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Servo pickup arm

Control via the mains

Foam in speakers

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DECEMBER 1979 50p

Servo pickup arm
Control via the mains
Foam in speakers

Front cover displays components of a fibre optics communication system, with magnified spots of light from the fibres, made by STC Optical Products Division. Photo by Paul Brierley.

IN OUR NEXT ISSUE

***Into the 'eighties,* a survey of radio and electronics developments that may be expected in the next decade. Specialists in a number of different fields contribute articles which first review the technology of the past ten years then attempt to look into the future.**

***Also,* more on the firm-ware of the Scientific Computer project (April-September 1979) and mechanical details for constructing the Parallel-Tracking Pickup Arm (December 1979).**

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DECEMBER 1979 Vol 85 No 1528

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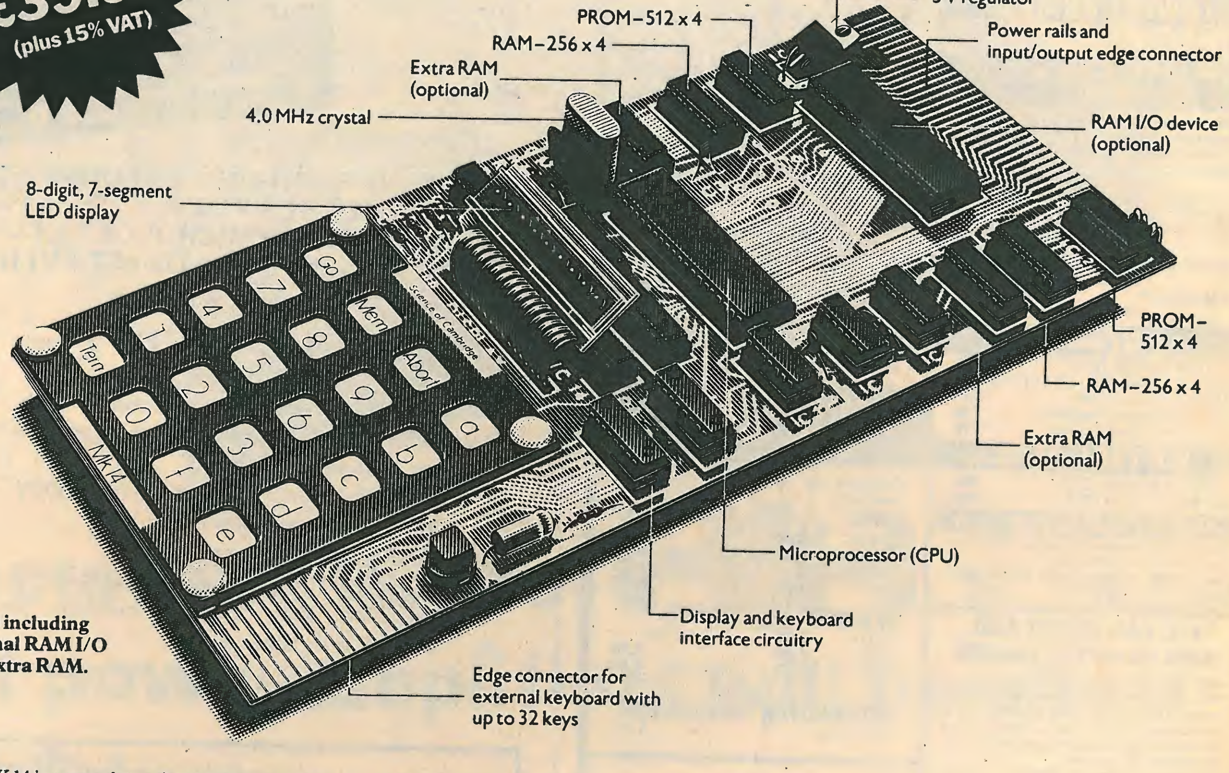

MK 14 including optional RAM I/O and Extra RAM.

The MK 14 is a complete microcomputer with a keyboard, a display, 8 x 512-byte pre-programmed PROM, and a 256-byte RAM programmable through the keyboard.

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All are available now to owners of MK 14.

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A set of Further Applications Programs is available covering advanced programs, dealing particularly with the use of the I/O capacity of the MK14 including the VDU and several programs written in a form of interpretative language called MINIL.

SPECIFICATIONS

● Hexadecimal keyboard ● 8-digit, 7-segment LED display ● 8 x 512 PROM, containing monitor program and interface instructions ● 256 bytes of RAM ● 4 MHz crystal ● 5 V regulator requires single 8 V power supply ● Space available for extra 256-byte RAM and 16 port I/O ● Edge connector access to all data lines and I/O ports.

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Every MK14 kit includes a Manual which deals with procedures from soldering techniques to interfacing with complex external equipment. It includes 20 sample programs including math routines (square root, etc), digital alarm clock, single-step, music box, mastermind and moon landing games, self-replication, general purpose sequencing, etc.

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WW/12/79

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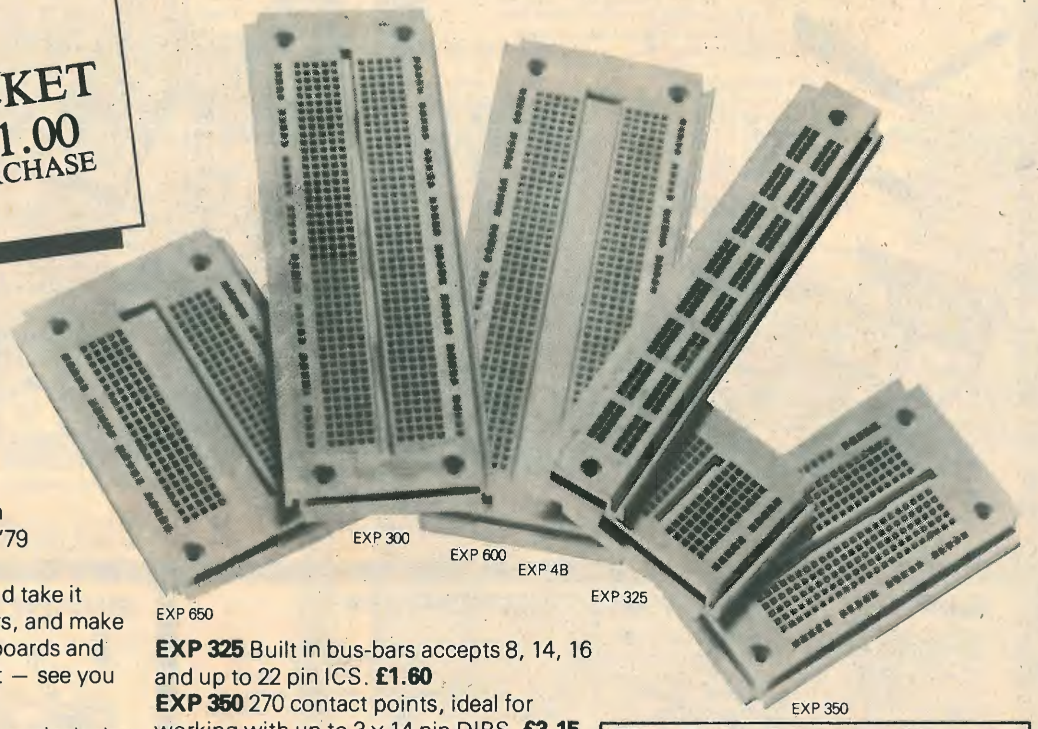

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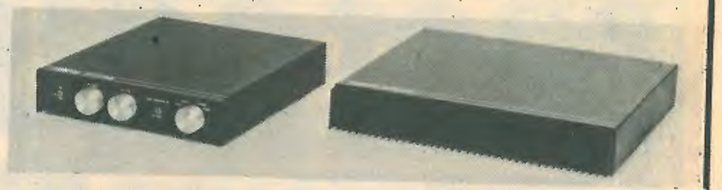

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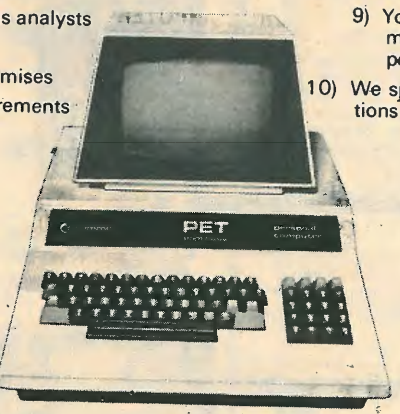

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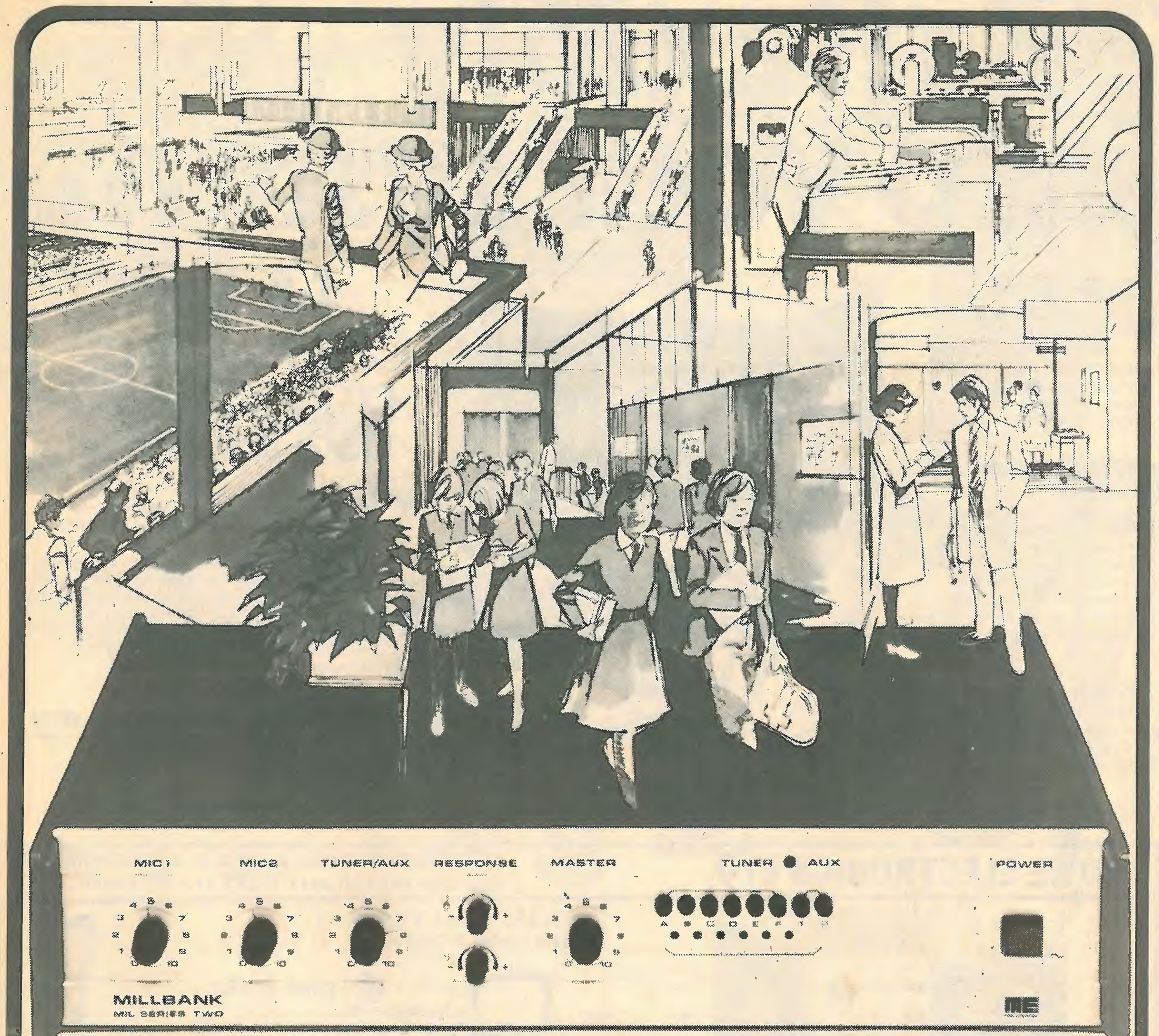

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MIL series amplifiers are designed and priced for installations in a wide range of applications including churches, schools, restaurants, factories, shops and offices.

Each amplifier is available with input facilities for microphones and music sources; six programme push button AM tuners or FM tuners and preannouncement chimes are available options.

One model incorporates automatic switching to a battery supply in the event of a power failure.

Such a versatile system can confidently satisfy your exact requirements.

Please tick as required.
For further information on this product ☐ Complete range of sound equipment ☐

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'STATE OF THE ART' PRE-AMP

Undoubtedly the best pre-amp on the market, it is supplied ready built, **not a kit,** and caters for disc, aux and 2 or 3-head tape machine. The built-in supply regulators require only rough dc, available from all our power amps or the matching mains supply kit, CSI. The performance is almost perfect, with virtually zero thd (< .002%, 1kHz), zero common mode distortion, fast slewing, high overload (40dB) and low noise (70dB mag). It is attractively finished in black and is also available in a special version to cater for moving-coil cartridges.

CI (mag): **£67.85**
CImc (m-coil): . . **£73.10**
CSI (mains supply kit): **£10.13**
Module (trade and export only): **£47.25, £51.60** (m-coil)

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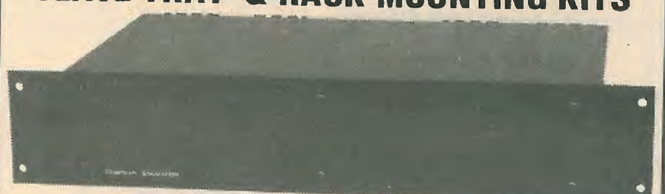
P3: Mono 1 x 130W/8Ω . **£83.32**
P4: Stereo 2x110W/8Ω . **£99.48**
P5: Mono 1 x 150W/8Ω, 260W/3Ω **£103.24**
P6: Mono 1 x 250W/8Ω **£112.35**
Also available ready built **POA**

Styled and finished to match the CI, they are supplied with ready built and tested pcbs and require only simple assembly and point-to-point wiring of power transistors, supply, etc. In this way the possibility of errors and subsequent damage is drastically reduced. The performance, again, is second to none in this magazine, with ultra low thd <.005%, 1k, 10W) and fast slewing contributing to their established exceptional subjective qualities.

'SLAVE TRAY' & RACK MOUNTING KITS



ST1: Mono 1 x 55W/8Ω, 80W/4Ω **£49.45**
ST2: Stereo 2 x 45W/8Ω, 65W/4Ω **£65.55**
ST3: Mono 1 x 130W/8Ω **£63.94**
ST4: Stereo 2 x 110W/8Ω **£93.61**
ST5: Mono 1 x 150W/8Ω, 260W/3Ω **£79.74**
ST6: Mono 1x250W/8Ω **£86.25**
Plain lid **£4.23**
Black lid **£7.68**

RACK MOUNTING KIT:
Slave tray (state which) plus **£15.41**
Also available ready-built . . . **POA**

These kits are designed to cope with sustained high level use, for which the domestic kits are not suitable. The same high performance circuitry is used with the power transistors mounted on substantial external heatsinks. The "slave tray" is the bare bones of a power amp and comprises a simple, plain finished chassis, tested amp pcbs and transistors, heatsinks and power supply. No specific connectors are supplied to allow flexibility of application. You can mount the slave tray in your cabinet or use our plain or black lid to achieve a match with our pre-amp. The slave tray forms the basis for the rack mounting kits which add a black lid and heavy guage 3½ ins black front. Low field toroidal transformers are used and there is spare room for extra circuitry if required. We stock a range of connectors for your convenience.

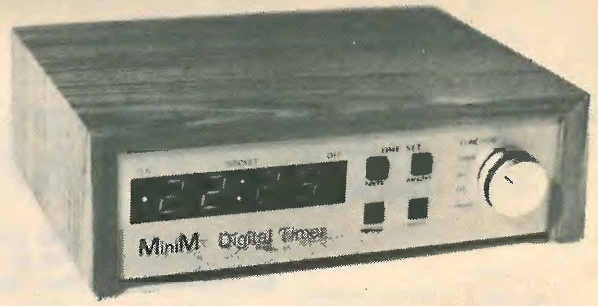
MODULES: UP TO 250W r.m.s.

These modules are available in a variety of powers and forms (including L bracket mounting) to trade and export customers only. They come ready built and tested and use the same proven circuitry as the other amps in our range and set an unsurpassed standard of performance and reliability. We also have power supplies for use with these. Please contact us for prices with competitive quantity discounts. The module illustrated is a medium duty 250W rms type using 4 of the latest Japanese "super" power transistors.

EXPORT: We can deal efficiently with orders to any country. Please write with your specific requirements for a quote by return. All power amps can be wired for 110v mains.
INFORMATION: Before ordering any of these or competitors' products, why not send for our detailed information? Large SAE or dollar bill please.
All prices shown are inclusive and all power ratings are real RMS watts, unlike the phoney ratings of many modules. Although we try to deal with orders promptly, please allow 28 days to avoid disappointment. Large orders please phone for delivery date.
DISTRIBUTORS: We are eager to establish distributors throughout the world and invite enquiries from interested parties.
SERVICING: We offer an after-sales service, with fixed maximum charges, for all our kits.

1A STAMFORD STREET, LEICESTER LE1 6NL
Tel: 546198
USA: OX DISCO, BOX 123, CLAYMONT, DE 19703

MiniM



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Price £39.95

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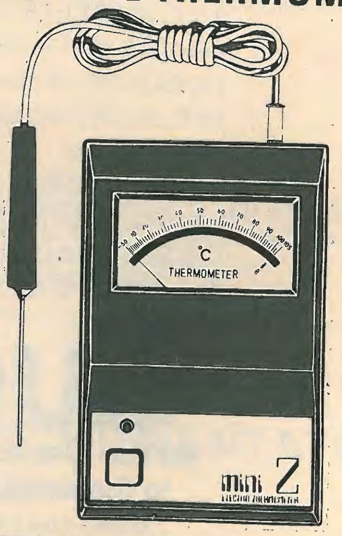

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(Phone 01-837 7937)

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Series IIIS precision pick-up arm

We took a hard look at the Series III because we wanted more people to enjoy it. We were not prepared to give an inch on performance or manufacturing quality and the nitrogen hardened titanium tone arm had to remain. However we found a number of ways in which economies could be effected and they have been incorporated in this new model.

Adjustments are made directly instead of through lead screws or rack and pinion, the absence of these things being a matter of operating convenience only. Lateral balance was also dispensed with as it is unimportant in this type of arm unless the deck is seriously out of level. The fluid damper is a refinement but not essential and so we made it an optional accessory. This simplified version of the Series III offers an attractive saving in price and either is immediately available through your usual dealer. We shall be glad to send you details on request.

**Another accolade for SME: the Series III precision pick-up arm was one of the Design and Engineering Awards at the 1979 U.S Summer Consumer Electronics Show, the only pick-up arm to be acknowledged in this way.*

SME

The best pick-up arm in the world

Write to Dept 0656,
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The Sullivan reputation for quality and accuracy is known and respected in electrical standards laboratories throughout the industry. But Sullivan also make some instruments that are just as much at home on the factory floor as on the laboratory bench. This is typified by the Megohmmeter T2900–a portable d.c. instrument designed for the measurement of high value discrete resistors and the insulation resistance of non-conductive materials, motors, cables etc. The T2900 can provide test voltages up to 1000V d.c.

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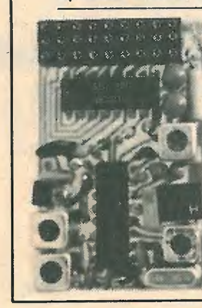
INTERNATIONAL

IT'S HAPPENNED* AGAIN !

THE PART THREE CATALOGUE IS PUBLISHED & WE HAVE MOVED TO BIGGER PREMISES.

Yes, it's here at last - the all new Part Three Catalogue. Fun for all the family, and the usual update on all that is new, worthwhile and exciting in the world of Radio and Communications. A big section on frequency synthesis techniques covering broadcast tuners, to communication quality transmitter systems. More new products than ever - RADIO CONTROL parts, crystal filters, ceramic filters for 455kHz and the new range of TOKO CFSH low temperature coefficient types for 10.7MHz. Details on new radio ICs, including the new HA11225, the CA3189E lookalike with 84dB signal to noise, and adjustable muting threshold. Radio control ICs - and an updated version of the RCM&E 8 channel FM receiver - now with an Ambit designed screened front end, with 27MHz ceramic bandpass filter. LCD panel clock/timer modules - the neatest and best LCD panel DVM yet (only £19.45 each + VAT), the new 5 decade resolution DFM3 for LW/HF/VHF with LCD readout. The DFM6 with fluorescent display to 10kHz resolution on VHF, 1kHz on SW. A 1kHz HF synthe siser with five ICs - the list is endless. Get your copy of the catalogue now. Post publication price is 60p (inc PP etc). The previous two sections are also required for a complete picture: Parts 1 & 2 £1 the pair. All 3 £1.50. And don't miss our spot the gibbon contest, together with a quiz to see if you can spot the differences between a neolithic cave drawing and a circuit diagram of one of our competitor's tuners. (* Yes, we still haven't learnt how to spell.)

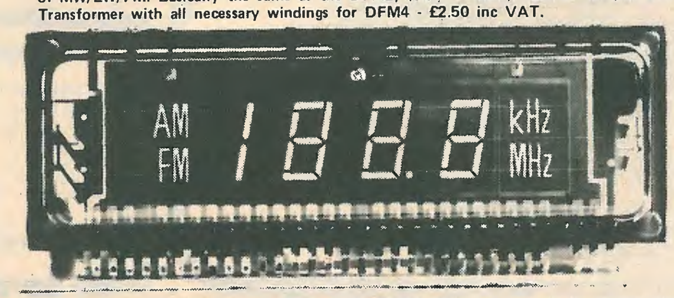
Updated RCME FM radio control RX kit



8 Channel RC receiver (FM)
- Single IC RF/IF/Detector
- Single IC decoder
- 27MHz ceramic filter input
- FET RF stage with double tuned bandpass filter
- Dual ceramic filter IF
- Based on RCM&E FM system
- Best quality SLM servo connector block
- ONLY £16.10 inc VAT (kit) (includes new SLM case)

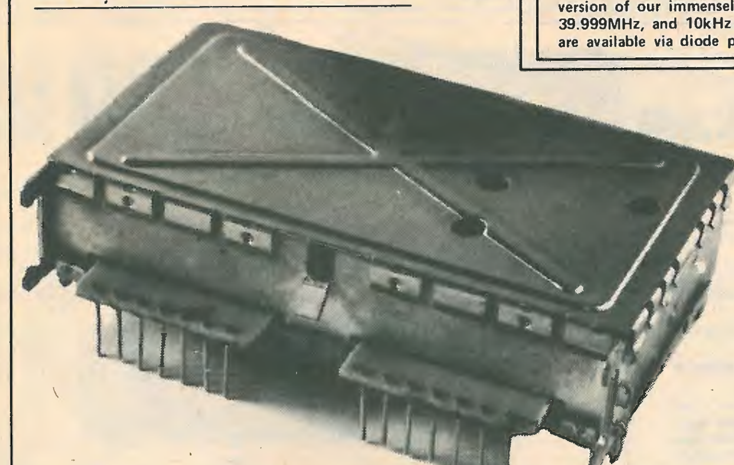
DOES YOUR ONE GLOW GREEN IN THE DARK ??

Our DFM4 does, since it uses a vacuum fluorescent display for direct readout of MW/LW/FM. Basically the same as the DFM2, (LCD Version). £24.45 kit (inc VAT) Transformer with all necessary windings for DFM4 - £2.50 inc VAT.



Not illustrated here - but also now available is the DFM6. This is a vacuum fluorescent display version of our immensely popular DFM3 (LCD). Resolution is 100Hz to 3.9999MHz, 1kHz to 39.999MHz, and 10kHz to 200.00MHz+; all standard IF offsets (inc. 10.7MHz on shortwave) are available via diode programming.

New series of radio modules in fully screened cans:



UM1181 VHF band 2 VARICAP TUNERHEAD
5 tuned circuit, with image/spurii better than −80dB, buffered LO output, MOSFET RF stage, FET IF preamp, tunes with only 1½ to 8v, −9dBm 3rd order intercept. 1off price £12.00 inc VAT. (100off/ OA)

911225 FM IF strip with all mod cons for the HiFi tuner:
All types use 80+dB S/N Hitachi IC, with muting, AFC, AGC, meter outputs for signal level and centre zero. IF preamp stage.
'A' Dual linear phase ceramic filters, with MOSFET (AGC'd) IF preamp and a 3rd narrow filter with DC filter selection. Dual tuned FM detector stage. £23.95 inc VAT (built)
'B' Dual ceramic filters, single tuned detector stage £14.95 inc VAT
(All 'A' series units are set up with a spectrum analyzer for best THD)

91072 AM RADIO TUNER MODULES · DC TUNED and DC SWITCHED Available February '80
All include buffered LO output, mechanical IF filter (TOKO CFMQ)
1-10v tuning bias, switching by a single pole to earth
A MW/LW (150 to 350kHz LW range) with ferrite rod antenna
B As 'A' but also including SW1 or SW2 (specify.)
SW1 = 1.8 to 4MHz SW2 = 5 to 10MHz
C With both SW ranges
Prices -one off INC VAT
'A' £14.43 'B' £15.90 'C' £17.50 (Custom types OA)

There is a danger - when advertizing in some magazines - that because we do not find space to list everything we sell in every ad., that some readers forget about half the ranges we stock. So to summarize the general ranges:

TOKO	Chokes, coils for AM/FM/SW/MPX, Audio filters etc Filters: Ceramic for AM/FM, LC for FM, MPX etc. Polyvaricons ICs for radio, clock LSI, radio control, MPX decoders etc
Micrometals	Dust iron cores for toroids for resonant and EMI filters Toroid mounts
Hitachi	Radio/audio/mpx linear ICs 100W MOSFETs, small signal FETs, MOSFETs and bipolar

And the following groups of products from a broad range of sources:
Semiconductors —specializing in radio devices, Plessey SL1600, EUROPE's best selection of AM/FM and communications devices. Power MOSFETs, WORLD's LOWEST NOISE AUDIO small signal transistors, BAR graph LED drivers for linear and log.
CD4000 series CMOS, TTL/LPSNTTL, standard linears (741, 301, 3080 etc). MPUs, memories.
Small signal transistors from AEG BC237/8/9 families etc. (1000 off BC239C : 5.2p ea)
LEDs: AEG 3mm/5mm round, 2.5x5mm flat, red, greem, orange, yellow. The best prices you will find for quality products.
MOSFETs for RF signal processing, including the BF960 UHF device, and 3SK51 for VHF. Varicap diodes for 17:1 capacity ratio tuning

FREQUENCY READOUT LSI from OKI with a one-chip answer to most digital frequency display needs (and various modules).
Crystal and ceramic ladder filters from leading manufacturers, ferrite rods, various ferrite beads and a range of crystals for 'standard' frequencies and both AM and FM radio control at 27MHz. Trimmer capacitors.
METERS - a new range of linear movement types, plus many 'indicator' types for VU, all types of tuning indicators etc.
SOCKETS - a new range that are better quality than Texas low profile, yet better priced.
Modules for AM/FM/STEREO, complete kits for tuners, audio amplifiers from Larsholt.
SWITCHES - complete low cost DIY systems for push button arrays, keyboard switches.
DOUBLE BALANCED MIXERS - MCL SBL1, replacement for MD108 etc. And cheaper.

OUR LATEST MOVING EXPERIENCE :: At last, we have moved to the address below. There is car parking for customers approaching via North Service Road (an extension of North Road Avenue, entrance opposite the Brentwood Fire Station.) Pedestrian access from the High Street (alongside 117 High Street). The new building is six times bigger than our Gresham Road offices, and we will be installing a much expanded sales counter in the fullness of time. NEW TELEPHONE NUMBER (0277) 230909, TELEX NUMBER (as before) 995194 AMBIT G. See you there !

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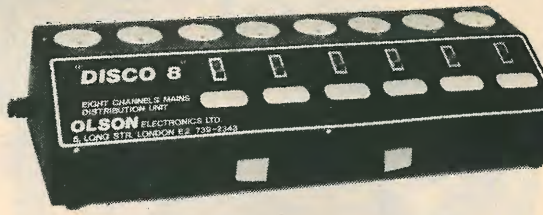
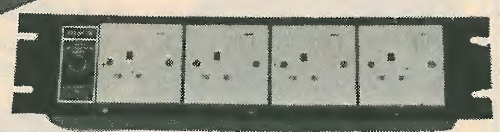
Special design for DJs



8-Channel Disco Unit **£33**
Plus P&P **£2+VAT**



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Instant Trunking System for Wall or Bench Mounting

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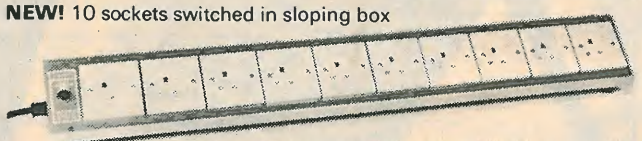
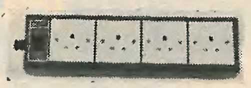
Plus P&P **£2 + VAT**

NEW! 10 sockets switched in sloping box



Type 13A/10SW **£27.50.** P&P **£1.85+VAT**



COMPLETE WITH 6FT. CABLE AND 13-AMP FUSED PLUG.

4 sockets 13A	£12.75
6 sockets 13A	£15.00
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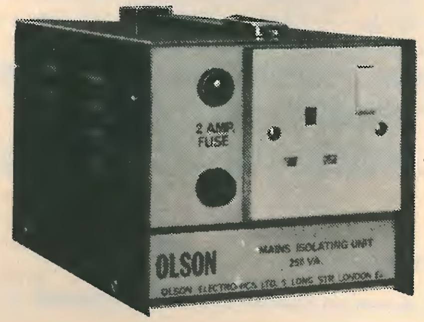
6 sockets 13A switched	£16.75

+ Post **£1 + VAT**



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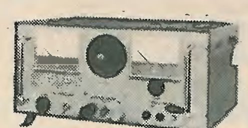

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OUTPUT 2: 0-70v, 10A AC
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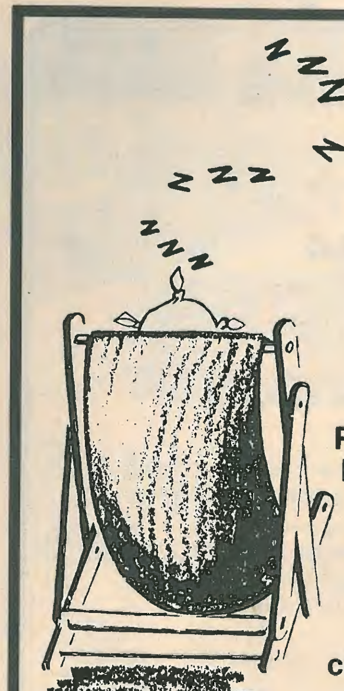

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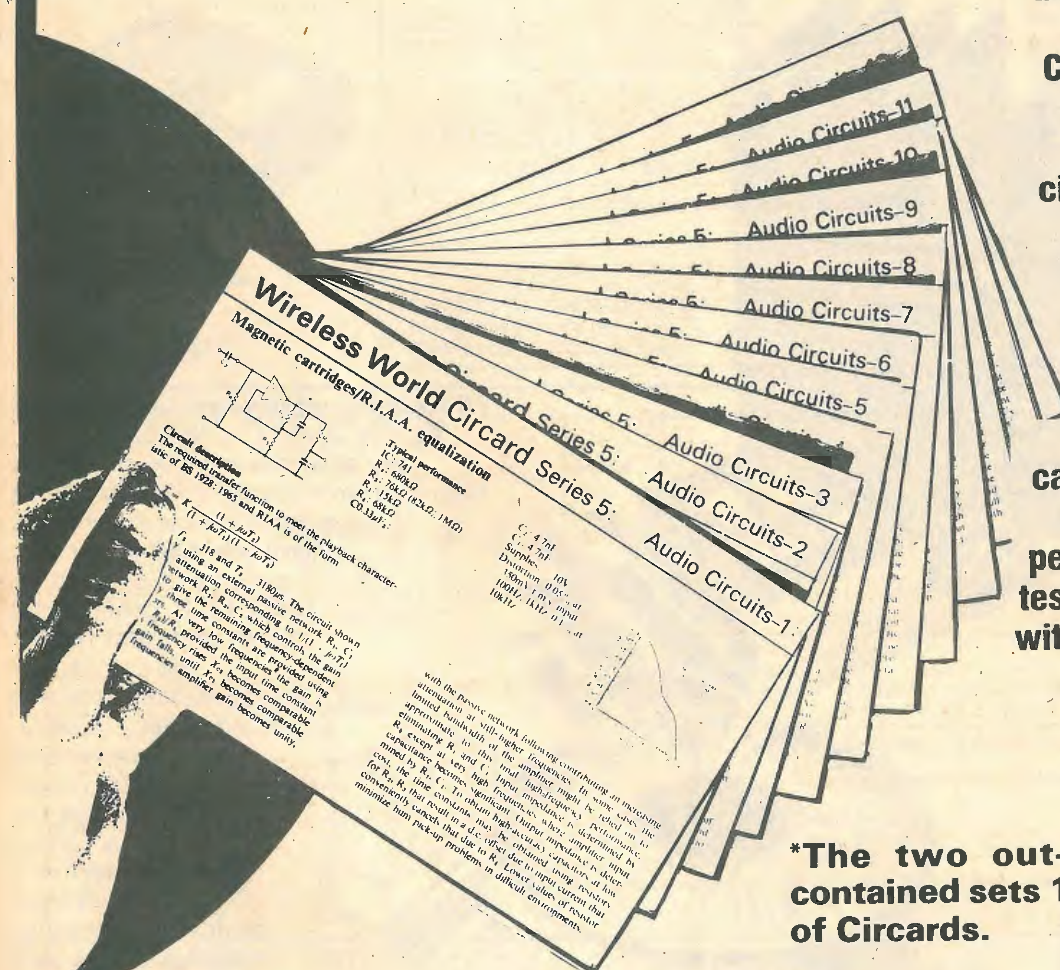
These unique circuit cards normally contain descriptions and performance data of 10 tested circuits, together with ideas for modifying them to suit special needs.



***The two out-of-print volumes contained sets 1 to 10 and 11 to 20 of Circards.**

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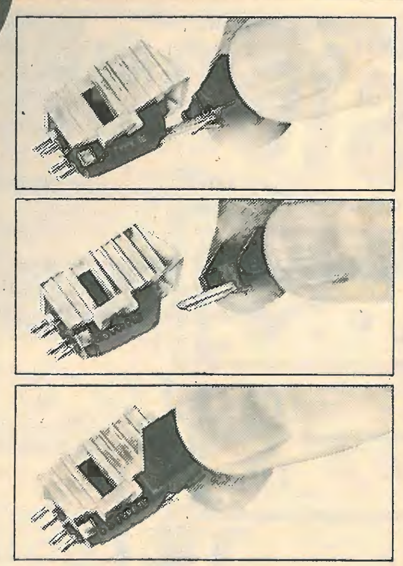

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One-way traffick

To complain about politics coming into discussions on frequency allocations at WARC 79 is either a hypocritical cover or extremely naive. But that is what the leader of the US delegation at Geneva, Professor Glen Robinson, has done (in a recent article in *Satellite Communications*). It's true that the allocations are being made to radio services in general for the whole world, but one cannot avoid the awkward fact that different countries have different priorities for the division of particular bits of spectrum between services, for example, between radio communication and broadcasting. These priorities depend on value judgements of what is important in the various societies — and what are these but political? For example, Professor Robinson makes it clear in his article that the first objective of the US delegation at WARC 79 is to seek agreement on incremental changes "in order to enhance US economic, social and national security interests". What is this but political?

As we have already reported, one of the main areas of political dissension at WARC 79 is the conflict of interests between the rich, industrialized nations of the northern hemisphere and the poorer, developing nations of the southern hemisphere — the so-called North-South confrontation. This conflict arises, of course, from the colonial past. What are now developing nations were formerly colonies of the 19th century powers. Having achieved political independence, these nations — particularly the non-aligned group — are struggling to secure their national sovereignty, their economic independence and their cultural integrity. This is difficult for them not only because they are poor but because the industrialized nations are dominant in communications — both in the amount of information received and transmitted (news, entertainment, education, technology, advertising etc.) and in the industrial development of the means of conveying it (books, newspapers, news agencies, telephones, data transmission, broadcasting, sound and video records etc). There is in fact a predominantly one-way flow of information from the powerful to the less powerful. Built up during the colonial past, it now subverts the efforts of the developing nations towards real autonomy and, according to UNESCO, has produced a gulf in communications which is widening alarmingly and may have irreversible consequences. This situation is made more intractable by the monopolization and concentration of information and entertainment that one now sees within the industrialized nations themselves. In the totalitarian countries the flow of information is controlled by the state; in market economies it has become an industry run for profit. Both systems exploit the media and can lead to distortion, conformism and the production of stereotypes. People become objects managed by professional communicators. Manipulated and homogenized, they devolve into mere consumers of packaged information products to which they have in no way contributed. These processes strengthen the position of the dominant groups and the established orders.

It is this flood of alien culture, and the networks which convey it, which the non-aligned countries are trying to resist, for very good reasons. As the UNESCO commission for the study of communication problems says, "Intellectual subjection is ..... as negative as political subjection and cultural dependence as pernicious as economic dependence". The developing countries are seeking a new democratization of communication, in which messages will not only reach but emanate from all parts of the population, including minorities and disadvantaged groups. They want a dialogue among equal partners instead of a one-way transmission from the rich and powerful who are still able to exploit them. It's small wonder that the politics of this resistance should play a significant part in an international conference like WARC 79 which has to make decisions about a means of communication as universal as radio.

The intelligent plug

Controlling remote domestic appliances by microcomputer

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This article describes a system for transmitting digital signals on the domestic mains wiring, to permit remote control of devices within a house from a central unit without having to install special cabling. Transmission is between Neutral and Earth, for maximum safety. It is envisaged that the central controller will be a microcomputer system to provide the necessary flexibility, although a special-purpose hardware controller could easily be built. The system described uses simplex (one-way) transmission from the controller to the receivers, which are situated at each plug, and performs reliably with a very low error rate. A modification is described for half-duplex (two-way) transmission, and this will permit information from remote sensors (such as a thermometer) to be sent to the central unit.

ONE ATTRACTIVE WAY of using a microcomputer is to devise a simple, computer-control system for domestic applicances, which can combine remote control of devices — like television sets, electric blankets, kettles — from a central unit, with timer facilities to switch any unit on or off automatically at preset times. Probably the biggest obstacle to the introduction of such a system into the home is the need for communication cables connecting the central control unit to the appliance, which might be in a different room. We really need a bus system to be installed around the house.

One solution to this problem is to transmit the control signals through the mains wiring. These signals can be picked up at any mains socket by a receiver which responds to unique digital address codes: the mains wiring constitutes the microprocessor's input-output bus. The plug-in receiver unit is dubbed an "intelligent* plug", and would ideally be housed in an extended 13A plug body, like those of battery eliminators used for calculators and radios. Using the mains as a data bus in this manner has the advantage that an appliance can be unplugged and moved to another part of the house where it will continue to function under automatic control. Plugs can be used to switch electric blankets, lights, radios, etc. from a remote microprocessor-based control unit. Furthermore, with duplex (two-way) transmission they can be incorporated as part of a heating system to relay temperature back to the computer and switch heaters on and off as necessary. The timing and logical capabilities of the microprocessor can allow control at preset times and under predetermined conditions (for example, if the kettle is switched on between 10 p.m. and midnight then the electric blanket is turned on!). When the house is vacant, one could arrange for lights to be switched on and off at intervals to simulate occupancy, as a burglar deterrent.

It appears to be perfectly legal to use the mains for data transmission in this way. Indeed, sometimes it seems that the only wiring the hobbyist can *not* use for signalling is the Post Office telephone system! Although the Electricity Generating Boards used to modulate the mains for signalling purposes, this was only between substations, and high-frequency signals cannot pass sub-station transformers. Eagle Electronics already sell baby alarms which operate on this ingenious principle. Indeed, intelligent plugs have recently been advertized on the computer hobbies market in the USA (we did not know this when we started the project a year ago).

This article describes the design and construction of an intelligent plug receiver and associated transmitting system. The work was undertaken as a final year student project by the first two authors in the Department of Electrical Engineering Science, University of Essex. Two working systems were constructed. The first is a simplex (one-way) system, capable of remote control and also of text transmission, using the ASCII code with normal asynchronous serial transmission. This operates at 1200 baud over a distance of several hundred metres, with an error rate of the order of 0.01%. The second system uses half-duplex transmission, with the same carrier frequency and an agreed polling protocol, which ensures that simultaneous attempts to transmit do not occur. The controlling microprocessor is capable of detecting when a device is unplugged, with a simple time-out program.

Several interesting system problems arise from the intelligent plug. For example, what happens if your neighbour installs the system? Can he control your home, and you his? Because of practical difficulties inherent in the nature of a student project, this question was not investigated. If house-to-house interference does prove to be a problem, it may be overcome by using different carrier frequencies in neighbouring homes, or by prefixing each transmission with an address byte to identify the house. The ability to transmit from house to house could be very useful — we know someone who uses his baby alarm when at parties across the street! — but obviously poses severe safety and security problems. Logical rather than physical solutions like those proposed above may well fail to meet adequate standards of safety, and one may have to resort to low-pass filters at the consumer unit where mains electricity enters the house. As mentioned, these issues were not tackled in the present project, but if intelligent plug systems were installed on a large scale they would certainly have to be faced. Some guidance or even legislation from the Electricity Generating Boards would be most welcome.

Another issue which was investigated is error performance in noisy environments. For example, an old and worn electric drill caused considerable degradation when plugged into a socket beside the transmitter (about 30% errors, almost all of which can be avoided with a single-bit parity check), but the effect decreased substantially when the drill was located two or three sockets away.

The standard a.c. mains system uses three wires: live, neutral and earth. This gives a choice of three different pairs of wires to choose when considering a mains transmission system. Wireless 'intercoms' commonly use live and neutral for transmission but this requires an isolating transformer and filter to remove the 240V a.c. signal. Isolation and filters are also required for transmission between live and earth, but not if neutral and earth are used.

Mains electricity is distributed in a three-phase system, with adjacent houses usually connected to different phases so that every third house is connected to the same phase. The neutral and earth wires, however, are common to all phases as far back as the 11kV distribution transformer at the substation, which is arranged in the delta-star configuration shown in Fig. 1. If the intelligent plug used the live and neutral pair, interference could only occur between every third house along the street whereas, since neutral and earth are common to all phases, a transmitter using these wires could affect every house. Although this may be seen as a partial solution to the problem of house-to-house interference, it is certainly not an adequate precautionary measure and so was not judged to give any substantial advantage to live-neutral transmission. Surprisingly, perhaps, when considering the configuration of Fig. 1, there is sufficient impedance in practice between neutral and earth to permit a carrier to be transmitted. There is only a small amount of mains hum present compared with that between live and neutral.

To help determine the best operating frequency and pair of wires to be used, a series of tests was made to measure the characteristics of the mains. The impedance and attenuation of a 20m section of wiring in our laboratory were measured using both live-neutral and neutral-earth pairs. The live and earth pair was not tested, since it seemed to offer no advantage over live and neutral, and had the risk of shorting live to earth under fault conditions.

The impedance and attenuation characteristics were very similar for transmission between neutral-earth and live-neutral. The graph of Fig. 2 shows a marked peak in impedance at about 300kHz, falling off rapidly at higher and lower frequencies. Since using neutral and earth has the advantage of safety, it was decided to use this pair.

It is worth noting that considerable variation is to be expected in mains impedance from place to place: we have not conducted tests outside the laboratory. However, we anticipate that the neutral-earth and live-neutral pairs will have similar characteristics, and recommend that the former be used, although the transmission frequency of the system may have to be altered if the mains impedance in domestic environments differs dramatically from our laboratory measurements.

Modulation technique

Because the impedance of the mains wiring is very low at d.c. and audio frequencies it is not feasible to transmit baseband digital signals directly: the signals must be modulated onto a carrier at a suitable frequency. There are three different types of modulation of digital signals in common use: amplitude-shift keying, phase-shift keying and frequency-shift keying. The choice of modulation type was made with the following criteria in mind:

—modulator and demodulator should be simple and inexpensive.
—mains is not suitable for transmission of frequencies below 50kHz because of its low impedance.
—bandwidth available is quite substantial — much more than is used for data transmission over telephone circuits.
—electric motors, fluorescent lights, and so on cause large noise signals to appear on the channel.
—signal level varies over a wide range depending on the distance between transmitter and receiver.
—large 50Hz signal and some harmonics appear in the channel.

The simplest way of modulating a digital signal is amplitude-shift keying, where the carrier amplitude is switched between two levels, usually on and off. This method is not widely used in data transmission systems because changes in channel gain can cause a 0 to be interpreted as a 1 unless the receiver threshold is variable. It is also rather prone to interference and noise.

With phase-shift keying, the phase of the carrier is switched, depending on whether a 0 or a 1 is being sent. This requires coherent demodulation and so the demodulator circuit is rather complex and expensive. It has the advantage that the carrier is transmitted at a constant level; furthermore its power spectrum contains no line components, and so all the transmitted power conveys information. This gives a good error performance at low power.

With frequency-shift keying two frequencies are transmitted, one to represent 0's and the other to represent 1's. The modulated waveform has constant amplitude, and the detection threshold need not be varied if the signal strength changes. Frequency shifts are easy to generate and detect, and so this method was chosen as the

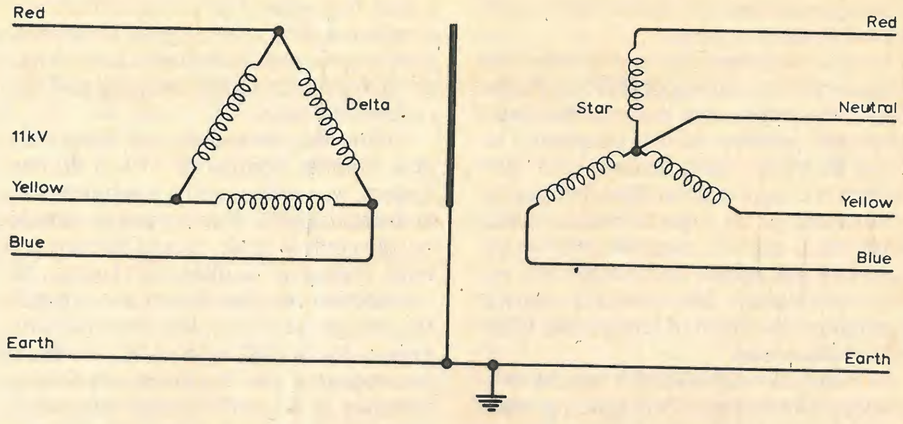

Fig. 1. *Power distribution at the electricity substation.*

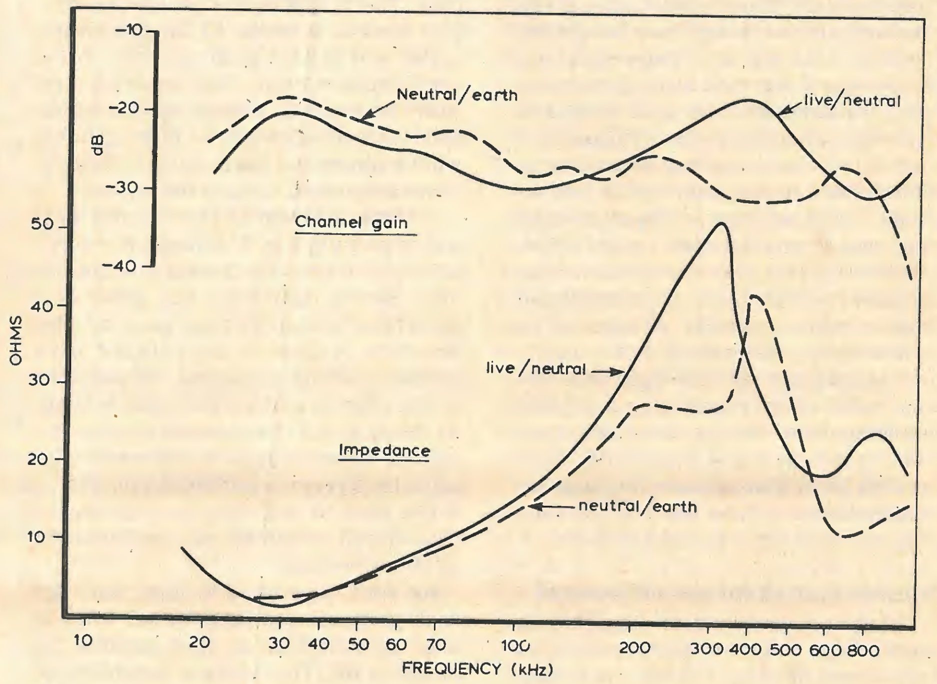

Fig. 2. *Impedance and channel gain versus frequency for live-neutral and neutral-earth pairs, measured in the laboratory.*

* "Intelligent" is used in the same hopelessly optimistic way here as in advertisers' "intelligent terminals", "intelligent v.d.us". It does not imply that the plug can pass IQ tests!

most appropriate modulation technique for the intelligent plug.

It was decided to use a carrier frequency in the region of 150kHz. From Fig. 2, the impedance that the neutral-earth pair presents at this frequency is about 20 ohms, quite suitable for the output of a power amplifier. If data is transmitted at as high a rate as 9600 baud, each digit is represented by 15 cycles of the carrier and so should be detected reliably. Also, 150kHz and its harmonics are clear of the public BBC radio frequencies.

In order to minimize the bandwidth used by the system, the spacing between the two tones used for frequency-shift keying should be as small as possible consistent with reliable reception. The Nyquist theory imposes a minimum bandwidth for transmission at a given rate, and no advantage is to be gained from increasing the tone spacing significantly beyond this minimum. Note, incidentally, that this contrasts with the situation for frequency-modulated transmission of analogue information, where bandwidth can be traded for an increase in signal-to-noise ratio, and the modulation index, which is defined as the peak carrier deviation expressed as a fraction of the baseband frequency, is generally chosen to be substantially greater than 1. We used a tone spacing of twice the digit rate: this was found to give perfectly adequate discrimination and at the same time does not use excessive bandwidth. With the 1200 baud transmission rate that we used for the prototype, this leads to tone frequencies of 150kHz and 152.4kHz.

Simplex system for on/off control

A simplex system, which implements transmission from the central controller to receivers in plugs around the house, is adequate for remote control applications, provided that feedback control is not required. For example, it is perfectly capable of switching a light or heater on or off either directly on command from the operator, or after a certain delay, or at a pre-specified time of day. If feedback control is needed, for example when monitoring heat or light levels with remote sensors to determine whether to switch on or not, or when detecting whether a "switch-on" command has actually taken effect, or whether a device is plugged in or not, then a two-way communication channel is required between the plug and the central controller.

Noting the cheapness and simplicity of a simplex, compared with a duplex system, we recommend it for home use, at least initially. Furthermore, simple on/off control is all that is needed for most domestic appliances. Hence, in this section we describe in some detail the design of a simplex transmission system for on/off control. However, it incorporates the features needed to enhance it to half-duplex operation (two-way but not in both directions at the same time), and we show later how to take advantage of this by adding a transmitter unit to the receiver in each plug. The component cost of the simplex system is about £3 for the transmitter and £14 for each receiver. For a very cheap system, one receiver can easily be made to switch several appliances at little extra cost — although this will be somewhat inconvenient if appliances are moved around the house.

A block diagram of the simplex system is given in Fig. 3. A Nascom microcomputer forms the central control device. Binary data from the serial line interface which forms part of the Nascom system is modulated into frequency shifts, amplified, and applied to the neutral and earth mains wiring. At the plug end the receiver detects the signal, demodulates it, converts the serial bit-stream to parallel form, and — if the data so indicates — activates a triac circuit to switch the appliance on or off as required.

An 8-bit data word is used, and for each plug one pre-determined word is used to switch it on and another to switch it off. This gives a capability of controlling 128 separate devices — although for economy only 4 bits, corresponding to on/off control of 8 devices were decoded in the prototype circuit which we describe.

Transmitter

The transmitter accepts t.t.l.-compatible logic pulses from the serial output port of the Nascom microcomputer and modulates these into a frequency-shift-keyed waveform, which is amplified and fed into the mains wiring. To minimize radio interference, the transmitted waveform should be as free from harmonics as possible, and so a sinewave output is desirable. A pair of fixed-frequency, sinusoidal oscillators could be used for transmission by switching the output from one oscillator to the other with the digital waveform. A simpler method is to have a single, voltage-controlled oscillator and to use the digital signal as the control voltage.

The low cost and ready availability of single-chip, voltage-controlled oscillators led us to use one, the Signetics NE566, for the prototype. This generates triangle waves, which have a strong fundamental with fairly low harmonic content. Still, substantially greater bandwidth is used than with a sine oscillator, and if it were intended to have different systems with different frequencies within a house, of if house-to house interference became a problem and different transmission frequencies were used in each house to eliminate it, we would revise our decision and reconsider sinusoidal transmission. The operating frequency of 150kHz is chosen so that harmonics do not fall on BBC transmission frequencies. In addition, the harmonics are filtered somewhat by the frequency response of the amplifier, and tend to be attenuated by the mains wiring. No radio interference trouble was experienced with the prototype.

The transmitter circuit is shown in Fig. 4. The first stage contains the 566 waveform generator and the components necessary to set the operating frequencies. Pin 5 of the 566 provides voltage control over the waveform frequency. It is driven from the logic output of the Nascom serial line via a potential divider, and the 100kΩ variable resistor controls the tone spacing. The 22kΩ tuning potentiometer is in the feedback loop of the 566 oscillator and sets the carrier frequency. This should be adjusted first, with the logic input high, to give a frequency of 152.4kHz. Then the logic level should be reversed and the 100kΩ resistor adjusted to give the lower tone of 150kHz. The controls interact slightly, so the procedure should be repeated until both frequencies are correct.

The output of the waveform generator is coupled to the input of a simple power amplifier, whose gain is controlled by the 220Ω resistor — we left it variable for experimentation. Additional circuitry is incorporated to remove the base bias from the output transistors so that the output appears as a high impedance to mains signals. This allows the transmitter output to be disabled in a manner analogous to tri-state driving of a bus line. The output enable/disable control is connected to a programmable (P10) line in the Nascom, via a buffer gate. To minimize the possibility of interference with radio or other devices, the transmitter output is disabled when not in use. This also provides the control necessary for half-duplex operation, discussed later.

Demodulator

The receiver uses a phase-locked loop to detect the frequency-shift modulation. The modulated signal is multiplied by the output of a voltage-controlled oscillator, and the result is low-pass filtered, amplified, and fed back to the oscillator control input. Any change in the frequency of the incoming signal causes a corresponding change in the control voltage applied to the oscillator. Thus, the control voltage itself represents the demodulated binary data. Demodulation using a phase-locked loop gives excellent signal-to-noise performance, even when the carrier is weak compared with the channel noise. The loop is available cheaply as a single integrated circuit — we used the Signetics NE565.

The block diagram of Fig. 3 shows how the receiver is organized. Mains isolation is achieved by capacitive coupling at the input to the bandpass filter. The filter rejects out-of-band noise and improves the error performance of the receiver — in particular, it helps to reduce the effect of impulsive noise on the phase-locked loop. A limiter removes amplitude fluctuations from the signal prior to detection by the phase-locked loop. The control voltage of the local oscillator, which is the demodulated binary signal, is further filtered and passed to a comparator which provides a t.t.l.-compatible output. A circuit diagram of the demodulator is given in Fig. 5.

