz-2400MHz with 50 Ohms insertion unit 20mV-10V £235.00

SIGN
AM324 AC Voltmeter 15Hz-500Khz 1mV-300V £60.00

Amplifiers

AVANTEK
UA101 RF Modular Amplifier 5-500MHz 10 5 dB gain £65.00
UA103 RF Modular Amplifier 10-500MHz 10 dB gain £150.00
UA301 RF Modular Amplifier 1-400MHz. 7dB gain £150.00

E.N.I.
320 RF Power Amplifier 150KHz-250MHz 40dB gain 5W max. O/P AS NEW CONDITION, GOOD SAVING ON NEW PRICE £1,600.00
406 RF Power Amplifier 250KHz-110MHz. 50dB gain. 20W max O/P. AS NEW £1,000.00
500L RF Power Amplifier 2-500MHz 27dB gain 300mW max O/P SUPERB CONDITION £315.00

Analogue Multimeters

AVO
Model 7 £40.00
Model 8 £55.00
Test Set No. 1 £65.00
Precision Avo £45.00
Leads, Prods. clips for Avo's £4.95

PHILIPS
PM 2412 AC/DC Volts & amps 40K Ohms/V £60.00

Analysers

BRUEL & KJAER
2112 AF Spectrometer 22Hz-45KHz £650.00

HEWLETT PACKARD
331A Distortion Analyser 5Hz-600KHz. 0 1%-100% £435.00
332A Distortion Analyser Spec as 331A also AM detector £495.00
33A Distortion Analyser Spec as 331A also Auto null £515.00

RACAL
409 Modulation Meter 3-1500MHz AM & FM £345.00

ROGERS/SIGN
DM.344 Distortion Meter 20Hz-20KHz £230.00

TEKTRONIX
1L20 Spectrum Analyser Plug-In used on 540 series scopes. 10MHz-40GHz £1,050.00

T.E.S.
D.566B Distortion Meter 10Hz-1MHz 0 03 to 100% £305.00

MARCONI INSTRUMENTS
T.F. 791D Deviation Meter 4-1024MHz Dev 10Hz-125KHz £195.00

Attenuators

GENERAL RADIO
874 GA Variable Attenuator 100MHz-4GHz 0-120dB. 50 Ohms £120.00

MARCONI INSTRUMENTS
TF.1073A Series Step Attenuator DC-100MHz 0-100dB 50 or 75 Ohms £75.00
TF.2162 Step Attenuator DC-1MHz 0-111db 600 Ohms £120.00

ROHDE & SCHWARZ
RBD Attenuator BN 33662/60 DC-600MHz, 20dB. 60 Ohms £40.00
DPR Step Attenuator BN 18042/60 DC-300MHz 0-100dB 60 Ohms £90.00

ROHDE & SCHWARZ
RBD UHF Attenuator BN33661/50 DC-2 4GHz. 10dB, 50 Ohms £55.00

Bridges

BRUEL & KJAER
1504 Deviation Bridge £190.00

MARCONI INSTRUMENTS
TF.2701 In Situ Universal Bridge £395.00
TF.1245 'Q' Meter Supplied with TF.1246 Oscillator 40KHz-50MHz £625.00

WAYNE KERR
B.221 (CT.530) Univ. Bridge 0 1% accuracy £275.00
Q.221 Low Impedance Adaptor for use with B 221 £75.00
B.521 (CT.375) Univ. Bridge 1% accuracy £120.00

Calibration Equipment

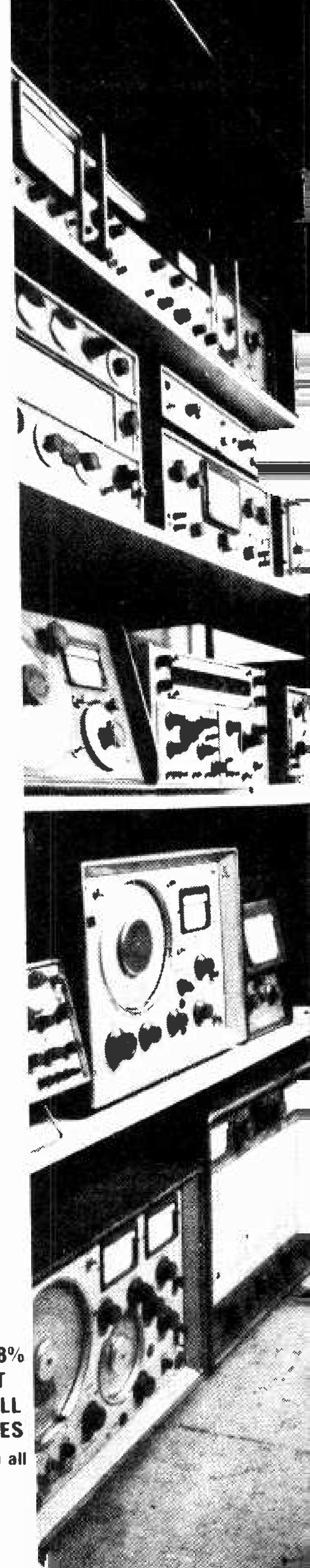
HEWLETT PACKARD
740B DC Voltage Source & Differential Voltmeter £850.00
741B DC Voltage Source & AC/DC Differential Voltmeter £975.00

FLUKE
931B True RMS Differential Voltmeter 10Hz-1MHz. 0.01V-1100V £1,050.00
883AB. AC/DC Differential Voltmeter 1mV-1100V £975.00
6011A Synthesised Signal Generator 10Hz-11MHz 0 1Hz resolution Facility to store and recall 9 front panel control settings inc freq level AM mod. etc. £2,650.00

TEKTRONIX
184 Time Mark Generator £275.00
191 Constant Amplitude Generator £375.00
2901 Time Mark Generator £400.00
2101 5nS Pulse Generator £525.00

Digital Counters

ADVANCE
TC.14 Frequency Counter DC-250MHz. 9 digit £295.00
TC.15 + TC.15P1 Counter & Plug In DC-500MHz. 9 digit 10mV sensitivity £495.00
TC.16 Frequency Counter 5Hz-80MHz £110.00
TC.17 or TC.17A Time Counter Freq. period. Period Average. Pulse width count DC-80MHz £195.00
TC.21 Time Counter Freq Time, Period, Count Pulse width 2Hz-10MHz £195.00
TC.22 Time Counter DC-100MHz £275.00



A copy of our trading conditions is available on request

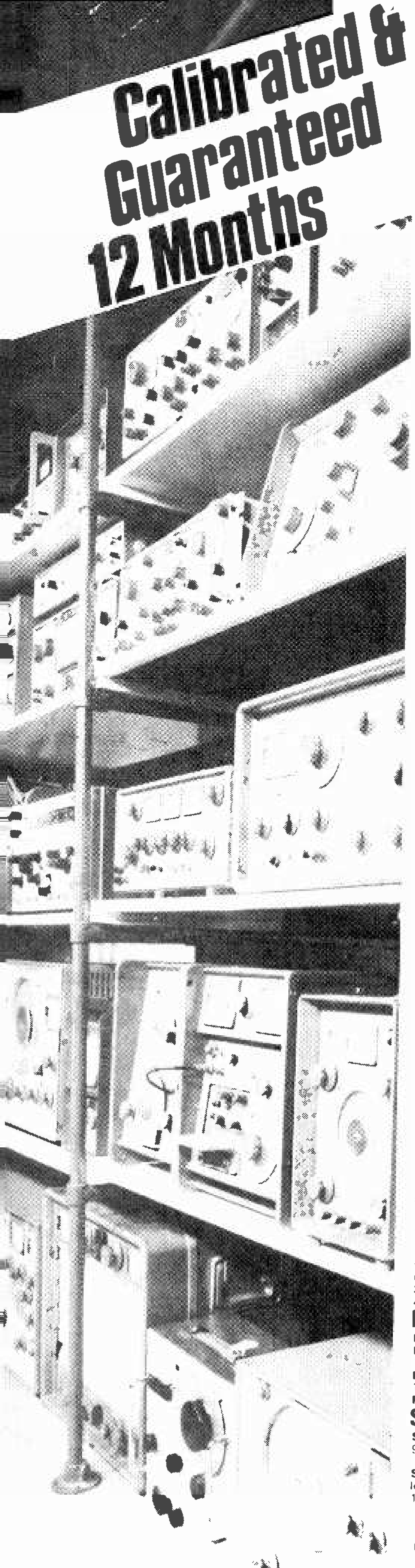
ELECTRONIC BROKERS LIMITED
49-53 Pancras Road, London NW1 2QB
Tel. 01-837 7781. Telex: 298694
Hours of Business: 9 a.m.-5 p.m. Mon.-Fri.: closed lunch 1-2 p.m.

ADD 8% VAT TO ALL PRICES

Carriage and Packing charge extra on all items unless otherwise stated.

WW—132 FOR FURTHER DETAILS

Calibrated & Guaranteed 12 Months



Electronic

49-53 Pancras Road, London NW1 2QB
Tel: 01-837 7781

FLUKE

1900A opt. 01 5Hz-80MHz 25mV Sensitivity with battery option £215.00
1941A Industrial Counter/Totaliser 5Hz-40MHz £120.00
1900A opt. 02 Same as 1900A 01 but with BCD O/P £195.00
1980A Communications Counter 5Hz-515MHz 15mV sensitivity 6 digit Battery operated £295.00

PHILIPS

PM.6612 Timer Counter 10Hz-80MHz 9 digit display £405.00
PM.6615 Timer Counter 10Hz-1GHz 10mV sensitivity £795.00
PM.6620 Timer Counter DC-45MHz 50mV sensitivity £395.00
PM.6625 Timer Counter DC-1GHz Sensitivity 20mV LF I/P 10mV RF I/P 9 digit £1,010.00
PM.6661 Frequency Counter 10Hz-80MHz 20mV sensitivity. 8 digit £185.00

PHILIPS

PM.6630A Timer Counter DC-160MHz 8 digit Display £600.00
PM.6645 Frequency Counter 30Hz-512MHz 5mV sensitivity £710.00

RACAL

836 Timer Counter DC-32MHz £250.00
9838 Timer Counter DC-100MHz 10mV sensitivity 6 digit £285.00
9905 Universal Timer Counter DC-200MHz Sensitivity 10mV into 1M Ohm 8 digit display £275.00

Digital Voltmeters & Multimeters

ADVANCE

DMM2 Digital Multimeter 3½ digit £95.00
DRM6 True R.M.S. DVM 4½ digit, scale 1999 10mV-1KV 10μV resolution Frequency range DC-1MHz £295.00

FLUKE

8030A DMM 3½ digit scale length 1900 AC Volts 200mV-700V true r m s Frequency range 45Hz-1kHz 100μV resolution DC Volts 200mV-110V 100μV resolution AC current 200μA-2A true r m s Frequency range 45Hz-5kHz 100nA resolution DC current 200μA-2A 100nA resolution. Resistance 200 Ohms 20M Ohms 100m Ohms resolution Battery operation Unused £135.00

HEWLETT PACKARD

3490A DM 5½ digit, scale length 120000 AC Volts 1V-1kV 10μV resolution DC Volts 100mV-1kV. 1μV resolution Resistance 100 Ohms-10M Ohms. 1M Ohms resolution Full auto-ranging and variable sample rate Self check facility £595.00
34702A DMM C/W 34740A Display 4½ digit AC/DC & Ohms £295.00

PHILIPS

PM2424 DMM 4 digit £300.00
PM.2443 DC DVM 4½ digit. scale length 19999 £430.00
PM.2513A DMM 3½ digit scale length 1999 £95.00
PM.2522 DMM 3½ digit £175.00

S.E. LABORATORIES

SM210 DC DVM 4 digit scale length 9999 100mV-1kV 10μV resolution £365.00
SM214 AC-DC DVM 5½ digit scale length 10999 SC-DC Volts 1 1V-1 1kV 10μV resolution £400.00

Miscellaneous R.F. Accessories

HEWLETT PACKARD

1100A Delay Line £75.00
8431A Pass Band Filter 2-4GHz 50 Ohms £75.00
8436A Pass Band Filter 8-12 4GHz 50 Ohms £75.00
8732A Pin Modulator 1 8-4 5GHz 50 Ohms £100.00
8734B Pin Modulator 7.0-12 4GHz 50 Ohms £100.00

ROHDE & SCHWARZ

ZDP Reflectometer 300-4,200MHz 50 Ohms £70.00
ZPW Directional Coupler 380 1000MHz 50 Ohms £75.00

Oscilloscopes

COSSOR

CDU 110 Dual Trace Oscilloscope with CAM 111 Vertical Preamplifier DC-20 MHz 5mV-20V/div £305.00
CDU 150 Dual Trace Oscilloscope DC-35MHz 5mV20V/div Full delayed sweep Long persistence CRT £450.00
3100 Dual Trace Portable Oscilloscope with 3102 and 3122 modules DC-40MHz 5mV-20V/div Full delayed sweep £450.00
4000 Dual Trace Oscilloscope DC-50 MHz 5mV 10V div Full delayed sweep Unused £495.00

DYNAMCO

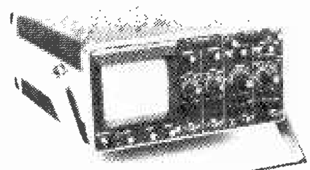
7100 Dual Trace Portable Oscilloscope with 1Y2 and 1X2 modules DC-30 MHz 10mV-20V/div Full delayed sweep £350.00
7500 Dual Trace Portable Oscilloscope DC-40MHz 10mV-20V/div Full delayed sweep Unused £495.00

HEWLETT PACKARD

180A Dual Trace Oscilloscope with 1802A and 1821A modules DC-100MHz £800.00

PHILIPS

PM.3240 Dual Trace Portable Oscilloscope DC-50MHz 5mV 2V div Full delayed sweep From £950.00



S.E. LABORATORIES

SEM 121 Six Channel Display Monitor DC-2kHz 20mV/cm £350.00

SOLARTRON

A100 Dual Trace Oscilloscope with A101 and A112 modules. DC-30MHz 5mV-20V div Full delayed sweep £380.00
A100 Dual Trace Oscilloscope with A101 and A111 modules Same spec as previous instrument but no delayed sweep £340.00
CD.1400 Dual Trade Oscilloscope with 2 off CX1441 and 1 off CX1443 modules. DC 15MHz 10mV-50V/div 0 5μS-0 5S div £180.00-£205.00

TEKTRONIX

531A Bench Oscilloscope with Dial trace vertical Plug-In unit CA DC 13 5MHz Sensitivity 50mV 20V div £290.00
647A Bench Oscilloscope with Dual trade vertical Plug-in unit 10A2A and delayed time base plug-in unit 11B2A DC-100MHz Sensitivity 10mV-20V/div £1,200.00
585A Bench Oscilloscope with Dual trace vertical Plug-in unit 82 DC-80MHz Sensitivity 10mV 50V/div £775.00
547 Bench Oscilloscope with dial trace vertical Plug-in unit 1A1 DC-50MHz Sensitivity 5mV-20V/div £775.00
545B Bench Oscilloscope with Dual trace vertical Plug-in unit CA DC-24MHz Sensitivity 50mV to 20V/div £425.00
543B Bench Oucilloscope with Dual trace vertical Plug-in unit CA £350.00
549 Storage Scope with Dual Trace Unit 1A1 DC-30MHz Bistable split screen, storage and conventional displays 5CM/μs. writing speed Calibrated sweep delay £975.00
575 Transistor Curve Tracer £400.00
556 Dual Beam Scope (Mainframe) DC-50MHz dependent on choice of Plug-ins £325.00
555 Dual Beam Scope (Mainframe) DC-33MHz wide choice of Plug-ins £300.00

TELEQUIPMENT

D.83 50MHz Oscilloscope c/w V4 & S2A Plug-ins DC-50MHz Delayed sweep £610.00

Oscilloscope Probes

PROBES

EB90 X1 Probe Kit DC-20MHz 1 5 mtr cable 40pF I P cap 500V DC max working BRAND NEW £9.00
EB91 X10 Probe Kit. DC-80MHz 1 2 mtr cable I/P Z 10M Ohms paralleled by 10 8pF Compensation 15-50pF BRAND NEW £11.00
EB95 X1 and X10 Switched Probe Kit. DC-15MHz in X1 DC-80MHz in X10 I/P Z 10M Ohms paralleled by 10 8pF in X10 1 2 mtr cable BRAND NEW £15.00

GREENPAR

GE81500/2 X1, X10 Probe Kit. DC-200MHz 10M Ohms I/P resistance Compensation 15-50pF UNUSED £27.00

Power Meters

HEWLETT PACKARD

430C RF Power Meter with 477B Thermistor Mount 10MHz-10GHz 100mW £225.00

MARCONI INSTRUMENTS

TF 893A AF Power Meter 20Hz-35KHz 1mW-10W I/P Z 2 5 Ohms-20K Ohms £185.00
TF.1020A Series RF Power Meter DC-250MHz 50-100W FS or 150-300W FS I P Z 75 Ohms on 50-100W model 50 Ohms on 150-300W model From £105.00

T.E.S.

MU964 AF Power Meter 20Hz-50KHz 1mW-10W I P Z 2 5 Ohms-20K Ohms £175.00

Pulse Generators

ADVANCE

PG.528 Modular Pulse Generator 0 1Hz-30MHz c/w 2 x P3 3 x P2 P4 P5 P1 £700.00
PG59 Dual Output Pulse Generator (CT600) 1Hz-10MHz £595.00

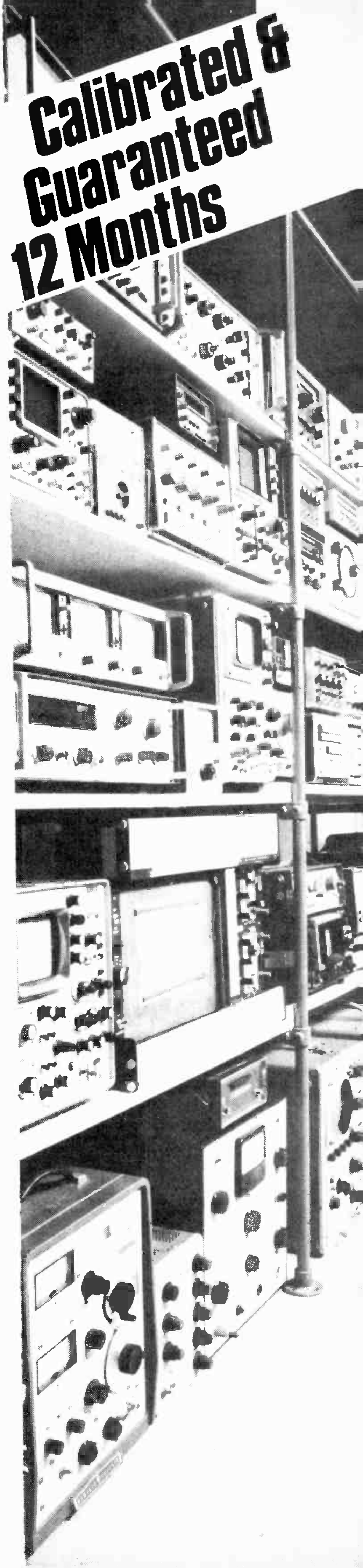
A copy of our trading conditions is available upon request

Carriage and packing charge extra on all items unless otherwise stated

Please note: All instruments offered are secondhand and tested and guaranteed 12 months unless otherwise stated

Hours of business: 9a.m.-5p.m. Mon.-Fri. Closed lunch 1-2p.m.

Brokers Ltd
The Test Equipment People



PHILIPS
PM5704 TTL Pulse Generator with P.S.U. 0.1Hz-10MHz. TTL O/P will drive up to 30 gates £250.00
PM5712 Pulse Generator 1Hz-50MHz Variable delay, width single or double pulse Base line offset £525.00
PM5715 Pulse Generator Similar spec. to PM5712 but with variable rise and fall times £575.00
PM5770 Pulse Generator 1Hz-100MHz Variable delay, width, rise and fall time Single or double pulse, base line offset £790.00
PM5775 Pulse Generator 1Hz-100MHz Variable delay, width, rise and fall time Single or double pulse, base line offset £800.00
PM5776 Pulse Generator Same spec. as PM5775 but dual O/P £900.00

Radio Receivers

EDDYSTONE
730/1A Communication Receiver 480KHz-30MHz in 5 ranges, BFO, noise limiting, AF filter, AVC, RF/gain, S Meter £175.00
730/4 Communications Receiver 480KH-30MHz, 5 Bands, BFO, noise limiting, AVC, RF gain, AF filter. UNUSED CONDITION £275.00
880 Communications Receiver 500kHz-30.5MHz in 1MHz wavebands. BFO, AGC, RF-IF gain, noise limiting, AF filter, S Meter £325.00
770R VHF Receiver 19MHz-165MHz in 6 ranges, AM/FM demod. Muting, noise limiting, IF gain, S meter £225.00

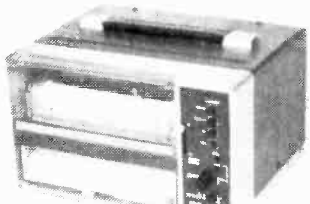
RACAL
RA117E Communications Receiver 1-30MHz MHz and KHz tuned separately. Selectivity 100Hz-13kHz in 6 ranges. BFO, AVC, Noise limiter, RF/IF gain, S meter £375.00

Recorders

ADVANCE
LR100/LP121/LP123 YT Recorder Y axis 50µV500mV/CM differential I/P. T axis 5S-500 Mins full sweep £225.00
Omniscribe 5000 Strip Chart Recorder 1 and 2 pen models available. Please contact us for full details on modules and main frames. From £200.00

HOUSTON INSTRUMENTS
6520 YT Recorder £450.00

PHILIPS
PM8110 Mini Single Channel Chart Recorder Sensitivity 10mV-10V full span Chart width 12cm. Chartspeed 5 and 20mm/min £300.00



RECORD
3" Paper Width Recorder with 500 µA sensitivity FS. Left-hand zero 1 and 6 per hour chart speed £75.00

YOKAGAWA
3047 Two Channel Chart Recorder Scan width 250mm. Sensitivity 0.5mV-100V Speeds 60cm/min to 2cm/hr £530.00

Signal Sources

ADVANCE
H1E LF Sine/Square Oscillator 15Hz-50kHz. Sine Square £75.00
J2E L.F. Oscillator 15Hz-50kHz £90.00
J3 L.F. Oscillator 10Hz-100kHz £150.00
J4 L.F. Oscillator 10Hz-100kHz £135.00
SG67A Wide Range Oscillator 1Hz-1MHz sine or square wave £95.00
SG68A Low Distortion Oscillator 1.5Hz-150kHz. Battery operated. Distortion less than 0.01% £150.00

HEWLETT PACKARD
202H AM/FM Signal Generator 54-216MHz. From £495.00
608D VHF Signal Generator 10-420MHz. From £495.00
612A U.H.F. Signal Generator 540-1230MHz. From £950.00
616A U.H.F. Signal Generator 1.8-4.2GHz £550.00
626A S.H.F. Signal Generator 10-15.5GHz £500.00

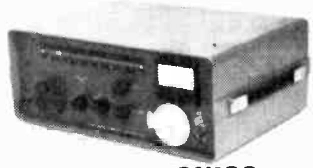
MARCONI INSTRUMENTS
TF.801D/1 AM Signal Generator 10kHz-470Mhz £400.00
TF.995A/5 AM/FM Signal Generator 1.5MHz-220MHz £380.00
TF1060 AM Signal Generator 450-1250Mhz. From £400.00
TF1066B/1 AM/FM Signal Generator 10-470MHz £625.00
TF1066B/6 AM/FM Signal Generator 10-470MHz £675.00
TF1101 R-C Oscillator 20Hz-200kHz 1mV-20V into 600 Ohms. Metered O/P £125.00
TF1370A R-C Oscillator 10Hz-10MHz £245.00
TF2000 AF Oscillator 20Hz-20kHz £325.00
TF2002 AM Signal Generator 10kHz-72MHz £675.00
TF.2005R Two Tone AF Signal Source £350.00
TF2100 AF Oscillator 20Hz-20kHz £150.00

