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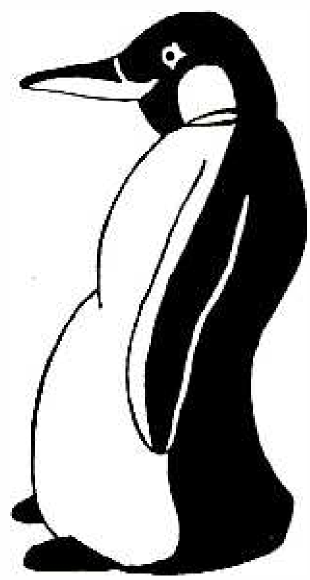

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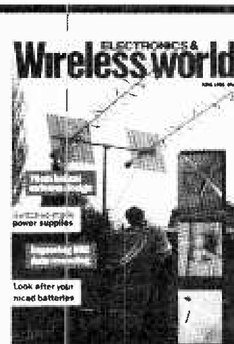

Front cover shows the 70cm aerial made by James Miller for the RSGB's headquarters station at Potters Bar. Photography by Grahame Richardson.

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META contains a fully integrated Editor. This follows Wordwise as closely as possible in its philosophy (ie cursor keys used to move text — quickly — up and down about central editing line etc), and includes Global/Selective Search/Replace, Markers (copy,save,delete, find marked text), load text to cursor, character count and heaps of other features.

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Can your computer climb Mount Everest? The challenge is posed by Summit, one of four entertaining games of strategy for young geographers in a new software pack from BBC Publications. The others include an exploration game designed to give an understanding of contour maps and an intercontinental airliner simulation in which the pilot must navigate his way safely to his destination. The games tie in with a BBC radio series for schools, but can be used independently in the classroom or at home. *Introducing Geography* is available for the BBC Micro on three well-filled discs at £20 and there is an accompanying book for £4.95.

From the same source comes *Maths with a Story*, which with subtlety and imagination introduces children of primary school age to elementary probability, the four-colour map problem, graphical co-ordinates and the concept of symmetry. A cassette for the BBC Micro (transferrable to disc) costs £10.95 and versions for the Acorn Electron, Spectrum and Commodore computers are in preparation. The associated book for parents will be published on May 23.

End of ATS-1 after 18 years

After more than 18 years of service, NASA's first Applications Technology Satellite, ATS-1 has failed to respond to commands to correct its eastward drift and will lose its useful orbital position in about six months.

Launched in 1966, with an expected life of three years, the satellite has provided voice and data communications to wide area around the Pacific Basin. During its service it has scored several significant achievements:

It was the first to transmit a full-earth, cloud cover picture from geosynchronous orbit.

It transmitted real-time tv pictures from the Apollo 4 splashdown in the Pacific.

It was used between 1967 and 1968 for two-way communications tests between aircraft to determine navigational effects of satellite communications.

In 1971 it was used for the link between us and Soviet scientists during an atmosphere, sea and ice conditions experiment in the Bering Sea.

It has been employed in several medical connections including the transmission of cardiographs from Hawaii to New Zealand and from Alaska to the University of Washington; for a link-up between 12 nations for medical conferences with the University of Hawaii and as a link to paramedics in remote parts of Alaska.

ATS-3, launched in 1967 is still in operation and covers the US and most of the Atlantic as well as the eastern Pacific including Hawaii.

Cellular data

A method of reliably transferring data by cellular telephone network from and to a mobile subscriber has been developed. Racal Vodata has worked with Racal Research to develop a protocol named CDLC (Cellular Data Link Control) which is specifically designed to overcome the problems of data transmission encountered on a cellular radio network, particularly when switching between cells which are subject to fading and hand-off. The first CDLC products will be add-on modems for cellular phones which will provide 1200/s pseudo-full-duplex transmission. Any digital equipment with RS232 interfacing may be connected to the system. These include personal computers, printers, v.d.us and other terminals. Racal-Vodafone believes that this is at the forefront of world cellular technology and will be a major factor in persuading customers to use their system.

Tape makers slam levy

The Government proposed levy on blank recording tape is condemned as unworkable, unnecessary and punitive by the Tape Manufacturers Group. Under the plans levies would be inposed of 10% on the price of audio and 5% on video tapes. Each cassette would carry a levy stamp and manufacturers and retailers selling tapes without stamps could be fined. Those caught using unstamped tapes could also be prosecuted. Christopher Hobbs, Chairman of the TMG likened the levy to "the Government adding £50 to the price of cars sold to allow for offences that the owners might commit." He also said that the scheme would be an "administative nightmare, full of loopholes for the unscrupulous to exploit the public."

The proposals of the percentage levies are for the manufacturers' prices. By the time the distributors and retailers have added their mark-up and v.a.t. is added, the levy could be doubled. The scheme could be circumvented by the import of tape from overseas undercutting the local product. "The incentives to counterfeit the levy stamp would be enormous."

The Group also maintains that the need for levies has not been proven. In an independent survey of video recorder use, less than 1% of recorded material is kept for repeat viewings. The vast majority of video usage is for time-shifting; recording programmes for viewing at a more convenient time. In audio, another survey has shown that less then 22% of the population buy blank tape for any purpose; almost 70% of record taping is from the user's own records and 25% do it to maintain their records in good condition.

Powerful exchange

Claimed to be the world's most powerful exchange, the international telephone exchange at Keybridge House, Vauxhall, London, can handle 800 000 call attempts an hour. The digital exchange can cope with data, text, facsimile and graphics as well as telephone speech. It is supplied by Thorn Ericsson and is based on the Ericsson AXE10 design with an APZ212 processor. At present it has capacity for 13800 circuits and this is to be expanded to 50 000 circuits on completion next year.

The exchange has been upgraded over the past nine months and all the operations including replacing the central processor have been carried out without disrupting the service. It is used primarily for international direct dialling calls and it is linked to BT's other international exchanges. It also handles transit calls (from one country to another through the UK) and operator-connected calls.

Here is the news. . . without interference

A 14GHz satellite terminal made by the British company GEC McMichael will soon be helping to bring American television audiences live pictures of new events which until now would have been impossible to cover.

The CBS network has ordered GEC McMichael's Newshawk satellite terminal, which is the first transportable Ku-band earth station to meet the Federal Communication Commission's exacting technical specifications.

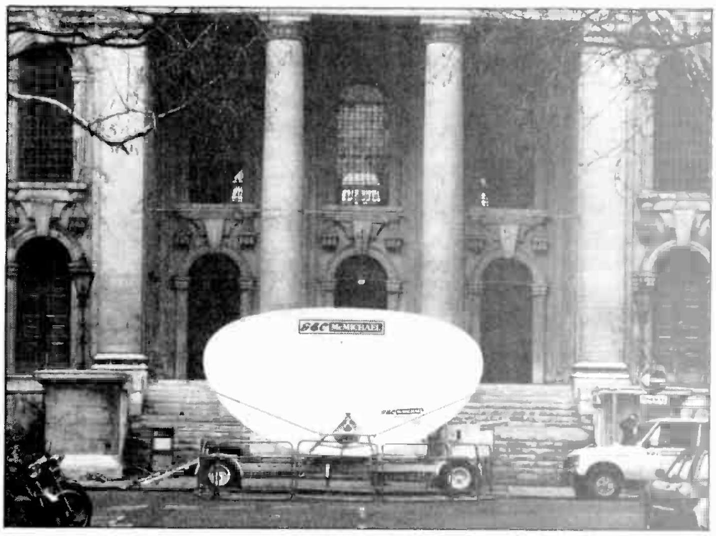
The orbital positions of satellites used by American broadcasters for temporary links are so close together that off-axis radiation by ground stations using them must be strictly controlled. Newshawk meets the requirements easily by virtue of its unique one-piece antenna design. An offset-fed Gregorian configuration provides an r.f. path unobstructed by mounting struts and hardware which in other designs lead to side-lobes.

GEC McMichael designed the antenna using specially-developed computer software. They say there is no simple mathematical expression to represent the curvature of the dish; but its overall shape is elliptical, combining a large radiating area with compactness, transportability and low wind-loading.

Two versions of the terminal are available: the 3m-high trailer-mounted model shown in the photograph, or the version bought by CBS which packs away so small that it can be taken as luggage on scheduled air services. A two-man crew can have it up and running in as little as 15 minutes.

A special feature of the package is a video compression codec which makes it possible to transmit the video and sound signals in digital form at a choice of data rates ranging farom 1.5Mbit/s to 8Mbit/s. The rate can be selected to suit the operating conditions: with the slower ones, the clarity of the picture is reduced in areas where movement occurs.

GEC McMichael Ltd., Sefton Park, Bells Hill, Stoke Poges, Slough SL2 4HD, tel 02816-2777.



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Coming to this screen shortly. . .

Now that negotiations for the BBC's tv licence fee are over, it is worth looking at what the opposition is up to. And by that we don't mean ITV. Or even radio.

The cable tv industry has been in the doldrums lately. The euphoria brought on by the Government's initial announcements a couple of years ago soon evaporated. And as disillusion with British prospects for the new medium set in, several powerful Anglo-American engineering marriages formed to exploit it found themselves on the rocks. But now things are looking up once more; and on council estates in Croydon and elsewhere a few brave spirits are hard at work pushing cables down holes.

But, these sporadic ventures apart, the British cable tv industry is far from booming. It still consists for the most part not of engineers or programme-makers but of dark-suited businessmen whose instinct tells them that there is money to be made out of cable, without so far having revealed precisely how.

The whole affair turns on money, of course, and it is interesting to note that there is general agreement that there is no prospect of supporting cable tv entirely through advertising income. The tv audience of the future will be fragmented into ten, twenty or more minority groups watching ten or twenty different channels. How could any programme deliver enough viewers to attract the advertisers? It would scarcely be worth the expense of producing the commercials.

So most of the money for cable programmes will have to come from viewers' subscriptions. In other words, while Westminster and *The Times* try to steer us away from the licence fee system, the cable tv industry is doing the exact opposite; the difference being that the monthly 'licence fee' for a cable tv connection now works out at two to four times as costly as the ordinary broadcast one (which cable subscribers have to pay as well).

Television costs money, and good programmes generally cost big money. From that point of view, signs from the cable tv business are not encouraging. Burdened by the heavy cost of setting up their networks without the government aid enjoyed by operators abroad, the new stations must get their programmes from the cheapest possible sources.

The cheapest network tv programmes now cost something like £50 000 an hour. Cable tv hopes to get by on £5000 an hour or less. Certainly, part of the difference can be accounted for by the broadcasters' organizational structure and high labour costs. But how can cable possibly compete? Even the rubbish from the BBC and ITV is usually good quality rubbish.

The inevitable conclusion must be that there is only one way cable can get anywhere in Britain. And that is by lobbying: by so demoralizing the existing broadcasters and undermining them financially that they lose the will to survive. If that happens, then cable tv's endless pop promo compilations, low-budget talking heads and wall-to-wall 'I Love Lucy" shows may just begin to look good by comparison.

New blood

Looking at higher education as a whole, the effect of cuts in spending continues to bite ever-more deeply. The Chancellor's Budget allocation of £43M to provide additional places in engineering and technology at selected higher education institution has to be seen against the overall picture, which still looks very grey indeed.

Nevertheless, the Engineering Council's campaign over the last year for more engineering education resources has been remarkably successful and is to have an immediate effect: 475 new places in the first phase of the programme will be available this coming October. Dr Kenneth Miller, Director-General of the Engineering Council, expresses himself as "extremely gratified" with the outcome of the campaign. He points out that "the squeeze could affect engineering education disproportionately" and that the new money will help to avoid this effect.

Those concerned with engineering will, no doubt, rejoice at this evidence that the Government's heart is in the right place, but it seems less than likely that the arts people are quite so overcome with euphoria. They may, however, derive some solace from the stated belief of the Council that "a broad education to a late stage is vital" for the provision of "numerate arts graduates and articulate science graduates". The intention is that pupils will not have to decide at, or before the age of 16 whether to be scientists or 'artists'. This has been said before, by the Council of Engineering Institutions in 1980, when the 'breadth' of proposed new courses was to be dealt with by the inclusion of "supplementary subjects as desired". A sideways glance at literature or history is mere lip-service to the concept of a broad education, and it is to be hoped that this time the Council means what it says.

However vital it is for the nation's economic growth that there should be a flow of well-trained scientists and engineers coming out of universities and polytechnics, it is equally as important in the longer term that they should be as "articulate" as the products of the other faculties and no less appreciative of those facets of life which have little commercial value. Education is not, or ought not to be, a meal ticket; nor is it a factory process to produce a generation of single-minded technocrats to bolster the economy.

Towards a thinking computer

Intelligent knowledge-based systems is one of the major research areas of the Alvey project; part of the quest for the next generation of super computers. Fifty projects, costing about £20M, have been announced which are aimed to establish the necessary technology upon which subsequent industrial and commercial applications of i.k.b.s. can be based. The researches into 'artificial intelligence' include projects on novel computer architecture, logic programming languages, expert systems, the under standing of natural language and image interpretation.

Each project is a collaboration between companies and/or academic research establishments and in all, 28 different firms and 26 universities, polytechnics and research establishments are involved.

The research is intended to develop systems which can reason and even guess the answer to a problem. They would need to be able to handle logical relationships and such trial-and-error based knowledge to be found in codes of practice, rules of thumb or 'hunches'. In effect they are trying to emulate the human reasoning process which often involves little actual mathematics but uses logical inference, comparison with previous situations using extrapolation and interpolation, and estimating. A start has been made in the development of symbolic processing languages such as Prolog and Lisp, but the development of much larger and more powerful expert systems is a long-term aim, likely to take decades.

Demonstation projects under way include a system to monitor the performance of machinery and to permit automatic adjustment to give optimum performance. Another is the formulation of mixtures in chemical works, such as a lubricating oil for a specific application.

The main research programme is carried out under a number of specific research themes and cover an enourmous range with thirteen projects related to expert systems, two on intelligent front-end interfaces, seven are exploring natural language, three for image interpretation and the development of robot vision. Other areas are inference and knowledge representation, intelligent computer-aided instruction, and declarative systems architecture.

There is also a support infrastructure for the programme and include community clubs where companies with common interests and problems can jointly commission the development of an expert system. One such club has been formed to produce software to demonstrate the use of expert systems in the real-time process control of chemical plants; another for the development of a system for use in civil engineering, particularly quantity surveying. The third club is to set up a financial advisor on the performance and health of small business companies. Several more are planned or are being set up.

This liquid level sensor, developed by the RNIB, vibrates when liquid bridges the metal probes in the cup and may be felt by those who are deaf as well as blind. Two sets of probes indicate low and high levels. The contact sets into motion a miniature Portescap motor with an eccentric load weight, producing an audible buzz and a gentle vibration.

Life-saving pager

Patients waiting for organ transplants can now be in constant touch with their hospitals through Life Page, a service offered free by BT Radiopaging. Many potential transplant patients are still active and mobile, not necessarily tied to their homes or beds. However if a transplant organ becomes available they need to be contacted very urgently so that the surgery can be completed rapidly. Under the scheme, patients waiting for heart, kidney, liver or other organ transplants will be issued with a standard radiopager. The first recipient of a pager at the official launch of the service recently was Paul Stokes who is on the waiting list for heart surgery at Papworth Hospital. BT launched the service to celebrate their 250,000th subscription to Radiopaging.

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At a price YOU can afford, our range of **EX EQUIPMENT** video monitors defy competition!! All are for 240v working with standard composite video input. Units are pre tested and set for up to 80 col use on BBC micro. Even where MINOR screen burns MAY exist – normal data displays are unaffected.

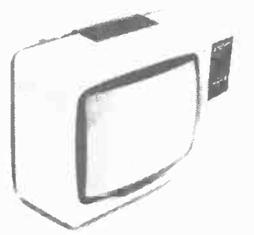
1000's SOLD TO DATE

12" KGM 320-321, high bandwidth input, will display up to 132 columns x 25 lines. Housed in attractive fully enclosed brushed alloy case B/W only ***£32.95***

24" KGM large screen black & white monitor fully enclosed in light alloy case. Ideal schools, shops, clubs etc. ***ONLY £55.00*** Carriage £10.00

A Major company's over production problems, and a special **BULK PURCHASE** enable **TWO** outstanding offers.

COLOUR MONITOR SPECIALS

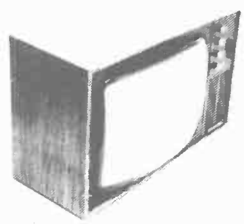


'SYSTEM ALPHA' 14" Multi Input Monitor.

Made in the **UK** by the famous **REDIFFUSION Co.** for their own professional computer system this monitor has all the features to suit your immediate and future monitor requirements. Two types of video input, **RGB** and **PAL** Composite Video, allow direct connection to most makes of micro computers and **VCR's**. An internal speaker and audio amplifier may be connected to your system's output or direct to a VCR machine, giving superior colour and sound quality. Many other features include PIL tube, Matching **BBC** case colour, Major controls on front panel, Separate Contrast and Brightness – even in **RGB** mode, Two types of audio input, Separate Colour and audio controls for Composite Video input, BNC plug for composite input, 15 way 'D' plug for RGB input, modular construction etc. etc.

This must be **ONE OF THE YEAR'S BEST BUYS!!!**

Supplied **BRAND NEW** and **BOXED**, complete with **DATA** and 90 day guarantee. **SUPPLIED BELOW ACTUAL COST – ONLY £149.00** + Carr.



DECCA RGB 80-100 Monitor.

Little or hardly used manufacturer's surplus enables us to offer this special converted **DECCA RGB** Colour Video TV Monitor at a super low price of only **£99.00**, a price for a colour monitor as yet unheard of!! Our own interface, safety modification and special 16" high definition PIL tube, combine with the tried and tested DECCA 80/100 series chassis to give 80 column definition and picture quality found only on monitors costing **3 TIMES OUR PRICE**. In fact, **WE GUARANTEE** you will be delighted with this product, the quality for the price has to be seen to be believed. Supplied complete and ready to plug directo to a **BBC MICRO** computer or any other system with a **TTL RGB** output. Other features include internal audio amp and speaker, Modular construction, auto degaussing 34 H x 24 D, 90 day guarantee. Supplied in **EXCELLENT** condition, **ONLY £99.00** + Carr. Also available **UN-MODIFIED** but complete with MOD DATA. Only £75.00.

Carriage and Insurance on monitors £10.00

DATA MODEMS

Join the communications revolution with our super range of **DATA MODEMS** with prices and types to suit all applications and budgets!!

Most modems are **EX BRITISH TELECOM** and are made to the highest standard for continuous use and reliability. RS232 interfaces are standard to all our modems, so will connect to ANY micro etc. with an RS232 serial interface.

DATEL 2B see **SPECIAL OFFER** centre of this ad.

MODEM 13A, 300 baud. Compact unit only 2" high and same size as telephone base. Standard CCITT tones. CALL mode only. Tested with data. ***ONLY £45.00 + PP £4.50***

MODEM 20-1, 75-1200 baud. Compact unit for use as subscriber end to PRESTEL, MICRONET or TELECOM GOLD. Tested with data. ***£39.95 + PP £6.50.***

MODEM 20-2 same as 20-1 but 1200-75 baud ***£99.00.***

TRANSDATA 307A, 300 baud acoustic coupler. Brand new with RS232 interface **ONLY £49.95**

DACOM DSL2123 Multi Standard Modem, switchable CCITT or USA BELL 103 standard V21 300-300, V23 75-1200, V23 1200-75 or 1200-1200 half duplex. Auto answer via MODEM or CPU CALL or ANSWER modes plus LED status indication. Dim 2.5" x 8.5" x 9". **BRAND NEW** fully guaranteed ***ONLY £268.00 + PP £4.50.***

DATEL 2412 Made by SE LABS for BT this two part unit is for synchronous data links at 1200 or 2400 baud using 2780/3780 protocol. Many features include Auto answer, 2 or 4 wire working etc. etc. **COST OVER £800.** ***OUR PRICE £185.00.***

DATEL 4800, RACAL MPS4800 high speed good condition ***£285.00 CARR £10.00***

SPECIAL 300 BAUD MODEM OFFER

Another **GIGANTIC** purchase of these **EX BRITISH TELECOM, BRAND NEW** or little used 2B data modems allows US to make the **FINAL REDUCTION**, and for **YOU** to join the exciting world of data communications at an **UNHEARD OF PRICE OF ONLY £29.95**. Made to the highest **POST OFFICE APPROVED** spec at a cost of hundreds of pounds each, the 2B has all the standard requirements for data base, business or hobby communications. All this and more!!

- 300 baud full duplex
- Full remote control
- CCITT tone standards
- Supplied with full data
- Modular construction
- Direct isolated connection
- CALL, ANSWER and AUTO modes
- Standard RS232 serial interface
- Built in test switching
- 240v Mains operation
- 1 year full guarantee
- Just 2 wires to comms. line

NOW ONLY £29.95

Order now – while stocks last. Carriage and Ins. £10.00

SAVE £250 SUPER PRINTER SCOOP

BRAND NEW CENTRONICS 739-2

The "Do Everything Printer" at a price that will **NEVER** be repeated. Standard **CENTRONICS** parallel interface for direct connection to **BBC, ORIC, DRAGON** etc. Superb print quality with full pin addressable graphics and 4 type fonts plus **HIGH DEFINITION** internal **PROPORTIONAL SPACED MODE** for **WORD PROCESSOR** applications. 80-132 columns, single sheet, sprocket or roll paper handling plus much more. Available **ONLY** from **DISPLAY ELECTRONICS** at the ridiculous price of ***ONLY £199.00*** + VAT. Complete with full manual etc. Limited quantity – Hurry while stocks last. Options: Interface cable (specify) for BBC, ORIC, DRAGON or CENTRONICS 36 way plg £12.50. Spare ribbon £3.50 each. BBC graphics screen dump utility program £8.60. Carriage and Ins. £10.00 + VAT

ONLY £199

HUNDREDS OF PRINTERS EX STOCK FROM £49.00. Call Sales Office for Details.

1 only large **CALCOMP 1036** AO 3 pen drum plotter and offline 915 magtape controller. Good working order. **£2500.00.**

ADD VAT TO ALL PRICES

EX STOCK

DEC CORNER

PDP 1140 System comprising of CPU, 124K memory + MMU 16 line RS232 interface, RP02 40 MB hard disk drive, TU10 9 track 800 BPI Mag tape drive, dual rack system, VT52 VDU etc. etc. Tested and running ***£3750.00***

BA11-MB 3.5" Box, PSU, LTC	£385.00
DH11-AD 16 x RS232 DMA interface	£2100.00
DLV11-J 4 x EIA interface	£310.00
DLVII-E Serial, Modem support	£200.00
DUP11 Sych. Serial data i/o	£650.00
DQ200 Dilog – multi RK controller	***£495.00***
DZ11-B 8 line RS232 mux board	£650.00
KDF11-B M8189 PDP 1123+	£1100.00
LA36 Decwriter EIA or 20 ma loop	£270.00
LAX34-AL LA34 tractor feed	£85.00
MS11-JP Unibus 32 kb Ram	£80.00
MS11-LB Unibus 128 kb Ram	£450.00
MS11-LD Unibus 256 kb Ram	£850.00
MSC4804 Qbus (Equiv MSV11-L) 256 kb	£499.00
PDP11/05 Cpu, Ram, i/o, etc.	£450.00
PDP11/40 Cpu, 124k MMU	£1850.00
RT11 ver. 3B documentation kit	£70.00
RK05-J 2.5 Mb disk drives	£650.00
KL8JA PDP 8 async i/o	£175.00
MI8E PDP 8 Bootstrap option	£75.00
VT50 VDU and Keyboard – current loop	£175.00
VT52 VDU with RS232 interface	***£250.00***

1000's of **EX STOCK** spares for **DEC PDP8, PDP8A, PDP11** systems & peripherals. Call for details. All types of Computer equipment and spares wanted for **PROMPT CASH PAYMENT.**

All prices quoted are for U.K. Mainland, paid cash with order in Pounds Sterling PLUS VAT. Minimum order value ***£2.00***. Minimum Credit Card order ***£10.00***. Minimum BONA FIDE account orders from Government Depts., Schools, Universities and established companies ***£20.00***. Where post and packing not indicated please ADD £1.00 + VAT. Warehouse open Mon-Fri 9.30-5.30, Sat 10.30-5.30. We reserve the right to change prices and specifications without notice. Trade, Bulk and Export

DISPLAY -ELECTRONICS-

32 Biggin Way, Upper Norwood, London SE19 3XF
Telephone 01-679 4414 Telex 894502 Data 01-679 1888

ERS — PRINTERS — PRINTERS — PRINTERS
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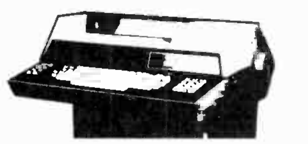
SUPER DEAL? NO — SUPER STEAL!!

The FABULOUS 25CPS TEC Starwriter

BRAND NEW AT ONLY £499 + VAT

Made to the very highest spec the **TEC Starwriter FP1500-25** features a heavy duty die cast chassis and DIABLO type print mechanism giving superb registration and print quality. Micro-processor electronics offer full DIABLO/QUME command compatability and full control via CPM Wordstar etc. Many other features include bi directional printing, switchable 10 or 12 pitch, full width 381 mm paper handling with upto 163 characters per line, friction feed rollers for single sheet or continuous paper, internal buffer, standard RS232 serial interface with handshake. Supplied absolutly **BRAND NEW** with 90 day guarantee and **FREE** daisy wheel and dust cover. Order **NOW** or contact sales office for more information. Optional extras: RS232 data cable **£10.00**. Tech manual **£7.50**. Tractor feed **£140.00**. Spare daisy wheel **£3.00**. Carriage & Ins. (UK Mainland) **£10.00**.

GE MODEL 30



A large purchase of these stand alone terminal units offers an EXTREMELY LOW PRICE for a professional printer for direct connection to your micro. The printer has a standard RS232 serial interface with switchable rates of 110, 200 and 300 baud. Upper and lower case characters are printed by a matrix head with character widths up to 132 columns. Unit accepts standard fan fold sprocket fed paper from 4" to 9.5". Many other features such as numeric keypad, electronic keyboard, auto motor on/off and FREE floor stand. Supplied in good S/H working condition – complete with manual **ONLY £95.00**
CARRIAGE & INS. £10.00

GE TERMIPRINTER

A massive purchase of these desk top printer-terminals enables us to offer you these quality 30 cps printers at a **SUPER LOW PRICE** against their original cost of over £1000. Unit comprises of full QWERTY, electronic keyboard and printer mech with print face similar to correspondence quality typewriter. Variable forms tractor unit enables full width – up to 13.5" 120 column paper, upper – lower case, standard RS232 serial interface, internal vertical and horizontal tab settings, standard ribbon adjustable baud rates, quiet operation plus many other features. Supplied complete with manual. Guaranteed working **£130.00** or untested **£85.00**, optional floor stand £12.50. Carr & Ins £10.00

PROFESSIONAL KEYBOARD OFFER

An advantageous purchase of brand new surplus allows a great **QWERTY**, full travel, chassis keyboard offer at fractions of their original costs.
ALPHAMERIC 7204/60 full **ASCII** 60 key, upper, lower + control key, parallel TTL output plus strobe. Dim 12" x 6" +5 & −12 DC. **£39.50.**
DEC LA34 Uncoded keyboard with 67 quality, **GOLD**, normally open switches on standard X, Y matrix. Complete with 3 LED indicators & i/o cable – ideal micro conversions etc. pcb DIM 15" x 4.5" **£24.95** Carriage on keyboards £3.00.

66% DISCOUNT ELECTRONIC COMPONENTS EQUIPMENT

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. Unbeatable value!! Sold by weight.

2.5kls **£4.25** + pp £1.25 — 5kls **£5.90** + £1.80
10kls **£10.25** + pp £2.25 — 20 kls **£17.50** + £4.75

EXTEL PRINTERS

EX NEWS SERVICE compact, quality built 50 column matrix printer, type AE11. Unit operates on 5 BIT BAUDOT code from current loop, RS232 or TTL serial interfaces. May be connected direct to micro, or comms receiver via simple filter network to enable printing of most world wide NEWS, TELEX and RTTY services. Supplied in tested second hand condition with 50 and 75 baud xtals, data sheet and large paper roll. **ONLY £49.95.**
Dimensions 15" D x 5" H x 10" W
CARR £6.00 Spare paper rolls £4.50 each

TELETYPE ASR33 I/O TERMINALS

FROM £195 + CAR. + VAT

Fully fledged industry standard ASR33 data terminal. Many features including ASCII keyboard and printer for data I/O auto data detect circuitry. RS232 serial interface. 110 baud, 8 bit paper tape punch and reader for off line data preparation and ridiculously cheap and reliable data storage. Supplied in good condition and in working order.
Options: Floor stand **£12.50** + VAT
KSR33 with 20ma loop interface **£125.00** + Sound proof enclosure **£25.00** + VAT

20,000 FEET OF ELECTRONIC AND COMPUTER GOODIES
ENGLAND'S LARGEST SURPLUS STORE – SEEING IS BELIEVING!!

D.C. POWER SUPPLY SPECIALS

Experimentors PSU Ex-GPO. All silicon electronics. Outputs give +5v @ 2 amps +12v @ 800 ma −12v @ 800 ma +24v @ 350 ma and 5v floating @ 50 ma. Dim 160 x 120 x 350 mm. All outputs are fully regulated and short circuit proof. Supplied in NEW or little used condition. Complete with circuit.
Only £15.50 +2 £2.50 pp
FARNELL 5 Volt 40 amps. Type number **G6-40A.** This miniature switching PSU measures only 160mm wide 175mm deep and 90mm high, yet delivers a massive 40 amps!! Fully regulated and smoothed with over voltage protection etc. 120 or 240 volts AC input. Supplied **BRAND NEW** and boxed with circuit at a fraction of the current list price. **Only £130.00 + £3.00** carr & ins.
LAMBDA LMCC 5V BRAND NEW 240v AC input with 5 volts DC at 8 to 10 amps fully regulated output. Completely enclosed unit measures only 9" x 4" x 5" **£29.99**
LAMDA LMCC5V 110v AC input with 5 volts DC at 8 to 10 amps fully regulated output. Slightly smoke damaged, hence **ONLY £10.95**
PERIPHERAL SYSTEM SUPPLY. Runs almost any system. Fully cased unit supplied in a brand new or little used condition. Outputs give 5v @ 11 amps "+" 15-17v @ 8 amps "−" 15-17v @ 8 amps and "+" 24v @ 4 amps. All outputs are crowbar protected and the 5 volt output is fully regulated. Fan cooled. Supplied tested with circuit. **£55.00 + £8.50** carr.
1000's of other POWER SUPPLIES EX STOCK – CALL SALES OFFICE FOR DETAILS

DUAL DISK DRIVE/ WINCHESTER CASES

Very smart, fully enclosed case unit custom made to accept two full height 5¼" floppy disk drives or two 5¼" winchesters such as the RHODIME RO200 or TANDEM series etc. An internal switched mode PSU supplies all the required voltages to enable you to plug in your drives and go!!
Other features include mains filter, internal cables with standard drive connectors, space for internal PCB, standard fan cut out and mounting, air filter. Overall dimensions 28 cm W x 30 cm D x 19 cm H
ONLY £55.00 + £6.00 CARR.

SEMICONDUCTOR 'GRAB BAGS'

Mixed Semis amazing value contents include transistors, digital, linear, I.C.'s triacs, diodes, bridge recs., etc. etc. All devices guaranteed brand new full spec. with manufacturer's markings, fully guaranteed. 50+ **£2.95** 100+ **£5.15.**
TTL 74 Series A gigantic purchase of an "across the board" range of 74 TTL series I.C.'s enables us to offer 100+ mixed "mostly TTL" grab bags at a price which two or three chips in the bag would nnormally cost to buy. Fully guaranteed all I.C.'s full spec. 100+ **£6.90** 200+ **£12.30** 300+ **£19.50**

NORTH STAR HORIZON

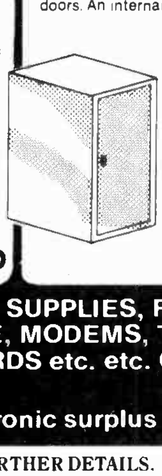
Pro S100 system with dual 5" floppy drives, software, manuals etc.
£850.00 Call sales office for details

ULTRA COMPACT 300 BAUD ACCOUSTIC MODEM — COUPLER

A Major manufacturer's over production and a bulk buy special enables us to offer this **BRAND NEW TRANSDATA 307A** ultra compact, **BT APPROVED**, 300 baud full duplex accoustic modem at a fraction of manufacturer's list price. The unit operates on the standard **CCITT V21** frequencies with **RS232** interface via 25 way 'D' skt.
Combine the adjustable cup system, which fits almost any phone with the benefit of "No jacks or phone cables" and a light weight of only 1.2 Kg and you have a truly portable modem!! Supplied complete with data, 90 day guarantee and ready to use.

ONLY £49.95 + £3.00 pp

PROFESSIONAL 6 FOOT 19" RACK CABINETS



LARGE 19" equipment cabinet. Totally enclosed with locking front and rear doors. An internal sub fram 63" high is pre drilled for standard 19" equipment etc. Other features include internal 12" cooling fan, two-tone blue and grey finish with alloy trims. Mounted on 4 heavy duty castors, mains panel etc. And at a current cost from **IMHOFS** of over **£500** A snip at **ONLY £125.** Supplied in **NEW** or little used condition. Carriage £22.00. Ext. Dim 72.5"h x 23.5"w x 26"d

LOGICAL KEYBOARD

Heavy duty unit in attractive satin alloy case. 55 full travel keys are laid out in a logical format of:

Making a very useful keyboard, ideal for persons unfamiliar with or confused by the standard **QWERTY** layout. All keys generate the equivalent **ASCII** outputs and various control codes shown in data. A 7 bit latched parallel **TTL** output with strobe enables direct connection to any similar micro port etc. Many other features such as internal 240v to 5v PSU, MAINS ON/OFF switch. **Supplied in NEW** or little used condition with data.
ONLY £25.95 Post and packing £4.50

1000's of other EX STOCK items including POWER SUPPLIES, RACKS, RELAYS, TRANSFORMERS, TEST EQUIPMENT, CABLE, CONNECTORS, HARDWARE, MODEMS, TELEPHONES, VARIACS, VDU'S, PRINTERS. POWER SUPPLIES, OPTICS, KEYBOARDS etc. etc. Give us a call for your spare part requirements. Stock changes almost daily.

Don't forget, ALL TYPES and QUANTITIES of electronic surplus purchased for CASH

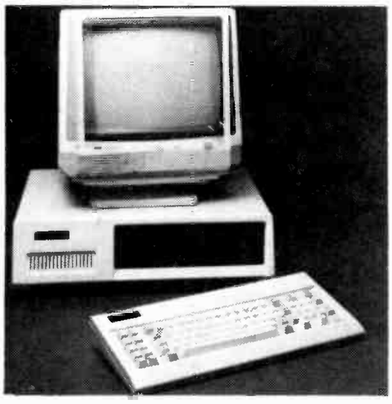
CIRCLE 63 FOR FURTHER DETAILS.

LOW PRICES

DIGITASK BUSINESS SYSTEMS LTD

56, MAPLE DRIVE, EAST GRINSTEAD, WEST SUSSEX, RH19 3UR

SERVICE ADVICE



The PC-16 16-bit computer provides PERFECT COMPATIBILITY with the IBM PC/XT range. The motherboard can be supplied in two versions for stereoscopic conveneince. The 'N' version has no memory on board and the 'B' version with space for 64 to 256K RAM. Addition of the Memory Expansion Card provides a further 64 to 512KB of RAM. BASIC FEATURES INCLUDE:

* 8088 CPU operating at 4.77 MHz
* Provision for 8087 co-processor
* Four DMA channels
* Three TIMER channels on board
* 8 EXPANSION SLOTS
* RUNS MS/PC-DOS & CP/M 86
* READS & WRITES IBM-PC format
* Accepts IBM-PC Peripherals
* Up to 256K RAM ON BOARD

SYSTEM—5 PC16 (B/3) — **PRICE £1599** — Main computer employing 'B' board with 128K on board (upgradeable to 256K on board) PLUS Colour/Graphics adaptor providing signal capable of running monochrome displays on RGB output for full colour. Multi I/O card, providing floppy drive controller for two drives, one parallel port, one serial port, one games port with batter backed clock calander. RAM extension card for 512K. Two DS/DD floppy drives. 83-key keyboard. All complete, built & tested in case with power supply together with Concurrent (multiuser, multitasking) CP/M, CCP/M manual, Basic manual and computer operations manual – ready to run!

MOTHERBOARD 'B', 8-slot, 128K **£490**
MOTHERBOARD 'N', 8-slot **£395**
MULTIFUNCTION card with 128K (expandable to 256K) one PLL-port, one SER-port (2nd option) Clock/Calendar with backup **£195**
MONOCHROME/**Graphic** adaptor with printer port **£279**
MULTI I/O CARD — one pll, one serial port, one games port, floppy drive controller, clock calender with battery backup **£256**

Sanyo DMC 7650 IBM/Apricot colour monitor **£349**
12in HI-RES GREEN MON **£84**
64K RAM EXTEND MODULE **£18**
TEAC 55B DS/DD Floppy drive **£172**
WD 1002 SWX-2 Winchester controller **£249**
512K Expansion RAM card — comes with 128K RAM installed fully IBM compatible **£119**
PC Case **£112**

MR521 10MB Hard drive **£523**
MR522 22MB Hard drive **£735**
IBM COMPATIBLE KEYBOARD (83 key) **£139**
KEYTRONIC 5150 K/BOARD **£175**
KEYTRONIC 5151 K/BOARD **£210**
130 watt Switching Power Supply **£160**
Add on serial port kit **£23**
FDD-100 drive controller for 4 drive **£96**

DRIVES — MEGABYTES FOR MICROPOUNDS!
5" Height 500KB 40/80 .... **£119**
5" Height 1MB 40/48 .... **£125**
5" Height 1.6MB 40/80 .... **£159**
5" Height 2MB 40/80 .... **£199**
5" Height 500KB **£119**
3" Height 1MB **£125**
8" Full Size 1.6MB **£309**
8" Size 1.6MB **£282**

All brand new, uncased, with full electronics — standard power requirements.
Full documentation and technical details available.

Add 15% VAT to all prices given. Remember, VAT is also applicable on carriage at 15%. Terms CWO. DEALER ENQUIRES WELCOME. FOREIGN enquiries if possible by telex please. However, French & German speaking staff at your disposal. MONEY BACK GUARANTEE. SEND £1.00 for our latest catalogue of over 3000 items, computers, peripherals, consumables, robotics, etc etc

TEL: (0342) 313427•24631/2 TLX: 957547

CIRCLE 86 FOR FURTHER DETAILS.

KITS

CT1000KB* Clock/Timer	17.40
CT6000* † Programmable Timer	39.00
XK114 Relay Kit for above	3.90
XK101 Electronic Lock	11.50
XK102* 3-Note Door Chime	5.50
XK104 Solid State Switch	2.40
XK112 Mains Wiring Remote Control	42.00
XK113 MW Radio	5.50
XK126 DVM/Thermometer	15.50
DL1000K 4-Ch Light Chaser	15.95
DLZ1000K 4-Ch Light Chaser	8.95
DLA/1 Opto Input for above	70
DL3000K 3-Ch sound to light	12.95
TD300K † 300W Touchdimmer	7.75
TS300K † 300W Touchswitch	7.75
LD300K † 300W Lightdimmer	3.95
TDR300K † IR Remote Controlled Lightdimmer	14.95
MK6* IR Transmitter for TDR300K & MK7	4.50
TDE/K † Touchdimmer Ext.	2.50
TSA300K † Time Delay Touch Switch (300W)	5.00
MK1 Thermostat	4.60
MK2 Solid State Relay	2.60
MK4 Proportional Temperature Controller	6.50
MK5 Mains Timer	4.50
MK7 Single-channel IR Receiver (240V)	10.50
MK9 4-way Keyboard	1.90
MK10 16 way Keyboard	5.40
MK11 10-channel 1 + 3 analogue o/p IR Receiver	13.50
MK12 16-channel IR Receiver	13.50
MK13 11-way Keyboard	4.35
MK14 AC Power Controller	5.20
MK15 Dual Latched SS Relay	4.50
MK16 Mains-powered IR Transmitter	3.50
MK17 Single-channel IR Receiver (12V)	10.50
MK18 Coded IR Transmitter	6.80
MK19 DC Controlled Audio Amplifier	10.70

*Includes box. † Includes frontpanel.
All kits include PCBs, components and assembly instructions.
For further details send S.A.E.

OPTO

		LED CLIPS	3
3mm red	9	5mm red	9
3mm green	12	5mm green	12
3mm yellow	12	5mm yellow	12

Rectangular, square, arrow or triangular (flat face)

Red 15	Green 18	Yellow 18	
Bicolour	65	Flashing Red	50
Tricolour		Red	
Round	32	Continuous	55
Rectangular	45		
IL74/TIL111	55	MDC3020	1.10
ILD74	1.70	MDC3040	1.50
ORP12	75	MEL11	35

Seven Segment LED Displays

DL704 3 cc	75	4 Dig 1 8" cc	
FND500 5 ca	85	DIRECT DRIVE	
FND507 5 ca	85	Display	7.08

400V TRIACS

4A	49	8A	58
		12A	85
8A isolated	65	16A	95
		25A	2.10
8A sensitive	66	Diac	18

SPECIAL OFFERS

2716	3.10	Z80A PIO	1.99
2732	3.20	Z80A CPU	1.99
2764	4.20	6821	1.40
		27128	7.50!!

COMPONENT PACKS

1 650 Resistors 47R 10M 10 per value 4.00
2 40 16V Electrolytics 10 1000µF 5 per value 3.25
3 60 - Polyester Capacitors 0.01 1µF 250V 5 values 5.55
4 45 Presets 100R 1M 3.00
5 30 Low Profile IC Sockets 8 14 & 16 pin 2.40
6 25 Red LEDs (5mm) 1.75

We stock: VERO, VELLEMAN KITS, PANTEC KITS, ANTEX IRONS, BOOKS FROM BABANI, T.I. AND ELEKTOR.

LINEAR ICs

555	21	ML926	1.80
556	40	ML927	1.80
741	22	ML928	1.80
748	30	ML929	1.80
AD590	3.30	MM74C911	6.50
AY38910	3.90	MM74C915	96
CA3080	65	MM74C922	3.90
CA3130	85	MM74C926	4.50
CA3140	40	NE567	1.25
ICL7107	9.00	S566B	2.20
ICL7126	8.00	S576D	2.20
ICM7555	95	SAB0529	3.50
ICM8038	3.10	SAB0600	2.50
LF351	40	SL440	1.95
LF353	70	SL441	1.35
LF356	80	SL486	1.85
LM324	40	SL490	2.05
LM3342	85	TBA800	70
LM3352	1.20	TBA810AS	90
LM339	40	TDA1024	1.20
LM348	55	TDA4290	1.98
LM358	48	TL061	40
LM380	1.20	TL062	60
LM381	1.40	TL064	1.30
LM382	1.10	TL071	45
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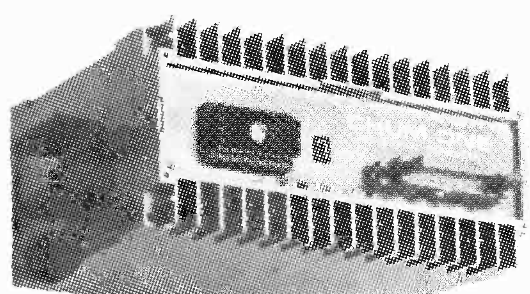

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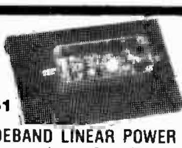

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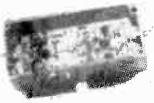

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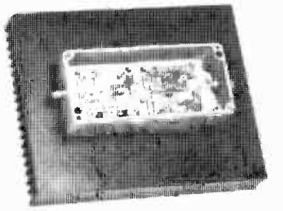
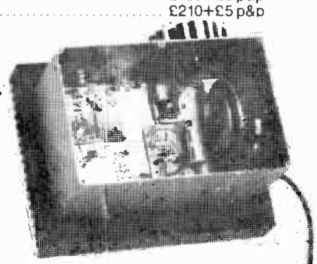


TYPE 9155



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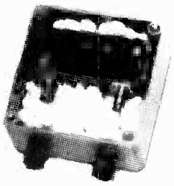

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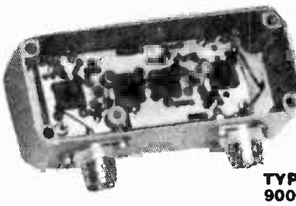

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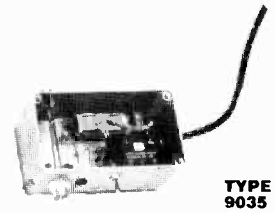

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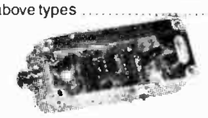

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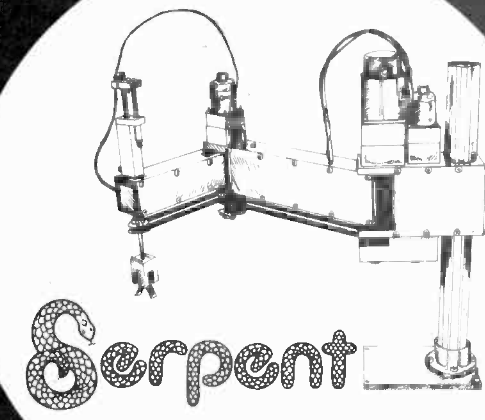

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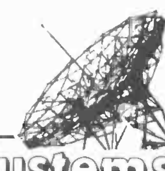

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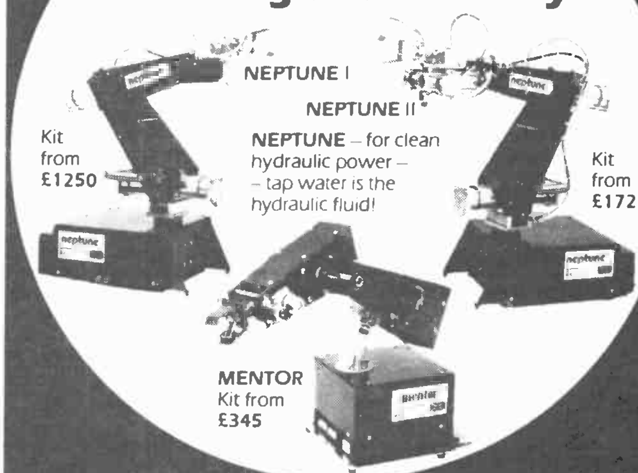

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CIRCLE 30 FOR FURTHER DETAILS.

Fast camera interface

by Safa S. Omran

Signals from standard video cameras are too fast to feed directly into a microcomputer. A solution is to take one picture element from each line in successive frames until a picture is built up. This design is faster, taking eight elements at each pass.

Video cameras scan a picture in a sequential series of horizontal lines. This scanning makes it possible for one video signal to include all the elements for an entire picture. Television frames conforming to the CCIR standard consist of two fields, each of 312.5 lines. A line is 64μs long and picture information is transmitted for about 40μs of this time.

A method of interfacing a video camera to a micro computer was described by P. Howard in the February 1982 issue of *WW* on pages 30-36. The major problem with this type of interface is the high speed of the camera relative to the microprocessor.

Howard's method involves storing one picture element, or pixel, from each scan line in the field then storing the next picture element from each line of the next field, and so on for all the pixels across the picture. In this way, the microprocessor has 64μs in which to store each pixel. An entire picture with a horizontal resolution of 256 pixels is stored in 5.12s.

Our method is to make the microprocessor store eight pixels from each scan line at each pass which redces the time for storing a picture by a factor of eight. The time needed to store a picture with a horizontal resolution of 256 pixels is thus 256 divided by eight, multiplied by 20ms, which is 0.64s. The circuit designed uses this resolution with an eight-bit

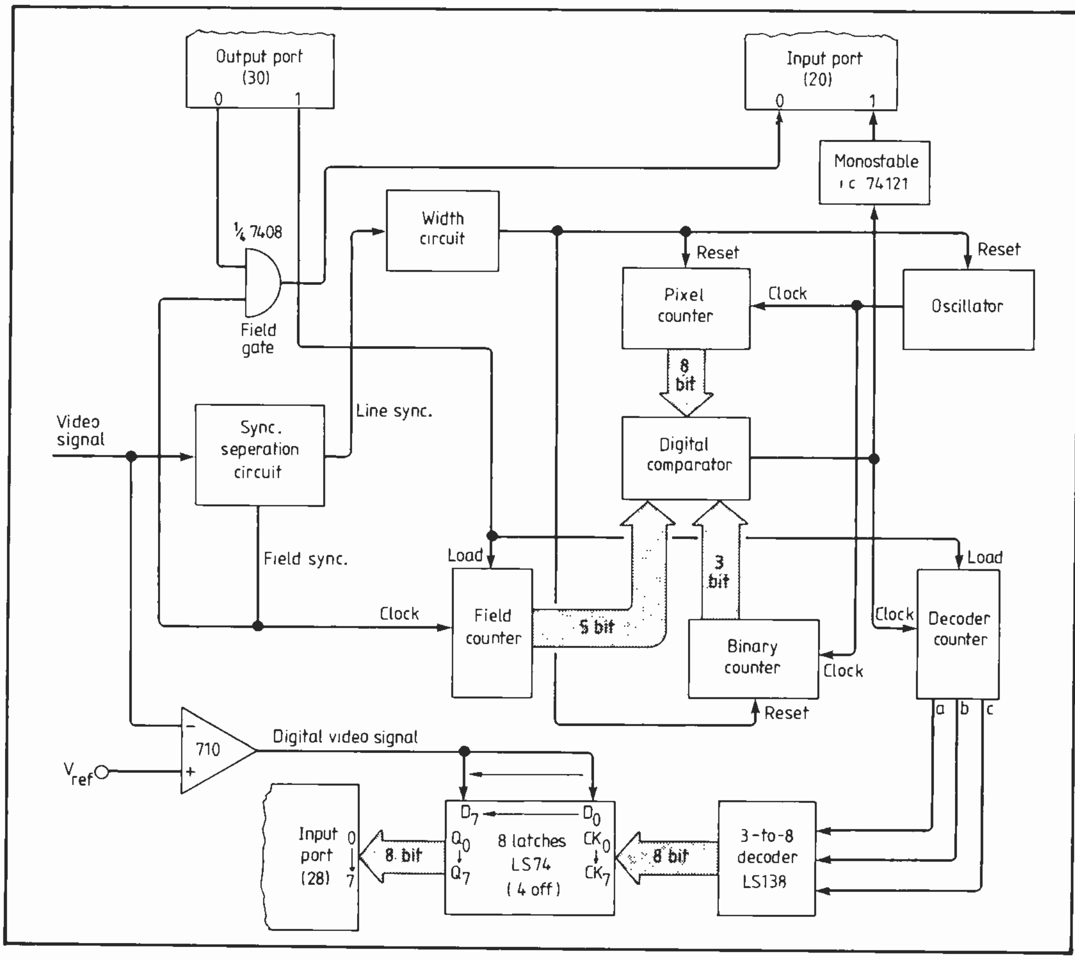


Fig. 1. **Block diagram for the video camera interface timing circuit. By taking eight pixels from each line in successive frames, the interface allows a 256-pixel by 256-line picture to be stored in 0.64s.**

Safa Omran is with the Institute of Technology in Baghdad.

Addr.	Content	Label	Instruction	Comment
6000	21 00 40		LXI H,4000	;Set HL register to start of picture store
6003	3E 00	STRT:	MVI A,00	;
6005	77		MOV M,A	;Clear memory location
6006	23		INX H	;Go to next location
6007	76		MOV A,H	;
6008	FE 60		CPI 60	;End of picture store?
600A	C2 03 60		JNZ STRT	;Go back if not
600D	21 00 40		LXI H,4000	;Set HL to start again
6010	11 20 00		LXI D,0020	;
6013	0E 00		MVI C,00	;Reg.C contents=no. of lines
6015	3E 02		MVI A,02	;
6017	D3 30		OUT 30	;Initialize video camera interface
6019	3E 03		MVI A,03	;
601B	D3 30		OUT 30	;
601D	3E 01		MVI A,01	;Open field gate
601F	D3 30		OUT 30	;
6021	DB 20	FLD:	IN 20	;Wait for field pulse
6023	E6 01		ANI 01	;
6025	FE 00		CPI 00	;
6027	C2 21 60		JNZ FLD	;
602A	DB 20	PLSE:	IN 20	;Wait for strobe pulse
602C	FE 02		CPI 02	;
602E	DA 2A 60		JC PLSE	;
6031	DB 28		IN 28	;Put data in A reg.
6033	77		MOV M,A	;Store it in memory
6034	19		DAD D	;Go to next video line
6035	0C		INR C	;
6036	79		MOV A,C	;End of 256 lines?
6037	FE 00		CPI 00	;
6039	C2 2A 60		JNZ PLSE	;If not, go back to store data from next line
603C	26 40		MVI H,40	;
603E	2C		INR L	;Increment content of Reg L
603F	7D		MOV A,L	;End of 256 pixels? (32 × 8)
6040	FE 20		CPI 20	;
6042	C2 21 60		JNZ FLD	;Go back if not
6045	76	END:	HLT	;Stop

Assembly language program for reading the camera interface using the 8085 microprocessor.

word 8085A microprocessor.

Circuit description

As shown in the block diagram, Fig. 1, the video signal feeds the synchronization separator which separates the line and field sync. pulses.

The video signal is +0.5V peak combined with synchronizing pulses of +0.2V. To separate sync. pulses, the video signal is first passed to a comparator with a reference of 0.1V, Fig. 2, which gives only sync. pulses at its output. This output is passed to an RC circuit with a time constant of about 50μs which integrates field pulses only. Width of the field sync. pulses is about 2ms, while that of line pulses is about 2μs. From the RC circuit, the signal feeds a comparator with a positive reference of 2V, which gives only field pulses.

Line-sync. pulses are passed to a circuit which increases their width. This is required because data only exists for about 40μs of the scan line. A voltage-controlled oscillator, v.c.o., determines the number of picture elements wanted on a line. Output from the width circuit enables the v.c.o. and only allows it to oscillate for 40μs.

Output of the pixel counter is compared with output from the field and binary counters by a digital comparator which generates a pulse when its two inputs are equal, Fig. 3. Assume that output from the field counter is one, i.e. 00001. When output from the pixel counter is zero, the binary counter output is also zero so the two digital comparator inputs are unequal, being zero and eight.

When output of the pixel counter increments by one, the binary counter output also increments by one, but the two inputs to the comparator are still not equal. They remain unequal until the output of the pixel counter becomes eight, in which case output of the binary counter is zero. Now the two inputs to the digital comparator are equal (00001000) so it generates a pulse.

In the next count, outputs of the pixel counter and field/binary counters are also equal (00001001) so another comparator pulse is generated. This is so for each count until output of the pixel counter becomes 16 (00010000), so eight pulses will be generated from the digital comparator in this scan line, Fig. 4.

After 64μs, another eight pulses will be generated for the next scan line, and the process will be repeated for all the scan lines of the field. This means that the comparator generates eight pulses corresponding to eight pixels (pixels 8-15) of each scan line.

In the next field, output of the field counter is two (00010) and the comparator inputs are equal when the output of the pixel counter is 16. In this case, output of the binary counter is zero. These inputs remain equal until the output of the pixel counter becomes 24 (00011000) which means that the digital comparator generates another eight pulses corresponding to the next eight pixels for each scan line. This process is then repeated so that eight pulses are generated by the comparator in each field.