Bandpass filter. An active filter of the "negative-immittance converter" type is used. This is cheaper than a corresponding passive circuit, and incorporates some gain, so that a passive limiter can be used as the next stage. The negative-immittance converter provides a high Q—31.5 for our design — whilst being relatively insensitive to component stability. A detailed discussion of the filter is given by Clayton[2]. Ours is centred on 151.2kHz, the mean tone frequency, with a 3dB bandwidth of 4.8kHz to encompass the two tones. The usual 741 operational amplifier does not provide a sufficiently high gain-bandwidth product for our requirements and so an RCA 3130 is used. This needs an external compensation capacitor which is shown on the circuit

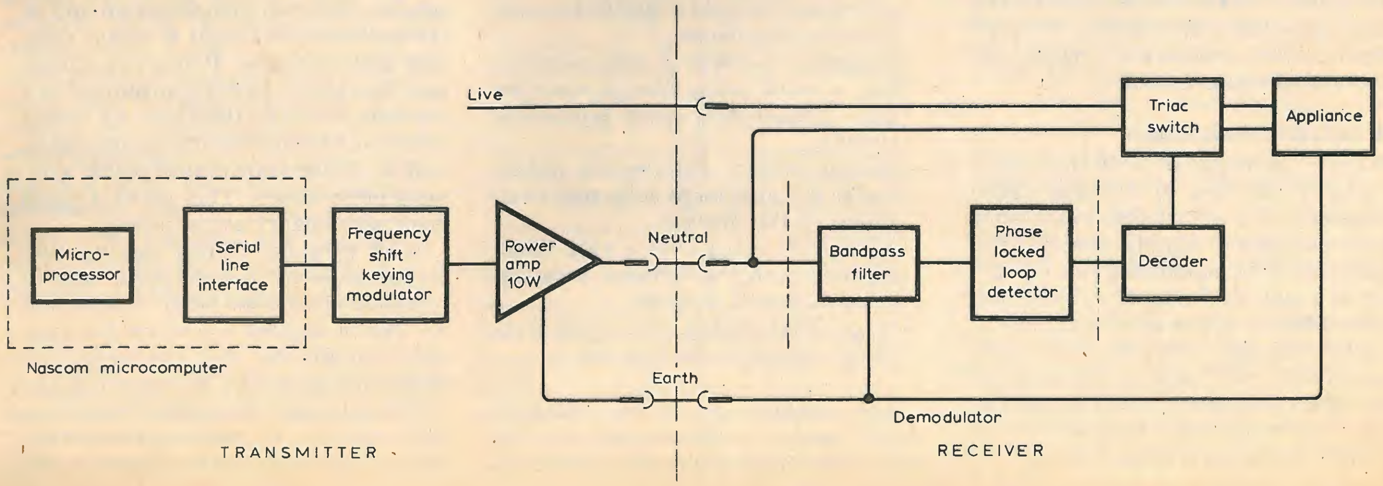

Fig. 3. *Block diagram of the simplex transmission system.*

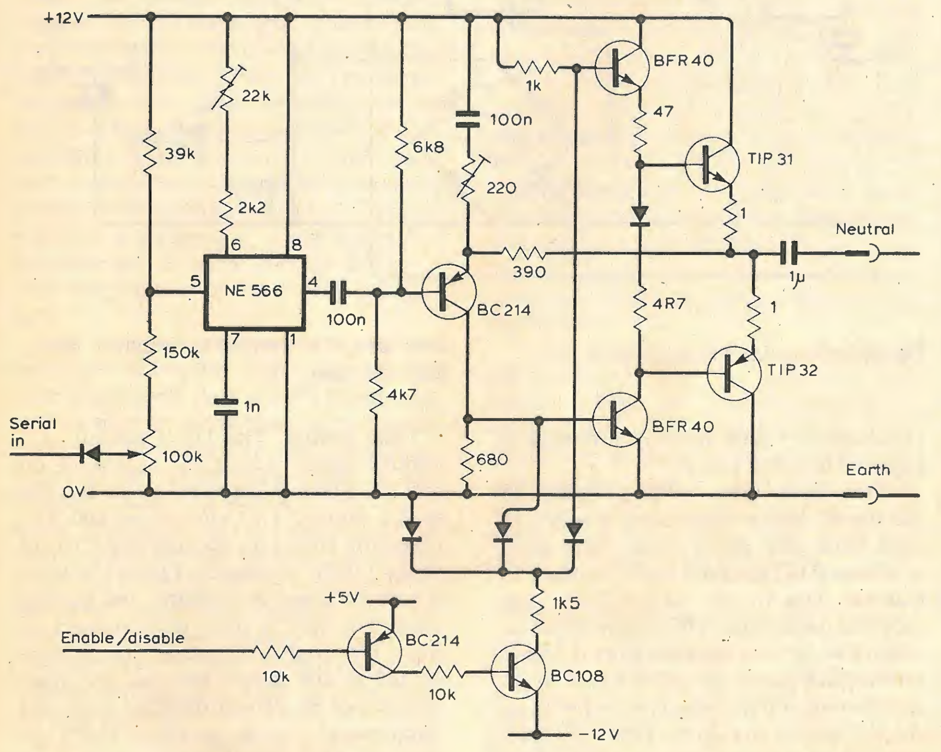

Fig. 4. *The transmitter circuit.*

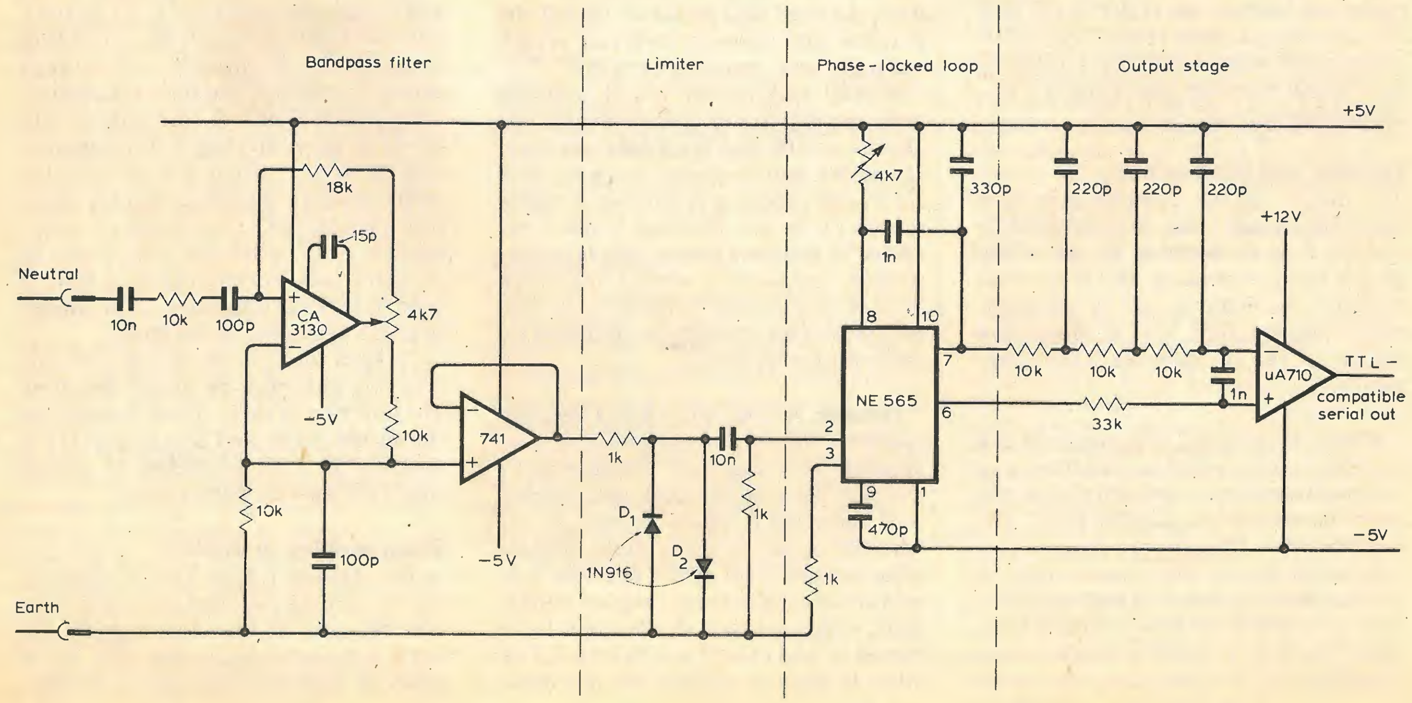

Fig. 5. *The demodulator circuit.*

The variable 4.7kΩ resistor controls the Q and will need to be adjusted if the tone spacing is altered, for example, to permit data transmission speeds greater than 1200 baud.

Limiter. The filter output has a very high impedance since it is taken from the inverting input of the operational amplifier. Hence, it is buffered by a unity-gain 741 before being limited by two silicon diodes and a resistor. It is important that the input level to the NE565 stays below 3V to ensure that the phase detector is operating in its linear region. The limiter produces a square wave of 1.2V peak-to-peak, providing that the received signal on neutral-earth does not fall below 40mV.

Phase-locked loop. The NE565 is a general-purpose phase-locked loop, and is suited to frequency-shift keying detection. Capacitive coupling is used at the input. The 4.7kΩ variable resistor allows fine tuning of the centre frequency, which is arranged to be 151.2kHz.

We will not describe the detailed design and operation of the phase-locked loop here (they are discussed in reference 2). The 330pF capacitor controls the damping of a low-pass filter. There is a trade-off between the short-term memory provided by the filter, which helps the loop to remain in lock if a momentary loss of signal occurs, and the speed with which the loop adjusts to keying shifts. A value of 330pF gives a damping factor of about 0.8, which results in a time-constant of 1.2 μs. The rejection offered to sum frequencies at around 300kHz is about 12dB, which is sufficient for loop operation.

Output stage. The phase-locked loop leaves a residue of double the carrier frequency in its output. This is attenuated by a passive low-pass filter with a 3dB band-edge at 78kHz, halfway between the keying rate (1200 baud) and the tone frequencies (150kHz). A 710 comparator completes the analogue part of the receiver, providing a t.t.l.-compatible output.

Decoder and triac switch

The output of the demodulator is a serial bit-stream. This is converted to parallel format, decoded to see if the plug is being addressed, and if so, used to switch the mains supply to the appliance appropriately. Fig. 6 shows the circuit of the decoder and the triac switch.

U.a.r.t. At the heart of the decoder is a u.a.r.t. – universal asycnhronous receiver-transmitter – which converts a serial bit-stream to parallel form. We used the AY-5-1013, simply because one was available in the laboratory: a c.m.o.s. device would be a better choice, since it requires less power supply voltages. The u.a.r.t. needs a clock whose frequency is 16 times the baud rate (19.2kHz for 1200 baud), and this is supplied by a 555 timer.

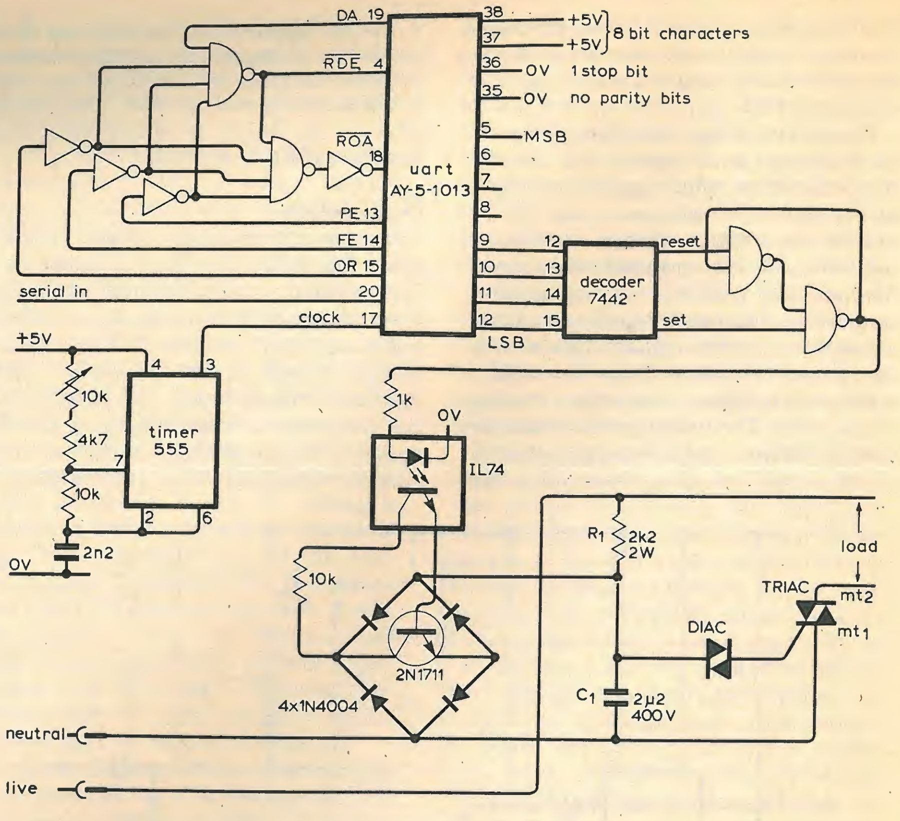

Fig. 6. *Decoder and triac switch.*

When the receiver holding register of the u.a.r.t. has accumulated a word of data from the serial input, the data available (DA) pin goes high. In order to transfer data to the output lines, the received data enable (RDE) pin must be taken low. It was decided that if frame errors (FE), parity errors (PE), or overrun errors (OR), occurred, the plug should ignore the data. This is implemented by the 4-input NAND gate, which feeds the RDE pin. When the data has been strobed to the output pins by RDE, the reset data available (RDS) pin is taken low to avoid overrun errors when the next character arrives.

Several pins on the u.a.r.t. require programming to suit specific needs. We use one stop bit (pin 36), 8 data bits (pins 37 and 38), and no parity checking (pin 35). Parity checking is omitted because the u.a.r.t. in our Nascom is not connected to generate parity: this is unfortunate, because it would increase further the overall reliability of the system, and we strongly recommend its use in future versions.

Decoder. A 7442, 4-to-16 line decoder examines the output of the u.a.r.t. and decodes "on" and "off" commands to the plug. Four of the data bits are not used, although it would be easy to extend the circuit to allow more addressable devices. Two of the decoder outputs are latched in cross-coupled NAND gates, which are set if the device is to be turned on and reset if it is to be off. The other 14 decoder outputs are not used: they provide control over plugs other than this one.

Triac switch. The latch output is a control signal to turn the appliance on and off, a triac being used to switch the mains supply. This should be 400 PIV minimum and of an appropriate current rating for the appliance. Firing the triac is accomplished by pushing and pulling current from the gate with respect to main terminal 1. Because this is connected to the mains neutral, the triac should not be driven directly from the latch output – to do so would short the neutral-earth signal path. Instead, an opto-isolator (Litronix IL74) is used.

The triac operates as follows. When live is positive with respect to neutral, current flows through R_1, charging capacitor C_1. Eventually, the voltage across C_1 reaches the diac breakdown voltage (33V), and C_1 discharges into the triac gate, driving it into conduction. Similarly, when live is negative with respect to neutral, current is taken from the gate until the voltage across C_1 reaches −33V, when the triac is driven on again. Load current can thus flow in both directions. Capacitor C_1 is chosen to give a negligible phase angle.

To keep the triac in an off state the charging capacitor is simply shunted. The direction of this current depends on the mains cycle, and so the 2N1711 is mounted in a diode bridge, to ensure that it remains forward-biased.

From simplex to duplex

A full-duplex transmission system, where the plug can send information to the controller at the same time as the latter is transmitting to the plug, could easily be created by frequency-division

multiplexing, so that different signalling tones are used for the two directions. However, with several plugs one would have to decide if they could all transmit at the same time, and if so, each would need its own operating frequency. This is cumbersome, and would increase tremendously the cost of the controller hardware, since receivers would be needed for each frequency. We decided instead to use a single pair of tones so that only one device can use the channel at any time. This is a half-duplex system.

With half-duplex, one must either ensure that two different plugs cannot send at the same time, or use a protocol which can tolerate garbled transmissions. The former approach is more suitable for this project, with each plug transmitting only on invitation from the central controller. (Use of the latter technique is briefly described in an earlier *Wireless World* article[1].) If any appliance is autonomous in the sense that it sometimes needs to initiate a transmission to the controller – as, for example, a thermostat might when the temperature exceeds certain limits – then the controller must poll it regularly.

One simple and useful mode of operation of a half-duplex system is for each plug, upon receipt of a command word which it recognises, to transmit the same word back to the controller. This lets the controller know if the correct device has received the command. If the reply has not been received after a certain (short) time then the controller must try again, whereas if an incorrect word is returned, due to transmission errors, it must reassert the intended state of the erroneously addressed appliance as well as repeating the transmission.

Another useful facility is a manual over-ride switch at each plug. With simplex transmission, an appliance is switched only from the central controller. Suppose you fit a manual over-ride, so that you can turn off the electric blanket in your bedroom without waiting for the programmed switch-off time or going downstairs to issue a command on the control console. Then you must remember to reverse the switch in the morning so that the blanket will not be over-ridden when the controller turns it on at the predetermined hour the next night! However, with half-duplex transmission, the manual over-ride can be a push-button which signals *to the central controller* to switch off the device. Then the controller will always know the true state of each appliance. Note that this is an example of an autonomous change in state of the plug – the controller will need to poll regularly to detect when over-ride occurs. Incidentally, it will even be able to tell whenever a device is unplugged – since it will fail to respond when polled.

Technically, half-duplex transmission is quite a simple enhancement to the simplex system described above. An essential feature is the "disable" input of the transmitter which is implemented by the clamping diodes of Fig. 4. Each plug, and the central controller, should only enable its output when actually transmitting information.

At the plug end, the u.a.r.t. generates as well as accepts serial information. To echo each character received, the parallel output of the u.a.r.t. is strobed back into the parallel input (one bit being reversed by the manual over-ride switch if it is fitted), and the serial output is fed into a transmitter identical with that of Fig. 4. Of course, since only characters actually recognised by the plug should be returned, the strobe signal comes from the relevant outputs of the 4-to-16 line decoder of Fig. 6. The "end-of-character" pin of the u.a.r.t. is used to enable the transmitter. This line goes low half a clock cycle before the digits appear at the u.a.r.t. serial output, and is connected to the transmitter to disable it, once the byte has been sent. The transmitter output can switch on and settle in much less than half a clock cycle (25 μsec). The u.a.r.t. serial output controls the tone frequency of the transmitter.

At the controller end, the demodulator circuitry of Fig. 5 is replicated and connected to the microcomputer's serial input. Since the transmitter is much less expensive in components than the demodulator and decoder, the cost for a half-duplex system with several plugs is much less than twice the cost of a similar simplex system.

We would like to thank the Department of Electrical Engineering Science, University of Essex for providing excellent development facilities in the third-year project laboratory, and for its enlightened attitude to microcomputer electronics which gave a stimulating environment foir this work.

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2. Clayton, G. B., Linear integrated circuit applications, Macmillan 1975.

Warning notes

Points for experimenters to be aware of are: neutral is sometimes locally earthed by the supply authority in the phase multiple earthing system (p.m.e.); the equipment could interfere not only with the consumer's own appliances, but with the signalling equipment used by the authority; it may be found that the 10W r.f. power causes an unacceptable level of radiation. The L.E.B. uses 1W for a similar purpose — Ed.

ELECTRONICS 79

OLYMPIA – LONDON 20-23 NOVEMBER 1979

Electronic Components Show

The wares of about 380 firms — a third of them overseas companies — will be on show in London at the biggest electronic components exhibition to be held in Britain for two years. Called Electronics 79 and held at Olympia, 20-23 November, it is really a continuation of the series that used to be known as the London Electronic Components Show, which ran for the long period of 34 years. It is in fact an official event of the British electronic components industry, being sponsored by the ECIF (Electronic Components Industry Federation). Organizers are Industrial and Trade Fairs Ltd. Opening hours are 09.30h-18.00h each day, and entrance fee is £2.00, valid for the whole period.

The exhibition provides a shop window for the latest developments in components for communications, entertainment, science, industry, education, medicine, data handling, navigation, aerospace — a large range of applications both civil and military. Among active and passive components on show will be discrete semiconductors, integrated circuits, chips, assemblies, electrochemical components, non-electrical parts, hardware and materials, production equipment and tools, instruments, test gear and services. A computerised enquiry service will enable visitors to locate specific products by stand number references.

Concurrently with the exhibition the ECIF will be running a three-day seminar on "Components of Assessed Quality". This will take place in the Pillar Hall, Olympia, 20-22 November. The first day will be devoted to electromechanical components, the second to passive components and the third to active components, including microprocessors. There is a fee of £12.50 (including VAT) per day for this event. Proceedings of the full three days will be published at £12.50 per copy and will be available at the seminar. See Prestel page 45638.

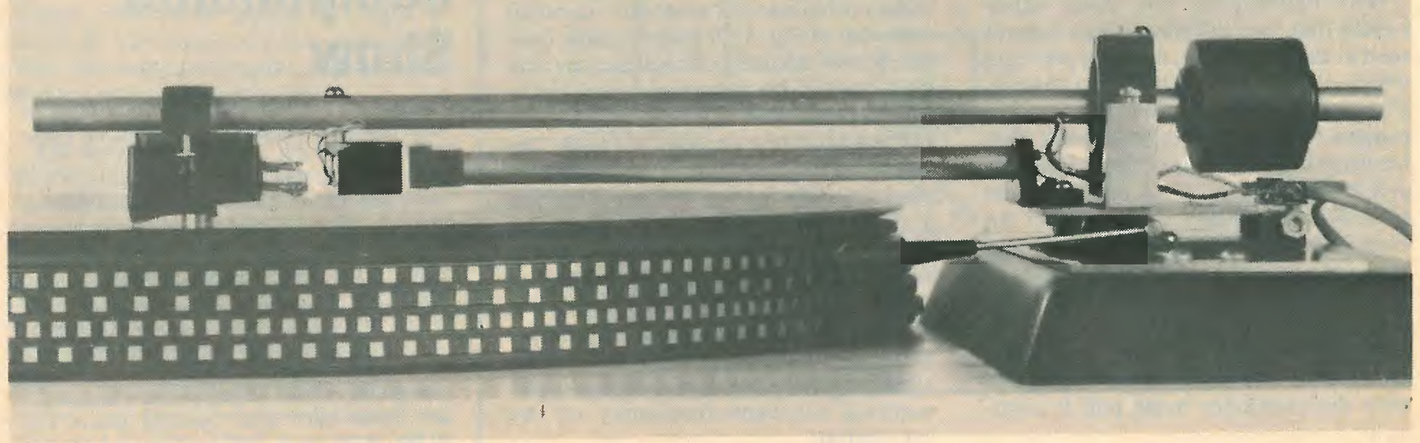
The following is a list of the categories of products that will be on show:

Aerials. Ancillaries and services for electronics. Batteries and power sources. Blowers and fans. Cables and wires. Capacitors, fixed and variable. Cases, cabinets, racks and fittings. Cathode ray tubes. Coils, inductors and transformers. Connectors, plugs and sockets. Electronic production equipment. Fasteners and fixings. Hardware, general electronic. Integrated circuits and microprocessors. Journals and other publications. Knobs, dials, drives and fittings. Loudspeakers, microphones, audio assemblies. Magnets and magnetic materials. Materials, metal, ceramic, plastic etc. Meters and indicators. Microwave components. Opto-electronic parts. Piezoelectric devices. Precision electronic instruments. Printed circuits. Power supplies. Relays. Resistors, fixed and variable. Semiconductor devices, transistors. Soldering equipment and materials. Switches. Test and inspection equipment. Thermionic valves and tubes. Tools and small appliances. Visual display devices.

Practical parallel-tracking pickup arm

Optoelectronic servo control gives low-inertia, fail safe operation

by Rod Cooper



Despite the many advantages of the parallel-tracking record deck, the high cost of owning one is a considerable deterrent to all but the well-heeled few. This fact prompted the design and construction of a pick up arm and control system with simplicity of construction specifically in mind. By avoiding complex engineering it is possible to construct the design described with non-specialized tools in about 40 hours. Part 2 will give detailed drawings, constructional hints and a source of supply for certain parts.

A CONVENTIONAL 9in pick up arm produces a tracking error of 2.3 degrees and hence a distortion figure of more than 0.7%. This is for an arm with optimum parameters so any discrepancy, whether by design of accident, will be sure to increase the distortion. The use of a longer arm to reduce tracking error is not the answer, because of increased inertia and, as Randhawa points out*, some manufacturers have now ceased production of long arms because of this. His article also highlights other shortcomings of the conventional arm, namely delay distortion introduced with elliptical styli, and the need for anti-skating compensation, plus lateral balance as well. These factors combine to make the conventional arm something of a dubious compromise, especially in the context of recent developments in almost every other branch of audio. Looking at it another way, the distortion introduced at this particular programme source make current efforts to produce amplifiers for example with vanishingly small harmonic distortion figure seem academic.

By adopting the servo-assisted parallel-tracking technique, all the undesirable effects of the conventional arm can be resolved at a stroke. This idea has been around for many years, but has remained a pipe dream because of the difficulties involved in manufacturing a reliable control system to keep the tracking arm on-station. Pivot-head arms as typified by Garrard's Zero 100, whilst reducing tracking error, do not solve all the problems and introduce some new ones as well. An anti-skating device is still needed, and inevitably the frictional forces involved in moving the arm across the record are increased due to the extra linkages. Also, the extra mass of the pivot-head mechanism increases the overall inertia of the arm, which goes against the principles laid down by Randhawa. It is interesting to note that the energy required to move the arm assembly across the record and thus actuate the pivot-head is derived from the record surface, whereas in the parallel tracking system the record is relieved from this duty altogether because the servo-motor supplies the energy.

An important benefit enjoyed by users of servo-assisted parallel tracking arms is much lower inertia of such arms. The tracking arm described has an effective length of 7.25in compared to 9in for a conventional arm. Now if $I_h = MR^2$ where I_h is the inertia of the arm about the pivot point, R the pivot-to-stylus length and M the mass of the arm, then substituting the values for R given above

I_h for parallel-tracking arms = 52 [illegible] M
I_h for conventional arm = $81M$

If M is equal for the two arms then the parallel-tracking arm shows a reduction in inertia of about 35%. In practice M can easily be made less despite the slight additional mass of the optoelectronics, because the arm is shorter to start with. Being short, less material can be used in its construction without loss of stiffness. An overall reduction in inertia of around 40% should be feasible. As the advantages of low inertia have been dealt with in detail in Randhawa's article, they are not repeated here.

Recently, with the advent of optoelectronics, a few manufacturers have produced workable parallel-tracking arms by using a light-operated switch mounted on a fixed reference arm alongside the actual tracking arm. Tracking errors are detected by the relative movement between the two arms and the error signal relayed to a servo motor. Unfortunately the production of an accurate light-beam, the alignment with it of an optical switch, and the integration of the two on a moving platform, usually requires precision mechanical and optical engineering far beyond the capability of most amateur constructors. These mechanisms are also very expensive, typically £450.

In this context, for a constructional project to be within the bounds of possibility, a different approach was clearly required, particularly for the switching device. The following list of requirements was drawn up. The switch should not add significantly to the mass of the arm, impose little or no loading on the tracking arm, have negligible hysteresis between switched states, and be fail safe, to prevent damage to records.

*Randhawa, T. S. Pickup arm design techniques, *Wireless World*, vol. 84 1978, March & April.

Several lines of enquiry were tried including capacitive and magnetic proximity switches but all suffered one drawback or another. However, two devices were developed, one an optoelectronic proportional control which is particularly suited to amateur construction as it needs virtually no optical engineering. The other device was developed after reading an article on the unique properties of mercury as used in frictionless switches†, and although very accurate and quite easy to make, is not really suitable as a constructional project, as it uses p.t.f.e., nickel and mercury, but it is described nevertheless as it may be of interest in other applications requiring a low-hysteresis microswitch.

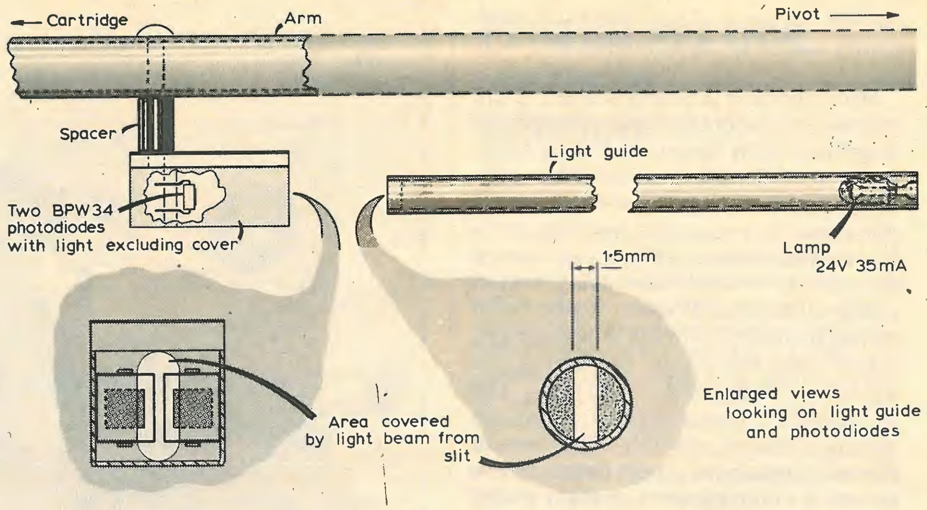


Fig. 1. *Lower reference arm is fixed to sliding platform pushed along a parallel track by motor-driven screw. Motor voltage is raised or lowered according to position of slit image on photodiodes.*

Optoelectronic system

Using the two-arm approach, a fixed reference arm and movable tracking arm are arranged vertically one above the other. The lower arm is the reference arm and is fixed to a sliding platform pushed along a parallel track by a lead-screw, details of which appear in part 2. The tracking arm is mounted on gimbals and holds the opto-switch in front of the end of the reference arm, which is a simple light-guide using an ordinary T1¼ filament bulb as a light source. A slit at the end of the tube produces a vertical beam of light 0.06in (1.5mm) across and 0.2in high which falls directly onto the sensitive face of two BPW34 diodes cemented side-by-side in a small holder attached to the tracking arm. Extraneous light is prevented from reaching the diodes by a shroud fitted over the holder. Fig. 1 shows the general set up, and it will be appreciated from the diagram that the small physical size and square shape of the BPW34 diode makes it perfect for this application.

The two diodes operate in a push-pull mode. When the light slit covers part of each diode equally, there is no effective output. When the slit moves to one side, an error current is produced which is fed to a simple current-to-voltage converter (the 741 in Fig. 2). The voltage output powers the tracking motor via an emitter-follower, and this voltage is either raised or lowered depending on which side of the two diodes the light slit moves. Vertical motion of the slit due to record warp has no effect. When there is no error current, the motor runs at a pre-determined speed corresponding to the average tracking speed, and is pre-set by the 2.2kΩ potentiometer and Tr_6. The 13V Zener diode simply limits the maximum voltage applied to the motor.

Besides excellent sensitivity, the advantage of using two diodes connected like this is that light falling on the unit from outside produces no error signal,

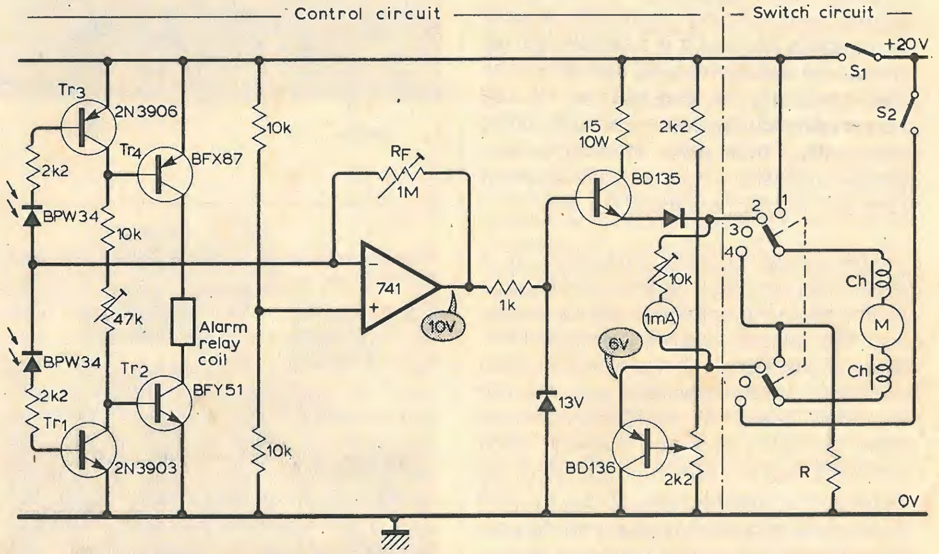


Fig. 2. *Motor runs at average speed set by 2k2 potentiometer. Variable resistor of 47k allows for spread in transistor H_{fe} and different types of relay. Switches S_1 and S_2 are microswitches; positions on rotary switch are fast forward 1, fast reverse 4 (select R on test), play 2 and stop 3. Chokes are motor interference suppressors.*

provided that the light is diffuse, is not so intense as to swamp diodes, and the diodes are reasonably well matched. In practice, this means that switching on the living-room light produces no adverse effect on the tracking system.

Transistors Tr_1 to Tr_4 form a fail-safe system. When light from the slit falls on both diodes, current flows in Tr_1 and $_3$, holding off Tr_2 and Tr_4 respectively and the relay remains de-energized. If the slit moves off one diode and on to the other, the relay remains de-energized as either Tr_2 or Tr_4 will still be fully turned off. However if the slit moves so far that neither diode receives light, then both Tr_2 and Tr_4 will turn on and close the relay. An alarm can then be triggered or the main power supply shut down, whichever is considered appropriate (I chose an audible alarm). The relay will only de-energize when the light slit is returned to the diode's field of vision.

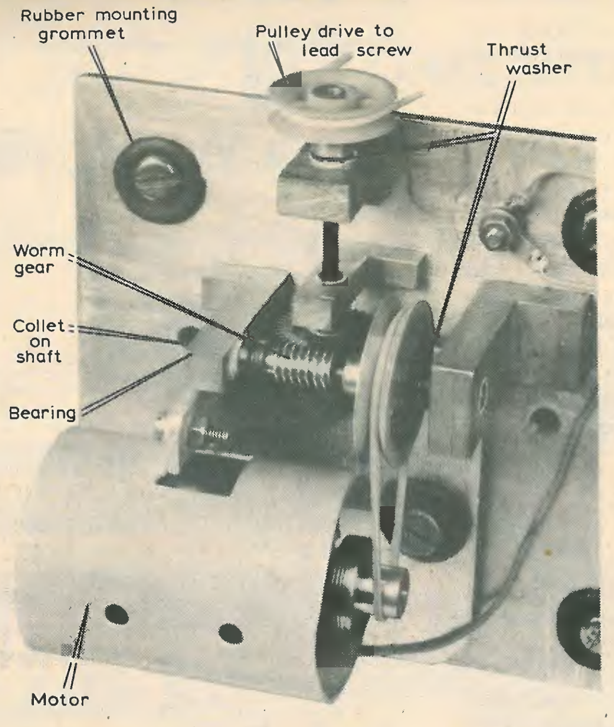
Normally the relay would operate only if there was a major failure of the tracking motor or the drive to the sliding platform, or if the filament bulb failed, or perhaps if the run-out groove at the end of a record is too large for the tracking motor to catch up. However, even if everything stops working, including the warning system, the tracking arm will still track the record as a conventional arm, albeit with rather poor design parameters. This should give confidence to those who would hesitate to trust their records to the mercy of a servo-system!

The system described avoids the use of lenses, prisms and mirrors, and greatly simplifies construction, yet is still very sensitive, and can switch the tracking motor from full-ahead to full-stop within ±0.2 degrees. The outline of the light beam is of course rather blurred at the edges and the intensity may not be uniform, but this does not in practice affect accuracy. This is determined by the differential action of the diodes and the voltage output of the 741 current-to-voltage converter which is $V_o = -I_{in} R_f$, where R_f is the feedback

†Linay, Engel & Gibbs. Mercury as a switching medium, *New Electronics*, 7 March 1978.

resistor in Fig. 2. Thus the basic sensitivity can be set by adjusting R_r.

Much greater accuracy than ±0.2 degrees may be obtained, even with this ill-defined light beam, but to a large extent it is pointless as record eccentricity begins to make itself felt at about this stage. To reduce the tracking error below ±0.2 degrees to cater for record eccentricity would mean using a fast-acting bi-directional servo system with no mechanical play in the moving parts, rather than the simple uni-directional system described, where the mechanical clearances are taken up during forward motion. The law of diminishing returns enters here, and the cost of a complex servo system would not justify itself when a much better solution of dealing with eccentric records exists. The meter included to monitor the voltage across the servo-motor will clearly indicate where eccentricity lies and it is a simple matter to enlarge the centre hole and place the disc centrally on the platter. If the eccentricity is the same on both sides, then with a little p.v.c. cement, a new permanent centre hole can be made to cure the problem once and for all.



Underside drive mechanism in original unit provides a 100:1 speed reduction from a 6-volt cassette-deck motor. Assembly details are left to the constructor and will depend on the components used.

The servo system consists of a motor-driven lead screw pushing a sliding platform, on which the two arms and the gimbal assembly are carried, along a parallel track via a mechanical coupling. At first glance it may appear easier to drive the platform directly from the lead screw and dispense with the track, but in practice it is difficult to produce a sufficiently straight and accurately threaded lead screw to prevent instability in the platform movement, for example side-to-side wobble. Even a hand-filed parallel track produces better results.

The motor originally used was a small 6V motor from a cassette deck and was resiliently mounted to avoid noise transmission to the tracking arm. Also to avoid noise, rubber belt drive was used from motor to gears and from gears to lead screw, giving an overall reduction of 100:1. The gearing used was a nylon worm gear, ideal because they require no lubrication, are silent in operation, produce the large reduction in a single step, and are easily assembled. Matched sets of 40:1 are available together with the associated hardware like shafts, bushes from good model shops.

When tracking a record, the motor drives the platform at a steady speed corresponding to the average rate of travel of the tracking across a typical l.p. record — about 3in in 15 minutes, say. To achieve this the voltage to the motor is pre-set as already explained. The opto-switch simply raises the voltage to the motor when the tracking arm lags behind the record, and reduces it to zero when the arm leads. The motor obviously has to have good self-starting properties for this system to work.

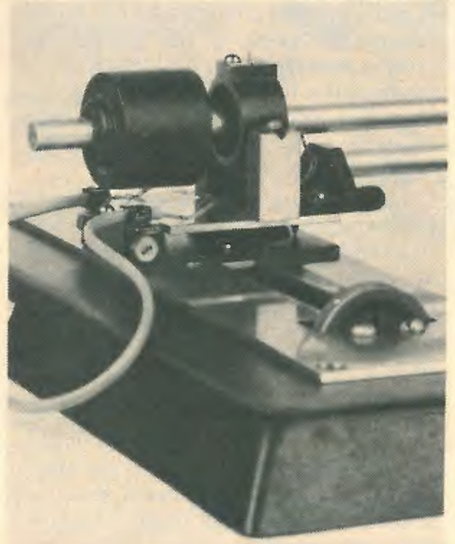
To return the arm to the starting position, the polarity of the supply to the motor is reversed and fed via a pre-selected resistor which limits motor speed to give a reasonable rate of return. On the prototype this was set at two minutes, which compares favourably with rewinding times for a tape recorder. For general use this may be too long, in which case it would be a good idea to incorporate a gear-change on the motor to speed things up. The prototype was used solely for transcribing disc to tape, hence two minutes was no problem.

For traversing fast forward, the motor is fed from the same pre-set resistor with the correct polarity. A microswitch at each end of the parallel track switches the motor off automatically at precise positions corresponding to the run-in groove at the start of the record and the end of the run-out groove at the finish.

To cue the arm at any point on a record, the sliding platform is constructed as two platforms hinged together. The lower platform follows the parallel track, and the upper platform carries the gimbals and the two arms. Cueing is achieved by tilting the upper platform through about 20° by means of a small cam underneath, operated by the cue lever. In this position the tracking arm rests lightly on a small bar on top of the reference arm, and records can be taken off, or put on.

Arm is cued by lowering hinged mounting platform; see part 2 for details. Meter is an essential part of design and indicates correct operation of the servo.

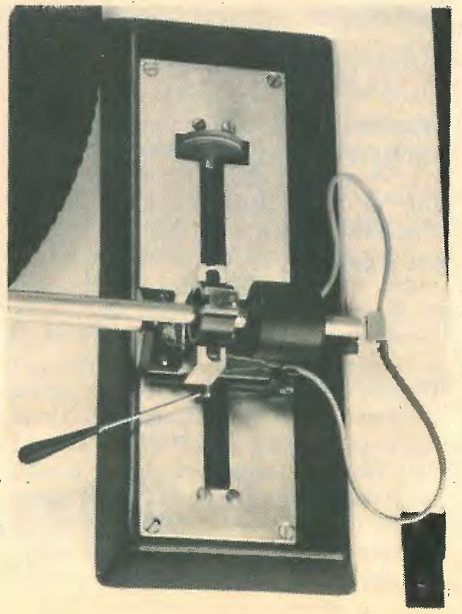
First constructional methods are not necessarily the best. Dual-purpose light slit with cue-bar to raise pickup arm (above) could be simplified; and author found simplifications could be made to the hinged platform, pivot pillars and gymbal, shown right and below (improvements in part 2).



Some accuracy is needed to make such a hinged platform, as the errors introduced by play in the hinge cannot be easily compensated for, and even a little play at this point can produce errors of one degree. A hinge consisting of a short rod pinched between two screwed pivot points can be designed to have no running clearance, but gives stiff operation. A compromise can be reached by screwing in the pivot points until the weight of the upper platform can just close the hinge. Such an arrangement does not wear very well, but any play can be readily taken up by tightening the pivots.

The MKL15 direct-drive motor and integral platter was chosen for the prototype as it was very easy to mount on a plinth and has excellent performance. With this turntable, the parallel track needs to be raised ½in or so for the tracking arm to be on the same level as the record, and a block of wood can be incorporated in the plinth to provide this raised platform.

To be continued



Photographs by A. McFaden.

Prestel service starts in London

Prestel, the Post Office's viewdata system, is now available as a full public service to 3½ million people in the Greater London area – to all those whose telephone numbers begin with 01 or are able to make local calls to 01 numbers (except those with shared-service or coin-box lines). The Post Office felt sufficiently confident to abandon the idea of a market trial, which we reported on earlier, and passed straight from their test service (which began in September 1978) to the full public service in October this year. Users can now access about 156,000 pages, from over 170 information providers, which are available at four retrieval centres within the London area: Wood Green (code name Juniper); Shoe Lane in the City (code name Byron); Ealing (code name Atlas); and Eltham (code name Vigilant). It will be noticed that the code names are revivals of old London telephone exchange names.

All these local retrieval centres receive their information from a single "update centre" at Clerkenwell (code name Duke), which was set up to enable the information providers to enter their information, and update it, at one centre only. This installation updates the four local centres automatically and almost instantaneously.

As we go to press the total number of users connected to the service is 1606. Of these 1082 are users who were asked by the Post Office to take part in the test service mentioned above. So far the total number of accesses made by users to the data base amounts to about 8,411,000.

The cost to the user of retrieving an information page is made up of three parts: (1) the charge for a telephone call to the local retrieval centre; (2) a time based charge for the use of the data base at the centre, which is 3p per minute between 8 a.m. and 6 p.m. Monday to Friday, or a cheap rate of 3p per three minutes between 6 p.m. and 8 a.m. Monday to Friday and all day Saturday and Sunday; and (3) a charge for each page retrieved on a system of prices ranging from 0p to 50p a page. In addition there is a £6 connection charge and 15p quarterly rental for the Post Office jack which links the telephone line to the viewdata television set. Users with a business line have to pay a further £12 quarterly charge.

Viewdata television sets, adaptors and business terminals are now available from about 16 manufacturers. As an example of the cost to a domestic user, the Decca 26in colour set CZ1096, which also includes teletext, can be bought through the central London dealer Tops TV Ltd for £1225, including two years' service, or hired from the same firm on a three-year lease for £45 per month plus v.a.t. (and £45 for the whole of the fourth year). According to one commentator, Richard Hooper of Mills and Allen Communications Ltd, this equipment side of Prestel is at present too expensive. Writing in *Viewdata and TV User* for October, he says "Prestel set prices must come down fast to ensure a large residential market ... But someone somewhere has got to make a heavy capital commitment to volume production for the costs to come down. There is no public evidence as yet that such a step has been taken."

WORLD OF AMATEUR RADIO

29MHz mobiles, repeaters and nbfm

During recent years there has been a considerable increase in amateur mobile operation using narrow-band-frequency-modulation in the 28MHz amateur band and a number of "repeaters" have been established in the USA, permitting long-distance operation with low-power mobile and hand-held equipment when the band is "open". According to Sam Voron, VK2BVS in the Australian *Amateur Radio* there is now increasing interest in this type of operation in many parts of the world, including Scandinavia, Japan and Australia. Factory-built equipment, including 80-channel 10-watt mobile transceivers, has recently appeared on the market although much of the activity is with modified c.b. units and surplus military v.h.f. sets; 144MHz to 29MHz "transverters" are under development, while several firms now offer n.b.f.m. adaptors for h.f. transceivers.

Activity is normally confined to "10kHz channels" between 29.3 and 29.5MHz. The American repeaters have 100kHz spacing between input and output channels, with the input channel on the lower frequency; some of these repeaters are "open" and activated by any incoming carrier, others use a variety of access tones, including some around 90-110Hz and others around 1950Hz. A repeater band plan lists four channels: Channel 1, 29.520MHz 'in' and 29.620MHz 'out'; Channel 2, 29.540MHz 'in' and 29.640MHz 'out' and so on. The frequency 29.6MHz is not used by repeaters but is a general calling channel. It should be noted that frequencies below 29.5MHz are used by satellites. The f.m. deviation should be limited to 3-5kHz. World-wide operation either direct or through the repeaters should prove possible for several years during the sunspot maximum period.

Vandals and interference

The problem of deliberate interference to amateur transmissions, including although not exclusively those through repeater stations, and vandalism of unattended equipment appears to be increasing world-wide (not amateur alone, a joint BBC-IBA television relay near Glasgow was wrecked by vandals a few months ago). The problems that have plagued the London GB3LO 144MHz repeater have been reported on previous occasions, but in recent months appears to have extended to include an element of physical violence.

Pierce Healy, VK2APQ in *Electronics Australia* reports that "in a completely moronic and pointless act of destruction" vandals destroyed a two-year project for the setting up of a repeater station on Mount Bindo in the Blue Mountains of New South Wales, serving a large area of the State and linking amateurs in the coastal areas with those in the plains west of the mountain range. Legs of the metal tower carrying the wind generator were sawn through at ground level causing the whole structure to crash to the ground and causing damage to the building housing the repeater. Previously, repeaters near Canberra and Melbourne have been vandalised, and an experimental moon-bounce project damaged.

Following many complaints and with co-operation between a Swedish amateur and Irish officials, a transmitter located in Eire that has for a considerable period deliberately interfered with 14MHz nets has been traced and closed down. On the West Coast of the USA the aid of congressmen has been enlisted to combat malicious interference.

Electronics Australia although it long campaigned for the introduction of c.b. radio in Australia has drawn attention to some questions that need to be faced if the service is not to become unpopular. The editor writes: "C.b. came to Australia a couple of years ago, amidst a tremendous barrage of publicity, supported by a whole range of people from 'progressives' through to businessmen who stood to benefit financially . . . but victory turned rapidly sour. C.b. users made headlines for obscenity, 'larrikinism', standover tactics and other questionable activities: the 'progressives' dropped it cold. C.b. ceased to be the 'in' thing and importers found themselves with huge stocks, which they had no hope of shifting in short order, even at giveaway prices — a problem that is still with us." It is recalled how c.b. lost public support as a result of a so-called "c.b. murder" and the role it played in an unpopular strike of lorry drivers. Since Australian c.b. is due to be moved from 27MHz to u.h.f. in July 1982 it is suggested that "c.b. certainly can't afford a repetition of these recent events: what it needs above all else is a low profile and improved internal discipline."

News from Holland

The national Dutch amateur radio station, PA0AA, transmits news bulletins and Morse code exercises in Dutch and English every Friday evening, with simultaneous transmission on 1827kHz, 3600kHz, 14,100kHz, 144.80MHz and 433.765MHz between 1900-2130GMT. An r.t.t.y. bulletin (45 baud) is transmitted at 2030GMT. The English-text news bulletins are at 1915GMT and 2115MT. Morse code exercises (in English and Dutch) are at 1930GMT (beginners) and 2000GMT (advanced). Code proficiency runs are transmitted at various speeds on the last Friday of each month at 2130GMT.

From all quarters

Italian stations have gained the world's 10GHz distance record in a remarkable series of contacts that progressively raised the record to 550km, 571km, 582km, 589km and then 633km. The 633km two-way contact was between 12FZD/2 and 14CHY/7 using 10mW Gunnplexers and 1-metre dishes.

The station PA0KKZ and a group of Dutch amateurs are now active on 24GHz with equipment including a home-built Gunn-diode oscillator with an output of 4mW and equipment made for amateurs by Microwave Associates.

24GHz beacons are likely to be installed soon at GB3IOW on the Isle of Wight and at GB3ALD on Alderney. A high-power beacon on 1296.83MHz which will radiate 400 watts e.r.p. from each of two aerials has been licensed with the call-sign GB3BPO and will be installed near Martlesham Heath. 10GHz beacons have been established at Leicester and Watford.

Over 80 per cent of the London centre candidates passed the first "multi-choice" Radio Amateurs' Examinations last May. The City and Guilds of London Institute have explained the long delay in announcing the results as being due to problems with new processing equipment and have stated that this will not occur again.

Peter Balestrini, G3BPT, who is to be the 1980 president of the RSGB has long been associated with the amateur radio emergency service, having been chairman of the Raynet Committee from 1967 to 1978.

Richard Thurlow, G3WW, of Wimblington, March, Cambridgeshire, has now confirmed two-way slow-scan television contacts with stations in 101 countries, representing contacts with more than 1300 different amateurs.

A new 190-page book, "Amateur Radio Operating Manual" edited by R. J. Eckersley, G4FTJ with contributions from over 30 British amateurs has been published recently by the RSGB. It includes much information, data and maps of value to h.f. and v.h.f. operators.

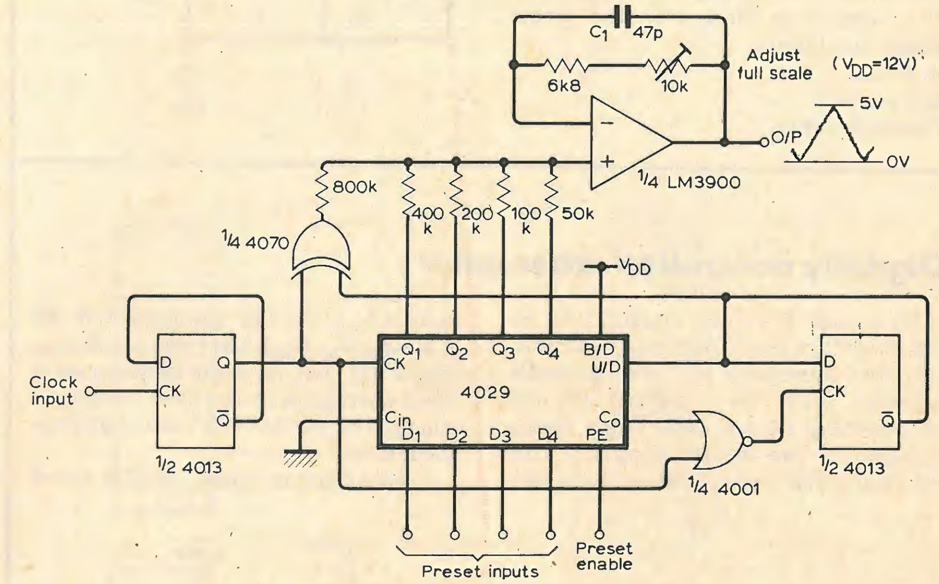
PAT HAWKER, G3VA

CIRCUIT IDEAS

Triangle-wave generator

A 30-step staircase approximation to a triangle wave can easily be achieved by using a c.m.o.s. up/down counter with 5-bit resolution. If 4-bit resolution is adequate, the exclusive-OR gate and the first flip-flop can be omitted. The most significant four bits can be asynchronously preset with extra gating. The weighted current outputs are summed in a Norton op-amp and C_1 suppresses glitches caused by the 3900's asymmetrical slew rate. Maximum operating frequency is limited by the 20μs/V negative slew rate. Note that the output period is 60 times that at the input and not 64. Accuracy is mainly dependent on the weighting resistors provided that the supply voltage is high enough for the 4029 outputs to source sufficient current.

T. Williams
Shoreham
Kent

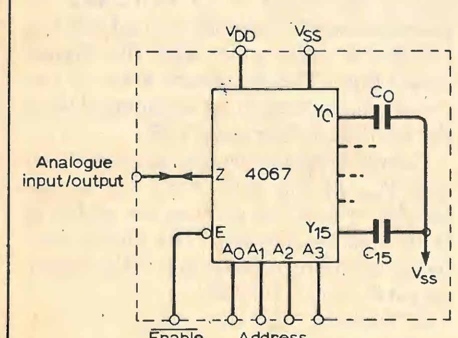


Analogue memory

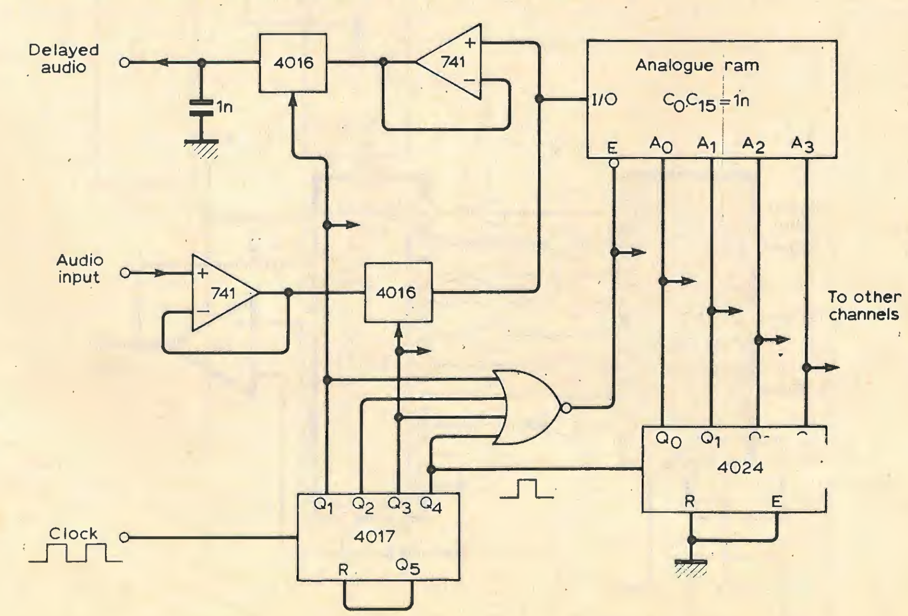
The bilateral multiplexer in diagram (a) is connected to an array of capacitors to form an analogue memory which functions in a similar way to a conventional r.a.m. Each sampling capacitor stores a charge which is dependent on the analogue input. Storage time is limited by the capacitor size, leakage current and permissible drift. With 1nF capacitors the decay time is several hundred milliseconds.

One application of this circuit is for variable audio delay as shown in diagram (b). With a sampling rate of 50kHz the delay is approximately 320μs, but this can be changed by altering the clock frequency. The memory is used in a read before write mode and effectively forms a serial shift register.

G. C. Hammond
Nuneaton
Warwickshire



(a)

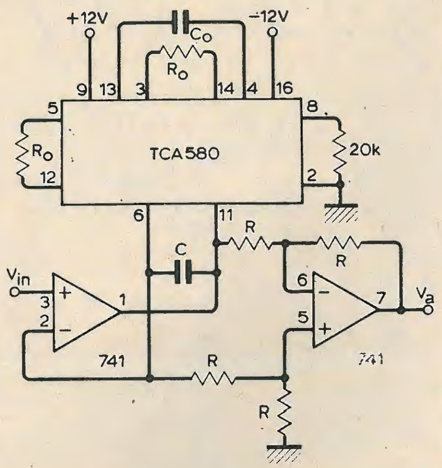


(b)

Band pass filter with high input impedance

By combining two op-amps and an i.c. gyrator a high input impedance band-pass filter can be built. The inductance simulated by the gyrator is $R^2_oC_o$ and the design equations are $L=R/2\pi f_oQ$ and $C=Q/2\pi f_oR$ where f is the resonance frequency. Bandwidth of the filter can be adjusted up to 10kHz where it operates with a low Q and high gain A. For $f_o=1.5$kHz, R is 10 kΩ, A is 100, L is 212.2 H and C is 53 pF. If L and C are connected in series, the circuit operates as a band-stop filter with the same design conditions.

K. Kraus
Rokycany
Czechoslovakia



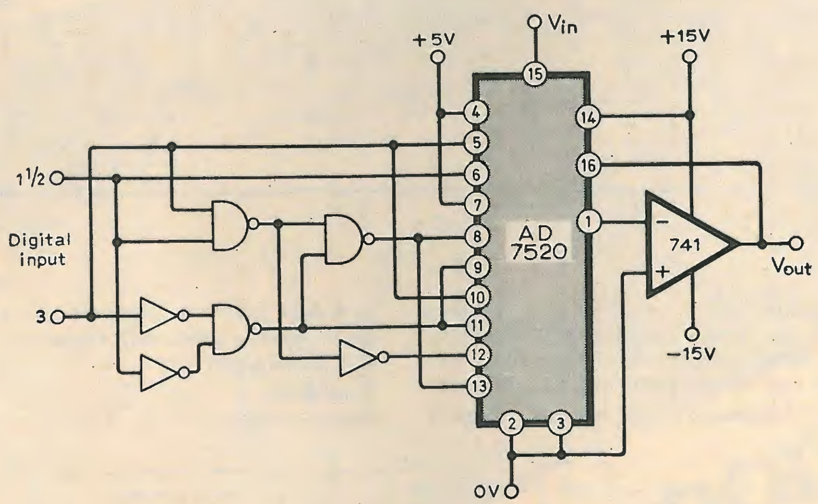
Digitally controlled attenuator

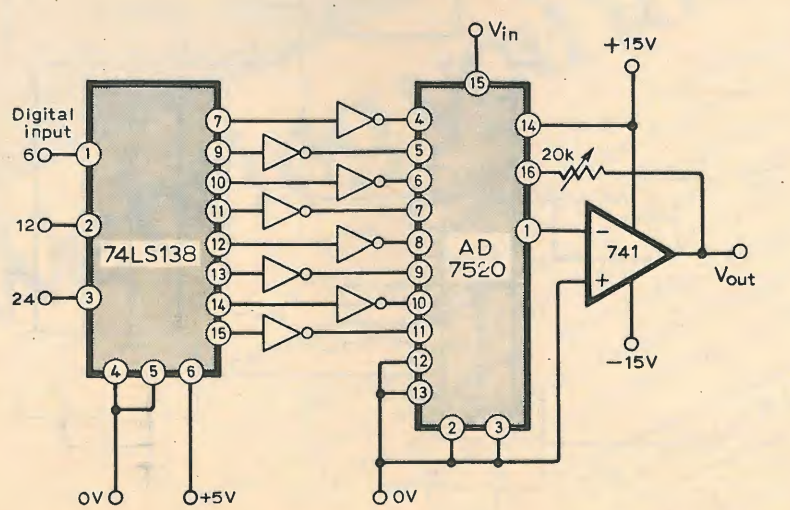
This circuit provides attenuation in increments of 1½dB from zero to 46½dB. The first attenuator is a zero to 4½dB version with two digital inputs representing 1½ and 3dB. Logic levels applied to the inputs program the AD7520 which then provides the correct ratio of V_{out}/V_{in}. The attenuation in dB is $20\log_{10}(V_{in}/V_{out})$. The circuit is shown with a 741, but for high frequencies a 318 or alternative can be used. Accuracy is limited by the AD7520, but the error is about 0.1%.

