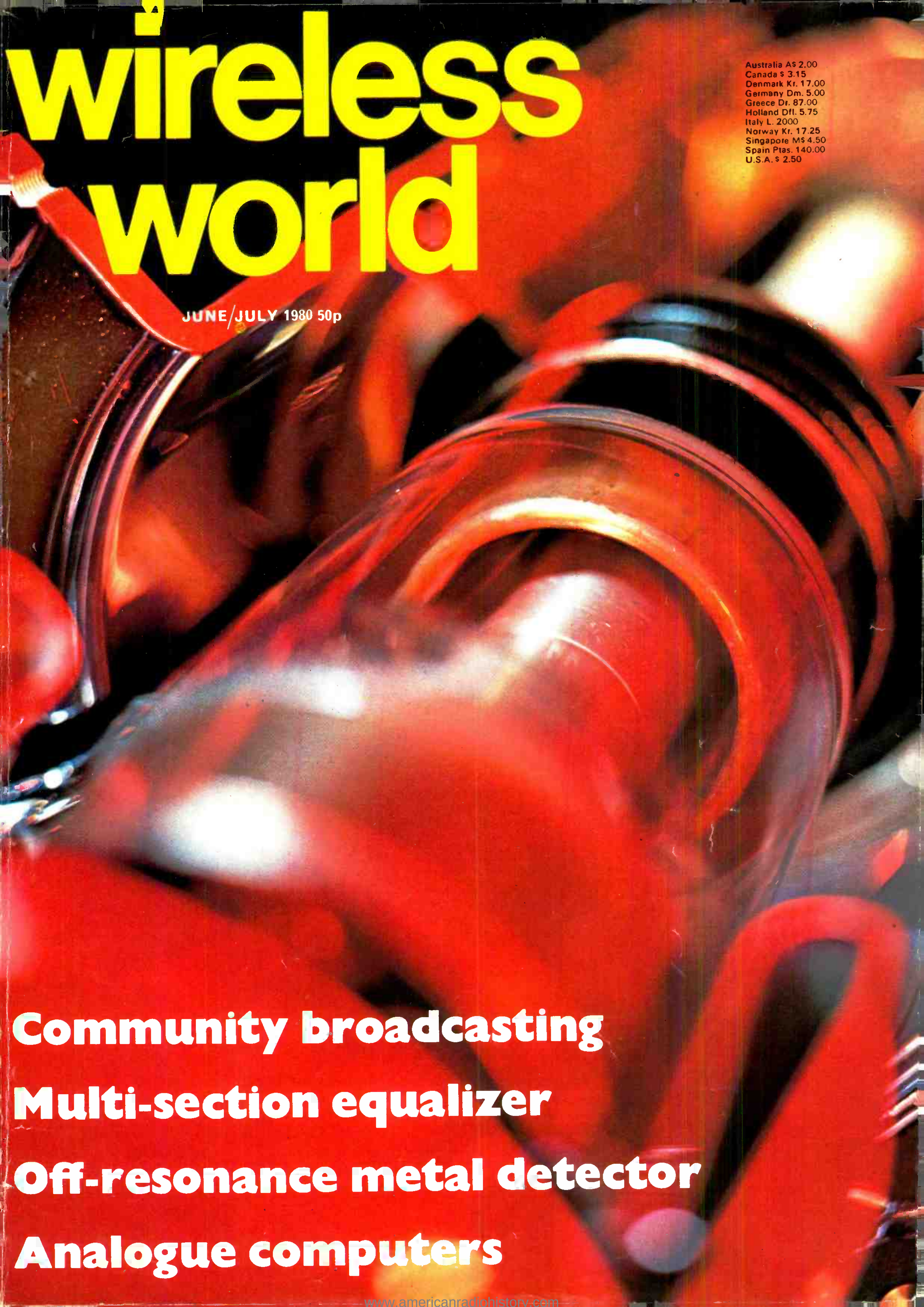

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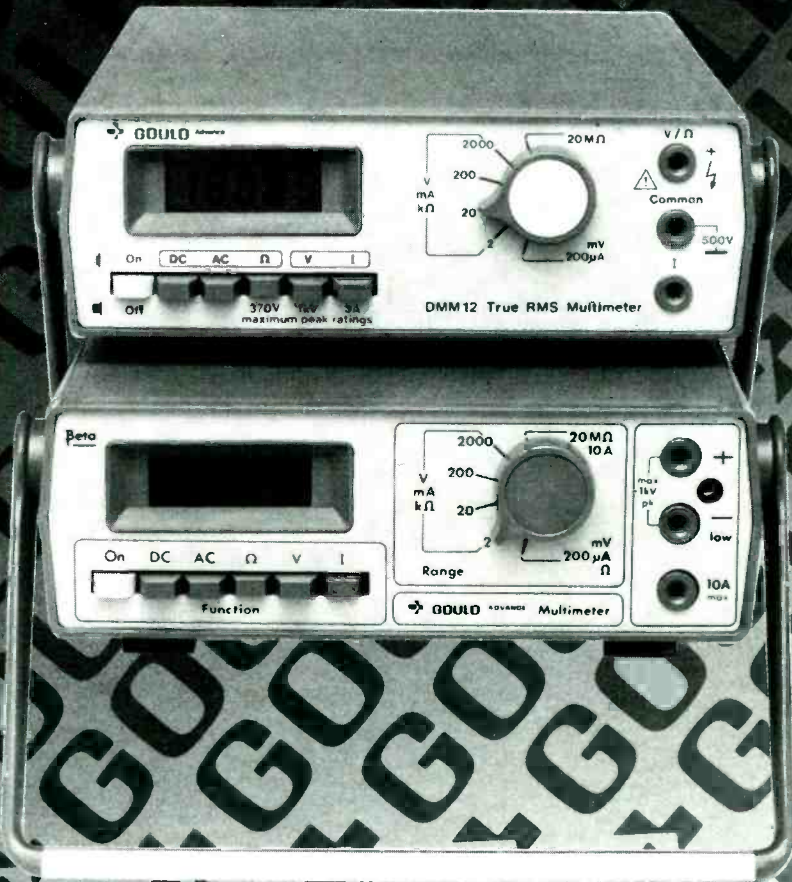

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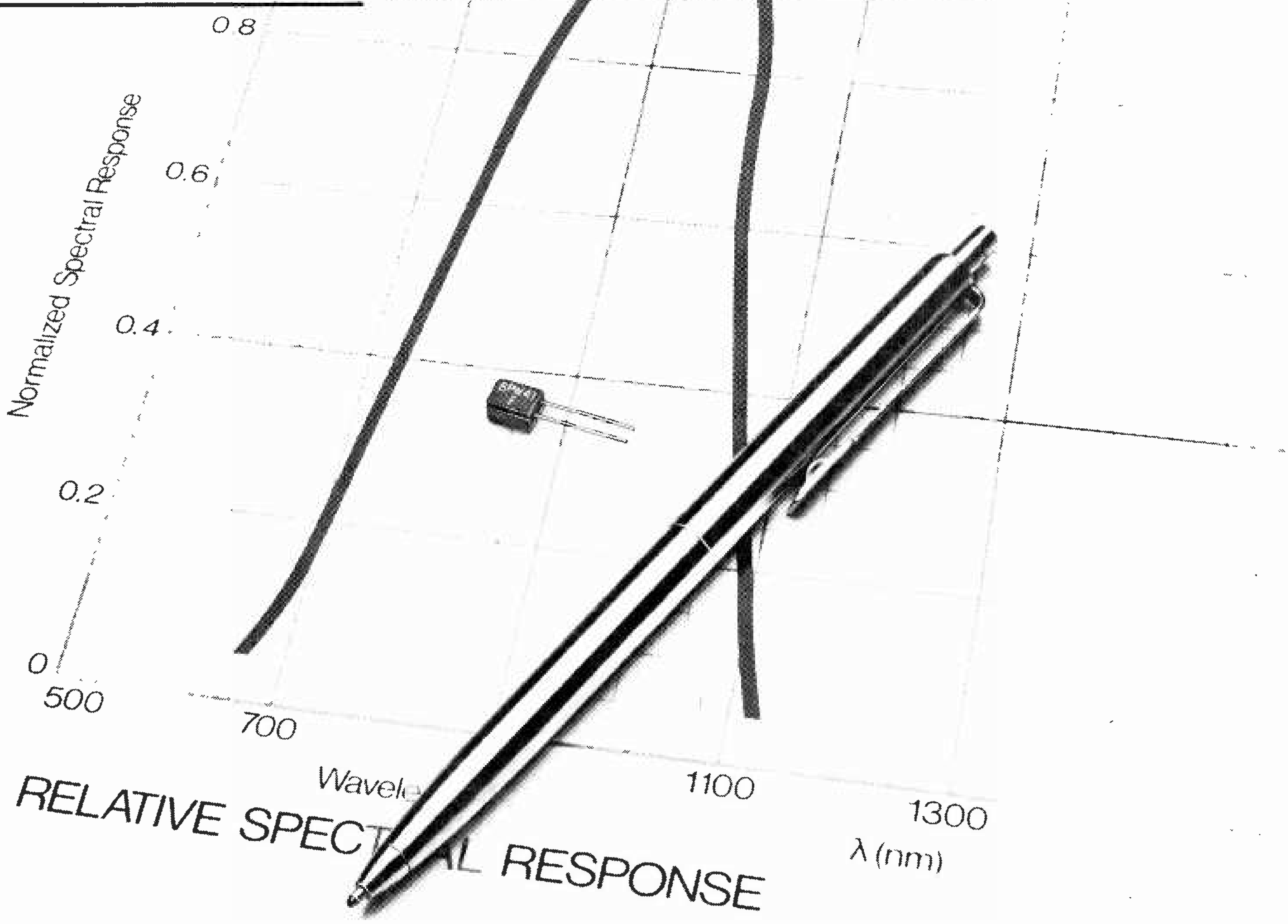
Remote control is seeing red. Infra red with Ferranti BPW 41.



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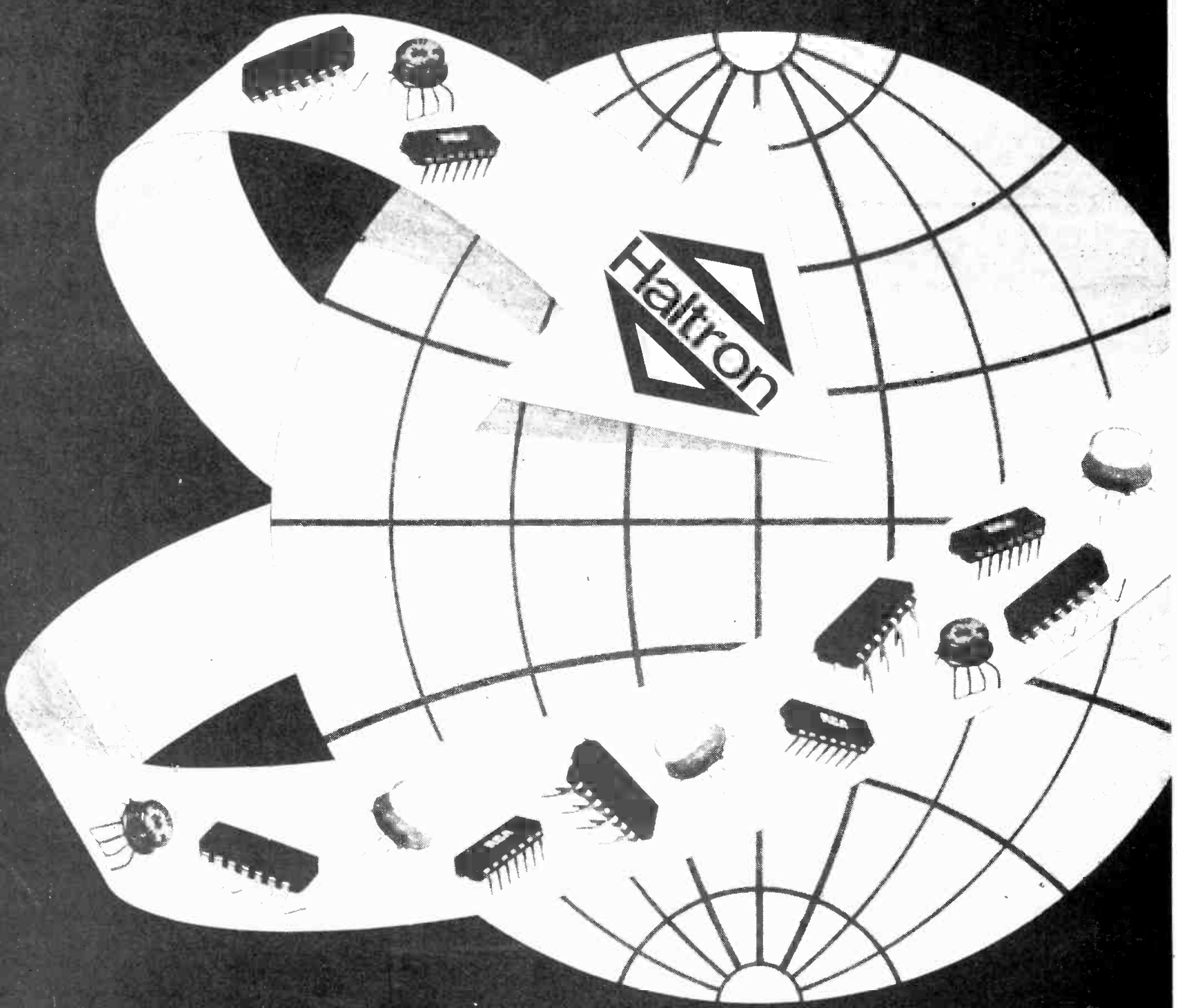

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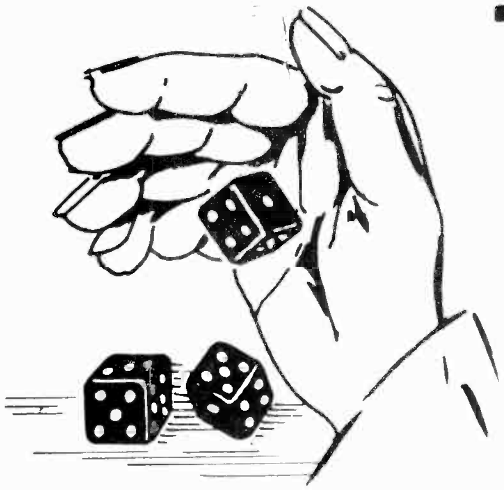

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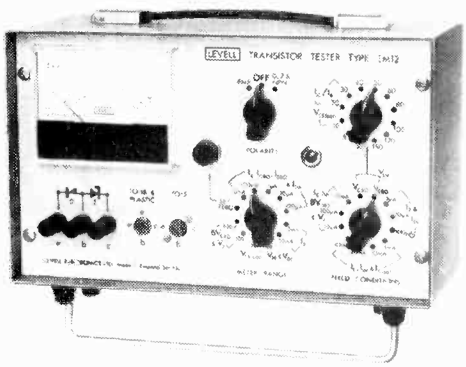

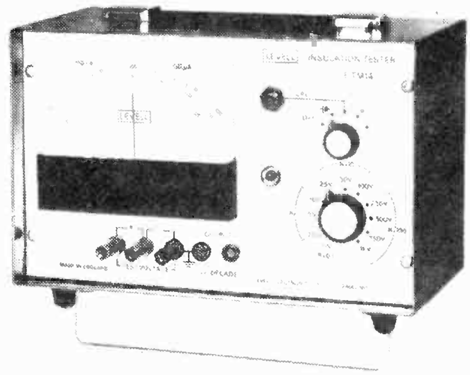

Tests bipolar transistors, diodes and zener diodes. Measures leakage down to 0.5 nA at 2V to 150V. Current gains are checked from 1µA to 100mA. Breakdown voltages up to 100V are measured at 10µA, 100µA and 1mA. Collector to emitter saturation voltage is measured at 1mA, 10mA, 30mA and 100mA for I_C/I_B ratios of 10, 20, 30. The instrument is powered by a 9V battery.

TRANSISTOR RANGES (PNP OR NPN)

I_{CBO} & I_{EBO}: 10nA, 100nA, 1µA, 10µA and 100µA f.s.d. acc. ±2% f.s.d. ±1% at voltages of 2V, 5V, 10V, 20V, 30V, 40V, 50V, 60V, 80V, 100V, 120V, and 150V acc. ±3% ±100mV up to 10µA with fall at 100µA < 5%+250mV.

BV_{CBO}: 10V or 100V f.s.d. acc ±2% f.s.d. ±1% at currents of 10µA, 100µA and 1mA ±20%.

I_B: 10nA, 100nA, 1µA ... 10mA f.s.d. acc. ±2% f.s.d. ±1% at fixed I_E of 1µA, 10µA, 100µA, 1mA, 10mA, 30mA, and 100mA acc. ±1%.

h_{FE}: 3 inverse scales of 2000 to 100, 400 to 30 and 100 to 10 convert I_B into h_{FE} readings.

V_{BE}: 1V f.s.d. acc. ±20mV measured at conditions on h_{FE} test.

$V_{CE(sat)}$: 1V f.s.d. acc. ±20mV at collector currents of 1mA, 10mA, 30mA and 100mA with I_C/I_B selected at 10, 20 or 30 acc. ±20%.

DIODE & ZENER DIODE RANGES

I_{DR}: As I_{EBO} transistor ranges.

V_Z: Breakdown ranges as BV_{CBO} for transistors.

V_{DF}: 1V f.s.d. acc. ±20mV at I_{DF} of 1µA, 10µA, 100µA, 1mA, 10mA, 30mA and 100mA.

type TM12 **£160**

A logarithmic scale covering 6 decades is used to display either insulation resistance or leakage current at a fixed stabilised test voltage. The current available is limited to a maximum value of 3mA for safety and capacitors are automatically discharged when the instrument is switched off or to the CAL condition. The instrument operates from a 9V internal battery.

RESISTANCE RANGES

10M Ω to 10T Ω (10^{13} Ω) at 250V, 500V, 750V and 1kV.
1M Ω to 1T Ω at 25V, 50V and 100V.
100k Ω to 100G Ω at 2.5V, 5V and 10V.
10k Ω to 10G Ω at 1V.
Accuracy ±15% +800 Ω on 6 decade logarithmic scale.
Accuracy of test voltages ±3% ±50mV at scale centre.
Fall of test voltages < 2% at 10µA and < 20% at 100µA.
Short circuit current between 500µA and 3mA.

CURRENT RANGE

100pA to 100µA on 6 decade logarithmic scale.
Accuracy of current measurement ±15% of indicated value.
Input voltage drop is approximately 20mV at 100pA, 200mV at 100nA and 400mV at 100µA.
Maximum safe continuous overload is 50mA.

MEASUREMENT TIME

< 3s for resistance on all ranges relative to CAL position.
< 10s for resistance of 10G Ω across 1µF on 50V to 500V.
Discharge time to 1% is 0.1s per µF on CAL position.

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1V per decade ±2% with zero output at scale centre.
Maximum output ±3V. Output resistance 1k Ω.

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7412	18p
7513	28p
7420	16p
7430	18p
7432	25p
7440	16p
7442	68p
7448	75p
7473	32p
7474	32p
7475	40p
7476	40p
7490	35p
7492	50p
7493	50p
7496	45p
74121	35p
74123	45p
74154	90p
74157	55p
74122	45p
74125	50p
74195	100p
74196	100p
74283	140p
74290	120p
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74LS12	30p
74LS14	60p
74LS15	38p
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74LS30	19p
74LS32	25p
74LS40	26p
74LS42	56p
74LS47	78p
74LS48	85p
74LS49	99p
74LS73	30p
74LS74	30p
74LS75	39p
74LS86	39p
74LS90	40p
74LS107	40p
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74LS155	65p
74LS161	78p
74LS163	90p
74LS164	90p
74LS168	190p
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74LS175	99p
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4016	35p
4017	75p
4018	76p
4019	42p
4020	88p
4021	100p
4022	88p
4023	22p
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4025	20p
4026	130p
4027	45p
4028	75p
4029	80p
4030	50p
4031	195p
4033	145p
4035	104p
4036	290p
4037	105p
4038	110p
4039	290p
4040	99p
4041	75p
4042	73p
4043	86p
4044	88p
4045	160p
4047	99p
4048	56p
4049	38p
4050	40p
4051	69p
4052	75p
4053	73p
4054	111p
4055	121p
4056	121p
4059	560p
4060	112p
4063	112p
4066	56p
4067	422p
4068	19p
4069	19p
4070	28p
4071	25p
4072	25p
4073	25p
4075	20p
4076	88p
4077	23p
4078	29p
4081	23p
4082	25p
4085	86p
4086	68p
4089	130p
4093	68p
4094	225p
4095	99p
4096	325p
4098	110p
4099	180p
4501	25p
4502	112p
4503	68p
4507	52p
4508	288p
4510	76p
4511	125p
4512	75p
4514	250p
4515	290p
4516	109p
4518	99p
4520	99p
4521	230p
4526	105p
4527	130p
4528	99p
4529	140p
4531	150p
4532	125p
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4543	160p
4556	70p
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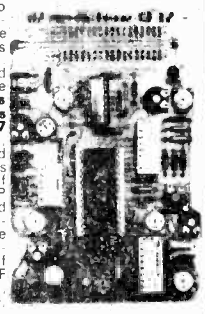
SE 01 Sound Effects Kit NEW



The SE-01 is a complete kit that contains all the parts to build a programmable sound effects generator. Designed around the new Texas Instruments SN76477 Sound Chip, the board provides banks of MINI DIP switches and pots to program the various combinations of the SLF Oscillator, VCO, Noise, One Shot and Envelope Controls. A Quad Op Amp IC is used to implement an Adjustable Pulse Generator, Level Comparator and Multiplex Oscillator for even more versatility. The 3¼" x 3" PC Board features a prototype area to allow for user added circuitry. Easily programmed to duplicate **Explosion, Phaser Guns, Steam Trains,** or almost an infinite number of **other sounds**. The unit has a multiple of applications. The low price includes all parts, assembly manual, programming charts and detailed 76477 chip specifications. It runs on a 9V battery (not included). On board 100MW amp will drive a small speaker directly or the unit can be connected to your stereo with incredible results! (Speaker not included.)

COMPLETE KIT ONLY £14.99 P&P 67p + VAT

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- SPST push button control
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- Rugged plastic case

JVC-40 .... £4.95 each

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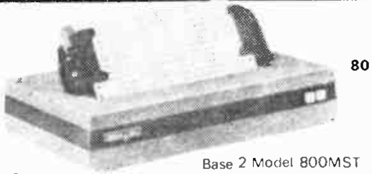

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The AY3-8910 is a 40 pin LSI chip with three oscillators, three amplitude controls, programmable noise generator, three mixers, an envelope generator and three D/A converters that are controlled by 8 BIT WORDS. No external pots or caps required. This chip hooked to an 8 bit microprocessor chip or Buss (8080, Z80, 6800 etc.) can be software controlled to produce almost any sound. It will play three note chords, make bangs, whistles, sirens, gunshots, explosions, bleets, whines, or grunts. In addition, it has provisions to control its own memory chips with two IO ports. The chip requires +5V @ 75ma and a standard TTL clock oscillator. A truly incredible circuit. Only **£8.25**.

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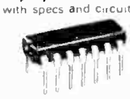

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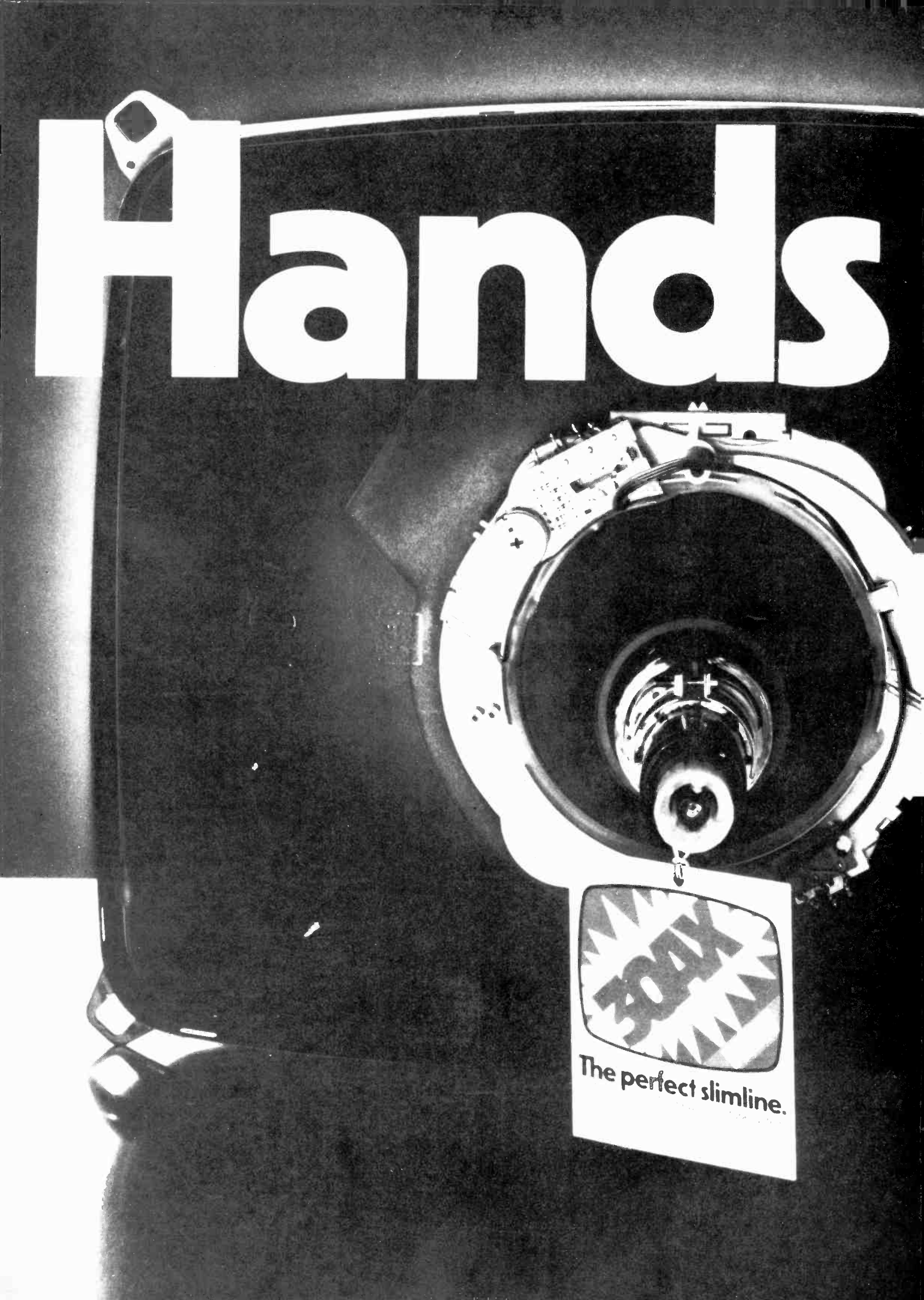
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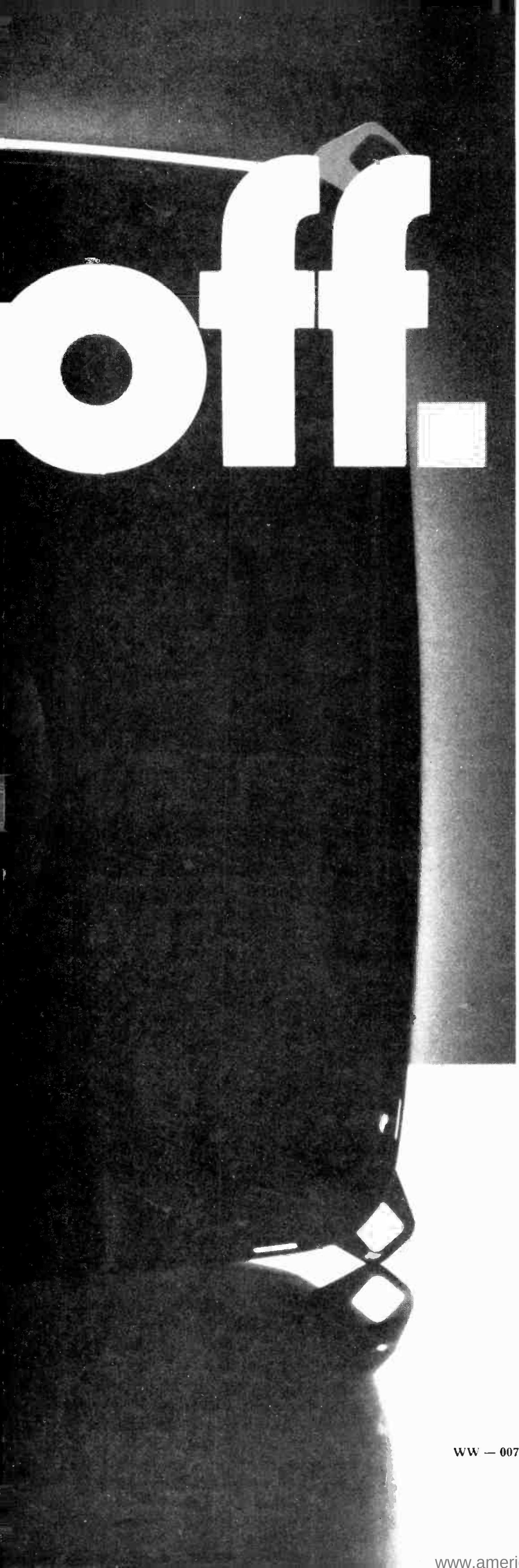
The perfect slimline.



We mean it.

The new 30AX colour tube system from Mullard doesn't need innumerable twists and turns of a screwdriver to set it up.

It needs no adjustments at all. Because every one has been 'designed out'.

Every tube that leaves our factory is completely pre-adjusted by us. Leaving only the turn of one screw to affix or remove the coil.

No dynamic convergence adjustments.

No colour purity adjustments.

And no raster orientation adjustment.

As for what it has to offer, the 30AX's focus is sharper and its definition greatly improved.

Its in-line guns and specially built coil provide the best picture shape yet.

And rest assured it'll stay that way. In a slim 110° package that trims about 3" off conventional 22" 90° TV cabinet depths.

Some features of the 30AX however, are a little more established.

Like its excellent colour registration. High brightness. Soft flash protection. Fast warm-up. And of course, greater overall reliability. This is the new 30AX colour tube system.

For more information just write your name and address on this page and send it to Dept. MCG2, Mullard Ltd., Mullard House, Torrington Place, London WC1E 7HD.

Mullard

30AX. The perfect slimline.

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Input advertisements are designed to meet the needs of our professional customers. They are a shop window for Philips Test and Measuring Instruments - and we will be changing the display frequently because we have a lot of products to show you.
Where you require full information about a product, tick the coupon and attach it to your name and address or letterhead - or, of course, use the journal's reader inquiry service. You will receive in return a detailed information pack reflecting your specific requirements.

The PM 2517 has set the standard and the pace in Europe for hand-held digital multimeters - and still it remains in a class of its own.

Remember, its many important features include full four digits, so on mains voltage readings, for example, you might get *240.3* instead of the *240*, which a 3½ digit meter would read.

Some other **PM 2517** plus points:
- LED or LCD display
- True RMS readings of AC voltage and current
- Autoranging with manual override
- Optional accessories include temperature and data hold probes

Reader inquiry number 220

NO WAITING FOR THESE TOP PRODUCTS

The PM 3207 - Super Scope - is a tough, general purpose oscilloscope which offers at a low price the quality and technology you expect from Philips Test and Measuring Instruments.
- 15 MHz dual trace
- Auto triggering from either channel with adjustable level between peaks and TV triggering
- 5 mV sensitivity, Y and X (via A input)
- B invert facility

Reader inquiry number 221

GREAT COUNTERS MYSTERY

Philips engineers have encountered the same reaction from customers and competitors alike when showing off the new microcomputer controlled **PM 6667** (120 MHz) and **PM 6668** (1GHz) frequency counters: "How do they do it for the price?". Here's a brief summary of what the counters offer.
- Reciprocal frequency counting (for higher resolution without ± 1 cycle error)
- Auto-triggering on all waveforms
- High contrast liquid crystal display
- Self diagnostic routine
- High stability TCXD: 10^{-7}/month
- Battery option

Reader inquiry number 222

Both these instruments are available off the shelf from the **Philips Electronic Instruments Department** (see address below) or from the following distributors **British Tungsram,** West Road, Tottenham, London N17 0RN Tel 01-808-4884 **Philips Service Centres** (25 throughout the country) Tel. 01-686-0505 for the address of your nearest branch **Wessex Electronics Ltd,** 114 116 North Street, Downend, Bristol BS16 5SE. Tel (0272) 571404.

	inquiry no	
PM 2517 multimeter	220	☐
PM 3207 oscilloscope	221	☐
PM 6667/8 counter	222	☐

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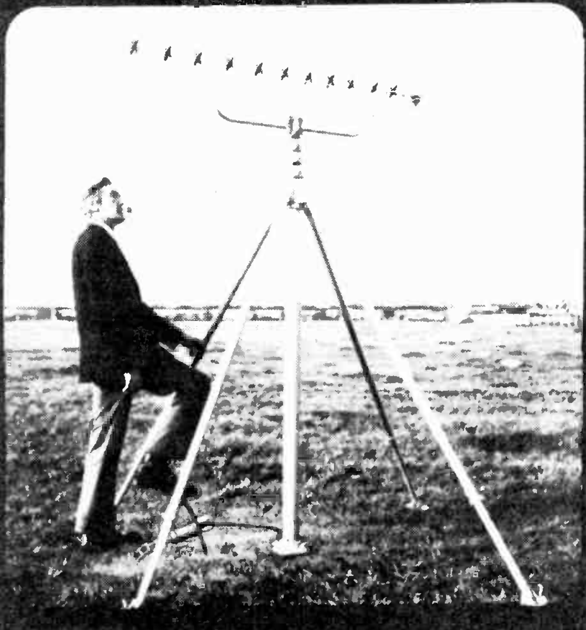

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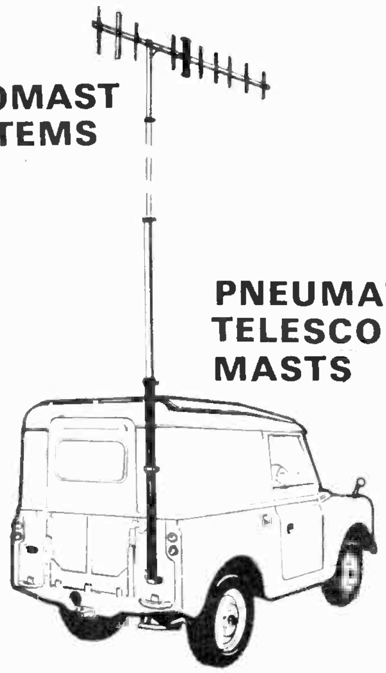

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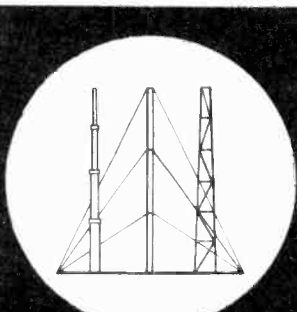

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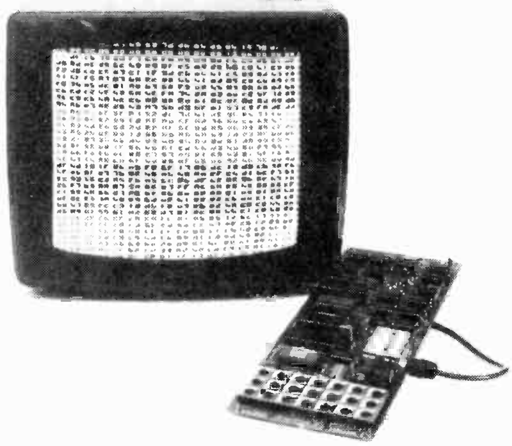
SOFTY Software Development System

EX-STOCK



MICROSYSTEM DEVELOPMENT USING SOFTY

SOFTY is intended for the development of programs which will eventually become software residing in ROM and forming part of a microsystem. During the development stage of a microsystem, SOFTY will be connected in place of the firmware ROM via a ribbon cable, terminated in a 24 pin DIL plug.
Data may be entered into the SOFTY RAM via the **serial port, parallel port, direct memory access, or the keypad,** and manipulated using the **assembler key-functions.** When the program has been entered, the internal microprocessor can be 'turned off', and the external microsystem and its resident microprocessor allowed to access and run the program in SOFTY's RAM and/or programming socket. In this way modification can be made until the required program is complete — **the contents of the RAM being clearly visible as a 'page' on TV or monitor.** 4 pages are available, 2 of the Data RAM an 2 of the programming socket.
In the end, when the program is complete and working, the DIL plug is removed and replaced by an EPROM device programmed by SOFTY. **SOFTY is able to program the 2704/2708/2716 family** which have 3 voltage rails — we supply with each SOFTY details of a simple modification which allows SOFTY to program the single rail 2716/2732, etc.
(If you want to program EPROMs/PROMs other than the 2704/2708/2716 family, we may be able to help you — our range of add-on Programming Modules is currently under development.)
To help in the process of program development SOFTY has various assembler key-functions, which include — **block shift without overwriting, block store, cursor control, match byte and displacement calculations (for jumps, etc.) A high speed cassette interface** is also provided for storing working programs and useful subroutines. Software is supplied for serial data transfers — which means that you can write an assembler for your favourite MPU in BASIC on your Superboard, UK101, NASCOM, etc. and transfer the hex code directly to EPROM via SOFTY. The serial transfer program runs in the scratchpad and can be easily loaded from cassette, or the programming socket. Besides software development and EPROM programming, SOFTY has other uses — as a **training aid,** or as a **control computer** in its own right, with up to **2K bytes firmware, 1K of RAM, 22 I/O ports and Direct Memory Access.**

SOFTY Kit-of-parts (including zero insertion force socket for EPROM programmer). Price £115 (inc. VAT, P&P). **SOFTY** Built and tested — £138 (inc. VAT, P&P).
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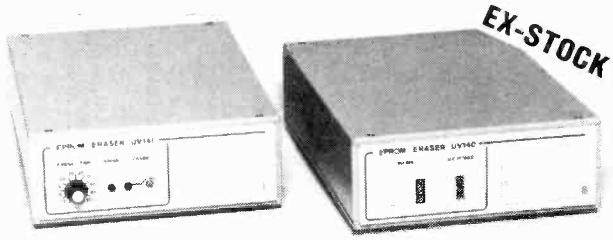

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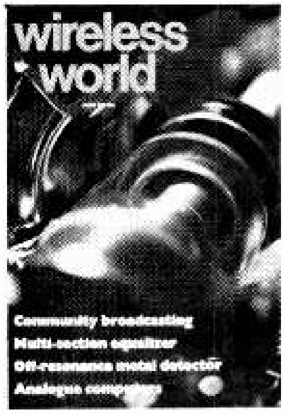

Front cover shows interior of an English Electric Valve Co. magnetron (cutaway model) for use in radar systems. Photographer: Paul Brierley.

wireless world

ELECTRONICS/TELEVISION/RADIO/AUDIO

JUNE/JULY 1980 Vol 86 No 1534

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Graphical communication with computers **introduces the technology of interactive computer graphics and describes input and output methods for information in this form.**

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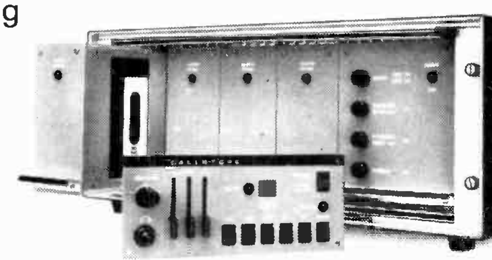

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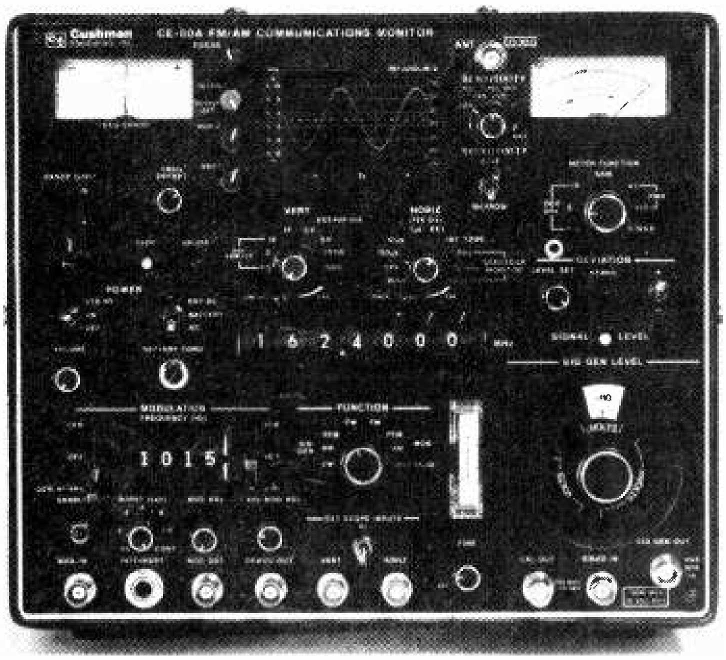

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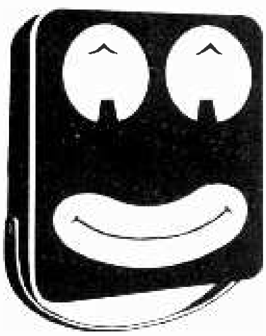

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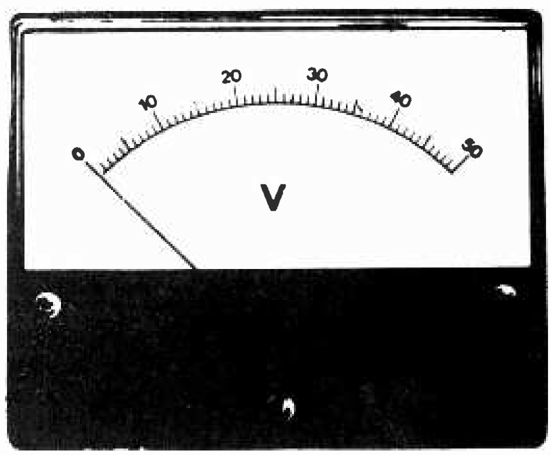

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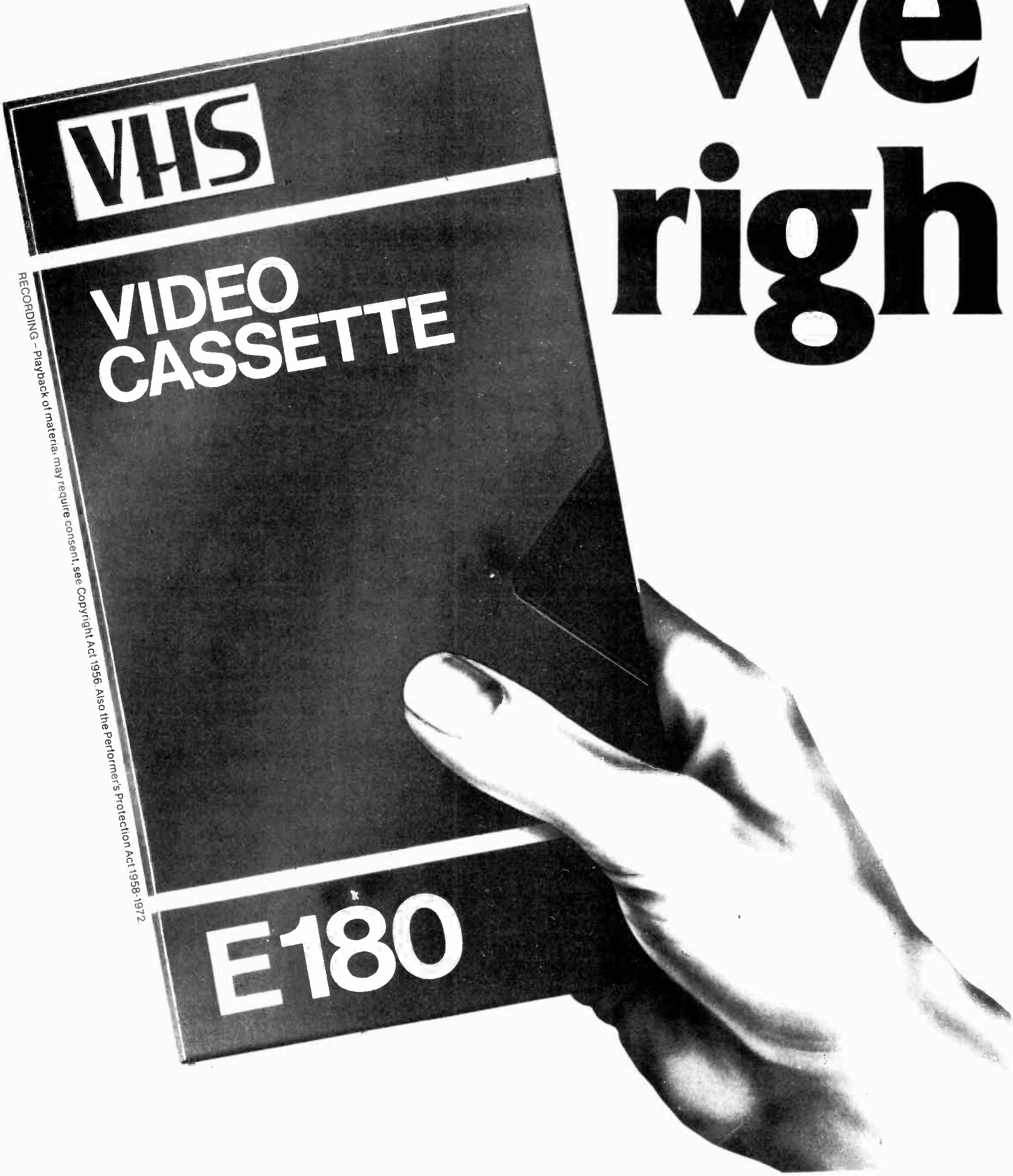

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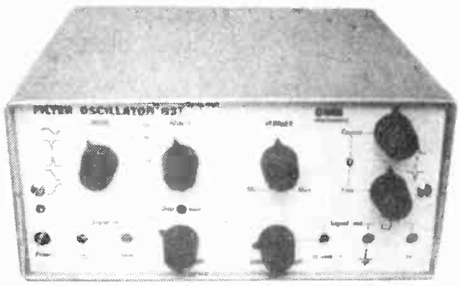

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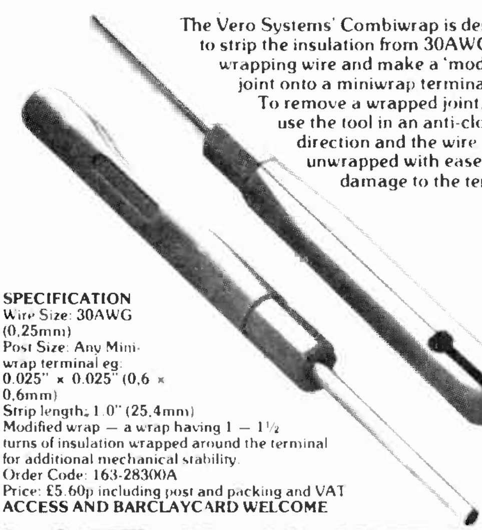

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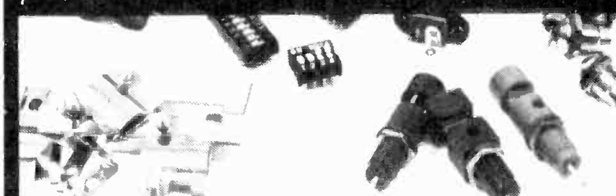

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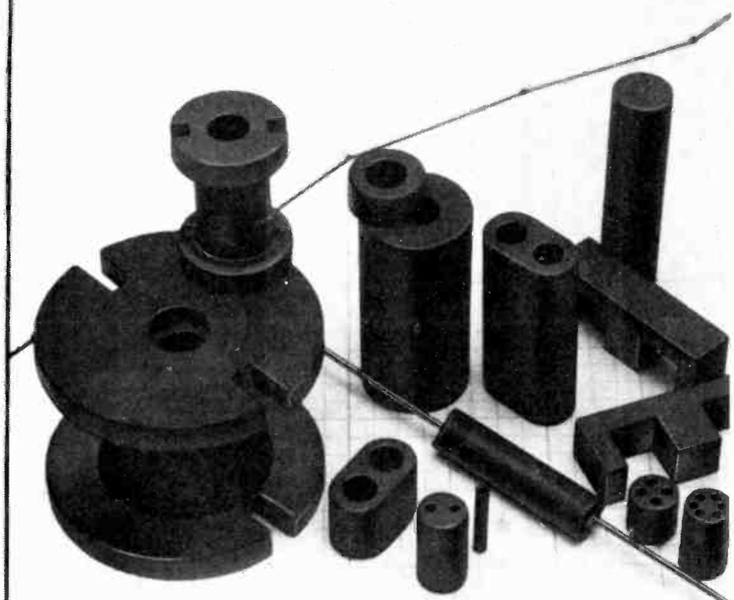

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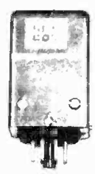

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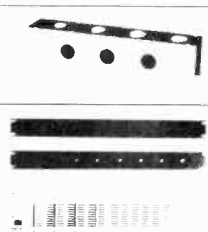

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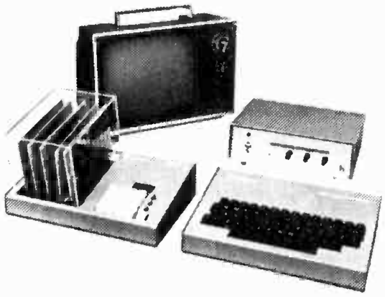

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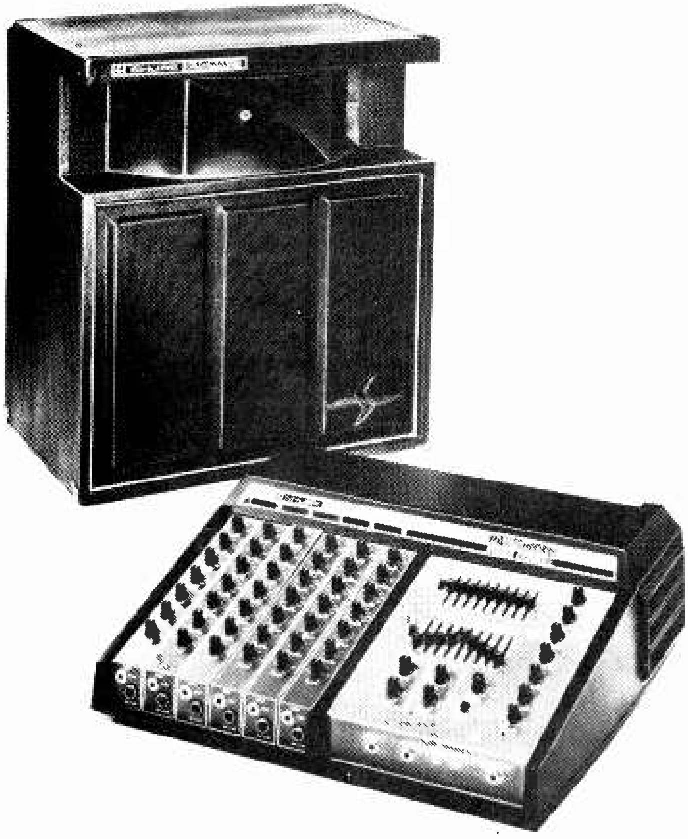

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Producers before products

It may be a coincidence that markets for office automation equipment and military electronics equipment are both growing at nearly 30 percent per year. But both trades are obviously doing well in the business of helping to get rid of people — in their different arenas and different ways, of course.

Whenever one deplores the fact that parts of our industry are thriving on activities which are fundamentally hostile to life and its environment one gets the sweetly reasonable answer that such expansion is increasing our prosperity, providing more jobs (in different kinds of work), improving the country's balance of payments and so on. And indeed it is this rise in the material standard of living which anaesthetizes us to accept the extraordinary contradictions of our industrialized society, to live docilely with what an observer from another planet might well consider insane. Planned obsolescence means that the ultimate purpose of production is waste. Peacefully we manufacture equipment for warfare; skilfully we design machines to abolish skill; high intellects are turned to the creation of trash; and great bodies of technical knowledge, built up over centuries, to bringing forth mere ephemera. We develop products to satisfy demands which don't yet exist, and sell these products to rich minorities in the midst of the poverty-stricken majority. Workers suffer intense boredom to produce goods the images of which are used to excite and stimulate other workers. Worst of all, in pursuing endless consumption we behave as if we did not know that the Earth's minerals and sources of energy cannot be renewed. One doesn't have to look far in electronics and communications to see examples of all these processes.

Some psychiatrists think that unavoidable contradictions in society (called "double-binds") are what lead to mental breakdown. Nevertheless our leaders treat them as inevitable, to be endured as the price we have to pay for what is called progress. Lord Zuckerman, for example, well known as a scientific adviser to the UK government, assured us last year in a lecture entitled "Look forward to the electronic future" that we must accept the fact that "the Garden of Eden has already been ploughed up".

For Lord Zuckerman and his contemporaries it probably doesn't matter too much. But thankfully there are some young people who do very much care about the world we are making for ourselves. They have decided they do not see life entirely in terms of manufacturing and acquiring products but that it is equally important to become fully awake, to widen and deepen one's experience and try to find more humane ways of living without the aggression and ambition which a competitive system encourages. In our own field of electronics, this optimistic aim formulates itself in the question of why a powerful technology such as this cannot be used *directly* for the benefit of human beings, instead of through the absurdly indirect process of first turning it into products of sometimes dubious utility and thence into money from which incomes and taxation are used to pay for the things and services we really need. Naive? Certainly, in the light of the conventional wisdom. Electronics as used in medicine, agriculture, education, the arts and all life-sustaining application is still entirely dependent on large-scale, high-technology, competitive industry for its basic components. But we shouldn't be confused into thinking that because the present industrial system is the reality of the world it is therefore rational. We must leave our minds open to the possibility of an alternative way, a rational way in which the producers are put before the products.

Community radio

A case for more accessible local radio broadcasting

by Norman McLeod

The effectiveness of radio broadcasting in satisfying the needs of small communities is examined. A case is made for smaller, more directly concerned stations, using either medium-wave or v.h.f. transmitters and costing less to install and run than existing local broadcasting stations which, the author feels, do not concern themselves with local interests. He makes a plea for more experimentation with a view to providing impetus and evidence for a public debate on the whole subject of UK radio broadcasting.

The community radio lobby in the UK wants to see the emergence of a "third force" in British broadcasting. This desire stems from a deep-seated discontent with radio broadcasting controlled by the BBC and the IBA, and can be seen as part of a general longing for more homely and decentralized forms of communication. Existing community activity, such as the production of small-scale and largely non-profit-making newspapers, has sprung up mostly in cities and larger towns, where many people feel more lonely and isolated than in rural areas.

It has occurred to a number of people that radio could be used to promote community feeling, debate and culture much more effectively than any printed medium. Not only does it offer a unique immediacy, and the ability to reproduce music and drama, but as the cost of newsprint, printing and paper distribution has risen dramatically in the past decade, so the cost of modest broadcasting equipment has fallen by comparison. The Government, however, remains committed to the policy that "responsibility for broadcasting services should be vested only in public authorities appointed as trustees for the public interest",[1] and has yet to be convinced that the BBC and the IBA are not the best organizations to control all future sound radio broadcasting in the UK. Supporters of community radio feel, on the other hand, that to put the present broadcasting superpowers in charge of a community radio station is about as thoughtful and sensitive as having a village corner shop at the mercy of a multinational food conglomerate.

The present "local" broadcasting operations of the BBC and the IBA are seen as having very little to do with community radio proper; the BBC is too hamstrung by bureaucracy and careerism, and ILR is overly preoccupied with making money. Both forms of station are much too large and formal to allow ordinary people much more in the way of access to the airwaves than the now statutory 'phone-in. As the Danish pioneers[2] put it: "Community radio is first and foremost . . . public access to the medium of radio on as fair conditions as possible. The need to express an opinion often arises from a desire to influence the political, social or cultural situation in the local district ... one must build up community radio and a structure which makes it possible for the public to use it."

Apart from the lack of community involvement in decision-making, the present local services have been widely condemned for the great similarity between stations up and down the country. The BBC stations have a "divide and rule" attitude to community involvement. Local "experts" are permitted to enter BBC stations in order to prepare specialist programmes on fishing, motoring, folk music, student activity, etc., but the programmes are brief, pre-recorded, and go on air at very odd times, sometimes fortnightly or even less frequently. The success of this sort of programme relies on potential listeners scanning the "Radio Times" a week previously, to mark off those programmes which look interesting. Subsequently they are expected to remember to switch on their receivers at the appointed time and listen carefully. In practice this simply does not happen. Most people are too busy with other things to plan their listening so religiously, and most community programmes are heard either by the few who listen almost continuously to the station every day, or by the odd soul who discovers one by accident rather than design. As a result, much of BBC local radio's "community" output has an audience so small as to be derisory.

The IBA's community record is even worse. Practically all commercial radio stations can be geared to play exactly the same pop records and commercials, interspersed by bland mid-Atlantic voices, up and down the country. Local information and news are fed unobtrusively into the general stream of pop and prattle: individual access is limited to the 'phone-in, and minority programmes are safely relegated to off-peak hours, when the loss of advertising revenue can be minimized.

By contrast,the word which best sums up the ideal state of a community radio development is "diversity". Instead of being united by common factors inimical to the development of a distinctive character, community stations would be free to go their own ways, being managed by and answerable to the local people in the area which they serve, and to no-one else. The only justification for a central authority would be for the management of frequencies, and the representation of community radio interests at national level. Stations would use low-power transmitters connected to much less expensive studios and equipment than are in use at present, and the central authority may be able to assist with engineering advice, but would not be in the business of laying down rigid standards.

Current experiments

There are a few exceptions to the current rigid and unappealing framework of local sound radio broadcasting — in Cardiff, a community-based group applied for and got the franchise for the forthcoming ILR station due to open this year. Half the shares were offered at £1 each to financial investors, and the other half were sold for 3p to the Cardiff Broadcasting Trust. This trust guarantees listeners the opportunity of influencing the type of programmes which are broadcast.

Universities have been running their own radio stations since 1968. They are permitted to do so provided they transmit using an inductive loop radiating system which does not permit reception outside the university campus. The University stations are compelled by the Home Office to operate under much stricter technical conditions than any other form of broadcasting. For example, the Home Office technical specification[3] requires that the medium-frequency transmitters used by student stations have their audio input filtered to reduce frequencies of 4.5kHz or above by 34dB. There is no need to protect the non-UK channels adjacent to university transmissions in this manner from slight sideband splatter, since university stations cannot, by definition, be heard in the local town, far less abroad. The National Association of Student Broadcasters has protested, unsuccessfully, to the effect that all BBC and IBA transmitters currently in use would fail this particular requirement[4]. Since much of the output of the stations is music, the dull and lifeless sound quality produced by the sharp cut-off filter needed to meet the specification is far from welcome.

The Home Office has also shown itself to be extremely sensitive about the possibility of non-university residents hearing student transmissions, even to the point of insisting that public highways passing alongside university grounds must not receive an audible signal, presumably in case a motorist jut happens to tune to the right frequency while passing in a car! In fairness it ought to be said that the Home Office is far too preoccupied to pay much attention to a university station once it is on the air, that the engineers who visit are invariably courteous and helpful, and that provided a station does not acquire any local notoriety it is generally left alone. Nevertheless, many university station managers look wistfully across the Atlantic, where their counterparts are permitted to broadcast freely, on stereo u.h.f. transmitters, to the whole of the local town or city.

The other form of community broadcasting licensed directly by the Home Office takes place on closed-circuit cable systems, such as the one operated by Rediffusion in Basildon. Radio Basildon has been operating since September 1978 to 24,000 homes, and proudly claims 60,000 listeners a week. It raises most of its revenue through the sale of advertising, and employs two full-time staff — a manager/programme editor and a sales manager. The rest of the work involved in producing a full spectrum of daily broadcasts is carried out by three part-time workers and about 40 volunteers.

Radio Basildon is formed as a company limited by guarantee, with each member having a limited liability of £1, and no share capital. It is governed by a board of twelve persons, who may not be serving local politicians and must be approved by the Home Office. The Home Office requires that programmes must be specifically designed for the local community and have a small proportion of commercially recorded music. It requires advance logs of programme output, and that the station's broadcasts be recorded on tape and held for three months, in a similar manner to the logging requirements imposed by the IBA on their operating companies. So far, the impression is that the Home Office is well satisfied with the success of the experiment, and Radio Basildon's major complaint is that it is not allowed to broadcast to those parts of Basildon not covered by the cable system, or to people with portable radios in kitchens or cars. It has formed a "Transmitter Campaign Committee", which has collected thousands of signatures on a petition to the local Member of Parliament, and an all-party motion was passed at a Basildon District Council meeting, pressing for a radio transmitter for the station.