These eight pulses enter the decoder counter, the output of which varies from 000_2 to 111_2 as shown in Fig. 4. This output is the input of the decoder, one output of which is active for each state of the decoder counter. The eight latches put eight consecutive pixels from

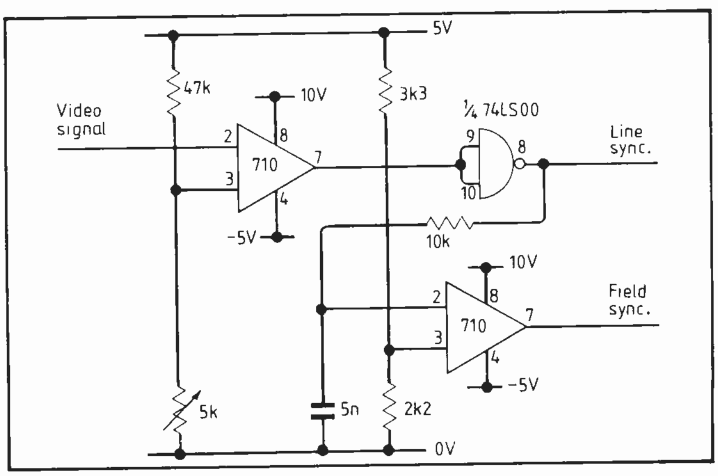


Fig. 2. Sync. separator circuit. The first 710 comparator takes composite line/field pulses from the video signal and the second one produces field pulses only with the aid of an RC integrator at its input.

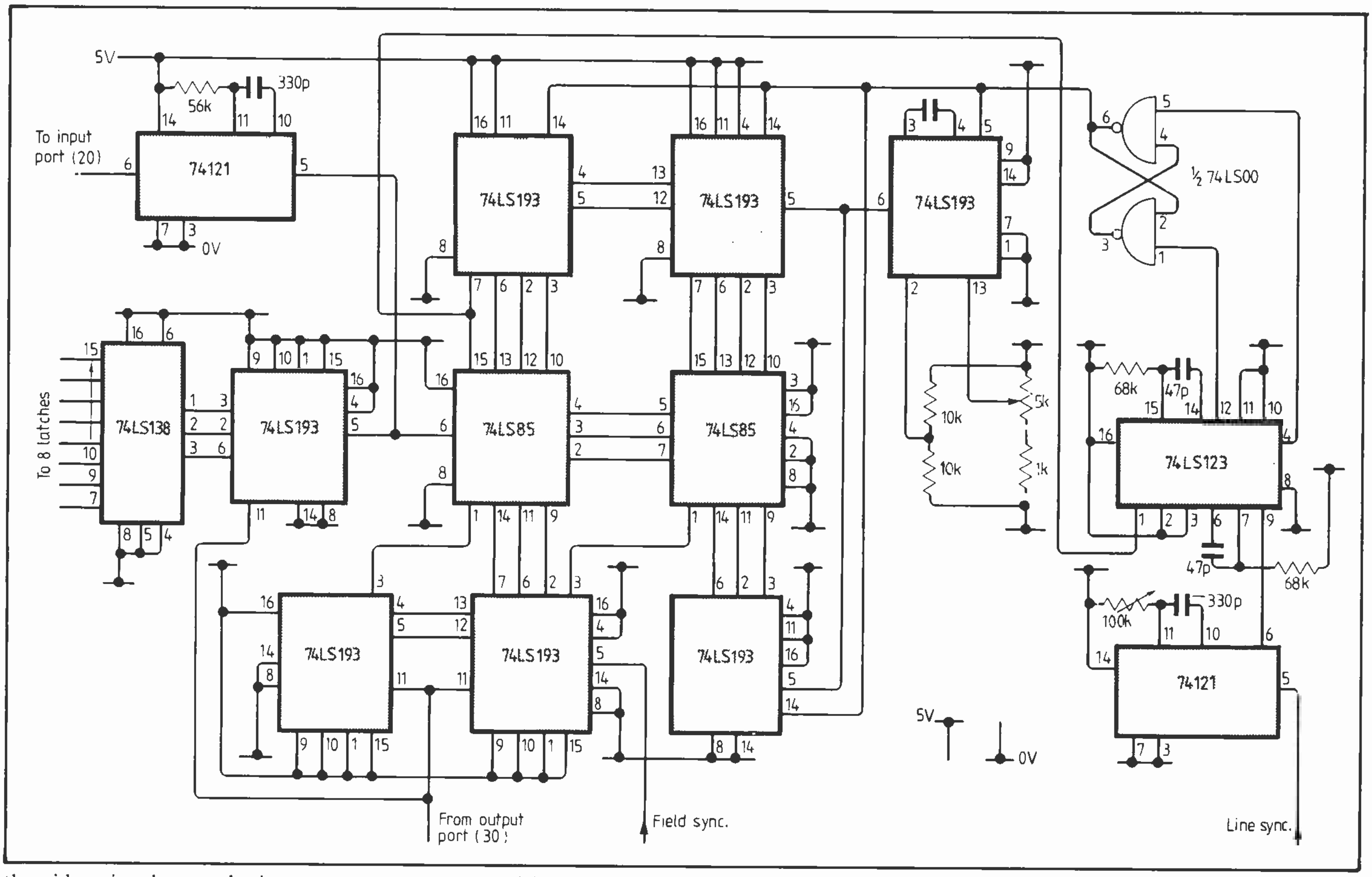


Fig. 3. **Timing circuit for the video-camera interface. Data latches, video driver and i/o gating are shown in the block diagram.**

the video signal on to the input port of the microprocessor, hence the microprocessor stores eight pixels at a time from each scan line.

Software

Movement of data from the camera to the microprocessor is controlled by software which stores 256 pixels per line for 256 lines in the field.

At the start, the field and decoder counters are loaded with their maximum counts by a pulse from the microprocessor. This ensures that the output of the field counter is zero after its first count and that output of the decoder is zero to ensure that the microprocessor stores the first pixel. Next the microprocessor opens the field gate and

a. waits for the field sync. pulse

b. waits for a strobe pulse from the digital comparator

c. stores the eight pixels from its input port in less than 64μs

d. repeats steps (b) and (c) 256 times, equal to the number of lines required

e. repeats steps (a) to (d) 32 times, equal to the number of pixels in a line, i.e. 32×8=256

f. ends

For step (b), a monostable i.c. stretches the strobe pulse to about 16μs to make it suitable for the microprocessor. An assembly-language program is shown for the 8085 microprocessor assuming 256 pixels by 256 lines. In this program, memory location 4000_{16} is the start of the picture store and location $5FFF_{16}$ is the end. Port 30 is used for output and ports 20 and 28 are used for input, see block diagram.

Figure 5 shows a circuit diagram which was digitized using the interface and displayed on a storage oscilloscope.

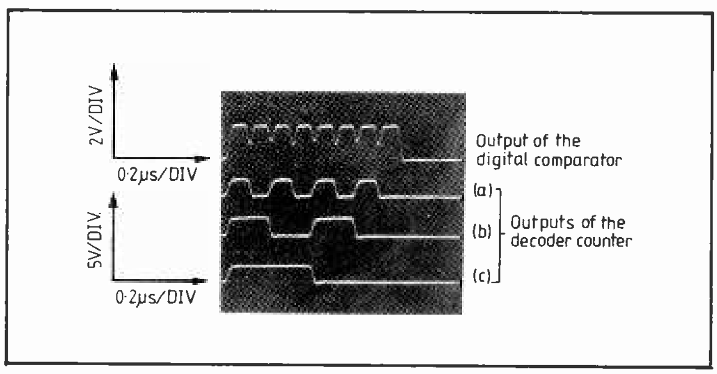
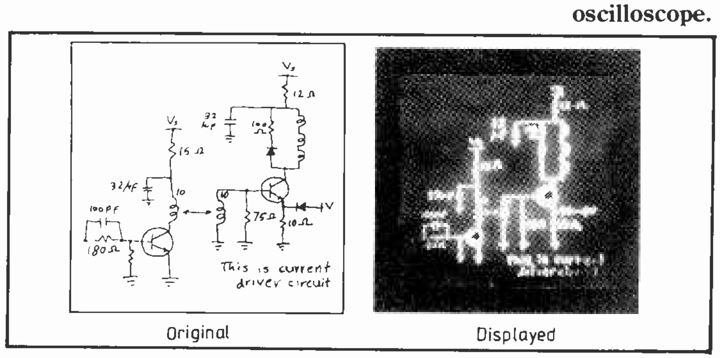


Fig. 4. **Output of the digital comparator, top, consists of eight pulses which step the decoder counter. On each count, one pixel from the line is latched ready for reading by the microprocessor.**

Fig. 5. **An example of a circuit diagram digitized using the video camera interface and displayed on a storage oscilloscope.**



The Hacker's Handbook by Hugo Cornwall: Century Communications, 149 pages, soft covers, £4.95. The Book They Tried To Ban. Fascinating guide to dial-up computer systems and the psychology of people who devise and use them. Gives few real secrets away, but could be worth having just for the technical reference material. Rather expensive.

An Introduction to Z80 Machine Code by R.A. and J.W. Penfold: Bernard Babani (Publishing), ref. BP152, 127 pages, soft covers, £2.25. Beginner's guide for the home computer user. Chapter 3, which describes the instruction set, takes up about half of the book. Addressing modes are covered rather sketchily in just four pages with no program examples. At the end are a few brief specimen listings for the ZX81, ZX Spectrum, Amstrad and Memotech micros.

An Introduction to 6502 Machine Code by R.A. and J.W. Penfold: Bernard Babani (Publishing), ref. BP147, 107 pages, soft covers, £1.95. Much the same treatment as in the Z80 version above. Demonstration listings at the end relate to the BBC Micro/Electron, Oric, VIC-20 and Commodore 64.

Microprocessors: Hardware and Applications, by Andrew Veronis: Prentice-Hall International, 928 pages, hard covers, £51.45, ISBN 0 8359 4382 8. Heavyweight guide to a wide selection of 8-bit and 16-bit types. Chapters cover chip architecture, programming, memory systems, i/o, interrupts, d-to-a and a-to-d conversion, disc and tape storage, single-chip microcomputers, arithmetic processors and trouble-shooting with logic analyzers. Data sheets for several of the chips are included among the ten appendices.

An Introduction to Programming the Atari 600/800XL by R.A. and J.W. Penfold: Bernard Babani (Publishing), ref. BP143, 108 pages, soft covers, £2.25. All about Atari Basic, with a few games listings thrown in.

An Introduction to Programming the Sinclair QL by R.A. and J.W. Penfold: Bernard Babani (Publishing), ref. BP150, 99 pages, soft covers, £1.95. Programming and interfacing with Superbasic. Listings look as if they have been printed by a bus-ticket machine — a pity.

Learning Microsoft Basic for the Macintosh by David A. Lien: Compusoft Publishing, 458 pages, soft covers, ISBN 0 932760 27 9. Chatty, persuasive introduction to Basic on the Apple Macintosh, with numerous examples, exercises and cartoons.

Learning TRS-80 Model 4/4P Basic by David A. Lien: Compusoft Publishing, 483 pages, soft covers, ISBN 0 932760 19 8. Ditto for the new TRS-80 models. Just shows what you can do with a word-processor!

Micro Interfacing Circuits, book 1 by R.A. Penfold: Bernard Babani (Publishing), ref. BP130, 96 pages, soft covers, £2.25, ISBN 0 85934 105 4. Practical guide for the hobbyist. Chapters cover address decoding, serial and parallel i/o chips, driving relays, de-bouncing switches, d-to-a and a-to-d conversion.

Pascal for Electronics Engineers by J. Attikiouzel: van Nostrand Reinhold, 148 pages, soft covers, £5.75, ISBN 0 442 30597 4 pbk. Tutorial guide at first-year undergraduate level, with exercises and worked examples. Makes attractive use of marginal notes for hints and asides. Three case studies at the end illustrate the use of Pascal for writing circuit analysis programs.

Practical Electronics Building Blocks, book 2, by R.A. Penfold: Bernard Babani (Publishing), ref. BP118, 94 pages, soft covers, £1.95. Audio stages, filters and flip-flops for beginners.

Questions and Answers on Radio Repair by Les Lawry-Johns: Newnes Technical Books, 106 pages, soft covers, £2.65, ISBN 0 408 01509 8. Heaps of practical advice and good humour from an experienced practitioner.

Radio and Television Servicing, 1983-84 models edited by R.N. Wainwright: Macdonald, 863 pages, hard covers, £22.50, ISBN 0 356 10259 9. Diagrams and servicing information for a variety of models by Alba, Binatone, Fidelity, G.E.C., Hitachi, Luxor, Mitsubishi, National Panasonic, Network, Perdio, Philips, Pye, Roberts, Saba, Salora, Sharp, Sony, Tatung, Teleton, Thorn-EMI and Toshiba.

Signal Processor Chips edited by David J. Quarmby: Granada Publishing, 179 pages, hard covers, ISBN 0 246 12171 8. Not ordinary analogue chips, but digital programmable l.s.i. chips with widespread applications in filters, modems, speech processing, sonar and video. The editor contributes chapters on what they are and how they work and then hands over to contributors from Intel (on the 2920), NEC (on the 7720) and Texas Instruments (on the TMS320) for the practical details.

Single-chip Microcomputers edited by Paul F. Lister: Granada Publishing, 231 pages, hard covers, ISBN 0 246 12106 8. An introduction to some commercial chips with design examples: the Motorola M6801 and M6805 (with a speedometer/tachometer/odometer); the Texas TMS1000 (with a speech synthesizer interface); the Zilog Z8 (with a data logger); the National Semiconductor COPS400 (with a digital tv tuning system) and the Mostek MK68200 (with a machine controller).

Telecommunication Principles by J.J. O'Reilly: van Nostrand Reinhold, 143 pages, soft covers, £5.75, ISBN 0 442 30592 3 pbk. Tutorial guide for first and second-year undergraduates covering communications theory, modulation methods, radio receiver principles and digital communications. Three case studies at the end describe techniques used in stereo f.m. broadcasting, U.K. colour tv and videotext.

Transmitted Picture Assessment by John Allnatt: John Wiley and Sons, 303 pages, hard covers, £19.50, ISBN 0 471 90113 X. A practical guide to assessing tv picture impairments in the laboratory and in the field. The author is head of the Visual Performance Standards Section at British Telecom's Martlesham laboratories.

The Motorola MC68000 Microprocessor Family by Thomas Harman and Barbara Lawson: Prentice-Hall International, 574 pages, hard covers, £37.90, ISBN 0 13 603960 X. Heavyweight guide to Motorola's 16-bitters. Chapters cover the instruction set, program control, arithmetic operations, programming techniques, system operation, i/o handling and interfacing. Numerous exercises.

Murphy's Law and other reasons why things go wrong, by Arthur Bloch: Price/Stern/Sloan Inc., Los Angeles, 94 pages, soft covers, $2.95 ISBN 0 8431 0428 7. Treasure chest of quips, axioms and aphorisms for engineers and others. Also **Murphy's Law Book Two,** 94 pages, $2.95 ISBN 0 8431 0674 3. Sample rib-tickler: "A computer does what you tell it to do, not what you want it to do" (Greer's Third Law).

Uosat data decoder p.c.b.

A new printed circuit board is available for the high-performance G3RUH Uosat data demodulator *(Wireless World,* May 1983).

The board includes the 1200 baud circuits, (limiter, phase-locked loop, integrate-and-dump and lock detector), regenerated and RS232C output interfaces. The input filter, 300 baud and c.c.d. line-sync detectors have been omitted. The p.c.b. is single sided and legended, measures 160×100mm and has space for an RS Components encapsulated 12V p.s.u., RS 591-281. A suitable case is RS 508-605. Connections to the p.c.b. are via a single 16-pin d.i.l. plug.

Prices: p.c.b., instructions and (air mail) postage — UK £10, Europe £11, overseas £12. Note that the *Wireless World* article is not included: a reprint is available at an extra £1 (abroad £1.40). Available now from the author (for address see table 3) or from Amsat-UK, London, E12 5EQ.

Data Recording

continued from page 64

may need to be varied for different heads. It does not seem critical.

During reading, the write output is shorted to prevent noise interfering with the read signal. The read signal is applied to A_3, a non-inverting amplifier with a gain of about 25. Because of the head's inductive reactance, this amplifier must have a high input impedance to preserve the signal at high frequencies. About 400mV (peak-to-peak) is available at the output of A_3.

Coupling between A_3 and A_4 is via a small-value capacitor which differentiates the signal. The output to the BBC Micro is a 1.4V peak-to-peak square wave with very little jitter on the edges.

This design has proved to be very reliable over the past year. The cost of the components is about £3 plus a cheap cassette recorder (mine was £9.99 from Woolco).

Costly Def

Do the Services and tax-payers obtain value for money in their purchases of radio, electronic and related equipment for advanced weapons and communications system? In the case of some projects, such as the painful long-running £5000-million saga of British torpedo development, patently not. For all military equipment, price tags tend to be very high when judged by civilian equipment standards. But are these not justified by the high standards of reliability and environmental testing involved in the manufacture of equipment to the defence and MIL-spec standards demanded by the UK, NATO and USA services?

In general terms all semiconductor devices and components are required to work over the impressively large temperature range of −55 to +125°C. Semiconductors for aerospace applications have to be in hermetically sealed metal or ceramic packages. Batch testing of samples, normal practice for most electronic equipment, is ruled out. To permit traceability, all stages of manufacture and assembly have to be documented and monitored.

As one reader who is involved with making equipment to defence specifications puts it: "The standard 'commercial' device will rarely have received very much in the way of testing before despatch; normally the procedure is one of lot sample testing with the entire batch accepted or rejected on the results of the sample testing. MIL-spec devices, on the other hand, will have been 100 per cent tested and burned-in for 168 hours at 125°C. . . Traceability also adds quite a cost penalty. It is necessary to be able to check on a specific semiconductor device, for instance, right back to the materials used and to the diffusion process. This facility is essential when batch related problems are discovered so that suspect batches can be isolated very rapidly and appropriate action taken. . . drop-offs do occur even in the best regulated circles! The most worrying thing, from an equipment manufacturer's point of view, is that such problems often to not become evident for quite a long time. So as soon as the problem is detected, it is necessary to establish very rapidly which equipments contain devices from the suspect batches — impossible to do without full traceability. . . The low cost of many consumer items is gained as the result of automated flow line production; once you disturb this process to add inspection and test stages, the production costs can increase very rapidly indeed."

These arguments seem very convincing, that is until you start to wonder how much all these extra precautions have really added to reliability in the field. When a few years ago I asked the technical director of a firm supplying military communications equipment what had been the effect of the DEF component specification he replied that it had greatly increased costs but had made very little difference to reliability. The Pentagon is currently complaining that it has to spend something approaching a quarter of its annual budget on maintenance and repair of equipment. Horror stories abound of the American services paying $110 for electric plugs available in hardware stores for about 5c, $7622 rather than less than $100 for coffee makers fitted in cargo planes, $170 for battery-operated torches. In the UK it is more difficult to discover just how much is paid for what — and with what results. Nobody likes the idea of people being sent into action with poorly made equipment, but it has been pointed out that video games in arcades are expected to withstand rough treatment without being made to MIL-spec standards!

Vhf changes

As a result of decisions made at the 1984 ITU Regional Administrative Conference for the planning of the v.h.f. broadcast band between 87.5 and 108MHz, attended by 500 delegates from 77 countries, a considerable number of frequency changes are due to take effect before July 1987 to UK local radio (BBC and ILR) stations, including some later this year. Eventually all UK local stations will be in two sub-bands of 94.6 to 97.6MHz and 102.0 to 104.9MHz with the possibility of "community radio" stations between 105 and 107.9MHz, a part of the spectrum now expected to be cleared of present communications services by about 1990 rather than the 1995 date originally written into the 1979 WARC.

The conference, the first part of which was held in 1982, produced a formal "Geneva Agreement 1984" covering Region 1 and part of Region 3. To this is annexed a "Geneva Plan 1984" covering frequency assignments for more than 53,000 sound broadcasting stations. The UK part of the plan foresees five national networks (four for BBC, one for Independent National Radio), the BBC and IBA local radio stations most of which will be grouped into separate sub-sub-bands, plus the proposed new tier of community radio.

Radar up-date

The Fylingdale long-range radar, which forms part of the American ballistic missile early warning system (BMEWS) is soon to be up-graded and modernized. A radically different solid-state phased antenna array, similar to one currently being installed at Thule, Greenland, is likely to be installed. These have 2560 active elements in each 84-ft high antenna face, providing almost a megawatt of power. Unlike the present mechanically steered antennas, the phased-array is fixed with electronic beam steering under the control of CDC865 computers. Such arrays can simultaneously track a number of targets.

The Americans are also currently building a network of over-the-horizon h.f. radars with an operational range of about 5000 miles, almost twice that of the BMEWS installations. For the reception of o.t.h. signals, 4980ft long-wire Beverage antennas are used.

Much longer antennas are needed for transmission of extremely low frequency (e.l.f.) communication signals at frequencies below 100 *hertz,* and a 30-mile antenna is reportedly to be erected in Scotland though it is not clear whether this will be an American or British operated system for broadcasting messages to submerged submarines at extremely low data rates. At e.l.f. even a 30-mile antenna is very short in terms of wavelength and efficiencies are extremely low. Signals can, however, be received at great range and at considerable depth on compact frame antennas.

The American customs service is planning to use six Orion long-range patrol aircraft equipped with airborne (AN/APG-63) radar capable of detecting and tracking small low-flying aircraft and surface vessels. This is part of the current American campaign to reduce the large-scale smuggling of drugs into the USA, although this campaign could be rendered ineffective by the increasing manufacture of synthetic hard drugs within the USA. Target information from the patrol craft will be passed to the US Coast Guard and other government agencies whose task it is to intercept and apprehend suspects.

Cordless tv

One of the most thankless, yet vitally important, tasks of governments is to uphold, and if possible improve, the regulation of the radio spectrum. While in recent years in the UK public attention has been focussed primarily on "pirate" broadcasters and before that on 27MHz c.b., the general situation has been deteriorating alarmingly rapidly. Point-to-point services are tending to occupy and hold channels not registered with the International Frequency Registration Board; megawatt over-the-horizon radars, including Russian pulsers and American continuous-wave radars, are taking over chunks of h.f. not allocated for radar in ITU Radio Regulations; out-of-band high-power h.f. broadcasting is flourishing (the DTI has described this as "semi-regulated anarchy"); by no means all private mobile radio networks strictly adhere to their regulations; licensing authorities find it increasingly difficult to cope with all the administration and paperwork; the Merriman Committee noted the increasing need for the UK Radio Regulatory Department to devote "adequate resources" to "spectrum monitoring, particularly of the mobile and fixed bands, as an aid to efficient spectrum management".

On one of the few occasions when the Radio Regulatory regime has been the subject of an adjournment debate in the House of Commons (March 26, 1985) it started at 8.43 a.m. after an all-night sitting and ended 17 minutes later at 9 a.m. when the motion duly lapsed "without Question put".

Barry Henderson, Conservativve MP for north-east Fife, who has been described as "an unobtrusive New Technology man with old values" attacked the efficiency of RRD, drew attention to its draconian powers and provided a number examples to show how delays and errors were adversely effecting business and personal users of the radio spectrum. In reply, John Butcher, Under-secretary of State for Trade and Industry, simply filled in time by describing some of the many tasks of RRD without getting round to his promised outline of "Government's policy on the enforcement of wireless telegraphy legislation" before being saved by the bell.

While RRD has been successful in closing some but by no means all of the pirate broadcasters, a good example of the confused state of enforcement concerns the power given to RRD by the 1984 Telecommunications Act to specify "restricted" transmitting equipment and so make manufacturing, selling, offering for sale or hire of it illegal. In the twelve months following the enactment of this legislation not a single restriction order has been formulated.

What is one to make, for example, of the low-power television transmitters recently announced by Waveview Holdings Ltd of South London? These range from outputs of 4 to 200mW for their "Multiview" series and 1 to 1000 watts for low-power television. The Multiview units are being offered for use in homes, hotels, etc. as local "cordless" distribution systems with outputs tuned to u.h.f. channel 36, one of the non-allocated channels between Bands IV and V and used by airport radars, etc. All such units, even the lowest power Multiview unit with its built-in antenna, have one feature in common; the use of any would clearly contravene the Wireless Telegraphy Acts and could be seized if used — yet is is perfectly legal, despite last year's Act, for the company to make, advertise and sell these transmitting units!

Amateur Radio

Jas-1 in 1986

An amateur radio satellite, JAS-1, currently being built and tested jointly by JARL the Japanese national amateur-radio society and NASDA, Japan's national space agency, is due to be launched from the Tanegashima space centre in early 1986 on board a newly developed H-1 two-stage launcher, as part of a multi-payload. This will be the first multi-payload launch by NASDA and the agency will depend on the telemetry from JAS-1 iin assessing results. Orbital height of the 50kg JAS-1 will be about 1500km, inclination about 50° and period about 120 minutes (roughly similar to Oscar 7). Ground stations will have about eight passes per day, with "windows" of about 20 minutes.

JAS-1 will carry two mode-J (145MHz up, 435MHz down) transponders with a design lifetime of three years. One will be a conventional linear transponder, the other a digital store-and-forward transponder for communication between stations in different time zones. The digital transponder will have four input channels in the 145MHz band using p.s.k./f.m. with a single 1200-baud downlink at 435.91MHz.

AMSAT-UK reports that two more Russian amateur satellites, RS-9 and RS-10, may be launched this year. RS-10 will carry Mode A (145.9MHz up, 29.5MHz down) and Mode K (21.2MHz up, 29.5MHz down) and possibly also a 21.2MHz up, 145.9MHz down transponders.

JARL hhas a special station at the large International Science and Technology Exposition 85 at Tsukuba (100km north of Tokyo) from March 17 to September 1, 1985. Visiting amateurs, including those from overseas, will be able to operate the station provided that they produce their licence certificate.

The Mark III

H.W. King's graphic account ("SOE" in *Feedback*, April 1965) of the travails of Veljke Dragićević, as SOE's first radio operator in Yugoslavia, in having to hump around a 80-100lb "Mark III" transmitter package, highlighted the problems of clandestine radio in occupied countries in the period 1941-42, though personally I doubt if his package included an HRO receiver in what became known as the "coffin" configuration. More likely is that the receiver was a "straight" r.f./regenerative detector/a.f. receiver similar to the Mark XV receiver. It once fell to my lot in less unfavourable circumstances to manoeuvre a "coffin" package up a steep narrow spiral staircase and can confirm it was no lightweight, miniaturized equipment!

However I must come to the defence of what Mr King terms "the notorious Mark III" — a two-stage transmitter built in various versions throughout World War II at Whaddon and Little Horwood, near Milton Keynes. Allegedly based on a 1938 design in one of the American amateur radio handbooks it usually comprised a wooden-boxed, crystal-controlled 6V6 oscillator and 807 power amplifier with a separate (heavy) mains power supply unit. It delivered about 25 watts r.f. output between about 3 to 16MHz with plug-in coils. It was a versatile and reliable transmitter although the power unit could occasionally catch fire, and it was all-too-easy to tune the p.a. to a harmonic.

Although not designed for field operation it was sometimes run from vehicle batteries with the aid of a rotary converteror alternatively from a 150 watt Onan petrol-electric generator, though these were far from "portable".

The original purpose of the Mark III was for the British Intelligence h.f. network organized from 1938 onwards by (Sir) Richard Gambier-Parry ("G.P." or "Pop") with most of the transmitters located in Embassies or other diplomatic buildings in the days when British Intelligence operated under the transparent cover of Passport Control. A more powerful transmitter, the Mark X, had an 813 power amplifier and was sometimes used.

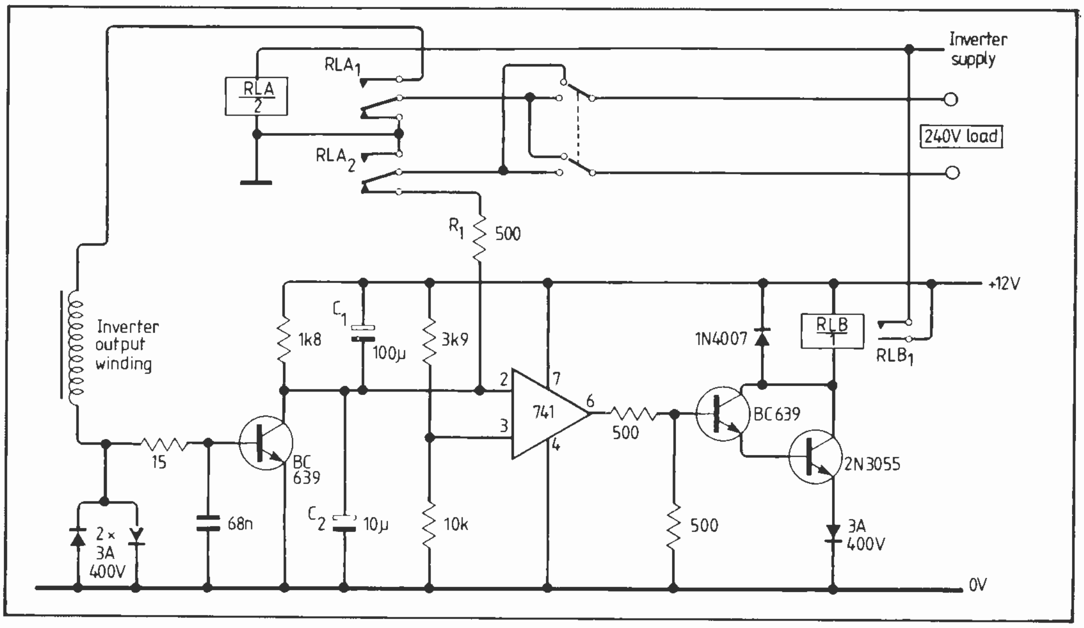
When early in 1940 the first results of Bletchley Park's cracking (with the aid of the Poles and French) of the German Enigma machine became available, Special Liaison Units were set up to distribute what became known as "Ultra" to overseas commands, and the Mark III became the mainstay of SLU communications. During late 1944, there were no less than about 45 SLU out-stations in contact with the "Windy Ridge" base station, handling large quantities of Ultra and Pearl traffic enciphered with one-time pads or Britain's successful answer to Enigma, the Type X cipher machine.

So while agreeing that the idea of mule-humping such equipment around the mountains of Yugoslavia must have been well calculated to fuel the often bitter rivalry between SOE and British Intelligence, it can be argued that the "notorious" Mark III successfully provided some of the most vital radio links of WWII, despite its bulk and lack of miniaturization!

In brief

After a long interval, amateur radio licences are again being issued in Turkey, with the first going to Dr Unal Akbal who becomes TA1A. . . A number of special callsigns with the prefix "GV" were issued for use in early May by special event stations marking the 40th anniversary of the end of World War 2 in Europe. . . British Standard BS6527:1984 provides a specification for "Limits and measurements of spurious signals generated by data processing and electronic office equipment" but does not appear specifically to cover home computers which can be the source of considerable problems to radio amateurs. . . The Tyne-Wear Repeater Group reports that both of their repeaters — GB3TW (R5) and GB3NT (RBo) — are now operational. Pat Hawker, G3VA.

Automatic inverter switch



Electrical appliances such as a blender or sewing machine require power intermittently and when run from an inverter, power consumption of the idling inverter can exceed consumption of the appliance. This circuit automatically switches on the inverter when a load is connected, and removes the need for remote switching when the power is to be distributed.

When a load is connected, it takes the lower contact of the second relay, and therefore the comparator inverting input via R_1, to ground. The first relay is energized by the comparator output being high and power is delivered to the inverter and the coil of the second relay.

With the second relay energized, the load is connected to the inverter-transformer output winding through the parallel-connected diodes. Voltage drop over these diodes keeps the left-most transistor switched on and therefore the comparator inverting input remains low.

When the load is disconnected, the leftmost transistor turns off and allows the comparator inverting input to go high, removing power from the first relay coil and therefore disconnecting the inverter input. Standby current is around 12mA.

The power-transistor emitter diode ensures that the transistor switches off when the comparator output goes low. Capacitors $C_{1,2}$ stop relay chatter during switch on and off. The first relay only has to be large enough to switch the inverter in its idling state; the second relay connects the load at 230V and the first relay does not open until the load is disconnected.

A changeover switch is included to change the inverter output phase since some appliances place a diode in series with the load for half-speed or half-power operation. If the anode of the appliance diode is connected to R_1, the load will not be sensed.

Heat sinking for the parallel diodes and power transistor should be isolated from earth and all connections to the inverter should be insulated for safety.

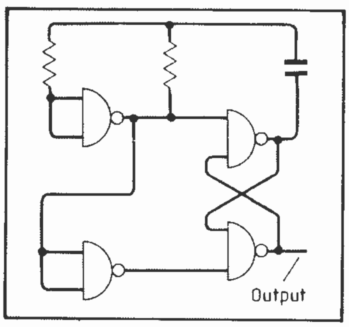
Nicholas Butt
Glemsford
Suffolk

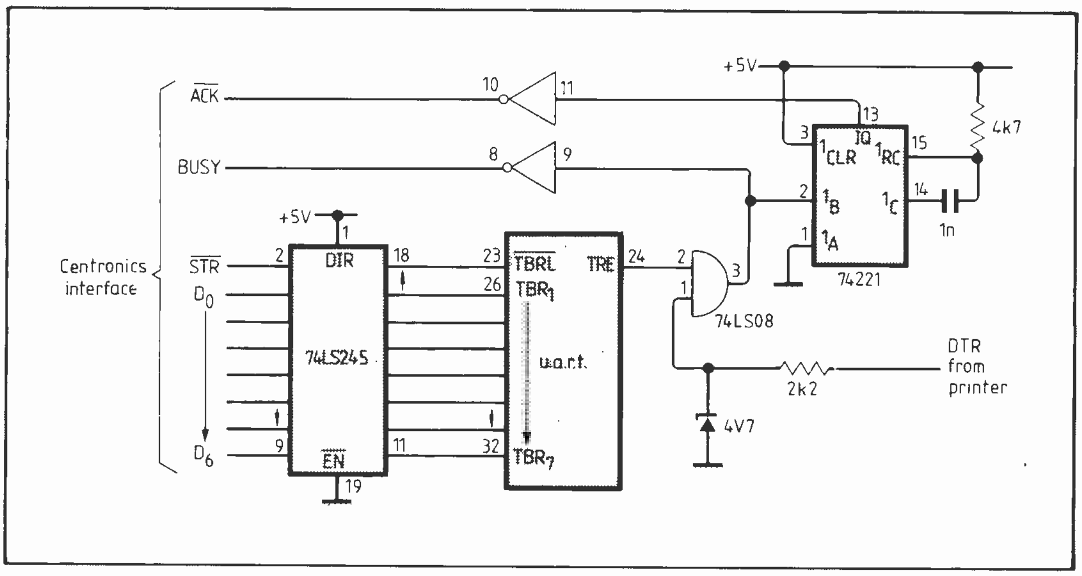
Lower-noise oscillator

Standard two-gate oscillators generate noise spikes around the zero-crossing point. This cheap circuit using a 4001/4011 type i.c. provides a much cleaner output which is also buffered. Further, the oscillator may be gated on and off using one of the inputs shown strapped together.

I have used more expensive 4093 i.cs for similar applications but I found that they had a higher failure rate.

I.J. Eamus
Ampro Enterprises
Aylesbury
Buckinghamshire





Centronics-to-RS232 converter

We have made one or two modifications to Burd's excellent idea for producing serial output from a Centronics printer interface, described in the February issue.

As the uart is a cmos device, we added a buffer to protect its inputs when power is on and the link is disconnected. The computer needs to stop sending data when a serial printer buffer is full so we added an And gate to combine the data-terminal ready signal from the printer with the uart TRE signal.

Finally, the Centronics standard specifies an acknowledge pulse of approximately 5μs. The original monostable circuit gave a pulse of approximately 25ms so we replaced it with a t.t.l. monostable i.c.

John Wike and Dave Pinch
South Wales Radio Therapy and Oncology Service
Velindre Hospital
Cardiff

Fast converter for repetitive signals

Flash analogue-to-digital converters and sample-and-hold circuits are widely used for sampling analogue data, but when the input signal is repetitive, there is a good case for using a successive approximation technique — an effective sampling rate as good as for flash converters is possible at a fraction of the cost. Speed of this circuit is only limited by the comparator and acquisition time of the D-type bistable devices of IC_1.

Commercial a-to-d converters are usually single-chip i.cs and the time taken for each approximation is not externally controllable, so discrete components are used. This circuit is for four-bit conversion, but expansion to six or eight bits is relatively easy.

When the reset line is pulsed, outputs of the bistable elements and the two-bit counter are cleared. The one-of-four decoder Q_0 output becomes high. This signal is sent to the d-to-a converter most-significant input through an Or gate; all other inputs are low.

To obtain a sample, the strobe line is pulsed. Its leading edge clocks bistable device IC_{1d} through the And gate, and the comparator output state appears at the output of IC_{1d}. The strobe signal trailing edge clocks the two-bit counter, making Q_0 and Q_1 outputs of the decoder low and high respectively. Thus if the input signal was greater than the most significant bit when the strobe leading edge occurred, output of IC_{1d} will be high, otherwise it will be low.

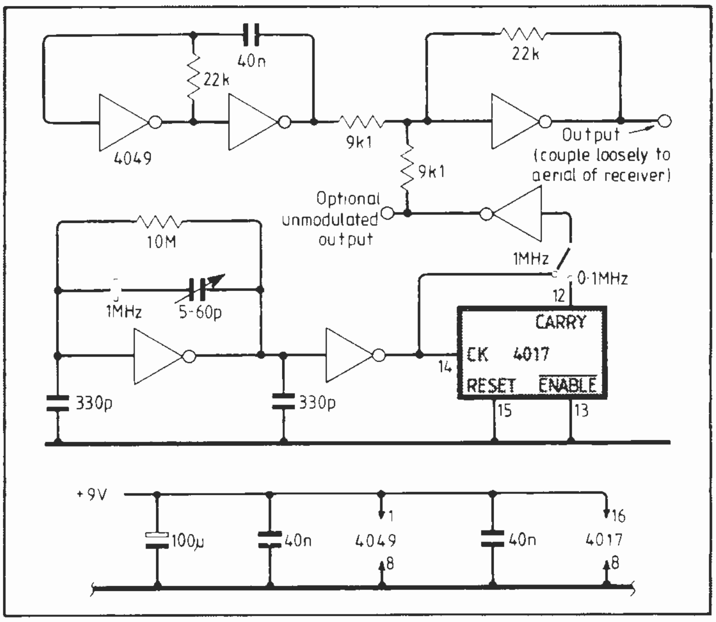
Four strobe signals must be applied at the same point in successive signal repetitions, allowing enough time for the converter to settle between each one. When four strobe signals have been applied, data can be read at outputs A to D, the reset signal applied, and the sequence restarted at a different point in the signal cycle. Device types depend on the application and resolution required.

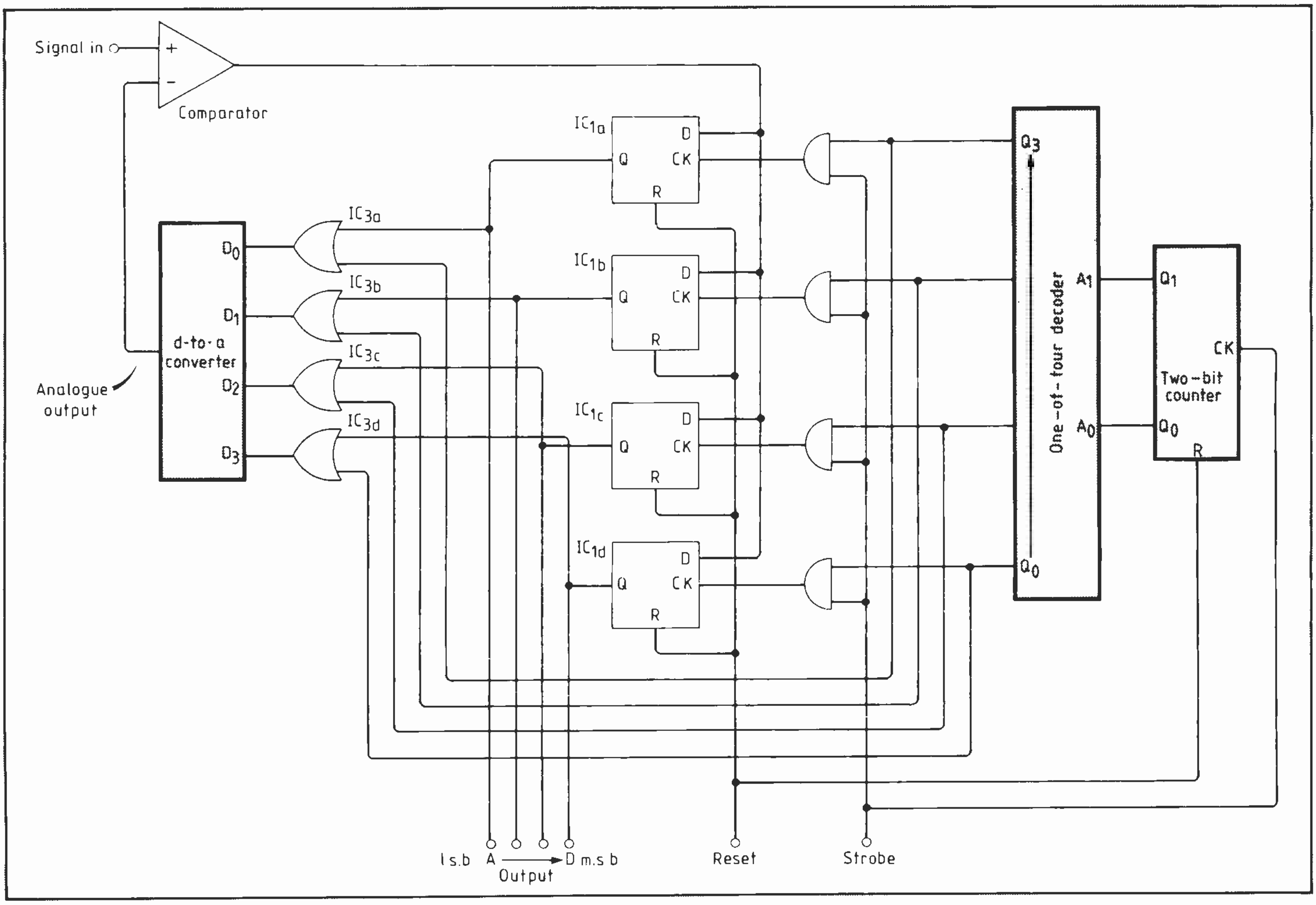
T. Hunter
Doncaster
South Yorkshire

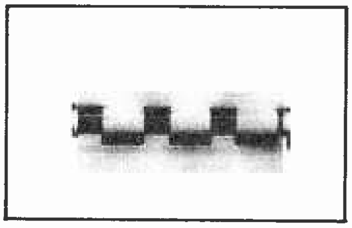
Two i.c. shortwave calibrator

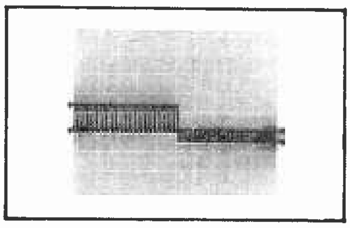
Inexpensive portable shortwave receivers are often quite sensitive but have vague dial markings, making tuning difficult. Lack of a b.f.o. precludes use of a conventional crystal calibrator since its signals would be inaudible in many cases.

This circuit uses two c-mos i.cs to generate a modulated calibration signal at switch-selectable frequencies of 100kHz or 1MHz. The signal is audible as a distinctive tone when the receiver is tuned to









any multiple of the calibration frequency.

The last inverter stage — actually a linear operational amplifier fed by a summing network — functions as a modulator. The output waveform is somewhat odd-looking (see photograph) but definitely amplitude modulated. Modulation can be adjusted by varying one or both of the 9.1kΩ resistors.

M. Covington
Athens
Georgia
USA

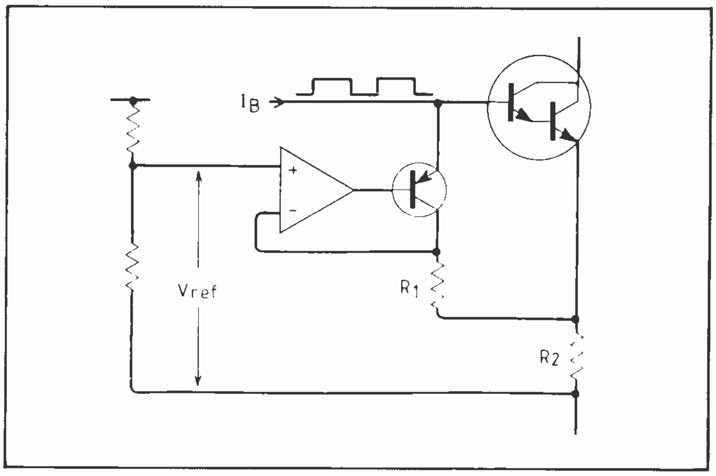
Trip for power switches

Overcurrent protection for switching power transistors is provided by this simple add-on circuit. Emitter current is monitored by R_2 and the comparator. At the trip current, the p-n-p transistor turns on and shunts the base drive away through R_2 to provide positive feedback. The stage remains disabled until the drive is removed, which is useful for p.w.m. systems.

The comparator is an open-collector one. Base-drive current multiplied by R_2 should be around 250mV and base-emitter voltage of the output Darlington should be at least 900mV; if not add a resistor or diode. To ensure that the comparator circuit switches right over, the rise in voltage of R_1 must exceed the fall over R_2. A safe rule is to let the normal excess drive, shunted through R_1, replace the drop across R_2 before the transistor comes out of saturation at the trip current. Typically, this makes R_2 quite small.

As an example using MJ11030 transistors at 50A, 339 comparators and 2N3703 p-n-p transistors, V_{ref} was 100mV and was shared between several stages. Resistor R_1 was about 2Ω and R_2 only 2 mΩ.

D.H. Potter
Axminster
Devon

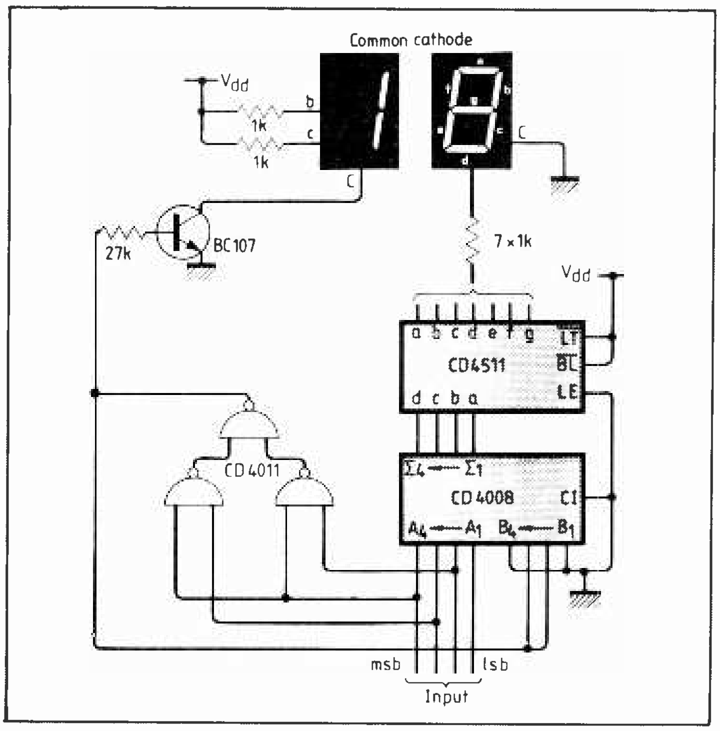


Easy to read hex. display

Onlug's circuit for displaying hexadecimal numbers in decimal form (Dec. 1984) can be simplified. This circuit does the same job, but saves 14 diodes. If only one display is needed it also saves two i.cs.

The 4011 detects inputs greater than nine and illuminates the second digit. The same signal causes six to be added to the 4008 adder input. The result always has an overflow of 16, with the effect that 10 is actually subtracted, leaving a number between zero and five which can still be decoded by the 4511 i.c.

John Cook
Ipswich
Suffolk



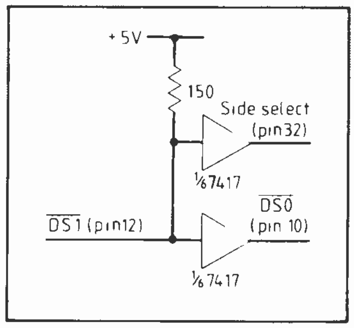
Adapting for double-sided drives

Microcomputers designed to select independent single-sided disc drives can be interfaced with double-sided drives using this small modification which makes the drive's second side appear as an independent drive to the computer. To do this, a drive-select signal forms the side-select signal.

The circuit, which may be installed in the microcomputer or in any of the drives, relies on drive and side-select signals being open-collector sourced; check this before installing. Using signals shown, DS0 selects the first side of the drive and DS1 the second side. Which drive-select signals are used will depend on the logical position required for the drive.

Decouple the 7417 close to the supply pins and connect all unused inputs to the positive rail through a common 1kΩ resistor. In many drives, supply, ground and signal lines will be available at dil sockets. Pin numbers shown are for a standard 5¼in drive interface (further details in the article Floppy discs on pages 44/45 of the January issue).

David March
London



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MC1327Q	0.95
MC1349P	1.20
MC1351P	1.50
MC1351P	1.50
MC1357	2.35
MC1358	1.58
MC1495	3.00
MC1496	1.25
MC145106P	7.95
MC1723	0.50
MC3357	2.75
ML231B	1.75
ML232B	2.50
MSM5807	6.75
PLL02A	5.75
SAA500A	3.50
SAA1025	7.25
SAA5010	6.35
SAS560S	1.75
SAS570S	1.75
SAS580	2.85
SL901B	4.85
SL917B	6.65
SL1310	1.80
SL1327	1.10
SL1327Q	1.10
SN76003N	1.95
SN76013N	1.95
SN76023N	2.75
SN76033N	3.50
SN76110N	0.89
SN76115N	1.25
SN76131N	1.30
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SN76227N	1.05
SN76533N	1.65
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TA7203	2.95
TA7204P	2.15
TA7205AP	1.15
TA7222AP	1.80
TA7227P	4.25
TA7310P	1.80
TA7313AP	2.95
TA7321P	2.25
TA7609P	3.95
TA7611AP	2.95
TAA310A	2.50
TAA320A	1.95
TAA350A	1.95
TAA550	0.35
TAA570	1.95
TAA661B	1.20
TAA700	1.70
TBA120AS/B/C/SA/SB/T/U	1.00
TBA395	1.50
TBA396	0.75
TBA440N	2.55
TBA480Q	1.25
TBA510	2.50
TBA510Q	2.50
TBA520	1.10
TBA520Q	1.10
TBA530	1.10
TBA530Q	1.10
TBA540	1.25
TBA540Q	1.35
TBA550Q	1.95
TBA560C	1.45
TBA560C	1.45
TBA560CQ	1.45
TBA570	1.00
TBA641A12	2.50
TBA651R	2.50
TBA720A	2.45
TBA750Q	2.65
TBA800	0.89
TBA810AS	1.65
TBA810P	1.65
TBA820M	0.75
TBA820Q	1.45
TBA890	2.50
TBA920	1.65
TBA950/2X	2.35
TBA990	1.49
TCA270	1.10
TCA270SQ	1.10
TCA650	3.50
TCA940	1.65
TDA440	2.20
TDA1001	1.95
TDA1004A	4.15
TDA1006A	2.50
TDA1010	2.15
TDA1035	2.50
TDA1037	1.95
TDA1170	1.95
TDA1190	2.15
TDA1270Q	3.95
TDA1327	1.70
TDA2002	1.95
TDA2020	2.95
TDA2030	2.80
TDA2522	1.95
TDA2523	2.95
TDA2524	1.95
TDA2530	1.95
TDA2532	1.95
TDA2540	1.95
TDA2541	2.15
TDA2560	2.15
TDA2571	3.50
TDA2581	2.25
TDA2593	2.95
TDA2600	5.50
TDA2610	2.50
TDA2611A	1.95
TDA2640	3.50
TDA2680A	2.75
TDA2690	2.45
TDA3310	2.95
TDA3560	5.50
UPC566H	2.95
UPC575C2	2.75
UPC1025H	1.95
UPC1028H	1.95
UPC1032H	1.50
UPC1156H	2.75
UPC1158H	0.75
UPC1167C2	1.15
UPC1181H	1.25
UPC1182H	2.95
UPC1185H	3.95
UPC1191V	1.50
UPC1350C	2.95
UPC1353C	2.45
UPC1365C	3.95
UPC2002H	1.95
555	0.35
556	0.42
723	0.50
741	0.35
747	0.50
748	0.35
7805	0.65
7808	0.60
7815	0.65

SEMICONDUCTORS

AAY12	0.25
AC126	0.45
AC127	0.20
AC128	0.28
AC128K	0.32
AC141	0.28
AC141K	0.34
AC142K	0.30
AC176	0.22
AC176K	0.31
AC187	0.25
AC187K	0.28
AC188	0.25
AC188K	0.37
AD142	0.79
AD143	0.82
AD149	0.70
AD161	0.39
AD162	0.39
AD161/2	0.90
AF106	0.50
AF114	1.95
AF121	0.60
AF124	0.65
AF125	0.35
AF126	0.32
AF127	0.65
AF139	0.40
AF150	0.60
AF178	1.95
AF239	0.42
AU106	4.50
AU107	3.50
AU110	3.50
BC107A	0.11
BC107B	0.11
BC108	0.10
BC108A	0.11
BC108B	0.12
BC109	0.10
BC109B	0.12
BC109C	0.12
BC114	0.11
BC116A	0.15
BC117	0.19
BC119	0.24
BC125	0.25
BC139	0.20
BC140	0.31
BC141	0.25
BC142	0.21
BC143	0.24
BC147A	0.12
BC147B	0.12
BC148A	0.09
BC148B	0.09
BC149	0.09
BC157	0.12
BC158	0.09
BC159	0.09
BC174	0.09
BC174A	0.09
BC177	0.15
BC178	0.15
BC182	0.10
BC182LB	0.10
BC183	0.10
BC183L	0.09
BC184LB	0.09
BC204	0.10
BC207B	0.13
BC208B	0.13
BC212	0.09
BC212L	0.09
BC212LA	0.09
BC213	0.09
BC213L	0.09
BC214	0.09
BC214C	0.09
BC214L	0.09
BC237B	0.09
BC238	0.09
BC239	0.12
BC251A	0.12
BC252A	0.15
BC258	0.25
BC258A	0.39
BC284	0.30
BC300	0.30
BC301	0.30
BC303	0.26
BC307B	0.09
BC327	0.10
BC328	0.10
BC337	0.10
BC338	0.09
BC347A	0.13
BC461	0.35
BC478	0.20
BC527	0.20
BC547	0.10
BC548	0.10
BC549A	0.10
BC550	0.14
BC557	0.08
BC557B	0.08
BC558	0.10
BCY33A	1.60
BD115	0.30
BD124P	0.59
BD131	0.42
BD132	0.42
BD133	0.40
BD135	0.30
BD136	0.30
BD137	0.32
BD138	0.30
BD139	0.32
BD140	0.30
BD144	1.10
BD150C	0.29
BD159	0.65
BD160	1.50
BD166	0.55
BD179	0.72
BD182	0.70
BD201	0.83
BD202	0.65
BD203	0.78
BD204	0.70
BD222	0.46
BD223	0.59
BD225	0.48
BC232	0.35
BD233	0.35
BD234	0.35
BD236	0.49
BD237	0.40
BD238	0.40
BD242	0.65
BD246	0.75
BD376	0.32
BD410	0.65
BD434	0.65
BD437	0.75
BD438	0.75
BD520	0.65
BD538	0.65
BD597	0.95
BD701	1.25
BD702	1.25
BD707	0.90
BDX32	1.50
BF115	0.35
BF119	0.65
BF127	0.39
BF154	0.20
BF158	0.22
BF160	0.27
BF167	0.27
BF173	0.22
BF177	0.38
BF178	0.26
BF179	0.34
BF180	0.29
BF181	0.29
BF182	0.29
BF183	0.29
BF184	0.28
BF185	0.28
BF194	0.11
BF195	0.11
BF196	0.11
BF197	0.11
BF198	0.16
BF199	0.14
BF200	0.40
BF241	0.15
BF245	0.30
BF257	0.28
BF258	0.28
BF259	0.28
BF271	0.26
BF273	0.18
BF336	0.34
BF337	0.29
BF338	0.32
BF355	0.37
BF362	0.38
BF363	0.65
BF371	0.25
BF394	0.19
BF422	0.32
BF457	0.32
BF458	0.36
BF459	0.36
BF467	0.68
BF595	0.23
BF597	0.25
BFR39	0.23
BFR40	0.23
BFR81	0.25
BFR88	0.30
BFR90	1.50
BFR91	1.75
BFT42	0.35
BFT43	0.35
BFW92	0.85
BFX29	0.30
BFX84	0.26
BFX85	0.32
BFX86	0.30
BFX88	0.25
BFY50	0.21
BFY51	0.21
BFY52	0.25
BFY90	0.77
BLY48	1.75
BRY39	0.45
BR100	0.26
BR101	0.49
BR103	0.55
BRC4443	1.15
BT100A/02	0.85
BT106	1.49
BT116	1.20
BT119	3.15
BT120	1.65
BU105	1.95
BU108	1.69
BU124	1.25
BU125	1.25
BU126	1.60
BU204	1.55
BU205	1.30
BU208	1.39
BU208A	1.52
BU208D	1.85
BU326	1.20
BU407	1.24
BU500	2.25
BU508A	1.95
BU526	1.90
BU80Y	2.25
BUY69B	1.70
MJ3000	1.98
MJE340	0.40
MJE520	0.48
MPSA13	0.29
MPSA92	0.30
MRF237	4.95
MRF4[illegible]0A	13.95
MRF453	17.50
MRF454	23.50
MRF455	17.50
MRF475	2.50
MRF477	10.00
OC16W	2.50
OC23	1.50
OC42	0.75
OC44	0.75
OC45	0.55
OC70	0.45
OC71	0.55
OC81	0.50
R2008B	1.45
R2010B	1.45
R2322	0.58
R2323	0.66
R2540	2.48
RCA16334	0.90
RCA16335	0.80
SKE5F	1.45
TIP29	0.40
TIP29C	0.42
TIP30C	0.43
TIP31C	0.55
TIP32C	0.42
TIP33B	0.95
TIP34B	0.95
TIP41A	0.45
TIP41C	0.45
TIP42C	0.47
TIP47	0.65
TIP120	0.60
TIP125	0.65
TIP142	1.75
TIP161	2.95
TIP2955	0.80
TIP3055	0.55
TIS91	0.20
TV106/2	1.50
2N1308	1.35
2N2219	0.28
2N2905	0.40
2N3053	0.40
2N3054	0.59
2N3055	0.52
2N3702	0.12
2N3703	0.12
2N3704	0.12
2N3705	0.12
2N3706	0.12
2M3708	0.12
2N3733	9.50
2N3773	2.75
2N3792	1.35
2N4427	1.95
2N4444	1.15
2N5294	0.42
2N5296	0.48
2N5298	0.60
2N5485	0.45
2N5496	0.95
2SA715	0.60
2SC495	0.80
2SC496	0.80
2SC1096	0.80
2SC1106	2.50
2SC1172Y	2.20
2SC1173	1.15
2SC1306	1.00
2SC1307	1.50
2SC1364	0.50
2SC1449	0.80
2SC1678	1.25
2SC1909	1.45
2SC1945	2.65
2SC1953	0.95
2SC1957	0.80
2SC1969	1.95
2SC2028	1.15
2SC2029	1.95
2SC2078	1.45
2SC2091	0.85
2SC2098	2.95
2SC2166	1.95
2SC2314	0.80
2SC2371	0.36
2SD234	0.50
3N211	1.95
3SK88	0.95

DIODES

AA119	0.08
BA115	0.13
BA145	0.16
BA148	0.17
BA154	0.06
BA156	0.15
BA157	0.30
BAX13	0.04
BAX16	0.06
BB105B	0.30
BT151	0.79
BY126	0.10
BY127	0.11
BY133	0.15
BY164	0.45
BY176	1.20
BY179	0.63
BT182	0.55
BY184	0.35
BY199	0.40
BY206	0.14
BY208-800	0.33
BY210-800	0.33
BY223	0.90
BY298-400	0.22
BY299-800	0.22
BYX10	0.20
BYX36-150R	0.20
BYX38-600R	0.60
BYX55-600	0.30
BYX71-600	1.10
BZY95C30	0.35
CS4B	4.50
CS10B	8.45
OA47	0.09
OA90	0.05
OA91	0.06
OA95	0.06
OA202	0.10
IN21DR	5.00
IN23B	5.00
IN23C	5.00
IN23ER	5.00
IN23WE	5.00
IN4001	0.04
IN4003	0.04
IN4004	0.05
IN4005	0.05
IN4007	0.06
IN4148	0.02
IN4448	0.10
IN5401	0.12
IN5402	0.14
IN5403	0.12
IN5406	0.13
IN5407	0.16
IN5408	0.16
ITT44	0.04
ITT923	0.15
ITT2002	0.10

ZENER DIODES

BZX61 Series	0.15
BZY88 Series	0.10

NEW BRANDED CATHODE RAY TUBES

PLEASE ALLOW ADDITIONAL £3 PER TUBE FOR CARRIAGE.