MUIRHEAD
D890A L.F. Decade Oscillator 1Hz-111.1kHz £260.00

PHILIPS
PM5125 Sine/Square Oscillator 10Hz-1MHz £145.00
PM5167 Function Generator 1MHz-10MHz. Sine, square, + pulse, ramp, triangle, single shot with variable phase £875
PM5105 LF Oscillator 10Hz-100kHz £156.00
PM5107 Low Distortion LF Oscillator 10Hz-100kHz £210.00

ROHDE & SCHWARZ
SBF Wide Band Oscillator BN40861 10Hz-10MHz £230.00
SMCB S.H.F. Signal Generator 1700-5000MHz £450.00
SMCC S.H.F. Signal Generator 4400-8300MHz £500.00
SMLR Power Signal Generator BN41001 100kHz-30MHz £350.00

TELECOMMUNICATIONS
SG5U Battery Operated F.M. Signal Generator 400-480MHz £390.00



SIGN ELECTRONICS
S324 Low Distortion Oscillator 6Hz-60kHz Battery operated £90.00

Sweep Generators

KAY
154C Sweeper Main Frame with PM7650B Plug-in Unit 50KHz-110MHz £450.00

MARCONI INSTRUMENTS
TF1099 MF Sweep Generator 100KHz-20MHz £175.00

ROHDE & SCHWARZ
Polyscop SWOB I Wideband Sweeper and Display 0.5-400MHz £1,000,00
Polyscop SWOB II Wideband Sweeper and Display 0.5-1000MHz. From £1,450.00
SWH LF Sweep Generator 50MHz £250.00

TELONIC
SM2000 Sweeper Main Frame with E-3M RF Plug-in Unit 530MHz-3.12GHz £600.00
SM2000 Sweeper Main Frame with LA-1M Plug-in 0-20kHz £200.00
S-6 Plug-in Unit for SM2000 Main Frame 600-1200MHz £250.00
S-4M Plug-In Unit for SM2000 Main Frame 150-500MHz £200.00
L-6M Plug-In Unit for SM2000 Main Frame 50-120MHz £200.00
HD-1A Sweep Generator 400-900MHz £400.00
SD-3 Sweep Generator 425-930MHz £450.00

HEWLETT PACKARD
8690A R.F. Sweep Generator C/W 8693/100 R.F. Unit. 3.7-8.3 GHz. 5mV O/P into 50 ohms £1050.00

Test Sets

FERROGRAPH
RTS2 Recorder Test Set. From £310.00

MARCONI INSTRUMENTS
TF.1065A Transmitter/Receiver Output Test Set £280.00
TF.2332 AF Transmission Test Set 20Hz-20kHz £425.00
TF.2333 MF Transmission Test Set 30Hz-560kHz £600.00
TF.2343 Quantization Distortion Tester £400.00

S.T.C.
74262B White Noise Test Set 12kHz-4.5 MHz £600.00

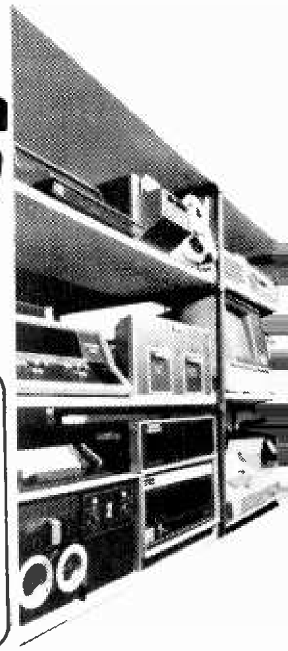
WANDEL & GOLTERMAN
3PS-1 Band Pass Filter Centre frequencies 70, 534, 1248, 3886 and 12150 Hz £175.00

A copy of our trading conditions is available upon request

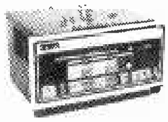
49-53 Pancras Road
London NW1 2QB
Tel: 01-837 7781. Telex: 298694

ADD 8% VAT TO ALL PRICES

Electronic Brokers
The Computer People



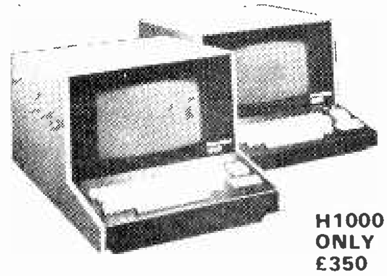
STOP PRESS



NEW LOW PRICES ON DEC PDP8E SERIES PROCESSORS — NOW ONLY **£1,500** FOR A 4K PROCESSOR WITH ASYNCHRONOUS SERIAL INTERFACE.

We also hold large stocks of PDP8E series options; such as: MM83 — 4K memory stack; MM8EJ-8K memory stack; KA8E-positive I/O bus convertor; KD8E — databreak module — KL8E — serial interface; KL8M — modern control; KM8E — memory extension module; KP8E — Power fail/auto restart; TD8E — single DECtape drive and control; TU55 — add-on DECtape drives.

SCOOP! MASSIVE BULK PURCHASE BRINGS YOU HAZELTINE VDUs AT LOWEST EVER PRICES



H1000 ONLY £350

H1200 ONLY £425

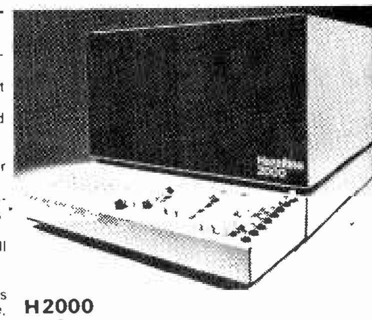
HAZELTINE H1000 and H1200 SPECIFICATION

SCREEN SIZE — 12 diagonal

SCREEN CAPACITY —
H1000 — 960 characters 80 per line x 12 lines
H1200 — 1920 characters 80 per line x 24 lines
CHARACTER GENERATION — 5 x 7 dot matrix 625 line raster
CHARACTER SET — 64 ASCII alphanumerics and symbols
CHARACTER SIZE —
H1000-1/8 inch (32cm) nominal height 3/32 inch (24cm) nominal width
H1200 — 1/10 inch (25cm) nominal height 3/32 inch (24cm) nominal width
CURSOR —
H1000 underline **H1200** reverse image block
TUBE PHOSPHOR — P4 (white on black)
REFRESH RATE — 50 fields per second
KEYBOARDS — TTY format attached
INDICATORS — Power On Parity Error Dataset ready
PARITY — Parity error indicated by Parity light and question mark (?) displayed in character position
TRANSMISSION — Asynchronous Switch-selectable for any two standard rates up to 9600 baud
OPERATING MODES — Full/half Duplex
MEMORY — High speed MOS refresh
STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B/C) 202C Optional

HAZELTINE H2000 SPECIFICATION

SCREEN SIZE — 12 diagonal 1998 characters, 74 per line x 27 lines
CHARACTER GENERATION — 5 x 7 dot matrix 625 line raster
CHARACTER SET — 64 alphanumerics and symbols 32 ASCII control codes
KEYBOARD — Detachable, solid state teletypewriter design 10-key numeric cluster plus editing and cursor control keys
TRANSMISSION — Asynchronous Switch-selectable for combinations of 5 standard rates 75 to 9600 baud
OPERATING MODES — Switch-selectable, full duplex, half duplex or batch (buffered)
MEMORY TYPE — 2048 x 8 RAM
EDITING FEATURES — Full Cursor controls plus Insert/Delete Character, Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Tab
STANDARD INTERFACE — CC ITT V-24 (EIA RS-232 B C) or 202C Compatible
REMOTE COMMANDS — Insert/Delete Line, Clear Screen, Clear Foreground Data Only, Home Cursor, Address Cursor, Set Background Intensity, Set Foreground Intensity Carriage Return, Backspace, Ring Bell, Transmit, Print



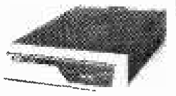
H2000 FROM £495

AUXILIARY OUTPUT — Standard printer interfaces standard cassette interface, remote monitor interface
TUBE PHOSPHOR — P39 (green on black)

Mini-Computer Exchange

DEC BIG SAVINGS ON OUR LARGE STOCK OF PROCESSORS, PERIPHERALS AND ADD-ON MEMORY

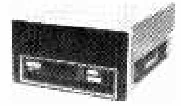
PDP11/04 PROCESSORS. Configured to suit your requirements — 8K and 16K MOS memory increment or 16K core memory increments Asynchronous interface/line clock — either DL11WA (20mA) or DL11WB (EIA) All in perfect as-new condition Prices from **£2,500.**



PDP11 ADD-ON MEMORY

11/04-11/34 series - MS11FP 8K MOS. £550 MS11JP 16K MOS **£1,200**; MM11DP 16K core **£1,750**; M7850 parity control £250
11/35-11/40-11/45 series - MF11UP 16K parity core complete with backplane — **ONLY £1,500**; MM11-UP 16K expander core (prerequisite MF11-UP) NOW ONLY **£1,250.**

DISKS
RK11D/RK05J Disk drive and controller **£4,500**
RK05J Slave disk drive **£2,500**
RK05F Dual density disk drive **£2,750**
RP02 Slave disk drive **£2,500**



CABINETS
DEC 4ft rack mounting cabinets complete with fans and power distribution unit **£450**

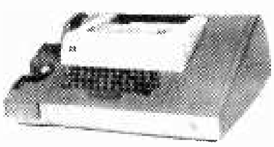
COMING SOON
PDP11-05SD Processors 16K core 10½ chasis
TMA11 TU10 9 track tape deck and control
TU10 9-track slave tape deck

Printers and Terminals

LARGE STOCKS OF ASR33 AND KSR33 TELETYPE TERMINALS

- ASCII Keyboard
- Hard-copy unit (friction or sprocket paperfeed)
- Paper tape punch and reader (ASR33 only)
- Line unit (20mA/6V/80V)

Prices from **£425** (KSR) and **£650** (ASR)



SPECIAL OFFER — Standard ASR33 Teletype with custom-built acoustic (sound-reducing) cover. **£675.00**

ALSO AVAILABLE: DATA DYNAMICS Model 390 KSR and ASR terminals from **£525.00.**

TEXAS SILENT 700 Model KSR725 portable terminal with integral acoustic coupler. **£695.00**

TEKTRONIX 611 STORAGE DISPLAY MONITORS

A further special purchase of Tektronix monitors in superb as-new condition. Provides stored displays of combined alphanumeric and graphic data via X Y and Z inputs through rear BNC connectors or remote program connector Operating functions View and Erase (manual or programmable control). Non-Store and Write-Thru (programmable control) Display area 16 x 21 cm — 4000 characters Viewing time at least 15 minutes without loss of resolution (Horizontal Display Format). ONLY **£950.00.**

MODEL 611/162C

Keyboards

NEW ASCII KEYBOARD MODEL KB756

NOW IN STOCK — BRAND NEW 56-STATION ASCII KEYBOARDS
Full 128 character set with ROM encoder (upper and lower case + control shift)
Fully TTL — compatible — power requirements + 5v-12v
Supplied with full technical data, code chart, pin connections, circuit diagram and applications notes

FANTASTIC VALUE AT £60.00

+ £1.50 p &p + 8% VAT (mail order total £66.42)

Also available — a range of spares and accessories for the KB756 — edge connector, mounting frame, plastic or steel enclosure, spare ROMs Send for data sheet/price list

All items quoted are refurbished second-user equipment unless otherwise stated.

ELECTRONIC BROKERS LIMITED (COMPUTER DIVISION)

49-53 Pancras Road, London NW1 2QB. Tel. 01-837 7781. Telex: 298694

A copy of our trading conditions can be supplied on request

Hours of business:
9 a.m.-5 p.m. Mon.-Fri. Closed lunch 1-2 p.m.

ADD 8% VAT TO ALL PRICES

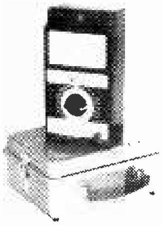
Carriage & Packing charge extra on all items unless otherwise stated

Z & I AERO SERVICES LTD.

Head Office: 44a WESTBOURNE GROVE, LONDON W2 5SF
Tel. 727 5641 Telex 261306

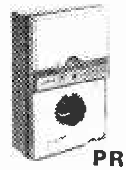
RETAIL SHOP
85 TOTTENHAM COURT ROAD, W 1
Tel. 580-8403

SPECIAL OFFER OF BRAND NEW USSR MADE MULTIMETERS VALID UNTIL 31st OCTOBER 1978



TYPE	U4313	U4315
Sensitivity D.C.	20,000 o.p.v.	20,000 o.p.v
Sensitivity A.C.	2,000 o.p.v.	2,000 o.p.v.
D.C. Current	60μA-1.5A	50μA-2.5A
A.C Current	0 6mA-1.5A	0.5mA-2.5A
D.C. Volts	75m V-600V	75mV-1000V
A.C. Volts	15V-600V	1V-1000V
Resistance	1K-1M	300Ω-500kΩ
Capacity	0 5μF	0.5μF
Accuracy	1 5% D.C 2 5% A.C.	2.5% D.C. 4% A.C.
Price complete with pressed steel carrying case and test leads	**£10.50**	**£10.50**
Packing and postage	**£1.50**	**£1.50**

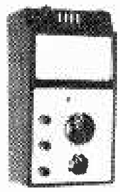
TYPE U4324



D.C. Current	0 06-0 6-60-600mA-3A
A C. Current	0.3-3-30-300mA-3A
D C. Voltage	0.6-1.2-3-12-30-60-120-600-1200V
A.C Voltage	3-6-15-60-150-300-600-900V
Resistance	500Ω-5-50-500kΩ
Accuracy	D C. 2 5% A.C 4% (of F.S.D.)

PRICE complete with test leads and fibreboard storage case **£9.50** Packing and postage £1.20

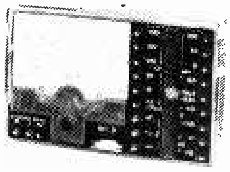
TYPE U4341
COMBINED MULTIMETER AND TRANSISTOR TESTER



Sensitivity	16,700Ω/V D.C., 3,300Ω/V A.C.
Current	0 06-0 6-6-60-600mA D C., 0 3-3.0-30-300mA A.C.
Voltage	0 3-1.5-6-30-60-150-300-900V D.C 1 5-7 5-30-150-300-750V A.C.
Resistance	2-20-200kΩ-2MΩ
Transistors	Collector cut-off current 60μA max D.C current gain 10.350 in two ranges

PRICE, complete with steel carrying case, test lead, battery and instruction manual **£9.50**
Packing and Postage £1.50

TYPE U4323
COMBINED WITH SPOT FREQUENCY OSCILLATOR



Sensitivity	20,000Ω/V
Voltage ranges	2.5-1000V A.C./D.C
Current ranges	0.05-500mA D.C. only
Resistance	5Ω-1MΩ
Accuracy	5% F.S.D.
Oscillator output	1kHz 50/50 squarewave 465KHz sinewave modulated by 1KHz squarewave

PRICE, in carrying case, complete with leads and manual **£8.00**
Packing and postage £1.00

WARRANTY

ANY INSTRUMENT FOUND FAULTY OR OTHERWISE UNSATISFACTORY ON RECEIPT WILL BE REPLACED FREE OF CHARGE OR FULLY REFUNDED PROVIDED IT IS RETURNED TO US WITHIN 7 DAYS FROM THE DATE OF RECEIPT. NO FURTHER FREE REPLACEMENT OR FREE REPAIR GUARANTEE IS OFFERED. ANY FAULT OR MALFUNCTION DISCOVERED LATER MAY BE REPAIRED BY US PROVIDED THE INSTRUMENT IS SENT TO US POST PAID WITH FULL DESCRIPTION OF THE FAULT. A CHARGE WILL BE MADE FOR SUCH REPAIRS AND SERVICING.

THIS OFFER IS VALID ONLY FOR ORDERS ACCOMPANIED BY REMITTANCE WHICH SHOULD INCLUDE DELIVERY CHARGES AS INDICATED AND 8% V.A.T. ON THE TOTAL.

OUR 1978 CATALOGUE/PRICE LIST OF VALVES, SEMICONDUCTORS, PASSIVE COMPONENTS AND TEST EQUIPMENT IS AVAILABLE PLEASE SEND P O for £0.30 FOR YOUR COPY

WW — 104 FOR FURTHER DETAILS

NASCOM 1

Microcomputer for the Hobbyist

AS CURRENTLY FEATURED IN WIRELESS WORLD

THE ONLY COMPLETE MICROCOMPUTER AVAILABLE TO THE HOME CONSTRUCTOR

FEATURES:

* Supplied in Kit Form for Self-Assembly
* Full documentation supplied
* Includes Printed Circuit Board
* Full Keyboard included
* Interfaces to Keyboard, Cassette Recorder & T V
* 2K x 8 RAM
* 1K x 8 Eprom Monitor Program
* Powerful Z80 CPU, Mostek
* 16 line x 48 Character Display Interface to standard, unmodifed T V set
* On board expansion to 2K x 8 Eprom
* On Board Expansion Facility for Additional 16 Lines I/O
* Total expansion to 256 Input Ports and 256 Output Ports

SOFTWARE FEATURES:

* 1K x 8 Nasbug Program in Eprom
* Provides 8 Basic Operator Commands including single step
* Expandable Software System via additional user Programs in Ram of Eprom

Manuals Separately **£3.50**

Complete Kits NOW IN STOCK

£197.50 +VAT 8% POST £2.50

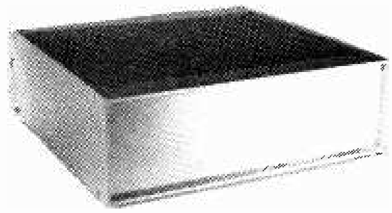
Sole Appointed London Stockists

Full after sales service available

HENRY'S RADIO

All mail to: Henry's Radio 404 Edgware Rd. London W2
PHONE (01)723 1008

New Style Instrument Cases



New Style Elegant Instrument Cases

In anodised aluminium with black vinyl top and bottom. Gives a professional finish to your assemblies.

Height	Width 8¾	Width 12	Width 16½
3	A	B	C
4½	D	E	F
6	G	H	I
	All Depth 9		

Available from your local stockist

Clacton Electronics, 10 Douglas Road, Clacton-on-Sea. 0255 27505
Dawes Electronics, 121 Dawes Road, London, S W.6 01-381 3975
Direct Supplies, 627 Romford Road, London, E 12 01-553 1174
Electro-Tech, 364 Edgware Road, London 01-402 5580
Foreway Services, 19 Old High St., Headington, Oxford. 0865 68472
Lektropacks, 17 Turnham Gn, London, W 4. 01-994 2784
G F. Milward, 369 Alum Rock Road, Birmingham B8. 021-327 2339
Shudehill Supply, 53 Shudehill, Manchester. 061-834 1449

WW — 066 FOR FURTHER INFORMATION

LOWEST PRICES EVER

T.T.L.

7400	8p	74S20	20p	7474	18p	7496	58p
74S00	20p	7430	8p	7475	34p	74107	26p
7402	8p	7437	22p	7476	18p	74109	43p
74S03	24p	7438	20p	7490	20p	74150	58p
7404	8p	7440	11p	7493	18p	74154	95p
7408	10p	7441	40p	7495	50p	74161	75p
7410	8p	7442	40p			74172	£3.90
7416	25p	7447	45p			74193	90p
		7451	11p			74198	£1.45
		7454	11p				

EQUIPMENT CASES

Yet another fantastic buy. Give that final touch of PROFESSIONALISM AND SAFETY to your electronic system with our brand new desk standing equipment cases. Made to the highest spec. for the G.P.O. it features modular attractive construction with two tiers of runners and edge connectors. Capable of housing up to 40 13½" x 5¾" P.C.B.'s, fully enclosed with aluminium sides and hinged removable front cover which can be secured by 2 screws to prevent prying fingers. Built in air ventilation system. Finished in two tone G.P.O. telephone grey, supplied complete with 9 edge connectors and 30 runners plus new 25 way "cinch" plug to match socket already installed on rear panel. Mains lead and internal wiring match up with our £16·50 P.S.U. Ideal M.P.U. system etc. etc. overall dimensions of 12½" H x 16¾" D x 17½" W. New and boxed **£10.75** P.P. £2·25

Purchase Power Supply and Cabinet together only £25·00 + P.P. £4·25.

SECONDHAND 'VINTEN' 16MM SCIENTIFIC MOVIE/SINGLE SHOT CAMERAS

precision made with quickchange 200ft cassette, ideal for time lapse, surveillance, event filming etc. Electrically selectable speeds of 24 fps and single shot. Flash contacts provided, removable Dalymer 12.5mm wide angle lens, focus and f stops adjustable from 1' 6" to infinity. Operates from 12v D.C. complete with reloadable cassette.

ORIGINAL COST £200! **£25** Complete with manual P.P.I. £2·50

ELECTRONIC COMPONENTS & EQUIPMENT 66⅔% DISCOUNT

Due to our massive bulk purchasing programme which enables us to bring you the best possible bargains, we have thousands of I.C.'s Transistors, Relays, Cap's., P.C.B.'s, Sub-assemblies, Switches, etc. etc. surplus to our requirements. Because we don't have sufficient stocks of any one item to include in our ads., we are packing all these items into the "BARGAIN PARCEL OF A LIFETIME". Thousands of components at giveaway prices! Guaranteed to be worth at least *3 times* what you pay plus we always include something from our ads. for unbeatable value!! Sold by weight.

7lb £ 4·75	14lb £ 7·50
28lb £12·75	56lb £21·00
112lb £28·00	P.P. £1·00

10-way ILLUMINATED SWITCHBANKS

Features 10 individual feather light pushswitches, each with 1 n/o and 1 n/c gold wiping contact. Each switch has integral replaceable bulb and removeable lens cap which may be split for engraving etc. Switch dimensions 19 x 19 x 90mm. Easily split for single use. Undoubtably the most attractive switch you will ever see. Original cost over £16·00 per bank! Ideal M.P.U. keyboards etc. **£3.00** PP45p

DISPLAY I.C. AND TRANSISTOR BARGAINS NEVER CHEAPER

All I.C.'s and Transistors by well known manufacturers and fully guaranteed. No fall outs. Comprehensive data on I.C.'s 12p per type.

High voltage power switching transistors BVcbo 600v BVceo 500v BVebo 5v Ic 5 amps Pc 125 watts HFE 60 typ ft 2.5 mhz ideal invertors, etc. TO3 £1·50 each 4 for £5·00.
BF258 NPN 250v @ 200 ma 40p each 3 for £1·00.
A.E.I. power TRIACS 10 amp 400v ready mounted on 2½" x 2½" heatsink 95p each 4 for £3.50.
I.R. BSB01 2.5 amp 100v bridge rec. P.C. mount long leads 30p each 4 for £1·00.
IN4998 4 amp 100v P.C. mount diodes Long leads 12p each 10 for £1·00.
I.R. 25G60 60 amp 600v silicon stud diodes £1·80 each 8 for £10·00.
E.C.C. 1.6 amp 400v triacs 35p each 4 for £1·00.
2N1671B unijunction 450mw 30v 45p each 3 for £1·00.
IN4004 SD4 1 amp 400v diodes 6p each 20 for £1·00.
2N3001 30 volt 350 ma S.C.R. TO18 20p each 6 for £1·00.
LM380N SL6051 14 D.I.L. 2 watt A.F. amp. 75p each 8 for £5·00.
MC7812CK TO3 1.2 amp + 12v I.C. regulator £1·00 each 6 for £5·00.
TMS3114 DUAL MOS 128 bit static shift reg. DC-2.5mhz £1·75 each 4 for £5·00.
TMS 4050 4096 x 1 dynamic ram £4·75 each 8 for £30·00.
TIL119 OC-147 opto coupler 6 pin D.I.L. each 3 for £1·00.
GE424 zero voltage switch, triac SCR, relay driver TO5 can £1·00 each 7 for £5·00.
CA3011 20MHZ wideband amp T099 case 60p each 2 for £1·00.
FSA 2719 8 diodes 1N4148-1N914 type in 16 D.I.L. pack all independently connected 35p each 4 for £1·00.
FPQ3725 4 NPN 50v 500ma silicon transistors in 14 D.I.L. pack 65p each 2 for £1·00.
Texas low profile I.C. sockets. 14 pin 14p each 9 for £1·00. 24 pin 30p each 4 for £1·00.
2N5109 R.F. power output 400ma 2.5 watts up to 1200 mhz TO5 70p each 2 for £1·00.
AF279 low noise P.N.P. germanium up to 780 mhz 30p each 4 for £1·00.