Radio Basildon serves a potential audience of around 90,000 people from a studio which cost £16,500 to set up and £28,000 to run per year. University stations serve between 1000 and 5000 students, and at today's prices would cost between £4,000 and £7,000 to set up and about half those figures for annual running costs, depending on the scope of activity. The new BBC local radio station at Lincoln will service half-a-million people for half-a-million pounds, and a figure of the same order annually.

Com-Com

The umbrella organization attempting to contain and reconcile the various parties is the Community Communications Group, known as Com-Com.[5] Com-Com supported the Annan committee's proposal for a Local Broadcasting Authority, which was put forward as a solution to the untidy growth of the present local broadcasting services. Annan recognized that "a different animal needs a different keeper", but the present government, like its predecessor, declined to implement this proposal, and does not appear to have any desire to break the hold on broadcasting maintained by the BBC, the IBA and the Home Office.

Many members of Com-Com sense a dark conspiracy amongst these three organizations to deny them their rights. On the other hand, officials privately denounce Com-Com as "a bureaucracy looking for a niche", while publicly explaining those technical facts which can be marshalled in support of the status quo. Com-Com has also suffered considerable internal agonizing over its structure, and has admitted that it has been less than influential in determining broadcasting policy in the UK.

Technical factors

Com-Com recently commissioned a report by the former IBA engineer Fred Wise on the possibility of v.h.f. spectrum use, in the existing band, by low-power stations in the London area. This takes an *ad hoc* approach to the problem, looking for gaps in the present v.h.f. broadcast band of 88.1 – 97.5 MHz, assuming that the present development of local and national services on these frequencies is complete and, for the time being at least, immutable.

London's principal v.h.f. services come from the BBC transmitter at Wrotham and the IBA site at Croydon, on 89.1, 91.3, 93.5, 94.9, 95.8 and 97.3MHz. There are also weaker network and local services appearing on various other frequencies. In essence, the Fred Wise report regards the bands ± 600kHz from the local high-power transmissions as sterilized for re-use, and then chooses those frequencies which are relatively 'quiet' among the remainder. Figure 1 shows that the channels which emerge for possible community use are 88.1/2, 90.2/3/4, 92.1, 92.5/6 and 96.4/5 MHz.

The report envisages three types of community station: Category A stations, being the smallest with a coverage area radius of 3 or 4km; Category B stations, medium-sized stations covering a sector of the city, and Category C stations, aimed at specialist interests and covering the whole city. The result of the frequency survey was that either one Category B station and "about a dozen" Category A stations would be practicable, or that the Category B station could be traded for two more Category A stations.

The great attraction of this scheme is that the frequencies proposed for community radio stations in London could never be used for anything else, and their use for this purpose would not be to the detriment of existing services. Unfortunately, interference in the reverse direction is accepted as likely: "... it should not be a condition that a community service should be developed only if good reception is possible in the whole of the target area for at least 95% of the time. The choice will frequently be not between a near-perfect coverage and a less good coverage, but between a less good coverage and no coverage at all. Thus planning should be approached in this light."

The Home Office takes a dim view of the prospect of very low-power community stations sharing channels used by high-power transmissions. The official line is that " ... a small low-powered station can have a significant effect on frequency planning, partly because it can cause interference over a

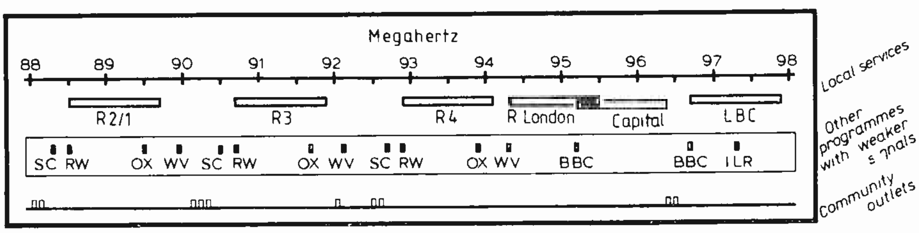


Fig. 1. The Wise plan for community stations on v.h.f. in London. Similar plans could be drawn up for all major cities, with similar or possibly more favourable conclusions, due to the smaller number of existing local services.

wider area than it is intended to serve, but principally because its presence inhibits the re-use of the same frequency over a wide area by more powerful stations serving larger communities, because they can cause unacceptable interference to the small station."[1] As far as it goes, this argument is perfectly sound. But it assumes that the community station will be established first, and the high-power services will come along later.

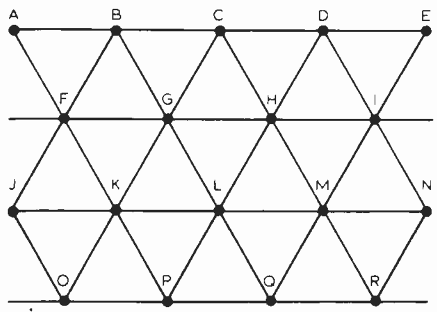
Medium frequency use

It is also worth looking at whether the medium-frequency broadcast band could similarly be exploited on an *ad hoc* basis for community broadcasting. In effect, this band is really two distinct animals: during the day, a number of channels have no discernible signals on them, while during the hours of darkness, every frequency has strong signals from European transmitters produced by sky-wave propagation. So a service planned for daytime use will have much more restricted coverage at night. This need be less of a handicap to community radio stations than it is for any other form of broadcasting, in that community stations are expected to be on the air for a few hours a day only, and most of them during daylight.

The current state of the medium-frequency band in London is such that there are a number of frequencies, well spaced from present services, which could be exploited under Article 8 of the Copenhagen convention. This states that a country may use a channel assigned to another for low-power transmissions, provided that no interference is caused to the foreign service. Since the power of the community transmitters is likely to be less than a hundred watts, compared to the hundreds of kilowatts used elsewhere, the amount of interference by ground or sky-wave caused to non-UK services by community stations is likely to be completely negligible.

Medium-frequency broadcasting of local services in the UK already makes use of a very large number of channels assigned in this manner; including low-power BBC network relays and university stations, the frequencies used are 603, 720, 756, 774, 801, 855, 945, 963, 990, 999, 1026, 1035, 1170, 1197, 1278, 1359, 1368, 1431, 1449, 1503 and 1521kHz. Not all these channels are occupied throughout the UK; some are used once only. As far as the prevention of foreign interference is concerned, it is of no consequence whether the 1 or 2kW of power radiated by the UK on these channels comes from one or two transmitters serving large communities, or from dozens of stations serving smaller ones.

Fig. 2. Idealized lattice structure made up of equilaterial triangles. In practice, the shape is distorted by geographical and environmental factors, but the diagram enables general conclusions to be drawn about the separation of stations and the service radius of each.



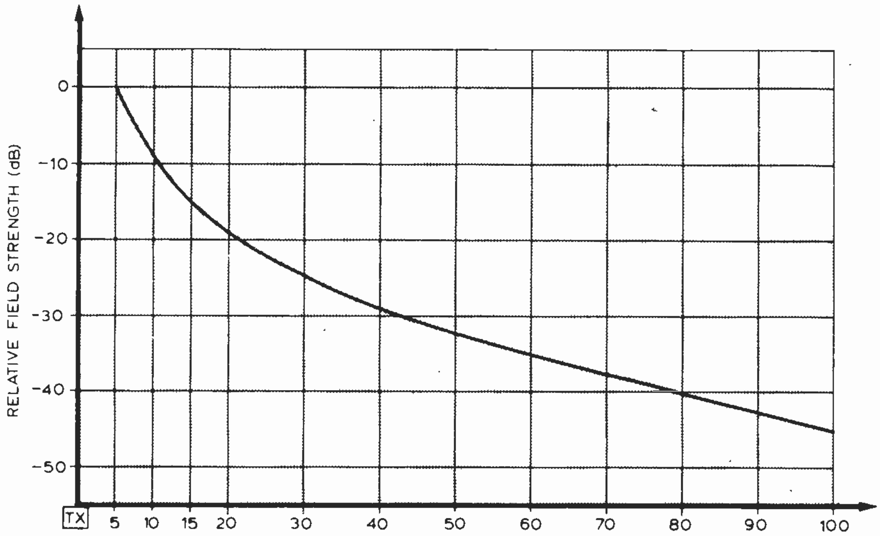


Fig. 3. Mean m.f. propagation curve, normalized at 5km from transmitter.

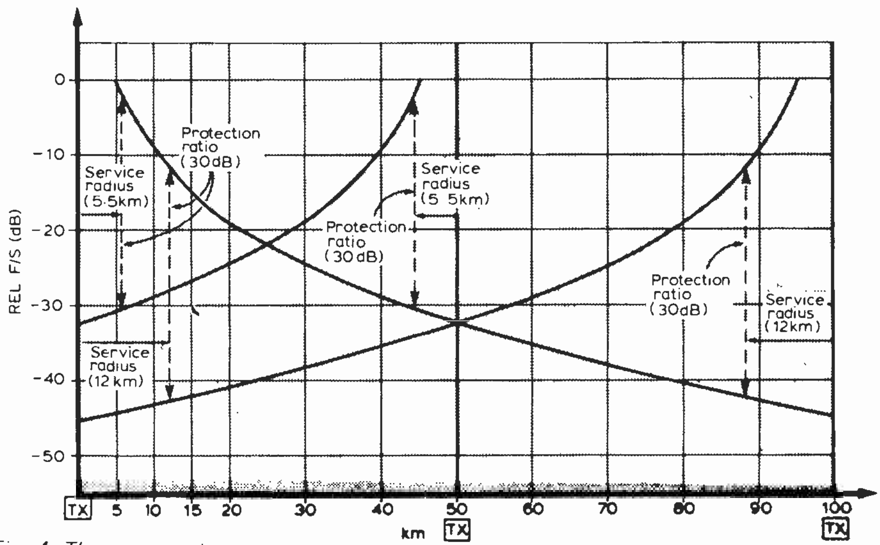


Fig. 4. Three transmitters, one as in Fig. 3, and two others, one 50km and the other 100km from the first.

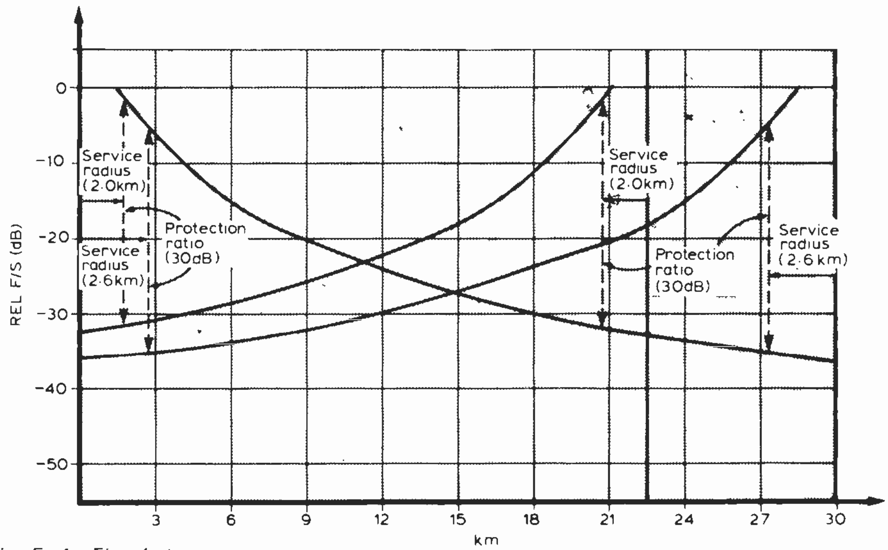


Fig. 5. As Fig. 4, but on a smaller scale. Basic curve is normalized for 1.5km.

The possibility emerges of building up a lattice structure, as shown in Fig. 2, across the UK on certain medium frequencies, for the use of community stations. Taking the average of five CCIR recommendations[6] for medium-frequency propagation at frequencies between 700 and 1500kHz and for ground conductivities between 1 and 30mS/m, produces the propagation curve shown in Fig. 3. Figs. 4 and 5 show how this curve may be applied to lattices of sides 22.5, 30, 50 and 100km, assuming that an inter-station protection ratio of 30dB is deemed the minimum necessary to provide an acceptable service.

For a service area boundary limit of 70dB/uV/m, which is the IBA planning norm, the effective monopole radiated power required by stations on 22.5, 30, 50 and 100km lattices would be approximately 500mW, 850mW, 5W and 45W for service radii of 2, 2.6, 5.5 and 12km respectively. In practice, the transmitter powers required would be a good deal higher due to aerial losses: even so, except for the last example, the transmitting equipment needed would not be particularly costly.

Studio standards

Both the BBC and the IBA insist on very high technical standards for the studio equipment used in local broadcasting: frequency response, noise, wow and flutter, sound insulation, acoustics and so on are rigidly specified.[7] Experience at hospital, university and other small-scale operations has shown that a much cheaper and less technically exacting studio can be constructed without regard for these strict requirements, which offers a performance to which no listeners have taken exception. It would appear that the technical standards insisted on for present-day professional broadcasting can be very substantially relaxed in the community radio context without giving rise to complaints from the general public. This would particularly be the case if amplitude-modulated, m.f. broadcasting were the norm for what the Fred Wise report describes as "category A" stations. However, even on v.h.f., the number of ordinary listeners who could tell the difference between a well-engineered £4,000 studio, and a professional outfit costing ten or even a hundred times as much is likely to be negligibly small.

This is not to say that the high performance standards insisted on by the BBC and the IBA are themselves unnecessary. Large-scale broadcasters are investing in equipment on behalf of a public who have in total invested far more in their receiving apparatus — no listener investing heavily on good-quality receiving apparatus should be let down by penny-pinching on the part of national and large-scale "local" broadcasters. However, the inherently low-cost nature of community operations will be destroyed, for co compensatory benefit, if the professional standards of technical excellence are insisted on as divine absolutes. In addition, audio technology is advancing so quickly that the performance of quite modestly-priced equipment of today is frequently superior to the professional standards of only a few years ago.

Conclusions

I believe that as many experiments in community broadcasting as are technically feasible should be allowed to take place with the minimum of delay, because the time is ripe for a public debate on the whole structure of radio broadcasting in this country, and this debate will be better-informed if a number of people have been able to experience and compare various forms of national, regional, local and community broadcasting, as a prelude to determining the best balance between these services in the years to come.

Technically, sound broadcasting in this country, although competently engineered, is in a mess. The v.h.f. band II is sadly neglected by the public, and rarely promoted by the broadcasters. It is ineffectually used by the BBC for an ugly hotch-potch of services on the national networks; the local radio stations, given the choice between f.m. and a.m., would choose the latter any day. Radio 2 is wastefully duplicated on literally dozens of unnecessary frequencies for long periods of time, while other services, or would-be services, are denied any frequencies at all.

It would be premature to say whether or not community radio is a good idea, because the idea has not been fully tried. But while the experiments are going on, consideration should also be given to the following questions. Is it not time that there was a clear general policy to encourage the use of v.h.f. by providing an attractive choice of programmes on that band? A.m. radio is better suited to speech than to music; it is likely to become increasingly unusable after dark; what, therefore, are the most appropriate services to use medium and low frequencies? What of the balance between large and small-scale operations — what do people want from these services? What is to become of the BBC: ill-funded it certainly is, but is it also crippled by its own sheer size and bureaucracy?

These questions have been considered by the Annan committee and similar bodies in the past. Governments of both parties, however, have shied away from major decisions about broadcasting and have frequently disregarded the recommendations of their own select committees. It is time to bring the future of sound radio broadcasting back under a spotlight in the public arena. □

References

1. Letter from Lord Belstead, Home Office, to Archie Hamilton, MP, 10 July 1979.
2. The first experiment with community radio in Denmark, Radio Svendborg, on the Danish island of Funen, took place from the 8th to the 14th October 1977. More information can be acquired from: Baandvaerkstedet, Jac. Dannefaerdsvej 15, DK 1973 Copenhagen V, Denmark.
3. Specifically the requirement is for "any sideband component displaced from the carrier by more than 4.5kHz (to be) attenuated below that of the carrier by more than 40dB". Since 100% modulation produces two sidebands each —6db relative to the carrier, the audio-frequency implications of this requirement are as stated.
4. See, for instance, IBA Technical Review No 5, p39, Fig. 5.
5. Com-Com's registered address is 8 Millfield Close, Farndon, Cheshire.
6. CCIR recommendation 368-2, XIIIth Plenary Assembly, Geneva, 1974. The curves used to obtain the mean value of Figs. 3-5 were 700kHz at 10^{-3} and 3×10^{-2}mS/m, 1MHz at 10^{-2}mS/m, and 1.5MHz at 10^{-3} and 3×10^{-2}mS/m. Frequency has a more important bearing on propogation than ground conductivity, in the UK at least.
7. The IBA Code of Practice for sound radio broadcasting is set out in the IBA Technical Review No 2. □

Expectations from community radio

John Thompson, the IBA's director of radio, warned recently of the danger of expecting too much from community radio as an instrument for dealing with social problems. Writing in *Independent Broadcasting* for April 1980, he said "I would raise some questions about the extent to which radio can claim to provide solutions to social or human problems. Radio can act as a channel between the social service agencies, the experts in social and human problems, and the general listening public. Local radio in particular can often mobilise the loyalty and affection of the audience to offer help or funds at times of emergency or with individual distress. Radio has stimulated much valuable aid and valid response, and long may it continue to do so. But hazards exist too, don't they? If the broadcasters stray too often or too heavily into the social field such worthy broadcasting can become unconvincing and tedious, rather quickly.

"Also radio stations have to be careful not to become confused in the public mind, especially among those listeners who are in personal trouble or difficulty, with the specialists whose job it is to try and provide first-hand social or specialist help. The utility of radio is mainly, isn't it, to act as a channel for information for referral? . . . . Some listeners can be very impressionable. Building up hopes of help and advice that probably cannot consistently be met by a radio channel on anything resembling a regular basis, any more than a popular disc jockey can become a real rather than a fantasy friend for his fans, is likely to be of dubious utility. Our radio services can, I suggest, continue during the next decade to offer much authentic help in social and human problems, possibly increasingly so, provided this aspect of radio's activity does not make exaggerated claims and cannot be accused of seeming to offer more than can be delivered in relation to that central triad of providing information, entertainment and education."

WORLD OF AMATEUR RADIO

Exposure to r.f.

Both amateurs and professionals have been watching with some anxiety the growing public controversy over the "safe level" of continuous exposure to non-ionizing radiation from communication, broadcast and radar transmitters, microwave ovens and high-voltage electricity cables. Although for many years the figure adopted in the UK, the USA and many other countries has been $10mW/cm^2$, based many years ago on a very conservative estimate of the known thermal effects of radiated r.f. energy, a number of countries, including the USSR, have for a long time put the level much lower, down to $0.01mW/cm^2$. This extremely low figure was apparently based on a number of experiments that suggested that exposure to non-ionizing radiation can result in biological effects of an athermal nature. Attempts over 20 years ago to repeat such experiments in the West failed to produce any really positive results; and since the alleged symptoms included headaches, inability to make decisions, general tension, sense of anxiety, lack of sex drive, etc., these were not easy to "measure" with any degree of accuracy.

Recently, as a result of the concern in the United States that the public was being "zapped" by microwaves, including the leakage from microwave ovens, a whole new series of experiments have been taking place. While full reports are still awaited, it would appear that this time biological effects are being observed in small mammals subjected to microwave radiation at power densities rather less than $10mW/cm^2$, at least in the sense that there appears to be some interference with body mechanisms regulating internal temperatures etc.

Experiments at the John B. Pierce Foundation, New Haven, Connecticut on squirrel-monkeys with 2.45GHz radiation at power densities of 6-8 mW/cm^2 are reported in "Electronics" as having proved positive, though of course this does not prove that there would be similar effects on humans, of very different physical size.

At the US Naval Medical Research Institute in Bethesda, Maryland it has been shown that radiation can greatly increase the stimulating effects on rats of dexadrine amphetamine with power densities down to about $1mW/cm^2$. This follows the discovery a year or two ago of unexplained behavioural effects when rats are given Librium while exposed to microwave radiation.

While this recent work in no way invalidates the belief that there is no danger to the public or to prudent operators from the levels of r.f. radiation at normal distances from amateur radio aerials, it does raise again the question of handheld equipments of more than a very few watts output, since these normally have the aerial held close to the head of the user. Similarly those of us who use "long wire" h.f. aerials coming right into the "shack", or indoor v.h.f. aerials, may need to take rather more precautions than has been thought necessary in the past.

H.f. broadcasting and WARC

There is increasing evidence that some of the frequency allocations to radio amateurs in the low h.f. bands came very near to being lost at WARC 1979. They were saved by determined opposition from "non-aligned" and "Third World" countries to the extensions to the h.f. broadcast bands so eagerly sought by many of the "developed" countries (including the UK). An article in the "EBU Review" commenting rather sourly on the lack of success of European broadcasters to secure any new frequencies below 9MHz states: "In fact Latin American countries were opposed to any extensions of the h.f. bands for broadcasting; they claimed they needed the h.f. spectrum primarily for their fixed services, together with other services such as the amateur service." European h.f. broadcasters consider their bands are "overloaded by a factor of three or four" but seem reluctant to ascribe the blame to the practice of using many channels directed simultaneously at the same target areas; the current power race; and the continued practice by some countries of "illegal" jamming. Their claims of "many millions" of listeners often fail to distinguish between those listening to overseas m.f. relays and those struggling to listen on h.f.

Despite their lack of success at WARC, the European broadcasters are continuing to press for the introduction of s.s.b. transmissions; while this would provide more channels (and in theory make possible a reduction in power) it would call for transmitter stabilities of about 0.1Hz and a receiver stability of about 2Hz to avoid distortion on music.

One topic *not* discussed at WARC was the Russian Woodpecker which makes a nonsense of the Radio Regulations. Although less troublesome than in its early days, the Pecker still causes a great deal of interference and this will become worse as the sunspot cycle advances and the diurnal span of m.u.f. contracts. For this reason considerable interest is being shown in a design by Ulrich Rohde, DJ2LR/W2, in "Electronic Design" of a noise blanker for pulse interference claimed to be effective against the Pecker over a dynamic range of 80dB. This uses two CP643 power f.e.ts in the signal path in order not to degrade the signal handling capabilities of high-performance receivers.

Scanning the bands

During March, 50MHz signals from South Africa were received in the south of England around noon, and a number of crossband 50/28MHz contacts were made. A 50MHz Hawaiian beacon station, KH6EQ1, was reported heard in Athens, Greece by SV1DH. Nevertheless it is becoming increasingly clear that November 1979 represented the peak of the present sunspot cycle.

British amateurs have been reminded of Air Navigation Order 1980 which prohibits the flying of captive balloons or kites higher than 60m above ground level or within 60m of any vessel, vehicle or structure, and the flying of kites within 5km of an aerodrome. A number of amateurs have discovered that kites can form very effective "sky-hooks" for long-wire h.f. aerials.

Home computers can be "abominable polluters of the r.f. spectrum" according to Paul Cooper, N6EY, as they frequently emit "hash" covering the entire spectrum. Where a computer is installed in an amateur station, some alleviation of the interference is usually possible using mains filters etc., but he claims that to achieve anything like a complete solution may involve complete re-packaging of the computer, the installation of copper-foil screens beneath the keyboard, better-shielded monitors, improved isolation, etc. — "an approach beyond the scope of the average amateur".

In brief

A world record for 1.3GHz is being claimed for a 2290-km s.s.b. contact across the Great Australian Bight between VK6KZ/P at Cape Leeuwin, Western Australia and VK5MC at Haterleigh, South Australia .... An illegal broadcasting station in Miami, Florida — long a centre of much anti-Castro activity by Cuban exiles — has been closed down by US Marshals and FCC agents. High-power amateur radio equipment was being used on the 7MHz band to make broadcasts of a political nature directed at Cuba, resulting in interference complaints.

PAT HAWKER G3 VA

Multisection tone equalizer

Low-cost unit uses pre-set controls, quad op-amps

by **C. Walker and W. Clinch,** Plessey Semiconductors Ltd.

As a preset unit, this stereo equalizer has been designed primarily to cancel room resonances and equalize loudspeaker responses. Circuit fits standard diecast box and uses preset potentiometers to control the gain of eleven overlapping active filters in each audio-channel. Second-order active filters require one op-amp, two resistors and two capacitors; outputs are combined in a summing amplifier.

Unless you live in an anechoic chamber your rooms are bound to have resonances at certain frequencies. A rectangular room 4.2×3.4×2.5m has damped resonances at 40, 50 and 70Hz to begin with and alcoves and chimney breasts give rise to much higher frequencies. The Baxandall type of tone control normally used provides a smooth bass or treble lift or cut by allowing the movement of a single pole-zero pair. The peak of the bass response is normally at about 30Hz with still some effect at 600Hz. The treble peak is at about 20kHz with still about 10% of the boost or cut as low as 1kHz. Clearly such a tone control is of little use to compensate for a room resonance at 500Hz due to the gap between a chimney breast and a near wall.

The tone equalizer, Fig. 1, has been designed with enough filter sections to allow flexibility of amplitude — frequency response. Filter sections are second order and require only two capacitors and two resistors and one operational amplifier, Fig. 2.

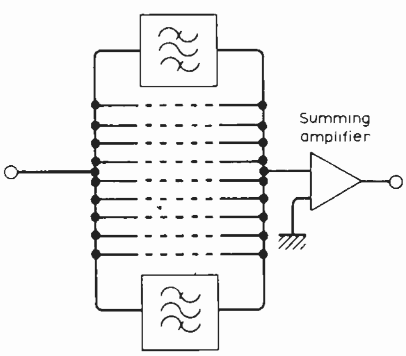


Fig. 1. Tone equalizer with eleven sections gives flexibility of amplitude response. Gain range of each filter is ± 12dB

With a high gain operational amplifier assume that the inverting input is a virtual earth, and also that a negligible current flows into the amplifier. The signal currents will be as shown in Fig. 2. Equating the currents at node A gives

$$\frac{V_{in}+\dfrac{V_{out}}{R_2sC}}{R_1}+\frac{V_{out}}{R_2sC}+V_{out}\,sC=-\frac{V_{out}}{R_2}$$

Rearranging

$$\frac{V_{out}}{V_{in}}=\frac{-\dfrac{s}{CR_1}}{s^2+\dfrac{2s}{CR_2}+\dfrac{1}{C^2R_1R_2}}$$

The general form of a second-order bandpass filter is

$$\frac{V_{out}}{V_{in}}=\frac{ks}{s^2+\dfrac{\omega_n s}{Q}+\omega_n^2}$$

Equating the coefficients of s gives

$$k=-\frac{1}{CR_1}$$

$$\omega_n=\frac{1}{CR_1R_2}$$

$$\text{and } Q=\tfrac{1}{2}\sqrt{\frac{R_2}{R_1}}$$

at the resonant frequency when $s=j\omega_n$.

$$\frac{V_{out}}{V_{in}}=\frac{kj\omega_n}{-\omega_n^2+\dfrac{j\omega_n^2}{Q}+\omega_n^2}=\frac{kQ}{\omega_n}$$

Substituting for k, Q, ω_n

$$\frac{V_{out}}{V_{in}}=-\frac{1}{CR_1}\times\tfrac{1}{2}\sqrt{\frac{R_2}{R_1}}\times C\sqrt{R_1R_2}=\frac{R_2}{2R_1}$$

Centre frequencies of the filters are spaced logarithmically in the audio band with a multiplication factor of 1.866. This gives the centre frequencies shown in the components table.

Filter sections are deliberately overlapping to maintain a smooth characteristic and although the phase response of individual filters changes from +90 to −90°, filter crossover points will have roughly zero phase change. This is because the phase lead of one filter cancels with the phase lag of the next.

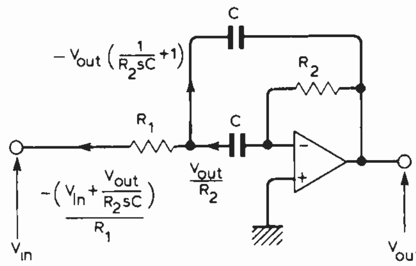


Fig. 2. Second-order filter sections use two capacitors, two resistors and ¼ of a quad op-amp.

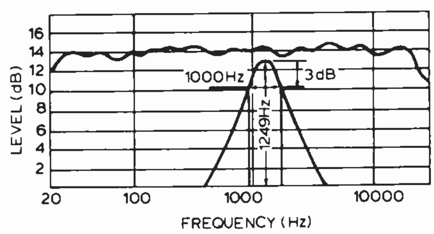
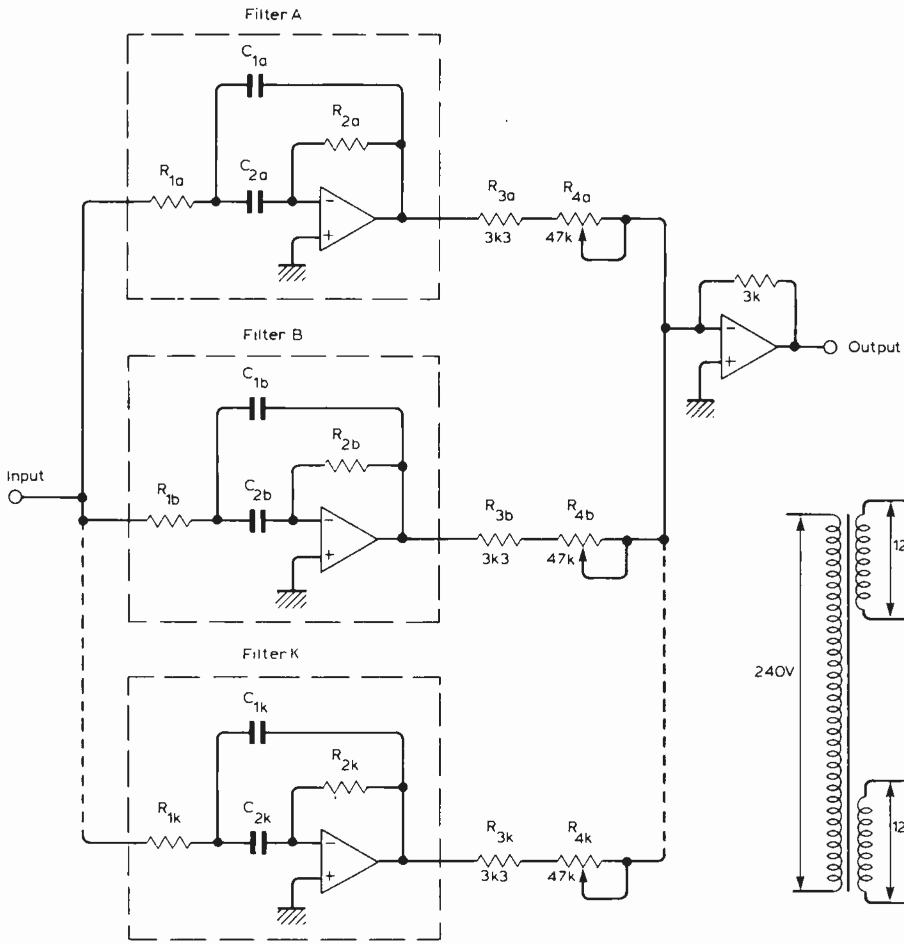


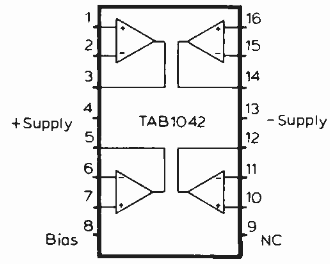
Fig. 3. Overlapping filter sections produce flattest response with Q value of 1.25. Diagram shows 1,249Hz filter response.

The equalizer is not intended for continual adjustment but rather as a "fit and forget" unit and preset potentiometers are perfectly adequate for this application and represent a considerable saving over the slider types normally provided on this type of unit.

The Q value of the filters to give the flattest response is 1.25 and this gives the 3dB cut-off frequencies at 18Hz and 21kHz. The overall flat-position amplitude response is shown in Fig. 3 together with the basic second-order filter response of the 1249Hz filter. The Q value of 1.25 gives a filter gain of $R_2/2R_1=3$ or approximately 10dB at resonance, and this is compensated for in the summing amplifier feedback resistor to give an overall equalizer gain of 0dB.

The low Q value used makes the filters very tolerant to component values, and with filter spacings of nearly an octave a 14% total frequency variation (made up of 5% on capacitors and 2% on resistors) is acceptable.





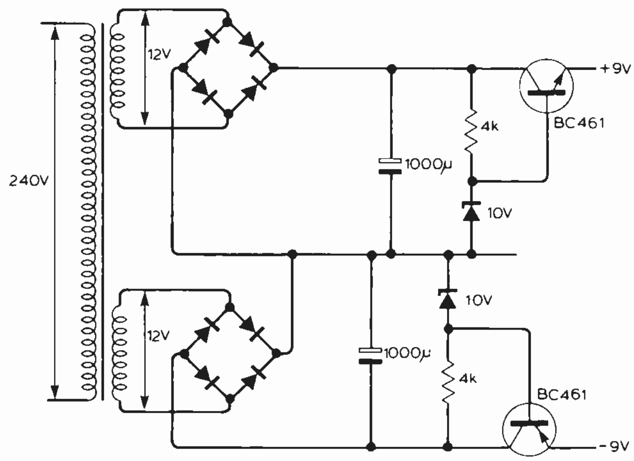


Fig. 4. Good supply rejection of the programmable op-amps allows use of simple power supply.

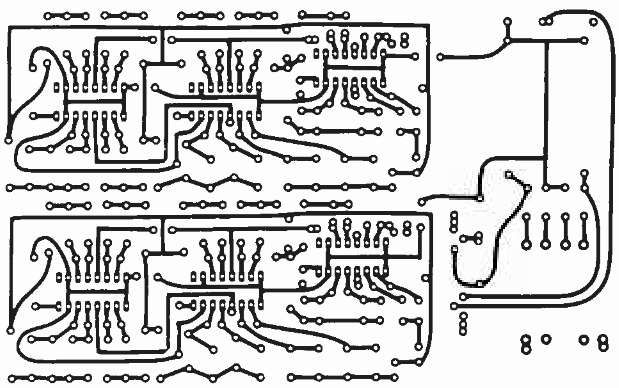
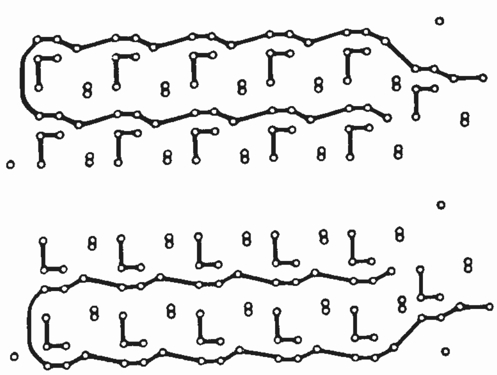


Fig. 5. Lower printed circuit layout carrying presets can be conveniently situated above main board.

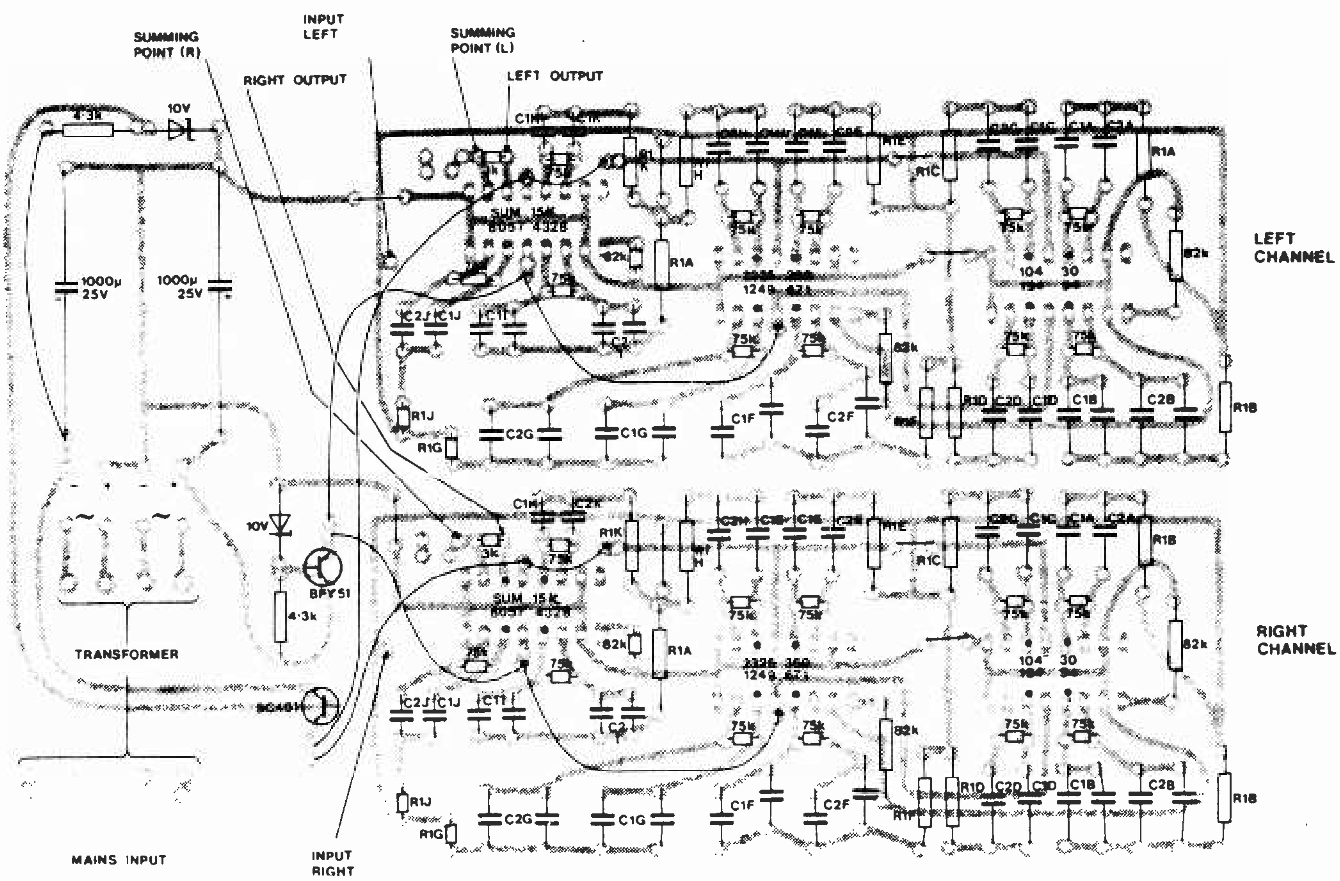
Fig. 6. Both boards can be housed in an earthed die-cast box, 12×17×5.5cm.

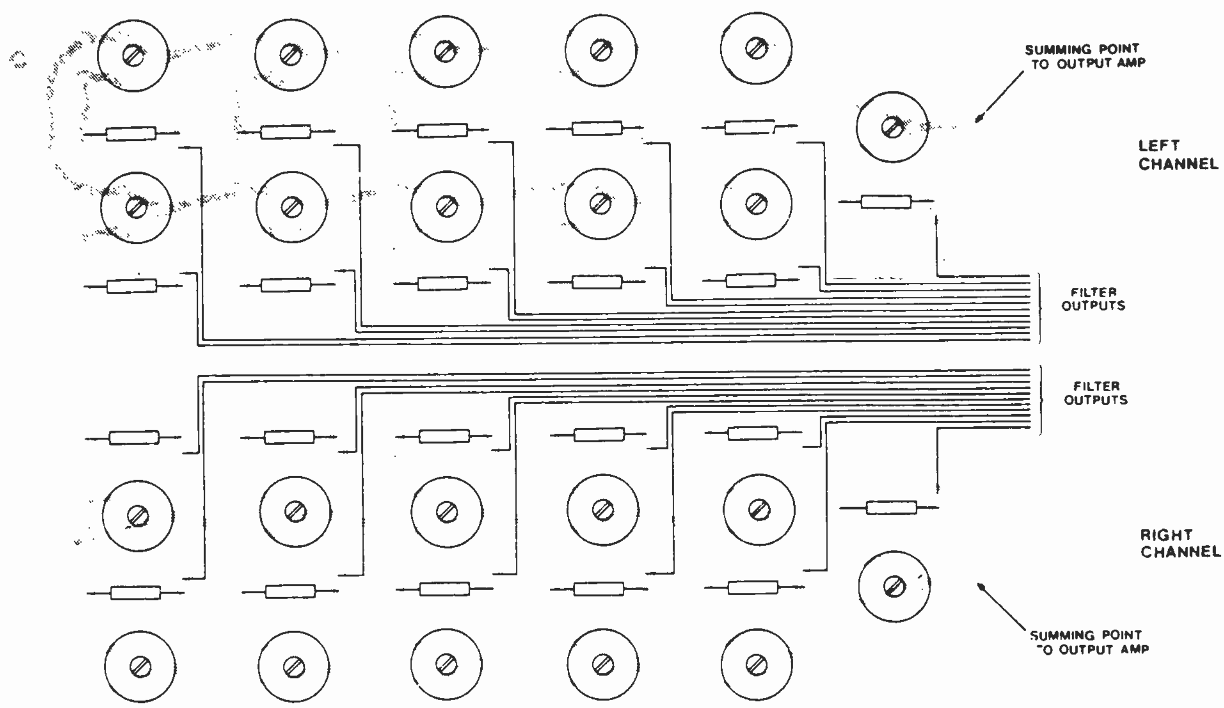


Gain range of each filter is designed to be ±12dB and $R_3A \rightarrow k$ prevents the gain going higher than this. The value of R_3+R_4 defines the signal current flowing into the virtual earth of the summing amplifier and this current will flow through R_5 giving a gain of $R_5/(R_3+R_4)$.

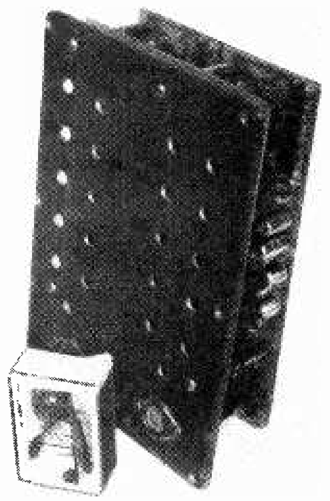
A supply voltage of ±9V allows signal handling of more than 0dBm (approximately 800mV) even with 12dB boost, i.e. 9.3V peak-to-peak at the output.

The TAB1042, made by Plessey Semiconductors, is particularly suitable for this application. It is an advanced bipolar integrated circuit containing four separate programmable operational amplifiers. The four amplifiers are programmed by current into a common





RESISTORS 3·3k
POTENTIOMETERS 47k



Mike Sagin plans to produce two single-sided printed circuit boards for the multi-section tone control for £8 including v.a.t. and UK postage. Write to 23 Keyes Road, London NW2.

Component values and centre frequencies

Filter		R_1	R_2	$C_1 = C_2$	Preferred value	Capacitor type
A	30Hz	12k	75k	180n	180n	1
B	56Hz	12k	75k	94n	100n	1
C	104Hz	12k	75k	50n	47n	1
D	194Hz	12k	75k	27n	27n	1
E	360Hz	12k	75k	15n	15n	1
F	671Hz	12k	75k	7.8n	2×15n in series	1
G	1,249Hz	12k	75k	4.2n	3900p	2
H	2,325Hz	12k	75k	2.3n	2200p	2
I	4,328Hz	12k	75k	1.2n	1000p//220p	2
J	8,057Hz	12k	75k	0.65n	560p	2
K	15,000Hz	12k	75k	0.35n	330p	2

Resistors are 2% tolerance. Mains transformer is RS Components 3VA p.c.b.-mounting type. Die-cast box 12 × 17 × 5.5cm from RS Components.

1. Polyester or polycarbonate 5% with 10mm lead spacing.
2. Polystyrene 5%.

bias pin which determines amplitude response, slew rate and supply current. For example, with a bias current of 75µA the TAB1042 will perform in a similar manner to four amplifiers of the 741 type but with improved frequency response and input characteristics.

The high supply rejection of the TAB1042 means that a rudimentary stabilized power supply can be used with the transistors simply buffering the zener diode. High loop gain of the operational amplifier means any non-linearities it may introduce are proportionally reduced by the feedback and the harmonic distortion of the unit is negligible. The circuit diagram of the complete unit is shown in Fig. 4.

Construction and use

Filters and power supply fit on a single board 10.2×16.5cm and the 22 presets on a second board normally mounted on pillars above the main board. This allows the filters to be adjusted through holes in the lid of the box. The filter output impedance is low and normal spindle or slider potentiometers could be mounted separately in a remote box without fear of degradation of response due to filter crosstalk.

Masks for the printed circuit boards are shown in Fig. 5 and the component layouts shown in Fig. 6. If the boards are spaced using one-inch spacers with the preset potentiometer board attached to the lid of a diecast box using suitable spacers, it is easy to access the copper track of the main board for testing.

Connect the earth of the mains to the box itself and not to the earth on the printed circuit board as this may cause earth loops with other equipment. Take care that the solder joints connecting the mains to the transformer are clear of the bottom of the box.

The equalizer is best fitted between the preamplifier and the power amplifier. The 0dB gain position is with the presets set to about 10kΩ. There is no simple way to accurately position the presets by measurements for a flat equalized room and loudspeaker response but quite satisfactory setting can be done by ear by adjusting for the quality of individual instruments. Several different records, or preferably live broadcasts on v.h.f. should be used as source material, and overall sound balance judged. Listen particularly for lack of deep bass, bass resonance, "boxiness" caused by low output in the middle frequencies, and over-emphasized "tiz" or lack of transients. Constant reference to the un-equalized sound will prevent confusion during this operation which may take some time to complete. □

References

1. Baxandall, P. J. Negative feedback tone control *Wireless World* vol. 58, 1952 pp. 402-5, 444.
2. Lancaster, P. Active filter cookbook. (Howard Sams).

Schools computer competition

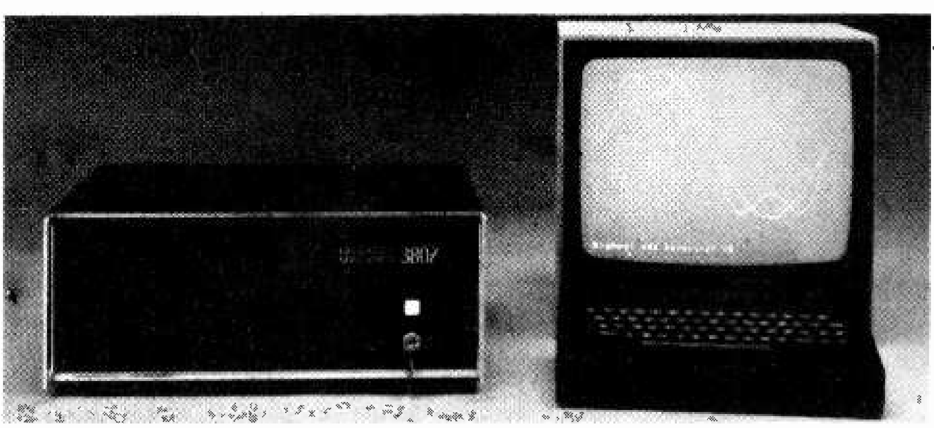
A hundred microcomputers are prizes in a competition for schools, arranged by the Department of Industry, which is intended "to encourage awareness and widespread development of the basic skills in computing and microelectronics in schools".

The competition is directed at the 7000 or so secondary schools which have no computer – there are around 8000 secondary schools in all – and requires pupils to submit details of a proposal for the use of a microcomputer in their school, preferably not in science or mathematics. No computing experience is needed to enter the competition. Prizes are a hundred 380Z microcomputers in either of two versions — for data handling or graphics — each worth around £2000. The DoI hope that additional prizes will be forthcoming from industrialists with an eye to the future.

The department cannot be faulted on its patriotism, on this occasion at least. The 380Z is designed and made by Research Machines Ltd. of Oxford, and is currently used by schools and colleges and in a data-processing role.

The competition closes on July 31, 1980; schools should contact The Department of Industry, Electronic Applications Division, Room 526, Dean Bradley House, 52 Horseferry Road, London SW1P 2AG.

Research Machines 380Z microcomputer, one of hundred offered as prizes in DoI schools competition.



Off-resonance metal detector

Gives finer distinctions than simple ferrous/non-ferrous discrimination

by G. Wareham

Off-resonance detectors are insensitive compared with induction balance and pulse induction types, but they work well in the field. They are less sensitive to the ground than balanced types and score over pulse induction types in discrimination. From the amateur point of view they are easy to make and will accept a variety of coil shapes to suit different uses. As the precise search frequency is unimportant, coils of unmatched inductance may be interchanged without redesigning the circuit.

The off-resonance metal detector is a comparative newcomer to "treasure hunting". But its basic principle is familiar enough. Like the old-fashioned b.f.o. mine detector, the off-resonance detector senses the change in the inductance of the search coil produced by the presence of a conducting or magnetically permeable object. The difference lies in the way this change is sensed and in the exploitation of the properties of a parallel-tuned circuit to enable more information to be obtained about the physical nature of the object. This article gives a simple explanation of the principles, with more elaborate notes on recent developments which may be of interest to those who wish to experiment.

When metal detectors are used for "treasure hunting" – which frequently means beachcombing for lost coins – the user soon learns that for every object of interest there are dozens of objects of no interest. These are bits of "silver" paper and other kinds of aluminium foil, bottle caps, ring-pulls from drinks cans, the cans themselves, and so on. It is desirable to distinguish this junk from coins, rings and other objects of value. Another need which soon becomes apparent is to prevent the conductivity and permeability of the ground itself from upsetting the operation of the detector.

No detector yet produced performs these functions perfectly and simultaneously, but the off-resonance detector goes a long way in the desired direction. The essentials of the simplest form of off-resonance detector are shown in Fig. 1. A variable frequency oscillator drives an LC circuit through a high resistance (R). The L of the LC is the search coil. The voltage across the LC circuit is rectified and the resulting d.c. applied to a comparator where it may be offset by a reference voltage. Deviations from the reference voltage, caused by the effect of the target object on L, give an indication on a meter or, more usefully, modulate the amplitude or frequency of a tone.

The effect of the target object on L depends on its size, distance, orientation and its electric and magnetic properties. Size, distance and orientation affect the strength of the detector's response. The other properties produce a variety of effects and it is these which give the detector its power to discriminate between types of target object.

A target which was purely lossy would merely damp the LC circuit and reduce the amplitude. A target with appreciable magnetic permeability detunes it low, by increasing L. A highly conductive target acts like a loosely-coupled short-circuited turn or metal tuning slug: L is reduced and the circuit is tuned high. So in principle a distinction can be made between permeable objects such as pieces of iron and non-magnetic metals such as copper, gold and silver. As we shall see in a moment, finer distinctions can also be made.

If the frequency is set to the peak of the resonance curve all targets produce the same general effect – a reduction in amplitude. There is no way of telling whether this reduction is the result of damping or detuning or a mixture of the two. No distinction between types of target is possible.

To achieve the desired discrimination, the frequency is set off-resonance, Fig. 2. A target which alters L must now either move the operating point further from the peak, causing a fall in output, or closer to the peak, causing a rise. Permeable targets and conductive targets will produce opposite effects, making possible discrimination bet-

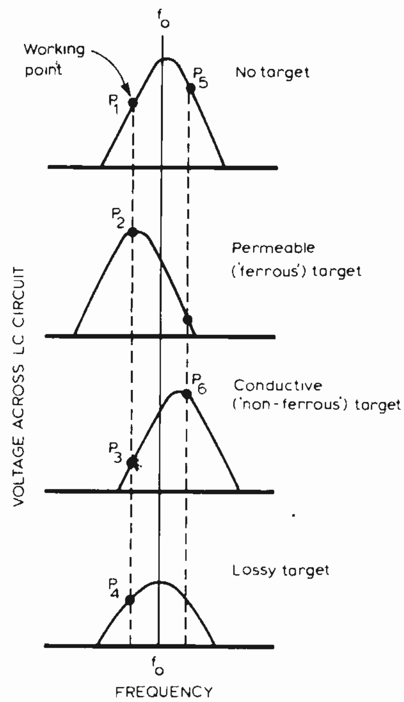
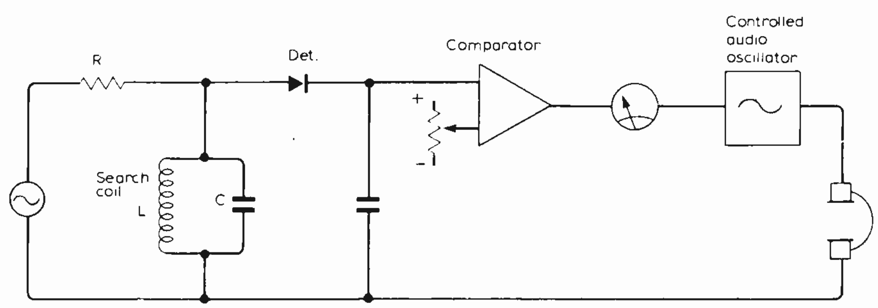


Fig. 2. With a working point set at P1, lossy and conductive metals reduce LC voltage, low-loss permeable metals increase voltage. With working point at P5, lossy and permeable metals reduce voltage, whilst low-loss conductive ones increase voltage. Finer discrimination is possible by choosing a working point where damping and detuning effects cancel.

Fig. 1. In the off-resonance detector, deviations from the reference voltage caused by the effect of a target object on the search coil L give an audible or visual indication.



ween "ferrous" (permeable) and "non-ferrous" metal. If, for example, the frequency is set to place the working point at P1, the appearance of a ferrous target moves the point to P2, say, giving an increased output. A conductive target (non-ferrous) moves the point to P3 where the output falls. A lossy target also produces a fall (P4), so the detector now discriminates in favour of low-loss ferrous targets and against everything else. Evidently, by setting the working point to the high side of resonance (P5) the detector can be set to accept non-ferrous targets and reject others (P6).

Because real-life targets are never lossless the response they produce is a mixture of damping and detuning. This is fortunate because it makes possible finer distinctions than a simple ferrous/non-ferrous discrimination. Aluminium foil ("silver" paper, cake cups), though fabricated from a high-conductivity material is so thin that the resistive losses cause a marked damping effect. If the operating frequency is set high to discriminate in favour of non-ferrous targets, the damping effect and the detuning effect oppose one another. But when the working point is set at the resonance peak they act in unison. It follows that there must be some point where the damping and detuning effects exactly cancel. When set to this point the detector does not see targets of this particular combination of damping and detuning; i.e. this particular Q.

In practice, the user sets the working point using a discrimination control so that foil is either ignored or rejected, i.e. output reduced. Thicker metal of higher Q is still detected, and this includes coins, precious-metal rings and similar objects.

Ground-effect cancellation

The conductivity or permeability of the ground below the search coil can produce a detuning effect. At first sight, this may seem small as the electric and magnetic properties of the ground are weak compared with those of the likely target objects. Unfortunately, this is not true in practice because the surface of the ground is so much closer to the search coil than a buried object. The response of a metal detector falls off rapidly with distance (the law contains something like a sixth power) so a small coin 10cm deep may produce a change in L of only one part in a million. The ground, being closer and larger, has a much greater effect and some means of nulling it is desirable. Although lossiness is the dominant characteristic of most soils, it is always accompanied by ferrous or non-ferrous effects so it can be nulled, usually by setting the working point just off resonance. The detector then loses its power to make fine discriminations, but simple ferrous/non-ferrous distinctions are usually still possible. Ground effect balance, as it is often called by detector makers, is particularly useful on brine-saturated beaches and iron-ore-laden or "mineralized" soils.

Fig. 3. In this design, frequency-determining network is that of the search-head LC circuit, so a phase shifter is used to give off-resonance operation. Read-out is obtained by mixing a harmonic of the search frequency with a crystal oscillator.

Choice of search frequency

Old-fashioned detectors of the b.f.o. mine-detector type generally used fairly high search frequencies, around 150kHz. This is much too high for good discrimination. Above about 100kHz, the skin effect limits current penetration to virtually the surface layer of an object. Thus all objects tend to look alike, irrespective of their real thickness, and coin/foil discrimination becomes difficult. Even ferrous objects are likely to appear non-ferrous because their conductivity prevails over their permeability.

For this reason the off-resonance metal detector, though it uses the same basic effect as the b.f.o., is operated at a much lower frequency, to reduce skin effect and facilitate thick/thin target distinctions. Practical search frequencies range from 30kHz down to audio frequencies of around a few kilohertz or even less. If the skin depth exceeds the thickness of commercial aluminium foils a measure of discrimination against these is automatically obtained. Unfortunately, the level of discrimination cannot in practice be raised to the point where all junk is rejected, because there is an overlap between the responses to junk and wanted objects. A highly conductive target such as a British two-pence piece, which is almost all copper, can readily be distinguished from even a large, thick aluminium foil cake cup. But the resistivity of metals is increased significantly when substantial amounts of alloy are incorporated. Cupro-nickel ("silver") coins have a much lower Q than copper ones. Similarly, a nine-carat gold ring is a relatively poor conductor compared with pure gold. Consequently, cupro-nickel coins and nine-carat gold rings may be rejected as junk by a detector set to reject thick foil.

A particular nuisance is caused by the ring-pulls from drinks cans. These are aluminium and good conductors, and a detector set to reject them will certainly reject some coins and rings as well. Detector designers usually provide a wide range of discrimination settings, which covers ring-pulls, but experienced treasure hunters prefer to use only a little discrimination in the interest of not missing objects of importance.

The tracking problem

When the frequency is changed the rectifier output level is also changed. The rectified output from the tuned LC circuit no longer matches the reference voltage to the comparator so this too must be adjusted. It would be good to arrange the controls so as to keep the two in step automatically but so far nobody seems to have cracked this tracking problem. The result is that every time the discrimination (search frequency) is adjusted the detector is thrown off balance and a separate readjustment of the reference voltage is needed. This is tedious. It would be desirable to gang the reference voltage control with the frequency adjustment control, or in detector makers' parlance, gang the tuning and the discrimination.

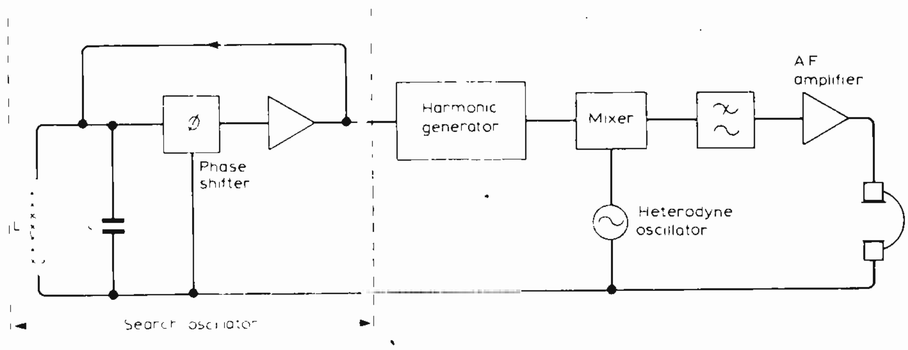
Self-oscillating detector

A way of side-stepping this tracking problem is to use a variant form of off-resonance detector which reverts to something like the old b.f.o. technique. In Fig. 3 the v.f.o. is dispensed with and the LC circuit of the search head is used as the frequency-determining network of the search oscillator. Off-resonance operation is obtained by inserting a variable phase-shift network into the oscillator feedback loop; adjustment of the phase sets the working point.

Appearance of a target object now alters the frequency. To obtain a read-out a high harmonic of the search frequency is heterodyned against an h.f. local oscillator, usually a fixed crystal oscillator. Target information is preserved in the beat tone. If, for example, the detector is set to accept coins but reject foil the beat frequency moves one way for coins and the opposite way for foil.

Heterodyne frequency selection

To obtain a useful range of discrimination, the search frequency has to be adjustable over a range which is about the same as the 3dB bandwidth of the



search LC circuit. As the search frequency is varied by adjusting the phase shift, successive harmonics come into zero-beat with the fixed heterodyne oscillation. It is important to select a heterodyne frequency high enough to permit an adequate number of harmonics to be tuned. Each beat point is associated with a different degree of discrimination, so discrimination is in effect adjustable in as many steps as there are zero-beat settings. In practice, to give a useful selection of discrimination settings, at least five steps are necessary. An estimate of the required h.f. heterodyne frequency is obtained from the empirical formula

$$f_h = (n-1)f_s Q_s$$

where f_h is the heterodyne frequency, f_s the search frequency, Q_s is the Q of the search LC circuit, and n the number of zero-beat tuning points. For example, if the search frequency is 10kHz, the LC circuit has a Q of 20 and eleven tuning points are required, the heterodyne frequency must be 2MHz minimum. (Extra tuning points may be provided by harmonics but these are disregarded in the calculation.) In this example, search frequency harmonics around the 200th are required. In general they have to be generated deliberately.

Perhaps the easiest method is to square the search oscillator output in a circuit with a rise time at least as short as the reciprocal of f_h (e.g. 1μs for f_h of 1MHz), differentiate, and use the resulting pulses to shock-excite an LC circuit tuned to f_h. The higher the heterodyne frequency the greater the sensitivity of the detector but the more vulnerable the system to drift in search frequency.