A1865/20	65.00
AW36.11	25.00
CME822W	19.00
CME822GH	25.00
CME1428GH	45.00
CME1428W	39.00
CME1523GA	39.00
CME1523W	39.00
CME1431GH	39.00
CME1431W	39.00
CME202GH	45.00
CME2024W	45.00
CME2325W	45.00
CME3126GH	45.00
CME3128GH	45.00
CME3128W	45.00
CME3132GH	45.00
CME3155W	45.00
CRE1400	25.00
CV429	89.00
CV1450	35.00
CV1526	19.00
CV2185	15.00
CV2191	19.00
CV2193	15.00
CV5119	85.00
CV5320	85.00
CVX389	55.00
D9-110GH	39.50
D9-120	45.00
D10-210GH	45.00
D10-210GH68B	65.00
D10-210GH72	65.00
D10-230GH	35.00
D10-230GM	35.00
D10-293GY/90	55.00
D13-30GH	49.50
D13-33GM	49.00
D13-47GH/26	55.00
D13-47GH/34	55.00
D13-51GL/26	85.00
D13-51GM/26	85.00
D13-450GH/01	55.00
D13-471GH/26	55.00
D13-550GH	65.00
D13-600GM	59.00
D13-610GH	59.00
D13-610GM	59.00
D13-611GH	59.00
D13-611GM	59.00
D13-630GH	59.00
D14-120GH08	65.00
D14-150GH	75.00
D14-150GM	75.00
D14-172GH/84	59.00
D14-172GR	55.00
D14-172GV	55.00
D14-173GH	55.00
D14-173GM	53.00
D14-173GR	55.00
D14-181GH/62	65.00
D14-181GH/98	65.00
D14-181GJ	55.00
D14-181GM	53.00
D14-181GM50	59.00
D14-182GH	59.00
D14-182GM/98	65.00
D14-200BE	89.00
D14-200GA/50	85.00
D14-200GM	75.00
D14-210GH	75.00
D14-270GH/50	75.00
D14-310W	110.00
D14-320GH	85.00
D14-320GH/82	85.00
D14-340GH/KM	45.00
D14-340KA	45.00
D16-100GH	65.00
D16-100GH/65	69.00
D16-100GH/67	65.00
D16-100GH67A	75.00
D16-100GH/79	69.00
D16-100GH/79A	75.00
D16-100GH97	65.00
D18-160GH	89.00
D21-10GH	65.00
D21-10GJ	69.00
D21-10LD	69.00
DG7-5	55.00
DB7.6	35.00
DB7-36	55.00
DG7.32	45.00
DG13.2	45.00
DH3-91	55.00
DH7.91	45.00
DP7.5	35.00
DP7.6	35.00
DN13.78	35.00
F15.101LC	49.00
F16-101GM	55.00
F16-101LD	55.00
F21-130GR	55.00
F21-130LC	55.00
F21-131GR	79.00
F31-10GM	65.00
F31-10GR	65.00
F31-10LC	65.00
F31.10LD	65.00
F31-12LC	65.00
F31-12LD	65.00
F31-13GR	65.00
F31.13LD	65.00
F31-13LG	65.00
F41-123LC	160.00
F41-141LG	160.00
F41-142LC	185.00
M7-120W	19.00
M14-100GM	45.00
M14-100KA	55.00
M14-100LC	45.00
M17-151GVR	175.00
M17-151GR	175.00
M19-100GY	55.00
M19-100W	45.00
M19-101GR	55.00
M19-103W	55.00
M23-110GH	55.00
M23-111W	55.00
M23-111GH	55.00
M23-111LD	55.00
M23-112GM	55.00
M23-112GV	55.00
M23-112GW	55.00
M23-112KA	55.00
M23-112LD	55.00
M23-112W	55.00
M24-120GM	59.00
M24-120GR	59.00
M24-120LC	59.00
M24-120WAR	59.00
M24-121GH	55.00
M24-121LC	59.00
M24-121WA	59.00
M28-12GH	55.00
M28-12LC	55.00
M28-13LC	49.00
M28-13LG	49.00
M28-13GR	49.00
M28-131GR	55.00
M28-132GM	55.00
M28-133GH	55.00
M31-100GH	55.00
M31-101GH	55.00
M31-182GR	55.00
M31-182GV	53.00
M31-183W	55.00
M31-184W	65.00
M31-184GH	65.00
M31-184P31	85.00
M31-185GH/VR	89.00
M31-186W	69.00
M31-190GH	55.00
M31-190GR	55.00
M31-190LA	55.00
M31-190W	59.00
M31-191GH	59.00
M31-191GR	59.00
M31-191GV	55.00
M31-191W	59.00
M31-192W	59.00
M31-195GH	59.00
M31-210GH	59.00
M31-220W	59.00
M31-270GY	65.00
M31-271P31	65.00
M31-271GW	65.00
M31-271W	65.00
M36-12W	75.00
M36-141LA	75.00
M36-141LG	75.00
M36-141W	75.00
M36-170LG	75.00
M38-100GR	65.00
M38-101GH	65.00
M38-103GR	65.00
M38-120W	65.00
M38-120WA	65.00
M38-121GR	65.00
M38-121GHR	65.00
M38-121LA	65.00
M38-121WA	65.00
M38-122GW	65.00
M38-140LA	65.00
M38-141LA	65.00
M38-142GR	65.00
M38-142LA	65.00
M38-340P31	65.00
M38-341GR	65.00
M38-341P31	65.00
M38-344P39	65.00
M40-120W	59.00
M43-12GM/01	65.00
M43-12LG/01	65.00
M44-120LC	65.00
M44-120GR	65.00
M47-25GR/22	65.00
M50-120GH	65.00
M50-120GR	65.00
M50-120GV	65.00
M50-120LC	65.00
M61-120LC	75.00
M61-120W	75.00
S6AB	45.00
SE4/D/P7	45.00
SE42BP31AL	55.00
SE42BP31	55.00
SE52AP31AL	55.00
SE5FP31	55.00
T937	65.00
T948N	65.00
T948H	65.00
V3191	59.00
V4150LC	55.00
V4254B	65.00
V4274GH	65.00
V4283W	65.00
V5002LD	65.00
V5004GR	59.00
V5004LD	59.00
V6001GH	65.00
V6006GH	65.00
V6007DP31	59.00
V6007GW	65.00
V6008GW	59.00
V6008W	85.00
V6034WA	59.00
V6048CLA	59.00
V6048F	65.00
V6048J	49.00
V6052GH	65.00
V6052GR	65.00
V6064BLA	65.00
V6064BP31	55.00
V6064CLA	55.00
V6069GH	55.00
V6070P31	49.00
V7016A	65.00
V7030	59.00
V7031GH	59.00
V7031/67A	59.00
V7035A	49.00
V7037GH	45.00
V8004GR	65.00
V8006GH	65.00
V8010A	65.00
2BP1	9.00
3BP1	13.50
4EP1	30.00
3WP1	18.50
3H/0BM	55.00
5BP1	9.00
5BHP1	30.00
5BHP1FF	30.00
5BHP31	30.00
5CP1	10.00
6EP7/S	39.00
13BP1	13.50
13BP4	17.50
17DWP4	25.00
32J/1085	69.00
88D/89B/89D/89L	15.00
1273	39.00
1564	39.00
1844	45.00
9442E1	80.00
95447GM	75.00
95449GM	75.00
7709631	78.50

TAPE HEADS

MOND HEAD	1.50
AUTO REVERSE	3.50
STEREO HEAD	2.95

ELECTRO-OPTICAL

9524H	25.00
9677M	22.00
P4231BAM	19.00

WIREWOUND RESISTORS

4 Watt	2R4-10K	0.20
7 Watt	R47-22K	0.20
11 Watt	1R5-15K	0.25
17 Watt	1R-15K	0.30

VALVE AND CRT BASES

B5D	5.50	B13B	0.50
B7G	0.25	B14A	3.00
B7G SKTD	0.25	12PIN CRT	0.95
B8G	1.50	NUVISTOR	2.95
B8H	0.70	OCTAL	0.35
B9A	0.35	SK610	35.00
B9A SKT	0.40	UX5	1.75
B9G	0.75	UX7	1.75
B10B	0.20	CANS	0.30

LINE OUTPUT TRANSFORMERS

DECCA 100	7.95
DECCA 1700 MONO	9.95
DECCA 1730	8.95
DECCA 2230	8.25
GEC 2040	8.95
GRUNDIG 1500	15.45
GRUNDIG 5010-6010, 2222, 5011-6011	13.45
ITT CVC20	8.20
ITT CVC30	8.25
PHILIPS G8	8.50
PHILIPS G9	8.99
PHILIPS G11	13.39
PYE 725	10.95
RBM T20A	12.40
TANDBERGE 90°	11.15
TELEFUNKEN 711A	11.15
THORN 1590	9.50
THORN 8000	9.20
THORN 9000	9.95
THORN 9800	22.40
THORN MAIN TRANSFORMER 3000/3500	9.70

EHT MULTIPLIERS

ITT CVC20	6.35
ITT CVC30	6.35
PHILIPS G8 550	6.96
RANK T20A	6.91
THORN 3000/3500	7.57
THORN 8500	5.80
THORN 9000	8.00
UNIVERSAL TRIPLER	5.45

REPLACEMENT ELECTROLYTIC CAPACITORS

DECCA 30 (400-400/350V)	2.85
DECCA 80/100 (400/350V)	2.99
DECCA 1700 (200-200-400-350V)	3.55
GEC 2110 (600/300V)	2.25
ITT CVC20 (200/400V)	1.80
PHILIPS G8 (600/300V)	2.25
PHILIPS G9 (2200/63V)	1.19
PHILIPS G11 (470/250V)	2.35

VARICAP TUNERS

ELC1043/05 MULLARD	8.65
ELC1043/06 MULLARD	8.65
U321	8.25
U322	8.25

POTENTIOMETERS

STANDARD VERTICAL POTS	0.12
MIN. VERTICAL POTS	0.12
SANDARD HORIZONTAL POTS	0.12
MIN. HORIZONTAL POTS	0.12
CONVERGENCE PRE-SETS	0.30
SLIDERS LOG	0.48
SLIDERS LINEAR	0.48

PUSH BUTTON UNITS

DECCA, ITT, CVC20 6WAY	7.95
ITT CVC5 7 WAY	10.19
PHILIPS G8 (550) 6 WAY	14.49

20MM QUICK BLOW FUSES

100MA	8p each
200MA — 5AMP	5p each

20MM ANTI SURGE FUSES

100MA — 800MA	15p each
1A — 5AMP	12p each

SPARES & AIDS

FOAM CLEANSER	0.79
FREEZE IT	0.82
SOLDA MOP	0.64
SWITCH CLEANER	0.79
WD40	1.25
PUSH PULL MAINS SWITCH (DECCA, GFC, RANK, THORN ETC.)	1.02
PYE IF GAIN MODULE	6.99
ANODE CAP (27kV)	0.69

PHONE 0474 813225 3 LINES

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MEOPHAM GREEN, MEOPHAM, KENT DA13 0QY

TELEX 966371 PM COMP

A SELECTION FROM OUR STOCK OF BRANDED VALVES

A1714	18.50
A1834	7.50
A1998	11.50
A2087	11.50
A2134	14.95
A2293	6.50
A2599	37.50
A2792	27.50
A2900	11.50
A3042	24.00
A3283	24.00
AC/HL/DD	4.00
AC/THI	4.00
ACT22	59.75
AH221	39.00
AH238	39.00
AL60	6.00
AN1	14.00
ARP12	0.70
ARP34	1.25
ARP35	2.00
ATP4	2.50
AX50	5.50
AZ11	4.50
AZ31	2.50
BL63	2.00
BS450	67.00
BS810	55.00
BS814	55.00
CIK	19.00
C3JA	21.00
C6A	9.00
C1108	54.95
C112G	70.00
C1134	32.00
C1148A	115.00
C1149/1	130.00
C1150/1	135.00
C1534	32.00
CCA	2.60
CC3L	0.90
CL33	2.00
CV Nos Prices on request	
D63	1.20
DA41	22.50
DA42	17.50
DA90	4.50
DA100	125.00
DAF91	0.70
DAF96	0.65
DC70	1.75
DC90	1.20
DCX4-1000	12.00
DCX4-5000	25.00
DET16	28.50
DET18	28.50
DET23	35.00
DET24	39.00
DET25	22.00
DET29	32.00
DF91	0.70
DF92	0.60
DF96	0.65
DF97	1.00
DH63	1.20
DH77	0.90
DH79	0.56
DH149	2.00
DK91	0.90
DK92	1.20
DK96	2.50
DL35	2.50
DL63	1.00
DL70	2.50
DL73	2.50
DL91	1.50
DL92	0.95
DL93	1.10
DL94	2.50
DL96	2.50
DLS10	13.50
DLS16	10.00
DM70	1.95
DM160	2.75
DY51	1.50
DY86/87	0.65
DY802	0.72
E81L	12.00
E82CC	3.50
E83CC	3.50
E83F	5.50
E86C	9.50
E88C	7.95
E88CC	3.50
E88CC Siemens Special	5.95
E90CC	7.95
E90F	7.95
E91H	4.50
E92CC	3.95
E99F	6.99
E130L	19.95
E180CC	6.50
E182CC	9.00
E180F	6.50
E186F	8.50
E188CC	7.50
E1T	15.00
E280F	19.50
E283CC	10.00
E288CC	13.50
E810F	25.00
E1148	1.00
E1524	6.95
EA50	1.00
EA76	1.95
EA79	1.95
EABC80	0.70
EAC91	2.50
EAF42	1.20
EAF801	2.00
EB34	1.50
EB41	3.95
EB91	0.85
EBC33	2.50
EBC41	1.95
EBC81	1.50
EBC90	0.90
EBC91	0.90

EBF80	0.65
EBF83	0.65
EBF85	0.95
EBF89	0.70
EBF93	0.95
EBL1	2.50
EBL21	2.00
EC52	0.75
EC70	1.75
EC80	9.50
EC81	7.95
EC86	1.00
EC88	1.00
EC90	1.10
EC91	5.50
EC92	1.75
EC93	1.50
EC95	7.00
EC97	1.10
EC8010	12.00
ECC32	3.50
ECC33	3.50
ECC35	3.50
ECC81	1.15
ECC81 Special Quality	1.95
ECC82	0.55
ECC82 Philips	1.95
ECC83	0.65
ECC83 Brimar	1.35
ECC83 Philips	1.95
ECC84	0.50
ECC85	0.60
ECC86	2.75
ECC88	0.95
ECC91	2.00
ECC180	0.72
ECC189	0.78
ECC801S	3.50
ECC803S	3.50
ECC804	0.60
ECC2000	12.00
ECF80	1.15
ECF82	1.15
ECF86	1.70
ECF200	1.85
ECF202	1.85
ECF801	0.85
ECF804	6.00
ECF805	2.50
ECF806	10.25
ECH3	2.50
ECH4	3.00
ECH35	3.50
ECH42	1.00
ECH81	0.65
ECH83	0.78
ECH84	0.69
ECH2000	1.50
ECL80	0.60
ECL82	0.65
ECL83	2.50
ECL84	0.74
ECL85	0.69
ECL86	0.80
ECL805	0.69
EF37A	2.00
EF39	1.10
EF41	3.50
EF42	3.50
EF50	2.50
EF55	4.95
EF70	1.20
EF71	1.50
EF72	1.20
EF73	1.00
EF80	0.55
EF83	3.50
EF85	0.50
EF86	2.25
EF86 Special Quality	3.15
EF89	1.50
EF91	1.95
EF92	2.15
EF93	0.95
EF94	0.85
EF95	1.50
EF97	0.90
EF98	0.90
EF183	0.65
EF184	0.65
EF730	1.80
EF731	3.50
EF732	3.50
EF800	11.00
EF805S	13.50
EF806S	14.50
EF812	0.65
EFL200	1.50
EH90	0.72
EK90	0.72
EL32	0.95
EL33	4.00
EL34	2.25
EL34 Mullard/Philips	4.50
EL36	1.95
EL37	9.00
EL38	4.75
EL41	3.50
EL42	2.00
EL81	6.95
EL83	5.95
EL84	0.75
EL85	4.50
EL86	0.85
EL90	1.75
EL91	6.00
EL95	0.70
EL153	12.15
EL183E	3.50
EL18P	3.50
EL360	6.75
EL500	1.40
EL504	1.40
EL509	5.25
EL519	6.95
EL802	3.65
EL821	8.50

EL822	12.95
EM1	9.00
EM4	9.00
EM80	0.70
EM81	0.70
EM84	1.65
EM85	3.95
EM87	2.50
EN32	15.00
EN91	1.10
EN92	4.50
ESU150	14.95
ESU872	25.00
EY51	0.80
EY81	2.35
EY83	1.50
EY84	5.95
EY86/87	0.50
EY88	0.55
EY91	5.50
EY500A	2.50
EY802	0.70
EZ35	0.75
EZ40	2.75
EZ41	2.75
EZ80	0.75
EZ81	0.75
E290	1.50
F6064	2.95
FW4/800	2.95
G55/1K	9.00
G180/2M	9.00
G240/2D	9.00
GC10B	17.50
GC10D	17.50
GC10/4B	17.50
GC10/4E	17.50
GC12/4B	17.50
GD86W	6.00
GDT120M	5.00
GE10	9.00
GN4	6.00
GN10	15.00
GR10G	4.00
GS10C	16.50
GS10H	12.00
GS12D	12.00
GT1C	14.00
GT1C S/S	13.00
GTE175M	8.00
GTR150W	1.00
GU20	35.00
GU50	17.50
GXU1	13.50
GXU3	24.00
GXU50SS	14.50
GY501	1.20
GY802	1.00
GZ30	1.00
GZ31	1.00
GZ32	1.00
GZ33	4.50
GZ34	2.15
GZ34 U L	3.95
GZ37	4.50
HAA91	1.00
HABC80	0.90
HBC90	0.75
HBC91	0.80
HF93	0.75
HF94	1.50
HK90	1.05
HL2K	3.50
HL23DD	4.00
HL41	3.50
HL42DD	3.50
HL90	0.70
HL92	1.50
HL133/DD	3.50
HR2	4.00
HY90	1.00
HVR2	3.00
JP9-7A	60.00
K3118	85.00
KR6/3	45.00
KT8C	7.00
KT33C	3.50
KT36	2.00
KT44	4.00
KT45	4.00
KT61	4.00
KT63	2.00
KT66 OSRAM	15.00
KT66 USA	9.95
KT66 GEC	14.95
KT77 Gold Lion	10.95
KT81	7.00
KT88 USA	10.95
KT88 G Lion	18.95
KT67	9.00
KTW61	2.50
KTW62	2.50
KTW63	2.00
KTZ63	2.50
L63	1.50
L102/2K	6.95
L120/2K	12.00
LB7-20	95.00
LS9B	6.95
M502A	60.00
	85.00
M537A	60.00
M5143	155.00
M8079	6.00
M8082	7.50
M8083	3.25
M8091	7.50
M8096	3.00
M8098	5.50
M8099	5.00
M8100	5.50
M8136	7.00
M8137	5.50
M8161	8.50
M8162	5.50
M8163	5.50
M8190	4.50
M8195	6.50
M8196	5.50
M8204	5.50

M8223	4.50
M8224	2.00
M8225	3.50
ME1401	29.50
ME1402	29.50
ME1501	14.00
MH4	3.50
MHLD6	4.00
ML4	4.50
MS4B	5.50
MU14	1.50
MZI-100	125.00
N37	12.50
N78	9.85
OA2	0.85
OA2WA	1.50
OA3	2.50
OB2	0.85
OB2WA	1.25
OC2	2.50
OC3	1.50
OD3	1.70
OM4	1.00
OM5B	3.00
OM6	1.75
ORP43	2.50
ORP50	3.95
ORP93	12.00
P61	2.50
P41	2.50
PABC80	0.50
PC86	0.75
PC88	0.75
PC92	3.50
PC97	1.10
PC800	1.10
PC900	1.25
PCC84	0.40
PCC85	0.54
PCC88	0.70
PCC89	0.70
PCC189	0.70
PCC805	0.70
PCC806	0.80
PCE82	0.80
PCF80	0.65
PCF82	0.60
PCF84	0.65
PCF86	1.20
PCF87	0.40
PCF200	1.80
PCF201	1.80
PCF800	0.40
PCF801	1.35
PCF802	0.60
PCF805	1.25
PCF806	1.00
PCF808	1.25
PCH200	1.50
PCL82	0.85
PCL83	2.50
PCL84	0.75
PCL85	0.80
PCL86	0.85
PCL800	0.80
PCL805	0.90
PD500	3.50
PD510	3.65
PE1-100	69.00
PEN25	2.00
PEN40DD	2.50
PEN45	3.00
PEN45DD	3.00
PEN46	2.00
PEO6-40N	42.00
PFL200	0.95
PL21	2.50
PL36	0.95
PL38	1.50
PL81	0.72
PL81A	0.72
PL82	0.60
PL83	0.52
PL84	0.78
PL88	1.00
PL95	1.75
PL302	1.00
PL345	12.50
PL500	1.10
PL504	1.15
PL508	1.75
PL509	4.85
PL519	4.95
PL802	5.95
PL802T	3.50
PL820	2.95
PL5557	29.50
PY32	0.60
PY33	0.50
PY81	0.70
PY82	0.70
PY83	0.70
PY88	0.65
PY500A	1.95
PY800	0.79
PY801	0.79
QB3-300	54.95
QE03-10	3.50
QE08-200	145.00
QF40	65.00
QP25	1.00
QQE03-12	6.50
QQE03-20	27.00
QQV02-6	19.50
QQV03-10	5.50
QQV03-10 Mullard	15.00
QQV03-20	25.00
QQV03-20B	32.00
QQV06-40A	27.50
QQV07-50	63.50
QQZ03-20	42.50
QS75.20	1.50
QS75/40	3.00
QS92/10	5.00
QS95/10	4.85
QS108/45	4.00
QS150/15	6.95
QS150/30	1.15
QS150/45	7.00
QS1200	3.95

QS1202	3.95
QS1203	4.15
QS1205	3.95
QS1206	1.05
QS1207	0.90
QS1208	0.90
QS1209	3.15
QS1210	1.50
QS1211	1.50
QS1212	3.20
QS1213	5.00
QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	4.95
QV05-25	1.75
QV06-20	29.50
QV08-100	145.00
QV2-250	45.00
QY3-125	65.00
QY4-250	70.00
QY4-400	78.00
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RK-20A	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	35.00
RS613	45.00
RS685	54.95
RS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
S30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.95
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/2000	9.00
SD6000M	45.00
SP41	5.00
SP42	3.00
SP4B	4.95
SS501	35.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/300	85.00
TB2-300	45.00
TB3/2000	
TBL-2-300	275.00
TD1-100A	25.00
TD03-10F	35.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT15	34.95
TT21	45.00
TT22	45.00
TT100	57.00
TTR-31MR	65.00
TY2-125A	85.00
TY4-400	70.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.95
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	2.50
UCH42	2.50
UCH81	0.65
UCL82	1.75
UF41	1.15
UF42	1.15
UF80	0.80
UF85	1.20
UF89	2.50
UL41	4.50
UL44	3.50

UL84	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V240C/2K	225.00
V241C/1K	195.00
V2464A/2K	315.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75/30	3.00
VR101	2.00
VR105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	1.00
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG2-6400	135.00
XG5-500	22.50
XL1-5V	1.50
XL628FT	7.50
XNP12	2.50
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	99.50
Y503	25.00
Y65	6.95
Y602	12.00
YD1100	75.00
YJ1060	265.00
YL1020	29.00
YL1070	195.00
YL1071	195.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z800U	3.00
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZA1002	1.50
ZC1040	8.00
ZM1005	8.00
ZM1020	8.95
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1B3GT	1.95
1B22	10.00
1B24	14.95
1B35A	29.50
1BC2A	2.50
1C1	2.50
1C5GT	2.50
1D5	2.50
1FD1	2.50
1G3GT	2.50
1K3GT	2.50
1N2	4.50
1N5GT	2.50
1P28	25.00
1T4	0.70
1U5	1.00
1X2B	1.40
1Z2	8.95
2B7	1.50
2B22	69.50
2C21	1.00
2C39A	32.50
2C39BA	39.50
2C40	37.00
2C42	29.50
2C51	0.75
2C53	32.00
2CY5	1.50
2D21	1.50
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	24.95
2K25 Raytheon	75.00
2K26	95.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95

3AT2	3.35
3B2	3.00
3B4	7.00
3B7	4.50
3B24	10.00
3B26	24.00
3B28	12.00
3BZ6	1.50
3C4	1.00
3C23	19.00
3C45	24.00
3CB6	1.50
3CN3A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3D22	19.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4687A	9.50
4-125A	55.00
4-250A	65.00
4B32	35.00
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4CB6	1.95
4CX250B EIMAC	49.00
4CX250BM EIMAC	75.00
4CX250K EIMAC	95.00
4CX125C EIMAC	125.00
4CX350A	95.00
4D26	75.00
4GS7	2.25
4GV7	2.25
4J52	75.00
4JC6A	2.95
4X150A	35.00
5A/102D	9.50
5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AMB	2.15
5ANB	1.20
5AR4	2.00
5AU4	1.50
5B8	2.50
5B.110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	9.00
5B-257M	9.00
5B-258M	14.50
5C22	125.00
5R4GB	3.50
5R4GY	3.50
5T4	5.95
5U4G	2.50
5U4GB	2.50
5V4G	1.25
5Y3GT	1.95
5Z4GT	0.85
6/30L2	0.70
6A/203K	9.00
6A7	4.95
6A8G	1.50
6AC7	2.00
6AF4A	2.50
6AF9	4.15
6AG5	1.50
6AG7	1.95
6AH6	2.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.50
6AK6	2.50
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.50
6AN5	2.65
6AN8A	2.65
6AQ5	1.75
6AQ8	0.85
6AR5	5.95
6AR8	3.95
6AS5	1.50
6AS6	2.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6AZ8	5.95
6B7	2.80
6B8G	1.50
6BA6	0.95
6BA7	4.50
6BA8A	3.50

6BC8	1.00
6BD4	1.50
6BD6	2.50
6BE6	0.72
6BF5	1.60
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.20
6BK4	4.00
6BK7A	1.95
6BL8	1.15
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	3.95
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.50
6BZ7	2.95
6C4	1.10
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C15	2.50
6C18	2.50
6CA4	4.95
6CA7	3.50
6CB5	3.95
6CB6	1.95
6CD6GA	4.50
6CF6	1.50
6CG7	2.25
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	1.50
6CM5	1.60
6CM7	2.95
6CS6	0.75
6CW4	6.50
6CY5	1.00
6D6	2.50
6DC6	2.35
6DJ8	0.95
6DK6	1.15
6DQ5	6.50
6DQ6B	2.50
6DT6A	1.50
6DW4	2.15
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	1.50
6EW7	4.50
6F1	2.00
6F5	4.95
6F6	2.50
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6FQ7	2.95
6G6G	5.50
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GS7	2.15
6GV7	2.50
6GW6	2.50
6H1	9.50
6H3N	1.10
6H6	1.35
6H6GT	1.95
6HF8	0.95
6HS6	4.95
6J4	2.15
6J4WA	3.15
6J5	2.50
6J6	0.85
6JB6A	3.95
6JE6C	4.95

6JU8	2.50
6JS6C	4.95
6J7G	4.15
6K7G	2.00
6K8Y/G	3.00
6KD6	5.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	3.95
6L6GT	1.50
6LD20	0.60
6LF6	7.50
6LJ8	2.50
6LQ6	4.95
6N7	2.50
6N7GT	2.50
6P15	1.50
6P25	4.00
6P26	4.00
6P28	2.00
6Q7	1.20
6Q7GT	1.20
6R7G	3.15
6S4A	1.50
6SA7GT	1.35
6SC7	1.50
6SG7	1.35
6SH7	1.35
6SJ7GT	1.20
6SK7	1.35
6SK7GT	1.35
6SL7GT	0.85
6SN7GT	1.35
6SQ7	1.35
6SS7	1.95
6U4GT	1.75
6U8	1.15
6U8A	1.50
6V6GT	1.15
6X2N	1.00
6X4	1.50
6X5GT	1.00
6X5GTY	1.00
6X8A	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7B6	3.50
7B7	2.50
7C5	3.50
7C6	2.50
7E7	2.50
7H7	3.50
7AU7	1.50
7J7	5.50
7Y4	2.50
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD11	1.00
10LD12	0.65
11E3	55.00
12A6	3.95
12AD6	1.50
12AG8	1.50
12AL5	1.00
12AT6	0.95
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12AU7	0.55
12AV6	1.95
12AV7	2.50
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AY7	3.95
12AZ7A	1.95
12B4A	3.50
12BA6	1.50
12BE6	1.95
12BH7A	2.50
12BL6	1.75
12BY7A	2.75
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12DW7	2.50
12E1	17.95
12E14	28.00
12GN7	3.95
12HG7	4.50
12HG7A	4.50
12J7GT	3.50
12K5	1.00
12K7GT	0.60
12K8	1.10
12SA7GT	1.00
12SG7	4.75
12SH7	1.00
12SK7	1.00

12SJ7	0.60
12SN7GT	1.85
12SR7	2.50
12SQ7GT	1.50
13D3	3.20
13D7	3.20
13D9	3.20
13DE7	2.50
13DR7	2.95
13E1	115.100
13EM7	3.50
14S7	1.00
17DW4A	2.95
17EW8	0.95
17JZ8	4.50
18D3	1.60
19AU4GT	2.50
19G3	17.00
19H4	23.95
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21LU8	2.50
24B1	39.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30C17	0.40
30C18	1.48
30F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6A	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	3.50
75C1	2.50
83	8.50
84	3.00
85A1	6.50
85A2	1.50
90AV	10.00
90C1	2.70
90CG	13.50
90CV	12.50
91AG	9.00
92AG	19.50
92AV	12.50
95A1	6.50
108C1	1.50
150B2	6.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	2.00
705A	8.00
708A	8.00
715A	6.00
715C	45.00
725A	275.00
803	14.95
805	39.00
807	1.95
810	45.00
811A	12.95
813	18.50
813USA	45.00
829B	14.50

833A	80.00
866A	4.50
872A	27.50
873	60.00
884	5.50
930	9.95
931A	13.95
954	1.00
955	1.00
958A	1.00
1299A	0.60
1619	2.50
1625	3.00
1626	3.00
2050W	4.50
2050	3.95
3545	4.00
404A	10.95
927	15.00
1927	25.00
4212E	250.00
4313C	4.00
4328D	9.00
5642	9.50
5651	2.50
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5687	4.50
5692	3.50
5696	2.75
5704	3.50
5718	6.15
5725	2.50
5726	1.50
5727	1.95
5749	2.50
5750	1.85
5751	2.95
5763	4.95
5814A	3.25
5829WA	6.50
5636	5.50
5678	7.50
5840	3.50
5842	11.00
5847	10.95
5879	8.50
5886	13.95
5894	39.50
5899	4.50
5963	1.75
5965	2.25
6005	1.85
6012	16.00
6021	3.65
6057	2.50
6058	3.95
6059	3.75
6060	2.25
6062	4.50
6063	2.00
6064	3.25
6067	1.95
6072	4.20
6080	8.50
6080WA	8.50
6096	2.85
6132	10.00
6136	2.50
6146B	9.95
6157	2.50
6158	3.20
6201	6.45
6205	6.95
6211	2.50
6267	2.25
6350	2.00
6360	4.50
6386	14.50
6545	8.50
6550A	10.95
6688	6.50
6870	11.50
6887	9.50
6883B	9.95
6973	5.95
7025	2.50
7027A	4.50
7032	2.00
7059	2.50
7167	3.95
7189	2.35
7193	7.50
7233	7.95
7247	2.95
7360	13.50
7462	15.00
7475	5.00
7486	75.00
7551	6.95
7558	9.45
7586	11.00
7587	26.95
7591A	4.95
7609	47.00
7733	5.50
7788	25.00
7868	3.95
8012	15.00
8042	55.00
8102	3.95
8106	2.95
8136	1.00
8156	10.95
8245	107.50
8298A	8.50
8417	9.00
9001	1.50
9006	0.90
18042	10.00
18045	10.00

THERMISTORS

VA1040	0.23
VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

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CIRCLE 62 FOR FURTHER DETAILS.

by D.M. Taub

Sampled data servos – a new analysis

This fourth instalment considers the response of a servo system to a sinusoidal signal

If a single frequency ω_o is applied to a conventional servo loop such as the one shown in Fig. 1, then provided that the system is linear, this is the only frequency that exists anywhere in the system. We can then define the 'open-loop gain' at this frequency as the ratio of the signal at Y to that at V. This ratio will of course be a function of ω_o, and the nature of the function determines whether or not the system is stable and how it will respond to any input stimulus.

In the case of a sampled-data servo such as shown in Fig. 18, the situation is more complicated. The important point to notice here is that over part of the loop the signal exists in sampled-data form, and over the remainder including the hold circuit and the plant, it exists as a continuous signal. As indicated in the last part (May) compensation may take place in either part or it may be divided between the two. The last-mentioned is assumed, for generality.

When a singlee frequency ω_o is applied to this system, the sampling action introduces new frequencies $\omega_s - \omega_o$, $\omega_s + \omega_o$, $2\omega_s - \omega_o$, $2\omega_s + \omega_o$ and so on. Within the sampled- data portion there is a simple relationship between the gains at these various frequencies as discussed in April but this is not so in the continuous-signal portion. Here the gains at these frequencies will be quite unrelated to one another and so one can no longer speak of an 'open-loop gain' in the same sense as in a continuous system.

There is a way out of the difficulty. For the purpose of analysis we can replace the single sampler following the subtractor (Fig. 18) by a sampler in each of its input lines (Fig. 19), the two operating in synchronism. Thus instead of doing a subtraction between two continuous signals and sampling the result, we sample the signals first, and carry out the subtraction on the sampled versions.

This is not something that would generally be possible in practice because it would entail measuring the input and output signals relative to some fixed reference, instead of merely measuring the difference between them. But if we could, it would give exactly the same error signal, and so there is no reason why we should not assume it in the interests of the analysis.

The signals at V and Y in Fig. 19 are now both of sampled-data form, and we can define the gain between them, the open-loop gain, as a function of frequency. This will be a periodic function of frequency (as explained in April's article) and the objective is to find it in terms of the gains of the sampled-data and continous-signal portions of the loop.

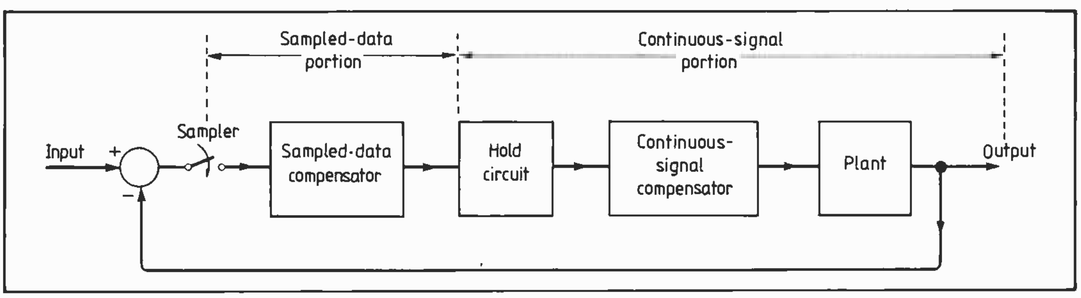

Fig. 18. Servo loop in which the error signal is sampled.

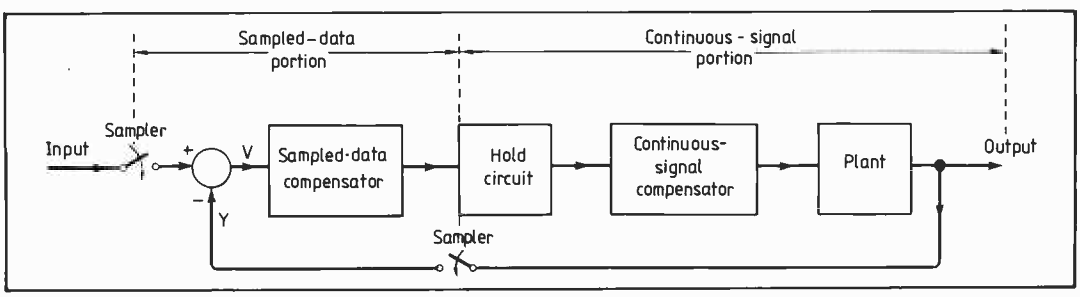

Fig. 19. Sampling the input and output signals is equivalent to the arrangement in Fig. 18.

Time delay in the sampled-data portion

In practice, there can be a time delay in the sampled-data portion of a loop; that is to say its output values can appear a fraction of a sampling interval later than the corresponding input values, as illustrated in Fig.20. Part of this delay can occur in the sampler, for instance when sample values are converted from analogue to digital form. Another contributor can be the compensator. If this uses digital techniques it generally has to carry out at least one multiplication and one addition between receiving an input value and producing the corresponding output value, and this takes time.

These delays can be allowed-for as follows. For the purpose of the analysis, assume the samplers and sampled-data compensator to be delay-free, and follow the last-mentioned by a pure-delay element representing the total delay through the sampled-data section. This element will introduce the same delay whether its input is a continuous or a sampled-data signal, and so it makes no difference whether we include it in the continuous or the sampled-data portion of the loop. Mathematically, it is easier to do the first which gives the arrangement shown in Fig. 21. In terms of complex frequency the gain of the time-delay element is

$$H_{AB}(S) = e^{-s\Delta\tau}$$

where $\Delta\tau$ is the delay introduced. In terms of ω it is

$$H_{AB}(j\omega) = e^{-j\omega\Delta\tau} \quad \ldots 4.1$$

In other words, the gain has a modulus of 1 at all values of ω, and a phase of $-\omega\Delta\tau$.

Gain characteristic of sampled-data portion

The output from a sampled-data network at any sampling instant n is generally expressed as a linear function of the input at that instant and the inputs and outputs at earlier sampling instants. Referring to Fig. 21, denote the sample values at V and X at instant n by v(n) and x(n) respectively, the values one instant earlier by $v(n-1)$ and $x(n-1)$, two instants earlier by $v(n-2)$ and $x(n-2)$, and so on. The algorithm of the sampled-data compensator can then be expressed as

$$x(n) = \beta_m v(n) + \beta_{m-1} v(n-1) + \ldots + \beta_0 v(n-m) - [\gamma_{m-1} x(n-1) + \ldots + \gamma_0 x(n-m)]$$

where β_m, β_{m-1} etc and γ_{m-1}, γ_{m-2} etc are constants. Moving the 'x' terms to the left-hand side,

$$x(n) + \gamma_{m-1} x(n-1) + \ldots + \gamma_0 x(n-m) = \beta_m v(n) + \beta_{m-1} v_i(n-1) + \ldots + \beta_0 (n-m).$$

From this expression, known as a 'recurrence formula', one can write down a corresponding expression relating the z-transforms of the signals at X and V, $X(z)$ and $V(z)$ respectively (see ref.5, sections 4.4 and 9.4). This expression is

$$X(z)[1 + \gamma_{m-1} z^{-1} + \ldots + \gamma_0 z^{-m}] = V(z)[\beta_m + \beta_{m-1} z^{-1} + \ldots + \beta_0 z^{-m}]$$

where $z = e^{Ts}$.

Both sides can now be multiplied by z^m and rearranged to give the gain as a function of z:

$$H_{VX}(z) = \frac{X(z)}{V(z)} = \frac{\beta_m z^m + \beta_{m-1} z^{m-1} + \ldots + \beta_0}{z^m + \gamma_{m-1} z^{m-1} + \ldots + \gamma_0}$$

To find the gain as a function of ω set $z = e^{jT\omega}$, giving $H_{VX}(j\omega) =$

$$\frac{\beta_m e^{jmT\omega} + \beta_{m-1} e^{j(m-1)T\omega} + \ldots + \beta_0}{e^{jmT\omega} + \gamma_{m-1} e^{j(m-1)T\omega} + \ldots + \gamma_0} \quad \ldots 4.2$$

All the exponential terms repeat their values whenever $T\omega$ increases by 2π, and so the function will be periodic as illustrated in the April issue.

Gain of continuous-signal portion followed by sampler

The gain of this section is found by assuming a sampled cosine wave at X (Fig. 21), calculating the spectrum of the signal this produces at Y, and taking the ratio between the spectral components of the two as in April's article. The mathematics can be kept simple by assuming the signal at X to be the sampled version of $2 \cos \omega_o t$, so that from the equations for $q(t)$ and $v(t)$, all its spectral components will have unit magnitude and zero phase angle. The spectral components at Y will then be a direct measure of the gain at the corresponding frequencies.

The spectrum of the signal at X is shown in Fig. 22(a), and as it passes from X to D each component is subjected to a different value of gain. The gain characteristics of the hold circuit, $H_{XA}(j\omega)$ and of the time delay, $H_{AB}(j\omega)$, have already been given (equations 3.2 and 4.1 respectively). The gain of any continuous signal compensation present is $H_{BC}(j\omega)$ and that of the plant, $H_{CD}(j\omega)$.

Multiplying these gains together gives the gain characteristic $H_{XD}(j\omega)$ covering the whole of the continuous-signal portion. A possible shape is sketched in Fig. 22(b). For the assumed signal at X, the signal at D will then be as represented by the line spectrum in Fig. 22(c).

The effect of sampling is to cause each component in this spectrum to be repeated indefinitely, at intervals of ω_s. After the sampler, therefore, the total component at ω_o, representing the gain $H_{XY}(j\omega_o)$, will be the sum of the following:

$H_{XD}(j\omega_o)$, which was already present before sampling,
$H_{XD}[j(\omega_s + \omega_o)]$, repeated from $\omega_s + \omega_o$,
$H_{XD}[j(2\omega_s + \omega_o)]$, repeated from $2\omega_s + \omega_o$,

and so on for higher multiples of ω_s,

$H_{XD}[j(-\omega_s + \omega_o)]$, repeated from $-\omega_s + \omega_o$,
$H_{XD}[j(-2\omega_s + \omega_o)]$, repeated from $-2\omega_s + \omega_o$,

and so on for higher negative multiples of ω_s.

This sum will also represent the gains at $\omega_s + \omega_o$, $2\omega_s + \omega_o$ etc and at $-\omega_s + \omega_o$, $-2\omega_s + \omega_o$ etc, ie at all values of $m\omega_s + \omega_o$, because the same terms are being summed in each case. In other words the value of H_{XY} at every one of the frequencies $m\omega_s + \omega_o$ is the sum of the values of H_{XD} at all of them. The corresponding relationship also exists for the frequencies $m\omega_s - \omega_o$. H_{XY}, the gain of the continuous-signal portion followed by the sampler is thus $H_{XY}(j\omega_o) =$

$$\sum_{m=-\infty}^{\infty} H_{XD}[j(m\omega_s + \omega_o)] \quad \ldots 4.3$$

The negative values of m in this expression can be eliminated by noting that the gains at equal positive and negative values of ω are the complex conjugates of one another. This gives

$$H_{XY}(j\omega_o) = H_{XD}(j\omega_o) + \sum_{m=1}^{\infty} \{ H_{XD}[j(m\omega_s + \omega_o)] + \text{conj}\, H_{XD}[j(m\omega_s - \omega_o)] \}$$

In practice the characteristics of the plant generally cause H_{XD} to fall to a

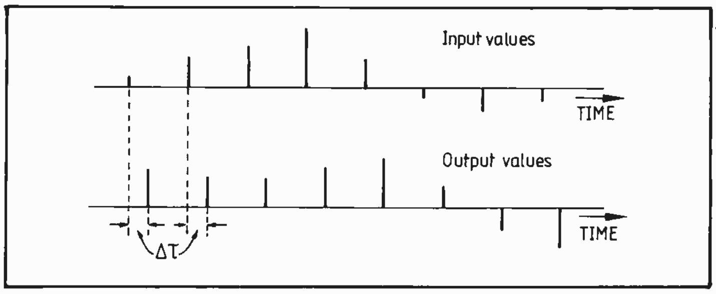

Fig. 20. **Sampled-data portion of the loop introduces a time delay caused by the analogue-to-digital conversion process and digital computation time.**

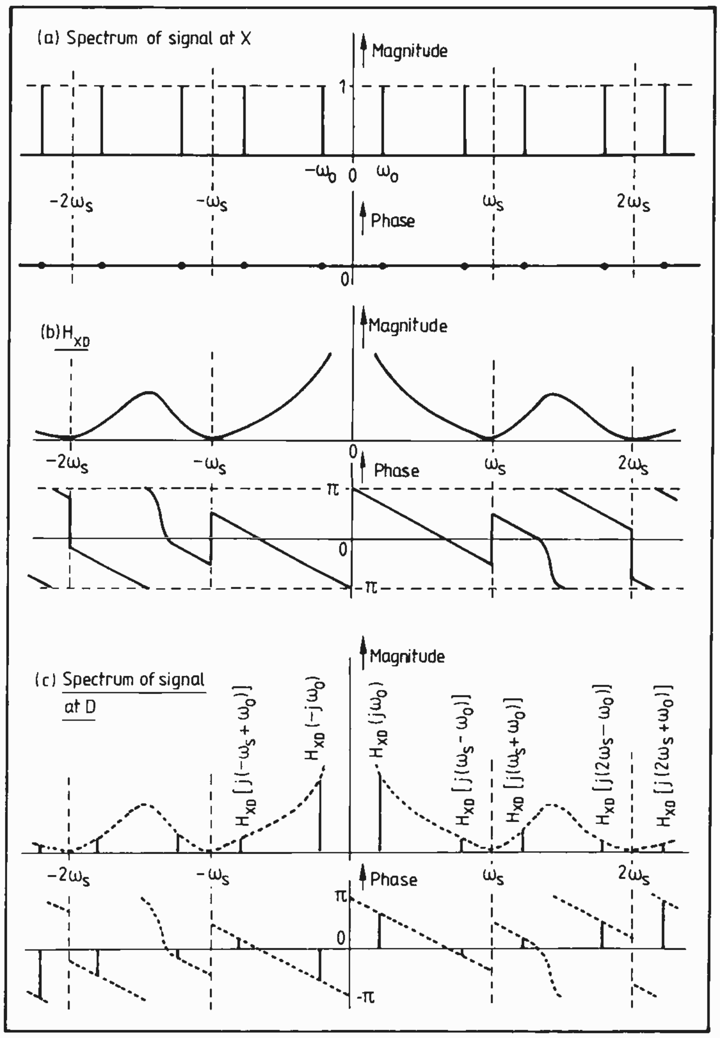

Fig. 22. **Derivation of the gain H_{XY} covering the continuous-sginal portion of the loop an the output sampler.**

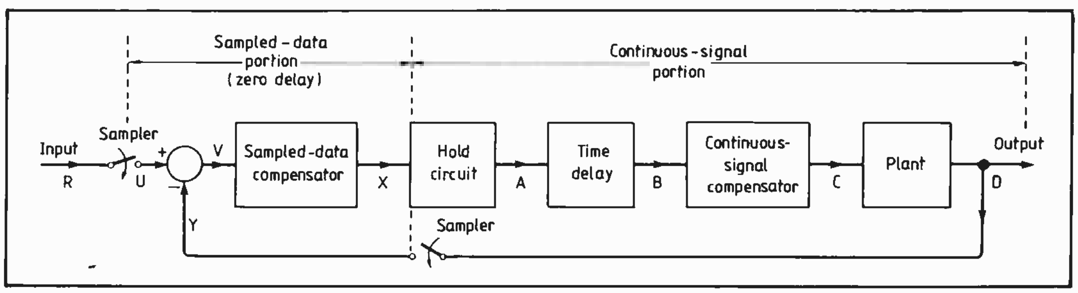

Fig. 21. **Time delay (Fig. 20) can be allowed-for in the continuous-signal portion of the loop.**

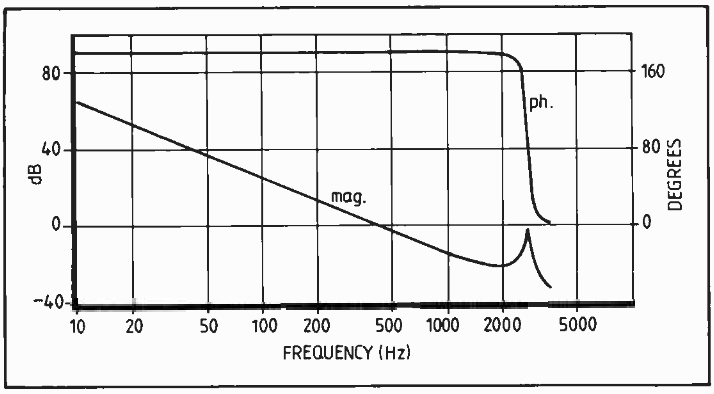

Fig. 23. **Gain characteristic of the plant being controlled: H_{CD}. Notice the resonance at 2750Hz.**

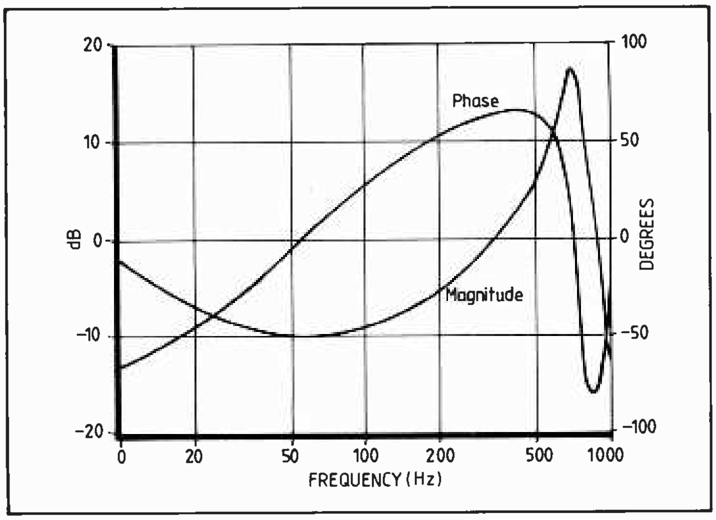

Fig. 24. **Gain characteristic of the compensator, H_{VX}, up to half the sampling frequency.**

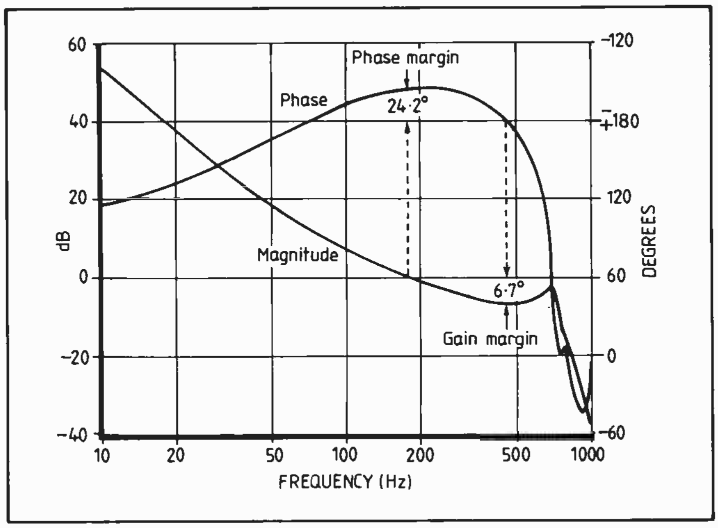

Fig. 25. **Open-loop gain characteristic, H_{VY}. Peaks between 500 and 1000Hz are caused respectively by the peak in the compensator gain characteristic (Fig. 24) and by the effect of aliasing on the 2750Hz plant resonance.**

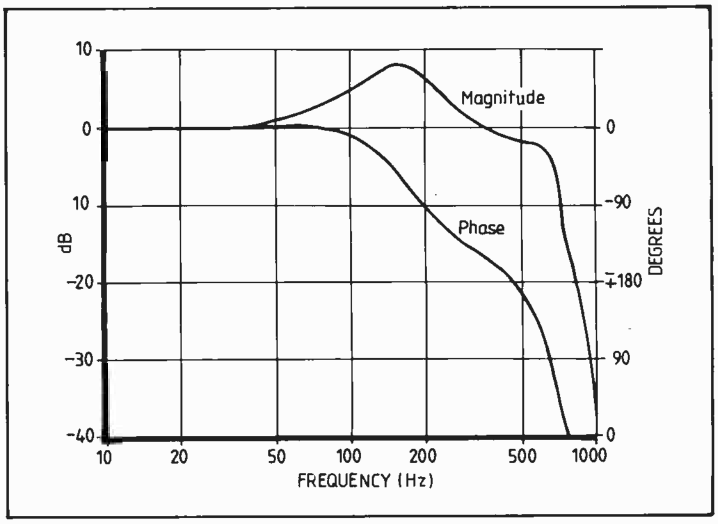

Fig. 26. **Closed-loop gain characteristic, H_{UY}. Notice that around 170Hz the output is about 2.5 times the input.**

negligible value beyond two or three times the sampling frequency. Therefore only the terms of the above summations corresponding to low values of m need to be taken into account.