A second circuit uses a 74LS138 3-to-8 line decoder to provide attenuation from zero to 42dB, and three digital inputs represent 6, 12 and 24dB. A potentiometer is provided to adjust the circuit for unity gain with the digital inputs high. The maximum error of the circuit, neglecting those associated with the AD7520, is less than 0.5%.

Connecting the circuits in cascade so that V_{out} of the first feeds V_{in} of the second, creates an attenuator which is controlled by five bits. The circuit can be turned off by removing the 5V supply on pin 6 of the 74LS138.

S. R. Taylor
Ferranti Ltd

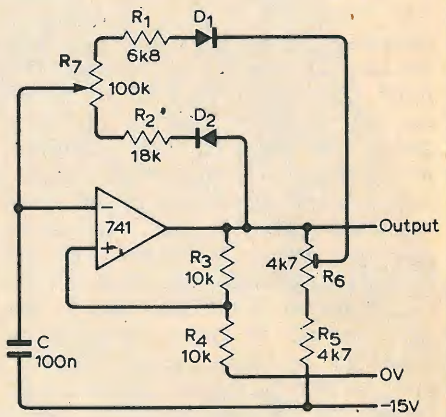




P.w.m. control

In a p.w.m. power controller it is difficult to achieve smooth control to maximum power with a simple multivibrator. A modification to the standard op-amp multivibrator provides smooth control from about a 15% duty cycle to full-on with an almost constant oscillation frequency.

The amplifier switches state when the voltage on C reaches the voltage at the junction of R_3 and R_4. Diode D_1 is fed from a potentiometer between the op-amp output and the -15 V rail. When the output is at -15 V, C discharges through R_7, R_1 and D_1. After the output has switched to +15 V, a current flows



through D_2, R_2, R_7 and D_1. The maximum voltage to which C can charge is dependant on R_6 and R_7 and if this is less than 7.5 V the op-amp remains in the same state.

With the wiper of R_7 at the top, R_6 is adjusted so that the circuit just stops oscillating, i.e. 100% duty cycle. If D_2 is fed from a potentiometer between the op-amp output and +15 V, the duty cycle can be varied down to zero. The output can be used to drive a switching transistor or thyristor.

D. K. Hamilton
Oxford University

L.e.d. display for 8080

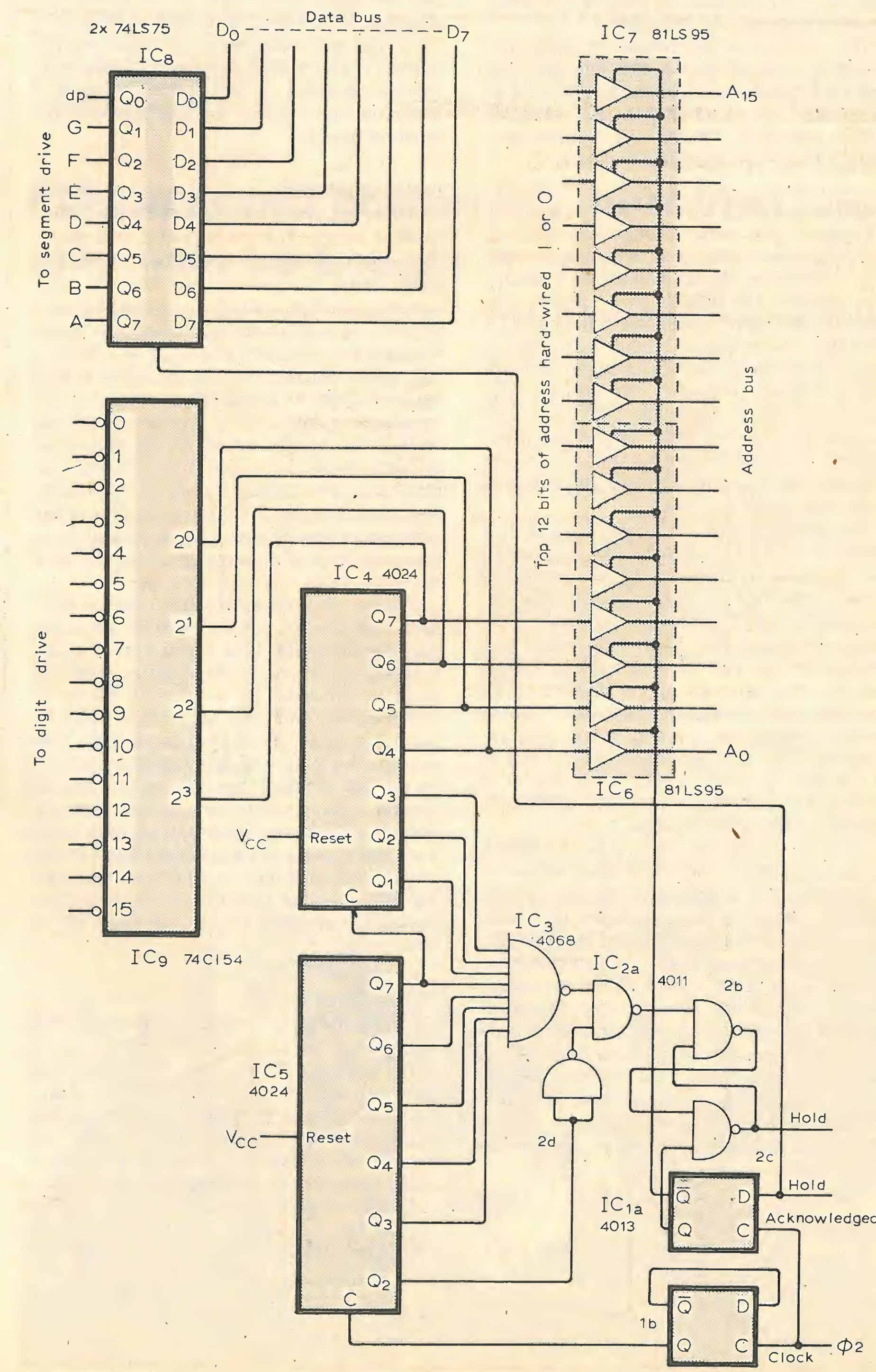
This circuit provides a low cost display for small 8080 based microprocessor systems. As all of the characters are generated by software, any symbol based on seven segments and a decimal point can be displayed. The HOLD input of the 8080 is used which sends the address and data bus outputs into the tri-state mode and allows peripherals to use the systems memory without interference from the c.p.u. Digit selection is dependent on the least significant four bits of the memory address generated by the circuit and the state of the segments is controlled by the output of the memory on the data bus. While the c.p.u. is not being held, the last received digit and segment data are stored in latches. A display buffer comprising 16 bytes of r.a.m. is required to store the information. However, if information is to be displayed in succession it is advisable to incorporate an incrimental loop to allow time for the display to be read. IC_{1b} IC_4 and IC_5 divide the clock to produce the lowest four bits of the display buffer (the upper 12 bits are hard wired into the circuit) and after decoding, the HOLD signal. Outputs from the dividers are gated to produce a pulse every 1ms which sets a flip-flop whose output feeds the HOLD input of the c.p.u. and remains until cancelled by a HOLD acknowledge. IC_{1a} delays the HOLD acknowledge signal because the address and data bus outputs from the c.p.u. become non-conductive after the HOLD acknowledge goes high. Segment data from the data bus is clocked into an 8-bit data latch by the HOLD acknowledge input and the digit to receive this data is selected by decoder IC_9.

The segment and digit outputs should be buffered and the clock should be derived from the Φ2 (t.t.l.) output of the 8224 clock generator or any t.t.l. compatible oscillator. The table of possible characters shown makes a very passable alphabet.

N. Granger Brown
Solihull
W. Midlands

CHARACTER	AS DISPLAYED	SEGMENTS USED	HEX CODE
A		abcefg	EE
B		cdefg	3E
C		deg	1A
D		bcdeg	7A
E		abefg	CE
F		aefg	8E
G		abcdfg	F6
H		cefg	2E
I		e	08
J		bcde	78
K		defg	1E
L		def	1C
M		abcef	EC
N		ceg	2A
O		cdeg	3A
P		abefg	CE
Q		abcfg	E6

CHARACTER	AS DISPLAYED	SEGMENTS USED	HEX CODE
R		eg	0A
S		acdfg	B6
T		efg	0E
U		cde	38
V		bcdef	7C
W		bcdefg	7E
X		bcefg	6E
Y		bcdfg	76
Z		ad	90
!		bcdp	61
?		abegdp	CB
.	.	dp	01
–	–	g	02
SPACE			00
"	"	bf	44
'	'	b	40



CHARACTER	AS DISPLAYED	SEGMENTS USED	HEX CODE
0		abcdef	FC
1		ef	0C
2		abdeg	DA
3		abcdg	F2
4		bcfg	66
5		acdfg	B6
6		acdefg	BE
7		abc	E0
8		abcdefg	FE
9		abcfg	E6

NEWS OF THE MONTH

WARC and the radio amateur

In January of this year the UK Home Office Radio Regulatory Division published a 300-page document containing the UK's proposals for WARC 79 (see p.57, June 1978 issue and p.47, July 1978 issue). Contained within this document were the UK administration's proposals for the radio amateur service into the 21st century. WARC, as readers may know, is currently in session, but by the time this issue is published the fate of the radio amateur may already be decided.

The portions of the frequency spectrum which are of importance to the radio amateur are, for convenience, 150kHz to 4MHz, 4 to 27.5MHz, 27.5 to 1215MHz, 1215MHz to 10GHz and 10 to 275GHz. We will consider each of these 'sub-spectrums' in turn.

150kHz to 4MHz

At present the radio amateur in the UK enjoys access to 500kHz of the sub-spectrum from 150kHz to 4MHz; 200kHz as a secondary service, and 300kHz as a primary service. The secondary allocation in the band 1.8 to 2MHz, means that the band may only be used for amateur operation under certain circumstances, to protect the primary services who share the band. This particular band does not permit r.t.t.y. operation either. In the 3.5 to 3.8MHz band, an amateur service may operate on a primary basis, sharing with fixed and mobile services.

It is proposed that the current 1.8 to 2MHz amateur band (the popular 160m 'top band') be deleted and replaced by an exclusive amateur-service allocation, but at the expense of a loss of bandwidth. At present the amateur shares this band with fixed and mobile services and UK and other administrations may allocate up to 200kHz to an amateur service within the band 1.715 to 2MHz, permitting a mean power not exceeding 10W. The new band, from 1.809 to 1.914MHz, is only 105kHz wide but it is intended to provide an exclusive worldwide allocation for amateur radio.

In the case of the 80m, 3.5 to 3.8MHz, amateur band the picture is even worse for the amateur. It is proposed that the present 300kHz, which the amateur shares with fixed and mobile services, be replaced by an 85kHz, 3.615 to 3.7MHz, exclusive amateur allocation and a 200kHz, 3.7 to 3.9MHz, secondary amateur allocation. The secondary allocation will mean that the amateur will not be guaranteed access to the band because the primary services, which would be fixed and mobile, would be protected first. It is proposed that the remaining band, 3.5 to 3.615MHz, be given to maritime mobile and land mobile services.

4 to 27.5MHz

As far as the sub-spectrum from 4 to 27.5MHz is concerned, the radio amateur stands to gain from the UK proposals. The 40, 20 and 15m (7 to 7.1MHz, 14 to 14.35MHz* and 21 to 21.45MHz) bands are expected to be retained, permitting amateur and amateur-satellite operation as before, but the amateur will probably be given new allocations at 30, 17 and 12m (10.1 to 10.2MHz, 18.568 to 18.768MHz and 24 to 24.3MHz). It should be noted that there is no proposal in the document to permit an amateur-satellite service access to these new bands. At present, the bands from 10.1 to 11.175MHz and 18.068 to 19.9MHz are allocated to the fixed service, and the band from 23.35 to 24.99MHz is allocated to the fixed and land mobile services. The new bands were proposed mainly to meet the increased demand for frequency space for amateur radio, but the 17m band is also required to reduce the gap between the amateur bands.

27.5 to 1215MHz

No major gains are to be made by the radio amateur in the 27.5 to 1215MHz sub-spectrum proposals. The 10m (28 to 29.7MHz) band, which is allocated for amateur and amateur-satellite operation, should be untouched, and although the amateurs were hoping for a proposed allocation at 50MHz, one was not forthcoming. At the moment the 6m band from 47 to 68MHz is allocated to broadcasting, but the UK proposals suggest a reallocation to the broadcasting and land mobile services. Some see in this the remote possibility that the land mobile permit might be a way towards a 6m band for the radio amateur, even though this proposal was made to meet the growing needs of land mobile services in some countries.

The 4m, 68 to 74.8MHz, fixed and mobile band and the 2m, 144 to 146MHz, amateur and amateur-satellite band remain untouched. At present the 70cm, 430 to 440MHz, band is allocated on a primary basis to radiolocation and on a secondary basis to amateur radio. It is proposed that this remains the same, which is a disappointment to the UK amateur because in the rest of Region 1 the amateur service has primary access to this band. The proposal does, however, open up the 432 to 440MHz band to the amateur-satellite service, which is good news for the amateur because at present this service is only permitted in the band 435 to 438MHz.

1215MHz to 10GHz

In the 1215MHz to 10GHz sub-spectrum, the amateur service stands to lose a portion of its 23cm band. At the moment the band from 1215 to 1300MHz is allocated on a primary basis to radiolocation and on a secondary basis to amateur radio. It is proposed that the band 1240 to 1300MHz should remain on a primary basis with radiolocation but be used on a secondary basis by amateur radio, earth exploration — satellite, and space research. The Home Office believes that the amateurs' loss of 1215 to 1240MHz is acceptable to amateur interests in view of the retention of the other part of the original band, but this is to be regretted by the amateur movement because it sees the possible need for more spectrum in the future as a result of an increase in amateur television.

If the proposals are carried, the amateur service will make a small gain in the 13cm, 2300 to 2450MHz, band. This band is currently allocated on a primary basis to the fixed service and on a secondary basis to amateur radio, mobile and radiolocation services. The UK proposals suggest that this remains the same but with a permit for secondary amateur-satellite operation in the 2300 to 2310MHz band.

The 9cm band, 3400 to 3475MHz, presently allocated on a primary basis to fixed, mobile and fixed-satellite services and on a secondary basis to radiolocation and amateur radio, remains the same, as does the 6cm band, 5650 to 5850MHz, presently allocated on a primary basis to radiolocation and on a secondary basis to amateur radio.

10 to 275GHz

Quite important allocations, as far as the amateur is concerned, are proposed in the 10 to 275GHz sub-spectrum.

In the 3cm band, from 10 to 10.5GHz, radiolocation currently has primary allocation and amateur radio has secondary allocation. While these allocations will remain the same, an amateur-satellite service will be permitted on a secondary basis between 10.35 and 10.375GHz.

The 12mm bands, 24 to 24.05GHz, presently allocated on a primary basis to the amateur and amateur-satellite services, and 24.05 to 24.25GHz, presently allocated on a primary basis to radiolocation and on a secondary basis to amateur radio, are to remain the same.

Four new bands are proposed for amateur and amateur-satellite services. The 7mm band, from 40 to 41GHz, is allocated to the fixed-satellite service at present, but it is proposed that this be reallocated from 40.5 to 41GHz for fixed and mobile services on a primary basis and for amateur and amateur-satellite services on a secondary basis. The other three new allocations would fall in the 6mm band, 48 to 50GHz, the 4mm band, 71 to 84GHz, and the 2mm band, 152 to 170GHz, which are presently not allocated. It is proposed that 49.5 to 50GHz be used for fixed and mobile services on a primary basis and, for amateur and amateur-satellite services on a secondary basis. An allocation for radiolocation, on a primary basis, and amateur and amateur-satellite services, on a secondary basis, is proposed for the 71 to 76GHz band, and an exclusive allocation for amateur and amateur-satellite services is proposed for the 160 to 165GHz band.

No change is proposed in the spectrum above 275GHz (1mm), which is not allocated at present.

G8AUU

*In the UK at present, 14 to 14.25MHz may be used for amateur and amateur-satellite operation, but 14.25 to 14.35MHz may only be used for normal amateur operation.

Better radio communications coverage needed for 21st century

Since the radio spectrum is limited, the increased communication demands expected in the future must be met by improving the efficiency of use of the spectrum to a "tolerable saturation level" and by more use of wide-band cable for point-to-point transmission. Radio spectrum efficiency can be improved by better methods of coverage, perhaps using satellites, and by more advanced radio systems involving "co-operation" between receiver and trasmitter. These were some of the points made recently by Charles Sandbank in a wide-ranging lecture "Communications in the 21st century" which was his inaugural address as new chairman of the Electronics Division of the IEE. Mr Sandbank is head of the BBC Research Department.

Our present method of allocating frequencies, said Mr Sandbank, "on the basis of signals decaying along the earth's surface to a level giving sufficiently low co-channel interference is far from efficient". Leaving aside long-distance h.f. transmission, "l.f., m.f., and v.h.f. frequencies are allocated on the basis of a small service area surrounded by a much larger sterilised area where signals are too weak for satisfactory reception but too strong to allow the frequency to be used by other transmitters. If one calculates the useful service area as a percentage of the area which has to be left unused to keep co-channel interference at an acceptable level on a particular frequency and polarisation, then one obtains a figure which is generally less than 12% for the coverage efficiency."

The main feature of communications satellites so far, went on Mr Sandbank, had been their ability to provide a platform for aerials high enough to avoid the line-of-sight limitations for long-distance wideband communication. "However, the possibility of providing a sharply defined service area may become a more important function of satellites than providing large area coverage. Although no special attempts have been made to use antenna aperture to optimise coverage efficiency current plans for broadcast satellites give about 30% coverage efficiency per channel compared with 12% for the terrestrial stations." He said his comparison was not strictly fair because he was comparing s.h.f. satellite allocations with v.h.f. terrestrial practice, "but in principle the efficient space-division multiplex possible with satellite-mounted antennas need not be restricted to microwave frequencies. Large aperture satellite antenna arrays seem a cost-effective way of solving future radio-spectrum allocation problems."

Another way of confining radio transmissions to wanted areas in order to improve efficiency was the increasing use of directional aerials and radiating cables. An example was the allowance made for the directivity of receiving aerials in the planning of u.h.f. television broadcast transmissions. "This would bring the coverage efficiency up to about 30% for receiving antennas having a discrimination of 15dB, although in practice this efficiency is not achieved at u.h.f. because of the effect of topography." But he felt that the future lay in "very much greater co-operation between the receiver and transmitter to reduce the effect of the unwanted signals." The BBC's Carfax broadcast traffic information system was an example of this (see January 1978 issue, p28, for details). For mobile communication there were the techniques of dynamic frequency sharing, which was essential, and spread spectrum transmission, which could lead to greater efficiency and flexibility in spectrum utilisation when channels were used intermittently (see News, October issue p54). There were also developments in military radio where "highly sophisticated technology is leading to a quantum step in the degree of co-operation between receiver and transmitter. Array signal processing whereby active antenna arrays are used in conjunction with the fast on-line signal processing will lead to a high level of wanted-signal acquisition in the face of multipath and jamming. It is only a matter of time before these techniques of beam switching and null steering can be realised in consumer products."

New IEE president

On October 1, 1979, Professor John Brown, D.Sc(Eng), F.I.E.E., succeeded Sir James Redmond as president of the Institution of Electrical Engineers. Professor Brown is presently head of the electrical engineering department at Imperial College, London.

Professor Brown's research interests are in the field of electrical communications — particularly in the application of antennas and guided-wave systems. In addition to Proc.-IEE papers, he has published books on "Microwave lenses," "Radio surface waves" with H. M. Barlow, and "Telecommunications" with the late Dr E. V. Glazier.

Professor Brown has a particular interest in engineering education and during his association with the IEE he has been a member of the Committees on Education and Training, which are associated with the CEI and the WFEO. He is chairman of the SRC Engineering Board and was chairman of the Standing Committee on Broadcasting, a small group, independent of the IEE, which attempted the task of looking at all aspects of the interaction between engineering and society.

PO-approved answering machines may now be bought

The Post Office has announced a change in policy which will enable customers, from next year, to buy as well as rent telephone answering machines from PO-approved suppliers. A PO spokeswoman told *Wireless World* that this had been made possible because of progressive developments in the manufacture of the machines, and had been decided before Sir Keith Joseph announced moves which might effect an early relaxation of the operation of the Post Office's telecommunications monopoly (see News, Nov. '79 issue).

For many years customers have been encouraged to use answering machines as private attachments provided that the units met the corporation's technical requirements and that they were used on a rental basis only — so that they could easily be traced for modification when necessary. Despite this, non-approved units are regularly advertised and presumably sold by a number of companies in the UK through the press medium.

After January 1, 1980, answering-machine suppliers will be able to submit their products for Post Office evaluation on the basis of sale as well as hire. The machines will still need Post Office permission to be used on the public network to ensure that they meet the requirements for safety and system compatibility. The Post Office expects that the revised arrangements will come fully into operation as soon as practicable after April 1, 1980.

Racal Electronics Group, who were responsible for supplying communications equipment for the Transglobe Expedition which set off from London in September to travel the world over both poles, recently arranged for one of the expedition team members to be re-united with his wife via a 1500 mile radio link. Rebecca Sheppard, wife of Oliver Sheppard, one of the three leading members of the team, led by Sir Ranulph Fiennes, spoke to her husband from a Racal radio car as he drove in a Landrover through a desert towards Abidjan, West Africa.

Radio paging uses broadcast network

A nationwide radio paging system, using the whole of the country's network of v.h.f./f.m. broadcasting transmitters, has now been operating in Sweden for over a year. Anyone carrying a paging receiver can be contacted anywhere in Sweden by a call from any telephone in the country. The telephone call transmits a digital code giving both the code number of the intended recipient's paging receiver and the telephone number of the caller. This code goes to a central equipment at Örebro and from there to all the 120 v.h.f. sound broadcasting stations, which transmit it on a 57kHz subcarrier on the frequency used for Sweden's third programme (P3). When its own coded signal is received the paging receiver gives a warning "bleep" to the person carrying it. In one variant of the system the pager then shows on an l.e.d. display the telephone number of the caller; in another variant the person paged goes to a telephone and rings a special exchange in Örebro and from this hears the caller's number spoken by an automatic announcing machine.

Using as it does an already established broadcasting network, the system, called MBS, runs economically and the Swedish Telecommunications Administration, which set it up, claims that the calls, at 0.34 Swedish Kroner each, are cheap. It has a capacity of 300,000 subscribers, and the paging number of each subscriber can be entered in the telephone directory alongside his/her ordinary telephone number. At present the pocket-sized paging receivers used are ones made by the Japanese firm Mitsubishi but later they may be manufactured in Sweden. A whole group of pagers can be alerted by one telephone call.

The subcarrier system on the f.m. broadcasting transmitters is the same as that developed in Sweden for programme labelling (see News, December 1978, p.50). The 1200 baud binary code signal is first made to phase modulate a 1187.5Hz square wave (1/16 of the broadcast pilot tone frequency) and in order to minimise interference with the normal stereo broadcast signal a symmetrical code is used. A binary "1" causes a 180° phase shift and a binary "0" produces no phase change. After filtering, this phase modulated square wave is used to product-modulate a 57kHz subcarrier, which is locked in phase (with a 90° shift) to the third harmonic of the 19kHz pilot tone — this phase relationship being adopted again to reduce interference. The two sidebands generated in the modulation process are added to the multiplex stereo signal, which then frequency modulates the transmitter's carrier. The paging/programme-labelling code signal accounts for ±3kHz of the total deviation in the transmitted signal.

The binary code system used is an error-correcting type which is able to correct bursts with up to 5 bit faults per block. Further reliability is provided by a system to cope with faulty transmitters. If a fault occurs in a transmitter the MBS signal is automatically switched to another one. The coding system of the paging calls is arranged so that the caller dials three sets of decimal numbers: first, a four-digit decimal number which gives access to the whole paging system; second, five digits forming the number of the particular paging receiver to be called; and third, seven digits which are the caller's own telephone number.

Bicycle battery to aid tired limbs

Lucas Industries Ltd, have developed a battery-assisted bicycle, affectionately given the name Bab, as a feasibility study. The bicycle is designed to provide electric muscle-assistance for the cyclist, without giving speeds greater than those which one would normally expect from a push-bike. Bab uses a 16Ah MC9 battery, which has a range of four miles with constant power-assistance or 13 miles with intermittent power-assistance. Alternately, a 30Ah A7 battery would give approximately twice these figures. The drive comes from a Lucas SIBA PM300T motor and a special purpose-designed gear box. With intermittent use the motor provides about 0.4h.p. and with continuous use it provides about 0.1h.p. A Lucas odd-leg charging plug enables the battery to be recharged in approximately eight hours, which means that the owner could take advantage of overnight off-peak rates.

Power-assistance is given only when the rider is pedalling and pressing a button on the handlebar. A switch on the driving chain takes advantage of the slack and taut conditions of the chain and only actuates the drive when it is taut. The normal three-speed gear permits the rider to make the greatest possible use of the narrow "maximum-torque" band of the motor by relating it to the riding conditions.

Bab, which is intended for housewives and commuters, was lent to the violinist, Yehudi Menuhin, who said it is "like having a friendly breeze behind you".

Lucas does not intend to build or market Bab itself, but sees it as a feasibility study which may ultimately lead to a demand for their components. Because in this country an assisted bicycle is classed as a moped, which requires tax and insurance to go on the road — and a crash helmet for the rider — the company is assessing its potential on overseas markets.

The power-assistance equipment can be fitted to a typical Raleigh shopper bicycle with no structural alteration other than the removal of the tyre-pump brackets to make room for the motor beneath the saddle. To give a low centre-of-gravity, the battery case is slung beneath the cross-bar.

Mr Yehudi Menuhin, the violinist, is seen here riding Lucas's new battery-assisted bicycle, which was designed to provide electric muscle-assistance for the cyclist, but not to give speeds greater than those which can be achieved with a normal push-bike.

New course for broadcast engineers

A post graduate course for broadcast transmitter engineers has been launched at Newcastle upon Tyne Polytechnic for the Independent Broadcasting Authority. The course is part of an eighteen month training scheme, developed by the IBA, which will lead to the first-ever nationally-recognised diploma in broadcast engineering. It is designed to meet the broadcasting demands of the 1980s and includes the introduction of the fourth television channel and the expansion of Independent Local Radio (ILR).

Newcastle Polytechnic, which was selected by the IBA from polytechnics throughout England and Wales, is providing an intensive six-months study in the theory of advanced broadcasting technology. The students, and there are eighteen of them on this years course, which started at the end of September, also receive specialist training at the IBA's own training college, the Harman Engineering Training College at Seaton, Devon. Here they gain first hand practical experience in the IBA's transmitter stations. If everything goes according to the IBA's plan, about twenty students will benefit from the scheme each year. The Authority also hopes that overseas students will be admitted in the future.

This year's students, when they complete their training at the end of 1980, will be qualified to take up positions as IBA maintenance engineers. In this capacity they will be responsible for helping to keep over 480 television and radio transmitters in England, Scotland, Wales and Northern Ireland on-the-air.

Teletext goes ahead

A boost for the chances of selling the UK teletext system abroad is announced by the BBC. Esmeralda, the computer originally used for the BBC Ceefax facility, has been replaced by a system developed by Logica in collaboration with the BBC, and named Selene.

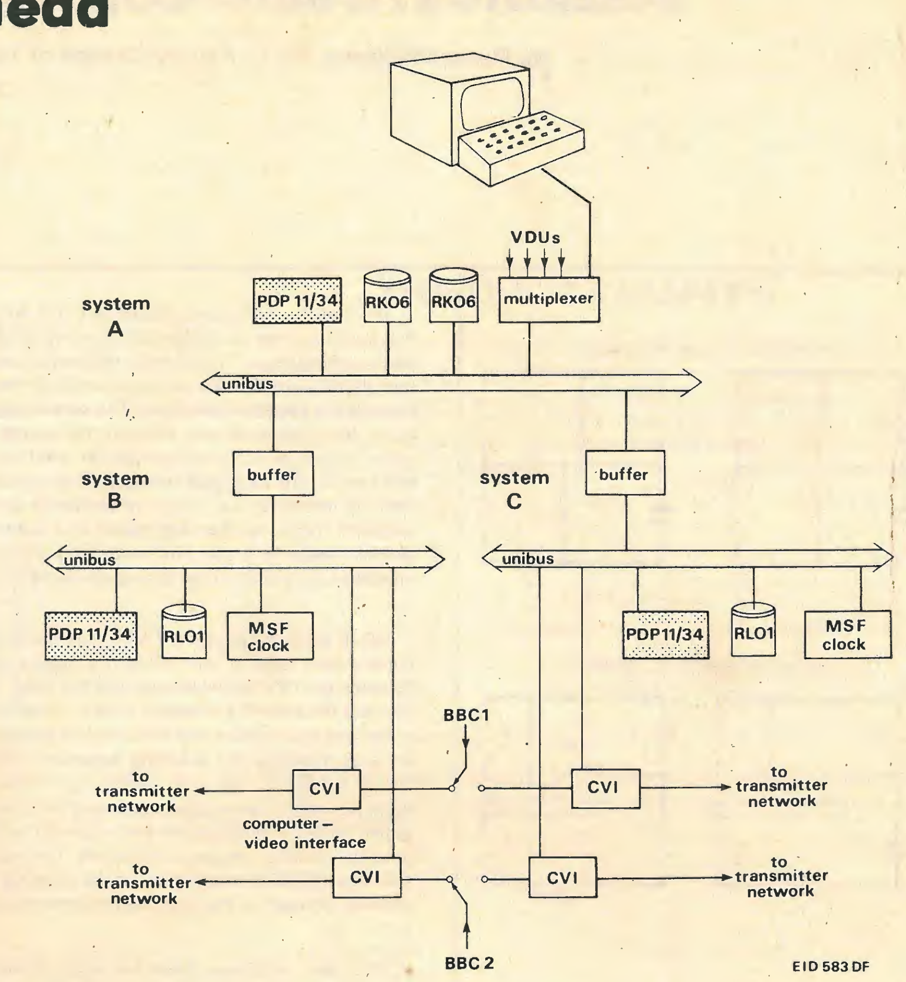
This second generation of text-handling equipment is composed of three PDP11/34s, one of which (A) will cope with sixteen input v.d.us. The second computer (B) inserts the Ceefax data into the transmission chain, while the third is a standby. Increased speed of access to the computer by journalists will be one advantage of the new equipment, since the v.d.us and computer communicate at 9600 b/s and, as blank lines in the teletext 'page' are not to be transmitted, waiting time at the receiver will be less. Logica are to market the system throughout the world.

A further benefit is the extension of the old set of 96 characters by 165 new ones, which include those used in most European languages. This is the result of a compromise, in that the parity bit is to be used to call up the additional characters instead of protecting the data. It has been found, say BBC engineers, that the teletext signal can manage without the protection. If parity is left at 'odd', as at present, the old set of characters will be seen: changing it to 'even' will produce the new set in lower case when a graphics control bit is introduced, while an alphanumeric control will give capitals.

The slow progress of teletext in the UK has given cause for concern to broadcasters, but Colin McIntyre, Ceefax editor, points out that there are now 32000 sets in use, and that the number is increasing at the rate of about 3000 per month. The rate has improved since 22in teletext sets became available.

BBC Ceefax now employs twenty journalists and puts out around 400 pages on the two channels. It seems possible, says McIntyre, that a further two pages in the vertical flyback interval will be made available, to increase the number of pages or reduce access time.

New Ceefax Computer System



Cosmos extends European space agreement

The members of the International Satellite Consortium, Cosmos, have agreed to co-operate in the European space programme for a further three years. The agreement was signed by senior executives of each of the consortium's members, one being Marconi Space and Defence Systems Ltd, at a meeting in Paris recently.

The first Cosmos agreement was established in 1971 and during its lifetime the most celebrated success is probably the weather satellite, Meteosat. Current activities include ESA's Exosat, which is due for launch in 1981, and ESA's and Ford Aeronautics Communications Corporation's provision of the first eight spacecraft so far ordered for the global Intelsat V programme.

Nobel Prize awarded for services to tomography

The Nobel Prize for Physiology and Medicine has been awarded to Godfrey Newbold Hounsfield and Allan M. Cormack for their services to computer-assisted tomography — a technique for constructing three-dimensional X-ray images of opaque solids.

Godfrey Hounsfield is a credit to the engineering profession, if only because he is one of the very few Nobel Prize winners who does not possess a degree qualification. His interest in electrical engineering started when he was a schoolboy and worked on his own projects in a laboratory at his home. His formal training probably began just after the Second World War at the Radar School of the Royal Air Force College, Cranwell, where he obtained a City & Guilds Certificate in Radio Communication, and later took up a post as lecturer. After obtaining a diploma at Faraday House Electrical Engineering College in London, Hounsfield joined EMI as a radar systems engineer. He later specialized in computers and became distinguished as the project engineer for the EMIDEC 1100, one of the UK's first large solid-state computers.

In the late 1960's, when he was working on pattern recognition by computer, Hounsfield came upon his idea for computer-assisted tomography, which eventually resulted in the development of the EMI scanner.

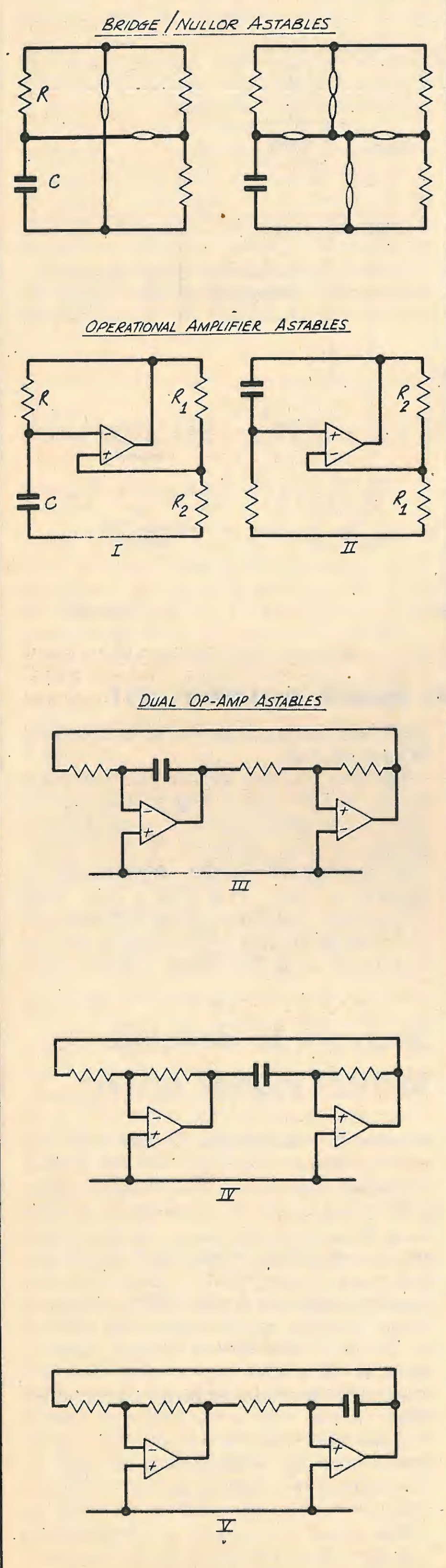
Cormack, who was working in the US independently and in mutual ignorance of Hounsfield, first came up with the idea of X-ray tomography in the late 1950's. He published papers in 1963 and 1964 describing the mathematics of the technique and the results of an experiment which he carried out using gamma rays on perspex and aluminium models) to back it up, but being a theorist and probably lacking Hounsfield's thirst to put his ideas into practice, his ideas were soon forgotten. It was not until 1971, when Hounsfield's prototype brain scanner was installed at Atkinson Morley Hospital, Wimbledon, that Cormack heard that Hounsfield had independently developed the idea and had built a working machine. Cormack, who in fact was born in Johannesburg of Scottish parents, politely wrote Hounsfield a letter of congratulation.

Marconi to develop tactical scatter system

Marconi Communication Systems Ltd has been awarded a contract by the British Government to develop a new tropospheric scatter communication system to provide long-distance multichannel tactical communications links of the kind which are necessary on the modern battlefield. The system, designated as the H7450, will have a single antenna option which will make it particularly suitable for military applications. It will require only a small crew and could be deployed in the field with minimum effort, either from a fixed base or from a transportable tactical system. The equipment, which is to be designed to the rigorous environmental standards set by the British Ministry of Defence, will be suitable for either digital or analogue transmission and will carry up to 300 frequency-division multiplex voice channels.

Astables: basic configurations

by Peter Williams, *Ph.D. Paisley College of Technology*



There are four distinct realizations of the single null or astable using an operational amplifier: the capacitor may be grounded or not and may be connected to either the inverting or the non-inverting input. Two of these will switch permanently into a latched-up state because in one case there is positive but no negative direct feedback, while in the other the positive feedback exceeds the negative feedback. The remaining two are both capable though the first, type 1 is by far the most common. In each the overall negative feedback ensures that the circuit can never be permanently latched up. On reaching the self-biased state, however, the capacitance ensures that the loop gain to alternating signals produces regenerative switching — in the first form by inhibiting a.c. negative feedback and in the second by increasing the a.c. positive feedback. Type I is often interpreted as a Schmitt trigger circuit with the amplifier and potential divider treated as a unit and producing a square wave — the RC section then appears as an integrator providing a near-triangular wave if the amplitude is small.

When an amplifier of very high gain forms part of a feedback system, the input voltage and current both tend to zero while the output voltage and current can take up arbitrary values depending on the signal source and the load. The nullator is a one-port defined as having v=o, i=o and the norator a one-port with v, i arbitrary. A nullator combined with a norator is called a nullor and may replace any infinite gain amplifier in feedback systems. Practical amplifiers with finite gain modify the resulting equations and behaviour but retain the basic nature of each circuit subject to the gain being high enough. The two circuits shown contain only one reactance with three resistors defining the characteristics. The bridge is activated by either one or two nullors, the constraint with operational amplifiers being that one side of each norator has to be grounded — op. amps with fully floating outputs not being generally available. As shown the nullors give no information on the phasing of the amplifiers and this has to be determined by considering each of the possible implementations in turn.

With two amplifiers there are eight distinct configurations corresponding to two different capacitor locations, coupling or feedback, with four different combinations of amplifier phasing for each location. Five of these configurations suffer from latch up with the remaining three either having overall direct negative feedback or with direct negative feedback over each stage separately and with capacitance coupling to isolate the stages. The first of these is type III, closely related to type I. The first stage is a standard inverting integrator which guarantees a triangular output for a square-wave input. The inversion requires the following circuit to be a non-inverting Schmitt circuit to restore the same phasing as in type 1. The triangular wave levels at which switching occurs are defined by the square-wave amplitude and the ratio R_1/R_2. Assume the Schmitt output is negative. The integrator output increases until it drives current through R_1 sufficient to neutralize that fed back through R_2. This drives the Schmitt amplifier briefly into its linear region when the positive feedback reinforces the charge sweeping the output into its saturated positive state. The integrator output now ramps negatively until the second switching level is reached. Then the negative current through R_1 cancels the positive current through R_2 and the Schmitt output is restored to its original state, restarting the cycle.

Type IV is the two-amplifier astable corresponding to the single amplifier form of type II. In the last case the potential divider can be considered as setting the voltage gain to some fixed positive value while the CR network transfers any output step back to the input; via the non-inverting gain the regenerative action forces any such step to saturate the output. The conducting path to ground restores the non-inverting terminal towards zero as a decaying exponential. At a voltage again controlled by R_2/R_1 and the saturation levels the amplifier enters its linear region briefly, only to be swept on to the other saturation level when the second and similar part of the cycle commences. For the two-amplifier form, the inverting differentiator then requires to be cascaded with an inverting amplifier of fixed gain to restore the overall phase relationship. The step voltage applied to the following input by the capacitor not only saturates the amplifier in each case but may bring any protective input circuitry into conduction modifying the time constants. In extreme cases damage might result if the amplifier input is not capable of withstanding large differential voltages.

This last type cannot be directly related to the other two. It has overall d.c. negative feedback and cannot therefore latch into a permanently saturated state. The heavy local regenerative feedback across the second amplifier ensures that the system will oscillate as an astable but during the transitions between one quasistable state and the next high-frequency oscillation may be superimposed. This particular astable has received little or no attention in its op. amp form though as will be seen later a similar form is known using logic gates. The importance of the approach adopted here is that it allows new circuits to be derived from known versions, uinfamiliar circuits to be recognized and classified and for the complete membership of a class to be established. Each of these examples has severe frequency limitations because based on high gain low frequency amplifiers. A convenient alternative at high frequencies is to use standard logic gates as the amplifiers.

Astables: basic configurations

THEORY

TYPE I. The output is assumed to switch between V_A and V_B where $V_A > V_B$

$$\text{upper threshold } V_U = \frac{V_A R_1}{R_2 + R_1}$$

$$\text{lower threshold } V_L = \frac{V_B R_1}{R_2 + R_1}$$

Time for C to change from $V_L \rightarrow V_U$

$$t_2 - t_1 = \tau \log_e \left[\frac{V_A - \dfrac{V_B R_1}{R_1 + R_2}}{V_A - \dfrac{V_A R_1}{R_1 + R_2}} \right]$$

For a symmetrical bipolar output $V_A = +V$, $V_B = -V$

$$\text{and } t_2 - t_1 = \tau \log_e \left[\frac{1 + \dfrac{R_1}{R_1 + R_2}}{1 - \dfrac{R_1}{R_1 + R_2}} \right]$$

$$= \tau \log_e \left[\frac{R_2 + 2R_1}{R_2} \right]$$

$$= \tau \log_e \left[1 + 2\frac{R_1}{R_2} \right]$$

By symmetry the time taken for C to change from $V_U \rightarrow V_L$ must be identical and the period of the waveform is

$$T = 2\tau \log_e \left[1 + 2\frac{R_1}{R_2} \right]$$

TYPE II. Under the same assumption, the threshold voltages are the same if referred to the amplifier output instead of to ground i.e. the passive bridge is subjected to identical waveforms and hence frequency. This is true provided the voltage steps transmitted to the non-inverting input via the capacitor do not drive the input or any associated protective network into conduction. A similar problem arises with type IV. With high Z in amplifiers a large resistor in series with the non-inverting input protects without disturbing the frequency.

TYPE III. This is the well-known square-triangle generator. Let the input and feedback resistors of the Schmitt trigger be R_1, R_2 and for simplicity assume that the saturated output levels are $\pm V$. The thresholds are then $\pm R_1 V/R_2$.

For the transition between these thresholds the integrator output has to change by $\pm 2R_1 V/R_2$ when the input current is $\pm V/R$.

$$\text{Hence } \frac{V}{R} = I = \frac{dQ}{dt} = \frac{CdV_c}{dt} = \frac{-CdV_o}{dt}$$

where V_o is the output voltage of the integrator.

$$\therefore \frac{2R_1 V}{R_2} = \frac{tV}{RC} \qquad t = \frac{2R_1 \tau}{R_2} \text{ for } \tau = RC.$$

$$\text{The period of the waveform is } T = \frac{4R_1\tau}{R_2} \qquad f = 1/T = \frac{R_2}{4R_1\tau}$$

The triangular wave amplitude is equal to the separation between the upper and lower thresholds.

$$V_o = V\frac{R_1}{R_2}$$

and $V_o \propto 1/f$ for τ constant.

THEORY/EXAMPLES

TYPE IV. Assume the saturated output levels of the differentiator when overdriven are $\pm V$. For $R_2 < R_1$ the corresponding inverter outputs are $\pm R_2 V/R_1$. This is the step size transferred to the differentiator inverting input with the transition initiated as the input passes through zero. Let the voltages across R at beginning and end of a half cycle be V_1, V_2 as usual.

$$\text{Then } t_2 - t_1 = \tau \log_e \frac{V_1}{V_2}$$

$$= \tau \log_e \left[\frac{V(1 + \frac{R_1}{R_2})}{V} \right]$$

$$= \tau \log_e (1 + R_1/R_2)$$

Period of the waveform is $T = 2\tau \log_e (1 + R_1/R_2)$

TYPE V. Frequency turns out to be identical to that for type IV. Inverter output is $\pm VR_2/R_1$ corresponding to $\pm V$ as the saturated output of the other amplifiers.

$$\text{Hence } V_1 = V + V\frac{R_2}{R_1}, \quad V_2 = V\frac{R_2}{R_1}$$

$$\frac{V_1}{V_2} = 1 + \frac{R_1}{R_2}$$

1. An operational amplifier has output saturated voltages of +14 and —12V. It is used with R_1 22kΩ, R_2 47kΩ in a type I astable with C 0.1μF, R 100kΩ. Find the frequency of oscillation, the output mark-space ratio and the amplitude at the inverting input.

$$\text{upper threshold } V_U = \frac{R_1}{R_2 + R_1} V_A = \frac{14 \times 22}{(22 + 47)}$$

$$\text{lower threshold } V_L = \frac{R_1}{R_1 + R_2} V_B = \frac{-12 \times 22}{(22 + 47)}$$

$$\text{Time from } V_L \text{ to } V_U = \tau \log_e \frac{17.8}{9.53} = 0.625\tau.$$

$$\text{Similarly time from } V_U \text{ to } V_L = \tau \log_e \frac{16.5}{8.17} = 0.702\tau$$

∴ Mark-space ratio = 1.12.

Period = 1.327τ

$$f = \frac{0.889}{\tau} = \frac{0.889}{10^5 \cdot 10^{-7}} = 88.9\text{Hz}$$

Peak-peak amplitude at inverting input $= V_U - V_L$

$$= \frac{26 \times 22}{69}$$

$$= 8.29\text{V}$$

The frequency is not far removed from the value for symmetrical thresholds i.e. for

$$T = 2\tau \log_e \left(1 + 2\frac{R_1}{R_2} \right)$$

$$= 1.321\tau$$

This allows the simpler relation to be used in most practical cases.

What's so natural about e?

A 'maths-made-easy' investigation of a mysterious number

by John C. Finlay

The author presents a study of Euler's number, the key to universal laws of change, that avoids pedestrian mathematics and brings out its value by various graphical methods. These include curve sketching for dy/dx=y; slope measurement on y=a^x curves and finding the one of slope=y; building a series for e^x and hence e (for more accurate calculation) from small steps along the $y=e^x$ curve, and comparing this with the compound interest law and a simple scheme for any pocket calculator; slope measurement on $y=\log_a x$ curves and finding the one of slope=1/x; and finding x for unit area under the rectangular hyperbola y=1/x. In Part 2 Napier's invention of logarithms will be discussed.

THAT mysterious number e, which rules so many of the laws of change in the universe, not only in the inanimate parts of science and technology but also in the living world of plants and animals and in business, social and even political affairs, is obviously important to technical people. It is said (by mathematicians, at any rate) to be a 'natural' number, but the engineer's traditional mistrust of mathematicians seems to be immediately confirmed when he finds that e is 2.7182 ...... Natural? Shouldn't we use that word only for things that we can count on our fingers, like numbers between 1 and 10 (or perhaps up to 20 if we bring in our toes as well)? At any rate we can then look smugly at the SI system, whose quantities are all reckoned in neat piles of ten. But hold on for a moment! Isn't there another 'natural' number which we first met in our schooldays, that baffling symbol π? At one time you had to be an earnest student of algebra before being introduced to it, but such is the spate of educational progress that now, every day, all over the country, thousands of industrious infants are patiently rolling coins along pencilled lines or stripping string off tin cans to reveal that hidden number. Then, of course, there is that almost magical quantity, practically worshipped by electrical engineers, $\sqrt{2}$!

Of course, e isn't as submissive, as eagerly ready to give up its secrets, as are its humbler brethren π and $\sqrt{2}$, and none of them can be expressed in simple nor even exact fractions. Just how were *you* first introduced to e? Did your maths teacher excite your interest by referring to the FA Cup knockout, or kindle your imagination by talking of population explosions or the shape of a grand piano, a cluster of organ pipes or a nautilus shell[1]? Maybe he appealed to your innate cupidity by calculating the dire effects (on the borrower!) of making loans at compound interest, but I'll bet you 2.7182 to 1 that he simply wrote down a series of queer-looking fractions, made you work them out and add them up and then said triumphantly "that's e!".

Now I must admit that the bald idea of a regular series of numbers stirs no emotion in my breast, especially when I am asked to do some work on them, so that I felt no compulsion, like Archimedes emerging from his bath, to shout 'Eureka!'. No doubt I should be ashamed to find that those same indefatigable infants, having conquered π are pressing on with series and have arranged themselves in arithmetical progression of age and geometrical progression of size or ability, thus getting dangerously near to discovering e! However, I can console myself with the thought that I *might* have got interested in series if I had been shown the really useful ones, such as those that enable you to calculate logarithms or sines (or even π itself!) and thus check out or even improve upon the work of the clever fellows who prepared those tables known as log tables (like many graven images they have now fallen, thanks to pocket calculators). But that was not to be, and so, for the same reason that I gave up learning to play the piano because I wasn't allowed to play *any* piece that I liked, I took a dislike to series. I also became disenchanted with logs for a time, after finding that a certain physics master traded on my ability to use them by devising a hysteresis experiment involving a tremendous number of diabolical calculations, generously loaded with the πs and colossal powers of 10 which were all the rage before SI system took over, which took hours to work out.

Both e and π are transcendental numbers, which sounds very trendy, but is in fact a description of their unearthly, extraordinary nature. As the Shorter Oxford English Dictionary informs us, such numbers cannot be 'produced by a finite number of ordinary algebraic operations of addition, multiplication, involution or their inverse operations' and can *only* be expressed 'in the form of an infinite series'. So there's no escape if you want a fairly accurate value! But at least the series for e can be built up on a commensense basis, as we will see later, instead of being just flung at you. In the meantime let's try another approach, a graphical one, which might just appeal to practical people like engineers.

Natural growth and decay

There is a vast group of changing quantities in the world around and within us whose numbers grow or decay quickly or slowly, but always in strict proportion to their values at any particular moment. I have already mentioned some of them and would like to include many more examples before the end of these articles. Mathematicians, in their usual succinct way, express all this in the bald statement

$$\frac{dy}{dx} = ky$$

so that *y* is the changing quantity and *x* the yardstick by which the change is gauged. *x* may represent time or just a series of numbers and *k* controls the proportion. Now every engineer knows that dy/dx represents the slope of a graph where *y* is plotted against *x*, so let's see if we can build up the shape of the curve for our equation above. Just to keep it simple we'll make *k*=1 so that it reduces to

$$\frac{dy}{dx} = y$$

Then if *y*=0, the graph slope is zero; for *y*=1, the slope is 1; for *y*=2, the slope is 2 and so on. If we sketch out these slopes alongside a pair of equal-length axes for *x* and *y* and to the same scale (Fig.1) and then roughly piece them together (Fig.2) we get some idea of the upward sweeping curve that represents dy/dx=y. By going to the trouble of making a lot more slope measurements at very fine intervals, we find a nice smooth curve as in Fig.3.

Next we place the curve between the waiting axes of *x* and *y*, but immediately hit a snag. Just *where* do we put it? Is it a b c d or e in Fig.4? To our dismay we suddenly realise that it doesn't seem to

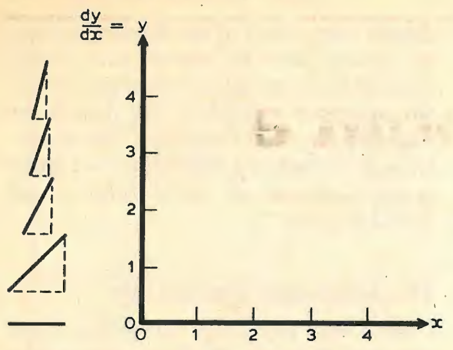


Fig.1


Fig.2

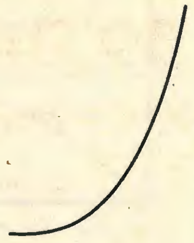


Fig.3

matter. As long as we move the curve sideways there are any number of positions where the slopes will be the same for any given value of *y*. Curve c might appear to be the favourite because the curve should go through the origin, but I am afraid I have deceived you here. The curve in fact *never* drops to zero because it keeps on diminishing in slope as it moves to the left and never quite flattens out.

The pure mathematician is of course by now laughing up his sleeve, if not openly. "That's what comes of monkeying about with graph slopes," he says. "You should have stuck to series!" Bruised, but not yet defeated, we try another tack, and even take a hint from his advice. If a quantity grows at a rate proportional to its own value, then surely it literally multiplies itself at regular intervals of time or reference number? Let's look then at a *simple* series of numbers which does just that, doubling each time:

1 2 4 8 16

and for good measure we'll look backwards, too, halving the numbers:

1 ½ ¼ ⅛ $\frac{1}{16}$

Examining the first set closely, you'll notice that the numbers are all multiples of 2 and can be set down, then, as powers of 2:

1	2	4	8	16
$=2^0$	2^1	2^2	2^3	2^4

Similarly the second set are also powers of 2, but negative:

1	½	¼	⅛	$\frac{1}{16}$
$=2^0$	2^{-1}	2^{-2}	2^{-3}	2^{-4}

You will see that the whole series can be described as 2^x where *x* is any whole number, positive, negative or zero.

Now that was for numbers which double or halve themselves. In the same way you can convince yourself that 3^x would represent numbers that treble themselves or that 4^x corresponds to a fourfold increase each time. The *x* in all such numbers is called an *exponent* (from the Latin *ex*=out of, *ponere*=to place), being literally then a figure placed out of its normal position to show how many times a number is to be multiplied by itself.

Fig. 1. *Slope increases with y for dy/dx=y.*

Fig. 2. *Rough build-up of curve for y=dy/dx from Fig. 1.*

Fig. 3. *Smooth curve built up from a large number of slope samples.*

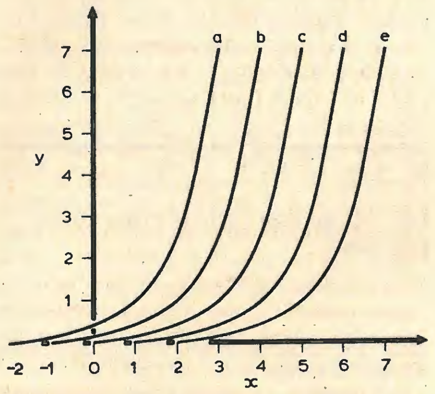


Fig. 4. *Spot-the-curve for y=dy/dx.*

Let's collect together a list of some of these exponential numbers for various whole-number multiplications:

x	−4	−3	−2	−1	0	1	2	3	4
1^x	1	1	1	1	1	1	1	1	1
2^x	$\frac{1}{16}$	$\frac{1}{8}$	$\frac{1}{4}$	$\frac{1}{2}$	1	2	4	8	16
3^x	$\frac{1}{81}$	$\frac{1}{27}$	$\frac{1}{9}$	$\frac{1}{3}$	1	3	9	27	81
4^x	$\frac{1}{256}$	$\frac{1}{64}$	$\frac{1}{16}$	$\frac{1}{4}$	1	4	16	64	256

One thing we can see straightaway about these exponentials is that they all pass through a unity value when *x*=0 (which will come as no surprise to anyone who knows his basic algebra, since any number raised to the power of zero becomes 1). If we now plot them in the form $y=a^x$ where *a*=1, 2, 3, 4, we get the exponential curves shown in Fig.5. All these curves are of the same shape if sufficiently stretched or squashed in the *x* direction, a point emphasized by Sawyer in his 'lazy tongs' model[2]. You can now test the slopes of these curves to see whether in fact they *do* grow at a rate proportional to their values at all points, by the time-honoured engineer's method of setting his ruler at a tangent to the point on the curve required, and marking off on the graph paper from this tangent line an 'x' coordinate of a length easy to divide by, and finding the corresponding 'y' coordinate. A couple of samples for 2^x are shown on Fig.5.

Now in our original statement dy/dx=*ky*, the constant of proportionality

$$k=\frac{dy/dx}{y}$$

$$\text{or} = \frac{\text{slope of curve at any point}}{\text{value of } y \text{ at that point}}$$

so that for 2^x and *y*=2,

$$k=\frac{1.4/1}{2}=\frac{1.4}{2}=0.7$$

and for *y*=5,

$$k=\frac{1.4/0.4}{5}=\frac{3.5}{5}=0.7$$

so that the idea of k as a constant is borne out. In the same way you will discover that *k*=1.1 for 3^x and 1.4 for 4^x.

Should you, like our pure mathematician, despise and distrust such a purely graphical method, then have a go at a fairly simple calculation instead. Let *x* increase by some tiny amount from a given value, say from 1 to 1.001 and calculate how much *y* changes correspondingly. Then for $y=2^x$,

when *x* changes from 1 to 1.001

y changes from 2^1 to $2^{1.001}$.

That last figure looks a bit awkward, and if you, like me, are too impecunious to enjoy the benefits of the latest microcomputer scientific pocket calculator then it's back to dear old logs:

$\log 2 = 0.30103 +$

$\times .001 = 0.00030$

$\log 2^{1.001} = 0.30133$

Antilog = 2.0014

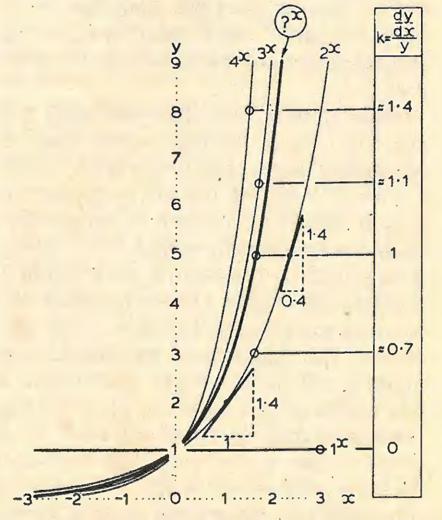


Fig. 5. *Which exponential curve has a slope always equal to its y value?*

(Incidentally, if you twist my arm, I will reveal that you can use even the simplest pocket calculator to work out figures like $2^{1.001}$ from an endless (but steadily diminishing) series of numbers, assuming that you can find the natural logarithm of 2 or whatever. Should the idea turn you off, then just skip the rest of this bracket. The series is

$$a^x = 1 + x\log_e a + \frac{(x\log_e a)^2}{2\times1} + \frac{(x\log_e a)^3}{3\times2\times1} + \cdots\cdots\cdots$$

and it is easily obtained from the series for e^x which we will discover later[3]. That could be a good reason for your looking back at this section after we have discussed e^x and natural logarithms!