Search oscillator design

The frequency change produced by a target depends on the relative change of inductance of the search coil, not the absolute change. The sensitivity is therefore the same for any value of L, and the designer is left free to use whatever inductance he finds suitable. It is convenient to use coils with inductance of the order of 1mH. These require relatively few turns and can be made with fairly thick wire. The associated tuning capacitance for search frequencies in the region of 10kHz is an appreciable fraction of a microfarad, and this is big enough to swamp the effects of search head to earth capacitance, so the search coil need not be fitted with a Faraday shield. The precise frequency is unimportant so tuning capacitors of close tolerance are not needed. Stability is what counts, and of the cheaper types of capacitor polycarbonate film is the best, with terylene next best and polyester a poor third.

Two convenient search oscillator circuits are shown in Fig. 4. In the top circuit, a single-ended LC circuit is used, with no taps. The necessary phasing is accomplished by R_5 and C_4. At one end

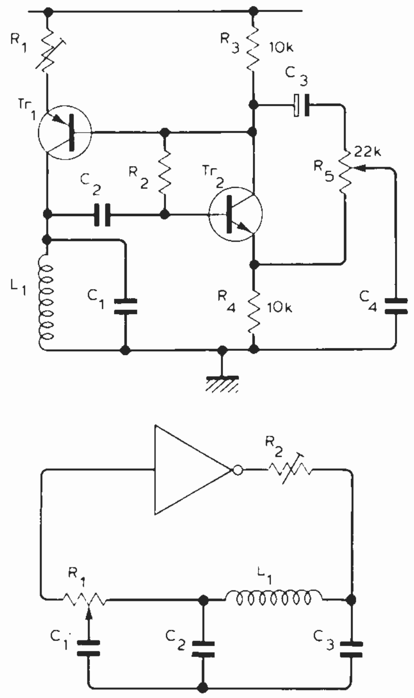


Fig. 4. In the search oscillator circuit (top) phasing is accomplished by R_5, C_4 and R_1 controls amplitude. For c.m.o.s. circuits bottom circuit is more convenient with R_1, C_1 altering phase and R_2 amplitude.

of R_5 slider's travel C_4 is effectively across R_3, giving a voltage lag which the tuned circuit has to make up with a lead. The frequency is pulled low. At the other end C_4 is across R_4. This gives a lead, and frequency goes high. Resistor R_1 sets the amplitude.

For use with c.m.o.s. inverters and gates the lower circuit is more convenient. Resistor R_2 controls amplitude and R_1, C_1 do the phasing.

Search coils

Greatest sensitivity is obtained with large coils. Pinpointing the position of a buried object is easiest with small coils. Most commercial detectors use a compromise coil size of about 18cm diameter, but a slightly smaller coil, of 13-15cm diameter may be preferable. Square coils are permissible, and rectangular ones if not too elongated. In any case it is easiest to begin by winding a circular coil on some suitable cylindrical former, such as a saucepan, then sliding it off and forming it to whatever shape is needed. Enamelled wire of around 26 s.w.g. is convenient, and 50 to 100 turns give a suitable inductance.

The finished coil should be waterproofed and fixed in some rigid, thermally insulating support. Sandwiching between sheets of Formica and filling the gap with resin is one possible construction. More convenient, but more difficult, is an open-centre form which enables the position of the buried object to be marked through the coil. The leads to the oscillator circuitry need not be screened; a twisted pair is good enough. □

IN OUR NEXT ISSUE

Graphical communication with computers

Pictorial input and output is an alternative to the more common alpha-numerical communication using keyboards. An article introduces the technology of interactive computer graphics and explains methods for putting in information and generating the displays in this form.

Constructing a transient recorder

This instrument captures one-shot events for later continuous display on an oscilloscope or chart recorder. Contents of the digital memory can be examined word-by-word to allow accurate measurement of the test signal. Interfacing to a computer is possible.

Solid state level meter

Using 20 l.e.ds of any colour mix, this solid-state level indicator offers a.c. or d.c. and dot or bar operation. Design options include 60dB dynamic range by cascading i.cs and a tape recording version for the range −20 to +3dB.

On sale 23 July

NEWS OF THE MONTH

Military electronics—the Defence Estimates

The arms race, spurred by international tension, continues to provide a substantial and growing source of income for the electronics industry. According to the UK government's 1980 Defence Estimates, presented to Parliament in April, over 20% of the output of the UK electronics industry in 1978/79 was taken by the Ministry of Defence. This does not include the considerable exports of electronics and communications equipment to foreign military forces from the various companies in the industry. In 1979 these exports amounted to £41.9 million for radio and radar equipment and £23.6m for guided weapons and missiles. For example Decca Radar, now part of the Racal group, in the first quarter of 1980 received orders for radars from ten foreign navies — Argentina, Bahrain, Brazil, France, Germany, Greece, India, Malaysia, Portugal and Quatar. In 1978/79 the UK's military defence expenditure on radio, radar and electronic capital goods was £429.4m and on radio and electronic components was £56.5m.

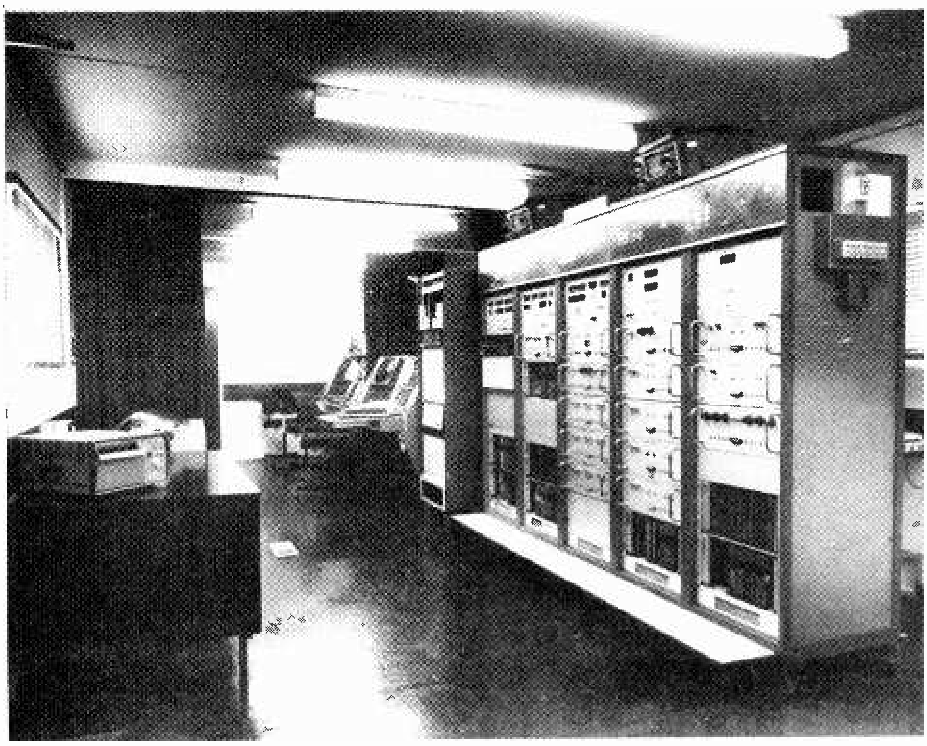
Of the total 1980/81 estimated Defence expenditure of £10,785 million, the portion devoted to military equipment is £4,336m (the remainder being mainly pay for military and civilian personnel). Of this, the estimates identify £272.8m to be spent on electronic equipment, guided weapons and instruments for land weapon systems, and £370m on electronic equipment and guided weapons for air systems. Electronics for sea systems is not listed separately, but £361.1m will be spent on "weapon systems, etc." One of the maritime weapons now under development is the Sea Eagle missile, intended to be launched from Navy and Air Force aircraft against ships. Described with callous cheerfulness as a "fire-and-forget weapon," it has an active radar homing system (developed by Marconi) and a computer using microprocessor technology. Before being fired the computer is supplied from the aircraft with information about the target's position. The computer then controls the flight path of the missile until the radar homing system locks on to the target during the final part of the attack, in which the missile skims the surface of the sea. This weapon, being developed by British Aerospace Dynamics Group, is claimed to have a greater range and resistance to electronic countermeasures than the earlier Martel missile of a similar type.

Microprocessor technology is also being incorporated as a technical improvement in the Rapier missile system, with which the Army and Air Force are equipped as a defence against low flying aircraft. This improvement programme, during the mid 1980s, will cost £320m. Similar technical updating is being considered for the Blowpipe man-portable missile.

Research and development in fact accounts for a considerable part — actually £1,479m — of the total 1980/81 estimated military expenditure. Of this, £231m will be spent on electronics and £183m on guided weapons. Ministry of Defence R & D staff in these two fields amounts to 7,600 but of course there are also many such workers employed by the various contractors. The Estimates state that, as a whole, the "defence equipment programme sustains about 200,000 job opportunities within the major defence industries and about the same number again are sustained indirectly elsewhere in industry."

What is known as "electronic warfare" is basically information processing for military purposes. "Electronic warfare support measures" provide information for the tracking and target-acquisition parts of guided weapons and communication systems. These are vulnerable to "electronic countermeasures" such as radio jamming, but "electronic counter-countermeasures" can reduce this vulnerability. The Estimates state that "electronic self-protection equipment" will be fitted to the Jaguar, Harrier and Tornado GR1 aircraft. The Nimrod MR MK2 and AEW aircraft will be fitted with support measures, and a new system of this kind for passive surveillance is being installed in the Navy's Lynx helicopters. A new radar jammer and improved support systems are due in service this year on some frigates. Britain will be taking part in NATO electronic warfare projects and particularly the Sea Gnat anti-missile decoy system with a view to deploying it later in the 1980s. Satellite communications terminals used by the Navy are to be improved, and the Army will be introducing the Ptarmigan tactical trunk communications system in the next few years.

A current development of military electronics, this "Electronic Warfare Engagement Simulator," made by Plessey Electronics Systems Research at Romsey, was a Ministry of Defence contract worth £750,000. The simulator is intended to aid development of "electronic countermeasures," which are used to protect aircraft against fire control radars. The simulator is to be used at the RAE, Farnborough, Hants.



Indian scientist wins Marconi award

Dr Yash Pal, Director of the Space Applications Centre of the Indian Space Research Organisation, has won the sixth Marconi International Fellowship, which takes the form of a 25,000 dollar grant; the recipient is expected to use the grant to undertake or complete a project of his own choice.

Dr Pal was honoured for his work on the Satellite Instructional Television Experiment (SITE) in India, a project run in conjunction with NASA, using the US ATS-6 satellite.

The object of SITE was to bring instructional tv to the rural villagers of India and Dr Pal's contribution included the development of hardware as well as the development of the screened material. The initial target of the project was to reach 3,000 isolated villages and eventually all 500,000 of India's villages.

Dr Vikram Sarabhai had proposed the project at the UN conference on exploration and peaceful uses of outer space in Vienna in 1968. Dr Pal took over the leadership of the project following Dr Sarabhai's death.

The award will be presented on October 12 1980 in Sydney, Australia, which was the receiving end of the first radio remote control experiment by Guglielmo Marconi fifty years ago in 1930.

405-line television to close

The BBC and IBA will start to close down their 405-line v.h.f. television services in 1982 and the closure will be phased over a period of about four years. This follows the international decision about the future of Bands I and III made at the World Administrative Radio Conference, Geneva, last year (see February issue, p.48, for details). As far as possible the two broadcasting organisations plan to close down their 405-line services in Bands I and III at the same time in particular areas, although this will not be possible everywhere since the BBC have 110 transmitters on 405-lines while the IBA have 47.

Stations to be closed earlier in the programme will be those in areas where there is good coverage from the u.h.f. 625-line services. The last stations to be closed will be some of the high-power main stations in areas where 625-line coverage is less complete. At least two years' notice will be given in any area before closedown, with wide publicity. The BBC and IBA engineering information services will advise those affected on alternative means of reception.

A further relay station building programme will extend u.h.f. coverage to groups of less than 500 wherever it proves reasonably practical for this to be done. In practice the broadcasters will try to provide stations for groups of 200 or more people and the first of these stations is expected to be built in 1984.

The Home Secretary has agreed that small groups who will not benefit from further relay stations will be able to set up small transmitters at their own expense. The broadcasters will give assistance to such groups to plan the small transmitting stations and will check that they will not cause interference to existing or planned stations. Those schemes which receive approval will be licensed by the Home Office. To help such groups the BBC and IBA are jointly preparing a booklet "Self-help television for small communities" which will be available in July (contact BBC Engineering Information Department, Broadcasting House, London W1A 1AA or IBA Engineering Information Service, Crawley Court, Winchester, Hants SO21 2QA).

Government approves CB in principle

As we go to press a UK Government discussion paper on citizens' band radio is expected at any moment. Many readers will already know that the Government have announced that they are in favour of c.b. in principle. But they intend to call it Open Channel and the scheme they are at present considering will differ in some respects from that advocated by the c.b. campaigners in the UK. One thing is certain: any c.b. service introduced by the Government will not operate on 27MHz, the frequency at present used by most of the illegal operators.

Dame Nellie and Winifred share broadcasting anniversary

A couple in their 80s visited Marconi Communications Systems in Chelmsford in February as part of activities to commemorate the first wireless telephony transmissions, which took place there in 1920.

Mrs Winifred Collins, then Winifred Sayer, was the first woman to make such a broadcast. She sang on three separate occasions and was paid ten shillings (50p) for each performance.

In 1920 Captain H. J. Round of Marconi's Wireless Telegraph Co. was granted a licence to experiment with wireless telephony. Wireless telegraphy had been in use for some years, notably at sea where ship to shore morse transmission was commonplace. The war of 1914-1918 increased the tempo of experiments and telephony had been shown as feasible.

Captain Round's transmissions were made on 2,800 metres for half-hourly periods, mornings and afternoons, beginning on February 23, 1920. Mrs Collins was certainly the first woman to make voice transmissions, although the significance of the event was somewhat overshadowed by transmissions in June, July and August of that year by stars such as Dame Nellie Melba, Lauritz Melchior, Jenny Lind and other well-known singers. Mrs Collins was present at one of the Melba broadcasts and recalls seeing Dame Nellie kick away the carpet because she feared the acoustic might be impaired by it.

*Mrs Winifred Collins at the time when, as Miss Winifred Sayer, she made the world's first **telephony broadcasts by a woman**, from the Marconi Works in Chelmsford during February and March 1920.*

Piston-type device tracks warped records

A new technique for reducing effects of record warp excitation on pick-up mass-compliance resonance is used on the "Z-Track." Though a UK invention, the damper has been selling for about two years in the USA and has only recently been announced in the UK. The device is a ½ gram piston-type oil damper that attaches to a pick-up head and rests on the record surface. This technique was first described by Alec Rargabe, applied physics consultant at the 1975 London AES Convention, and about a year ago he assigned his patent rights to Zerostat Components. The problems with warps are not only with the obvious difficulties of groove-tracking and cantilever warp wow but also the more subtle effects of intermodulation of recorded signals, with consequent sideband production. In reducing such effects the Z Track applies critical damping through a pad that spans 10 or 12 groove turns and contacts only "land" between, so largely avoiding "needle talk". According to its designer, over 50 different materials were tried for the skid pad; p.t.f.e. was chosen as it gave "by far the lowest coefficient of friction" and measured about 0.05 to 0.1 against average record material. Besides low friction, undoubtedly contributing to its 1000-side lifetime, the device has minimal "needle talk". With its mechanical resistance of 2000 the amplitude of pick-up excursions for a cartridge Q of 3 is reduced by 12 to 15 dB. Price is £9.95 from Zerostat Components Ltd., Edison Road, Industrial Estate, St. Ives, Huntingdon, Cambridgeshire PE17 4LF.

Office market super-group formed

Four companies within the Philips group have been integrated to produce a single company, Philips Business Systems, which is aimed at the electronic office market.

The four companies brought together are Pye TMC Ltd, which has specialised in telephone equipment, Philips Data Systems, Pye Business Communications Ltd, and Philips Business Systems. According to Brian Manley, the new super-group's managing director, it has been formed to exploit Philips' "unique position in the electronic business equipment market of today ... we have drawn together our strengths in manufacturing, marketing, systems engineering and support in order to make a unified attack on a market which is both expanding and converging."

Philips see the rapidly-growing market developing in two distinct phases. For several years there will be an increase in the volume of stand-alone equipment installed, which more and more will possess its own "intelligent" communications capability. Phase two will see the integration of equipment forms until, in the 1990s, complete intercommunication facilities are achieved amongst terminals handling word and data processing, audio and message transmission, data and text storage and a wide variety of personal computing functions.

Set makers grapple with technology

The uses and abuses of technology seem to be of particular concern at the moment to the UK manufacturers of consumer electronics equipment. At the annual general meeting of BREMA in April, Lord Thorneycroft, the president of this trade association, said that the growth of new electronic information techniques such as teletext, viewdata and home computers presented many new problems and opportunities to the industry. Britain had shown great skill in design and technical development in these fields but in the past we had sometimes failed in manufacturing and marketing. "If we are going to make a success of this business we have got to match the manufacturing efficiency and standards of our competitors in the rest of the world . . . I am confident that the companies represented in this room can do this". Lord Thorneycroft added that, in recognition of these new electronic techniques coming into domestic equipment, the name of the association had been extended to The British Radio and Electronic Equipment Manufacturers' Association.

One abuse of technology, according to BREMA, is the exploitation of technical legislation as a barrier to free trade. The association's 1979 annual report says: "There are of course subjects, such as safety, where legislation is appropriate and valuable to industry as well as to the general public. However, it does appear that legislation which emerges in some countries is devised to introduce, or at least results in, barriers to trade. This is particularly regrettable when it occurs in member states of the EEC and when the response of the EEC, in general, is to propose similar legislation throughout the Community, rather than to question the justification for mandatory requirements being introduced in the first place. BREMA has and will continue strongly to oppose technical legislation which is not justified on its own merits."

One example of this activity, according to a BREMA official, was some proposed French legislation to make compulsory the fitting on colour tv sets of a 21-pin socket for connecting peripheral equipment such as tv games, video recorders and teletext terminals. The annual report says ". . . no sooner had BREMA made known its objections than a draft EEC Directive was received which embodied the French specified connector and forbade the use of any other interconnection device. BREMA informed the Department of Industry that whilst the very short notice did not allow for a detailed response, BREMA was totally opposed to the imposition of mandatory technical requirements in this area, pointing out that the only justification for mandatory technical requirements is where protection of the individual is concerned, for instance safety, or where matters of general environmental concern arise such as radio interference. From a technical point of view BREMA raised a number of criticisms of the connector. It is agreed that standardisation in this area is highly desirable but this must be through the relevant international standards bodies."

On the possibility of a citizen's band service in Britain, the annual report says that BREMA maintains its view that c.b. radio "would provide a valuable service and could be administratively self-financing. The recent World Administrative Radio Conference did not make any specific frequency allocations for this service. Instead, it considered that it was part of the terrestrial mobile radio service and subject to allocation by national administrations. In expectation of a favourable government announcement, the BREMA Citizens Band Radio Sub-Committee is to investigate the expected performance of the range of products that could be associated with the various possible frequencies that might be authorized. This will permit a prompt response to technical and manufacturing questions and aid commercial planning".

Coastal radio extended

With the opening of a Post Office v.h.f. radio station on the Isle of Islay at the end of March, another stage has been completed in the POs five-year programme to improve communications for coastal shipping and pleasure craft.

Islay Radio, controlled from Portpatrick, is the second remotely-controlled station the PO has opened this year, the first being on the Isle of Skye in February. At present, there are 23 v.h.f. maritime radio stations, 15 of them remotely-controlled, around Britain's coastline.

In the last ten years the demand for v.h.f. maritime radio services has increased from an estimated 20,000 calls annually, to more than 250,000. Much of the rising demand has come from an increasing awareness in yachtsmen etc. that such a service not only maintains contact with the shore but offers an important safety aid.

News in brief

The North London Hobby Computer Club has joined up with several other London computer clubs, to form the Association of London Computer Clubs. The first major meeting of the new club, to be called the London Computer Fair, will be held at the Polytechnic of North London on July 11th and 12th. Interested parties should contact the Chairman, Robin Bradbeer, either at the Polytechnic or through his home telephone number, 0483 35711.

An American company specialising in analogue signal processing devices, as well as image sensors and microcomputer-based image processing systems, EG and G Reticon, has now opened a UK office at Doncastle House, Bracknell, Berks. Cameras, systems and technical data will be available from the Bracknell office, as will an "off the shelf" component supply service.

A Japanese company, Nippon Electric of Tokyo, has been given a 25,000 million yen contract by the national telecommunications agency of Argentina (ENTEL) for the construction of a digital telephone network in Buenos Aires. Digital switching and optical fibre transmission systems will link more than 60 telephone offices in the city, making it comparable to networks being planned by the American Telephone and Telegraph Co.

One of the best-known companies supplying components in the South of England, Ambit International of Brentwood, wishes it to be made known that it is no longer operating from Gresham Rd., Brentwood, Essex, and is now established at 200 North Service Rd., Brentwood. Ambit International is the official distributor for the product ranges of Toko, Alps Electric, Hung Chang Meter Co., Micrometals and Faital Loudspeakers.

The annual meeting of the British Association for the Advancement of Science is to be held at the University of Salford from 1st to 5th September 1980. Registration forms and details of cost are available from the British Association for the Advancement of Science, Fortress House, 23 Savile Row, London W1X 1AB or telephone 01-734 6010.

Another home computer

During April, Texas Instruments held a press conference to promote their new home computer, first shown at TV-Mex last January. Originally planned to have a 4K random access memory, the 99/4 computer r.a.m. was extended to 16K when plans for a "professional" computer — requiring more than 4K of r.a.m. — were shelved some time back. Total memory of the computer is 72K bytes, with an internal 26K r.o.m. and up to 30K in plug-in "solid-state software" modules. It is sold with a Skantic 14in colour tv monitor/receiver for a price of £990, and programmed modules cost £17 to £45. Those available now include pre-school early learning fun, beginning grammar, number magic, household money management, personal record keeping, statistics, video games, video chess, video graphics, physical fitness, American football, plus two others. Alternative programming uses TI basic. For connections to other computer peripheral equipment an RS-232 serial interface adapter is needed (£150). Also available is a 32-column thermal printer (£269), a speech synthesizer (£95 for 373 words) based on the Speak & Spell chips with floppy disc storage to follow.

You can buy the 99/4 without the Skantic monitor/receiver for £655 but you'll need either an NTSC set or a dual standard set with mains isolation. According to their home computer manager, Mike Lunch, TI were unable to find a UK maker that offered a mains isolated set suitable for conversion to the NTSC standard, so they looked to European makers Luxor (Skantic in the UK), Barco and Grundig. Portatel Conversions Ltd of Sunbury-on-Thames — who do the Skantic conversion for about £85 — say they are unable to guarantee the convertibility of other sets. So if you want to use your own colour set you'll need to contact them first.

The need for mains isolation appears to be because an r.f. output of the 9918 chip didn't meet FCC radiation limits, which meant using an NTSC composite video output — in effect it had to feed a monitor, rather than an un-isolated domestic set with its "live" chassis. Texas say they will have a PAL version of the 9918 graphics chip, which wouldn't be subject to the same restrictions, by the "end of 1981." Could this be a planned time for introduction of another home computer? TI were unable to comment. What then was the market expectancy of the product—the 99/4 brochure calls a home computer a long-term investment? "That's a forbidden subject," answered Mike Lunch.

Wideband audio power amplifiers

Ideas for class A designs with no overall feedback

by **Y. Miloslavskij,** Dipl. Ing. Institute of Constructional Physics, Moscow

Author suggests ideas for a wideband class A power amplifier (2-10 watts) without overall feedback using single-ended and/or push-pull circuits for his efficient loudspeakers and passive linear-phase filters with 6dB/octave slope. Input transistor is carefully selected for good linearity and Darlington pairs selected using a curve tracer. 10-20% instability in operating current can either be tolerated or reduced using thermistor biasing.

Nowadays it is not enough to possess only a good frequency response within an audio band; it is necessary to achieve more accurate reproduction of transients for which one needs extremely broad-band systems. In many cases, the importance of accurate reproduction of transients in music reproduction can be explained by considering the sound reproduction process and the specific characteristics of individual musical instruments, as pointed out and explained, for example, in "The Physics of Musical Sounds" by C. A. Taylor. There are many serious problems, which can hardly be solved in complete form in audio monitors because of the presence of several loudspeakers and accompanying filters.

Use of one radiator within the audio band is out of the question because of intense intermodulation, because of an increase in radiation directivity with increase in frequency, and because of conflicting design requirements of the radiator within the low and high frequency ranges. Direct-cut recordings can eliminate the imperfections of tape recordings, provided great attention is paid to the quality of other units. But such recordings are not often possible.

But it is a more unpleasant thing if serious problems arise within preamplifiers and power amplifiers. And so we face the problem: what if we use broadband amplifiers both as audio preamplifiers[1] and as audio power amplifiers? This article suggests single-cycle and push-pull versions of a broad-band power amplifier with a maximum power output of 10W. Such output power is quite enough to create a sound pressure level within the peaks of 100 to 108dB inside a room with the volume of 30 to 120m³ with high-output loudspeakers. Studies made in different countries show that such a level of sound pressure is plenty even for prolonged listening. This level of sound pressure is about the same as the peak levels in concert halls while listening to symphonic music somewhere in the centre of the pits at the fortissimo. Upper frequency limit of amplification of such amplifiers may be 20MHz and more[2].

Low frequency limit of amplification in the amplifiers depends only on the value of isolating capacitors. The output stages operate as emitter followers in class A. This helps to get low non-linear distortion, low output resistance and acceptable efficiency without negative feedback. Non-linear distortion of the emitter follower depends primarily on the ratio between resistor R_3 and the input resistance of the emitter follower, as well as on transistor linearity. The smaller the ratio, the lower the distortion. Also, the smaller the ratio, the lesser is the shunting effect of R_3 and the efficiency becomes greater, especially in the push-pull version. In the push-pull version of Fig. 1, to reach the best linearity it is necessary to achieve maximum symmetry of arms.

Fig. 1. Example of push-pull class A amplifier without external feedback used in author's l.f. loudspeaker channel. Output transistors have a $V_{ce(max)}$ of 120 to 400V, $I_{c(max)}$ of 8 to 12A, $P_{c(max)}$ of 50 to 120W, f_T of 3 to 20MHz and an heat dissipator of 1200 to 1800cm². Darlington pair: current gain 5000 to 10,000, output device 60 to 90.

Maximum value of non-linear distortion is 0.1 to 0.2%. Non-linear distor- of the amplifiers is also determined by linearity of transistor Tr_1 and the local negative feedback of this stage. It is a good idea to choose the transistors, especially the complementary pairs, with an accurate curve tracer. At the same time, it is possible to estimate the value of current gain (β), V_{min}, I_{min}, linearity, and the important dependence $\beta = \beta(I, V, T^o)$. Output resistance in these cases is determined mainly by the following ratios:

$$R_3/\beta_{Tr2} \times \beta_{Tr3} \text{ and } R_3/\beta_{Tr4} \times \beta_{Tr5}$$

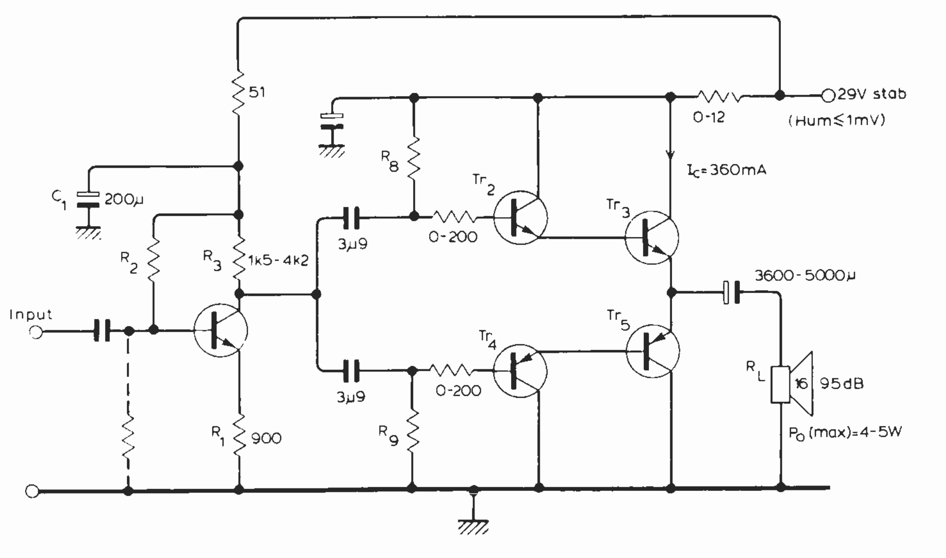
For horn loudspeakers with high outputs exceeding 105 to 108dB (1m, 1W) one may use the single-cycle circuit of the power amplifier, Fig. 2, for outputs of 0.5 to 2W (and even for an l.f. power amplification channel up to 4 to 5W). Efficiency of such a circuit is 4 to 5%. Maximum efficiency for the circuit on a sinusoidal signal is approximately 8.7% (reference 2) at $R_6 = 1.41R_L$. The basic formulae are

$$I_{C(out)} \approx 2.41\sqrt{P_{out(max)}/R_L} + I_{min}$$

$$V \approx 4.83\sqrt{P_{out(max)}R_L} + V_{min} + I_{min}R_6 + V_{BE(Tr3)}$$

In the given circuit the resistor $R_6 =$ 3 to $6R_L$ ($R_L = 15\text{-}20$ ohm) which leads to decreasing the power dissipated in Tr_3 and allows the amplifier to be fed from the voltage source for the l.f. power channel.

Temperature of the transistor junctions must not exceed 70-80°C. Ignoring



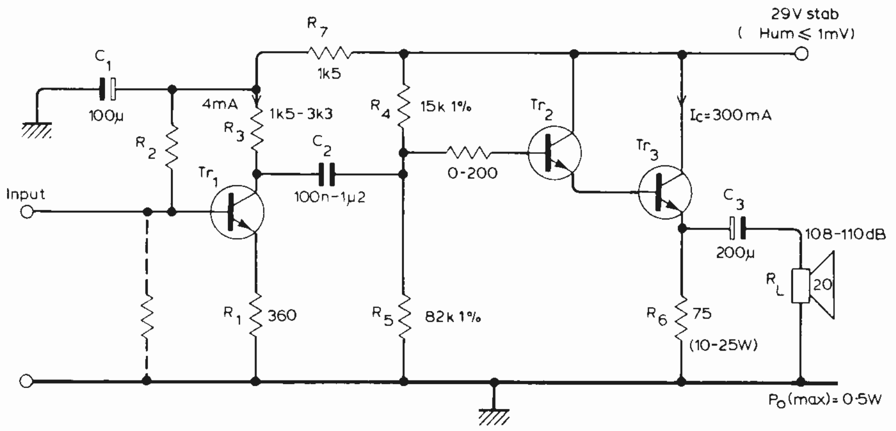


Fig. 2. Single-ended version of m.f. and h.f. horn loudspeaker channels uses 2 to 5A output transistors with $V_{ce(max)}$ of 300 to 500V and $P_{c(max)}$ of 25 to 50W. Heat sink 150 to 300cm^2. Darlington pair gain 3,000 to 5,000. Input transistors have $V_{ce(max)}$ of 120 to 300V, $I_{c(max)}$ 0.5 to 1A, f_T 20 to 50MHz, $P_{c(max)}$ 0.6 to 1.5W and current gain 70 to 140. Capacitors C_2, C_3 have been chosen to attenuate l.f. gain.

this condition may lead to the increase of the coefficient α_2 to α_n of the transfer characteristics and will worsen the stability of the operating current of the transistors. The instability of operating current (with a sufficiently high current running through the R_4/R_5 bias chain) is approximately 1mA. The circuit needs no adjustment, except for preliminary circuit calculations and selection of components with the required parameters. Subjectively, such a single-ended amplifier sounds no worse than the push-pull one.

The required operating current is obtained automatically. Calculation of the operating current value and of R_6 depends on the maximum output power and power supply voltage, and is not given here. Rearranging the formulae

$$I_{C(out)} \approx 1.1 \text{ to } 1.2\sqrt{2}\,\frac{\sqrt{R_4 \cdot P_{out(max)}}}{\dfrac{R_L R_6}{R_L + R_6}}$$

$$V_{CE(Tr3)} \geqslant N2\sqrt{R_L \cdot P_{out(max)}} + V_{min(Tr2.3)} + 0.8V$$

For good symmetry of arms of the push-pull stage, $R_9 \approx R_8$ and

$$\beta_{Tr3} \times \beta_{Tr2} \approx \beta_{Tr4} \times \beta_{Tr5}$$

and preferably $\beta_{Tr3} \approx \beta_{Tr5}$.

Instability of the output current has the same quality as the current in the power amplifier by J. L. Linsley-Hood[3]. It is desirable that the Tr_1 to Tr_5 transistors should be high-voltage ($V_{c(max)}$ 100 to 400V) and with optimum current margins. As a rule, this improves linearity.

Generally from the point of view of quality, total cost and total efficiency the combination of a 1W power amplifier plus high-output horn loudspeaker seems more rational than the choice of almost kilowatt power amplifier plus loudspeakers with 80 to 88dB (1m, 1W) output. For the last-mentioned case it is essentially more difficult to build a high quality power amplifier. Moreover, the problem of heat drainage from the loudspeaker voice coil arises as well as the problem of steady and stable loudspeaker performance, not to mention distortion. Let R_6 be heated, for its heating influences absolutely nothing!

For an l.f. power amplifying channel with a loudspeaker output of 94-97dB (1m, 1W) it is possible to employ the push-pull version for an output of 4 to 10W. The maximum coefficient of performance of such a circuit is somewhat less than 50%. Basic formulae for calculation are

$$I_{C(out)} = \sqrt{P_{out(max)}/2R_L} + I_{min}$$

$$V = 2(\sqrt{2P_{out(max)}R_L} + V_{min} + V_{BE(Tr5)})$$

if $V_{BE(Tr5)} = V_{BE(Tr3)}$, $V_{min(Tr2,3)} = V_{min(Tr4,5)}$.

The instability of $I_{C(out)}$ can be reduced if necessary with the help of thermistors, used instead of R_8 and R_9. Values should be calculated or experimentally chosen, and the thermistors must have a positive temperature coefficient.

Each arm of the amplifier is "trimmed" separately. Choose R_2 so that symmetrical clipping of the sinusoid is reached after applying voltage to the circuit for 15 to 20 minutes. Further, using half the value of the calculated supply voltage, the value of current $I \approx 0.9I_{c(out)}$ is set (using the initial ammeter reading) in the complementary Darlington pairs by adjustment of resistors R_8 and R_9; then the arms are connected.

This circuitry is adopted as the basis for a three-way power amplifier (0.5 to 10W) with passive (phase-linear) filters having 6dB/octave steepness at the power amplifier input. Capacitors C_2, C_3 serve also to attenuate low frequencies in the m.f. and h.f. power channels. □

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1. Miloslavskij, Y. Audio preamplifier with no t.i.d. *Wireless World*, vol. 85, August 1979, pp. 58-60.
2. Cykin, G. S. Sherokopslassiy Kaskaly Moshnogo Usilenja (Broad-band stages of powerful amplification) *Radiotechnica*, no. 5, 1968.
3. Linsley-Hood, J. L. Simple class A amplifier, *Wireless World*, vol. 75, 1969, p. 148 (see also correction & correspondence).

Literature Received

"How to become a radio amateur" is, as its title suggests, a set of regulations and licensing conditions for those wishing to take up the hobby. It contains information on frequency bands, types of transmission and a syllabus of the examination, with all necessary addresses. The booklet can be obtained free from the Home Office, Radio Regulatory Department, Radio Regulatory Division, Licensing Branch (Amateur), Waterloo Bridge House, Waterloo Road, SE1 7UA. WW 401

Data sheets on the Telrex range (900 models) of aerials, aerial arrays, masts and rotators can be obtained from Telrex Laboratories, Asbury Park, 07712 New Jersey, USA. WW 402

An application note dealing with theoretical and practical aspects of **charging high-voltage capacitors** (resistive, constant-current and constant-power) forms one of a series, available from Hartley Measurements Ltd, Kenwood House, Hartley Wintney, Basingstoke, Hampshire. WW 403

Fibre-optic cables, connectors, receivers and transmitters made by Suhner are described in a brochure entitled 'Fibreoptic', which is obtainable from Suhner Electronics Ltd, Telford Road, Bicester, Oxon, OX6 OLA. WW 404

A catalogue of **home computers,** peripherals and accessories is produced by Microdigital, 25 Brunswick Street, Liverpool L2 OP1. The company runs a hiring system in addition to its sales operation. WW 405

IMS is the **Industrial Microcomputer System** developed by Mullard. It uses Signetics 2650 microprocessors and is associated with Modest, a development system. The whole system is modular in form, avoiding too-complex or too-simple solutions to specific problems. A booklet on IMS can be obtained from Central Enquiry Handling Unit, Tech. Publications Dept, Mullard Mitcham, New Road, Mitcham, Surrey CR4 4XY. WW 406

A booklet on the range of **r.f. power** meters and dummy loads, working in the frequency range 2-1000-MHz, manufactured by Dielectric Communications, is obtainable from the UK representative, Tony Chapman Electronics Ltd, 80a, High Street, Epping, Essex CM16 4AE. WW 407

The first of a range of digital **transit recorders,** Model VK-22, which has a 2K × 8-bit memory, has been announced by Prosser, who can supply a descriptive leaflet. Prosser Scientific Instruments Ltd, Lane Lane Industrial Estate, Hadleigh, Ipswich, 1P7 5DQ. WW 408

Power supply modules for X-ray image intensifiers are described in a leaflet, available from Brandenburg Ltd, 939 London Road, Thornton Heath, Surrey CR4 6JE. WW 409

Switches of various types for printed-board mounting are marketed by Waycom, who have a brochure "EECO PCB Switches", which can be had from Waycom Ltd, Wokingham Road, Bracknell, Berks RG12 1ND. WW 410

Guides to the selection and use of Scotchcast **liquid resin** (potting resins) and Scotch electrical tapes are obtainable from 3M, PO Box 38, Yeoman House, 57-63 Croydon Road, London S.E.20 7TR. WW 411

Analogue computing techniques

Introduction to the electronic solution of differential equations

by **David F. Dawe, B.Sc.** Cornwall Technical College

This article fills a gap in the literature on analogue computing: there is little that is not too advanced or too elementary. Originally written for HND students, the article covers both modes of operation and programming techniques, as well as including an introductory section on basic modules.

Basically the digital computer does arithmetic, arithmetic that most people could do by the age of ten or so. It takes two or three simple types of decision, has an enormous memory, and works at high speed. It simply does arithmetic in a series of predetermined steps, but quickly. As someone has rightly said, "The digital computer is a high speed idiot!"

The analogue computer is any arrangement of equipment coupled together so that it models or analogues a real system. Early analogue computers were developed using mechanical computing devices such as differentials, cams, shafts and gears. (For example see Electronic Computers Made Simple, chapter 3, by Jacobowitz). These mechanical computers were built specifically for single-purpose operation such as the early gunnery control systems developed for use by the armed forces.

Large-scale analogue computers, which are capable of rebuilding to model many different systems and thus perform varied computations, have only come into use due to the introduction of the electronic operational amplifier. With this equipment models of proposed systems can be made at a fraction of the cost of the real system. Evaluation of system response for varying system parameters can be obtained and optimized before a real system is constructed. It is also possible to incorporate some real parts and some model parts into a prototype mock-up system for evaluation.

The accuracy of an analogue machine is seldom better than one part in 1000. This is better than the physical data for most problems. If this accuracy is not good enough then a digital solution becomes essential.

A fairly detailed comparative costing of the computation of some integrals involving Bessel functions has been performed (see Analogue Computing Methods by D. Welbourne). The analogue solution, accurate to two figures, took two hours to programme, 50 minutes to compute and was costed at \$53. A digital solution of the same problem took two weeks to programme, 50 minutes to run and was costed at \$1377.

With many analogue computers a large problem can tie up its use for weeks or even months until the final results have been obtained. On a digital computer the programme can easily be removed and other work done whilst the first programme is dormant. Generally the analogue computer has its application only in the solution of differential-type equations. It has limited storage facilities, if any, unless it is coupled to a digital computer, the overall installation then being called a hybrid computer.

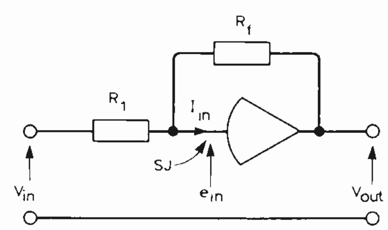
Basic analogue computing modules

Operational amplifier. The op-amp is the basic building block of the electronic analogue computer. It can sum, multiply, integrate, differentiate and drive voltmeters, oscilloscopes, chart recorders and other such measuring devices. It is a high-gain, high-bandwidth amplifier with high input impedance and low output impedance. Typical values for the 741 series are

gain	20,000, nom. ∞
unity gain-bandwidth	1MHz
input resistance	2MΩ, nominally ∞
output resistance	75Ω nom. zero

The following sections indicate how an op-amp is connected to produce the basic circuits used in an analogue computer. The circuit analysis used is deliberately simplified; a more rigorous analysis may be found in most standard textbooks on the subject.

Inverting and summing amplifiers. The inverting amplifier consists of an op-amp plus two resistors R_1 the input resistor and R_f the feedback resistor

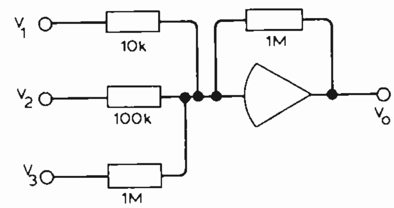


Resistors R_1 and R_f have precision values. I_{in} is zero because of the high input impedance, e_{in} is zero because V_{out} will be finite and the gain is virtually infinite. Apply Kirchhoff's first law to SJ, the summing junction,

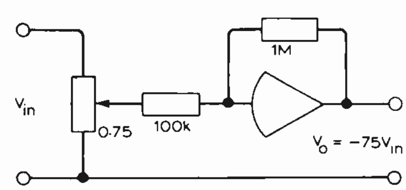
$$\frac{V_{in}}{R_1}+\frac{V_{out}}{R_f}=I_{in}=0$$

$$\text{hence}\quad \frac{V_{out}}{V_{in}}=\frac{-R_f}{R_{in}}.$$

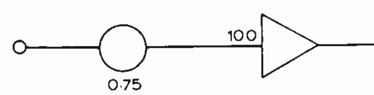
The amplifier now has a gain completely dependant on the choice of R_f and R_{in} and is always phase reversing (negative sign). A typical inverting amplifier would have a single feedback resistor of say 1MΩ and a choice of input resistors that can be used, say 10kΩ, 100kΩ and 1MΩ



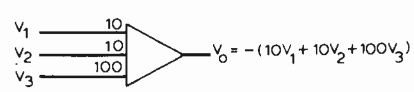
Thus input V_1 has a gain of −100, V_2 has a gain of −10, V_3 has a gain of −1. If some other gain is required a potentiometer is used before the amplifier. For a gain of −75.



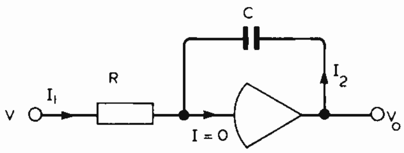
which would normally be drawn



If more than one input is used simultaneously the superposition theorem applies and the stage becomes a summing amplifier.



Summing integrator. To obtain an integrator a capacitor is connected in the feedback path.



Sum the currents at the input to the op-amp to zero, $I_1+I_2=0$, and as a virtual earth exists at summing junction

$$\frac{V}{R}+\frac{C\,dV_0}{dt}=0$$

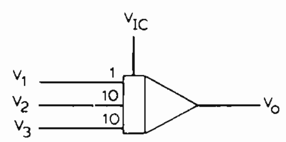
$$\text{hence } V_0=\frac{-1}{CR}\int V\,dt$$

in words, the arrangement integrates and also scales by the factor $1/CR$.

The integral as given is an indefinite one. In practice the integration must commence from some value and this is the initial condition or boundary value in a mathematical solution. An integrator circuit for use on an analogue computer is arranged so that an initial condition can be introduced. This initial voltage is sensed and the output of the integrator at the start of the computation becomes -1 times this value. Immediately computation has commenced it is then ignored and the rate of integration depends on the input signal and the scale factor $1/CR$. Thus the integrator produces

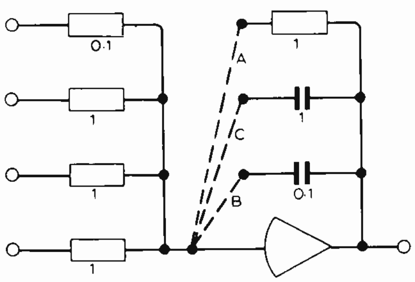
$$V_0=\frac{-1}{CR}\int_0^t V_1\,dt$$

A typical value for C is 1µF, thus choice of R of 1MΩ gives unity gain; other gains are possible in similar fashion to that used for the summing amplifier. A diagrammatic representation of a typical integrator is



$$V_0=-\int_0^t (V_1+10V_2+10V_3)\,dt-V_{IC}$$

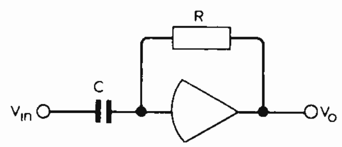
Generalised circuit for integrator or amplifier.



The capacitors and resistors are annotated not in their absolute values but in their relative values as these are less cumbersome to handle. To use the circuit as an amplifier link by external patching the summing junction to the feedback resistor. The op-amp can now be used as a summing amplifier with four inputs of gain 10, 1, 1, 1 by making the link A. Linking the summing junction to the 0.1 capacitor with link B gives four integrating inputs with gains of 100, 10, 10, 10. Using the 1.0 capacitor and link C gives integration with gains of 10, 1, 1, 1.

The initial condition voltage is applied to the input marked IC either directly from the machine voltage supply or via a potentiometer as required. When the initial condition required is zero the IC socket may be left unconnected, but it is preferable to connect the socket to earth: this ensures slightly quicker resetting times. The remainder of this section may be omitted on first reading.

Differentiator. To obtain a differentiator replace the input resistor of the amplifier circuit with a capacitor.



Summing currents at the junction

$$\frac{C\,dV_{in}}{dt}+\frac{V_0}{R}=0$$

$$\text{hence}\qquad V_0=-RC\frac{dV_{in}}{dt}$$

the arrangement differentiates and has a multiplying factor of RC. The differentiating circuit is rarely used and is to be avoided if at all possible. (This is usually possible by re-writing the equations in integral form). The differentiator introduces unwanted noise into the solution. Any noise present at say, mains frequency at the input of a differentiator will be amplified far more than any wanted signal at a lower frequency because its gain increases with frequency. Thus it is possible to have a differentiator output which has more noise than signal.

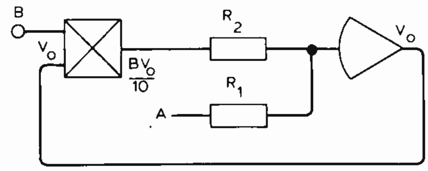
Multiplier. A four-quadrant multiplier will multiply together the instantaneous values of two inputs of either sign and produce the product at the output which is of the correct sign.

Analogue computers operate within certain prescribed voltage ranges, usually ±10V or ±100V depending on the type of the machine. As both of the inputs to the multiplier can lie within this range, to restrict the output to the same range the multiplier function is normally

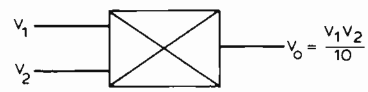
$$V_0=\frac{V_1V_2}{10}\text{ for a 10V computer}$$

$$\text{or } V_0=\frac{V_1V_2}{100}\text{ for a 100V computer}$$

where V_1 and V_2 are the instantaneous values of the two inputs and V_o the instantaneous value of the output. (Use of a ±10V computer is assumed.) The symbol normally adopted for a multiplier is



The multiplier may be used for other functions, for example to obtain A/B



At the summing junction

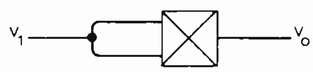
$$\frac{A}{R_1}+\frac{BV_0}{10R_2}=0$$

$$\therefore V_0=-\frac{A}{B}\cdot\frac{10R_2}{R_1}$$

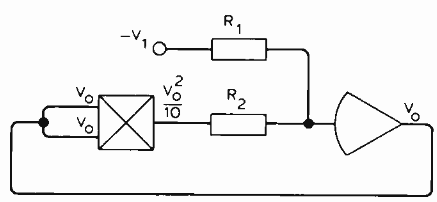
$$\text{and if } 10R_2=R_1 \text{ then } V_0=-A/B.$$

For correct operation as a divider the circuit must remain stable and hence the loop gain must be negative. This means that A and B must have the same sign. In addition B must not approach zero otherwise V_o can easily become outside the ±10V computing range.

For squaring the inputs to the multiplier are connected together



The square root uses an operational amplifier as well



The negative of the number to be rooted is required as input, then at the summing junction

$$\frac{v_1}{R_1}+\frac{v_0^2}{10R_2}=0$$

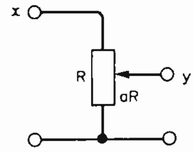
$$v_0=\sqrt{\frac{10R_2v_1}{R_1}}$$

$$\text{and if } 10R_2=R_1 \text{ then } v_0=\sqrt{v_1}.$$

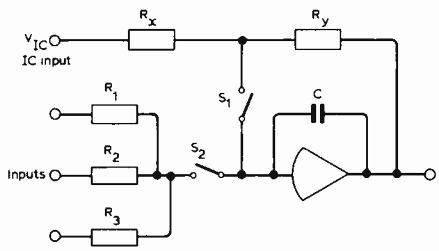
Operational modes

There are various modes of operation the computer can be put through to obtain a solution to a previously obtained interconnection diagram.

Potset. In this mode all the potentiometers are set up to the values allocated in the patching diagram. The output of the potentiometer is $y = ax$ for $a < 1$, assuming zero loading on the potentiometer by the next stage. (The potentiometers are set electrically, not mechanically.)



Reset or initial conditions mode. Initial condition circuits can take various forms but the principle may be illustrated thus



At $t<0$ S_1 is closed and S_2 open. R_x and R_y of equal value establish the voltage $-V_{IC}$ at the output of the op-amp and hence integration will start from this.

Compute, operate or normal mode. For this S_1 is opened, S_2 is closed and computation commences and continues until stopped by the operator.

Hold. The computation can be stopped at any time by switching to hold. This opens S_2 and the charge stored at the moment of switching is held on all capacitors. All points in the circuit remain at the voltage at the moment of switching. The hold may be sustained for some tens of seconds with most computers.

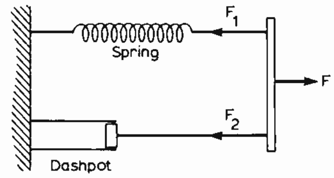
Repop or repetitive operation. With many problems the integration leads to a steady-state value after a few seconds of computing and there is no virtue in sustaining the computation. It is useful to be able to re-sense the initial conditions and repeat the solution. This can be done many times per second (variable control) by electronic operation of S_1 and S_2. The multi-computation may then be fast enough to display on an ordinary oscilloscope using the external triggering facility.

PROGRAMMING TECHNIQUES

An analogue computer programme consists of a drawing of the blocks required and the interconnections necessary between them to solve an equation. This diagram is often called the problem patching diagram as it gives details of the interconnecting patching links which are used on the actual machine. To illustrate its application firstly consider the first-order differential equation.

First-order equations

A parallel mechanical system which links together a spring and a dashpot consists of a bar B of negligible mass attached to a spring and a damper. The other ends of spring and damper are held fixed. The spring is initially unextended. If a steady force F is applied to the bar B, what will happen to the bar B as a function of time?



Plainly the restraining forces F_1 and F_2 balance the applied force F, so $F=F_1+F_2$. F_1 is the stiffness force kx newtons and F_2 the damping force $a\,dx/dt$ newtons, where a and k are constants and x is the displacement of the bar. Hence

$$F = a\frac{dx}{dt} + kx,$$

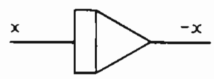
normally written

$$F = a\dot{x} + kx$$

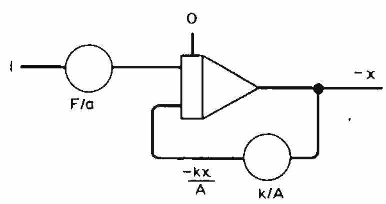
Initial displacement is $x=0$, usually written $(x)_0=0$. For analogue solution this equation is re-written with the highest differential on the left-hand side

$$\dot{x} = \frac{F}{a} - \frac{k}{a}x$$

Integrating $\dot{x}$ to obtain x also introduces a sign change.



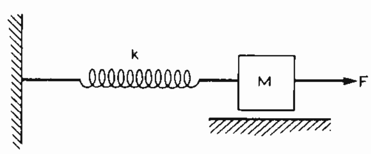
Multiply the output of this integrator by k/a and add F/a to obtain its own input.



Note the addition of the IC $x=0$ at $t=0$. This is the problem patching diagram. When implemented in hardware on the computer x may be obtained as a function of time by monitoring the output of the integrator with an oscilloscope or pen recorder.

Second-order equations with zero damping

Consider a mass m on a frictionless plane which is attached by a spring, stiffness k to a wall. This illustrates the solution of the simple harmonic motion equation.



The equation of motion using Newtons second law is $m\ddot{x} + kx = 0$. Assume that $k/m = 1$ to make things a little easier thus $\ddot{x} + x = 0$.

The solution to this equation is

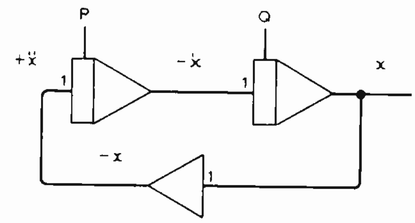
$$x = A\cos t + B\sin t$$

the values of A and B depending on the initial conditions of the problem. If $(x)_0 = 0$ and $(\dot{x})_0 = 10$m/s, i.e. initial displacement zero, initial velocity 10m/s, then $x = 10\sin t$. If the initial conditions were $(x)_0 = 10_m$ and $(\dot{x})_0 = 0$, then $x = 10\cos t$. We should be able to obtain these solutions by the analogue method.

Firstly, re-write the equation with the highest derivative on the left-hand side,

$$\ddot{x} = -x$$

Two successive integrations gives x from $\ddot{x}$



The circuit is completed to fulfil the requirements of the equation at the input to the first integrator. By addition of the initial conditions either the sine or cosine solution can be obtained; $x = 10\sin t$ for $P = 10$V, $Q = 0$ and $y = 10\cos t$ – for $P = 0$, $Q = -10$V.

By assuming $k/m = 1$ the angular frequency has been set at unity i.e. $f = 1/2\pi$ Hz.

Amplitude scaling

The arbitrary choice of scale factors in the previous problem ($1V \equiv 1m$ and $1V \equiv 1m/s$) must normally be avoided; it may lead either to the solution being outside the voltage range of operation or alternatively being so small as to be lost among the inherent noise.

Two main types of analogue computer in use have the voltage ranges $\pm$ 100V and $\pm$ 10V. Assuming the last-mentioned value, an amplifier modelling velocity cannot cope with a maximum output of 20m/s if the scale for velocity is $1m/s \equiv 1V$. In such circumstances we are compelled not to compute v but $v/_2$ and then the amplifier output will not exceed the specified limits. This restriction also applies to initial condition voltages. It may also be necessary to re-scale a problem to ensure that the initial conditions can be handled by the amplifiers.

Generally, scale factors 1, 2, 5, 10 are used, plus multiples and sub-multiples of these by a factor of 10. The factors are always chosen to make the maximum values of the problem lie within the operating range with maximum ease in interpreting results. For example if in a dynamics problem the expected maximum values were x_m 0.1m, $\dot{x}_m$ 5m/s and $\ddot{x}$ 100m/s^2 one would not compute x_m, $\dot{x}_m$ and $\ddot{x}_m$ but $10x$, $2\dot{x}$ and $\ddot{x}/10$. These values are bracketed and called the computed variables $(10x)$, $(2\dot{x})$, $(\ddot{x}/_{10})$.

The task of obtaining the maximum values can be a difficult one. A first approach is to re-examine the original physical problem and see if there are any constraints which would lead to a choice in maximum values. If there are none, try mathematical analysis of the problem equation on one of the following lines.

Equations with r.h.s. zero

There are two types, the first of the form $\ddot{x}+9x=0$, i.e. second order but zero damping and the second, $\ddot{x}+5\dot{x}+9x=0$, with damping. The first case has a sinusoidal solution of the form

$$x=A\sin 3t+B\cos 3t.$$

The initial conditions given for the problem lead to the values of A and B. The substitution and differentiation values for x_m, $\dot{x}_m$, $\ddot{x}_m$ are obtained. So it appears one needs to know the solution before sensible values of scale factors can be chosen. This is true for the simple case, but it is necessary to compute the solution even though the answer is known, should x or its derivatives be required as inputs elsewhere.

In the second case, the maximum values will be no higher than those for the undamped version of this equation and would be taken for a first estimate, the problem run and re-scaled if necessary.

Equations with r.h.s. constant

If the constants in $A\ddot{x}+B\dot{x}+Cx=F$ form a monotonic series, i.e. gradually increase or decrease in amplitude from left to right, then the "equal coefficient rule" applies which states that the maximum value of x is no greater than $2F/C$, of $\dot{x}$ is no greater than F/B, of $\ddot{x}$ is no greater than F/A; higher coefficients follow the same pattern. If the coefficients do not form a monotonic series this is still the best starting place, but it may be necessary to re-scale the problem after the first computing run.

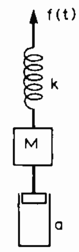
Equations with r.h.s. = f(t)

Estimate the maximum value of f(t) and apply the equal coefficient rule. Re-scale if necessary. If the right-hand side is to be generated on the computer, rather than supplied as an external forcing function, then treat $A\ddot{x}+B\dot{x}+Cx=F$ and $f(t)=F$ as separate circuits to be patched, taking F in each case as the estimated maximum value of the opposite side of the equation, and then making the interconnection. Re-scaling may be necessary.

Second-order equations with viscous damping

Consider the mass-spring system with viscous damping indicated

The free end of the spring is moved according to f(t) whilst x is the displacement of the mass m. The equation of motion is $m\ddot{x}=-k(x-f(t))-a\dot{x}$ or $m\ddot{x}+a\dot{x}+kx=kf(t)$



Assume that the mass is initially at rest and measure x from this datum, hence $(x)_0=0$ and $(\dot{x})_0=0$. Taking the values $m=10$kg, $a=30$Ns/m and $k=100$N/m gives

$$10\ddot{x}+30\dot{x}+100x=100f(t).$$

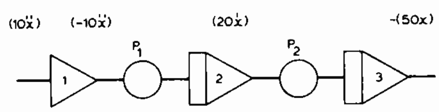
Assume that f(t) is a step displacement of 0.1m. Thus $\ddot{x}+3\dot{x}+10x=1$ is the equation of motion for this particular problem. Using the equal coefficient rule $x_{max}=0.2$, so compute $(50x)$, $\dot{x}_{max}=0.33$, so compute $(20\dot{x})$, and $\ddot{x}_{max}=1$, so compute $(10\ddot{x})$. The initial conditions are now $(20\dot{x})_0=0$ and $(50\ddot{x})_0=0$. Substitution of these variables into the problem equation, taking care to re-balance the equation, leads to

$$\frac{(10\ \ddot{x})}{10}+\frac{3(20\ \dot{x})}{20}+\frac{10(50\ x)}{50}=1$$

Re-writing to obtain the patching or machine equation

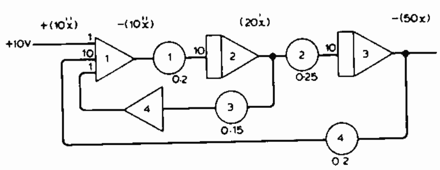
$$(10\ddot{x})=10-1.5(20\dot{x})-2(50x)$$

which is implemented by first drawing the forward computing path without interconnections and labelling the outputs of the amplifiers and integrators according to the computing variables



Next choose the interconnecting potentiometers and integrator gains to suit, i.e. $P_1=0.2$, with gain of amplifier 2 as 10, and $P_2=0.25$ with gain of amplifier 3 as 10. This completes the forward path.

The machine equation is now satisfied using feedback loops to the input of amplifier 1 and the initial conditions added.



Outputs for $50x$, $20\dot{x}$, and $10\ddot{x}$ can be obtained simultaneously. The machine equation summing could be performed at the input to integrator 2, thus dispensing with amplifier 1 and transferring the position of amplifier 4 to the other feedback loop. This would be the method usually adopted, but it does add an additional complication to the scaling procedure.

Two further worked examples follow which illustrate variations to the basic design procedure shown here.