Miniature Tantalum Beads 10mf 25v and 33mf 16v 14p each 10 for £1·00.
Scotch 215 Long Play Tape Brand new ¼" low noise on 1200' 5¾" spools £1·50 each 4 for £5·00 + P.P. 45p.
1000 Watt fully shrouded **auto transformers** term. block connections £13·75 + P.P. £2·25.

Bulbs 24v 14 watt white frosted S.B.C. 8 for £1·00.
S.B.C. Bulb Holders All steel cad. plated panel mount easily fixed via nut and round hole, ideal disco displays, scoreboards etc. 4 for £1·00.
Xtal filters S.E.1. QC1121t/B miniature low insertion loss P.C. mount C.F. 10.7 mhz with B.W. of 7.5 khz. 2000 Ω imp. in-out Brand new at £7·50.

Heavy Duty Flat Insulated Earth Braid 80-100 amp braided tinned copper in heavy clear P.V.C. sheath 40p per metre £5·00 for 15 metres P.P. 8p per metre.

Red L.E.D.'s full spec. 0.2" 12p each 10 for £1·00.
Dynamic Stick Mics 600 Ω with built in on/off switch complete with lead and min. jack plug £1·00 each.

MANY HUNDREDS OF TRANSFORMERS IN STOCK – SEND SAE FOR LIST

MINIATURE P.S.U. 5 volt 3 amp D.C. 240-110 A.C. INPUT, fully smoothed and regulated ex computer equipment made to run T.T.L. SUPPLIED COMPLETE BUT UNTESTED **£4·50** P.P. 75p.

DIODES · DIODES · DIODES

1N4148-1N914 types etc. mixed and untested 1000+ bag £1·50 P.P. 40p. Buy some for a friend!

Where cost of post and packing not indicated please add 25p per order. Collection saves cost of postage but if collecting please telephone to check availability.

We are always interested in buying P.C.B.'s surplus components, test equipment, valves, etc. Phone for details.

DISPLAY ELECTRONICS

215 WHITEHORSE LANE LONDON SE25 TEL 01-771 2027

All prices inclusive of V.A.T. Cash with order. Minimum order value £1.00. Postage quoted for UK only. Export and trade enquiries welcome. Orders despatched same day where possible. Callers welcome, but by appointment please.

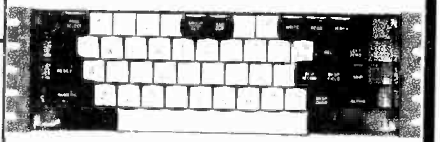
M.P.U. CORNER

POWER SUPPLY UNITS

The answer to the experimenters dream. Just arrived a Power Supply Unit that could have been custom made for your lab etc. 240v A.C. input, with fully regulated D.C. outputs of +5v @ 2 amps, +12v @ 800ma, −12v @ 800ma, +24v @ 350ma and if that's not enough a 5v @ 50ma fully floating output which may be interconnected to give a host of other voltages. All inputs and outputs are available on edge connector at rear with L.T. outputs duplicated via miniature sockets on front panel. Made to Ministry spec. by Marconi, features include continuous electronic short circuit protection on all outputs, "C" core transformer, compact construction, etc. Dimensions 160 x 120 x 350mm. Order now while stocks last!!! CIRCUIT DIAGRAM INCLUDED

BRAND NEW & BOXED UNREPEATABLE AT **£16.50** P.P. £2·00

SPECIAL KEYBOARD OFFER



A special bulk purchase enables us to offer the above Keyboard at a lowest ever price. 49 coded keys encoded into a direct TTL compatible 7 bit output. Features such as delayed strobe, 5 volt D.C. single rail operation and rollover protection make this an absolute must for the MPU constructor! Supplied complete with connection diagram and edge connector, at a secondhand "no time to test" price of only **£18.50** P.P. £1·50

Also available a free standing version housed in an attractive two colour moulded case, unit also features additional P.C.B. with over 27 TTL I.C.'s etc. believed to be parallel to serial convertor. No details availabel on convertor. **£22.50** P.P. £1·75

THIS MONTHS SNIP

C90 AUDIO CASSETTES

Superior quality compact cassettes. Excellent mechanics, screw type construction.

40p Each 3 For £1·00

Top Grade MULLARD+PLESSY CAPS

Ultra low ripple 10 amp. smoothing

1500 mf 100v Screw Term.	50p*
3300 mf 63v Screw Term.	60p*
5000 mf 40v Solder Tag	60p

*ex equipment but tested

HIGH EFFICIENCY SMITHS RADIAL BLOWERS

Are your hot parts sweltering? Then keep them cool with our high efficiency radial snail type blowers. Made by Smiths, designed for continuous use in expensive electronic equipment very powerful and quiet, gives massive air flow to prolong component life and reliability. Easily mounted, air aperture 2½" x 3" supplied complete with fixing bolts. Ideal linears etc. Please state 240v or 110v operation. 50hz only.

BRAND NEW **£4.25** P.P. £1-10

WW—117 FOR FURTHER DETAILS

COMPUTER APPRECIATION

86 High Street, Bletchingley, Redhill, Surrey RH1 4PA. Tel: Godstone (0883) 843221

INTERSIL 'INTERCEPT' PDP 8E compatible Protyping system for IM 6100 microprocessor. Includes full operator's console. 4K CMOS memory with battery back-up & TTY interface **£995.00.**
PDP 8E SYSTEM comprising 8K processor with KE 8E extended arithmetic option, DK 8EC crystal clock, TU 56 twin DEC tape unit, & KL 8E TTY interface. **£3500.00.**
PDP 8E PROCESSOR with 4K, KL 8E TTY interface, MI 8E ROM bootstrap loader & VK 8E control providing graphics & alpha-numeric display & printer/keyboard interface **£1150.00.**
NATIONAL SEMICONDUCTOR SC/MP. Low cost development system with TTY interface, key pad entry & LED display **£225.00.**
DEC MEMORY & OPTIONS. NEW LOW PRICES. For example, MM11UP 16K memory for PDP 11 **£925.00;** MM11LP 8K memory **£575.00.**
TELETYPE MODEL ASR 33. Various options available **£375.00-£475.00.**
TELETYPE MODEL KSR 33 110 Baud, ASCII coded but 500mA drive current required **£150.00.**
TELETYPE MODEL KSR 33 in suitcase version by MOORE REED. With RS 232 interface. As new **£295.00.**
OLIVETTI Model 328. As ASR 33 but with correspondence-quality upper/lower case character set. **£345.**
UNIVAC UNISCOPE 100 VDU with RS 232 interface **£225.00.**
VIATRON Microprocessor-controlled intelligent terminal. With keyboard, VDU, cassette drive & 9-track reel to reel mag. tape. **£285.00.**
FACIT MODEL PE 4001 1000 cps capacitance paper tape reader **£225.00.**
DEC Reader/Punch & control for PDP 8E **£675.00.**
ICL High Speed (250 cps) tape reader **£68.00.**
ELLIOTT High Speed (250 cps) tape reader **£48.00.**
TELETYPE MODEL BRPE 110 tape punch **£95.00.**
GNT tape punch with SAGGICORN electronics **£75.00.**
ROYTRON 50 cps tape punch **£65.00.**
REPCO Model 120 High-speed matrix printer with parallel TTL interface **£185.00.**
LOGABAX LX 180 High-speed (180 cps) upper/lower case matrix printer. Ex-demo **£750.00.**
IBM Model 735 I/O SELECTRIC (golfball) typewriter **£150.00.**
DATA PRODUCTS 16K x 16 planar core memory with all electronics **£98.00.**
INTERSCAN video terminal with twin PERTEC floppy discs, ex-demo **£475.00.**
PHILIPS Model X1109 Key-to-magtape unit. 9-track, with search etc **£150.00.**
WEIR digital multimeter/frequency meter/comparator. As new **£185.00.**
TEKTRONIX Model 585 dual trace 80 MHz oscilloscope **£195.00.**
AKAI Model VT110 portable video recorder with camera, monitor, tuner & 2 RF units **£350.00.**
SONY Model AU3420 CE Video-ranger kit (includes optional RF unit) **£750.00.**
PYE LYNX CCTC Camera, with vidicon but without lens **£45.00.**

* Callers welcome, but by appointment please
* VAT & carriage extra all items
* FREE stocklist now available showing new LOW PRICES

Is it 'goodbye' to the Dynamometer?

The new Feedback Electronic Wattmeter EW 604 could be your ideal replacement for the conventional dynamometer.

It's inexpensive yet amazingly versatile, reliable and efficient. A self-contained unit which needs no other accessories, the Feedback EW 604 is really robust – both physically and electronically.

It performs over a remarkably wide range of power (250mW to 10kW full scale), current (50mA to 10A) voltage (5V to 1000 V) and frequency (d.c. to 20 kHz).

The instrument is fully protected against misuse or incorrect terminal connection. It's the ideal answer to most power measurement problems in power systems, audio systems, heating plant, vibration testing, pumps, machine-tools, compressors, generators, aircraft systems, transformers, domestic equipment and education.

It's an instrument whose wide ranging performance should bring an equally wide grin to the face of even the testiest tester! Particularly when he learns it's covered by a **two-year** guarantee. For fully detailed literature on the Feedback EW 604, simply complete and post the coupon today. Or contact our distributors

electroplan P.O. Box 19, Orchard Road, Royston, Herts. SG8 5HH.

Please send further information on the EW 604 and the other 5 instruments in the range.

Name ______________________

Position ______________________

Company ______________________

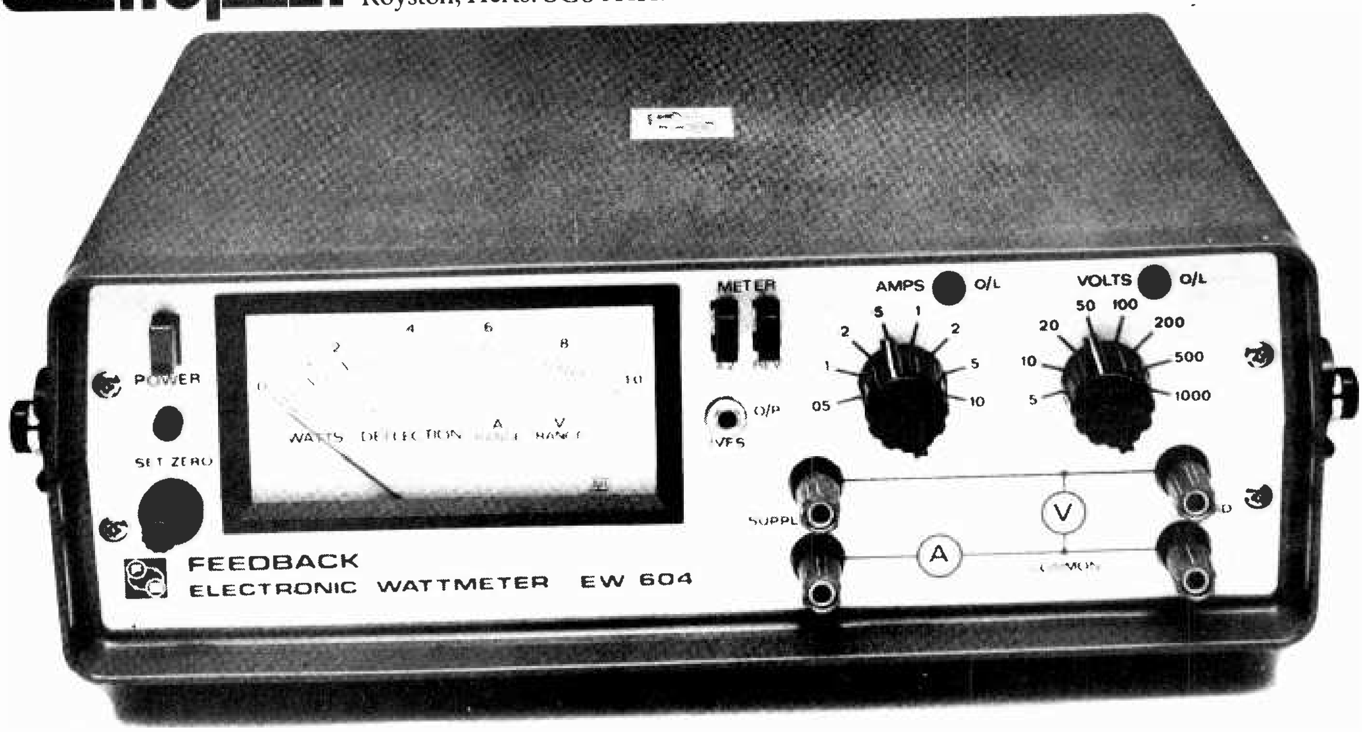
Address ______________________

____

Telephone ______________________

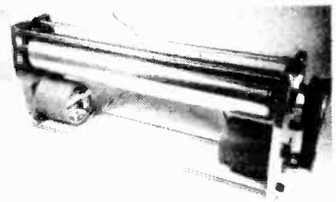
Feedback Instruments Limited

Park Road, Crowborough, Sussex TN6 2QR.
Telephone: Crowborough (08926) 3322.
Cables: Feedback Crowbr. Telex: 95255.

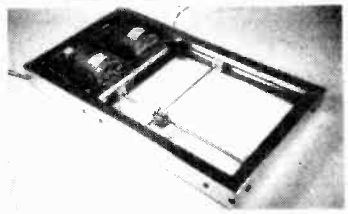


The Feedback Wattmeter will make even the testiest tester smile!

WW — 125 FOR FURTHER DETAILS



BARREL TYPE X-Y PLOTTER ASSEMBLY



X-Y PLOTTER ASSEMBLY

BARREL TYPE X-Y PLOTTER ASSEMBLY

120V Stepping Motor. Provision for Pen (Pen not supplied) AS PICTURE **£55** ea. With alternative motor for non-reversible requirements recorder/printer applications etc **£48 ea.** With Pen and Paper guides **£78.** With Pen, Sprocket and Paper guides **£88.** Other voltage options available. P&P all units £2.50.

X-Y PLOTTER ASSEMBLY

Consisting of frame with X & Y assemblies (No pen but provision) Bed size 12 ×9 Motor options 120V only **£43.45 ea.** 120V (can be changed to 12/24V), data supplies **£51.15 ea.** 12/24V **£70.40 ea.** P&P all versions £2.50.

STEPPING MOTORS ONLY

Motors as used in plotters etc. All motors 200 steps per revolution. 20 oz. inch torque. 120V 1000-0-1000 ohm. Can be changed with care to 12/24V. Data supplied **£8** ea P&P £1. Supplied for 12/24V operation **£13** ea P&P £1. Just think about the uses!

OSCILLOSCOPE TUBES

Brand New Boxed — Carriage all tubes **£3.25.** Telequipment S52 **£10** ea; D51, **£15** ea; S42, **£10** ea; D53A, **£20** ea; D52, **£15** ea; S31, **£10** ea. Bradley 200, **£85** ea; Advance OS3000 **£85** ea; GEC types 924F, **£25** ea; 924E, **£17.50** ea; 14968, **£75** ea; Brimar D13-51GH, **£65** ea; D10-210GH/32, **£40** ea; D13-46GM, **£35** ea.

NOT BOXED — NEW — WARRANTED. Telefunken D14-131 replacement for Solartron CD1740, Cossor CDU150, S.E. Labs SM112 and GEC/MOV 1474 at **£55** ea.

BUILD YOUR OWN BUS

Approx 1½ metre multiway ribbon cable terminated each end with a 50-way female edge connector. Takes 0.1 printed circuit board **£2** ea. P&P 75p.

TELEPHONES. Post Office style 746 Black or two-tone **£6.50** ea. Modern style 706 Black or two-tone grey **£4.50** ea. P&P £1. **HANDSETS** 706 style **£1.75** each. Older style **£1.** P&P 75p. **TELEPHONE EXCHANGES.** Eg 15-way automatic exchange only from **£95.**

74S00	**12p**	74S10	**5p**	74H51	**7p**
7401	**5p**	7417	**14p**	7453	**5p**
74S02	**12p**	74S38	**10p**	74H74	**12p**
74S04	**12p**	7451	**5p**	74S74	**12p**

75325 — Memory Core Drivers. 600ma capability. Fast. Other uses. RIDICULOUS at £1 each.
75453 — Dual Peripheral or Drivers. **75p** each.

NOW—INCREASE AREA GIVEN TO PICK-A-PACK AT 50p per lb

Larger volume of new components you can't afford to miss

TELETYPE ASR33 with 20MA LOOP. Good condition. Special low price **£395 ea.** KSR33s from **£275.**

TEKTRONIX OSCILLOSCOPES
541A with G Plug-in **£169. 545** with CA Plug-in **£200. 647** Main Frame **581A**, Main Frame **535** with 82 Plug-in **£425. 661** with 4S1 **£350.**

Stocks of better oscilloscopes always changing. Enquiries please. Plug-in units not sold separately.

MARCONI Sweeper TF1099 **£45** each.
H.P. Oscilloscope Type 185B **£100** each.
TEKTRONIX OSCILLOSCOPE Type 502 High Gain. Limited bandwidth **£185** each.
R & S POWER METER BNRD-BN2412/50 **£50.**
R & S Z-g DIAGRAPH 300-2400MHZ BW3512. Good condition **£60.**
MARCONI Signal Generator TF801D/8/S. Very Good Condition **£385** each.
MARCONI R.F. POWER METER TF1152A/1 (CT419) 50 ohms. **£65** each.
MARCONI VVM TF428B. **£12.50** each.
H.P. AC/OHMS CONVERTER 2410B **£80.**
H.P. DIGITAL COMPARATOR £80.
PLUG-INS for Telonic Sweeper SM2000. From **£50** each.
TELONIC SWEEPER SD3M. 425-930MHZ **£120** each.
MARCONI TF868 UNIVERSAL BRIDGE **£70** each.
AIRMEC SIG. GEN. Type 204 1-320 MHZ **£250.**

R & S POLYSCOPE SWOB1 at the low price of **£375** each. Some **POLYSCOPE** SWOB11 at **£550** each.

MARCONI SIGNAL GENERATOR. Freq range 10-470MHZ Type TF8018/3/S **£160** each.
POLARAD RECEIVER Model FIM 82 1-10GHZ **£325.**
RHODE & SCHWARZ Turntable Indicating Amp UBM **£75.**
FM/AM SIGNAL GENERATOR Type AN/USM 16, 10 to 420MHZ. Limited quantity **£195** each.
MARCONI TF 1064B/6M. Very Clean **£250.**
MARCONI TF 1066B/1 £375.
POLARAD SPECTRUM ANALYSER TSA with **STU-1A.** 10-1000MHZ **£350.**

★ TRANSISTORS/DIODES/RECTIFIERS, ETC. ★

Guaranteed all full spec devices. Manufacturers' Markings.
At **5p** each
BC147; 2N3707; BC172B; BC251B; BC348B; BC171A/B; BC413; D10; BAX13; 1N937; BA102BE; BZX83; TIS61; 2N5040.
At **10p** each
1N4733A; SN7451N; BYX10-15KV 0.36A; BYZ10 **15p** ea. TIP34A — **50p** ea. BD538 — **40p** ea. Heavy Duty Bridge Rectifier — **20p** ea. CA3123E — **£1** ea. BDY55 — **£1** ea. 2N3055 — **40p** ea. TIP31B **12p** ea. BFY51 — **12p** ea. 2N5293 — **16p** ea.
TBA560CO **£2** ea. 1N4436T-TO3 Flat mount 10A 200piv **£1** ea. 2N5897 with 2N5881 Motorola 150W Comp. pair **£2.** BU208 **£1.20** ea. BD535, BD538 Comp. pair — **75p.**
Linear Amp 709 — **25p** ea.
P&P Extra on all items.
FINNED HEAT SINK — single TO3 — size 4¾in x 3in x 1¼in **50p** ea. P&P 75p.
Texas Bridge Rectifier 5SB05-50V 5A, **60p** ea. P&P 20p.
MOTOROLA POWER TRANSISTORS type W0993/441. T03 Min voltage 500. **20p** ea. P&P 15p.

DON'T FORGET YOUR MANUALS
S.A.E. WITH REQUIREMENTS

EX-MINISTRY OSCILLOSCOPE CT436
Double Beam DC-6 MHZ **£120**

A MILLION MUST GO

HIGH NOISE IMMUNITY LOGIC
DUAL IN LINE 16-PIN CERAMIC. 12V Rail. Conventional TTL package. Guaranteed spec. devices. Full data. **2p** ea.
MIXED PACKAGE — **£1** P&P 25p.

POLARAD MICROWAVE RECEIVER MODEL TR. 1GHZ to 2.04GHZ **£200** each.
BRUEL & KJOER Automatic Vibration Exciter Type 1016. Sine Wave sweep from 5HZ to 10KHZ **£75** each.
GENERAL RADIO PULSE SWEEP GEN. Type 1391B **£90.**
GENERAL RADIO. Osc. Unit 1209B 250-920Megs **£50.**
MARCONI RF POWER METER. TF1020A/1.75 ohm **£65.**
JERROLD SWEEP GENERATOR 900A £165.
POLARAD SPECTRUM SIGNATURE MONITOR 140HZ ± 12.5MHZ Sensitivity 120dbm. Price from **£250.**
POLARAD SIGNAL GENERATOR GB2/G-711 **£250.**
GENERAL INSTRUMENTS TRANSFER FUNCTION & IMMITANCE BRIDGE Type 1607A. In transit case. Complete **£525.**
RACAL UNIVERSAL COUNTER TIMER UNIT 100MHZ. Ex-Ministry **£50** each.
MARCONI SIGNAL GENERATOR TF1060 **£185.**
BRADLEY MULTIMETER CT471 **£45** each.
HEWLETT PACKARD Pulse Gen. 212A **£55** each.
HEWLETT PACKARD microwave frequency convertor. Type 2590B **£175.**
MARCONI CT44 Watt Meter 0-6 watts **£25** each.
MARCONI Signal Generator TF867 15kc-30MHZ **£55.**
SPERRY MK2 RADAR UNIT. As in — no info **£85.**
AVO TRANSISTOR & DIODE TESTER CT537. £50.
AUTO TRANSFORMERS. 240V input. 110V output. 1.25KVA **£14** each. Carr £3.25.

TELETYPE ASR28 with built-in tape reproducer and print on tape facility. **£375.**
TELETYPE ASR35. Nice condition. **£425.**

FEED BACK LTD. Wave Form Gen. Sin/Trap/Saw/Sq. + DC offset. **£80.**
FLUKE AC-DC VOLTMETER. Model 803B. **£90** each.
WOODEN C.V. TRANSFORMERS. 230V input. 5.5V 5A output. **£2** each.
ALCAD CELLS 40APH Type EP4. Size 4½ x 2½ x 9 high. Supplied less fluid **£4** each. P&P £1.75.