Then for $2^{1.001}$, $x\log_e a = 1.001(0.69315) = 0.69384$
or $2^{1.001} = 1 + 0.69384 + 0.24071 + 0.05567 + 0.00966 + 0.00134 + 0.000155 = 2.0014$ to four decimal places.

Wasn't that hard going compared with our original calculation, using 'ordinary' logs? Still, it may satisfy the sticklers for accuracy, especially when they can control it!)

So then, using the symbol Δ to stand for a small but definite change, for $y=2^x$ and when $x=1$, $y=2$, $\Delta y=0.0014$ for $\Delta x=0.001$ and $\Delta y/\Delta x=1.4$. Then $\Delta y/\Delta x/y=1.4/2=0.7$, which is the same result we obtained anywhere on the curve by measuring its slope.

(The P.M. shudders and rolls his eyes heavenwards. "You can't say that $\Delta y/\Delta x$ is the slope," he hisses. "You know damn well that it ought to be dy/dx, and k's value, which is $\log_e 2$, should be 0.693 not 0.7, at least to the sort of accuracy you fellows are prepared to put up with." "So what?" I rudely reply, "it's only the *order* of k that I'm interested in, and I can work out the value of e as accurately as I like when I'm good and ready. What's more, *I* can look up my tables of natural logs too and see that, for 3^x, $k=\log_e 3=1.099$ and for 4^x is $\log_e 4=1.386$!" But that would be cheating, because we haven't got to logs yet!)

After all that, let's discover what we can from Fig.5. All the curves have a constant k factor, and if this is 0.7 for 2^x, 1.1 for 3^x and 1.4 for 4^x, it stands to reason that there must be a curve between the first two for which $k=1$. What is its equation? If we call it $y=e^x$, then it is crystal clear that e lies between 2 and 3, so we have made our first great discovery. But just where between these limits is e? Now we might just recruit a few teams of our infants, who, having measured and calculated everything within reach, are driving their teachers up their respective walls. We'd press into each hot eager little hand a scientific calculator, with the instruction "Go and work out a lot of values for 2.001^x up to 2.999^x at one thou spacings and draw the graphs. Find out which one has a k of unity!"

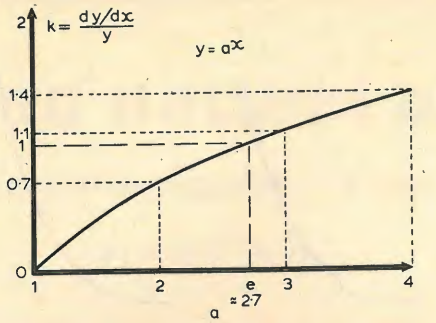


Fig. 6. *e finally emerges for k=1 on the k/a curve.*

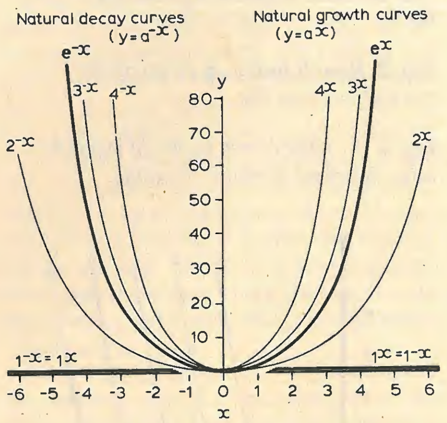


Fig. 7. *Graphs of various exponential functions.*

But despite the gratitude we would earn from the exhausted teachers, we as engineers would prefer to select one of our oldest and most cunning work-saving methods – interpolation – which to many a hard-pressed laboratory student means getting the most information out of the fewest (or less) possible results. Suppose we plot the k-values we have found against a (in $y=a^x$) in Fig. 6. Then, from the curve, when $k=1$, e comes out as around 2.7! (if you want to draw as nice a curve as possible, you can always cheat by looking up values for $k=\log_e a$, but it does rather spoil the thrill of discovery, especially if you go straight for $k=1$!).

Next you might wish to fit in the true e^x curve on Fig.5 (which in fact I have already done for you with the queried value) and check that its slope is everywhere equal to y. This is *the* exponential function, when so described. Now at last we have located the unique function whose differential is equal to itself! Incidentally if $x=1$, $y=e^1=e$, so that the value of e is identified on the y scale for $x=1$. This will be better shown on Fig.8 later.

So far we have dealt with natural or exponential *growth*. Exponential *decay* is evinced by similar curves, formed with negative exponents, of the general type $y=a^{-x}$. Fig.7 shows these for the same a values as in Fig.5, and over slightly wider x and y ranges. Note how the a^{-x} curves are the mirror images (about the y axis) of the corresponding a^x curves. We can expect the slopes, then, to have the same numerical values for any given value of y but now to be negative instead of positive. The curve, then, for which the differential or slope is the *negative* of the y value at all points is $y=e^{-x}$.

The compound interest law

I hope that you have now seen, from one viewpoint at any rate, that e *is* a natural number. Having got a rough idea of its value, we ought now to find out how to obtain a more accurate result, in fact as precisely as we might ever want. It's got to be a series, since nobody can defy the S.O.E.D., so let's try a couple of natural ways of building up the series.

It could be profitable to look again at the $y=e^x$ curve which we have discovered, and examine how y gradually increases with x. We'll divide up the space under the curve into a large number n of vertical strips (Fig.8), the side lengths of which represent various values of y against the corresponding x values. If these strips are narrow enough we can consider the e^x curve to be virtually a straight line of constant slope across the top of any strip (like a much finer version of the Fig.2 build-up). Then if x_n stands for the x value at the outer edge of the nth strip (the corresponding y value being y_n), the width of each strip is x_n/n. Taking a sample strip between x_{10} and x_{11} you will see from the corresponding increase in y value that

y_{10} = gradient at y_{10} (by definition)

$$\approx \frac{y_{11}-y_{10}}{x_n/n}$$

$$\text{so that } y_{11}-y_{10} \approx y_{10}\frac{(x_n)}{(n)}$$

$$\text{or } y_{11} \approx y_{10}\left(1+\frac{x_n}{n}\right)$$

Any other consecutive pair of numbers could replace 10 and 11, so that the very start of the curve

$$y_1 \approx y_0\left(1+\frac{x_n}{n}\right)$$

$$\text{but } y_0=1 \text{ so that } y_1 \approx \left(1+\frac{x_n}{n}\right)$$

$$\text{similarly } y_2 \approx y_1\left(1+\frac{x_n}{n}\right) = \left(1+\frac{x_n}{n}\right)^2$$

$$\text{and } y_3 \approx y_2\left(1+\frac{x_n}{n}\right) = \left(1+\frac{x_n}{n}\right)^3$$

from which you will realize that

$$y_n \approx y_{n-1}\left(1+\frac{x_n}{n}\right) = \left(1+\frac{x_n}{n}\right)^n \approx e^x$$

Now although this answer is only approximate it becomes exact if we allow n to become so large as to approach infinity, and we can replace x_n simply by x. then in the usual mathematical language

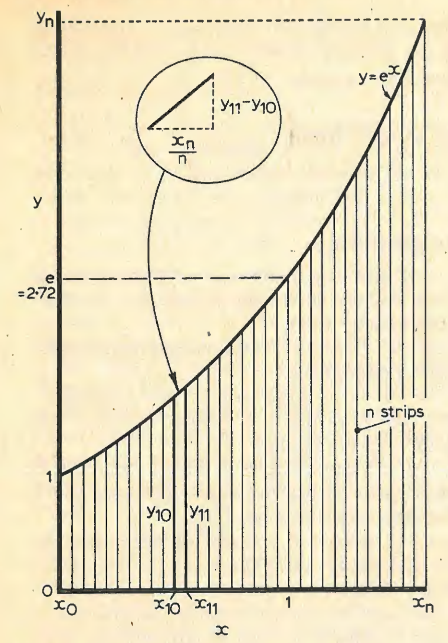


Fig. 8. *Building a series for e^x from small steps along the $y=e^x$ curve.*

$$e^x = \lim_{n\to\infty}\left(1+\frac{x}{n}\right)^n$$

As yet the formula can hardly be described as practical – can you divide x by ∞ and multiply $(1+x/n)$ an infinite number of times? Even if you restrict yourself to a dozen for n, the calculation is still both tedious and inaccurate. What we need is to multiply out the expression into a number of terms which can be simply added, i.e. a series.

Anybody who has done a bit of simple algebra can work out that

$(a+b)^2=a^2+2ab+b^2$

or, more to the point, that

$$\left(1+\frac{x}{n}\right)^2 = 1+\frac{2x}{n}+\frac{x^2}{n^2}$$

This is where the Binomial ('two-termed') Theorem comes in handy, as it saves a lot of work by neatly organizing the way in which we multiply out the two added terms.

$$\text{Then } \left(1+\frac{x}{n}\right)^n = 1+n\frac{x}{n}+ \frac{n(n-1)\,(x)^2}{2.1\,(n)}+\frac{n(n-1)\,(n-2)\,(x)^3}{3.2.1\quad(n)}+\cdots\cdots$$

(Note, by the way, how this confirms the $(1+x/n)^2$ result above, for $n=2$, in its first three terms, lopping off all further terms which each becomes zero.)

Continuing with the general case for n, we can rearrange the result as

$$\left(1+\frac{x}{n}\right)^n = 1+x+ \frac{n(n-1)x^2}{n^2\ 2!}+\frac{n(n-1)\,(n-2)x^3}{n^3\quad 3!}+\cdots\cdots\cdots$$

($3!=3\times2\times1$, etc.)

As n approaches infinite value, all parts of the above terms containing n approach unity value,

i.e. $\frac{n^2}{n^2}, \frac{n^3}{n^3}$, etc. so that

$$e^x = \lim_{n\to\infty}\left(1+\frac{x}{n}\right)^n = 1+x+\frac{x^2}{2!}+\frac{x^3}{3!}+\frac{x^4}{4!}+$$

Now we *have* got a calculation for e^x which is reasonable to handle and produces a figure of good accuracy from reasonably few terms. Let's check it by putting $x=0$. Anything raised to the power of 0 is unity, including e^0, and sure enough it is, as all the x terms vanish. More important, though, if you put $x=1$, you will at last get the famous series

$$e = 1+1+\frac{1}{2!}+\frac{1}{3!}+\frac{1}{4!}+\frac{1}{5!}+\cdots\cdots$$

(which is where I, at any rate, first came into the scene). It was introduced in 1731 by the brilliant and prolific Swiss mathematician Leonhard Euler. According to one writer, Euler had already used '*a*' for the general base of any system of logarithms, as we did in plotting $y=a^x$, and apparently took 'e', as the next available vowel, for the natural base[4], which we will talk about later. A more obvious suggestion for the origin of 'e' is that it is taken from the first letter of 'exponential'[5] (Euler also introduced a record number of other durable mathematical symbols[5,6], including π, $i\,(=\sqrt{-1})$, $f(x)$ for function of x, Σ for summation and the schoolboy favourites (?) of a, b, c for the three sides of a triangle and A, B, C for the opposite angles[7]. He also related e, π and i by the remarkable equation $e^{\pi i}+1=0$,[8] which we will meet again). e is known as Euler's number, and nowadays both the English 'e' and the Greek 'ε' (epsilon) are used for the same purpose.

I won't spoil your fun in working out the value of e with your pocket calculator, but since everybody likes to be able to check his figuring I will reveal that the first eight terms are enough to confirm a practical working figure of 2.7183. Even so, unless your calculator has a memory capability, there is plenty of scribbling on paper to do in summing the series. What may not be so well known is an ingenious series that enables e to be calculated, *without writing down anything at all, on an ordinary four-function calculator* (+ − × ÷). This is described by Jon M. Smith in his book Scientific Analysis on the Pocket Calculator[9] (which everyone should have a look at). The author's stratagem is to use what he calls 'nested parenthetical forms' (or brackets, to us humbler brethren) and dramatically reduce both the number of data entries and the time required to make it a power-series-type calculation. In this form

$$e \approx 1+1(1+\tfrac{1}{2}(1+\tfrac{1}{3}(1+\tfrac{1}{4}(1+\tfrac{1}{5}(1+\tfrac{1}{6})))))$$

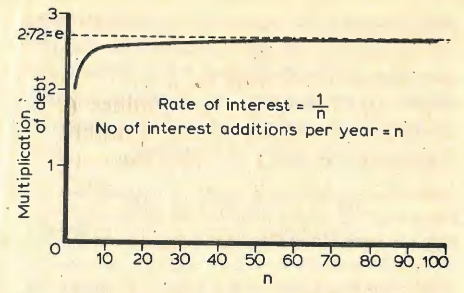


Fig. 9. *Increase of repayment by compound interest with frequency of interest additions.*

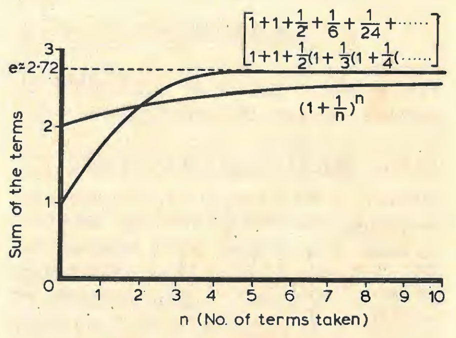


Fig. 10. *Which is the easiest way of calculating e?*

giving an answer of 2.718 (to 4 sig.figs). To calculate, you start at the *right-hand side* and work steadily to the left:

1÷6+1÷5+1÷4+1÷3+1÷2+1+1

What could be simpler? The unity multiplier outside all the brackets is redundant, but came in because I took e^1 as a special case from the general series for e^x, which is what Mr Smith actually quotes:

$$e^x \approx 1+x(1+\frac{x}{2}(1+\frac{2x}{6}(1+\frac{6x}{24}(1+\frac{24x}{120}(1+\frac{120x}{720})))))$$

Have a try at that one in the same way as for e (you can extend the series as far as you like to get any accuracy you wish for, but you have of course decided the number of terms and thus the accuracy as soon as you have entered your first quotient). You can then make up your own tables of natural (hyperbolic) logarithms or check those you may have, remembering that if you put e^x equal to the number concerned, x is the natural logarithm of that number. (Actually, the energetic Mr Smith quotes nested parenthetical forms for the direct calculation of these logarithms as well as all the common trig. functions, and gives much more advice on evaluating scientific functions in general. All the incentives that I was looking for years ago!).

Later in his book, Mr Smith also describes two tricks for setting the value of e on a calculator that doesn't have a button for it. One of them, due to Texas Instruments Corporation, is simply to divide 193 by 71 = 2.7183098. As he points out, this is accurate only to the fourth digit (i.e. 2.718) and one might as well memorize e itself to five places (e=2.71828). He then describes an ingenious method of his own which he claims to be simpler, more accurate and more easily remembered. He starts with a sequence of pairs of numbers:

00 11 33 55 77 99
(zero and all the odd numbers)

Then he cuts out the 11 and 77 pairs (a symmetrical operation). Next he inserts a decimal point after the first zero and a bracket before the last 9 (another symmetrical operation) to give:

(0.0 33 55)9

This product has to be multiplied by another 9 to give the setting for e:

$$e=(0.0\ 33\ 55\ 9)9\times 9=2.718279$$

and when rounded off to 6 sig.figs gives 2.71828. The relative error here is less than $7.10^{-5}\%$! After all that, isn't it nice of some calculator manufacturers to actually *print* the value of e on the front of their instruments?

Another method of finding the series for e, and probably the most familiar, one, is from the calculation of compound interest, a fearful object lesson to those would-be borrowers who haven't read their consumer reports. A certain moneylender, having noticed a potential sucker nervously pacing up and down outside his office, finds out that he wants to borrow £1,000 'only for a year' and offers him a choice from the following tariffs:

(a) 100% interest, added at the end of the year,
(b) 50% interest, added two times during the year,
(c) 33⅓% interest, added three times during the year,
(d) 25% interest, added four times during the year,
(e) 1% interest, added 100 times during the year.

The mug (which he certainly is) thinks these are all much the same, but likes the look of the 1% interest and plumps for (e). We'll find out just how stupid he was by calculating the different costs:

(a)	Total	=£1000+£1000=**£2000**
(b)	After 1st ½ year, debt	=£1000+ £500=£1500
	After 2nd ½ year, debt	=£1500+ £750=**£2250** (=£1000(1+½)(1+½))
(c)	After 1st ⅓ year, debt	=£1000+ £333=£1333
	After 2nd ⅓ year, debt	=£1333+ £444=£1777
	After 3rd ⅓ year, debt	=£1777+ £593=**£2370** (=£1000(1+⅓)(1+⅓)(1+⅓))
(d)	After 1st ¼ year, debt	=£1000+ £250=£1250
	After 2nd ¼ year, debt	=£1250+ £313=£1563
	After 3rd ¼ year, debt	=£1563+ £390=£1953
	After 4th ¼ year, debt	=£1953+ £488=**£2441** (=£1000(1+¼)(1+¼)(1+¼)(1+¼))
(e)	After 1st 1/100 yr, debt	=£1000+ £1=£1001
	After 2nd 1/100 yr, debt	≈£1001+ £1=£1002
	After 3rd 1/100 yr, debt	≈£1002+ £1=£1003
	After 100th 1/100 yr, debt	=**£2704** (=£1000$(1.01)^{100}$)

So the grand total which our long-suffering debtor has to pay is very nearly e times his £1000, whereas it might have been only twice. Obviously the smaller the rate of interest ($1/n$), and the more frequently it is charged (n), the nearer the debt multiplies to exactly e, as can be clearly seen in Fig.9 (the steadily-moving tortoise in Aesop's fable obviously knew what he was about when he dared to compete with the erratic whizz-kid hare). All the calculations above are examples of a debt multiplication of $(1+1/n)^n$, which evidently approaches e as n approaches infinity. It *should* do so, if we look back to our original formula for

$$e^x=\lim_{n\to\infty}\left(1+\frac{x}{n}\right)^n$$

because, if we substitute $x=1$, $e^x=e$, or

$$e=\lim_{n\to\infty}\left(1+\frac{1}{n}\right)^n$$

On expansion, this leads to the same series again for e which we have already found. Small wonder, then, that Lord Kelvin, that eminent engineer and mathematician, pioneer of electrical and other scientific measurements and of refrigeration, absolute temperature, metric units and much else, described the exponential growth relation, in which he had good reason to be interested scientifically, as the Compound Interest Law.

Having shown the way in which $(1+1/n)^n$ approaches e in Fig.9, this could be a good moment to take stock of the build-up in general and show how the rate of approach varies between the different ways we now have for calculating e. If we plot the sum of the terms against the number (n) of terms taken (Fig.10) for $(1+1/n)^n$ and for the two series

$$1+1+\tfrac{1}{2}+\tfrac{1}{6}+\tfrac{1}{24}+\ldots\text{ and}$$
$$1+1+\tfrac{1}{2}(1+\tfrac{1}{3}(1+\tfrac{1}{4}(\ldots)))\ldots)$$

we can immediately see that the series, although starting at a lower value, converge on e much faster than the multiplied terms as n increases, which doubly justifies using them (easier to calculate and fewer terms required). You'll note also that for the same number of terms the two series have identical values, as they should, justifying Jon Smith's 'bracket formula.'

To be continued

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Conferences and exhibitions

Electronics '79, the Electronic Components Industry Fair, is to be held at Olympia, London, from November 20 to 23, 1979. See page 51 for more details.

Switchex '79, the second conference and exhibition to be arranged by ERA Ltd's Marketing Action Group, will be held at the Wembley Conference Centre, London, from December 5 to 7, 1979. The conference will have five sessions, each concentrating on a particular aspect of switching technology, and will cover devices, applications, materials and components.

Automatic Testing '79, an exhibition and conference covering all aspects of automatic testing in the electronic and electromechanical fields, is to be held at the Metropole, Brighton, England, from December 11 to 13, 1979.

Microsystems '80 conference and exhibition will be held at the Wembley Conference Centre, London, from January 30 to February 1, 1980. The conference format has been improved upon that of previous events.

IEA-Electrex '80, the international instruments, electronics and automation exhibition, will be held at the National Exhibition Centre, Birmingham, England, from February 25 to 29, 1980. Iphex '80 (International Pneumatics and Hydraulics Exhibition incorporating Compressors and Power Transmission Equipment) will be staged simultaneously and one registration will obtain admission to both events.

LETTERS TO THE EDITOR

STUDY THE HISTORY OF OUR SUBJECT

It was very interesting to read the fascinating article in the September issue on Victorian Microwaves by an old acquaintance, Dr Ken Smith. I believe it was James Clerk Maxwell himself who said that every student of science should be an antiquary of the subject. It would be an excellent thing if courses on electronics, physics etc. had a greater component of historical coverage, especially of the standard and content of Dr Smith's article. The usual excuse of 'there is hardly time even for the modern stuff' would not apply, because the real reason is that the frenetic busywork in much of modern life is often a cover for shallowness and lack of culture. The main explanation for a lack of balance in much that passes for modern 'advanced' study is that the lecturers themselves do not know much beyond their specialised noses.

Much of the other work of Oliver Lodge is of great interest. It is well known that he foresaw the vital use of tuning or resonance in radio communication. He in fact patented systems of tuning, calling the mechanism 'syntony'. It is less well known that his interest in resonance led him to experiment with Leyden jars discharged through such a large inductance that the resultant oscillatory discharge resulted in the emission of a musical note – in other words, the frequency of oscillation was lowered into the audio band.

It is quite surprising to realise that Lord Kelvin had derived the differential equation for the discharge of a capacitor through a resistive self-inductor and had shown all the types of oscillation that would be produced. This was published in *Philosophical Magazine*, 4, 5, p.393, 1853. And this was only ten years after Joseph Henry had noted that the discharge of Leyden jars appeared to be, "... several reflex actions backward and forward..."

This note of the remarkably early understanding of tuning and resonance, although not directly relevant to Dr Smith's microwaves article, nevertheless does show how versatile some of the early workers were, and shows that Lodge especially probably quite deliberately set up tuned cavities of the type shown in the diagrams reproduced in the article.

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AUDITORY CUES IN STEREOPHONY

I was fascinated by Philip Vanderlyn's article "Auditory cues in stereophony" (September 1979 issue), not least because of his description of the almost insuperable obstacles which face the designers of stereophonic systems. This being so, I was puzzled as to why he omitted a couple of practical points: the ability of the brain to construct a sound image when certain cues are missing, and the use of headphones in overcoming nearly all the problems that loudspeaker systems raise.

Mr Vanderlyn dismissed headphones as being unnatural and unaesthetic, yet they are not necessarily so. Agreed, the head cannot move in relation to the source — but how much does one move one's head when listening to loudspeakers? Agreed, with unmodified headphones the source does appear to be "in the head" – but the addition of a simple cross-field connection between the channels moves the source forwards (even though there is no front/back information for the brain to use), removes any discomfort caused by components present only in one channel, and even makes ambient noises (e.g. reverberations, or sounds from an audience) seem to come from around or behind the head. In addition, once can sit anywhere in one's living room, without worrying about either its acoustic properties or the neighbours.

Some years ago I purchased a pair of inexpensive headphones (Toshiba HR-50) which happened to be fitted with a cross-field connection and also with extraordinarily comfortable ear-pieces. They proved to be more satisfying to listen to than any loudspeaker system (or any other headphones) I have encountered, and I cannot understand why the value of these two particular features is apparently not widely appreciated or publicised by manufacturers.

Could the reason be that there is more money to be made out of expensive loudspeakers and high-quality power amplifiers?

P. B. Soul
Earley
Berks

The author replies:

Mr Soul has raised the question of the ability of the brain to form a sound image in the absence of certain cues (unspecified). The brain is often presented with incomplete sensory information from which to build up a picture of its acoustic surroundings: I hope I have not given the impression that it cannot do so unless it is given a full set of all possible cues. This was not my intention and I agree that an observer continually makes judgments based on incomplete information.

He also takes issue with me on the subject of headphone listening. We are, fortunately, still a free country and if anyone cares to listen to stereo programmes on headphones he can enjoy the advantages Mr Soul mentions, of acoustic isolation and freedom to sit anywhere in his living room. But the fact is that stereo transmissions generally are tailored to the use of loudspeakers (*pace* "dummy head" arrangements) and I think one can presume that most listeners are unwilling to wear headphones and to be joined umbilically to their reproducing equipments. If the "crossfield" connection means what I think it does it presents the headphones listener's ears with approximately the same signals as they would normally get from a pair of loudspeakers. I would need to be convinced that it does anything towards getting the sound images "outside the head". Nevertheless, much of what the brain makes of its sensory input is subjective, and observers differ widely in the way they describe their experiences.

I find Mr Soul's comment on the economics of loudspeakers versus headphones unrealistic. Surely it costs every bit as much to provide a group of listeners with several good quality headsets and something to drive them as to give them a conventional amplifier and pair of loudspeakers.

Philip Vanderlyn

ACOUSTIC BREAK-THROUGH IN RECORD PLAYERS

My friends Poul Ladegaard, Martin Colloms, and James Moir deserve the thanks of us all for their work on measuring and exposing turntable isolation characteristics. We at *International Audio Review* have been experimenting in this area for some time (see discussion in *IAR* 1/2), but with impluse excitation instead of sine waves or noise (for several reasons, one of which is given below). I'm not happy with the calibration of our instrumentation yet, so we have qualitative, generalized comparisons so far in our lab; I hope a computer will soon change this situation, and we'll then have some quantitative evaluations to offer.

Meanwhile, there are some points I'd like to suggest regarding Mr Moir's article in *Wireless World* (May-June 1979). First, I'm not sympathetic to the popular choice of the word "breakthrough". The term "acoustic breakthrough" implies that there are no deleterious effects until some unwanted phenomenon breaks through some barrier. Some people could easily take that barrier to be the 0 dB reference level of the acoustic feedback loop, which the feedback breaks through at some frequency, thus causing oscillation. But, as Moir himself correctly points out, the deleterious sonic effects begin many dB below this level.

Furthermore, these effects both commence and increase gradually, both as a function of tighter feedback coupling and as a function of the temporal passage of a music signal (which continually changes in both amplitude and spectral content). They do not suddenly *break through* in any of these four senses, with some quantum jump – only full fledged oscillation does that (at a much higher level).

So far, I'm inclined to think that the old fashioned term "acoustic feedback" is preferable to "acoustic breakthrough". If any word needs alteration, it is "acoustic". Some of the feedback travels a path that entirely *excludes* air, and travels more via transverse waves than via compression waves; the study of this mechanical coupling belongs more to structural mechanics than to acoustics. And note that virtually none of the feedback travels *only* through the air via compression waves, from loudspeaker directly to stylus.

Second, I suspect the deleterious effects of feedback coupling might in fact be audible far below the –15dB level Mr Moir heard in his basically well conceived aural experiment (part 2 of article). Let us assume that foreign signals, such as disc surface noise and ticks, can easily be heard on either side of a musical peak even if that foreign signal is 50 dB down from that peak (else why should we be unhappy with today's disc surfaces?) Let's assume the same reasoning for tape print through and groove echo. Then the same should be true of time delayed positive feedback as a foreign signal, with the following provisos. (a) The original recording is sufficiently anechoic so the listener doesn't confuse the feedback induced artificial hangover with natural room reverberation on the recording. (b) The loudspeaker used for listening has small enough energy storage so its own hangover does not mask feedback induced hangover. (c) The listener is well trained in hearing minute differences in hangover/reverberation (e.g. an expert at concert hall microphone placement). I might suggest that Mr Moir uses dry or special anechoic recordings, and electrostatic speakers (or headphones) for listening.

Third, there's a question of experimental design. Many listening evaluations, correlations, or studies of what can or can't be heard are nowadays invalid, thanks to methodologically ill conceived or sloppily executed experimental design. If Moir's experimental procedure in part 2 was to turn up the volume in the feedback inducing loudspeaker until the listener detected an 'objectionable' quality, then the experimental results would be misleading, as well as unreliable and subjective. Instead, focusing on an instantaneous difference might relevantly improve a listener's sensitivity. A special A-B switch should be used, which would supposedly turn the feedback inducing loudspeaker instantly on and off (but sometimes in fact would not). The subject listener would be asked if he heard a difference with each flick of the switch. The correctness of his answers in detecting whether or not the A-B switch was truly functioning would be correlated with the volume level of the feedback inducing loudspeaker, to give a true indication of what levels of foreign signal audibly intrude upon accurate high fidelity. That's an example of difference testing methodology, which can yield scientifically valid, objective (not subjective) conclusions, even using a human ear/listener as a data collection device (see *IAR5* for further discussion of this).

Fourth, Moir's graphs (and Colloms's in *Hi Fi Choice)* repeat audio engineering's historical preoccupation with amplitude steady state response as a virtually sole criterion for design and evaluation. We at *IAR* are trying to reform the audio community's attitude about this, and we've been introducing new instantaneous audio response criteria and tests. We also seem to be finding in our psychoacoustic research that the human ear/brain detects (and subjectively interprets as amplitude response deviations) not only literal amplitude response deviations (in surprisingly minute degree), but also linear phase deviations and transient ringing (not to mention frequency dependent non-linearities). Investigation of the pattern, degree, and duration of the transient ringing, or overhang, is therefore germane to evaluating any system with sharp slopes in its amplitude response (see *IAR3*). It's even more germane to a resonant system, with its energy storage. And even more germane to a sharp sloped, resonant system with time delayed feedback coupling. That's one reason we've been working with impulse excitation, and have been looking at the system behaviour in both frequency and time domains, for evaluating devices including turntables and tonearms (n.b. the eigenmode behaviour is sonically relevant even with ideal isolation from loudspeakers – see *IAR1/2*).

Moir's amplitude graphs (and those of Colloms and Ladegaard) would imply, for example, that two resonant peaks of equal height (amplitude) would be equally audible and objectionable (disregarding frequency differences). But this would not in fact be so if one of the peaks were narrow with sharp slopes while the other were broad with shallow slopes. The former would ring longer and be more aurally intrusive on music than the latter (assuming the music's spectral energy could fully charge the sharp, high Q resonance most of the time). An evaluator's comparison of the time domain response of these two peaks to transient excitation would make obvious the sonic differences to be expected. Alternatively, a graph of the differential (slope), in addition to the amplitude graph, would be useful.

And now the fifth point. I think there's a minor practical error in Mr Moir's measurement procedure that may reflect a grave fundamental misconception. No RIAA network should be used. I think I see his motive in using it: he wanted to measure the amount of vibration *output* from the record player that would typically, in the real world of music listening, arrive at the loudspeaker – and the amount of this output from the record player is typically modified by two elements, a velocity cartridge and a preamp's RIAA de-emphasis. But the record player's vibration output from the vinyl groove (constituting music), which represents the 0 dB *reference level* in that real world typical listening situation, is *also* spectrally modified by those two elements. The reference level in Moir's measurement setup is not.

The concept underlying this slip is more important. One cannot characterize any device's instrinsic behaviour (e.g. measure its transfer function) by observing only its *output*. One must also observe its *input*. The device's behaviour is the *relationship* between its input and output (see "The P Rule", *IAR4*). The amplitude transfer function Moir seeks, to characterize record players, relates (i) how much external vibration is put into a record player, to (ii) how much vibration arrives at its output, which is the stylus (the input port to the electrical system).

The drive system of Moir's measurement setup (and Ladegaard's) does an admirable job of supplying a swept sine vibration input with flat amplitude response (at least up to 1000Hz or so). But then he obviously should design the sensors, for measuring the record player's vibration *output*, to observe amplitude through the same curve as the *input* (in his case a flat amplitude curve). Hence he should use an amplitude sensing cartridge (or impose a 6 dB per octave slope on a velocity cartridge).

Conceptually, the nature of the curve (velocity + RIAA, or otherwise) through which the music listener typically hears the record player's total vibration *output is* utterly *irrelevant* to measuring the intrinsic performance of the record player. Of course, if Moir's measured curves were to vary with absolute volume level (which he says they don't), then he'd want to shape his *driving* signal and 0 dB reference level with a non-flat curve to typify music, etc. And I'm sympathetic to his suggestion that the observed curve be weighted by some spectral audibility (Stevens) curve.

In practice, his measurements aren't far off, since a velocity + RIAA curve is close to a flat amplitude sensor curve, except below 50Hz and where the arm/cartridge low frequency resonance skews the results (see Ladegaard's work on this). But in principle the observation part of Moir's measurement setup is wrong, and may reinforce some fundamentally erroneous concepts, already prevalent throughout the audio community, about how one legitimately evaluates device performance (for example, most people try to 'evaluate' a device's sonics by listening only to that device's output and not to its input as well).

J. Peter Moncrieff
International Audio Review
2449 Dwight Way
Berkeley, CA 94704, USA

The author replies:
Mr Moncrieff's letter raises a number of points of interest to the audio engineer and I will comment on these, omitting discussion of the semantic aspects in an endeavour to economize on space.

Mr Moncrieff suspects that the audio effects of acoustic feedback should have been more obvious than we found, on the assumption that because disk surface noise can be heard when it is 50dB down on the peak music signal, the acoustic feedback effects should also be audible at similar relative levels. I think that he has overlooked the effect of the frequency spectrum on the audibility of an interference signal. Ticks, surface noise, tape noise etc., have a frequency spectrum that is radically different to that of music or speech, whereas the signal produced by acoustic feedback has a smilar spectrum to that of the recorded signal. It should also be remembered that the signal induced by acoustic feedback does not have a constant level. Instead it remains a constant number of dB below the recorded music. This and the difference in spectrum shape makes surface noise much more obvious than the acoustic feedback effects.

The listening tests were by no means a series of careful comparisons beyond any possible statistical criticism; they were simple separate checks by two engineers to obtain some approximate idea of how severe the feedback effects had to be before they were audible. It came as a minor surprise to find that the acoustic feedback was thought to improve the sound quality from some records. We were trying to decide when the effects were detectable, not when they were objectionable. There can be no precise indication of the 'just detectable' or 'just objectionable' point, for this is a function of the type of music and the quality of the recording.

Our analysis of the data from very many panel tests and the comments of panel members suggests that a comparison of sound quality of two signals should be made with relatively short excerpts of programme material. We find that long sections of the programme confuse the issue, for the listeners only compare the quality of these sections of the test material just before and just after changeover. Any intermediate material only serves to confuse the listener by making it more difficult to remember the quality of the first sample.

Audio engineers' preoccupation with steady state response as a criterion is soundly based, though I do not think that it has ever been suggested that it is the sole criterion. The use of pulse, square waves or similar techniques has a peculiar attraction for critics

of the traditional approach but I would suggest that the criticism cannot be justified. It finds favour because it is claimed that pulse signals are more accurately representative of music or speech signals and it is assumed that we need to reproduce waveshapes to ensure the best sound quality. Any deterioration in the waveshape of the test pulse is assumed to indicate some loss of quality because a waveform change that can be seen should also be audible.

This superficially attractive assumption is ill-founded. Information about the waveshape of a short pulse is carried by the amplitude/frequency response and by the phase/frequency response of the equipment. Any departure from linearity of either characteristic affects the shape of the reproduced pulse. However, the hearing system does not recognise those effects due to non-linearity of the phase/frequency characteristic provided that the consequent differential time delays do not exceed those specified by CCIR. In phase shift terms this is tens of thousands of degrees.

I can outline some of our experiments now three or four years old that readers will find interesting. We developed some sub-circuits for insertion into a high quality amplifier chain. These allowed us to:

1. Vary the amplitude/linearity of the system. In simple words we would change the harmonic and intermodulation content without significantly changing the amplitude of the signal.
2. Vary the phase/frequency characteristics of the system without change in the amplitude/frequency response.

The test signals were music, square waves or sine waves, all of the same peak-to-peak amplitude monitored by an oscilloscope. The results were significant.

A waveshape distortion produced by changing the circuit linearity produced obvious audible distortion of the music when the waveshape distortion on sine or square waves was so small that it required an experienced investigator to detect the change.

A waveshape distortion produced by manipulating the phase shift/frequency response had an undetectable effect on the quality of the music when the wave shape distortion on sinusoidal or square wave signals was so drastic that the output waveform appeared to have no relation to the input waveform.

If Mr Moncrieff has any evidence to support his statement that linear phase deviations are detectable as an audible distortion then it will be well received by the engineering community, for many workers, apart from my group, have sought this proof without finding any evidence. The engineers who have tried to find evidence of this include the engineering and scientific staff of most of the world's telecommunication organizations. The effect, or lack of effect, on sound quality of the phase shift in a monaural channel were discussed in more detail in a contribution to *Wireless World* dated March 76. Perhaps Mr Moncrieff is describing the results he expects to obtain from experiments he has not yet carried out.

Mr Moncrieff's comments about the audibility of resonant peaks of equal height but differing Q are attractive but suspect. More than fifteen years ago I thought, like Mr Moncrieff, that there should be an obvious difference, but our experiments failed to confirm this, or at least appeared to show that to be audible there must be very large differences in Q. I doubted this and we did not publish the results. Since that time others have investigated the problem and have come up with the general conclusion that the Q of a resonance has no great effect on the sound quality. An increase in Q appears to be largely compensated by the decrease in bandwidth that is the automatic result of increased Q.

Finally, the question of measurement procedure when assessing the effect of acoustic breakthrough. We were comparing the *relative* sensitivity of different types of record player to the vibration to which they were exposed. Thus the only requirement of the system used for applying the vibration is that it should treat all the record players in the same way. It is of little consequence whether the feedback control system holds the amplitude velocity or acceleration constant over the frequency range, or whether an RIAA network is, or is not, included in the amplifier. The input quantity was held constant for all the players so the output/frequency relation is a true indication of the relative performance of each system and there is no need to know the transfer function.

These are rather brief observations on Mr. Moncrieff's letter for he raises so many points that it would require an issue of *Wireless World* to deal with them all in detail.
James Moir

AS CHRISTMAS APPROACHES. . .

Your editorial in the January issue is unnecessarily unkind to the electronics industry. The problem starts before the electronics industry becomes involved. What about the manufacturers of toys, who seem to produce nothing but warlike action men, tanks, guns and even field hospitals! Visiting the average toy department of a multiple store before Christmas, one would be led to believe that our main aim in life is to teach children to kill and maim each other. Nothing is more disturbing than to see children of tender years firing extremely realistic machine-guns at each other and playing "dead". Perhaps it would pay to put real bullets in some of the guns. It might bring some parents to their senses.

The electronics industry may produce some devilish devices, but usually and promptly produces a cancelling device in each case. The industry supplying children's toys has a lot more to answer for. It produces year after year more and more realistic soldiery and weapons. Let's call a halt to this first.
W. H. Jarvis
Coleford

SCIENTIFIC COMPUTER

May I first congratulate John Adams on his design recently published in your pages. It is rarely acknowledged that standard c.p.us are far from efficient when applied to mathematical tasks. However, this is clearly true and it is totally logical to utilise "number orientated" technology which has been developed as part of the consumer "pocket calculator explosion."

Having constructed a unit based on this design, I would like the opportunity to make a number of comments which might be helpful to present or prospective constructors of this or similar designs:

1. For constructors who do not wish to interfere with their television sets, perfectly acceptable v.d.u. definition can be obtained by using a cheap u.h.f. modulator. I have used a commercially available one-transistor modulator with single fixed resistors from the video and sync outputs of the computer to the input of the modulator.
2. Provided that memory expansion beyond 32K is not contemplated, the limited decoding of the v.d.u. memory addresses represents a useful and novel technique. This enables a single program to output page after page of data to the v.d.u. without any additional management routines. However, it is worth pointing out to those who might get "carried away" with this freedom that there are limits and hazards which should be remembered. The system allows for 16 pages of output; successive 2K blocks from 8000 to FFFF are decoded as 8000-8800, the address of the v.d.u. r.a.m. Attempts to go beyond 16 pages will result in disaster. After FFFF the program will start outputting data to memory starting from 0000; after an initial period when nothing happens, as the program attempts to write data into the r.o.m. (0000-OBFF), the controlling program will be destroyed as it starts outputting to 0C00 onwards. The technique is therefore useful so long as its limitations are recognised.
3. In order to save some r.a.m. space and result in some increased speed of operation it is possible to use abbreviated BURP commands and statements. Only the first and last letters of the word are necessary for program operation. If this is done, the MOD command cannot be used unless the firmware is modified, since it would result in an attempt to substitute the complete words "WRITE" or "PRINT" in the program space previously occupied by the abbreviated version. Such a minor restriction might not be a problem to someone needing every available byte of r.a.m.

Following these general comments, I would also like to make a few observations regarding the firmware. It is, of course, only too easy to be critical of someone else's "magnum opus" and I must stress that I have every admiration for the achievements of Mr Adams.

4. Reverse Polish Notation is undoubtedly ideal in this situation. Some would argue that BASIC is not the ideal language for a mathematically orientated machine but the wide popularity of BASIC is undoubtedly an important consideration.
5. Users might be shocked by the slowness of BURP. Attempts to apply standard "benchmark tests" require patience, rather than a stopwatch. When it comes to complicated mathematical operations, the MM57109 is probably at least as fast as the equivalent lengthy Z80 routine, but the MM57109 is relatively much slower than the Z80 when it comes to simple arithmetical or logical operations. In BURP, the MM57109 is used to control FOR . . . NEXT loops (normally the basis of "benchmarks") with the result that each loop can take as long as 200ms to implement. Even those lucky enough to have a MM57109 which will operate at 800 kHz will still be aware of this lack of speed, if they are used to other forms of BASIC.
6. The monitor programme lacks many of the facilities (single step, breakpoints, register examination etc.) that would be useful in program development. I think it is fair to say that developing programs is not very easy with this monitor. It is a brave man who uses the COR command; one has to study the

software very carefully in order to ensure that no unwanted changes will be made. In practice it would be just as quick to alter the program one item at a time using ALT.

7. Both the monitor and BURP are very particular about the format of entries, in particular the placing of "spaces". A v.d.u. cursor would be helpful, since without it one can often be uncertain as to whether or not a space has been typed after the last character, although it would probably be less frustrating if there was a little more flexibility of input data.

8. From my personal point of view, the greatest limitations of the firmware relate to the BASIC facilities available. In order to be appropriate for complex scientific purposes, a more sophisticated version of BASIC would be highly desirable. BURP is very limited in terms of number of program lines, number and format of variables and flexibility of statements. To keep the situation in perspective, it must be realised that the use of the MM57109 has enabled a 2K BASIC interpreter to be written which would put any Z80 2K BASIC to shame. I am merely suggesting that the addition of an extra 1K or 2K of interpreter could result in a BASIC far more powerful than many 8K versions available.

9. Finally, I am sure that Mr Adams would be the first to agree that prospective constructors must realise that his design is specifically orientated towards scientific usage. A person whose main interests were in games, business use or control applications would be far better advised to look to one of the many straightforward Z80 designs available.

Having been critical, may I finish on a constructive note. I am at present engaged in writing a somewhat extended interpreter for this design, in order to overcome some of the limitations outlined above. Assuming that this comes up to expectations I hope to be able to make it available to constructors of this design in the foreseeable future.

John R. Whittington
North Harrow
Middlesex

WHAT'S WRONG WITH TELETEXT

The attitude taken by BREMA towards the future of teletext is an excellent example of the lack of initiative that contributes to the present malaise of the UK radio and television industry (news, July issue, p. 61).

It is very easy to snipe at the general public for ignoring teletext without really looking into the reasons why the service has never captured the interest of the so-called 'man in the street'. The reason is, in a word, ignorance. I mean that not in a derogatory sense, but simply that where technical innovations in the electronics field are concerned few people outside the industry can grasp just what is happening.

It was clearly shown last year when the radio wavelength changes took place that few people had any idea what the v.h.f. radio service was, or that it even existed. This was after the service had been in existence for over 20 years. It is also a fact that "stereo" is a misunderstood word. A "stereo" has come to mean almost anything that plays gramophone records whilst a "cassette" is a system which plays tapes, either stereo or mono. Against this background we are now expecting the public to accept that their television sets can be made to produce pages of information which they can select at will and see in colour. It is beyond the bounds of comprehension of most people, who probably think it is something from "Star Wars".

The UK broadcasting organisations were the first in the world to initiate this service, on a limited budget. Here was an opportunity for BREMA to lead the world, but what happened? Virtually nothing; the publicity behind the teletext sets was almost non-existent. It was left to an American company to provide the electronics for the decoder circuits.

The second generation of decoders is largely due to the financial resources of a Dutch company and yet BREMA, which held almost all the cards in the beginning, is now complaining that nobody wants to know, and uses the general public as a scapegoat.

Almost every home in Britain has the apparatus for demonstrating teletext, so why don't the BBC and IBA show teletext pages during the course of normal service to create interest*. A few sample pages of sports information shown during Grandstand would be great publicity. From the manufacturers' point of view perhaps they are asking too much to expect people to buy new sets when only a short while ago they may have purchased a new colour set. A teletext conversion unit that plugs into the aerial socket may have some technical hang-ups but it might be a more interesting alternative to up-date the existing set rather than go to the expense of a new one. A design of set could be produced whereby a teletext module can be plugged in at some future date when the viewer can afford it, thus splitting the financial outlay.

The potential is still there and so are the customers, so now is the time for the broadcasting organisations and the manufacturers to get together and discuss how, for their mutual benefit, they can expand and promote the service. Just give someone a teletext set to play with and you will find that he will soon realise its potential.

Now about Prestel....

Mike Hutchinson
King's Lynn
Norfolk

* They have done occasionally. – Ed

CITIZENS' BAND FOR THE INFIRM ONLY?

Much has been said for and against c.b. radio, in the UK, for a long time now. I have studied the question and find more facts in favour than against. As a paid up member of the RSGB, may I say I am not one of the short-sighted members that can't see the vast good that c.b. radio could do in the UK, but it must be in the hands of those who really do need it, i.e. the infirm and disabled only.

Many of these people cannot take the Radio Amateurs Examination, for many reasons, and others, given a test paper to do, would just break down. I go along with J. Berry of Bristol (June letters) when he says that far too many of the radio amateurs in the RSGB are feeling far too high and mighty just because they have a licence. Many amateurs look down on the S.W.L. or on those that can't for some reason pass the examination. As for pirates, there are many in clubs under the umbrella of the RSGB, I'm sorry to say.

Alf Brimming
Lawrence Weston
Bristol

VICTORIAN MICROWAVES

The article "Victorian microwaves" in the September issue illustrates a point I am repeatedly making to our more youthful engineers and which is very aptly covered in the second paragraph of the article.

In my case I have frequently used as an illustration of the point that "there is nothing new under the sun" an incident which I experienced as a lecturer at RAF Radar School, Yatesbury, during the War (at a time when microwaves were regarded as the new magic). On one occasion I idly picked up a book in the instructors' common room in which was reported demonstrations of Hertzian waves showing their analogous behaviour with visible radiation. The demonstrations were such that the Hertzian waves had to be in the very short wave region — e.g. microwaves.

The book turned out to be a record of one of the annual children's Christmas lectures given by the Royal Society in 1894 and published in 1896. So much for microwaves being "invented" just before the last war!

L. Taylor
Dartford
Kent

CONSULTATION FOR SPECTRUM USE

I refer to the very interesting letter by Mr Bob Eldridge in the December 1978 issue about the activities of the Canadian Radio Technical Planning Board.

In Australia, commercial television and other interests were invited to participate in discussions leading to the preparation of the Australian brief for WARC 79 and the Federation of Australian Commercial Television Stations (FACTS) has been an active participant. Our representation on the Australian preparatory group and its sub-committees handling matters of concern to the television industry has been through members of the FACTS engineering committee. FACTS is a body which parallels the National Association of Broadcasters in the United States as a secretariat maintained by commercial television stations to further the interests of members in areas of concern to the industry as a whole.

Whilst we seem to have had some success in our representations concerning the preparation of the Australian draft for WARC 79, we have on the other hand been endeavouring, without much success, to foster the creation of an industry consultative committee which would be "the working interface representing all users of the radio spectrum and suppliers of radio equipment" in exactly the manner achieved with the Canadian Radio Technical Planning Board.

It would therefore be most helpful to us if Mr Eldridge could supply further information concerning the guidelines/constitution/or terms of reference under which the Canadian Radio Technical Planning Board operates. This would be most useful in furthering our efforts to set up what we have called the Broadcasting Industry Consultative Committee as an interface between users and the government departments, as regulating authorities in the radio and television field.

Murray Stevenson
Secretary, FACTS Engineering Committee
Sydney
Australia

Two-metre s.s.b. and f.m. transceiver—3

Transmitter amplifier, control circuits and constructional details

by G. R. B. Thornley, G2DAF

SO FAR THIS article has described the generation units for s.s.b. and f.m., the squelch unit, and the converters for the transmitter and receiver sections of the two-metre transceiver. This third part completes the design with the transmitter power amplifier, s.s.b. filter switching circuit and the control circuits. The author's constructional details are also given.

Transmitter power amplifier

Figure 11 shows the circuit of the output power amplifier. This is constructed on a copper clad board measuring 7 × 4in with all components hard wired, and power and bias r.f.cs. and associated components supported on 1,000pF soldered-in feed-through capacitors. Because of the s.s.b. requirement, all stages must operate in a linear manner in Class AB, and the necessary forward bias for each transistor is supplied by the base "bleed" chains R_{226}, R_{227}, R_{228}, R_{229}, R_{231} and R_{232}. Additional thermal stabilization of the base voltages of Tr_{58} and Tr_{59} is provided by the clamp diodes D_{33} and D_{34}.

Any semiconductor r.f. power amplifier operating in a linear manner is much more prone to instability than an equivalent Class C amplifier. This particularly applies where there is a high power gain. Instability may occur for a number of reasons. Parasitic oscillations may appear near the signal frequency, or parametric oscillations may arise due to the varactor action of the collector-base or emitter-base diodes of the transistor. Both of these oscillations generally occur at frequencies between 1 and 10MHz. Oscillation could also be caused by external or internal feedback. As an additional precaution to ensure the maximum stability of the amplifier, all sensitive points are triple-by-passed to v.h.f., h.f. and audio frequencies. The extra cost of these components is of small importance, compared with the replacement cost due to premature failure of an r.f. power transistor.

The collector voltage for Tr_{58} and Tr_{59} may be connected to the common +12V rail and this would be convenient where the power source was a 12V accumulator. This would give an output power from Tr_{59} of approximately 12W p.e.p. However, if a higher voltage power supply is available this will give a greater power output, together with improved linearity. Advantage can be taken of the Motorola 2N5641 and 2N5642 ratings of V_{CEO} 35V and V_{CB} 65V. These transistors will give reliable service for s.s.b. and f.m. modulation with a collector supply of 28V, and under these conditions the 2N5642 is rated at 20W power output.

In practice the limit of power output is determined by the temperature rise of Tr_{58} and Tr_{59} and this in turn is effected by the efficiency of the heat sinking. The output amplifier as constructed relies on the 7⅜ × 4¾ × 2in aluminium die-cast screening box for heat sinking and this has proved to be effective, with a collector supply of 20V, during continued operation over an 18 month period. However, for continuous opera-

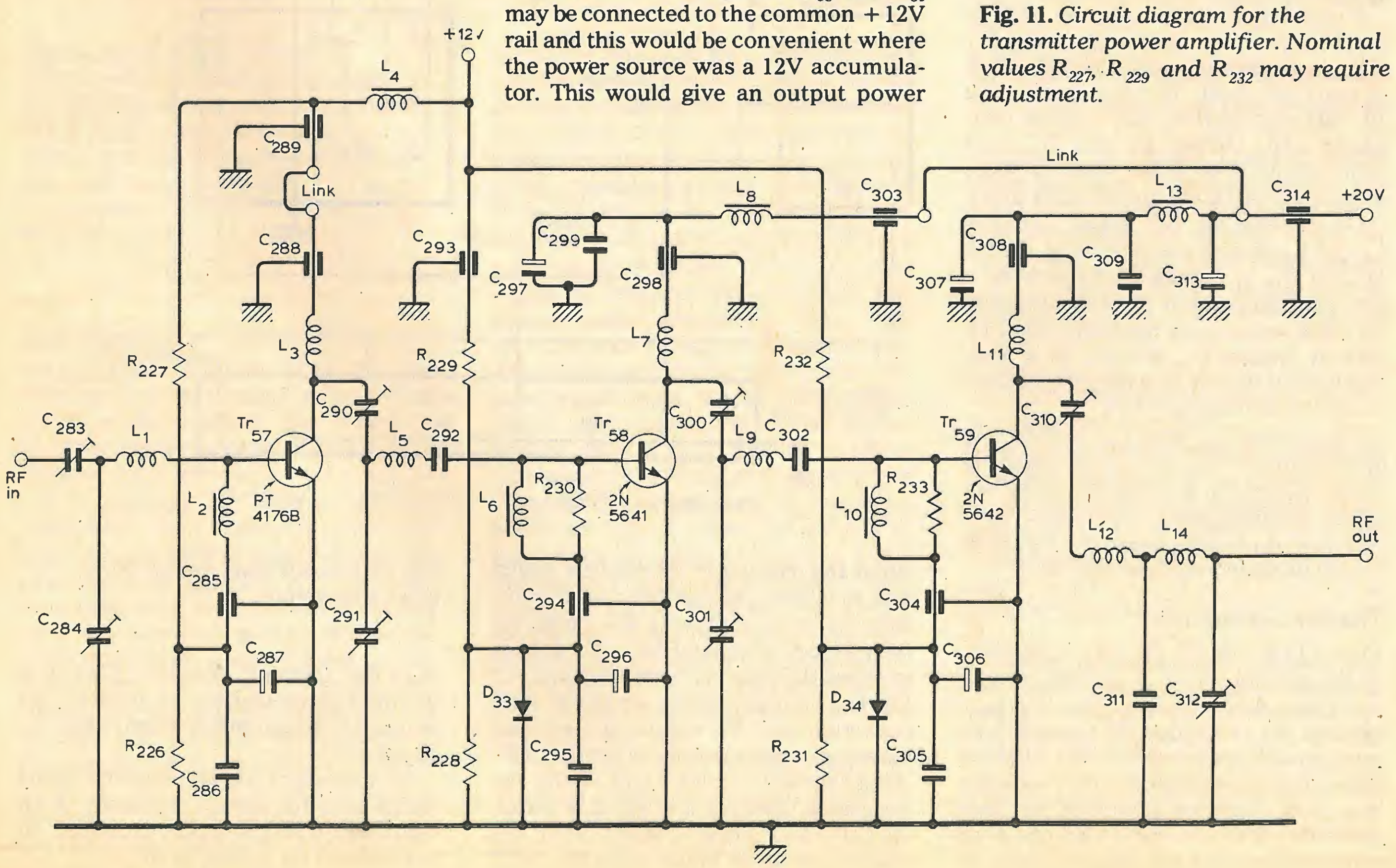


Fig. 11. *Circuit diagram for the transmitter power amplifier. Nominal values R_{227}, R_{229} and R_{232} may require adjustment.*

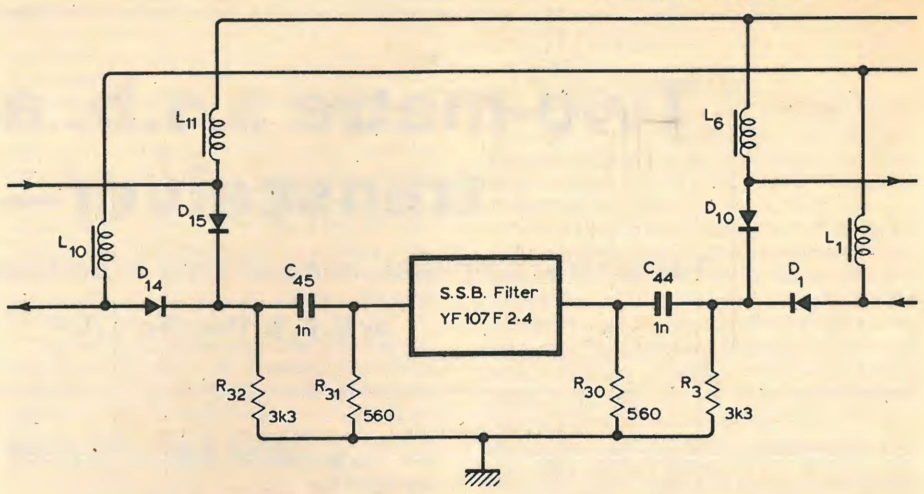


Fig. 12. *Circuit diagram showing the method of filter switching.*

tion with a 28V supply the heat sinking would have to be improved.

The wired links between the feed-through capacitors C_{228}, C_{289}, C_{303} and C_{314} are removed to allow a milliammeter to be connected in circuit. It is necessary to be able to measure the collector current of each stage separately, while adjusting the final value of R_{227}, R_{229} and R_{232} to obtain the specified zero signal collector current for each transistor.

L_{53}, L_{57} and L_{61} are tuned by air-spaced pre-set capacitors and due to the low Q of the resonant circuit will hold setting across the required 144 to 146MHz band. However the output circuits are effected by the impedance and reactance of the aerial load, and to allow necessary adjustment C_{310} "power amplifier" and C_{312} "loading" are air spaced variable capacitors brought out to panel operated control knobs.

It is quite easy when using a trimming tool to momentarily short circuit the pre-set capacitors associated with the collector circuits. This would be disastrous to the following transistors, and as a safety precaution blocking capacitors C_{292} and C_{302} are included in the circuit.

S.s.b. filter switching

Figure 12 is a simplified circuit diagram showing the method of filter switching. The transmit-receive function of the s.s.b. generator unit (Fig. 2) is controlled by switching the +12V supply to the appropriate audio and i.f. stages.