Time scaling

The time occupied by the physical problem and the time over which it is convenient to look at it on the computer may differ enormously. One may require to compute in say 30 seconds a problem which in real life occupies only micro-seconds (a chemical reaction) or years (a biological or astronomical problem). It is then necessary to compute the equations not in real or problem time but in a scaled version of it, called computer time.

In addition it may be necessary to apply time scaling because of one's choice of ancillary equipment. Many of these, which are used to obtain a hard copy of the computation, cannot respond outside the frequency range 0 to 20Hz. Thus the solution may have to be slowed down to suit the equipment.

Let problem time be t_p and computer time be t_c, then to scale up a solution to take place in a shorter time, and taking a scale factor of ten as an example, $10t_c=t_p$.

$$\text{Then}\ \frac{dt_p}{dt_c}=10\ \text{and}\ \frac{dx}{dt_c}=10\frac{dx}{dt_p}$$

More generally, it can be shown that for the derivatives of x

$$\frac{d^nx}{dt_c{}^n}=10^n\frac{d^nx}{dt_p{}^n}$$

There are two ways to implement time scaling, one could introduce the equations given above during the mathematical formulation of the machine equation. More simply, one could alternatively ignore time scaling initially and produce the machine equation as in previous work. Then to change the time scale alter the gains of all the integrators by the same amount.

Application of time scaling

Produce a solution of the problem shown in Fig. A, in one tenth of the real-time solution.

Machine equations is

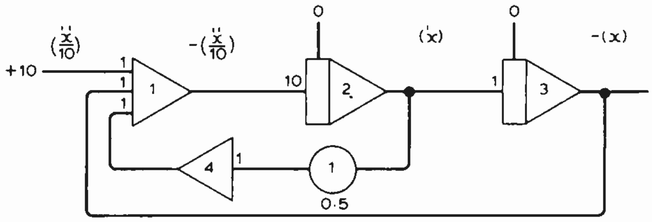
$$\left(\frac{\ddot{x}}{10}\right)=10-(x)-0.5(\dot{x})$$

When $t_p=t_c$, $(\dot{x})_0=(x)_0=0$. To speed up the solution by ten times, make $t_c=t_p/10$ and change integrator gains by the same factor.

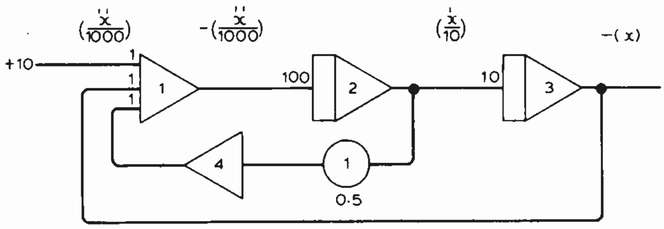
$$\ddot{x}=\frac{d^2x}{dt_c{}^2}=100\frac{d^2x}{dt_p{}^2}\ \text{and}\ \dot{x}\doteq\frac{dx}{dt_c}=10\frac{dx}{dt_p}$$

So the new machine equation is

$$\left(\frac{\ddot{x}}{1000}\right)=10-0.5\left(\frac{\dot{x}}{10}\right)-(x)$$



a



b

WORKED EXAMPLES

1: Initial conditions too high. Produce a suitably-scaled patching diagram to solve

$0.5\ddot{y} + 2\dot{y} + 15y = 4$ with $(\dot{y})_0 = -3$, $(y)_0 = 1.5$

Estimate maximum values: $\ddot{y}_m < 8$, use $(\ddot{y})$ for computation, $\dot{y}_m < 2$, use $(5\dot{y})$, and $y_m < 8/15$, use (10_y).

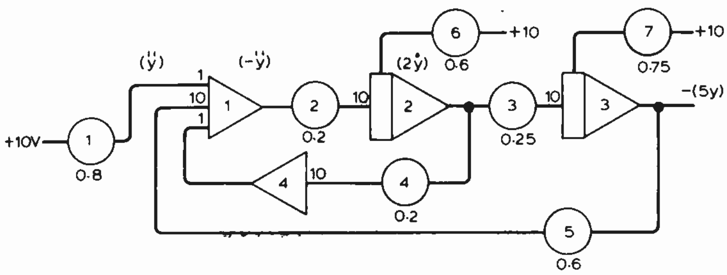
The initial condition inputs are $(5\dot{y})_0 = -15$ and $(10y)_0 = 15$ but both of these are too high for a 10V computer so the choice must be amended. For $(\ddot{y})$, $(2\dot{y})$ and $(5y)$ the initial conditions will be $(2\dot{y})_0 = -6$ and $(5y)_0 = 7.5$, well within the limits of the computer.

The scaled equation becomes

$$0.5\,(\ddot{y}) + \frac{2}{2}\,(2\dot{y}) + \frac{15}{5}\,(5y) = 4$$

giving the machine or patching equations as

$$\ddot{y} = 8 - 2(2\dot{y}) - 6(5y).$$



2: Second-order equation with r.h.s. zero. The equation of motion of a mass which starts from rest at a distance 5 cm from a datum is

$$\ddot{x} + 9\dot{x} + 64x = 0$$

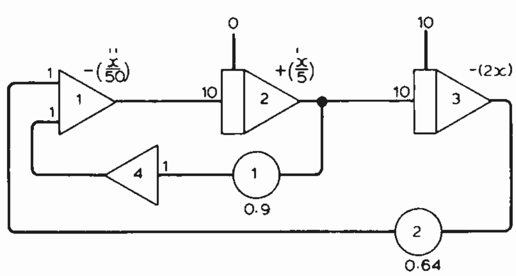
Construct an analogue computer solution to obtain x as a function of time.

Estimate maximum values by assuming no damping; i.e. $\ddot{x} + 64x = 0$. This has a solution of the form $x = A\sin 8t + B\cos 8t$. Initial conditions are $(\dot{x})_0 = 0$ and $(x)_0 = 5$ so, by substitution at $t = 0$, $B = 5$ and $A = 0$, and the undamped solution is 5 cos $8t$. Hence make $x_m \leqslant 5$, $\dot{x}_m \leqslant 40$ and $\ddot{x}_m \leqslant 320$ and compute $(2x)$, $(\dot{x}/5)$ and $(\ddot{x}/50)$ with initial conditions $(\dot{x}/5)_0 = 0$, $(2x)_0 = 10$. The scaled equation becomes

$$50\left(\frac{\ddot{x}}{50}\right) + 45\left(\frac{\dot{x}}{5}\right) + 32(2x) = 0$$

and the machine or patching equation is

$$\left(\frac{\ddot{x}}{50}\right) = -0.9\left(\frac{\dot{x}}{5}\right) - 0.64\,(2x)$$



with $\left(\frac{\dot{x}}{10}\right)_0 = (x)_0 = 0.$

Hence the equations are identical in magnitudes but the solution, Fig. B, is ten times as fast.

Ancillary equipment

The variation of voltages in an analogue computer circuit cannot be seen except by using them to drive some ancilliary equipment. Very often, especially with electromechanical output devices, the operating speeds of this equipment severely limits the maximum frequency which can be present in the analogue solution. Thus time scaling becomes unavoidable.

An oscilloscope is useful because it can provide a visual presentation of computing variables with comparatively simple setting up procedures. A double-beam oscilloscope will display two analogue variables simultaneously in correct time relationship with each other. If the computation is slow then a storage oscilloscope with slow sweep speed is used with the computer in the compute mode. Faster computations can be displayed with increased sweep speed on an ordinary oscilloscope using the Repop mode and synchronizing the computations to the oscilloscope time-base sweep. □

David Dawe studied for higher national certificate in electrical and electronic engineering at Devonport Dockyard Technical College. He then won a Ministry of Defence sponsorship at Southampton University to read electronic engineering and subsequently spent two years as design authority for new audio and recreational tv systems for the Navy at Ministry of Defence headquarters in Bath. He now lectures in electronics and computing at Cornwall Technical College.

RCA says "Video disc system has enormous potential"

Speaking at the 4th International Videodisc and Videogram Conference in New York city, Herbert S. Schlosser, RCA's executive vice-president, claimed that the company's "SelectaVision" video disc system will be "world-wide in scope and its potential for entertainment and education is enormous."

Although he did not diclose specific marketing plans for the system overseas, Mr Schlosser said RCA is committed to the development of its system for Europe and that technical development work has been under way for many months. He said "RCA intends to take a leadership role in developing the market for the video disc in Europe, both by direct participation and through licensing arrangements for both discs and players with other participants.

Development of the RCA system in Europe will be supported by a variety of programming and Mr Schlosser said that programmes produced in Europe will also find their way back to the USA. RCA has already obtained licenses to market in the US much European-produced material including Sir Laurence Olivier in "Henry V", "Hamlet" and "The Merchant of Venice."

One reason there will be a big demand for the video disc in Europe, he said, is that European viewers cannot receive the same number of tv channels as their American counterparts. In the US, about 50% of households can receive nine or more stations with those in New York and Los Angeles capable of receiving 15 different broadcast stations and many more over cable systems.

In contrast, a household in the middle of London can choose from only three channels and this is also the case in Paris and Hamburg. Furthermore, in Britain and France there is virtually no programme activity on weekdays until noon, while Germany has only limited morning programme activity.

"Thus", Mr Schlosser said, "the video disc has great potential in Europe. It is a way for consumers to choose programmes they want and to play them when they want, day or night". RCA's catalogue will offer feature length films, popular and serious music, children's programmes, television feature material, d.i.y. and highlights of sporting events.

The RCA VideoDisc employs a "capacitance" technique in which a grooved disc is tracked by a diamond stylus and has been in development for 15 years. The re-play unit is attached to a colour or monochrome tv receiver and will carry a suggested retail price under $500 in the US. Market introduction of the system in the US will take place in the first quarter of 1981 and first units will be delivered to distributors for demonstration in December 1980.

● *A co-operation agreement was recently announced by Thorn EMI and JVC, the Japanese Victor Company, to manufacture and distribute JVC's video discs and the machines which will use them.*

The JVC VHD/AHD (video high density/ audio high density) system is expected to be introduced into Europe and the US by late 1981 and the UK could well become a manufacturing base, with automation in Thorn-EMI being left to "standard" products and skilled labour being shifted to the video disc side.

Philips, whose system is scheduled for launch in mid 1981, plans to use a factory in Lancashire for the pressing of discs.

Computer watches the factory

Both temperature and ventilation in the petrol engine workshop of the Scania division of the Swedish Saab-Scania group in Stockholm, are now under the control of a minicomputer.

Drawing on real-time data supplied by a network of sensors, temperature and air flow are continuously monitored and compared with outside levels; the computer continuously adjusts the working of fans and air heaters in order to maintain optimum working conditions at minimum power consumption, with a claimed 10% reduction in heating oil consumption.

During the winter months indoor temperature can be held down when work is not in progress as well as during the night, at weekends and on public holidays, ready to be started up at just the right moment to ensure that premises are at a suitable temperature for human habitation.

In summer, the computer makes sure that cold night air is fed in to reduce the temperature, thereby postponing the switch-on of cooling systems in the daytime.

Construction of third satellite aerial begins

Work has started on another aerial to supplement the two already in use at the Post Office's satellite earth station at Madley in Herefordshire. The new aerial will work to a satellite in geo-stationary orbit 23,000 miles above the Indian Ocean. The first Madley aerial, in operation for more than a year, also works to a satellite over the Indian Ocean and the second, which went into operation earlier this year, beams telephone calls to a satellite positioned over the Atlantic.

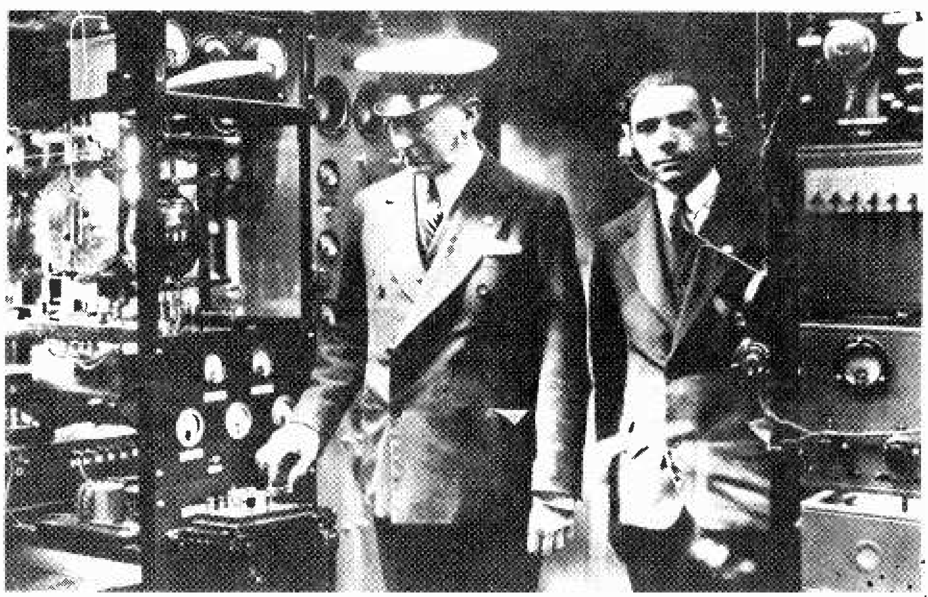
Increasing telephone traffic has made the new aerial essential, with more than a million calls a month being made between Britain and 40 other countries. Call density to some countries is growing at a rate of 30% per year and this is matched by increases in telex and data traffic. Intercontinental phone calls have reached 4 million a month with 60% going by satellite either through Madley or the Goonhilly earth station in Cornwall.

The aerial project, which will cost £7.5million, is due for completion by the contractors in mid-1981. £3 million worth will be completed by Marconi Communication Systems, the remainder being in the hands of Mitsubishi Electric Corporation via a British subcontractor, IDC Construction.

There are now eight satellites operating in the Intelsat (International Telecommunications Satellite Organisation) global system and, in addition to transmitting telephone and telex calls, live tv programmes are carried. So far, the PO has spent £17 million at Madley under its £1,000 million a year programme of investment.

The "Madley Three" aerial will have a dish diameter of 105ft (32m) and will be capable of transmitting 2,000 telephone calls and two tv programmes simultaneously. A feature of the design is that the structure has been modified to withstand higher wind pressures than the previous two. Tubular steel is to be used instead of angle steel, making it resistant to winds gusting up to 45m a second.

Working will take place initially to an Intelsat IV A, moving later to an Intelsat V, capable of carrying 12,000 calls simultaneously.



Guglielmo Marconi, with his personal radio operator Adelmo Landini, aboard the Elettra in Genoa Harbour, about to activate the switch which, by radio remote control, turned on the lights at the Electrical and Wireless Exhibition in Sydney City Hall. The event took place on 26th March 1930, and Marconi had designed the selector device himself. (See "Indian scientist wins Marconi award".) Photo, courtesy of GEC-Marconi Electronics Ltd.

LETTERS TO THE EDITOR

UHF CITIZENS' BANDS

Mr Hooper's account (February letters) of the success of the u.h.f. citizens' band in Australia (not the world's first by the way — that honour probably belongs to the United States, which had Citizens Radio Class A at 462.55 to 462.725MHz from well before 1973) is interesting in that once again it shows there are several sides to a story and some silver clouds have dark linings.

In Canada we have recently been discussing the possibility of a new citizens' band at 900MHz. In commenting on this, our Council made a suggestion that if such an allocation is made, the modulation system should be different from that used on other services on adjacent frequency bands.

Our reason for this was that we understand there is a problem in Australia in that cheap equipment produced for the citizens' band is often used illegally on other nearby bands, instead of equipment meeting the proper type-approval specification applicable to those bands. Mr Hooper's comment about the u.h.f. c.b. equipment being used on the amateur bands reminded us of this.

This is not to say u.h.f. c.b. is a bad thing; it certainly is a better bet than 27MHz, if a frequency slot can be found which does not disrupt other services, and if something is done to prevent the c.b. equipment from becoming the standard equipment for commercial services nearby.

Bob Eldridge
Western Canada
Telecommunications Council
Burnaby
B.C., Canada

CITIZENS' BAND RADIO GROUP

I represent a group of people in North London keen on the establishment of citizens' band radio in this country. We see recent events (the favourable attitude of the new government, the statement made by way of ministerial reply to the Adjournment Debate on 6th December last, the establishment of national committees inside and outside parliament) as giving realistic hope that legalisation is imminent and we see the time as ripe for a new emphasis, which our group will express.

Some of us are licensed amateurs – others are technologically untutored – and most are already members of existing groups, with whose activities we do not see ourselves as competing. We will wish to co-operate fully, in word and deed, with other local organisations and with the National Committee for Legalisation in the present campaign for early government action.

Our main aims, however, will be forward-looking in anticipation of the early days of the new service after it is established. Technically, we will fight no rearguard action for 27MHz a.m., for which we see no justification on technical or other grounds; sure that the British service will be at higher frequencies and with f.m. and/or s.s.b. only, we shall be informing ourselves by reference to Australian experience and USA research. Socially, we shall be studying the safety, utility and community aspects of existing services in other countries and considering similarities and differences in what is likely to be appropriate here; and we shall give particular attention to the less obvious applications – besides those concerned with motoring use – especially applications for the benefit of such groups as the elderly, the disabled and the housebound. We shall be in touch with REACT International, make contact with local RSGB groups, study the available material on US Federal volunteer programmes such as NEAR (National Emergency Aid by Radio) and look at the European c.b. scene.

Would anyone interested in joining the group and able to reach meetings in the Barnet area once or twice a month please write to BM/NSCJ, c/o British Monomarks Ltd, London WC1.

(Name and address supplied)

WET AERIAL INSULATORS AT SEA

It is not uncommon to find in text books of the spark transmitter era some reference to "salt and soot shorting out the insulators of ships' aerials". Designers of the day took heed, usually making the aerial an "L" or "T", slung between high masts with strain insulators at either end and the down lead terminating at a feed-through insulator located at the highest point on the bridge, shielded from spray by a large brass bell. There were three points of possible leakage only, placed at maximum distance from the source of contamination.

Later text books ceased to dwell on "what everybody already knew" and gave the space to other aspects of a rapidly developing technology. As long as ships had the bridge amidships and two masts, this style of aerial was traditional, but about 1960 the shape of ships began to change; accommodation began to move aft, masts were abolished or merged with funnels. Aerials had to be hung wherever they would fit, with insulators at each zig and zag. Optimum placement of feed-through insulators was abandoned.

There is evidence that some such aerials, when wet with spray, undergo such a large shift in characteristics that they will no longer match the transmitter pi-coupler, or to put it in plain language, transmitters are rendered useless in bad weather. I refer readers to my article in the September 1979 issue of *Nautical Review* and my letter in your June 1979 issue.

Since modern 'sophisticated' manuals on radio technique fail to even recognise the *existence* of the "wet insulator" problem, it is necessary, in seeking an explanation of the nature of the "leakage", to turn to the fundamental literature on the physics of electrolytes. Most of these books have long since been removed from library stacks as "obsolete", but can still occasionally be found in back street second-hand bookshops.

One of the most important of these books is "Electrolytes", published in 1932 by Prof. Hans Falkenhagen of the University of Cologne, dealing with the work of a number of German researchers into the conductivities of a wide range of electrolytes at radio frequencies, up to about 60MHz. Falkenhagen found that above about 1MHz, conductivity increases with frequency by up to 50%, and Wien, whose work is also described, found a similar increase of conductivity with increased field strength. The methods used to determine conductivity were indirect, depending either on heat generated in a cell containing the electrolyte placed in an r.f. field, or on the damping of the amplitude of resonance peaks. Falkenhagen notes that ". . most of the earlier methods used for determining conductivities with direct currents are inapplicable at high frequencies . .". (May government radio inspectors remember that when attempting to measure the quality of insulation of ships' aerials.)

In 1907 the Carnegie Institute of Washington published a report by Arthur A. Noyes on measurement of the conductivities of a vast number of aqueous solutions over a wide range of concentrations and temperatures. Noyes tells us that "The conductance was measured by the ordinary Kohlrausch-Wheatstone Bridge method, using the induction coil and telephone", and this leads us to "Electrochemistry and Electromechanical Analysis" by Dr Henry Sand, who tells us that "... a difficulty inherent in the measurement of electrolytic resistances and conductivities is due to polarization of the electrodes. This difficulty was overcome by Kohlrausch in 1879 by the introduction of alternating current in which equal and opposite pulses neutralise each other, ... expressed in greater detail, each pulse may be assumed to produce a polarization proportional to the amount of current that has passed through the electrode, the latter thus acting as a *condenser*. The whole cell therefore behaves to alternating current as a *resistance in series with a large capacity* . . ."

In his "Text-Book of Practical Physics", 1919, Lt.-Col. W. Watson goes further:

"The difference of potential between the electrodes of an electrolytic cell through which a current i is passing, when the resistance of the electrolyte is R is given by:–

$$E = Ri + P\int i\,dt$$

where P is a constant which depends on the area of the electrodes . . . and the electrolyte. Suppose that alternating e.m.f. of frequency $p/2\pi$ applied to the terminals of the cell . . . if applied e.m.f. follows simple harmonic law it may be represented by $E_0 \sin pt$ . . . . . .

$$Ri + P\int i\,dt = E_0 \sin pt$$

Differentiating with respect to time

$$R\frac{di}{dt} + Pi = E_0\, p \cos pt$$

The integral of this equation is

$$i = \frac{E_0}{R\left[1 + \frac{P^2}{R^2p^2}\right]^{\frac{1}{2}}} \sin(pt + \theta)$$

Where $\tan\theta = \frac{P}{Rp}$ . . . ."

p corresponds to ω and P could be rewritten k/c. The equation can then be written:-

$$i = \frac{E_0}{R\left|1 + k^2\frac{X_c^{\,2}}{R^2}\right|^{1/2}} \sin(\omega t + \theta)$$

where $\tan\theta = k(X_c/R)$

A frequency of 1kHz was considered adequate for the measurement of conductivities of cells of a few hundred ohms between electrodes. If the capacitive reactance of the cell at that frequency introduces negligible error, then that implies a large capacitance. The ability of an electrolytic cell to behave as a capacitance might be called "The Kohlrausch Effect". An aerial insulator coated with a film of sea-water constitutes such a cell; the actual area of its electrodes is probably quite small due to the customary heavy corrosion of copper at sea. (P is larger.) The presence of one or more such 'cells' on a ship's aerial may well alter the capacitance of that aerial to the extent that the pi-coupler of the transmitter connected to it, operating at about 500kHz, can no longer be dipped to resonance.

Sea water is certainly an excellent electrolyte. In every 1000 grams of the water of the Atlantic Ocean there is dissolved 27.37 grams of sodium chloride, 3.36 grams of magnesium chloride, 2.24 grams of magnesium sulphate, and significant amounts of 8 or 9 other salts. The concentration on the insulator surface will possibly be greater due to evaporation by action of the wind.

John Wiseman
London E3

Further reading

"Electrolytes," Hans Falkenhagen, OUP, 1934 (English edition).
"The Electrical Conductivity of Aqueous Solutions," Arthur A Noyes. Carnegie Inst. 1907.
"Electrochemistry & Electro-Chemical Analysis", Henry J Sand, London 1941.
"A Text Book of Practical Physics," Lt-Col. W. Watson, London 1919.
"La Concentration En Ions Hydrogene De L'Eau De Mer — Le pH", R. Legendre, Paris 1925.

EDUCATION FOR INTEGRATION

Your leader in the March issue, "Education for Integration", left me wondering whether *Wireless World* is positive, neutral or negative about the "chip", and its manifestations. I don't expect you to be totally polarised, but I did expect a more direct lead on the subject than this piece appears to offer. It is a great pity that its rhetorical force was not backed up by a coherent set of ideas rather than the tango which emerged from "doom-laden prophecies" (the chip is O.K.) through "its lineage and capabilities do not warrant..." (the chip is unimportant) to "the microprocessor is not a work of the Devil" (a negative proposition, presumably from Kant?)

You accuse those "non-engineering persons" who dare to venture an opinion of failing to appreciate that their technical ignorance renders them incapable of forming valid opinions on the subject of the chip in general and its eventual impact on employment in particular. This sentiment is enlarged upon in a piece of expert nit-picking which points out that these n.e. persons have not yet (silly people), sorted out the difference between decade counters, op-amps and microprocessors. It seems that one needs to be told which is which and when to jump or stand at ease by the informed engineering club member.

The most glaring assumption is that which claims that a system cannot be recognised or its movement predicted unless the entire device structure is intimately understood. I don't need an engineer's intimacy with a London bus to know that unless I make the right moves when crossing the road I'm going to get flattened. In a similar fashion, it is becoming increasingly clear that those who can see the wood for the trees (without necessarily knowing how to measure the height of each pine), such as some of those who "walk out on strike whenever new technology is in the offing," are quite capable of foreseeing accurately the shape of the juggernaut which might lumber its way across their jobs, if the decisions of the professional and business manipulator are allowed to forge ahead unchallenged.

It's now pretty certain that, unlike the sentiment you have expressed, the next decade *will* see the retention of a smaller workforce, especially in the clerical trades, whether such workers are technically informed or not. The waving of IEE flags won't save a single job! Your claim that those who know are better able to see that things will be O.K. and, if they aren't, everyone will simply have to change, qualifies as both red herring and "inevitable march of science" dictum, but doesn't really help in the debate.

The Conservative Party's working report of April 1979, "Proposals for Information Policy", suggests in a section on trades unions that "certain computer operations, all telecommunications and some government publications and information services would be included among the limited category of vital services from which withdrawal of labour would be illegal." This indicates the importance of the issue and supports my main point because those whom you accuse of rampant ignorance — cabinet ministers, trade union leaders etc — although prone to ineffective or naive utterances on the subject, nevertheless do clearly appreciate the wider nature of the new systems even if they think Boolean Algebra is an odd modern language.

All the while you continue to carp about ill-informed comment in the media, i.e. that which concentrates on the "wonders of science" type of reporting, and fail to convince anyone that you have a better-considered view of what will probably be one of western industrial society's most far-reaching professional and social upheavals.

I. B. Hawk
Farnham
Surrey

SCIENTIFIC COMPUTER

Like Mr Freeman (February letters) I too built the Adams scientific computer to gain experience in micro-computing, but I came to it from a programming background, wishing to become more acquainted with hardware and also programming at machine code level. I was attracted by the concept of two microprocessors interacting and in my view this works well.

However, the machine has had scant, if any, mention in the micro-computing magazines. Why not? I venture to suggest that this is because (apart from only being available in kit form) there is almost no relevant software available. Effective software takes time and money to develop and most manufacturers adopt existing systems and programs, and encourage others to jump on the bandwagon. Although Mr Adams's BURP works well, with only 26 variables and primitive control statements the machine is no more powerful than a programmable calculator with video display. The monitor is totally non-standard and existing machine code software would require extensive alteration to run under its operating system. Unless and until considerable effort is made modifying other microcomputer operating systems and interpreters to utilise the number cruncher (which ought to be perfectly feasible), Mr Freeman and others like him who want better computing facilities would be well advised to buy one of the more popular machines.

For my part, the machine has certainly fulfilled its original purpose, since the monitor is not at all difficult to understand, analyse or use. My main criticism was the automatic reset within the NMI routine, which I am pleased to see has been removed in the new version. Perhaps one can now program some dynamic video games.

Machine code programming is, however, laborious; you have to write your program on paper, assemble it on paper into machine code, then enter it. All screen listing is in machine code. So you can see what is there, but it is impossible to follow through the steps by looking at the screen because you actually think and program in the assembler mnemonics, not in the derived machine code. Furthermore if you used Mr Adams's boxed coding sheets there is no room for insertion of code during debugging. Here you have to physically move memory contents and check all jumps for altered addresses.

To overcome these difficulties I have written a disassembler/editor. This produces 31 lines on screen, each showing memory address, up to 4 bytes of machine code comprising one instruction, the standard Z80 assembler mnemonics and also, for relative jumps, the destination address. You can amend sections of code whilst looking at the listing on screen and immediately see the new disassembled mnemonics produced. An extremely useful feature for modifying programs is the facility to insert or delete blocks of NOPs (No Operation instruction) anywhere as chosen, automatically expanding (or contracting) the program and altering relative and absolute jump and call parameters as appropriate. In this way you can alter, insert and delete code extremely easily, effectively working in assembler language, instead of unintelligible machine code.

The program occupies just over 2K, which could be placed in r.o.m., and needs only a few bytes of 'scratchpad' r.a.m. and some 'stack' r.a.m. At the moment I load it from tape into r.a.m. but I have over 2½K left which has so far proved enough for my machine code programs under development.

In my view this method of development is ideally suited to this machine as it does not need the extensive r.a.m. storage that an assembler/editor would use in storing the assembler mnemonics and labels. I would be pleased to make it available to any of your readers who might be interested for, say, £5.00 to cover the cost of magnetic tape, photocopying and postage.

Regarding hardware, I am considering expanding the capabilities to include RS.232c communication as an intelligent terminal, by adding u.a.r.ts and using vectored interrupts. I also intend to add a further 1K r.a.m. as alternative development monitor with software select (by gating the enable lines controlled by an output port latch); to extend the v.d.u. memory to 8 bits and adding read-back facility; and possibly also to add a single step facility for debugging machine code programs.

Russell A. Gadd
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TRICKLE, TRICKLE LITTLE CHIP

The first page of *Wireless World* plays an important part in setting the status of the magazine and it is this which has made me a regular reader of the journal. As I write, the editorial page of your November 1979 issue lies in front of me. In the first paragraph of this piece ("Trickle, trickle little chip") your aim, if I am not mistaken, is to illustrate the large reduction in the cost of microprocessors by giving the example of an Indian peasant as a possible but unlikely possessor of one of these devices. As a first class electronics engineer of state level in India, I feel it is my responsibility to remove this type of misunderstanding.

I should explain that I am 20 years old and work as a junior engineer in a computer manufacturing company called Operational Research Group System. I am at present engaged in testing a microprocessor system using an 8080 device.

I have to agree that Europe is leading us in technology by one or two decades, but it doesn't mean you can write this kind of thing. It's a question of the credit of our country and, even more, your knowledge of India and its technical development. At present about a dozen organizations here are manufacturing products using microprocessors.

Mehta Subhash Vrajlal
Baroda
India

INTERFERENCE WITH MSF RECEPTION

With reference to MSF reception in the North-West (March letters), the following comments based on tests near Manchester over the past four years may encourage your correspondents.

Using a ferrite rod aerial assembly as the sole tuning element and a r.f. amplifier, both derived from a design by Bateman[1], followed by a detector designed by Cross[2], reliable reception of the MSF signal has been achieved in the presence of strong signals centred on 61.835kHz. The measured loaded Q of the experimental receiver is 156, with a bandwidth of 385kHz and a rejection of 20dB at 61.8kHz. The signal level presented to the detector is set at 6dB above the trigger threshold, high enough to avoid output jitter yet not so high as to seriously degrade selectivity. Constant input to the detector also minimises complications arising from unequal switching delays at the detector output, an aspect of performance which must be considered when designing the decoders. Interference at 61.8kHz is some 5dB above the 60kHz Rugby signal in this area so the net rejection is about 9dB. Perhaps surprisingly, this has proved adequate for driving fast and slow format decoders, but I would not recommend such a limited margin for a permanent clock.

Further selectivity has been obtained by adding a single tuned stage ($Q=94$) after the aerial (Q now raised to 168 because of improved loading), this reducing the bandwidth to 290Hz, giving 35dB rejection at 61.8kHz. This bandwidth is lower than that adopted by Helsby[3] but a c.r.o. display of the incoming code shows the 5ms pulse – the shortest in the MSF signal – to be clearly delineated. Decoder function has been consistently reliable with this more selective circuit. If only the slow code is required, an even narrower bandwidth might be practicable but I have not tested this possibility.

The 61.8kHz signal from the 100kW[4] transmitter in Fylde is certainly an interference hazard in this district since its reception direction is only 8° from that of the Rugby signal, so little is gained from the directional properties of the typical ferrite rod aerial. Moreover, the hazard will increase if the whole of the transmitter's assigned bandwidth, centred on 61.75kHz, is brought into service[4]. However, as a receiver with a 290Hz bandwidth can deliver the MSF data, reception in difficult areas such as Salford and even Preston seems a possibility. Like Messrs Izattt and Samain, I also wonder if commercial designs, which seem to originate in the South, work successfully in the North-West, especially along the line joining the 60 and 61.8kHz transmitters.

D. J. Jeffers
Cheadle Hulme
Cheshire

References

1. D. A. Bateman, *Wireless World*, Jan 1976.
2. A. F. Cross, *Wireless World*, Feb 1976.
3. N. C. Helsby, *Wireless World*, Aug 1976.
4. Private communication.

I was interested to read the letter from Messrs Izatt and Samain in your March issue. We suffer a similar problem in the area of East Sussex, and have never achieved 100% reception of MSF fast code signals despite repeated attempts during the last four years, using various receiver designs.

As in the Manchester area, we are plagued by another transmitter using an adjacent frequency. This operates irregularly, and is at its most troublesome in the pre-dawn period. Could you or your readers help in identifying this transmitter?

Your correspondents may be interested to know that the most effective method found here for achieving usable MSF reception with the Mullard design is to add a second ferrite rod. In my case this is oriented on Rugby, overlaps the original rod by about 1½in and is bound to it with string.

I imagine that NPL must now possess a considerable fund of information on MSF reception and the various problems encountered. A contribution from them would be of interest to many of your readers.

P. J. Thomas
Seaford
East Sussex

TELETYPE COMPATIBLE TRANSMISSION PROTOCOLS

I am working on a project that involves using v.d.u. terminals in a page transmission mode and I am concerned at the lack of standardisation in Teletype compatible transmission protocols.

There appear to be two main methods of sending the information displayed on the screen. The first is to send literally everything stored in the display memory, a blank line being represented as the number of spaces (ASCII 32) in a full line (usually 80). The second is to compress the data by suppressing trailing spaces; they are represented by either space, carriage return, line feed or just carriage return, line feed. Using the first method, carriage return, line feed may or may not be inserted at the end of a line; this is generally controlled by a switch on the terminal. However, if carriage return, line feed is typed in, it is always sent.

A problem arises at the end of a transmission as there is no easy way of determining when the last character has been sent. Some v.d.u. manufacturers overcome this problem by arranging for the terminal to send an ETX character (ASCII 03), which can easily be decoded in software by the receiver. This is the solution I favour as it provides a positive indication of the end of page. Further, I favour sending an STX character (ASCII 02) before the actual information is transmitted. The reason for this is that, in framing the transmission, substantial immunity to random characters caused by noise is obtained.

These characters must be sent automatically rather than relying on operator insertion as some manufacturers do. The reason for this is that if the operator forgets to insert characters, as will always happen eventually, the system will either lose all the data or will be hung up awaiting an ETX character. To recover from this state the receiver would need to be reset. This presents severe problems if the receiver is remote from the transmitter.

Alternatively a timeout could be used but this again presents problems, especially in terminals that compress the data, as there are often long pauses between characters. Delays of up to 42 characters have been measured. This leads to inordinately long timeouts which are inconvenient and not very easy to implement.

The simplest and most satisfactory solution to these problems is to send an STX character before page transmission and ETX after. These characters are ignored by devices not requiring them, at the most being printed as a space.

I would be grateful for reaction from readers to the above suggestion.

S. A. Jackson
Plessey Communications & Data Systems Ltd
Beeston
Nottingham

JAMMING AMATEUR REPEATERS

Many amateurs claim that "citizens' band" operators are mainly responsible for the jamming and abuse which takes place on GB3SL and other repeaters. The c.b.ers i have met show equal contempt for jamming, both on the two-metre and their own illegal 27 MHz band.

On Sunday February 17th, GB3SL was being jammed by a 'bug'. Other amateurs and myself were on the 'parade' trying to locate the device. Although we tracked the bug down to within a few yards, it took the chairman of the Citizen's Band Radio Action Group to finally spot it.

While all the excitement was taking place a few amateurs who could still access the repeater gave graphic descriptions of their direction finding gear. With such equipment why were these amateurs not on the 'parade' – they must have been within easy travelling distance of GB3SL to be able to access it! Where was the FM Group?

So many amateurs use the illegal c.b. operators as a scapegoat for every irregularity that occur on repeaters. We need less bickering and more action. Only by ignoring the squeakies and the grandads, using effectively your d.f. gear, will things improve. The authorities will not do it: it is up to us all.

R. C. Kennedy, G8UMB
Orpington
Kent

PICOBELS AND MILLIBELS

Peter Moncrieff's letter (March 1980, p 64) can be interpreted so as to unintentionally associate my name with a number of statements with which I disagree. I do agree that broadband frequency response differences of the order of 0.1dB (i.e. 10 millibel) can be audible under suitable conditions. My experience, however, does *not* confirm Mr Moncrieff's subsequent statements, and his use of the word "we" in the remainder of his letter should not be construed to imply my agreement therewith. For example, 1 picobel represents a voltage difference of approximately one part in 10^{12}, which is well below the noise level in any meaningful bandwidth. We doubt his ability to measure differences this small, even assuming they were audible!

Stanley P. Lipshitz
University of Waterloo
Ontario, Canada

C-D IGNITION PROBLEMS

Your correspondent D. J. Bruyns raised some interesting points (March letters) on c.d. ignition problems. If indeed the intermittent misfire in some engines is caused by non-ignitable mixtures at the spark gap, at the time of the spark, then surely the way to solve the problem is to improve the carburation, gas swirl and flow, to provide ignitable mixtures. The c.d. ignition derives many of its advantages by producing a short, sharp spark, and to prolong this would detract from these advantages, as the spark energy (area under the curve) would remain constant. It is significant that this has shown up in car engines as these have some of the worst gas-flow and porting arrangements of all internal combustion engines. It may well not be found on 4-stroke motorcycle engines as these have generally far greater volumetric efficiencies and b.h.p./litre figures, achieved by careful design and tuning.

However, this may not in fact be the cause of these problems. The r.p.m. at which the misfire occurs (2000) is curiously close to the usual regulator cut-in and -out speed, when the supply line may be expected to show peculiar transients. This would explain why this does not occur with conventional ignition, or on Mr Bruyns's lathe-driven test, as he presumably used a battery to power the system with no charging circuit. More modern vehicle regulators, of the solid-state variety, sometimes exhibit deliberately or accidentally oscillatory tendencies, and this could also cause problems.

My motorcycles have monotonic regulator characteristics, and alternators, and have never shown any such effects with c.d. ignitions.

On a different tack. I am surprised at the catastrophic demise of s.c.rs and u.j.ts when the h.t. lead falls out of the coil. My favourite demonstration is to run the engine (a single-cylinder motorcycle 4-stroke) at various r.p.ms and carefully to pull the h.t. lead out of the coil, to show its ability to generate sparks up to one inch long in series with the sparking plug. In the limit, the spark will track down the outside of the h.t. coil and the engine will stop. Admittedly this will tax the coil h.t. winding insulation, but no failures of any components or h.t. coils have ever been sustained as a result of this practice. Maybe insufficiently conservatively-rated components are being used. (I now use 8A, 800V s.c.rs or triacs and a pre-trigger potential of 400V). I consider that this over-rating is essential in c.d.i. units as a failure may cause an accident, e.g. during overtaking.

Graham McLeod, G8PHA
Old Headington
Oxford

COLOUR-GRAPHICS VISUAL DISPLAY

I was greatly distressed when reading the article by Mr S. J. Marchant in your April 1980 issue to find that he claims development of an opto-isolator interface for a 14-in Sony portable television set.

This interface was developed last July by myself while working in the same department as Mr Marchant and has subsequently been marketed by Keen Computers of Nottingham.

Clive Loughlin
Hull
Yorkshire

Mr Marchant replies:

I sincerely regret my omission to acknowledge Mr Loughlin for his part in the development of the tv interface circuit, which formed a small part of my recent article. This omission was a genuine oversight on my part and I am now happy to acknowledge Mr Loughlin as the originator of the idea to use opto-isolators in this application.

The particular circuit in question was included only for the incidental reason of illustrating a suitable tv interface, and therefore did not form an integral part of the v.d.u. design.

S. J. Marchant
Beeston
Nottingham

3D TELEVISION

I disagree with Mr Lott (March letters) when he says that the relationship between convergence and focus of the eyes is the same for a stereoscopic presentation as for perspective. In a 'normal' perspective illustration there is only one picture and the two eyes always converge on the same point in that picture. There is only one tree in the distant background and both eyes look at it.

In a stereoscopic presentation there are two pictures, and they only coincide at points in the plane of the screen. There are now two trees side by side in the distant background, each eye looks at one of them but both eyes must remain focused on the screen. This is an anomalous situation and to an unpractised viewer must cause some feeling of strain.

However, as Mr Lott points out, in practice this is small in comparison with the strain induced by inappropriate camera or projector geometry, or, worse, by vertical disparity or a relative twist between the two pictures caused by misaligned projectors.

It is important, if stereo television is to be acceptable, that the system be designed so that conditions for comfortable viewing are easily attained and, once attained, are held.

J. M. Adams
Guildford
Surrey

TRANSISTOR MUTUAL CONDUCTANCE

Mr Beasley ("Circuit analysis by small computer — 2" April issue) is almost, but not quite, correct in stating that the mutual conductance of a bipolar junction transistor is given by

$$g_m(A/V) = 35 \times 10^{-3} I_E(A)$$

The correct form, for the assumed conditions of operation, is

$$g_m = I_c \times (q/KT)$$

where q is the magnitude of the electronic charge, K is Boltzmann's constant, and T is absolute temperature. This reduces to $g_m \approx 38.7$ mS per mA of *collector* current at $T = 300°K$. At very low collector currents Mr Beasley's formula, which involves the *emitter* current, will give appreciable error. It is proposed to consider some fundamental aspects of g_m in a future article.

B. L. Hart
School of Electrical and
Electronic Engineering
North East London Polytechnic

CB RADIO AND POPULATION DENSITY

In reply to W. C. Ritson's letter in your April issue I would like to make the following comments. The c.b. system described by Mr Hooper is u.h.f./f.m. and therefore essentially limited in range. I cannot see the relevance of population density figures which are averages for areas far in excess of the range of the system. Mr Ritson's only other argument seems to be the vague and highly questionable statement that "In most of the UK one is within easy reach of a telephone". It is surely obvious that the telephone and c.b. radio would provide complementary and not alternative services.

Personally, I doubt if the familiar chaos/abuse/impossible-to-police argument is the real reason for Home Office opposition. This argument, if valid, must apply with equal or greater force to an illegal 27 MHz system, but no serious attempt seems to be made to stop the sale of such equipment. 27 MHz equipment of all types is widely and quite openly advertised. One would have to be naive indeed not to believe that there is already an extensive c.b. network in this country.

By refusing to consider the allocation of the relatively small amount of spectrum space needed for a system similar to that used in Australia while turning a blind eye to the sale of 27 MHz equipment, the Home Office seems to have achieved the worst of both worlds, a situation where c.b. is denied only to the more responsible, law abiding section of the community.

W. J. Williamson, GM8MMA
Yell
Shetland

Designing with microprocessors

2 — Step-by-step operation of the microprocessor chip

by **D. Zissos and Laurelle Valen** Department of Computer Science, University of Calgary, Canada

This is the second article in a series which aims to help the electronics engineer understand and use the microprocessor as a down-to-earth component in the design of electronic systems. Last month's article dealt with the basic components of the microprocessor chip. The authors now go on to describe the chip's internal functioning from the designer's point of view, using the example of a character printing operation and the sequence of states needed to achieve it.

Although the circuit complexity and range of functions of microprocessors vary widely from chip to chip, their basic operation is essentially the same. It consists of repeating cycles during which instructions are fetched from memory and executed, as shown in Fig. 1. Some instructions contain only one byte, whereas others contain two or more bytes — see Fig. 2.

This description of microprocessor operation, although it may prove adequate for the user, is inadequate for the designer who, in addition, must treat the microprocessor chip as a circuit element which can perform a multitude of functions. Although at first sight treating the microprocessor chip as a circuit element may appear to be a formidable task, when viewed as a multi-state device, its step-by-step operation can be seen in fairly simple terms, as we illustrate next by means of an example.

In our example we shall trace the step-by-step activity required to print a character which has been previously loaded into the accumulator in Fig. 3 (which is a repeat of Fig. 7 in the previous article). The peripheral in Fig. 3 is assumed to be a printer. The software required for this purpose is stored in memory and consists of three eight-bit bytes, the op code followed by two bytes defining the address of the printer (An). To print the character, the microprocessor chip in our case goes through nine states as shown in Fig. 4 (a repeat of last month's Fig. 8). If we assume for the sake of convenience a 1MHz clock, our circuit will change states every 1μs. The action taken in each state is explained below.

State M1. T1. The microprocessor-end of the 16-bit address bus is connected to the program counter, which contains the address in memory where byte 1 is stored — see Fig. 3. At the same time a read ($R/\overline{W}$) pulse is generated on the control bus by the timing and control unit, which causes the first byte (op code) to be released from memory and be made available on its output terminals. Note that during this state the data bus, *d*, is not being used.

State M1.T2. Let us assume that the memory takes less than 1μs to respond. This means that when our circuit enters state M1.T2, the first byte (op code) is available on the memory's data terminals. In this state the data bus is connected internally to the instruction register (i.r.) in Fig. 3. At this point the system designer also connects the memory chip to the data bus. This clearly establishes a direct link between the memory and the instruction register (i.r.). A suitably-timed pulse, generated during this state, causes the op code to be copied into i.r. Note that the address bus is not being used in this state.

State M1.T3. During this state the op code is decoded. The output of the instruction decoder in Fig. 3 determines the correct sequence of states the timing and control unit is to go through for the correct execution of the instruction. In our case M2.T1, M2.T2, M3.T1, M4.T1 and M4.T2 are the relevant states. Note that in this state the address and data buses are not being used.

State M2.T1. The action taken in this state is identical to the action taken in M1.T1, with the exception that the program counter (p.c.) has been incremented. Note again that during this state the data bus *d*, is not being used.

State M2.T2. In this state the second byte of the instruction (defining the high component of the address) is available at the data terminals of the

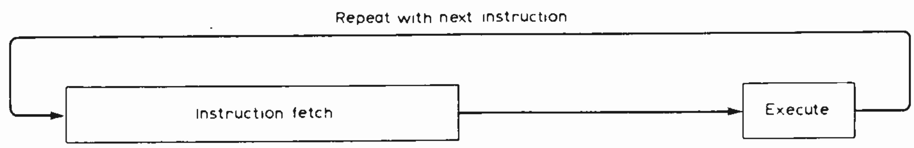
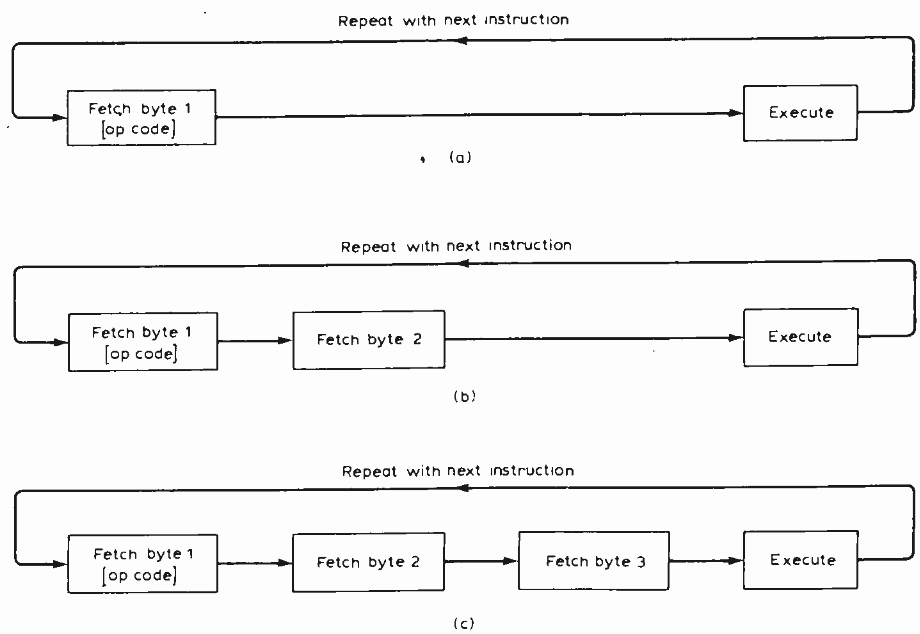


Fig. 1. The basic cycle of operation of all microprocessors, in which an instruction is fetched, executed and succeeded.

Fig. 2. Fetch-and-execute cycles for (a) a one-byte instruction, (b) a two-byte instruction, and (c) a three-byte instruction.



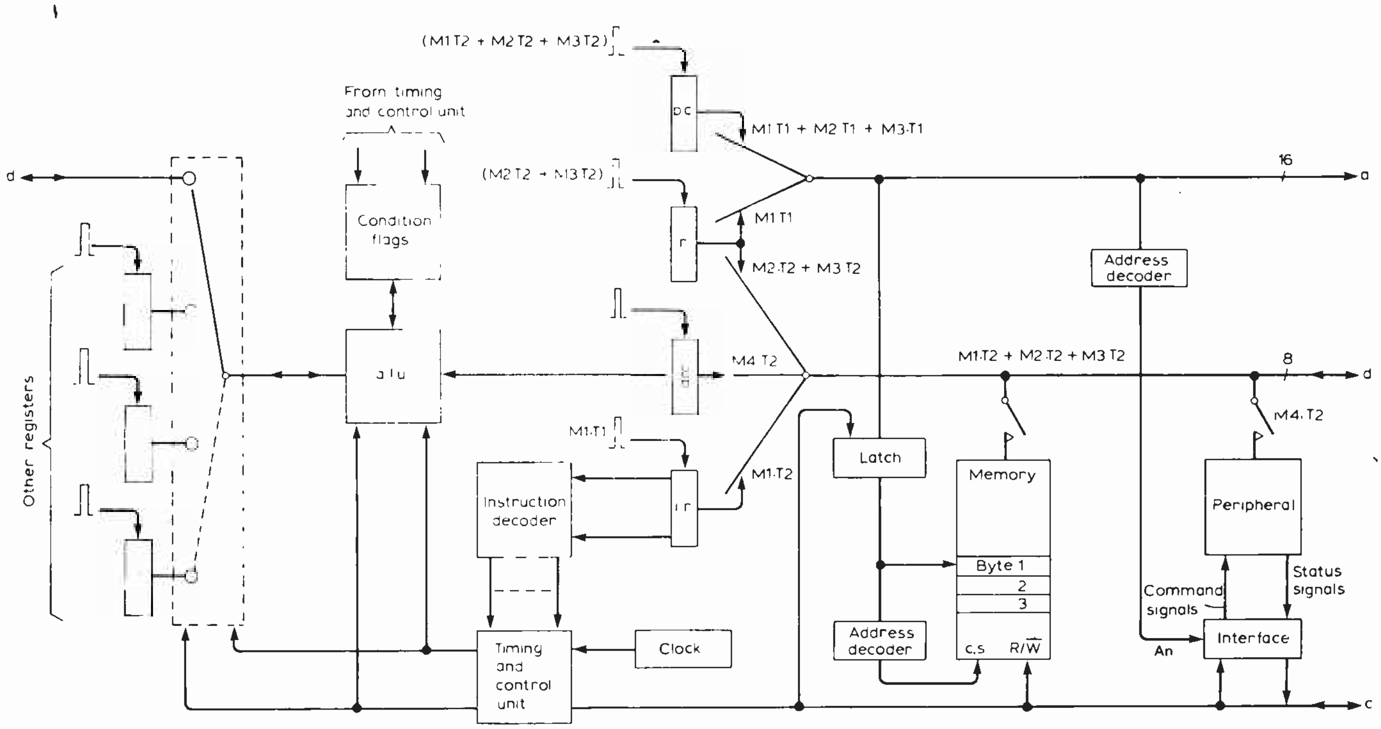


Fig. 3. Components and internal ▲ *organization of an eight-bit microprocessor (repeat of Fig. 7 in last month's article).*

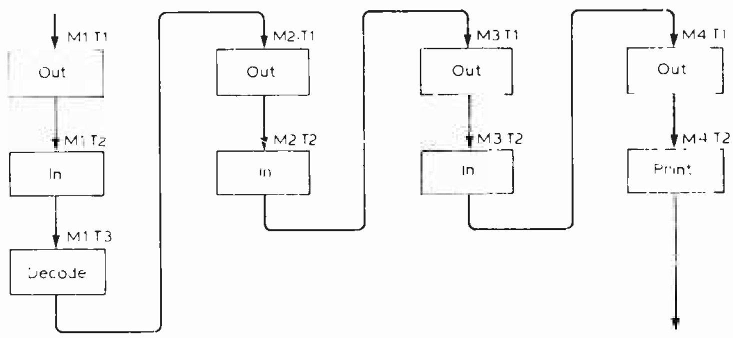
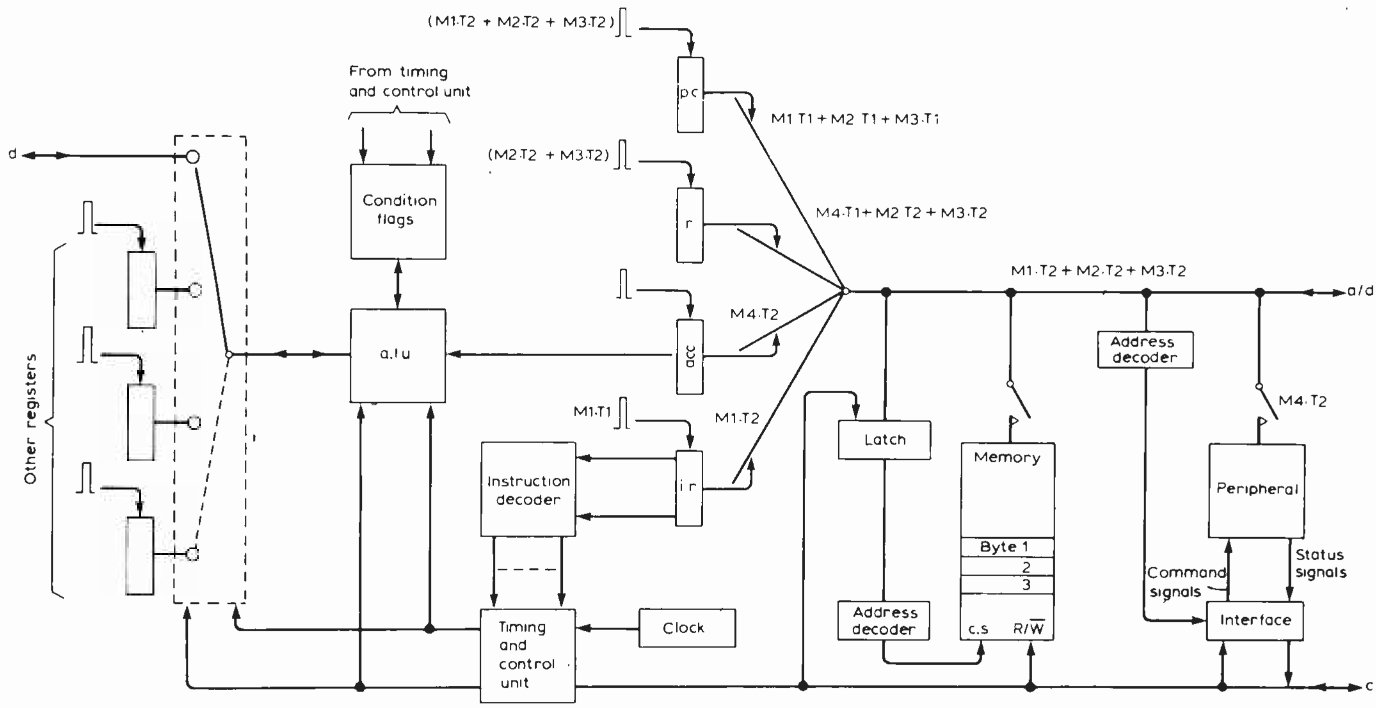


Fig. 4. Internal operation of a ▶ *microprocessor chip (repeat of Fig. 8 in last month's article).*

Fig. 5. Components and internal organization of a sixteen-bit microprocessor. Note that it is similar to the eight-bit microprocessor in Fig. 3 except that the address and data buses are now put onto one set of conductors, labelled here a / d. ▼



memory. It is copied into the 'high' section of the addressing register r in Fig. 3 by connecting the data bus to it (which takes place within the m.p.u. chip) and to the memory. This condition is indicated in our diagram by the closure of the two switches, labelled M2.T2 in Fig. 3, and application of a pulse to the high section of addressing register r. Note that, as in the case of M1.T2, the address bus is not being used in this state.

State M3.T1. The action taken in this state is identical to the action taken in state M1.T1 and M2.T1, except that the program counter is pointing to the memory location holding byte 3, the 'low' component of the printer address. Note once more that data bus, *d*, as in the case of states M1.T1 and M2.T1, is not being used.

State M3.T2. When the microprocessor chip assumes this state, the low component of the printer address is available from memory. The timing and control unit, as in the case of state M2.T2, generates appropriate routing signals that connect the data bus, *d*, to the low section of the addressing register and a timing pulse, which allows the signals on the data bus to be copied into it. The system designer must therefore ensure that the memory is connected to the data bus during this state, by closing the external switch M3.T2 in Fig. 3. 'External' in this context means not in the microprocessor chip. Note again that, as in states T2 of machine cycles 1 and 2, the address bus is not being used.

Going through the sequence of states M1.T1 to M3.T2 constitutes the *instruction fetch* cycle in Fig. 1. At this point the microprocessor chip contains the op code defining the print operation, and the printer's address.

State M4.T1. The address bus is connected to the address register, allowing the printer's address to appear on it. This address is decoded by the printer's address decoder in Fig. 3, generating signal An. Note again that the data bus has not been used in this state.

State M4.T2. In this state M4.T2, the data bus is connected to the accumulator and the printer, as shown in Fig. 3, establishing a direct link between them. Simultaneously, the interface monitors the microprocessor's status signals on the control bus, which it uses to generate the appropriate command signals needed to activate the printer, allowing the character in the accumulator to be printed. Note again that the address bus has not been used in this state.

16-bit microprocessors

Reference to Fig. 3 shows that the address lines carry signals only in state T1 of each machine cycle, and that the data lines carry signals only in state T2 of each machine cycle. No signals are carried by either set of lines in state M1.T3. It therefore follows that the same set of lines can be used for both the data and the address bus, as shown in Fig. 5. This is the basic configuration of 16-bit microprocessors.

In these first two articles we have shown that the microprocessor chip contains no special circuit, architectural or operational features that do not exist in conventional digital computers. The main difference is that in recent years the rapid development in technology has allowed more and more circuits to be accommodated in less and less space. This has created an access problem, which in practice is solved by time-sharing the microprocessor pins. A more efficient use of the time-sharing mechananism results in 16-bit microprocessors.

It follows that the design and implementation of microprocessor systems involves *injecting* and *capturing* data from the system lines at the correct time, that is, during the appropriate time slots.

The next article will deal with the need for different addressing modes. A concise description of the most commonly-used modes will be given.

BOOKS

It is comparatively rare to see an author taking seriously the subject of testing and fault finding of electronic equipment at technician level. G. C. Loveday, in his book **Electronic Testing and Fault Diagnosis,** is an exception, having written a worthwhile introduction to the art which covers the theory of operation, possible malfunctioning and fault diagnosis of a wide variety of circuits.

The first two chapters are extremely thorough examinations of specification and reliability. The first covers the raising of a specification, standard forms and testing to a specification, while the second chapter goes more deeply into the subject of reliability and failure than many, more advanced texts. There follows a chapter on active and passive components, which includes details of the construction of many types and their failure modes, and three chapters on circuitry, both analogue and digital, with a practical bias towards fault finding. A final chapter is devoted to system maintenance and fault location. Exercises in construction and written tests are provided throughout. The book is a valuable contribution to the education of technician engineers. It contains 212 pages, costs £5.00 and is published by Pitman Publishing Ltd, 39 Parker Street, London WC2B 5PB.

Electronic Devices, by F. R. Connor, is concerned solely with semiconductors and thermionic valves — devices using the properties of electronic motion — rather than with electronic equipment, as a loose interpretation of the title might imply.

The book is small, having only 121 pages, and though the treatment is concise, it is not possible to go into much detail on the large number of devices described. For example, junction transistors are allotted only five pages, one of which is taken up with a specimen problem and its solution. Again, although the author points out in his preface that a knowledge of vacuum devices is still essential, thermionic valves are given five and a half pages, in which diodes, triodes and pentodes are described. The sub-title of the book indicates that it is an introductory text, which may account for the summary treatment of some devices.

It is wide-ranging and begins with a better-than-average look at atomic and semi-conductor theory. The rest of the text is devoted to solid-state and vacuum devices, finishing with descriptions of c.r.ts, photocells, l.e.ds and microwave tubes. The book is in paperback, costs £3.95 and is published by Edward Arnold (publishers) Ltd, 41 Bedford Square, London WC1B 3DQ.