NEW ITEMS

ALMA Min. PUSH BUTTON REED SWITCHES. High reliability 18 x 27 x 18mm. Ideal for **KEYBOARD 50p** ea. P&P extra.
MOTOROLA MC 4028 60p ea.
MOTOROLA MC 7441 40p ea.
IC 7402 12p each.
MINIATURE FANS 3 square (like muffins) 115V **£5** ea. P&P 75p.
HONEYWELL HUMIDITY CONTROLLERS 25p ea. P&P 25p.
SPRAGUE 100mfd + 500mfd 210VDC working. Brand new **5 for 50p.** P&P 50p.
REED SWITCHES. Sub-min. Size 20mm **10p** ea.
SMITHS encapsulated transistorised **AUDIBLE WARNING DEVICES** 4V-12V. Can be driven from TTL. **50p** ea. P&P 25p.
AMPHENOL 17-WAY CHASSIS MOUNT EDGE CONNECTOR. 0.1 spacing **20p** ea. P&P extra.
BURROUGHS 9 digit **PANAPLEX** numeric display. 7 segment 0.25 digits with red bezel. With data. **£1.95** ea. P&P 30p.
MINIATURE NIXIE TUBE type ITT 5870ST. Digit size 0.5. Wire ended. **50p** each. P&P 20p. **4 for £1.75.** P&P 35p.
TRANSFORMERS 115V AC input. Secondary 30V and 2.6V 10VA. **50p** ea. P&P 50p.
21-WAY SELECTOR SWITCH. Single pole with reset coil 240V AC coils. Additional switch contacts for auto reset, etc. **£1.45** ea. P&P 75p.
As ABOVE with additional 240V relay on base *and* full black plastic cover. **£2.45** ea. P&P £1.50.
SNAIL BLOWER 110V AC 500 MA. Brand new by Airflow Developments. Quiet and very good looking. **£2.50** ea. P&P £1.
POTTER & BRUMFIELD 18-48V DC Relay. 3 pole c/o. Heavy Duty. Plug-in type with base **50p** ea. P&P 25p.
MINIATURE KEYBOARD. Push contacts, marked 0-9 and A-F and 3 user definable keys. **£1.75** ea. P&P 35p.
MULLARD CORE LA4245 at **15p** ea. P&P 10p.
CLARE REED RELAYS 24V DC Coil. Single pole make. Size 1¼ x 7/16 x 7/16 at **25p** ea. P&P 10p.
ROTRON CENTAUR FANS. Size 4.5 x 4.5 x 1.5 115V 5 blade. **£4** ea. P&P 75p.
Min. PLUG-IN type RELAYS. Plastic covers. 2-pole c/o 24V **25p** ea. P&P 15p.
CROUZET/MURTEN SCHWEIZ MOTORS. 110V 50HZ 4 rpm. Gear box can be removed. **75p** ea. P&P 75p.
FRAMCO MOTORS. 115V 50HZ Input single phase. 1/12th HP, 1,450 rpm; on silent mount. As new **£2.75** ea. P&P £1.75.
PYE DYNAMICS THICK FILM 1 MHZ Clocking Osc. 5V supply. Size 19 x 25 x 6mm. Drives one TTL load. **72p** ea. P&P 15p.
COMPRESSOR UNIT. Compact. 115V 50HZ single phase 1.5A continuous 1,425 rpm. Outside piston housing approx 3. **£18** ea. P&P £2.
MAGNETIC DEVICES. Plug-in RELAYS 240V AC. 3-pole c/o. Heavy duty. 10 amp. Complete with base. BRAND NEW EQUIPMENT. NOT USED. 3 on sub assembly **£2.50.** P&P £1 or **£1.25** ea. P&P 45p.
SMALL MAINS TRANSFORMER 240V Pri. 12V 100MA sec. 60 x 40 x 42mm. **50p** ea. P&P 75p.
G.I. BRIDGE RECTIFIER type W01 (ideal for above) **17p** ea.
FAIRCHILD FND10 7 segment display 0.15 Red. Common cathode **65p** ea. P&P 15p. Info supplied.
MULLARD TUNER MODULES — with data.
LP1171 combined AM/FM IF strip. 10.7MHZ. **£3.50** ea.
LP1179 FM front end with AM tuning and 87.4MHZ to 104.5MHZ tuning. 10.7MHZ IF. **£3.50** ea. P&P 50p each unit. **The Pair £5.75.** P&P 75p.
POWER UNIT MODULE containing 2 small, 3 med & 1 large ferrite cores; 3-TO3 power transistors, caps, resistors, high powered diodes, 9 transistors, 3 min fuse holders, etc. **£1.50** ea. P&P £1.25.
GENERAL ELECTRIC OPTO-ISOLATORS type H15VX504. **65p** ea. P&P 15p. **10 for £5.** P&P £1.
MINIATURE REED SWITCHES 9p ea. P&P 15p.
ROTARY SWITCHES. 250V 10A. **10p** ea. P&P 15p.
LEDEX ROTARY SOLENOIDS 115V DC. No switch assembly. **25p** ea. P&P 25p.
POTTER & BRUMFIELD TIMER RELAYS 24/48V. Heavy duty 2 pole c/o with 5 secs delay at 48V increasing with voltage reduction. Timing can be altered by changing value of resistor/capacitance. **50p** ea. P&P 25p.
CABLE NEATERS — neaten up your wire on a chassis with these push-on clips. 10 for **20p.** 100 for **£1.50.** P&P extra.
AUDIO AMPLIFIER BOARD. Size 4½ x 2½. Output pair of TIP31s. Circuit supplied. **£1.50** ea. P&P 30p.
DIGITAL 24 HOUR CLOCK with built in Alarm as used in BRAUN Digital Clocks. Silent running. Large illuminated Numerals. AC Mains. Size 6⅜ x 2⅜ x 2¾. **ONLY £4.25** ea. P&P 50p.
BROOKE CROMPTON & PARKINSON extractor fan assembly 115V operation. **£1** ea. P&P £2. OR TWO for **£1.50.** P&P £3.25.

½" MAG TAPE.

Approx. 1,500ft **Now 20p each** P&P £1 or 7 for **£1,** carr £3.25.

FOR THE VDU BUILDER, tube M28-13GH 23 x 17cm at **£12.** Base connections supplied.

Limited quantity of 35RO — 20ma loop — can be changed to ASC11 code (3 hours' simple work and £10 parts) **OUR PRICE EXCLUDING PARTS REQUIRED £70** ea.
Ex-Ministry Teletype Punches 8 level 110 char per sec. **£50** each.
Polished Wooden Cases to take normal 'QWERTY' KEYBOARDS, or can be carefully cut to take any size. **£3** each. P&P £1.50.

A LARGE QUANTITY OF MISCELLANEOUS TEST GEAR — CHASSIS UNITS, ETC., ON VIEW AT LOW COST

Minimum Mail Order £2. Excess postage refunded. Unless stated — please add £3.25 carriage to all units
VALUE ADDED TAX not included in prices — Goods marked with ★ 12½ % VAT, otherwise 8%
Official Orders Welcomed. Gov./Educational Depts., Authorities, etc., otherwise Cash with Order.
Open 9 a.m. to 5.30 p.m. Monday to Saturday

Buy it with Access

CHILTMEAD LTD

BARCLAYCARD

7/9 ARTHUR ROAD, READING, BERKS (rear Technical College, King's Road). Tel: Reading 582605

Appointments

Advertisements accepted up to 12 noon Friday, September 29 for the November issue, subject to space being available.

DISPLAYED APPOINTMENTS VACANT: £7.50 per single col. centimetre (min. 3cm).
LINE advertisements (run on): £1.10 per line, minimum three lines.
BOX NUMBERS: 50p extra. (Replies should be addressed to the Box Number in the advertisement, c/o Wireless World, Dorset House, Stamford Street, London SE1 9LU.)
PHONE: Barry Leary on 01-261 8508
Classified Advertisement Rates are currently zero rated for the purpose of V.A.T.

Radio Officers

Sea Sick?

If you've seen quite enough of the sea, and are thinking now of a shore-based job that suits your qualifications, the Post Office Maritime Service can offer you interesting work, job security, good pay, plus the pleasure of enjoying all the comforts of home where you appreciate them most – at home!

Vacancies exist at several coast stations for qualified Radio Officers to carry out a variety of duties that range from Morse and teleprinter operating to traffic circulation and radio telephone operating. And for those with ambition, the prospects of promotion to senior management are excellent.

You must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. And, ideally, you should have some sea-going experience.

At 25 or over, salary starts around £4093 and after three years, rises to around £5093. (Starting salary for those between 19-24 varies between £3222-£3732.) Overtime is additional, and there is a good pension scheme, sick-pay benefits and at least 4 weeks' holiday a year.

For further information, please telephone Andree Trionfi on Freefone 2281 or write to her at the following address:
ETE Maritime Radio Services Division (W.W.),
ETE17.1.1.2, Room 643, Union House,
St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

HOLLAND

WE NEED SOMEBODY TO WRITE ABOUT TOMORROW'S ELECTRONIC TECHNOLOGIES TODAY . . .

The successful applicant will work in an atmosphere of peace and tranquility in a charming Dutch village close to the Belgian border. Despite the rustic atmosphere, the task requires the skills of a highly competent technical author with a good knowledge of a wide range of state-of-the-art electronic components and materials. This knowledge must be backed by enthusiasm, writing ability and a thorough understanding of publication practice and procedures.

If this responsible position interests you, send your c.v. to:

Mr. Les Price, Managing Director
Howard Technical Communications B.V.
Markt 50/52 5521AN
N. Br. Holland

(8537)

CITY AND HACKNEY HEALTH DISTRICT

RF ENGINEER

The Dept.of Medical Electronics, St. Bartholomew's Hospital, is seeking an engineer to assist in:

1. The maintenance of hospital VHF and UHF radiotelephones.
2. The development of VHF biomedical radiotelemetry.
3. The development of computer data links.

The successful applicant must demonstrate a good working knowledge of RF techniques and understand current digital and analog circuits.

Postgraduate facilities may be offered to a suitably qualified applicant.

Salary scale: £4098 to £5142 pa.

Please telephone 01-600 9000 extension 3186, quoting PTB/175 for an application form.

(8543)

AMBITIONS IN COMPUTING?

Use your experience to improve your life style

DESIGN — TEST
SERVICE — SUPPORT
SALES — SOFTWARE

For expert confidential advice contact GEOFF ALDRIDGE

01-229 9239

Technomark
Engineering and Technical Recruitment

11 Westbourne Grove
London, W2

(8423)

UNIVERSITY OF LONDON
GOLDSMITH'S COLLEGE
New Cross, London SE14 6NW
Applications are invited for the post of

TECHNICIAN GRADE 5

in the Psychology Department. Applicants should ideally possess HNC/HND in electronics or equivalent qualifications. Duties will include construction, repair and maintenance of electronic equipment as well as particular responsibility for the development of equipment for experimental projects in the Department.
Salary according to qualifications and experience, will be on the scale £3.210x5 increments to £3.747 p.a plus £465 London Weighting Allowance.
Write for further details, enclosing a medium sized self-addressed envelope, to the Personnel Officer, to whom applications should be sent by **29th September, 1978.**

(8538)

SERVICE MANAGER

Applications for this post are invited from candidates who have previous experience of managing electronic servicing or testing departments, or, as experienced engineers now desire to enter management.
The successful applicant will have overall control of a small specialised electronic instrument servicing department which undertakes the repair and calibration of the Company's range of ultrasonic and electronic measuring products, both on the bench and at customers' premises.
Please telephone or write to

Mrs. T. M. Wernham (Personnel)
DAWE INSTRUMENTS LIMITED
Concord Road, Western Avenue
London W3 0SD
Telephone: 01-992 6751 (8524)

CANCER RESEARCH CAMPAIGN

JUNIOR TECHNICIAN/TECHNICIAN

REQUIRED, to assist with the operation and maintenance of the new 4MV Van de Graaff accelerator at the Gray Laboratory. Candidates should preferably have experience of some of the following, electronic, electrical and vacuum systems, particle accelerators, ionising radiations. Salary, including London Weighting, and terms of employment similar to those in M.R.C. laboratories.
Write for application form and information to: Deputy Director, CRC Gray Laboratory, Mount Vernon Hospital, Northwood, Middlesex.

(8521)

Telecommunications & Recording Specialists

A challenge to your skills — with the Metropolitan Police.

There are opportunities to put your specialist knowledge and training to the fullest possible use in the following sections:

Equipment Control — New Scotland Yard and Thornton Heath

. . . to lead teams of technicians engaged on installation, operation, modification and maintenance of a wide range of equipment from mobile radio to intruder systems and control centres. Sound theoretical knowledge and sufficient practical aptitude to maintain systems at peak efficiency essential.

Tape Recording — Denmark Hill

. . . work includes preparing tapes for specialised tape recorders; copying and processing tapes; giving evidence in Court about work carried out on tapes; occasionally analysing various phenomena on tape recordings. Candidates should have a thorough understanding of tape recorders and recording techniques, have experience of work in professional broadcast studios on audio and video recorders, and be fully conversant with checking tapes for quality and defects.

VHF/UHF Communications — Denmark Hill

. . . to be concerned with the use and modification of VHF and UHF communications equipment for specialised Police use together with the prototype design and development of electronic equipment. Candidates should have a good general knowledge of VHF and UHF communications techniques and digital logic systems, some laboratory experience in the design and development field, and ability to innovate and develop ideas.

Intruder Alarm System — East Dulwich

. . . work includes surveying and planning alarm systems for use by Met. Police, managing tests on alarm systems, and suggesting modifications to systems to reduce false calls. Candidates should have a clear understanding of the requirements for power supplies used in the alarm systems industry (active and standby). Current full driving licence essential.

A challenge to your skill - with the Metropolitan Police

(8497)

AMBITIOUS ELECTRONICS/AUDIO ENGINEER

Videotone are a highly successful fast-growing company in the audio field. We have become very well known for our loudspeakers and cartridges and are now entering the amplifier and professional markets.

We need the help of a qualified ambitious Electronics Engineer to become head of our design and evaluation team.

Our opportunities are excellent and we are continuously investing. This is a remarkable opportunity for the right person. Salary range from £4300 to £6000 with many added benefits including foreign travel and possible use of company car.

Write or telephone **Mr C. Hardcastle, 98 Crofton Park Road, Crofton Park, S.E.4. Tel: 01-690 1914.**

8555

INNER LONDON EDUCATION AUTHORITY
Learning Materials Service, Television Centre, Thackeray Road, London, SW8.

TELEVISION ENGINEER

required for MASTER CONTROL SECTION, (STUDIO TECHNICIAN 3)

The vacancy for a fourth engineer in the Master Control section exists at the Battersea Television Centre of the Learning Materials Service.
This highly operational post involves recording, editing and post production of programmes using broadcast video tape recorders, and, at the moment, their transmission over a large closed circuit network. Within a year the transmission network will be replaced with a video cassette distribution system and all technical facilities will be converted to colour. Applicants will therefore be expected to be familiar with the technical features of helical machines for school use as well as those of broadcast type.
The successful candidate should have the appropriate experience to operate and perform first line maintenance on the wide range of television equipment used in a central equipment area with special emphasis on VTR's. Suitable academic qualifications would be an advantage but experience of the right type will be the first consideration in filling the post. At present some evening work is involved connected with transmissions.
Salary within the scale £5.545-£5.905 inclusive of London Weighting and Phase 1, 2 and 3 supplements.
Application forms from EO/E estb. 2A/2, Room 365, County Hall, London, SE1. Tel. 633 7456.
Closing date will be 4 October, 1978.

(8511)

Electronics Research and Development with Ferranti

Expansion and reorganisation within the Aircraft Equipment Department has created a number of interesting positions for Electronic Engineers (male or female) in the R & D Laboratories at Bracknell.

The Department is active in both the commercial and defence fields with airborne and ground based equipment and covers a broad range of activities extending from power conversion equipment to small signal microcircuit technology.

The laboratories are based in a pleasant manor house within Lily Hill Park on the northern outskirts of Bracknell. If you join us you will enjoy working conditions conducive to an R & D activity and share our amenities—which include a good dining room and ample car parking. Housing assistance may be available if required and generous relocation expenses are paid.

Areas of activity in which vacancies have arisen are highlighted below:

Power Conversion

A PROJECT ENGINEER is required to lead a team engaged in the development of power conversion equipment. He/she will be responsible for new developments of static invertors, battery chargers and other power equipment which Ferranti has been supplying for more than a decade. A proven capability of power equipment design is essential and the candidate should be familiar with the requirements demanded by military users.

This is a senior position and is unlikely to be filled by a candidate with less than 5 years relevant experience.

Candidates with less experience may be considered for other positions in the group. (Reference A/211/WW).

Navigation/Guidance Systems

A SENIOR ENGINEER is required to work in a group specialising in the latest techniques of vehicle guidance. The candidate should ideally have some knowledge of strapdown inertial navigation but, more importantly, a good mathematical background. New projects under development are based on microprocessor control and, where required, training courses in the use of microprocessors will be provided.

Professional engineers with a minimum of two years experience could fill the above position. (Reference A/210/WW).

Flight Control Systems

New developments in the field of helicopter flight control systems have led to a vacancy at senior engineer level. The candidate should have a good knowledge of control theory, and design capability with both analogue and digital systems is essential. This post offers a good oppotunity for an analytically minded engineer to gain further experience in this interesting field. (Reference A/212/WW).

Communications

The Department is actively involved in areas of work covering signal processing. New projects demand a good knowledge of audio/low frequency communication systems using analogue and digital techniques.

Vacancies are at senior engineer level and candidates should preferably be of graduate status.

In addition we have a number of other interesting vacancies for recent graduates to join our professional development scheme. (Reference A/213/WW).

Details may be obtained by writing or telephoning (quoting the appropriate ref. no.) Mrs. J. Hunt, Ferranti Instrumentation Limited, Lily Hill House, Bracknell, Berkshire RG12 2SJ. Tel: Bracknell 24001 ext. 8.

FERRANTI
Selling technology

(8496)

Technical Service Engineer

–professional audio/visual equipment

3M is a major international organisation with extremely diverse interests in world-wide markets A graduate electronics engineer (or the equivalent) is currently needed to work as a member of a small, highly specialised team on the following products –

* Professional audio multi track tape machines
* Video character generators and ancillary equipment
* Specialised test instruments
* Data cartridge drives

The work will involve bench servicing and field service visits to customers' premises. Whilst full product training will be provided, candidates must possess both digital and analogue circuit design knowledge, with the emphasis on digital, due to the forthcoming introduction of a 32-track digital audio recorder for studio use

A first class salary plus large company fringe benefits are offered – including a company car after the initial training period The position is based in West London and relocation assistance will be given if appropriate

Please write with concise personal and career details, including your home telephone number, to P. G English, 3M United Kingdom Ltd, 3M House, P.O Box 1, Bracknell Berks RG12 1JU

3M

(8506)

CTVC

CTVC require a SENIOR VISION ENGINEER

A qualified engineer with experience of working as a Vision Controller in broadcast television and able to take responsibility for the output of a studio during production. Salary £5852.

Please apply to **Chris Hillier or Peter Rudd, CTVC, Hillside, Merry Hill Road, Bushey, Herts. Tel: 01-950 4426.**

Electronics Engineer

Telemotive U K Limited is a Company in association with a major U.S.A manufacturer with world leadership in the radio control of industrial machines, systems, and processes, in collision prevention, in remote positioning, and in other industrial electronics activities

Our principal products are founded on the Near Field Induction Effect and on other inductive techniques in the 300 kHz band No other U K Company has a comparable product line, and our business therefore offers engineering experience of unusual interest Training in our techniques is provided

Our current requirement is for a young engineer with versatile abilities because at different times the work will involve application engineering, testing, commissioning of systems on customers' sites, field and base service, the anglicisation of designs originating in other countries, and a measure of production control In each of these fields there is scope for personal engineering contributions

The position involves some travelling within the U K and will take the engineer into a wide variety of industries

Telemotive is a good employer It only employs people who are exceptional in their particular job and it treats them accordingly The salary will depend upon the capability of the chosen applicant

A company car is provided

Please forward personal details to

Telemotive U.K. Limited

**TELEMOTIVE HOUSE, 100 HIGH ROAD
BYFLEET, WEYBRIDGE, SURREY
BYFLEET 47117**

(8505)

H.M.G.C.C.

ELECTRONIC ENGINEERS

Designers and Development Engineers are required for work in the HF and UHF fields and in general analogue and digital circuitry.

The Establishment is sited in rural surroundings in North Bucks. within easy reach of Northampton, Bedford and Milton Keynes. A frequent rail service and the M1 motorway provide easy access to London. House prices in the area are still at provincial levels.

Minimum academic qualification is HNC and, for Higher Scientific Officer, five years' post-qualification experience (for graduates with First or Second Class Honours this is reduced to two years' post-graduate experience).

Salaries are:

Scientific Officer £2839-£4415
Higher Scientific Officer £4101-£5448

DRAWING OFFICE STAFF

Drawing Office Staff are required in a supporting role to the above engineers.

Salaries are in the ranges: £3148-£4326
£4326-£4869

Salaries for Drawing Office Assistants are £2119-£3189, depending upon age, qualifications and experience.

For application form please apply to:

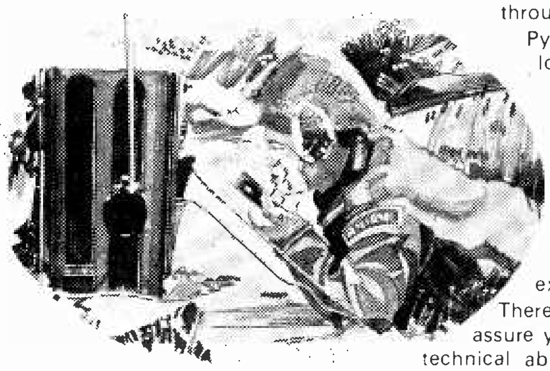
The Administrative Officer (Dept. WW)
HM Government Communications Centre
Hanslope Park
Hanslope
Milton Keynes
Bucks.
MK19 7BH

(8376)

TEST ENGINEERS

When reliability matters, people come to Pye

Radio communication under battlefield conditions calls for equipment that is rugged, efficient, and above all reliable, and with the famous "88" Set, carried by the Allied Forces throughout the 1939–45 War, Pye achieved all three.



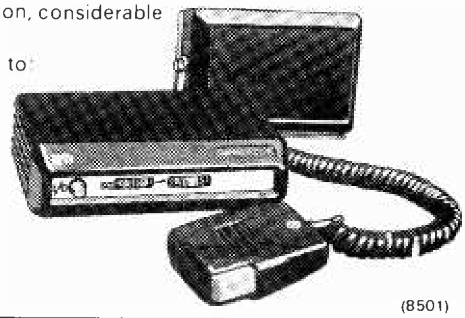
Pye's reputation for reliability under arduous conditions has long been a byeword. Part of that reliability comes from the quality of the design and the components used, but the final seal is set by the highly skilled men and women who check our UHF/VHF systems to very exacting specifications prior to delivery.

If you already have experience of fault diagnosis, alignment and testing of electronic equipment, especially communication equipment, perhaps gained in the Armed Forces, then why not get in touch and find out for yourself exactly why people come to Pye.

There's not room to tell you all the details here, but we can assure you of a salary between £3500 and £3900 dependant on technical ability. There is also company stability, job security and satisfaction, well equipped workshops and a variety of equipment, using both IC and transistor.

Openings are available at Haverhill, Suffolk and at Cambridge, both extremely pleasant places to live, with key-worker housing available at Haverhill. In addition, considerable assistance is provided for those moving from other parts of the country.

Please write or phone for further details (reversing charges if necessary) to: Catherine Dawe, Pye Telecommunications Ltd., Colne Valley Road, Haverhill, Suffolk CB9 8DU. Telephone: Haverhill 4422 or Claire Barton, Pye Telecommunications Ltd., St. Andrews Road, Cambridge. Telephone: Cambridge 61222.



Pye Telecommunications Ltd

(8501)

YAMAHA Nakamichi

AUDIO ENGINEERS

We have vacancies for 2 Bench Engineers capable of working to a high standard, on Nakamichi and Yamaha high fidelity equipment.

Applicants should be fully conversant with present-day circuit applications and servicing techniques on stereo amplifiers, cassette decks and AM/FM tuners, and should possess a minimum of 3 years' working experience in this field.

Please apply in writing or telephone for an application form to:

Terry Finn—Service Manager

Natural Sound Systems Ltd.

10 Byron Road
Wealdstone, Harrow, Middx.
Tel: 01-863 8622, Ext. 5

(8560)

GOLD DUST OR ODD BALLS . . .??

When you or your application form enter these illustrious premises, you are classed as Gold Dust (young, reasonably priced circuit designers, computer engineers, quality engineers). Saleable Goodies or Odd Balls — (the unusual, indeed inimitable engineer for whom even WE cannot find the right socket immediately).

Some of our companies need
ODD BALLS
—please help us lay our hands on them. We need

VF ANALOGUE CIRCUIT DESIGNER

for work on Air Traffic Control systems i.e. amplifiers for speech compression, active filters and analogue aspects of modems. Middlesex. Salary to £6,500.