On receive, the 12V supply through L_6 and L_{11} causes the switching diodes D_{10} and D_{15} to conduct and provide a low impedance path for the incoming 10.7MHz signal from the receive converter unit. Diodes D_1 and D_{14} in a non-conducting state offer a high impedance barrier to the transmit units.

On transmit the 12V supply through L_1 and L_{10} causes the switching diodes D_1 and D_{14} to conduct, and provide a low impedance path for the outgoing 10.7MHz signal from the transmitter i.f. section. Diodes D_{10} and D_{15} in a non-conducting state offer a high impedance barrier to the receive units.

Capacitors C_{44} and C_{45} isolate the filter from the d.c. switching potential while R_{30} and R_{31} provide the manufacturers specified input and output resistive load. R_3 and R_{32} provide a d.c. path for the diode forward current flow.

The control circuits

Figure 13 shows the circuit connections to the control relays. Both relays have energising coils suitable for a 12V supply and are controlled by a single pole press-to-talk switch — in the authors case, a bell-push screwed to a wood base 8 × 4 × ½in and operated by foot pressure. The two-pole change-over relay switches the 12V power supply to either the receiver or transmitter units. The four-pole change-over relay controls the aerial switching and connects the transceiver coaxial AE input socket to either the receiver converter unit, or the transmitter power amplifier and converter unit. To reduce the contact resistance and increase the current carrying capability, poles 9 and 15 and the associated contacts are wired in parallel. Pole 6 and contact 7 short circuit the receive converter input when the relay is in the transmit position. This is a worthwhile precaution to protect the m.o.s.f.e.t. r.f. amplifier from stray induced r.f.

All necessary external connections (other than the aerial) are taken to an eight-way terminal block mounted on the chassis rear apron, as shown.

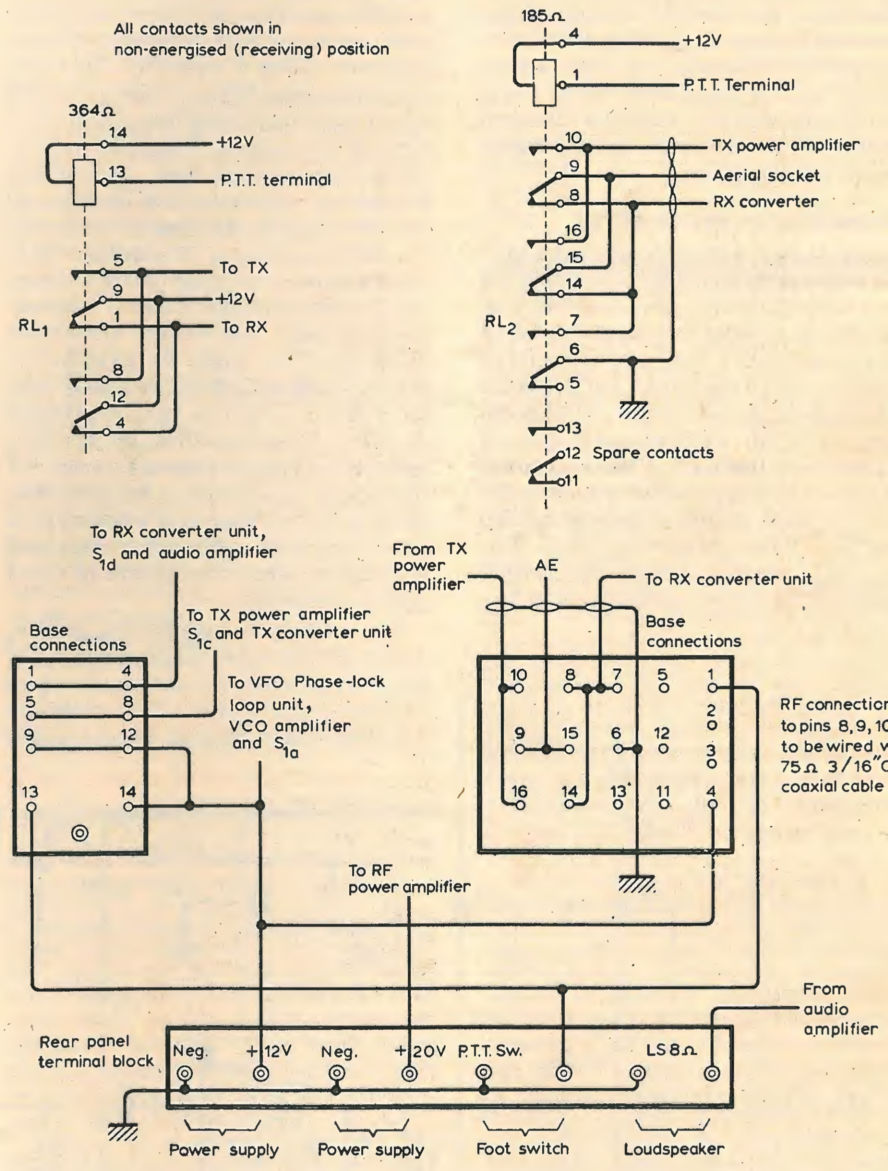
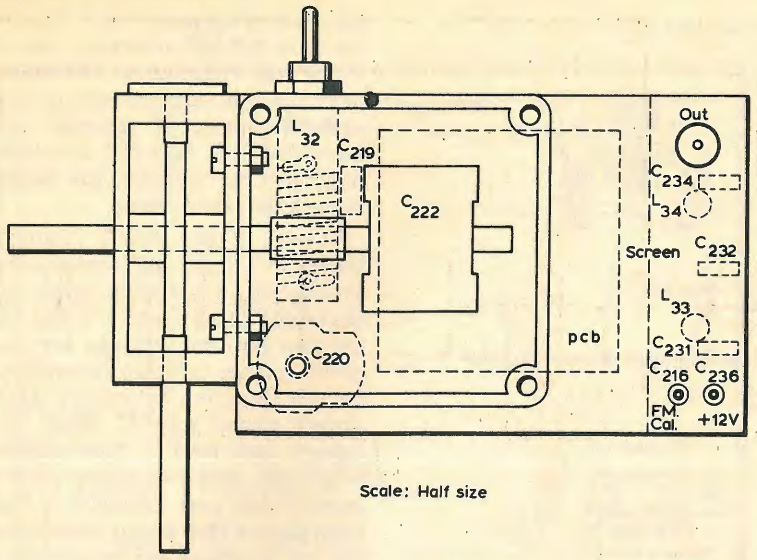


Fig. 13. *Control relay and terminal block connections.*



◀ **Fig. 14.** *V.f.o. layout showing the die-cast box bolted to the side of the worm-drive gearbox and supporting C_{222}, L_{32}, C_{219}, C_{220} and the low pass filter components are in the 18 s.w.g. box underneath. The hole above C_{220} is clearance for a trimming tool.*

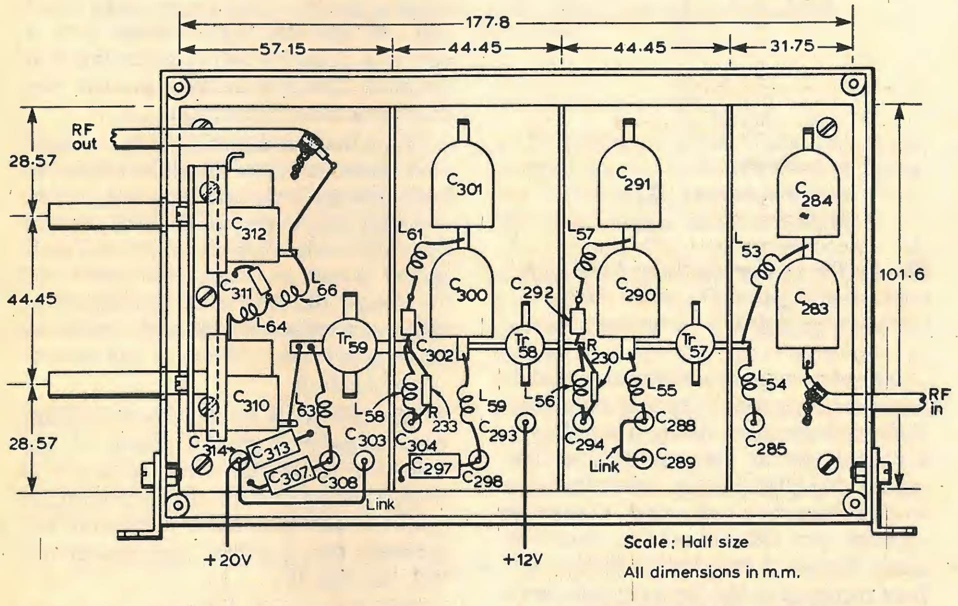


Fig. 15. *Power amplifier layout, showing double-sided copper clad board supported on stand-off pillars in 7⅜ × 4¾ in die-cast screening box. All components not shown are wired on the underside of the board. C_{310} and C_{312} are supported by an aluminium bracket bolted to the board.*

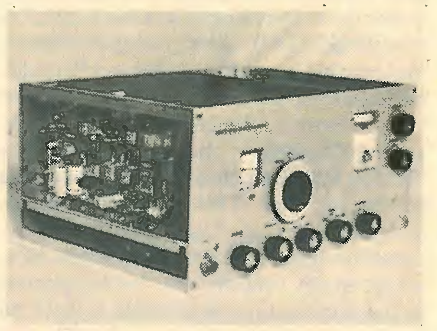
Construction

All units are constructed on double-sided epoxy-glass copper clad board and with the exception of the r.f. power amplifier all component assembly is on printed circuit boards.

It is necessary to fully screen the phase-lock unit, transmit converter unit, transmit power amplifier and the v.f.o. unit but the p.c.bs. for all other units need only to be mounted on ⅜in high 6BA stand-off pillars. While the transceiver will operate from a 12V battery in a car, it was designed primarily for main station use so no attempt was made at miniaturization. The overall size of the cabinet is largely a matter for individual choice but in practice it will be determined partly by the size of the reduction gear box and the tuning dial to be used. In the authors case the cabinet was made larger than is strictly necessary to leave space for future 70cm Band transmit and receive converter units.

The complete transceiver, which measures 15¾ × 7¼ × 11in deep, has front and back panels constructed from 10 s.w.g. aluminium. These are connected by four horizontal bars of ½in square section aluminium 10¾in long with the ends drilled and tapped 2BA. The panels are fixed to the bars by countersunk-head ½in by 2BA nickle-plated machine screws. The L-section support rails of ⅜ × ⅜in by 16 s.w.g. aluminium 15¾in long are bolted to the front and back panel so as to support a platform 15¾ × 10¾in of 14 s.w.g. aluminium 2in above the bottom edge. The platform is further stiffened by two L-section edges with 6BA machine screws and nuts. To form a complete cabinet, top, bottom and side panels of 16 s.w.g. aluminium are fitted to the chassis with 4BA screws tapped into the square section bars.

It was considered of importance to have all units, wherever possible, accessible for voltage checks, final alignment and adjustment. Accordingly, "layer" or "side-by-side" layout has been avoided. The s.s.b. generator p.c.b. and transmit power amplifier in its die-cast box are mounted vertically on the rear panel. All other units are mounted horizontally, with the transmit converter in its screening box and the v.f.o. unit on top of the platform. The phase-lock loop in its screening box, together with the v.c.o amplifier p.c.b., f.m. generator p.c.b., receive converter p.c.b. and the two change-over relays are mounted under the platform. The general method of assembly can clearly be seen from the photographs.



Threequarter view of the transceiver showing the chassis assembly

With all double-sided p.c.bs., the top side of the board is used as a ground plane, and the underside being etched to form the circuit interconnections. De-soldering and removal of faulty components can present problems where certain pin connections are through the board, and other connections are directly to the ground plane, so all two pin components — such as resistors and capacitors — have the chassis earth connection soldered directly to the top copper foil ground plane. With multi-pin components all connecting pins go through the board, and where necessary into an etched earthing lug in the bottom copper foil. This is electrically connected to the ground plane by a 24 s.w.g. tinned copper-wire link.

All component mounting holes must have the copper of the top ground plane removed by lightly countersinking the hole with a 4BA twist drill. This is best undertaken by hand. This also applies to the unused pins of IC_3 and IC_4 because these will be internally connected and "live".

For the power amplifier, where normal point-to-point wiring is adopted, and both sides are used as chassis earth returns, the top ground plane is connected to the underside copper plate by soldering 24 s.w.g. tinned copper-wire U links, spaced approximately 1½in apart, along each edge.

The performance of the v.f.o. is dependent not only on the electrical stability but also on the mechanical stability of the unit. A recommended method of supporting the tuning capacitor C_{222} is to use a 3¼ × 3¼ × 2in by 10 s.w.g. rigid die-cast aluminium box, with the end bolted directly to the reduction drive gear assembly. A second box of 18 s.w.g. aluminium or tinned steel plate 5¼ × 3½ × 1½in can be bolted to the die-cast box with the two bottoms adjacent. The variable tuning capacitor should be the two bearing type and this can be supported in the top box. The remaining components L_{32}, C_{219}, C_{220} and the p.c.b., together with the low-pass filter in a screened-off section, can be supported in the bottom box. A suitable layout, as used by the author, is shown in Fig. 14.

For good v.f.o. stability it is most important that the coil L_{32} can be adjusted initially to the precise inductance value required and that it will hold its setting over a long period of time. The dust core should be held in position by a screwed brass rod, running through the mounting bush of the coil former, and capable of being locked in position by either a spring-loaded clutch, or alternatively a locking nut, so that there is neither end or side float of the core within the winding. The former used by the Author is a baked paper type 2⅛in long by ⅜in diameter. (As used in the coil pack of the surplus Marconi CR100 receiver). Winding should be put on under tension, and then thoroughly doped with coil cement (polystyrene rod dissolved in Benzene).

Temperature compensation is provided by C_{219}. This is a tubular ceramic with a specification of N750M (negative 750 parts per million) supported by the coil connecting tags, and positioned so that its length is pressing against the winding. Although a nominal value of 27pF has been specified, in practice the actual value needed for full compensation will have to be determined by experiment.

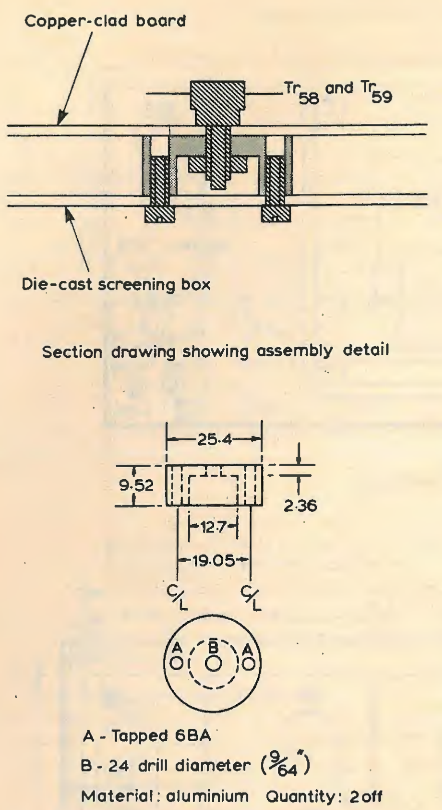


Fig. 16. *The power amplifier heat-sink spacers. If Tr_{227} and Tr_{228} have 4 BA studs, a size 25 drill is recommended.*

One advantage of a Colpitts parallel-tuned v.f.o. is that a tuning capacitor with semi-circular rotor plates will give a roughly linear dial calibration. The actual departure from linearity is a small progressive reduction of angular rotation per 100kHz as the circuit is tuned higher in frequency. In the authors transceiver the linearity has been improved so that the dial calibration is correct within ± 1kHz right across the tuning range, by slightly re-shaping the rotor by judicious use of a hand file.

The calibrated tuning dial can be seen clearly in the chassis photographs. This is made in a simple manner by cutting a piece of 20 s.w.g. aluminium 9 × 1½in, and cementing it with Araldite to the rim of a standard 4½in diameter cord drive drum (Jackson Part No. 4029 or similar). The calibrated scale is hand printed with Indian ink on a piece of glazed drawing paper 8½ × 1½in held in position by self-adhesive tape along either end. This enables the calibration points to be initially marked up in pencil and the paper scale removed for final hand printing, without upsetting the alignment by removing the drum from the gear box drive shaft.

Layout of the Power Amplifier is shown in Fig. 15. All components are assembled on a double-sided copper-clad epoxy glass board 7 × 4in. As both top and bottom surfaces are used as ground planes they are electrically connected together by twelve 24 s.w.g. tinned copper-wire U links, as previously described — four along each long edge, and two along each short edge. Three cross screens 4 × 1¼in cut from copper clad board are soldered to the top ground plane to provide inter-stage screening. Each screen has a small slot cut into the bottom edge with a square section file before soldering into position. This is necessary to clear the transistor base connection.

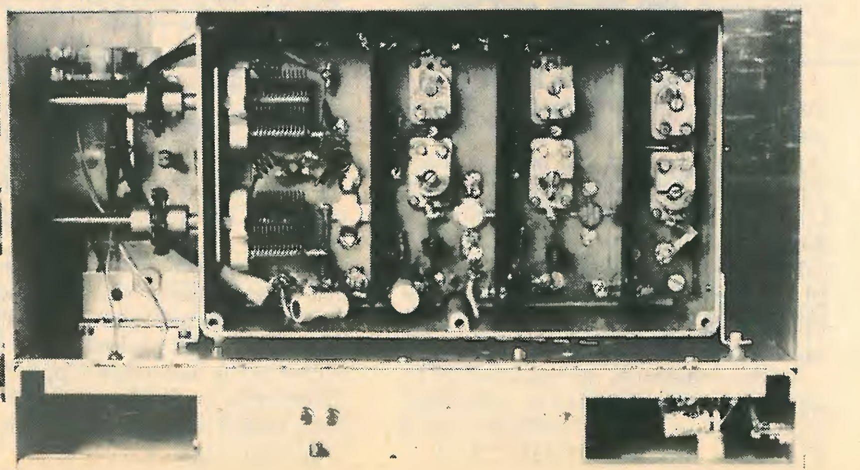
Tr_{57} is bolted directly to the copper clad board and this provides adequate heat sinking. Tr_{58} and Tr_{59} are bolted through the board and through the aluminium heat sink spacer. Each spacer is held in firm contact with the 7⅜ × 4¾ × 2in die cast screening box by 6BA machine screws through clearance holes previously drilled in the appropriate position.

The aim is to effect the maximum heat transfer from the shank of the transistor to the die cast box, and it is important to ensure that all contact surfaces are free from burs and are perfectly flat. For heat sink spacer details, see Fig. 16.

The screening box is mounted vertically and bolted to the chassis platform with four 6BA machine screws and nuts. To avoid circulating r.f. currents, the top rear end of the box is electrically "bonded" to the chassis rear panel with an aluminium strip 2¼ × 2in bent up 90 degrees for ¼in at the narrow end, and held in position with four 6BA machine screws and nuts. Drive shafts from the panel control knobs to C_{310} and C_{312} are coupled by Eddystone type 893 insulated shaft coupler, or similar.

Figure 17 shows the layout of the phase-lock unit. All d.c. connections are taken through 1,000pF nut fixing feed-through capacitors mounted through the walls and the internal screen of the 7½ × 5½ × 1½in aluminium screening box. These are C_{200}, C_{206}, C_{203}, C_{204} and C_{193} in the circuit diagram. The l.e.d. indicator is mounted externally and supported on C_{203} and C_{204}. If a position external to the chassis is preferred, suitable panel mounting l.e.ds are available. The MC7805 regulator for the 5V supply to the phase detector and loop filter p.c.b. is mounted on a small aluminium bracket, held in position by the 6BA support pillars at the IC_4 end of the p.c.b.

The "S" meter zero setting potentiometer R_{63} and the +12V feed resistor R_{62} are assembled on a small paxolin panel 1¼in by 1in supported by the square section aluminium rail — between the front panel and the end of the s.s.b. generator p.c.b. Terminal posts and test points can be provided by using the usual p.c.b. tapered wiring pins. However, because of the danger — when making the top connections — of solder running down the pin and shorting across to the ground plane, the author prefers to use Oxley "Barb" insulators Type 093/20P. These have a p.t.f.e. lipped bush which ensures firm mounting in the p.c.b., and also affords an effective barrier to molten solder. The connecting post of the bush is soldered to the underside p.c.b. track with a wire link.



Power amplifier unit and drive shafts to the panel tuning and loading controls

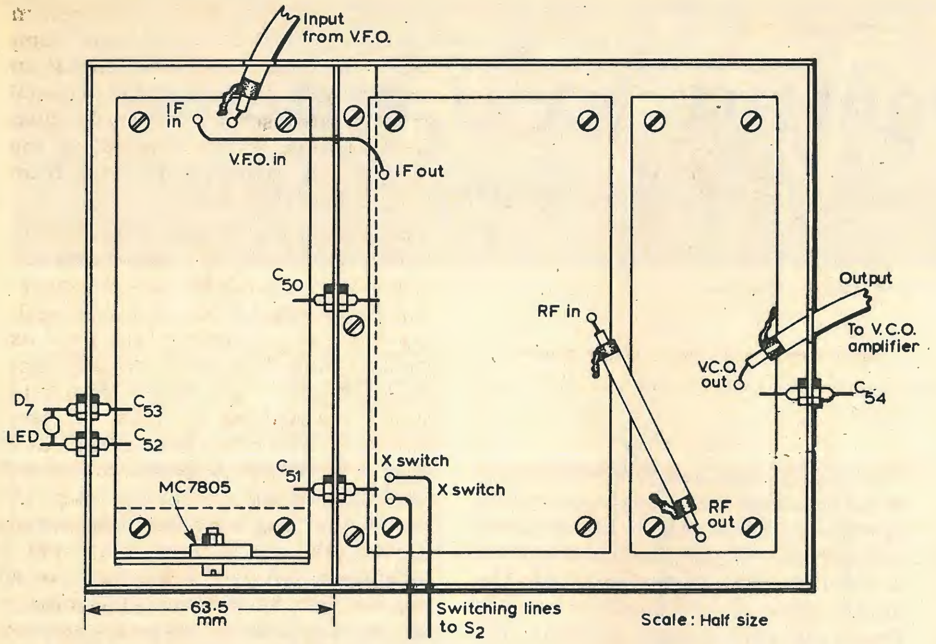


Fig. 17. *Layout of the phase-lock v.c.o. unit, showing the 18 s.w.g. aluminium screening box with internal screen and position of the feed-through capacitors. Heat sink for the MC7805 regulator is provided by the 2 × 1¼ × ½ in L-shaped support bracket. The p.c.bs are mounted on ⅜in 6BA pillars.*

Corrections to Part 1.
The second terminal (bottom left corner of Fig. 2, p44) should read "Signal input *to* FM generator unit," not *from*. C_{121} in Fig. 3, p46, is not an electrolytic, as the drawing wrongly shows. The label for transistor, Tr_{24}, in Fig. 3, should be 2N3819 as the symbol indicates, not BC108. A misalignment in the components list, p56, leaves doubt as to the value of capacitors, C_{73}, C_{125}, C_{127} and C_{143}. These should be 100pF polystyrene 5%. The wiper on S_{1a} is shown incorrectly connected to +12V TX. This should be connected to +12V COMMON.

Corrections to Part 2.
Capacitor C_{219} should be type N750M *not* N750K as shown in the Parts list. Caption with Fig. 6 should read ..... 133.3 to 135.3MHz (not 134.3MHz). End of caption with Fig. 10 should read ..... Tr_{56} to be fitted with TO-5 clip-on heat sink ..... (not Tr_4). Resistors R_{223} and R_{225} in this figure are shown incorrectly as C_{223} and C_{225}. Parts list – Resistors R_{208} and R_{209} are 47k and not 4k7 as shown; C_{251} is a 5.6pF tubular ceramic; L_{41} should have a centre tap on the primary.

This concludes the constructional details for the transceiver. The fourth and final part of this article will describe the alignment procedure for the finished equipment.

Components list

Power amplifier

Resistors
(all ±10% ½W unless otherwise stated)

226, 228, 231	22
227	150 + 150 1W
229	150 + 100 + 10 1W
232	150 + 100 1W
230	100
233	27

Capacitors

283, 284, 290, 291, 300, 301	25p air-spaced trimmer
310, 312	30p air-spaced variable
285, 288, 289, 293, 294, 298, 303, 304, 308, 314	1,000p solder-in feed through
286, 295, 299, 305, 309	100n polyester 20%
287, 296	32μ 18V electrolytic
292, 302	10n polyester 20%
297, 307, 313	32μ 50V electrolytic
306	100μ 18V electrolytic
311	33p silvered mica

Transistors

57	PT4176B or 2N5641
58	2N5641 Motorola
59	2N5642 Motorola

Diodes

33, 34	1N914

Inductors

53, 57, 61, 64	2t 18 s.w.g. enamel ¼in inside diameter, spaced wire diameter
66	3t 18 s.w.g. enamel ¼in inside diameter, spaced to ½in long
54, 56, 58, 60, 62, 65	2½t 24 s.w.g. enamel on FX1115 bead
55, 59, 63	5t 20 s.w.g. enamel ¼in inside diameter, close wound, self supporting

Main chassis — miscellaneous

1	2 pole changeover, 185 ohm coil, type G2/18 M.D. Ltd (alternative Radio Spares type 40)
2	4 pole changeover, 185 ohm coil, Radio Spares type 44

Terminal block, feed-through type, Belling-Lee L1409
1in diameter control knobs, 7off
Chassis mounting sockets, Belling-Lee L604/S, 2 off
Aluminium screening boxes:—
7½ × 5½ × 1½in, 18 s.w.g.
5¼ × 2¾ × 1½in, 18 s.w.g.
7⅜ × 4¾ × 2in, die-cast
V.f.o. screening boxes as required

V.f.o. Unit — miscellaneous

Chassis mounting socket, Belling-Lee
Shaft coupler
100:1 ratio worm gear reduction drive unit
4½in diameter drum Jackson Cat. No. 4029

Transmit converter unit — miscellaneous

Heatsink, TO-5, clip-on type

Further coil details

The following component boards can be obtained from:
Neosid Small Orders,
PO Box 86, Welwyn Garden City,
Herts AL7 1AS.

Screening can	Cat. No. 622
Base plate	Cat. No. 610
Coil former	Cat. No. 240
Screw core F29	Cat. No. 504

Printed circuit boards

A set of ten double-sided glass fibre p.c.bs is available for £35.00 (inclusive of v.a.t. and UK post) from M. R. Sagin at 23 Keyes Road, London NW2. The boards are supplied roller tinned and drilled, and have all clearance areas etched in the ground plane. The ten boards accommodate a s.s.b. generator, f.m. generator, Rx converter, tx converter, crystal oscillator and mixer, phase detector and loop filter, squelch unit, v.f.o. circuit, v.c.o. circuit and v.c.o. amplifier.

Seven-segment/b.c.d. encoder

Design procedure for a clock/calculator chip add-on unit

by David D. Clegg

Calculator and clock chips are now so cheap that with the correct interfacing they can become useful additions to a microprocessor system, saving considerable programming and, indeed, processing time. It is this interfacing that can be a problem because most l.s.i. calculator and clock chips are designed to directly drive seven-segment displays. This article, therefore, describes the design of a practical seven-segment-to-b.c.d. encoder, which can be added to the output of a calculator or clock chip to provide a direct b.c.d. output. The design procedure is of interest because of its potential instructional value.

CONSIDER the normal seven-segment display shown in Fig. 1, with a view to designing a seven-segment-to-b.c.d. encoder. Most, but not all, calculators output segment A on the 6 and segment D on the 9, and while the decoder to be described here has been designed to accept this more usual format, it will be shown later that the final design actually handles both styles of 6 and 9.

A casual glance at the seven-segment display will reveal a certain redundancy in the segments and it might, therefore, prove useful to investigate this in case it is unnecessary to use all of the segments as inputs to the encoder. To do this, the display group for the numbers 0 to 9 is drawn out seven times, omitting one segment at a time, and the end results are inspected to see if two or more of the ten numbers in any display group can be confused. If the omission of a segment results in ten different patterns for the ten numbers, that segment is redundant and need not be used as an input to the encoder.

Figure 2 shows the display group when the segment A is omitted. It can be seen that confusion arises between the numbers 1 and 7, so segment A is therefore essential and cannot be omitted.

Similarly, when segment B is omitted, confusion arises between 6 and 8 and between 5 and 9, so segment B must also be retained. When segment C is omitted, however, ten quite distinct patterns result. This segment is therefore redundant and need not be used as an input to the encoder. It is also interesting to note that a 6 without segment A and a 9 without segment D do not alter the result. Omitting segment D also results in ten different patterns, so it too is redundant and need not be used as an input to the encoder. Even if segment A on the 6 is omitted, there are still ten distinguishable patterns, and since segment D has already been eliminated, either style of 9 is obviously acceptable.

Further investigation shows that omitting segment E confuses numbers 5 and 6 and 8 and 9, omitting segment F confuses 3 and 9 and omitting segment G confuses 0 and 8. These segments are therefore essential and must be retained.

Omission of segments C and D individually does not result in confusion but it is not obvious that omission of both C and D together also does not cause confusion. This is shown to be true in Fig. 3. It can be seen that there are ten distinct patterns and that segments C and D in combination are indeed redundant. As before, both styles of 6 and 9 are acceptable. At this stage in the design it can be stated categorically that an encoder where the redundant segments C and D are not used would only accept the two styles of 9 but care will have to be taken later on in the design to ensure that both styles of 6 are also accepted.

Fig. 1. *Seven-segment displays of the decimals 0 to 9. Segment A on decimal 6 and segment D on decimal 9 are normally included.*

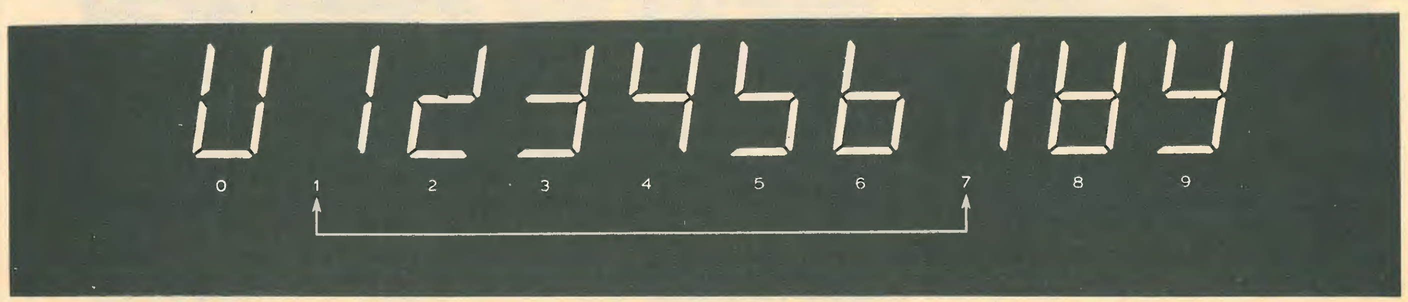


Fig. 2. *Displays of the decimals 0 to 9 with the segment A omitted. Decimals 1 and 7 can be confused.*

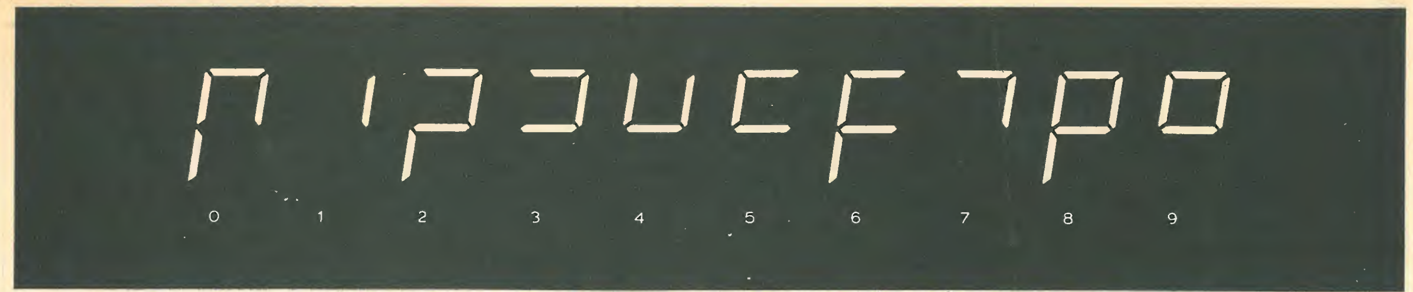


Fig. 3. *Displays of the decimals 0 to 9 with both the C and D segments omitted. There are still ten distinct patterns and no confusion between the decimals.*

Decimal	Seven-segment input							B.C.D. output			
	A	B	C	D	E	F	G	2^3	2^2	2^1	2^0
0	1	1	1	1	1	1	0	0	0	0	0
1	0	1	1	0	0	0	0	0	0	0	1
2	1	1	0	1	1	0	1	0	0	1	0
3	1	1	1	1	0	0	1	0	0	1	1
4	0	1	1	0	0	1	1	0	1	0	0
5	1	0	1	1	0	1	1	0	1	0	1
6	1	0	1	1	1	1	1	0	1	1	0
7	1	1	1	0	0	0	0	0	1	1	1
8	1	1	1	1	1	1	1	1	0	0	0
9	1	1	1	1	0	1	1	1	0	0	1

Table 1. *Truth table for the seven-segment-to-b.c.d. encoder.*

Table 1 is a truth table for the encoder. For clarity, it has been drawn as if it was for a b.c.d.-to-seven-segment decoder, and the very numerous "don't care" conditions have not been tabulated. From this table the following expressions for the b.c.d. output of the encoder can be obtained:

$$2^0 = \bar{A}B\bar{E}\bar{F}\bar{G} + AB\bar{E}\bar{F}G + A\bar{B}\bar{E}FG + AB\bar{E}\bar{F}\bar{G} + AB\bar{E}FG$$
$$2^1 = ABE\bar{F}G + AB\bar{E}\bar{F}G + A\bar{B}EFG + AB\bar{E}\bar{F}\bar{G}$$
$$2^2 = \bar{A}B\bar{E}FG + A\bar{B}\bar{E}FG + A\bar{B}EFG + AB\bar{E}\bar{F}\bar{G}$$
$$2^3 = ABEFG. + AB\bar{E}FG$$

These expressions can now be taken one at a time and minimised using five-variable Karnaugh maps from which the logic circuit can be obtained. The Karnaugh Maps for the 2^0 expression are shown in Fig. 4, and from these we get:

$$2^0 = A\bar{E} + \bar{E}\bar{G} = \bar{E}(A + \bar{G})$$

$$= \overline{(E + \overline{(A + \bar{G})})} \text{ ...... (de Morgan)}$$

A logic circuit can now be obtained from this reduced expression, as shown in Fig. 5.

Now consider the Karnaugh maps for 2^1, as shown in Fig. 6. From these we get:

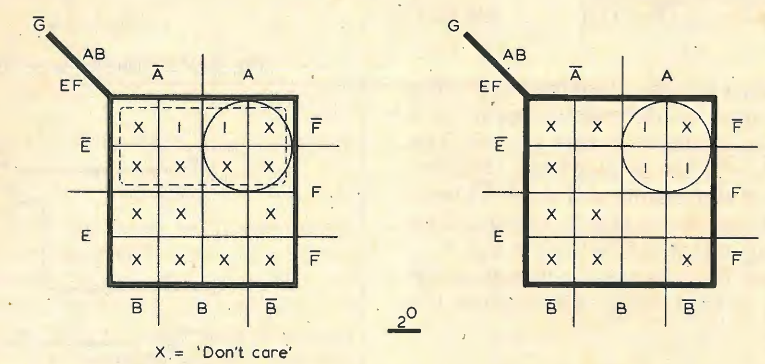


Fig. 4. *Karnaugh maps for the expression 2^0 derived in the text.*

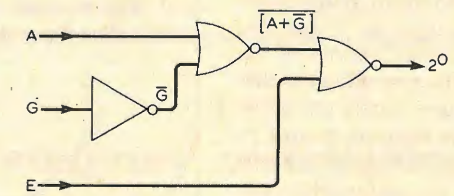


Fig. 5. *Logic circuit for expression 2^0.*

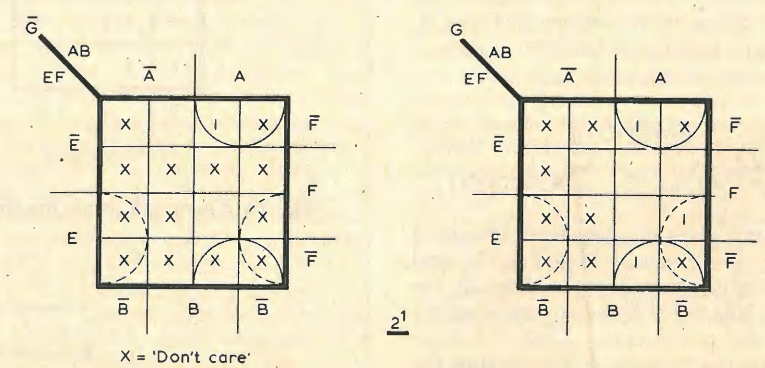


Fig. 6. *Karnaugh maps for the expression 2^1 derived in the text.*

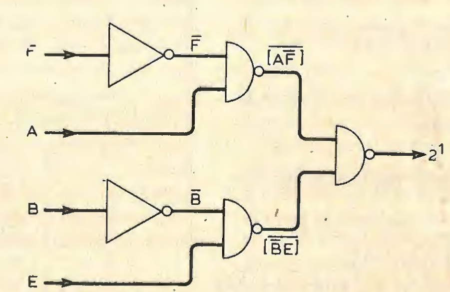


Fig. 7. *Logic circuit for expression 2^1.*

$$2^1 = A\bar{F} + \bar{B}E$$

$$= \overline{(\overline{A\bar{F}})(\overline{\bar{B}E})} \; \ldots\ldots \text{(de Morgan)}$$

The logic circuit for the 2^1 output is therefore as shown in Fig. 7.

The Karnaugh Maps shown in Fig. 8 give the following:

$$2^2 = \bar{B} + \bar{A}G + A\bar{F}\bar{G}$$

$$= B + \overline{(A+\bar{G})} + \overline{(\overline{A\bar{F}}) + G} \; \ldots\ldots \text{(de M.)}$$

$$= \overline{B(\overline{(A+\bar{G})} + \overline{(\overline{A\bar{F}}) + G})} \; \ldots\ldots \text{(de M.)}$$

This rather complex looking expression is not quite as difficult to apply to a circuit as it would at first appear. The term $\overline{(A+\bar{G})}$ has already been obtained for the 2^0 expression, and the $(\overline{A\bar{F}})$ term is available from the 2^1 circuit. The resulting circuit can be seen in Fig. 9.

Figure 10 gives the Karnaugh maps for the 2^3 expression, which gives the output:

$$2^3 = ABFG$$

This has the straightforward circuit shown in Fig. 11.

A careful inspection of the truth table shows that the 2^3 output is '1' for decimals 8 and 9 only. It may, therefore, be possible to simplify the encoding for the 2^3 output using the previously encoded 2^2, 2^1 or 2^0 terms. The outputs 2^2 and 2^1 are both '0' on 0/1 and 8/9 only and it is therefore necessary to use another input to distinguish between decimals 0/1 and decimals 8/9. Investigation of the segment inputs shows that segment G is suitable for this as it is at '0' for decimals 0 and 1 and at '1' for decimals 8 and 9. From this argument the 2^3 output expression can be simplified to

$$2^3 = \overline{2^1}\,\overline{2^2}\,G$$

$$= \overline{(2^1 + 2^2 + \bar{G})} \; \ldots\ldots \text{(de Morgan)}$$

The term $\bar{G}$ has already been obtained for the 2^0 expression (see Fig. 5), and hence we have a simplified circuit for the 2^3 output encoder, as shown in Fig. 12.

The truth of this intuitive design for the 2^3 encoder can be verified by applying a little basic Boolean algebra, as follows:

$$\text{Let } Z = \overline{(2^1 + 2^2 + \bar{G})}$$

$$\text{Therefore } \bar{Z} = 2^1 + 2^2 + \bar{G}$$
$$= (A\bar{F} + \bar{B}E) + (\bar{B} + \bar{A}G + A\bar{F}\bar{G}) + \bar{G}$$

duplicating $(A\bar{F}\bar{G})$ and rearranging we get:

$$\bar{Z} = (\bar{B} + \bar{B}E) + (\bar{G} + A\bar{F}\bar{G}) + (A\bar{F} + A\bar{F}\bar{G}) + \bar{A}G$$
$$= \bar{B}(1+E) + \bar{G}(1 + A\bar{F}) + A\bar{F}(1+\bar{G}) + \bar{A}G$$

and since $(1+X) = 1$ we have:

$$\bar{Z} = \bar{B} + \bar{G} + A\bar{F} + \bar{A}G$$

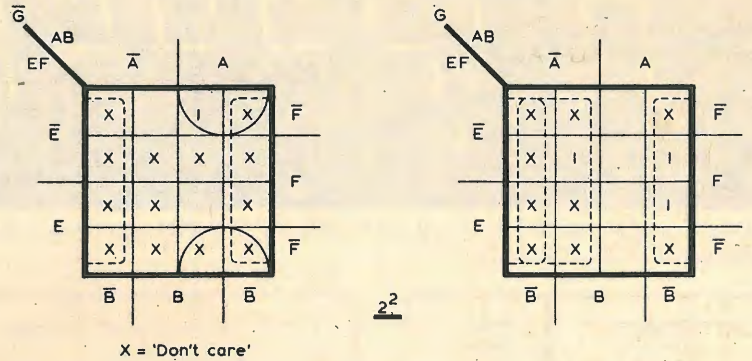


Fig. 8. *Karnaugh maps for the expression 2^2 derived in the text.*

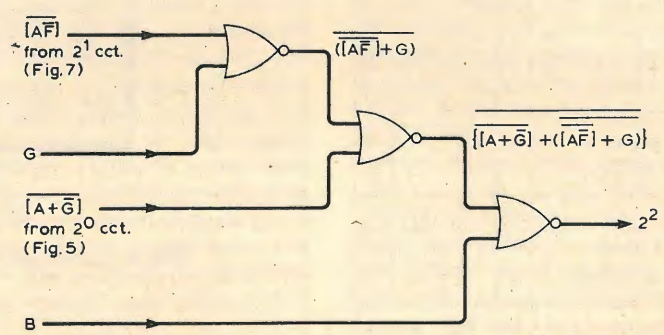


Fig. 9. *Logic circuit for the expression 2^2. The inputs $(\overline{A\bar{F}})$ and $\overline{(A+\bar{G})}$ are taken from the circuits in Figs 7 and 5 respectively.*

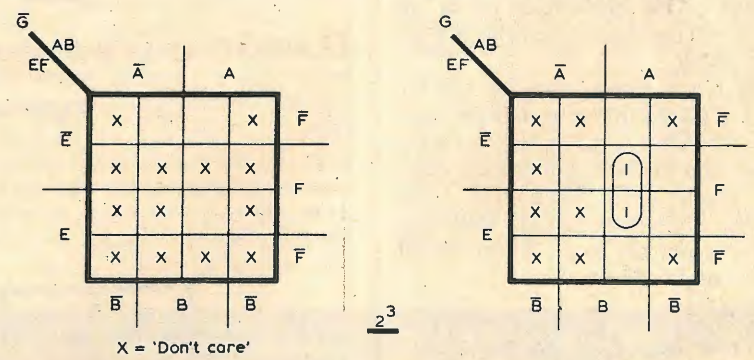


Fig. 10. *Karnaugh maps for the expression 2^3 derived in the text.*

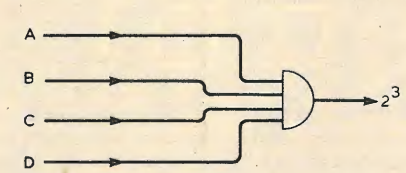


Fig. 11. *Logic circuit for expression 2^3.*

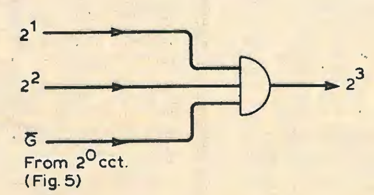


Fig. 12. *Simplified circuit for the expression 2^3. This makes use of the circuit derived for $\bar{G}$ in Fig. 5.*

duplicating $\bar{G}$ and multiplying by $1 = (A + \bar{A})$ gives:

$$\bar{Z} = \bar{B} + \bar{G} + A\bar{F} + \bar{A}G + \bar{G}(A + \bar{A})$$
$$= \bar{B} + \bar{G} + A\bar{F} + \bar{A}G + A\bar{G} + \bar{A}\bar{G}$$

and rearranging:

$$\bar{Z} = \bar{B} + A\bar{F} + \bar{A}(G + \bar{G}) + \bar{G}(A + 1)$$

Now, since $(G + \bar{G}) = 1$ and $(A + 1) = 1$

$$\bar{Z} = \bar{B} + A\bar{F} + \bar{A} + \bar{G}$$

and repeating the above steps with $A\bar{F}$:

$$\bar{Z} = \bar{B} + \bar{G} + A\bar{F} + \bar{A} + \bar{A}(F + \bar{F})$$
$$= \bar{B} + \bar{G} + A\bar{F} + \bar{A} + \bar{A}F + \bar{A}\bar{F}$$
$$= \bar{B} + \bar{G} + \bar{A}(F + 1) + \bar{F}(\bar{A} + A)$$
$$= \bar{B} + \bar{G} + \bar{A} + \bar{F} = \overline{(BGAF)}$$
$$= \overline{2^3}$$

Therefore $Z = \overline{(2^1 + 2^2 + \bar{G})} = 2^3$

The simplified encoder circuit shown in Fig. 12 is therefore a valid means of arriving at the 2^3 output.

The four parts of the design can now be brought together, as shown in Fig. 13, to make up the complete seven-segment-to-b.c.d. encoder. As already stated, this design will accept both styles of 9 but it has not yet been shown that it will accept both styles of 6. Figures 6 and 8 show that in both the 2^1 and 2^2 expressions, the 'don't care' term $(A\bar{B}\bar{E}FG)$ has been included in the reduction, thus effectively eliminating the variable 'A' from the $(A\bar{B}\bar{E}FG)$ term. The result of eliminating segment A from this term in the 2^1 and 2^2 expressions which describes decimal 6, is that a 6 either with or without segment A will be correctly encoded.

The actual logic family used to construct a practical circuit will, obviously, depend on individual requirements, but for many applications c.m.o.s. will be quite fast enough. However, the propagation delay through to the 2^3 output may be too long for some systems and t.t.l. or Schottky t.t.l. may be required.

The final circuit shown in Fig. 13 is not a unique solution to this encoder problem, as a close inspection of the Karnaugh Maps will show, but the author believes that it is one of the simplest solutions.

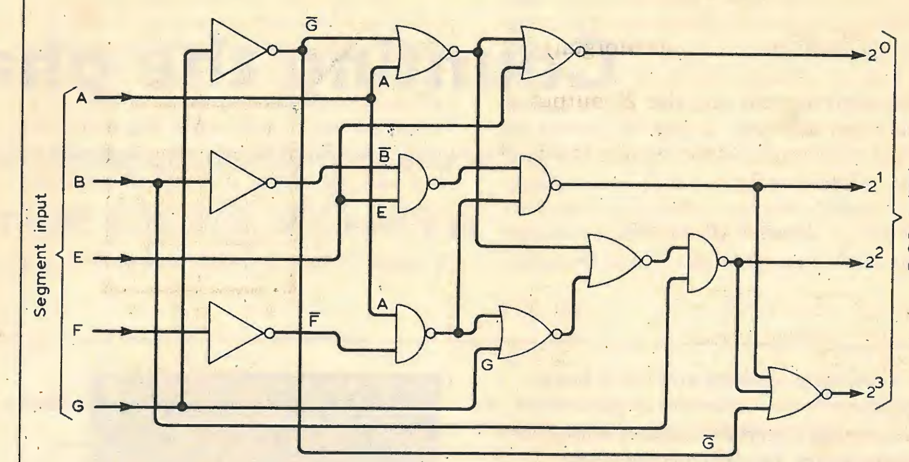


Fig. 13. *The complete logic circuit for the seven-segment-to-b.c.d. encoder.*

David Clegg was educated at Dollar Academy, Clackmannanshire in Scotland. In 1967 he joined the BBC, initially as a transmitter maintainence engineer and later as a technical author. Before emigrating to Alberta, Canada, in April 1978, he held the post of television-studio design and installation engineer with the BBC's studio capital projects department in London. David is now a senior design engineer and technical author with Athabasca Research Corporation Ltd, which is a small Edmonton-based company manufacturing a wide range of meteorological and environmental pollution monitoring equipment. Many of the company's products are microprocessor-based and are designed to withstand the harsh Canadian winters. David is particularly interested in digital electronics, especially in the area of timekeeping electronics and microprocessors.

Random frequency communication

Military radio communication is of course subject to jamming and interception of messages. One way of trying to avoid these unwelcome attentions is "frequency hopping". The transmitted band of frequencies carrying, say, voice information, is made to hop about from channel to channel in a random sequence of channels. Obviously the receiver tuning must be arranged to hop about in a corresponding sequence for communication to be achieved. What was claimed to be the first public demonstration of frequency hopping was put on by Racal at their own exhibition, Racalex, in London recently. It was a prototype system developed for a portable military transceiver called Jaguar-V (an acronym from Jamming Guarded Radio-V.h.f.) which operates in the 30 to 88MHz frequency range using 25kHz channels. The transmitter's frequency synthesizer is controlled by a quasi-random sequence generator, the random numbers in the sequence being determined by a code selected by the operator. The output from the synthesizer is modulated by the baseband signal, amplified and then radiated. At the receiver the frequency synthesizer is controlled by an identical quasi-random sequence generator which is synchronized with that at the transmitter. A truly random sequence would go on for an infinite time, but in this case the time taken for the quasi-random sequence to complete itself exceeds 24 hours.

Synchronization between transmitter and receiver is achieved by transmitting a periodical sync signal in the form of a digital data stream along with the voice information. But since this digital data would stand out clearly against an analogue voice signal and so make the sync information available to an enemy, the voice signal is in fact also transmitted digitally. The audio signal is converted to a 16kbit/s digital form in a delta modulator. The digital signals are then compressed into short packages and transmitted at a slightly higher rate than normal to make time for channel changing and the sync signals. At the receiver, the sync signals are extracted and the remaining information packages are "stretched" into a continuous digital stream ready for demodulation.

The rate at which the system hops between channels is a matter for careful decision. If it is too slow, a conventional sweep receiver can find the signal and lock on a jammer. If it is too fast, the cost becomes excessive. Also the ratio of time occupied by useful information to that for changing frequency becomes too small. As rapid frequency changes inevitably generate spurious signals, the faster the hop, the more spurious signals are generated. Pollution of the whole v.h.f. spectrum by fast hopping is, therefore, a serious risk. Furthermore fast hopping can only send a small amount of information during each hop period and the synchronizing sequence must be spread over a number of hop periods. This makes it more vulnerable to jamming and slower to synchronise. In fact Racal have chosen a medium hopping rate of several hundreds per second. This operates among 256 channels to give a total bandwidth for the system of 6.4MHz, which is selectable within the 30-88MHz range.

Incidentally, Racal make jammers too, so they can get in on both sides of electronic warfare.

Counting the phases

Circuits for multi-phase generation

by **D. Price,** B.Sc., M.Sc., Ph.D., M.I.E.E.

In many logic systems and some linear applications it is necessary to generate a multi-phase signal with accurate angular relationships. This article describes several circuits which provide such signals and outlines several short cuts that can be made.

A VARIABLE FREQUENCY multi-phase signal with accurate angular relationships can only be generated digitally because a linear system only has the correct phase relationship at a single frequency.

In a true multi-phase logic signal each phase has an equal mark-to-space ratio, see Fig. 1(a), and the leading edges of successive phases are $360/n$ degrees apart, where n is the total number of phases. Alternatively, pulses $360/n$ degrees long can be generated sequentially as in Fig. 1(b) and (c).

A simple method of implementing a multi-phase reference signal is to use a recirculating shift register as shown in Fig. 2(a). Initially the flip-flops can be in any state and after the first few clock pulses the outputs are either all at 1 or 0. The register then alternately fills and empties and the truth table in Fig. 2(b) shows that the filling action occurs sequentially. The $2n$ phases can be generated from n flip-flops, or n phases can be obtained by selecting every other output from the shift register, i.e. ϕ_1, ϕ_3, ϕ_5 etc. Selecting every mth output gives $2n/m$ phases separated by an angle of $180m/n$ degrees. Both m and n are integers and m must be a factor of n. Except in the case where $2n$ phases are derived from n flip-flops, a minimal logic circuit is not obtained. However, it may be advantageous for practical circuits to choose a more complex design.

When the required number of phases is odd, n bistables are required for n phases, but an even number of phases can be generated with $n/2$ bistables.

Circuit operation

When all of the flip-flops are in the zero state, except for FF_1, all J inputs will be 0 and all K inputs at 1. Therefore, a clock pulse will have no effect on FF_2 to FF_n. Because FF_1 has its K input at 0 and its J input at 1, the first clock pulse will set Q_1 to 1 which puts FF_2 into a receptive state for the second clock pulse. A line of ones will propagate down the chain until the last (n^{th}) flip-flop is reached and when Q_n becomes 1, the next clock pulse will switch Q_1 to 0 and start the negative half of the multi-phase signal.

Each clock pulse alters the state of one flip-flop in the chain. The generation of an even number of phases requires one clock pulse per phase for a complete cycle, whereas an odd number requires two clock pulses per phase. Provided that the single-phase clock has a constant frequency, the phase angle will be correctly maintained on all phases as show in Fig. 1.

Although it is theoretically possible to have a random pattern propagating through the shift register, in practice this never occurs and therefore no precautions are needed to ensure the correct initial conditions.

Short cuts and special cases

Several modifications and simplifications can be made for a three-phase signal. The addition of three exclusive OR gates, see Fig. 3, enables a non-symmetrical but correctly phased supply to be generated. The resultant waveform has a frequency of $f_c/3$, whereas the initial three-phase symmetrical waveform runs at $f_c/6$. This is important when operating near the frequency limit of the logic family.

The pulse waveform can also be obtained by wiring a basic register without the cross connection. In this case it is necessary to set the flip-flops to the correct initial state by using one of the circuits shown in Fig. 4.

If the clock is a square wave with an equal mark-to-space ratio a three-phase signal can be generated at a frequency of $2f_c/3$. The three phases cannot easily be combined with the clock because switching delays cause spurious pulses as shown in Fig. 5. A better approach is to generate two three-phase signals with a 30° phase angle between them. Fig. 6 shows the logic circuit necessary to obtain one phase. This complexity is only justified when operating close to the maximum speed of the logic system. Because flip-flops are usually packaged in pairs, it is advantageous to use a design which requires only two circuits as shown in Fig. 7. The flip-flops are used as counters with a reset after three clock pulses. If the small reset spike can be tolerated, for example when the signal is subsequently filtered, ϕ_2 can be obtained directly from Q_1 and two gates

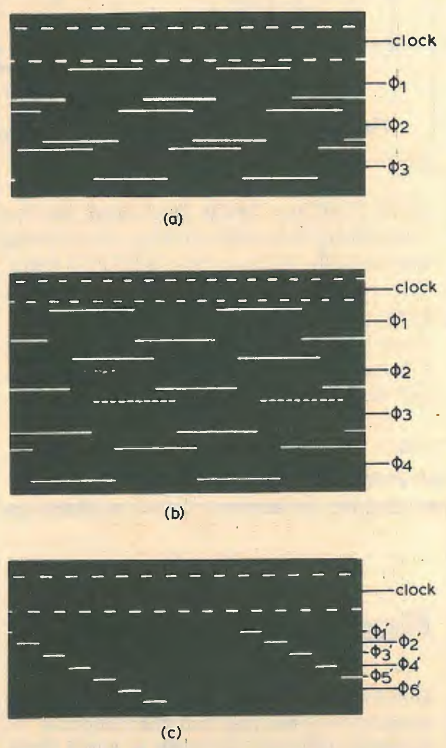
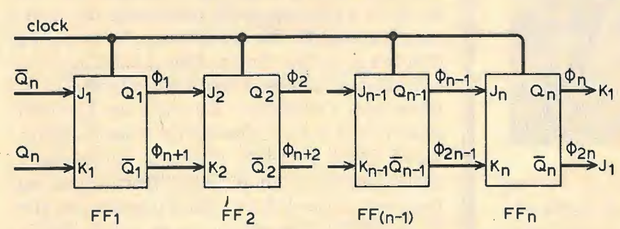


Fig. 1 (a) Three-phase signal, (b) first five phases of an eight-phase signal and (c) first six phases of a ten-phase pulsed signal.



Q1	Q2		Qn−1	Qn	clock pulse no.
1	0		0	0	1
1	1		0	0	2
1	1		1	0	n−1
1	1		1	1	n
0	1		1	1	n+1
0	0		1	1	n+2
0	0		0	1	2n−1
0	0		0	0	2n

(b)

Fig. 2 (a) An n pulse recirculating shift register, (b) truth table. Although t.t.l. and c.m.o.s. can be used in this and other circuits, all of the diagrams are shown using the positive edge of the clock pulse.

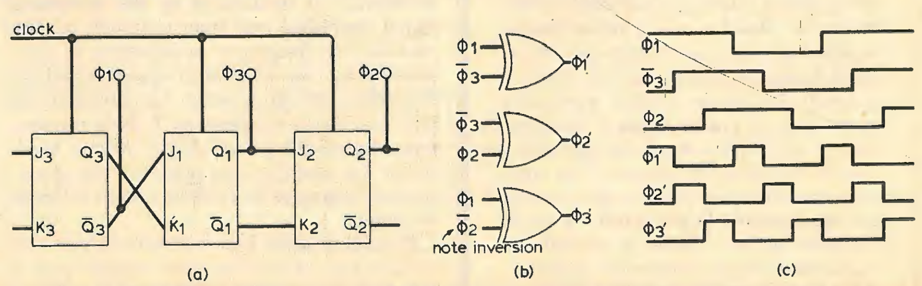


Fig. 3 (a) Basic three-phase generator, (b) addition of exclusive OR gates, (c) three-phase waveforms.