Two paperbacks in the Macmillan **Electronic Projects** series are on projects around the home (No. 1) and for the car and garage (No. 2). The projects described are fairly elementary and are clearly intended for beginners, although in No. 1 there is a complete model radio control system and the second volume includes an electronic ignition design. The books are produced with a very welcome thoroughness which is of particular importance to the newcomer to the art. The components for each project are listed at the end of each book, with type numbers where necessary, and a list of suppliers is given. Printed-circuit layouts are given for the 'home' designs (those for the car are on Veroboard) and the boards are also obtainable ready made. As an introduction to practical electronics, these two books can be highly recommended. They are published in paperback by Macmillan Press, 4 Little Essex Street, London WC2R 3LF at £3.95 (No. 1) and £3.50 (No. 2).

ECIF Buyers' Guide, published by the Electronic Components Industry Federation of 7/8 Savile Row, London W1X 1AF, is in two distinct sections. The first part lists components alphabetically, with the relevant manufacturers and precise kinds of component in the broad type class, while the second part provides much information on manufacturers, including factory and sales office addresses, associate companies, distributors, type-approvals held, trade names and company contacts, together with cross-referencing to the product section. The Guide costs £1.

Programmable attenuator — 2

Logic control for remote operation

by J. M. Didden

Part 1 of this series covered the design of a programmable attenuator/line amplifier with gain switching. This concluding article describes a digital control which will drive two attenuators in a remote volume/balance system.

Because the gain of the programmable attenuator is set by a 6-bit word in steps of 1dB, a control word which increases or decreases linearly can be used to make a volume control with the desired log. slope. A simple way to achieve this is with a 6-bit binary up/down counter but, because conventional potentiometers have endstops, the counter must not overrun. An important feature of a potentiometer is the preset capability, and this can be implemented in the attenuator by using a presettable counter and preset-pulses at switch-on.

For balance control, the most straightforward system has one channel counting up and the other down. This method is not satisfactory because for every count the volume difference changes by 2dB, and in this design the problem is overcome by clocking each channel alternately.

Counter and preset circuit

To limit power consumption and to simplify connections to the 4007 switches, c.m.o.s. is used throughout. The counter and preset circuit in Fig. 19 uses two 4029 i.cs, and signals $\overline{TC_1}$, $\overline{TC_2}$, B4 and B5 detect the terminal counts. Signals B6 and B7 are always preset to 1, and the all-ones terminal count at maximum attenuation is detected by $\overline{TC_2}$ going to 0. When all zeros are present at minimum attenuation, B0 to B5 are 0 but B6 and 7 are still at 1. This setting is detected by $\overline{TC_1}$ for the least significant counter, and by B4, B5 and the Up/Down signals for the most significant counter. Signals B2 to B7 were not used to drive the attenuator because there are problems in keeping the two channels synchronized when going from volume to balance changes and vice versa.

Counter drive circuit

The counter drive circuit in Fig. 20 comprises a 4047 clock generator which also provides a signal at half the clock frequency for balance control. Four signals control the enabling and direc-

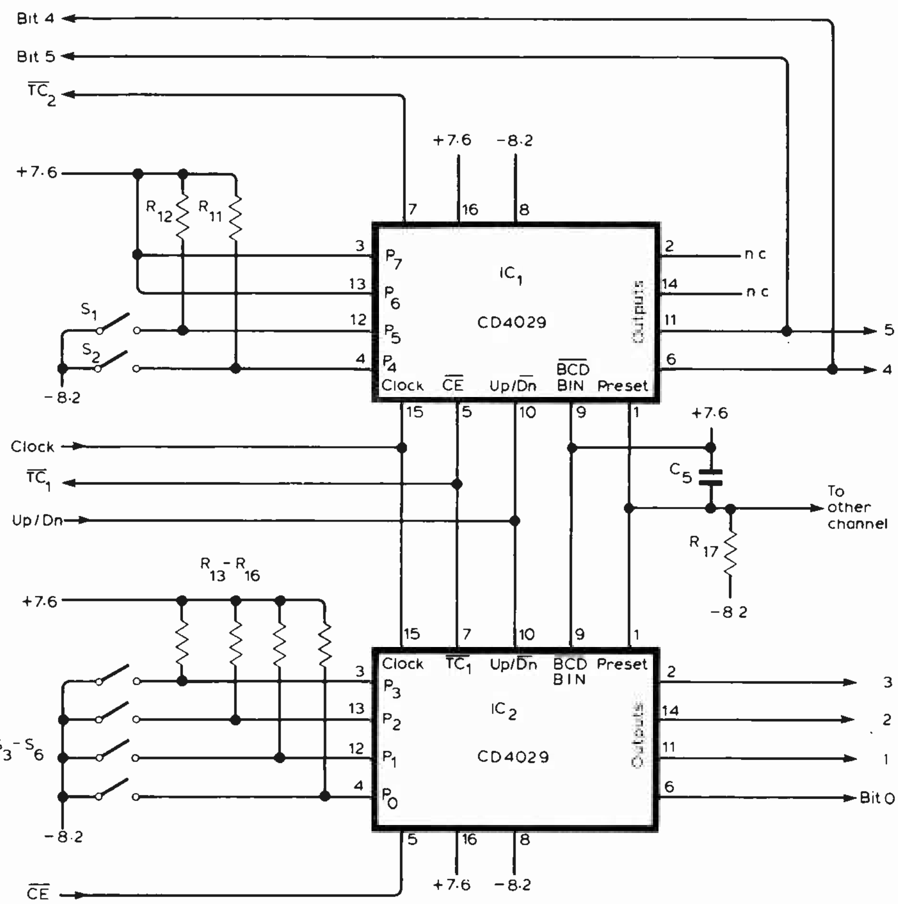


Fig. 19. Counter circuit for one channel. Switches S_1 to S_6 preset the attenuator.

Components for one channel

Resistors ¼ W

1, 5	56k
2	220k
3	1M (see text)
11-16	1M
4, 19	4k7
6-10	10k
17	100k
18	1k5
20, 24a	15k
21a	12k
21b	330k
22, 27, 28	5k6
23	2k7
24a	82k
25, 26	1k

Capacitors

1, 4	33nF
2	150pF
3	100nF (see text)
5, 6, 9-13	470nF tant. 35V
7, 8	2000μF 35V

Semiconductors

D_1-D_3	1N4148
D_4-D_7	1N4002
D_8-D_9	8.2V 400mW
Tr_1	2N1613
Tr_2	2N2905
Gate 1, 2	4072
Gate 3-5	4073
Gate 6-9	4030
IC_1, IC_2	4029
IC_3	4047
IC_4	uA 78GU
IC_5	uA 79GU
A1-A4	TL084C

Miscellaneous

S_1-S_6	6 way d.i.l.
S_7-S_{10}	push button, momentary make
Transformer	2 x 15V, 100mA, c.t.

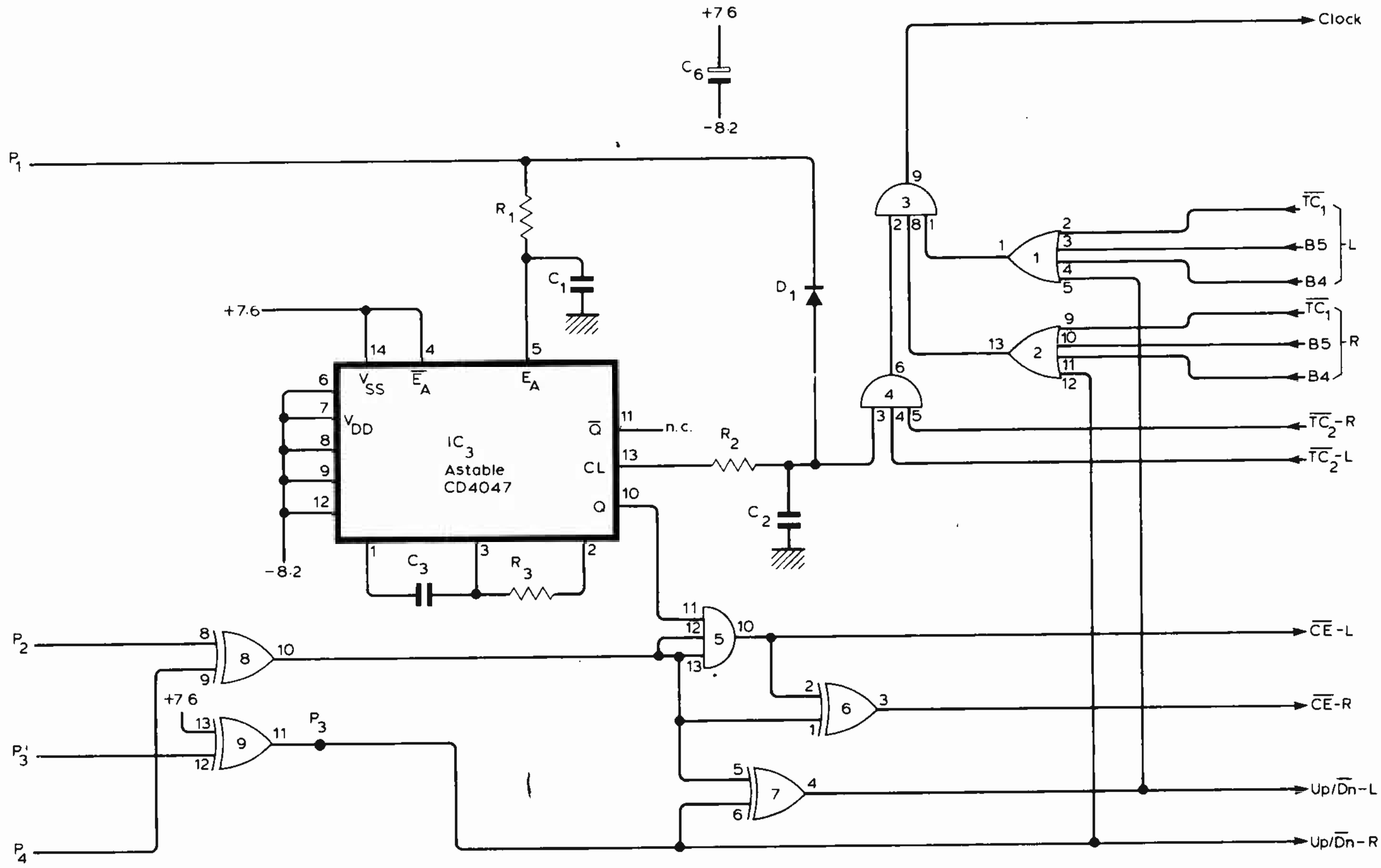


Fig. 20. Counter control circuit generates enable and up/down pulses for left and right channels.

tion of the counters. Signal P1 enables the clock-generator and R_1C_1 delay this command to ensure that the other control signals have settled before the first clock pulse occurs. Diode D_1 ensures that the clock pulse immediately returns to 0 if P1 goes low, so that changes in the other control signals then have no effect. This precaution is necessary because the count-enable signal can act as a clock pulse if the clock input to the counters is a 1.

Gates 1 and 2 provide an AND function for the logic 0 signals that provide all-zeros terminal count detection, while $\overline{TC}_2$ detects the all-ones end count. These signals inhibit the clock pulses through gates 3 and 4. A half clock-frequency signal from the Q output enables the counters if necessary. If P2 and P4 are 0, $\overline{CE}$-L and $\overline{CE}$-R are low and both counters are enabled. This is the volume control mode and P3 determines whether the volume goes up (P3 = 0), or down (P3 = 1). Gates 6 to 8 are used as programmable inverters where, if one input is 0 the other input is not changed, and if one input is 1 the other input is inverted. If P2 becomes 1 and P4 remains 0, $\overline{CE}$-L follows Q and the left-channel counters are enabled every other clock-pulse. The right-channel counters are enabled when the left-channel counters are not, which provides the balance mode, and P3 determines whether the volume will increase in the left channel (P3 = 1) or the right channel (P3 = 0). Signal P3 is inverted by gate 7 so that the counters count in opposite directions. Again, a delay network R_2C_2 is used to prevent the enable and clock signals from

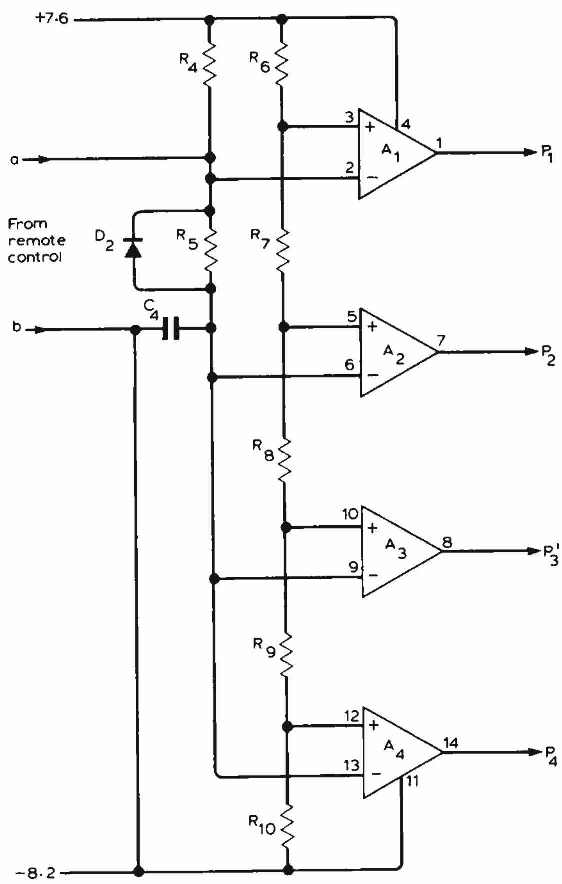


Fig. 21. Window-comparator interface provides four control signals from a two-wire remote control.

changing state simultaneously. The count-inhibit signals differ in the two modes because the $\overline{TC}$ signals only respond to the terminal count if $\overline{CE}$ is low. In the volume mode, when one channel reaches a terminal count, both channels stop counting. In the balance mode however, if one channel reaches the terminal count, clock-pulses for that channel only are inhibited and if the other channel is enabled it will continue to its terminal count. The count rate is determined by R_3C_3 and with the values shown it is about 5 dB/s. Maximum counting rate is limited by the switch response, but 100dB per second can be achieved.

A remote control unit can be interfaced to the circuit with a modified window comparator as shown in Fig. 21. Outputs P1 to P4 are normally at 0, but if V_{ab} is lowered to below the junction voltages of the divider R_6 to R_{10}, one comparator output after the other goes high and control signals are generated as shown in table 3. The voltage is varied simply by connecting a resistor across ab as shown in Fig. 22. With this circuit the remote control facility only requires two wires.

A power supply for the complete system is shown in Fig. 23. The logic supplies are derived from the op-amp supplies and the total current consumption is about 50mA. To ensure maximum switching accuracy, the component values shown must not be altered.

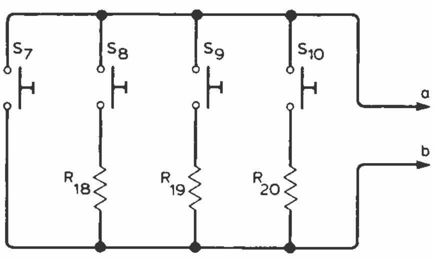


Fig. 22. Remote control connections.

Table 3. Remote control commands

Pushbutton	Control signal P1	P2	P3	P4	Command/direction
None	0	0	0	0	None
S_{10}	1	0	0	0	Volume, level decrease
S_9	1	1	0	0	Balance, right decrease left increase
S_8	1	1	1	0	Balance, left decrease right increase
S_7	1	1	1	1	Volume, level increase

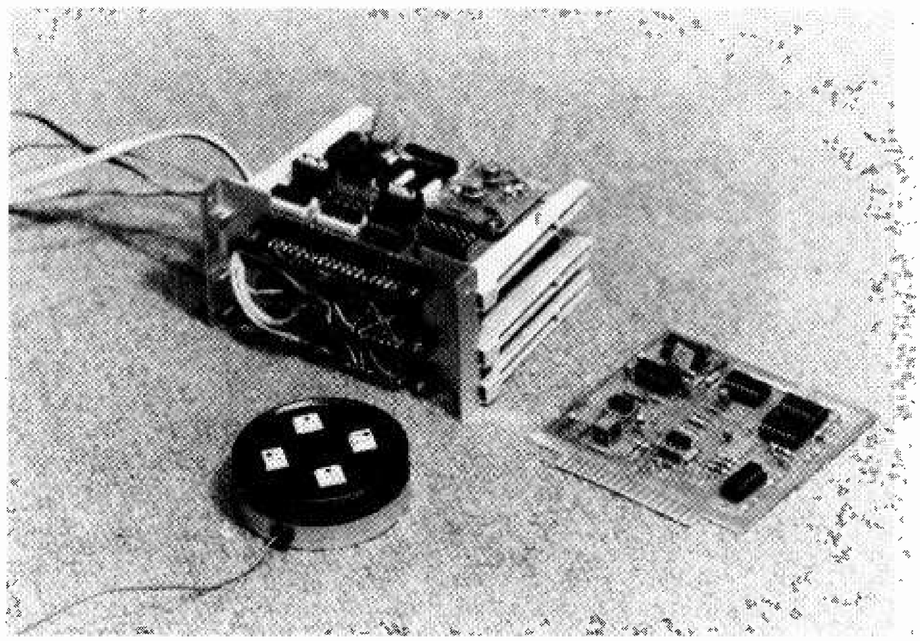
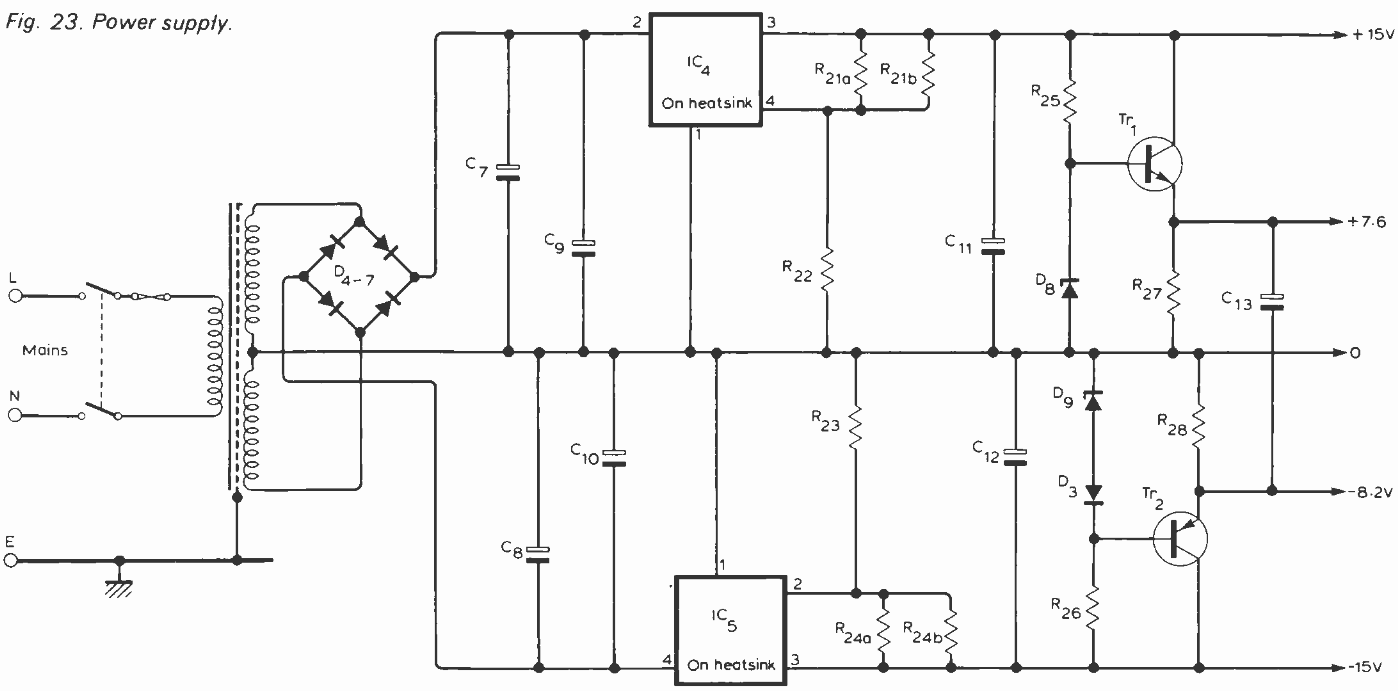


Fig. 24. Prototype remote volume/balance control system with one attenuator board removed.

Fig. 23. Power supply.



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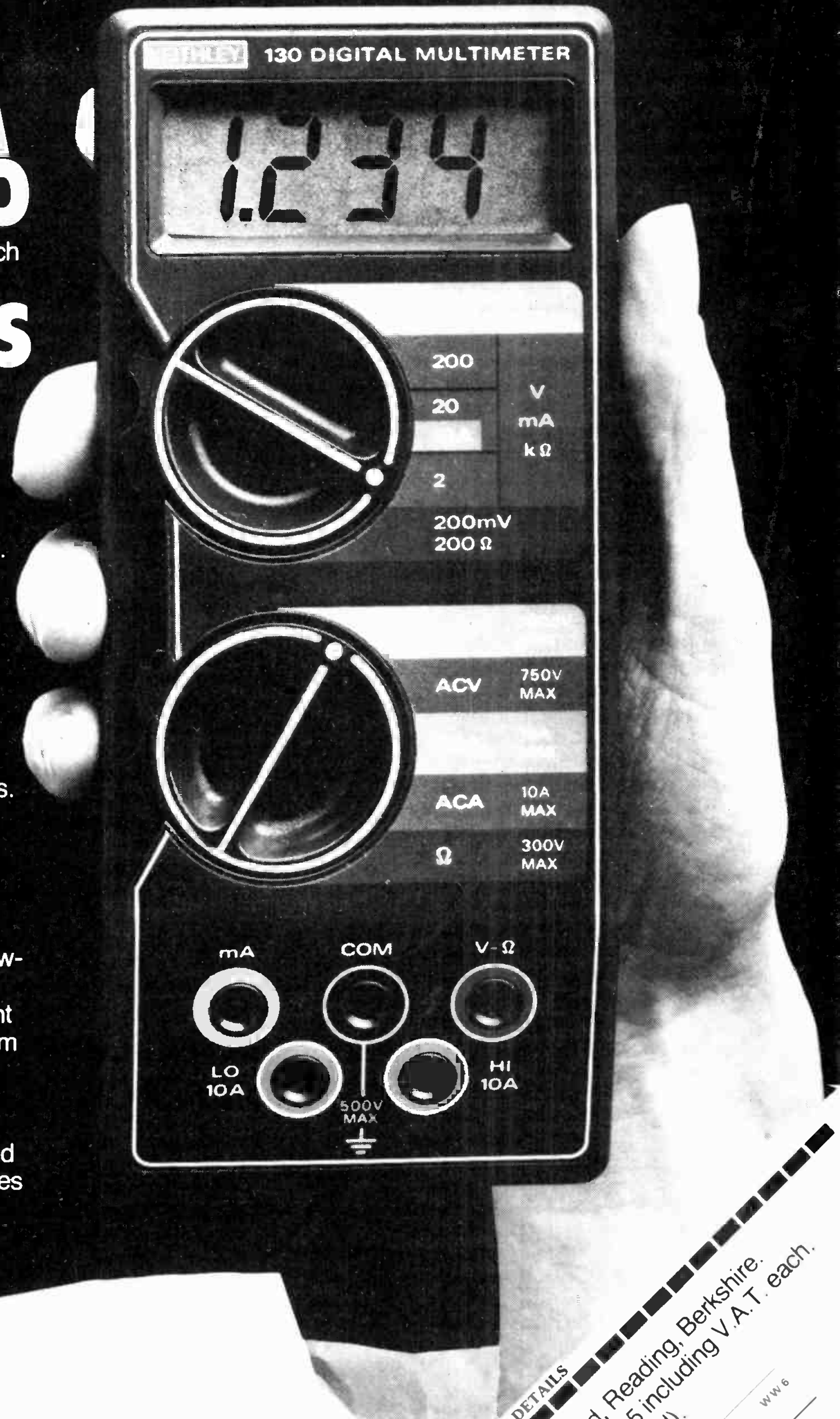

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I.E.E.E. bus standard

Controlling measuring instruments with minicomputers

by P. R. Ellefsen B.Sc.(Hons), M.I.E.E, Hendry Electronics

The variety of so-called "standard" bus systems in existence nowadays may at first seem confusing, but it is possible to categorize them in a number of ways. The most tangible division is to be made between what may be called "internal" and "external" buses. Internal buses tend to be "fixed" in nature, often taking the form of a system backplane. Examples of mini and microcomputer buses conforming to this description are Intel's "Multibus," Zilog's "Z-Bus," National's "Microbus," Altair's "S-100," and the recently proposed "Modbus." External buses, by contrast, tend to be temporary or movable, the hardware normally taking the form of a flexible cable with a plug fitted to one or both ends. The bus described by the I.E.E.E. 488 standard is such a system. This article will attempt to acquaint readers with the fundamental philosophy and nature of the I.E.E.E. 488 interface bus standard, together with some of its physical attributes.

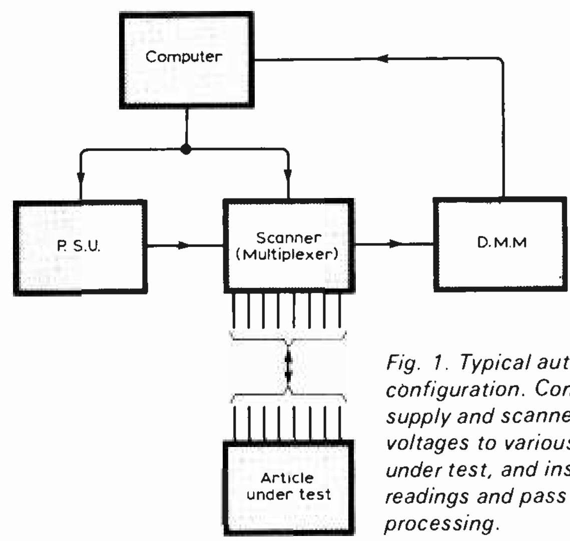

Fig. 1. Typical automatic test configuration. Computer instructs power supply and scanner to connect various voltages to various points on equipment under test, and instructs d.m.m. to take readings and pass them to computer for processing.

The first question to be answered must be: why do we need an interface bus standard? The answer lies in the rapid development during the last ten years of cheap and powerful mini-computers and microprocessors, together with versatile and accurate programmable measuring instruments. This development has led to the possibility of building "automatic" (i.e. program-controlled) measurement and test systems from separate instruments as in the example of Fig. 1. The benefits obtainable from such automatic systems are manifold and result largely from the ability of the system to perform repetitive measurement tasks swiftly and accurately without getting bored, or needing holidays. To realize this sort of system, a communication network is required and, to achieve uniformity in various programmable instruments from various manufacturers, the I.E.E.E. 488 standard was created and now has almost universal acceptance.

The interface standard is defined in the publication "I.E.E.E. 488-1975"[1] which has also been adopted by the American National Standards Institute (A.N.S.I.) as "A.N.S.I. MC1.1.-1975." The International Electrotechnical Commission (I.E.C.) also intends to publish the standard, with a few minor differences, but it is still in draft form at the moment[2]. Recently, the I.E.E.E. published a revision, I.E.E.E. 488-1978, which contains a few clarifying additions to the 1975 standard. The interface system is commonly known by many names: I.E.E.E. bus, I.E.C. bus, GPIB (General Purpose Interface Bus) ASCII bus (misleading), and HP-IB (Hewlett Packard Interface Bus, a trade mark). This last title refers to the fact that Hewlett Packard Limited developed the interface system, and hold a patent on the three-wire handshake protocol.

Of the five essential elements of a complete interface system, four are fully defined in the I.E.E.E. standard: – the mechanical features, e.g. connectors, cables; the electrical aspects, e.g. logic levels, loading; the device capabilities (called functions); and the communications protocol, i.e. the way in which information is transmitted and received. The fifth element, which is undefined in the standard, is the coding and interpretation of the data transmitted on the bus. To explain this omission, an analogy is possible with human communications, in that we communicate vocally by setting up air vibrations, and we do not all speak at once (protocol) but the meaning of the air vibrations is defined by language (or even sometimes by dialect). Thus data representing for example "R3" may be interpreted by a programmable meter as "set range 3 (2.000V)" and by a printer as "print the letter 'R' followed by the digit '3'." Clearly, not all possible interpretations can be dealt with by this standard. An important concept to note is that the bus-to-device interface system may be divided into four functional elements, shown in Fig. 2; the device itself, the device interface, the bus interface, and the bus itself. The standard

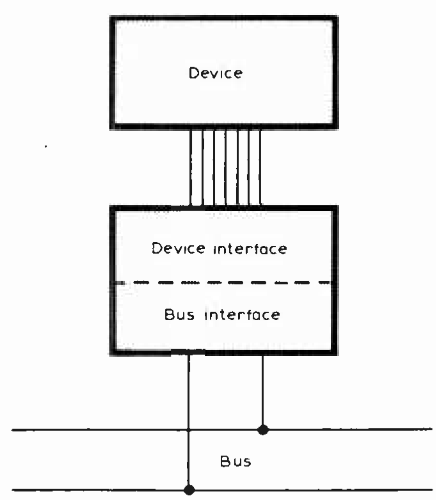

Fig. 2. Four elements of the bus-to-device interface.

covers only the latter two sections. In practice, the division between the bus interface and the device interface may be difficult to discern, but the important functional distinction to be made is between the device which performs its normal functions of measurement etc., and the bus interface whose job it is to connect the device to the bus.

Bus description

The tangible elements of the interface bus are the cable and the characteristic "piggy-back" connectors. The cable is a screened and sheathed cable containing 24 (or more) conductors terminated at each end in a standard connector, which comprises two elements, a plug and a socket, both 24-way, arranged so that the open (mating) ends of both point away from each other, as in Fig. 3. This enables the cables to be connected to instrument rear panel sockets, and attached using jack-screws integral to the piggy-back connector, and further cables to be connected in parallel ("piggy-backed"). This system ensures that all pins 12 (for example) are automatically connected together, to ensure that, using standard, readily available leads, the system builder can assemble a working set of equipment without having to do any soldering, or worry about which wire goes where.

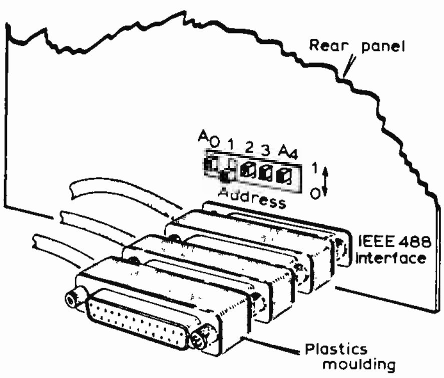

Fig. 3. Typical instrument rear panel, with piggy-back connexion of several plug-and-socket combinations.

The typical rear panel in Fig. 3. shows a miniature switch, which allows the instrument to be uniquely identified to the bus system by means of an "address" settable by the user. Occasionally, the address switches may be inside the instrument, and may even be wire links on a p.c.b.

Sixteen wires (lines) carry t.t.l. signals, the remaining eight ways of the 24-way connector being used for earths. The sixteen signal lines are all low active true (i.e. logic '1' is <0.8V), and can conveniently be divided into three groups; data, management, and data-byte transfer control (handshake), each being assigned a mnemonic, as shown in Fig. 4.

Since all the devices connected to the bus are in parallel, some means of allowing one device to control the state of a bus line has to be provided. The available options are twofold: three state logic, and wired-OR. The more universal, and cheaper, wired-OR system is used. To reduce the delaying effects of distributed line capacitances, every instrument connected to the bus has a resistive terminating network at its terminals, together with a receiver, or a driver, or both, depending on whether the instrument has to receive or transmit data, or both. Figure 5 shows the arrangement.

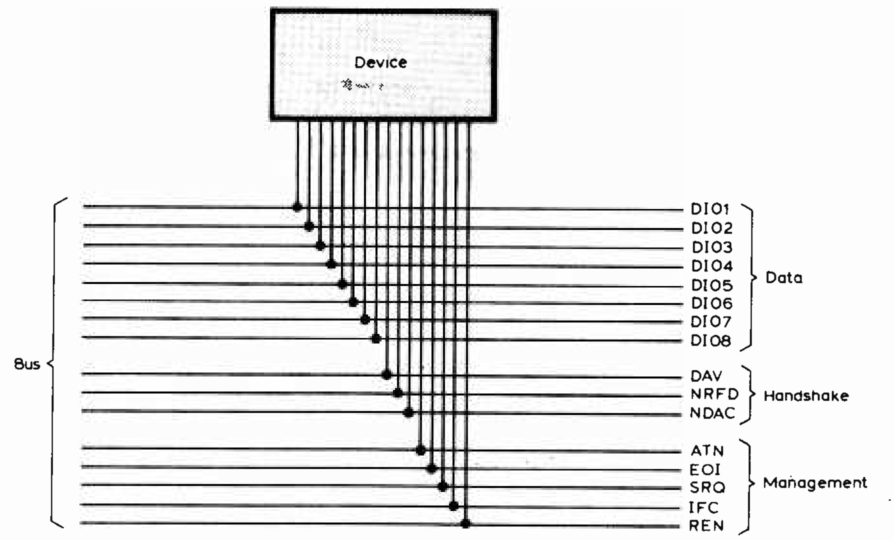

Fig. 4. I.E.E.E. bus lines.

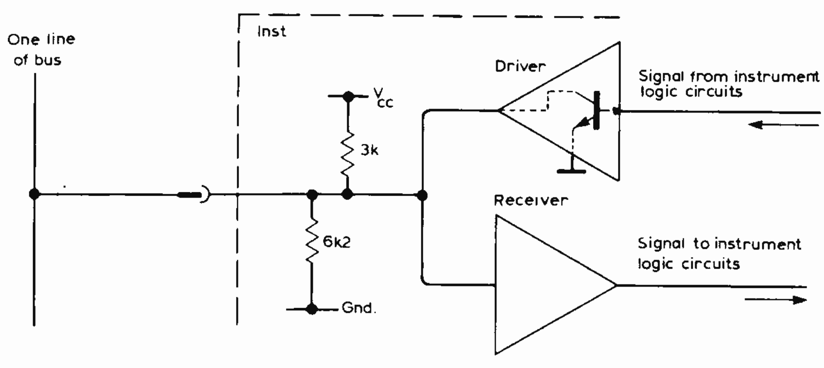

Fig. 5. Instrument interface to reduce effects of stray capacitance.

Boundary specifications

At this stage, one can now appreciate the boundary specifications set out in Table 1. The cable length restriction,

Maximum cable length:	2m/device or 20m, whichever is least.
Maximum data transfer rate:	1 Mbyte/sec (1 byte = 8 bits) (practically limited to <250 kbytes/sec.)
Maximum number of devices on standard bus:	15

Table 1

imposed by cable capacitances, is not normally a problem but can be overcome, if necessary, by the use of a 'bus extender,' a device which converts the bus traffic into serial form for transmission over, for example, telephone lines, and re-converts at the remote end of the telephone lines. The timings imposed by the standard ensure that data will be satisfactorily transferred at 1 Mbyte/sec, although very few instruments will handle data at this rate, and careful layout of interconnecting leads is needed. A tacitly agreed limit of 250 kbytes/sec is therefore normally accepted. The limitation of 15 devices is imposed by fan-out considerations of the drivers but, again, this can be overcome by a bus buffer or bus extender.

Device functions

A device connected to the bus can be in one of three distinct states – inactive, receiving or transmitting. To enable the last two states to occur, two functions are defined in the standard; acceptor handshake (AH), and source handshake (SH) respectively. These functions, when active, ensure that data is successfully taken from or put on, the bus. The details of the actual data transfer process (handshake) are described later on.

The transition from, for example, an inactive state to a receiving state is achieved by commanding the device (using its address as set up on the switches on the device) to "listen:" if the device can be addressed in this manner, it is said to be fitted with the listener (L) function. The transmitting counterpart is called, logically enough, the talker (T) function. Normally, a computer or desk-top calculator has overall control of the bus, and *alone* is able to address (assign) talkers and listeners. To enable it to do this, it is fitted with the controller (C) function. Only one controller may be active at any time in a system. Note that the controller function does not imply any ability to make decisions, nor has it any intelligence: the sequential functioning of the system is executed by a software program which is in communication with the controller function, a difficult but important concept. These five functions are the main five described in the standard, a further five being shown in Table 2: remote/local – means of setting a device to be controlled by bus commands (remote) or by its own front panel controls (local); device trigger – devices fitted with this function can all be triggered (e.g. to start a measurement) simultaneously by the bus; device clear — a function to allow a device to be reset to a known condition (normally the power-on or idle state); service request and parallel poll, which are described later on in the section on polling. Various subsets of these functions are defined in the appendix to the standard, the number of subsets being shown at the right of Table 2 for each function. Note that "not fitted" is a valid subset, so that for example, T0 describes the absence of any talk capability.

Addressing

If it is required to make a particular device become a talker, its 5-bit address is put onto the data lines (in the least significant five bits) by the controller, which also sets DIO7 and DIO6 to logic 1 and logic 0 respectively to indicate that it is a talk address. While transmitting this address, the controller also sets ATN, one of the management lines, true to indicate that a command (as opposed to data) is present on the data lines. As soon as the controller sets the ATN line false, the addressed device will start to put data on the bus. If a device has both talker and listener functions, it still only needs one address, and the distinction between addressing it as a talker and addressing it as a listener is provided by the controller, which sets DIO7 and DIO6 to 0 and 1 for a listen address. The address "11111" is reserved for use by the controller as an "unaddress" command. Hence "1011111" sent with ATN true means "unlisten," and sets all existing listeners to their unaddressed state (i.e. not receiving data). Talker unaddressing has another aspect to it; obviously only one talker can exist on the bus at any one time, otherwise chaos would result, and two ways of unaddressing a talker therefore exist – the "untalk" command "0111111," and also any talk address except that of the present talker. Thus if device A is currently a talker, and device B is addressed to talk, device A automatically unaddresses itself. Provision is also made in the standard for minimal systems to be constructed. To this end, devices may have 'talk only' and 'listen only', and a possible system comprises a 'talk only' instrument, one or more 'listen only' instruments and no controller.

DIO 7				0	0	0	0	1	1	1	1
6				0	0	1	1	0	0	1	1
5				0	1	0	1	0	1	0	1
4	3	2	1								
0	0	0	0	NUL	DLE	SP	0	@	P		p
0	0	0	1	SOH	DC1	!	1	A	Q	a	q
0	0	1	0	STX	DC2	"	2	B	R	b	r
0	0	1	1	ETX	DC3	#	3	C	S	c	s
0	1	0	0	EOT	DC4	$	4	D	T	d	t
0	1	0	1	ENQ	NAK	%	5	E	U	e	u
0	1	1	0	ACK	SYN	&	6	F	V	f	v
0	1	1	1	BEL	ETB	'	7	G	W	g	w
1	0	0	0	BS	CAN	(	8	H	X	h	x
1	0	0	1	HT	EM	)	9	I	Y	i	y
1	0	1	0	LF	SUB	*	:	J	Z	j	z
1	0	1	1	VT	ESC	+	;	K	[	k	{
1	1	0	0	FF	FS	,	<	L	\	l	¦
1	1	0	1	CR	GS	–	=	M	]	m	}
1	1	1	0	SO	RS	.	>	N	^	n	~
1	1	1	1	SI	VS	/	?	O	–	o	DEL

Fig. 6. ASCII 7-bit code.

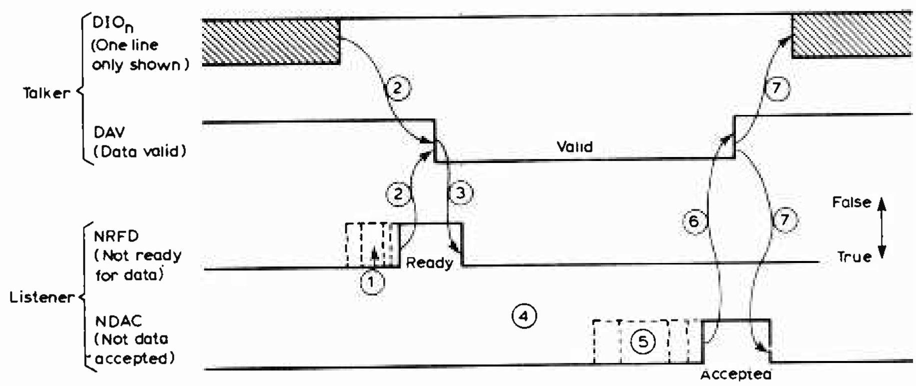

Fig. 7. Sequence of events during the handshake process.

Description of individual lines

Data lines. The data lines (DIO1 to DIO7) carry all the variable information on the bus; data, addresses, and commands. As mentioned earlier, the coding and interpretation of the data on these lines is not defined, and is left to the user, and the instrument manufacturer. Normally, the ASC11 7-bit code shown in Fig. 6 is used, the last (most significant) bit, DIO8, being unused, or occasionally, at the user's discretion, used as a parity bit. The 128 characters definable with this code include lower and upper case characters, digits, punctuation marks and symbols, and about 30 control characters (e.g. line feed).

Management lines. The five management lines allow the controller to perform all the management operations on the bus. The attention line (ATN) is used to inform the system that an interface message (e.g. address, or other command) is present on the DIO lines. Data transfer does not and indeed cannot take place while ATN is true. End or identify (EOI) is used, optionally, by a talker to indicate the end of a multi-byte transfer (e.g. at the end of a voltmeter reading), and is set during the transfer of the last byte. It is also used during parallel polling, described later. Service request (SRQ) is set by any device, assuming that it is fitted with the SR function, to indicate that it requires service. It is effectively a flag, analogous to a pupil raising his hand to attract the attention of the teacher (controller). It may be set for a number of reasons defined by the instrument designer; for example it may indicate the end of a long measurement period on a timer-counter, or over-range on a meter, or out-of-paper for a printer. Interface

Table 2

Mnemonic	Description	No of sub-sets
AH	acceptor handshake	2
SH	source handshake	2
L	listener	5
T	talker	9
C	controller	29
RL	remote-local	3
DT	device trigger	2
DC	device clear	3
SR	service request	2
PP	parallel poll	3

clear (IFC) is used, by the controller only, to reset the interface to a known state, normally the idle state. Note that it has no effect on the device status, and so is distinct from and complementary to the device clear function. Remote enable (REN), when set true by the controller, sets all devices fitted with the RL function into a state where their information is derived from the bus rather than from their front panel controls. The instruments are returned to local operation by the controller sending the "go to local" message (0000001) with ATN set true.

Handshake lines. The set of three lines called data byte transfer control lines, more familiarly known as the handshake lines, operate in an interlocked manner according to a protocol which ensures accurate and successful transfer of data bytes. The three lines are designated "data valid" (DAV), "not ready for data" (NRFD), and "not data accepted" (NDAC). Data is transferred on the bus in a bit-parallel, byte-serial manner, that is, all eight bits of an eight-bit byte are transferred at the same time, followed by the next eight-bit byte. The bytes are transferred asynchronously; in other words, there is no system clock to determine transfer speed and timing, transfer occurring at a speed determined by the slowest (addressed) device on the bus. How this happens can be seen with the help of Fig. 7.

1. The addressed listeners set NRFD false (i.e. ready) as soon as they are ready to accept a data byte.
2. As soon as the slowest listener has set NRFD false, the NRFD line acquires a value of false (open collector drives used as wired-or). When NRFD is false, and the talker has valid data, the talker sets DAV true to indicate the authenticity of the data byte present on the DIO lines.
3. On seeing DAV go true, all listeners reset their NRFD line to true.
4. The listeners now accept, and probably latch, the data byte.
5. One by one, the listeners indicate their acceptance of data by setting NDAC false, but as with NRFD, the NDAC line only acquires a value of false when all the listeners have accepted.
6. The talker, on seeing NDAC false, resets DAV to false.
7. The listeners reset NDAC to true immediately DAV goes false, and the talker can now place another data byte on the DIO lines. The cycle can now recommence.

Polling

Polling is the name given to a systematic invitation to instruments to inform the controller of their status. Two types of poll are provided for in the standard: serial poll and parallel poll.

Serial poll. Serial polling is a one-by-one interrogation of the devices on the bus by the controller, usually as a result of one or more devices having set SRQ true. The sequence of events constituting a typical serial poll is as follows.

— The control program (the software providing the sequencing information) notices SRQ is set true, and decides whether or not to take any action. The criteria for this decision are built into the control program by the program writer.

— If it decides to respond, it commences a serial poll by terminating, normally in an orderly manner, the current bus transactions, and unaddressing the current listeners and talker.

— The controller then transmits the "SPE" (serial poll enable command), by setting DIO7 to DIO1 to 0011000.

— The first device in the list of devices to be polled (the list being contained in the software program) is addressed as a talker by the controller.

— On removal of the ATN signal by the controller, the addressed device, instead of putting data on the DIO lines as it would normally, puts onto the DIO lines a word containing its status information. In particular, DIO7 is set true if the device had set SRQ true. The other DIO lines may be used to signify other messages, but this is left to the instrument designer.

— If the addressed device was the one which had set SRQ, it now resets it, and the control program will normally exit the serial poll mode by sending the serial poll disable (SPD) message (0011001) on DIO7 to DIO1. Otherwise, it continues its search for the device which set SRQ by addressing the next device on the list.

Parallel poll. The parallel poll differs from serial poll in four major respects: it is not a function of, nor does it reset, the SRQ line; it is fast; it requires a commitment on the part of the control program to conduct the poll on a regular basis; and it can only ascertain uniquely the status of eight devices.

The speed advantage of the parallel poll derives from the fact that up to eight devices can simultaneously declare their status without the need for any of them being addressed.

At the beginning of the software control program is a configuration section whose purpose is to define, in the devices to be parallel polled, the manner in which they are to respond to the poll. This configuration comprises three steps.

- The first device is addressed as a listener by the controller.
- The controller then sends the parallel poll configure (PPC) message (0000101) on DIO7 to DIO1. The device is now prepared to receive its configuration information.
- The controller then transmits the parallel poll enable (PPE) message which contains the information on how the device is required to respond in the event of a parallel poll: DIO7, 6 and 5 are set to "110," DIO4 is set to 1 or 0 according to whether a 1 or a 0 is required as an indication that the device wishes to request service, and DIO3, 2 and 1 are set to the binary representation of the DIO line number on which the device is to place that indication. Thus "1101011" will configure the device to set DIO3 to logic 1 during parallel poll if it has requested service.

The controller unaddresses the device, and addresses and configures the next until all required devices have been configured. The parallel poll system is now ready for use.

To conduct a parallel poll, the controller simply sets ATN and EOI true, and all the configured devices respond within 200ns with their status. The restriction of eight instruments is imposed by the fact that there are only eight DIO lines. However, due to the open-collector drivers, more than one device can be assigned to a particular DIO line, and wired-OR or wired-AND configurations can be set up by configuring the devices to set a 1 (low, true) or a 0 respectively in response to parallel poll.

I.E.E.E. 488 realization

The simpler, basic functions, (AH, SH, L, and T), can be fairly simply realized using a few t.t.l. packages, but the package count increases rather swiftly as other functions are included. However, a number of devices are available, or will be shortly, which achieve the interface functions using a single chip with external bus transceivers. Among these are the HEF4738 from Mullard, and the Motorola MC68488 and Intel 8291, both of which are very suitable for use with microprocessors. All three provide talker and listener functions. The Intel 8291 will shortly have a companion, the 8292, the pair together providing talker, listener, and controller functions.

Apart from dedicated integrated circuits, modular bus interfaces are available in card form from Ziatech (USA) and Micrologic (Germany), and in cased, self-powered form from such manufacturers as Fairchild and Micrologic.

Another machine which is useful is the CBM "PET" which is fitted with the I.E.E.E. interface as standard, except that an edge connector, rather than the standard connector, is used. The PET enables the user to operate the controller function through a high-level language (Basic) or, with more flexibility, from assembler language.

References

1. "I.E.E.E. Standard 488-1975, I.E.E.E. Standard Digital Interface for Programmable Instrumentation:" Institute of Electrical and Electronics Engineers Inc., 345 East 47 Street, New York, NY.10017. (obtainable through B.S.I.)
2. "Système D'Interface pour Appareils de Mesure Programmables Bits Paralleles/Mot Serie:" 66 CO 22 International Electrotechnical Commission.

Extending mobile radio coverage

Quasi-synchronous operation of two or more transmitters at u.h.f.

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To get good coverage for land mobile radio in areas with difficult topography, several transmitters on the same frequency can be used in quasi-synchronous operation. The author explains, however, that certain parameters in this method are rather critical, and that to achieve successful operation careful attention must be paid to site selection, signal level, oscillator stability, frequency response, phasing and group delay. However, although the method is more expensive than simple systems in some respects, two- or three-station quasi-sync systems are worth considering if only to simplify control.

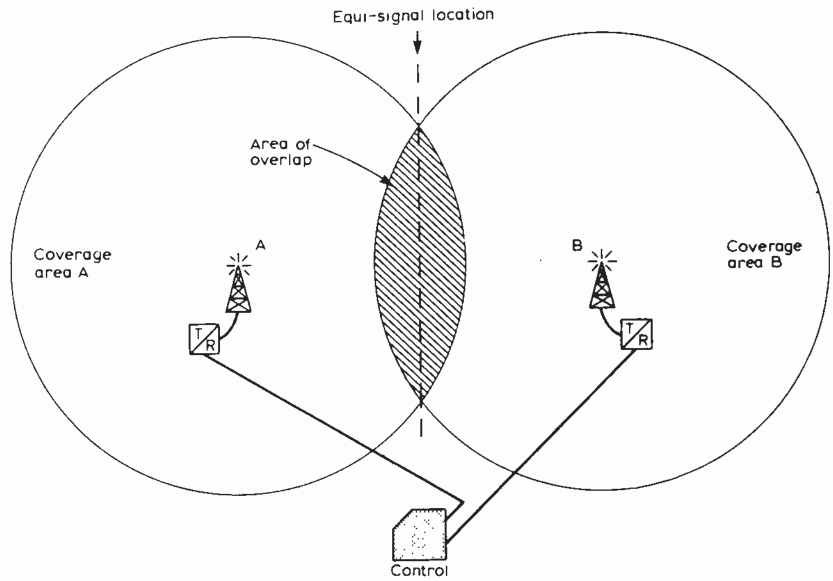

Fig. 1. Simplest quasi-synchronous arrangement, using two transmitters, A and B.

In areas where coverage for land mobile radio systems is restricted by topographical features it is often necessary to install more than one base station to enable adequate signals to be received at all points. These additional base stations can, however, cause operational problems requiring the use of separate radio frequency channels, or additional control facilities, or specialised techniques involving quasi-synchronous operation. The third method of operation has been developed as a means of providing satisfactory coverage when two or more transmitters radiate simultaneously in the same radio frequency channel. The transmitters carry identical modulation intelligence and, by adhering to certain rules, satisfactory operation is possible in standard mobile equipment located anywhere in the areas covered by at least one of the transmitters.

Both amplitude modulation and frequency modulation have been studied at length and decisions reached as to the possibilities and/or shortcomings of these modes for operation using quasi-synchronous techniques. In general a.m. has been found to be much more tolerant insofar as phase errors are concerned, while the carrier beats are less objectionable than on f.m. 25kHz f.m. systems are easier to engineer than those on 12½kHz.

At u.h.f. — 450MHz — it is possible to overcome some of the problems which arise at v.h.f. and thus systems using f.m. quasi-sync are easier to engineer. A.m., even at 450HHz, would possibly be even better for the purpose. However, the exclusive use of f.m. at these frequencies for land mobile operation precludes the use of a.m. systems.

Whether or not other modes of modulation — s.s.b. for example — would prove to be even more suitable must await the completion of any development of such techniques. Indications are that s.s.b. could show much greater tolerance and that quasi-synchronous systems using single sideband could prove to be appreciably easier to engineer. Until such work has been undertaken however, quasi-synchronous operation must be confined to existing modulation methods. The rest of this article is devoted to the main aspects of f.m. quasi-sync in the u.h.f. 450MHz band.

Advantages and disadvantages

Before examining the requirements for successful quasi-sync operation, let us consider firstly the advantages of using such a technique.

Instead of individual control of each transmitter, as would be the case with a conventional system, the total complement of transmitters can be modulated and switched from a single point if required. This ability, coupled with the use of voting techniques for the receivers, enables an extremely complex system to be operated from a simple single channel remote control unit.

As a direct result of using one channel instead of a number of channels to cover an area, the mobile unit channel switching requirement is simplified. Only the channels needed to enable a number of separate systems to be accessed are needed, while with each individual system the need for the mobile operator to switch channels as he or she moves between various parts of the area is eliminated. Thus loss of the vital message by failing to change channel at a critical point in the coverage area is eliminated.

Talkthrough operation becomes extremely simple. By merely feeding the received signal into the transmit pair at the control point, a mobile in any part of the area (assuming receiver voting is employed) automatically is heard throughout the total system area.

The result of using quasi-sync is a marked saving in channel requirement in the areas employing the technique. Channel re-use is not excessively affected by the use of quasi-sync, provided the coverage of each transmitter site is not abnormally extended. A more solid cover of an area can be achieved by virtue of the reception of signals in the mobile from different transmitter sites.

As well as the advantages, we must of course, consider the disadvantages. Quasi-synchronous techniques are used mainly for area cover systems where consistent, reliable communication is required. The engineering of such systems must allow sufficient signal strength over the area to take into account adverse factors normally encountered in area coverage systems plus an amount necessary to reduce "chopping" effects to an acceptable level.

Correct audio levels, frequency responses and phasing requirements are essential to the satisfactory operation of quasi-sync.

A more accurate and stable frequency source is required for each of the transmitters than with conventional systems. The order of frequency stability must be under $\pm 1 \times 10^{-9}$ per °C over a temperature range of -10 to $+55$°C, while, more importantly, the ageing source should certainly not exceed the frequency stability figure over any period of 24 hours if frequent and costly adjustments are to be avoided.

Where overlap occurs between two areas, "chopping" and distortion of the signal can occur in quasi-sync areas, especially with stationary mobiles and where adequate signal levels are not available. Short sector multi-path fading will tend to modify this effect. With moving vehicles at frequencies in the u.h.f. bands, however, the fluctuations associated with multipath short sector fading will be quite rapid and thus the overall "chopping" may not be as marked as at the lower frequencies.

Indications are that the overlap achieved by three sites is optimum for f.m. systems and more overlapping sites should be avoided.

Site considerations

Fig. 1 shows the simplest quasi-sync transmitter configuration employing two sites. Typical overlaps of the operational areas are shown, based on the use of plane earth propagation. It can be seen that the signal received by the mobile can be predominantly from Station A, predominantly from Station B, through all intermediate signal ratios until a point is reached — shown by the broken line — where the signals received are exactly equal in amplitude.

It is at this point that one of the main disadvantages of f.m. compared with a.m. is highlighted. With a.m. two signals of equal strength, but with a small frequency offset, should — provided the general precautions outlined later in this article are observed — be completely intelligible. Two f.m. signals of equal level, on the other hand could, unless the deviations of all transmitters are held to a close tolerance, result in distortion becoming excessive. If this occurs, not until the difference between signals exceeds 4 to 5 dB will the stronger signal start to exhibit capture and improved intelligibility results.

This problem, together with the noise bursts which occur when the carriers arrive in phase opposition, contribute to the fact that f.m. systems are much more difficult to engineer than their a.m. counterparts. These difficulties however, are eased considerably at u.h.f. by the faster multipath fading rate associated with an urban environment and the differing degrees of random coincidence of equi-signal areas.

The use of more than two overlapping areas can help further in producing an area of random and non-coherent signal levels.

Quasi-sync frequency

To ensure correct operation of a quasi-sync system there must be finite and controllable small differences in frequency between all the carriers concerned in an area of overlap. The difference must be based on several fundamental requirements. First, beat notes must be outside the range of audibility. Secondly, too low a separation will cause excessively long nulls produced by cancellation in equal signal areas between two stations. These nulls will cause the receiver squelch to "chop," or alternatively produce bursts of noise if the squelch is rendered inoperative. Excessively long periods of distortion can also appear. Thirdly, too high a separation could start to produce audible effects, for example, speech break-up.

The optimum separation for a two-station system appears to be around 3Hz, while for a three station system the separations can, with advantage, be a little lower.

In order to maintain the offset requirements over the longest possible time period, the stability of the frequency source in each of the transmitters must be of certain minimum standard. By using proprietary high stability sources, these requirements can be met.

One has to consider first the ageing of the reference crystal in the frequency source and secondly the effects of temperature on the derived frequency. The first can be reduced by time and adjustment while the second is a function of the environmental changes, which in turn can be further controlled by temperature control if so desired. Fortunately fixed equipments tend to be less subjected to violent excursions of temperature compared with mobile units and, therefore, with care, the effects of temperature changes can be minimised.

Let us examine the likely effects resulting from the use of a proprietary high stability source. Typically the ageing will be $\pm 5 \times 10^{-10}$ per day (averaged over a period of ten days) three months after the start of operation. The monthly ageing rate will therefore be $\pm 1.5 \times 10^{-8}$. This is equal to ± 0.225Hz per day at 450MHz (± 6.75Hz per month). The high quality 5MHz source used in the unit will tend to be reasonably well aged by the time it is incorporated in the equipment. Furthermore, this type of high grade crystal can be selected to show an ageing characteristic in the same direction for all units. On this basis the frequency offset variation in any one system installed and adjusted at the same time should be considerably less than the above figures indicate.

Nevertheless, it is essential that, at least in the initial months of use, monthly checks should be made to establish the rates of ageing and to make adjustments correcting the frequencies to maintain the desired offsets. As the ageing rate improves, the check periods can be less frequent.

Let us now look at the shorter term changes caused by temperature. It is here that the importance of minimising

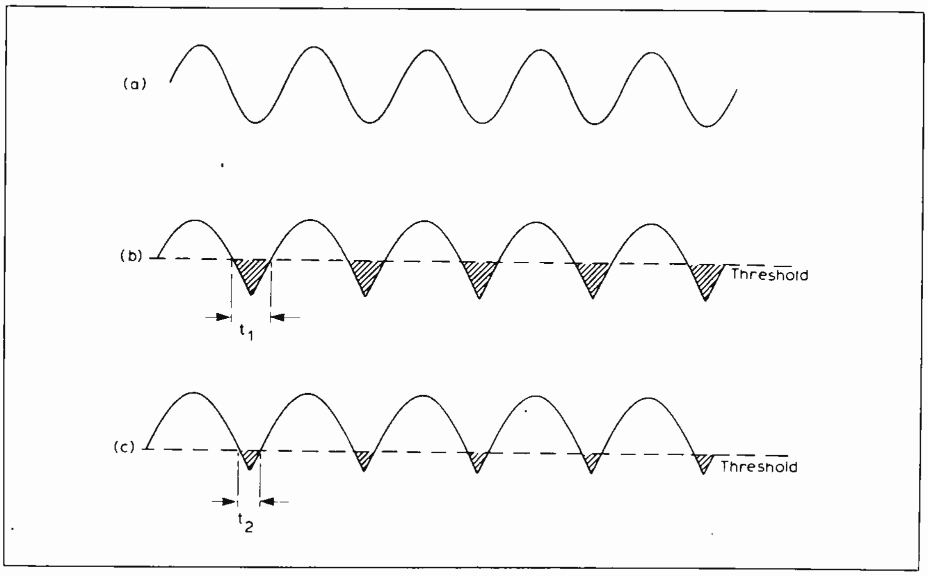

Fig. 2. Duration of a complete null is reduced, from t_1 in (b) to t_2 in (c), as the individual carrier levels of the transmitters increase. When two signals are approaching anti-phase, weak carriers are below the required threshold for longer than when two signals each with a higher individual level are present.

ambient temperature changes is emphasised. With a frequency stability of the order of $\pm 0.6 \times 10^{-9}$ per °C, the high stability oscillator should be located in as constant a temperature as practical to take advantage of high stability. In an area system it is to be expected that changes in the ambient temperature of the outside atmosphere will follow a cycle having a similar "phase" relationship throughout the area although not necessarily having identical absolute values.

It can be seen that suitable offsets must always exist if the nulls and therefore the noise bursts and any quasi-signal distortion are to remain acceptable. It therefore follows that the frequency sources must have had approximately the same degree of age-ing if the offsets are to remain within acceptable limits between test periods. This particularly applies if, in the un-likely event of failure of a 5MHz crystal in the frequency source, a replacement unit is required. Such a unit should not be of recent manufacture but should be taken from a small stock of units which have been aged for reasonable periods. By so doing, the need for frequency ad-justment at abnormally short intervals is avoided.

Signal levels

The direct result of chopping which can occur when equi-signal areas exist, in particular in the two carrier condition, is to introduce noise bursts as the in-dividual signals arrive out of phase with each other. This tends to cause the squelch to switch on and off as well as contribute to a reduction in audio quality which is trying to the operator. The effective intelligibility reduction is worsened by excessive modulation levels and it is essential not to exceed the rated deviation.

Most important, the deviation of all transmitters must agree, by as close a degree as possible, to avoid excessive distortion in equi-signal areas.