PROJECT MANAGERS

to supervise telecomms installations in Middle East (either telephone multiplexing or microwave systems for telephony and T.V.) Bachelor status. £11,000-£15,000+ bonus.

TRAINING OFFICERS

to run course for service engineers and customers on the use of the very latest computer controlled graphic equipment. Lots of overseas travel. Circa £5,000. South Coast.

TEAM LEADER

for group engaged on design of CMOS for a wide range of applications — particularly telecomms. Experience in MOS design and some systems experience. To £8,000.

NO JOKING — whether you are an Odd Ball, Gold Dust or just an ordinary Electronic Bloke, someone, somewhere needs you.

Apply as usual to Charlies Angels, that sophisticated team of Electronic Talent Detectors . . . scores of satisfied clients and followers.

Charles Airey Associates

"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY" — FINANCIAL TIMES

155 KNIGHTSBRIDGE, LONDON, SW1. TEL: 01-581 0286

(8577)

AUTOMATIC TEST EQUIPMENT ENGINEERS

SUSSEX

M.E.L., a division of the International Philips Electronic and Associated Industries Group is an established world leader in the development and production of sophisticated Electronic Systems.

Due to an expanding activity in digital circuit techniques, we have vacancies for A.T.E. programmers and test engineers to work in a team using GenRad Automatic digital test equipment to provide a service to all departments. This activity supports the design, development and production of digital circuits used in a wide variety of applications.

Applicants should be qualified to H.N.C. or degree level with preferably test programming, testing or design experience of digital circuits.

These important A.T.E. positions offer high job interest and the equipment is the basis of one of the most advanced microwave/digital test facilities in the U.K.

All positions attract excellent starting salaries, generous holiday and sickness entitlements, staff shop and subsidised restaurant facilities.

Please write or telephone: Mr. A. G. Budd, Personnel Officer, M.E.L., Manor Royal, Crawley, Sussex. Tel. Crawley 28787 Ext. 364. (8504)

M E L

---

university of wales

university college of swansea

Chair of Electrical Engineering

The Council of the College invites applications for the vacant post of

PROFESSOR OF ELECTRICAL ENGINEERING

Further particulars may be obtained from the Registrar/Secretary, University College of Swansea, Singleton Park, Swansea SA2 8PP, to whom applications (10 copies) should be returned by 31 October, 1978. (8514)

ELECTRONIC DESIGN ENGINEER

Salary negotiable

A leading manufacturer of artificial limbs and aids for the disabled require an electronic engineer to work in its research and development dept.

Applicants should have experience in digital techniques and small servo systems, preferably with a knowledge of microprocessors. HNC, HND or degree preferred.

Apply in writing stating age, qualifications, experience and present salary or telephone for further details.

D. Hawkins
HUGH STEEPER LIMITED
237 Roehampton Lane
London S.W.15 (Tel: (01) 788 8165
(8567)

R & D Engineers at senior and intermediate levels

required to work on digital and cable television systems for the domestic and surveillance market.

Engineers should hold a degree, HNC or equivalent qualification and have some knowledge of either HF video or digital circuit design.

Salaries will be commensurate with qualifications, age and experience.

Fringe benefits include a contributory pension, life assurance scheme, subsidised canteen, etc.

If you are seeking an enjoyable position in R & D, write, giving full details of your career to date, or telephone Dr. G. O. Towler, B.Sc., Ph.D. (Manager), Research and Development Establishment, British Relay Ltd., Cleeve Road, Leatherhead, Surrey. Tel. 76056.

8469

british relay

RADIO TECHNICIANS

Government Communications Headquarters has vacancies for Radio Technicians. Applicants should be 19 or over.

STANDARDS required call for a sound knowledge of the principles of electricity and radio, together with appropriate experience of using and maintaining radio and electronic test gear.

DUTIES cover highly skilled telecommunications/electronic work, including the construction, installation, maintenance and testing of radio and radar telecommunications equipment and advanced computer and analytic machinery.

QUALIFICATIONS: Candidates must hold either the City and Guilds Telecommunications Part 1 (Intermediate) Certificate or equivalent HM Forces qualification.

SALARY (inc. supps.) from £2,927 at 19 to £3,700 at 25 (highest pay on entry) rising to £4,252 with opportunity for advancement to higher grades up to £4,706 with a few posts carrying still higher salaries.

Opportunities for service overseas.

Further particulars and application forms available from

GCHQ

Recruitment Officer (Ref. WW/9)
GCHQ, Oakley
Priors Road, Cheltenham GL52 5AJ
Cheltenham (0242) 21491 ext. 2270

(8035)

Electronics Engineers on the move

INVEST 5 MINUTES IN YOUR FUTURE

DESIGN, TEST, Q. A; FIELD SERVICE, MANAGEMENT, ETC.

Take advantage of the best opportunities being offered in the Electronics Industry from amongst over 3000 U.K. Companies with whom we deal. We are seeking all categories of Electronics Engineers for equipment ranging from computers to communications.

By returning the application form below, your job requirements will be matched against our clients' numerous vacancies, many of which are not advertised. Your application will be treated in strict confidence and no approaches will be made to existing employers or to any other companies you care to specify. Please remember, our service is completely FREE to applicants.

So don't delay - act now to give yourself the best chance of finding the perfect job.

If you wish to discuss any aspect of the Electronics job market, you are welcome to phone anytime. Please ask for Brian Cornwell.

Capital Appointments Ltd. 29/30, Windmill St. London, W.1. ☎ 01-637 5551

PLEASE WRITE IN BLACK INK.

NAME: ADDRESS:

Tel: (Home): (Office):

Date of Birth: Place of Birth: Nationality now: If not British, is a

Marital Status: Car Driver: Car Owner: Work Permit req'd?

Type of Position required: Approx. Salary level:

Please indicate areas in which you are prepared to work:

Cent. London		S. Coast		E. Midlands	
S.E. London		West Country		W. Midlands	
S.W. London		N. E. Engld.		E. Anglia	
N.E. London		N. W. Engld.		Wales	
N.W. London		Scotland		Overseas	

Home Counties: N.W. | N.E. | S.W. | S.E.

Are you a houseowner? Are you willing to relocate?

Are you prepared to travel - In U.K? Overseas?

State of health:

Notice Period required: Availability for Interview:

EDUCATION:

Secondary School Qualifications:

College or University Qualns:

Any Professional Membership:

INDUSTRIAL EXPERIENCE:

Period of Employment	Company & Location	Products	Job Title	Responsibilities	Reason for leaving	Final Salary
1. Current or last employment From: To:						
2. Previous employment From: To:						
3. Previous employment From: To:						

ELECTRONICS PROFILE: Indicate extent of experience- A-Extensive; B-Moderate; C-Limited; If Nil experience, leave blank.

☐ Telephone Eqpt.	☐ Data Commns.	☐ Radio/Hi-Fi/T.V.	☐ Broadcast Eqpt.
☐ Digital/Logic	☐ Analogue Eqpt.	☐ Software/Programming	☐ Minis/Microprocessors
☐ Computers/Periphs.	☐ Test Gear/ ATE.	☐ Process Control	☐ Power Supplies
☐ UHF/VHF. Comms.	☐ Microwave	☐ Radar/Navaids	☐ Medical Electronics
☐ Signalling Systems	☐ Security Eqpt.	☐ Avionics	☐ Simulators
☐ Weapons	☐ Scientific Eqpt.	☐ Data Recorders	☐ Photocopiers
☐ Phototypesetting	☐ Servo-mechs.	☐ Components-Active	☐ Components-Passive
☐ Production Eng.	☐ Electrical Eng.	☐	☐

Others - Please state.

Please indicate any Companies you do not wish us to contact.

If you wish to detail further aspects of your experience or job requirements, please enclose on a separate sheet. WW41

(8507)

PRODUCT SUPPORT
SUSSEX

M.E.L. is the professional equipment division of the International Philips Electronic Group and is an established world leader in the design and manufacturing of a wide range of Electronic Equipments for defence and civil markets. Due to major expansion of our product support activities, the following vacancies have arisen.

PRODUCT SUPPORT ENGINEERS

To deal with 'post design' problems, resulting from the production and in service use of a wide variety of equipments and systems including military Radio and Radar. Engineers with a good knowledge of electronics up to H.N.C. standard will find these positions have the interest and challenge they require. Experience of similar work within H.M. forces and/or knowledge of M o.D. procedures would be extremely useful.

SERVICE ENGINEERS

These positions require applicants willing to use their own initiative and skills in carrying out diagnostic fault finding, repairs and retest of a variety of equipments including airborne radar units. The work will also involve some liaison with customers.
A good general knowledge of electronics, including semi-conductors circuits, is essential and H.M. Services 2nd/3rd line maintenance experience will be especially useful.
These positions attract good starting salaries and excellent conditions of employment in a stimulating modern working environment and generous relocation expenses will be given where appropriate.
For further details or an Application Form please contact:
MR. A.G.BUDD, Personnel Officer, M.E.L., Manor Royal, Crawley, Sussex. Tel. Crawley 28787 Ext. 364.

(8503)

M E L

UNIVERSITY OF LIVERPOOL
Department of Building Engineering

TECHNICIAN
(Electronics)

within the Acoustic Group. The work involves research in the development and construction of signal processing equipment and is also concerned with computer interfacing problems. Post available for three years. Salary in a range up to £3,720 p.a. according to qualifications and experience.
Application forms available from the **Registrar, The University, P.O. Box 147, Liverpool L69 3BX. Quote Ref. RV/914/WW.**

(8510)

UNIVERSITY COLLEGE CARDIFF
A TECHNICIAN
Grade 4

is required to design, build and maintain equipment for the ELECTRONIC MUSIC STUDIO in the DEPARTMENT OF PHYSICS. Salary range, Technical Grade 4 £2955-£3402 p.a. Duties to commence as soon as possible.
Applicants should be interested in digital and audio electronics and be able to maintain analogue and digital equipment and tape recorders. For further information contact Dr Michael Greenhough, Physics Department Tel (0222) 44211, Ext. 2136.
Applications, together with the names and addresses of two referees, should be forwarded to the Vice-Principal (Administration) and Registrar, University College, P.O. Box 78, Cardiff CF1 1XL. Closing date 1st October 1978. Please quote reference 1588. (8541)

DEPARTMENT OF MEDICAL PHYSICS AND BIO-ENGINEERING
University College Hospital

ELECTRONICS ENGINEER

To join a team engaged in design, development, maintenance and repair of a wide range of electromedical and physiological measurement equipment.
Qualifications O.N.C. or equivalent in a relevant subject.
Salary Medical Physics Technician Grade IV £3423-£4488 per annum, inclusive of London Weighting.
Apply to the Personnel Department, University College Hospital, Gower Street, London WC1E 6AU. Tel: 01-387 9300 Ext. 381.
Please quote reference EE/DMP/AP (8552)

DIXONS TECHNICAL LTD

SERVICE ENGINEER
£4,000 p.a.+

Dixons Technical is a specialist company involved in supplying CCTV and video equipment to commerce and industry. We are currently looking for a Service Engineer to be based at our Croydon Headquarters. Applicants should have a minimum of two years experience of VCR equipment. Service experience relating to cameras and monitors is not essential however, since we are prepared to give training in this field. The job will provide a great deal of variety and interest because of the wide range of equipment which we handle. We are offering a competitive salary of around £4,000 p.a. but it could be more if you have good solid experience and can convince us of your ability. Other benefits include four weeks holiday rising to five weeks, a company pension scheme and a special discount scheme. Relocation expenses will be available in appropriate circumstances. Interested! Then contact our Workshop Manager, Arthur Dyson at 68/70 Windmill Road, Croydon or 'phone 01-689 6021.

Technician
(Electronics)

Salary £3279-£3651
(includes latest pay supplement)

Man or woman required in the FINE ART DEPARTMENT, to demonstrate and maintain video and tape recorders and equipment, and to give technical advice to students and staff as to the means of achieving envisaged projects. Requirements are three years appropriate experience in radio/TV servicing or in industrial electronics. HNC or CGLI Final in electronic engineering or radio/TV servicing an advantage.

S.A.E. for forms and details from
CHIEF ADMINISTRATIVE OFFICER
EXETER COLLEGE OF ART AND DESIGN
EARL RICHARDS ROAD NORTH
EXETER. Tel 0392 50381
Closing date
29th September, 1978

DEVON

(8533)

TEST EQUIPMENT REPAIR AND CALIBRATION OPPORTUNITIES.

We need Section Chiefs for Test Equipment Repair and Calibration.

The continued expansion of our Company's business in the design, production and installation of advanced radar systems, places an increasing demand on our "in house" facility for calibration and repair of test equipment.
We are looking for experienced Test Equipment Engineers as Section Chiefs to run small teams of engineers and technicians engaged in the calibration, fault diagnosis and repair of proprietary test equipment for the Company's establishments and, to a limited extent, customers in the field. The sections are set up to handle equipment in the following categories:

Display Instruments
Digital and Analogue Instrumentation
Signal Generation and Analytical Instruments
Microwave Instruments and Devices

If you are qualified to HNC or C & G Full Tech. Certificate or equivalent and have had several years' experience in one or more of the above fields, why not contact us to discuss your possible future in the Company. In addition to the Section Chief positions, we also have vacancies for Calibration and Repair Test Equipment Engineers.
You would be working in a custom built clean air, temperature controlled laboratory, using a wide range of standard and back-up equipment spanning DC to 18 GHz.

The Company offers excellent career progression prospects to both men and women, with generous salaries related to qualifications and experience, and excellent fringe benefits, including relocation expenses where appropriate.

Why not find out more by telephoning John Palmer on Chelmsford (0245) 67111 ext 2226 for an informal discussion. Alternatively complete the coupon and send it to him at Marconi Radar Systems Ltd., "Freepost", Chelmsford, CM1 3BR (no stamp required).

Name ____________

Address ____________

____

Home Tel No. ____________ Bus. Tel No. ____________ (if appropriate)

Qualifications ____________

____

Marconi Radar

A GEC-Marconi Electronics Company

TECHNICAL WRITER

A Technical Writer is required to assist in the preparation of technical handbooks and similar documentation of VHF/UHF Radiotelephones, Radiotelephone Systems and related Test Equipment.
A sound technical background and the ability to write clear and precise English is essential.

Please apply to:

DYMAR

Mrs. A. Bowles
DYMAR ELECTRONICS LTD.
Colonial Way, Radlett Road
Watford, Herts.
Tel. Watford 37321, Ext. 27

(8500)

TEST ENGINEERS

Vacancies exist within our Radio Test, Final Test and Service Departments for experienced Test Engineers with knowledge of VHF Radiotelephone Equipment.

★ Good salaries.
★ Pleasant working conditions.
★ Subsidised canteen.

For application form and further details contact:

DYMAR

Mrs. A. Bowles
DYMAR ELECTRONICS LIMITED
Colonial Way, Radlett Road
Watford, Herts.
Tel. Watford 37321, Ext. 27

(8499)

Sound Operations Manager Brentford.

c.£7,500 p.a. + car

Rank Strand Sound has been set up as a new unit operating within Rank Strand Electric with the objective of achieving the same level of success in the field of professional audio and acoustic systems as the division already enjoys thanks to its sophisticated lighting equipment for auditoria and theatres.

We are confident of a bright future for the new unit as it will be able to capitalise on the division's technical and marketing expertise to develop fully-integrated, processor-controlled sound/lighting systems for a range of applications as broad as the world of entertainment itself.

But before things can really start to happen, we need the right person to fill the key position of Operations Manager.

Responsible for a design and sales team that is currently 15-strong, you will need to demonstrate a high degree of commercial ability and an in-depth knowledge of professional live sound systems plus a real understanding of the demanding needs of the professional entertainment industry.

In return for these talents, we can offer an attractive salary and benefits package including company car and the opportunity of overseas travel. Assistance with relocation expenses will also be provided where appropriate.

Please write with full career details to: Chris Hough, Personnel Manager, Rank Audio Visual, P O Box 70, Great West Road, Brentford, Middlesex. Tel: 01-568 9222.

RANK AUDIO VISUAL

(8498)

BROADCAST ENGINEER

WSM Community Radio, a capable radio station serving 20,000 people in the Telford, Salop area requires an experienced Broadcast Engineer to join local residents and professional broadcasters who are designing and constructing a broadcast studio and associated transmission equipment.

The successful applicant must be sympathetic to the concept of community broadcasting and will be required to build, install and maintain the appropriate equipment.

Rented housing accommodation can be made available through the Telford Development Corporation.

6 months contract with the posibility of an extension £300/month.

Application by 10 October 1978 to **Secretary WSM Community Radio Ltd., 215 Willowfield, Woodside, Telford, Salop TF7 5NY Telephone (0952) 583520 WSM.**

WSM Community Radio

UNIVERSITY OF SURREY

LECTURER IN RECORDING TECHNIQUES

Applications are invited for the above post in the Department of Music.

The Lecturer will be responsible for teaching practical and theoretical aspects of recording for the Tonmeister Course leading to the degree of BMus(Surrey)(Tonmeister). Applicants should have a thorough knowledge and experience of studio work in the recording/broadcasting industry.

Salary will the within the range £3660-£7308 per annum.

Further particulars may be obtained from the Academic Registrar(LFG), University of Surrey, Guildford, Surrey GU2 5XH or Tel. Guildford 71281 Ext 452. Applications from men and women, in the form of a curriculum vitae, including the names and addresses of two referees should be sent to the same address by 6 October 1978.(8557)

BROMPTON HOSPITAL

SENIOR MEDICAL ELECTRONICS TECHNICIAN

To undertake work involving maintaining, installing and developing medical electronics equipment. A knowledge of ultrasonics and micro-computer based systems would be a distinct advantage.

Applicants should have a good general knowledge of electronics and be qualified to HNC [Electrical and Electronic Engineering] standard or equivalent. Previous hospital experience not essential.

Salary will been scale £4098-£5142 according to experience.

Further information from the **Physicist in Charge, Mr. R. B. Logan-Sinclair.** Tel: 01-352 8121, Ext. 4252.

Application forms and job descriptions from Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3. Ext. 4357. (8518)

UNIVERSITY OF OXFORD
DEPT OF HUMAN ANATOMY

ELECTRONICS TECHNICIAN

(Grade 6) Salary £3654

The Department of Human Anatomy requires an Electronics Technician to assume responsiblity for running 3 Electron Microscopes, closed circuit television installation and other sophisticated equipment including the supervision of research students in their use.

Application with details of qualifications and previous experience (particularly of Electron Microscopes and closed circuit television) should be sent in writing together with the names of two referees, to

Professor C. G. Phillips FRS
Dept. of Human Anatomy
South Park Road
Oxford OX1 3QX

(8583)

IMPORT FIRM OF ELECTRONIC EQUIPMENT IN BENGHAZI, LIBYA

has vacancies for

a. **SENIOR ENGINEER** —video cassette recording and CTV

b. **SENIOR ENGINEER** —B/W TV/radio/recording

Both engineers are required to lead a group of local service technicians in the respective article groups. The responsibilities include assisting and training service engineers in the use of appropriate fault-finding methods. They should be able to organize the workshop accordingly.

WE OFFER

Salary for position a. **LIBYAN DINAR 750/MONTH** (appr. **£1400.**/month)

Salary for position b. **LIBYAN DINAR 600/MONTH** (appr. **£1100.**/month)

Bonus: One month's salary per year (both positions).

Holidays: One month annually plus one return ticket for each only.

One **furnished flat** for two single technicians is available for the company's account.

Salaries are taxable according to Libyan law.

Applications should be sent under number WW8549 of this magazine.

RADIO COMMUNICATION ENGINEERS AND RADIO PAGING ENGINEERS NEEDED

£4,900 AND £4,400

(Remuneration inclusive of bonuses)

Applications are invited for the above positions. Due to continuing expansion we need engineers at our London depot and also our new branch at Harrow, Middx. We are London's largest independent radio-telephone company, and would be interested in hearing from you if you have knowledge of mobile V.H.F. equipment.

Contact Mike Rawlings or Bill Clarke, on 01-328 5344.

London Communications (Equipment) Ltd
30 Boundary Road, London NW8 01 328 5344

(8547)

Calling all professional Electronics Engineers and amateur electronics enthusiasts

The Electronics Industry has always been a breeding ground of professional talent, particularly within the specialist areas. At EMI, we have always attracted talented people, graduates and specialist engineers with valuable experience to contribute.

We're a flexible company, which is undoubtedly one of the attractions to professional people. We're also an acknowledged major force in the industry. Our training is excellent, our products ahead of the field. Our expertise has changed the face of electronics time and time again.

People joining us at any level rapidly acquire a great deal of knowledge and experience which puts them on a steady path to promotion. And right now, we have a very special need for a limited number of men and women as Semi-Conductor Consultant Engineers within our Engineering Standards Group.

We are extending our invitation to both experienced Electronics Engineers and men and women who have a particular interest, though not necessarily experience, in electronics as a hobby.

Your role with EMI Electronics will be to advise engineers, production personnel, buyers and Q.A. staff on various aspects of semi-conductor and micro-processor products, to liaise with suppliers and initiate/draft standards. You will also be expected to undertake laboratory testing, evaluate devices and be responsible for seeking out new products.

These varied duties require people with at least HNC qualifications but probably more important for this work, is the right personality. You must enjoy resolving technical problems and yet be capable of confident and effective communication with a wide and varied range of people. Knowledge of passive components, the foreign components markets and a working fluency in another European language, would be very useful though is not absolutely essential.

The men and women we envisage joining us will be aged between 20 and 40 and will be looking for a challenging and rewarding career with one of the major forces in international electronics.

For further information, please contact:
Neil Robotham, Personnel Department, EMI Limited, 135 Blyth Road, Hayes, Middlesex.
Telephone 01-573 3888 or Record-a-call anytime on 01-573 5524.

EMI Electronics Ltd.

A member of the EMI Group. International leaders in music, electronics and leisure

(8581)

EMI

SALES ENGINEER ELECTRONICS

N. ENGLAND & SCOTLAND

A rare opportunity for career advancement exists with Burr-Brown — a world leader in hybrid microcircuits. Our products are for instrumentation and data aquisition — specialised amplifiers, analogue functions and A-D, D-A converters.

We urgently need an ambitious, enthusiastic young engineer with some sales experience, or a very keen desire to achieve the rewards this sales position offers.

Applicants should have studied to HNC level or have solid experience in analogue signal processing and data acquisition.

The benefits include
- Top Salary
- Bonus
- Pension Scheme
- Life Assurance
- Company Car
- Expenses

If you feel you can meet our challenge, phone Roger Isaacson at

BB

BURR-BROWN INTERNATIONAL LTD. WATFORD (0923) 33837

(8516)

AN INTERNATIONAL COMPANY BASED IN LONDON (HOLBORN)

requires

ELECTRONIC DEVELOPMENT/ SERVICE ENGINEERS

£4,500-£5,000 PA (Depending on experience)

The Service section is part of an expanding, fast-moving Research & Development Department. The successful applicants will spend approximately half their time on Research work, where their innovative abilities and skills will be fully utilised.

They will be able to demonstrate 2-3 years' experience in a calibration or servicing environment.

Duties include developing improvements to existing equipment and experimental work on electronic and mechanical systems; the maintenance and calibration of electro-mechanical systems, including electronic weighing systems and electronic test equipment.

Applicants should have experience of analogue and digital circuitry; a basic knowledge of microprocessors would be an advantage.

The successful candidates will have a minimum qualification of ONC, C&G finals or equivalent for electronic servicing and may be qualified to degree level.

There are above average fringe benefits, which include membership of a non-contributory pension scheme, free life assurance and staff restaurant.

Applicants should write with CV to:

D. R. Pannett
2 Charterhouse Street
LONDON EC1N 6RX

(8544)

WHAT'S NEW IN MODEMS AND MULTIPLEXERS?

Uncle Sam has created a new generation. There's the Microprocessor based Modem, Time Multiplexing equipment and advanced Diagnostic Surveillance Systems for network control.