Open and closed-loop gain and error ratio

The total gain between V and Y in Fig. 21, i.e. the open-loop gain, is the product of the gains of the sampled-data and continuous-signal portions, i.e.

$$H_{VY}(j\omega) = H_{VX}(j\omega)\,.\,H_{XY}(j\omega)\,|\ldots 4.4$$

where $H_{VX}(j\omega)$ is given by equations 4.2 and $H_{XY}(j\omega)$ by 4.3.

The input signal at U is the sum of the signals at V and Y, and so the gain between U and Y, the closed-loop gain, is

$$H_{UY}(j\omega) = \frac{H_{VY(j\omega)}}{1+H_{VY}(j\omega)} \quad \ldots 4.5$$

The gain between U and V, i.e. the ratio of the error signal to the input, is

$$H_{UV}(j\omega) = \frac{1}{1+H_{VY}(j\omega)}\,.$$

Example

The results obtained so far will now be used to compute the open and closed-loop response of a position-control servo. Details of the system are as follows.

Plant: Two stages of integration together with a 30db resonance at 2750Hz, as shown by the gain characteristic in Fig. 23. The gain is

$$H_{CD}(j\omega) = \frac{-2.137\times10^{15}}{\omega^2(j\omega+273-j17280)} \times \frac{1}{(j\omega+273+j17280)}$$

Sampled-data compensator: a digital compensator is used. Its gain is given by equation 4.2 the polynomials being of fifth order. The numerator coefficients β_5 to β_0 are respectively
1.258 0.03125 −1.711 −0.03516 0.5664 0.
The denominator coefficients γ_5 to γ_0, (γ_5 being the coefficient of the z^5 term, ie 1) are respectively
1 0.7344 −0.2891 −0.9688 −0.4609 −0.01172

Time delay in sampled-data section: $\Delta\tau = 117\ \mu s$

Continuous-signal compensation: none, but the gain multiplication constant within this section, K_{BC}, is adjusted to give an open-loop gain of unity at 180Hz. Its value is 0.3555.

Sampling frequency: $f_s = 2000$Hz

Hold circuit (see May issue): Zero-order, i.e. $\alpha = 0$

Figure 24 shows the characteristic of the compensator, computed from equation 4.2. Fig. 25 the open-loop gain computed from equations 4.3 and 4.4, and Fig. 26 the closed-loop gain, computed from the above equations and 4.5. Fig. 25 shows the stability margins to be as follows:
phase margin 24.2°
gain margin 6.7dB.
These terms are explained in Ref.1, section 10.4. Details of the programs used in the computations are given in ref.9.

Appendix

Gain of continuous-signal portion of loop followed by sampler:

$$H_{XY}(s) = \frac{1}{T}\sum_{m=-\infty}^{\infty} H_{XD}(s+jm\omega_S) \quad \ldots U4.3$$

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Managing research and development

by R.E. Young, B.Sc (Eng.), F.I.E.E., M.R.Ae.S.

Our series continues with a description of the working of a small integrated team's approach to R & D, in contrast with the hierarchical approach often found. Management of large projects is discussed.

Examples of successful 'small-team' projects have been given in earlier articles, notably the 'video-on-telephone-cable' system developed by the BBC prior to World War II. This "——— model of engineering R & D" was outstanding in several respects, especially with regard to the way in which research and development were made, in effect, an integrated whole, and did not exist in watertight compartments. This is virtually impossible with 'family-tree' — separated level — style management which, by its very nature, almost invariably brings a comparatively large organisation with it. It should be pointed out that such extensive management organisations have to be set up for large-scale projects; where, as an extreme example, putting men on the moon demands the deployment of immense resources, both technical and human, and which all have to be managed and controlled.

Reverting, however, to the BBC case, the integration of research and development also included a user-component with all members of the team having in-the-field experience of the equipment, both in setting-up the complete video links and in their operation for actual programme service.

Thus, among the economic advantages which can be claimed for the small-team approach, (and which have been outlined in earlier articles), is the way in which the coordination and interchange possible with a closely-knit small team enables them to finalize the product as development proceeds. This means that, with suitable experience behind them (see Article 1), the group can cut expensive development time sufficiently to hold a project within acceptable cost limits. By the same token, interchange can prevent more than one being altered at a time. Violation of this ground rule of engineering R & D, i.e. for members of a team to make major technical changes in isolation, can be one of the biggest threats that a project has to face.

That this small-team approach is considered vital at the present time, in the context of advances development engineering, is shown quite specifically in an interview given late in 1984 by car designer and innovator, Sir Alec Issigonis, on the occasion of the 25th 'birthday' of his world-famous 'Mini'. His success as the originator of the transverse-engine, front wheel drive layout — now "the norm for most small cars" — is seen, not only in the way the Mini continues (has not become out-dated, rather the reverse), but also in the fact that he is ---still doing research on small cars. His statement that "It is terribly important to have a small team, otherwise communication breaks down" takes on a special significance in the present

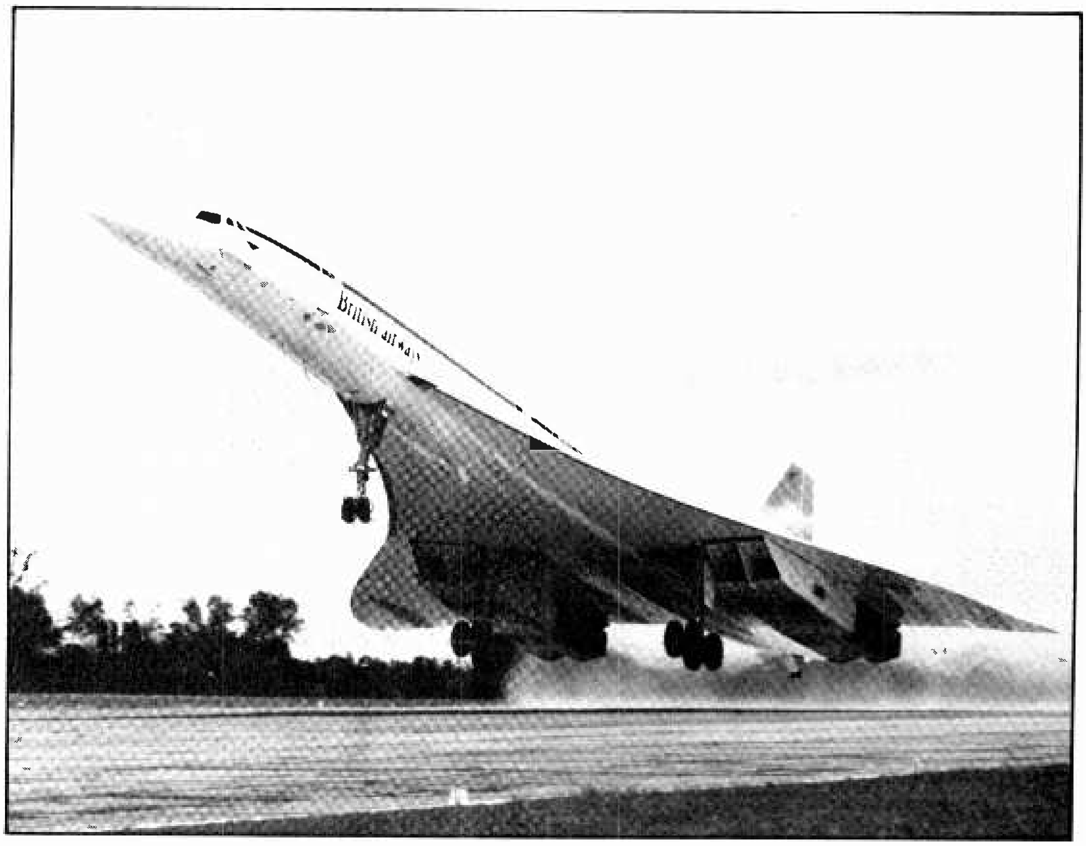

Fig. 1. **An example of a 'supra-management' project — the Anglo-French Concorde.**

connection.

The implications of this statement, together with the spread of Sir Alec's achievements, will be examined more closely in a later article, which is based to some extent on a current private venture R and D programme on a combined electronics system/automobile engineering approach to vehicle design and development. Its first part describes some aspects of early work carried out on telemetry (instrumentation) equipment for development testing of motor vehicles; and it is of interest that, with relevant documentation published in early 1961, this original work was carried out towards the end of the 1950s.

Activity chart and project administration

In general, an engineering project taken to a successful conclusion has a certain well-defined 'shape'. This is shown in the activity chart of Fig. 1, with its build-up to a pronounced peak and associated distribution of effort. Drawn in this instance for a multi-team R & D project, it may be taken as applying equally to a single small-team programme or as an overall criterion for a major new technology venture at national level, or the equivalent. This aspect is covered in the next section — on Supra-Management — particularly in terms of the British ability to evolve a wide-ranging and yet flexible management approach, where much of the coordination and organization *appear* to develop almost automatically, but nevertheless where unobtrusive, but full, control is maintained.

It will be appreciated that, despite its apparent simplicity, the activity chart brings out clearly 'project-state' information crucial for R & D technical (progress) management and for control and direction of resources. These can be, of course, 'survival' issues; as for instance, where the extent of the peak in activity has not been realised, and the peak has become a crisis with the future of the project possibly in doubt from then on.

Obviously, drawing any form of activity diagram does not necessarily guarantee the elimination of all R & D problems; but, although the experienced manager draws the equivalent of these diagrams mentally and revises them continuously, this is not a complete substitute for putting them on paper. Thus, one of the advantages of producing such diagrams is seen with the situation in which more and more effort is being brought to bear on a particularly intractable problem without any sign of its being cracked. The accumulation of resources can pass almost unnotices in the absence of diagrammatic analysis when attention is focussed almost exclusively on the effective deployment of the additional effort. In addition to its 'real-time' reporting role, the rapidly rising activity diagram can often provide valuable early warning and enable anticipatory action to be taken.

Also among the facilities given by the generalized activity chart is the ability to keep a watch on the manning position, particularly with regard to peak loading. Two working rules may be quoted here. The immediate one is that peaks in manning on any single sub-project or the equivalent should be held to a ratio not greatly exceeding 2:1 on the initial level of staff allocation for that particular section of the work. This corresponds with the other guideline principle that if the chart shows a rise in activity continuing much beyond the half-way point in the programme time scale, serious reassessment of the whole situation is required.

From the background given in the introduction and from subsequent articles, it will be realised that a peak usually represents the appearance of the unknowns which are inseparable from R & D, and which because a new field is being entered, cannot be foreseen, at least not for the particular combination of circumstances being encountered. It is, in fact, the need to cope with the unexpected that singles out R & D [project] administration from all other forms of management.

In the attack on such a peak and its underlying causes, the project manager, as a team leader, must plan to 'stretch' his team, and the test of his leadership will be to do this with the full knowledge and cooperation of each individual in it. This will be recognized as one of the elements in the small team approach; and it will be realized that this approach has contributed to the technical flexibility seen, for example, in the industrial 'clusters' of Great Britain.

These points have made in some detail to show how full 'family-tree' management control can be exercised over an R & D project being run in the much more open style as described, and without obtruding on it.

The name 'Farmer's Foot', adopted a number of years ago for this style of management, has proved its worth as a self-defining term with its allusion to the golden days of British agriculture when the watchword was 'the farmer's foot is the best fertilizer'. This allusion covers an individual approach to management just as applicable to modern technology as to those years of advance in agriculture. Thus, during that period, when enormous advances were made in the breeding of plants and animals, British farmers were in effect engaged in an international level-project indistinguishable in principle from a modern engineering R & D programme.

One aspect of R & D which should be introduced at this point is the way in which research and applications of it have been transferred from one branch of UK technology to another. A generalized illustration of this may be given in terms of biotechnology, announced publicly in 1980 as a potential foundation of a new industry; and which obviously involved a number of earlier technological developments. Also, the technical continuity maintained over the whole field of UK advanced engineering, with the accumulation of experience that goes with it, represent a national asset which should never be under-estimated; and which is particularly significant as being one of the main factors giving a flying start to any new work.

The advantage that can be taken of this flying start depends on the flexibility that can be shown during development, especially during the crucial early stages; and this, of course, is where 'shop-floor' management often makes its greatest contribution. In turn, the efficacy of this contribution will be determined to a great extent by the rapport (the Issigonis 'communicaton') that has been established between the manager and his team, and between the individuals in it.

In fact, as noted earler, it is the need to deal with the unknowns that is one of the main justifications for adopting this style of management involvement. As already indicated, this approach can be reconciled with family-tree management principles; but it does place heavy demands on the manager's judgement, not least with regard to his allocation of time between his overall responsibility for the project itself and the direct contribution which his range of experience enables him to make to the actual work on it. The spread of this contribution may extend from giving guidance during the evolution of 'sub-inventions' to producing the solution to a problem which appears totally intractable. The latter, which may well be the key to the successful continuation of the project, is perhaps best illustrated by one of the achievements of Sir Robert Watson-Watt.

In his book on the development of radar[2], A.P. Rowe recalls how a critical point had been reached in the original work at Orfordness where aircraft were being 'followed' by radar with "--- the range from the observers being continuously measured", but no method of finding bearing seemed in sight. In other words, it was not possible to bring even a primitive form of single-station radar system into operation until this key problem of obtaining bearing — direction finding — had been overcome. (Full operational use of these stations also demands determination of height; but the fundamental requirement is for range/bearing, and the original CHL stations did work on this 'plan-position' basis.)

The astonishing speed with which the problem was solved, and what may be called the 'project stream' restored, is best shown by quoting from Rowe. After being presented with an explicit statement of the situation seen operationally, "--Watson-Watt was back with a solution --*within a few days*"; and the future of radar [notably in interception was never again in doubt.

There is no need to stress the vital nature and importance of this high technology breakthrough. Even if not quite so spectacular, similar turning-point successes by individuals are on record[3] extending over the whole spectrum of British radar; while Sir Stanley Hooker's recently published autobiography[4] gives an up-to-date account of how one individual, admittedly of unquestioned international standing, provided the crucial direction which "saved" a major high-technology development project - the RB 211 jet engine - from the diastrous failure which seemed inevitable at the time.

As with Sir Robert Watson-Watt the value of Sir Stanley's work is incalculable. Also, even before these outstanding achievements, both men had demonstrated their extraordinary capacity to move into any plane of development engineering, and, however new, to make a master contribution to it. Hooker had 'sorted-out' a number of aero-engines, beginning with the Merlin piston engine and culminating with the RB 211 (the names of fifteen are given in his Appendix 1); while the degree of Watson-Watt's participation is exemplified by his being named as sole or co-inventor for five British patents coming from the work alone done in the 1930s and associated with the Slough research station.

Supra-management and R & D

The individual manager is concerned primarily with the 'management economics' aspect of running a comparatively small but carefully selected team; and, at the same time, maintaining his own technical interest in the project to give it the maximum benefit of his background and experience. Although basically for single-project administration and control, this general management style can be adapted for more than one team, provided the limitations of 'spread' are recognised.

'Supra-Management' — mentioned by name for the first time at the beginning of this article - has already been introduced indirectly in this series, notably in connection with the unparalleled evolution of British radar in World War II. In this general context, A.P. Rowe[3] has given insight into the workings of "that grand body" the Tizard Committee, with its"--- objectivity and driving power" which, in effect, set in train these "momentous events". Not only did this mark - as has already been noted - the commencement of the high-technology era in Great Britain, but it also represented the emergence of supra-management in the coordination and direction of the work of a *number* of independent (Government-level) organisations achieved by the Tizard Committee. This achievement was perhaps seen at its height in the period of 'getting it going'. This colloquialism covers intensive effort directed over a range extending from gaining technical support at high level for what was little more than an unproved idea, to obtaining the necessary Cabinet authority for the unprecedented amount of finance required for carrying out the programme which was being put forward.

As noted in the first article, the magnitude of the technological strength that was eventually brought together on a national scale for this programme has not really been approached in the UK since those days. It was suggested at the same time, however, that the potential for undertaking such an extensive project still existed (was "--- not far below the surface"); and indeed this can be taken futher with the recent publication of 'inside' information on the Concorde development programme. Though not of the same absolute size, the Anglo-French Concorde was strictly comparable - as a supra-management project - with the UK radar development; and thus it can be said that in implementing their share of the programme, the British demonstrated that the potential was there and could be activated.

The main source of informatior on the Concorde programme, seen as an interlocking 'multi-project', is Sir Stanley Hooker's autobiography[4]. Already brought into this article, this book gives a penetrating view of the complexity and difficulty of maintaining project flow and cohesion in a co-operative undertaking of this size. This is done not only with regard to the propulsion side with Sir Stanley's involvement with the application of the Olympus engine to the Concorde; but also in terms of the remarkable overall management of the development of this unique airliner. Problems there were with this 'bi-national' venture, not the least being language (with technical interchange, this involves 'way of thinking' in addition to straight translation), but with this, as with the engineering problems, there was managerial anticipation and — evidently — almost inspired forward planning.

The immensity of the task that lay ahead cannot be over-emphasized, with entrance into a *number* of technological worlds; but the success of the supra-management is seen in the project development times achieved despite the 'design interplay' which compounded all the problems as they were uncovered and then attacked.

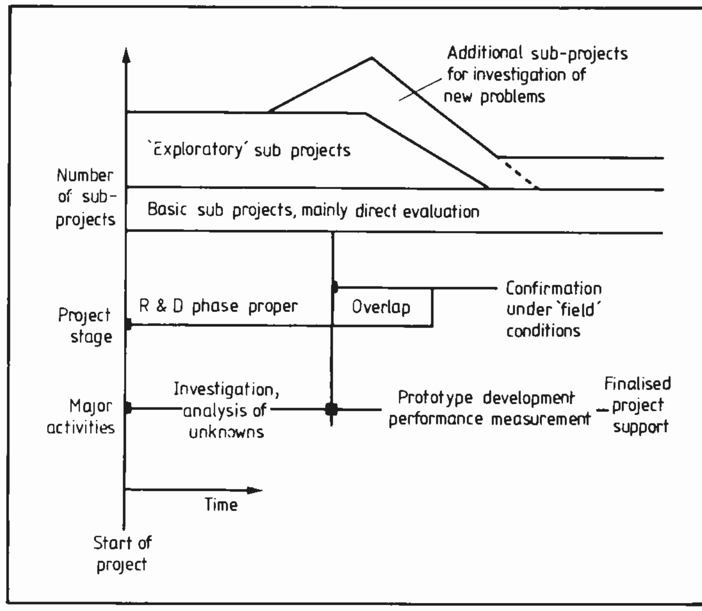

Fig. 2. **Generalized activity chart for multi-team R&D projects**

These problems could fairly be called high-technology ones (almost invariably the techniques evolved to meet them were entirely new, and usually had an electronic content). Typical of this was the means which was developed to deal with the very large variations which take place in engine airflow with change in aircraft speed, varying from virtually zero at take-off to the supersonic cruise condition at Mach 2. In this instance, an engine inlet system was developed consisting of very large movable flaps, ramps and doors, the control of which is scheduled by an automatic electronic system.

From experience of comparable project work it will be apparent that, with the interaction with other areas of technology, such a development programme would call for a correspondingly large amount of time and effort to be expended on it.

Of even more significance in the present context is a paper by Hilton and Steed, published in Aerospace for March 1984[5], which throws considerable light on the Concorde flying control system and its development.

More than one major aspect is brought in here, outstandingly that of the spin-off and exchange achieved as part of management economics. The key is in the title, initially perhaps somewhat surprising in this instance — Fly-by-wire Actuation for *Combat* Aircraft. As stated in the paper "Many of the system characteristics of Concorde, such as pressures, temperatures and performance are typical of those required for actuation in the field of military aircraft".

This information flow had started with an experimental Tay-engined Viscount aircraft equipped with two electrical control systems and one mechanical standby system with the co-pilot in control of it. This general system philosophy, as developed, appears in the Concorde with two electrical lanes (channels) in an active/standby arrangement with self-monitoring of the operating lane. Control is automatically switched to the standby lane in the event of failure on the active system. As a further safeguard, there is a back-up mechanical monitoring system which comes into operation should a common fault or the equivalent develop on the electrical side.

It will be appreciated that there is a certain independent check element in such a main/standby multiple system; but that near-instantaneous decision-taking required in an emergency demands human intervention for changeover action. The question of human intervention — its degree and timing — is, of course, common to other complex control systems; and represents just one element in flight trials and in analysis and assessment which can rarely be carried out concurrently. With the multiple-programme character of the Concorde project in mind, it will be realised how remarkable was the

The national 'mix' and the universities

During the earlier part of 1984, an advertisement appeared in the British Press for "real engineers" — all rounders with management-grade experience in more than one field of engineering. The pros and cons of bringing non-specialists into innovative work have already been discussed at several points in this series; and it does seem possible to state that provided the necessary flexibility and adaptability are there the more broadly based engineer can contribute to the practical development of an idea, which after all is specialized in itself .

Now it is one of the main submissions of the series that these qualities of flexibility and adaptability to the new and untried are found in Great Britain, almost as a national characteristic. It has also been made clear that of the many factors that have contributed to this result, education in its widest sense is of crucial importance; and it is in this connection that the invention of the cavity magnetron[3] can be used to illustrate how the 'British' approach works in practice and, at the same time, to show how this remarkable advance was made by a university.

The cavity magnetron of J.T. Randall and H.A.H. Boot, with its initial basic development in the physics laboratory at Birmingham University, "---on the second design, worked - and worked so well that it is literally true to say that for years no substantial variation from the original main lines was an improvement". Anyone who has been engaged in R & D at a comparable level will realise the full import of this quotation from 'Science at War', not least the soundness of the way of thinking it represents.

The account that follows of the work on the ten-centimetre front continues to show the same pattern of high-technology achievement, and specifically the transfer to manufacture by GEC with "--no inconsiderable part" played by B.T.H.

As found by all who write on this era, it is only possible to include a fraction of the names of those who were responsible for advances in this area of British radar; but, in the present context, it is imperative to list the following, not necessarily in chronological order.

J. Sayers in Birmingham introduced strapping between cavity segments to obviate mode jumping on the generated radio frequency.

A team at Leeds under Prof. E.C. Stoner, working in collaboration with one at Manchester under Prof. D.R. Hartree, explained and determined a full physical picture of the complex path distribution of electrons inside the magnetron when oscillating.

A new technique to overcome the difficulty of making the reflex klystron (used as a local oscillator) was developed in the University of Bristol under R.W.Sutton, "with close contact ——— with the G.E.C.,and in particular,with E.M.I."

In addition, a paragraph in 'Science at War' gives "Prof. J.D. Cockcroft, Prof. M.L.E. Oliphant, Lewis and others" as the team brought in from fundamental research in atomic physics to look into the need for very short waves. The contribution that was made by this team is stated to have been a most important factor in the success achieved in this national programme.

Professor J.D. Cockcroft, who became Sir John Cockcroft, O.M.,F.R.S., represents another golden age in Britain. This is essentially associated with that great institution the Cavendish Laboratory at Cambridge and the nuclear research carried on there. Apart from his pre-eminence as a research physicist, Cockcroft was an outstanding development engineer possessing all the talents of the ideal 'participation' R & D manager. Also, as with Sir Stanley Hooker, he was a brilliant mathematician.

In rounding off this section, the word 'mix' has been chosen to cover two specific and interlinked issues in the conduct of technology in the UK. Both of these issues will be considered from the national point of view, and in the case of the first largely from that of the 'total' education of the individual. Thus, as an illustration, and by virtue of the dovumentation that exists on his career, the mix of Cockcroft's deliberately acquired and immense technical experience, combined with his world-level research, may be said to represent, within the technological climate of Great Britain, the ultimate, and ideal, career training course for the engineering student.

Two examples will be taken from Egon Larson's book 'The Cavendish Laboratory'[6] to give some indication of Cockcroft's depth of penetration into most branches of engineering practice.

The first shows Cockcroft winding armatures, assembling switchgear, and testing electrical machines at Metropolitan-Vickers in Manchester. He had joined the firm as a college apprentice in 1920, following the interruption to his studies with his three year service in the Army in the 1914-18 War. Larson quotes Cockcroft's recalling that he found that his mathematics '---came back with surprising completeness" on his return to the (then) Manchester College of Technology.

The second example speaks for itself. During his construction of the first particle accelerator at the Cavendish (significantly in the period 1929-32), the workshop-trained Cockcroft built his machine, in effect, round two disused petrol-pump cyclinders. He had to overcome formidable high-vacuum problems, while it is worthy of note that the machine worked at 300,000 volts.

The second of these two issues is firmly on the national scale. In the present context it concerns the mix within each university (including the apportioning of resources and effort generally), between the various universities and between them and the outside world, e.g. their Government-type sponsoring/directing authorities.

The structure and existence of this mix will have already been gathered from the accounts given earlier in this series and more particularly from this article. There is perhaps one aspect which might be elaborated — relations with the local industry-based cluster. This has already been mentioned with the reference to the Manchester University contribution to computers; and, in line with the preceding treatment it seems appropriate to couple the name Ferranti with the Manchester computer mix.

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Articles in this series

- British invention, innovation and electronics (March)
- Radar and television — interchange and spin-off (April)
- The post war stride into aerospace (May)
- R & D management and economics
- Big system automation and telemetry
- Vehicle instrumentation
- Human communications
- The future

Helical antennas for 435MHz

by James Miller B.Sc. G3RUH

An easy-to-construct design offering true circular polarization

This antenna design was produced for satellite working with Oscar-10, but it has also proved excellent for ordinary local and long-distance operation. It has eliminated at a stroke the frustration of accurately matching and phasing crossed Yagis to true circular polarization and obtaining an acceptable s.w.r. throughout the band.

Compared with other antennas it has a very wide bandwidth - a low Q - which makes it forgiving of dimensional inaccuracies. It is therefore easy to construct successfully.

This article describes 9 and 16-turn helices for the 430-440MHz amateur band. The nine-turn version simply has fewer turns and spacers, but it is short enough to permit end-mounting. Gain figures of the two versions are 12.8 and 15.2dB respectively. You can use more turns, but the mechanical penalties increase rapidly at this wavelength, whilst the extra gain per turn is marginal.

For many years Kraus[1] has been a central figure in promoting helix antennas, and a little detective work reveals dimensions identical to his figures in almost every design guide (for example the R.S.G.B. VHF/UHF Manual, ITT Reference Data for Radio Engineers etc.).

More recently, King and Wong in their brief summary paper[2] presented performance characteristics based on a large number of gain and pattern measurements of helices of 5 to 35 turns, with various pitch angles and other parameters. The paper augments and expands Kraus's theories.

The design of this antenna is based on that work. A pitch angle of 12.8° with a circumference of about 1.08 wavelengths are used. From King and Wong's curves this yields a maximum gain (allowing for mechanical tolerances) at 435MHz, for aerials of reasonable size (Fig. 1). These gains are typically 3dB lower than Kraus gives, but seem to be representative of actual practice.

Materials

In choosing materials I was guided by the need to make an antenna that could survive several years' weathering with only minor attention; and that for the most part used common material and needed simple workshop practice. I did not consider timber stable enough - but you could try it.

The reflector and boom are aluminium and the helix copper. The feed-strap is brass and the screws are zinc-plated. The spacers are of black Delrin. A waterproof N-type connector is used for the r.f. connection. For protection, the completed antenna should be varnished.

To ensure success, it is important to do things in the right order: for example, the length to which the spacers must be cut depends on the final diameter of the helix. Handling the helix itself calls for a boom through its middle and so it is easier to do drilling first. So:

- obtain all materials — see table 3;
- build up the reflector assembly;
- drill the boom;
- wind the helix and stretch along the boom;
- make and fit spacers;
- fix the copper spiral to spacers;
- fix reflector to boom;
- install feed strap;
- adjust s.w.r.

Reflector

The reflector is a nominally 600mm square piece of expanded aluminium fret, obtainable as *Expamet* 351A, which is widely used as a grille material. The size is not critical and 500mm square could be used if windage is a problem. Take especial care to cut the Expamet sheet without leaving jagged edges.

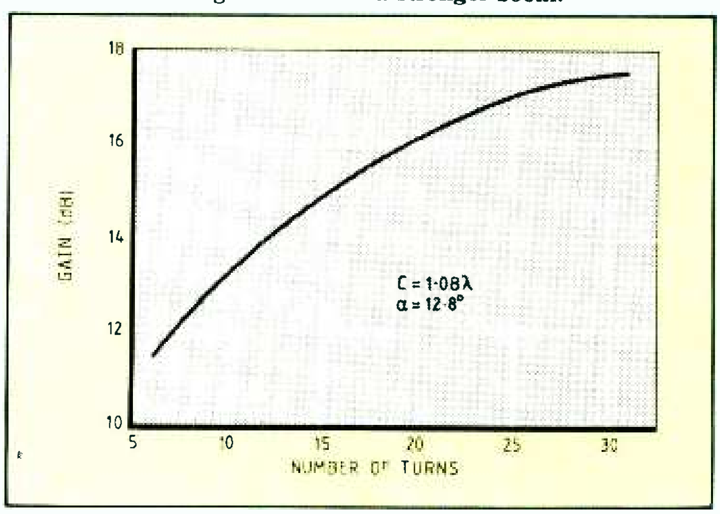
The mesh must be stiffened, or it will bend easily in a light breeze and may quickly break. In one prototype the support/stiffening was fabricated from a 100 x 100mm 16 s.w.g. (1.6mm) centre plate and some 10 x 10mm 18 s.w.g. (1.2mm) aluminium angle, and was quite satisfactorily strong and lightweight.

For the final version model I tried a simpler design, bent up entirely from 18 s.w.g. sheet metal (Fig. 2,3). The stiffening is bolted through the mesh with M3 × 10 screws and stiffnuts, using 16mm diameter washers on the front face, cut from waste metal. To keep the reflector all-aluminium, 3mm (⅛") pop rivets could be used instead of screws.

Once the stiffening is fixed, mesh can be snipped away to allow the boom and N-type connector through. The connector is a single-hole-fixing type and can be fitted either way round depending on whether the feed is to be from the rear or along the boom from the front.

Aluminium tube 19mm square and of 16 s.w.g. wall is obtainable from most ironmongers or non-

Fig. 1. Gain versus number of turns for helical antennas having a pitch angle of 12.8° and circumference of 1.08λ (based on curves in reference 2). The 9 and 16-turn designs described here have gains of 12.8dB and 15.2dB respectively. At 435MHz, longer antennas would need a stronger boom.



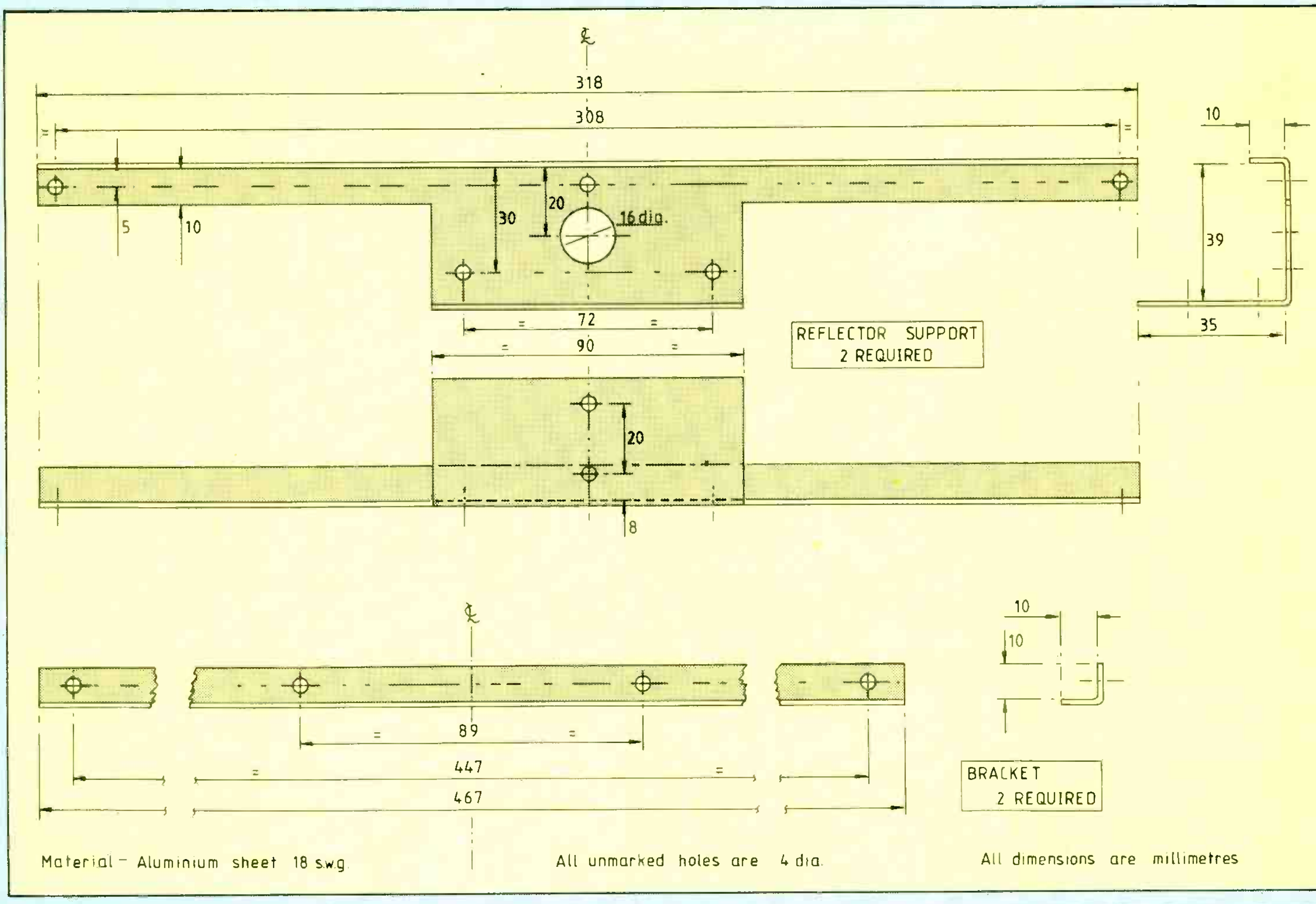


Fig.2. **Reflector support is fabricated from 18 s.w.g. aluminium sheet; two of each part are needed. Assemble as shown in Fig.3. The parts are fixed through the reflector mesh with twelve 10mm M3 screws and stiff-nuts, backed with 16mm diameter washers cut from waste aluminium.**

ferrous metal suppliers. You will need two or three metres, which will allow you a little surplus at each end to clamp the boom for support during construction.

Drill holes of 4.3mm diameter for the spacers and to secure the relector (see Fig.4). Spacers are used every 1.75 turns: the holes must therefore be alternately vertical and horizontal on a 3.5 turn (595mm) pitch. The first spacer is a quarter-turn into the helix; the last supports the end of the final turn.

First drill the spacer holes. Position the reflector mounting holes so as to locate the front face of the reflector 53mm from the first spacer hole. This will ensure an adjustment gap of about 5mm between the reflector and the start of the helix.

Helix

The helix is made from 10mm diameter copper central-heating pipe, which is readily available, easy to bend by hand and quite cheap. It usually comes in 10 or 20m coils. Each turn takes 0.7m, so you can get up to 13 turns out of a 10m length; 20m will make two antennas, one of nine turns and one of 16. If you can obtain odd lengths from a plumber then the pieces can be soldered together. Do not uncoil the raw tubing before winding.

You will need a mandrel around which to wind the helix. It should have a diameter of 229mm and, for comfort, a length of at least 180mm. A search around your attic, scrapyard or the shops may well produce a suitable object. I found a nine-inch cake tin exactly the right diameter though a little short, and I was able to wind the first prototype, somewhat unevenly, using two pairs of hands and a lot of patience. For subsequent models this experience prompted me to make up a proper drum of the correct size out of two plywood discs and some slats.

Particular thanks to Francis Pullen G4XXX for machining services during the development of this antenna, and to Cambridge Consultants Limited for the free use of facilities.

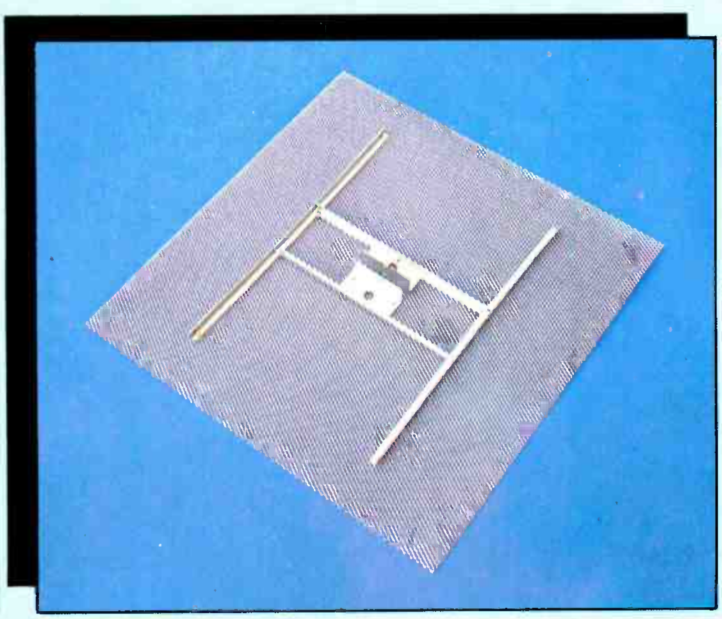


Fig.3. **Rear view of the reflector showing assembly of support parts. Rear feed may be obtained by reversing the N-type connector and omitting the feedthrough insulator. Anti-static protection (not shown) can be effected with a small inductor from connector pip to a solder tag on the boom.**

Table 1: measured performance data

Size	9	16 turns
Gain	12.8	15.2dB
3dB beamwidth	–	±11°
First nulls	–	±23°
Typ. sidelobe	–	−18dB
F/b ratio	–	14dB
S.w.r. (typ.)	less than 1.1:1	1.1:1
Overall length	1.59	2.78m
Weight incl. clamp	2.7	4.0kg

Table 2: electrical and mechanical design

Frequency	430-440MHz
Wavelength	λ = 690mm nominal
Pitch angle	p = 12.8°, circumference C = 1.08λ

	symbol	wavelengths	size, mm
Circumference	C	1.08	745
Diameter	D = C/π	0.344	237
Turn length	Lt = C/cos(p)	1.108	764
Turn spacing	S = C tan(p)	0.245	170
Tube diameter	d	0.014	10
Reflector		0.87	600 x 600

Table 3: materials

Quantities for a 16-turn helix [figures in brackets are for nine turns]:

Reflector:
Expamet 351A expanded aluminium mesh, about 600 x 600mm
Support/stiffeners fabricated from 500 x 250mm 18 s.w.g. aluminium sheet
12 M3 x 10 pan-head screws and stiffnuts, plated
12 16mm diameter washers drilled 3.3mm, cut from aluminium waste
2 M4 x 30 pan-head screws and stiffnuts
1 N-type socket e.g. Cirkit (formerly Ambit) part no. 10-01301
1 feedthrough insulator, 4mm dia. x 13.7mm e.g. Sealectro type FT310P51

Boom:
3 [1.8] metres aluminium tube, 19 x 19mm section, 16 s.w.g. wall thickness
2 19mm square plastic end plugs – e.g. Dexion finishers
1 antenna clamp, double U-bolt type, e.g. Jaybeam type 9891 or similar

Helix:
13 [7] metres 10mm diameter copper micro-bore central heating tube
1 10mm end cap, e.g. Yorkshire type 61

Spacers:
1.2 [0.7] metres 16mm diameter black Delrin rod
10 [6] M4 x 30 screws, pan-head, plated

Feed strap:
100 x 7mm 16 s.w.g. brass strip

The following parts may be obtained from the author:

1. Pre-formed reflector support/stiffeners, screws, nuts, and washers: £15 per set.
2. Machined spacers with screw: £2.30 each.

Complete antennas and kits are also available to special order. Prices include carriage to U.K. addresses only. For more details, please send a stamped, self-addressed envelope to J.R. Miller, 3 Benny's Way, Coton, Cambridge, CB3 7PS.

There is no need to worry if the mandrel is not exactly 229mm in diameter, but be sure to err on the small side, since the design is already close to the maximum size for 440MHz. If your helix diameter ends up N mm less than nominal, then simply make the spacers (N/2)mm shorter.

Start winding about half a metre into coil. Holding the short end tight against the mandrel, pointing away from you, pull the long end down on to the mandrel into a curve. Slip the helix back an eighth of a turn and bend again. In this way a whole turn can be built up smoothly and will start gripping the mandrel as soon as tension is applied.

After winding the first turn, stop and inspect your work. Make absolutely sure you are winding a right-hand or left-hand spiral as you really want. If in doubt, compare it with a normal woodscrew. Most people instinctively wind left-handed spirals.

Continue to close wind the copper until you have 9 or 16 tightly coiled turns. The helix will spring out naturally to the desired (coiled) diameter of about 253mm outside.

Stretching

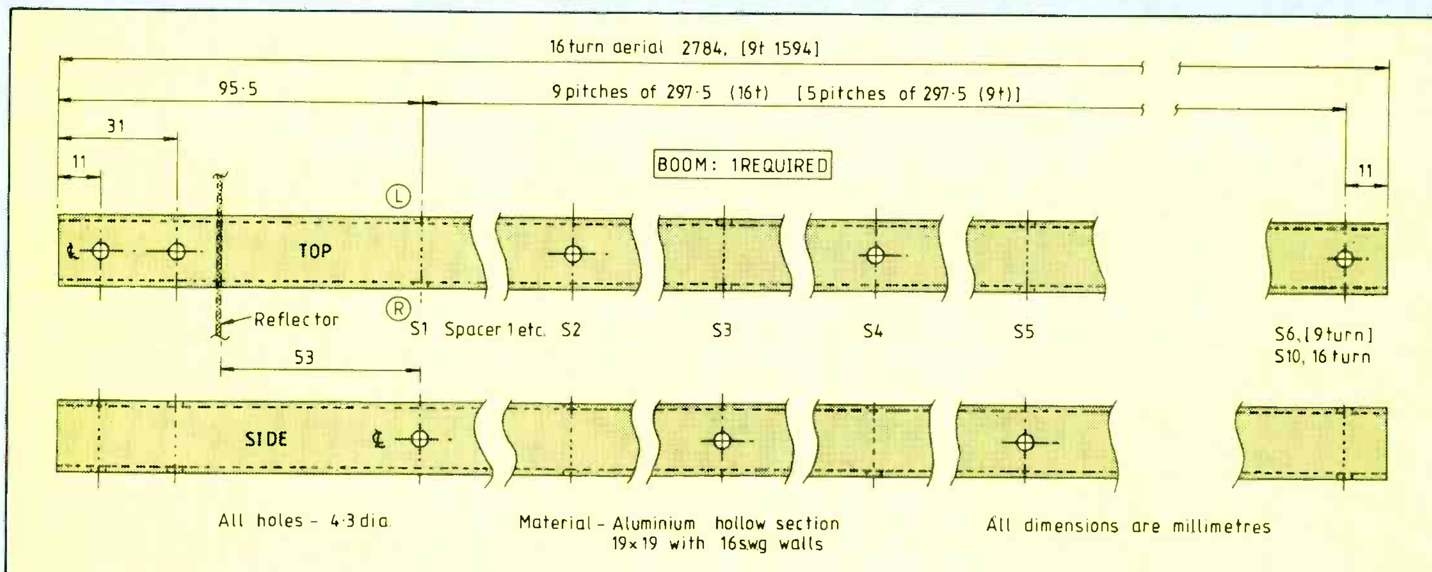
First mark the top of each turn: stick black tape along the outside of the coil, slit the tape between turns and smooth each marker down firmly

Support the boom at each end. Mark the location of the first and last turns on the boom (1.53 or 2.27m apart) boldly, with black tape.

Now slip the coiled helix over the boom. With an assistant holding one end, draw the other, gently stretching the coils apart, keeping the top markers vertical until the full extent is reached. Take care to avoid distorting the first and last turns through rough handling.

You should now have a fairly even helix with the correct average spacing of 170mm and nominal o.d. of 247mm.

Fig.4. **Boom drilling. Material is 19×19mm aluminium tube. The reflector is secured via two vertical holes to prevent twisting; spacers are used every 1.75 turns.**



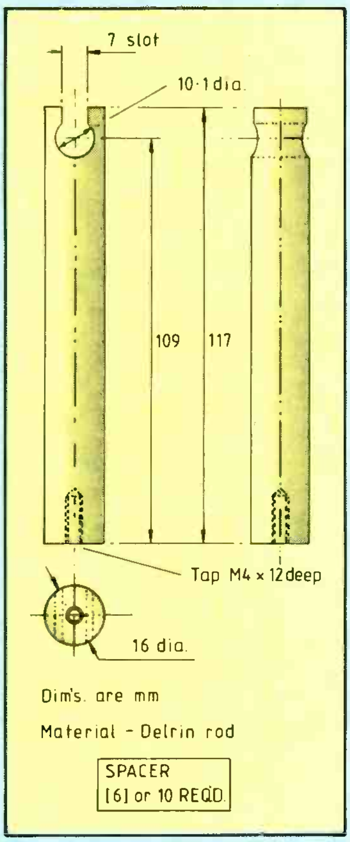


Fig.5. **Spacers are machined from 16mm black Delrin rod and are fitted at $1\frac{3}{4}$ - turn intervals. The helix structure snaps into the slot. A vee-notch may be used as an alternative to the slot and hole illustrated here: the copper is then secured by wire passed through a small hole beneath the notch.**

Fig.6. **The feed strap: an accurate match is found by adjusting the spacing between strap and reflector. An s.w.r. of better than 1.1:1 can be obtained easily over 430-440MHz.**

The spacers are made from 16mm extruded black Delrin rod, which can be obtained from plastics suppliers listed in the classified telephone directory; but any ultra-violet and weather-resistant loss-free material could be used instead. Cross sections of the spacers are shown in Fig.5. They can be made by hand using a saw and drill, though a lot of care will be needed; I used a lathe. You will needs six or ten spacers.

The slot in the top is wide enough to allow the copper tube to be snapped into place. Other methods of mounting may be just as effective, though. One possibility is a V-notch, with the tube secured by a couple of turns of 18 s.w.g. copper wire (as used in mains power wiring) via a small hole drilled beneath the notch. Whichever method is used, the tube centre must be supported 109mm above the boom surface, allowing for any error in the dimensions of the spiral.

Fix the spacers loosely to the boom in such a way that the start turn will be uppermost. Lift the helix on to the top spacers at 2, 9 and 16 turns, guided by the markers, and secure it. Next, fix the spiral at the bottom, and then at the sides.

Fine adjustment of spacing may be needed to correct any distortion. Make up a 160mm-long gauge from a strip of metal: it should just slip between the turns.

Now bolt on the reflector assembly.

Feed strap

This consists of a strip of 16 s.w.g. brass, 7mm wide and about 100mm long running from the start of the helix down direct to the connector (for rear feed). For front feed, the strap is about 85mm long and runs to a feed-through insulator mounted on the reflector support. It is linked by an 18 s.w.g. insulated copper wire across to the connector pip.

Carefully squash flat about 10mm of the start of the helix so that the strap can be soldered flat, close and parallel to the reflector. The tube can be sealed up at the same time.

If a large soldering iron or blowtorch is available, a 10mm copper end-cap makes a neat finish for the front end of the helix; but while fitting it, temporarily remove the leading spacer from the heat.

Tuning

First make sure that all screws are tight. Using an s.w.r. bridge, adjust the spacing between strap and reflector, gently bending the first quarter turn as needed. The gap should be about 3mm. Relieve any stress at the connector or feed-through by re-melting the solder.

Tuning can be done at ground level, with the antenna on a two-metre pole. In fact, after the initial adjustments indoors, little further tuning seems to be needed when the aerial is taken outside.

Use no more then 5W when experimenting, and remember the e.i.r.p. at the sharp end is high: avoid prolonged exposure. With care a virtually perfect match can be achieved from 430 to 440MHz.

Installation

In a gale the force acting on the reflector is very high, and results in a considerable torque at the clamp. Therefore pay special attention to this fixing point. Use a double U-bolt design and install with care. If in doubt run an M8 bolt right through clamp and mast. There is just room.

Consider also the parking position when the aerial is not in use. Small rotators such as the Hirschmann 250 are not really suitable for the 16-turn antenna. Windage can be reduced by cutting the reflector to a 500 × 500mm square or to a circular pattern.

The centre of gravity of the 16-turn antenna is about 6.7 turns along the boom, and at this point the bending moment of 1.6kg.m results in a 20mm sag at each end, which is quite acceptable.

The nine-turn antenna can be fixed in the same way, or end-mounted with a counterbalance weight of moment 1.7kg.m referred to the clamp. (Front-end sag will be 20mm again).

Using a metal mast through the helix seems to produce no ill effect. Glass-fibre masts are becoming more common, but unfortunately are still expensive.

The antenna's finish can be preserved with a coat of yacht varnish. This will flake off if the metalwork in not first degreased using hot soapy water, blue Ajax or Inhibisol.

This type of antenna inevitably picks up a static charge which will damage pre-amplifiers or receivers that do not have a low input resistance to d.c. Check your system! A simple protector would be a 4.7kΩ 1W resistor from connector pip to boom, which I have not tried, or small inductor in the same place, (say 300nH, a few turns), which I have. You are warned!

Performance

I would have welcomed an opportunity to evaluate the antenna on a proper test range, but lacking both of these I had to devise another method. My local u.h.f. repeater is fortunately only 1km distant and it provides a strong, steady line-of-sight signal. I rotated the antenna in small increments and measured the response using a calibrated 1GHz variable attenuator.

With this test I was able to assess the nulls and sidelobes, and by graphically integrating the polar plot[3] I arrived at an estimate of the gain achieved (table 1).

In actual practice, performance has surpassed my expectation. Oscar-10 working has been transformed since my crossed Yagis were replaced. Terrestrial working is excellent, the circular polarization eliminating the need for dual feeds, changeover relays and the like. Of course there is a 3dB penalty for using circular instead of linear, but does anyone actually notice? The polarization from mobile signals constantly changes, and circular polarization should actually be better than vertical alone.

The prototype has been in use since December 1983, and apart from the redesigned reflector stiffening has needed no attention. Without doubt it has been one of the easiest antennas of all to design and build.

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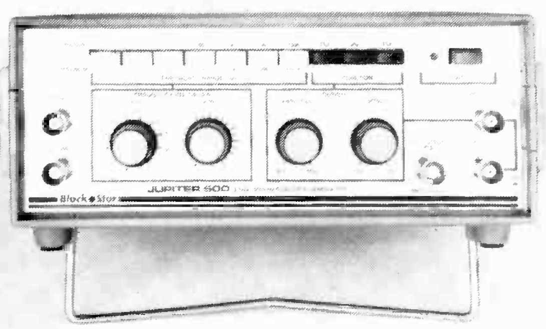

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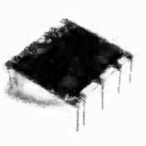

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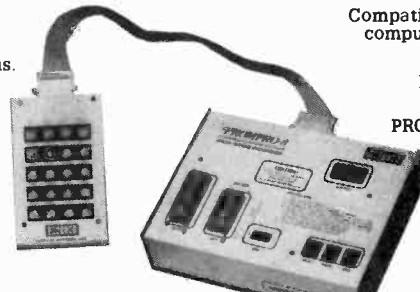

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D.c. supplies from a.c. sources – 5

by K.L. Smith, Ph.D.*

* University of Kent at Canterbury

Switched-mode supply design

The brief excursion into s.m.p.s. principles in Part 1 pointed to the tantalisingly high efficiencies in power conversion they promise. This means small sizes and mass in the equipment for a given throughput, but at the cost of a higher component count and r.f.i. problems. Control and drive circuit complications can be overcome to some extent by means of circuit integration, together with good filtering, screening and circuit layout to reduce harmonic interference.

Circuit development

The three broad categories of s.m.p.s. circuits are often developed further than the simple outline I discussed before. You will find multiple windings on chokes and transformers, with the mains isolation these provide. Consider the flyback converter, which includes a limiting case, the ringing choke converter. Flybacks find the greatest use in low and medium level power supplies and work well for relatively high voltage outputs. Figure 1 offers a rough breakdown of the useful power and voltage ranges obtainable from the various types.

One advantage of the flyback circuit is the ease of obtaining multiple outputs (the rectification is simpler). Disadvantages include the high ripple component in the output and the larger choke required for a given throughput. This is because all the energy has to be stored by the magnetization current flowing in the winding round the core. Of interest is that in the ringing choke case, choke utilization is best.

The semiconductor switch and rectifier diodes have to withstand high peak voltages and currents. Because of these high switching levels, transients and interference tend to be larger in flyback designs.

In comparison, the forward converter delivers power to the output while the switch is 'on'. The inductor acts as a true transformer and a high throughput can be obtained with a relatively small cross section of core. The circuit is suitable for medium and high powers at low output voltages. One disadvantage is the requirement for a second inductor to store the energy over the 'off' period – tending to put up the cost. But this is compensated by the resulting low ripple component in the output, which requires a less stringent filter. Another slight disadvantage is the need to recover the magnetization current (or rather, energy) in the transformer core during the 'off' period. Unlike in the flyback circuit, the magnetizing current does not form part of the output. In practice, a similar recovery circuit is also used in a flyback s.m.p.s. for safety, to limit spikes and return the magnetization energy if the load is removed.

The inductance of the main transformer in a forward converter is kept high to minimize the magnetizing current. A rule of thumb is to aim for I_m to be about 10% of the load current.

The third circuit technique uses push-pull or bridge connections in the switching stage. There is a number of versions of these, including half bridge or full bridge designs. The switch drive circuits are necessarily more complex to cope with all the transistors going on and off in the right sequence, but you can obtain high and very high throughput powers, (Fig.1.) The transformers are magnetized in both directions, since the push-pull action reverses the current, which means that a maximum flux swing can be obtained for a given core.

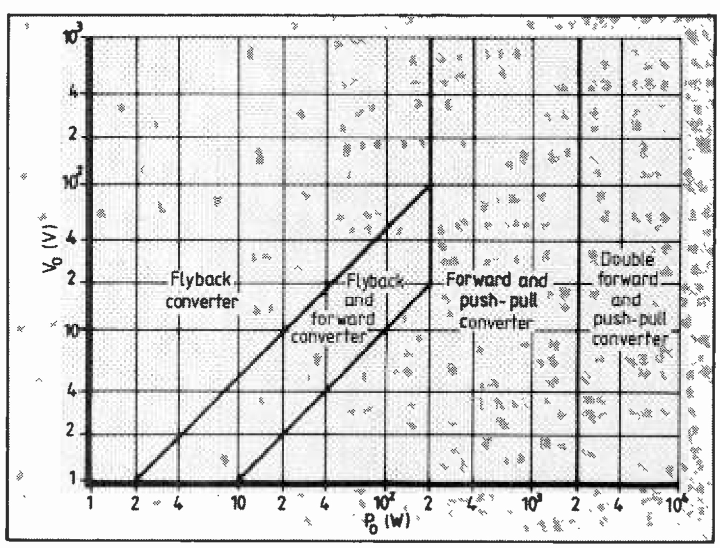
Flyback converter

Figure 2(a) is a two-winding choke version of the circuit. Figure 2(b) shows the waveforms when operating. You might think that L looks like a transformer, but in the flyback circuit it actually works as two 'chokes' because only one winding conducts at any given time. It operates on a 'bucket-brigade' principle: the primary choke stores the energy, some of which is extracted later by the secondary at a different pressure and quantity level, according to the turns ratio. The other quantity which adjusts the relative levels is the duty cycle δ, of the switching waveform, the amount of energy stored during the 'on' time varying with δ. The rest of the period is available to abstract this variable amount of stored energy.