The duration of a complete null is reduced as the individual carrier levels of the transmitters increase. This is explained by the fact that when two signals are approaching an anti-phase condition, weak carriers are below the required threshold for a longer period than when two signals each having a higher individual level are present. Fig. 2 shows how this occurs.

Tests have been made to ascertain the level of the signals necessary for the nulls between carriers to be acceptable, and the figure finally chosen as a com-promise between performance and site economy is approximately 5μV p.d. The variations at this order of carrier level can be markedly improved upon if further signals are also received at the same time from other areas (systems with more than two sites) with these additional carriers at a level of around 1-2μV. The action of these extra lower level signals is to reduce the nulls by ensuring that signals other than those from equi-signal areas are available in the areas affected normally by chop-ping. For example, two out-of-phase signals of 5μV and one or more of 1.2μV will not produce such a pronounced null pattern as would two signals only of equal amplitude.

At u.h.f., as the multipath reinforce-ment and cancellation occurs at much faster rates owing to the use of a shorter wavelength, the probability of being in an exact location of two equal signals is much less, particularly at the higher carrier levels suggested. The nulls and distortion periods will therefore be much shorter in duration. In all quasi-synchronous systems, the coverage of urban areas is much improved if the sites for transmitters are chosen to illuminate the likely blank areas from markedly different angles, avoiding whenever possible, however, the condi-tions where two or more transmitters have a direct line of sight and, conse-quently, possible free space propagation to the mobile. It is in these situations that extended areas and periods of equisignal are likely to occur.

Audio requirements

Reception of satisfactory speech at the mobile receiver over a quasi-sync sys-tem depends on the intelligence from all transmitters arriving at the mobile receiver in phase and at approximately the same amplitude at all frequencies within the speech pass band.

The first requirement, phase relation-ship, is a function of the design of the equipment and the group delay perfor-mance of the various media bearing the intelligence to the different transmit-ters, e.g. the delay characteristics of the path of the radio links and, to a lesser degree, of the paths between the dif-ferent transmitters and the undefined positions of all or any of the mobiles. The second requirement mentioned above has relatively fixed characteris-tics and, once adjusted, should remain constant.

As some of the phase considerations are to a certain extent dependent upon certain aspects of the frequency res-ponse characteristics, it is as well to start with the latter. Normal speech is of adequate and acceptable intelligibility if the overall response over any pair of transmitter and receiver (fixed to mobile) equipments is reasonably flat from 300 to not less than 2500Hz. The response characteristic of the quasi-sync transmitters should avoid resonances wherever possible and any filters used to obtain the desired cut-off should not cause any marked phase changes at the points immediately prior to cut off.

Now let us consider the bearer circuits. The major problem with land-lines is that they are not normally under the control of the radio system user or supplier. Consequently, any rerouting or line reversal can cause a sudden change in operating conditions and the appearance of distortion in equi-signal areas as a result of modifi-cations to the delay, equalisation and/or frequency response. Although pref-erably avoided, therefore, they can however be used under certain control-led circumstances.

Where radio links are used, it is es-sential that the frequency response is corrected for maximum flatness with-out sharp cut-offs at low and high frequencies. This proviso greatly sim-plifies the delay setting and equalisation as both frequency response and phase change are inter-related.

Derived circuits should not be used unless suitable equipment is employed to ensure that both phase and frequency are locked over the circuit at all times.

In the multi-transmitter quasi-sync system the individual frequency res-ponse characteristics of each path should be checked to see if they con-form generally with the foregoing. Taking the frequency response of the worst link as the base limit, each other path should be adjusted by the addition of relevant constants to approximately the same response characteristics.

Phase and group delay

Probably of even more importance to adequate intelligibility than frequency response is the need to maintain correct phase relationships throughout the total system. As these can be of a vari-able nature and caused in part by vari-able propagation paths within the sys-tem — in particular those affecting the fixed to mobile paths — it can be seen that some compromise is necessary. The acceptable delays are a function of the audio bandwidth accepted.

Group delay is the period of time by which a band of audio frequencies is retarded during its passage through a network or medium. A given delay will affect the phase of different frequencies over the audio band at a constant in-creasing rate as the frequency is raised and it is essential that there should be substantially similar delays between the audio source and each quasi-sync transmitter output. Fig. 3 shows how various audio frequencies are affected by different values of group delay.

The individual equipments must have identical phase parameters, starting with the essential need that no conflict-ing phase reversals should exist in any of the units. At the same time delays existing through each of the equip-ments must agree if at all possible. Equipment interconnections must also be such as to ensure overall phasing compatibility. Errors can be consider-ably reduced if the broadcast method of linking is used. Here a single trans-mitter broadcasts to all link receivers thus minimising equipment differences.

Having ensured that all equipments

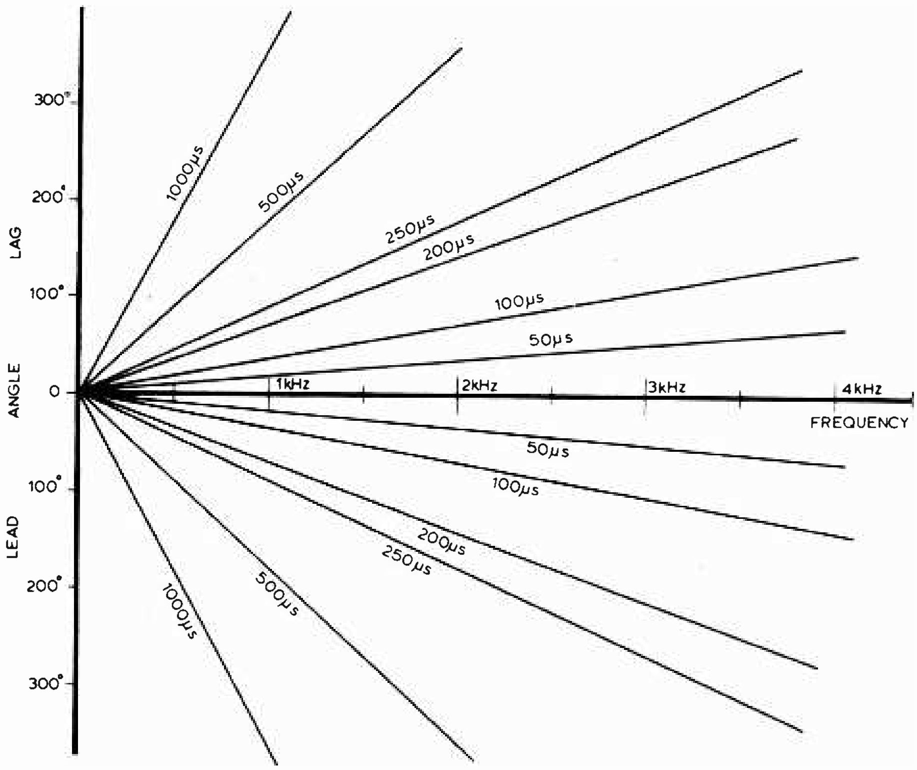

Fig. 3. How various audio frequencies are affected by different values of group delay.

have similar characteristics, we now have to equalise the group delay caused by the differing path lengths between the link transmitter(s) and their associated receivers. Path delay can be taken as equal to 5.4μs/mile or 3.34μs/km. Thus, if the delays associated with the link paths are calculated, it is easy to appreciate that additional delays must be added to all but the longest path to equalise the path delay throughout.

Systems using multi-hop radio links, although feasible, introduce many more problems associated with delays than single hop systems and, therefore, if possible should be avoided unless common elements can be included. If landlines fulfilling the essential requirements are available then systems can be engineered taking into account the group delay characteristics of the landlines used.

The delay produced by the path between any of the transmitters and the mobile receivers will obviously be of an appreciable and varying amount. Unfortunately, the position of any mobile is random and therefore it is extremely difficult to introduce delays which can compensate for this ever-changing situation. However, *provided the coverage areas of the individual quasi-sync transmitters are similar*, the areas of quasi-sync will tend to follow a common pattern throughout and therefore path delays will be approximately equal under the majority of circumstances.

In the isolated case where one station is situated on a high site and has a large coverage area, there will, however, be a different path delay between that station and others at the equi-signal points. Thus in this particular case it may be necessary to increase the delay at all the stations where the coverage is considerably less than that of the single high site. Generally, all sites should have a similar area of coverage in order to avoid these difficulties.

Work has indicated that usually, if group delay compensation is adjusted to less than 10% of the delay at the highest audio frequency, then performance will be adequate. Assuming 2.5kHz as the top audio frequency — duration of a single cycle equalling 400μs — then if the individual quasi-sync transmitters radiate in phase within 40μs intelligibility will be acceptable. However, u.h.f. systems are likely to be used in urban areas where there is a likelihood of weak signals in certain locations (within buildings, etc) and it has been ascertained that it is preferable to improve the delay tolerance at u.h.f. to better than 5%. This means a maximum delay at 2.5kHz of 20μs.

Deviation levels

Over deviation and excessive limiting can cause a marked reduction in intelligibility in quasi-sync systems. In addition care should be taken during adjustment to ensure all transmitters have a similar level of deviation held to close tolerances to avoid an unnecessary high level of distortion in equi-signal areas.

Talk-through

One type of system which benefits from the use of quasi-synchronous operation is that employing talk-through. Whereas with conventional systems talk-through is fairly simply applied to discrete sectons of a wide area system, the application where total wide-area talk-through is required introduces many more difficulties, some of which can prove insuperable in certain configurations.

With quasi-sync operation, however, the system layout is such that, provided the receiver path problems are solved by the use of voting, the application of talk-through exhibits no major difficulty. The talk-through switching path, together with the audio feeds, are routed by the control operator via the control unit and any incoming signal on the receive path is fed to all transmitters for total area coverage.

One difficulty with any two-frequency system is to prevent mobiles calling simultaneously, particularly during a message sequence. In a wide area system using receiver voting this effect can be particularly frustrating and a method to reduce the problem has been devised. Where a calling mobile is routed by the voting equipment to the control, it at the same time switches on the transmitter chain modulated by an interrupted audio tone. This signal warns all other mobiles that the circuit is in use.

Test equipment

An essential requirement when operating a quasi-sync system is that adequate and suitable test equipment should be available. First, we must be able to measure accurately and quickly the exact frequency being radiated from each transmitter. For this purpose a digital counter type of frequency measuring equipment is needed, capable of determining the output frequency to within 0.1Hz. The use of Droitwich 200kHz, MSF 60kHz, WWV 5, 10 and 15MHz as "off air" standards is considered essential to enable the counter to be checked and adjusted.

The critical system parameter is the frequency difference between stations. A method of checking this is to make use of a continuously powered (by batteries) high stability oscillator which can be transported between sites. This unit can be used as a main reference with which to adjust the local oscillator. Taking the "standard" source as the nominal frequency and assuming a transmitter has a frequency multiplication factor of 32 times, then a 1Hz carrier offset will show up as a beat between the two oscillators of 1/32Hz. Seen on the oscilloscope, the oscillations will coincide once every 32 seconds.

To enable the various phasing adjustments to be made, it helps to use a special tone generator with a gated output. This output consists of 4Hz on, alternating with 4Hz off, capable of being swept over the audio band. The device can consist of an external unit in association with a conventional oscillator/t.m.s. □

Colour tv receiver design

Circuit and construction techniques for a single-panel chassis

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After outlining the general criteria which have to be considered in producing tv sets for today's mass market, the author starts in this article to describe the circuit and construction features of a PAL colour chassis introduced by his company last year, for initial use in a 14-inch portable. It includes a surface acoustic wave filter for the i.f., a fully isolated switched-mode power supply, an adaptive sync separator and field sync count-down. Most of the circuitry is on a single printed circuit panel.

The design of a complex piece of electronic equipment for mass production, and subsequent sale to the consumer, involves the skills and decisions of many people. In the particular case of a television receiver the end product is affected by numerous requirements at every stage of its history from initial conception to operation in the customer's home. Some of the more important factors which affect the design are (not in any particular order of preference):

Overall performance
External appearance
Cost
Advances in technology
The customer
Serviceability
Manufacturing methods

A chassis recently introduced by the author's company in a 14in portable receiver is the basis of a new range of sets and, as such, has been designed to be as adaptable as possible. Before going on to describe some of the innovations in this chassis in detail, and to show how the above factors have influenced its design, I shall consider each factor in a more general way.

Overall performance

Most customers seem to buy a television set because it gives a pleasing picture; or because the cabinet looks nice; or because the price is reasonable; or, perhaps, because the set has a good record of reliability; or possibly a combination of all these.

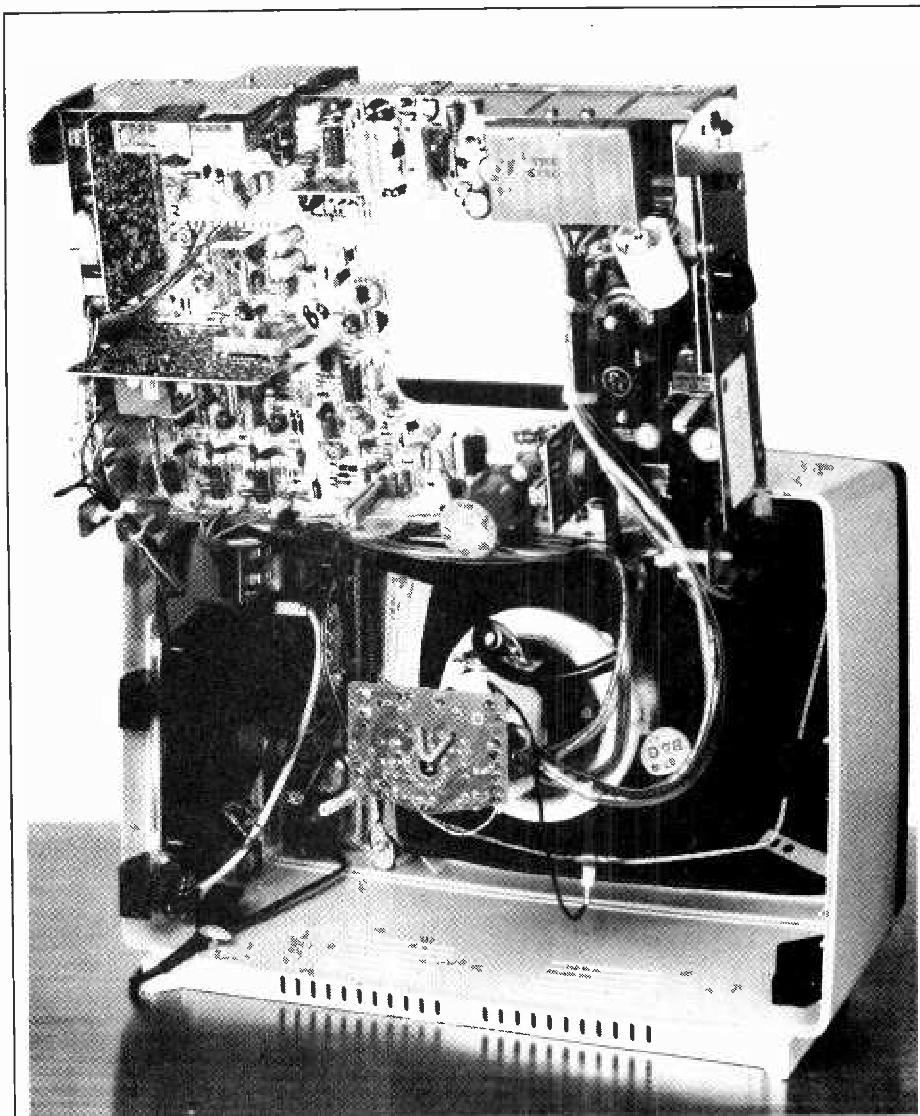
The more controls there are which affect the displayed picture and sound, the greater the likelihood that something could be adjusted wrongly or knocked out of adjustment. So for good, consistent performance there should be a minimum number of adjustments. Cathode-ray tube developments in recent years have helped this trend and modern tubes with in-line guns and fixed yokes do away with the need for factory or dealer adjustment of purity and convergence.

Recent developments in the r.f. section, notably the surface acoustic wave filter, have helped to achieve great stability and repeatability of the r.f. and video performance. Channel tuning for the customer can be helped by careful use of a.f.c., and improved tuner design together with the well-established techniques of a.g.c. and a.c.c. ensure acceptable pictures with a wide range of aerial signals.

Increasingly advanced timebase circuitry, particularly in the line and field synchronising areas, is ensuring more stable pictures and a greater tolerance of poor signals.

Higher efficiency scan coils and careful power supply design (as well as careful consideration of the power consumption of each section of the receiver) have dramatically reduced the overall power consumption of the latest tv sets.

Fig. 1. The 70 series receiver chassis.



The external appearance

It may be thought by the layman that the electronic design department of a tv manufacturer presents a working prototype chassis to a stylist with the instruction, "There, put a box around that!" Alternatively, that the stylist presents an attractive cabinet to the electronics engineer, saying "Put your chassis in there!" Of course, the truth lies between the two extremes and there is a good deal of adaptation and modification to both chassis and cabinet size and shape before the result is agreed to be satisfactory.

The objective is usually a compact, slim, pleasing cabinet and unobtrusive back with a clean arrangement of controls, a reasonable size of loudspeaker and a well ventilated chassis. Although the power consumption in modern sets is low, some heat is still produced. In this respect care must be taken in placing potentially warm components well away from heat-sensitive components: for example, it is good practice to keep a "watty" resistor away from, say, a power transistor or an electrolytic capacitor.

The requirement to combine compactness with good ventilation can cause some headaches to the designers. This problem is particularly acute in the case of a portable set. The principles established with and previous designs of chassis have been incorporated in the present chassis, whose normal vertical position in the set aids convection.

Cost

The final works cost is principally made up of components, labour and overheads. All three elements can be reduced by cutting down the number of components and this can also improve the reliability. However, indiscriminately reducing the number of supposedly inessential components or using apparently equivalent but cheaper components without adequate testing or appraisal can lead to a reduction in reliability.

The keyword for this aspect of design is that jargon phrase — cost-effectiveness. Each section of the receiver must be designed to be as inexpensive as possible, but performance, quality and long-term reliability must not be sacrificed to achieve this.

Integrated circuits have helped this aim by providing improved or equivalent performance with a greatly reduced component count. However, the partitioning of the circuitry, i.e. which sections of the circuitry are incorporated in which i.cs, has to be done with careful consideration of the whole receiver to avoid duplication.

Apart from the effect of reducing the number of components, labour costs can also be reduced by careful design of the chassis itself. For example, the way the printed panels are arranged or connected; the way various wires and cableforms are arranged; the way components are fitted; the way the chassis fits in the cabinet; the way the tube and the control assemblies fit in the cabinet; the number and complexity of test and adjustments required.

Advances in technology

Every time a new range of products is planned the question inevitably arises: which sections of circuitry should be retained and which sections should be considered for the introduction of new technologies.

If a particular section of the receiver had proved to be reliable and to perform well over a number of years, there would be little point in changing it if the components continued to be readily available. If the older technology becomes unavailable or expensive or if the new technologies can be shown to give improvements in performance, reliability or cost then the time is right for a change. In fact, Decca continued manufacturing a hybrid chassis (i.e. semiconductors and valves — remember them?!) for some time after many setmakers had gone over to full "solid-state" sets, for the simple reason that the 30 series chassis had proved to perform well and reliably (by the standards of the day) and was popular with the trade and public alike.

The solid-state 80 and 100 series chassis were introduced when improved c.r.ts were becoming available — the s.s.i. or p.i.l. and 20AX tubes have simpler tube adjustments and more efficient scan coils — and by that time, of course, valves and valve-bases were becoming increasingly more difficult to obtain. In addition, i.cs were becoming more standardised and the partitioning of their functions more clearly defined; and, most important, the critical area where valves had retained their superiority, the line output stage, could now be transistorised with reliable components.

After 3½ years of production of the 80/100 series sets, the present chassis, known as the 70 series, was introduced last year. The first model, as already mentioned, is a 14in 90° portable (Fig. 1) but the chassis has been designed to drive all sizes of tube up to 26in 110° with a minimum number of changes. As will be seen, new circuitry and techniques have been used alongside well-established ones. The chassis is much more compact than its predecessors and the latest manufacturing techniques have been provided for in its design.

Random flashover in the c.r.t. has had destructive effects, in the past, on semiconductors. In recent years extensive studies have been made into the mechanism of flashover and into ways of simulating and monitoring it reliably and ways of designing the circuitry to prevent destruction of semiconductors. The results of work along these lines using advanced equipment became apparent in the reduction of failures during the production of 80 to 100 series receivers. This work has continued during the development of the 70 series.

The techniques used seek to contain the high currents (hundreds of amps), generated during a flashover, within a closed loop around the c.r.t.; and to ensure current paths around i.cs are kept very short. In some cases resistors or small chokes are used to buffer off potentially vulnerable points. Recent developments in c.r.ts have produced "soft-flash" tubes in which the flashover current is considerably less. However, it is felt preferable to use this development as extra protection rather than relax any of the above circuit techniques.

The customer

The general public's opinions on good performance are not always predictable; indeed it is remarkable how poor a picture some people will tolerate. On the other hand, it is almost as remarkable how critical other people are regarding (to others) insignificant details of performance or operation. All that the poor design engineer can do is to provide the best picture, reliably, at a reasonable cost (cost effectiveness again).

However, there is one aspect of operation in the customer's home which is of paramount importance, and this is safety. Fortunately the catastrophic fires which beset some early colour sets are now a thing of the past. In a modern receiver every component which can be so specified is flameproof or flame retardent. The reduction of power consumption helps considerably too, since hardly any components get more than appreciably warm. (The 70 series takes about 60W from the mains with an average picture, compared with the 80 series' 130W and 100 series' 200W.)

The requirements of BS415 and IEC 65 and the various test houses (BEAB, SEMKO, VDE etc.) discipline the designer to achieve a very high standard of safety. The designer must consider numerous potential faults such as short-circuit or open-circuit capacitors and resistors; faulty semiconductors; open or short-circuit coils and transformers; voltage breakdown between components or across copper tracks on printed panels; the temperature of all components at the highest ambient temperature in which the set is expected to operate. These are just some of the conditions which must be analysed during the design to ensure that no fault will cause a hazard of any sort to the customer. Combinations of worst-case tolerance components have to be considered when calculating for maximum voltage or power conditions in any part of the set. The use of fusible resistors helps in cases where a fault could leave a component over-dissipating permanently without the customer being aware of it.

Serviceability

We all hope the receiver will never go wrong. But we live in an imperfect world and no matter how carefully a set

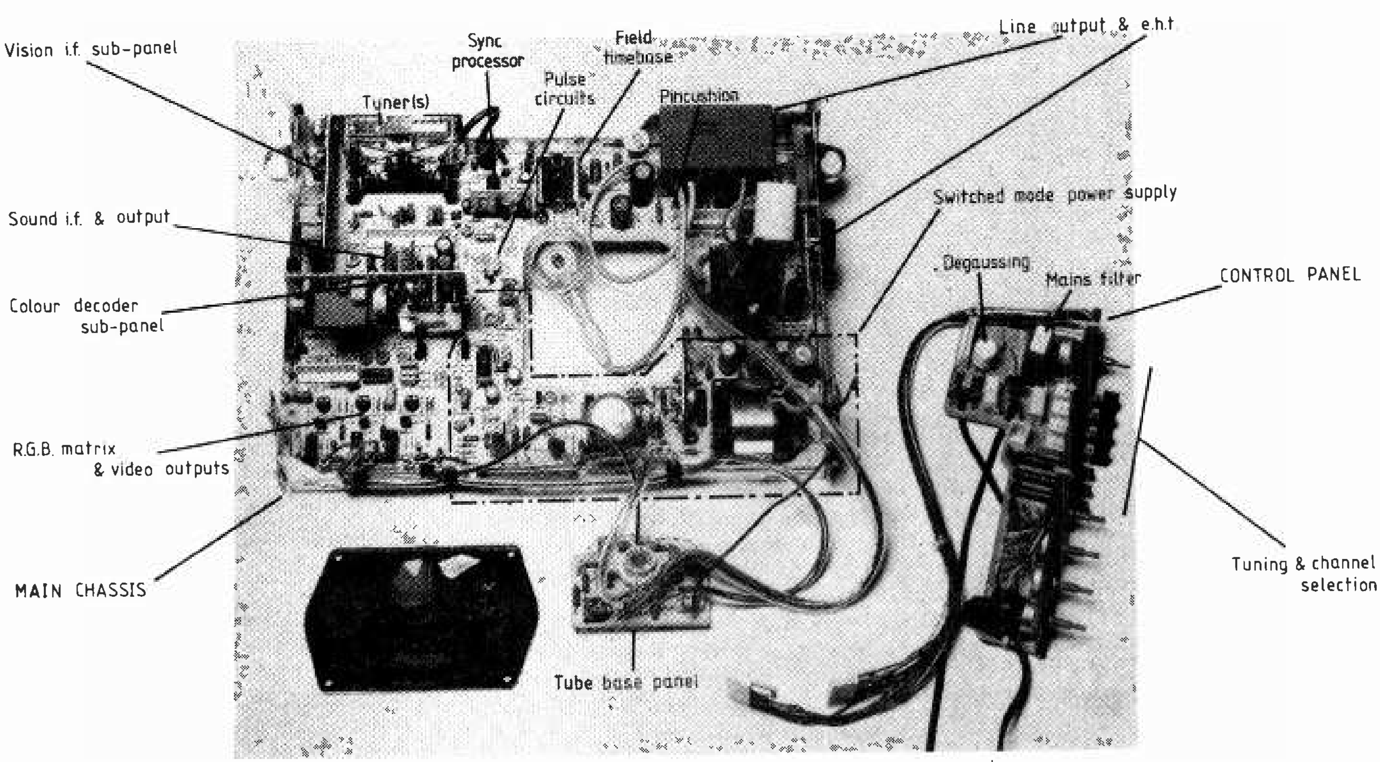


Fig. 2. Identifying the various sections of the 70 series chassis and control unit.

is designed, built and tested faults will occur from time to time. Service calls are costly, so it is worth while designing the set for ease of servicing. Too many service aids, however, can make the cost of the set prohibitive and a careful balance has to be maintained considering the greatly increased long term reliability of modern receivers.

Some servicing features are relatively easy to provide; for example, the fixing of the cabinet back. This is normally the first thing a service engineer will need to remove if something has gone wrong with the set. It is such a simple thing and yet there are sets which need as many as eleven screws removing before the back comes off.

The 70 series receivers retain the feature introduced nearly four years ago with the 80 series: the cabinet back is retained by two fasteners which are disengaged by the use of a coin. The chassis, too, is retained by two similar fasteners and, when released, hinges up to lock in a convenient position which gives access to both sides of the printed panel (Fig. 1).

The 70 series chassis has most of its circuitry on a single printed panel (Fig. 2) with the i.f. and decoder circuitry on two sub-panels. This means that servicing by substitution of printed panels is only possible with faults in the i.f. or decoder area. However, the remainder of the chassis is sectioned into blocks of circuitry which can be isolated by means of pluggable test links.

Most of the i.cs and the tuner(s) are fitted in sockets to ease servicing and aid testing and fault-finding in the factory.

Manufacturing methods

If a set is designed to be easy to make and straightforward to test and set up, the factory will take a greater pleasure and pride in producing it. Their greater concern will be reflected in the quality and reliability of the finished product. The introduction of automatic component insertion and automatic test equipment in certain areas also aids consistency and reliability. These methods have to be considered during the design. Automatic component insertion demands greater accuracy of printed panels and the physical characteristics of the machine puts certain constraints on the positioning and size of components.

Automatic testing can ensure that many more tests, both component checking and functional measurement, can be done on each chassis in a shorter time. Reliability is improved and fault-finding and inspection are made much easier.

The 70 series chassis

Fig. 3 shows how the various blocks of circuitry interconnect while Fig. 2 shows their relative positions on the chassis. As can be seen, in block form much of the circuitry appears straightforward and conventional. For example, the progress of the signal from aerial to tube follows the same course (at least in block form) as in most receivers although, as will be seen, some details are far from conventional.

The way the timebases and their by-products such as e.h.t., and focus supplies and pincushion correction circuitry, cluster around the tube will be recognised by all familiar with tv receivers. However, the way the power supply is intimately connected with the line timebase is somewhat unconventional.

The major part of the chassis is isolated from the mains and the stabilised power supply is a switched mode type with its operating frequency locked to that of the line timebase. Since the chassis is intended for use in a variety of models, this isolation helps with features such as sockets for headphones or video or audio recorders; video monitors; and certain markets which require isolated chassis.

A switching power supply is, of course, much more efficient than a linear stabiliser and a high operating frequency enables the output electrolytics to be reduced in value. Also, the presence of a transformer increases the flexibility of the various supply voltages required. The main disadvantages with this system are the more stringent requirements on the insulation of all the transformers which bridge the isolation barrier; the need to have at least a 6mm gap on the printed panel all round the 'live' area of the chassis; and the greater care needed in the choice and parameter specification of the power supply output device. The fact that the supply is locked to line frequency means that any interference spikes are locked to the picture and will not cause variable beat patterns all over the screen. It also means that the supply must be within the phase control loop of the line timebase. As can be seen from Fig. 3 a line sync signal from the line oscillator and a reference flyback signal

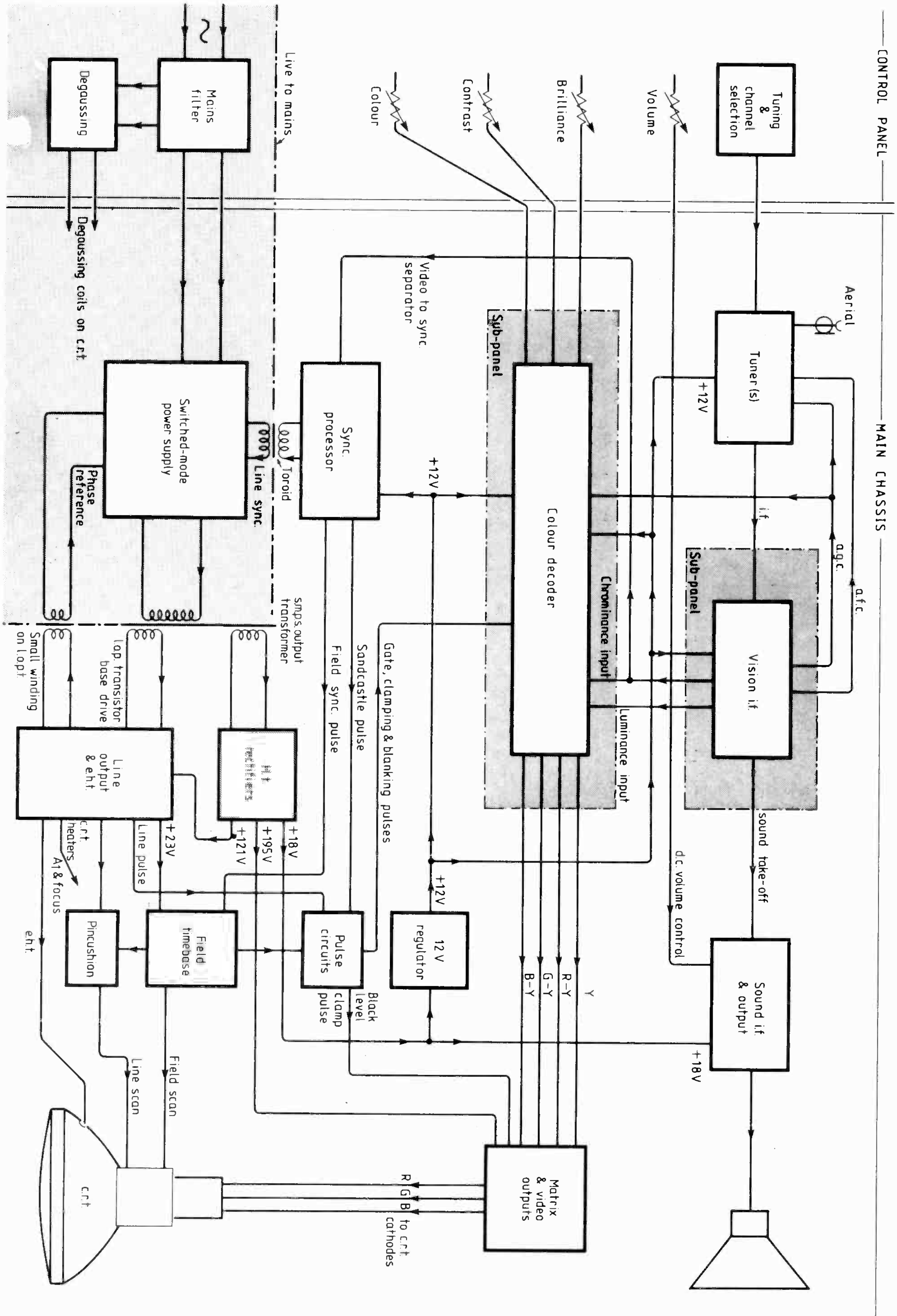


Fig. 3. Block diagram of the complete television receiver.

from the line output transformer are fed into the supply and the base drive for the line output transistor is taken from it. This removes the need for a separate line driver transistor and transformer.

The switched mode power supply (s.m.p.s.) provides three stabilised supply lines, of 121V, 195V and 18V. The 121V supply to the line output stage must be stabilised because the scan current, and hence picture width, is directly proportional to this supply; moreover, the derived voltages of e.h.t., focus, and field timebase h.t. are also dependent on this supply and so the whole picture size and focus will depend on its stability.

The 18V supply voltage was chosen to provide an adequate level of audio output power and yet maintain a low dissipation in the i.c. stabiliser which provides 12V for most of the signal processing circuitry.

The audio output stage uses the 18V supply directly from the s.m.p.s. to give approximately 3.5W r.m.s. into 8Ω.

The extra stabilisation down to 12V helps to buffer off any disturbances on the 18V line caused by large current pulses drawn by the audio stage during bass transients. Also, the tolerance on the output of the 12V stabilser i.c. is closely specified by the manufacturer under all conditions (11.4 to 12.6V) and ensures that the circuitry driven from the 12V line is always operating within its design limits. One of the major problems of circuit design for mass production is to ensure that for all combinations of tolerances the circuitry will work within specification and safely (i.e. will not over-dissipate nor produce too high a voltage). With thousands of receivers leaving the factory every week the chance of any combination of adverse tolerances occurring is fairly high. It's probably exaggerated by a well-known law ('Finnagle's Law', *W.W.* Sept.'59) which ensures that a batch of, say, resistors at the top end of their tolerances will be delivered at the same time as a batch of, say, i.cs at the bottom end of their tolerances.

In cases such as this the laws of chance fly out of the window and the tolerances add arithmetically instead of statistically. It is thus important to investigate, at the design stage, as many combinations of tolerance extremes as possible.

In the smaller models the chassis drives a 14in or 16in c.r.t. with an e.h.t. of 22.5kV which is sufficiently high to give good focus performance whilst maintaining a safety margin from the tube's maximum limit of 25kV. In the larger models the e.h.t. is 25kV and slightly different line output and power supply transformers are fitted.

For the British market a u.h.f.-only tuner is required but for CCIR or Eire standards both u.h.f. and v.h.f. tuners are needed and a modified i.f. sub-panel (which includes the luminance delay line – also different for these transmission standards) is fitted. Both tuners and i.f. sub-panel are pluggable, so a stock of standard chassis can easily be changed in the factory from one version to another.

The basic 14in portable has four push-buttons for channel selection. Three positions are tuned by multi-turn presets and are intended for setting to the normal channels viewed in the home. The fourth button selects a multi-turn control (called Varitune) available on the front panel which can be easily set to another channel if, for example, the set is taken to another part of the country during a holiday. There is then no need to disturb the "home" settings.

Since the tuning is effected on the chassis by a variable direct voltage applied to the appropriate pin on the tuner it is easy to provide a range of tuning methods at the control panel and thus cater for a wide range of models.

The customer controls are also d.c. operated and are applied, like the tuning voltage, to a plug on the main panel. Thus the addition of features such as remote control, touch tuning and memory tuning is easily catered for without the need to alter the main panel.

The next article will look at new features of the circuitry in more detail.

Ray Wilkinson, the author, is Decca's assistant head of television receiver design, working in the development laboratory at Bradford. He got his degree at Northampton College of Advanced Technology (now City University) and his first job was with Siemens Ediswan, which later became Thorn-AEI Radio Valves and Tubes. In the Thorn-AEI applications laboratory at Brimsdown he worked on colour tv circuitry and colour demonstrations, then in 1969 joined Rank Cintel to work on studio slide scanners and telecine machines. He moved to Decca in 1972. Among Ray's other interests are music and model railways.

SIXTY YEARS AGO

The first London newspaper to receive news by wireless was the *Daily Mail*, taking a message from Marconi's at Chelmsford, on May 28, 1920. The June issue of *Wireless World* carried an article on the *Mail's* station and took the opportunity to do a bit of crystal-gazing.

"The *Daily Mail* installation consists chiefly of a six-foot frame aerial of the solenoid type, wound with 48 turns of wire, used in conjunction with Marconi 7-valve high frequency amplifiers and detectors, Types 55A and 55D, which have been previously described in our pages and are familiar to most of our readers. Type 55 is one of the most sensitive receivers in existence and is particularly suitable for use with a loop aerial. The tuning arrangements permit of reception on wavelengths of from 600 metres to 18,000 metres. Damped and undamped waves and wireless speech can be equally well received on this apparatus, which is no amateur set but an instrument which has been thoroughly proven both in war and commerce, and is capable of detecting signals from any high-power station within a radius of 3,000 miles. In a vision of the future one sees the inside of a newspaper office, where reporters are busy receiving "copy" from their colleagues in provincial towns, whilst automatic receivers click out tape records of news messages sent at 100 words a minute from the world's high-power news-distributing stations. From this to direct type-setting by wireless is, maybe, not so far a cry as from Marconi's early experiments to his first great achievement, transatlantic wireless telegraphy!

"If, in addition, this future newspaper draws its electrical power from some huge Wireless Power Station, why then – then we shall have really begun in earnest to use that incomparable, universal medium, the aether.

"A visit to Carmelite House and a conversation with *Daily Mail* officials revealed that the latter intend to lose no time in assisting wireless and journalism to join hands. They look forward to the time when a reporter shall start for the scene of his "story" in an aeroplane – "and arrive," one of them humorously interpolates – and deliver his "copy" to headquarters by a system of linked wired and wireless telephony, the message being received at the paper's own wireless station. They intend to make as much use of wireless as possible and entertain no doubt but that present day apparatus can fulfil all the demands likely to be laid upon it by Fleet Street in general. The idea of an "exclusive" message being flung out on an indiscriminating, generous aether, and intercepted by rival papers, created a disturbing ripple in the flow of conversation. Knowing that a similar objection has been levelled at wireless telegraphy for twenty years we do not view this question in quite such a serious light. There is this point, too, which must be taken into account – directive wireless is probably not far distant."

Acoustics conference

The tenth International Congress on Acoustics runs in Sydney, Australia from 9 July to 16 July 1980. Advance programmes and registration forms are available from the Congress secretariat, GPO Box 2609, Sydney, NSW, Australia 2001.

NEW PRODUCTS

Educational micro kit

Although there are several microcomputers and kits available, most are offered as "useful" computers which can be expanded to form a complete system. Edukit, however, is aimed at beginners who want to learn the basics of computing as cheaply as possible and do not want to be left with a redundant piece of expensive hardware.

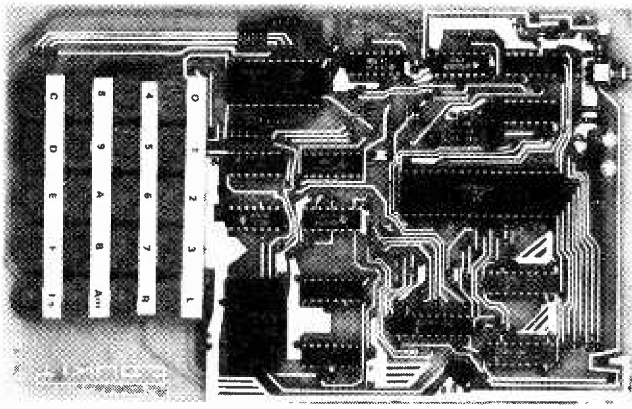
The kit is supplied with a comprehensive manual which describes construction, basic theory, initial use, machine code programming, hardware and troubleshooting. An appendix covers soldering and provides a bibliography and a list of opcodes. Edukit, which is based on the 1802 and has 256 bytes of addressable r.a.m., is priced at £29.95 plus v.a.t. Modus Systems Ltd., 29A Eastcheap, Letchworth, Herts SG6 3DA.

WW301

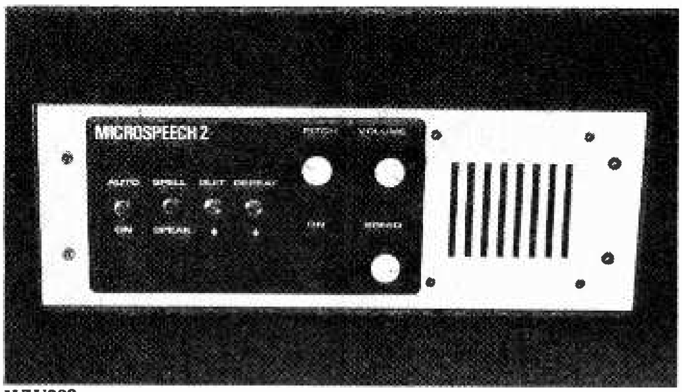
Speech synthesizer

All the computation required to synthesize speech is performed by its own dedicated microprocessor in the Microspeech 2, manufactured by Costronics Electronics. This is a stand-alone speech synthesizing unit which converts phonetic code or any text (which is fed in via a standard RS232 connection) into a speech output, and "loop-through" connections permit the unit to be plugged "in line" to any v.d.u. with RS232 capabilities. It is possible to run the unit solely from an ASCII keyboard and up to 1,000 phonetic characters, representing about one minute of speech, may be assembled in the unit's internal buffer before it is commanded to speak. The controlling microprocessor has a spare r.o.m. capability of 4K bytes which can be used to store an optional text-to-phonetics translator program, the phonetic equivalents of standard symbols allowing operation directly from English text. Additional musical phonems and an exponential frequency control on the glottal pulse generator allow the unit to add musical sequences to speech. The complete unit, which contains loudspeaker and power supply, costs £875 for the phonetic model and £950 for the English-to-phonetics model. Costronics Electronics, 13 Pield Heath Avenue, Hillingdon, Middlesex.

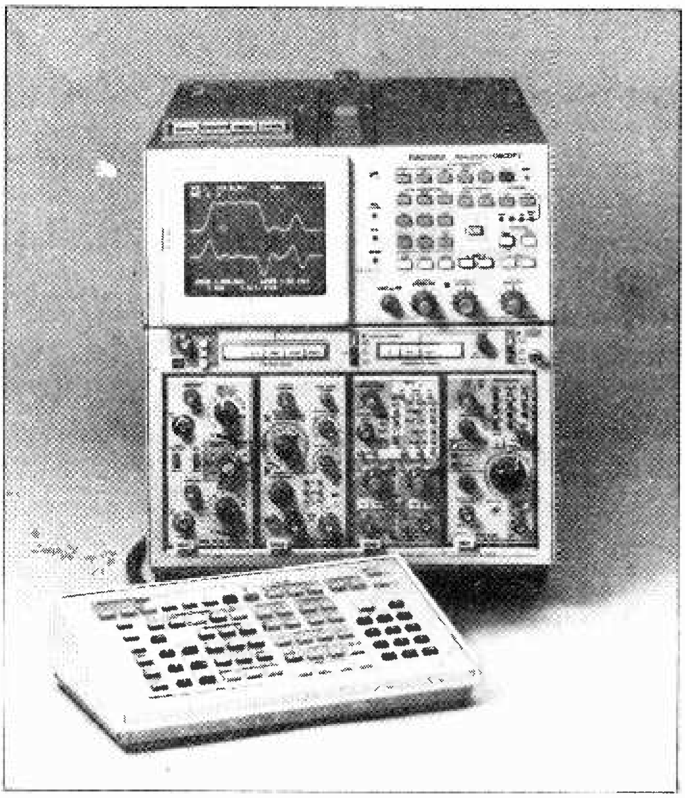
WW302



WW301



WW302



WW303

Micro-based oscilloscope

Fast, automatic signal processing is the result of adding a TMS 9900 microprocessor to Tektronix' latest 7000 Series oscilloscope. Many measurements, such as rise and fall time, pulse width r.m.s., peak-to-peak values, energy, are all reduced to single-button operation. The instrument can be programmed to calculate specific answers and check for errors; keystroke programs of 1000 lines can be written for repetitive testing and long series of measurements automated. Digital storage allows signal averaging and recovery, integration and differentiation, while more complicated routines — correlation, Fourier transformation, convolution high resolution graphics — are possible by adding 300K byte model 4052 graphics computing system. A separate keyboard prevents overcrowding of the front panel which in its program mode displays on the c.r.t. instruction mnemonics and results of computations. A general purpose interface bus is provided for the additional processing, data storage, co-ordination and program transfer. At a cost of £19,000 with four plug-in units and keyboard, the market for this kind of instrument is limited to "high technology R & D". Tektronix UK Ltd., Beaverton House, PO Box 69, Harpenden, Hertfordshire.

WW303

Static charge locator

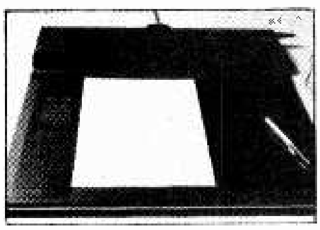
Noise generated by dust on the surface of a record is a perennial problem, much of the dust being attracted to the surface by a static electrical charge. The Technotrend Stati-Control is designed to operate as a simplified charge locator, using an l.e.d. as an indicator rather than the more common meter. The locator indicates electrostatic charges down to a field strength of 50V/cm and measures 150 × 35 × 20mm; battery life is claimed to be 150 hours in normal operation. The makers quote many other uses such as the detection and elimination of charges affecting

invoicing machines, data terminals and printers and c.m.os. devices. The Stati-Control costs £33.85 plus v.a.t. and a full list of application instructions is available from the makers. Technotrend Ltd, 15 South St, Farnham, Surrey.

WW304

Versatile data interface

An input device in the form of a "tablet" which will accept data in several forms and is claimed by the manufacturer, Image Data Products Ltd, to be the first of its kind, functions in concert with a microcomputer. The tablet recognises hand-printed material, accepts drawings and sketches and produces solutions to hand-printed mathematical problems. It also accepts inputs from Teletype-compatible touch tables or conventional calculator

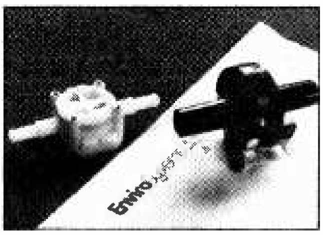


touch tables. The unit takes either A4 or quarto size paper and, with a special pen, shapes and characters may be drawn, digitized and stored in a computer. Characters entered on the tablet are converted to ASCII code for transmission to a host computer via an RS-232-C/V24 interface, at rates up to 9600 baud. The tablet may be put on-line to most microprocessors, minicomputers and mainframes, either directly or through a telephone line. The complete Image Data system, including writing surface, screen, pen, microprocessor, power supply and associated operating software, is available for £1,700 plus v.a.t. or for £1,560 without screen. Image Data Products Ltd, 1-4 Portland Square, Bristol BS2 8RR.

WW305

Digital flow and speed sensors

A range of flow and speed sensors which provide an output signal suitable for digital processing can be fitted to most standard speedometer cables for indication of fuel flow or speed. The sensors are manufactured from a plastics material, give a 5V square wave output dependent upon speed and flow and are intended for use in automotive applications. The flow sensor provides a linear output in the range 0.3 to 22g/h and can be used with liquids of viscosity in the range 1-10cST. Connections are made to hoses with an internal diameter of 4 to 8mm and each sensor is supplied with 2m of co-axial cable. The



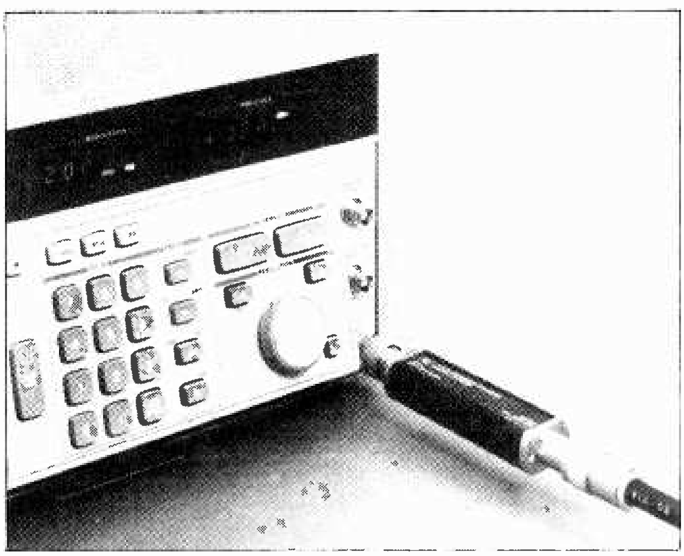
speed sensor is an optoelectronic device and can be fitted to standard speedometer cables with an inner core diameter up to 3.2mm and is claimed to be independent of cable fittings. Speed sensors for an inner core diameter of 4mm can be supplied on request; speed sensors provide an output of 10 pulses per revolution. Flow sensors are available ex stock at £12.65 and speed sensors at £9.95, both prices including v.a.t. Envirosystems Ltd, Hampsfell Rd, Grange-over-Sands, Cumbria LA11 6BE.

WW306

Signal generator frequency doubler

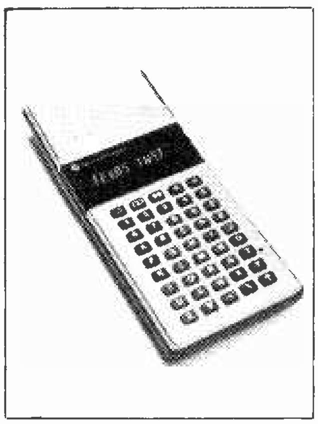
When used with a suitable signal generator, the HP 11721A doubles the output frequency. The makers, Hewlett-Packard, say that the doubler has low distortion and "predictable" conversion loss. At drive levels greater than +10dBm for example, conversion loss is claimed as less than 15dB. The doubler is suitable for both c.w. and f.m. signals and a Hewlett-Packard application note (AN-283-2) describes the operating performance of the unit and its effects on modulation, spectral purity, conversion loss and dynamic range. Software routines are included for use in programmable applications of the HP8662A signal generator, which this doubler complements. Hewlett-Packard Ltd, Scottish Mutual House, 308-314 Kings Rd, Reading, Berks.

WW307



Language translator

Using the same techniques as the company's Speak & Spell machine, the Texas translator gives a pronunciation of foreign words and phrases as well as a visual indication of spelling. Plug-in language modules, French only available, but English and German are shortly to follow at £50 — feature visual translation in three languages plus one spoken language. Vocabulary is 699 words, of which 550 are spoken. Five modes of operation are possible: access to 75 commonly used expressions, use of enter-word

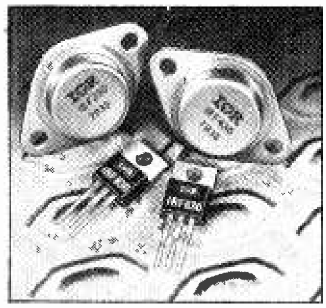


phrases, translation of entered words, vocabulary scan in 16 categories, and selection of words for both pronunciation and translation. With the French module Spanish, English and German words can be translated into French, but only French is spoken. With this module price is £180 including v.a.t. "Vowel power" module at £15 is now available through W. H. Smith & Sons. Texas Instruments Ltd., European Consumer Division, Manton Lane, Bedford.

WW308

High voltage Hexfets

Further devices have been added to the International Rectifier range of high voltage m.o.s.f.e.ts, extending the range to include 200V and 500V devices. In addition to the well known perfor-



mance features of f.e.ts such as high input impedance, fast switching, low drive current requirements and absence of secondary breakdown features, the makers also quote specific applications; for the 200V family these include power amplifiers, converters, fractional horse-power motor controllers, r.f. amplifiers and audio amplifiers, operating from a 48V supply. The 500V family is quoted as suitable for switching mode power supplies, motor speed controllers and inverters, among other applications. The 200V family comprises 4 devices in TO-3 packages featuring 200V and 150V selections at 0.4Ω and 0.6Ω on-state resistance respectively. Type numbers are IRF230 to 233 and IRF630 to 633 and the same devices are offered to TO-220AB packages. Similar packaging is used for the 500V family but with on-state resistances of 1.5Ω and 2.0Ω with type numbers IRF430 to 433 and IRF830 to 833 applicable. Typical input capacitance of both device families is approximately 700pF and typical output capacitance between 100 and 250pF, making rise and fall times of about 100ns possible. Operating temperature range is −55°C to +150°C with junction to case thermal impedance standing at 1.67kW. Typical prices are: IRF230 range £12.80 each or £9.76 in batches of 100. International Rectifier, Hurst Green, Oxted, Surrey.

WW309

SIDEBANDS By Mixer

"Bethumped with words . . ."

There is no doubt about it, buzz words are useful little devils. Faced with a pressing need to say something bright and not having too much time for thought, a marketing man (for example) has great long list of beautifully turned words and phrases, polished by use, from which to draw. If someone came up to me and asked my opinion of the Budget, I would probably utter some such penetrating, masterly exposition as "Well, er, it, er, depends, dunnit?" Not so your practical purveyor of froth. No, he would instantly summon to mind page 26 of "Speech without Thought" and make a random selection of useful phrases, stitching them together as he went on. "In today's economic climate, an on-going liquidity situation is the only fiscal scenario that can be validated, in a global context, particularly in a recessional period. And as for the Green Pound, well, need I say more?". Collapse of questioner, who was only wondering about the price of a pint, anyway.

You can do this sort of thing with technical articles, of course, very successfully, the reasons for using them being (a) to make the article look longer, (b) because the writer thinks you have to write in a peculiar, stilted manner to make an article look respectable, and (c) to impress you with his brain power.

We've all suffered. All the way from the relatively innocuous "It can be shown that . . .", without reference to who has shown it and where, to the really humiliating "Clearly . . . ", preceding a clump of impenetrable verbiage which is anything but clear.

From the above, it will be clear that it can be shown to be self-evident that I'm all for the direct way of writing. The only excuse for going into print at all is because you have something to say: to prevent readers understanding your message is perverse, to put it mildly. If there really is something to write about it doesn't make a lot of sense to camouflage it in an imitation of Civil Service jargon. I thought I might start a movement called CLEAR (Council for Lucidity, Elucidation And Readability) but I decided the words were too long.

Take a note

I have no idea how composers think of a tune — or rather, thought of one, because modern composers don't seem to bother much about tunes. Did Beethoven wander about muttering "di di di di dah, no; di di dah, damn!", getting peculiar looks from passers by? It seems unlikely. All right for 'On Ilkla Moor B'aht 'At' maybe, but not really on for the Fifth.

We know how it's done in films, of course. The chap writing the music sits sideways-on to the piano, a pencil between his teeth, tie loosened and a cigarette burning the varnish off the piano top, and churns out a masterpiece while waiting for his bath to run.

All this is a thing of the past, because of Alf. That isn't Alf Oakroyd, the nipsy champion and trombone blower with the Pogmoor and Gawber brass band, but Alf the synthesizer — a new gadget for the Apple computer. The circular doesn't say why it's called Alf, but the device lets you enter notes on v.d.u. staves, adjusting envelope, sustain, volume, etc. through eight octaves. It will then play your creation through the hi-fi. It says it will do very well for musicians and educators, which may be true, for all I know, but it also claims that businessmen can have it as a "bonus" for their Apples.

So! It's all coming out now. I can easily see how playing with those little steel balls can get a bit boring and I suppose after a morning of 7-iron chip shots into the w.p.b. a chap needs a change, but I do honestly feel that this is going just a teeny bit far. Perhaps it could be reserved as a prize for sales reps who exceed their targets.

"Congratulations, Golightly, you've done it again! I need hardly stress that we're all absolutely delighted with your performance and we have decided that instead of a boring old wodge of money as a reward we'd go one better this time. Here it is, the new type of bonus for businessmen — Alf. You can play with it just as long as you like, so long as it's free when the Chairman comes in after lunch; say around 4 o'clock."

Damn clever, these Chinese

I am reliably, if unexpectedly, informed by the people responsible for telling us all about Hong Kong and its capabilities that a firm in HK have produced "a uniquely-design electronic musical toy". Turns out to be an electronic organ in the shape of a guitar.

I suppose there's no reason why electronic versions of established instruments should look anything like them, since they don't work in the same way, but I can't make out why they should look like any other instrument either. I mean, why a guitar? I should think that an organ keyboard is pretty well unbeatable for playing the organ, and you don't have to sling it around your neck.

Having made this giant leap forward, though, there doesn't seem to be any point in stopping there. If you can make an organ look like a guitar, it ought not be too difficult to make a grand piano resemble a mouth organ and to do something about those monstrous tubas, which would be a lot more convenient to cart about if they were slightly remodelled into Jew's harps. The whole thing is wide open.

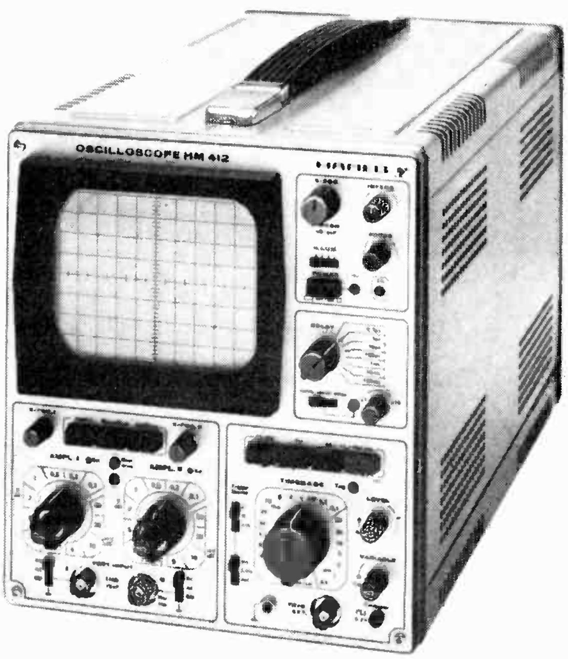
Far and wide

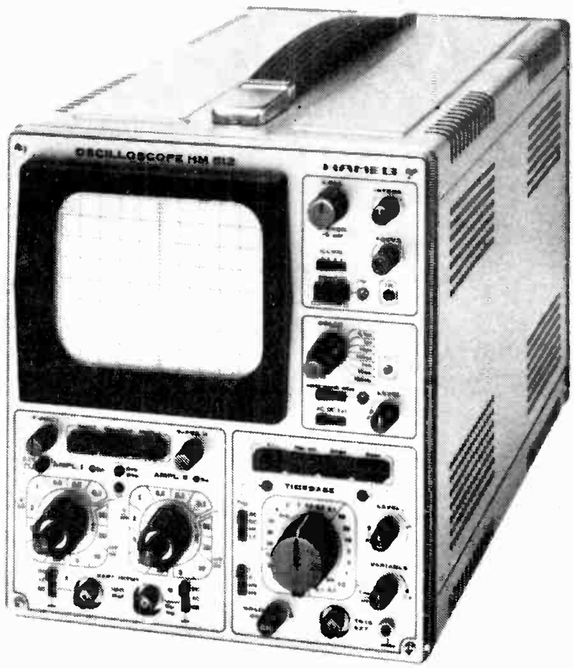
From the correspondence we get in these offices you might assume that radio and electronics is carried on almost exclusively by youngish men inhabiting the south east corner of England. Occasionally we hear from middle-aged persons in Manchester, a Finn or two, Americans who write extremely long letters as if atoning for the break with the old country, and of course our Russian contributor in Moscow. But on the whole what seems to be shaping up very much as the British equivalent of Silicon Valley is the sleepy old Thames Valley, the only difference being that ours has rather more water and less silicon in it. So it's quite refreshing to discover that we do actually have a reader who lives south of Guildford and another to the east of Clacton-on-Sea — in fact even further than Yuri Miloslavskij in Moscow.

The one beyond Guildford is a gentleman who resides at King Edward Point, South Georgia, Antarctica. He wrote to enquire about an article we published in 1928 on wireless telephony in whale fishing in that area. As I have not yet been as far south as Antarctica for my summer hols and my engineering activities in 1928 were still confined to the possibilities of coloured wooden bricks, I found this particular conjunction of time and place exceedingly difficult to take in. It might just as well have been something out of J. R. R. Tolkien.

Equally beyond my horizons was the letter from the easterly direction. This was an application for a vacancy on *Wireless World's* editorial staff. It came from a young man in Canton who wrote in a flowing copper-plate hand and thoughtfully enclosed a snapshot of himself smiling and waving from the middle of a public park. Fraternal as the message was, I gather from the editor that our accountants took a rather dim view of the idea that we should invite the Chinese applicant here for an interview and pay his return fare from Canton out of the petty cash.