Launch these on the British user and you need considerable engineering and managerial back-up for your company. The circuitry needs evaluation. The products have to be incorporated into systems. The customer needs educating in up-to-date applications (the products used to be the prerogative of Mr Big, now Mr Everyman needs to know that life is easier with data modems than without them). Technical support to the service department becomes more complex. The first new systems need the green fingered touch of one of nature's engineers as they are commissioned and installed.

If you are au fait with the equipment and wish to leave a type-cast engineering environment to develop broader based skills, please telephone for further details of our client company. Location: West London. Salary to £6,500. Fringe Benefits — in our opinion about the best in the country.

For further details please contact:

Charles Airey Associates

"PROBABLY THE BEST KNOWN SUPPLIER OF ELECTRONICS ENGINEERS IN THE COUNTRY" — FINANCIAL TIMES

155 KNIGHTSBRIDGE, LONDON, SW1. TEL: 01-581 0286

(8576)

FOREIGN AND COMMONWEALTH OFFICE
COMMUNICATIONS DIVISION

has vacancies for

RADIO TECHNICIANS

to carry out shift duties concerned with MW and HF broadcasting systems involving frequency changing, fault finding and routine maintenance, keeping logs, and recordings.

Applicants should have minimum qualifications of City and Guilds Intermediate Certificate in Telecommunications or its equivalent.

The successful candidates will serve initially at Crowborough, but may be required to serve elsewhere in the UK or overseas should the necessity arise.

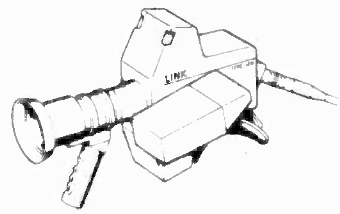
Salary is according to age, e.g. £3,176 per annum at age 21, £3,435 at age 23, £3,700 at age 25 or over on entry rising by annual increments to a maximum of £4,252 per annum.

The appointments attracts 4 weeks ' paid holiday and prospects of pensionable employment.

Recruitment Section
Foreign and Commonwealth Office
Hanslope Park, Hanslope, Milton Keynes MK19 7BH

(8320)

LINK



TELEVISION
SENIOR TEST ENGINEERS

WE ARE Link Electronics Limited, a successful, expanding company with room for individual ability to make itself felt.

WE MAKE A full range of TV studio broadcast equipment, including colour cameras for studio and O/B applications.

WE NEED Senior Test Engineers to undertake test and commission of advanced and complex TV cameras and associated equipment, including our multi-roll colour camera now going into production. This appointment is at a senior level, engineers are required with a good knowledge of modern circuitry and preferably with some broadcast television experience.

WE OFFER Salary above average, according to ability and not a rigid grade structure, generous holidays, free life and health insurance, pension scheme, staff restaurant, relocation expenses.

LOCATION A modern factory in a very pleasant part of Hampshire with no traffic problems and easy access to London, the South Coast, Midlands and many major towns.

HOUSING A wide choice, in urban and rural settings.

TO APPLY Either phone Jean Smith at Andover (0264) 61345 and ask for an application form or write to Mic Comber with enough information to make a form unnecessary.

LINK ELECTRONICS North Way, Andover Hampshire, England Telephone Andover (0264) 61345

(8548)

RADIO TECHNICIANS

WORK IN COMMUNICATIONS R&D AND ADD TO YOUR SKILLS

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham but we have other centres in the UK, all of which require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

You should be at least 19 years of age, hold (or expect to obtain) the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

You start on £2927 at 19, up to £3700 if you are 25 or over, rising to £4252, and promotion will put you on the road to posts carrying substantially more. There are also opportunities for overtime and on-call work paying good rates.

Get full details from our **Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491. Ext. 2269, or write to him at GCHQ (Ref. WW/10), Oakley, Priors Road, Cheltenham, Glos GL52 5AJ.** If you seem suitable, we'll invite you to interview in Cheltenham — at our expense of course.

(8508

A challenging career in the Medical Field

International X-Ray Company, a leader in its field, has several interesting positions for

X-RAY ENGINEERS

These vacancies occur in the North West and Southern England.

Very generous salaries will be paid to the successful applicants.

A Company Car will also be provided.

There are excellent promotion prospects for the right persons.

Those applying should be suitably qualified electronically and preferably have some experience in the X-Ray Field.

Please apply in writing to:

C. G. R. Medical Ltd.

Astronaut House, Hounslow Road, Feltham, Middlesex

Giving full details of education and career to date.

(8520)

ITN

SENIOR ENGINEER VTR Cassettes

Salary £5,920 p.a. (Under Phase III Review)

Independent Television News has a vacancy for a Senior Engineer in their Facilities Centre in the West End of London.

The successful applicant will be employed on operation and maintenance in the busy Cassette VTR Section and is likely to have had previous editing experience. Broadcast VTR experience would be a plus but is not essential.

Benefits include contracted out pension scheme, life insurance, four weeks' annual holiday.

Please telephone our Personnel Department on 01-637 3144 quoting reference number 8314.

(8513)

LOUGHBOROUGH CONSULTANTS LIMITED

Electronics Development Engineers

We wish to recruit additional Senior Engineers capable of accepting responsibility for the development of electronic equipment for the wide range of industries which our clients come. The Company is currently engaged in computer peripherals, microprocessors, video signal processing and industrial instrumentation. Much of the work is connected with our clients' large scale engineering projects and provides good opportunities for experienced engineers to develop their careers in an expanding Company.

Applicants with considerable relevant experience preferably with a degree of equivalent qualification should write to:

Mr. J. D. Britton, Director
Loughborough Consultants Limited
University of Technology
Loughborough, Leicestershire LE11 3TU

Applications should include details of qualifications and experience, age and present salary. The Company offers good conditions of service including generous holidays and a first-class pension scheme. Starting salaries offered will be up to £5000 per annum.

(8512)

We are a well-established progressive, small company designing and manufacturing advanced electronic instruments. We have the following vacancies:

SENIOR TEST ENGINEER

With comprehensive knowledge and experience of complex digital logic. Minimum qualification C&G or H.N.C.

JUNIOR TEST ENGINEER

With working knowledge of analog and digital circuitry.

If you feel that you are the right person please contact us and we are sure we can make an offer which will satisfy your ambition.

Please write or ring **Mr. D. Pearson: 01-649 5321, Data Laboratories Limited, 28 Wates Way, Mitcham, Surrey CR4 5HR.**

(8523)

ELECTRONICS TECHNICIANS

When you see a good job advertised what do you look for next?

Obviously, before you contemplate a change of job and possibly area you must weigh-up your present job prospects, pay and surroundings and measure them against those that have attracted you.
Really that's all we want you to do NOW—we are confident that the combination of Marconi Instruments and its locations in St. Albans and Luton will persuade you to give very serious consideration to the appointments we have vacant.

Job Satisfaction
If you would like working for a successful Company you'll like us—66% of our products ranging from microwave test equipment to automated test systems are exported. Unlike any other in the business we achieved the 'double' in 1977 with the Queen's Award for both Exports and Technological Achievement—just two reasons why our people have every reason to be proud of their Company and its expertise.

Housing
The Hertfordshire/Bedfordshire area is probably one of the most picturesque of the counties surrounding London and contains some very reasonably priced housing both of the modern and rural varieties. The average family house is priced in the region of £16,000 to £22,000.

Schooling
The family man will be particularly impressed with the local schools both Junior and Senior—modern, spacious buildings are the order of the day and individual successes are very encouraging.

Sports and Social Activities
For the energetic our own sports and social club is very active, particularly with the recent addition of a squash court. Golf courses, cricket and football clubs abound and for the less energetic many social activities are available.

Local Amenities
If you still have time on your hands you will enjoy a visit to the theatre in either St. Albans, Luton or Watford. The local Rep. is very well supported.

All in all we can offer you a really worthwhile job, attractive pay, relocation and equally important, excellent local surroundings. Why not ring John Prodger, Personnel Officer, he lives locally and can give you first hand information about the jobs and surrounding districts.

MARCONI INSTRUMENTS LIMITED
Longacres, Hatfield Road, St. Albans, Herts.
Tel: St. Albans 59292 or after 6pm and weekends St. Albans 30602

(8562)

mi A GEC MARCONI ELECTRONICS COMPANY

Radio Engineer

Up to £7,990 (married) £5,752 (single)
Inclusive of TAX FREE supplements*

Required by the Department of Civil Aviation, Ministry of Power, Transport and Communications

Requirements:

3 'O' levels, or Electronics or Telecommunications Engineering apprenticeship or appropriate Army, Air Force or Navy Trade Certificate; appropriate I.C.A.O. or D.C.A. Certificate of Competency, driving licence; knowledge/experience of two of the following communications groups:

a) Medium-powered HD transmitters and associated receivers
b) Low and high-powered VHF AM direction finders
c) Instrument landing systems.
d) Radar X & S, Bank Terminal and PPI talk-down equipment
e) Audio/remote-control equipment, PA's, inter-officer communication, underground control cables, impulses and D.C switching
f) Teleprinter telegraph (Torntape) and associated page printer type readers (autoleads), printing reperforators and associated switching equipment.

Responsibilities:

To ensure that telecommunications systems allocated are properly maintained, field technical duties at outstations plus reports

*The British Government pays TAX FREE supplements to British Nationals. These supplements are reviewed annually but at the present time are up to £5,046 (married) and £2,808 (single). The salaries quoted are at the current exchange rate with the Kwacha and subject to fluctuation

As well as salary and supplements you will also be entitled to a TAX FREE terminal gratuity, low cost accommodation and free passages. Together, these add up to exceptional real earnings. The salary quoted is the maximum on the scale and starting salaries will relate to qualifications and experience

For those receiving supplements the British Government also gives appointment grants, education allowances, car loans, medical aid assistance and free holiday visits for children educated in Britain

For further information please send full personal/professional details (without obligation and in total confidence), to: Recruiting Officer, Zambia High Commission, 7-11 Cavendish Place, London W1

(8534)

ZAMBIA

AUDIO + VIDEO LTD.

SENIOR VIDEO ENGINEERS AND HIGH GRADE TELEVISION ENGINEERS

Because Audio + Video are the largest video duplicators in Europe, we naturally have a lot of high-class equipment tp produce our top quality video tapes. We have in house, the Marconi D.I.C.E., the Rank Cintel Flying Spot Telecine, the RCA TK28 Telecine, TR60, TR70c and Ampex 2000 2" Quad machines, Sony D100 duplicator, 2850, 2600, 2030, 2630, Betamax, Philips VCR 1500 and 1700, VHS, Keyline editor, etc.

We now require Senior Video Engineers with experience of maintaining and servicing any or all of the above equipment and high grade Television Engineers who can be trained to help maintain most of it. We will pay salaries in excess of £5,500 for the right people who enjoy working in television.

Please contact Cliff Carroll on 01-580 7161.

(8446)

Electronics Engineer/ Technician

for Electronic Test and Measurement Equipment

The Lucas Research Centre, a modern spacious laboratory, situated in the green belt, provides an R & D service to the whole of the Lucas Group. The wide range of advanced technology being used requires an interesting and varied complement of electronic laboratory equipment.

We wish to recruit an engineer/technician to assist in fault finding, repairing and calibrating this equipment together with the provision of service records and safety checks.

Work situations range from fault finding on complex circuits associated with oscilloscopes, pulse/function generators, various analysers, DMM's, counter/timers etc. to the simpler but responsible task of checking equipment for safety.

Candidates are likely to be over age 30, educated to HNC/T6, with recent experience in this type of work.

The location is 15 miles from Stratford-on-Avon with excellent social, housing, school and shopping facilities close at hand.

Applicants, male or female, should write quoting this advertisement and state briefly their age, recent work experience and qualifications. They will be asked to complete an application form in detail.

Apply to: The Personnel Manager,
Lucas Group Services Limited,
Lucas Research Centre,
Monkspath, Shirley,
Solihull,
West Midlands B90 4JJ.

Lucas

(8502)

Home Office

telecommunications

We require staff, male or female, to prepare and maintain the latest in communications equipment used by the Police and Fire Brigades in England and Wales.

You will need to be qualified at least to City and Guilds Intermediate Telecommunications standard and be able to demonstrate practical skills in locating and diagnosing faults in a wide range of equipment from computer based data transmission to FM and AM radio systems. You would live near to and work from our service centres located throughout England and Wales or our Headquarters in the London area. Specialised courses of training are run to assist staff to keep up to date with developments and new equipment, and there are opportunities for day release to gain higher qualifications. Applications from registered disabled persons will be considered.

Promotion prospects are good and the work represents a secure future with generous leave allowances and a non-contributory pension scheme.

Possession of a driving licence is essential since some travelling will normally be involved.

The salary is £2627 (at 17), £3176 (at 21) and £3700 (at 25), rising to £4252.

If you are interested in working with us, then write for further details and an application form to —

Mr C B Constable
Directorate of Telecommunications
Horseferry House
Dean Ryle Street
LONDON SW1P 2AW
Telephone: 01-211 6420

(8428)

REW AUDIO VISUAL CO.

THE LEADING VIDEO DEALERS

GENERAL MANAGER

Due to reorganisation and expansion we have a vacancy for an energetic and self-motivated person. The successful candidate will be based at company head office at Colliers Wood, will be responsible for the efficient operation and co-ordination of various departments. Previous experience in a similar position essential. Excellent salary negotiable. Company car plus expenses.

TECHNICAL MANAGER

for Video/CCTV Systems Division. Due to expansion a vacancy occurs for a suitable person with previous experience in Video/CCTV fields. The successful candidate will be required to motivate and lead the existing team, should be able to negotiate at all levels and ideally will currently hold a similar position. Competitive salary, company car, expenses and excellent prospects for the right person.

VIDEO SALES REPRESENTATIVE

Professional representative required to sell video equipment, tapes and accessories to end users. An opportunity for an enthusiastic and self-motivated person to join a successful company. Product training given, competitive salary plus company car. Commission and expenses for the right applicant.

Please write in confidence to:

M. Murray, Managing Director
REW AUDIO VISUAL COMPANY
Rew House
10-12 High Street, Colliers Wood
London, SW19 2BE

(8554)

Radio Communications Electronics Engineers and Software Designers

Mid-Sussex - S.W. London

Salaries up to £7,000

To join our expanding R & D Laboratories covering a wide range of the R. F. spectrum, from L.F. to V.H.F. Equipments include transmitters and receivers for marine and land based use, radio navaids and radio monitoring remote computer controlled systems.

Electronics Engineers should have experience in transmitter or receiver design, analogue or digital circuit design, micro processor applications.

Software Designers should be experienced Programmers with an interest in control, signal processing or navigational software.

Attractive salaries are complemented by excellent prospects and generous benefits.

Contact: The Personnel Manager, Redifon Telecommunications Limited, Broomhill Road, Wandsworth, London, S.W.18. Phone: 01-874 7281 (Reverse charge).

(8315)

Sound out your new career in Hi-Fi

Hardman's are now the No. 1 name in hi-fi retailing in Birmingham, Chester, Liverpool, Manchester and Preston with superb spacious showrooms offering the best hi-fi selection in town. But we're not just a single fast expanding company with five stores and more to follow; we're part of a large and successful Group with interests throughout the leisure industry. To you that means the big benefits that only a large Group can offer you: security plus the almost unlimited scope that an enthusiast like you will relish.

Expansion has created these vacancies in all five stores:

Senior Audio and Hi-Fi Sales Staff

You must have a proven sales ability and/or sound audio or hi-fi experience. We'll give you specific sales training and keep you up to date with regular seminars. Good salary plus commission. PLUS excellent opportunities for promotion to management within the group.

Hi-Fi Engineers

You're a qualified hi-fi/audio/video engineer, or you're mid way through an apprenticeship scheme with no immediate opportunities. You'd like to service, test and repair hi-fi equipment in our well-equipped premises. We'll tell you all about the equipment and keep you updated on new developments. Excellent salary.

Please write for an application form to:

The Managing Director, Hardman Radio Limited, 26 Exchange Street East, Liverpool, L2 3PH.

(8401)

Talk to the helpful Hi·Fi people

HARDMANS

INSTRUMENT TECHNICIANS

FOR THE OIL INDUSTRY

NEC Gas, the only British company offering formation mud logging services to the oil industry, is rapdily increasing its penetration in both North West Europe and Overseas.

This expansion has created excellent opportunities for experienced Instrument Technicians to become involved in a variety of development, commissioning and maintenance projects both on and offshore. Although based at Kilwinning, Ayrshire, offshore working would amount to a total of around 100 days per year and candidates would be expected to travel, sometimes at short notice, both in Europe and Overseas.

Applicants should be qualified to H.N.D. standard and have at least 3 years' experience in industrial electronics, electronic process instrumentation or a related field. Although not essential, experience with digital logic systems and/or gas analytical instruments would be an advantage.

Candidates in good physical shape who can show above average commitment both in initiative and in the ability to work under arduous conditions will be suitably rewarded by the company, financially as well as in terms of career progression.

Write or telephone:

NEC

NEC Gas Analytical Services International Ltd.,
2/4 Simpson Place,
Kilwinning, Ayrshire.
Tel: 0292 41752

(8580)

Systems Test Engineer

for Pye TVT, the Broadcast Company of Philips

We now have vacancies in our Test Department for Systems Test Engineers.

The job carries responsibility for the preparation of complete TV systems to meet final acceptance by the customer.

Duties therefore include diagnosing deviation and changing faulty units and components, setting up and aligning complex systems and generally ensuring that the performance required of the system is achieved.

Pye TVT offer pleasant working conditions, generous holiday entitlement and relocation expenses.

For an application form, contact
David Barnicoat, Personnel Officer,
Pye TVT Limited, Coldhams Lane,
Cambridge CB1 3JU
Telephone Cambridge (0223) 45115.

Pye TVT Limited
The Broadcast Company of Philips

(8582)

£15,000 YOUR WAVELENGTH

If you are a successful **Sales Person/Manager** but are not quite tuned in to your present career you could be the person we are looking for.

Please phone us on 01-580 9183
Penthouse Personnel Consultants

(8561)

DEVELOPMENT/TEST ENGINEER

ELECTRONICS STOCKPORT

A small design and development team working on a new application in the field of numerically controlled machines, require an Engineer who will be responsible for the day-to-day running of the electronics laboratory. He will be expected to construct and test prototype equipment working from engineers sketches and to assist in the development of special purpose test equipment.

The post provides an opportunity for an enthusiastic young Engineer to develop his skills both in circuit design and micro/mini-computer programming.

The salary will be in the range £3,000 to £3,500 depending on qualifications and a written application is requested.

Neric Automation Ltd.
P.O. Box 64
Whitehill Industrial Estate
STOCKPORT, Cheshire SK4 1QT

(8522)

SITUATIONS VACANT

Electronics Engineer

The Diesel Division of Rolls-Royce Motors Limited, is continuing its expansion and investment programme. To meet the demands of this expansion we are looking for an Electronics Engineer who will be responsible for the design and development of electronic measuring equipment used in the Research and Development Testing of Diesel Engines.

The work involves all stages of equipment development, from initial conception to construction of working prototypes, and is mainly concerned with signal conditioning, recording and computer data acquisition.

Applicants (male or female) should possess a Degree or HNC/HND in electronics engineering and have had at least 3 years relevant experience.

Job prospects are excellent and we offer a good range of fringe benefits, including Contributory Pension Scheme, Sickness Scheme, Subsidised Canteen, and generous relocation allowances where applicable.

Please write in confidence, with brief details of age, qualifications, experience and salary, to:

Paul Sambrook,
Personnel and Training Officer,
Rolls-Royce Motors Limited,
Diesel Division,
Shrewsbury SY1 4DP.

ROLLS-ROYCE MOTORS
Diesel Division

(8425)

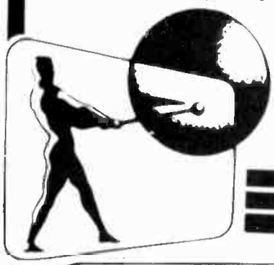
Electronics Engineers

Are you technically ambitious? Are you looking for a challenging job? If you are then opportunities exist at Rank Research Laboratories, a Company within the Rank Organisation.

We are looking for engineers (male or female) who are keen to tackle interesting work in the following fields — automatic production aids, automatic test equipment, specialised machining processes and controls, new electronic device applications and thermal imaging systems for industrial, military and medical applications.

If this is the type of work that excites you and are seeking to broaden your knowledge, then you could be the person we are looking for.

Ideally you will possess a degree, HND or HNC in Electronic Engineering and have two or three years' practical experience in electronic circuit design. Your salary will be competitive and negotiable, supplemented by the excellent Rank Organisation benefits package.



If interested, please drop a line to the Director of Rank Research Laboratories for an application form at: PO Box 33, Phoenix Works, Great West Road, Brentford, Middlesex TW8 9AG.

RANK RESEARCH LABORATORIES

(8495)

THORN CONSUMER ELECTRONICS LIMITED

TELEVISION ENGINEER

A young engineer is required to join a team involved with the research and development of television receivers for overseas markets. He or she will also be concerned with other related activities including application and feasibility studies and direct liaison with U.K. and overseas personnel.
The ideal candidate will be qualified to H.N.C. level or equivalent and have knowledge of current television receiver technology.

Please write in the first instance giving brief details of career to date to

Personnel Manager (TE/WW), Thorn Consumer Electronics Ltd.
Great Cambridge Road, Enfield, Middlesex EN1 1UL

THORN

(8553)

ST. GEORGES HOSPITAL, S.W.17

ELECTRONIC MAINTENANCE TECHNICIAN III

A new position has been created in the recently formed department of Electronic Maintenance at St. George's Hospital, S.W.17.

This post is intended to expand the existing electronic servicing to a hospital which is in the process of being re-built and enlarged.

Knowledge of medical equipment is desirable but experience in servicing a wide range of electronics equipment is essential.

Salary £3,744 to £4,788 + London Weighting.

For further information write or telephone to

The Assistant Unit Administrator, St. George's Hospital, Blackshaw Road, Tooting, S.W.17 0QT. Tel. 01-672 1255, Ext. 4121. (8509)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH AGY, 46 SELVAGE LANE, LONDON, NW7. 01-959 3517.**

(8490)

T.V./VIDEO ENGINEER

With at least five years experience required by rapidly expanding video company to service and maintain semi professional video cassette recorders, cameras, monitors and additional equipment. Salary negotiable.

Contact: Val Moore, 289 0123

(8584)

ARTICLES FOR SALE

THE FABULOUS D2 MICROPROCESSOR EVALUATION KIT FROM MOTOROLA

Featuring '24 key keyboard 'Seven segment display 'Cassette interface 'Erom & Ram Expandable 'Interface Capability. 'Full Documentation '5 Volt power supply required 'One year's FREE membership of The Amateur Computer Club with every purchase' **£176** + £1.50 P&P + 8% VAT.

ENAMELLED COPPER WIRE

SWG	1 lb	8 oz	4 oz	2 oz
14-19	2.60	1.40	.66	.55
20-29	2.80	1.60	.85	.65
30-34	3.00	1.70	.95	.70
35-40	3.35	1.90	1.10	.79
40-43	4.50	2.50	1.90	1.25
44-46	5.00	3.00	2.10	1.65
47	8.00	5.00	3.00	1.76
48	15.00	9.00	6.00	3.30

Tinned Copper. Even Gauges 14-30 £3 per lb. Multicore 60/40 Solder 18SWG £3.24 per lb. Prices include P&P and VAT.
SAE brings list of copper and resistance Wires.

THE SCIENTIFIC WIRE COMPANY
PO Box 30 London E.4 (7771)

VHF MONITOR RECEIVERS, air, marine or business bands (low, mid, high or AM or FM). All crystal controlled high performance models. Send 15p P.O., not stamps, Radio Communications Ltd, St Sampsons, Guernsey, Channel Isles.