The third winding on L with D_3 is the one that returns any stored energy with nowhere else to go, back to the primary source. This limits the voltage peaks across the transistor.

A simple analysis of how the circuit operates clarifies the picture and yields design information. To start, there are a few assumptions to simplify things. One is that the inductance of the windings on L is large enough to prevent current falling to zero during the 'off' period. (It falls to zero in the ringing choke converter). Given L, you will find there is a certain minimum current, $I_{o(min)}$ to satisfy this requirement. As we saw in article 2, designers write down a quantity called η for

Fig.1. **Voltage and power output obtainable from the three main classes of switched-mode supply.**



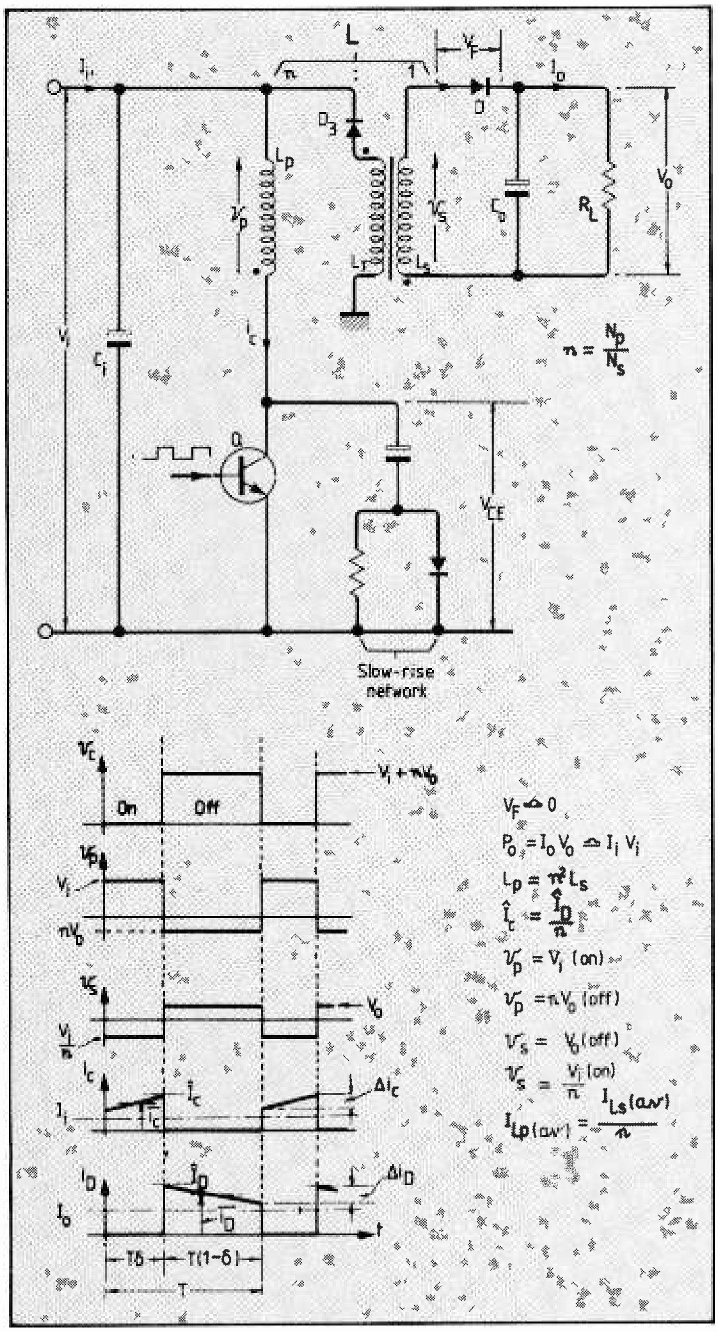


Fig.2. **Two-winding choke type of flyback converter at (a). Operating waveforms are shown at (b).**

a choke or transformer, such that

$$\eta = \frac{I_{o(MIN)}}{\text{MAXIMUM } I_o}$$

Another assumption made is linear growth and decay of currents in the windings on L. As you know, switching transistors take a finite time to operate, but assume they are very fast for the moment. More detailed investigation of the current commutation effects and to rise and fall times at the switching edges is a little complex and will stretch your reasoning. Designers have to consider these effects for peak and average switching loss calculations.

The voltage across any winding carrying a current i is

$$v = L\frac{di}{dt}$$

if L is its inductance. The linear current ramps in L's windings mean constant di/dt's. I have defined all the quantities 'by implication' in Fig. 2. So from these we can write:-

$$\frac{di}{dt} = \frac{\Delta i_c}{T\delta} = \frac{\Delta i_D}{(1-\delta)T}$$

$$\therefore \Delta i_c = \frac{V_i T\delta}{L_p}$$

and

$$\Delta i_D = \frac{V_o(1-\delta)T}{L_s}$$

Referring everything to the input side by using $\Delta i_D = \eta\Delta i_C$ and $L_S = Lp/n^2$ enables us to eliminate T, the inductances and Δi_C, Δi_D from the previous two equations. This yields,

$$V_o = \frac{V_i}{n}\cdot\frac{\delta}{1-\delta} \qquad (1)$$

Equation 1. shows that the volt-seconds product in the choke sums to zero over one cycle. In particular, it also shows that V_o depends on the duty cycle parameter δ as well as on the usual 'transformer' turns ratio n:1.

As you can see from v = Ldi/dt, to keep v constant over the 'off' period, L must be sufficiently large. This is to make di/dt slow enough to keep the diode current going throughout the period. As I mentioned, if i_D does fall to zero, we have the ringing choke condition.

Again working in terms of quantities from Fig. 2 reflected into the primary circuit, you can find $L_{p(min)}$ to avoid the ringing choke condition. By equating areas on the i_D graph,

$$\bar{i}_D = I_o\frac{1}{1-\delta}$$

Now from this result, if the output current just reaches zero, then the peak value, $\hat{I}_D$, will just reach,

$$2\frac{I_o}{1-\delta}$$

As an aside, this gives a useful result for the peak current in the rectifier diode. For example if δ = 0.5 the worst case $\hat{I}_D = 4I_O$. In other words, the repetitive peak forward current, I_{FRM} rating of the diode must be equal to or greater than $4I_O$.

$$2I_o/(1-\delta)$$

will also be the change Δi_D under the conditions of minimum inductance.

$$\therefore \Delta i_D = \frac{V_o(1-\delta)T}{L_{S(min)}} = \frac{2I_o}{1-\delta}$$

(where I_o should strictly be written $I_{o(min)}$ here.) We know

$$\delta = \frac{nV_o}{V_i + nV_o}$$

from Equation 1.

$$\therefore 1-\delta = \frac{V_i}{V_i + nV_o}$$

Also, $I_o = P_oV_o$ where P_o is the output power. Together with this, of course,

$$I_{o(min)} = \frac{P_{o(min)}}{V_o}$$

Inserting these quantities and solving for $L_{s(min)}$ gives:

$$L_{S(min)} = \frac{V_o^2(I-\delta)^2\,T}{2P_{o(min)}}$$

$$= V_o^2\left(\frac{V_i}{V_i + nV_o}\right)^2\frac{T}{2P_{o(min)}}$$

Or in terms of $L_{p(min)}$:

$$L_{p(min)} = \left(\frac{V_i\,\eta\,V_o}{V_i + \eta\,V_o}\right)^2\frac{T}{2P_{o(min)}} \qquad (2)$$

You can see that there is a definite $I_{O(min)}$ for constant V_o given $L_{P(min)}$.

Your semiconductor switches must withstand peak values $\hat{I}_C$ and $\hat{V}_{CE}$ in this application. Finding $\hat{I}_C$ is fairly simple:

$$\hat{I}_c = I_{Lp(ave)} + \frac{\Delta i_c}{2}$$

By reflecting through the n:1 transformer ratio again, this can be written:

$$\hat{I}_c = \frac{I_{Ls(AVE)}}{n} + \frac{\Delta i_D}{2n}$$

$$= \frac{I_o}{n(I-\delta)} + \frac{V_o(I-\delta)nT}{2L_p}$$

$$= P_o\frac{V_i + nV_o}{V_i nV_o} + \frac{T}{2L_p}\cdot\frac{V_i nV_o}{V_i + nV_o} \qquad (3)$$

Finally, for the peak collector to emitter voltage:

$$\hat{V}_{CE} = V_i + nV_o \qquad (4)$$

These equations express general, or average operation. It is the worst case conditions that would see off your devices.

The worst case will occur if $P_{o(min)}$ is being drawn when V_i is equal to $V_{i(max)}$.

$$\hat{V}_{CE(max)} = V_{i(max)} + nV_{o(max)}$$

and the constraint on L_p is:

$$L_{p(min)} \geqslant \left(\frac{V_{i(max)}\,nV_o}{V_{i(max)} + nV_o}\right)^2\frac{T}{2P_{o(min)}} \qquad (2a)$$

On the other hand, $\hat{I}_{c(max)}$ will occur when P_o is running at the maximum demand, coincident with the lowest V_i.

$$\hat{I}_{c(max)} = P_o\left(\frac{V_{i(min)} + nV_o}{V_{i(min)}\,nV_o}\right) + \frac{T}{2L_p}\left(\frac{V_{i(min)}\,nV_o}{V_{i(min)} + nV_o}\right) \qquad (3a)$$

In order to keep V_o constant with varying V_i, δ will have to change.

$$\delta_{min} = \frac{n\,V_o}{V_{i(max)} + n\,V_o}$$

$$\delta_{max} = \frac{n\,V_o}{V_{i(min)} + n\,V_o}$$

The 'd.c.' value V_i will be at maximum when the mains supply is high and the peak of the 100Hz ripple from the primary full-wave rectification. Conversely, $V_{i(min)}$ will occur with a low mains input together with the trough of the 100Hz ripple. If the maximum mains r.m.s. voltage is 265 volts, the $V_{i(max)}$ might reach 375 volts d.c. If the ripple amplitude is, say, 25 volts peak to peak, then when the mains is low at 190 volts $V_{i(min)}$ will be about 244 volts.

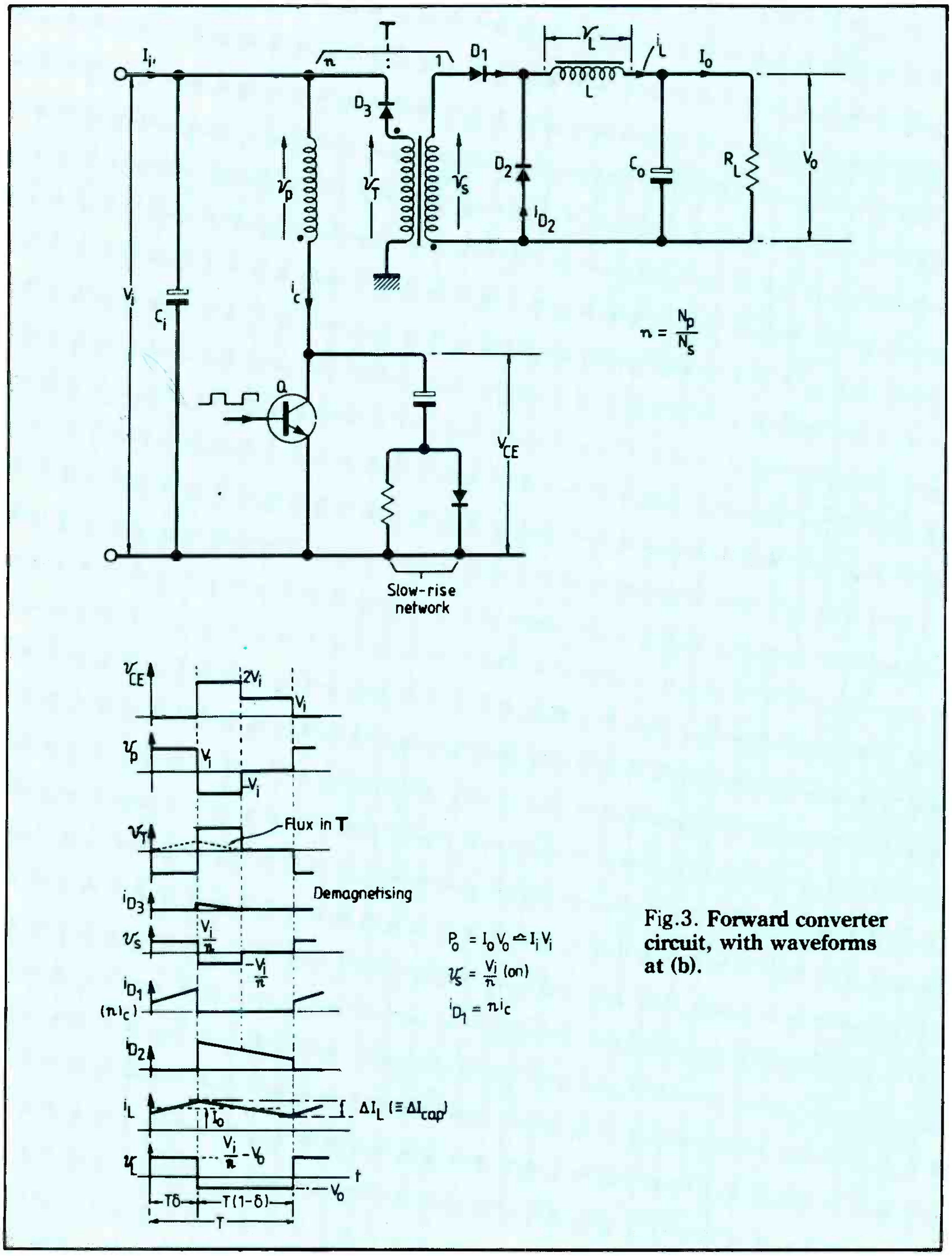


Fig.3. **Forward converter circuit, with waveforms at (b).**

Forward converter

The circuit and waveforms given in Fig.3. enable you to understand the operation in a similar way to the flyback converter. I won't go through the analysis, as space hardly permits such a duplication, but to quote a cliché 'it is left as an exercise for the student'. A brief note of a few details about the circuit operation and a quotation of the results for comparison should help anyone to derive the formulae.

The magnetic component T, operates as a true transformer. With Tr 'on', D_1 is on and energy is passed through from the input. Some is stored in L, some flows on to the output load. When T turns off, primary and secondary currents, i_c and i_{D1} cease. The voltage v_L across the choke reverses, diode D_1 goes off and 'flywheel diode' D_2 comes on. The current in choke L 'commutes' from D_1 to D_2. The magnetizing current in the transformer would also stop flowing, since no path now exists for it in the primary or secondary circuits. An extremely high voltage inductive 'kick' would occur across T. Therefore the energy recovery winding with D_3 is essential in this form of converter. D_3 limits v_{CE} to $2V_i$ by returning the stored magnetic energy to the source.

The designer must consider two limiting requirements. The transformer core should reach zero magnetization in less time than the 'off' period of the switching, so that the circuit starts the next cycle with a clean slate, as it were. The choke L should be large enough to keep the current going during the 'off' period, for a similar reason to that given for the flyback converter. As you can see, current flows through a sufficiently large L all the time. In fact it ramps gently (and linearly...) up and down. This means the ripple duty for C_o is much less stringent than the corresponding filter component in the flyback circuit, where bursts of current arrive followed by nothing for a while.

In a similar argument for Equation 1. you can show V_o and V_i relate as:

$$V_o = \frac{\delta V_i}{n} \qquad (5)$$

The criterion for the design of T is to make its winding inductance large enough to keep the magnetizing current small compared to the load currents. The energy storage inductor L has a certain minimum value L_{min}, which will keep the current going, down to a stipulated minimum current out, $I_{o(min)}$. With a similar approach to Equation 2. for the flyback circuit:

$$L_{min} = \frac{V_o^2\,T}{2\,P_{o(min)}}\cdot\left(1 - \frac{n\,V_o}{n_i}\right) \qquad (6)$$

$\hat{I}_C$ is also found in a similar way:—

$$\hat{I}_c = \frac{V_o\,T}{2\,L}\left(1 - \frac{n\,V_o}{n_i}\right) + \frac{P_o}{n\,V_o} \qquad (7)$$

Finally D_3 clamps $\hat{V}_{CE}$ to $2V_i$,

$$\therefore \hat{V}_{CE} = 2\,V_i \qquad (8)$$

Precisely similar arguments as before will give you the 'worst-case' magnitudes the devices would have to handle in practice.

Will the transformer handle the power?

Always central to power supply design is the question of whether your transformer will burst into

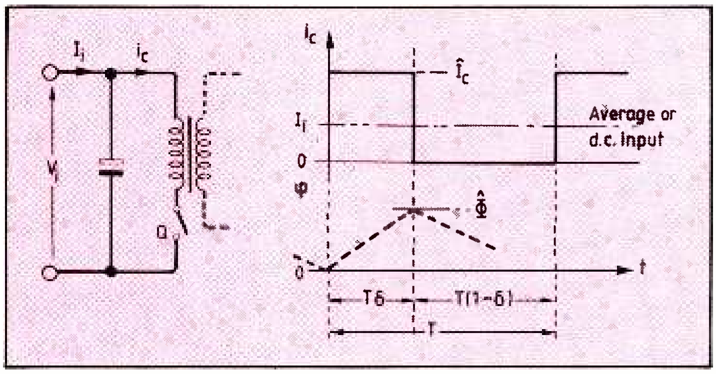


Fig.4. **D.c. pulse drive in a forward-converter transformer.**

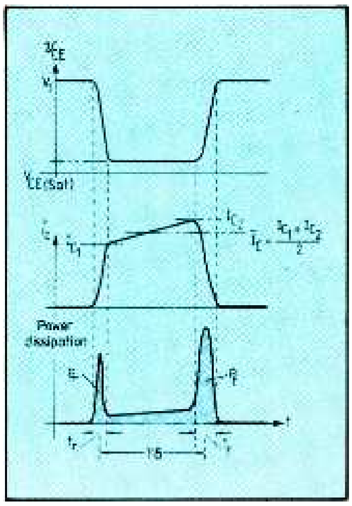
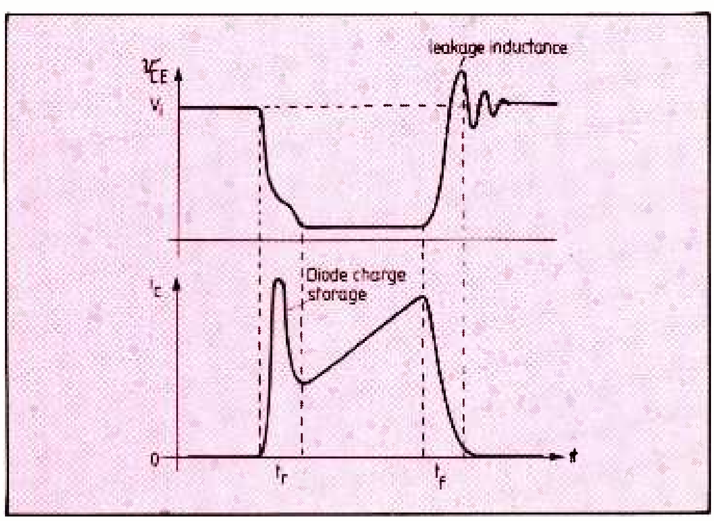


Fig.5. **Calculating losses due to finite switching times.**

Fig.6. **Modified waveforms caused by reactances in a practical circuit.**



flames. The inductors in s.m.p.s. systems are no exception. We hope their power to weight ratio will be very good, but they must still handle the VA. Because forward converters and flyback circuits deal with the throughput in different ways, we must consider the inductors accordingly. Designing flyback chokes is quite involved and I have relegated the discussion of these to an appendix, (always assuming the Editor can find room for it...) *(next article - Ed.)*

The throughput performance of a forward converter transformer is reasonably simple to analyse; you can try your hand with the flyback choke later. However, we cannot get away with only the simple forward converter or push-pull transformer design. Both of these circuits require energy storage chokes in addition to the transformers. The choke design requires the full 'flyback-type' analysis — complete with the appropriate parameter, η.

Forward converter transformer.

I will draw on the discussion we had in Part 2, especially details given in the appendix there. In particular, it all starts with:

VA = ampere—turns × volts per turn

The true transformer action in the forward converter means that magnetizing currents can be ignored for the moment. They can be checked at a later stage in the design. The d.c. pulse drive is illustrated in Fig.4, from which, the peak primary current is:

$$\hat{I}_c = \frac{I_i}{\delta} \qquad (9)$$

R.m.s. current I_C is given by:

$$I_c = \left[\frac{1}{T}\int_0^{T\delta} \hat{I}_c^2\, dt\right]^{\frac{1}{2}} = \hat{I}_c\sqrt{\delta}$$

or in terms of I_i:

$$I_c = \frac{I_i}{\sqrt{\delta}} \qquad (10)$$

The transformer efficiency is high (about 96%) which means:

$$VA_{(in)} = VA_{(out)}$$

Equations A5 in Part 2 give the resistance of the windings. Equations A6 built up a picture of current density in the copper and power dissipation. We can quote via Equation A6(a):

$$P_W = 2\rho_c\, m\, I_d^2 A_W F_W l_W \qquad (11)$$

The rate of change of magnetic flux gives the volts per turn:

$$\frac{V_i}{N_p} = \frac{d\varphi}{dt}$$

where the linear rate of change of flux $d\varphi/dt$ is simply $\hat{\Phi}/T\delta$ from Fig. 4.

$$\frac{V_i}{N_p} = \frac{\hat{\Phi} f}{\delta} \qquad (12)$$

And from Equations 10 and 12 we obtain:

$$VA = V_i I_i = \sqrt{\eta}\; I_d A_W F_W \times \frac{\hat{\Phi} f}{\delta}$$

where I_C has been replaced by the current density I_d times the effective copper area, $A_W F_{W/2}$ of the primary winding, the number of turns, N_p, cancelling. Now substitute for I_d from Equation 11:

$$VA = \left(\frac{P_W A_W F_W}{\rho_c\, m\, l_W}\right)^{\frac{1}{2}} \frac{\hat{B} A_{core} f}{2\sqrt{\delta}} \qquad (13)$$

Or writing in terms of the cooling surface, A_c, and the heat transfer, P_h (see Part 2) Equation 13 becomes:

$$VA = \left(\frac{2F_W A_W A_c P_h}{3\rho_c\, m\, l_W}\right)^{\frac{1}{2}} \frac{\hat{B} A_{core} f}{2\sqrt{\delta}}$$

Looking at this result, you can see that the throughput VA is a minimum (or temperature rise is maximum for a given VA) when δ is at its maximum value, 0.5 — together with minimum V_i. $V_{i(min)}$ minimizes $\hat{B}$ and so we have the smallest numerator divided by the largest denominator in Equation 13. Hence the throughput conditions are explained.

Design note. In practice, you would calculate the windings from the minimum supply voltage and maximum $\delta(=0.5)$ conditions. The volts per turn for the three types of converter work out as:

forward converter $\frac{V}{N} = 2f\hat{\Phi}$

flyback converter $\frac{V}{N} = \frac{4f\hat{\Phi}\eta}{1+\eta}$

push-pull circuit $\frac{V}{N} = 4f\hat{\Phi}$

Some d.c. flux will occur in a forward converter transformer core — and might occur in an unbalanced push-pull circuit. A slight reduction in your chosen $\hat{\Phi}$ can be made to take this into account.

Chokes carrying d.c. such as those in the flyback converter and the smoothing chokes in forward converter and push-pull circuits, require some thought. The d.c. component biases the flux in one direction and the relatively small alternating swings go round and round a minor hysteresis loop. The incremental permeability might very well be much less than the amplitude permeability we have assumed to apply. The inductance is optimized by using an air gap in these cases, since a gap in the magnetic circuit can increase the incremental permeability. The best approach would be for you to use the appropriate Hanna curves for the chosen core.

Switching to new endeavours

The efficiency of conversion will only remain high if you endeavour to keep down the dissipation in the switches as well as the transformers. The primary switch has been bipolar transistors, but power fets are challenging this position. We can look upon the steering and rectifier diodes as secondary switches. In all of them, time is required to turn on and off. Especially in the diodes, charge storage can cause trouble at turn-off.

While the current rises through the switches at turn-on, the previously high voltage across the devices has to fall rapidly. The power dissipation is high during the rise and fall times but, averaged over a whole period, the fractional energy lost can be quite small.

There is always an offset, or forward saturation voltage across semiconductor devices. The 'on' period dissipation arises through the product of this voltage with the saturation current. The time taken by the switching edges is so short that they are a tiny fraction of the steady periods of the cycle. The fraction of time a particular device is 'on' and dissipating steadily changes with δ. You can see that operating at higher frequencies increases the switching edge average losses, as there are moreof them per second, but the 'on' dissipation remains steady. If you consider a simplified set of switching waveforms, for example those shown in Figure 5, a loss estimate is straightforward. The 'on' dissipation is the average on current, multiplied by $V_{CE(sat)}$ over period nT, averaged over the whole period T:

$$P_{on} = \delta \frac{I_{c_1} + I_{c_2}}{2} V_{CE(sat)} \qquad (14)$$

The approximately linear rise and fall ramps on the switching edges makes for a simple integral of the following form. At switch on:

$$v_{CE} = -\frac{V_i}{t_r} t + V_i$$

and

$$i_c = \frac{I_{c_1} t}{t_r}$$

The energy dissipated and averaged over the period T is:

$$P_r = \frac{1}{T}\int_0^{t_r} v_{CE}\, i_c\, dt =$$

$$= \frac{1}{T}\int_0^{t_r} V_i I_{c_1}\left(1-\frac{t}{t_r}\right)\frac{t}{t_r}\, dt$$

$$= \frac{V_i I_{c_1} t_r}{6\,T} \qquad (15)$$

Similarly at turn off:

$$P_f = \frac{V_i I_{c_2} t_f}{6\,T} \qquad (16)$$

The sum of these powers gives the total dissipation in the switch:

$$P = P_{on} + P_r + P_f$$

$$= \delta \frac{I_{c_1} + I_{c_2}}{2} V_{CE(sat)} +$$

$$+ \frac{V_i}{6}\left(I_{c_1} t_r + I_{c_2} t_f\right) f_s \qquad (17)$$

where I have written f_s, the switching frequency, for 1/T. You can see from this that the power lost is proportional to the frequency f_s. Fast rise and fall times are required in the devices to minimize t_r and t_f, and a low saturation voltage $V_{CE(sat)}$.

The estimate for P is optimistic and applies best to switching in resistive circuits. S.m.p.s. circuits are anything but resistive: there are additional effects from leakage inductance, charge storage in the diodes and capacitances charing and discharging. The transient losses are likely to be worse than the simple analysis shows. Typical waveforms in s.m.p.s circuits are shown in Fig.6.

Optimising t_r and t_f

The problems of getting the switching transistor to turn off include the need to prevent the emitter-base junction losing control. If this happens, the charge storage in the base-collector junction causes energy dissipation over a long time with high loss. The trajectory of the operating point at turn off must be arranged to avoid the dangerous second breakdown region of the devices. The slow rise network ensures this, see Fig. 3.

Stored charge must be taken out via the base-emitter circuit. The current i_c remains constant during the time this occurs in a correctly designed circuit, then snaps off quickly. The V_{CE} edge has begun to rise, but overall the power lost, P_f, is minimized. Figure 7 shows the two possibilities: the required base drive waveforms to achieve the desired result are shown. A series induc-

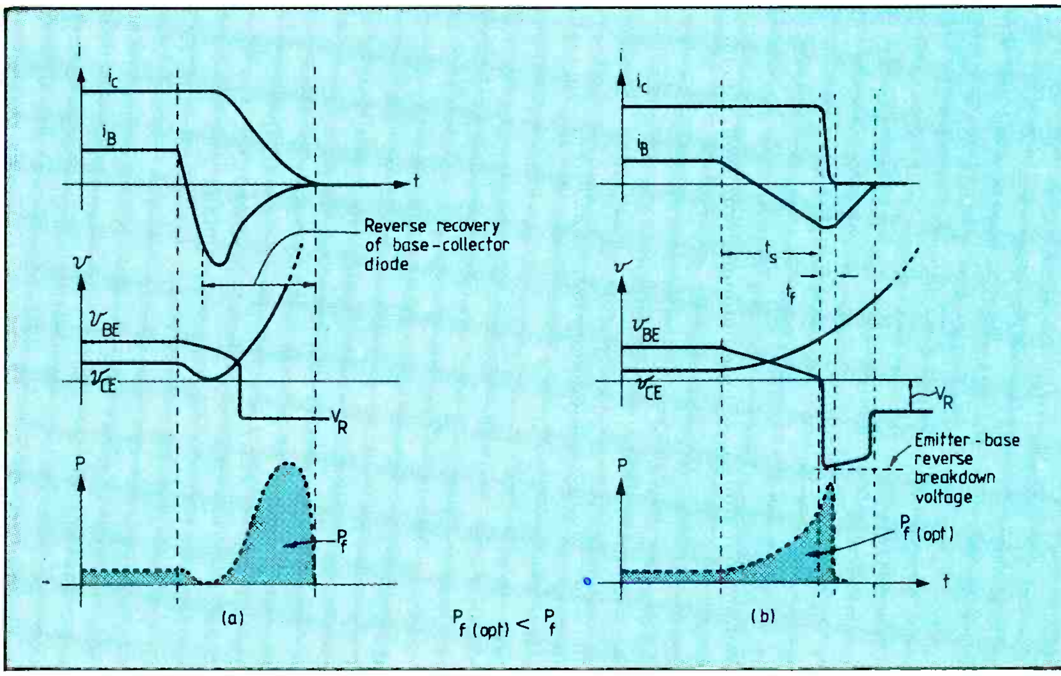


Fig.7. **Minimizing loss of power during transistor turn-off. Rapid turn-off of collector current at (b) produces optimum result.**

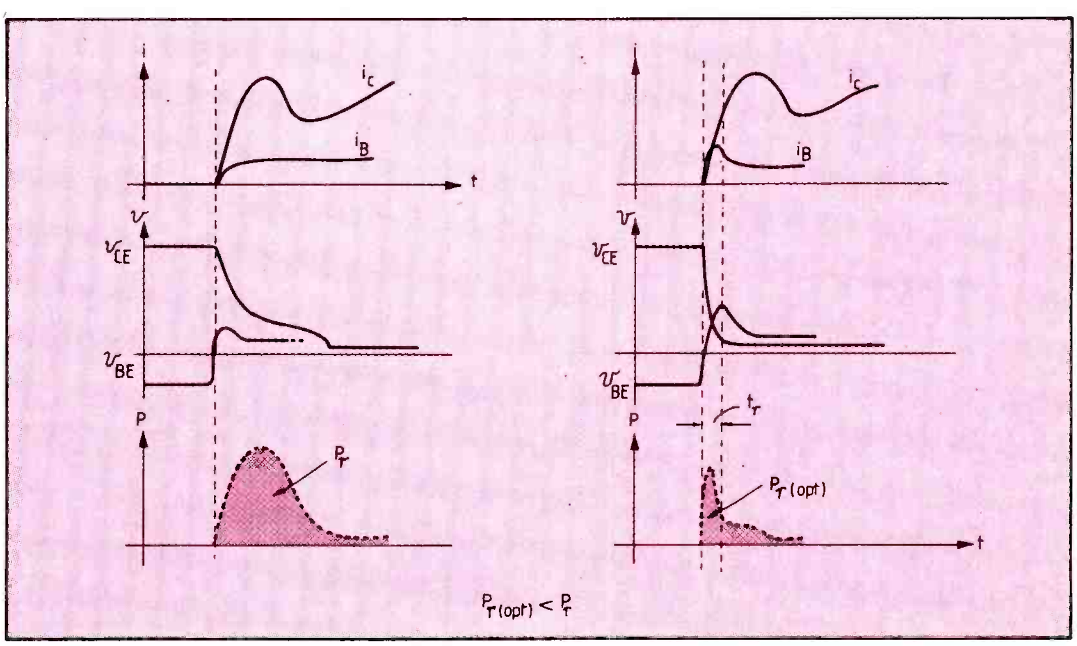


Fig.8. **Optimum turn-on waveforms at (b), while (a) shows result without extra i_b pulse.**

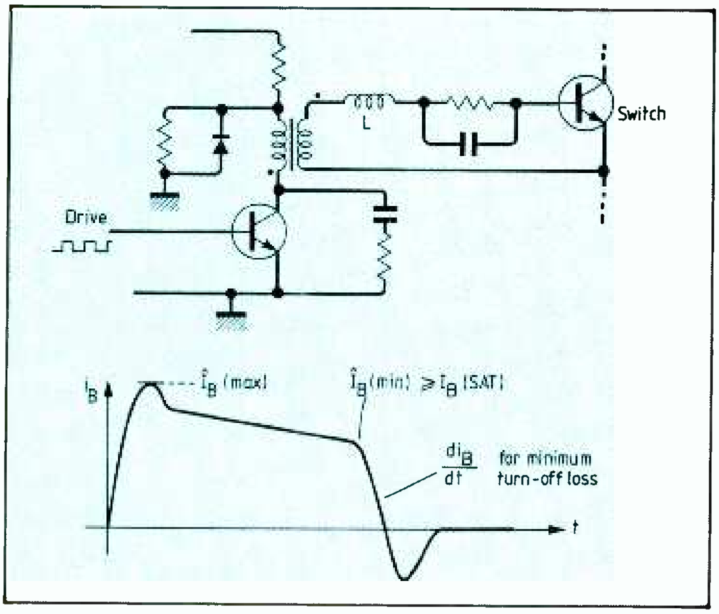


Fig.9. **One type of base drive to obtain optimum switching.**

tor is used to store energy to form the waveshapes at switch off.

During switch on, the base current drive must rise above the $I_{B(sat)}$ level in order to flood the base-collector region with injected charge. This produces a fast rise in i_c and minimizes t_r. The extra pulse of base current at turn on is usually obtained from a capacitor. Figure 8 shows the rising edge of current at switch on for two conditions. The kind of results that can be achieved in practice are impressive: for instance, special s.m.p.s. transistor type BUS13 switching directly rectified and smoothed 230 volt mains in a forward converter, can handle a maximum throughput of 1000 watts at 20kHz switching rate. The BUS13 has an $I_{C(sat)}$ of 10 and a V_{CEO} of 400 V. Its makers state that test results gave $<1\mu s$ for the turn-on time and typically 40ns for t_f, with the 'off' storage time t_s, less than 3μs, (Figs 7 and 8). You would have to exercise some caution because, as I have shown, the switching times can be very circuit dependent.

To achieve circuit optimization of the switching characteristics, you will come across base drive arrangements such as that shown in Fig.9 which also illustrates the desired base current waveform it provides.

Rectifiers

There was a hint earlier that unless you choose carefully, diodes can cause trouble in high-speed switching circuits. At turn-on, the depletion layer in a p-n junction has to be flooded with charge. This is called forward recovery and lifts the voltage drop (and therefore the power dissipation) slightly. Things are worse at turn-off: charge storage can cause a big increase in power loss and transients. Typical waveforms for an ordinary double-diffused diode are shown in Fig.10. The diode cannot support any reverse voltage until the reverse current reaches its peak. Then reverse voltage increase rapidly while the remaining reverse current sweeps out the remnants of stored charge Q_s. This accounts for the pulse of energy dissipation shown in (b). The usual forward V_F times I_F dissipation is also occurring and by adding up the total over one cycle, you can calculate the heat sinking requirement for the diode, if any, to remove the waste watts in your particular application.

The reverse current pulse has ramifications elsewhere. The transformer winding is effectively short circuited by the diode in the first part of t_{rr}: the current pulse is reflected through to the main switch (see Fig. 6) and increases the dissipation there. All in all, very fast recovery epitaxial diodes should be chosen for this duty. For example, a BYW30 has a t_{rr} less than 35 ns and a stored charge, Q_s, less than 15nC. Figure 11 compares an ordinary diode with one from the BYW series. As a bonus, these diodes also tend to have a lower forward voltage drop, V_F.

Output filtering: just a capacitor?

There is further trouble if we take the well known smoothing capacitor techniques from 50Hz linear supplies and apply them to s.m.p.s. systems without thought. Figure 12 illustrates a straightforward s.m.p.s. output circuit, with the real equivalent circuit of the filter capacitor. At 100Hz say, the e.s.l. has negligible effect, but consider 50kHz...? Also, very high peak currents can occur in an s.m.p.s. and the e.s.r. becomes significant. The upshot of all this is that it is difficult to get ripple components down in switching systems. The capacitors have to be carefully designed for this service. They tend to be expensive — and any old electrolytic won't do.

The forward converter shown in Fig. 12 supplies a sawtooth current wave whose mean value is I_o. The variable component flows through the capacitor and its parasitic series components. If we know the value of this ripple current, then the ripple voltage amplitude is easily calculated. Fig. 13 shows the current waveform i_{cap}, and the resultant peak to peak voltages across the e.s.r., e.s.l. and capacitor itself. These voltages are found as follows.

A glance at Fig. 3 with linear current ramps again, enables you to write down the peak to peak ripple current as:—

$$\Delta I_L = \Delta I_{cap} = \frac{\left(\frac{V_i}{n} - V_o\right)T\delta}{L}$$

But from Equation 5:

$$V_o = \delta \frac{V_i}{n}$$

$$\therefore \Delta I_{cap} = \frac{(V_i - n V_o)}{f L V_i} V_o$$

Continued on page 79

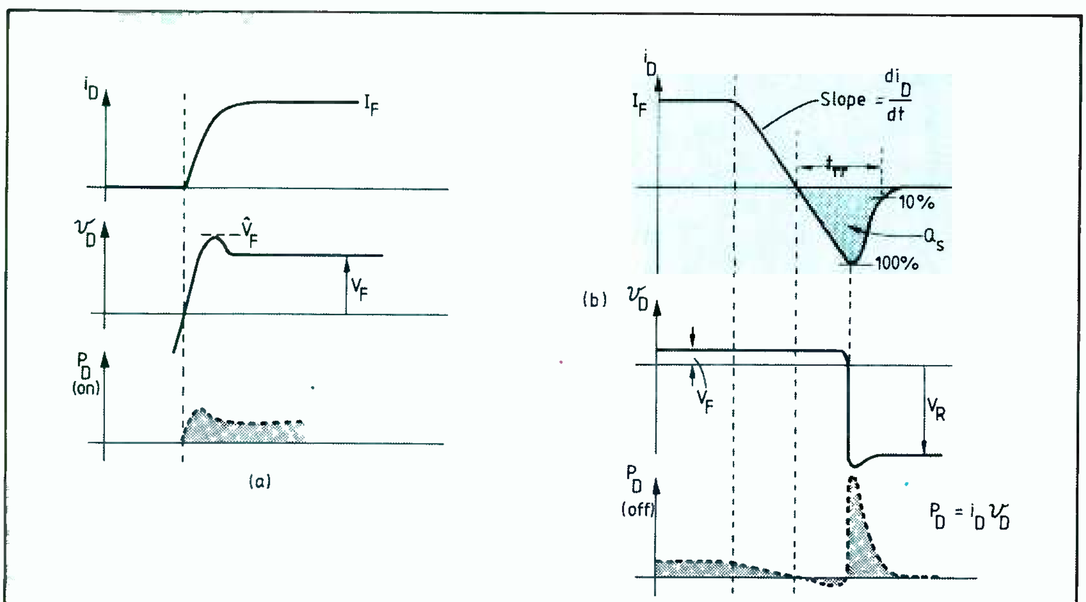


Fig.10. **Waveforms in the diodes. Power pulse at (b) is caused by stored charge remaining after peak of reverse voltage.**

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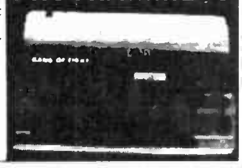

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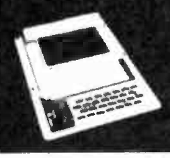

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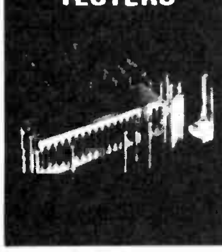

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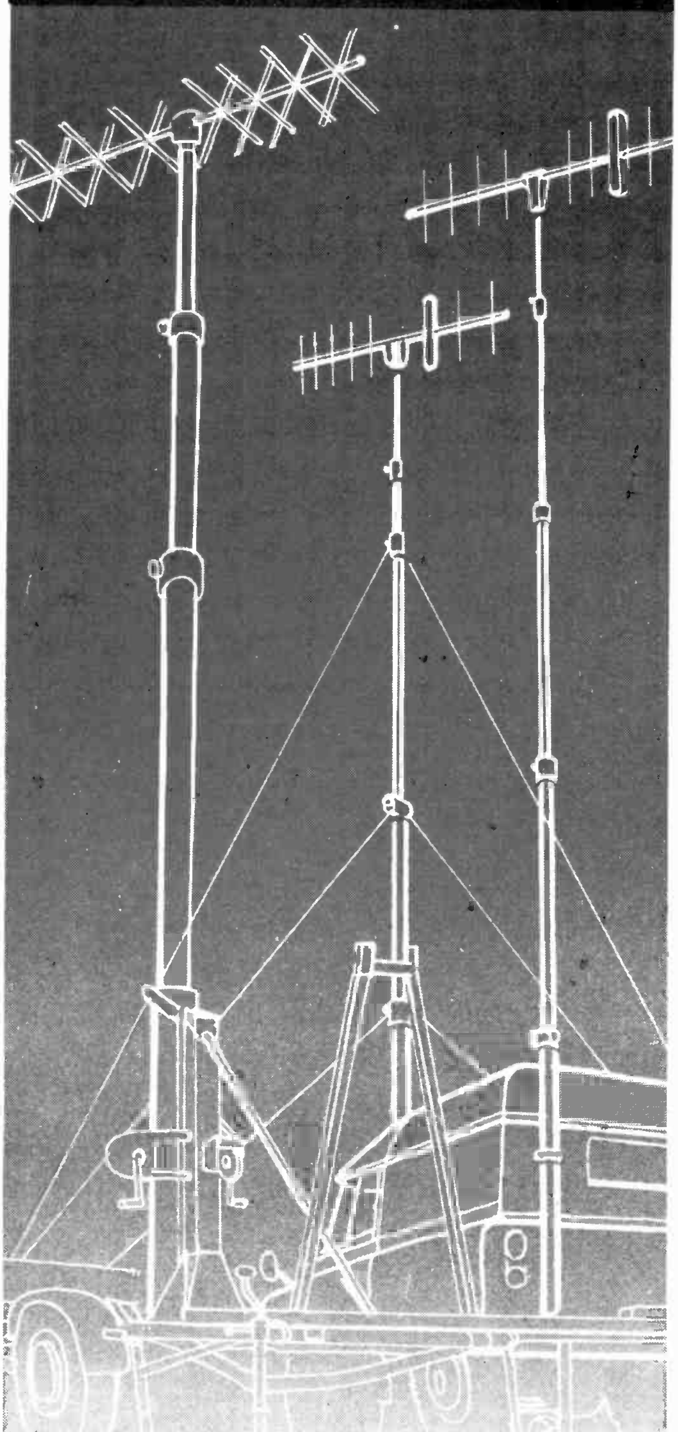

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DY802	0.70	EL86	0.95	QQV03/10	5.95	3S4	0.70	6F14	1.15	12J5GT	0.55
E92C	2.80	EL90	1.00		10.10*	4B32	18.25	6F15	1.30	12K7GT	0.70
E180CC	8.25	EL91	6.50	QQV03-20A		5R4GY	2.20	6F17	3.20	12K8GT	0.80
EA76	2.25	EL95	0.80		21.50	5UAG	1.40	6F23	0.75	12Q7GT	0.60
EABC80	0.80	EL504	2.70	QQV03-25A		5V4G	0.75	6F24	1.75	12SC7	0.65
EB91	0.60	EL509	5.85		36.50	5Y3GT	0.95	6F33	10.50	12SH7	0.65
EBC33	1.15	El519	6.90	QQV06/40A		5Z3	2.80	6FH8	17.80	12SJ7	0.70
EBC90	0.90	El821	8.20		22.50/45.50	5Z4G	1.25	6GA8	1.95	12SQ7	1.45
EBF80	0.60	El822	9.995	QV03-12	4.20	5Z4GT	1.15	6GH8A	1.95	12S7GT	0.85
EBF83	0.60	ELL80(SE)	2.80	SP61	1.80	6/30L2	0.90	6H6	1.60	12Y4	0.70
EBF89	0.80	Em80	0.85	TT21	32.20	6AB7	0.70	6JU6	5.85	13D3	2.80
EC52	0.65	EM87	2.50	TT22	29.50	6AC7	1.15	6J4	1.35	13D5	0.90
EC91	4.40	EY51	0.95	UABC80	0.75	6AG5	0.60	6J4WA	2.00	19AQ5	0.85
EC92	0.85	EY81	0.65	UAF42	1.40	6AH6	1.15	6J5	2.30	19G3	11.50
ECC81	0.85	Ey86/87	0.60	UBF80	0.70	6AK5	0.65	6J5GT	0.90	9G6	8.50
ECC82	0.60	EY88	0.65	UBF89	0.70	6AK8	0.60	6J6	0.85	19H5	39.55
ECC83	0.65	EZ80	0.70	UCC84	0.85	6AL5	0.60	6J6W	2.80	20D1	0.80
ECC84	0.60	EZ81	0.70	UCC85	0.70	6AL5W	0.85	6JE6C	5.50	20E1	1.30
ECC85	0.60	GM4	5.90	UCF80	1.30	6AM5	4.20	6JS6C	4.85	20P1	0.65
ECC88	0.80	GY501	1.30	UCH42	1.65	6AM6	1.50	6K7	1.45	25L6GT	1.60
ECC189	0.95	GZ32	1.05	UCH81	0.75	6AN8A	2.50	6KD8	5.50	25Z4G	0.75
ECC804	0.90	GZ33	4.20	UCL82	0.95	6AQ4	4.40	6KD6	4.60	35W4	0.80
ECF80	0.85	GZ34	2.75	UF41	1.35	6AQ5	1.30	6L6M	2.80	85A2	1.40,2.55*
ECF82	0.85	GZ37	3.95	UF80	0.95	6AQ5W	2.20	6L6GC	3.70	807	160/2.40*
ECF801	1.05	KT66	14.50	UF85	0.95	6AS6	1.15	6L6GT	1.95	812A	21.80
ECH34	2.25	KT81	7.00	UL84	0.95	6AS7G	4.195	6L18	0.70	813	
ECH42	1.20	KT88	23.00	UM80	0.90	6AT6	0.90	6LD20	0.70		28.50/68.50*
ECH81	0.70	ML4	2.80	UM84	0.70	6AU6	1.25	6LQ6	4.85	829B	24.00
ECH84	0.80	ML6	2.80	UY82	0.70	6AV6	0.35	6Q7G	1.30	832A	8.90
ECL80	0.70	N78	9.90	UY85	0.85	6AX4GT	1.30	6SA7	1.80	866A	5.05
ECL82	0.75	OA2	0.70	VR105/30	1.25	6AX5GT	1.30	6SG7	1.80	866E	9.80
ECL85	0.80	OB2	0.80	VR150/30	1.35	6BA60		6SJ7	1.80	931A	19.80
ECL86	0.90	PCL82	0.95	X66	1.80		0.70/1.20*	6SK7	1.40	954	1.20
EF37A	2.15	PCL84	0.90	X61M	1.70	6B49	3.45	6SL7GT	0.85	955	1.20
EF39	1.50	PCL86	0.75	Z759	19.00	6BE6		6SN7GT	1.60	956	1.20
EF80	0.65	PCL86	0.75	Z749	0.75		0.65/120*	6SQ7	0.95	5763	5.75
EF83	3.10	PCL805/85	0.95	Z800U	3.45	6BG6G	1.60	6SR7	4.60	6060	1.95
EF85	0.60	PD500/510	4.30	Z801U	3.75	6BJ6	1.30	6V6G	1.50	6080	5.30
EF86	1.25	PFL200	1.10	Z803U	16.00	6BQ7A	0.85	6V6Gt	1.30	6201	5.20
EF89	1.60		2.80*	Z900T	2.45	6BR7	4.80	6X4	1.50	6146	10.35
								6X5GT	0.65	6146B	10.35
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CIRCLE 26 FOR FURTHER DETAILS.

Reactivating Band III

Trunked repeater networks and worsening interference problems were among the topics discussed by mobile radio users at their annual conference

These are exciting times for the mobile radio industry: in January, cellular radio opened for business on 900MHz while at the same time tv broadcasting ended in Band III leaving the way clear for a big expansion in private mobile radio. So there was no shortage of subjects for consideration when members of the Mobile Radio Users' Association met at Wadham College, Oxford in March.

Opening the conference, Lord Lloyd of Kilgerran said that the emergence of cellular radio would act as a prod to the entire mobile industry. He emphasized its value to the small businessman: for a large company, cellular could mean better service and improved efficiency, but to a self-employed plumber it could be the difference between profits and bankruptcy.

Speaking of his own role in Westminster, Lord Lloyd said that five years ago no-one in Parliament had been interested in information technology; but now things were different. And he called on the industry to give presentations to Pitcom, the Parliamentary Information Technology Committee, so that MPs could be better informed.

One of the more provocative speakers at the conference was Walter Stevenson of Air Call, a founder-member of the MRUA He criticized the "unhelpful" regulatory attitude in Britian, which he said had fallen behind the United States in mobile radio. And he reminded his audience of the about-turns by the regulating authority from which the industry had suffered.

For example, Band III had been given to the land mobile service in the early 1950s because the BBC did not require it for television; yet on the opening day of one of the largest mobile radio schemes outside the US, a 1000-unit radio-taxi network in London, the Government changed its mind and handed over the band to the new commercial tv service. The same had happened to Band II, where the presence of public service transmissions continued to restrict the expansion of broadcasting.

Smarting, perhaps, under this onslaught there came next Rod Stewart of the Radio Regulatory Department of the DTI, one of a strong contingent from that unit, whose involvement in the conference was warmly welcomed by several speakers.

Allocating band III

Mr Stewart spoke about the technical problems of frequency assignment, especially those of Band III. This band is still in use by television broadcasters in continental Europe and in Ireland; and Britain, through bilateral agreements, has a duty to minimise interference caused there by mobile services.

The most serious source of difficulty for British users, he explained, would be the new French 625-line service Canal Plus. Strong signals from this service were often present over wide areas of Britain, their interference-causing potential being greatest around the vision carrier frequencies. For this reason, the new mobile band had been split into six sub-bands with intervening gaps centred on those frequencies. With this arrangement the Department hoped to be able to provide up to 1200 interference-free channel pairs, with scope for trunked systems where needed.

Answering questions afterwards, Mr Stewart said that there were no plans to use the gaps for mobile radio, although they might be assigned later to low-power services in the cities.

Another questioner raised the issue of delays by the department in granting allocations: he was told that the cause was a serious manpower shortage.

Also from the DTI came Les Barclay, who described his department's activities in monitoring interference and spectrum usage.

The Monitoring Section's main centre of activity is at Baldock in Hertfordshire, where it can monitor frequencies ranging from 10kHz to 12.75GHz. This station, recognised by the ITU, concentrates on the h.f. band, where it is mainly concerned with protecting British services against interference from abroad. Baldock now has two 12m satellite dishes, covering 4GHz and 12GHz.

For investigating mobile services, the department has a van newly equipped with automatic and manually-controlled equipment covering the spectrum up to

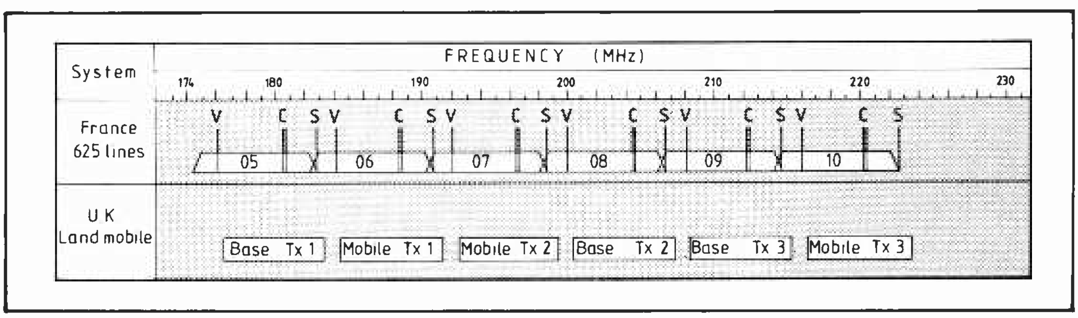


Fig. 1. **Band plan for the new U.K. land mobile allocation in band III. The gaps are to avoid interference caused by strong signals around the vision carrier frequencies of the French Canal Plus network.**

Table 1: post-WARC '79 allocations to the mobile service in Britain (Walter Stevenson)

Band	Name	MHz	Total r.f.
1	v.h.f. low band	30–88 (F,B)	57.9MHz
2	v.h.f. mid band	97–102 (B) (until 1989)	4.5MHz
3	v.h.f. high band	104–108 (until 1995)	4.0MHz
4	v.h.f. high band	138–235 (F)	94.85MHz
5	v.h.f.–u.h.f.	235–399 (F)	168.1MHz
6	u.h.f. band	401–470 (F)	58.9MHz
7	u.h.f. band	862–960 (F)	98.0MHz
	total, all bands 30–960MHz,		486.25MHz

(F) – shared with fixed services
(B) – shared with broadcasting

Table 2: mobile radio users in Britain, 1985 (Walter Stevenson)

400 000	despatch-type radio-telephone, including police, fire, prisons and civil defence
220 000	radio message and signalling pagers, including wide-area, national and on-site pagers
35 000	public mobile radio telephones, including message-handling and cellular
100 000	vehicle and portable telemetry and radio-control devices
30 000	amateur radio, mobile and portable
200 000	citizen's band radio including unlicensed users
100 000	cordless telephones

1300MHz. The automatic system scans 300 channels per second and measures the signal level on each. Data is stored on a Winchester disc and then transferred to magnetic tape for off-line computer analysis later on. Up to 10 hours of data can be held on a single tape.

With this information, operators can list channels in order of their traffic congestion. And they can study in detail any channels with anomalous traffic loadings. A second van is to go into service later this year.

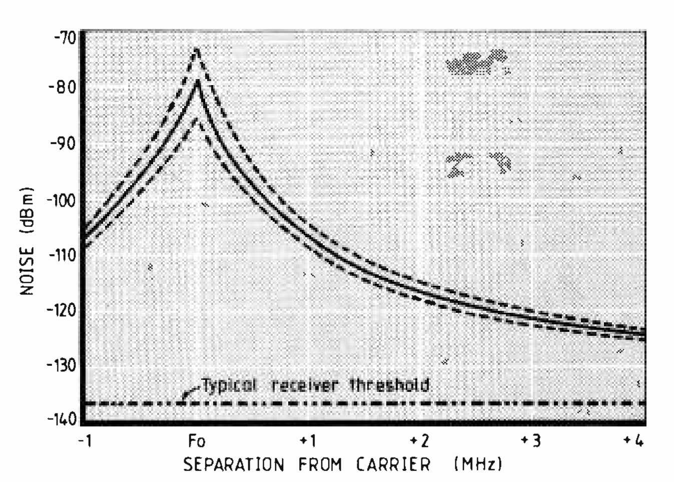


Fig. 2. **Typical noise output of a high-band solid-state transmitter. Even at frequencies several megahertz away from the carrier, the noise is still strong enough to open the muting of other receivers on the same site. Ferrite isolators and careful filtering can provide a cure. (Gerald David)**

Spectrum pricing

The final DTI speaker was the head of the Licensing Branch, Ian Jones, who was introduced light-heartedly as the man delegates would most like to stick pins into.