Electronic Brokers give you a lot more scope with the Hameg range





HM 307-3 **£149.00**

Single Trace, Display Area 6 × 7cm, Built-in Component Tester, Bandwidth DC-10MHz, Risetime (approx.) 35ns, Defl. Coefficients 5mV-20V/cm, Timebase, Time Coefficients 0.5μs-0.2s/cm.

HM 412-4 **£350.00**

Dual Trace, Display Area 8 × 10cm, Sweep Delay Overscanning, Bandwidth DC-20MHz, Risetime (approx.) 17.5ns, Defl. Coefficients 5mV-20V/cm down to 2mV/cm. Timebase, Time Coefficients 0.5μs-2s/cm.

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Dual Trace, Display Area 8 × 10cm, Full X-Y Op., Magnifier × 5, Bandwidth DC-20MHz, Risetime (approx.) 17.5ns, Defl. Coefficients 5mV-20V/cm, Timebase, Time Coefficients 0.5μs-0.2s/cm.

HM 512-8 **£580.00**

Dual Trace, Display Area 8 × 10cm, After Delay Trig. Single-Shot, Bandwidth DC-50MHz, Risetime (approx.) 7ns, Defl. Coefficients 5mV-20V/cm up to 50V/cm, Timebase, Time Coefficients 0.1μs-2s/cm.

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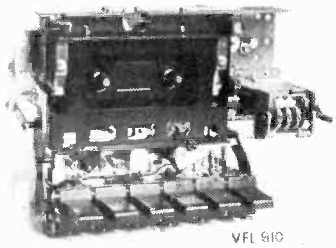
LINSLEY HOOD CASSETTE RECORDER 2

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.
This latest version has the following extra features. Ultra low wow-and-flutter of .09% — easily meets DIN Hi-fi spec. Deck controls latch in rewind modes and do not have to be held. Full Auto stop on all modes. Tape counter with memory rewind. Oil damped cassette door. Latching record button for level setting. Dual concentric input level controls. Phone output. Microphone input facility if required. Record interlock prevents re-recording on valued cassettes. Frequency generating feedback servo drive motor with built-in speed control for thermal stability. All these desirable and useful features added to the excellent design of the Linsley-Hood circuits and the quality of the components used makes this new kit comparable with built-up units of much higher cost than the modest **£94.90** + VAT we ask for the complete kit.

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 aseembly 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.
REPRINT of Postcript article **30p** No VAT.



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.

CASSETTE HEADS

HS15 SENDUST ALLOY SUPER HEAD. Stereo R/P. Longer life than Permalloy. Higher output than Ferrite. Fantastic frequency response. Complete with data	**7.60**
HC20 Stereo Permalloy R/P head for replacement uses in car players, etc.	**4.25**
HM90 Stereo R/P head for METAL tape. Complete with data	**7.20**
H561 Special Erase Head for METAL tape	**4.90**
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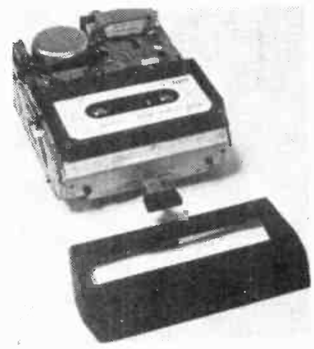
4-Track R/P Head. Standard Mounting	**7.40**
R484 2/2 (Double Mono) R/P Head. Std. Mtg.	**4.90**
ME151 2/2 Ferrite Erase. Large Mtg.	**4.25**
CCE/8M 2/2 Erase. Std. Mtg.	**7.90**

We are the actual importers of these heads and invite Trade/quantity enquiries.

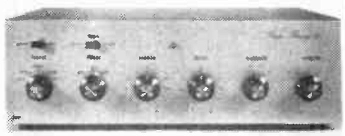
All prices plus VAT

SUPER BARGAIN OFFER
LENCO FFR CASSETTE DECK



For those who missed our recent bargain CT4s we now are delighted to be able to offer Brand New Lenco FFR Decks complete with motor speed and auto-stop control board fitted and tested. These will operate with any supply between 9 and 16 volts. This deck can be used for both record and playback applications and is fitted with an erase head. A mono record/play head is fitted and we can supply an extra stereo head, if ordered with the deck at the very special price of £2 plus VAT. We also supply, with each deck and completely FREE, one of our specially moulded escutcheons. This deck would normally cost about £25 but we are able to offer them, while they last, at only £9.99 plus VAT.

BAILEY 30 WATT AMPLIFIER



We have now completed our redesign of this popular amplifier to make it as easy to build as our latest kits. The power amplifiers are complete modules plugging into a power supply master board, all possible wiring has been eliminated but faith has been maintained with the existing metal work to enable owners to update if they wish. Send for full details in our list.

LINSLEY HOOD 30-WATT AMPLIFIER

Advanced new cost-effective amplifier of impeccable specification from the 'master'. Published in the January and February issues of Hi-Fi News. We are supplying full kits to our usual professional standard.

STUART TAPE CIRCUITS
(For reel-to-reel decks)

These circuits are just the thing for converting that old valve tape deck into a useful transistorised recorder. Total system is a full three head recorder with separate record and replay sections for simultaneous off tape monitoring. We also stock the heads. This kit is well engineered but does not have the detailed instructions that we give with our more recent designs. We would not therefore recommend it to beginners. Reprints of the original three articles 45p. Post free. No VAT.

We regret that due to the latest increase in postal costs we must now charge for carriage. Please add as follows:

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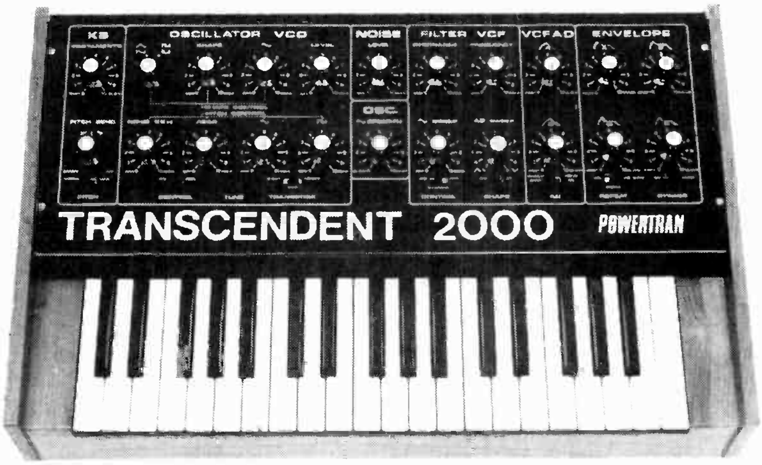
All kits also available as separate packs (e.g. P.C.B. component sets, hardware sets, etc.) Prices in FREE CATALOGUE

LIVE PERFORMANCE SYNTHESIZER DESIGNED BY CONSULTANT TIM ORR (FORMERLY SYNTHESIZER DESIGNER FOR EMS LIMITED) AND FEATURED AS A CONSTRUCTIONAL ARTICLE IN ELECTRONICS TODAY INTERNATIONAL.

The TRANSCENDENT 2000 is a 3 octave instrument transposable 2 octaves up or down giving an effective 7 octave range. There is a portamento, pitch bending, a VCO with shape and pitch modulation, a VCF with both low and high pass outputs and a separate dynamic sweep control, a noise generator and an ADSR envelope shaper. There is also a slow oscillator, a new pitch detector, ADSR repeat, sample and hold, and special circuitry with precision components to ensure tuning stability amongst its many features.

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 trim!) 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 fibreglass 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!



Cabinet size 24.6" × 15.7" × 4.8" (rear) 3.4" (front)

COMPLETE KIT ONLY £168.50 + VAT!

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

WE'VE MOVED! NEW FACTORY UP! PRICES DOWN!

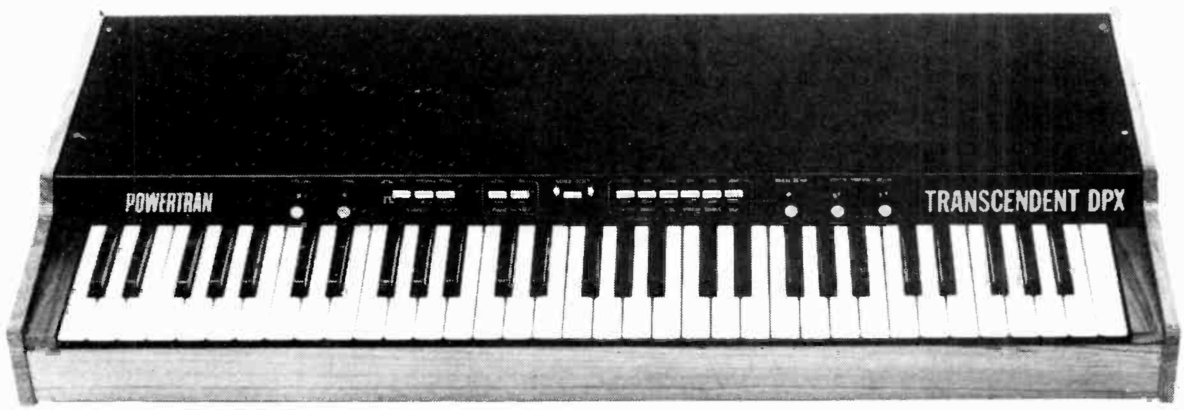
INCREASED CAPACITY AT OUR BIG NEW FACTORY MEANS MANY PRICES DOWN! ALL OTHER FROZEN!

TRANSCENDENT DPX

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

ANOTHER SUPERB DESIGN BY SYNTHESIZER EXPERT TIM ORR! AS FEATURED IN ELECTRONICS TODAY INTERNATIONAL AUGUST, SEPTEMBER, OCTOBER 1979 ISSUES

The Transcendent DPX 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 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 touch 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" × 15.0" × 5.0" (rear) 3.3" (front)

COMPLETE KIT ONLY £299.00 + 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 digital data can be easily taken to and from a computer (for storing and playing back accompaniments 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 £1,200!

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THE CS1830 30 MHz + Sweep Delay

The CS1830 is a completely new 30 MHz dual trace oscilloscope employing a square format, internal graticle, PDA tube for accurate bright display. A new feature is the inclusion of calibrated sweep delay with a range of 1μS-100 mS and trace bright up to show the delay position. As you can see from close study of the photograph, the CS1830 has **all** the facilities you could require in a high performance instrument but for more detail, simply ask us for a comprehensive leaflet

Brief specification

Rectangular PDA tube 120 × 96 mm. P31 phosphor
Bandwidth DC—30 MHz
Sensitivity 5mV/cm (30 MHz)
2mV/cm (20 MHz)
Input R.C. 1 M /23 pF
Risetime 11.7 nS
Overshoot less than 3%
Sweep time 200nS/cm-0.5 S/cm
Linearity better than 3%
Trig. bandwidth DC—30 MHz
Sweep delay 1μS-100 mS

CS1830 only **£455** + VAT includes 2 probes

NEW

THE C51572 30 MHz for the VTR Lab

If you are in Video, **you need the CS1572**

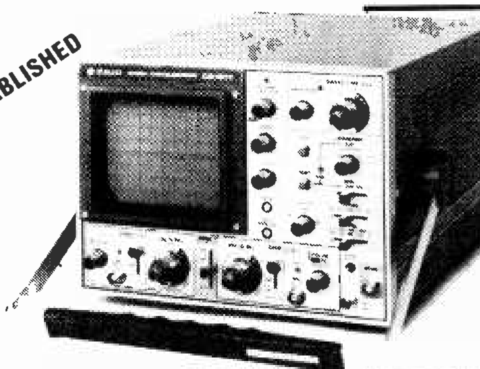
The CS1572 is a dual trace 30 MHz oscilloscope designed for the video tape recorder engineer. Video delayed sweep facilities are provided to allow magnification and analysis of any point in a single video frame together with separation of video odd and even fields. A truly unique tool for anyone concerned with video measurements as well as a top specification dual trace wide band oscilloscope for general lab use. The complete range of video facilities is too great to explain in a small advertisement so why not call us and ask for the full story on the CS1572

Brief Specification

As for CS1830 except that the sweep delay feature is replaced by comprehensive video sweep delay facilities which allow complete analysis of video wave forms and VTR alignment.

CS1572 only **£425** + VAT, includes 2 probes

ESTABLISHED



THE CS1577 30 MHz at 2mV + Signal Delay

The most popular scope in the range

The CS1577 is, without doubt, our most popular oscilloscope and hundreds of satisfied users in all sections of the electronics industry will confirm this. The CS1577 combines a wide bandwidth DC-30 MHz performance with extremely wide trigger bandwidth (DC-40 MHz) and 2 mV sensitivity over the full bandwidth

Fixed signal delay is provided by a helix delay line which allows viewing of the leading adges of fast pulses for accurate rise time measurement, and the 130 mm PDA tube gives a bright, stable trace even at the highest sweep speeds (20 nS/cm using × 5 expansion). Good triggering, even at low levels has always been an outstanding feature of Trio oscilloscopes and the CS1577 demonstrates this to perfection. Triggering, as in the other 30 MHz instruments can be from CH1 or CH2 **or** can be alternated with the beam switching so that input signals of differing frequency will provide stable displays.

Truly an oscilloscope masterpiece CS1577

CS1577 only **£410** + VAT, includes 2 probes.

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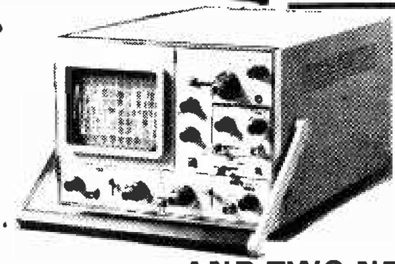

THE CS1575, unique dual trace 4 function Audio Scope

The CS1575 is a unique tool for the audio engineer. It features the normal facility of dual trace display with sensitivity to 1 mV/cm but not only can it display the input signal on two channels, it can **simultaneously** display the phase angle between them and measure the phase angle referenced to a zero phase calibration display. In addition to these unique features, you also have independent triggering from each channel to give stable displays even with widely differing input frequencies.

Absolutely indispensable to the professional audio engineer, the CS1575 is now in use all over the world. See it in action or send for complete details

CS1575 only **£235** + VAT.

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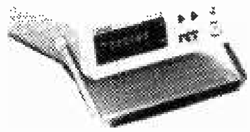

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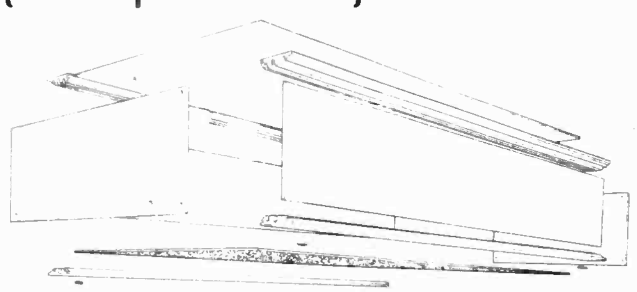
ALUMINIUM BOX CASES
(for the professionals)



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Example of the competitive prices of Aro Box Cases

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3X010 3X011 3X012 3X013 3X014 3X015 3X016	80	6+6 9+9 12+12 15+15 18+18 22+22 25+25	6.64 4.44 3.33 2.66 2.22 1.81 1.60	90 x 30mm	1.0	EACH £5.76 + £1.20 P&P + £1.04 VAT
4X010 4X011 4X012 4X013 4X014 4X015 4X016	120	6+6 9+9 12+12 15+15 18+18 22+22 25+25	10.00 6.66 5.00 4.00 3.33 2.72 2.40	90x40mm	1.2	EACH £6.72 +£1.30 P&P +£1.20 VAT
5X016 5X017	160	25+25 30+30	3.20 2.66	110x40mm	1.8	EACH £8.88 +£1.40 P&P +£1.54 VAT
6X016 6X017	300	25+25 30+30	6.00 5.00	110x50mm	2.6	£12.27 +£2.50 P&P +£2.07 VAT

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For 110V Primary please insert 0 in place of 'X' in type number.
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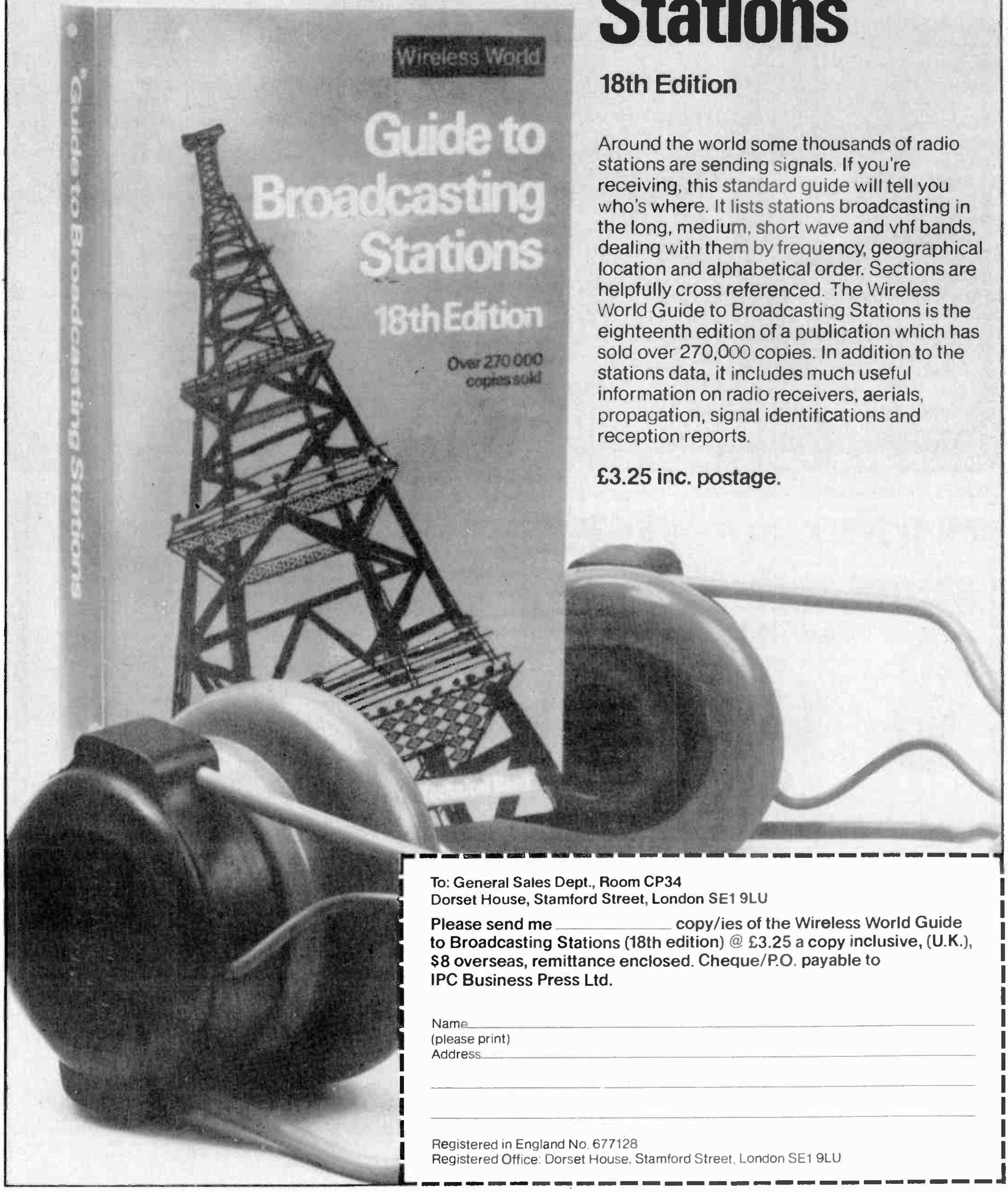

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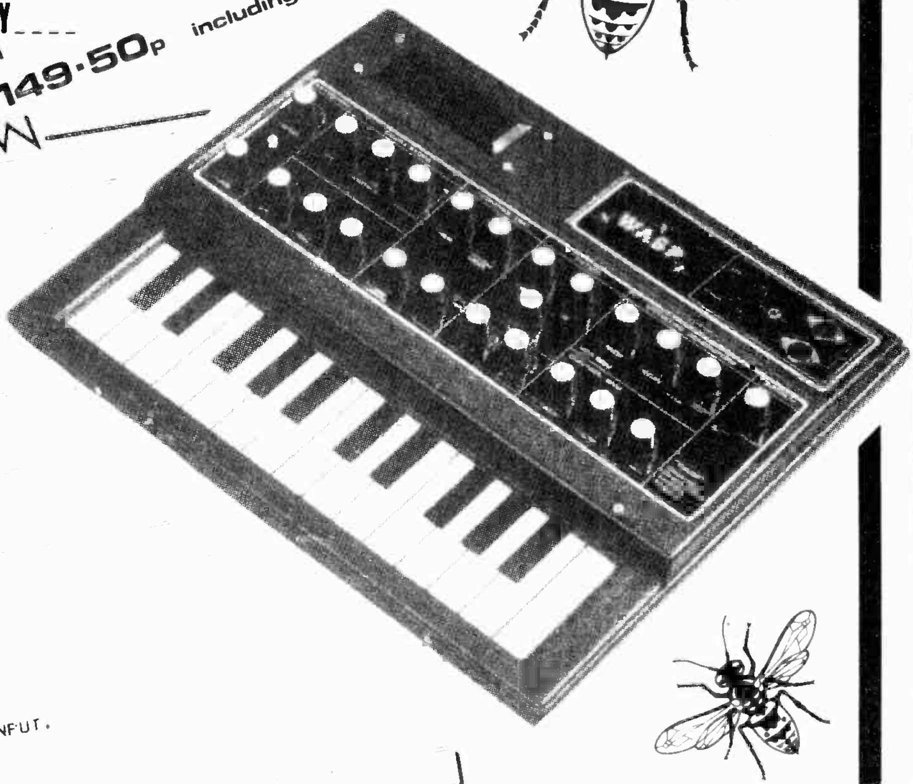

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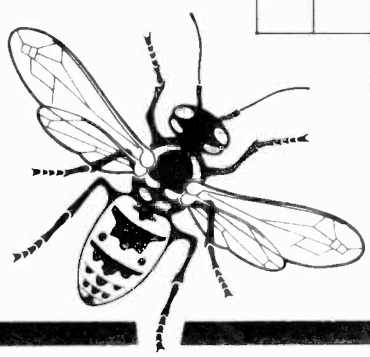

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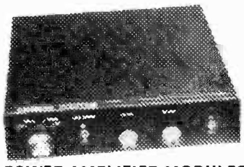

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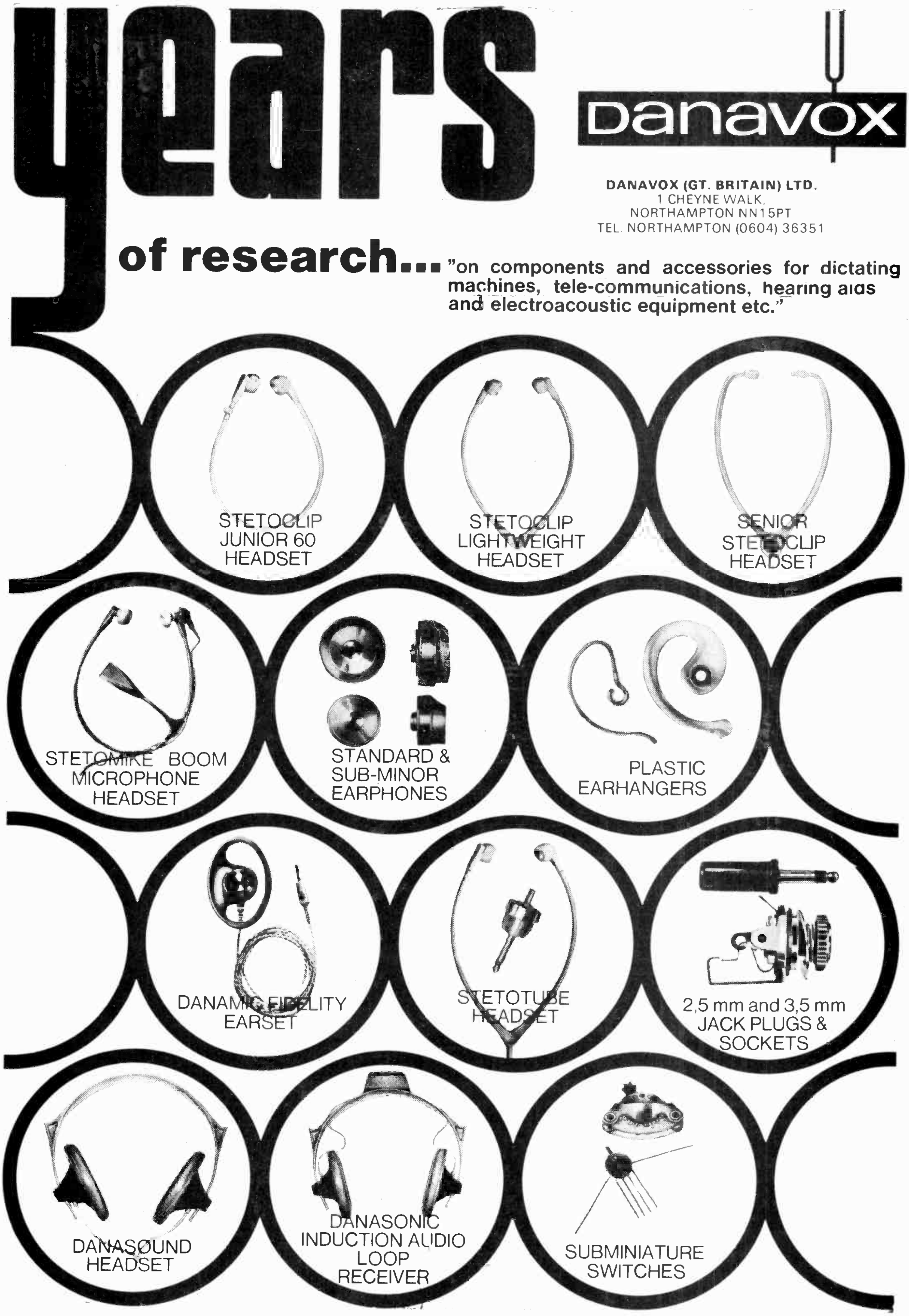

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(1% + 2 digits accurate)
DC current:
1μA to 200mA
(1% + 1 digit accurate)
Resistance:
1Ohm to 20 MOhms
(1.5% + 1 digit accurate)
Power source:
9V battery or AC with optional adaptor
Size:
155 x 75 x 30 mm
22 – 198

PRICE
53.19

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A portable, compact sized multimeter with a full 3½ digit LCD display. Auto polarity operation, low battery indicator. 10 MOhm Input impedance.

Scales:
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AC volts:
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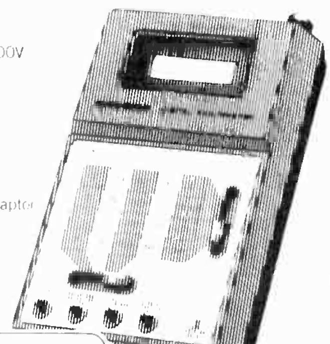
DC current:
2 20 200MA
Resistance:
2 20 200
2000 KOHM
Power source:
9V battery or AC adaptor
Size:
37 x 85 x 130 mm
22 – 197



PRICE
39.93

COMPONENTS AND PARTS

CAT No	DESCRIPTION	PRICE
276 – 032	LED	4 for 69p
276 – 033	LED	2 for 48p
276 – 034	LED	2 for 59p
276 – 142	Infra Red Emitter Detector Pair	£1.37
277 – 1003	12V DC Automotive Digital Clock Module	£17.52
276 – 9110	6 pin edge connector for 277 1003	40p
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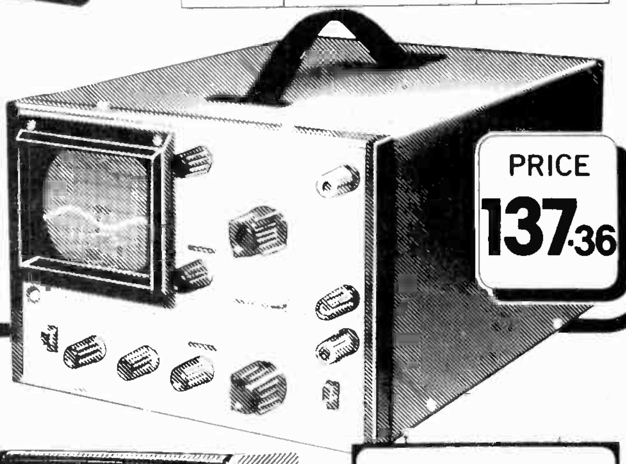

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Electrolytic Axial Leads — Order Code Cap 018 + µF + V d.c.
−10% to +60% Tol.

µF	V d.c. 16	25	40	63
1.0				9
1.5				9
2.2				9
3.3				9
4.7				9
6.8			9	10
10		8		10
15	8		9	11
22		8		13
33	8		9	
47		8	11	13
68	9			
100		9	13	
150	9	10		31
220	13		26	38
330			30	40
470		23	32	47
680	21	30	39	54
1000	25	30	59	
1500	35	39		
2200	42			

P.C.B. Components
Dalo Pen, Blue Ink, Slow Drying 98 Pen 33PC

Miniature Low Value — Order Code
Polystyrene, Axial, ±1% Tol., >63V DC Wkg. Cap 424
Ceramic Plate, Radial, Low K, 100V DC Wkg. Cap 632
Ceramic Plate, Radial, Med K, 100V DC Wkg. Cap 630
Ceramic Plate, Radial, High K, 63V DC Wkg. Cap 629
+ Value

pF	424	632	pF	424	632	630	nF	424	629
1			100	18	7		10	27	8
1.2			120	18	9		12	29	
1.5			150	18	9		15	29	
1.8		6	180	18	9		18	31	
2.2		6	220	18	9		22	31	9
2.7		6	270	20	9		27	42	
3.3		6	330	20	9		33	45	
3.9		6	390	20		6	39	50	
4.7		6	470	20		6			
5.6		6	560	20		6			
6.8		6	680	20		6			
8.2		6	820	20		6			
10		6	1000	20		6			
12		6	1200	20		6			
15		6	1500	20		7			
18		6	1800	20		7			
22		6	2200	20		7			
27		6	2700	20		7			
33		6	3300	20		7			
39		6	3900	20		7			
47		6	4700	25		8			
56		7	5600	25					
68		7	6800	25					
82		7	8200	25					

Polyester Radial Leads — Order Code
Dipped Type, C280/352 Style Cap 352
Moulded Type, 10.2mm Pitch Cap 360
+ Value

µF	352	360	µF	352	360
.001		7	.1	7	9
.0015		7	.15	8	10
.0022	6	7	.22	9	11
.0033	6	7	.33	11	
.0047	6	7	.47	14	
.0068	6	7	.68	17	
.01	6	8	1.0	21	
.015	6	8	1.5	30	
.022	6	8	2.2	35	
.033	6	8			
.047	6	8			
.068	7	8			

Tantalum Bead — Order Code Cap PR + µF + Volts
20% Tol.

µF	V d.c. 10	16	25	35
0.1				11
0.22				11
0.47				11
1				11
2.2		11		13
4.7		12	16	18
10	13	16	18	22
22		18		
47	22			

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0.25W, E24 Values 1R0-10M, 5% Tol. 2 each 100/100 (Mult 10/Value) Res RD¼
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+ Value

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2.5W, E12 Values, 10R-27K, 5% Tol. 18 each 800/100 (Mult 10/Value) Res PR52
+ Value

Metal Glaze, Fixed
0.5W, E24 Values, 1M-33M, 5% Tol. 18 each 800/100 (Mult 10/Value) Res VR37
+ Value

Skeleton Presets, Miniature
0.1W, E3 Values, 100R-1M, Lin. Vertical Mounting 8 Min. Preset V
0.1W, E3 Values, 100R-1M, Lin. Horizontal Mounting 8 Min. Preset H
+ Value

Skeleton Presets, Standard
0.3W, E3 Values, 100R-4M7, Lin. Vertical Mounting 11 Std. Preset V
0.3W, E3 Values, 100R-4M7, Lin, Horizontal Mounting 11 Std. Preset H
+ Value

Potentiometer, Rotary
0.5W, E3 Values, 1K-2M2 Lin 39 Ro Pot Lin
0.25W, E3 Values, 4K7-2M2 Log 39 Ro Pot Log
+ Value

Potentiometer, Slider
0.5W, E3 Values, 2K2-470K Lin. 45 Sl Pot Lin
0.25W, E3 Values, 1K0 - 1M0 Log 45 Sl Pot Log
+ Value

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HEF4000	22	HEF4044	105	HEF4512	138
HEF4001	22	HEF4046	133	HEF4514	313
HEF4002	22	HEF4047	109	HEF4515	374
HEF4006	119	HEF4049	57	HEF4516	127
HEF4007	22	HEF4050	57	HEF4517	478
HEF4008	100	HEF4051	87	HEF4518	118
HEF4011	22	HEF4052	90	HEF4519	69
HEF4012	22	HEF4053	90	HEF4520	118
HEF4013	57	HEF4066	62	HEF4521	235
HEF4014	105	HEF4067	475	HEF4528	124
HEF4015	100	HEF4068	22	HEF4532	150
HEF4016	57	HEF4069	22	HEF4534	638
HEF4017	100	HEF4070	22	HEF4539	138
HEF4018	100	HEF4071	23	HEF4543	194
HEF4019	58	HEF4072	23	HEF4555	98
HEF4020	112	HEF4073	23	HEF4556	98
HEF4021	107	HEF4075	23	HEF4557	458
HEF4022	103	HEF4076	130	HEF4585	122
HEF4023	22	HEF4077	22	HEF4724	214
HEF4024	76	HEF4078	23	HEF40097	113
HEF4025	22	HEF4081	23	HEF40098	92
HEF4026	244	HEF4082	23	HEF40106	78
HEF4027	57	HEF4085	80	HEF40160	149
HEF4028	89	HEF4086	80	HEF40161	149
HEF4029	113	HEF4093	63	HEF40162	149
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HEF4042	83	HEF4510	135	HEF40194	149
HEF4043	100	HEF4511	157	HEF40195	149

74LS

74LS00	19	74LS83A	106	74LS174	141	74LS373	173
74LS01	19	74LS85	104	74LS175	119	74LS374	173
74LS02	19	74LS86	39	74LS181	306	74LS375	117
74LS03	19	74LS90	59	74LS190	117	74LS378	155
74LS04	27	74LS92	76	74LS191	117	74LS386	56
74LS05	27	74LS93	76	74LS192	119	74LS390	196
74LS08	27	74LS95B	82	74LS193	119	74LS393	196
74LS09	27	74LS96	126	74LS194	161	74LS395	207
74LS10	19	74LS107	41	74LS195A	119	74LS490	143
74LS11	26	74LS109	45	74LS196	132		
74LS12	26	74LS112	45	74LS197	132		
74LS13	48	74LS113	45	74LS240	206		
74LS14	74	74LS114	45	74LS241	206		
74LS15	26	74LS125	53	74LS242	206		
74LS20	19	74LS126	53	74LS243	206		
74LS21	26	74LS132	78	74LS244	206		
74LS22	26	74LS136	49	74LS251	117		
74LS28	35	74LS138	99	74LS253	117		
74LS30	19	74LS139	99	74LS257	117		
74LS32	27	74LS153	88	74LS258	117		
74LS33	35	74LS154	136	74LS260	29		
74LS37	35	74LS155	93	74LS261	321		
74LS38	35	74LS156	93	74LS266	54		
74LS40	27	74LS157	93	74LS273	143		
74LS42	60	74LS158	97	74LS283	117		
74LS51	27	74LS160	129	74LS290	117		
74LS54	27	74LS161	117	74LS293	119		
74LS55	27	74LS162	144	74LS298	149		
74LS73	35	74LS163	117	74LS365	121		
74LS75	44	74LS164	119	74LS366	121		
74LS76	46	74LS170	220	74LS367	121		
74LS78	39	74LS173	132	74LS368	121		

Plessey I/C's

SL440	331
SL445	182
SL610	245
SL612	245
SL620	369
SL621	369
SL622	910
SL624	342
SL630	232
SL640	409
SL680	245
SL1610	177
SL1611	177
SL1612	177
SL1621	239
SL1626	267
SL1630	177
SL1640	206
SL1641	206
SL6640	270
SP8629	475

LINEAR

CA3046	84
CA3080E	77
CA3130E	99
CA3140E	48
CA3189E	293
LM301AN	34
LM339N	78
LM380N	104
LM381AN	198
LM3900N	75
MC3403P	156
NE531	131
NE536T	259
NE555N	28
NE556N	66
NE566N	171
NE570N	485
NE571N	505
RC4136	146
TBA120S	88
TDA1022	713
TDA1034B	239
TL081CP	84
TL084CN	156
UA741CN	20
UA741CT	47
UA748CN	39

400mW C4V7-C33 BZY88/BZX79 + Voltage 9

SEMICONDUCTORS

IN914	5	2N3705	10	BC182L	12	BFX85	29
IN4001	5	2N3773	297	BC184	11	BFY50	17
IN4002	5	2N3819	22	BC184L	12	BFY51	17
IN4004	7	2N3820	39	BC212	11	BFY52	20
IN4007	9	2N3904	9	BC212L	12	BLX65	262
IN4148	4	2N5457	39	BC214	11	BRY39	50
IN5402	15	2N5459	35	BC214L	12	BSX20	21
2N2218A	31	40673	88	BC547	13	CL8960	2850
2N2369	21	AD161	42	BC548	11	MPF102	36
2N2646	46	AD162	42	BC549	12	OA91	8
2N2926G	13	BC107	14	BC557	15	OC28	118
2N3053	19	BC108	14	BC558	15	OC35	105
2N3054	55	BC108C	18	BCY70	15	TIP31A	48
2N3055	55	BC109	14	BCY71	15	TIP32A	54
2N3055	–	BC109B	19	BD131	39	TIP41C	76
Full ISB Test	95	BC109C	20	BD132	39	TIP42C	76
2N3442	155	BC148	10	BD139	39	TIP2955	75
2N3702	9	BC158	10	BD140	39	TIP3055	60
2N3704	9	BC177	17	BFR90	333	TIS43	36

Voltage Regulators

LM309OA(K)	119
UA723CN	42
UA7805CU	78
UA7812CU	78
UA7815CU	78
UA7912CU	97
UA7915CU	97
UA78L05CS	38
UA78L12CS	38

OPTO ELECTRONICS
Light Emitting Diodes, Individual

.125" (3mm)	Red	16	CQY54
	Green	18	CQY95
	Yellow	20	CQY97
Panel Mounting Clip to suit		3	LED3 Clip
.2" (5mm)	Red	16	CQY24A
	Green	18	CQY94
	Yellow	20	CQY96
Panel Mounting Clip to suit		5	LED5 Clip

Photoresistors
ORP12 95
ORP61 95

Phototransistors
OCP71 220
BPX25 195
BPX29 195

Photocoupler
FCD820 165

Plastic Boxes — Boss Industrial Mouldings

Moulded Box and Close Fitting Flanged Lid
ABS Box, C/W Brass Bushes, and Lid In Orange

		Order Code
L112 W62 D31	99	Case BIM2003 OR
L150 W80 D50	131	Case BIM2005 OR
L190 W110 D60	223	Case BIM2008 OR

Plastic Boxes with Metal Lids
Recessed Top Box
ABS Box, C/W Brass Bushes, in Orange
1mm Aluminium Top Panel Finished Grey

		Order Code
L85 W56 D29	112	Case BIM4003 OR
L111 W71 D42	150	Case BIM4004 OR
L161 W96 D53	208	Case BIM4005 OR

Diecast Boxes
Diecast Box and Close Fitting Flanged Lid
Aluminium Box and Lid in Natural Finish

		Order Code
L113 W63 D31	124	Case BIM5003 NA
L152 W82 D50	215	Case BIM5005 NA
L192 W113 D61	334	Case BIM5008 NA

SWITCHES

Miniature Toggle — Honeywell

			Order Code
SPDT		67	SW 8A1011
SPDT	C/Off	81	SW 8A1021
SPDT	Double Bias To Centre	90	SW 8A1041
SPDT	Single Bias To Centre	90	SW 8A1051
SPDT	Bias	84	SW 8A1081
DPDT		99	SW 8A2011
DPDT	C/Off	111	SW 8A2021
DPDT	Double Bias To Centre	123	SW 8A2041
DPDT	Single Bias To Centre	123	SW 8A2051
DPDT	Bias	116	SW 8A2081

Miniature Push — C & K

SP	Push To Make, Momentary	62	SW 8531
SP	Push To Break, Momentary	62	SW 8533

D.I.L. Sockets

8 Pin Low Profile Socket Tin	12	DIL SKT 8
14 Pin Low Profile Socket Tin	14	DIL SKT 14
16 Pin Low Profile Socket Tin	16	DIL SKT 16

MAINS TRANSFORMERS — Order Code

Secondaries may be connected in series or parallel to give wide voltage range
Primaries 0-220, 240V

6VA — Clamp Type Construction 235 each
Approx 18% Regulation F.C 54, H36, W35

0-4.5V, 0-4.5V Secondaries	Trans 6VA	45
0-6V, 0-6V		60
0-12V, 0-12V		120
0-15V, 0-15V		150
0-20V, 0-20V		200

20VA — Clamp Type Construction 360 each
Approx 16% Regulation F.C 70, H48, W46

0-4.5V, 0-4.5V Secondaries	Trans 20VA	45
0-6V, 0-6V		60
0-12V, 0-12V		120
0-15V, 0-15V		150
0-17.5V, 0-17.5V		175
0-20V, 0-20V		200

VERO ELECTRONICS PRODUCTS

2.5" x 5" .1" pitch Veroboard	71	200-21069J
3.75" x 5" .1" pitch Veroboard	79	200-21072D
2.5" x 1" .1" pitch Veroboard (5)	85/Pack	200-21076C
3.75" x 5" .1" pitch Plain Board	68	200-21078H
5.82" x 2.9" .1" pitch V-Q DIP Board	135	200-21084E
Spot Face Cutter	107	203-21013A
Pin Insertion Tool for .040 type pin	147	203-21015F
DS Pins .040 (100)	44/Pack	200-21087G
SS Pins .040 (100)	44/Pack	200-21017B
Veropins Kit (1-pan, 2-wire, 25-comb)	454/Kit	200-21341D
Verowire Combs (25)	109/Pack	200-21339F
Verowire Wire (2)	109/Pack	200-21340G

Heatsinks

Individual Type for 1 x TO5 50°C/W	12	Sink 5F
Individual Type for 1 x TO66 10.5°C/W	28	Sink TV2
Individual Type for 1 x TO3 7.2°C/W	26	Sink TV3
Individual Type for 1 x TO126 17°C/W	26	Sink TV4
Individual Type for 1 x TO220 17°C/W	26	Sink TV5

G.M.T. ELECTRONICS KITS

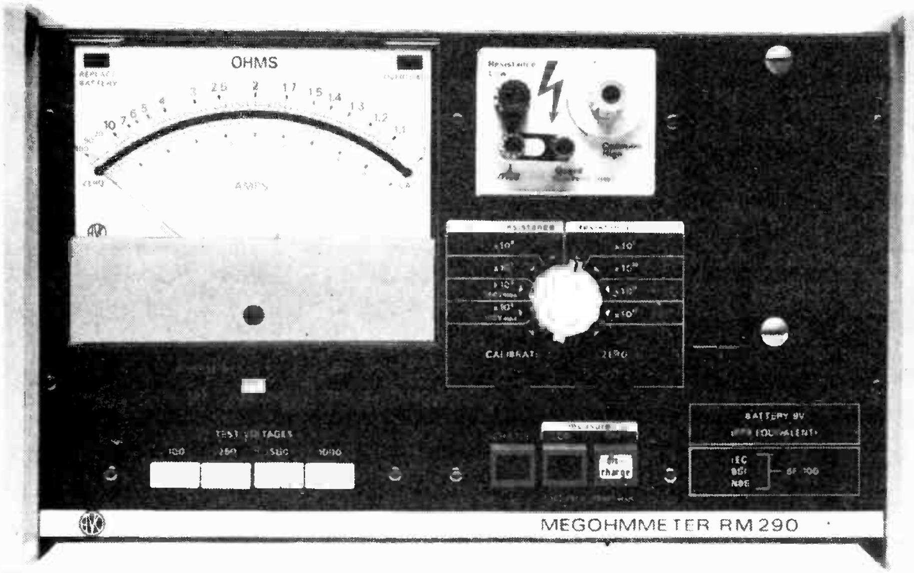
FULL TELETEXT KIT (Free-standing unit - no internal connection to T.V.)	£199-90
TELETEXT DECODER + REMOTE CONTROL KIT (For wiring into existing television)	£135-90
PAL ENCODER/MODULATOR KIT	£ 22-90
DOPPLER RADAR ALARM KIT	£ 44-90
F.E.T. POWER AMPLIFIER OUTPUT MODULE KIT	£ 27-50
ONE AMP POWER SUPPLY MODULE KIT - FIVE VOLTS	£ 6-00
ONE AMP POWER SUPPLY MODULE KIT - TWELVE VOLTS	£ 7-50
MODEL INERTIA CONTROLLER MK I - SLOT RACER	£ 30-00
MODEL INERTIA CONTROLLER MK II - TRAIN (HAND UNIT)	£ 25-00
MODEL INERTIA CONTROLLER MK III - TRAIN (CONSOLE UNIT)	£ 25-00

PUBLIC ADDRESS EQUIPMENT

A55	20W AC/12vDC MOBILE AMPLIFIER	£ 69-00
A56	50W AC/12vDC AMPLIFIER	£117-30
A70	175W AC/24vDC PROFESSIONAL AMPLIFIER	£276-00
L78	20W WEATHERPROOF HORN SPEAKER, 8 OHM & LINE	£ 41-40
L83	16W MEGAPHONE (SEPARATE MICROPHONE)	£ 69-00
L110	40W CABINET SPEAKER 8 OR 16 OHMS (SPECIFY WHICH) (c/w block 'vynide' covering, metal corners and overall cover)	£ 89-70
M21	UNI-DIRECTIONAL ELECTRET CONDENSOR MIKE, 600 OHM	£ 19-32
M30	BALL WINDSHIELD DYNAMIC CARDOID MIKE, 600/50K OHM	£ 28-98
M104	SIX CHANNEL STEREO MIXER AND PRE-AMPLIFIER (accepts high and low imp mikes, and has RIAA input)	£ 62-10
M124	FLOOR TYPE MICROPHONE STAND, EXTENDS TO 60"	£ 14-49

WW — 104 FOR FURTHER DETAILS

100,000,000,000,000 Ohms



The AVO RM290 is a bench type megohmmeter with a resistance range that goes up to $10^{14}\ \Omega$:making it ideal for those applications where there is a need to measure the electrical resistance of non-conducting materials...accurately!

You can use the RM290 for tests on insulating components in electronic assemblies or on capacitor dielectrics. Resistance measurements can be made at test voltages of 100, 250, 500 or 1000 V. Readout from the single resistance scale on the meter is direct, irrespective of the test voltage selected.

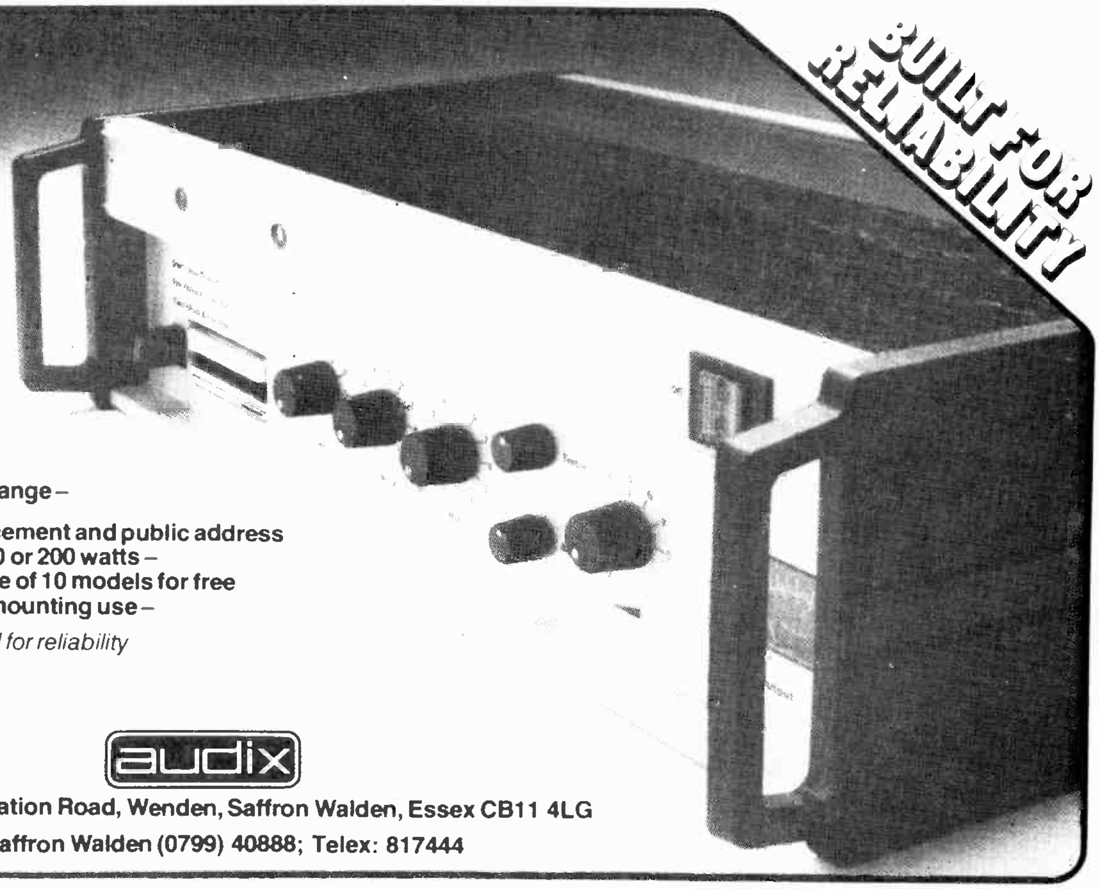
You'll find the AVO RM290 a great asset. Get in touch with us today and we'll let you have the full facts.

You'll never meet a better meter

AVO Limited, Archcliffe Road,
Dover, Kent, CT17 9EN
Tel: 0304 202620 Telex: 96283

Thorn Measurement & Components Division

WW—120 FOR FURTHER DETAILS



Newport Range –

Sound reinforcement and public address amplifiers; 30, 60, 120 or 200 watts – with a range of 10 models for free standing and rack mounting use –

engineered for reliability

audix

Audix Limited, Station Road, Wenden, Saffron Walden, Essex CB11 4LG
Tel: Saffron Walden (0799) 40888; Telex: 817444

Peace and quiet

The quietest sound the ear can hear moves the eardrum about 10^{-9}cm, one tenth the diameter of a hydrogen molecule. Movement due to random thermal bombardment of the eardrum by air molecules is around this same level and largely accounts for this limit of sensitivity.*

But the distortion contribution from a QUAD 405 amplifier in normal use (say 85dBa) moves the eardrum <u>less</u> than this amount.

Perhaps sitting in a very quiet room at –100°C and without the music we might nearly hear them ....but "'tis bitter cold."

For further details on the full range of QUAD products write to:

The Acoustical Manufacturing Co. Ltd.
Huntingdon, PE18 7DB. Tel: (0480) 52561.

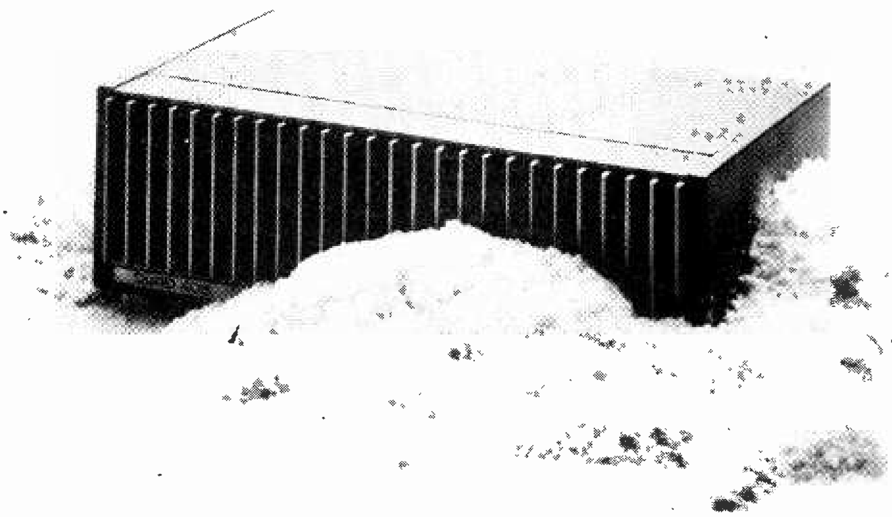
*Sensitivity is never made more acute by the presence of other sounds.

QUAD

for the closest approach to the original sound

QUAD *is a Registered Trade Mark*

1978



WW—130 FOR FURTHER DETAILS

elcomatic

DISTRIBUTION DIVISION

RADIO & T.V. SERVICE COMPONENTS

DIODES

TYPE	PRICE
AA 119	0.09
B 40	0.60
BA 115	0.15
BA 127	0.08
BA 128	0.23
BA 145	0.15
BA 148	0.15
BA 154	0.07
BA 155	0.12
BA 156	0.10
BA 159	0.10
BAX 13	0.05
BR 100	0.20
BY 126	0.12
BY 127	0.12
BY 133	0.12
BY 134	0.12
BY 164	0.06
BY 179	0.07
BY 199	0.12
BY 206	0.15
OA 90	0.07
OA 91	0.07
OA 95	0.07
OA 200	0.10
OA 202	0.10
IN 649	0.06
IN 914	0.06
IN 4001	0.07
IN 4002	0.07
IN 4003	0.07
IN 4004	0.07
IN 4005	0.07
IN 4006	0.07
IN 4007	0.09
IN 4148	0.05
IS 44	0.05
ITT 2002	0.17
Y 723	0.18
Y 969	0.92

ZENER DIODES

BZY88 series	0.11
BZX61 series	0.18

TRANSISTORS

TYPE	PRICE
AC 126	0.20
AC 127	0.20
AC 128	0.28
AC 128K	0.28
AC 141	0.23
AC 141K	0.33
AC 142	0.27
AC 142K	0.36
AC 151	0.23
AC 154	0.21
AC 176	0.22
AC 176K	0.33
AC 187	0.22
AC 187K	0.30
AC 188	0.23
AC 188K	0.36
AC 193	0.21
AC 193K	0.28
AC 194	0.26
AC 194K	0.32
AD 140	0.85
AD 143	0.95
AD 149	0.75
AD 161	0.50
AD 162	0.50
AF 114	0.30
AF 124	0.30
AF 125	0.35
AF 126	0.38
AF 127	0.38
AF 139	0.45
AF 178	0.58
AF 180	0.70
AF 181	0.80
AF 239	0.52
AU 106	1.25
AU 110	2.00
AU 111	1.25
AU 112	1.25
AU 113	2.00
BC 107	0.10
BC 108	0.11
BC 109	0.10
BC 113	0.11
BC 114	0.10
BC 115	0.10
BC 116	0.12
BC 117	0.14
BC 118	0.10
BC 119	0.28
BC 125	0.10
BC 126	0.15
BC 127	0.40
BC 132	0.10
BC 135	0.10
BC 136	0.35
BC 137	0.14
BC 138	0.28
BC 139	0.28
BC 140	0.35
BC 141	0.23
BC 142	0.24
BC 143	0.28
BC 147	0.10
BC 148	0.09
BC 149	0.10
BC 153	0.10
BC 154	0.10
BC 157	0.10
BC 158	0.12
BC 159	0.12
BC 160	0.28
BC 161	0.30
BC 171	0.12
BC 172	0.12
BC 173	0.13
BC 174	0.22
BC 177	0.14
BC 178	0.12
BC 179	0.12
BC 182	0.22
BC 183	0.12
BC 184	0.13
BC 186	0.18
BC 187	0.14
BC 204	0.14
BC 212	0.14
BC 213	0.12
BC 214	0.12
BC 237	0.12
BC 238	0.12
BC 251	0.14
BC 253	0.12
BC 258	0.14
BC 294	0.30
BC 300	0.30
BC 301	0.23
BC 302	0.35
BC 303	0.35
BC 304	0.30
BC 327	0.15
BC 328	0.18
BC 337	0.15
BC 338	0.12
BC 460	0.30
BC 546	0.22
BC 547	0.12
BC 548	0.12
BC 549	0.13
BC 550	0.13
BC 557	0.14
BC 558	0.12
BCY 70	0.14
BCY 71	0.14
BCY 72	0.12
BD 115	0.35
BD 116	0.70
BD 124P	1.00
BD 131	0.40
BD 132	0.44
BD 133	0.44
BD 135	0.40
BD 136	0.30
BD 137	0.40
BD 138	0.44
BD 139	0.44
BD 140	0.44
BD 144	1.60
BD 177	0.40
BD 181	0.70
BD 182	0.70
BD 183	0.70
BD 184	0.70
BD 222	0.48
BD 225	0.55
BD 232	0.65
BD 233	0.50
BD 234	0.50
BD 235	0.40
BD 236	0.44
BD 237	0.44
BD 238	0.44
BD 437	0.80
BDX 32	1.50
BDY 20	0.70
BF 115	0.20
BF 121	0.14
BF 123	0.23
BF 127	0.14
BF 152	0.29
BF 154	0.20
BF 157	0.35
BF 158	0.12
BF 160	0.18
BF 167	0.23
BF 173	0.23
BF 178	0.35
BF 179	0.35
BF 180	0.35
BF 181	0.35
BF 182	0.35
BF 183	0.29
BF 184	0.18
BF 185	0.15
BF 194	0.10
BF 195	0.10
BF 196	0.12
BF 197	0.14
BF 198	0.14
BF 199	0.23
BF 200	0.31
BF 218	0.15
BF 224	0.23
BF 240	0.18
BF 241	0.15
BF 256	0.25
BF 257	0.28
BF 258	0.30
BF 259	0.32
BF 336	0.35
BF 337	0.35
BF 338	0.34
BF 355	0.34
BF 457	0.66
BF 458	0.66
BF 459	0.66
BFT 41	0.54
BFT 42	0.32
BFT 43	0.30
BFW 60	0.22
BFX 29	0.30
BFX 84	0.23
BFX 85	0.23
BFX 86	0.35
BFY 50	0.23
BFY 51	0.30
BFY 52	0.30
BR 101	0.33
BRC 4443	0.88
BRY 39	0.33
BSY 52	0.35
BT 100A	1.90
BT 106	1.20
BT 108	1.50
BT 109	0.90
BT 116	1.15
BT 119	2.40
BT 120	2.60
BU 105-2	1.75
BU 108	2.00
BU 126	1.35
BU 204	2.00
BU 205	2.00
BU 206	1.50
BU 208	2.00
BU 208/02	3.00
E 1222	0.32
E 5024	0.18
MJE 340	0.40
OC 28	1.50
R 2008B	1.60
R 2009	1.65
R 2010B	1.60
R 2030	2.60
R 2265	1.80
R 2354A	1.20
R 2354B	1.55
R 2540	3.25
RCA 16029	1.20
RCA 16039	1.55
RCA 16334	1.00
RCA 16335	1.00
TIP 29A	0.44
TIP 30A	0.44
TIP 31A	0.46
TIP 32A	0.46
TIP 33A	0.70
TIP 41A	0.55
TIP 42A	0.55
TIS 90	0.26
TIS 91	0.26
2N 2904	0.28
2N 2905	0.28
2N 3053	0.30
2N 3054	0.58
2N 3055	0.70
2N 3702	0.12
2N 3703	0.12
2N 3704	0.12
2N 3705	0.12
2N 3904	0.12
2N 5294	0.50
2N 5296	0.52
2N 5496	0.52
2SC 643A	1.70

INTEGRATED CIRCUITS

TYPE	PRICE
ETT 6016	2.40
ETTR 6016	2.40
LM 1303	1.52
MC 1310P	1.20
MC 1327P	1.20
MC 1330P	1.10
MC 1351P	1.00
ML 231B	2.40
ML 232B	2.40
SAS 560S	1.45
SAS 570S	1.45
SAS 580	2.70
SAS 590	2.70
SL 901B	6.00
SL 917B	7.00
SL 918B	7.00
SN 76003N	1.80
SN 76013N	1.45
SN 76013ND	1.45
SN 76023N	1.45
SN 76023ND	1.45
SN 76033N	1.95
SN 76104N	0.60
SN 76110N	1.20
SN 76115N	1.20
SN 76131N	1.45
SN 76226DN	1.85
SN 76227N	1.30
SN 76530P	1.00
SN 76532N	1.70
SN 76533N	1.35
SN 76544N	1.50
SN 76660N	0.72
SN 76666N	0.95
TA 717P	1.45
TA 7171P	1.45
TAA 350	2.40
TAA 550	0.40
TAA 661B	0.75
TAA 700	1.85
TBA 120S	1.30
TBA 395	1.60
TBA 396	2.30
TBA 480Q	1.50
TBA 500P	3.00
TBA 510Q	3.00
TBA 520Q	1.50
TBA 530Q	1.50
TBA 540Q	1.50
TBA 550Q	1.80
TBA 560Q	1.90
TBA 800	1.20
TBA 920Q	2.40
TBA 950	2.75
TCA 270	1.80
TCA 800	2.65

CAPACITORS

TYPE	PRICE
EN12.12	
470/10V	0.25
22/16V	0.16
47/16V	0.16
100/16V	0.18
220/16V	0.22
330/16V	0.24
470/16V	0.30
1000/16V	0.40
10/25V	0.15
22/25V	0.15
47/25V	0.18
100/25V	0.24
220/25V	0.34
330/25V	0.36
470/25V	0.42
1000/25V	0.45
33/35V	0.20
470/50V	0.72
0.47/63V	0.12
1/63V	0.12
2.2/63V	0.14
3.3/63V	0.14
4.7/63V	0.14
10/63V	0.15
22/63V	0.18
100/63V	0.38
220/63V	0.48
1000/63V	1.08
0.47/500V	0.13
2.2/500V	0.36
22/500V	0.50
47/500V	0.80

SPECIAL CAPACITORS

TYPE	PRICE
BRC 150/40V	0.30
BRC 470/40V	0.45
BRC 220/100V	0.75
RBM A823 2500-2500/30V	1.00
GEC 10/38 200-200-150-50/350V	1.80
RBM 600/300V (Short)	1.70
PYE 600/300V (Tall)	1.80
BRC 3000 1000/70	0.72
BRC 1500 150-150-100/350V	1.70
BRC 3000 175-100-100/400-300V	2.20
BRC 3000 1500/63	0.90
TCE 850/950 100-300-100-16/275V	1.92
TCE 1400 150-100-100-100-150/320V	2.20
Decca 30 400-400/350V	2.90
Decca 1700 200-200-400/350V	3.00
Pye 691 200-300/350V	2.85
0.47/1000V	1.00
0.1/1000V RIFA	0.55
0.068/1000V RIFA	0.22
0.047/1000V SPRAGUE	0.20
0.033/1000V RIFA	0.18
0.0033/1600V	0.18

Capacitors Cont

PMA	
2.2/100V	1.00
4.7/100V	1.50
0.047/250V	0.14
0.068/250V	0.14
0.33/250V	0.16
0.47/250V	0.26
0.68/250V	0.26
1.5/250V	0.36
2.2/250V	0.42
0.001/400V	0.18
0.0022/400	0.18
0.0033/400V	0.18
0.0047/400V	0.18
0.0068/400V	0.18
0.01/400V	0.18
0.015/400V	0.10
0.022/400V	0.10
0.033/400V	0.12
0.047/400V	0.12
0.068/400V	0.12
0.1/400V	0.16
0.15/400V	0.20
0.22/400V	0.25
0.33/400V	0.26
0.68/400V	0.36
1/400V	0.40

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TYPE	PRICE
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24R 12W	
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33R 12W	..
39R 12W	..
47R 12W	..
51R 12W	..
56R 12W	..
68R 12W	..
75R 12W	..
82R 12W	..
100R 12W	..
120R 12W	..
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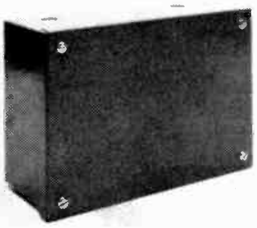

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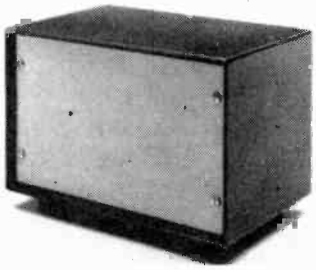

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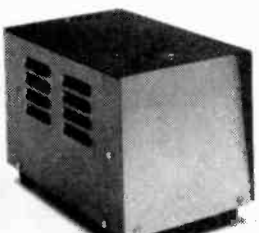

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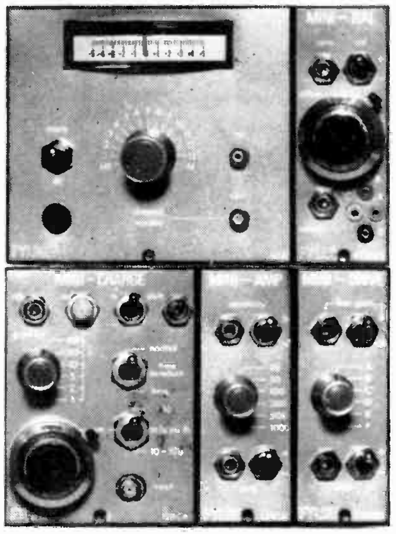

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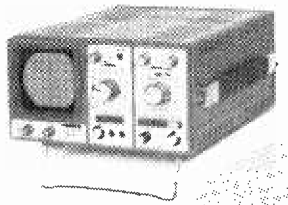

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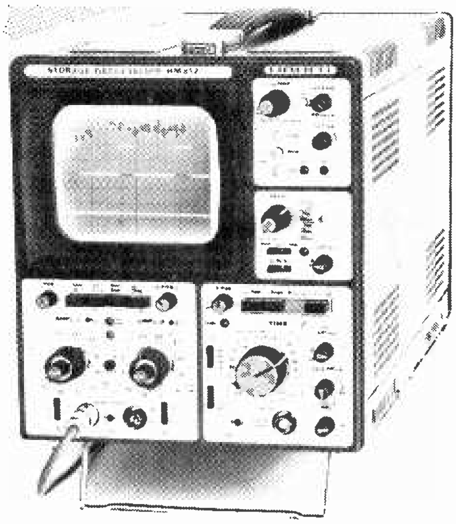

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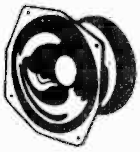

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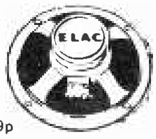

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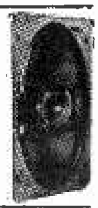

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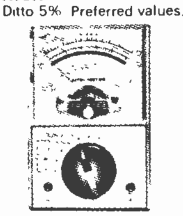

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"MINOR" 10 watt AMPLIFIER KIT £12.50

This kit is suitable for record players, guitars, tape playback, electronic instruments or small PA systems. Two versions available. Mono, **£12.50;** Stereo, **£20.** Post 45p. Specification 10W per channel, input 100mV, size 9½ × 3 × 2in approx. SAE details. Full instructions supplied. AC mains powered. Input can be modified to suit guitar.