ELECTRONIC KITS — SAE for new catalogue, and clearance list of obsolete kits. AMTRON, 7 Hughenden Road, Hastings, Sx. (8226

REWINDING TRANFORMERS, a new manual covering 1VA to 5KVA single phase, from Magnum Power Tools, Brinksway, Trading Estate, Stockport, Cheshire, SK3 0BZ. £4.30 post paid by return. (8230

60KHz MSF Rugby Receiver, BCD TIME OF DAY OUTPUT. High performance, phase locked loop radio receiver, 5V operation with 1 second LED indication. Kit complete with tuned ferrite rod aerial £14.08 (including postage and VAT). Assembled circuit and cased-up version also available. Send for details, Toolex, Sherborne (4359), Dorset. (8252

SITUATIONS VACANT

Field Service Engineers

Electronics

N.W. London £4-5,000+car

Linotype-Paul is a world leader in the design and manufacture of computerised photocomposing equipment and associated peripherals. With a widening range and an ever increasing demand for our products, as well as new service contracts, we have a substantial requirement for further Electronics Service Engineers in the following areas.

Phototypesetters

We are looking for Digital Engineers at BSC/HNC or equivalent level, particularly those with a knowledge of computer technology, to service our large and medium sized phototypesetters.

V.D.U.'s

We would like to hear from Engineers with field experience in computers and peripherals, with HNC/ONC or equivalent qualifications.

In the main, we want men and women who either live or are prepared to move to within one hour's driving distance of our office in Kingsbury.
The appointments offer stimulating opportunities to work with the latest electronic technology and entail thoroughly interesting and varied work in a lively and professional environment. Individual career prospects are excellent. In addition to the benefits you would expect from a progressive company, we offer a company car, generous expenses, and relocation assistance where appropriate.

Please ring or write to David Hilton, Personnel Manager, Linotype-Paul Limited, Kingsbury Works, Kingsbury Road, London NW9 8UT. Tel: 01-205 0123

Linotype Paul

(8536)

Development Test Engineers

Electronics

Wouldn't you like to work in a well-equipped laboratory that's got the best in modern equipment, including ATE and manual testers?

And wouldn't you like to work for a company renowned for advanced technological innovations?

Ferranti are looking for Development Test Engineers to prove specifications and test equipments; also to test and fault diagnose on a wide variety of prototype and pre-production equipment.

If you have an ONC/HNC or C&G in electronics together with the experience and enthusiasm to tackle the job, Ferranti can offer you a good salary (opportunities for overtime if you want it), a productivity bonus scheme, flexible working hours and other benefits associated with a large and successful company.

You have nothing to lose, and probably a great deal to gain by talking to us. So why not telephone or write to

The Personnel Department
Ferranti Computer Systems Limited
Western Road
Bracknell, Berkshire
Tel. 0344 3232, ext. 471
Please quote reference no. D/855/WW

FERRANTI
Selling technology

9535

ARTICLES FOR SALE

UNDERSTANDING DIGITAL ELECTRONICS

By Texas Ins. **Price £3.95.**

CHEAP VIDEO COOKBOOK by D. Lancaster **Price £6.95.**

BEGINNER'S GUIDE TO MICRO-PROCESSORS by C. M. Gilmore. **Price £4.85.**

MINIPROCESSORS FROM CALCULATORS TO COMPUTERS by D. L. Heiserman **Price £4.85.**

REPAIRING POCKET TRANSISTOR RADIOS by I. R. Sinclair. **Price £2.50.**

USING DIGITAL AND ANALOG INTEGRATED CIRCUITS by L. W. Shacklette & H. A. Ashworth. **Price £8.50.**

HOW TO BUILD YOUR OWN STEREO SPEAKERS by C. Robin. **Price £12.00.**

WORLD DX GUIDE by J. Vastenhoud. **Price £5.30.**

OP-AMP CIRCUIT DESIGN & APPLICATIONS by J. Carr. **Price £4.00.**

FOUNDATIONS OF WIRELESS AND ELECTRONICS 9th Ed. by M. G. Scroggie. **Price £4.25.**

DESIGN TECHNIQUES FOR ELECTRONICS ENGINEERS. Price £11.60.

All Prices Include Postage

THE MODERN BOOK CO.
SPECIALISTS IN SCIENTIFIC & TECHNICAL BOOKS
19-21 PRAED STREET
LONDON W2 1NP
Phone 723 4185
Closed Sat. 1 p.m.

44;

BRUEL & KJAER low noise measuring amplifier type 2607. Precision sound/vibration measurement 10/UV to 300V. List £2,000 plus. Offers. 0827 892378. (8410

DIGITAL CAPACITANCE METER, 2½ digits. 1PF to 10UF in 6 ranges. acc. ±2%. £25 inc. C. Tsang DI.I Keynes College, Canterbury, Kent CT2 7NP. (8438

SADIE (IBM 735) input/output typewriter with fitted desk £200. Buyers collect, Essex (0787) 60055. (8570

NASCOM 1 built and working, keyboard and literature. Offers Box No. WW8566.

5 VOLS. Wireless World, 1950-1954, £3 per volume. Tel. 06755-2342. (8558

TIFAX MODULE, and data £71, Chess challenger, new 10 level version, normally £200, special £175. Large s.a.e. details. TCA 730/740 DC stereo, remote control devices, normally £5.98, special including data £2.95, T.T.L. Cadd (15p P&P) 74150 83p, 7400 8p. Mail order. Jagberry Limited, 95 Ardwell Ave., Ilford, Essex. (8563

LINSLEY-HOOD cassette recorder, complete Hart electronics kit available, £70, plus £2 postage if not collected. Box No. WW8565.

Classified

ARTICLES FOR SALE

EXCLUSIVE OFFER

RACK MOUNTING CABINETS
HIGHEST QUALITY 19"

Ref	Ht"	Width"	Depth"	Price
PE	10	21	13	£10.00
LL10	54	21	18	£20.00
TT	64	25	26	£45.00
SL	71	25	26	£50.00
PT	72	20	21	£20.00
TK	75	22	21	£20.00
ST	85	22	24	£70.00
Racal cabinets for RA-17/117				£30.00

Over 60 types available from 12" to 90" high.
Also twins, triples and consoles. Below are only a few types. Please send for full list.

AUDIO AND INSTRUMENTATION-TAPE RECORDER-REPRODUCERS

★ Plessey 1033 Digital Units. 7 track ½
★ Plessey M5500 Digital Unit. 7 tracks ½
★ Amplex FR-1100. 6 speeds. stereo ¼
★ Ampex FR600. 4 speeds. 7 track ½
★ D.R.I. RM1. 4 speeds. 4 tracks ¼
★ Mincom CMP-100. 6 speeds. 7 tracks ¼, ½, 1
★ Leevers Rich DA-2P. 2 speeds. 2 tracks 1¼
★ Leevers Rich Console. 2 speeds. 2 tracks ¼"

Prices of above £70 to £500

Also Transport Decks only available

We have a large quantity of "bits and pieces" we cannot list — please send us your requirements, we can probably help — all enquiries answered.

All our aerial equipment is professional MOD quality

★ Thermionic Time Injection Units £70
★ Manson TFM-101 Multipliers £240
★ Bradley CT 471B Electronic Multimeters £90
★ Servomex 2kw Auto-regulators £130
★ 125ft. Lattice Masts. 26" sides .... P.U.R.
★ 30ft. Lattice Masts. 14" sides £55.00
★ 10ft. Light Lattice Sections. 6" sides £18.00
★ Rhode and Schwarz Polyscopes SWOBI £450.00
★ Rhode and Schwarz SMLM Sig Gens £375.00
★ Roband Oscilloscopes 50A and plug-ins £190.00
★ Solartron CD 523 Oscilloscopes £95.00
★ Solartron CD 426 Oscilloscopes £90.00
★ Solartron CD 1014 Oscilloscopes £110.00
★ Solartron CD 1016 Oscilloscopes £95.00
★ Kay Sonographs £225.00
★ Munson Multimeters .... P.U.R.
★ Weinshel Precision Attenuators .... P.U.R.
★ Aerial Rotator Displays £90.00
★ Coquelet Code Teleprinters £250.00
★ EMI ½" Audio Tape 3600 FT Nab £4.50
★ 25-watt R.C.W. Experimental Speakers £25.00
★ SE4/2B C.R.T.s £18.00
★ SE5/2A C.R.T.s £19.00
★ 3AZP/Z (DMN-9) C.R.T.s £19.00
★ Plessey 3 & 6KCS S.S.B. filters £14.00
★ AVO CT 471A Electronic Multimeters £75.00
★ EMI R 301 Tape Recorders £40.00
★ Stenorette L Tape Recorders £29.00
★ DG-7-32 C.R.T.s £4.00
★ DG-7-5 C.R.T.s £4.00
★ Uniselectors. 10 Bank 25-way £3.50
★ 40ft. Sectional Aluminium Masts. complete ... £55.00
★ Racal MA-79 Universal Drive Units £450.00
★ Racal RA-17P Receivers (new) £950.00
★ Rhode & Schwarz ESM Tunable VHF Receivers 180-300 M/cs £285.00
★ Rhode & Schwarz HFH Field Strength HF Loop Aerials £140.00
★ Narda 504 Freq. meters 200-500 M/cs £45.00
★ B&K 2409 Electronic Multimeters £55.00
★ Multi-purpose Trolleys with Jacks 19 x 17 ... £16.00
★ Rhode & Schwarz fibreglass HA Diversity Dipoles £120.00
★ Ion pump power supply. E.H.T. £44.00
★ E.M.I. Documents CCTV Outfit £250.00
★ Advance 3KVA CV Transformers £150.00
★ Grainger HF Long Log Aperiodic Aerial ...... P.U.R.
★ Metal V.D.U. Tables 30" x 36" x 30" £24.00

MANUALS
We have a quantity of Technical Manuals of Electronic Equipment, not photostats. 1940 to 1960. British and American. No lists. Enquiries invited.

★ Data Efficiency Respoolers 240v £28.00
★ Belling Lee 100 Amp Interference Filters £76.00
★ Oscilloscope Trolleys from £18.00
★ Racal MA197B pre-Selectors £65.00
★ Rack Mounting Operator Tables £10.00
★ Gaumont Kalee 1740 Flutter Meters £75.00
★ Heavy Aerial Rotators .... P.U.R.
★ 75ft Aluminium Lattice Masts. 20" sides ... £400.00
★ Rhodes & Schwarz SBR sig. gen. 1.6 2.4 gmc £470.00
★ Large Aerial Turning Units .... P.U.R.
★ 45 feet Uniradio 4 Co-ax 50 ohms £2.00
★ Addo 5 8 Track Punches £48.00
★ Quality Weather Vanes 8 contacts (unused) ... £25.00
★ Racal MA-175 I.S.B. Modulators (new) £45.00
★ Imslide Cabinet Shelf Sliders £3.00
★ Tally 5 8 Track Tape Readers 60 cps £48.00
★ Tally 5 8 Track Tape Readers Track Spooling . £65.00

We have a quantity of Power Transformers 250 watts to 15KVA at voltages up to 40KV. Best quality at low prices. Lists available.

★ Racal RA-64 SSB Adaptors. new £70.00
★ Racal RA 298 L.S.B. Transistorised Converters (new) £120.00

We have a varied assortment of industrial and professional Cathode Ray Tubes available. List on request.

PLEASE ADD CARRIAGE AND V.A.T.

P. HARRIS
ORGANFORD, DORSET, BH16 6BR
BOURNEMOUTH (0202) 765051

COLOUR, UHF AND TV SPARES. CEEFAX, ORACLE IN COLOUR. MANOR SUPPLIES "EASY TO ASSEMBLE" TELETEXT KIT. Including TEXAS Decoder. Aerial Input, completely external unit, no further connections to set. Full facilities, mixed TV programme and Teletext, Newsflash. Update, and many special features not found in other units. Demonstration model in operation at 172 West End Lane, NW6. Phone or write for further information. **TEXAS TIFAX XM11** Decoder module, new, £130, p/p £1.00. **NEW COMBINED COLOUR BAR GENERATOR PLUS CROSS HATCH KIT (Mk4)** UHF Aerial input type. Eight vertical colour bars plus R-Y, B-Y, Luminance combinations, Grey scale etc. Pushbutton controls. Battery operated £35*, De Luxe case £4.80*, aluminium case £2.40*, battery holders £1.50*, mains supply kit £5.78*, p/p £1.00. Built and tested (battery) £58*, p/p £1.20. **CROSS HATCH KIT,** UHF Aerial input type, also gives peak white and black levels. Battery operated, £11* p/p 45p. Add-on Grey Scale kit £2.90* p/p 35p. Aluminium case £2*, p/p 85p. Cross Hatch Unit,* complete and tested in De Luxe case £20.80*, p/p £1. **"WIRELESS WORLD"** TV Tuner and FM Tuner Projects by D. C. Read. Kits of parts available, CRT test and reactivator kit for colour and mono £19.80 p/p £1.20. UHF Signal Strength Meter kit £18* p/p 90p. 625 TV IF Unit for Hi-fi amps or tape recording £6.80 p/p 70p. Decca Colour TV Thyristor Power Supply Unit, incl. H.T., L.T., etc. Incl. circuits £3.80 p/p £120 Bush A823 (A807) decoder panel £7.50 p/p £1. Bush 161 T-B panel A634 £3.80, IF panel A583 £3.80 p/p 90p. Bush Portable TV 11V stab power supply unit £4.80 p/p £1. Bush CTV 25 Convergence Panel plus yoke, blue lateral £3.60 p/p 90p. Philips Single Standard Convergence Units complete, incl. 16 controls £3.75 p/p 85p. Colour Scan Coils, Mullard or Plessey, £6 p/p 90p. Mullard AT 1023/05 Converg. Yoke £2.50 p/p 75p. Mullard or Plessey Blue Laterals 75p p/p 35p. BRC 3000 type Scan Coils £2 p/p 90p. Delay Lines: DL20 £3.50. DL50 £3.50. DLIE, DLI 85p p/p 45p. Lum delay lines 50p p/p 40p. G8 Tripler £6. BRC 300 Tripler £6.60 p/p 75p. Others available. Philips G8 Decoder part-complete £2.50 p/p 75p. GEC 2040 Ex-Rental Panels. Decoder £5.00. Time Base £5.00, p/p 90p. VARICAP TUNERS UHF: Gen. instr. £3.50. ELC 1043 £4.50, ELC 1043/05 £5.50. VHF: ELC 1042 £4.80, Philips VHF £3.80. Salvaged UHF & VHF Varicaps £1.50 p/p 35p. VARICAP CONTROL UNITS, 3 position, £1.20. 4 PSN £1.50, 5 PSN £1.80, 7 PSN £2.80. Special offer 6 position £1, p/p 35p. UHF Transd. Tuners incl. slow motion drive £2.80 4 position push button £2.50. 6 psn. £4.20, p/p 90p. Helical Pots 100K, 4 for £1.20 p/p 30p. Thorn 850 Dual Std. Time Base panels 50p. Philips 625 IF panel incl. oct. 50p p/p 70p. Mullard Mono Scan Coils for Philips, Stella, Pye, Ekco, Ferranti, Invicta £2.00 p/p 85p. Large selection LOPTs, FOPTs available for most popular makes. MANOR SUPPLIES 172 WEST END LANE, LONDON, N.W.6. Shop Premises. Callers welcome. Thousands of additional items available not normally advertised. (Nos. 28, 159 buses or West Hampstead-Bakerloo Line and British Rail). Mail Order: 64 Golders Manor Drive, London, N.W.11. Tel: 01-794 8751. V.A.T. Please ADD 12½% TO ALL PRICES (EXCEPT WHERE MARKED*. V.A.T. 8%). (60

WE INVITE ENQUIRIES from anywhere in the world. We have in stock several million carbon resistors, ⅛, ¼, ½ and 1 watt, ½ million wire wound resistors 5 and 10 watt — 1 million capacitors — 1 million electrolytic condensers — ½ million transistors and diodes, thousands of potentiometers, and hosts of other components. Write, phone or call at our warehouse. — Broadfields and Mayco Disposals Ltd., 21 Lodge Lane, North Finchley, London, N.12. 01-445 0749, 445 2713. (8403

SURPLUS TO REQUIREMENTS
NEW PLASTIC TTLs — ITT

DEVICE	£ EACH	DEVICE	£ EACH	DEVICE	£ EACH
7401N	0.06	7492N	0.24	74160N	0.30
7433AN	0.15	7495N	0.23	74162N	0.37
7433N	0.15	7496N	0.30	74163N	0.37
7443N	0.31	74104N	0.16	74165N	0.41
7445N	0.22	74105N	0.16	74175N	0.29
7446N	0.22	74109N	0.14	74180N	0.35
7446AN	0.22	74122AN	0.16	74190N	0.49
7448N	0.18	74131N	0.13	74193N	0.35
7451N	0.06	74139N	0.13	74194N	0.35
7483N	0.28	74151N	0.25		
7484N	0.36	74156N	0.28		

MINIMUM ORDER VALUE £50 + 8% VAT
MINIMUM QUANTITY 25 OF ANY ONE TYPE

R. S. EVANS & CO.
BIRMINGHAM ROAD, SHENSTONE
NR. LICHFIELD, STAFFS.
(0543-480694) (8527)

SOWTER TRANSFORMERS

WITH 37 YEARS' EXPERIENCE we have the expertise to design and manufacture ANY TYPE OF AUDIO TRANSFORMER AT THE RIGHT PRICE

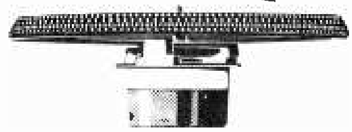
Whilst we specialise in every kind of transformer for audio control decks and mixers, demands are increasing for **LOUDSPEAKER TRANSFORMERS** and **100 VOLT LINE AUDIO OUTPUT TRANSFORMERS** for most kind of amplifier from 30 watts to 500 watts output. We have standard designs for AMCRON and BOSE amplifiers and can also supply **Multi-output transformers for COLUMN LOUDSPEAKERS** in a wide variety of powers. A recent tendency is the demand for **OUTPUT TRANSFORMERS FOR ULTRA LINEAR VALVE AMPLIFIERS** using KT88 and KT66 BEAM TETRODES and for these we have standard designs with exceptional performance. Many of our output transformers for loudspeakers have been installed in Theatres, Television Studios, Lecture and Concert Halls, Churches and Outdoor Arenas whilst others are in constant use for high quality portable Public Address Systems. We will supply single transformers, or any quantity, with short delivery times and, without obligation on your part, will quote price and exact dispatch on receipt of your requirements.

KINDLY NOTE OUR NEW ADDRESS AND TELEPHONE NUMBER: E. A. SOWTER LTD., Transformer manufacturers and designers, P.O. BOX No. 36, IPSWICH IP1 2EL, ENGLAND. Tel: Ipswich (0473) 52794-219390. (8289)

MSF 60KHz

TIME RECEIVER, built-in antenna 1000 Km range. £13.70 or with parts (no case or pcb) for sequential YEAR, MONTH, DATE, DAY, HOURS, MINUTES, SECONDS display £24.40
PROGRAM YOUR OWN tunes on a Musical Doorbell, new tune each day, needs bell transformer and speaker. £19.50
SIG. GEN.? 10Hz-200KHz, sine/square £10 80
V.L.F.? 10-150 KHz Receiver £10 70
Each easy-assembly kit includes all parts, printed circuit, case, postage, etc., money back assurance so SEND off NOW
CAMBRIDGE KITS
45(WL), Old School Lane, Milton Cambridge. (8568)

BUILD YOUR OWN HIGH QUALITY TURNTABLE



Direct drive motor/die cast turntable pack - £25.00

Further details of these top quality components in return for s.a.e - or personal callers welcome.

Add £2.50 for post & packing within UK and Eire
Ask for quote on export packing.

Symot Limited,
22a, Reading Road Henley on Thames
Oxfordshire RG9 1AG
Telephone (049 12) 2663 8583

COMMUNICATIONS L.W.B. LAND ROVER, fitted Clark 40ft mast, air compressor, capstan winch, roof-rack, etc., exc. cond., 48,000 miles, ex Belling Lee £2,250. Tel. 0468 61819. (8569

ELECTRONIC KITS — SAE for new catalogue, and clearance list of obsolete kits. AMTRON, 7 Hughenden Road, Hastings, Sx. (8579

CRYSTALS for MPU, timing, markers. Large stocks — HC13/U: 100 kHz £3.25, HC6/U: 200.0, 240.0, 262.144, 307.2, 312.5, 455.0 kHz, £3.85. HC33 U: 1.0, 2.0, 3.0, 1.008, 1.8432, 2.4576, 2.5625, 3.2768 MHz £3.35. 3.579 and 4.433 £1.20 ea. HC18/U: 4.0, 5.0, 6.0, 7.0, 8.0, 10.0, 10.7, 18.0, 20.0, 4.096, 4.194, 4.608, 4.8, 4.9152, 5.12, 6.144, 6.4, 6.5536, 18.432, 48.0 MHz £3.00. U.K. post paid. No V.A.T. Also low-cost AM/CW/SSB communication receiver modules. S.A.E. details P. R. GOLLEDGE ELECTRONICS, Merriott, Somerset, TA16 5NS. Tel. 0460 73718. (8572

SOLAR CELLS: bits, books and bargains. Send stamp for list or 95p for Solar Cell booklet and Data sheets. Edencombe Ltd, 34 Nathans Road, North Wembley, Middlesex HA0 3RX. (8292

PORTABLE TX/RX type RC555/TR minus crystals and batteries QYT5. Offers to Airport Director, East Midlands Airport, Castle Donington, Derby, before 10/9/78. (8530

LINSLEY-HOOD 75 watt power amp modules, built and tested, from £12.50 each. Complete module kit £10.50. Large range of spares in stock. Linsley-Hood 75 watt amps constructed and repaired. Details of kits and list of components free. Mains touch switch kit. 240V toggle action safe capacitive triggering, 400 watt resistive or inductive load. Details free. I. B. Bowman (Dept WW), 59 Fowey Avenue, Torquay, S. Devon. (8532

RF USERS! New UHF AC/DC Converters, vacuum junction, 50% per cent off normal price. While stocks last. Suitable for RF and UHF Power Measurement (5mA range, with 6mV open circuit output, 200 per cent overload permitted). £1.50 each plus 25p post and packing or, £7.50 pack of 6. Postage included (UK only). Cheque with order please. Allow 7 days for delivery. Prosser Transducers, Lady Lane Industrial Estate, Hadleigh, Ipswich IP7 6BQ. (8525

ARTICLES WANTED

WE PURCHASE ALL FORMS OF ELECTRONIC EQUIPMENT AND COMPONENTS, ETC.
SPOT CASH
CHILTMEAD LTD.
7, 9, 11 Arthur Road
Reading, Berks.
Tel. (0734) 582 605

RCATXs WANTED ET4336 or ET4332
also spares for same
WE PAY VERY HIGH PRICES
COLOMOR ELECTRONICS LTD.
170 Goldhawk Road, London W.12
01-743 0899 (8574)

WANTED IN LARGE QUANTITIES
Electronic components, resistors capacitors, potentiometers, chassis loudspeakers, semi-conductors, diodes, TV tubes, especially colours, etc., etc., etc. First or second grades Finished or incomplete products, record players, amplifiers, radios, tuners, tape recorders, enclosures, etc., etc., etc.
We will buy complete factories and pay cash
TEL. 01-491 4636
E.C.E. AVON HOUSE
360/366 OXFORD STREET
LONDON, W.4 (7950)

MINICOMPUTERS PERIPHERALS INSTRUMENTATION
For fastest, better CASH offer Phone:
CHILTMEAD LTD.
Reading (0734) 586419

STORAGE SPACE is expensive, why store redundant and obsolete equipment? For fast and efficient clearance of all test gear, power supplies, PC boards, components, etc., regardless of condition or qualities. Call 01-771 9413. (8209

TURN YOUR SURPLUS Capacitors, transistors, etc., into cash. Contact COLES-HARDING & Co., 103 South Brink, Wisbech, Cambs. 0945-4188. Immediate settlement. We also welcome the opportunity to quote for complete factory clearance. (7439

★ MINICOMPUTERS
★ PERIPHERALS
★ INSTRUMENTATION
For fastest, best CASH offer, phone
COMPUTER APPRECIATION
Godstone (088 384) 3221
7677

ELECTRONIC SCRAP. Components, etc., Receivers, Transmitters Test Equipment wanted. Ferrographs from £15 in stock. Contact M & B Radio, 86 Bishopgate Street, Leeds 1. Tel. Leeds 35649. (8011

WANTED ALL TYPES R/T equipment urgently, good prices paid. Ring Nauto Telecommunications Ltd, Norwich (0603) 24936 29444. (8392

B.D. ELECTRONICS offer prompt settlemen for surplus electronic components, t.v./audio spares are of particular interest. Contact Miss Hughes, 9 Westhawe, Bretton, Peterborough. Tel 265219. (7632

WANTED, all types of communications receivers and test equipment. Details to R. T. & I. Electronics Ltd., Ashville Old Hall, Ashville Rd., London, E.11. Ley 4986. (63

WANTED. Clean new semiconductors, IC's, etc. Good prices paid. Hewitts, 52 Barkby Road, Syston, Leics. LE7 8AF. (8571

ELECTRONIC EQUIPMENT and components bought and sold. Anytime considered, immediate cash settlement. Ring Mr Q. Yateley 0252 871048 any time. (8407

AR88D WANTED
WE PAY £90.00
for sets in good condition
COLOMOR ELECTRONICS LTD.,
170 Goldhawk Road, London W.12
01-743 0899 (8573)

WANTED: Quad video recorders, Ampex VR 1200, VR 2000, RCA TR70, any condition, cash waiting, collection worldwide. Box No. WW8564.