Mr Jones discussed, among other matters, the issue of 'spectrum pricing', an approach to frequency allocation by which channels might be let to the highest bidders. His department had decided to investigate the feasibility of spectrum pricing, though he stressed that there was no commitment to implement it. The first study would take six months and would deal with fixed services; the second, covering private mobile radio, broadcasting, the amateur and emergency services and others, was unlikely to be completed before late 1986.

If adopted, spectrum pricing might enable R.R.D. to drop its existing spectrum-loading criteria in deciding whether to assign further channels: the user's willingness to pay would become the main factor. At present, he said, licensing costs were "quite incredibly low" in relation to the other costs of running a mobile system, and some operators made excessive demands for frequencies. Spectrum pricing might sharpen their appreciation of a valuable resource. "Why must the Government decide what is a frivolous use of radio?", he asked; "shouldn't the market decide?".

Mr Jones spoke also about the announcement in January by the industry minister, Geoffrey Pattie, of the Government's initial decision on the uses to which Bands I and III would be put. The minister was considering the possibility of one or more large national mobile radio networks; these would not however be allowed to interconnect with the public telephone system, except possibly on a very limited basis. Applications would probably be invited for up to five trunked radio systems in major conurbations, using the common signalling standard now being drawn up. The government also wanted to hear from companies interested in setting up two-way mobile data transmission systems.

Mr Jones promised further ministerial announcements by early summer.

A questioner asked why the 900MHz band had been given so cheaply to the cellular radio operators. Mr Jones said that the charge was £1000 per national channel (for 160 channels) plus £8 per mobile user, which he felt was quite a good start to spectrum pricing.

Trunked systems

The theme of trunked networks, or community repeater systems, was taken up by Norman Croft of Motorola, a company which has played a large part in introducing such systems in North America.

Trunked systems can provide a big increase in the efficiency of channel usage. Users, instead of having their own private frequencies, share between them a much smaller number of pooled channels. Each user has access to all of them, and on initiating a call is switched automatically (via a separate control channel) to a vacant communications path as soon as one is free. When the call is over, the channels are released for other users.

Such a system, according to Mr Croft, had many advantages. It was simple to use, offered privacy (though not secrecy), reliability (failure of an individual channel did not mean total loss of communication) and easy expansion to accommodate new users. Since costs were shared it was especially attractive to the small user. As a bonus, trunked repeater systems offered reliable mobile-to-mobile contact.

Even greater traffic densities could be achieved by grouping the mobiles under network controllers or 'dispatchers', such as were used by taxi firms.

Cellular radio was itself a trunked system, though the networks now envisaged would not permit hand-off from one base-station to another as the mobile roamed about. To cover adequately a large region such as the London area, trunked systems would probably have to transmit simultaneously from multiple sites and incorporate voting techniques on the receive side.

Cellular radio

The first three months' experience with Cellnet, one of Britain's two new cellular radio systems was the subject of a presentation by Bernard Mallinder, formerly the consortium's technical director and now general manager. (No representatives of the rival Racal-Vodafone system were present at the conference.)

At the end of March, Cellnet had just over 4000 subscribers. Areas covered now include Birmingham, Manchester and Liverpool, and the system is expected to cover 80% of the population by the middle of next year.

The busiest times for callers are just before noon and just after. Four-fifths of all traffic occurs between 0800 and 2000; 70% of it is originated by mobiles and the average call duration is about 93s. Calls cost 25p per minute at peak times but fall to 8p per minute in the evenings and weekends.

Cellnet is now working on protocols to permit data communication with mobiles: at present there are difficulties because of the momentary interruptions as the mobile passes from one call to another.

Tackling interference

With the rapid growth in mobile radio during the last few years, there has been a marked increase in the number of radio stations sharing a common site. Co-siting can result in severe mutual interference; and the mechanisms by which this occurs were described by Gerald David of Aerial Facilities Ltd.

One problem results from the fact that the transmit-receive frequency spacing is generally constant within a given band. An incoming signal from a mobile will mix at the base station's transmitter output to produce a difference frequency. Any other transmitter in that base station can now mix with that difference frequency to produce its own receive frequency, which will be treated as a valid input on that channel. With 1mV of received signal coming in, up to 50μV of the transmit-receive difference frequency could be floating about in the installation.

Interference problems at shared base stations could be very hard to solve. Mr David mentioned one case of intermodulation interference at a site equipped with 35 transmitters, where it had taken four hours of mainframe computer time to track the fifth-order intermodulation products. The signal being looked for turned out to be an 11th order product.

A further source of interference was the noise generated by modern solid-state transmitters. The spurious noise 2-3% away from the carrier in a typical 25W unit is rarely better than 130dB below, which is much worse than with earlier thermionic designs. Thus, at a multi-channel transmitting site, the accumulated noise can be sufficient to open the muting of all the receivers.

The cure, said Mr David, was to add cavity and bandpass filters throughout and to insert ferrite isolators in each transmitter's output to prevent unwanted mixing.

A switch to s.s.b.?

The prospect of novel modulation modes was looked at by Prof. J.D. Parsons of the University of Liverpool in a paper which was published at the conference, but which he was unable to present in person.

The Government, he wrote, was under pressure to allocate a substantial part of Band III to systems using amplitude-companded single-sideband transmission. This would greatly increase the traffic capacity of the band by making possible a reduction in channel spacing to 5kHz. But its cost in receiver complexity would be significant. However, some sort of pilot-tone would need to be added to the transmission to provide a.g.c. and a.f.c.

Further investigation of a.c.s.s.b. was needed to evaluate its susceptibility to interference, particularly on the signalling channel; however, in the meantime it looked as though the first systems to be licensed would employ conventional f.m.

Improving coverage

A common source of complaint among mobile radio operators is failure to achieve adequate coverage of a system's service area. Brian Collins of C & S Antennas said that many of these problems could be avoided at the planning stage by a better choice of site for the base station and by better aerials.

A folded dipole mounted on the side of a steel mast was usually not good enough, since the mast created unwanted lobes which would confound the intentions of the planners. Attempting to deal with this by mounting a dipole on each side of the mast produced even worse results: a radiation pattern with deep nulls. A better approach was to use dipole or slot-fed panels on each face of the tower, driving them in phase: this would be more expensive, but the antenna would have a broadband characteristic and so could be shared by several services.

Typical aerials used by cellular systems consisted of ten-tier panels, which gave high gain in the horizontal direction, but could have sharp nulls at other angles. This could give rise to poor coverage in areas close to the base-station, especially where the station was at a high site above a town. In this case, Mr Collins said, mobile operators could borrow an idea from broadcasters, who phased the elements of such arrays so as to produce a slight downward tilt. A tilt of about 2.5° to 3° was common in tv practice: it directed the main beam more accurately at the boundary of the service area and filled in the nulls close to the station.

Another idea worth borrowing from broadcasters was to avoid hilltop sites where possible: it could help reduce co-channel interference.

Mr. Collins added that coverage with mobile systems was often restricted by multi-path reception: the use of polarization diversity at the receiving site could bring about worthwhile performance improvements.

Guest speaker at the conference dinner was Professor Brian Carsberg, director-general of Oftel since its inception last year. Prof. Carsberg outlined the functions of Oftel, which by next year will have a staff of up to 110, with powers to enforce the licence conditions of telecommunications operators and to investigate complaints within the industry.

Speaking of Bands I and III, Prof. Carsberg said the Government had asked his advice on their allocation, and that he would be reporting shortly. The interests of the consumer would be paramount, he said. "We welcome the opportunity to have contacts with organisations on matters which are important. They should not wait to be invited."

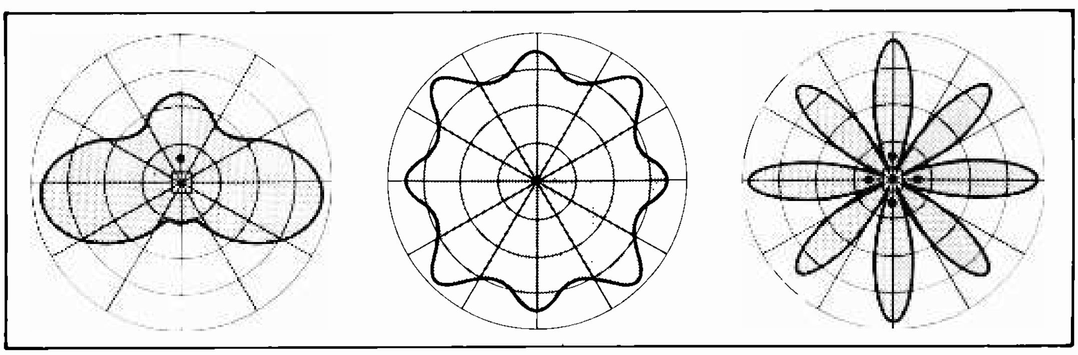


Fig. 3. **Polar diagram of a vertical high-band folded dipole stood off a 2m-square solid mast on a 1.5m boom (left): a common arrangement in mobile radio practise, but one which gives disappointing coverage. Adding dipoles on the other faces of the mast (right) makes matters even worse: eight deep nulls appear and the strong lobes between them frustrate the efforts of frequency planners. Much more even coverage (centre) results from phased array of dipole or slot-fed panels mounted around the mast. This arrangement costs more, but has broadband characteristics and can be shared between several users. (C&S Antennas)**

by Rod Cooper

Avoiding failure of sealed NiCd cells

Nickel-cadmium cells are expensive to buy, yet are often thrown away for lack of a few drops of water! More attention is needed in their day-to-day use to achieve their full lifespan, argues Rod Cooper — the use of cheap chargers that do not do their job properly is a completely false economy.

Failure mode no.1 (May issue) dealt with the importance of water to cell operation, and how loss of even a small amount caused by reverse-charging could result in a drastic shortening of cell life. The article continues with loss of water as the theme.

Failure mode 2: loss of electrolyte water due to incorrect charging

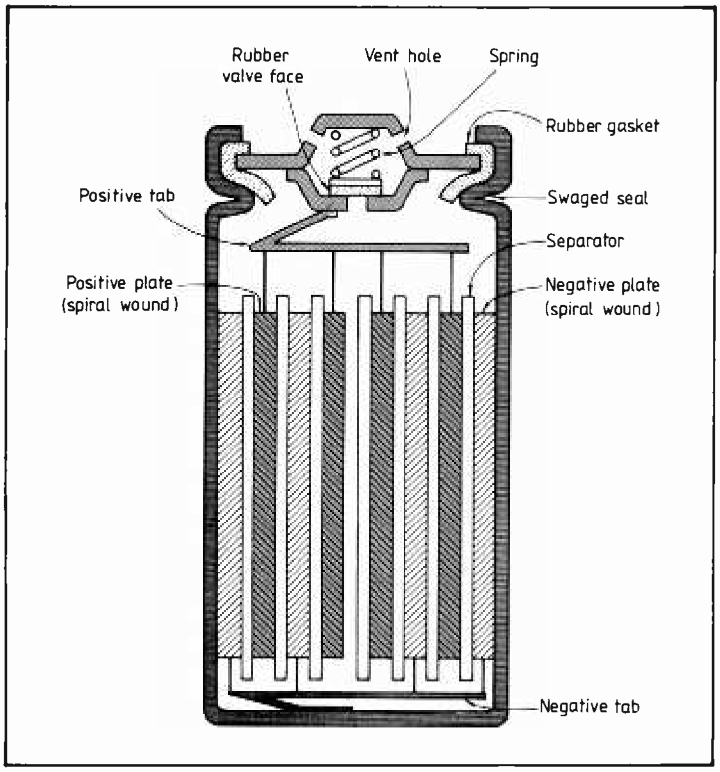
Oxygen is absorbed in a recombination process with cadmium during normal overcharge. The rate at which this reaction can proceed is determined by how much extra active material is provided by the manufacturer at the negative plate and by the ambient temperature, all other factors being equal. For standard cells the designed rate is C/10 where C is the capacity in amp-hours, the cell being able to tolerate this rate at 20°C without immediate problems (but see failure mode 3).

During normal overcharge (i.e. C/10 at 20°C) the internal pressure will rise slightly due to the presence of oxygen and the small increase in temperature. Neither of these effects present a problem until the C/10 rate is exceeded, when the internal pressure will rise rapidly until the safety vent opens, due to an accumulation of unrecombined oxygen. This condition is often exacerbated by a rise in temperature if the charge current is uncontrolled because this lowers the internal resistance and increases the current further i.e. thermal runaway, Fig. 6. The end result of exceeding C/10 is loss of capacity, and often an abused cell will show one or two other symptoms; a bulge in the bottom of the steel case as shown in Fig. 7 and splitting of the plastic sleeve, both due to the high internal pressures that are generated before the safety vent opens. Opening pressures in excess of 140 p.s.i. are quoted.

There is another way that electrolyte can be lost via the safety vent which is often overlooked. At low temperatures, like most chemical reactions, the oxygen recombination process becomes much slower. If charging is maintained at C/10 the pressure will build up due to excess oxygen in just the same way as during overcharge with excessive current. Indeed a reasonably high temperature is needed for the oxygen recombination process to place at so-called 'safe' rates. For standard cells a temperature of 20° to 30° is suitable. Even charging at 10C can result in a doubling of the usual overcharge pressure, a point worth remembering if attempting to charge standard cells at fast rates at low temperatures, for example out of doors on a cold day.

A common practice is to recharge NiCd cells overnight, which usually means that the charger is unattended, so for safety's sake many people choose to do this in an outbuilding where a malfunction can do little damage. More often than not such an outbuilding is unheated, and in winter it is quite easy to damage cells at a supposedly safe rate of charging.

Construction of typical sealed nickel-cadmium cell.



Avoidance tactics

Both of the above effects are more likely to happen during fast-charging so for standard cells it is best to adhere to the recommended rate of C/10 *and* ensure an ambient temperature of 20°C. Some fast-chargers have a temperature cut-out which operates when overcharge has been reached, so it might be thought that this neatly avoids such problems with standard cells. However, some excessive overcharging has already taken place by the time a temperature cut-out can operate, because of the time-lag between the rise in internal pressure and the rise in temperature which follows it.

If fast charging is required it is far better to adopt special fast-charge cells which have a greater oxygen recombination capacity.

The penalty paid is a reduction in Ah capacity — generally about 10% — but such cells can withstand typically a charge of C/3 during overcharge at 20°C. An example of this type of cell is the Cadnica N-500 AAF. The capacity of this cell is 450mAh compared to 500mAh for the standard cell, but it can be recharged in 4 to 6 hours instead of the usual 14 to 16 hours. The size and weight are about the same and the price only slightly more.

Experimental cure

Several D and C-size cells in my own collection of NiCd cells had been subjected to severe overcharge, reverse-charge and low-temperature abuse, due to accidents in faulty charging equipment and also deliberate experiment, and were known to have little or no capacity. Some of these cells were stripped of their steel casing (this was done precisely by machine-tool and so did not damage the contents — it is not recommended due to the highly hazardous nature of the KOH/LiOH electrolyte and the possibility of internal pressure) the electrodes removed and wound with nylon cord to prevent disintegration. Immersion in fresh electrolyte and subsequent recharging showed that much of the capacity had returned, indicating that the active materials of the plates were relatively undamaged.

Following this successful experiment, a small hole was drilled and then tapped in the nylon top of another 'dead' cell. A matching nylon screw and neoprene washer resealed the hole, Fig. 8. Small quantities of distilled water were gradually introduced via the hole with a hypodermic syringe during a succession of recharge/discharge cycles, until most (but not all) of the capacity had returned. This cell was eventually returned to service.

The only cells that refused to respond to this treatment were those that had been subjected to high temperatures, the inference being that high temperatures cause more damage of an irreversible nature than does excessive overcharging or reverse-charging.

It is easy to calculate the minimum theoretical amount of water needed in any particular type of cell from the basic reaction shown on page 61, May Issue.

$$2NiOOH + Cd + H_2O \rightarrow 2Ni(OH)_2 + Cd(OH)_2$$

The electrochemical equivalent and atomic weight of cadmium can be looked up in any reference book on electrochemistry, and these are 2.097g/Ah and 112.4 respectively for cadmium.

A D-cell has 4Ah capacity and thus 8.388g of active cadmium. From the above equation, 112.4g of cadmium reacts with 18g of water. Thus 8.388g of cadmium will react with 1.342 g water.

Of course, this may not be the amount put into a cell but it shows the order of magnitude of the quantities used, which is very useful when refilling a dead cell.

Failure mode 3: degradation of plates and seperator

Due to the dangers of loss of electrolyte already detailed, it is tempting to think that a low rate of charge spread over a long period was the best solution. However, this would be a mistake because low rates of charge over extended periods appear to cause another type of failure. This is referred to obliquely in manufacturers data sheets as 'crystal deformation' of the plates, but what it means in practice is that the cell develops an internal short-circuit which renders it useless long before the expected life-span is reached.

The trouble is caused by the pronounced crystalline nature of cadmium, which is of the hexagonal-pyramid type, and also the very slight solubility of cadmium in the electrolyte. During the charging process, if conditions are right, cadmium can be deposited in the form of dendrites, which are miniature tree-like growths with spiky branches sprouting from a central trunk and standing clear of the electrode. There is also a sub-species of dendrite, the whisker; these are single filament or rod-like structures 1 — 2μm in diameter which stand out like stubble on an unshaven chin. Cadmium has the dubious distinction of being the first metal in which whiskers were observed. There are some good photomicrographs of dendritic growth in ref.2.

The dendrite can grow through the seperator and eventually bridge the very small gap between the plates, providing an internal short-circuit. This often happens to an apparently healthy cell; during the charging process a dendrite will bridge the gap and divert further charging current through itself so that the cell never becomes fully charged. When put into service, any charge already in the cell rapidly leaks away through the dendrite, perhaps in only a few hours. The short time needed for a healthy cell to become 'dud' must provide a source of surprise, puzzlement and possibly indignation to the user, who may well have followed instructions to the letter and who cannot see that he has done anything wrong to the cell to cause it to malfunction.

The charging conditions that favour dendritic growth, on the evidence available, appear to be low current over extended periods. The Cadnica handbook for example warns of 'continuous charge over a long period' and the article by K.C. Johnson on NiCd cells (WW Feb. 1977) suggests that 'gentle cycles of charging and discharging are likely to accelerate the process'. My own experience confirms this.

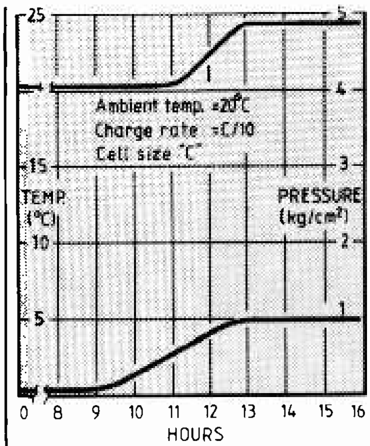
Apart from this problem, the plates of a NiCd cell are both physically and chemically robust and cause few problems. The same cannot be said of the separator, usually polypropylene or nylon in fibrous form. During normal over-charge the separator material is subjected to attack by the oxygen which must diffuse from positive to negative plate for recombination. This attack is made worse by the high pressures and temperatures encountered during excessive overcharge. A cell temperature of 50°C is often quoted as being the maximum permissible to avoid failure.

The more usual form of deterioration is a slow process and failure occurs due to accumulated effects over a long period. Manufacturers state in their data sheets that prolonged or repeated overcharge even at safe rates has a deleterious effect on cell life, yet it is still common proceedure to leave cells on charge for hours after full charge has been reached. This is bad practice. Unfortunately there is an almost universal belief that an indefinite amount of overcharge at C/10 is perfectly alright.

To assure full life expectancy a NiCd cell should have its recharge period terminated shortly after the oxygen recombination process has set in, preferably by automatic means.

Avoidance tactics

A cycle life of 500 times and up to



Correlation between rise in pressure on reaching overcharge phase and rise in temperature that follows one or two hours after (from the Cadnica Engineering Handbook).

Do's and Don'ts

Recharging

- Don't recharge cells connected in batteries if at all possible. Recharge cells singly instead.
- Avoid temperatures above 50 and below 5°C.
- Don't persistently overcharge cells — use an end-of-charge cut-out.
- Recharge standard cells at C/10 — invest in fast-charge cells if you want faster recharge.

Discharging

- Where possible, don't use cells connected in batteries. Use a d.c./d.c. converter to step the voltage up whenever such a technique is suitable or redesign circuit around a working voltage of 1.25V.
- If batteries are essential to the application, make use of protection diodes or low voltage cut-out.

General

- Avoid encapsulated batteries like PP9
- Don't replace dead cells in a battery with brand-new cells, and do not add partly-used cells onto a new battery.

Fig. 6. An overcharged cell, sectioned to show the collapsed base. This cell was overcharged due to a fault in the charger, but shows what can happen when any cell is charged for longer than is necessary at a rate which is too high. The contents of this cell were expelled when the cell became hot, and on cooling the case collapsed inward.

Fig. 7. An overcharged cell showing a bulge in the base caused by high internal pressure prior to the safety vent opening. A normal cell is shown for comparison. A condition like this is a sure sign of abuse, whether due to charging at too low a temperature, reverse charging or to charging in excess of C/10.

Fig. 11. Localised pin-hole corrosion caused in this instance by contact with sea water for a short time. This also could have been prevented by grease or paint.

Fig. 9. The effects of electrolyte creepage on two types of cell. The deposit has started to corrode the cell on the left.

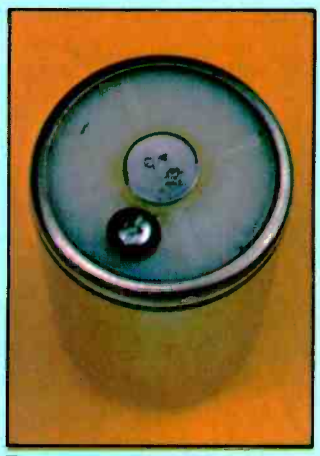


Fig. 8. A cell which has "dried out", modified by putting a filler hole in the top so that water can be introduced in controlled quantities. The filler hole in this particular cell is sealed with a nickel-plated steel pan-head M2.5 screw, which does not interfere with normal use of the cell. A small neoprene washer completes the seal.

Fig. 10. Generalised corrosion caused by water being trapped between the plastic sleeve and the side of the cell. Plastic sleeves are best removed and replaced if necessary with full-width adhesive tape. Exposed parts can be coated with "Komoline" grease or painted with "Celvar" to prevent this type of corrosion.

2000 times has been claimed by the manufacturers at charge rates of C/10. It would seem from this that charging at this rate does not lead to dendrite problems, at least in laboratory tests. My own experience is that, in practice, charging at C/10 does lead to dendrite problems in some cells but not in others, although they may be in the same battery. There seems to be no hard and fast rules about predicting which cells are prone to form dendrites.

I have experimented with a promising technique for supressing the initial formation of dendrites, and this will be described as a practical construction project in a later article.

To avoid material degradation it is safe to assume that a standard cell should be charged at C/10 provided that the overcharge period is detected and curtailed.

Experimental cure

There is no cure for a damaged seperator, but an interesting cure for dendrites was put forward in K.C. Johnson's article. Essentially this consists of a charge and discharge programme at controlled but very high rates, to melt the dendrites and reform the cadmium on the negative plate. A period of normal overcharge is recommended to oxidize remaining dendrite material, the theory being that the dendrites are in a relatively prone position for oxidation compared to the rest of the electrode. There must be a compromise between controlling dendrites and degradation of the separator with the oxygen of the overcharge mechanism.

Temperature must be carefully

controlled during the above treatment or more problems will be created than solved. I recommend looking at this article in detail. I have tried it and it works, but I have reservations about the separator failing, as nylon melts at around 220°C and polypropylene at 170°C so localized melting may occur in the areas around dendrites which will lead to premature failure anyway. Also, I have found that cells treated with this method rapidly reform their dendrites.

Failure mode 4: electrolyte creepage

Electrolyte creepage manifests itself as a furry white deposit, often confined to the top of the cell but sometimes spreading to sides and onto surrounding components such as circuit boards and wiring where it wreaks havoc due to corrosion, particularly of copper, zinc and tin parts. The cause of this phenomenon lies in the penetrating nature of the potassium hydroxide solution used as the electrolyte, which seems able to get past seals which on the face of it appear to be well designed. After creeping past the seal the hydroxide is converted to carbonate by reacting with CO_2 in the atmosphere. Potassium carbonate is less hazardous that the hydroxide (which can remove skin with rapidity) but still presents a corrosion problem for metal parts particularly in damp conditions.

Loss of electrolyte leads to loss of capacity but experience suggests that this is a lengthy process. In the battery of cells in the photograph (Fig. 9) the cells that showed the most efflorescence also showed the largest drop in capacity, as one would expect, but it took 12 months to get to the stage shown.

Avoidance tactics

Some manufacturers' products tend to suffer more than others from this defect. The only avoidance tactic one can practice is based on experience — simply avoid those manufacturers whose cells give creepage. I have tried four different makes of cell and only one — the nylon-topped variety made by Saft — has shown freedom from this trouble.

Experimental cures

I have tried re-sealing cells suffering from efflorescence with neoprene compounds, urethane and nitrile rubbers, epoxy resin and also thermal sealing with various thermoplastics. All attempts failed, although sealing with urethane solution (used for making the seams in neoprene wet-suits) did last several months before the signs of creepage re-appeared. I concluded that there is no really satisfactory cure and that it is better to throw away a faulty cell than risk corrosion damage to surrounding equipment.

Failure mode 5:

The external case material is commonly thin-walled steel. Rusting is prevented by nickel-plating, which is adequate for most purposes but not entirely satisfactory. The case is usually covered by a plastics sleeve, and this can assist corrosion by trapping moisture between sleeve and case. Fig. 10 shows an example of such corrosion, which was completely hidden despite its advanced state until the sleeve was removed. The cause was moisture from a damp atmosphere assisted by slight electrolyte creepage.

Fig. 11 shows another cell which was exposed for a short time to a small amount of sea-spray, again trapped by the sleeve despite washing down in fresh water. This rapid corrosion resulted in a pin-hole and a ruined cell.

In another instance of corrosion, a zinc-plated screw was left on top of a NiCd cell and this caused a pin-hole with surprising rapidity, probably assisted again by slight electrolyte creepage.

Avoidance tactics

It is best to keep dissimilar metals like copper and zinc away from the steel case. Where a damp environment is likely, it is a good plan to strip off the plastic sleeve altogether — it is more trouble than it is worth, especially if the cell is subject to electrolyte creepage. If insulation is required then the cell can be wrapped in 50mm wide adesive fabric-backed tape (RS Components 512-058). Exposed metal can be painted with Celvar cell paint or smeared with Komoline grease, both these products being made by Chloride-Alcad* for nickel-cadmium cells. I have tried all three techniques and they are effective in avoiding corrosion.

* Celvar is an alkali-resistant paint for steel cell containers, Komoline is a special mineral jelly for greasing steel cell tops, both available from J. Biles Engineering.

Unfortunately there is no effective cure for pinholes or remedy for advanced corrosion as shown Figs 10 and 11.

Multiple failure modes

Damaged cells are less amenable to diagnosis, and corrective action more difficult to implement, if more than one failure mode is present. For example, a cell may be suffering simultaneously from being over-charged and reverse-charged, or may be dendrited and have separator failure.

Recharging and discharging cells in series tends to promote the disparities between cells and increase the number of defects. This is explained as follows. Suppose a battery has seven cells; after a period in service perhaps four of these cells have full capacity, two slightly less capacity and one cell is in the early stages of dendrite formation. Cells are never exactly equal to start with and diverge in their performance in service even if they are of the same type and same manufac ture, so this is a realistic assumption.

If this battery is recharged so that the four healthy cells are fully charged, then the two reduced-capacity cells will be over-charged. The dendrited cell may not reach full charge. When this battery is fully discharged, the two cells of reduced capacity and the dendrited cell will be reverse-charged. The two cells of reduced capacity will also eventually suffer from separator deteriation by being persistantly over-charged. One cycle of the charge/discharge described may not make much difference but 20 or 50 cycles certainly will, and two failure modes will have been introduced simply by cycling the cells in series.

Even if the charging process is modified so that the two cells with reduced capacity are fully charged, leaving the healthy cells undercharged, the dendrited cells will in all probability still not be fully charged and will be reverse-charged when the battery is discharged. Further modifying charging so that this dendrited cell receives an extra charge leads to overcharging of the other six cells.

The correct way to charge cells is to charge them individually each according to their needs. This is not a difficult requirement if the battery is made up of cells like the AA, C, D and F types held in a battery compartment, but is ruled out if the cells are spot-welded together or are encased in a container like the PP9 or PP3. These batteries are best avoided for this reason.

Conclusion

NiCd cells are expensive to buy, they use up the relatively scarce and finite resources of nickel and cadmium, and consume large amounts of energy and industrial capacity in their production, yet they are often thrown away for lack of a few drops of water!

More attention is needed in the practical day-to-day usage of NiCd cells so that the full lifespan of 500 to 2000 cycles can be achieved, present practice being more akin to that associated with a throw-away product.

In particular, because NiCd cells are expensive, the use of cheap charging equipment that does not do the job properly is a completely false economy. (These are the ones that charge cells in series, have no over-charge limiting device and no low-temperature control.)

Also, it would be useful if the makers provided some means of giving the electrolyte a partial service; a re-sealable valve similar to that already provided for venting excess pressure so that a measured quantity of water could be injected for example. This is not a suggestion that diverges too far from the sealed-cell concept. It would be expensive and could be made quite safe. The other item that manufacturers could assist with is the provision of more comprehensive information on fault-finding than in presently available.

An article dealing solely with failure modes naturally gives a false impression of the technical integrity of the subject under dis cussion. Given a proper system of management, it must be said that nickel-cadmium cells can give superb performance, paying back many times over the investment in recharging gear, the higher cost of the cells themselves over other types of cell, and the extra equipment needed to prevent accidental abuse in service.

Further reading

Alkaline storage batteries, by Falk & Salkind. Wiley, 1969.
Cadmium, by D.M. Chizhikov. Pergamon, 1966.
Nickel-Cadmium Battery, by Grant. General Electric, 1975.
Nickel cadmium cells, by K.C. Johnson, *Wireless World*, February 1977, pp. 47,48.

by David Stonebanks

Cassette recording with the BBC micro

Improved performance with conventional recorders and an alternative digital method

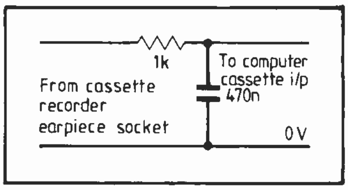


Fig. 1. **This simple integrating network can help reduce uncertainty at data transitions.**

The cassette port of the BBC Microcomputer encodes logic 0 as one cycle of 1200Hz tone and a logic 1 as two cycles of 2400Hz. These tones are synthesized sine waves, the frequency changes occurring at the zero-crossing point (trace 1).

When such a waveform is replayed from tape, the read head differentiates it, giving an output proportional to the rate of change of flux (trace 2).

After amplification and limiting, the waveform is as shown in trace 3. Continuous logic zeros correctly produce 1200Hz square waves (417μs for each half-cycle) and continuous logic ones produce 2400Hz square waves (208μs for each half-cycle). But where the logic value changes for consecutive bits, the result is a pulse of intermediate length (312μs), which is impossible to interpret correctly. No wonder cassettes are so unreliable!

Tape recorders do integrate the read waveform somewhat to overcome this uncertainty, but not always enough. A simple integrating circuit (Fig.1) can often improve reliability. It causes some attenuation and reduces the amplitude of the 2400Hz waves to half that of the 1200Hz waves; but the BBC Micro includes a limiting amplifier and is quite tolerant of amplitude variations provided that the signal is correctly phased.

If the frequency change could be made at the peak of the recorded waveform (trace 4) the differentiated waveform would be as required (trace 5). When amplified and limited, this produces the easily-interpreted waveform of trace 6.

Digital recording

The advantages of digital recording over analogue (audio) methods are

- a high output from the head when reading because of full flux reversals on the tape;
- elimination of the need for a replay volume control (there is nothing to set incorrectly);
- reliability.

In the circuit of Fig.2, amplifier A_1 limits the writing (record) signal from the computer to square-off the waveform. The input capacitor is not really necessary, but I am happier with the input isolated.

Amplifier A_2 provides a $\pm$6V square wave drive to the write head via a 4.7kΩ current-limiting resistor. If the power supply used is itself $\pm$6V then the zener diodes are not required.

To ensure fast current reversals the head must be driven from a high impedance. Head current must be enough to saturate the tape fully, but not so great as to leave the head magnetized, erasing the signal instead of reading it. With the recorders I have modified, 4.7kΩ was suitable, but it

cont. on page 20

Fig. 2. **Replacing the cassette recorder's electronics with this digital read-write chain gives high reliability at low cost.**

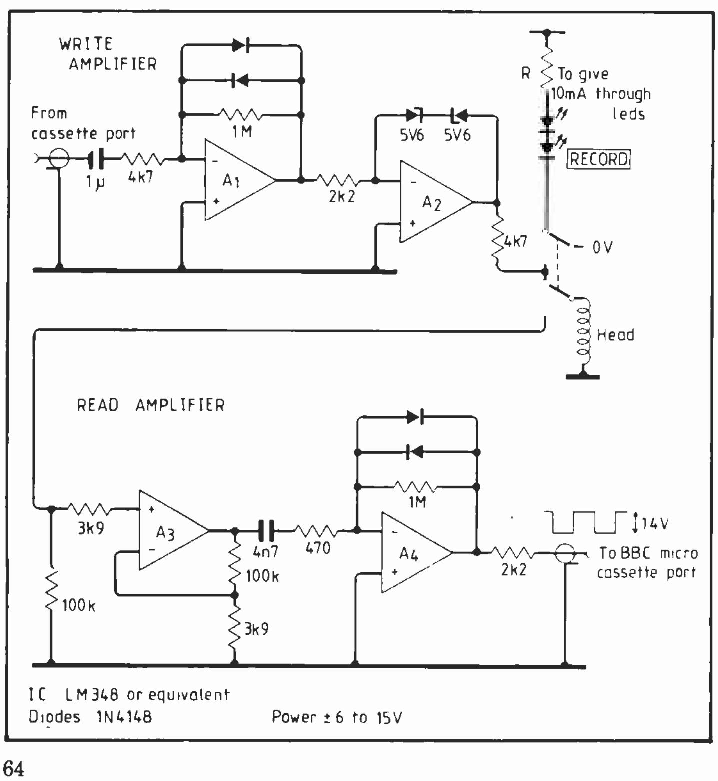
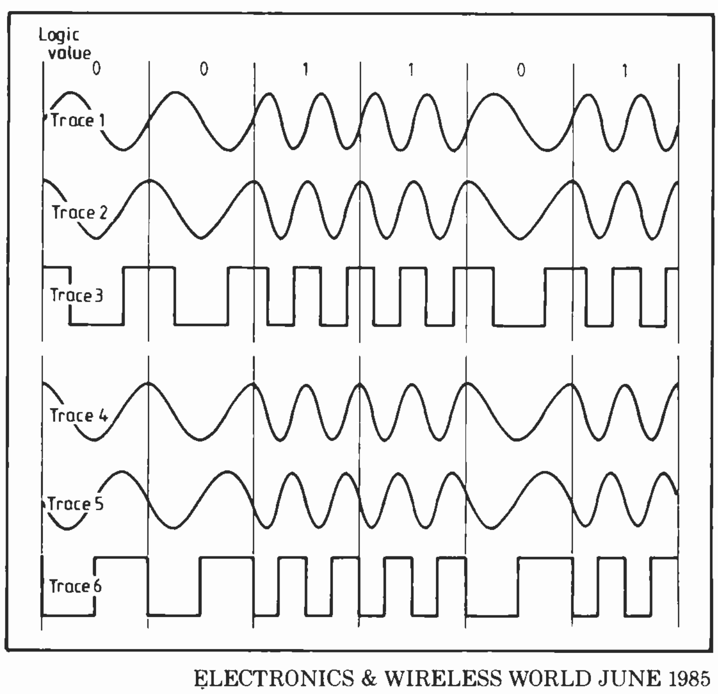


Fig. 3. **Data recording on cassette: the problem and the solution (see text).**



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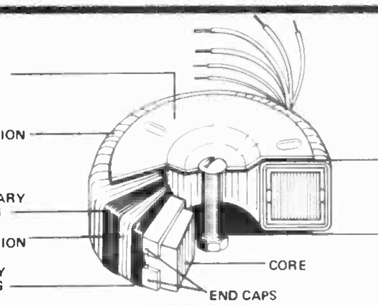

15 VA
62 x 34mm 0.35Kg
Regulation 19%

SERIES No	SECONDARY Volts	RMS Current
0x010	6+6	1 25
0x011	9+9	0 83
0x012	12+12	0 63
0x013	15+15	0 50
0x014	18+18	0 42
0x015	22+22	0 34
0x016	25+25	0 30
0x017	30+30	0 25

(encased in ABS plastic)

30 VA
70 x 30mm 0.45Kg
Regulation 18%

1x010	6+6	2 50
1x011	9+9	1 66
1x012	12+12	1 25
1x013	15+15	1 00
1x014	18+18	0 83
1x015	22+22	0 68
1x016	25+25	0 60
1x017	30+30	0 50

50 VA
80 x 35mm 0.9Kg
Regulation 13%

2x010	6+6	4 16
2x011	9+9	2 77
2x012	12+12	2 08
2x013	15+15	1 66
2x014	18+18	1.38
2x015	22+22	1 13
2x016	25+25	1 00
2x017	30+30	0.83
2x028	110	0 45
2x029	220	0 22
2x030	240	0 20

80 VA
90 x 30mm 1Kg
Regulation 12%

3x010	6+6	6 64
3x011	9+9	4 44
3x012	12+12	3 33
3x013	15+15	2 66
3x014	18+18	2 22
3x015	22+22	1 81
3x016	25+25	1 60
3x017	30+30	1 33
3x028	110	0 72
3x029	220	0 36
3x030	240	0 33

120 VA
90 x 40mm 1.2Kg
Regulation 11%

4x010	6+6	10.00
4x011	9+9	6 66
4x012	12+12	5 00
4x013	15+15	4 00
4x014	18+18	3 33
4x015	22+22	2 72
4x016	25+25	2 40
4x017	30+30	2 00
4x018	35+35	1 71
4x028	110	1 09
4x029	220	0 54
4x030	240	0 50

160 VA
110 x 40mm 1.8Kg
Regulation 8%

5x011	9+9	8 89
5x012	12+12	6 66
5x013	15+15	5 33
5x014	18+18	4 44
5x015	22+22	3 63
5x016	25+25	3 20
5x017	30+30	2 66
5x018	35+35	2.28
5x026	40+40	2 00
5x028	110	1 45
5x029	220	0 72
5x030	240	0 66

225 VA
110 x 45mm 2.2Kg
Regulation 7%

6x012	12+12	9 38
6x013	15+15	7 50
6x014	18+18	6 25
6x015	22+22	5 11
6x016	25+25	4 50
6x017	30+30	3 75
6x018	35+35	3 21
6x026	40+40	2 81
6x025	45+45	2 50
6x033	50+50	2 25
6x028	110	2 04
6x029	220	1 02
6x030	240	0 93

300 VA
110 x 50mm 2.6Kg
Regulation 6%

7x013	15+15	10 00
7x014	18+18	8 33
7x015	22+22	6 82
7x016	25+25	6 00
7x017	30+30	5 00
7x018	35+35	4 28
7x026	40+40	3 75
7x025	45+45	3 33
7x033	50+50	3 00
7x028	110	2 72
7x029	220	1 36
7x030	240	1 25

500 VA
140 x 60mm 4Kg
Regulation 4%

8x016	25+25	10 00
8x017	30+30	8 33
8x018	35+35	7 14
8x026	40+40	6 25
8x025	45+45	5 55
8x033	50+50	5 00
8x042	55+55	4 54
8x028	110	4 54
8x029	220	2 27
8x030	240	2 08

625 VA
140 x 75mm 5Kg
Regulation 4%

9x017	30+30	10 41
9x018	35+35	8 92
9x026	40+40	7 81
9x025	45+45	6 94
9x033	50+50	6 25
9x042	55+55	5 68
9x028	110	5 68
9x029	220	2 84
9x030	240	2 60

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120	4	10.65	625	9	22.30

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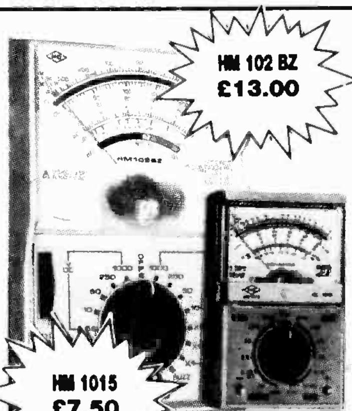

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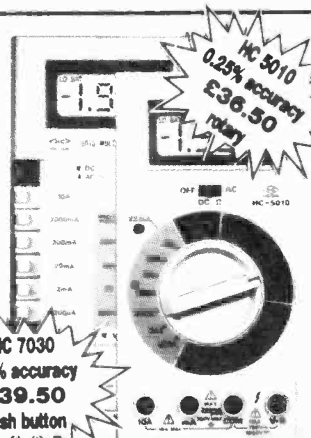

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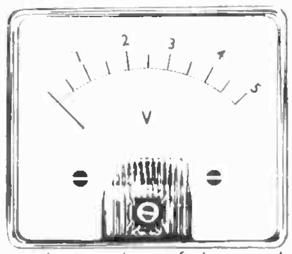
METER PROBLEMS?



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CIRCLE 14 FOR FURTHER DETAILS.

FUNDAMENTALS OF ENERGY TRANSFER

Mr Catt evidently assumes that the often-repeated statement that the field round a transmission line if TEM has been proved. But has it?. If there is a proof that the electric field is everywhere strictly transverse then, please believe me. I would be really glad to see it.

The proof would have to deal with the following point. As a step wave passes down the line it sets in motion the electrons in the conductors. That is, the electrons are given (kinetic) energy by the field. Hence, somewhere, energy passes through the surface of each conductor, that is, somewhere there is a component of the Poynting vectro into the conductor. So somewhere, there is a component of electric field along the conductor.

P.L. Taylor
Marple
Cheshire

I believe Mr Catt (Letters, February 1985) has made an error.

He seems to be saying that the principle of superposition should apply to the situation he describes — the case of the forces between conductors carrying overlapping pulses. It is, of course, wrong to try to apply superposition here, since the equations he has written down for his forces F_1 and F_2 are not linear (as superposition demands), but quadratic.

The equations

$$F_1 = iB \text{ and } F_2 = qE$$

appear at first sight to be linear, but since B is itself proportional to i, and E to q

$$F_1 = k_1 i^2 \text{ and } F_2 = k_2 q^2$$

Thus the forces are quadratic functions of the current and charge on the conductors and linear superposition is invalid. We should therefore not be surprised by the appearance of these 'strange' forces.

This is perhaps more clearly illustrated by the corresponding problem in electrostatics. The forces on a positively and negatively charged sphere are shown in Fig 1.

The forces on the spheres in Fig. 2 are the same in magnitude and sign. However, in the situation of Fig. 3 where we have superposed the charges on the spheres from Figs 1 and 2, we find that the forces disappear.

If Mr Catt is searching for unification of electric and magnetic forces, he may be interested to consider the following.

In the double beam c.r.o. mentioned in Chris Parton's letter (December, 1984), the force per unit length on each beam of electrons can be written as the sum of the electrostatic repulsion and magnetic attraction

$$F = \frac{\mu_o I^2}{2\pi a} - \frac{q^2}{2\pi\,\epsilon_o a}$$

where a is the separation of the two beams.

But, if you transform to the rest frame of the electrons, travelling at speed v, the magnetic field disappears since the charges are now at rest. Now, if q is the charge per unit length in the beams in the laboratory frame, then the length part of q must be Lorentz transformed to q′ giving

$$q' = q/\gamma$$

where $\gamma = (1 - v^2/c^2)^{-\frac{1}{2}}$.

Thus the electrostatic repulsive force can be rewritten

$$F = \frac{q'^2}{2\pi\,\epsilon_o a} = \frac{q^2 v^2}{2\pi\,\epsilon_o a\,c^2} - \frac{q^2}{2\pi\,\epsilon_o a}$$

Finally, substituting

$$C^2 = \frac{1}{\mu_o \epsilon_o}$$

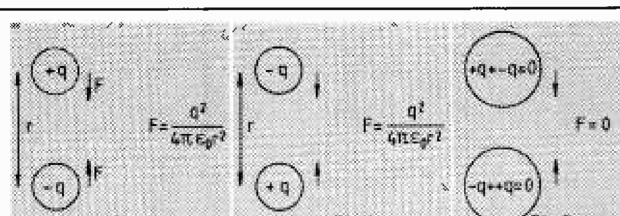
where the current in the beams is I=q.v, we have

$$F = \frac{I^2 \mu_o}{2\pi a} - \frac{q^2}{2\pi\,\epsilon_o a}$$

which is exactly the same force as we derived using magnetic theory.

This is a general result embodied in the relativistic invariance of Maxwell's equations and may be considered to be the unification of electromagnetic and electrostatic field theory.

N.C. Hawkes
Abingdon
Oxfordshire



RELATIVITY

Recent articles and letters on relativity and the speed of light make me consider the greatest observable experiment, the "red shift" of distant astronomical objects. The faster the object recedes, the slower the peaks arrive so the redder they appear. Now suppose the object recedes at light speed: then no energy is arriving, no phase is changing, in fact nothing is happening, yet according to standard theory the light — at infinitesimal energy — is still arriving at c. In what sense can anything be said to be travelling past an observer's position if it is impossible even in principle to observe it? We cannot escape this by claiming that it is impossible for even astronomical objects to travel at light speed away from us, since there is no evidence of their behaving with any such limiation. The only sensible way to iinterpret it is that we cannot *observe* a velocity greater then c, which may well be true in most cases.

R.A. Rees
Kirkland
WA
USA

May I draw your readers' attention to the implications of E. Eastwood's article 'Radio and the birth of the universe' (*Wireless World*, August 1981). H. Aspden has already recognised the significance of the article's subject. (*Spec. Sci. Tech*. 5, pp. 421-431, 1982).

Eastwood's article deals with experiments (actual, not thought) performed to determine the peculiar or absolute velocity of our galaxy relative to the 3K cosmic microwave background radiation. As velocities are calculated relative to a point in space assumed to be at rest, the 3K microwave radiation is assumed to be at rest, i.e. standing waves caused by the constructive interference of crests and troughs of waves moving relative to Newton's absolute space at rest.

In the part of Eastwood's article headed 'Anisotropy of microwave background' Eastwood gives the true or absolute velocity of the earth relative to the 3K background assumed to be at rest as about 390 km/sec. This velocity vector is the Newtonian vector sum of three other velocity vectors assigned to empty space filled with 3K electromagnetic radiation by cranks and crackpots. (". . .nor assign a velocity vector to a point in the empty space in which electromagnetic processes take place." — the introduction to Einstein's 1905 paper).

The other three velocity vectors are:-

(1) The orbital velocity of the earth relative to the sun assumed to be at rest — 30 km/sec.
(2) The orbital velocity of the sun relative to our galaxy's centre of gravity assumed to be at rest — about 300 km/sec.
(3) The absolute linear (?) velocity of our galaxy's centre of gravity relative of the 3K background assumed to be at rest — about 600km/sec.

The earth's absolute velocity vector of 390 km/sec. relative to the stationary 3K background is constantly directed from Aquarius to Leo but continuously variable in direction relative to a point on the earth's surface. In the northern hemisphere Aquarius is an autumn constellation and Leo a spring constellation.

Lorentz used the earth's orbital velocity vector of 30 km/sec. to calculate the earth's constant equatorial contraction of "about 6.5 cm." due to the constant pressure exerted by the ether wind. (The Principle of Relativity, Dover. p.6.) The model of the relative motions of the heavenly bodies used by Lorentz in his calculations is one step removed from the flat earth theory and just as dangerous.

Michelson, Morley, Lorentz and Einstein assumed the velocity vector of Stoke's hypothetical ether wind was equal in magnitude but opposite in direction to the earth's orbital velocity vector relative to the sun, which they believed to be stationary at the centre of the universe. They believed the orbital directions of the vectors were absolute and constant relative to the supposedly stationary sun, and that both vectors were directed parallel to the plane of Michelson and Morley;s apparatus.

They were unaware of the real experimental fact that the direction of the earth's absolute velocity vector is a continuous variable relative to the plane of Michelson and Morley's apparatus, and that Stokes's ether wind blows seasonally and daily at continuously varying angles through the ceiling of Michelson and Morley's laboratory.

Any theory based on a false model of the universe is false. The stationary sun and stars model is as false as the flat earth model in explaining the Doppler shift of receding galaxies. Hence Einstein's self-contradictory assumption that as his 'fixed stars' were stationary in Newton's stationary space, the magnitude of a star's red-shift is a function of the intensity of the star's gravitational field. Proved mathematically, of course.

M.G. Wellard
Kenley
Surrey

RELATIVITY

In Dr W.A. Murrays' article on Relativity (*WW* May, 84) some assumptions were made that I feel were not quite as cut and dried as he made them seem.

Firstly, Time Dilation has been experimentally demonstrated with the aid of the atomic clocks on board the later Apollo space missions. These results agreed closely with those predicted by Special Relativity.

Secondly, relativistic principles have been shown to affect sub-atomic particles travelling at speeds in excess of 0.9c. It has thus been shown that the physical velocity limit of c is a reality when the $E=Mc^2$ equation is used. If one assumes that mass is constant, as Dr Murray presumably does, then where does the exponential increase in energy input arise?

Thirdly, in his argument on the train experiment it would appear that a subtle change takes place between the disproving of Einstein assumptions and its paraphrasing on the following page.

In Einstein's argument the flash at A and B take place at the moment M and M′ coincide, hence it is to the observers future positions that the light will arrive.

However, in Dr Murray's analysis he maintains that the light will travel the distance A-M and A-M′ in the same time, hence reaching both observers simultaneously. In other words he has their future positions coinciding, not their present ones.

But in the paraphrasing of the above paragraph this has been changed back in order to refute the Einsteinian argument, which naturally will not agree with the author's assumptions.

I must point out that I neither agree or disagree with Einsteinian Relativity, but surely a principle that can be demonstrated to work would require a very strong argument to topple.

G.R. Moore
Braintree
Essex

I have been following the arguments about Einstein's train hypothesis with amazement and incredulity. There have been so many assertions and counterclaims that now we cannot see the wood for the trains.

In the February 1985 issue, Messrs Marquis and Scott Murray fall into opposite ends of the same trap, in describing apparently similar but actually different cases.

In Mr Marquis's case, M′ and M perceive the flashes simultaneously, but will measure different distances. The error here is to transfer measurements from one world to the other. Scott Murray's observers would measure identical distances, but perceive the flashes at different times; he begs the question by transferring Ms definition of simultaneity to the world of M′.

An incident recently brought to my attention is a good illustration of the problem. My friend Tom was sitting in his signal box, watching the up and down trains rattling past, when he noticed two flashes of lightning at different points of the track. His portable Lightning Detector informed him that the flashes had arrived at precisely the same instant. Dick on the up-train and Harry on the down-train happened to be opposite the signal box then, and got similar results from their instruments.

Tom subsequently discovered that the scorch marks on the track were precisely equidistant from his box. Dick and Harry found that the scorch marks on their respective trains were not equidistant from their seats; the differences were several thousand nanometres.

When the three of them compared notes that evening in the taproom of the Monkey's Nest, there was some initial disagreement, not only over the simultaneity of the flashes but also which came first. However, when Dick and Harry made allowance for the velocity of light and of their respective trains, all agreed that the flashes had been truly simultaneous in their present frame of reference. Old Lorentz in the corner muttered something about comparing the sums of the pairs of measurements, as well as the differences, but a game of dominoes was now in progress and this was not taken up.

Had Dick and Harry remained on their trains for ever, each would have been confident that the lightning strikes had NOT been simultaneous. Both would have been correct, even though the order of occurrence was not the same.

I trust that this incident adequately explains the situation, and will terminate this particular dispute.

R. Priestley
Southsea
Hants

Let there be a pyramid upon an ever-changing foundation of information, its four courses being (upwards) systems, scientific laws, abstract laws, and Causation. Let Max Planck sit on top of it as an abstract quantum of energy positively glowing with absolution. Let a special relation in the shape of a creative ape called Roy Hodges MIEE run down and up the pyramid, translating the abstraction of method into material means and vice versa, so demonstrating the creative and analytical process of visualisation so abhorred by digital theoreticists who use computers when they run out of fingers, so to get it as declinatory as the average monetarist.

One might now be deboggled as Mr A.H. Winterflood was when he grasped that energy is and mass becomes — between them lies a Constant Time Function, the fastest thing on wheels, which also has a reverse gear so allowing Mr Hodges to run up as well as down. (Wheels are frictional — when energy is in abstraction it has none, so it can go as fast as it is pushed).

Special Relativity applies when correcting the error of scale seen in our tiny Cyclopsian local frame after leaping from it either to a microcosm (an abstraction) or to the macrocosm (another abstraction). For those bogged down in the mud of our local frame the golden oldies are quite accurate enough for everyday use — may they rest in their wellies.

A pleasantly harmonic orchestration of an original theme, Mr Hodges! Let us rename it the Planck-Hodges Constant, whose dimensions are Md^2/t, or in this context Mdc, where d is the single directional dimension of linear movement of a quantum of energy towards a mass M: the change occurs at c (regardless of the speed of approach) and represents the change of state of mass from which we deduce the existence of energy, even in the case of human receptors (for those who possess them).

The photon leaving an atom is a little more tired than the one arriving, having wound it up a bit during its brief stay. It's that entropy thing.

Now, gentlefolk, what happens to the energy radiated by an atom which is moving at the speed of light? Seemingly it is caught in the act of being radiated, so what happens to the atom? And what happens to an atom rushing at the speed of light towards a source of energy? It can only translate the energy (or whatever it does to it) at the speed of light: one likes to imagine that there is a limit for relativistic mass just as there is for everything else.

Might the four horsemen of quadrature have a little something to say upon the matter? Or the mass-energy dualism? Or are we coming to the monistic conclusion that there is no such thing as energy, that all mass is inherently static, all movement being imaginary and causation non-existent?

Thank you for your revelation, Mr Hodges: wellies rot eventually. But do tell us; in considering the photon, who are they that play pass-the-parcel?
J.A. MacHarg
Wooler
Northumberland

In the February Letters Dr Scott Murray once again quotes Einstein with the provisos (as judged from the embankment) and (considered with reference to the embankment) faithfully included, and once again proceeds to argue as if he were blind to their presence in the text, as I previously pointed out in the December 84 letters, and A.J. Clayton in the January letters.

However the real crunch comes with the second half of his letter, and with his description of Figs 5 and 6 as Minkowski diagrams. A basic feature of a Minkowski diagram is that any event or encounter which is represented at all is represented by one point and one point only. Thus Dr Murray's figures and the discussion in which he talks about a single event being represented by two distinct points show not only that he doesn't understand Minkowski diagrams, but also that he doesn't even understand the physical interpretation of Lorentz transformations. In fact they relate the coordinations attributed to a given event relative to the two noncoincident sets of time and position axes which according to special relativity are used by any two observers such as M and M′ who are at rest in two distinct inertial frames. No one worries about a point having different coordinates with respect to two sets of spatial axes which are rotated with respect to one another; special relativity says that something rather similar occurs with mixed time and space axes.

If his Fig. 5 had really been a Minkowski diagram he would have shown the t-axis along the line labelled M, and the x-axis along the line between the points labelled (wrongly) A′ and B′. With respect to those two sets of axes the lightning strike at A at time zero in the embankment frame would be represented by the point labelled A′, which has the coordinates Dr Murray calculates with respect to these two sets of axes, the embankment axes being oblique. Similarly the strike at B would be respresented by the point labelled B′. The sloping lines through the points labelled A′ and B′ would then represent the world lines of A and B, while vertical lines through those points would represent the world lines of the observers on the train who are present at the lightning strikes, A′ and B′.