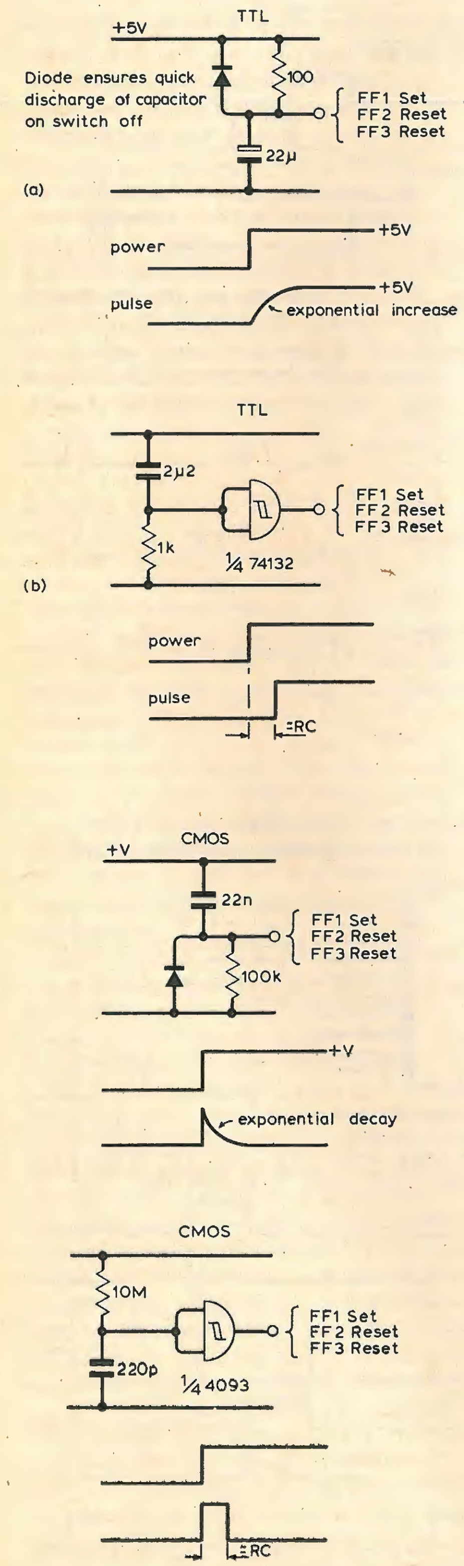
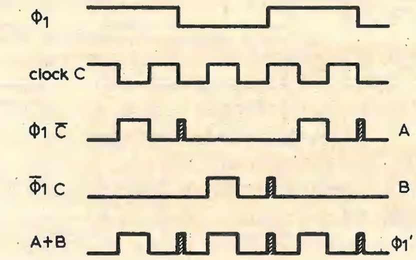


Fig. 4 (a) Simple initial condition pulse, (b) addition of a Schmitt trigger to give an improved pulse.



N.B. These spurious pulses are less likely to occur if the faster TTL logic system is used

Fig. 5 Spurious pulses from a high frequency three-phase generator.

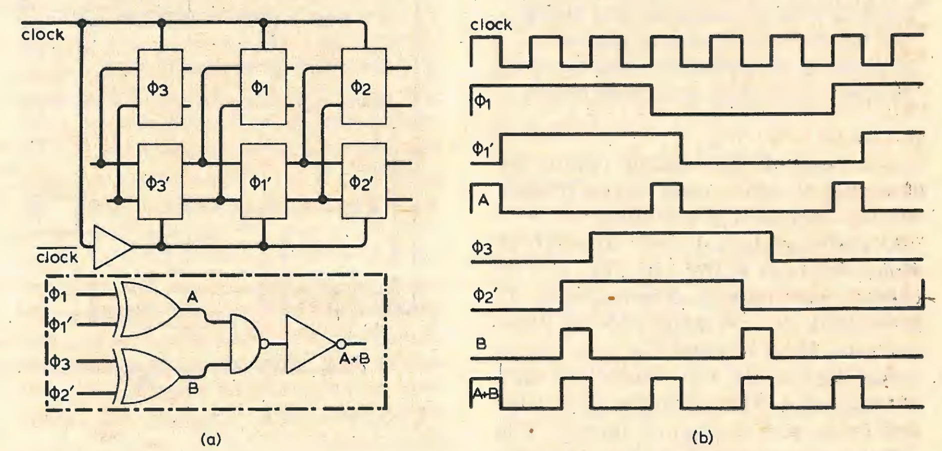


Fig. 6 (a) High frequency three-phase generator. Logic for only one phase is shown. Each extra phase requires a set of gates as shown in the box, (b) waveforms.

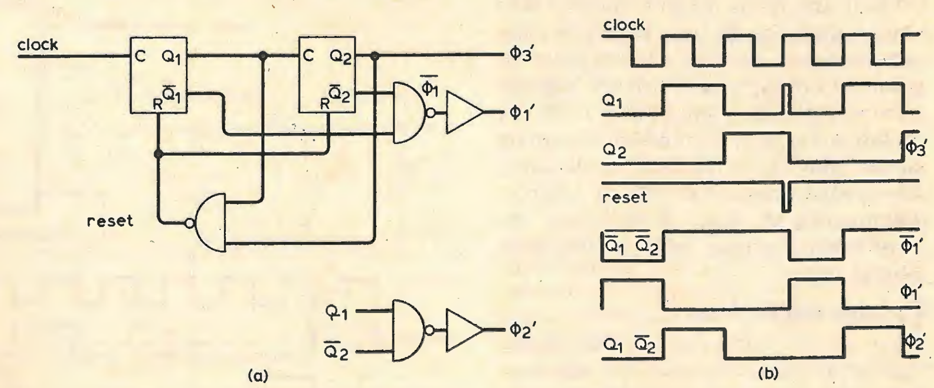


Fig. 7 (a) Three-phase generator using two flip-flops, (b) waveforms.

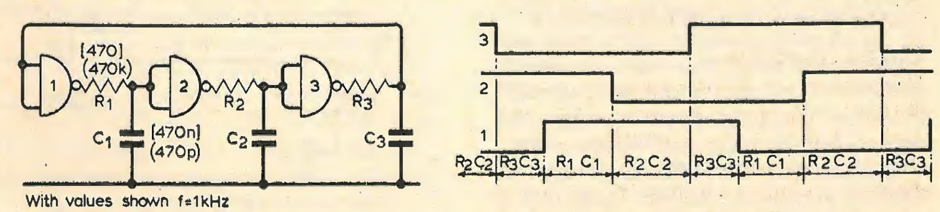
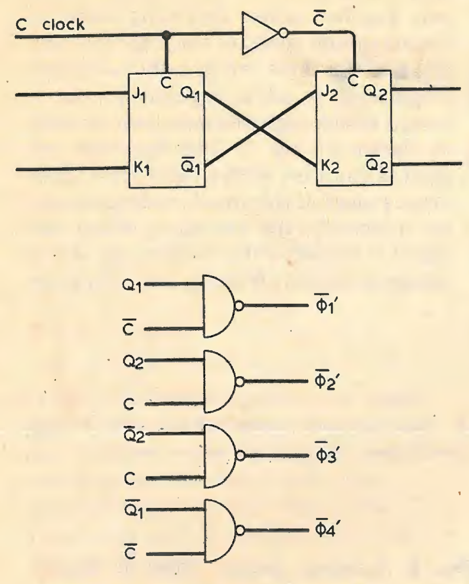


Fig. 8 (a) Simple three-phase generator suitable for (2n−1) phases only. Capacitance and resistance values must be matched for correct switching, (b) possible unequal time periods if resistance and capacitance values are not matched.



Addition of gates to obtain pulse waveform

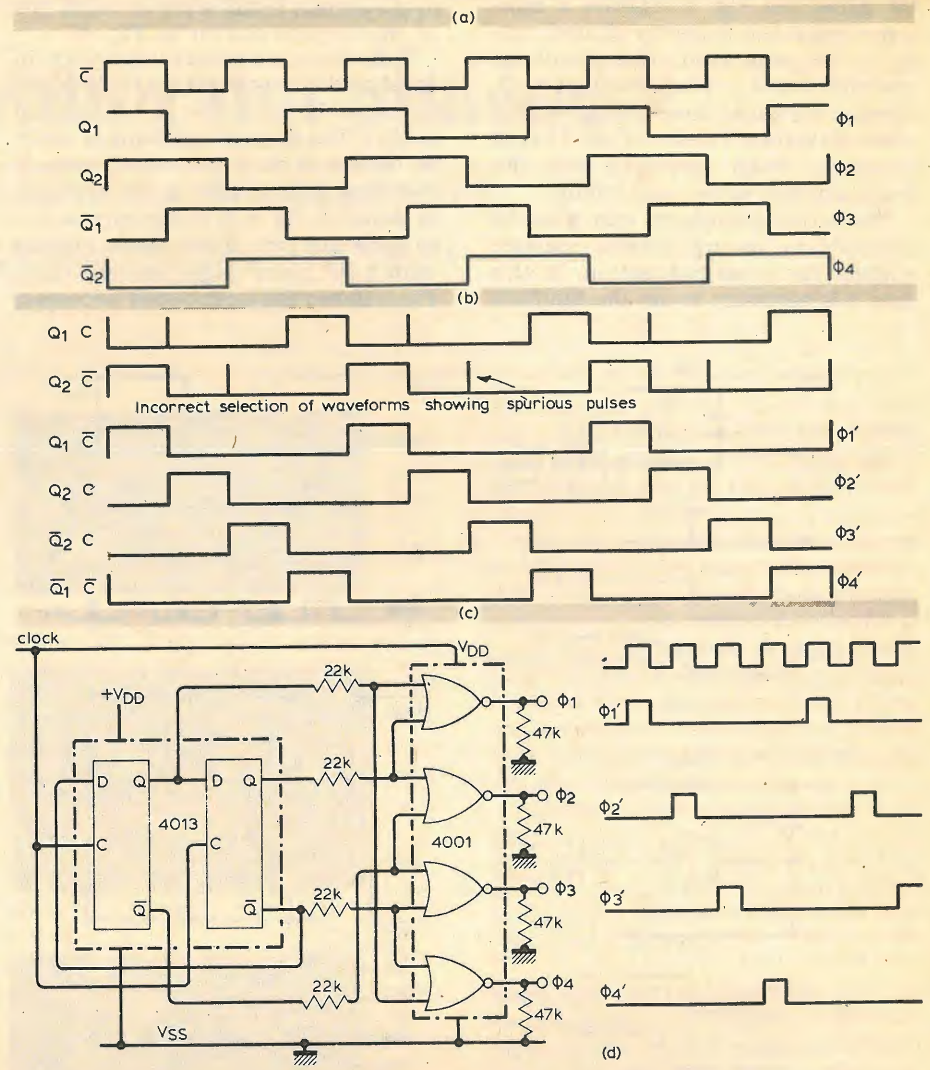


Fig. 9 *(a) Four-phase generator using two flip-flops, (b) true four-phase waveforms, (c) pulsed waveforms and (d) variation to give separated pulses.*

can be omitted. This system cannot be extended to more than three phases without complicated decoding.

A simple circuit for uncritical applications is shown in Fig. 8. The width of each pulse is determined by its associated RC network and the time constants must be carefully matched to obtain equivalent waveforms for each of the phases. This circuit is only suitable for an odd number of outputs. The values in square brackets give a frequency of about 1kHz with t.t.l. and the values below are applicable to c.m.o.s.

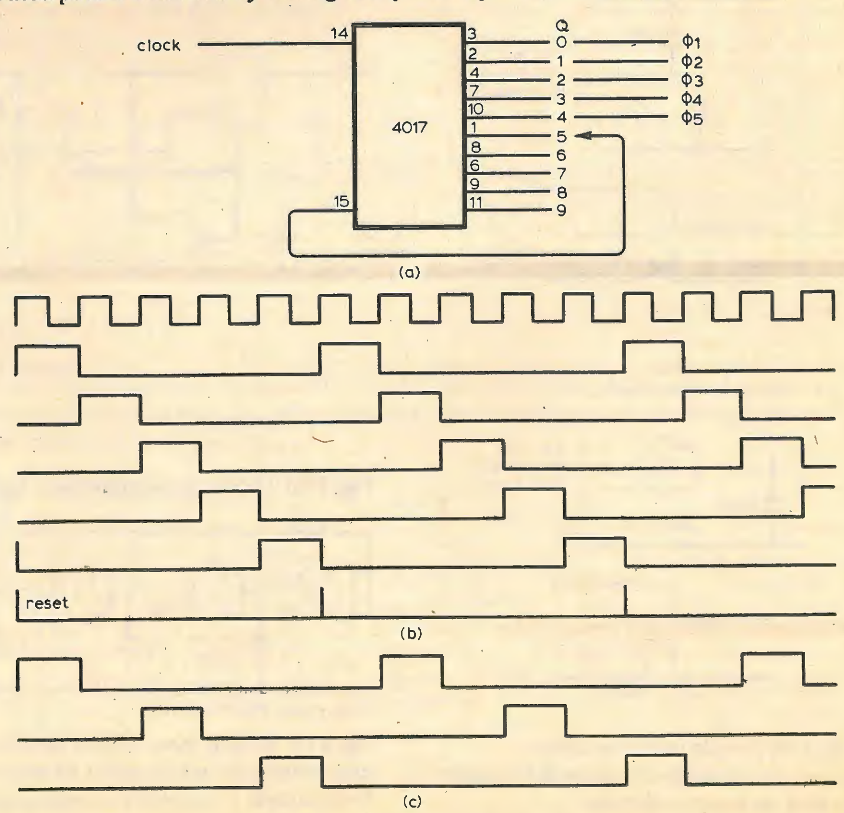
Two flip-flops and a quad two-input NAND can be used to derive four pulsed phases, see Fig. 9. Care must be taken to combine the correct signals otherwise spurious spikes may occur as shown in Fig. 9(c). Symmetrical signals can be taken from the flip-flop outputs. A variation applicable only to c.m.o.s., designed by M. Burn of Motorola, ensures that the pulses are well separated, see Fig. 9(d).

Variable multi-phase

When pulses with the correct phase relationship are required for applications such as oscilloscope beam splitting, one 4017 i.c. can be used as shown in Fig. 10. A pulse equal in length to a clock cycle appears on each line every ten counts and the counter can be reset at any stage by connecting the relevant output to the reset. Thus, any number of phases from two to ten can be produced. A similar t.t.l. circuit can be constructed using a 7493 counter and 7442 decoder.

If separation of the pulses is required, signals should be taken from every other output. A three-phase source should be wired as a six-phase generator and only half of the outputs used as shown in Fig. 10(c). □

Fig. 10 *(a) Multi-phase generator, (b) waveforms for a five-phase signal and (c) separated pulses obtained by taking every other pulse from a six-phase system.*



Why your loudspeaker is full of foam

Calculating the effects and properties of acoustic damping

by **Desmond Thackeray,** M.Sc., Ph.D., F.R.P.S. Music Dept., University of Surrey

For many years loudspeakers have contained acoustic damping material, made necessary by peaks in drive unit response or cabinet resonance. With a computer as a calculating colleague in the measurement of the various effects and their influence upon each other, the author of this article presents a method of assessment of the damping required by the complete loudspeaker. The results are given as "transconductance"* versus frequency curves and also on a log scale showing the related mass, frequency and compliance factors.

The task of a loudspeaker seems agreeably simple on the face of it. All one asks of it is that it should drive plenty of air molecules forward and backward at velocities proportional to the voltages applied and at all frequencies the ear can detect. An electromagnetic coil driving a massless diaphragm carried by a suspension of infinite compliance would itself have a constant velocity characteristic. As soon as the diaphragm is allotted a realistic mass however, the characteristic becomes constant amplitude. Alternatively, if a realistic spring is used for the suspension, the characteristic becomes constant acceleration.

With both of these mechanical features present we have a genuine moving coil loudspeaker unit, with an embarrassing low-frequency resonance of considerable Q. Below this frequency is a 'constant amplitude' region and above this frequency a 'constant acceleration' region, both presenting severe droop in the characteristic. Fortunately, as long as the cone diameter is less than a wavelength, the rise in acoustic radiation resistance with frequency compensates for the constant acceleration droop of the cone motion. The radiated sound intensity therefore tends in theory to a constant value above the resonant frequency and falls at a rate of 12dB per octave below the resonant, frequency. Not surprisingly, if the mechanical resonance is damped by acoustic losses, the situation improves.

The serious listener has always had an inch or two of felt inside his loudspeaker cabinet. However, measurements by Small indicate that the most significant damping contribution in many cases may have been air leakage by-passing the bass driving unit.

In the last decade particularly, this damping has been augmented by foamed materials, occupying in many cases just about all the remaining air volume of the cabinet and the cabinet is now an 'enclosure'. The increase in acoustic losses has been easily met by driving the loudspeaker with more power and the cone of the unit itself is more robustly built to cope with the extra mechanical labour imposed on it. Undeniably the sound has changed and there are devotees of both the old and the new. Empirical adjustments to loudspeaker systems, aimed at providing a useful measured frequency response and at the same time a tolerable sound to the ear, have been fairly successful. One would expect therefore, to find good underlying theoretical reasons for specific features of contemporary designs and predictable optimum damping for the loudspeaker and cabinet system as a whole. R. H. Small[1,2,3] has provided an extensive analysis of the behaviour of three different loudspeaker systems, together with charts and graphs for use by intending designers. Although this is certainly obligatory reading for the serious investigator, there is much to be said for 'learning by doing'.

Mounting a loudspeaker unit in a closed cabinet raises the frequency of the mechanical resonance. To avoid this, a venting aperture can be cut in the cabinet. This has the extra advantage of supplementing the effective radiating area. The mass of air moving in the vent is often increased by building in a throat, or is substituted by a piston or 'drone-cone' acting as an auxiliary bass resonator (a.b.r.). Traditionally, and often mistakenly, this mass tunes the compliance of the air volume in the cabinet to the same frequency as the mechanical resonance of the loudspeaker unit itself. These two strongly-coupled resonators then evince a double-humped characteristic with the two peaks in the response situated above and below the original common frequency of resonance.

Adding these further degrees of freedom to the design extends the system designer's problem of optimising his system experimentally, there now being the damping of *two* resonances to optimise. It is presumably helpful to know what *should* happen theoretically in such a system, but the arithmetical labour involved in the calculations must have been a severe discouragement before the digital computer came along. Even with a computer there is still opportunity for human errors in programming. For this reason it is reassuring to have an entirely independent method for providing some check on the results.

If one adopts a fairly simple model of the loudspeaker in a vented cabinet, an equivalent electrical circuit is not difficult to deduce. One such is given in Figure 1 and you are asked to suppose that the input voltage V is proportional to the voltage applied to the voice-coil of the loudspeaker and the currents in the three arms are proportional to the velocities of the loudspeaker cone, the air in the cabinet and at the vent. Damping is controlled by the adjustment of the three variable resistors. I have, however, omitted any damping due to driver leakage. Use of an a.b.r. requires the introduction of an additional

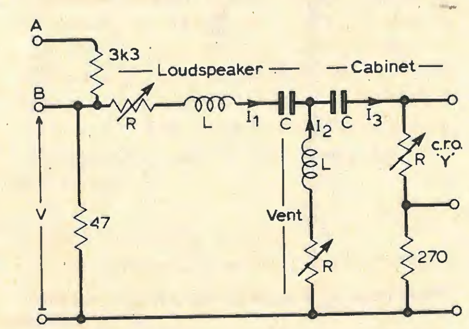


Fig. 1. *Electrical analogue of a moving coil loudspeaker unit in vented cabinet. L is analogous to mass, and C analogous to compliance. Component values for uncoupled resonant frequencies of about 150 kHz are: L about 2mH; C = 470 pF; R zero to 4k7Ω. Voltage inputs are either a swept radio frequency to B or a voltage step (from (say) the c.r.o. timebase) to A. Substitution of a small inductance (50μH?) for the 270Ω monitoring resistor will provide a simulation of the 'lift' contributed by radiation resistance.*

* "Transconductance" = ratio of cone velocity to the speech coil voltage producing it.

capacitance to represent the compliance of the a.b.r. suspension, in the manner shown by Roger Driscoll[4]. His analogue circuit shows no cabinet damping — a touch of reality!

Frequency response

I assembled such a circuit for use in demonstrations several years ago and with the values approximately as given, the resonant frequencies were in the region of 150 kHz. Then with the driving voltage V supplied to 'B' from a wobbulator, and the 'cabinet current' I_3 displayed on an oscilloscope, the frequency response of the whole system could be seen at a glance and the effect of adjustments visualised instantly. Twiddling the three damping knobs immediately showed that the height of the higher frequency peak was controlled principally by adjusting the cabinet damping. Either of the other two damping contributions served to control the height of the lower frequency peak or they could be used together to produce an optimum flattening of this part of the response. Neither of these conclusions was known to me previously, but I hope that knowledgeable readers will tell me where in the literature they are to be found. I think that the explanation is that air is cyclically compressed into the cabinet at the higher frequency response. At the lower frequency resonance the air is cyclically displaced between driver and vent. The other striking revelation was that the resistor settings, for an optimum knee-shaped response, conferred very low 'Q' values on the two coupled tuned circuits, namely ω_0 CR of the order of unity. Reference to Small shows that in many of his graphs the optimum overall Q lies between 0.1 and 0.6. That our cabinets are full of foam arises therefore because the manufacturers are trying to produce experimentally the heavy cabinet damping that seems to be required theoretically.

It was a task for the computer to provide me with confirmation of these results in the form of some relevant numbers, together with more flexibility in varying the component values. The programme was arranged to plot the results of its complex arithmetic on log-log scales, thus resembling the usual frequency response. Some of the log "transconductance" vs. log frequency curves are shown in Figure 2. As was experienced with the electrical analogue, the higher frequency peak requires a cabinet 'A' of 0.5 to tame it (strictly ω_0 CR = 2), while the lower frequency peak is smoothed out by a loudspeaker 'Q' of 1.4 (ω_0 CR = 0.7). The result is a response with a nicely shaped knee, extending (−3dB points) over a frequency range of 0.6 to 1.6 of the original loudspeaker and cabinet plus vent resonant frequencies (both equal to ω_0 when uncoupled). The phase response listed (not shown here) for the underdamped condition showed 180° of phase shift as the frequency moved from one peak to the other. Will this distress readers who may be conscious of low frequency phase errors? What it can do to waveforms is depicted on page 79 of the November 1977 issue of *Wireless World*.** The steepness of the low-frequency cut-off is markedly sensitive to the way in which the damping is split amongst the three variables.

The 'best' response of such a simple model is unlikely to tally with what is achievable with loudspeakers in practice. As far as damping is concerned "not too little, not too much", applies to both cabinet **and** loudspeaker (and/or vent, drone cone or a.b.r.). As the velocities are at their highest (and therefore most easily damped) at the loudspeaker and the vent, little material is required at these points. Conversely, farther back in the cabinet, where the velocities are lower, much more material is needed.

As the frequency range in the damped condition differed only a little from the spacing of the two undamped peaks, I investigated the peak positions as the other variables were changed in magnitude. The computer program permitted changes in both cabinet air compliance and vent air mass and by altering both together I could change the cabinet plus vent resonant frequency. The results are shown in diagrammatic form in Fig. 3, where the end of each plotted line indicates the positions of the resonant peaks in the system characteristic. The cabinet plus vent resonance is indicated by a dot. The frequency scale is again logarithmic, centred about a frequency of unity for the loudspeaker unit itself. It can be seen from the top group of three lines that if the cabinet plus vent resonant frequency is kept equal to the loudspeaker resonant frequency, then the extent of the response remains symmetrical about this frequency, but the limits change. A large cabinet compliance and small vent air mass brings the

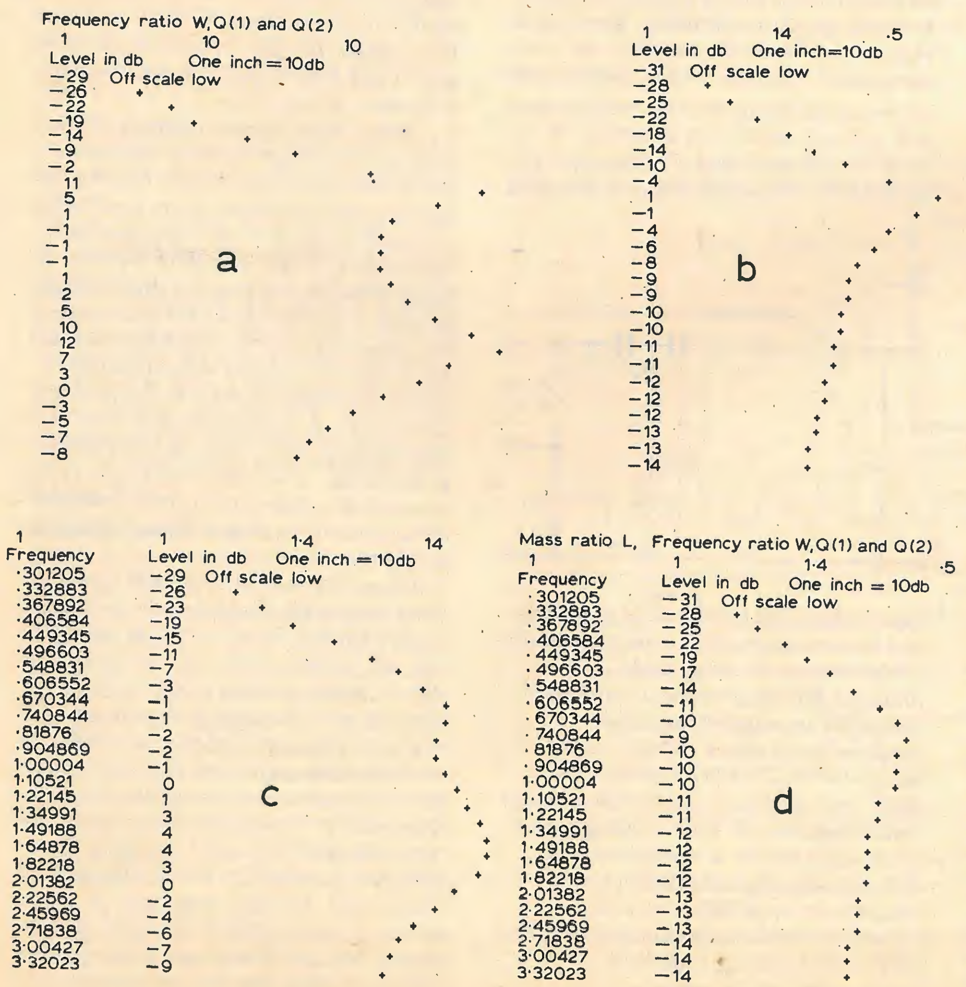


Fig. 2. *Calculated "transconductance" vs. frequency response curves for the analogue circuit of Fig. 1 with zero 'vent' damping. In (a) the loudspeaker and cabinet are both underdamped; in (b) the cabinet has been suitably damped, but not the loudspeaker. In (c) the loudspeaker has been suitably damped but the cabinet is under-damped, while in (d) they are both suitably damped. The frequency scale is logarithmic, is centred about a value of unity, and is ratioed to the resonant frequency, F_0, of the loudspeaker unit. The response at each frequency has been rounded off to the nearest decibel before plotting. It can be seen in (d) that slopes of 20 dB per octave and − 3 dB per octave are obtained, the response being about 2 dB down for each octave of bandwidth, more than half an octave of which is below F_0.*

** "A check on Fourier", by M. G. Scroggie.

peaks together; a large vent air mass and small cabinet compliance moves them apart. Does this explain why it is possible to squeeze some low frequency radiation from 'bookshelf' cabinets?

In the remaining sets of three lines, the whole range is pulled upwards or downwards by changes in the cabinet plus vent resonant frequency. There is however, a choice of frequency spread and if an extended frequency range is required it can either be pulled upwards by reducing the cabinet air compliance or downwards by increasing the vent air mass. Doing both simultaneously spreads the frequency response without displacing it as observed in the first set of lines. This explains how it is possible to 'tune' a vented system for optimum response by altering the length of the vent throat or the mass of the piston in the case of an a.b.r. With the peaks widespread, a cabinet Q value of about 0.5 is again required to flatten the upper frequency peak and the lower peak now requires a similar Q, i.e. smaller than that noted before. The frequency range is about 3 octaves, i.e. nearly a decade. The peaks differ in their tolerance of mis-Q-ing. For the cabinet damping, near enough might be good enough but the loudspeaker or vent Q needs careful adjustment. This is a possible area for home experiment by any readers conscious of undesirable low-frequency humps in their system's response.

Transient response

Another way of examining the (same) information available from electrical analogue or from computer arithmetic is to present it not as a frequency response but in the form of an impulse response. The impulse response is a function of time, following excitation by either a voltage impulse of short duration, or a steep-fronted voltage step. A step is available on many oscilloscopes as the flyback or the sweep gating signal from the time-base circuit. I checked with my analogue circuit using two different oscilloscopes that one oscilloscope alone is sufficient to stimulate and display the impulse response. The timebase connection is to 'A' in Fig. 1. A sweep time of about 40μs was convenient with the component values given, and the Y amplifier was used up to its maximum gain. With the analogue adjusted for minimum damping, the circuit rings splendidly, as one might expect. The ringing disappears at values of ω_0 CR for 'cabinet' and 'loudspeaker' of about 1.4. The time for the response to droop to $1/\epsilon$ of its maximum value can then be doubled by increasing the 'vent' damping to a similar value.

The relative influence of the three damping controls differed a little from that found when exploring the frequency response. It seems important in shaping the transient to provide both cabinet and vent damping and the vent damping was not really interchangeable with the loudspeaker damping. Control

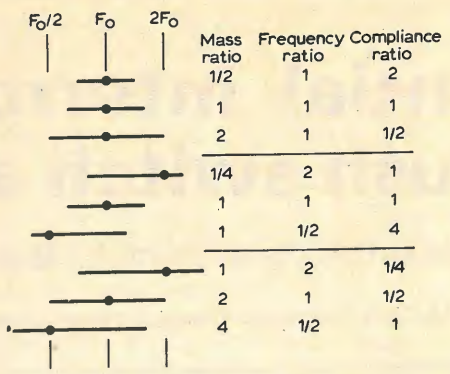


Fig. 3. *Extent of frequency response for the analogue circuit of Fig. 1. This is shown for various tabulated ratios of vent mass to cone mass, cabinet plus vent resonant frequency to loudspeaker resonant frequency and cabinet compliance to loudspeaker suspension compliance. The frequency ratio is also shown as a dot on the diagram, which has a log frequency scale centred on the loudspeaker resonant frequency F_0.*

over all three seemed preferable. Using this 'poor man's transient tester' is probably the simplest experiment with such networks that interested readers might easily try for themselves. It provides rapidly the kind of qualitative information that is not easily deduced from algebra or arithmetic. Nevertheless, knowledge of the experimental result often enables one to guide the mathematics to the same end-point.

For the benefit of readers who may like to try some simple arithmetic on their own 'enclosures', the following formulae provide some of the parameters: The adiabatic compliance K of an air volume $\bar{V}$ at atmospheric pressure P, and vented by an aperture of area A, is given by $K = V/P\gamma A^2$ (units are metres per newton if working in m.k.s.). The mass of air M of density D in a vent pipe of throat length X is given by $M = DAX$. The resonant frequency F of the vented volume is then given by

$4\pi^2 F^2 MK = 1$

or

$4\pi^2 F^2 = (\gamma P/D)(A/X)(1/V)$

The constants required here are sufficiently accurate for such a crude model:

Vel. of sound $(\gamma P/D)^{1/2} = 340$ m/sec

atmospheric pressure $P = 10^5$ newtons per metre ^{2}

atmospheric density $D = 1.2$ kilograms per metre^3

spec. heat ratio $\gamma = 1.4$

The very simple analogue circuit of Fig. 1 in the text above is only directly applicable where the masses and compliances have been scaled according to the relative areas of the loudspeaker cone and the venting aperture. If, for example, the cone area is Φ times the area of the venting aperture, then one can multiply M by Φ^2 and divide K by Φ^2 before they are compared with (or ratioed to) the cone mass and compliance. This is equivalent to interposing a transformer of ratio Φ:1 between the loudspeaker series LCR section and the cabinet plus vent parallel LCR section of the circuit, to represent the acoustic transformer factor introduced between two apertures in a cabinet. It can be seen that the remaining step is to gather some information on loudspeaker resonant frequency F_0, cone mass M_0 and suspension compliance K_0. Since we are not looking for great accuracy, it may be satisfactory to take the manufacturer's estimate of F_0, but this at least is not difficult to measure non-destructively. I can think of no way of measuring cone mass that does not involve destruction of the unit, but if the compliance is measured then the mass can be calculated from $4\pi^2 F^2_0 M_0 K_0 = 1$. Measuring the compliance involves resting weights on the cone (buffered by a disc of card and a felt pad) and measuring its displacement. A millimetre or two is not likely to damage a rugged woofer if the load is well spread, but nevertheless there is still some element of risk. The force produced by one kilogram is 9.81 newtons.

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1. R. H. Small, *Jour. Audio Eng. Soc* (1972) *20*, 798.
2. R. H. Small, ibid (1973) *21*, 11, 363, 438, 549, 635.
3. R. H. Small, ibid (1974) *22*, 592, 683
4. R. Driscoll, *The Gramophone* (1975) April, 1884.

Further reading:

E. J. Jordan, *Wireless World*, (November 1970), 533 – 537

E. J. Jordan, *Wireless World*, (January 1971), 2 – 6

□

Hi-fi amplifier standard

An international standard giving minimum performance requirements for high fidelity amplifiers is announced by the International Electrotechnical Commission. It is the latest in a series being produced by the IEC for high fidelity audio equipment and systems. Called Part 6 of the Publication 581 series, it provides minimum performance requirements for linear and equalizing pre-amplifiers, power amplifiers and integrated amplifiers primarily intended for domestic high quality reproducing systems. A first section, on minimum requirements for characteristics directly related to sound quality, covers, for example, effective frequency range, gain alignment, total harmonic distortion, and rated output power. Other characteristics mentioned in this section include those related to crosstalk attenuation (between stereo channels as well as inputs), wideband signal-to-noise ratio, and weighted signal-to-noise ratio. A second section deals with other characteristics, and requirements and includes items on balance control, loudness control, the marking of controls, mechanical and electrical interconnections and characteristics to be specified in manufacturers' manuals.

Publication 581-6, comprising 19 pages, can be obtained from the IEC at 1 Rue de Varembé, 1211 Geneva, Switzerland, at a price of 25 Swiss francs.

Sequential interrogation of push switch arrays

Simple circuit prevents multiple switching

by **H. A. Cole,** M.I.E.R.E. Atomic Energy Research Establishment, Harwell

A method is described in which an array of push switches is electronically scanned to simulate the action of a make-before-break rotary switch. The method ensures that no matter how many switches are closed at any given time, or in what order, only one will be effective.

The selection of an event or facility by operation of a push switch is an attractively simple method and easy to operate. It is ergonomically efficient and lends itself to clear and unambiguous legending. However, when an array of such switches is provided precautions are sometimes necessary to prevent abnormal operation of the circuits being controlled, due to the accidental or deliberate operation of more than one switch at the same time. This problem is particularly important in vending machines where, for the minimum outlay, an enthusiastic entrepreneur may attempt to obtain a cocktail composed of tea, coffee, orange juice and soup, with milk and sugar, all in one small cup!

Complicated electro-mechanical interlocks are sometimes used which prevent operation of the entire array should an attempt be made to operate more than one switch simultaneously. Purely electronic precautionary methods[1-4] usually rely upon rapid-action latches which greatly reduce the likelihood of chance coincidences. Nevertheless, neither method is completely foolproof and the possibility of a jammed mechanism or abnormal circuit operation is always present.

The circuit described here was designed to simulate the foolproof action of a break-before-make rotary switch. In the circuit a push switch array is electronically scanned and the condition of each switch is interrogated, one after the other by a sequence of short-duration pulses. As soon as an interrogation pulse intercepts a switch which is closed, the function associated with that switch is automatically selected by a latch and the source of the interrogation pulses is inhibited. No further interrogation occurs and the circuit remains locked in the selected state until a reset is applied. Thus, no matter how many switches are closed, or in what order, only one of them will be effective and this will be the one first recognised by the interrogation pulses.

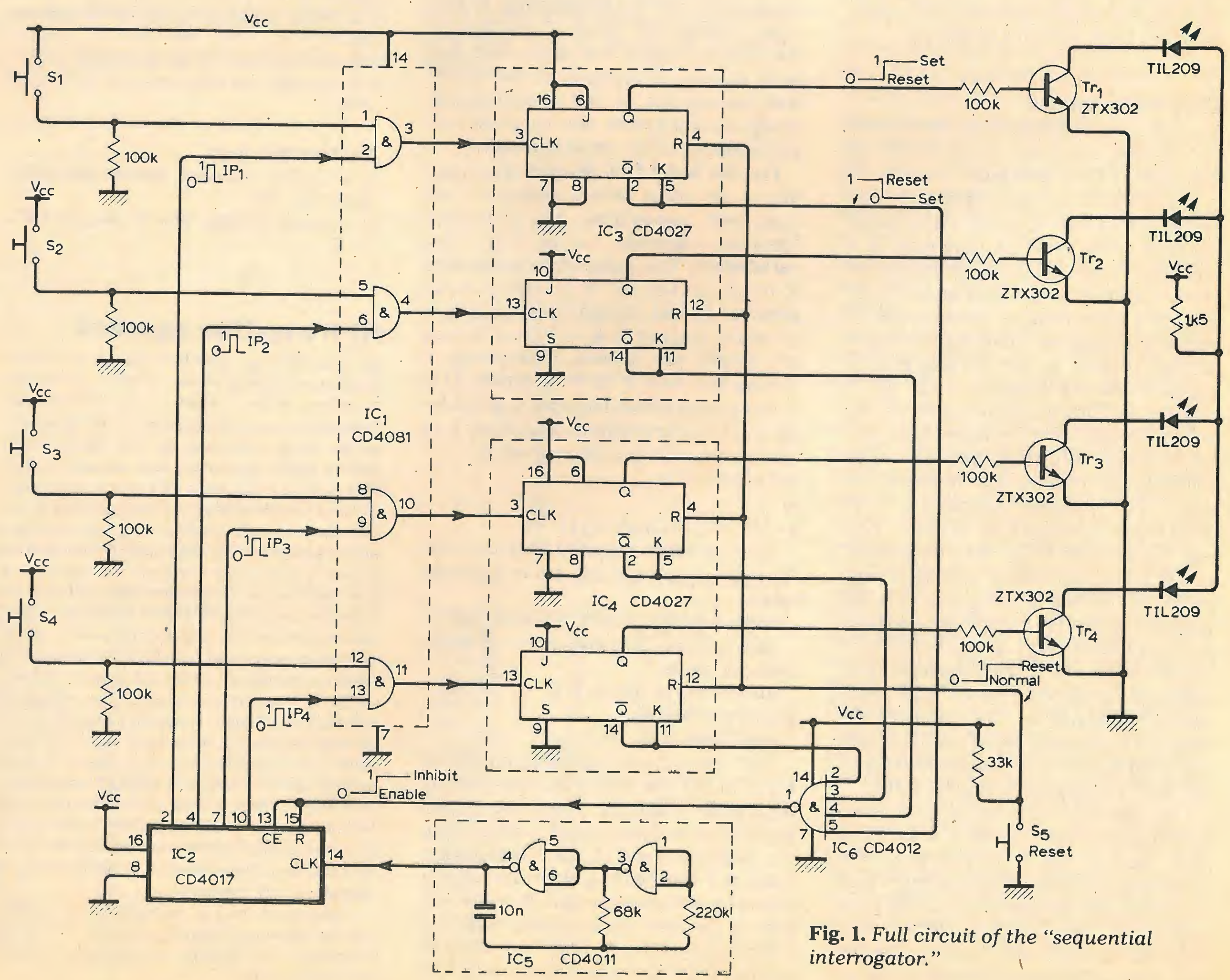

Fig. 1. Full circuit of the "sequential interrogator."

It is arranged that the interrogation pulses are each of more than adequate duration for the latch to be established and the "inhibit" to be applied and that they recur at a rate which ensures a complete scan of the array well within the expected dwell time of the operator's finger on the switch.

The circuit diagram of an arrangement suitable for a 4-station push switch array is shown in Fig. 1. In the quiescent (reset) condition the Q and $\bar{Q}$ output levels of the four latches formed by IC_3 and IC_4 are at logic 0 (near-earth) and logic 1 (near-V_{cc}), respectively. The transistor switches formed by Tr_1 to Tr_4 are not conducting and the l.e.d. indicators are unlit; in a practical circuit these indicators would be replaced, or supplemented by, function-controlling switches.

The reset terminals of IC_3 and IC_4 are normally held at a logic 0 level, via the normally-closed contacts of the reset switch S_5. During the reset operation these terminals are taken to a logic 1 level through the resistor R_7. For convenience the reset switch has been shown as a manually-operated push switch. In a practical circuit, however, the reset potential would probably be applied automatically at the termination of a specific sequence of events. A square wave oscillator formed from gates 1 and 2 of IC_5 produces a continuous output waveform at a repetition rate of 1kHz. This is connected to the input terminal of IC_2, a decade counter producing 10 decoded output pulses at separate output terminals. These are the interrogation pulses (IPs) and are positive-going. They occur one after another at 100Hz, and each has a duration equal to one period (1ms) of the input waveform. The operating condition of IC_2 is controlled by the voltage levels applied to its clock-enable (CE) and reset (R) terminals. When these terminals are both held at a logic 0 level IC_2 is enabled, providing a continuous sequence of interrogation pulses. When these terminals are both held at a logic 1 level IC_2 is inhibited and no interrogation pulses are produced. The controlling level for IC_2 is derived from the 4-input NAND gate IC_6. When IC_3 and IC_4 are in the reset state all inputs to IC_6 are at a logic 1, its output is at a logic 0 and IC_2 is enabled. Since only four switches (S_1-S_4) are employed in the circuit shown in Fig. 1, only four of the interrogation pulses (IP_1-IP_4) from IC_2 are used. These are individually connected to the four AND-gates comprising IC_1 and for convenience are arranged so that their order of occurrence corresponds to the numbers allocated to the push switches. When push switches S_1-S_4 are in the normally-open state the interrogation pulses have no effect on the gates comprising IC_1, due to the logic 0 levels present on the other input terminals. The outputs from these gates therefore remain at a logic 0 and the circuit is quiescent.

Consider now the case where switches S_3 and S_4 are simultaneously closed. This places a logic 1 on gates 3 and 4 of IC_1, which become enabled. Interrogation pulses scan the gates of IC_1 in numerical order and, depending upon the point in time when the switches were operated, the first gate to experience a logic 1 on both its inputs terminals will be gate 3. The interrogation pulse present at this gate is therefore able to pass through and reach the input terminal of the latch feeding Tr_3 (upper section of IC_4) which is immediately triggered to the "set" state.

When this happens, its Q-output rises to a logic 1, transistor Tr_3 is turned on and the l.e.d. in its collector line is illuminated; at the same time, the $\bar{Q}$-output falls to a logic 0. This is immediately recognised by IC_6, the output of which causes an inhibit to be placed on the clock enable and reset terminals of IC_2. No further interrogation pulses are therefore produced and the circuit remains latched to the connection selected by S_3. A similar operation results if one or all of the switches are depressed, or if the reset switch is operated whilst all the switches are depressed.

The time taken for a latch to be established and the interrogation pulses to be inhibited is determined by the response times of the i.cs. These are typically less than 200ns for the c.m.o.s. types specified in Fig. 1, a period which is negligible when compared with the 1ms duration of an interrogation pulse. The time taken by the interrogation pulses in making one complete scan of up to 10 push switches (the maximum possible using IC_2) is 10ms; a period which is very small when compared with the expected dwell time of the operator's finger on the switch and with the mechanical inertia of the switch mechanism.

This circuit can be expanded to operate with up to 10 push switches by the addition of latches using i.cs and connections similar to those given for IC_3 and IC_4 and by replacing IC_6 with an equivalent 10-input gate.

Simplification of the circuit may be achieved by the use of quad-type latches in place of IC_3 and IC_4 (e.g. CD4042/4) and possibly by using transistor arrays (e.g. CA3081/2) in place of Tr_1 to Tr_4.

References

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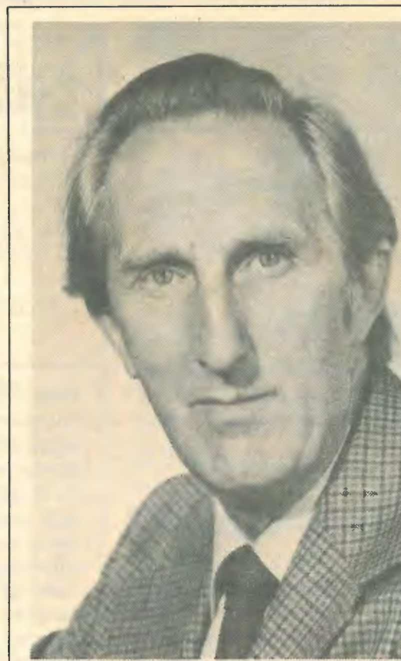
2. de Haan, J. Circuit eliminates switch bounce in keyboards and gives latched output. *Electronic Design*, 1, Jan 4, 1975, p118.
3. 10-line and 8-line priority encoders types SN74147, SN74148. Texas Instruments bulletin No. DL-3 7211727, Dec 1972.
4. C.o.s./m.o.s. 8-bit priority encoder type CD4532BE. RCA Integrated Circuits data book SSD-203C, 1975, p417.

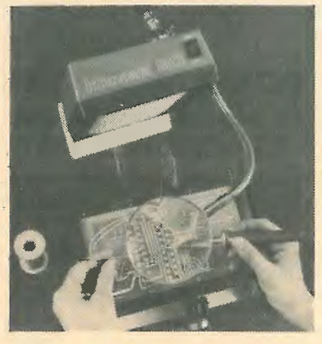


A professional electronics engineer, Harry Cole spent his first twenty years at Harwell designing portable instruments for the location of radioactive minerals as well as originating a wide range of laboratory instruments for particle sizing, nucleonic counting, and analysis of plutonium and other radionucleides. He is the author of three books on television principles and of several papers dealing with scientific and electronics topics, some of which have appeared in *Wireless World*.

NEW PRODUCTS

Solder fume extractor

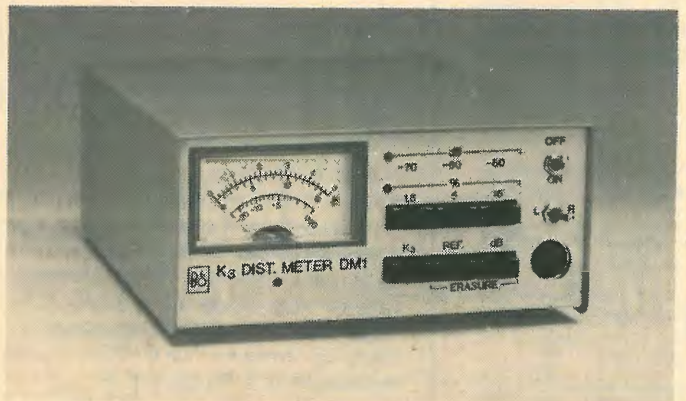
One of the prime hazards involved in batch or production line soldering is the cloud of acrid smoke which emerges from the inevitable burning flux. A solder fume absorber, designed for individual work stations, is now available from Vero Systems. This is the Komax 80 and it



makes use of an axial fan which draws fumes through a polyamid filter. The filter has an absorption rate of about 80% measured against ASHRAE Standard 52-68 and the makers say that it will remain effective for about three weeks in normal use. Vero Systems (Electronic) Ltd, 362 Spring Rd, Sholing, Southampton, SO9 5QJ.
WW 301

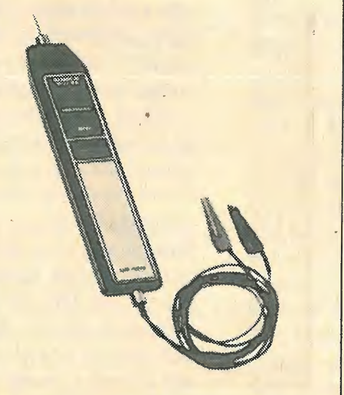
Tape recorder distortion meter

The DM1 distortion meter is intended for measuring third-harmonic distortion(K_3)in tape recorders, and will also measure tape erasure and channel separation. Using a 333Hz signal, this compact instrument will measure distortion from 0.15% to 15% in three switched ranges with meter f.s.ds of 1.5% and 15%. For erasure and channel separation there is another meter scale marked in dB allowing measurements from -70dB to -50dB in three switched ranges. Three output sockets at the rear provide for other instruments to be connected, for example a wow and flutter meter in conjunction with a decibel/voltmeter, which combination also allows measurement of frequency response and recording level. A low-high switch allows the oscillator output to be adjusted to the Japanese standard. Bang & Olufsen Nederland. Measuring Instruments Division, Koninginneweg 54, 1241 CV Kortenhoef, Postbus 36, Netherlands.
WW 302



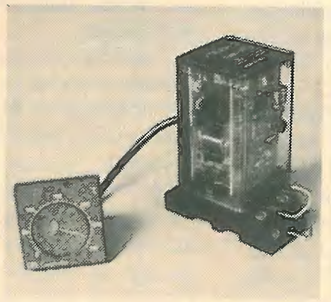
Logic test probes

Fast analysis and trouble-shooting of i.c. logic systems is the prime function of the DP-100 "pulser" probe and the DP-50 digital proble. The two items, manufactured by the (American) Dynascan Corporation, are intended to be used together in most checking operations. DP-100 "pulser" probe senses the state of the logic and can change this state if required or inject substitute logic pulses to speed debugging. It generates either a "one-shot" or a continuous 5Hz pulse train. The DP-100 obtains its operating power from the circuit under test, is fully overload protected and compatible with t.t.l., m.o.s. and c.m.o.s.



as is the DP-50. The DP-50 digital probe is a 50MHz instrument which displays logic activity as three l.e.d. indicators to indicate pulse presence and high/low logic states. An unusual feature is a "memory freeze" which stores pulse display. The DP-50 has a 2MΩ input impedance, is fully protected from overload and detects pulses to within 10ns. Distributed by Empire Exporters, Inc, Plainview New York, USA.
WW 303

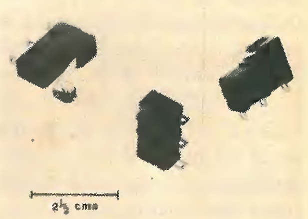
Remote temperature controller



Operating over the range -200°C to +1600°C, the CAL 6101 electronic temperature controller from Controls and Automation can switch a 3kW resistive load (at 14A, 220V 50Hz). This range is covered by nine versions of the controller, each of which comprises two separate sections, the plug-in control section and a remote bezel and dial giving, according to the makers, greater flexibility in mounting. The dial potentiometer is connected to the controller by a single flexible lead. The controller makes use of proportional control methods and features an error margin of ±1%. It will also accept thermocouple or PT100 inputs, two or three wire. Controls and Automation Ltd, Regal House, 55 Bancroft, Hitchin, Herts SG5 1LL.
WW 304

Sub-miniature microswitch

The SSL series is the latest addition to the IMO/OMRON range of microswitches. Measuring only 10 × 6.5 × 19.7mm, they offer a contact current rating of 5A at 240V a.c. and an estimated life of 10 million operations. They



are available in three styles: plunger (SSL1), hinge lever (SSL1L) and hinge roller (SSL1L2). Construction is of polycarbonate and stainless steel while connection is made through 0.5mm thick terminals for p.c. board or solder connection. The complete series is available ex-stock. IMO Precision Controls Ltd, 349 Edgware Road, London, W2 1BS.
WW 305

Signal-powered receiver

A package containing an earpiece, a silicon diode, a compression trimmer, a short length of ferrite rod and a length of enamelled copper wire comprise the Home Radio crystal receiver construction kit. An earpiece jack, two capacitors and a connecting block are also included for the total cost of £2.50, inc. v.a.t., and postage. Home Radio (Components) Ltd, 234-240 London Road, Mitcham, Surrey CR4 3HD.
WW 306

Logic slide switch

Applications including speed control of models and process control programming are quoted by Egen Electric for its logic slide switch. This is based on the Egen slide potentiometer and provides 15 outputs on a grey-scale code with 0 to 9 b.c.d. outputs. Maxi-

mum working voltage is 20 and normal operating current is 10mA. Contact resistance is quoted as 500Ω after 50,000 operations. Egen Electric, Ltd, Canvey Rd, Canvey Island, Essex SS8 0PG.
WW 307

Rain detector

An instantaneous warning, triggered, so the makers, Chromatronics claim by the first drop of rain, is provided by the "Rain Check", a device which operates from a single 9V battery. The unit is housed in a plastics box measuring 13 × 9 × 4cm and this is designed to be mounted in the home. The gold-plated rain sensor is connected by twin flex and can be mounted in any external location where advance warning of rain is required. Battery life is reckoned at one year in normal operation. Cost is £9.95 including VAT. Chromatronics, Coachworks House, River Way, Harlow, Essex.
WW 308

80A earth leakage contact breaker

Designed primarily to meet the changing load requirements in new electrical installations, the HO5 earth leakage circuit breaker is said by the makers, B and R Relays, to fulfil such demands by operating at a maximum rating of 80A. Two versions are offered, preset to a tripping sensitivity of either 100mA or 500mA, the latter to prevent "nuisance" tripping in an unusual electrical environment. Tripping speed is 30ms which the makers say is adequate to isolate faulty equipment before serious damage can occur and with the HO5's introduction, this manufacturer's range of circuit breakers now extends from 13 to 80A ratings, with trip currents from 7mA to 500mA. B and R Relays Ltd, Templefields, Harlow, Essex CM20 2BG.
WW 309

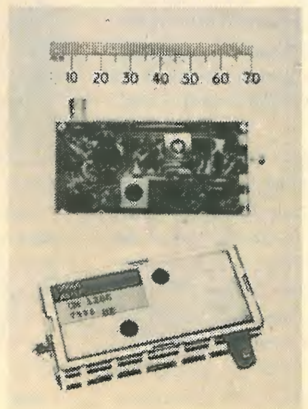
Hole cutters

As well as offering a compact wallet for the pocket, G and J Hall also provide a 30cc pot of "Conecut" cutting compound for use with their standard sheet and tube drills. Two sets are available for specific trade applications. The "electrician's" set, CP2025, contains "Conecuts" 1 and M25, providing a set of tools to produce holes of 20mm and 25mm in diameter. The "electronics" set, CP2230, contains "Conecuts" 1A and 2 which can be used for 22.2mm and 30.5mm International Standard hole sizes for the

fitting of pushbuttons and indicator lights in control panels. Photo shows the comprehensive "pocket kit", CP210. G and J Hall Ltd, Burgess Rd, Sheffield, S9 3WD.
WW 310

U.h.f. modulator

Computer graphics and v.c.r. applications are the areas of use for which Astec's UM1286 u.h.f. modulator is intended. The vision carrier is pre-tuned to channel E36 (591.25MHz) and the integral sound sub-carrier oscillator may be pre-tuned to either 5.5MHz or 6.00MHz. Separate balanced modulator circuits are used to provide improved linearity and



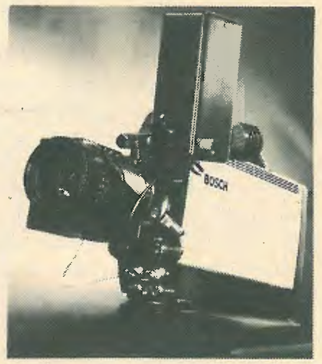
low content of undesirable mixing products. Colour sub-carrier and sound sub-carrier beat product is -55dB with respect to carrier, resulting, according to Astec, in interference-free pictures. The modulator measures 71 × 37 × 20mm and current consumption is 9mA with a recommended supply of 5V ±10%. Astec Europe Ltd, 4A Sheet St, Windsor, Berks.
WW 311

Slave telephone dialler

Instant dialling, with attendant savings in time spent at the telephone, is the function of the TeleDialer 32. The makers, STC, point out that it can prevent unnecessary delays by holding in electronic memory important numbers, ready for instant connection to the wanted party at the push of a button. Up to 16 digits can be programmed for a single number and changes can be easily keyed in. A standard push-button key-pad and a 32 space programmable directory is featured and as well as 28 buttons set up in column form for frequently-made calls, four colour-coded buttons accommodate emergency numbers. Further features include a "reconnect" facility, where, by pushing button 32, the latest number committed to the memory can be reconnected, and a built-in speaker allows the number to be dialled without lifting the telephone handset. William Love and Co, 720 George St, Sydney, NSW, Australia.
WW 312

Optical fibre e.n.g. camera

Shoulder or tripod operation is possible with the KCA 100 optical fibre camera now in production by Bosch of Germany. The camera head weighs 5.5kg and consists of a fold-down section containing the optical block, a central section for signal-processing p.c.b.s and various optional add-on rear units. By exchanging these units, the KCA 100 can be adapted to operate in the e.n.g. (electronic news-gathering) mode or as a remotely-controlled unit operating from a base station via multiwire or optical fibre cables. Laser transceivers at the base station and camera head in conjunction with optical fibre enable the camera to be remotely controlled from several miles away with a cable weight saving of approximately 30:1 when compared with conventional methods. Auto-centering and auto-focus are unusual features of this camera, the focus system using a low intensity infra-red laser which provides reflections for distance evaluation leading to



accurate focussing. Robert Bosch GmbH, Darmstadt, W. Germany.
WW 313

Peak programme meter

"Very nearly the same specification as the BS5428" (BBC-recommended) peak programme meter, is the recent claim made by the Soundex Division of Bulgin Electronics for their PPM402 meter. This is a peak-reading meter which has been introduced to complement the makers' range of "professional" meters, and dynamic range, frequency response and "ballistics" are claimed as similar to the BS5428 form. The scale is calibrated in dB with a red "overload" region. The price of the meter, complete with amplifier and instruction leaflet, is £34.95 excluding v.a.t. and Soundex are offering a free "line-up" oscillator with each order received before 24 November 1979. Bulgin Electronics, Soundex Ltd, Park Lane, Broxbourne, Herts.
WW 314

Field strength receiver

High precision measurement of field strengths and interference (to CISPR and MIL specifications) and tuned frequency voltage measurements in laboratory and test departments are the principal applications of the ESH2 test receiver now available from Rohde and Schwarz. The unit monitors the frequency range 10kHz to 30MHz with an input sensitivity (sine wave) extending from −30dB to +137dB; voltage measurement error is <1dB, field strength measurements <2dB, and the unit is intended to complement the ESU2 v.h.f./u.h.f. test receiver, which covers the range 25 to 1000MHz. The ESH2 can be tuned in steps of 100Hz or 10kHz over the complete frequency range without the need to change ranges, and can be powered from the mains or from a 12V or 24V adaptor for use in the field. Rohde and Schwarz GmbH and Co KG, Pressestelle, Muhldorfstr 15, Munich 80, W. Germany.
WW 315

Advanced comfort

Advanced Passengers wondering when their Train is going to come on-line, so to speak, ought to be informed that their comfort is not being neglected. There exists the Jacobmeter, which is nothing to do with measuring the brittleness of biscuits or the strength of ladders, but is a device which uses accelerometers, amplifiers, and a.-to-d. converters and a bit of calculation to determine the 'comfort level' when the whole lot is whistling along at some unnatural speed. British Rail have your well-being at heart, as always.