WE PURCHASE, FOR CASH the following: R. F. Power Transistors, Varactor Diodes, and all special components normally used in VHF/UHF Transmitting equipment. MODULAR ELECTRONICS, 95 High Street, Selsey Sussex. PO20-0QL. Tel. Selsey 2916. (7696

PRE-WAR Comn, receivers using B5 and B7 based valves. Also good S/H 2P's and TV4's. Box No. WW8559.

ARTICLES FOR SALE

TRANSFORMER PROBLEMS?
1VA-1KVA Prototypes in 7-10 days. Phone Vince Sellar on 06076-66716.
TRENT TRANSFORMERS LTD
Chapel Street
Long Eaton, Nottm.
(8363)

ENAMELLED COPPER WIRE

s.w.g.	1lb reel	½lb reel
10 to 19	£2.95	£1.60
20 to 29	£3.15	£1.80
30 to 34	£3.45	£1.90
35 to 40	£3.65	£2.10

All the above prices are inclusive of postage and packing in UK
COPPER SUPPLIES
102 Parrswood Road, Withington, Manchester 20
Telephone 061-445 8753 100

T.V. TUBE REBUILDING. Complete plant, equipment, supplies and training. If you can afford the best contact Western-Whybrow Engineering. Tel. 073 676 2265. (8048

VALVES RADIO. — T.V.-Industrial-Transmitting. We dispatch valves to all parts of the world by return of post, air or sea mail, 2,700 types in stock 1930 to 1976. Obsolete types a speciality. List 20p. Quotation S.A.E. Open to callers Monday to Saturday 9.30 to 5.00. Closed Wednesday 1.00. We wish to purchase all types of new and boxed valves. Cox Radio (Sussex) Ltd., Dept WW, The Parade, East Wittering, Sussex PO20 8BN, West Wittering 2023 (STD Code 024366). (8266

SMALL MANUFACTURERS, ETC. We have a comprehensive stock of electronic components at reasonable prices. Enquiries welcomed. Claro Electronics Ltd., 7 The Grove, Harrogate M91 5NN. Tel: 0423 66659. (8480

TEKTRONIX 545A OSC. Complete with CA., H., plug ins, £240 ono. Tel: Boston (0205) 66292. (8528

LAB CLEARANCE: Signal Generators; Bridges; Waveform, transistor analysers; calibrators; standards; millivoltmeters; dynamometers; KW meters; oscilloscopes; recorders; Thermal, sweep low distortion true RMS, audio FR, deviation. Tel. 040-376236. (8250

CAPACITY AVAILABLE

AIRTRONICS LTD. for coil winding Large or small production runs. Bobbin — Layer — Wave — Biflar — Miniature Toroidals. Airtronics Limited, Gardner Industrial Estate, Kent House Lane, Beckenham, Kent BR3 1UG. Tel. 01-659 1147. (7158

BATCH Production Wiring and Assembly to sample or drawings. McDeane Electricals, 19B Station Parade, Ealing Common, London, W.5. Tel: 01-992 8976. (7531

PRINTED CIRCUITS. Ultra fast turnaround. Very competitive prices paper or glass. Punched or drilled. Single or double sided. Also prototypes, artwork, photography. Kidmore Circuits Ltd., 120 Garlands Road, Redhill, Surrey RH1 6NZ. Phone Redhill 68850. (7283

A COMPLETE and efficient PCB Service from layout through to assembly. Incorporating quality reliability and price. No order too large or too small. Also mechanical detailing is undertaken. For details and free estimates please contact: J. S. Roberts on 01-553 2577 H.R.C. Artwork Design, 45 High Street, Maldon, Essex. (7731

PRINTED CIRCUIT ASSEMBLY. Assembly services to customer specification. Also, design, layout and wiring service available. A. E. Electronics, 4-6 Sandy Lane, Stockton Heath, Warrington WA4 2AY. Tel. 0925-68339. (7912

SMALL BATCH PRODUCTIONS wiring assembly to sample or drawings. Specialist in printed circuits assembly. Rock Electronics, 42 Bishopsfield, Harlow, Essex. 0279 33018. (7674

HIGHWAY ELECTRONICS. Logic design, PCB artwork, assembly, testing, custom built electronics, Unit 112, Springvale Ind. Estate, Cwmbran, Gwent NP44 5BG. Telephone Cwmbran (06333) 68042. (8347

PCB ARTWORK DESIGN SERVICE with component notation masters and assembly drawings. PADS Electrical Ltd, 01-850 6516, 45 Southwood Road, New Eltham SE9. (7905

TECHNOVA DEVELOPMENTS offer a comprehensive and fast service in: quality P.T.H., single and double sided PCBs; precision artwork and draughting services. Send drawing etc. for quotation. Samples available. Technova Developments, 136 Whitehall Road, Norwich, Norfolk. Tel. 0603 28015. (8355

SPECIALISTS in printed circuit assembly, and small batch production wiring assembly, to sample or drawings. ASEMCO Electronics, 123 Seabourne Road, Bournemouth 0202 427836. (8460

I.H.S. SYSTEMS
Due to expansion of our manufacturing facilities we are able to undertake assembly and testing of circuit boards or complete units in addition to contract development.
We can produce, test and calibrate to a high standard digital analogue and RF equipment in batches of tens to thousands.
Telephone to arrange for one of our engineers to call and discuss your requirements, or send full details for a prompt quotation.
TEL. 01-253 4562
or reply to Box No. WW 8237
(8237)

PCBS. Production runs or Prototypes. Assembly to sample or drawings. Design service if required. Quick response to demand. Expert hand soldering. Nothing too large or too small. Telephone or write. SEASHORE ELECTRONICS Ltd., Unit 2, Picow Farm Road Service Industry Estate, Runcorn, Cheshire. Phone Runcorn (09285) 75950. (8439

CAPACITY AVAILABLE for electronic assembly, setting up, fault finding, etc. Also available to any would be or current metal detector manufacturers 8in. injection moulded A.B.S. search heads, attractive design with internal jigs for coils, one off sample, £4. To Thornhill, Ashleigh Estate, Crundale, Haverfordwest, Dyfed, S. Wales. (8447

Specialised PCB Service
Layouts · Photography · Drilling
Roller Tinning · Gold Plating
Legend Printing · Profiling
Special quick prototype service
Crofton Electronics Limited
35 Grosvenor Road, Twickenham
Middlesex · Tel. 01-891 1923
8210

RECEIVERS AND AMPS

HRO Rx5s, etc. AR88, CR100, BRT400 G209, S640, etc., etc. in stock. R. T. & I. Electronics, Ltd, Ashville Old Hall, Ashville Rd., London, E11. Ley 4986. (65

SIGNAL Generators Oscilloscopes, Output Meters, Wave Voltmeters, Frequency Meters Multi-range Meter, etc., etc., in stock. R. T. & I. Electronics Ltd, Ashville Old Hall, Ashville Rd., London E.11. Ley 4986. (64

COURSES

RADIO AMATEURS EXAMINATION CITY & GUILDS. Pass the important Examination and obtain your G8 licence with an RRC Home-study course. For details of this and other courses (GCE, professional examinations etc), write or phone: The Rapid Results College, Dept: JW1, Tuition House, London SW19 4DS. Careers Advisory Service, 01-947 7272 or ring 01-946 1102 for prospectus only (24hr answering service). (8575

SERVICES

W.K.F. ELECTRONICS

(R.P.C.B.S. Ltd.)

THE CIRCUIT BOARD SPECIALISTS — UNIVERSAL SUPPLIERS

Contractors for: P C B Production Contract Drilling, Electroplating Laminate Cutting
Services for: Master Artwork Preparation Process Photography, Circuit Diagrams Layouts & Legends
Consultants for: Instrument Engineering Automatic Control & Applications

Do-It-Yourself Won't Do: Today's assemblies demand close tolerances
Goodbye to the Long Wait: 3 to 7 Day Prototype P C B Production Service
Quotations: By Return **Guaranteed Quality** on every process
Short or Long Term Production now acceptable from **1 to 10,000 units.**
We Universally Distribute: Laminate Carbide Drill Bits & Routers Process Chemicals (any). Pre sensitised Laminate, Drilling Machines (Manual Multi-spindle N C /C N C Control), Graphic Art Draughting materials & aids
We Manufacture to Specification: Quality Circuit Boards (Single or Double Sided with any finish) Due to expansion we now have space available for prototype or long term production
For Quotations: Submit Copy Masters, Roughs Circuit or Sample units for costing

To:
W.K.F. ELECTRONICS
FLEET HOUSE, WELBECK STREET
WHITWELL, WORKSOP, NOTTS.
TEL. WORKSOP (0909) 720695
TELEX: 547616
Telephone Quotations: Ask for pricing

NOTICE TO OTHER MANUFACTURERS

IS YOUR DRILLING ROUTING DEPARTMENT A BOTTLENECK?
IF SO TRY OUR SERVICE FOR DRILLING AND ROUTING

THE RATES ARE VERY RESONABLE AND THE FAST SERVICE WILL ENSURE THAT YOUR CUSTOMERS' DELIVERIES ARE MET

PRECISION SHEET METAL work. chassis, panels, etc., steel, stainless or aluminium, long/short runs, good deliveries. EES Ltd., Clifford Rd, Monks Road, Exeter 56280 36489. (8060

CIRCUIT DESIGN and prototype construction. Instrumentation, test rigs, production run designs to your requirements. Professional audio, analogue, digital, SC/MP microprocessor circuits our specialities. HAMILL ELECTRONICS LTD., Box BCM-2090, London WC1V 6XX. Tel.: 01-542 9203. (7984

TEST EQUIPMENT

We are disposing of a considerable amount of good quality test gear including Tektronic scopes at silly prices.

✱ Ring Derek Pattinson now and discuss your requirements.

Crofton Electronics Ltd.
35 Grosvenor Road, Twickenham, Middlesex.
Tel. 01-891 1923 (8211)

RADIO OPERATED REMOTE CONTROL SYSTEMS

(Home Office approval)
Range up to 50 mtrs.
We welcome inquiries for your particular application.

R.D. ELECTRONICS
112 High Street, Barry
South Glamorgan CF6 8DT
Tel: Barry 739653 (8281)

MICROPROCESSOR CONSULTANCY

Hardware - Software - Systems - Intel - Motorola - Intersil - DEC - Consultancy Training - Turnkey Systems

MICRO LOGIC CONSULTANTS
Horsham (0403) 730464
24-Hour Answering Service 8327

DESIGN SERVICE. Electronic Design Service. We offer a Design Development and Production Service with many years' experience working for Civil and Government Departments throughout the world in Digital and Analogue Instruments, RF Transmitters, Receivers, Telemetery Video Equipment, including U.H.F. TV Transmitters and Monitors, Cameras, Motorized Pan and Tilt Heads, general electronics, including Micro Processors using the latest techniques and hardware. Phone or write Mr. Falkner, R.C.S. Electronics, 6 Wolsey Road, Ashford, Middlesex. Phone Ashford 53661. (8341

FOR CLASSIFIED ADVERTISING RING BARRY LEARY ON 01-261 8508

EQUIPMENT WANTED

BROADFIELDS AND MAYCO DISPOSALS

21 Lodge Lane, N. Finchley
London, N12 8JG
Telephone:
01-445 2713
01-445 0749 **01-958 7624**

MAY WE ASSIST YOU TO DISPOSE OF YOUR **SURPLUS** AND **REDUNDANT** STOCKS.

We will call anywhere in the British Isles, and pay **SPOT CASH** for Electronic Components and Equipment.

TELECOMM SPARES

291 Holdbrook Court South
Waltham Cross, Herts EN8 7SL
Tel: Lea Valley 716945

May we as component factors, be of service to you in offering to purchase your obsolescent electro mechanical devices, test equipment, semiconductors, wire and cable, etc.

We will call anywhere throughout the British Isles, and assure you of a prompt cash settlement at a most competitive price.

A.R. Sinclair

Electronic Stockholders
Stevenage 812193

We purchase all types of Mechanical and Electronic Equipment and Surplus stocks.
(8189)

CLASSIFIED ADVERTISEMENTS

Use this Form for your Sales and Wants

To "Wireless World" Classified Advertisement Dept., Dorset House, Stamford Street, London, SE1 9LU

PLEASE INSERT THE ADVERTISEMENT INDICATED ON FORM BELOW

- Rate £1.10 PER LINE. Average six words per line. Minimum THREE lines.
- Name and address to be included in charge if used in advertisement.
- Box No. Allow two words plus 50p.
- Cheques, etc., payable to "Wireless World" and crossed "& Co."

NAME ....

ADDRESS ....

....

....

			REMITTANCE VALUE .... ENCLOSED		

PLEASE WRITE IN BLOCK LETTERS. CLASSIFICATION .... NUMBER OF INSERTIONS ....

INDEX TO ADVERTISERS

Appointments Vacant Advertisements appear on pages 137-159

	PAGE
Ace Mailtronix Ltd.	100
AEL Crystals Ltd.	37
Ambit International	41
Amplicon	7
Antex Ltd.	87
Aspen Electronics Ltd.	36
Astra-Pak	40
Aura Sounds	35
Avo Ltd.	27, 33
Bamber Electronics	18
Barr & Stroud Ltd.	66
Barrie Electronics Ltd.	117
Bayliss, A. D. & Sons Ltd.,	32
Bell & Howell	17
Beyer Dynamics (G.B.) Ltd.	28
Bentley Acoustic Corp. Ltd.	122
Bi-Pak Semiconductors Ltd.	104
Boss Industrial Mouldings Ltd.	6
British Nat. Radio School	121
Bulgin Electronics Soundex Ltd.	14
Cambridge Learning	25
Cardross Eng. Co. Limited	134
Caracal Eng.	100
Carter Associates	37
Catronics	117
CEC Corporation	26
Chase Electronics	102
Chiltmead Ltd.	135
Circuit Designs No. 3	133
Circuit Services	134
C. N. Stevenson	38
Colomor (Electronics) Ltd.	116
Computer Appreciation	130
Concept Electronics	38
Consumer Association	Loose insert
Cramer	110
Crellon	5, 9
Crimson Elektrik	40
Datong Electronics Ltd.	38
Dau (U.K.)	28
Dawes Electronic	128
Display Electronics	130
Doram Electronics	16, 20
Drake Transformers Ltd.	14
Eagle International	11
Electronic Brokers Ltd.	123, 124, 125, 160
Electronic Brokers Ltd. (Second User Computer Div.)	127
Electronics Weekly	120
Eng. Electric Valve Co.	77
Faircrest Eng. Ltd.	34
Feedback Instruments	131
Farnell Instruments Ltd.	4
Future Film Developments	34

	PAGE
GEC M.O. Valve	26
Genrad Ltd.	2
Gould Advance	42
Greenway Elec. Comps.	101
Greenwood Electronics	21
Harmsworth Townley & Co. Ltd.	30
Harris Electronics (London) Ltd.	21, 26
Hart Electronics	111
Henry's Radio	121, 128
Hi-Fi Year Book	134
Imos	103
Industrial Tape Applications	39
Integrex Ltd.	108, 109
ITF Elec. Insts. Exhibition	100
ITT Components	88
ITT Instrument Services	112
JPS Associates	100
Keithley Instruments Ltd.	88
Kemat Electronics	40
K.G.M. Electronics	31
K. T. Manners Design	132
Labgear Ltd.	22
Langrex Supplies Ltd.	107
Lascar Elec.	122
Leevers-Rich Equipment Ltd.	21
Levell Electronics Ltd.	3
Light Soldering Developments Ltd.	20
Linstead Mfg. Co. Ltd.	35
Lion House	117
London Inst. Repair Centre	110
Lowe Electronics Ltd.	34
L.P. Enterprises	105
MacInnes Laboratories Ltd.	24
Maclin Electronics	35
Magnum Audio	20, 22
Maplin Electronic Supplies	12, (Bound-in Insert Between pages 16, 17)
Marconi Instruments Ltd.	Cover ii
Marshall, A. (London) Ltd.	114
Martin Associates	18
Membrain Ltd.	103
MHZ Electronics	37
Milward, G. F.	122
Mills, W.	110
Modern Book, The	156
Monolith Electronics Co. Ltd.	32
Multicore Solders Ltd.	Cover iv
Neal Ferrograph	33
Newbear Computer Stores	106
Olson Electronics Ltd.	36

	PAGE
Pattrick, J. B.	103
Pelco	36
Personal Computer W/show	101
Plessey Controls	23
Powell, T.	111
Powertran Electronics	118, 119
Precision Petite Ltd.	38
Pye Unicam Ltd.	13
Quality Electronics	31
Racal Thermionic	8
Radford Lab. insts. Ltd.	33
Radio Components Specialists	115
Radio Shack Ltd.	106
Ralfe, P. F.	116
Rank	7
R.C.S. Electronics	34
Rola Celestion Ltd.	113
R.S.T. Valves Ltd.	107
RTVC	129
Sabtronics	15
Science of Cambridge	99
Scopex Instruments Ltd.	112
Service Trading Co.	136
Servo & Elec. Sales Ltd.	101
Shure Electronics Ltd.	Cover iii
Sintel	121
Sintrom Electronics Ltd.	30
Sonic Hi-Fi Discount	106
Sonic Sound Audio	31
Southwest Technical Prods. Ltd.	29
Sowter, E. A.	157
Special Products Ltd.	30
Strumech Engineering Ltd.	22
Sugden, J. E. & Co. Ltd.	32
Sullivan, H. W. Ltd.	65
Surrey Electronics Ltd.	132
Swanley Electronics Ltd.	101
Technomatic Ltd.	132
Tektronix U.K. Ltd.	78
Teleradio Hi Fi	102
Television	102
Trident Exhibition	126
Valradio Ltd.	24
Vero Electronics Ltd.	24
Vero Speed Ltd.	28
West Hyde Developments Ltd.	114
West London Direct Supplies	102
Wilmot Breeden Electronics	10
Wilmslow Audio	19
Wings Appeal	111
Z. & I. Aero Services Ltd.	122, 128

'OVERSEAS ADVERTISEMENT AGENTS:

France: M D. Soubeyran, Compagnie Francaise D'Editions, Division Internationale, 40 Rue du Colisee, Paris Be Telephone 225-77-50 — Telex 280274.

Hungary: Mrs Edit Bajusz, Hungexpo Advertising Agency Budapest XIV Varosliget Telephone 225 008 — Telex Budapest 22-4525. INTFOIRE

Italy: Sig C Epis, Etas-Kompass, S.p a. — Servizio Estero, Via Mantegna 6, 20154 Milan Telephone, 347051 — Telex 37342 Kompass.

'Japan: Mr Inatsuki, Trade Media — IBPA (Japan). B 212, Azabu Heights. 1-5-10 Roppongi, Minato-ku, Tokyo 106 Telephone (03) 585-0581

United States of America: Ray Barnes, 'IPC Business Press, 205 East 42nd Street, *New York*, NY 10017 — Telephone (212) 689 5961 — Telex 421710 Mr Jack Farley Jnr, The Farley Co Suite 1584, 35 East Wacker Drive, *Chicago*, Illinois 60601 — Telephone (312) 6 3074
Mr Victor A Jauch, Elmatex International, P O Box 34607, Los Angeles, Calif. 90034, USA — Telephone (213) 821-8581 — Telex 18-1059.
Mr Jack Mentel, The Farley Co., Suite 650, Ranna Building, Cleveland, Ohio 4415 — Telephone, (216) 621 1919
Mr Ray Rickles, Ray Rickles & Co, P O Box 2008, *Miami Beach, Florida* 33140 — Telephone (305) 532 7301.
Mr Jim Parks, Ray Rickles & Co, 3116 Maple Drive N E, Atlanta, Georgia 30305 Telephone (404) 237 7432
Mike Loughlin, IPC Business Press, 15055 Memorial, Ste 119, Houston, Texas 77079 — Telephone (713) 783 8673

Canada: Mr Colin H MacCulloch, International Advertising Consultants Ltd, 915 Carlton Tower, 2 Carlton Street, Toronto 2 — Telephone (416) 364 2269

'Also subscription agents.

Printed in Great Britain by QB Ltd, Sheepen Place, Colchester and Published by the Proprietors IPC ELECTRICAL-ELECTRONIC PRESS LTD., Dorset House, Stamford St London, SE1 9LU, telephone 01-261 8000. *Wireless World* can be obtained abroad from the following: AUSTRALIA and NEW ZEALAND: Gordon & Gotch Ltd. INDIA: A. H. Wheeler & Co. CANADA: The Wm. Dawson Subscription Service Ltd, Gordon & Gotch Ltd. SOUTH AFRICA: Central News Agency Ltd: William Dawson & Sons (S.A.) Ltd. UNITED STATES: Eastern News Distributors Inc., 14th Floor, 111 Eighth Avenue, New York, N.Y. 10011.

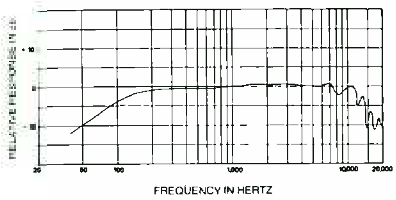
fact: you can choose your microphone to enhance your sound system.

Shure makes microphones for every imaginable use.
Like musical instruments, each different type of Shure microphone has a distinctive "sound," or physical characteristic that optimizes it for particular applications, voices, or effects.
Take, for example, the Shure SM58 and SM59 microphones:

SM59

Mellow, smooth, silent...

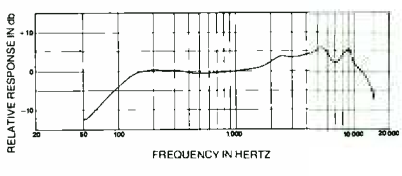
The SM59 is a relatively new, dynamic cardioid microphone. Yet it is already widely accepted for critical studio productions. In fact, you'll see it most often where accurate, natural sound quality is a major consideration. This revolutionary cardioid microphone has an exceptionally flat frequency response and neutral sound that reproduces exactly what it hears. It's designed to give good bass response when miking at a distance. Remarkably rugged—it's built to shrug off rough handling. And, it is superb in rejecting mechanical stand noise such as floor and desk vibrations because of a unique, patented built-in shock mount. It also features a special hum-bucking coil for superior noise reduction!



SM58

Crisp, bright "abuse proof"

Probably the most widely used on-stage, hand-held cardioid dynamic microphone. The SM58 dynamic microphone is preferred for its punch in live vocal applications...especially where close-up miking is important. It is THE world-standard professional stage microphone with the distinctive Shure upper mid-range presence peak for an intelligible, lively sound. World-renowned for its ability to withstand the kind of abuse that would destroy many other microphones. Designed to minimize the boominess you'd expect from close miking. Rugged, efficient spherical windscreen eliminates pops. The first choice among rock, pop, R & B, country, gospel and jazz vocalists.



professional microphones...by SHURE®

Shure Electronics Limited, Eccleston Road, Maidstone ME 15 6AU—Telephone: Maidstone (0622) 59881