The points labelled (wrongly) A and B represent nothing in particular, but the cuts of the line through them with the world lines for A and B would represent the positions relative to the train of those observers at the train time of the encounter between M and M′, represented by the intersection of the t′ and x′ axes. An important feature is that the lines labelled 'c', which represent light rays, bisect both the angle between the x′ and t′ axes, and the angle between the x and t axes, which means that both the train and the embankment observers imterpret the light flashes as travelling at the speed 'c'. Almost any question one can ask about the interpretation of events by the train and embankment observers can be read off this diagram.

Dr murray asserts that direct demonstrations of any correspondence between the predictions of special relativity and the workings of the world as it is are 'conspicuously non-existent'. The prediction of time dilatation was verified over fifteen years ago by measurements of the lifetime of pi mesos travelling with respect to the laboratory at a speed very close to the speed of light, so that the time dilatation factor was not just marginally larger than one, but over 2.5. The measurements (see refs) agreed with the special relativity predictions to better than 0.5%.
C.F. Coleman
Wantage
Oxon

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Ayres, D.S, Cormack, A.M, Greenberg, A.J,, Kenney, R.W, Caldwell, D.O, Elings, V.B, Hesse, W.P, and Morrison, R.J, *Phys Rev Lett* 21(1968)261.
Greenberg, A.J, Ayres, D.S, Cormack, A.M, Kenney, R.W, Caldwell, D.O, Elings, V.B, Hesse, W.P, and Morrison, R.J, *Phys Rev Lett* 23(1969)1267.

D.C. SUPPLIES

It may be helpful to Dr Smith to have two additional references brought to his attention. These are:

1. Walz, F.C. and Burkhard Analysis of Capacitive filtering of full wave rectification' *International J. Elect Engng* 1967 5 pp 563-572.
2. Ridler P.F. 'Analysis of single phase capacitor input rectifier circuits' *Proc. IEEE 17* 12 December 1970 pp 2261 — 2266.

Schade's original work was extremely good for the full and half-wave rectifiers, but for the voltage doubler circuits waas seriously in error due to a false assumption. Also his work was done at a time when the low values of load resistance imposed by solid-state circuits were unusual and it did not predict the instantaneous minimum voltage which is needed to ensure that regulators do not 'drop-out'.

The writer can supply, for non-commercial users, a listing of a Pascal program which will produce instantaneous minimum output voltage, peak-peak ripple voltage, peak rectifier current and r.m.s. rectifier current, given the values of $\omega C'R_L$ and r/R where C is the filter capacitance R_L — load resistance and r is the equivalent source resistance.

The calculations take about eight seconds using a 4MHz Z80 machine and the 'Turbo Pascal' compiler.
Professor P.F. Ridler
University of Zimbabwe
Harare

ELECTRO-REDUCTIONISM

Thank you, *Wireless World,* for coining the useful term: electro-reductionism, to describe the fashionable variety of intellectual suicide. But anyone can disprove it; we do not need an irrational leap of faith.

The failure of rationalism to account for your own consciousness means that it is a rotten theory. So its failure to address values, human nature and ultimate questions is only to be expected.

We cannot answer whether a machine could have a conscious mind until we have a model that predicts the know fact of human awareness.

It is the reductionist who is forced to a leap of faith — that science will one-day be able to tackle consciousness. What is consciousness? What is colour? We divide colour into the objective wavelength and physiology model, and the sensation. We divide morality into behaviour, absolute moral imperatives, and subjective conscience. Science refuses to touch the absolutes or the subjectives. And consciousness is both indisputably factual, and subjective.

Which leaves a fact hanging. Which destroys the garbage. Which makes monkeys of them all, as, no doubt, they would agree.
D.H. Potter
Axminster
Devon

RAILROADING RELATIVITY

Over the last year Dr Murray has used a lot of your column inches attacking Einstein and his theories. I have no particular objection to this as a sport, but in his case both of the main lines of his arguments are based on easily demonstrable fallacies.

With regard to Einstein's "rare but crucial conceptual error", Dr Murray asks us to believe that Einstein tells us that when the train is moving, both the light flashes reach M′ together. Since he twice quotes for us the passage where Einstein says precisely the opposite, it is hard to see the justification for such an allegation. Einstein says quite clearly that M′ will see one flash before the other, and this is based on the argument that M sees them arrive together. Since at that moment M and M′ do not coincide, it is a physical impossibility for the flashes to reach M′ together, and we hardly need to invoke Minkowski to tell us this. Now what is a physical impossibility in one frame of reference is still a physical impossibility in any other, so the statement that M′ sees one flash before the other is an absolute statement for this experiment. Of course, there is no denying that if the conditions for simultaneity had been met in the frame of reference of the train, those flashes much indeed arrive at M′ together. The impossibility of this is proof that the events were not simultaneous in the train's frame of reference. Which is precisely what Einstein said.

The other argument concerns the constancy of the speed of light. Dr Murray is one of the very numerous band who tell us that Einstein's "second postulate" says that the velocity of light is the same for all observers despite their mutual relative motions. It doesn't. This is a paraphrase of the conclusions reached from the experiment of the two similar laboratories passing in space and the light at the centre of each flashing as they draw level. This makes it a little difficult to support the contention that this is an "irrational assumption", or that Einstein "accepted it without evidence". We need to go rather further back in the argument to find what the "second postulate" really does say.

When he set out to save Maxwellian theory, Einstein encountered therein the concept of the aether. The characteristics of this where that light would be propagated through it at constant speed, and that any motion of the source through the aether would not alter this speed. The analogy of sound through air is apt. Einstein adopted these ideas in the form that in the absence of matter, light travels with a definite speed c that does not depend on the motion of its source. It is worth our while to take a further look at this assumption.

Suppose for a moment that we invert these characteristics, so that the light does not travel with constant speed, and that speed is dependent on the source's motion. In the first case, the speed would have to depend upon some function of time/distance. The alternative that it might be totally random belongs, I think; to the realm of science fiction, and it could hardly depend on the value of some local field, because there is no matter to anchor it to. The consequence of time/distance dependence is that any change in the position of the source would result in a change of the "local" value at every other point in space. No matter whether the observer's motion enters into the final equation or not, this change in value would be detected by that observer, who would thus be able to detect any motion of the source. The same thing happens if the value is altered by the source's motion. The "local" value will change, and though the observer would again be able to detect the source's motion. But to detect such motion is a violation of Newton's principle that no experiment exists that is capable of detecting absolute rest or uniform motion. This must be applied equally to the light and its source as it is to everything else. The conclusion is clear. The requirement that light travels at constant speed and that the speed is independent of the source's motion comes directly from Newton's principles, and in introducing his "second postulate" Einstein introduced no new information not already implicit in those principles. This puts the mathematical arguments into their correct perspective. As Dr Murray says, they are circular and do not constitute a proof of any assumption at all, only being a demonstration that the conclusions can be handled mathematically. I suggest that that is all they were ever intended to be.

In saving Maxwellian theory, Einstein found the way to save Newtonian theory. By the end of the 19th century the cracks were beginning to show: by now the evidence against it is overwhelming. Fortunately Einstein realised that the basic inconsistency in Newtonian theory that was causing all the trouble was that the existence of absolute space and absolute time was not compatible with Newton's principles. Fortunately for us, too, he produced in 1915 the necessary correction, otherwise the "baby with the bathwater" brigade would long ago have been screaming for us to abandon those principles, too. Of course it is a profound emotional shock to find that all those terrible consequences are only the logical outcome of Newton's principles, and I don't blame anyone for hoping they will go away if we pretend they are not there. It is interesting that many scientists are just as irrational as the rest of us.

Finally, Dr Murray is highly dogmatic about the non-existence of direct demonstations of the correspondence between the "workings of the world as it is" and the predictions of the theory. I would refer him to the experiments of Hafele and Keating in 1971, who set out to see if the predictions of theory about clocks could be confirmed. They were. (*SCIENCE* vol. 177, 1972, p.68ff).

Alan Watson
Pollensa
Mallorca

NEXT MONTH

Among the features in the July issue is a Z80-based telephone call-charge indicator which, among other facilities, provides a running total cost. It is usable anywhere in the world.

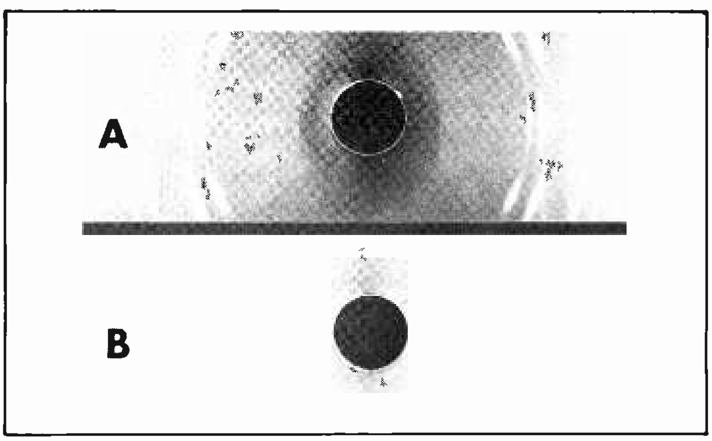
John Linsley Hood describes a mains power controller intended mainly for use with a photographic enlarger to ensure stability of light output, but useful for other application as well. It uses triacs to control the amount of a mains cycle passed to the load.

Ken Smith writes of his work with young people and electronics. His views are provocative and may raise a few hackles amongst those of a more conservative disposition.

Correction

Ivor Catt has asked me to point out an error in his letter on The Catt Anomaly in the May issue. On page 18, the penultimate line of the second paragraph should refer to the conductor, not the dielectric.

Amorphous metals, previously only possible to produce in strips on 0.05mm thick, have now been made 1mm thick using a technique known as rapid diffusion. The picture shows X-ray diffraction photographs of a nickel-zirconium sample. In A, typical X-ray reflexes of crystaline metals can be seen from an NiZr sample before annealing. After annealing, B, the sample is amorphous and causes diffusion.



Disc preamplifier

by Richard Brice

This valve design with no overall feedback uses passive equalization and a cascode input stage.

I designed this disc preamplifier working on three assumptions. The first is that good valve amplifiers sound better than good solid-state ones. Secondly, records sound better when passive equalization is used and lastly, amplifiers sound better when loop feedback is not used and linearity is an inherent part of the gain block.

The only problem with passive equalization is overloading of the first stage due to high-level treble signals. A valve with a high-voltage supply handles high-level signals and provides good linearity but the first stage must also have high gain to reduce the effect of noise in the following RC network.

For a high-gain stage, the obvious choice of valve is a pentode but these valves generate more shot noise than triodes because the cathode current splits between the anode and screen. The amount of shot noise depends on valve construction. Good low-noise pentodes are expensive so I chose a cascode circuit.

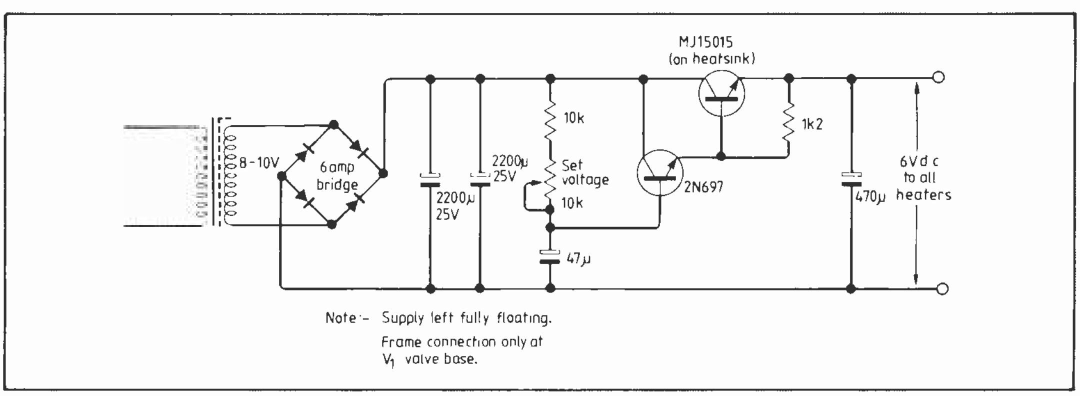
The second valve, V_{1b} contributes little to noise; total stage noise is substantially that of V_{1a}. Gain obtainable is approximately the product of the anode V_{1b} and the working mutual conductance of V_{1a}.

Equalization components are shown boxed. You may want to calculate values for the network more accurately than I have. At the expense of the convenience of using easily obtainable high accuracy capacitors, the network could operate at a lower overall impedance which would thus reduce the noise contribution of R_e.

Current consumption is low, at around 11mA for both channels, so a very smooth h.t. supply can be obtained using simple RC filtering. To keep hum to a minimum, a 6V d.c. supply feeds the heaters as shown in the upper diagram. A complete valve is used for V_1. Of the remaining three valves, one half is used for one channel, the other half for the other channel.

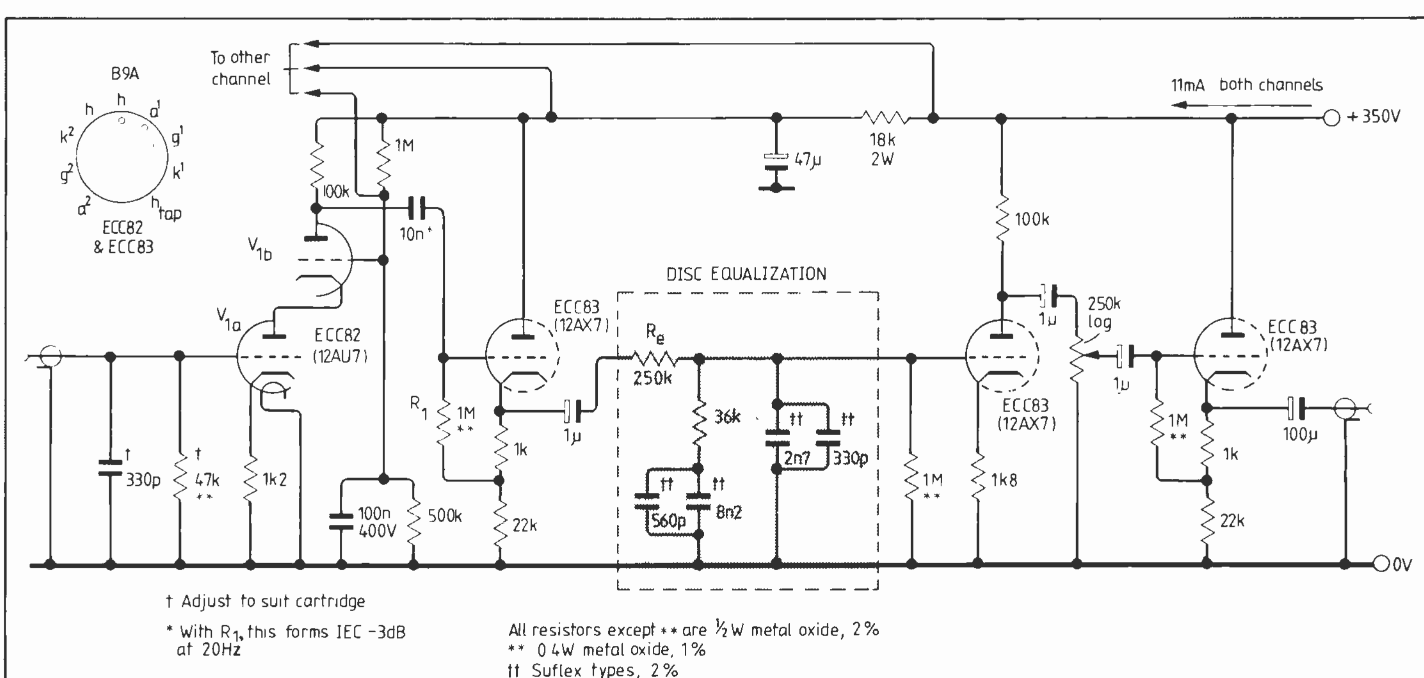
Total gain is around 40dB and distortion is calculated as well below 0.1% for 10mV r.m.s. input a 1kHz. Distortion is mainly produced by the triode directly following the equalizing network.

It's all too easy to jump to conclusions but I, together with interested friends and musicians, consider this circuit to be as good as or better than my previous design using a frequency-dependent shunt 5532 op-amp. In turn, this circuit had proved better than any series feedback equalization circuit and better than shunt-feedback circuits using simple transistor triples.



A d.c. regulated supply feeds the valve heaters to reduce hum, top.

The cascode input circuit feeds a passive equalization network, tinted area, whose component values are a compromise, bottom.



Power '85 Exhibitor List

Power '85 Exhibition and Conference, sponsored by the Power Supply Manufacturers Association at the Brighton Metropole Exhibition Centre from the 21st to the 23rd May 1985, is supported by the manufacturers listed below. The exhibition includes virtually everything connected with all types of power-handling equipment from batteries to automatic test gear and from components to systems.

A full conference and seminar programme will run concurrently. For free tickets apply to TCM Expositions Limited, Exchange House, 33 Station Road, Liphook, Hampshire GU30 7DN. Opening Times: 9 — 5 on Tuesday and Wednesday, 9 — 4.30 on Thursday.

GREEN HALL

	Stand No.
Allbatteries (Medicharge) Ltd.	515
AVX Limited	618
APLAB (UK) Ltd	515
R Baker (Electrical) Ltd	419
F W O Bauch Limited	505
Boschert Incorporated	508
Bowes Electronics Ltd	407
Bowthorpe EMP Ltd	425
Brandner U.K.	516
A F Bulgin & Co plc	404
Campbell Collins-Rifa Ltd	418
Cerberus Ltd	617
Cole Electronics Ltd	512
E D Transformers Ltd	667
Electronic Product News	620
Frako GmbH.	518
Hinchley Engineering Co Ltd	520
Hipotronics Inc.	609
Hi-Wire Ltd	616
Hollidyne Electronics Ltd	409
Huethig Publishing	605
Hunting Hivolt Ltd	412
Kingshill Electronic Products Ltd	416
M A Systems Ltd	509
MTL Microtesting Ltd	626
Merrimack Magnetics	621
Nedap N V	507
New Electronics	422
Papst Motors Ltd	608
Plessey Wound Products Ltd	612
Power Concepts Ltd	511
Power Conversion Ltd	519
Power Electronics	606
Powertron Ltd	526
R W Electronics Ltd	619
Renata AG.	406
Salicru SA.	411
Sharetree Ltd	522
Starkstrom (London) Ltd	408
Startronic Ltd	414
Systron-Donner Ltd	405/506
Techmation Ltd	613
Technitron Ltd	663
Tekelec Ltd	611
Venable Industries Inc.	622
Verospeed	415
Wavetek Electronics Ltd	615
Yuasa Battery Sales	521

RED HALL

Abbott Transistor Labs.	900
Cetronic (P F) Ltd.	1004
Ferranti Computer Systems Ltd	906
Gardners Transformers Ltd	707
Hanover Press Ltd	1006
Kollmorgan (UK) Ltd	1007
Micro Forecast	705
Transduktor Teoranta	706
Tungstone Batteries Ltd	704
Varta Limited	700
Watford Control	1001

BLUE HALL

Advance Power Supplies Ltd	118
Amplicon Electronics Ltd	119
The Belix Company Ltd	206
Brandenburg Limited	251
California Instruments	312
Canadian Instruments & Electronics Ltd.	303
Celab-Exem Limited	109/210
Chloride Power Electronics	113/214
Coutant Electronics Ltd	205/306
Electronic Product Review	220
F R Electronics	207
GEC Avionics Ltd	305
Gates Energy Products	315
Grenson Electronics Ltd	213
Gresham Lion Power Technology Ltd	209/211
Gresham Powerdyne Ltd	112
Harmer & Simmons Ltd	208
Hartley Measurements Ltd	310
ILP Electronics Ltd	320
Kenure Developments Ltd	311
Keysource Technology Ltd	108
Kingslo Limited	313
Power International Ltd	309
Power Supply Manufacturers Assoc.	102
Rel Industrial Ltd	217
Rhopoint Ltd	308
STC Components Ltd	105
Savage Power Ltd	104
VA Electronics Ltd	106
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by R.N. Gorgui-Naguib, K.M. Henein and R.A. King

2-D digital filter design techniques

A comparison of different techniques for designing two-dimensional digital filters.

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Two-dimensional digital signal processing is a relatively new field. Almost all of the work reported in this area has occured during the last 15 years. In spite of its recent origin, significant progress has been made in the analysis, design and implementation of two-dimensional digital signal processors. This article focuses particularly on the design techniques of two-dimensional finite impulse response (f.i.r.) filters and infinite impulse response (i.i.r.) filters.

In the case of f.i.r. filters, most of the methods used for the design of one-dimensional (1-D) filters can be extended to the two-dimensional (2-D) case:

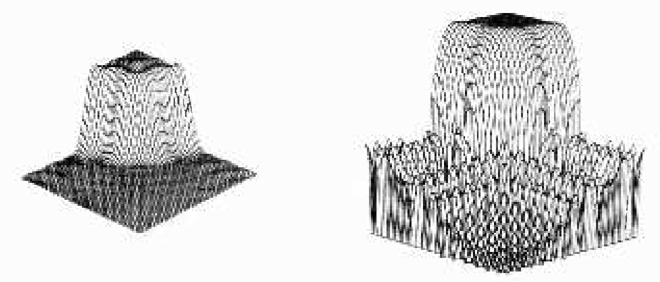
— frequency sampling technique
— window method
— optimal design methods.

Another, different, technique is used in the design of 2-D f.i.r. filters and is compared to the previous ones. This is

— frequency transformation.

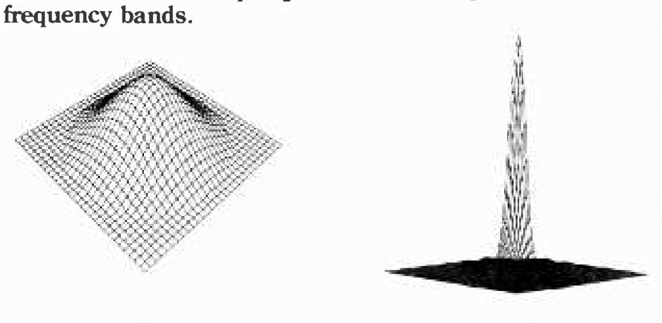
In the design of 2-D i.i.r. filters, on the other hand, 1-D techniques are not carried directly to the two-dimensional case. This is due to the fact that in two dimensions the 2-D z-transforms cannot generally be factored into lower order systems. This leads to many design problems, such as the difficulty in determining the stability as well as in finding an efficient realization where the coefficients of the transfer function may be truncated to a reasonable number of bits. Because of the these difficulties very little work has been done on designing 2-D i.i.r. filters.

Consequently, we concentrate more on the design techniques of 2-D f.i.r. filters and give a brief survey of some design principles for 2-D i.i.r. filters.



(a) (b)

Fig. 1. (a) **Linear and (b) log magnitude spatial frequency response of a 2-D frequency sampling digital low-pass filter for the case where $N_1=N_2=25$ and for a specified set of frequency bands.**



(a) (b)

Fig. 2. **Type and frequency responses of a 2-D Kaiser window defined as**

$$w(n_1,n_2) = I_0\left(\alpha\sqrt{1-\sqrt{n_1^2+n_2^2}/14}\right) / I_0(\alpha)$$

where $\alpha=5.0$ and $i_0(x)$ is the modified zero-order Bessel function. (a) is a perspective plot of the window and (b) the 2-D amplitude response.

Two-dimensional f.i.r. filter design

If $h(n_1,n_2)$ is the impulse response of 2-D filter where n_1 and n_2 are finite and defined over the range

$$0 \leqslant n_1 \leqslant N_1 - 1$$

and

$$0 \leqslant n_2 \leqslant N_2 - 1$$

then the system function of a 2-D f.i.r. filter can be expressed as

$$H(z_1,z_2) = \sum_{n_1=0}^{N_1-1}\sum_{n_2=0}^{N_2-1} h(n_1,n_2)\,.\,z_1^{-n_1}.\,z_2^{-n_2}$$

where $H(z_1,z_2)$ is the 2-D z-transform of the finite length sequence $h(n_1,n_2)$.

The convergence of the z-transform is guaranteed because the above equation has finite limits on all the summations and as $h(n_1,n_2)$ is bounded, so is $h(n_1,n_2)\,.\,z_1^{-n_1}\,.z_2^{-n_2}$ bounded for finite values of z_1 and z_2. As the z-transform converges everywhere in the z_1 and z_2 planes for finite sequences, this guarantees that filters designed from finite sequences will be stable.

Frequency sampling technique

This method is based on the principle that any 2-D finite duration sequence can be represented by its 2-D discrete Fourier transform $F(k_1,k_2)$. This is an approximation of the analogue frequency response at the appropriate samples, and so $h(n_1,n_2)$ can be obtained via the inverse discrete Fourier transform given by $h(n_1,n_2) =$

$$\frac{1}{N_1}\frac{1}{N_2}\sum_{k_1=0}^{N_1-1}\sum_{k_2=0}^{N_2-1} F(k_1,k_2)\,e^{j2\pi(a+b)}$$

where

$$a = \frac{k_1n_1}{N_1} \quad b = \frac{k_2n_2}{N_2}.$$

And, since for the designed filter,

$$H(z_1,z_2) = \sum_{n_1=0}^{N_1-1}\sum_{N_2=0}^{N_2-1} h(n_1,n_2)\,.\,z_1^{-n_1}.\,z_2^{-n_2}$$

then the frequency response may be calculated by substituting the value of $h(n_1,n_2)$, obtained from the inverse discrete transform, in the z-transform equation given above and by putting $z_1 = e^{j\omega_1}$ and $z_2 = e^{j\omega_2}$. This gives

$$H(e^{j\omega_1}, e^{j\omega_2}) =$$

$$\sum_{k_1=0}^{N_1-1}\sum_{k_2=0}^{N_2-1} F(k_1,k_2)\,.\,I_{\omega_1,\omega_2,k_1,k_2}$$

where

$$I_{\omega_1,\omega_2,k_1,k_2} = \frac{1}{N_1N_2}\,.\,\exp(1).\,\exp(2)$$

and
$$\exp(i) = \frac{1-e^{-j\omega_iN_i}}{1-e^{[j(2\pi k_i/N_i-\omega_i)]}}.$$

As in the 1-D case, the above relation is called the frequency interpolating function and it forms the basis for the design of 2-D f.i.r. digital filters using the frequency sampling technique. This function expresses the interpolated frequency response as a linear combination of its frequency samples, and Fig. 1 shows the frequency response of a low-pass filter designed through this method.

Again, as in 1-D case, the interpolation effect may be highly reflected in the oscillations that occur in the transition region since peak in-band and out-of-band ripples may develop at the edges of the passband and stopband respectively.

The Window method

The window method can be directly extended to 2-D f.i.r. filters where the 2-D impulse response sequence $h(n_1,n_2)$ is multiplied by a 2-D window function, $w(n_1,n_2)$, defined equal to zero outside a certain region of interest.

This results in truncating the impulse response to obtain a finite matrix of finite dimensions and is expressed as follows: $h'(n_1,n_2) =$

$$h(n_1,n_2)\,.\,w(n_1,n_2) \left\{ \begin{array}{l} 0 \leqslant n_1 \leqslant N_1-1 \\ 0 \leqslant n_2 \leqslant N_2-1 \end{array} \right.$$

$= 0$ otherwise.

In this case, the frequency response is equal to the convolution of $H(e^{j\omega_1},e^{j\omega_2})$ and $W(e^{j\omega_2}$ where $W(e^{j\omega_1},e^{j\omega_2})$ is the Fourier transform of $w(n_1,n_2)$.

If a window sequence (corresponding to the rectangular window in the case of one dimensional design) is defined as

$$w(n_1,n_2) = 1 \left\{ \begin{array}{l} 0 \leqslant n_1 \leqslant N_1-1\,; \\ 0 \leqslant n_2 \leqslant N_2-1 \end{array} \right.$$

$= 0$ otherwise.

then some oscillations are bound to occur in the frequency transfer function of the filter and, consequently, the task for windowing is to choose an appropriate window function $w(n_1,n_2)$ which will have the following transform properties

1. $W(e^{j\omega_1},e^{j\omega_2})$ should approximate a circularly symmetric function.
2. The volume under the main lobe of $W(e^{j\omega_1},e^{j\omega_2})$ should be large.
3. The volume under the side lobes should be small.

Huang showed that

$$w(n_1,n_2) = \hat{w}(\sqrt{n_1^2 + n_2^2})$$

is a good circularly symmetric 2-D window where $\hat{w}$ is a good symmetrical 1-D window sampled at the appropriate values.

Accordingly, through the above equation, one can design approximations to circularly symmetric rectangular, Hamming, Blackman and Kaiser windows. As an example, Fig. 2 shows a 2-D Kaiser window.

Optimal design methods

As in the case of 1-D filters, the problem of designing 2-D optimum f.i.r. filters in the Tchebycheff sense involves techniques where all the impulse response coefficients of the filter or, equivalently, all the discrete transform coefficients are allowed to vary and are solved by an optimization routine.

However, a direct multiple exchange algorithm such as the Remez exchange algorithm devised for 1-D f.i.r. filter design cannot be directly extended to the 2-D case. This is because of the alternation problem which is not directly generalizable in the 2-D case.

On the other hand, although theoretically the problem is in principle solvable by means of linear programming, practically it becomes computationally intractable because of the extremely high number of variables involved in the computations and because of the number of constraints that have to be set to solve the problem.

Frequency transformation method

This is an efficient technique developed by McClellan for the design of 2-D f.i.r. filters consisting of mapping an optimal 1-D f.i.r. filter into its 2-D counterpart.

To illustrate the technique, consider the frequency response of a linear phase 2-D filter with N_1 and N_2 odd where $a(n_1,n_2)=R(h(n_1,n_2))$:

$$H(e^{j\omega_1}, e^{j\omega_2}) = \sum_{N_1=0}^{(N_1-1)/2} \sum_{n_2=0}^{(N_2-1)/2} \Big[a(n_1,n_2) \cos n_1\omega_1 \cos n_2\omega_2 \,.\, \times e^{-j(\omega_1 n_1+\omega_2 n_2)} \Big]$$

Then multplying both sides of the equation by $e^{+j(\omega_1 n_1+\omega_2 n_2)}$ a real function $H_R(e^{j\omega_1}, e^{j\omega_2})$ may be defined as

$$\sum_{n_1=0}^{(N_1-1)/2} \sum_{n_2=0}^{(N_2-1)/2} a(n_1,n_2) \cos n_1\omega_1 \cos n_2\omega_2$$

Now consider the frequency response of a 1-D filter with N also odd

$$H(e^{j\omega}) = \sum_{n=0}^{(N-1)/2} a(n)\cos n\omega$$

If we let $x = \cos\omega$, then

$$\cos n\omega = \cos[n(\cos^{-1}(x))] = C_n(x)$$

where $C_n(x)$ is a Tchebycheff polynomial of the nth order. However

$$\sum_{n=0}^{(N-1)/2} a(n)\,C_n(x) = \sum_{n=0}^{(N-1)/2} \tilde{a}(n)\,x^n$$

and therefore

$$H(e^{j\omega}) = \sum_{n=0}^{(N-1)/2} \tilde{a}(n)\cos^n(\omega).$$

Hence, by the transformation

$$\cos\omega = A\cos\omega_1 + B\cos\omega_2 + C\cos\omega_1\cos\omega_2 + D$$

then $H(e^{j\omega_1}, e^{j\omega_2}) =$

$$\sum_{n_1=0}^{(N_1-1)/2} \sum_{n_2=0}^{(N_2-1)/2} \tilde{a}(n_1,n_2) \cos n_1\omega_2 \cos n_2\omega_2\,,$$

which can be put in the form

$$\sum_{n_1=0}^{(N_1-1)/2} \sum_{n_2=0}^{(N_2-1)/2} a(n_1,n_2) \cos n_1\omega_1 \cos n_2\omega_2\,,$$

which corresponds with $H_R(e^{j\omega_1}, e^{j\omega_2})$.

An example of spatial frequency response of a digital filter designed by this technique is shown in Fig.3.

This design method appears to be the most efficient and for many filters of practical interest the resulting 2-D approximation is nearly optimal in the Tchebycheff sense.

Moreover, higher order transformations may be developed to give a better approximation.

Two-dimensional i.i.r. filter design

Although much research has recently been done on half-plane filters, almost all of the work reported in this area is concerned with the design of causal, quarter-plane stable filters from two different approaches: the frequency and the spatial domain approaches.

In the frequency domain case, most of the design efforts can be grouped into two categories: those involving spectral transformations and those involving computer-aided optimization techniques.

In the spectral transformation approach, a design technique proposed by Shanks consists of mapping analogue 1-D into 2-D filter with arbitrary directivity in a 2-D frequency plane. These analogue filters are called rotated filters because they are obtained by rotating the 1-D filters and then converting them into their digital two-dimensional equivalent via a 2-D bilinear transformation defined by the following two equations:

$$s_1 = \frac{1-z_1}{1+z_1} \qquad s_2 = \frac{1-z_2}{1+z_2}$$

However, for angles of rotation above 90°, this technique does not guarantee the stability of the designed filter and the warping effects of the bilinear transformation affect the filter frequency response.

Costa and Venetsanopoulos improved this method by using a number of rotated filters whose angles of rotation are uniformly distributed over 180°. This results in a filter having a magnitude response which approximates a circularly symmetric cut-off boundary by a polygon.

Also, as a necessary but insufficient condition for the stability of the designed filter, the angle of rotation must be in the range of 270° to 360°.

Alternatively, in computer-aided optimization approaches, an iterative nonlinear optimization proceduure is used to adjust the filter coefficients to minimize a specified error criterion. Again, the chief problem is to ensure the stability of the resultant 2-D digital transfer function.

In the spatial domain design problem, a filter transfer function is chosen to approximate a finite extent, 2-D, impulse response. A least-squares approach is developed with a spatial error criterion to reach a best approximation of the spatial error criterion to reach a best approximation of the spatial response. Unfortunately, as with other 2-D i.i.r. design techniques, this approach does not lead to stable filters. Furthermore, it may lead to a filter whose impulse response does not adequately meet the prescribed specifications.

However, a technique has been developed which relies on the fact that, by using an infinite sequence rather than of finite length, the least mean square solution would then necessarily lead to a stable filter. But the main disadvantage of using such a method lies in the very complicated computational effort involved in the analysis.

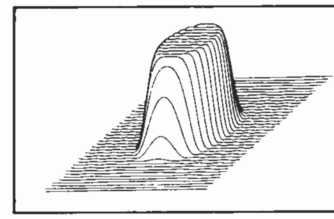


Fig. 3. Spatial frequency response of a digital filter designed by means of the McClellan transformation method for $N_1 = N_2 = 27$.

Conclusions

Most of the techniques used for 1-D f.i.r. filter design can be extended to the 2-D case, amongst them, the window method proves to yield good 2-D non-recursive ideal low-pass filters.

The other two techniques discussed in this category, namely the frequency sampling technique and the optimal design methods have some problems associated with their implementation. In the frequency sampling technique, the interpolating function gives rise to oscillations and when using optimal methods, the design problem becomes extremely complicated by the number of variables and constraint equations that must be solved to obtain a reasonable solution.

The last design technique considered for f.i.r. filters involves designing a 1-D filter and then transforming it to a corresponding 2-D filter directly, according to a certain mapping criterion. This technique is very efficient and the resulting approximations are reasonable.

In the case of 2-D digital i.i.r. filters, problems associated with the stability of the resulting filters are very dominant and hence most of the design principles suffer from them and, although two design approaches were presented, no simple technique is readily available.

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so that the peak value of the current through the capacitor is given by:

$$\hat{I}_{cap} = \frac{(V_i - nV_o)}{2fLV_i}V_o \qquad (18)$$

Because the ripple current has a triangular waveshape, the r.m.s. value is:

$$I_{cap} = \frac{\hat{I}_{cap}}{\sqrt{3}} \qquad (19)$$

Now using these results, we can proceed to get:

a) the ripple voltage across the e.s.r., which is simply:

$$\Delta V_{ESR} = \frac{(V_i - \eta V_o)V_o \times ESR}{fLV_i} \qquad (20)$$

b) the peak to peak voltage across the e.s.l. by means of:

$$v_{ESL} = (ESL)\frac{di_{cap}}{dt}$$

which on the positive ramp gives:

$$\hat{V}^+_{ESL} = (ESL)\frac{\frac{V_i}{n} - V_o}{L}$$

and on the negative ramp:

$$\hat{V}^-_{ESL} = \frac{V_o}{L}(ESL)$$

The peak to peak voltage across the e.s.l. is the sum of these:—

$$\Delta V_{ESL} = \hat{V}^+_{ESL} + \hat{V}^-_{ESL} = \frac{V_i}{nL} \times ESL \qquad (21)$$

c) finally the ripple across the actual capacitor.

The charge going on and off the capacitor Δ_Q, is represented by the shaded area on Fig. 13.

$$\Delta_Q = AREA = \tfrac{1}{2}base \times height$$

$$= \frac{1}{2}\cdot\frac{T}{2}\cdot\frac{di_{cap}}{dt}\cdot\frac{T\delta}{2}$$

and:

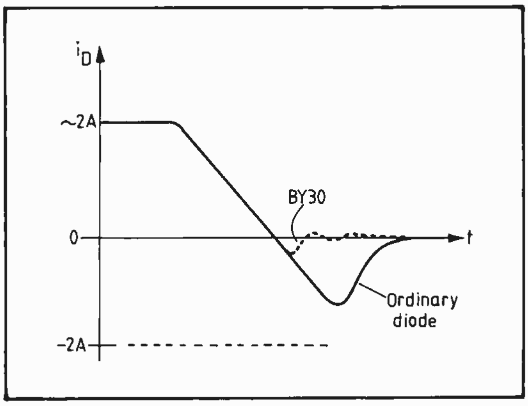


Fig.11. **Ordinary diode compared with fast-recovery type.**

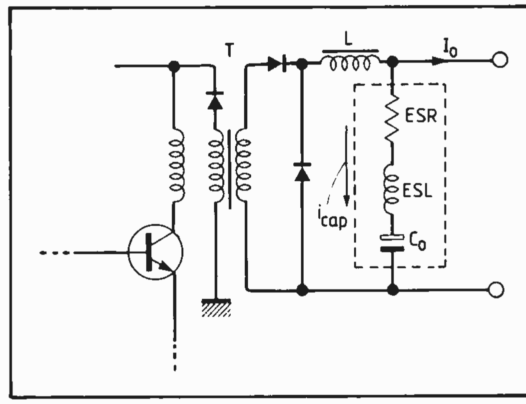


Fig.12 **S.m.p.s. output circuit, showing 'invisible' components of C_o.**

$$\Delta V_{cap} = \frac{\Delta Q}{C_o} = \frac{\delta}{8f^2C_o}\cdot\frac{di_{cap}}{dt}$$

$$= \frac{\delta}{8f^2C_o}\cdot\frac{(\frac{V_i}{n} - V_o)}{L}$$

again,

$$\delta = \frac{nV_o}{V_i}$$

from 5.

$$\therefore \Delta V_{cap} = \frac{(V_i - nV_o)V_o}{8f^2LC_oV_i}$$

Thus the output ripple is the sum of all these and it can be a complicated, noisy residue.

Commutation effects in the flyback circuit impose considerably worse constraints on the performance of the filter. In particular, the flyback choke leakage inductance significantly affects the performance, particularly the effect of the e.s.l. The analysis is involved.

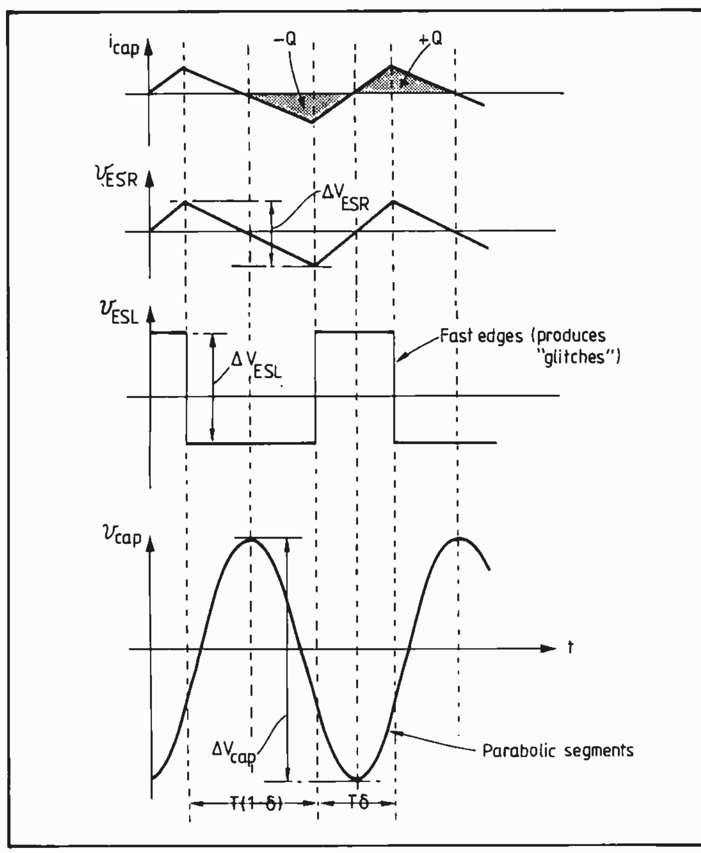


Fig.13. **Output ripple is sum of all these components.**

BOOKS

Designing Microprocessor-based Instrumentation by Joseph J. Carr: Prentice-Hall International, 323 pages, hard covers, ISBN 0 8359 1270 1. Practical guide to microprocessors (the Z80 in particular) and their support chips, and how to interface them to the outside world. Later chapters deal with basics of data conversion, transducers, sample-and-hold circuits and interfacing keyboards, switches and displays.

Fault Tolerant Hardware Design by Parag K. Lala: Prentice-Hall International, 263 pages, hard covers, £24.95, ISBN 0 13 308248 2. Chapters cover basic concepts of reliability, types of faults in digital circuits and how to model them, test generation, fault-tolerant design of l.s.i. and v.l.s.i. chips, self-checking and fail-safe logic and design for testability.

Going Online 1984, ed. Jacky Deunette: Online Information Centre (Aslib, 26-27 Boswell Street, London WC1N 3JZ), 60 A4 pages, soft covers, £5. What services are available, how to use them and how much they cost. An extensive list of addresses covers UK user groups and system operators on both sides of the Atlantic; there is also a useful bibliography.

International Electrotechnical Vocabulary, chapter 521: Semiconductors and Integrated Circuits. International Electrotechnical Commission (3 rue de Varembé, Geneva), 90 pages, soft covers, Sw.Fr.103. How to render 'reverse recovery time' and several hundred other phrases into German, Spanish, Italian, Dutch, Polish and Danish. Translations and fuller explanations are given in French, English and Russian.

Fundamentals of Electric Circuits by David A. Bell (of Ontario, Canada): third edition, Prentice-Hall International, 847 pages, hard covers, £32.90, ISBN 0 8359 2125 5. A-level style textbook covering basic theory, units, resistive and reactive circuits, phasors and complex numbers, resonance, transformers, a.c. systems and non-sinusoidal waveforms. Rather expensive.

Microprocessors: Hardware, Software and Design Applications, by Wunnava V. Subbarao: Prentice-Hall International, 364 pages, hard covers, £30.85, ISBN 0 8359 4394 1. A self-teaching book for the engineer or student. Describes eight-bit processors in general and 8085, 6800, 6502, Z80 and 1802 in particular. Numerous design examples.

By J.R. Watkinson

Channel code and disc format — 2

How information is organized on the disc surface

The last article in this series discussed channel code and showed how binary data is adapted to a form which suits the characteristics of the medium. This part explains how information is organized on the disc surface.

Fig. 6 reveals the timing relationships of the CD format. The sampling rate of 44.1kHz with 16-bit words in left and right channels results in an audio data rate of 196.4kbyte/s (k = 1000). There are 24 audio bytes in a data block, so the block rate will be

$$\frac{196.4}{24}\ \text{kHz} = 7350\text{Hz}.$$

If this block rate is *divided* by 98, the subcode block rate of 75Hz results. This frequency will be divided down to provide running time display in the player. If the block rate is *multiplied* by 588, the number of T periods in a block, the master clock rate of 4.3218MHz results. From this the maximum and minimum frequencies of e.f.m., 720kHz and 196kHz, can be obtained using the run-length limits.

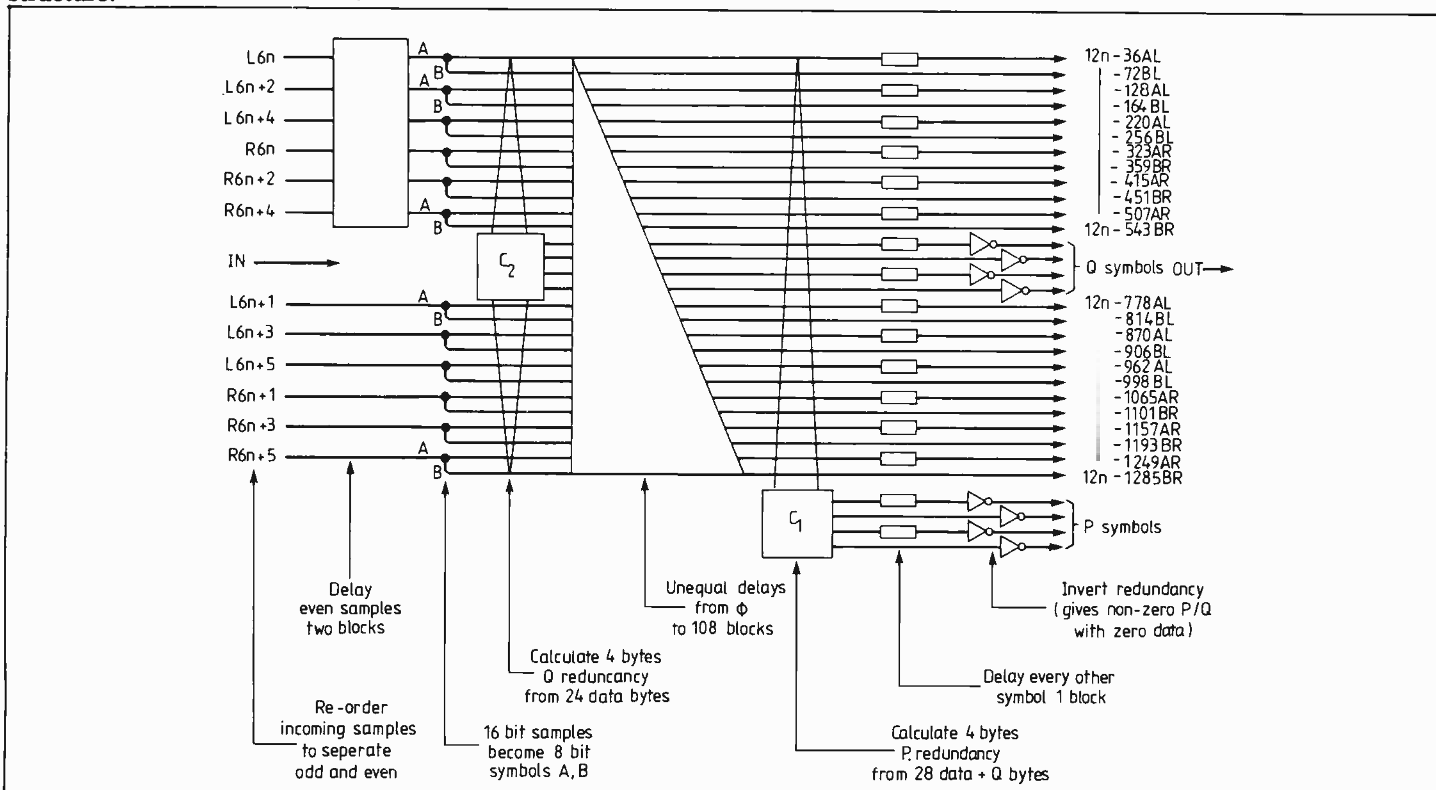
Each data block contains 24 non-contiguous audio bytes. Their sequence and their relationship to the redundancy bytes is discussed next.

The error correction system has to deal with large burst errors resulting from surface contamination and the technique of interleaving reduces the amount of redundancy necessary[5]. The principle is that by storing data in a non-contiguous fashion, several adjacent symbols destroyed by an error burst become single-symbol errors spread more widely.

There are a number of interleaves used in CD each with a specific purpose; the full structure is shown in Fig. 7(a). The first stage of interleave is to introduce a delay between odd and even samples. The effect is that uncorrectable errors cause odd and even samples to be destroyed at different times and interpolation can then be used to conceal the errors, with a reduction in audio bandwidth. The odd/even interleave is performed first in the encoder, as de-interleave in the player will be the reverse order, and interpolation is the last process. An odd/even delay of two blocks permits interpolation in the case where two uncor-

5. Error Correction Techniques in Digital Audio, John Watkinson. *Ibid.*

Fig. 7(a). CD **interleave structure.**



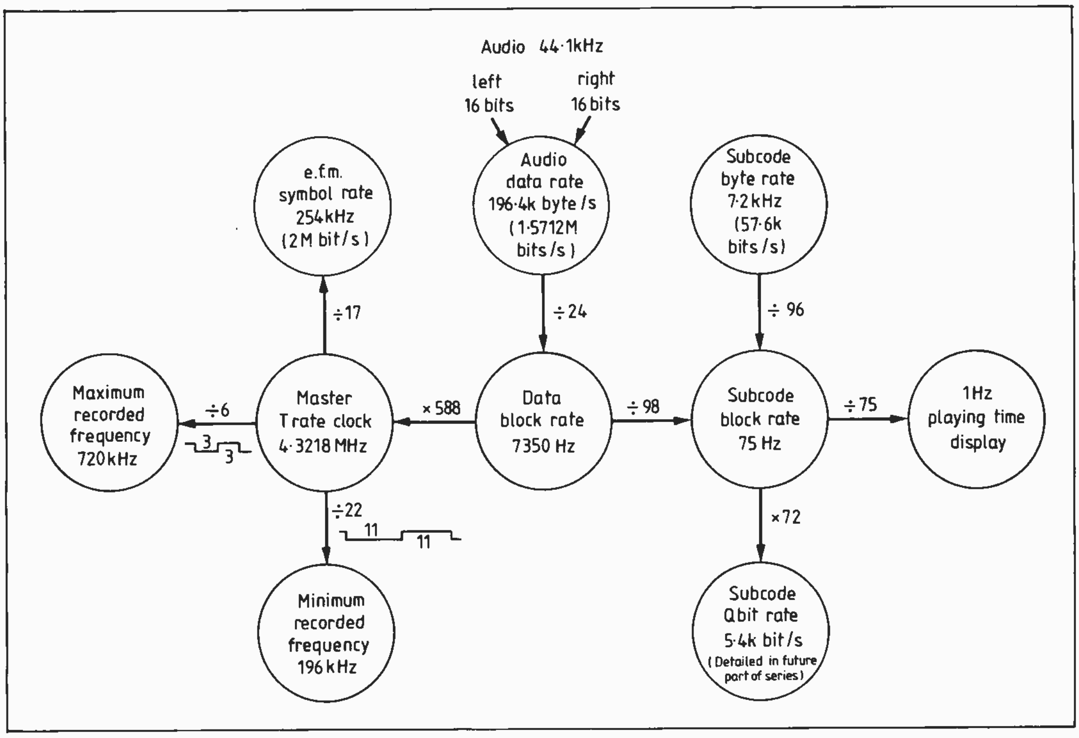


Fig. 6. **The frequencies of the various events in compact disc timing are intimately connected — as the diagram shows — and the relationship cannot be broken. It should be self-evident that the drop frame time code should not be fed into a CD cutter.**

rectable blocks leave the error correction system, Fig. 7(b).

Left and right samples at the same instant form a sample set. As the samples are of 16 bits, each sample set will be of four bytes, AL, BL, AR, BR. Six sample sets form a 24-byte parallel word, and the C2 encoder produces four bytes of redundancy Q. By placing the Q symbols in the centre of the block, the odd/even distance is increased, permitting interpolation over the largest possible error burst. The 28 bytes are now subject to differing delays, which are integer multiples of four blocks. This produces a convolutional interleave, where one C2 code word is stored in 28 different blocks, spread over a distance of 109 blocks.

At one instant, the C1 encoder will be presented with 28 bytes which have come from 28 different C2 code words. The C1 encoder produces a further four bytes of redundancy P. Thus the C1 and C2 code words are produced by crossing a data array in two directions ('cross interleaving').

The final interleave is an odd/even output symbol delay which causes P code words to be spread over two data blocks on the disc, as shown in Fig. 7(c). This mechanism prevents small random errors destroying more than one symbol in a P code word. The choice of eight-bit symbols in the e.f.m. channel code assists this strategy.

The expressions in Fig. 7(a) determine how the interleave is

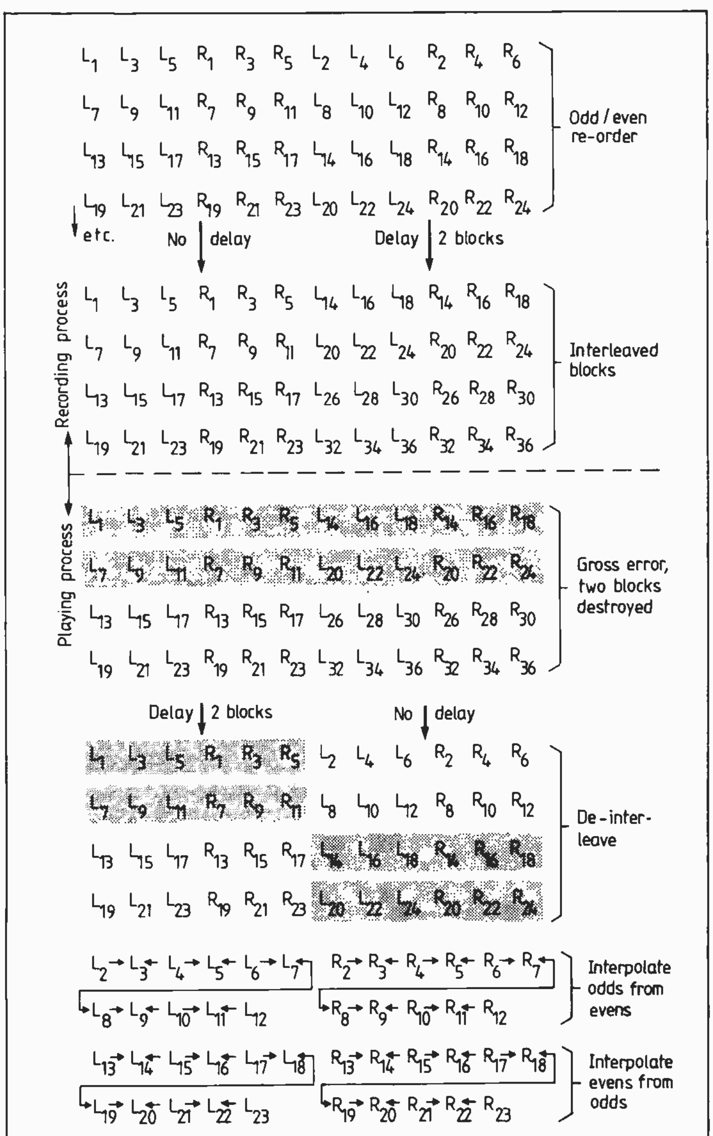


Fig. 7(b). **Odd/even interleave permits the use of interpolation to conceal uncorrectable errors.**

Following an M.Sc. course at Southampton's Institute of Sound and Vibration, John Watkinson worked in research before joining Digital Equipment Corporation, first as a field engineer, later as an instructor, specializing in mass storage devices. He joined Sony Broadcast in 1982 specialising in professional digital audio and timebase corrector training, and is currently training manager at Ampex International.

calculated. Fig. 7(d) shows an example of the use of these expressions to calculate the contents of a block and to demonstrate the cross interleave.

The calculation of the P and Q redundancy symbols is made using Reed-Solomon cyclic polynomial division. The P redundancy symbols are primarily for the purpose of detecting errors, to provide error flags for the Q system. The P system can however correct single symbol errors. This mechanism will be described in greater detail in a later part.