Those like myself who are not likely to be advanced passengers may just possibly admit to a touch of mild irritation at these gladsome tidings. Hurriedly, I must admit that I am not against comfort — indeed, my wife holds the sincere conviction that I invented it. No. if I ever become a temporary Advanced Passenger, I shall revel in the 'comfort level' so painstakingly achieved: it is just that I feel we ordinary Retarded Passengers could do with a bit of attention too. Nothing dramatic — just a reduction in the depth of old fag packets and discarded copies of the advertising magazines those girls hand out.

If they've got money and staff to expend on electronically measuring comfort level when a few human bottoms, strategically deployed, could provide much the same information, then I don't want to hear any more about trains being cancelled because of staff shortages.

It may not be such a sybaritic experience as all that, anyway, to be an Advanced Passenger. The electronics are "built in a rugged, die-cast box, designed to withstand the buffeting endured by a portable instrument in an industrial environment".

Response time

When you have parted with a wodge of hard-earned cash, posted off the order and sat back to wait for your piece of electronic gubbins to come, and waited and waited and waited, unworthy thoughts sometimes flit, unbidden, through the minds of even the most tolerant of people. Correspondence with the company in question begins with a polite enquiry, progresses through highly libellous accusations of skulduggery and malpractice and then, as often as not, ends with a despairing letter to us, copy to the company. It is, one supposes, the letter writer's hope that a quick 'phone call from us will cause a frenzy of activity, with incompetent fools of dispatch clerks being instantly dismissed and a year's supply of free transistors immediately sent to the complainant as a softener.

Well, all-powerful we may be, scourge of the ungodly — perhaps, but miracle workers we are not. To drive this point home to me, I had cause, recently, to adopt the stance of complainant myself and, at one point, wished I had a kindly and protective journal to espouse my cause. I ordered a speaker drive unit some time ago and had to wait four months to get it; a cheque for a pickup spare went off in June and I heard nothing till September. Telephone calls were met with promises of rapid action, which were evidently forgotten the second the 'phone was put down.

SIDEBANDS by Mixer

There may be good reason — shortage, for example — for the inability to deliver, but the deafening silence which is very often the result of one's offer to trade does tend to cause one to suspect the worst, particularly when one's cheque has been whistled into someone else's bank account at the speed of thought.

Is it too much to ask that the ordinary courtesies of commerce be preserved? A simple post-card, saying that the goods aren't in stock, but that you aren't being ignored, would save an awful lot of ill-feeling.

While Rome burns

There is famine in Cambodia. The Vietnamese have nowhere to go and precious little to sustain them. India has starving millions, as always. In any one of a dozen areas of the world the people are having a pretty thin time of it from the cradle to the grave, what with not having enough food and suffering from diseases which curtail life or make it well nigh unbearable. Clearly, what is needed is a concerted effort by the nations with a surplus of material and a good supply of brain power to equalise the load. Science could help by developing methods of distribution, agricultural technics, easily-administered medicines and uncomplicated communications.

So what happens? We get a microprocessor-controlled doorbell! According to the handout, it will "brighten our lives". I don't want to single it out for attack, but it is symptomatic of what is going on without much in the way of protest. There is nothing wrong with using a microprocessor to play Greensleeves or with flooding the market with gadgets that tell the time, date, day, year, century and cast one's horoscope at the touch of a button.

Neither is there anything inherently reprehensible in allocating billions of dollars to discover that the Moon, Mars and Jupiter are no match for Majorca as a resort. Taken in conjunction with the knowledge that a major proportion of the world's population hasn't even a door, let alone a doorbell, this schedule of priorities does, nevertheless, seem bizarre, to say the least.

I haven't any answers to this problem of misdirection of effort, except to observe that scientists have been known to work in disciplines other than their own. Still, millions of undernourished people can't expect to assume the same importance in the scale of affairs as the development of a better mouse-trap or the next world-beating range of hi-fi separates. Can they?

Flights of fancy

Some time fairly soon, a rather nervous pilot is going to sit in the right (maybe even the left)-hand seat of a Braniff International Boeing 727 and wonder if he ought to own up to the passengers. If asked, he will possibly come clean and admit that, until this moment in his career he hasn't, to be absolutely frank, actually been in a 727 before. He will, no doubt, feel impelled to point out that although his practical experience of driving this particular aeroplane leaves something to be desired, he has put in a lot of hours on a simulator, which is very largely the same as flying except it doesn't use nearly so much jet fuel. He may also mention, in passing, that he has sat at the sharp end of many other aeroplanes; it's just this one he can't claim to be entirely on first-name terms with.

Candour compels me to admit that, if I were the above passenger, entrusted with the pilot's little secret, I would be out of that 727 in a matter of seconds, hammering on the booking counter of another airline. Any other airline.

Redifon, who make the Novoview flight simulator, have a lot of experience with these devices and, over the years, must have saved operators a great deal of time and money in reducing the conversion time on to new aeroplanes. But I feel sure that they always intended simulator training to be in the 'as well as' category, not the 'instead of'. However convincing the accelerations produced by the movement of the simulator, and however pretty the computer-generated pictures seen through the windscreen, I for one would take a lot of persuasion that flying a computer is as good as doing it the hard and expensive way.

We're safe for the time being, at least. Our Civil Aviation Authority don't seem to be as keen on the idea as the Americans.

AUDIO TEST SET. Services pattern bench test set comprised in one case Audio Osc 17c/s to 170Kc in 4 ranges direct calibration O/P var up to 10V into 25 to 600ohm. Valve Voltmeter 100Mill/V to 100V FSD in 5 ranges response to 170Kc this can be used to read O/P from osc or ext I/P. Distortion meter with amp & tuned filter 20c/s to 20Kc with direct cal as 3 ranges 10, 30 & 100% dist read on VTVM meter. Contained in metal case size 14×17×21" for use on 200/250 50c with connecting leads in new cond. **£65**

GRID DIP OSC. American Services pattern PRM-10 I/P 115V 50c 20w covers 2 to 400Mc/s by means of 7 plug in coils with direct cal as 4 functions Grid Dip, Osc Det, Absorbtion WM, Sige Gen complete in fitted metal case size 11×9×5", uses 100 Ua meter & 5 valves good cond. with circ. **£45**

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INVERTOR UNITS I/P 12V DC provides O/Ps for Rx or Tx, 180V DC 40Ma or 425V 125Ma, also 6.3V DC at 2.5 amps, a number of other O/P voltages could be obtained by int connection (uses volt doubler), in case size 5½×4×3" with circ tested. **£10.50**

MOTOR DRIVE & CONTROLLER. Consists of 24V DC motor driving into two stage gearbox the O/P shaft drives a sine cos pot & a 360' dial the speed & direction can be controlled up to 1 RPM by means of a transistor controller and control pot, supplied with mains trans rect circ etc. **£15**

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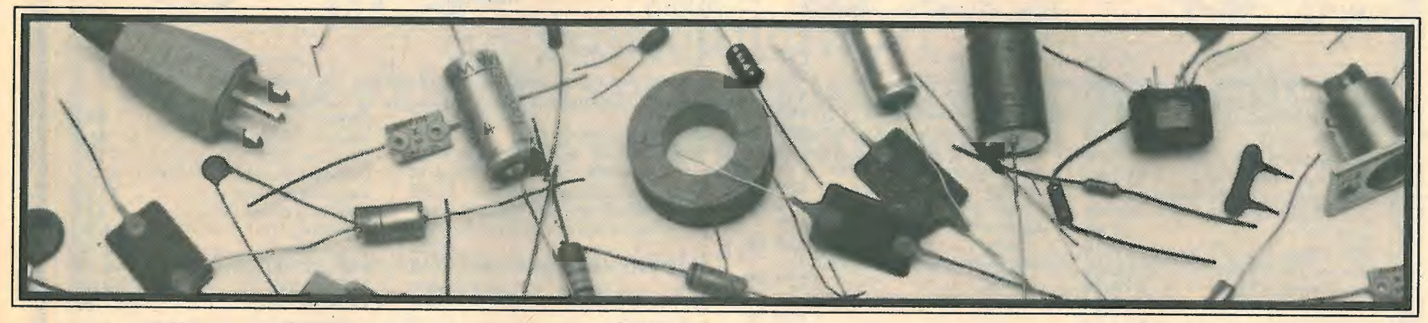

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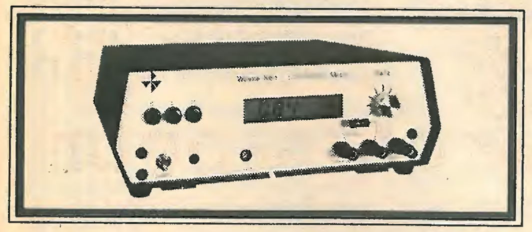

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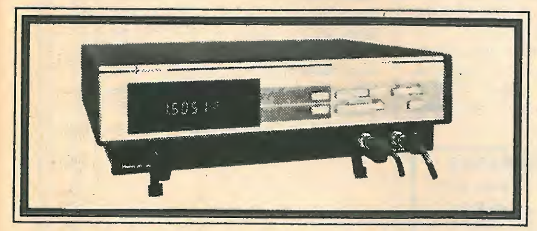

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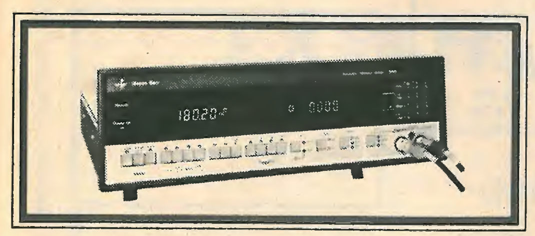

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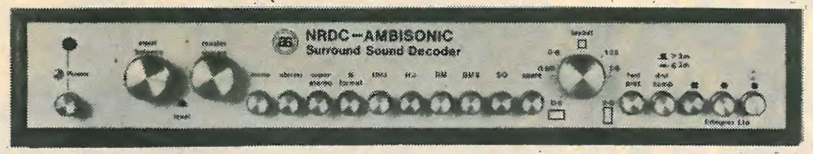

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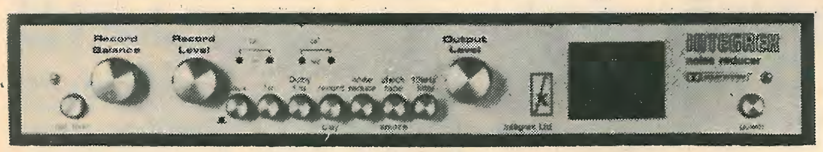

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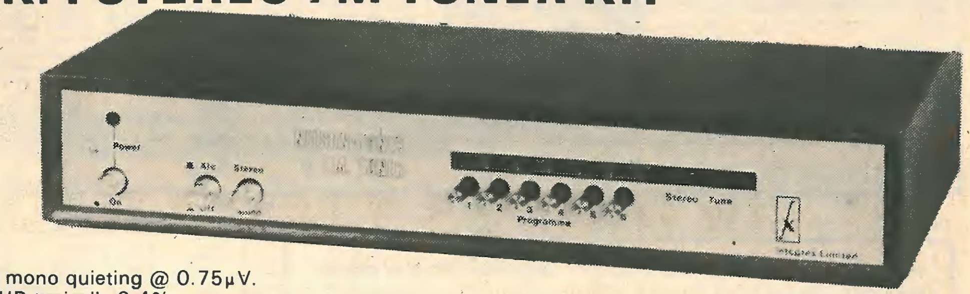

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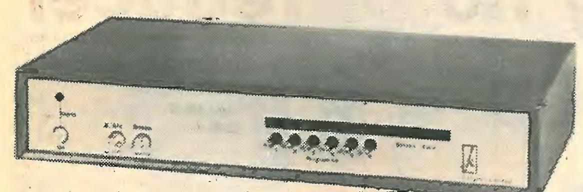

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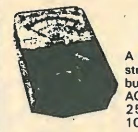

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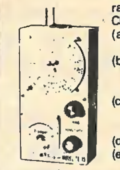

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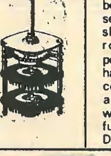

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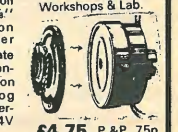

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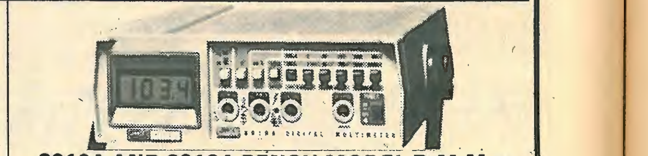

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CA3014	£1.55	CA3090	£4.14	LM380	£0.98	NE555	£0.28	72711	£0.37	TAA550B	£0.40
CA3018	£0.75	CA3123	£2.19	LM381	£1.67	NE556	£0.69	UA723C	£0.52	TAA621A	£2.30
CA3020	£1.96	CA3130	£1.07	LM3900	£0.67	NE565	£1.38	72723	£0.52	TAA621B	£2.88
CA3028	£0.92	CA3140	£0.81	MC1303L	£0.98	NE566	£1.73	UA741C	£0.28	TAA661	£1.73
CA3035	£1.61	LM301	£0.33	MC1304	£2.19	NE567	£1.96	72741	£0.28	TAD100	£1.50
CA3036	£1.15	LM304	£1.84	MC1310	£1.09	UA702C	£0.53	741P	£0.23	TBA540	£2.42
CA3042	£0.73	LM308	£1.15	MC1312	£2.19	72702	£0.53	UA747C	£0.69	TBA810S	£0.85
CA3043	£2.13	LM309	£1.73	MC1350	£1.38	UA703	£0.29	72747	£0.69	TBA810	£1.13
CA3046	£0.81	LM320-5V	£1.73	MC1352	£1.61	UA709	£0.29	UA748	£0.40	TBA820	£0.81
CA3052	£1.84	LM320-15V	£1.73	MC1469	£3.30	72709	£0.53	72748	£0.40	TBA9200	£2.88
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AAY30	£0.10	BAX16	£0.09	BY128	£0.18	BYZ16	£0.47	OA85	£0.12	IN34A	£0.08
AAZ13	£0.17	BY100	£0.25	BY130	£0.20	BYZ17	£0.41	OA90	£0.12	IN914	£0.07
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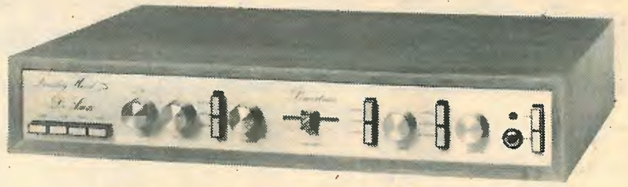
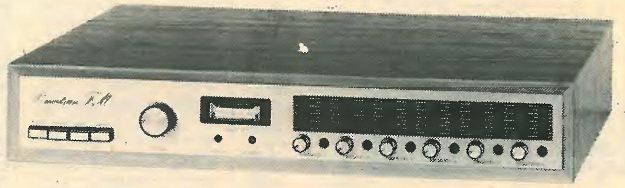
DE LUXE EASY TO BUILD LINSLEY-HOOD 75W STEREO AMPLIFIER £99.30 + VAT

This easy to build version of our world-wide acclaimed 75W amplifier kit based upon circuit boards interconnected with gold plated contacts resulting in minimal wiring and construction delightfully straightforward. The design was published in Hi-Fi News and Record Review and features include rumble filter, variable scratch filter, versatile tone controls and tape monitoring whilst distortion is less than 0.01%.



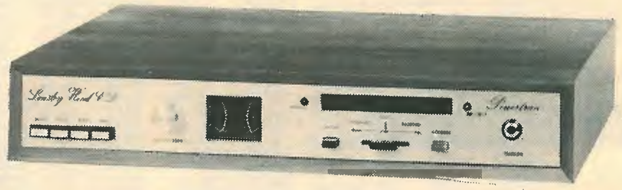
WIRELESS WORLD FM TUNER £70.20 + VAT

A pre-aligned front-end module makes this Wireless World published design very simple to construct and adjust without special instruments. Features include an excellent a.m. rejection push-button station selection as well as infinitely variable tuning and a phase locked loop stereo decoder, incorporating active filters for "birdy" suppression.



LINSLEY-HOOD CASSETTE DECK £79.60 + VAT

This design, published in Wireless World, although straightforward and relatively low cost provides a very high standard of performance. There are separate record and replay amplifiers and switchable equalisation together with a choice of bias levels are also provided. The mechanism is the Goldring-Lenco CRV with electronic speed control.



TRANSCENDENT 2000 SINGLE BOARD SYNTHESIZER

As featured in Electronics Today International

Cabinet size 24.6"x15.7"x4.8" (rear) 3.4" (front)

The kit includes fully finished metalwork, fully assembled solid teak cabinet, filter sweep pedal, professional quality components (all resistors either 2% metal oxide or ½% metal film!) and it really is complete — right down to the last nut and bolt and last piece of wire! There is even a 13A plug in the kit — you need buy absolutely no more parts before plugging in and making great music! Virtually all the components are on the one professional quality fibre glass PCB printed with component locations. All the controls mount directly on the main board, all connections to the board are made with connector plugs and construction is so simple it can be built easily in a few evenings by almost anyone capable of neat soldering! When finished you will possess a synthesizer comparable in performance and quality with ready built units selling for between £500 and £700!

COMPLETE KIT ONLY £172.00 + VAT!

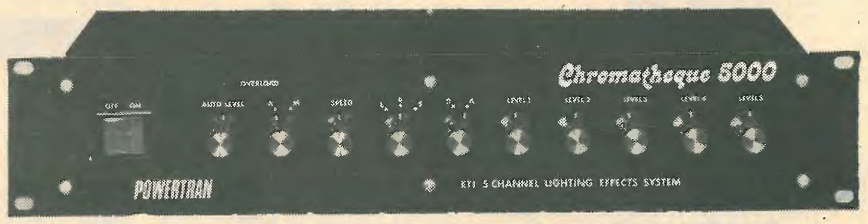
Comprehensive handbook supplied with all complete kits! This fully describes construction and tells you how to set up your synthesizer with nothing more than a multi-meter and a pair of ears!

CHROMATHEQUE 5000 5-CHANNEL LIGHTING EFFECTS SYSTEM

This versatile system featured as a constructional article in ELECTRONICS TODAY INTERNATIONAL has 5 frequency channels with individual level controls on each channel. Control of the lights is comprehensive to say the least. You can run the unit as a straightforward sound-to-light or have it strobe all the lights at a speed dependent upon music level or front panel control setting or use the internal digital circuitry which produces some superb random and sequencing effects. Each channel handles up to 500W and as the kit is a single board design wiring is minimal and construction very straightforward.

Kit includes fully finished metalwork, fibreglass PCB, controls, wire, etc. — Complete right down to the last nut and bolt!

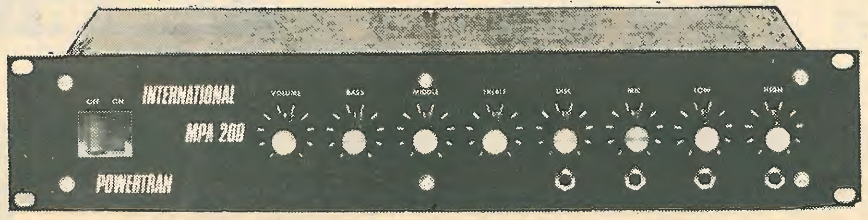
COMPLETE KIT ONLY £49.50 + VAT



Panel size 19.0"x3.5". Depth 7.3"

MPA200 100W MIXER/AMPLIFIER

Featured as a constructional article in Electronics Today International the MPA 200 is an exceptionally low-priced but professionally finished general purpose, rugged, high-power amplifier which has an adaptable range of inputs such as disc, microphone, guitar, etc. There are 3 wide range tone controls and a master volume control. Mechanically the design is simplicity in the extreme with minimal wiring making construction very straightforward. Kit includes fully finished metalwork, fibreglass PCB's, controls, wire, etc. — Complete right down to the last nut and bolt!



Panel size 19.0"x3.5". Depth 7.3"

COMPLETE KIT ONLY £49.90 + VAT

All kits also available as separate packs (e.g. P.C.B. component sets, hardware sets, etc.). Prices in FREE CATALOGUE.

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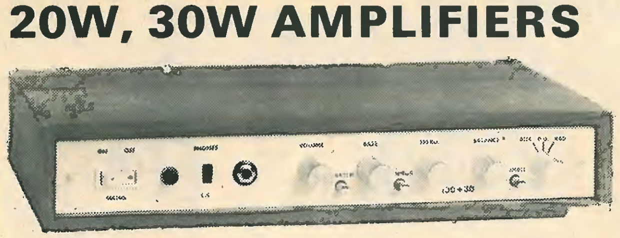
T20+20 AND T30+30 20W, 30W AMPLIFIERS



Designed by Texas engineers and described in Practical Wireless, the Texan was an immediate success. Now developed further in our laboratories to include a Toroidal transformer and additional improvements, the slimline T20+20 delivers 20W rms per channel of true Hi-Fi at exceptionally low cost. The **easy to build** design is based on a single F/Glass PCB and features all the normal facilities found on quality amplifiers including scratch and rumble filters, adaptable input selector and headphones socket. In a follow-up article in Practical Wireless further modifications were suggested and these have been incorporated into the T30+30. These include RF interference filters and a tape monitor facility. Power output of this model is 30W rms per channel.

SPECIAL PRICES FOR COMPLETE KITS

T20+20 KIT PRICE £33.10 + VAT

T30+30 KIT PRICE £38.40 + VAT

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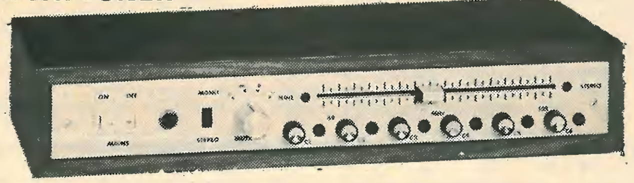
WWII TUNER



SPECIAL PRICE FOR COMPLETE KIT £47.70 + VAT

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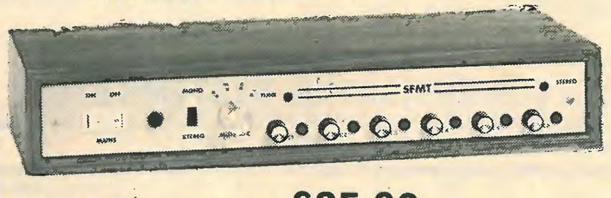
Following the success of our **Wireless World FM Tuner Kit** this cost reduced model was designed to complement the **T20+20** and **T30+30** amplifiers and the cabinet size, front panel format and electrical characteristics make this tuner compatible with either.

POWERTRAN SFMT TUNER



PRICE FOR COMPLETE KIT £35.90 + VAT

AVAILABLE AS COMPLETE KIT ONLY

This is a simple, low cost design which can be constructed easily without special alignment equipment but which still gives a first-class output suitable for feeding any of our very popular amplifiers or any other high quality audio equipment. A phase-locked-loop is used for stereo decoding and controls include switchable afc, switchable muting and push-button channel selection (adjustable by controls on the front panel). This unit matches well with the **T20+20** and **T30+30** amplifiers.

NEW!

Another superb design by synthesizer expert Tim Orr!

TRANSCENDENT DPX

As featured in Electronics Today International August, September October, 1979 issues

DIGITALLY CONTROLLED, TOUCH SENSITIVE, POLYPHONIC, MULTI-VOICE SYNTHESIZER

The Transcendent PDX is a really versatile new 5 octave keyboard instrument. There are two audio outputs which can be used simultaneously. On the first there is a beautiful harpsichord or reed sound — fully polyphonic i.e. you can play chords with as many notes as you like. On the second output there is a wide range of different voices, still fully polyphonic. It can be a straightforward piano or a honky tonk piano or even a mixture of the two! Alternatively you can play strings over the whole range of the keyboard or brass over the whole range of the keyboard or should you prefer — strings on the top of the keyboard and brass at the lower end (the keyboard is electronically split after the first two octaves) or vice versa or even a combination of strings and brass sounds simultaneously. And on all voices you can switch in circuitry to make the keyboard touch sensitive? The harder you press down a key the louder it sounds — just like an acoustic piano. The digitally controlled multiplexed system makes practical sensitivity with the complex dynamics law necessary for a high degree of realism. There is a master volume and tone control, a separate control for the brass sounds and also a vibrato circuit with variable depth control together with a variable delay control so that the vibrato comes in only after waiting a short time after the note is struck for even more realistic string sounds.

Cabinet size 36.3"x15.0"x5.0" (rear) 3.3" (front)
Also available as separate packs — prices in free catalgoue

COMPLETE KIT ONLY £365.00 + VAT!

To add interest to the sounds and make them more natural there is a chorus/ensemble unit which is a complex phasing system using CCD (charge coupled device) analogue delay lines. The overall effect of this is similar to that of several acoustic instruments playing the same piece of music. The ensemble circuitry can be switched in with either strong or mild effects.

As the system is based on digital circuitry data can be easily taken to and from a computer (for storing and playing back accompaniment with or without pitch or key change, computer composing etc., etc.) and an interface socket (25 way D type) is provided for this purpose.

Although the DPX is an advanced design using a very large amount of circuitry, much of it very sophisticated, the kit is mechanically extremely simple with excellent access to all the circuit boards which interconnect with multiway connectors, just four of which are removed to separate the keyboard circuitry and the panel circuitry from the main circuitry in the cabinet.

The kit includes fully finished metalwork, solid teak cabinet, professional quality components (all resistors 2% metal oxide), nuts, bolts, etc., even a 13A plug — you need buy absolutely no more parts before plugging in and making great music! When finished you will possess an instrument comparable in performance and quality with ready-built units selling for over £1200!

EXPORT A SPECIALITY!

Our Export Department can readily despatch orders of any size to any country in the world. Some of the countries to which we sent kits last year are shown in this advertisement. To assist in estimating postal costs our catalogue gives the weights of all packs and kits. This will be sent free on request, by airmail, together with our "Export Postal Guide" which gives current postage prices. There is no minimum order charge. Prices same as for U.K. customers but no Value Added Tax charged. Postage charged at actual cost plus 50p documentaton and handling. Please send payment with order by Bank Draft, Postal Order, International Money Order or cheque drawn on an account in the U.K. Alternatively for orders over £500 we will accept Irrevocable Letter of Credit payable at sight in London.

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QUALITY: All components are brand new first grade full specification guaranteed devices. All resistors (except where stated as metal oxide) are low noise carbon film types. All printed circuit boards are fibreglass, drilled roller tinned.

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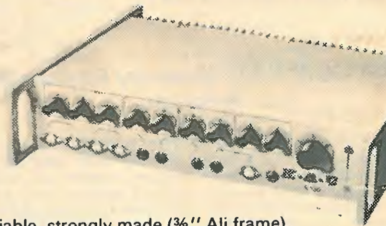

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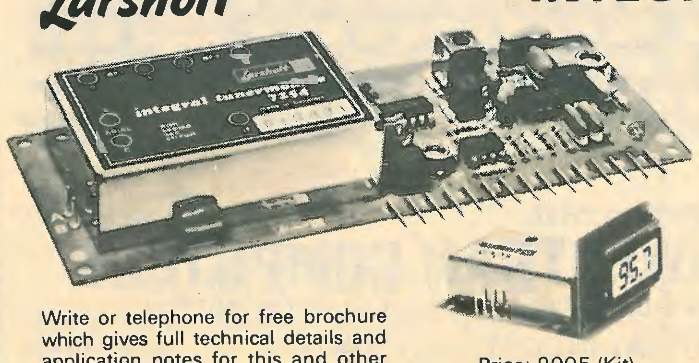

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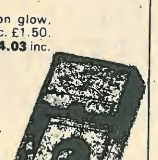

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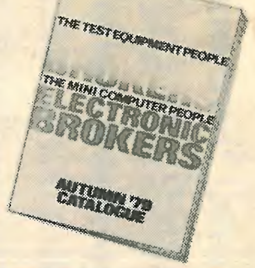

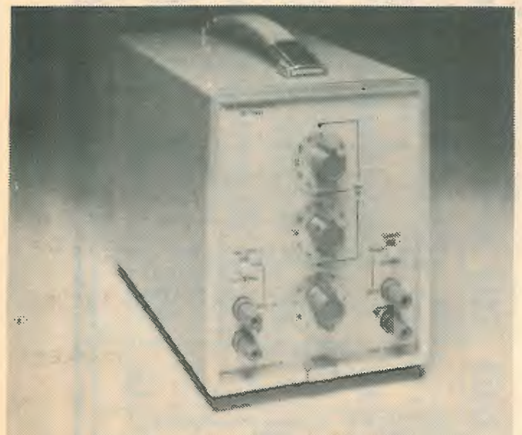

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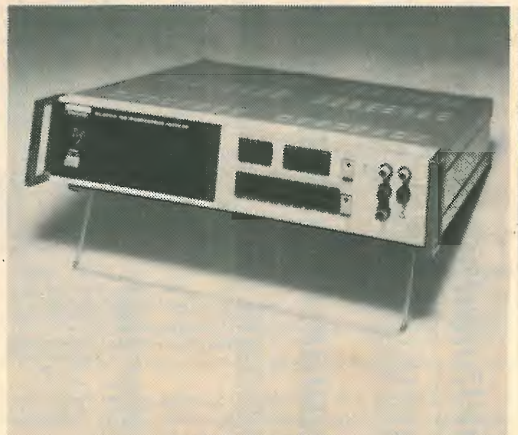
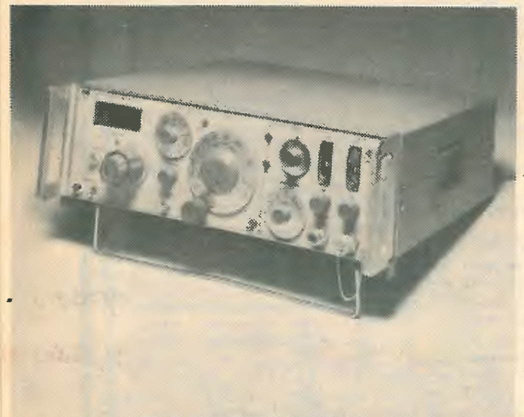


SOLARTRON
7055 Microprocessor Controlled D.M.M.
Without processor option **£975.00**
With processor option **£1300.00**

HEWLETT PACKARD
1703A Storage Oscilloscope
35MHz Delayed Sweep.
Storage, Dual Channel **£1850.00**



MARCONI INSTS.
TF2012 U.H.F.F.M. Signal Generator. 400-520MHz. Very low noise & freq. drift
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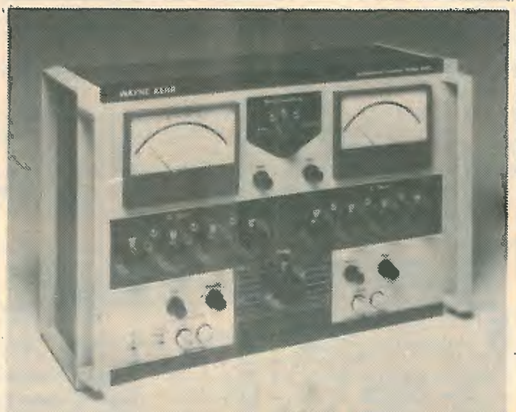

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Typically 0.1% accuracy. L.C.R. & G measurements
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AC-DC volts and resistance
Self check facility
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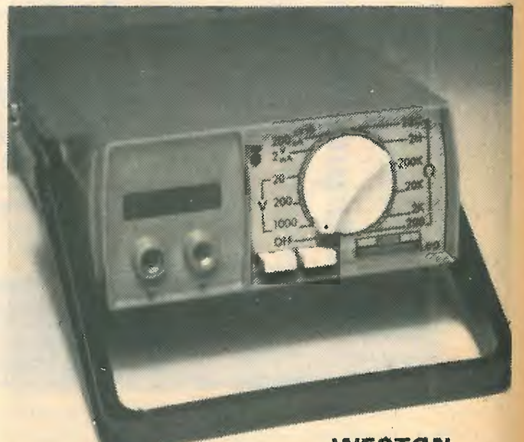

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TF1066B/6 AM Signal Generator.
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TF1101 R-C Oscillator.
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Later version of TF1370 Main difference is four switched low O/P impedances of 75, 100, 130 and 600Ω **£275.00**

TF2000 AF Oscillator.
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Frequency Range 5-520MHz. AM, FM, Phase & Pulse modulation. **£1900.00**

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FM-10 Decade Switched FM Signal Generator.
Up to 500MHz. **£1200.00**

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1MHz-10MHz. Sine, square, ± pulse, ramp, triangle, single shot with variable phase. O/P 40V Pk-Pk into 50Ω Reduced frequency range on triangle and ± pulse. Variable DC offset, ext sweep. **£675.00**

PM5326 AM/FM Signal Generator with digital readout of frequency.
100kHz-125MHz. Up to 50mV into 75Ω AM @ 30% @ 1kHz. FM. @ ± 22.kHz @ 1kHz. Ext counter 0-999.99kHz. **£695.00**

PM5326X AM/FM Signal Generator.
Same spec as PM5326 but ext. counter up to 99.999MHz. **£735.00**

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SM2000 Sweeper Main Frame with E-3M RF Plug-In Unit.
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VS40 Sweep Generator.
Frequency range 1MHz-300MHz. **£650.00**

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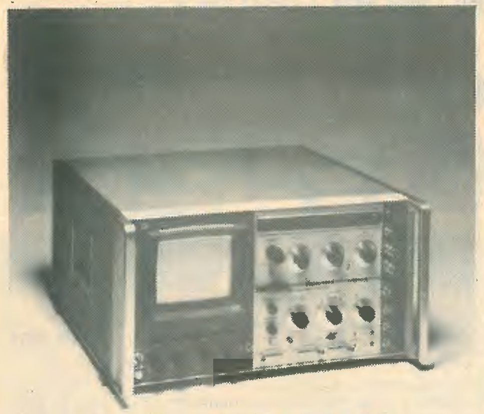

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Spectrum Analyser System
141T Display
8552A IF Section
8554L RF Section
500KHz-1250MHz
TOTAL PRICE £5,250

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Superb specification including full edit capability, direct cursor addressing, 5 switch-selectable baud rates (110-9600) detachable keyboard, printer port, standard RS232 (V.24) Interface.

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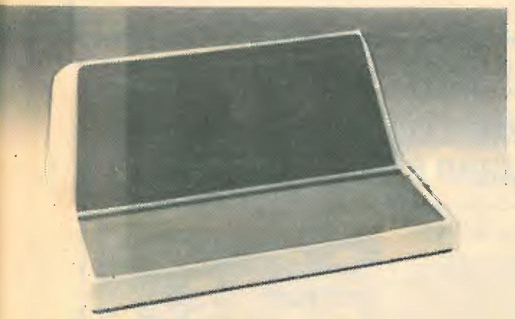

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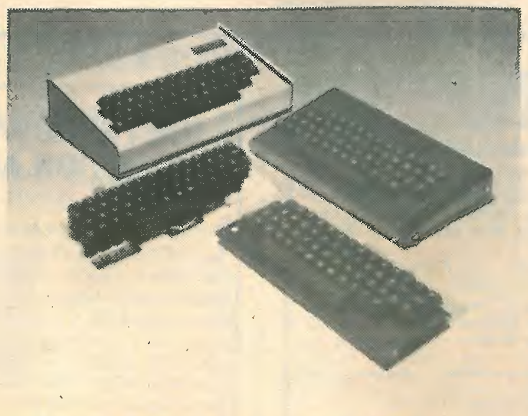
9" diagonal P4 phosphor tube Bandwidth 12MHz (—3dB) Input voltage 220V 50 60Hz 24W Output voltage + 15V DC (short circuit protected) + 12kV DC 12 6V rms Separate horizontal and vertical sync Supplied complete with high and low voltage power supplies amplifier and attractive moulded plastic housing including space for keyboard Full technical manual provided **£95** (total including carriage and VAT £123)



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		(mail order total)
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LATEST ADDITION TO THE RANGE
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Electronic Brokers

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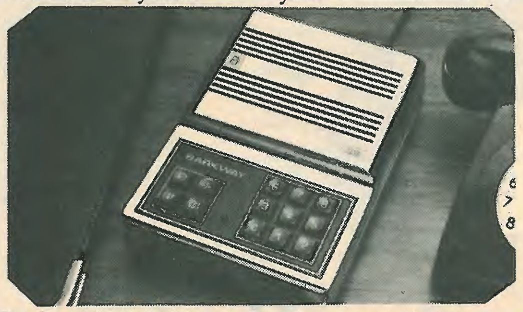

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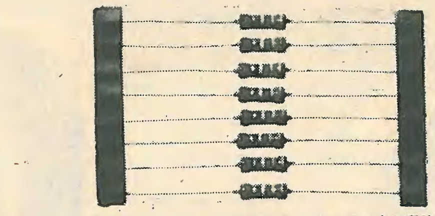

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ww/12/79

J. L. Linsley-Hood High Quality Cassette Recorders

LINSLEY-HOOD CASSETTE RECORDER 1

We are the Designer Approved suppliers of kits for this excellent design. The Author's reputation tells all you need to know about the circuitry and Hart expertise and experience guarantees the engineering design of the kit. Advanced features include: High quality separate VU meters with excellent ballistics. Controls, switches and sockets mounted on PCB to eliminate difficult wiring. Proper moulded escutcheon for cassette aperture improves appearance and removes the need for the cassette transport to be set back behind a narrow finger trapping slot. Easy to use, robust Lenco mechanism. Switched bias and equalisation for different tape formulations. All wiring is terminated with plugs and sockets for easy assembly and test. Sophisticated modular PCB system gives a spacious, easily built and tested layout. All these features added to the high quality metalwork make this a most satisfying kit to build. Also included at no extra cost is our new HS15 Sendust Alloy record/play head, available separately at **£7.60** plus VAT, but included FREE as part of the complete kit at **£81.50** plus VAT.

REPRINTS of the 3 articles describing this design **45p** No VAT.
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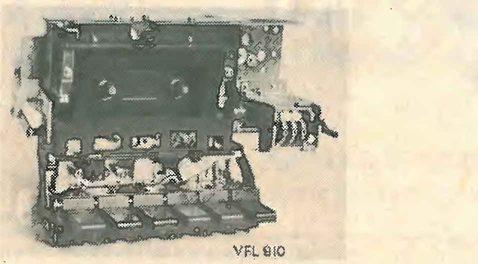
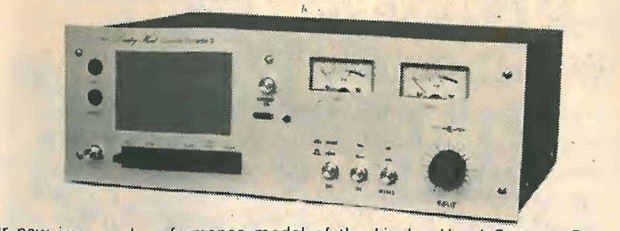


VFL 910

VFL 910. Vertical front loading Super Hi-fi deck, as used in our new Linsley-Hood, Cassette Recorder 2. **£31.99** + VAT. Set of knobs **£1.46** + VAT.

LINSLEY HOOD CASSETTE RECORDER 2



Our new improved performance model of the Linsley Hood Cassette Recorder incorporates our VFL 910 vertical front mechanism and circuit modifications to increase dynamic range. Board layouts have been altered and improved but retain the outstandingly successful mother and daughter arrangement used on our Linsley Hood Cassette Recorder 1.

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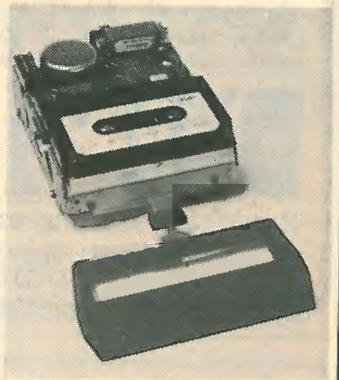

LENCO CASSETTE MECHANISMS

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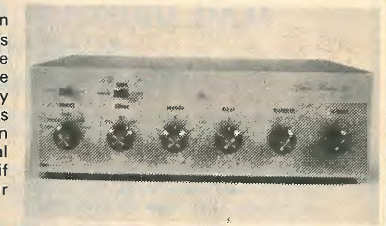

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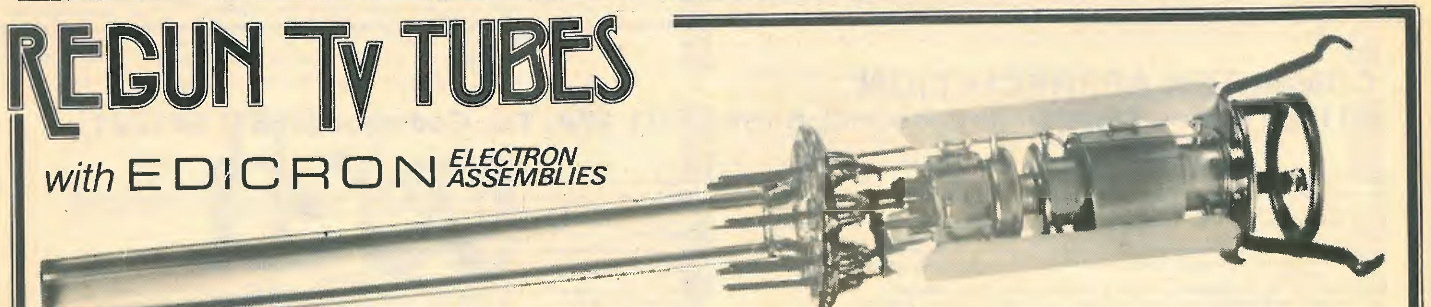

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Special issue appearing January 1980

The past ten years, as we all know, have shown quite remarkable developments in the technology of the many fields covered by Wireless World—electronics, radio, communications, television and audio, to name but a few.

What about the next decade? It's not so much a question of whether it will be as dramatic as the last, but how much more so. Indeed everybody seems to be looking towards the '80s with bated breath and excited anticipation. We on Wireless World feel much the same, and to make our own distinctive contribution to the scene will be publishing a special issue "Into the '80s" in January 1980.

In this, experts from industry and related fields will be predicting and discussing the changes we will all see—changes of course in which your company will be playing a major role. Listed below are some of the subjects to be covered:

Radio communications
Broadcasting
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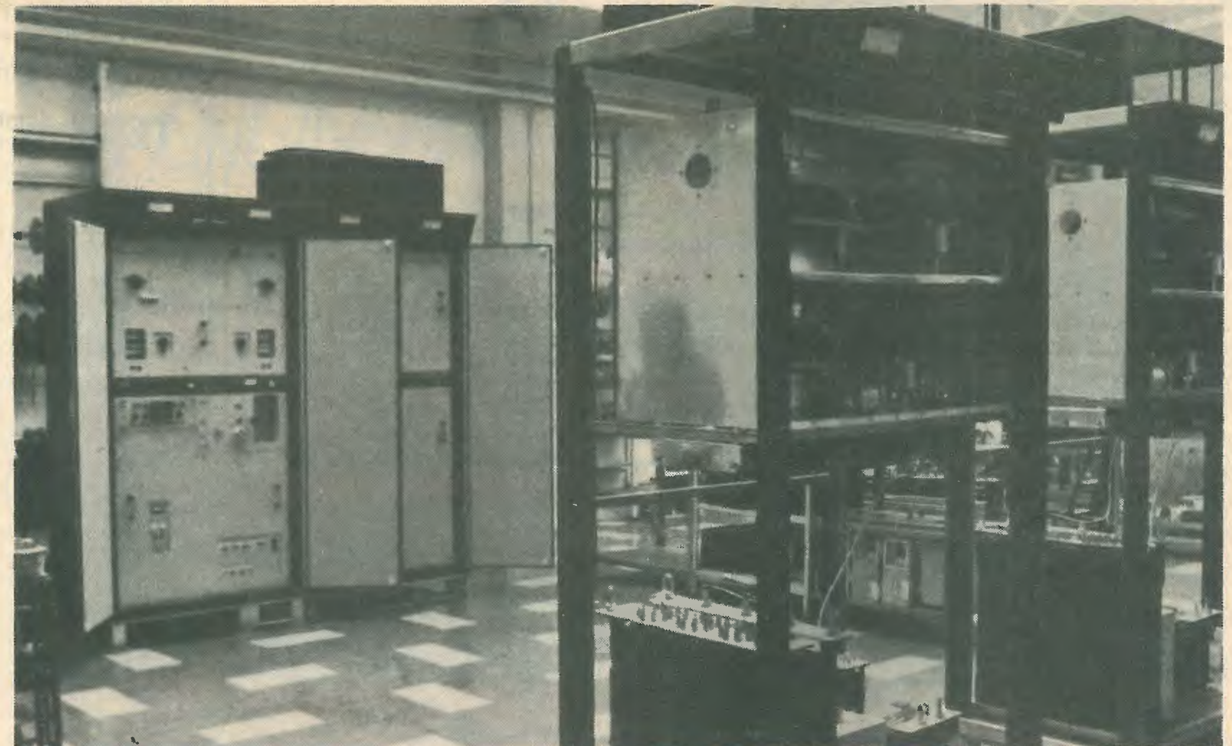

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Head of Training Section (Engineering), BBC, Wood Norton Hall, Evesham, Worcestershire quoting reference 79.E.2492/WW. Closing date for completed application forms is: 14 days after publication.

BBC

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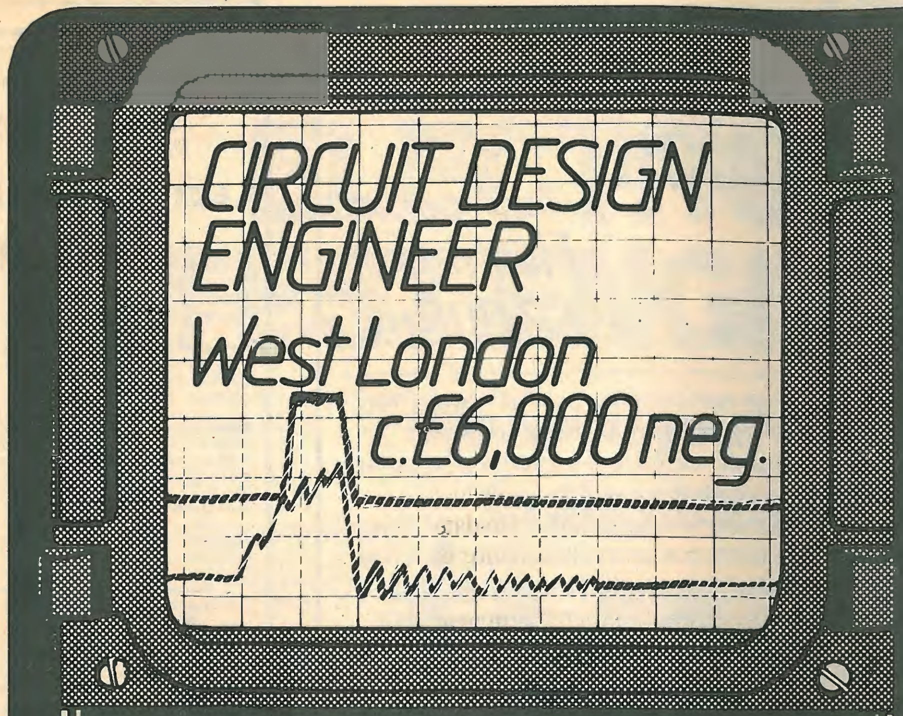

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(9810)

ELECTRONIC TECHNICIAN

REES INSTRUMENTS LTD.

have vacancies for Electronic Technician Engineers at their Old Woking headquarters. The successful applicant will be working as part of a small progressive team engaged on specialist CCTV system production.

The duties will include test and fault diagnosis on sub-miniature CCTV.

Whilst academic qualifications are desirable, applicants with experience in the field of TV will also be considered. Company offers a 37½ hour week with four weeks' annual holiday.

If you are interested, telephone Woking 62221, ext. 229 for an application form, or write to:

Mrs. F. Griffith-Jones
REES INSTRUMENTS LTD.
Westminster House, High Street
Old Woking, Surrey

(9849)

PIONEER
Product Evaluation Engineer
Iver, Bucks.
Electronics c.£8,000p.a.

Our Client, Pioneer High Fidelity (G.B.) Limited is engaged in the importation and marketing of their highly successful and top quality range of Hi-Fi equipment. They are looking for a Product Evaluation Engineer to work in their head office in Iver, Buckinghamshire.
If you are aged over 28, have a university degree or equivalent qualification in electronics and have five years' experience on the technical side of high quality sound reproduction and radio equipment, preferably Hi-Fi, we would like to hear from you.
You should be able to tackle advanced technical problems and be confident that you can contribute to an already high performance product range. You will have the most up-to-date and sophisticated test equipment to assist you in this.
Pioneer will negotiate a salary of around £8,000 p.a. and will provide the fringe benefits normally associated with a progressive company. In appropriate cases, they will also pay reasonable relocation expenses.
Please write stating age, current salary and how you meet our Client's requirements quoting reference PE/4055/WW on both letter and envelope. Men and women are invited to apply. No information will be disclosed to our Client without permission.

Urwick, Orr & Partners Limited
Management and Selection Consultants
Baylis House
Stoke Poges Lane
Slough SL1 3PF

(9837)

Inner London Education Authority
London College of Furniture

DEPARTMENT OF MUSICAL INSTRUMENT TECHNOLOGY (ELECTRONICS)

LECTURER GRADE I

Is required as soon as possible to teach electronics to Technician Education Council (T.E.C.) Diploma level in subjects related to electronic musical instruments and audio frequency engineering.

The person appointed should have a C & G Final or HNC/HND in electronics and a practical knowledge of electronic music systems.

Salary: On an incremental scale within the range of £3,480-£5,988 plus supplement of £6 per month, subject to formal approval (plus £474 Inner London Allowance), starting point depending on qualifications, training and experience.

Application form and further details available from:

Senior Administrative Officer
London College of Furniture
41-71 Commercial Road
London E1 1LA
Tel. No. 01-247 1953

(9873)

IMPERIAL COLLEGE

ELECTRONICS TECHNICIAN
—GRADE 5

To assist with the construction, development, servicing and testing of electronic equipment in the Department of Chemical Engineering.

The job consists of service and maintenance of a wide variety of electronic laboratory instruments, test equipment, computer terminals and printers. There will also be opportunity to work on the construction, development and modification of specialised electronic equipment involving both analogue and digital techniques such as amplifiers, controllers, data loggers and microprocessor based systems.

Candidates should hold a minimum qualification of O.N.C. or equivalent and have 7 years' experience.

Salary scale £4,480-£5,100 inc. under review 1.10.79 with further minimum increase of £226-£264 from 1.4.80.

Post is superannuable; there is a generous sick pay scheme. The working week is 37 and a half hours; 5 weeks' annual holiday plus several days in addition to public holidays at Christmas and Easter. There is a modern staff club and excellent facilities with sports centre, swimming pool.

Apply to Mr. J. S. Oakley, Departmental Superintendent, Chemical Engineering Department, Imperial College, London, S.W.7. Tel. 01-589 5111, ext. 1912.

(9847)

PHILIPS

PHILIPS MEDICAL SYSTEMS
require

ENGINEERS
For Diagnostic Medical Apparatus

We require several suitably qualified, technical personnel, to train in our headquarters in Eindhoven, Netherlands, as Installation and Service Engineers to install and maintain the very latest in advanced diagnostic apparatus.

After the comprehensive training is completed, you will be offered a contract with us somewhere outside the U.K. for a period of at least two years.

We feel that you should be at least twenty years old, preferably single, and be in possession of an ONC in electronics, C&G Technician Certificate or equivalent.

Experience of the medical field is advantageous but not essential for these positions.

If you feel that you have the qualifications to take this opportunity of joining a major Company in this field, then you will be amply rewarded with a job that is both satisfying and financially very worth while.

Although Philips Eindhoven would be the employer, please contact initially: *Mr. O. J. Skinner, Regional Co-ordinator, Philips Medical Systems, Kelvin House, 63/75 Glenthorne Road, Hammersmith, London W6 0LJ. Tel. No. 01-741 1666.*

(9851)

APPOINTMENTS IN ELECTRONICS
£5 – £10,000

Take your pick of the permanent posts in:

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COMPUTERS
RADAR — COMMS
MICROPROCESSOR
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For free expert advice and immediate action on salary and career improvement, 'phone or write to, Mike Gernat BSc.

Technomark
Engineering and Technical Recruitment
11 Westbourne Grove
London W2. 01-229 9239

(9257)

ELECTRONICS TEST ENGINEERS

We need your skills to stay true to type

Staying true to type is our business.
We're Linotype-Paul, world leaders in the design, development and marketing of an advanced range of photo-typesetting equipment. Our highly sophisticated computer-controlled machines are revolutionising the graphics industry and setting increasingly higher standards of type production. Keeping our systems on the leading edge of technology is our aim – and to back us in our efforts, we need more skilled electronics test engineers.
If you have 2-3 years experience of testing complex digital equipment, ideally reinforced by ONC or equivalent, you could build a great career with us. A knowledge of analogue circuitry would be an added advantage.
The work is deeply interesting and stimulating – and never routine. Staff facilities include superb working conditions, sick pay scheme, a subsidised canteen and relocation expenses where appropriate.
And salary structures are highly competitive.
Posts are open to both men and women. For full details, write or telephone to the Personnel Department, Linotype-Paul Limited, Runnings Road, Cheltenham. Tel: Cheltenham 45001.

Linotype-Paul

(9827)

Some of your best work will be thrown away. None of it will be wasted.

Engineers at UEL can be expected to work on a series of projects as diverse as can be imagined.

As leaders in the manufacture of communications systems, we've recently pioneered a unique railways communicating system. And since we've always been European leaders in the manufacture of Sonobuoys, we must warn you that some of your best work will be thrown away. Into the ocean, that is, to provide a vital contribution to this country's defence network.

We foster an unrivalled atmosphere of creative, enthusiastic and inspired engineering in which a good idea is applied in the most unlikely capacity. If you have the kind of talent which responds to this sort of environment, we have several positions which are bound to interest you.

Senior Electronic Engineers and Engineers
£5500-£7500 Aged 22-45

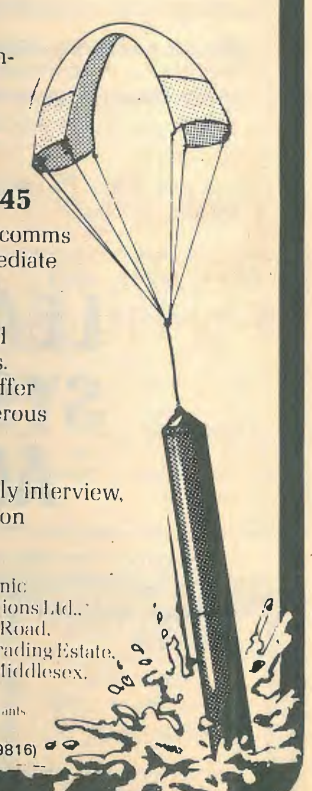
HNC/HND or Degree in Electronics, preferably a Chartered Engineer, to design analogue systems and circuits, technical staff control and infrequent travel to trials locations in the UK and abroad.
Preference will be given to Engineers with R.F. experience.

Transducer Engineer
£4500-£7500
High Wycombe

To contribute to the design, development and trials of electro-acoustic underwater transducers in connection with several interesting projects at our transducer laboratory. A degree or equivalent in either physics or electronics with ideally experience of government or industrial development establishments is required.

Development Technicians
£3500-£4500 Aged 25-45

C & G Electronic/Radio/TV/Telecomms Certificate up to Part 1 or intermediate level desirable. Duties to include building and testing prototypes, developing analogue circuits and assisting development engineers.
For all the above vacancies we offer highly competitive salaries, generous benefits and stimulating highly rewarding careers.
For more information and an early interview, please telephone Gavin Rendall on 01-578 0081 or write to:



DOWTY UEL

Ultra Electronic Communications Ltd., 419 Bridport Road, Greenford Trading Estate, Greenford, Middlesex.

The above vacancies are open to male and female applicants

(9816)

Site Survey Engineer

Radio Communication Equipment – Excellent Salary + Car

Multitone design and manufacture a world beating range of radio communication equipment, we're now beginning an exciting expansion programme, designed to consolidate our market position in the 1980's.