Fig. 8 the encoder modulates the cutting laser. Audio and subcode data streams are supplied, and the cross interleaved block structure created. The e.f.m. encoder produces a 14T pattern for every 8-bit symbol, and sync. patterns and merging patterns are multiplexed in.

The next article in the series assembles the disc, optics, servos and error correction system to form a CD player.

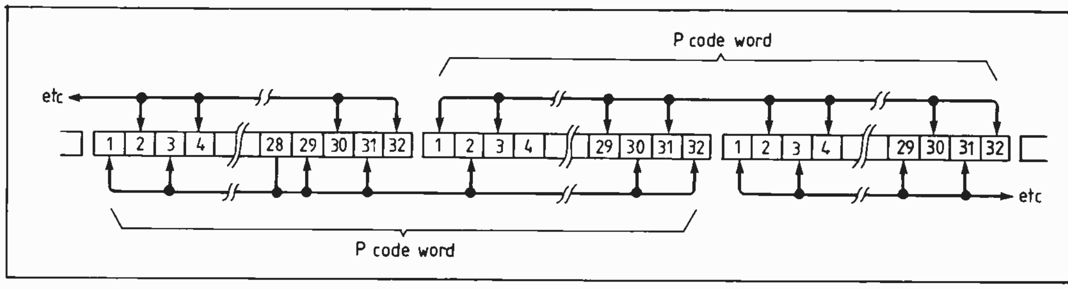


Fig. 7(c) **The final interleave of the CD format spreads P code words over two blocks. Thus any small random error can only destroy one symbol in one code word, even if two adjacent symbols in one block are destroyed. Since the P code is optimized for single symbol error corrections, random errors will always be corrected by the CI process, maximizing the burst correcting power of the C2 process after de-interleave.**

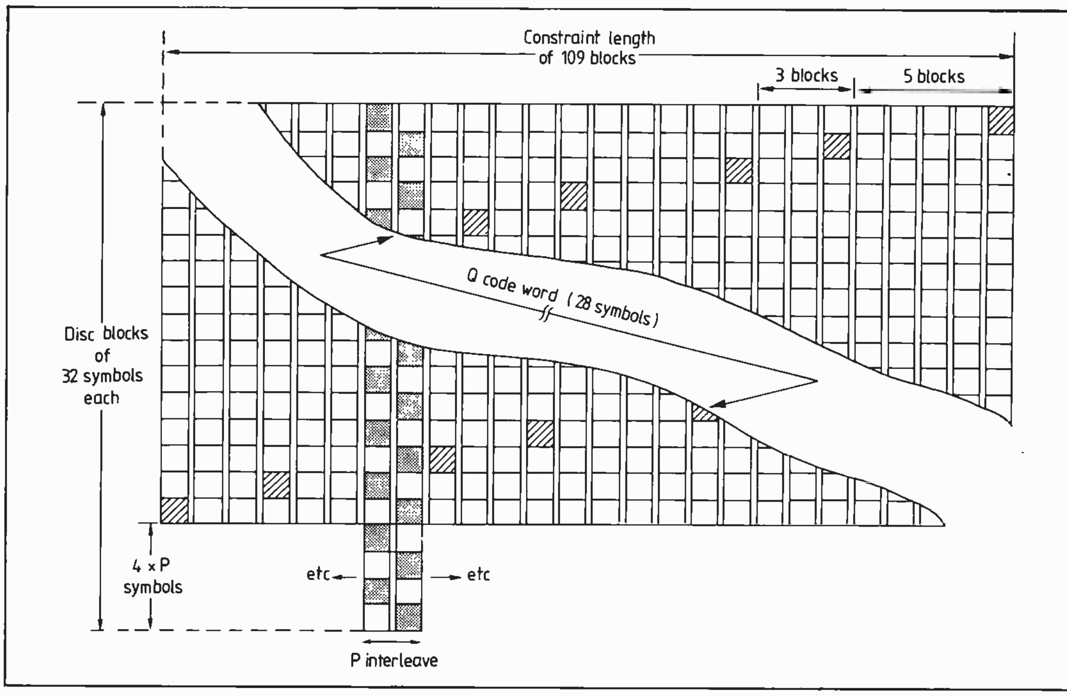


Fig. 7(d) **Because of cross-interleave, the 28 symbols from the Q encode process (C2) are spread over 109 blocks, shown hatched. The final interleave of P code words, as in Fig. 7(c), is shown shaded. Result of the latter is that Q code word has 5,3,5,3 spacing rather than 4,4.**

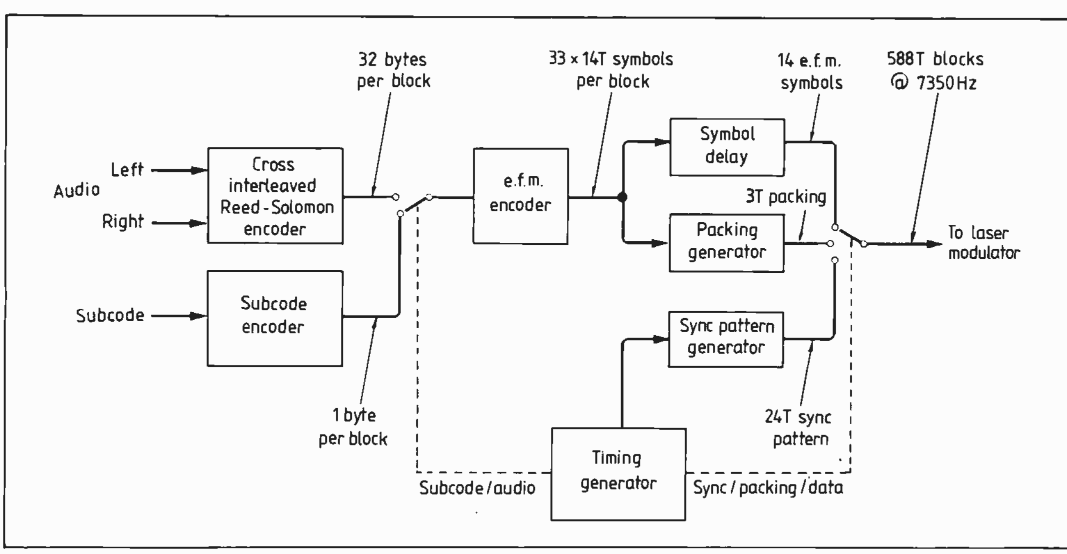
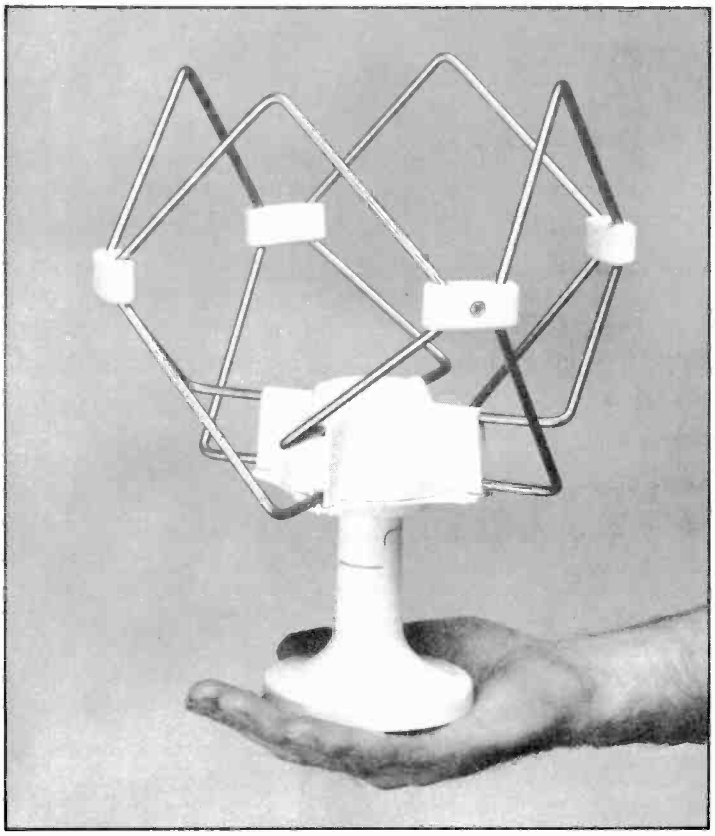


Fig. 8. **CD encoder modulates cutting Laser. Audio samples are cross-interleaved and combined with subcode data. These 8-bit symbols are encoded into 14T e.f.m. symbols. The packing generator prevents run-length violations and provides d.c. content control via 3T packing symbols. The e.f.m. symbol delay allows the packing generator to look ahead. Two of the many functions of the timing generator are to switch in subcode bytes (left) and to assemble blocks by selecting syne patterns, data and packing (right).**



Mobile tv aerial

Patents have been applied for the design of a u.h.f. tv receiveing aerial for use on vehicles. It is an adaptation the quad configuration. The objective behind the design was to evolve an aerial that would provide an omnidirectional field pattern where the direction of the wanted transmission station changes as the vehicle moves from one location to another. Of course it is possible to redirect a Yagi-type aerial but this requires physical movement of the aerial and the new design eliminates this. The success of the design can be judged by looking at the polar field strength diagrams; it is not worth reproducing them as they are just circles! Suggested applications are for use in coaches, cars, caravans and on water craft. Because vehicles often operate in areas of low signal strength, the aerial is provided with a broadband amplifier giving a 22dB gain over the whole u.h.f. band. The UK price of the Omnimax Aerial, including the amplifier and 5m coaxial cable is £39.50 inclusive. Maxview Aerials Ltd. Setchey, King's Lynn, Norfolk. PE33 OAT. EWW213

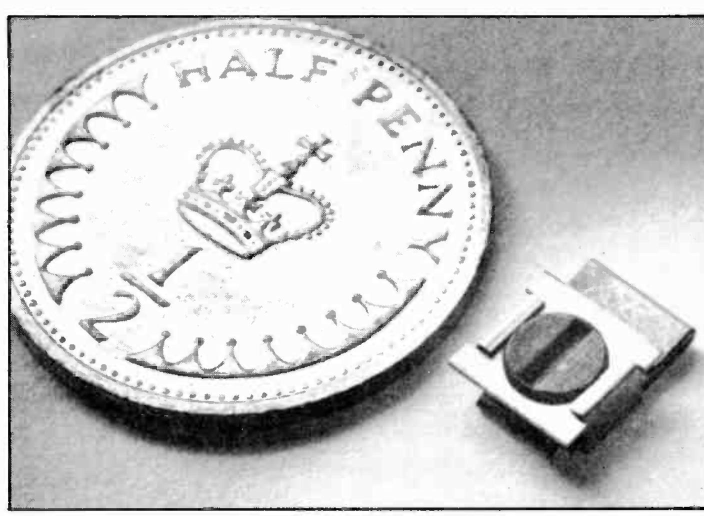
Transportable Unix

Trumpeted as the world's first transportable, fully integrated Unix-based computer the Hewlett-Packard Integral PC, Incorporates multi-tasking, Multi-window facilities and combines processor, display, printer and disc drive all in one 11.2Kg (25lb) package. The Unix operating system is on a 256K rom, the computer is built around the Motorola 68000 processor, uses the fast H-P thinkjet printer and has a 3.3in double-sided, double-density disc drive.

The computer operates from a.c. mains supply. Display is provided by an amber electroluminescent screen with a 9in diagonal. There is an HP-IB (=GPIB) interface, an input port for a mouse, and 512K of ram with expansion slots for more (up to 1.5MByte) and/or for a V23 modem. By using bus expanders, memory can be increased to 5.5MBytes. Eventually the computer will be able to address up to 8MB of user ram. An additional 32K ram is used for the screen memory. For software development, C and Technical Basic are available, as is a wide range of applications software. Stocked by Rapid Recall Ltd.,Denmark Street, High Wycombe, Bucks. HP11 2ER EWW205

Tiny trimmer

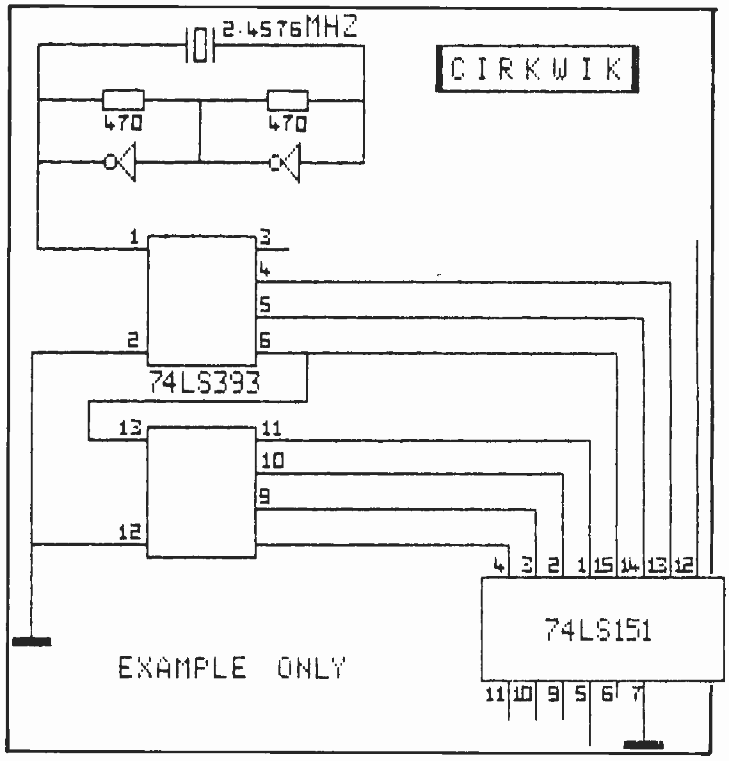
Another world's first is claimed for this device. The smallest ever precision trimmer capacitor. Designed to provide screwdriver adjustable tuning of high frequency circuits (up to 5GHz), The Voltronics CPA10 achieves it small size by eliminating the outer case and internal screw mechanism. Extreme precision is used to manufacture the parts and the Teflon dielectric is fused to the stainless steel moveable shuttle. Both the contact clamp and the shuttle clamp are gold-plated beryllium copper. Very low contact resistance ensures low r.f. loss and high Q. The capacitior has been vibration tested to 40G with no variation in the set capacitance value. The use of the CP series of trimmers eliminates the cost of wirebonding small capacitance elements, allows the rough tuning of several stages before final tuning, eliminates the cost of matching and tuning integrated circuits and the r.f. loss is lower than for ceramic elements.Pascall Electronics Ltd, Hawke House, Green Street, Sunbury-on-Thames, Middlesex. TW16 6RA. EWW211



Circuit diagrams on a micro

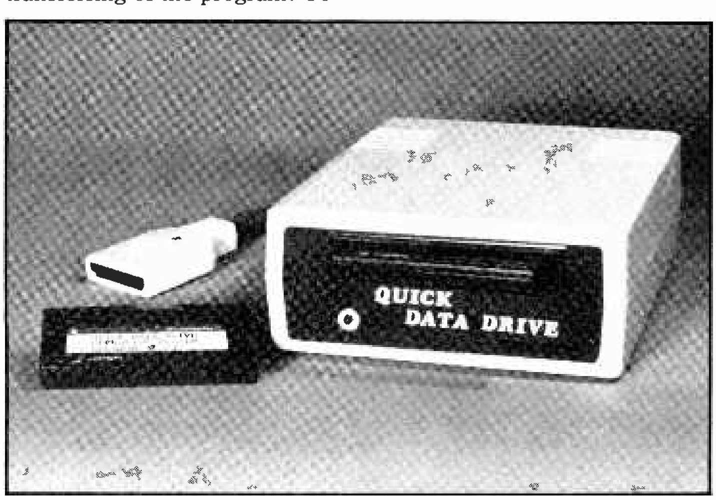
Using a light pen directly on the screen and a library of pre-programmed images it is possible to draw circuit diagrams, with a BBC Micro, very quickly and obtain a high-quality printout from a low-cost dot matrix printer. The Cirkwick kit consists of software on a disc and a lightpen which incorporates a switch. The graphics image of the circuit is displayed on the screen which acts as a window on a much larger 'virtual' screen; eight times the size of the screen in use. Although the system has been designed for electronic diagrams it may also be used for flow charts, power systems, pipework diagrams, fluid logic diagrams and many other engineering applications. A large number of electronic symbols are included in the package and it is also easy to create further symbols with the light pen, on a magnified scale, even when drawing is in progress.

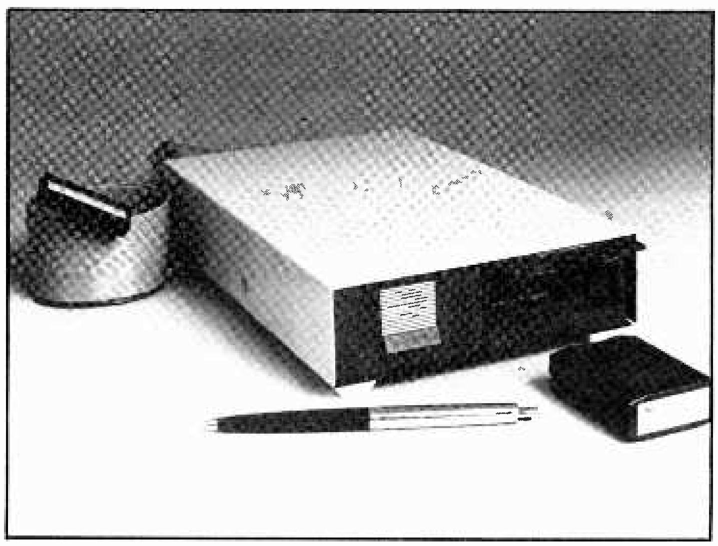
Printout is obtained from any dot matrix printer that can provide dual-density graphics. The printout is produced in one continuous action using a screen dump routine that manipulates the drawing file so that the correct portion of the diagram is on the screen while being printed. The drawing is stored in memory as a file of symbols and co-ordinates and may be manipulated by other programs if desired. The software costs £19.95 and the lightpen £25.00 (inclusive). Datapen Microtechnology Ltd., Kingsclere Road, Overton, Hants. RG25 3JB. EWW203



Fast tape storage

A new wafer tape drive is available for the Comodore 64 computer which loads faster than cassette and is claimed to be more reliable and, because of the slow serial interface with Commodore discs, is even faster than disc. The medium is a continuous loop of 1.6mm magnetic tape in a tiny cartridge, somewhat similar, though a little larger and more robust, to the Sinclair Microdrive. The interface software for the Quick Data Drive includes an audio simulation which makes the Commodore think that it is communicating with a normal cassette and this routine takes up as much time as the actual transferring of the program. To load the full 64K capacity of the computer takes 30s, compared with 2min for a Commodore dics drive and 23min for a Commodore tape. The drive complete with the operating system, one blank cartridge and one game cartridge costs just under £100. A wide range of software is already available on Wafadrive cartridges including many games, a word processor and a spreadsheet program. Other versions are planned for the BBC micro. The Rotronics Wafadrive for the Sinclair Spectrum uses the same mechanism. Dean Electronics Ltd, Glendale Park, Fernbank Road, Ascot, Berks. SL5 8JB EWW 201





Solid-state disc

Based around the Fujutsu 1Mbit bubble memory, the SSD1 has been designed to emulate a 5.25in floppy disc in applications where extra reliability and ruggedness are required. With no moving parts it has none of the potential mechanical problems of disc drives and offers a high immunity to the effects of temperature, humidity, dust, shock or vibration.

The unit can take two 1Mbit cassettes offering 125KBytes each, or the equivalent of two single-sided, single-density disc drives. The two cassettes can be combined to offer the equivalent of a single-sided double density disc. Full emulation is included in the internal electronics so that the unit may be plugged into the disc drive port of most microcomputers. It operates from a single 5V supply. Track access time is about 150ms and data transfer rate is 125KByte/s. Bubble memory has an error rate of 1 in 10^{16} and a calculated m.t.b.f. of 400 000h.

The units cost £960 including two cassettes and each additional cassette is £260. Tempatron Ltd., 6 Portman Road, Battle Farm Estate, Reading, Berks. RG3 1JQ. EWW216

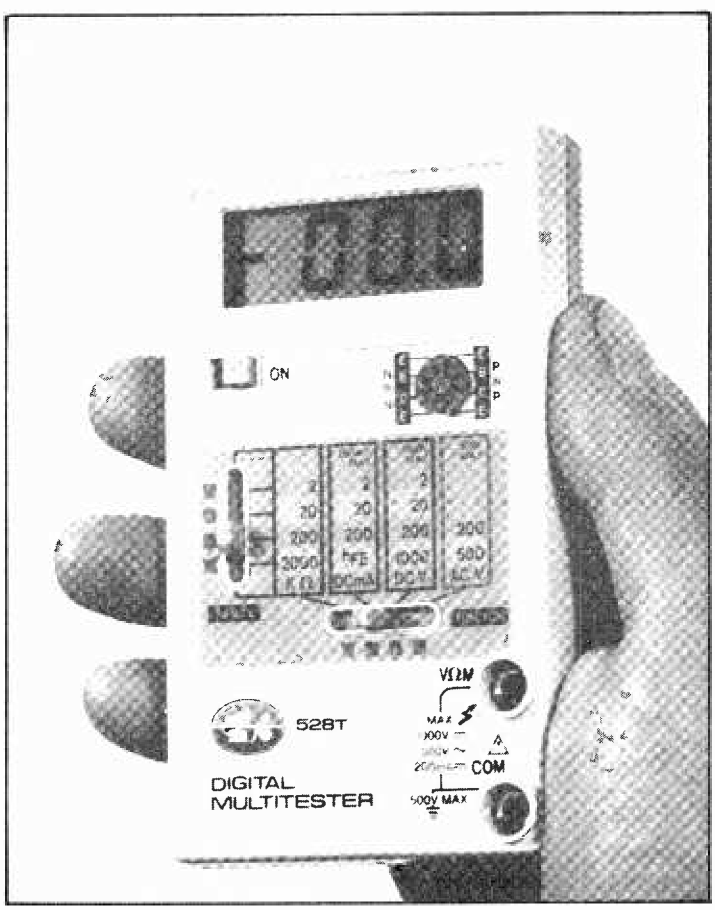
Pascal on the QL

The USCD p-system has been translated into a format usable on the Sinclair QL computer. This includes compilers for Pascal, Fortran-77 and USCD Basic, a screen editor, filer, utilities, print formatting and the Advanced Development Toolkit. USCD Pascal is widely used in as a teaching tool in universities and colleges and was chosen, for example, by the Open University for their course on structured programming in Pascal.

The P-system also provides a useful software development environment with its integrated editor and compilers. Programs so compiled are highly portable and may be used on a variety of microcomputers. The system is very fast; 700 lines of Pascal can be compiled in a minute on the QL, twice as fast as a similar operation on the IBM PC. Standard benchmark tests show that the system takes the QL from its current position of 31st in the league table to 6th place, much faster than the IBM PC and close to the speed of the IBM AT. Pascal or Fortran-77, together with a full set of development utilities, is available for £99.95, The Advanced Development Toolkit costs £49.95. TDI Software Ltd, 29 Alma Vale Road, Bristol BS8 2HL EWW208

Multitester

A miniature hand-held mult-meter includes a socket for transistor testing. It is housed in a book-hinged box with a manual, battery, leads and a spare fuse. The instrument features a 12mm high 3½-digit l.c.d. It has an overload protection circuit and automatic polarity and zero adjustment. The ranges and accuracies for each range are: alternating voltages, 0-200-500V (1.2%); direct voltages 0-20-200-1000V (0.8%); d.c. 0-2-20-mA (1.2%); Resistance 0-2-20-200kohms (1%). Transistors up to 1000_{HFE} may be tested. Available through Semiconductor Supplies International Ltd, Dawson House, Carshalton Road, Sutton, Surrey. SM1 4RS. EWW219



STE-Bus to Micro interface

When an STE-bus system is connected to a BBC Micro using Arcom's Beebop interface board, both systems benefit. The BBC can have access to STE's data acquisition and control features, such as 1MByte addressing range and 4Kbyte of input/output space; and the STE system gains a fast and easy means of developing Basic programs, and the BBC's colour display facilities.

The interface is a single Eurocard which sits in an STE card frame and is connected to the BBC through the 1MHz bus port. A 'filing system' eprom is installed in a BBC sideways rom socket and provides the computer with an additional set of STE-oriented commands to the Basic interpreter. These include dedicated facilities for a-to-d conversions, reading or writing to memory or i/o locations, and performing block moves. The BBC can be used as the only processor in the system or as one processor in a multiprocessor system. It is possible to use an STE processor board for applications while the BBC provides colour graphics. STE, which is reaching the final stages of standardization by the IEEE in the USA, offers a variety of expansion boards including digital and analogue interfaces and real-time clocks. The interface includes two v.i.a. chips which send and receive data between the BBC and STE buses with the necessary logic to set up the required bus cycles and an arbiter circuit for use when the BBC is part of a multi-processor system. Beebop costs about £120. Arcom Control Systems Ltd., Unit 8, Clifton Road, Cambridge. CB1 4BW. EEW218

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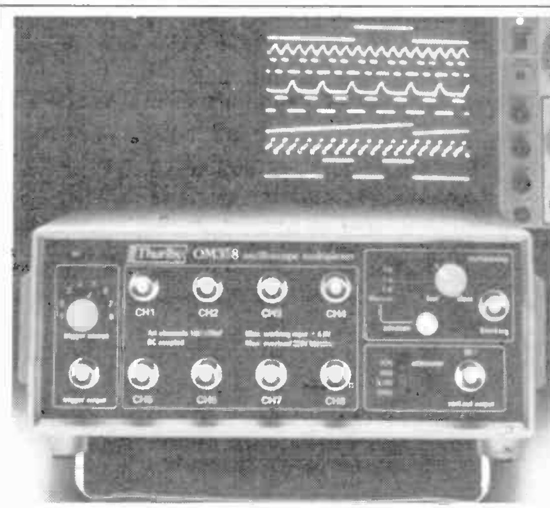

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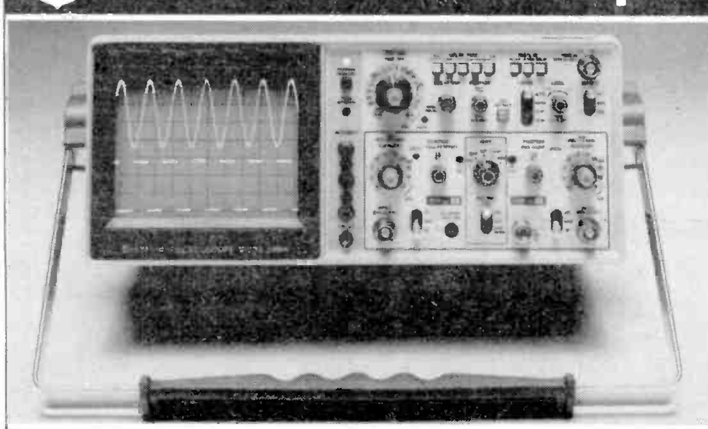

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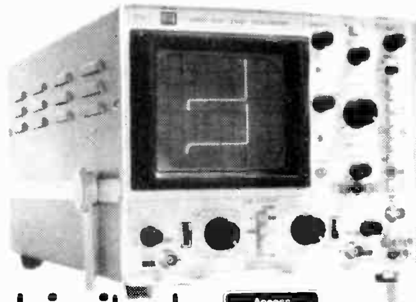

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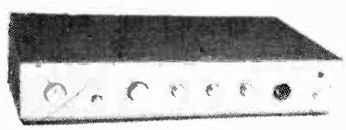

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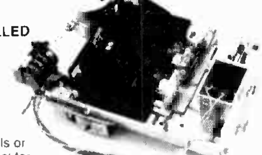

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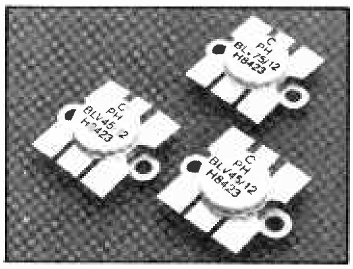
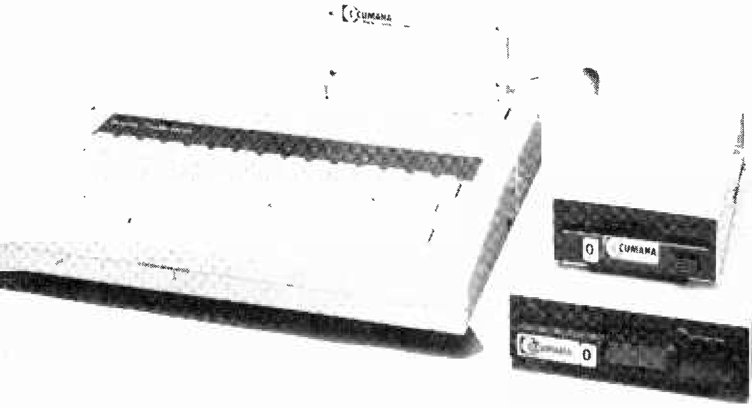
Output power for mobile radio



For operation between 140 and 175MHz, the BLV45/12 power transistors are intended for use with v.h.f. mobile radio transmitters. They are designed for optimun performance under adverse conditions and can withstand a 20-to-1 v.s.w.r. under severe output mis-match conditions. They feature internal matching, diffused emitter balancing resistors and gold metallization. They can deliver 45 and 74W output power respectively in amplifiers powered from a 12V battery. They offer a gain of 6.5dB at 175MHz. Mullard Ltd., Torrington Place, London. WC1E 7DH. EWW220

Alternative disc for Electron

Unlike the disc interface for the BBC micro, Acorn's Electron has a double density drive and would seem to provide all that may be required. Except that it exclusively uses a 3in drive. Cumana have come up with an alternative that may be used with 3.5 or 5.25in drives, double or single density, up to 89 file names and an interface that includes a battery-backed real time clock so that file may be 'date stamped' when saved. Software included with the package includes the ability to copy to and from Acorn DFS discs that can be used with a BBC micro. It is also possible to format single-density discs for the Acorn DFS. Cumana Ltd, Pines Trading Estate, Broad Street, Guildford, Surrey. GU3 3BH EWW202



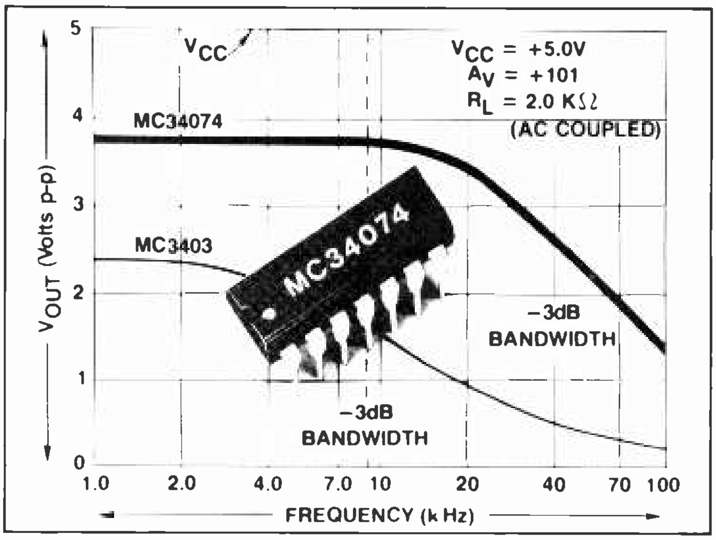
Dry lubricant in a can

A special anti-stick and mould release agent is provided by Electrolube's Dry Film Lubricant. It is designed for use where mineral oils or silicones are not appropriate. Especially suitable for electronics applications, DFL assists in the insertion of p.c.bs into edge connectors, stops squeaks in disc drives caused by friction between metal and plastics and improves the action of keys in keyboards. It may also be used for any plastic or plastic/metal connectors in such equipment as video recorders, tape recorders, typewriters and printers.

The material is based on p.t.f.e. It is clean and non-oily, water repellant, fast drying, non-flammable and chemically inert. This enables it to be used on most materials, including leather, wood synthetic or natural fibres, glass, metals and most plastics. It is available in aerosol cans and in bulk containers. Electrolube Ltd, Blakes Road, Wargrave, Berks. RG10 8AW. EEW207

Single-rail quad op-amp

High stability, fast slew rate and wide banwidth are claimed for the Motorola MC3074 op.amp, comparable to those characteristic associated with bi.fet devices whilst offering single supply operation with input common mode range down to ground (V_{EE}). In addition the NPN output stage provides a minimum output swing 36% greater than other standard op.amps and a capacitive drive capability of 10000pF. Its high stability results in a settling time of 1.lus. Suitable for use in battery-operated equipment, automotive systems and in switch-mode power supplies, the op.amp can be operated from split supplies as well as single raile if required. Stocked by Celdis Ltd., 37 Loverock Road, Reading Berks. RG3 1ED. EWW221

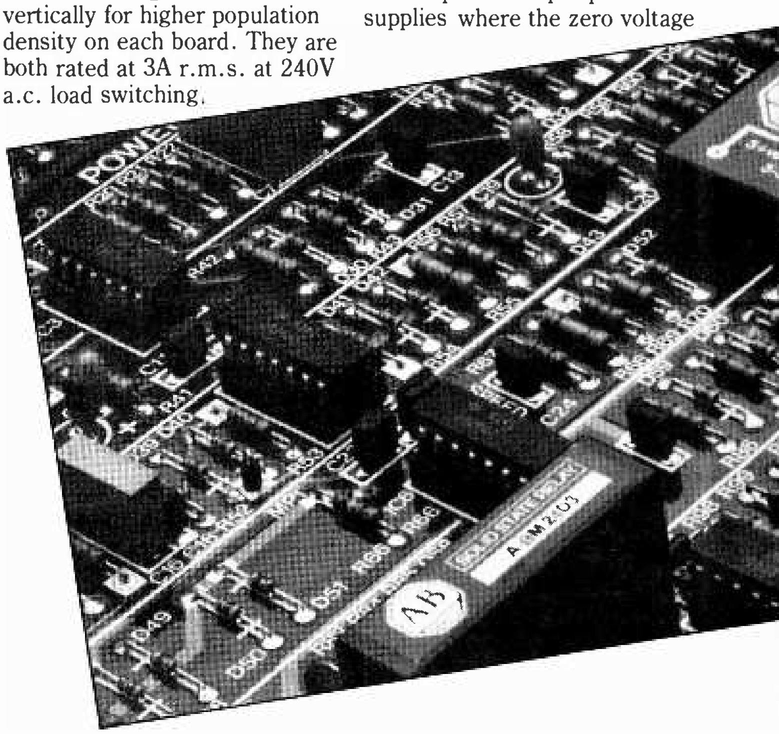


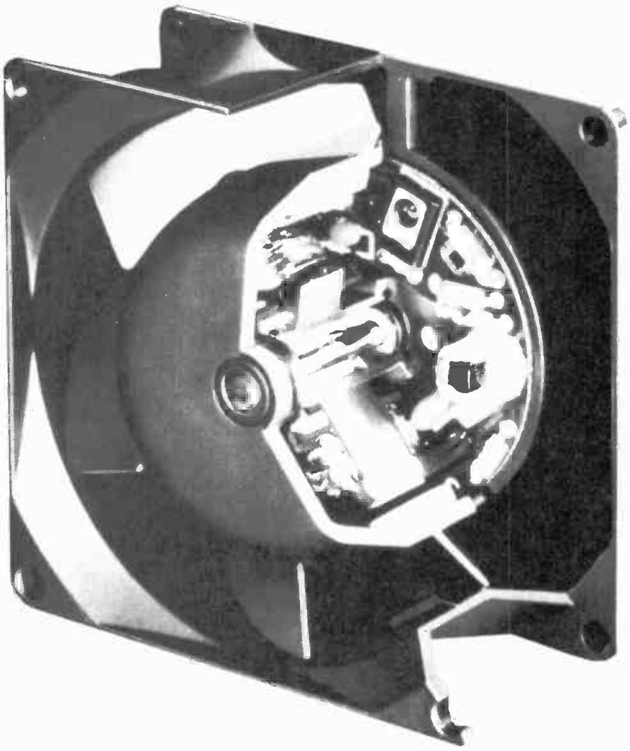
Solid-state relays

Designed and manufactured in the UK by Allen-Bradley, relays are available in three formats, two for p.c.b. and on for chassis mounting. The p.c.b. relays differ in their shapes one being flat to allow rackmounting the other being mounted vertically for higher population density on each board. They are both rated at 3A r.m.s. at 240V a.c. load switching.

The chassis mounted versions have three current ratings 10, 25 and 45A r.m.s. for mains power switching. They all offer zero-crossing switching to reduce r.f.i. to negligible levels.

Applications include switching a.c. motors, burst fire regulation of electric heating elements and with capacitive input power supplies where the zero voltage



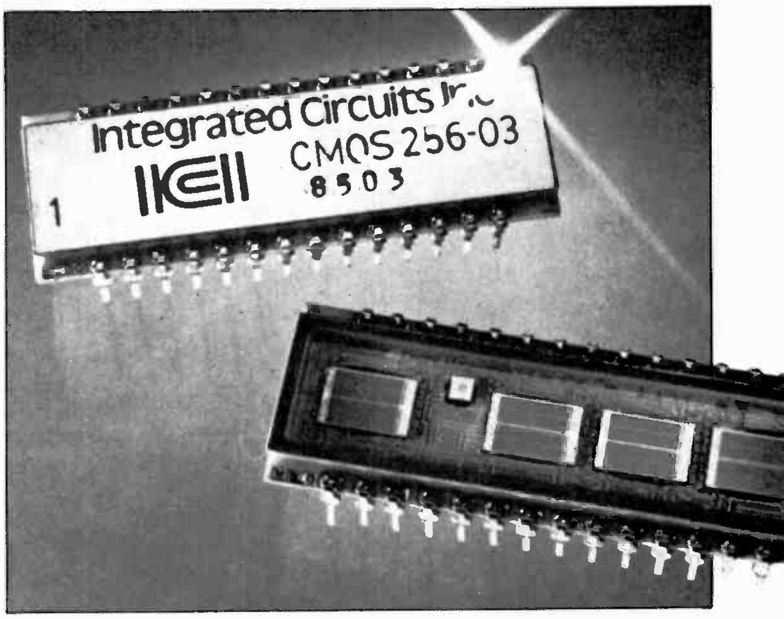


D.C. fans

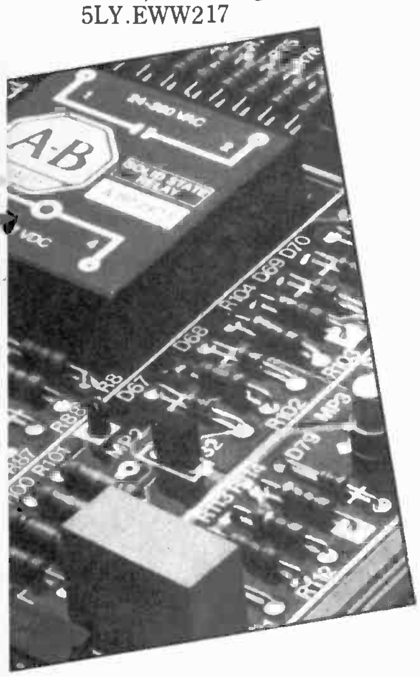
The shapes of the blades and the airflow venturi have been designed by computer in the latest range of 80 and 92mm fans from papst. The fans in this range have a depth of only 32mm but may move air up to 80^3/h. The series III Multifan is driven by a 4-pole brushless d.c. motor which features polarity protection and automatic restart. The use of a p.t.c. thermistor in the drive electronics allows the fan to start with a very slow ramp-up voltage. Papst Motors Ltd., East Portway, Andover, Hants. SP10 3RT. EWW210

256K S.RAM

By combining memory chips onto a hybrid substrate, it is possible to make up larger memories. The C.mos 256-03 combines four ram chip and a decorder to give a 32Kbyte static ram, with an access time of 100ns, an operating current of 40mA and a standby current of only 10uA. The hybrid is mounted in a standard 28-pin d.i.l. package and there are standard and military temperature tolerance versions available. Manufactured by Intergrated Circuits Inc. and available from Pascall Electronics, Hawke House, Green Street, Sunbury-on-thames, Middlesex. TW16 6RA EWW222



switching limits inrush current. They may be used as transformer tap changers and for primary disconnect. The relays are suitable for driving by logic circuitry. Allen-Bradley Electronics, Ennia House, High Street, Edenbridge, Kent TN8 5LY.EWW217



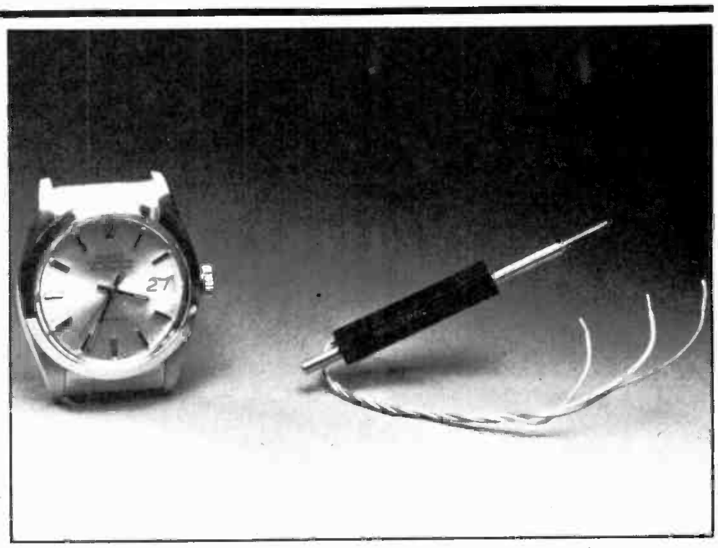
Computer-video synch

A device to allow the superimposition of computer text subtitles and graphics onto an incoming video signal has been developed by CCI Associates under licence from the BBC. Having been successfully prototyped the Super Genlock unit will be available very soon. It is capable of synchronising the RGB and video outputs of a BBC Micro to a stable reference as offered by a tv camera, video disc or time-base corrected v.t.r. It can also synchronize with lower quality video recorders such as VHS or Betamax when it can cope with such errors as a line frequency difference of 2%, 7us line timing variation relative to a stable reference over one second, and it will correct a quarter line period timing error following head switching in about 15 lines.

The unit has an input for a 1Vp-p composite video signal. The 15-way output is connected to the computer which needs to be slightly modified. It is powered either from auxilliary power output of the computer or can have a built in mains power supply. The price of the basic unit will be £199 without or £249 with a power supply. CCL Associates Ltd., Beechwood House, Depot Road, Newmarket, Suffolk. CB8 OHA. EWW214

Motion sensor

A ultra-miniature precision linear motion potentiometer may be used in short-travel position sensing, in confined places and for linear movement voltage adjustment. The body is 31.75mm long with screwholes for mounting at 25.4mm centres. The shaft, 3.2mm thick has 16.6mm travel. A range of resistances from 1K to 10ohms are offered and independant linearity is specified as 1%. Spectrol Reliance Ltd., Drakes Way, Swindon, Wilts. SN3 3HY.EWW215



Timing and signature analysis

Standard operating modes of this 40-channel instrument include the ability to save and recall blocks of data on disk, screen dumps of timing diagrams, signatures and the printing of data listings and dissasembled code. Timing waveforms may be labelled automatically and software enables the user to create a label file or enter labels directly. The instrument has a 24-bit trigger and area trace with trigger and clock qualifiers operating up to 10MHz. Each of the 40 channels can have up to 1K memory allotted to it. Standard operations include the dissassembly of 6502, Z80, 6800, 6809, 8080, 8085 and other 8-bit processors.

Additional options include direct processor access for 6502 processors and cross-assemblers for 8088 and 68008 without the need to get expensive personality modules. Data may be transmitted to emote stations through a modem.

The system is based around a re-packaged BBC micro with a detachable keyboard. The housing includes two disc drives and space for such expansions as a hard disc drive, modem and a second processor. Lawrie T&M Ltd., Mercury House, Mercury Row, Otley, W Yorks LS21 3HE.
EWW209

Low-cost 8048 development system

Writing software for the popular 8048 family of single-chip microcomputers normally entails the use of an expensive microprocessor development system. But a low-cost alternative is now available in the form of the Saldep-48, development system based on the BBC microcomputer.

The unit, which is self-powered, plugs into the computer's 1MHz bus. The software, provided in eprom, includes a text editor for entering programs, a symbolic two-pass 8048 assembler and interactive de-bugging tools. User programs can be stored on disc or cassette. The unit can program, read and verify the 8748, 8748H and 8749H eprom versions and it can act as an 8048 hardware emulator.

Saldep-48, which costs £925, was developed in co-operation with the Department of Electrical and Electronic Engineering at the University of Salford. Similar systems are in preparation for other single-chip microcomputers, such as the 8051 and 6800, and the IBM personal computer.

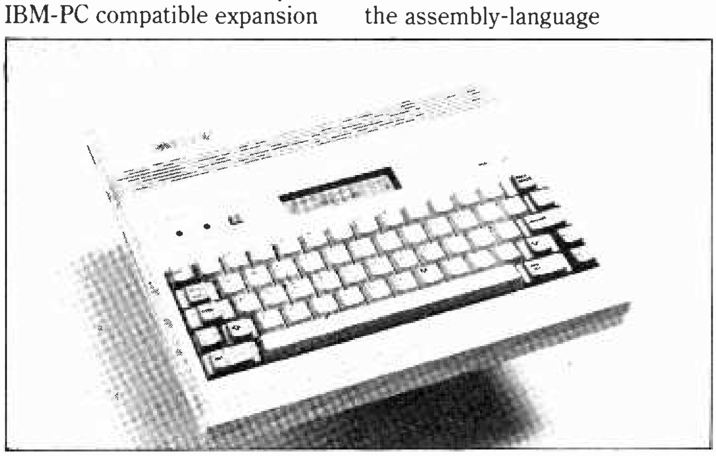
Volex Electronics Ltd., Volex House, Lissadel Street, Salford M6 6AP.
EWW212

8088 educational system

The latest in the series of Microprofessor single-board computers is the MPF1/88 which is built around the 16-bit Intel 8088 processor. It is designed to teach the fundamentals of 8088-based hardware and may also, at £325, be used as a low cost development system. It allows designers to prototype control devices for robotics and other servo-systems and unlike many 'packaged' computers allows direct access to the processor.

Included in the standard software are instructions on writing and debugging programs, and introduction to assembly language and the fundamentals of i/o interfacing. Included on the board is 4K of ram (expandable to 24K) and a 16K rom which may be added to up to a total of 48K. There is a two-line l.c. display which is actually a window onto a 20 column by 24 lines virtual screen. A full-sized qwerty keyboard is provided, together with a Centronics parallel interface and a 64-pin edge connector which allows any IBM-PC compatible expansion cards to be used. This allows for memory expansion, RS232c communications, colour video output and many other facilities in common with the IBM PC.

Standard features include an on-board monitor with many interactive sub-routines to aid the assembly-language programmer, routines to interface with any standard ASCII terminal, printer driver, and asynchronous communications routines. Also provided are a cassette interface, a power adaptor and a built in loudspeaker. Documentation includes a User's manual, monitor source listing, and a software reference guide which introduces 8088 assembly-language instructions and explains the internal working of the monitor system software. Future options include a two-pass assembler with editor, a rom-based Basic interpreter and Forth. A low-cost 20-column thermal printer is available and an eprom programmer. Flight Electronics ltd., Quayside Road, Bitterne Manor, Southampton SO2 4AD.
EWW206



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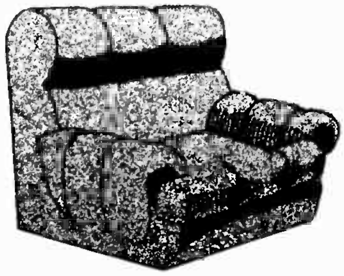

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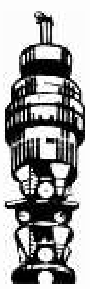

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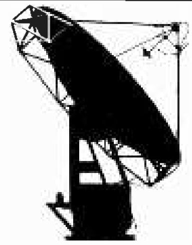

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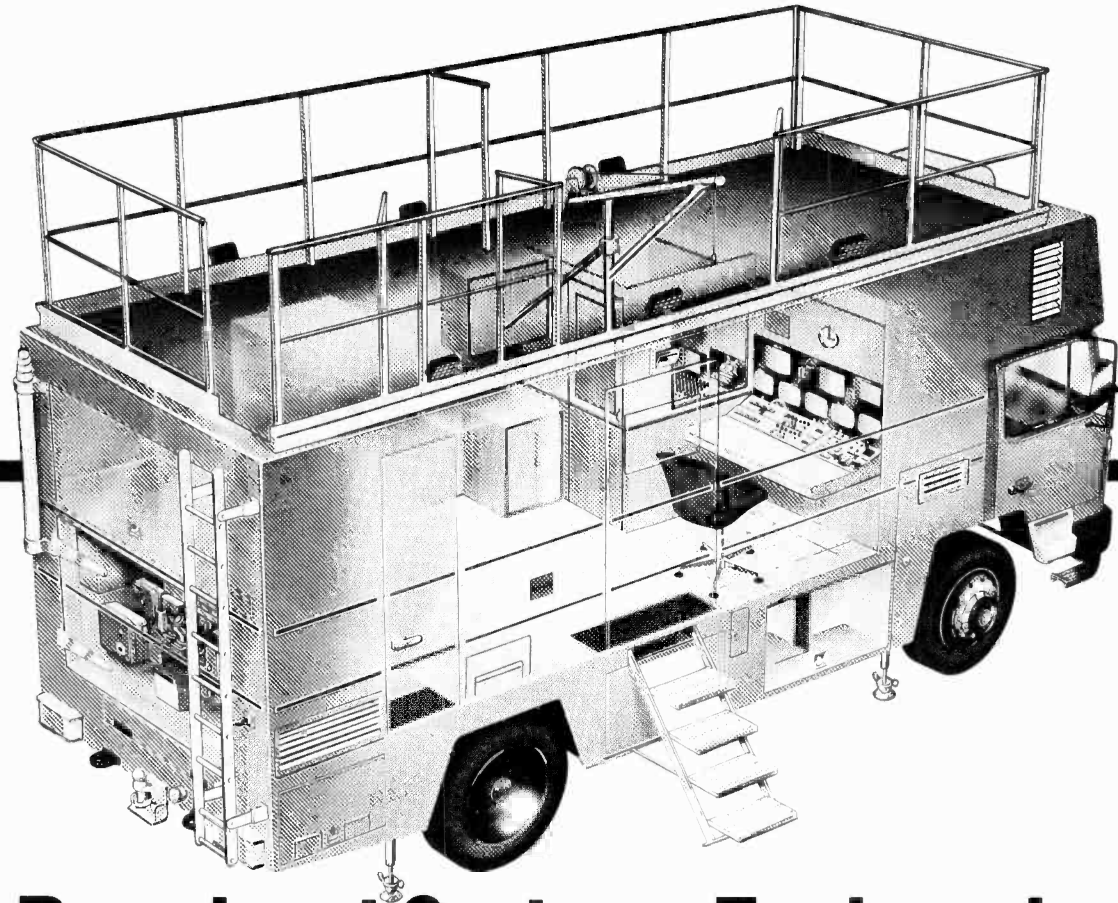

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Project and test engineers are required to work in the Systems Engineering Group which primarily deals with the custom design, manufacture and test of studio talkback and intercom systems.

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(2589)

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Write in the first instance detailing age, qualifications and salary expected to:

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(2575)

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DEPARTMENT OF CLINICAL PHYSICS AND BIOENGINEERING

ELECTRONICS TECHNICIAN — MEDICAL PHYSICS TECHNICIAN III

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Day release is available for approved studies for higher qualifications.

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For further information contact **Mr. F. Trowell**
Tel: 01-407 7600 Ext: 2574

Application forms are available from the Personnel Department Guy's Hospital, St Thomas Street, London SW1 9RT. Tel: 01-407 7600 Ext: 3471 quoting Ref. No: P/153.

Closing date for completed applications: 31st May 1985.

(2588)

SOUND ENGINEER

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The successful candidate will work in the field of SOUND ENGINEERING for film post-production, and must have a thorough theoretical background in electronics and light electrical engineering. Ability in project management is a priority, involving audio and control systems, planning, specification and installation, with skills at the drawing board and development bench. A working understanding of remedial and routine maintenance is required, and experience with video systems would be an advantage.

The prospects for advancement would be best for an applicant having a good manner and appearance, an even temperament, and the ability to deal with clients, to handle administrative duties and to write clear English. The suggested age range is 28 to 40 years.

In conformity with studio practice, membership of ACTT (the Association of Cinematograph, Television and allied Technicians) would be expected, and due weight would be given to applications from present members. Non-members should be willing to apply for acceptance by this union.

Please forward a full c.v. (quoting ref: ACN/GFL/A) to:—
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(2593)

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Initial salary will depend on qualifications and experience and will be on the scale £6,600 to £10,330.

Further particulars may be obtained from the Registrar, University of Leicester, University Road, Leicester LE1 7RH, to whom applications should be sent on the form provided by 31st May 1985.

(2577)

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(MPT IV)

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For further details please contact the Unit Personnel Department, Riverside Health Authority, Parsons House, Charing Cross Hospital, Fulham Palace Road, Hammersmith W6. Tel. 01-748 2040 extn 2992.

(2580)

College of Technology, Yarmouk University, Jordan.

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(2574)

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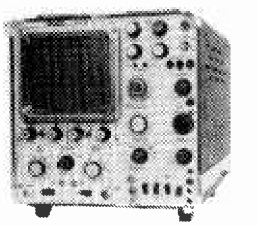

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To "Wireless World" Classified Advertisement Dept., Quadrant House, The Quadrant, Sutton, Surrey SM2 5AS

- Rate £4.00 PER LINE. Average six words per line. Minimum £25 (prepayable)
- Name and address to be included in charge if used in advertisement
- Box No. Allow two words plus £5
- Cheques, etc., payable to "Business Press International Ltd." and cross "& Co."
- 15% VAT to be added.

NAME ....

ADDRESS ....

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....

			REMITTANCE VALUE .... ENCLOSED		

PLEASE WRITE IN BLOCK LETTERS. CLASSIFICATION .... NUMBER OF INSERTIONS ....

CIRCLE 35 FOR FURTHER DETAILS.

ELECTRONICS & Wireless World

INDEX TO ADVERTISERS

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OVERSEAS ADVERTISEMENT AGENTS

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Hungary: Ms 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 106. Telephone: (03) 585 0581.

United States of America: Jay Feinnan, Business Press International Ltd, 205 East 42nd Street, *New York*, NY 10017 — Telephone (212) 867-2080 — Telex: 23827.
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MSF Rugby Simulator.
Tape Search System.
Radio Clock (5 mSec)
Radio Clock (500 μSec)
Made in England.
CIRCLE 2 FOR FURTHER INFORMATION
ARDEA WERNER CURTH

Model C
– 15 Watts. Available for 250, 220, 115, 100, 50 or 24 volts.

Model XS
– 25 Watts. Available for 240, 220, 115, 100, 50, 24 or 12 volts.

Model XS-BP
– 25 Watts. 240 volts, fitted with British Plug.

ST4 Stand
– To suit all irons.

SK5 Soldering Kit. Contains model CS 240v Iron, an ST4 Stand and solder.

SK6 Soldering Kit. Contains model XS240v Iron, an ST4 Stand and solder.

SK5-BP and **SK6-BP**
Soldering Kits as above with British Plug.

Model CS
– 17 Watts. Available for 240, 220, 115, 100, 50, 24 or 12 volts.

Model CS-BP
– 17 Watts. 240 volts, fitted with British Plug.

TCSU1
– Very robust temperature controlled Soldering Unit, with a choice of 30 Watt (CSTC) or 40 Watt (XSTC) miniature irons. Range 65°C to 420°C. Accuracy 2%.

TCSU-D
Elegant Temperature Controlled Soldering Unit with 50 W Iron (XSD) and built around FERRANTI custom-made ULA. Range Ambient to 450°C. Accuracy ± 5°C. Zero crossing switching. Detachable sponge tray.

EWW/ 6 /85

ANTEX Made in England
ANTEX (Electronics) Ltd., Mayflower House, Plymouth, Devon. Tel: 0752 667377 Telex: 45296
Please send literature, price list and my nearest stockist to:
Name
Address
Telephone

CIRCLE 3 FOR FURTHER INFORMATION