In line with these plans, we're now looking to appoint an experienced Site Survey Engineer to undertake radio coverage surveys in the UK and occasionally overseas. This will involve working away from home for up to two weeks at a time.

Your main area of involvement will be the setting up of small transmitting stations and measuring the coverage achieved. This will occasionally entail climbing antenna masts, normally not more than 100 ft., and using a pump-up antenna mast where existing facilities do not exist.

You must therefore be qualified to at least City & Guilds standard and preferably have some previous radio experience.

For this responsible and demanding post, we offer an excellent salary together with a benefit package which includes a company car, pension plan and free life assurance. Our general attitude to business ensures that promotion prospects are both genuine and progressive.

For more information, write to or telephone:

The Personnel Department,
Multitone Electric Co. Ltd.,
6-28, Underwood Street, London N1 7JT
Tel.: 01-253 7611

9854

multitone

WALSGRAVE HOSPITAL

Clinical Physics and Bio-Engineering Department

A Career in Electronics with the NHS

MEDICAL PHYSICS TECHNICIANS

Grade II and III

are required in the above Department to join a team involved in the maintenance and development of a wide range of electronic equipment associated with patient care, diagnosis and treatment. A knowledge of diagnostic maintenance of instrumentation and/or minicomputers is desirable.

Candidates for the post should hold an ONC, HNC or equivalent qualification.

Salary Scales:
Medical Physics Technician Grade II £5148 rising to £6396 per annum (£5547 rising to £6918 with effect from 1st January, 1980).
Medical Physics Technician Grade III £4320 rising to £5511 per annum (£4605 rising to £5952 with effect from 1st January, 1980).

Application forms and job description (quoting ref. WW) from Sector Administrator, Walsgrave Hospital, Clifford Bridge Road, Coventry. Telephone Coventry 613232, Ext. 618.

(9820)

ROYAL COLLEGE OF ART

A TELEVISION TECHNICIAN

is required in the School of Film and Television to assist in the daily operation and maintenance of colour television studio and mobile equipment. A sound knowledge of colour television systems is essential and some experience with studio equipment would be an advantage. Candidates should hold C & G Part II Certificate or equivalent although Part I Certificate holders may be considered. The salary will be in the range £4480-5100 (£4706-£5364 from April 1, 1980) according to qualifications and experience. 4 weeks' holiday.

Interested applicants should write giving full details of previous experience, etc., to: **Assistant Registrar (Staff), Royal College of Art, Kensington Gore, SW7 2EU.**

(9818)

We are a German group of companies which during the past 10 years have built up a reputation in banking, government and industry in the field of computer controlled Video Motion Detector Systems, Access Control Systems and Automation of Buildings. Development and execution of complete systems is done by us.

For our Data Processing Division reporting directly to the management we are looking for the

LEADING ANALYSER SYSTEMS ENGINEER AND OPERATORS

Qualification for these attractive positions are several years' experience in processing, preferably with DEC PDP-11 Computers and with calculation of hardware and software. Experience with microprocessors of Intel and Motorola would be an advantage.

Please write to Mr. T. H. Stolskij
Inform Systems GMBH
Heyestrasse 35, 4000 Duesseldorf 12

(9880)

AUDIO VISUAL AIDS TECHNICIANS

£5,034-£5,457 per annum

Two experienced Technicians are required by the Croydon Education Service to maintain and repair a range of Audio and Video equipment including TV receivers in schools.

Commencing salary in the scale will be according to qualification and experience.

In appropriate cases assistance towards removal and lodging expenses will be paid.

CROYDON

Apply in writing, giving details of age, qualifications, present post, relevant work experience and the names and addresses of two referees, to the Superintendent, Education Service Centre, Princess Road, Croydon, Surrey CRO 2QZ, or telephone the Superintendent, Mr. A. Bevan (telephone number 01-684 9393) for further details.

(9836)

Radio Technicians

Work in Communications R&D and add to your skills

At the Government Communications Headquarters we carry out research and development in radio communications and their security, including related computer applications. Practically every type of system is under investigation, including long-range radio, satellite, microwave and telephony.

Your job as a Radio Technician will concern you in developing, constructing, installing, commissioning, testing, and maintaining our equipment. In performing these tasks you will become familiar with a wide range of processing equipment in the audio to microwave range, involving modern logic techniques, microprocessors, and computer systems. Such work will take you to the frontiers of technology on a broad front and widen your area of expertise — positive career assets whatever the future brings. In the rapidly expanding field of digital communications, valuable experience in modern logic and software techniques will be gained.

Training is comprehensive: special courses, both in-house and with manufacturers, will develop particular aspects of your knowledge and you will be encouraged to take advantage of appropriate day release facilities.

You could travel — we are based in Cheltenham, but we have other centres in the UK, most of which, like Cheltenham, are situated in environmentally attractive locations. All our centres require resident Radio Technicians and can call for others to make working visits. There will also be some opportunities for short trips abroad, or for longer periods of service overseas.

You should be at least 19 years of age, hold or expect to obtain shortly the City and Guilds Telecommunications Technician Certificate Part I (Intermediate), or its equivalent, and have a sound knowledge of the principles of telecommunications and radio, together with experience of maintenance and the use of test equipment. If you are, or have been in HM Forces your Service trade may allow us to dispense with the need for formal qualifications.

Pay scales for Radio Technicians start at £3900 per annum, rising to £5530, and promotion will put you on the road to posts carrying substantially more; there are also opportunities for overtime and on-call work, paying good rates.

Get full details from our **Recruitment Officer, Robby Robinson, on Cheltenham (0242) 21491, Ext 2269,** or write to him at **GCHQ, Oakley, Priors Road, Cheltenham, Glos GL52 5AJ.** We will invite suitable applicants (expenses paid) for interview at Cheltenham.

GCHQ

Recruitment Office

Government Communications Headquarters

Oakley, Priors Road, Cheltenham GL52 5AJ

(9813)

ELECTRONICS TECHNICIAN

Vacancy with established Sound and Lighting Company in West London. Some experience essential, but must be willing to work and learn, so no posers, ballerinas or cowboys need apply.

'Phone Paul 01-579 2535

(9870)

TESTERS, TEST TECHNICIANS, TEST ENGINEERS. Earn what you're **really** worth in London working for a World Leader in Radio & Telecommunications. Phone Len Porter on 01-874 7281, or write: REDIFON TELECOMMUNICATIONS Ltd., Broomhill Road, Wandsworth, London, SW18. (9856

Nene College Northampton

Applications are invited for the temporary post of

SENIOR LECTURER IN ELECTRICAL ENGINEERING

Candidates should be graduates or Chartered Engineers with recent industrial experience. The successful applicant will be able to lecture in one of the fields of Industrial Control, Power or Electronics.

The post terminates on 30 August, 1980.

Salary scale £6,597-£8,253, point of entry depending on previous experience.

Application forms and further particulars are available from:
The Senior Administrative Officer
Nene College, Moulton Park, Northampton NN2 7AL

(9868)

TOP JOBS IN ELECTRONICS

Posts in Computers, Medical, Comms, etc. ONC to Ph.D. Free service.

Phone or write: **BUREAUTECH AGY, 46 SELVAGE LANE, LONDON, NW7. 01-959 3517.**

(8994)

CAPITAL APPTS.

29, Windmill St. London. W.1.

FREE LISTS

101 Design/Development and Test Jobs

Permanent and Contract

To £8,500

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£10-12,000 tax free

Candidates must have a minimum of ONC or equivalent together with at least four years experience in one of the following:–

Laboratory	(Ref. T.1)
...quency Standards Laboratory	(Ref. T.2)
...equency Laboratory	(Ref. T.3)
...pair Laboratory	(Ref. T.4)
...Physical Laboratory	(Ref. T.5)

...salaries, suitable ...eive free furnished ...ear, full medical cover and ...y four months with air

Telephone for an application form, quoting the relevant reference number, to *Gordon Newton, Lansdowne Recruitment Limited, Design House, The Mall, London W5 5LS. Tel: (01) 579 9642/6665.*

Lansdowne

Offices throughout the Middle East, Asia, North America and Australasia. **Middle East**

(9891)

UNIVERSITY OF CAMBRIDGE

Department of Biochemistry

SENIOR ELECTRONICS TECHNICIAN

and

ELECTRONICS TECHNICIAN

Two members of staff are required in the Electronic and Technical services group. This group plays a key role in the Department by servicing, repairing and modifying laboratory equipment in the Teaching and Research Laboratories. The wide range of scientific instrumentation involves analogue, digital and micro processor techniques. Members of the group are also responsible, in consultation with academic and other technical staff, for the development and construction of new equipment.

Good experience in electronics essential for senior post.

Minimum qualifications ONC in electronics or City & Guilds.

Technician post up to £3958. Senior post salary up to £4456 per annum.

Applications including curriculum vitae and the names of two referees should be sent to: **The Superintendent, Department of Biochemistry, University of Cambridge, Tennis Court Road, Cambridge CB2 1QW.**

(9817)

SERVICEMAN. London-based telephone answering machine company require immediately a part-time Serviceman to do repair work on a wide range of telephone answering machines. For further details tel: 01-373 8503. (9863

Unequalled in its range of job opportunities

BRITISH AEROSPACE

RADIO AND RADAR ENGINEER

DUNSFOLD AERODROME

This is a worthwhile position for a man or a woman wishing to strengthen a small team responsible for servicing and maintaining air traffic radio/radar installations.

Applicants should have a minimum of 5 years' current air traffic radio/radar equipment maintenance experience.

We will pay you an attractive salary and facilities include a subsidised Canteen and an active Sports and Social Club.

Please write or telephone quoting WW/70. to:
The Personnel Officer, British Aerospace, Aircraft Group, Kingston – Brough Division, Dunsfold Aerodrome, Nr. Godalming, Surrey. Telephone: Cranleigh 2121

BRITISH AEROSPACE
AIRCRAFT GROUP Dunsfold

(9889)

Our client, a major U.K. electronics company involved in providing a range of services to the oil industry, requires:–

TELECOMMUNICATIONS ENGINEER
(Aberdeen) £10,000 p.a.

Working on a rota system of 2 weeks offshore/2 weeks field break, maintaining vital offshore communications systems, on equipment ranging from hand-held portables to tropospheric scatter. This challenging position demands a high degree of technical ability coupled with self-motivation. Preference will be given to applicants with HNC qualifications (or Forces equivalent).

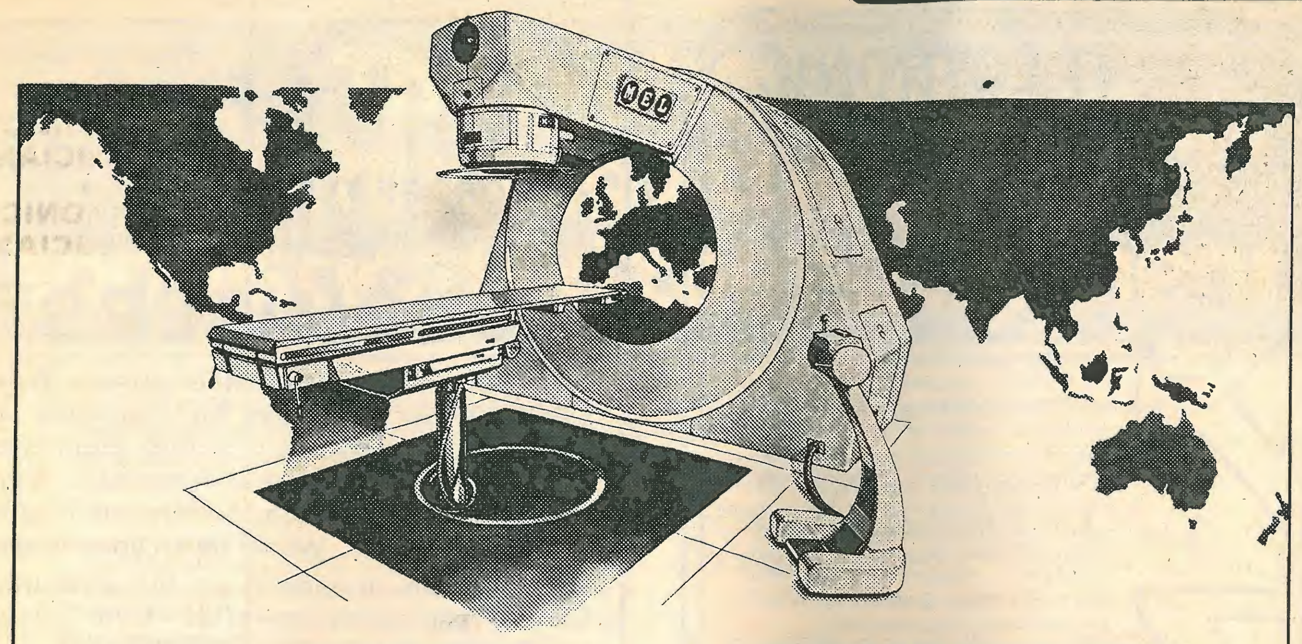
RADIO TECHNICIANS (Aberdeen)
Average earnings in excess of £8,500 p.a. plus:–
– Generous field break allowance for offshore work
– 4 weeks holiday p.a.

The work involves installation and maintenance of a wider range of marine radio equipment. Applicants must be capable of operating on their own in a demanding industry where the rewards are high for initiative and hard work.

PROJECT ENGINEER (Great Yarmouth)
Involving experience of a wide range of communications systems. This position will entail project planning at Head Office in East Anglia, and work in both offshore and onshore locations in the U.K. and overseas. Excellent salary and company benefits exist, along with good opportunities for career advancement.

Assistance with relocation will be given for all these positions.

Applications in confidence to:
Dept. 14E, BRJ APPOINTMENTS,
26 PARK PLACE, STEVENAGE SG1 1DF.



Installation Engineers around the World

M.E.L. a Division of Philips Electronic and Associated Industries is committed to the Development, Manufacture and Marketing of advanced Linear Accelerators. They are installed in major hospitals throughout the world. These machines play an important role in the treatment of Cancer, a subject which demands sustained development, sophisticated equipment and highly professional Engineers.

If you are a self-reliant mature and adaptable Engineer prepared to spend periods of six to sixteen weeks away from base, join our team and share the challenge and rewards of worldwide installation work.

You will need to be qualified to HNC level with a good knowledge of semi-conductor and digital circuitry and ideally with experience of modern high power radar and computer systems.

Based in Crawley, Sussex midway between London and Brighton you could become involved in projects as far afield as the U.S.A., Austria, Switzerland, Yugoslavia, Holland, China, Saudi Arabia, Brazil and Norway. So if you are looking for the opportunity to carry out worthwhile medical installation work on a worldwide basis, get in touch – NOW.

John Shuttleworth, Personnel Officer, M.E.L., Manor Royal, Crawley, Sussex. Telephone: Crawley 28787.

M E L

(9877)

Thomas Mercer Limited are developing a range of electronic precision gauging equipment which incorporates the latest microprocessor techniques, and they now wish to increase their staff by appointing an:

ELECTRONIC ENGINEER

The Electronic Engineer will be required to design hardware related to Intel 8080 microprocesser support I.C.'s, to design analogue and digital circuits and to progress the completed system through to delivery to the customer. He/she will be given training to write software in assembler and machine code.

The successful applicant will probably be a young engineer, who has preferably one year's experience in microprocessor applications.

Applications should be made by completion of an application form obtainable from:

Mrs. T. I. Breed, Personnel Officer
THOMAS MERCER LIMITED
Eywood Road, St. Albans, Herts.
Telephone: St. Albans 55313

(9876)

ROHDE & SCHWARZ
Independent concern represented in 80 countries

INSPECTOR

QUALITY ASSURANCE DEPARTMENT

ROHDE & SCHWARZ are one of the world's leading manufacturers of communication and instrumentation equipment for the RF market. A career opportunity exists at AVELEY/ROHDE AND SCHWARZ U.K. Ltd., for an experienced ELECTRONIC INSPECTOR who will be required to maintain our very high reputation for quality and reliability on both new and serviced equipment.

We operate at the forefront of technology therefore candidates will be expected to hold at least ONC or equivalent qualification in electronics. Wide ranging experience in electronics and Q.A. inspection is essential.

If you consider you are a suitable candidate and would like to be part of our friendly team please telephone 01-397 8771 for an application form.

We offer an attractive salary together with pleasant working conditions at our Chessington office.

Ring now!

Electronic Instruments & Communications Equipment

aveley electric LTD
**Roebuck Road
Chessington
Surrey KT9 1LP
01-397 8771**

(9845)

ELECTRONIC ENGINEERS

SONY®

Here at Bridgend, where we manufacture our Trinitron colour televisions, we are proud of the reputation we have earned for our progressive technology and high standards of production.

We now wish to strengthen our technical team and are looking for ELECTRONIC ENGINEERS, responsible to the Quality Manager, who will be involved in development, and the solution of technical, circuitry and engineering problems associated with high volume flow-line production.

Successful candidates, aged 21–30 years, will have a degree, or equivalent qualification, in electronics. Experience in a similar industrial environment and a knowledge of colour television production would be an advantage. However, strong consideration will be given to graduates whose qualifications and approach will indicate the level of potential and expertise that we are looking for. Enthusiasm, and the desire to extend practical as well as theoretical knowledge are essential.

Our modern plant is pleasantly situated near to the coast in the Vale of Glamorgan midway between Cardiff and Swansea.

Sony operates a progressive payment policy and initial salaries will be attractive. Conditions of employment are excellent including a first-class dining-room, company pension scheme, an active sports and social club and discount on ALL Sony products.

If you are interested in joining a young and progressive company please telephone or write for an application form to:

Andrew Goodwin, Personnel Officer,
Sony (U.K.) Ltd.,
Kingsway Industrial Estate,
Bridgend. Telephone: Bridgend 55441
Ext. 230 (9872)

A leading company in the Phototypesetting Industry requires Senior Systems Test and Commissioning Engineers.

Capable of testing and installing a range of minicomputer based VDU terminal equipment, incorporating the latest in MSI and LSI Techniques in Real-Time applications. The right candidates will be qualified to at least HNC level and/or have considerable experience in digital electronics with the knowledge of 74 Series TTL. A background of word processing or the printing industry would be advantageous. The job involves some U.K. and European Travel to handle back-up service for our agents. Salary: £5,500+.

JUNIOR TEST ENGINEER

This position requires a young engineer with a degree or Dip. Tech. in Electrical Engineering with an electronics bias.

Some experience in TTL Logic or Microprocessors would be useful, but a real interest in electronics is more valuable. Salary: Circa £3,000.
The company provides 4 weeks' holiday and a pension scheme.

Phone for application form to: Miss Bux, Datek Systems Ltd., 849 Harrow Road, Wembley, Middx. Tel. No. 01-904 0061.

(9885)

BORDER TELEVISION LTD.

Vacancies for

ENGINEERS

Due to an increase in the establishment, Border Television has vacancies for engineers with experience in Television studio engineering (Telecine, VTR or Central Apparatus areas). The possession of an appropriate qualification, while not essential, would be an advantage.

The Company is located on the outskirts of Carlisle only a few minutes' from unspoilt countryside and near the English Lakes.

Basic salary would be up to £6025, depending on qualifications and experience (under review).

Applications should be addressed to:

The Chief Engineer
Border Television Ltd.
CARLISLE
CA1 3NT

(9862)

MEET CHARLIE'S ANGELS

AT HAMMERSMITH FISH MARKET

You may have to put up with the odd waft of cod and rotting vegetables but at least you can see the new Lyric Theatre. More important you will be able to relax and scan thousands of vacancies which include: Microprocessor Engineer for Hardware/Software aspects of a Data Communication Management System, which allows diagnostics and reconfiguration of data networks under remote control. Middlesex. To £9,200.

Exceptional opportunity for young RF Circuit Designer to work on UHF Telemetry. Work includes: Interfaces between transducers and radio transceivers including filter design. London. To £7,000 + profit share.

Senior and Junior Design Development Engineers for the new generation of Teletext - Viewdata Products. High technology including microprocessor controls, interfaces to CRTs and audio telephone techniques. To £8,000. Essex.

Young RF Engineer to work on phase lock loop techniques associated with UHF oscillators, frequency counters and frequency synthesizers. Good theoretical background — strong bias towards communications. To £7,500.

Senior Engineer for group of consultants engaged on design of microprocessor based systems for the process industries. Familiarity with M.6800, RPA 1802, GM 1650 an advantage. Berks. Salary "wot, ees werf."

Computer Engineers for either: Field service, permanent site, technical support or systems test. Vacancies throughout U.K. Salaries vary enormously.

For further details of these and other vacancies contact:

4 HAMMERSMITH GROVE, LONDON, W6
Tel. 581-0286

(9866)

The higher the technology the more sophisticated the equipment

EMI are pioneers in some of the world's most advanced electronics technologies. Achievements such as ours – particularly in defence electronics – demand a total commitment to excellence, and quality assurance plays a vital role in our success.

Test and calibration engineering are more than peripherals roles at EMI. Joining us as a Test or Calibration engineer will mean working with some of the world's most advanced systems, using the latest automatic test equipment, much of it custom-built. If you have gained your experience in these fields, a move to EMI now will mean greater involvement, good prospects and really worthwhile rewards.

Your work will span a wide range of projects, including radar systems, and environmental testing. Competitive salaries are backed up by the EMI benefits package which includes relocation assistance, where appropriate, discounts on Group products, and excellent health and pension arrangements.

For more information contact Mike Barwell, Personnel Department, EMI Limited, FREEPOST, 135 Blyth Road, Hayes, Middlesex UB3 1BR.
Tel: 01-573 3888 or 24hr. Record-a-Call service on 01-573 5524.

A testing use for your talents as a Test or Calibration Engineer with EMI.

EMI
EMI Electronics Limited, Hayes

A member of the EMI Group of companies—International leaders in music, electronics and leisure.

(9823)

DESIGN OF MICROCOMPUTER SYSTEMS FOR THE 1980's

VACANCIES EXIST **NOW** FOR WELL QUALIFIED STAFF

DEVELOPMENT ENGINEERS

able to apply creative techniques in a wide variety of microprocessor-based applications. We are looking for engineers with degree and experienced in designing microcomputer systems; also for graduates due to qualify July, 1980.

SOFTWARE SPECIALISTS

with experience in writing programs in assembler language for 6800, 8080, Z80, 2650, 9900 computer applications and Nova minicomputers.

DRAUGHTSMEN

with experience of P.C. design for training on Racal-Redac C.A.D. equipment about to be installed.

LABORATORY TECHNICIANS

able to give intelligent and adaptable support to the design staff.

Competitive salaries, bonuses etc., will be paid in keeping with qualifications and experience.

WRITE, GIVING DETAILS TO:

QUARNDON ELECTRONICS LTD
SLACK LANE—DERBY DE3 3ED

(9833)

ELECTRONIC ENGINEERS

We are looking for a number of engineers (male/female) to work with electronic equipment at our premises in the London Area and for small numbers of vacancies in Belfast and Bristol. Initial Salary
£5170 to £5620 in London
£4720 to £5170 elsewhere
Plus additional payments for shift or irregular hour working.

Applicants should have a Degree, HND or HNC in Electronic or Electrical Engineering or Applied Physics
OR
A City & Guilds Full Technological Certificate in Telecommunications (Course 271).

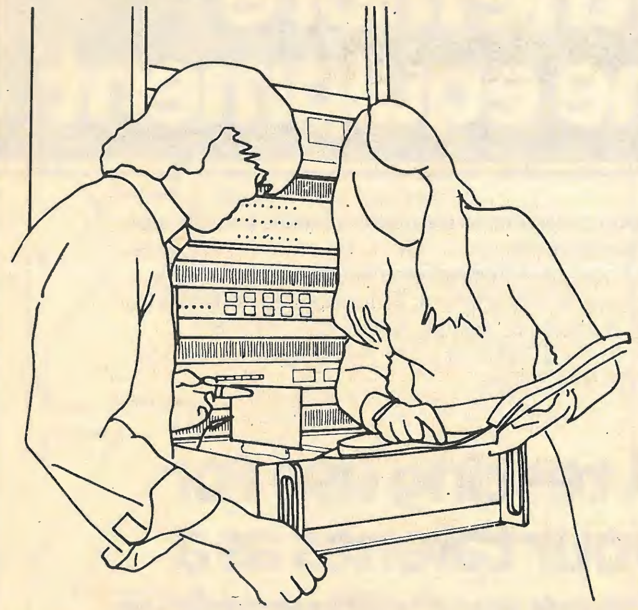
All our engineering staff receive comprehensive training, so experience is not essential.

Write for further information and application form to: **The Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA,** Quoting Ref: 79.E.4119/WW.

BBC

(9838)

Professional Careers in Electronics



All the others are measured by us...

At Marconi Instruments we ensure that the very best of innovative design is used on our range of communications test instruments and A.T.E. We have a number of interesting opportunities in our Design, Production and Service Departments and we can offer attractive salaries, productivity bonus, pension and sick pay schemes together with help over relocation.
If you are interested to hear more, please fill in the following details:-

Name ____________ Age ______
Address ____________

Telephone Work/Home (if convenient) ____________

Years of experience 0-1 ☐ 1-3 ☐ 3-6 ☐ Over 6 ☐

Present salary £2,500-3,500 ☐ £3,500-4,500 ☐ £4,500-5,500 ☐ over £5,500 ☐

Qualifications None ☐ C & G ☐ HNC ☐ Degree ☐

Present job ____________

Return this coupon to John Prodger, Marconi Instruments Limited, FREEPOST, St. Albans, Herts, AL4 0BR. Tel: St Albans 59292

Marconi Instruments
A GEC MARCONI ELECTRONICS COMPANY

(9200)

PROJECT ENGINEERS

STUDIO CAPITAL PROJECTS DEPARTMENT.

The advantages of a career in the Studio Capital Projects Department of the BBC are self evident. To put the matter simply, broadcasting is exciting.
There is the prestige of working in a department involved in many of television and radio's most brilliant innovations. Then, there's the challenge of planning, installing and commissioning entire sound and vision systems for film, radio and television studios. Your work is varied, stimulating and demanding.
You should therefore be able to demonstrate a thorough understanding of some of the many aspects of broadcasting and have practical experience of the operation, maintenance or installation of the relevant equipment. In addition, you must hold a degree, HND or HNC qualification in either Electrical or Electronic Engineering. Applied Physics or a City & Guilds Full Technical Certificate in Telecommunications and be aware of the financial and commercial aspects of project planning and execution.
Although you will be based in London, you must be prepared to travel anywhere in the United Kingdom. Salaries, ranging from £5745 to £7535 rising to £8405 will reflect your qualifications and experience and relocation expenses will be considered.
There is, of course, much more to say about broadcasting. If you want to discover just how much, write giving full career details to: **Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA. quoting reference no. 79.E.2453/WW.**

BBC

(9828)

ATTENTION! ALL CALIBRATION & TEST ENGINEERS...

We are looking for experienced Engineers with a thorough knowledge of professional tape recording equipment and associated products. The work involves the maintaining, servicing and overhauling of top quality audio equipment supplied to the Television Companies, Recording Studios and Film Industry. Full product training will be given, and when fully conversant with our products you would be dealing directly with our clients, both on the telephone and in person. On some occasions you would also be required to visit customers in the U.K. Initially, you would be based at our Service Department in London, N.W.1 (near Marylebone Station), but we are moving to new premises in the High Wycombe area this autumn. We are offering starting salaries around £6,000 p.a. plus a non-contributory pension scheme and four weeks' annual holiday.

If this sounds interesting — please write, giving full career history to the Managing Director (marked confidential),

HAYDEN LABORATORIES LTD

HAYDEN Churchfield Road, Chalfont St. Peter, Bucks.

(9825)

Radio Officers

When the ship comes home, why not settle down?

We're the Post Office Maritime Service and we have everything in a job that you'd want: the kind of work you're trained to do, good pay, job security and all the comforts of home where they really count – at home!

Vacancies exist at several coast stations for qualified Radio Officers to carry out a variety of duties that range from Morse and teleprinter operating to traffic circulation and radio telephone operating. And for those with ambition, the prospects of promotion to senior management are excellent.

You must have a United Kingdom Maritime Radio Communication Operator's General Certificate or First Class Certificate of proficiency in Radio-telegraphy or an equivalent certificate issued by a Commonwealth Administration or the Irish Republic. Preferably you should have some sea-going experience.

The starting pay at 25 or over will be about £4450; after 3 years service this figure rises to around £5750. (If you are between 19 and 24 your pay on entry will vary between approximately £3500 and £4050). Overtime is additional, and there is a good pension scheme, sickpay benefits and at least 4 weeks' holiday a year.

For further information, please telephone Andree Trionfi on Freefone 2281 or write to her at the following address: ETE Maritime Radio Services Division (WW), ETE17.1.1.2, Room 643, Union House, St. Martins-le-Grand, London EC1A 1AR.

Post Office Telecommunications

(9741)

Project Engineers – Electronic Systems

BRITISH RELAY ELECTRONICS LIMITED
a subsidiary of the Electronic Rental Group, is an internationally known Company specialising in the design and installation of low voltage communication systems in hotels, hospitals and industry.

As a result of rapid expansion, a number of project engineers are now required.

Our project engineers are responsible for the design of systems and their costing, through to the responsibility for their installation.

These vary between audio and video communication systems, including multi-channel carrier and microprocessor based systems.

Qualifications to HNC or HND standards are desirable although a City & Guilds certificate in the relevant subjects may be acceptable.

A highly competitive salary is offered and company car and the usual fringe benefits associated with a major Group.

Please write, in complete confidence, in the first instance, with a c.v. to:
The Technical Director
British Relay Electronics Limited
32 Biggin Way,
Upper Norwood,
London SE19

9688

British Relay Electronics

COMPLETE ENGINEER!

Or ready to become one?

We require someone who can combine an understanding of basic device parameters and system requirements with a flair for engineering problem free products.
He, or she, will have the task of developing advanced designs of Quartz Crystal Oscillators as part of a team dedicated to maintaining our leadership of the European market. The qualities required of the successful candidate combine a high level of analytical ability with drive and vision and the instinct to identify the most appropriate approach to engineering problems.
Qualifications: A good Honours Degree in Mathematics, Physics, Electronic Engineering or a related subject. Extensive experience is not necessary.
The appointment carries an excellent starting salary and an attractive range of company benefits, including relocation expenses where appropriate. The Quartz Crystal Division is the largest crystal manufacturing facility in Europe and there are first class career development prospects within the Division and the ITT Group as a whole.
Please write or telephone R. J. Coster, ITT Components Group, Quartz Crystal Division, Edinburgh Way, Harlow, Essex. Telephone Harlow 26811 ext. 2562.

Components ITT

(9893)

SENIOR LABORATORY TECHNICIAN

The BBC requires a Senior Laboratory Technician in its Communications Department, London to assist engineers with the development and construction of a wide range of communications equipment.

Candidates must have some experience of workshop practice and the ability to work from verbal instructions, rough sketches and drawings and be able to convert the basic design into practical equipment of high standard.

He/she will be responsible for servicing all Communications Department laboratories, including first line maintenance, alignment and calibration of apparatus.

He/she will work mostly unsupervised.

A Higher National Certificate or equivalent qualification is required but training is available for those not yet qualified.

The post offers an attractive package of: a starting salary in the range of £5170 p.a. – £5620 p.a. or £4630 p.a. – £5020 p.a. depending upon whether qualified or not, a higher starting salary would be considered for exceptional experience; Relocation expenses where applicable; 23 days leave per year excluding Bank Holidays and a very good contributory Pension Scheme.

Please write for an application form to: **Engineering Recruitment Officer, BBC, Broadcasting House, London W1A 1AA** quoting reference 79.E.2478/WW.

BBC

(9848)

Radio Technology
ELECTRICAL ENGINEER
Up to £8375

The Radio Interference Laboratory at Stanmore, Middlesex, undertakes a wide variety of research and development projects in the frequency range up to 21 GHz. As engineer in charge of the laboratory, the officer appointed will be responsible for the day-to-day management of staff and development projects. Duties also include participation in electro-technical committees at national and international levels and liaison with industry and other government departments. Present projects include investigations into methods of measuring the total power radiated by microwave ovens, the immunity of television sets from external signals, the interference potential of ADP equipment, the development of radio frequency measuring, receiving and television detection equipment and the measurement and suppression of a wide range of electrical equipment.

Candidates must have qualified for corporate membership of IEE or IERE, and have several years' professional experience in addition to the minimum requirement for chartered status. They must have at least two years' experience in a relevant field, and should have a broad outlook enabling them to appreciate the general principles of frequency spectrum engineering.

Starting salary between £6,865-£8,375 depending on qualifications and experience. **(Salaries under review).** Promotion prospects. Non-contributory pension scheme.

For further details and an application form (to be returned by 13 December, 1979), write to Civil Service Commission, Alencon Link, Basingstoke, Hants. RG21 1JB, or telephone Basingstoke (0256) 68551 (answering service operates outside office hours). **Please quote: T(Z)85.**

HOME OFFICE

(9826)

Telecommunications Project Engineer

Salary up to £7,116 per annum (inclusive)

This is an important post within an established group of telecommunications and electronics engineers (based at Reading) dealing with the specification, design, installation, commissioning, operation and maintenance of sophisticated systems of telecommunications control and instrumentation within the Thames Water Area.

Applicants should be chartered engineers (male/female) with several years' experience of design or project work, including budgetary control, in large telecommunications systems. A sound knowledge of transmission principles and practice is required and some experience of telephony is desirable.

Excellent conditions of service apply including a pension scheme, a 35-hour 5-day week (flextime), plus generous sick leave and holiday entitlements. There is also a staff restaurant and an active social club.

Application forms and further details can be obtained from the Personnel Office, Thames Water, Thames Conservancy Division, Nugent House, Vastern Road, Reading RG1 8DB (Tel: Reading 593331). Please quote reference P.24.

Closing date: 4th December, 1979.

Thames Water

(9824)

ELECTRONICS TECHNICIANS

GRADE 6

DEPT. OF MECHANICAL AND PRODUCTION ENGINEERING, S.E.1.

to be responsible for small controls laboratory. Able to design/construct circuits from verbal instructions and to rectify faults on a wide range of electronic equipment. Salary range £4,767-£5,592 p.a.

GRADE 6

DEPT. OF ELECTRICAL AND ELECTRONIC ENGINEERING, S.E.1

To service a wide range of electronic and digital equipment, design and modify electronic circuits and apparatus. Applicants must have a thorough knowledge of, practical experience in, electronic servicing procedure. **Salary range £4767-5592 p.a.**

GRADE 5

DEPT. OF CIVIL AND STRUCTURAL ENGINEERING, S.W.8.

To be responsible for the repair and modification of electronic instruments. Salary range £4,224-£4,845 p.a.

Polytechnic of the South Bank

Application forms from the Staffing Office, Polytechnic of the South Bank, Borough Road, London SE1 OAA. Telephone 01-928 8989, Ext. 2023.

SITUATIONS VACANT

IMPERIAL COLLEGE GEOLOGY DEPARTMENT

ELECTRONICS TECHNICIAN

(Grade 5) required for workshop to work on development and construction of specialised electronic equipment and repair of existing equipment. Minimum qualification ONC Electrical or equivalent. Salary scale £4480-£5100 (under review 1.10.79 with further min. increase of £226-£264 from 1.4.80). Post is superannuable: generous sick pay scheme. 37½-hour week: 5 weeks' annual holiday plus several days in addition to public holidays at Christmas and Easter. There is a modern staff club and excellent facilities, with sports centre with swimming pool.

Application form and job details from J. R. Blount, Departmental Superintendent, Imperial College, London SW7 2BP or Phone 01-589 5111, Ext. 1685. (9808)

WEST AFRICA
NATIONAL IRON ORE COMPANY OF LIBERIA

invites application for an

ELECTRONICS/RADIO TECHNICIAN FOREMAN

with technical diploma and specialising in radio communications systems and instrumentation. Minimum 5 years' experience, with some supervisory responsibility. Two year renewable contract with three months' paid leave. Free family accommodation, family passages and medical attention. School for children up to age 13 years, education allowances plus contract renewal bonus. SALARY US$18,000 per annum.

Please reply in writing, giving full details, qualifications and experience to Caemi International Limited, Garrard House, 31/45 Gresham Street, London EC2V 7DN.

(9850)

TECHNICAL SALESMAN

with knowledge of

SHORTWAVE RECEIVERS

To sell shortwave equipment to embassies and other outlets. Good salary and commission for right person. Keen amateur with shortwave experience acceptable. Training given if necessary.

Write with details and experience to:
Box No. 9822

(9822)

MANCHESTER POLYTECHNIC Department of Communication Arts and Design, School of Film and Television require TELEVISION STUDIO ENGINEER. The post is one of responsibility and entails assisting the Chief Engineer with studio operations and maintenance in closed circuit television. Candidates should have experience of broadcasting or educational television operations and should be conversant with both television and sound studio practice. Appropriate technical qualifications such as HNC or City and Guilds Certificate would be an advantage. A Union Membership Agreement is in operation under which new employees are required to join a recognised union. Salary scale: Technician 5, £5,220-£5,547. For further particulars and application form (returnable by December 7, 1979). Please send a self-addressed envelope marked "A/335" to the Secretary, Manchester Polytechnic, All Saints, Manchester M15 6BH. (9853

Service Engineers
Take a glimpse into 1980

This is your opportunity to discover what the new year will be like for Engineers who join Kodak to service an exciting range of microfilm machines **in and around central London.** We're inviting you to chat to our Regional Manager, Rowland Elvidge, about the work, the rewards and the prospects you can expect when you join a large international company.

We are expecting a high standard from you, you will need a sound knowledge of practical electronics coupled with mechanical skills, preferably having had previous servicing experience. You are going to be responsible for the installation, maintenance and repair of business equipment, initially from our basic range, building up to computer linked systems.

To men and women aged over 21, joining our Induction Course commencing 7th January, we can offer a rewarding career with fast progression, potential earnings of £7,000 p.a. including some overtime, allowances and productivity bonus, plus plenty of attractive employee benefits.

So phone in and speak to Rowland Elvidge, on 01-405 7841 Ext.133 or write to Mr. C. Long, Personnel Department, Kodak Limited, Station Road, Hemel Hempstead, Herts, with full career and personal details.

Kodak

1978

(9841)

ARTICLES FOR SALE

TELEQUIPMENT E1011 SCOPE, only nine months old, twin trace, variable time base, first-class order, £245 inc. VAT. Dorset (09297) 257. (9883

WIRELESS WORLD, 1952 to 1966. Offers? — Chamberlain, 60 Harpool Rd., Redditch, Worcs. Tel. (0527) 24995 (9882

VHF MONITOR RECEIVERS, Air or Marine band from £50. FM Business bands from £90. For leaflets send 50p P.O., not stamps. Radio Communications Ltd, 13 Clos du Murier, St Sampson, Guernsey, Channel Isles. (9874

TWO WELL maintained recently serviced ASR-33 teletypes with 20mA interface for sale. In good working order. Each £600. Box No. 9830.

MICRO COMPUTER — Nascom I with T4 monitor, power supply, built, tested, and working £180. — Phone Charles Frater, 01-937 3347. (9839

1IN COMPUTER tape ½in computer tape, can be used as video tape on some machines. Three teleprinter 54's. Phone for further details 0622 50350. MKS, 27 Upper Stone St, Maidstone, Kent. (9442

SPEAKER KITS

Two great new kits from KEF — the Speaker Engineers respected by HiFi enthusiasts all over the world.

One is based on the Model 104aB and the other on the larger, free standing Cantata.

We'll give you helpful advice and full instructions.

And you can hear how good the speakers are before you build.

F. D. BAILEY
131 The Parade
Watford, Herts.
Tel. 0923 34644 (9657)

SITUATIONS VACANT

Swaziland Senior Technical Officer (Broadcasting)

Up to £7,785 p.a. (under revision) plus allowances

Candidates should have City and Guilds Telecommunications Final Certificate or equivalent and at least seven years' experience in broadcasting. Studio experience is required and block transmission experience would be advantageous. Duties will include the installation and maintenance of broadcasting equipment in the studio block and/or transmitting stations. He will take charge of major outside broadcast assignments and supervise operational and maintenance staff. Posting will be to the Capital of this scenic African country which employs many British experts.

Salary includes a substantial tax-free allowance (reviewed annually) paid under Britain's overseas aid programme. Basic salary attracts 25% tax-free gratuity.

Benefits include free passages, generous paid leave, children's holiday visit passages and education allowances, subsidised housing, appointment grant and interest-free car loan.

The terms on which civil and public servants may be released if selected for appointment will be subject to agreement with their present employers.

For full details and application form write quoting MX/010/WD.

Crown Agents

The Crown Agents for Oversea Governments and Administrations, Recruitment Division, 4 Millbank, London SW1P 3JD. (9858)

If you don't want to work, you have to work to earn enough money, so that you don't have to work — Ogden Nash.

So, start the 1980s with a new career.

Phone us now to register for these and many other positions.

PROJECT LEADER

Self-motivator for computer peripheral evaluation. Leading to management. £7K + car (W. London)

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VHF & UHF communications engineers for new generation systems. Herts./Beds. and Greater London. £4.5-£5.5K + car

DEV. MANAGER

Logic systems design and computer architecture. Varied applications. London. £12K

FIELD SERVICE

Computer based process control. Full training in Europe (2 months). Berkshire. £5-£6K + car

NC ENGINEER

KTM & DSG/MONARCH CNC & NC Machine experience. South Coast. c £7K + relocation. Also NC Programmer for same client c £7.5K.

24-hour secretarial answering service on 01-464 7714, ext. 502

LOGEX

ELECTRONICS RECRUITMENT SERVICE

309 HIGH ROAD, LOUGHTON, ESSEX, IG10 1TD.

01 502 1589/0937 READYCALL 01 464 7714 EXT. 502 (9861)

Computer Maintenance Engineers

The Company:

Burroughs is an international computer company with world-wide activities. The high technology of its products designed and manufactured at Cumbernauld demands the extensive use of computers as shown below.

The Job:

Installation and maintenance of a wide range of computer equipment which covers:

* 3 large scale (B 6800) computer systems and peripherals
* 4 medium scale (B 1800) computer systems and peripherals
* 24 small scale (B 80) computer systems and peripherals
* over 100 terminals linked to the above.

Qualifications:

Ideally, a degree but emphasis will be on ability.

Salary:

Salary will not be a limiting factor in the selection of suitable candidates.

Personal Development:

All necessary training on mainframes and peripherals will form part of the successful candidates personal development.

For Further Information:

Write or phone
Recruitment Manager
Burroughs,
Cumbernauld G68 0BN.
Telephone 023-67-35457.

Men or women may apply.

Burroughs

(9806)

ARTICLES FOR SALE

LAB CLEARANCE: Signal Generators; Bridges; Waveform, transistor analysers; calibrators; standards; millivoltmeters; dynamometers; KW meters; oscilloscopes; recorders; Thermal, sweep low distortion true RMS, audio FR, deviation. Tel. 040-376236. (8250

YAESU TRANSCEIVER FT101, input 260 watts, PEP, SSB, 160-10 metres £350, KW Viceroy transmitter, 180 watts input PEP-SSB 80-10 metres, KW 1000 (watts) linear amplifier, all in very good condition. — 01-346 4468. (9843

SITUATIONS VACANT

Audio and TV Servicing

Sanyo Marubeni, one of the world's leading electrical/electronic organisations, utilise high technology capability in a wide range of domestic audio and video products. Continuing success in the U.K. has created the following positions.

Chief Engineer/ Asst. Dept. Manager

A challenging new position, which has been created to strengthen our management team, with prime responsibility being for the leadership of our service engineering team involved with audio and T.V. equipment.

Applicants aged 25-40 should be qualified to City and Guilds standard and possess the personal qualities necessary to ensure effective management and training.

Quality Control Engineer

Following action by the Service Department you will be responsible for ensuring that a high standard of work has been achieved.

Good experience in the trade is required as is the ability to work closely with the Service Engineers.

Audio Service Engineers

Service Engineers are needed to assist in the fault finding, repair and reconditioning of domestic equipment.

You will need the technical ability to service a wide range of goods and to work with the minimum of supervision.

All the above positions are open to men and women and carry very good salaries in addition to usual company benefits.

Please apply to Mr. J. Careford, Sanyo Marubeni UK Limited, Greycaine Road, Watford, Herts. Tel: Watford 46363.

SANYO

Technology at your Fingertips (9846)

TEST/QUALITY ASSURANCE ENGINEERS

At senior and intermediate level wanted to work on our range of advanced broadcast television studio products including colour and monochrome television studio cameras.

Applicants should have an up-to-date knowledge of digital and linear circuit techniques gained from experience working on television studio equipment, radar equipment or similar sophisticated products, and qualified to HND, HNC, or equivalent level.

SYSTEMS ENGINEER

You would be involved in all stages of product management on the design and building of studio and mobile TV systems and should be prepared for occasional world-wide travel. The appointment requires someone with a background in this type of work, or in the operational side of television with the ability to take charge of people and deal with problems in the field on your own initiative.

Employment benefits incude excellent salary, generous holidays, free life and health insurance, pension scheme, subsidised meals and relocation expenses.

Please apply for further details and application forms to Jean Smith at the address given below.

Advanced Broadcasting Equipment

LINK ELECTRONICS

Link Electronics Limited, North Way, Andover, Hants, SP10 5AJ.

Telephone: (0264) 61345 (9842)

UNIVERSITY COLLEGE, CARDIFF
Department of Geology

Applications are invited for a

S.R.C. (CASE) STUDENTSHIP

for research, leading to the degree of PhD, into the development of a new analogue video comparison and measurement system for a wide variety of shape-analysis applications in the natural, physical and applied sciences, and in industry. The project is run jointly by the Geology Department, whose specific interest in the shape-analysis of deformed rock and fossil material, and E.O.S. Electronics Ltd., Barry, South Glamorgan (the Co-operating Body in this S.R.C. Co-operative Award in Science and Engineering).

Applicants should possess or expect to gain a first or upper second-class Honours Degree in Electronics or a closely related subject. Interest in application of electronics to the natural sciences would be an advantage.

Applications should be made as soon as possible to the Head of Geology Department, University College, P.O. Box 78, Cardiff CF1 1XL, from whom further details may be obtained. Reference 1916.

(9871)

ARTICLES FOR SALE

SURPLUS TO INDUSTRIAL REQUIREMENTS

100 mixed Min. Electrolytics	£3.00
300 pack 220mfd 10V	£1.50
25 mixed Large Can	£3.00
10 4700mfd 40V Tag 3 x 1¼	£1.20
10 2000mfd 70V Tag 1¾ x 2¾	£1.20
10 200mfd 450V Tag 4½ x 1¾	£1.20
100 mixed Preset Spindle Pots	£3.00
10 100K Dual ½Watt Lin. Pots	£2.00
24 mixed Voltage S/pole Relays	£3.00

Add 30p per item P&P
All prices inc. VAT

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Reedham House, Burnham, Bucks (9815)

ENCAPSULATING, coils, transformers, components, degassing, silicone rubber, resin, epoxy. Lost wax casting for brass, bronze, silver, etc. Impregnating coils, transformers, components. Vacuum equipment low cost, used and new. Also for CRT regunning metallising. Research & Development. Barratts, Mayo Road, Croydon, CR0 2QP. 01-684 9917. (9678

ARTICLES FOR SALE

MFS CLOCK

NEW! Shows Date, Hours, Minutes, Seconds, 8 digit LED, also parallel BCD output, 5x8x15cm, Time Signal accuracy **£48.80**

MSF Receiver, serial data output **£13.70**

Still **NO RADIO 4?** All the NEWS with a 200KHz to Med. Wave Converter **£11.40**

V.L.F? 10-150KHz Receiver .. **£10.70**

SIG. GEN., 10Hz-200KHz, logic and variable sine and square waves . **£10.80**

Each fun-to-build kit includes all parts, printed circuit, case, postage, etc. Money back assurance so SEND off NOW.

CAMBRIDGE KITS
45 (WZ) Old School Lane
Milton, Cambridge (9812)

PRINTED CIRCUITS. Make your own simply, cheaply and quickly! Golden Fotolak Light Sensitive Lacquer — now greatly improved and very much faster. Aerosol cans with full instructions. £2.25. Developer 35p. Ferric Chloride 55p. Clear Acetate sheet for master 14p. Copper-clad Fibre-glass Board approx. 1mm thick. £1.70 sq. ft. Post/packing 60p. White House Electronics, P.O. Box 19, Penzance, Cornwall. (9681

USE A REAL KEYBOARD

Brand new, built and tested. 60 keys including cursor control, stepped rows, typewriter style. Auto repeat. UC + LC ASCII coded. **£44.75** (£53.19 inc p&p and VAT).

S.a.e. for details: **TIMEDATA Ltd., 57 Swallowdale, Basildon, Essex.** (9864)

FERROGRAPH stereo recorder, 422V, excellent condition. Best offer accepted. Contact Mr. Fraser, 41 High Street, Nairn (Scotland) 066 753038.

TELEPHONE ANSWERING machine available for outright purchase. — Telephone Burton-on-Trent (0283) 47427. (9609

SITUATIONS VACANT

Join the Meteorological Office as a
Radio (Meteorological) Technician

You would be expected to install, test and maintain a wide range of meteorological electronic instrumentation including radars, communication, facsimile, data handling and logging equipment, incorporating computers and micro-processors. You would also assist R & D teams in the construction and testing of prototype equipment. Jobs involve a considerable amount of travelling in the field, and you would need to possess a valid driving licence. Some travel by sea and air would also be involved.

After specialist training, you would be posted to one of the Meteorological Office stations throughout the U.K.; during your career you could expect to move areas several times, and there are opportunities to work overseas. Working hours may include some day-shift working and also on-call duties.

You will be eligible if you are:

a) Aged 19-25 and hold C & G Telecommunications Technicians Part 1 Certificate (former course No. 270); or C & G Telecommunication Technicians or Engineering Intermediate Certificate (former courses No. 49 or 50); or ONC in appropriate electrical/electronics subjects; or TEC/SCOTEC Certificate in a relevant discipline, **together with** normally 3 years' practical experience; or

b) A former member of HM Forces (or will be leaving soon) with relevant experience.

Starting salaries will depend upon age, e.g. £3,389 at 19, £4,270 at 25 and over, rising to a maximum of £4,899. From 1.1.80 an agreed pay award will raise the maximum on the scale to £5,530, with appropriate adjustments at other levels.

Opportunities for promotion to TTO III and above are excellent, and will depend mainly on your individual abilities.

Requests for application forms, and all enquiries to: **The Secretary, Meteorological Office, Room 612, London Road, Bracknell, Berks. RG12 2SZ or telephone Bracknell (0344) 20242, Extn. 2596.**

(9859)

EXPERIENCED PRODUCTION MANAGER

WISHING TO PROGRESS

Opportunity to join a London-based company producing high quality sound mixing consoles for live media, professional recording and broadcast applications.

The individual most suitable for this responsible and challenging situation would be aged 30/40, preferably with an HNC (or similar), qualification, and several years' of production planning and management experience in a high growth rate company environment with products designed to a high reliability specification.

Ability to analyse and formulate production procedures, to determine movement of materials and work-loading, to maintain growth of production output without compromise to quality standards, and to control and motivate an enthusiastic production team is considered to be essential. Good technical knowledge of audio electronics is very desirable.

In return we offer: Excellent remuneration, good conditions and opportunity to progress within an organisation committed to growth through new product innovation.

Please contact Chas Brooke on 01-388 7060 or 01-387 7679 for an application form and company information, or write to him giving résumé of career to date.

MIDAS

Audio Systems Ltd.
54-56 Stanhope St., London NW1 3EX.

(9892)

ARTICLES FOR SALE

TEK 545 B mainframe	£80
TEK 547 mainframe	£150
TEK 151 Sampeling plug in	£100
1 L10 Spectrum analyser plug in	£450
TEK 422 15 MHZ portable	£350
RACAL 9913 200 MHZ counter	£150
SYSTEM Donner 5008 500 MHZ sweeper	£495
POLYSKOP 1 400 MHZ	£350
POLYSKOP 2 1200 MHZ	£850
POLYSKIP 3 110 MHZ	£600
FLUKE 8300 DMM AC/DC/OHMS	£195
BRADLEY 233 post generator	£250
PHILIPS PM 6505 television analyser	£100
MARCONI TF 144 H sig/gen	£195
MARCONI TF 868/1 LCR bridge	£85
MARCONI TF 1370/9 oscillator	£100
MARCONI TF 2162 attenuator	£85
MARCONI TF 2201 30 MHZ scope	£195
MARCONI TF 2169 pulse modulator	£195
HP 3200 B VHF oscillator	£195
HP 211A square wave gen	£75
HP 400H voltmeter	£75
HP 140 A mainframe	£175
HP 1416 A swept freq ind	£300
HP 8694 A 8-12.4 GHZ sweeper plug in	£400
HP 8694 B 7-12.4 GHZ sweeper plug in	£400
HP 8693 A 3.7-8.8 GHZ sweeper plug in	£400
HP 1403 vertical plug in	£75
HP 1420 horizontal plug in	£75
SINTEL Capacitance bridge	£150
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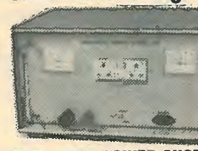

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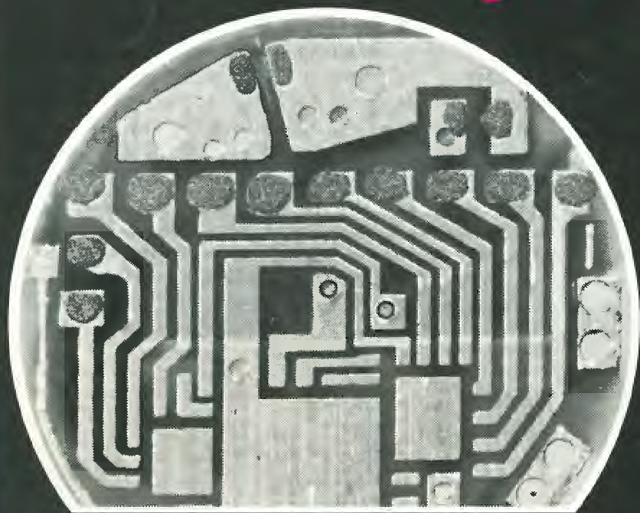
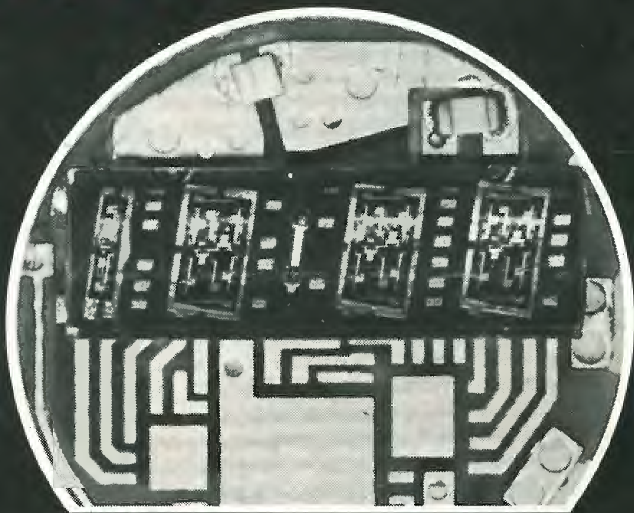
To see how Multicore Oxide-Free Solder Creams offer you higher profits – just watch





Applications don't come much more critical than digital watch manufacture.
Here, discrete deposits of Multicore Oxide-Free Solder Cream are screened onto the PCB. A precision job, with no risk of operator error or fatigue. And, a convenient temporary adhesive for the positioning of components.

Solder-flow is accomplished by simply passing the units over a hot plate.
Fast. No oxide to contend with. No dirty residues.
This manufacturer says Multicore Oxide-Free Solder Cream has *reduced reject rate substantially* and offers superior soldering quality.

ordinary solder creams cannot match this profitable performance. Here's why...

...because ordinary solder creams or pastes contain rosin-based flux mixed with solder powder produced by atomisation. This means that every particle of the powder is covered with a layer of oxide – slowing down the soldering process, leaving a dirty flux residue and causing solder globules to stick to the flux and possibly fall loose into the equipment after shock or vibration. But, Multicore have developed a very special method of producing solder powders that are virtually oxide-free.

These can be used in cream form – comprising an homogeneous stable mixture of pre-alloyed powder and flux, designed specifically for hybrid microcircuits, PCB's and critical component joints.

When heated, Multicore Oxide-Free Solder Creams melt and flow as quickly and cleanly as rosin-cored solder wire, leaving a pale clear flux residue without solder globules.

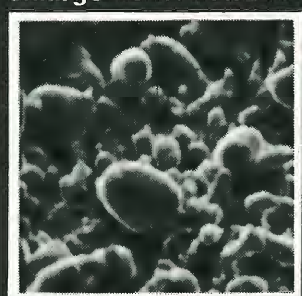
The in-built quality of Multicore Oxide-Free Solder Creams make them the ideal specification for almost any application calling for low cost yet high reliability.

They are available in a wide range of combinations of solder alloys, fluxes, particle sizes, flux contents and viscosities – often replacing solder preforms.

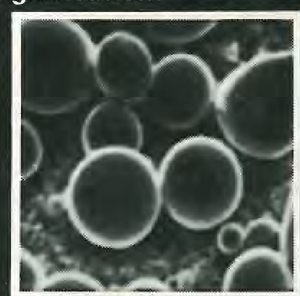
However, if you have an application that specifically requires preforms, remember that Multicore supply a wide variety of those as well.

Multicore Solders Ltd are Ministry of Defence Registered Contractors and on Qualified Products List QQ-S-571E of U.S. Defense Supply Agency for solder creams and preforms.

Compare these electron-microscope enlargements at x 240 magnification:



'Ordinary' cream solder powder, revealing poor particle shape and dross.



Solder powder from Multicore Oxide-Free Solder Cream displays clean, uniform particles.

Multicore

For full information on Oxide-Free Solder Creams or any other Multicore products, please write on your company's letterhead direct to:

Multicore Solders Limited,
Maylands Avenue, Hemel Hempstead, Herts. HP2 7EP.
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