RCS STEREO PRE-AMP KIT. All parts to build this pre-amp. Inputs for high, medium or low imp per channel, with volume control and PC Board **£2.95**
Can be ganged to make multi-way stereo mixers. Post 35p

MAINS TRANSFORMERS ALL POST 99p.

250-0-250V 70mA 6 5V 2A	£3.45
250-0-250V 80mA 6 3V 3 5A 6 3V 1A	£4.60
330-0-330V 200mA, 6 3V 2A 6 3V 2A 6 3V 3A	£12.00
300-0-300V 120mA, 2×6 3V 2A C T 5V 2A	£10.00
220V 45mA, 6 3V 2A	£2.50

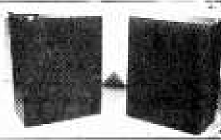
GENERAL PURPOSE LOW VOLTAGE. Tapped outputs available

2 amp 3, 4, 5 6 8 9 10 12 15, 18 25 and 30V	£6.00
1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36 40 48, 60	£6.00
2 amp 6, 8 10, 12 16, 18 20, 24, 30, 36 40 48, 60	£9.50
3 amp 6, 8 10, 12, 16, 18, 20, 24, 30, 36 40 48 60	£12.50
5 amp 6, 8 10 12 16 18 20, 24, 30, 36, 40, 48 60	£16.00

12V 100mA	£1.30	20V, 40V, 60V, 1 amp	£4.00
12V 750mA	£1.75	12V, 3 amp	£3.50
10-0-10V 2amp	£3.00	10V, 30V, 40V, 2 amp	£3.50
30V, 5 amp and 17V-0-17V		40V, 2 amp	£3.50
2 amp	£4.00	20V, 1 amp	£3.00
0 5 8 10 16V 4 amp	£2.50	20V-0-20V, 1 amp	£3.50
9V 3 amp	£3.50	30V-0-30V, 2 amp	£8.00
25-0-25V 2 amp	£4.50	2 of 18V, 6 amp, each	£11.00
30V 1½ amp **£3.00** 2 amp	£3.50	12-0-12V 2 amp	£3.50
6V ½ amp	£2.00	9V, ¼ amp	£1.50
15-0-15V 2 amp	£3.75	32-0-32V, 6½ amp	£11.00

AUTO TRANSFORMERS 115V to 240V or 240V to 115V 500W **£10.00.**
FULL WAVE BRIDGE CHARGER RECTIFIERS
6 or 12V outputs 2 amp **£1.** 4 amp **£1.75**
CHARGER TRANSFORMERS 3 amp **£4.00.** 4 amp **£6.50**
12V 1½ amp Half Wave Selenium Rectifier **25p**

OPUS COMPACT SPEAKERS



TEAK VENEERED CABINET
11 × 8½ × 7in **£20 pair**
50 to 14,000 cps. Post £2
15 watts 8 ohm

LOW VOLTAGE ELECTROLYTICS 10p
1 mfd, 2 mfd, 4 mfd, 8 mfd, 10 mfd, 16 mfd, 25 mfd, 30 mfd, 50 mfd, 100 mfd 250 mfd. All 15 volts. 22 mfd/6v/10v, 25 mfd/6v/10v, 47 mfd/10v, 50 mfd/6v, 68 mfd/6v/10v/16v/25v, 100 mfd/10v, 150 mfd/6v/10v; 200 mfd/10v/16v, 220 mfd/4v/10v/16v, 330 mfd/4v/10v; 500 mfd/6v; 680 mfd/6v/10v/16v, 1000 mfd/2 5v/4v/10v, 1500 mfd/6v/10v/16v, 2200 mfd/6v/10v, 3330 mfd/6v; 4700 mfd/4v.
500mF 12V **15p;** 25V **20p;** 50V **30p.**
1000mF 12V **17p;** 25V **35p;** 50V **47p;** 100V **70p.**
2000mF 6V **25p;** 25V **42p;** 40V **60p;** 1200mF 76V **80p.**
2500mF 50V **62p;** 3000mF 25V **47p;** 50V **65p.**
4500mF 64V **£2.** 4700mF 63V **£1.20.** 2700mF/76V **£1.**
5000mF 35V **85p.** 5600mF/76V **£1.75**

HIGH VOLTAGE ELECTROLYTICS

8/350V	22p	8+8/450V	50p	50+50/300V	50p
16/350V	30p	8+16/450V	50p	32+32/450V	75p
32/500V	75p	16+16/450V	50p	100+100/275V	65p
50/500V	£1.20	32+32/350V	50p	150+200/275V	70p
8/800V	£1.20	50+50/500	£1.80	220/450V	95p
16/500V	65p			80+40/500V	£2

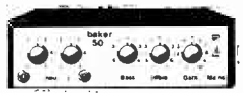
SHORT WAVE 100pf air spaced gangable tuner, **95p.**
TRIMMERS 10pF, 30pF, **5p.** 100pF, 150pF, **15p.**
CERAMIC, 1pF to 0 01mF, **5p.** Silver Mica 2 to 5000pF, **5p.**
PAPER 350V-0 1 **7p;** 0.5 **13p;** 1mF 150V **20p;** 2mF 150V **20p;** 500V-0 001 to 0 05 **12p;** 0.1 **15p;** 0 25 **25p;** 0 47 **35p.**
MICRO SWITCH SINGLE POLE CHANGEOVER 20p.
SUB-MIN MICRO SWITCH, 25p. Single pole change over
TWIN GANG, 385 + 385pF **80p;** 500pF slow motion **75p.** 365 + 365 + 25 + 25pF, Slow motion drive **85p.** 120pF **50p.**
TRANSISTOR TWIN GANG. Japanese Replacement **50p.**
NEON PANEL INDICATORS 250V 30p.
ILLUMINATED ROCKER SWITCH, single pole Red **65p.**
WIRE-WOUND RESISTORS 5 watt, 10 watt, 15 watt **15p**
CASSETTE MOTOR. 6 volt **£1.00**
CASSETTE MECHANISM. Mono heads, no motor **£3.00**

BAKER LOUDSPEAKERS "SPECIAL PRICES"

Post £1.50 ea.

MODEL	SIZE INCHES	OHMS	POWER WATTS	TYPE	OUR PRICE
MAJOR	12	4-8-16	30	HI-FI	£12
DELUXE MK II	12	8-16	15	HI-FI	£14
SUPERB	12	8-16	30	HI-FI	£20
AUDITORIUM	12	8-16	45	HI-FI	£20
AUDITORIUM	15	8-16	60	HI-FI	£29
GROUP 35	12	4-8-16	40	PA	£12
GROUP 45	12	4-8-16	45	PA	£15
GROUP 50	12	4-8-16	60	PA	£20
GROUP 75	12	4-8-16	75	PA	£22
GROUP 100	12	8-16	100	PA	£26
GROUP 100	15	8-16	100	PA	£29
DISCO 100	12	8-16	100	DISCO	£26
DISCO 100	15	8-16	100	DISCO	£29

BAKER 50 WATT AMPLIFIER



£69 Post £2.00
Ideal for Halls/PA systems, Discos and Groups. Two inputs. Mixer, Volume Controls, Master Bass, Treble and Gain Controls. 50 watts r.m.s. Three loudspeaker outlets 4, 8, 16 ohms.

BAKER 150 WATT MIXER/AMPLIFIER

Professional 4 inputs with volume controls. Will mix mics, decks, musical instruments, etc.
£89 Post £2.00 — Slave version available **£75**

FAMOUS LOUDSPEAKERS "SPECIAL PRICES"

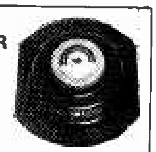
Post £1.50 ea.

MAKE	MODEL	SIZE	WATTS POWER	OHMS	OUR PRICE
SEAS	TWEETER	4in round	50	8	£7.50
GOODMANS	TWEETER	3½in square	25	8	£4.00
AUDAX	TWEETER	3¾in square	60	8	£10.50
SEAS	MID-RANGE	4in	50	8	£7.50
SEAS	MID-RANGE	5in	80	8	£10.50
SEAS	MID-RANGE	4½in	100	8	£12.50
GOODMANS	FULL-RANGE	5½in	15	8	£6.50
GOODMANS	FULL-RANGE	8in	20	8	£5.50
SEAS	WOOFER	8in	30	8	£14.00
R.C.S.	GENERAL	10in	20	8	£8.50
McKENZIE	DISCO-GROUP	15in	150	8+16	£56.00
CELESTION	DISCO-GROUP	18in	100	8+16	£59.00
CELESTION	DISCO-GROUP	18in	200	8+16	£69.00

TEAK VENEERED HI-FI SPEAKER CABINETS
For 13×8in. or 8in. speaker **£9.50** Post 99p
For 6½in. speaker and tweeter **£8.50** Post 99p
Many other cabinets in stock. Phone your requirements.
SPEAKER COVERING MATERIALS. Samples Large S.A.E.
LOUDSPEAKER CABINET WADDING 18in wide **25p** ft.

GOODMANS TWIN AXIOM 8 inch dual cone loudspeaker. 8 ohm. 15 watt hi-fi unit **£10.50.** Post £1.
CROSSOVERS. TWO-WAY 3000 c/s 3 or 8 or 15 ohm **£1.90.** 3-way 950 cps/3000 cps. **£2.20.**
LOUDSPEAKERS PM 3 ohm 7x4in. **£1.50;** 6½in., **£2.20;** 8x5in., **£2.50;** 8in., **£2.50.**
SPECIAL OFFER: 64 ohm, 2⅝in., **35 ohm,** 3in., **25 ohm,** 2½in., 3in., 5x3in., 7x4in., **8 ohm,** 2in., 2⅝in., 3in., 3½in., 5in., **15 ohm,** 3½in. dia. 6x4in., 7x4in., 5x3in., **3 ohm,** 4in., 5in, 7x4in., **120 ohm,** 3¼in. dia. **£1.50 each.**
RICHARD ALLAN TWIN CONE LOUDSPEAKERS
8in diameter 4W **£2.50.** 10in. diameter 5W **£3.50;** 12in diameter 6W **£4.50.** 3/8/15 ohms, please state.
MOTOROLA PIEZO ELECTRIC HORN TWEETER £6.50
Handles up to 100 watts. No crossover required.
BLACK PLASTIC CONSTRUCTION BOX with brushed aluminium facia. Sturdy job. Size 6¼ × 4¾ × 2in. **£1.50**

GOODMANS RUBBER SURROUND BASS WOOFER



Standard 12in. diameter fixing with cut sides 12" × 10". 14,000 Gauss magnet. 20 watts RMS 4 ohm imp. Bass resonance = 30 c.p.s. Frequency response 20-8000 c.p.s.
BARGAIN, £8.50. Post £2

ALUMINIUM HEAT SINKS. FINNED TYPE.
Sizes 5"×4"×1" **95p.** 6½"×2"×2¼" **45p.**
JACK PLUGS Mono Plastic 25p; Metal 30p.
JACK PLUGS Stereo Plastic 30p; Metal 35p.
JACK SOCKETS. Mono Open 20p; Closed 25p.
JACK SOCKETS Stereo Open 25p; Closed 30p.
FREE SOCKETS — Cable end 30p.
2.5mm and 3.5mm JACK SOCKETS 15p.
2.5mm and 3.5mm JACK PLUGS 15p.
DIN TYPE CONNECTORS
Sockets 3-pin, 5-pin 10p. Free Sockets 3-pin, 5-pin 25p.
Plugs 3-pin 20p; 5-pin 25p.
PHONO PLUGS and SOCKETS ea. 10p.
Free Socket for cable end ea. 15p.
Screened Phono Plugs ea. 15p.
TV CONVERGENCE POTS 15p each
Values = 5,7, 10, 20, 50, 100, 200, 250, 470, 2000 ohms.

"VALVES" special offer subject to being unsold £1 ea. Post Free

6AM6	12K7GT	PCF82	PL84	EBF80	EF80
6K8G	35L6GT	PCF86	PY33	UF85	EM84
6Q7G	954	PCL82	PY80	ECC84	EM85
6V6G	UY41	PCL84	PY82	ECF80	EM87
12Q7GT	35Z4GT	PL81	PY83	ECL80	EY51
12K8M	PCC84	PL82	EB91	ECL82	EY86
25Y5G	PCC89	PL83	EBC81	EF41	EZ40

RADIO COMPONENT SPECIALISTS

337 WHITEHORSE ROAD, CROYDON
Open 9-6. Closed all day Wed. Open Sat. 9-5.

Radio Books and Components Lists 20p. (Minimum post/packing charge 50p.) Access or Barclaycard Visa. Please Tel: 01-684 1665 for same day despatch. Cash prices include VAT.

SIX DIGIT COUNTERS

One pulse moves one digit—Type 1 for 230v AC or 100v DC not resettable. Price **30p**—Type 2 for 48v DC or 115v AC and resettable. **£1.35.**

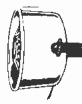
NEW KIT

5 WAVE BAND SHORT WAVE KIT. Bandspread covering 13-5 to 52 metres. Complete kit includes case, materials, six transistors and diodes, condensers, resistors, inductors, switches etc. Nothing else to buy, if you have an amplifier to connect it to or a pair of high resistance headphones. Special price is **£11.95** inc.

PUNCHED TAPE EQUIPMENT

For controlling machine tools etc. motorised 8 bit punch with matching tape reader. Ex-computers, believed in good working order, any not so would be exchanged. **£15** the pair. Carriage £3.

SIREN OR BLEEPER



American Delta mechanical type, works on 6 to 12v to DC or 12 to 24v AC. Price **75p** or **£60** per 100. Electronic Bleeper **TH35** emits high pitched wailing note of varying pitch. In red plastic case with fixing bracket. **£5.00.**

CASSETTE PLAYER/RECORDERS

With record and playback heads, all electronics, switches and speaker. Price **£9.95** (surely this must be the bargain of the year). Music centre replacement stereo with heads but not electronics. **£14.95.**

FRUIT MACHINE HEART

4 wheels with all fruits, motorised and with solenoids for stopping the wheels, with a little ingenuity you can defy your friends getting the "jackpot". **£9.95** + £4 carriage.

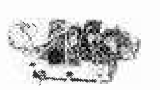
DESOLDERING PUMP

Ideal for removing components from computer boards as well as for service work generally. Price **£6.35.**

4 CORE FLEX CABLE

White pvc for telephone extensions, disco lights etc. 10 metres **£2**, 100 metres **£15.** Other multicore cable in stock.

HEADPHONE AMPLIFIER (STEREO)

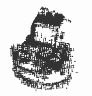


With volume, tone and balance control 9v operation. All made up ready to go. Price **£4.50.**

MUGGER DETERRENT

A high note bleeper, push latching switch, plastic case and battery connector. Will scare away any villain and bring help. **£2.50** complete kit

ELECTRONIC JIGSAW PUZZLE

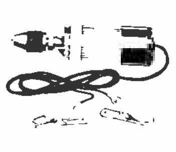


One of the many things you can make with this miniature uniselector. We give the circuit free when you order. Price **£3.45.**

SAFE BLOCK

Mains quick connector will save you valuable time. Features include quick spring connectors, heavy plastic case and auto on and off switch. Complete kit **£1.70** + 25p or made up **£3.00** + 45p.

VERSA DRILL



A 12 volt battery operated power drill, not just suitable for printed circuit boards but will do all the jobs and is powerful enough to perform all the functions and operations normally expected of Black & Decker and other mains drills. Its chuck accepts up to ¼" drills. Size approx. 150mm × 50mm. Price **£16.75.**

V3 MICROSWITCHES

Over 50,000 in stock all 250 AC working, with 3 silver contacts for c/o circuits—10 amp **25p** each or **£20** per 100. 15 amp **35p** each or **£30** per 1000.

MINIATURE MAGNETIC CIRCUIT BREAKERS

Operate faster than fuses. 1 amp, 2 amp, 5 amp, 10 amp, 15 amp and 25 amp types. All **£2.30** each.

PLEASE NOTE: The "+" sign after the amount shows the amount of V.A.T. The postage, if quoted, is based upon the amount the article costs to send if it forms part of a larger parcel. Should your order be less than £10.00 however, please send an additional 50p. BARCLAYCARD & ACCESS WELCOMED. Phone 01 688 1833.

TERMS: Cash with order—but orders under **£10** must add **50p** to offset packing etc.

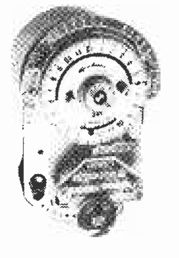
BULK ENQUIRIES INVITED. PHONE: 01-688 1833.
ACCESS & BARCLAYCARD ACCEPTED

MULLARD UNILEX

A mains operated 4+4 stereo system. Rated one of the finest performers in the stereo field this would make a wonderful gift for almost anyone in easy-to-assemble modular form and complete with a pair of speakers this should sell at about **£30** — but due to a special bulk-buy and as an incentive for you to buy this month we offer the system complete at only **£15** including VAT and postage

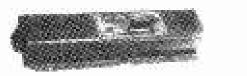
DRILL CONTROLLER

Electronically changes speed from approximately 10 revs to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions. £3·45
Made up model £1 00 extra



VENNER TIME SWITCH mains operated with 20 amp switch, one on and one off per 24 hrs. repeats daily automatically correcting for the lengthening or shortening day. An expensive time switch but you can have it for only **£2.95.** These are new but without case, but we can supply plastic cases (base and cover) **£1.75** or metal case with window **£2.95.** Also available is adaptor kit to convert this into a normal 24 hr. time switch but with the added advantage of up to 12 on/offs per 24 hrs. This makes an ideal controller for the immersion heater. Price of adaptor kit is **£2.30.**

FLUORESCENT TUBE INVERTER

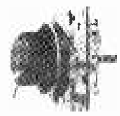


For camping — car repairing — emergency lighting from a 12v battery you can't beat fluorescent lighting, it will offer plenty of well distributed light and is economical. We offer Phillips inverter for 12" 3 watt miniature tube for only **£5.25** with tube and tube holders as well.

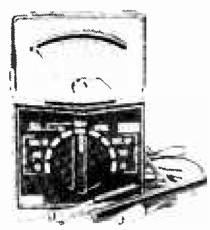
THIS MONTH'S SNIPS

3 CHANNEL SOUND TO LIGHT KIT Complete kit of parts for a three channel sound to light unit controlling over 2000 watts of lighting. Use this at home if you wish but it is plenty rugged enough for Disco work.
The unit is housed in an attractive two-tone metal case and has controls for each channel, and a master on/off. The audio input and output are by ¼" sockets and three panel mounting fuse holders provide thyristor protection. A four pin plug and socket facilitate ease of connecting lamps. Special snip price is **£13.50** in kit form or **£16.50** assembled and tested.
REMOTE CONTROL for Sound to Light (ours or any other circuit) saves connecting to speaker or amp—kit consists of 1 watt amplifier, crystal mike, case, sundries and diagram. Price **£3.95.**
LIGHT EXPANDER AND LATCH for Sound to Light, enables 3000 watts of lighting to be controlled by single channel or each channel and enables lights to be latched on. Kit consists of latching relay, control switch, case, sundries and diagram. Price **£4.25.**
SINGLE CHANNEL KIT still available. Price **£5.18.**

DELAY SWITCH



Mains operated—delay can be accurately set with pointers knob for periods of up to 2½ hrs. 2 contacts, suitable to switch 10 amps—second contact opens a few minutes after 1st contact. **95p.**



MINI-MULTI TESTER
Deluxe pocket size precision moving coil instrument, jewelled bearings – 2000 o.p.v. mirrored scale.
11 instant ranges measure:-
DC volts 10, 50, 250, 1000.
AC volts 10, 50, 250, 1000.
DC amps 0-100 mA.
Continuity and resistance 0-1 meg ohms in two ranges.
Complete with Test Prods and instruction book showing how to measure capacity and inductance as well.
Unbelievable value only **£6.75** + 50p post and insurance.

FREE Amps ranges kit to enable you to read DC current from 0-10 amps. directly on the 0-10 scale. It's free if you purchase quickly but if you already own a mini teacher and would like one send **£2.50p.**

J. BULL (ELECTRICAL) LTD

(Dept, WW)
103, TAMWORTH ROAD,
WEST CROYDON, SURREY.
Tel: 01-688 1833

SUB-MIN MICROPHONE
Size only ½" × ⅜" × 3/16" so small enough for a bugging device, ex-hearing aids but guaranteed Price **£1.60.**
TRANSMITTER SURVEILLANCE
Tiny, easily hidden but which will enable conversions to be picked up with FM radio Can be made in a matchbox — all electronic parts and circuit **£2.00.**
RADIO MIKE
Ideal for discos and garden parties, allows complete freedom of movement Play through FM radio or tuner amp **£6.60.**

CONSTRUCTOR'S SNIP
6v 1 amp transformer with 230v mains primary. This has fixing clamp and is in fact a normal transformer usually listed at £2.50. We are offering this at only **£1** including postage and VAT and for good measure we are including free plans and diagrams for two very popular items. 1. Sound to light adaptor. 2. Whistle op. switch. Secure this bargain by ordering parcel ref. 8J1.

BURGLAR ALARM CONTROL PANEL
Contains labelled connection block, latching relay, test switch and removable key control switch. Simplifies the whole installation, all you have to do is to take wires to pressure pads and to alarm bell. Price **£6.00** + 90p. With complete diagram.

PRECISION MAINS OPERATED CLOCK
For only **£1.50** + 22p. Sounds unbelievable but that's what you can have if you send your order right away. The clocks which have large clear dials were made by the famous Smiths Company for use with their domestic cooker switch and are brand new and guaranteed.

15-0-15v @ 2 AMP MAINS TRANSFORMER
Mains transformer, upright mounting primary and secondary wound on separate bobbins with fixing lugs. Price **£3** + 45p. Post 60p.

25-0-25v @ 750 mA MAINS TRANSFORMER
Mains transformer. C core construction, heavily varnished for dead quiet operation. Upright mounting with fixing lugs. Price **£2.75** + 41p. Post 50p.

25 WATT MID-RANGE SPEAKER 5¼"
Made by Goodmans so there's none better. 4 ohm coil. Price **£3.50** + 45p. Post £1.00.

8 OHM TWEETER
Made by Goodmans, 3½" square, 4" across fixings. Price **£1.50** + 22p. Post 30p.

ROTARY SOLENOID
As most customers know we have solenoids of the normal types for pulling and pushing through a magnetic assembly. We have now acquired some which have a rotating action. D.C. operated. A shaft which comes out of the centre, rather like a motor spindle, travels approx. 90°. Price **£5** + 75p.

WATERPROOF HEATING WIRE
As used for electric blankets, etc. This has dozens of other applications—in gloves or socks for people with poor circulation are obvious uses. One unusual use suggested by a customer is a 'grow' bag heater. The wire which consists of an element wound on glass fibre then PVC covered has a resistance of 60 ohms per yard. The price is **20p** + 3p per yard.

TELEPHONE PICK-UP coil attaches by suction to phone body, enabling conversation to be recorded, put through amp or headphones. Price **£1** + 15p.

TRANSDUCERS
As used remote control T.V. receivers. Price **£1.50** + 22p.

2½" ROUND PANEL METERS
All flush mounting through 2½" round hole, with flange makes item 3" wide approx. Made to stringent Ministry specifications. We have the following types in stock, all are moving coil unless otherwise stated. **VOLTMETER** Scaled 0-200 volts, res. 2,500 o.p.v. Price **£2** – 30p. **MICRO AMPMETER** 500 UA—scaled 0-5. Price **£2.50** + 38p. **MILLIAMP METER** 500 MA—scaled 0-500 mA. Price **£2** + 30p. **AMPERE METER** Hot wire, scaled 0-9 amp. Price **£2** + 30p.

0-1 MA PANEL METER
2" square made by Sifam for Ferrograph for peak level indication, so reads right to left—1 milliamp f.s.d., scaled 0-1. Price **£3** + 45p.

VU METER
Edgewise mounting, through hole size 1⅞" × ⅞" approx. These are 100 micro amp f.s.d. and fitted with internal 6 volt bulb for scale illumination, also have zero reset. The scale is not calibrated but has very modern appearance. Price **£2.50** + 38p.

BALANCE METER
Edgewise mounting 100 UA centre zero. Price **£2.00** + 30p.

1¾" SQUARE PANEL METER
Eagle full vision plastic front. 50 UA. Price **£4.00** + 60p. **1 mA.** Price **£3.50** + 53p.

LARGE PANEL MOUNTING MOVING COIL METER
Size 5" × 4" 200-0-200 UA. It has a plain scale, also it is a fairly easy job to reset the pointer to the left-hand zero position and thus obtain a 0/400 UA movement. Made by Sangamo Weston. Price **£6** + 90p.

GALVANOMETER 7-0-7 UA f.s.d.
Moving coil precision laboratory instrument of extremely high sensitivity (0.3 UA per division). Size approx. 6½" × 2½" × 2". Price **£12** + £1.80.

4" SQUARE PANEL MOUNTING moving coil movement with scale for multi-range test meter made for the Taylor Electric Co., a truly beautiful instrument with mirrored scale, end stops and zero adjustment. If you have contemplated building a 20,000 o.p.v. multi-tester then this is your chance. Price **£4.50** + 68p.

3" EDGEWISE PANEL METER
0-25 MA moving coil made for the G.P.O. A very useful instrument especially when panel space is limited. Price **£2.50** + 38p.

SPEAKER CABINETS
Simulated teak finish, nice handy size 11" × 8" × 4½" approx., modern black sponge type front. Price **£2** + 36p, post £1.50. Special price to bulk buyers.

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All the parts to make up the beginner's model Price **£2 + 30p.** Crystal earpierce **57p + 8p.** High resistance headphones (give best results) **£3.25 + 50p.** Kit includes chassis and front but not case

RADIO STETHOSCOPE
Easy way to fault find — start at the aerial and work towards the speaker — when signal stops you have found the fault Complete kit **£4.25** + **65p.**

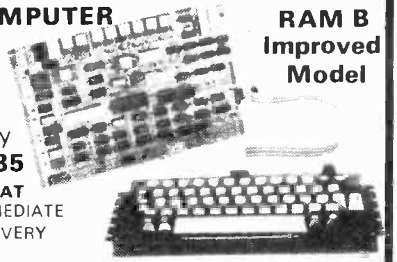
INTERRUPTED BEAM KIT
This kit enables you to make a switch that will trigger when a steady beam of infra-red or ordinary light is broken Main components — relay photo transistor, resistors and caps, etc Circuit diagram but no case Price **£2** + **30p.**

12v SUBMERSIBLE PUMP
Our drill pump is useful, but this new one is even more so. Just join it to your car battery, drop it into the liquid to be moved and up it comes, no messing about, no priming, etc., and you get a very good head. Suitable for water, paraffin and any non-explosive, non-corrosive liquid. One use if you are a camper, make yourself a shower. Price **£6** + 90p. A free gift, first 100 purchasers will get tap with built in switch and length of plastic tubing.

E.H.T. MAINS TRANSFORMER with inductance control, normal primary, secondary output by our equipment, 3·5 kv 3 mA. E.H.T. voltage can be varied by applying a DC voltage to the lower normally unused bobbin. We are not sure how much the voltage may be increased or decreased but using a 9 volt battery we seem to get a rise or fall of about 50 volts. Ex unused P.S.U.'s. Price **£2** + 30p. Post 40p.

NASCOM-2 MICRO-COMPUTER

FREE 16k RAM B Improved Model



only **£335** + VAT
IMMEDIATE DELIVERY

780A 8 bit. This will run at 4 Mhz but is selected between 2/4/Mhz.
On-board, addressable memory 2K
2K Monitor — Nas-sys 1. 1K Video RAM
(MK 4118). 1K work space/User RAM
(MK 4118) (8K Microsoft Basic PR)
(MK 3600 ROM). 8K Static RAM/2708E Pr.
Power Supply £29.50 + VAT.

Microprocessors Z80A, 8 bit CPU. This will run at 4MHz but is selectable between 2/4 MHz. This CPU has now been generally accepted as the most powerful 8 bit processor on the market.

INTERFACE

Keyboard New expanded 57 key Licon solid state keyboard especially built for Nascom. Uses standard Nascom, monitor controlled, decoding.

T.V. The Iv peak to peak signal can drive a monitor directly and is also fed to the on-board modulator to drive the domestic T.V.

I.O. On-board UART (Int. 6402) which provides serial handling for the on-board cassette interface or the RS232/20mA teletype interface.

The cassette interface is Kansas City standard at either 300 or 1200 baud. There is a link option on the NASCOM-2 for 2400 Baud.

The RS232 and 20mA loop connector will interface directly into any standard teletype.

The input and output sides of the UART are independently switchable between any of the options — i.e. it is possible to have input on the cassette and output on the printer.

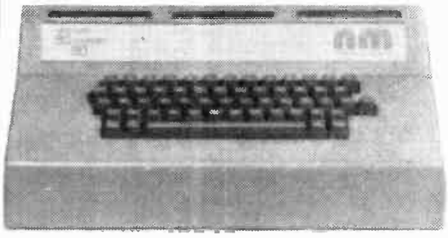
PIO There is also a totally uncommitted Parallel I/O (MK 3881) giving 16, programmable, I/O lines. These are addressable as 2 × 8 bit ports with complete handshake controls.

Documentation Full construction article is provided for those who buy a kit and an extensive software manual is provided for the monitor and Basic.

Basic The Nascom 2 contains a full 8K Microsoft Basic in one Rom chip with additional features like DEEK, DOKE, SET-RESET for simple programming.

SYSTEM 80

KITS from £225



Microprocessor board* (Nascom 2)
4MHz Z80 CPU; TV or Video + 1200 baud Kansas City + Serial RS 232 printer Interfaces; Keyboard; 128 character ASCII plus 128 Graphics in 2 × 2K ROM; free 16-way parallel port; 8K BASIC; NAS SYS operating monitor. £280 built and tested.

Firmware & MOS ICs
Zeap Assembler (4, 1K×8 EPROMS) £50
Nas Pen text editor (2, 1K×8 EPROMS) £30

Floppy disc system
Double sided, double density 5¼in disc giving 280K bytes formatted, including controller board/PSU/Housing and interconnects. £480. Controller board £127.50. Second Disc £240. CP/M £80.

System 80 housing
High strength GRP moulding
Accepts 12×8 Nascom 2 CPU board, four 8×8 expansion boards. £85 incl. frame racking, interconnects and motherboard.

Expansion Boards* (in kits)
16K RAM £127.50 ● 32K RAM £175
48K RAM £220
High Resolution Programmable Graphics £90
High Resolution Colour add on £37.50
Colour Board Kit £140

All prices subject to VAT.

No more slaving over a hot soldering iron. The Nascom 1 is now supplied BUILT!
Britain's biggest small system is available fully constructed for you to slot into your own housing for the ridiculously low price of £140 plus VAT (kit price still only £125 plus VAT).

nascom-1

12" × 8" PCB carrying 5LSI MOS packages, 16 1K MOS memory packages and 33 TTL packages.
There is on-board interface for UHF or unmodulated video and cassette or teletype.
The 4K memory block is assigned to the operating system, video display and Eprom option socket, leaving a 1K user RAM.
The MPU is the standard Z80 which is capable of executing 158 instructions including all 8080 code.

NASCOM-1 £125 VAT P&P £1.50

NASCOM PRODUCT LIST + VAT

I/O board kit less I/O chips	45.00
UART + BAUD rate generator + crystal for I/O board	16.00
CTC — MK3882 multiple interrupt driven clock generator for I/O board	8.25
P/IO — MK3881 + interconnect for I/O board	8.50
P/IO interconnect only (for I/O board)	3.80
Econographics kit for additional 128 characters (N1 only)	30.00
2708/2716 Programmer for Nascom 1 and 2 under NAS-SYS	20.95
Nascom 19" rack mounting card frame for N1 and N2	32.50
Nas-DA disassembler 3 EPROM for Nas-sys	37.50
MK36271 8K BASIC in 8K × 8 ROM	40.00
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ZEAP 1.2 tape and documentation for N1	30.00
ZEAP 2 tape and documentation for Nas-sys	30.00
8K BASIC tape and documentation for N1	15.00
MEMORIES Discounts 10% for 4, 15% for 8, 20% for 16	
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MK3880-N4 (Z80A) for N2	7.95
MK4116 16K × 1 dynamic RAM	7.50
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Unprogrammed 2708	7.50
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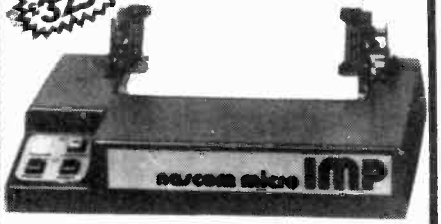
IM6402 UART	4.50
2114 1K × 4 Static RAM	3.95
8080A	5.25

NASCOM IMP

£325



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Fully built and housed in a stylish enclosure

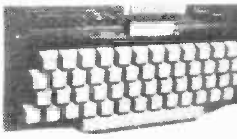
for just **£325** plus VAT. Interfaces with all micro computers.

The Nascom IMP (Impact Matrix Printer) features are

● 60 lines per minute ● 80 characters per line ● Bi-directional printing ● 10 line print buffer ● Automatic CR/LF ● 96 character ASCII set (including upper/lower case, $, :, £). ● Accepts 8½" paper (pressure feed) ● Accepts 9½" paper (tractor feed). ● Tractor/pressure feed ● Baud rate from 110 to 9600 ● External signal for optional synchronisation of baud rate.

IDEAL FOR WORD PROCESSING

COMPUTER KEYBOARDS



TASA 56 key touch sensitive keyboard. All ASCII characters including control keys. Parallel output with strobe. Shift lock. Keys coded in 3 colours to indicate function. 18 V DC at 35 mA. 15" × 6.25" × 0.385" thick. Black resin encapsulated.
£49.50 + VAT

Star Devices Mk III 71 key touch sensitive keyboard. With numeric pad. All ASCII characters including control keys. Auto key repeat. Parallel output with strobe. Shift lock with indicator LED. Built in 'beeper' with level control. 5 V DC at 300 mA 15" × 7" × 1.25". Grey case with white keys on blue.
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Carter 57 key ASCII keyboard. Conventional keyboard. 128 ASCII characters including control keys. Parallel output with strobe. Shift lock. + 5 V and −12 V DC. 12" x 5.5" x 1.5". Black keys with white legends.
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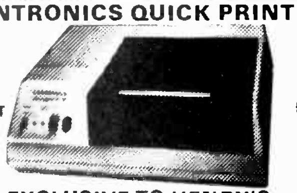

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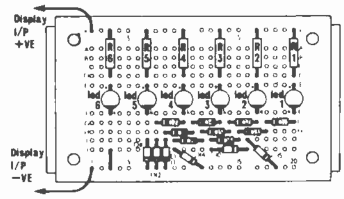
Look at the diagram, select RI, plug it in to the letter numbered holes on the EXPERIMENTOR BREADBOARD, do the same with the other components, connect to battery and ANYBODY can build a perfect working project.



YOU WILL NEED

e.g. LED Bar Graph (a previous project)
components EXP300 or EXP350
D1 to D15 — Silicon Diodes
R1 to R6 Resistors
LED 1 to LED 6 Light emitting diodes

For the full detailed instructions, including "Electronics by Numbers" circuit diagrams, simply take the coupon to your nearest CSC stockist or send direct to us and you will receive "THREE FREE PROJECTS FROM CSC".

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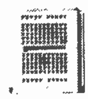
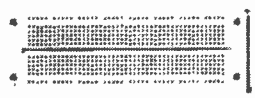
EXP 325 £1.60 The ideal breadboard for 1 chip circuits. Accepts 8, 14, 16 and up to 22 pin ICs. Has 130 contact points including two 10 point bus-bars.

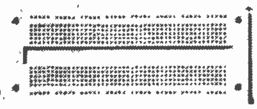


EXP 350 £3.15 Specially designed for working with up to 40 pin ICs perfect for 3 & 14 pin ICs. Has 270 contact points including two 20 point bus-bars.

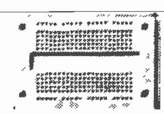
EXP 300 £5.75 The most widely bought bread-board in the UK. With 550 contact points, two 40 point bus-bars, the EXP 300 will accept any size IC and up to 6 × 14 pin DIPS. Use this breadboard with Adventures in Microelectronics.



EXP 600 £6.30 Most MICROPROCESSOR projects in magazines and educational books are built on the EXP 600.



EXP 650 £3.60 Has ·6" centre spacing so is perfect for MICROPROCESSOR applications.



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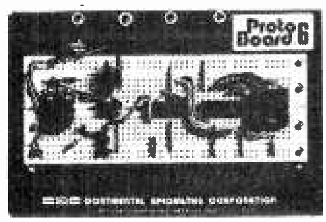
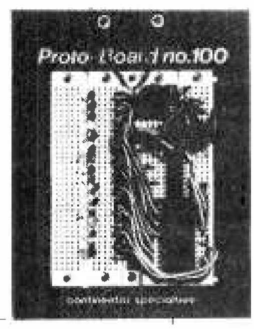


PB6 Kit, 630 contacts, four 5-way binding posts accepts up to six 14-pin Dips.

PROTO-BOARD 6 KIT £9.20



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EXP 350	270	3	£ 4.48	
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EXP 600			£ 8.39	
EXP 650	270	use with 0.6 pitch Dip's Strip Bus Bar	£ 5.00	
EXP 4B	Four 40 Point Bus Bars		£ 3.50	
PROTO-BOARDS				
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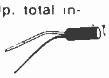

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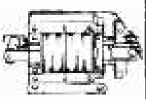

Mfg by Magnetic Devices, 240V AC intermittent operation, approx 20lb pull at 1 25in Ex equip Tested Price **£4.75** + 75p P&P (**£6.33** inc VAT & P) R&T

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12V DC heavy duty Solenoid 4 Kp pull Easily removable from plate Ali chassis containing 4 × 24V DC Push Solenoids (1½ lb approx) 5-fig Counter 6 min photo cells Sub-min Microswitches etc. etc Ex-equip London Transport Printer Price **£9.00** + £1 00 p & p (total incl VAT **£11.50**)

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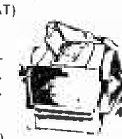

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Black Silver Skirted Knob calibrated in Nos 1-9, 1½in dia brass bush. Ideal for above Rheostats **24p ea.**

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HY-LIGHT STROBE KIT Mk. IV
Latest type Xenon white light tube Solid state timing and triggering circuit. 230/240V AC operation. Speed adjustable 1-20 fps. Designed for large rooms, halls, etc Light output greater than many (so called 4 Joule) strobes. Price **£22.00** post £1.00 (**£27.03** inc. VAT & P) Specially designed case and reflector for Hy-Light **£9.00** Post £1.00 (**£12.08** Inc. VAT & P)

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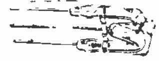

Range of Xenon tubes available from stock SAE for full details

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Arrow 2 c/o 15 amp **£1.50** (**£1.96** inc. VAT & P) T.E.C. open type 3 c/o 10 amp **£1.10** (**£1.50** inc. VAT & P).
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7½ rpm KLAXON motors approx 25lb inch
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Above four motors are designed for 110V AC supplied with auto transformer for 240V AC operation **£7.75** (P&P 75p). Total incl. VAT & P **£9.78**, N M S.

19 rpm FHP 220/240 AC reversible torque 14 5kg Gear ratio 144—1 Brand new, including capacitors, mf. **CITENCO.** Price **£14.25** + £1.25 P&P (**£17.83** inc VAT) N M.S
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Parvalux type SD12L 24 D C. shunt wound Motor. **133rpm. 65lbs.** in Gearbox ratio 30-1 Current 6-8 amp Rating continuous. Will operate on reduced power and speed at 9V D C. or less. Size Dia. 16mm, Width 150mm, Shaft dia. 16mm Price **£16.00** plus p&p £2 00. (**£20.70** inc. VAT) N M S
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12V DC type SD2 Shunt 1/30th ph continuously rated 4,000 rpm. Mf. **PARVALUX.** Price **£10.00** + P&P (**£12.35** inc. VAT). N.M.S.
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24V DC 200 rpm 10 lbs/ins continuously rated geared Motor mfg by either Parvalux or Carter. Easily removable from heavy ali chassis containing 9 × 24V DC Solenoids, microswitches, friction clutch, precision gearing, etc. etc. Ex-equipment London Transport Ticket Printer. Price. **£11.00** + £2 00 p. & p. (total incl. VAT **£14.95**).

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Direct coupled to 1/3 h.p 110/115V A.C. Motor 4 2 amp. 1380 rpm. Motor manuf by A E I Pump by Williams Max Vac 25" H.G Max pressure cont 10 p s i. int. 15 p.s i Max airflow 3 c.f m at "0" H.G. Price **£30.00** + P & P **£3.00** (**£37.95** inc VAT) N.M.S
Suitable transformer for 240V op **£10.00** P & P £2.00 (**£13.80** incl VAT) N M.S.

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AC Wkg TUBULAR CAPACITORS
Fraction of maker's price. Motor start etc:

1 5 mfd	440V AC	**60p**	10 mfd	400V AC	**£1.75**
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2 mfd	450V AC	**75p**	15 mfd	250V AC	
2 2 mfd	440V AC	**75p**	(block)		**£1.50**
3 mfd	440V AC	**£1.00**	19 mfd	280V AC	**£2.00**
4 1 mfd	440V AC	**£1.00**	20 mfd	250V AC	**£2.25**
5 mfd	400V AC	**£1.25**	50 mfd	370V (block)	
5 3 mfd	160V AC	**60p**			**£5.00**
5 4 mfd	280V AC	**75p**			
6 5 mfd	280V AC	**£1.00**	P&P. up to 2 5 mfd 25p 3 mfd		
7 5 mfd	200V AC	**£1.00**	to 20 mfd 50p 50 mfd £1 50		
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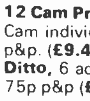
PROGRAMME TIMERS
12 Cam Programmer Timers. 240v. A.C. op. Each Cam individually adjustable. Price **£7.50** plus 75p p&p. (**£9.49** inc V.A.T.). R&T.
Ditto, 6 adjustable 6 fixed cams. Price **£6.00** plus 75p p&p (**£7.76** inc. V.A.T.) R&T.

MINIATURE PROGRAMMER
Crouzet 1 rm. 115V AC Motor operating 2 Roller Micro switches (4 amp) Can be used on 240V AC with either 0 25 mfd 250V Condenser or 5 6K wirewound Resistor 7 watt supplied. Price **£2.50** + 50p P&P (**£3.45** inc. VAT P&P). N M S.

800 WATT DIMMER SWITCH


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PLUG-IN for TEKTRONIC OSCILLOSCOPE: Type 3B3 Time Base £95. Type 3A6 Dual Trace £95. Carriage extra.
AUTO TRANSFORMER: 230/115v 50 c/s 1000 watts. Mounted in strong steel case 5" × 6½" × 7". Bitumen impregnated. £17.25 + carriage.
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PRI 120 or 240V Sec 120 or 240V
Centre Tapped and Screened

Ref.	VA (Watts)	£	P&P
07★	20	**4.84**	.91
149	60	**7.37**	1.10
150	100	**8.38**	1.31
151	200	**12.28**	1.31
152	250	**14.61**	1.73
153	350	**18.07**	2.12
154	500	**22.52**	2.47
155	750	**32.08**	OA
156	1000	**40.92**	OA
157	1500	**56.52**	OA
158	2000	**67.99**	OA
159	3000	**95.33**	OA

★115 or 240 sec only. State volts required. Pri. 0.220-240V.

12 or 24-VOLT
Separate 12V windings Pri 220-240V

Ref	Amps 12v	Amps 24v	£	P&P
111	0.5	0.25	**2.42**	.52
213	1.0	0.5	**2.90**	.90
71	2	1	**3.86**	.90
18	4	2	**4.46**	1.10
85	5	2.5	**6.16**	1.10
70	6	3	**6.99**	1.10
108	8	4	**8.16**	1.31
72	10	5	**8.93**	1.31
116	12	6	**9.89**	1.52
17	16	8	**11.79**	1.52
115	20	10	**15.38**	2.39
187	30	15	**19.72**	2.39
226	60	30	**40.41**	OA

50 VOLT RANGE
Pri 220-240V. Sec. 0-20-25-33-40-50V. Voltages available 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40 or 20V-0-20V and 25V-0-25V Screened

Ref.	Amps	£	P&P
102	0.5	**3.75**	.90
103	1.0	**4.57**	1.10
104	2.0	**7.88**	1.31
105	3.0	**9.42**	1.52
106	4.0	**12.82**	1.75
107	6.0	**16.57**	1.89
118	8.0	**22.29**	2.39
119	10.0	**27.48**	OA
109	12.0	**31.79**	OA

30 VOLT RANGE
Pri 220-240V Sec. 0-12-15-20-24-30V
Voltages available 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30V or 12V-0-12V and 15V-0-15V.

Ref.	Amps	£	P&P
112	0.5	**2.90**	.90
79	1.0	**3.93**	1.10
3	2.0	**6.35**	1.10
20	3.0	**6.82**	1.31
21	4.0	**8.79**	1.31
51	5.0	**10.86**	1.52
117	6.0	**12.29**	1.67
88	8.0	**16.45**	1.89
89	10.0	**18.98**	1.89
90	12.0	**21.09**	2.24
91	15.0	**24.16**	2.39
92	20.0	**32.40**	OA

60 VOLT RANGE
Pri 220-240V
Sec 0-24-30-40-48-60V. Voltages available 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60V, or 24V-0-24V and 30V-0-30V

Ref.	Amps	£	P&P
124	0.5	**4.27**	1.10
126	1.0	**6.50**	1.10
127	2.0	**8.36**	1.31
125	3.0	**12.10**	1.39
123	4.0	**13.77**	2.12
40	5.0	**17.42**	1.89
120	6.0	**19.87**	2.12
121	8.0	**27.92**	OA
122	10.0	**32.51**	OA
189	12.0	**37.47**	OA

SCREENED MINIATURES
Primary 240V

Ref.	mA	Volts	£	P&P
238	200	3-0-3	**2.83**	.63
212	1A, 1A	0-6, 0-6	**3.14**	.90
13	100	9-0-9	**2.35**	.44
235	330, 330	0-9, 0-9	**2.19**	.44
207	500, 500	0-8-9, 0-8-9	**3.05**	.85
208	1A, 1A	0-8-9, 0-8-9	**3.88**	.90
236	200, 200	0-15, 0-15	**2.19**	.44
239	50MA	12-0-12	**2.88**	.37
214	300, 300	0-20, 2-20	**3.08**	.90
221	700 (DC)	20-12-0-12-20	**3.75**	.90
206	1A, 1A	0-15-20, 0-15-20	**5.09**	1.10
203	500, 500	0-15-27, 0-15-27	**4.39**	1.10
204	1A, 1A	0-15-27, 0-15-27	**6.64**	1.10

HIGH VOLTAGE
MAINS ISOLATING
Pri 200/220 or 400/440
Sec 100/120 or 200/240

VA	Ref.	£	P&P
60	243	**7.37**	1.58
350	247	**18.07**	2.12
1000	250	**45.94**	OA

AUTO TRANSFORMERS

Ref.	VA (Watts)	TAPS	£	P&P
113	15	0-115-210-240V	**2.73**	.81
64	75	0-115-210-240V	**4.41**	1.10
4	150	0-115-200-220-240V	**5.89**	1.10
67	500		**12.09**	1.91
84	1000		**20.64**	2.39
93	1500		**25.61**	OA
95	2000		**38.31**	OA
73	3000		**65.13**	OA
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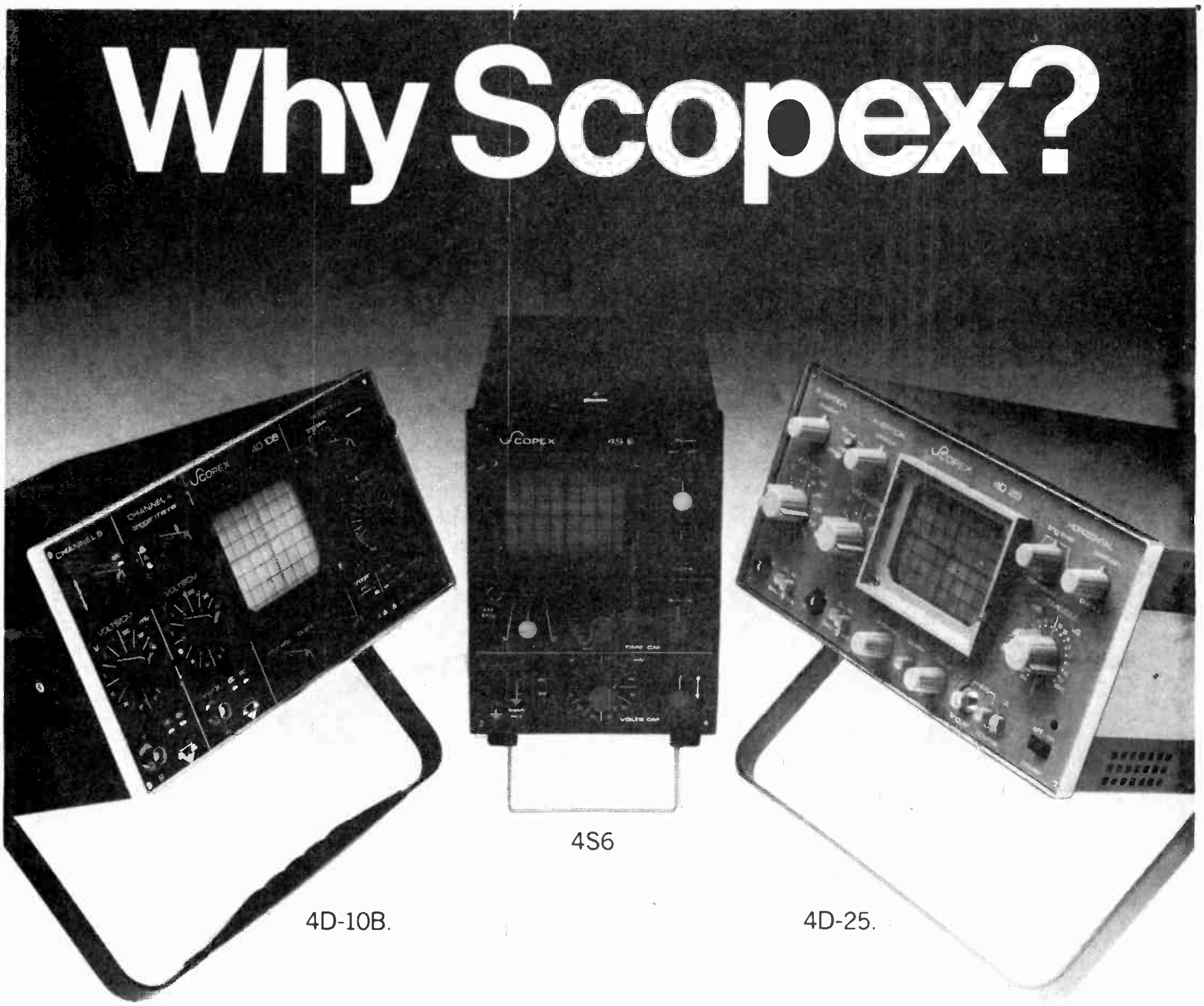

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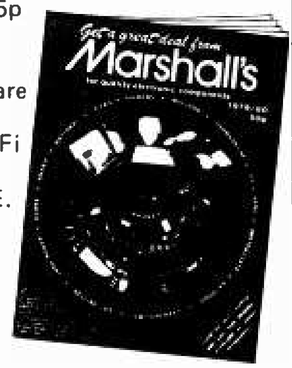

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12	12-15-20-25-30v	5	**£10.50**	£1.50
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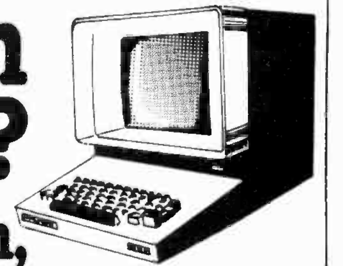

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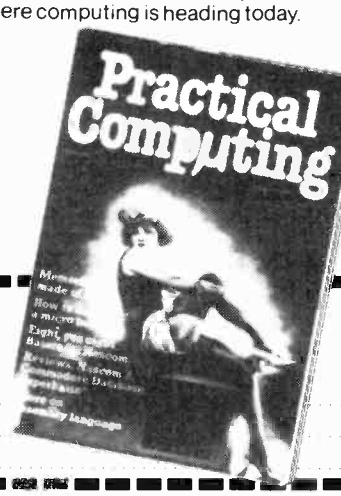

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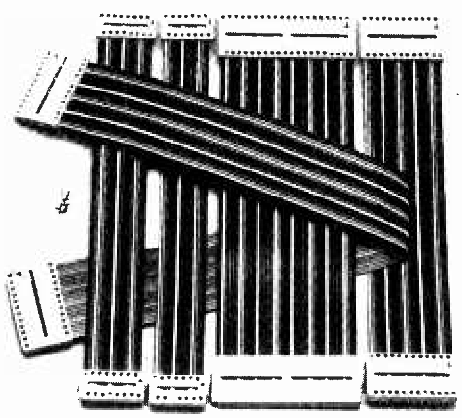

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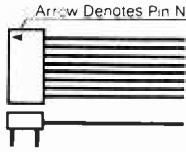

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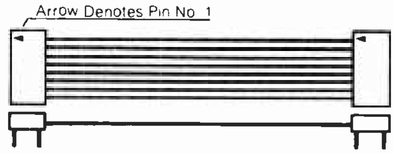

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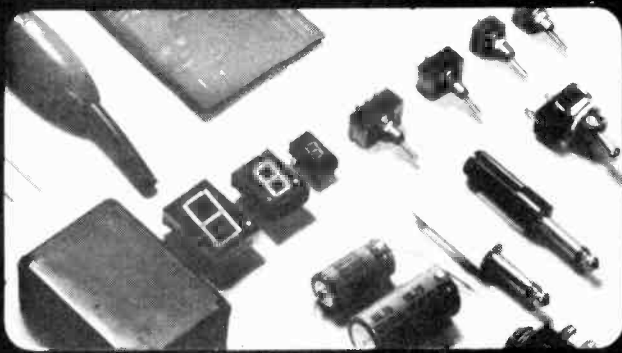

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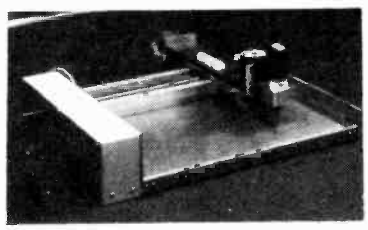

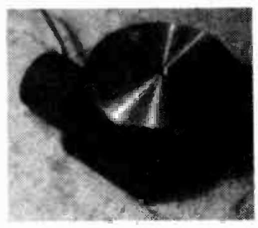

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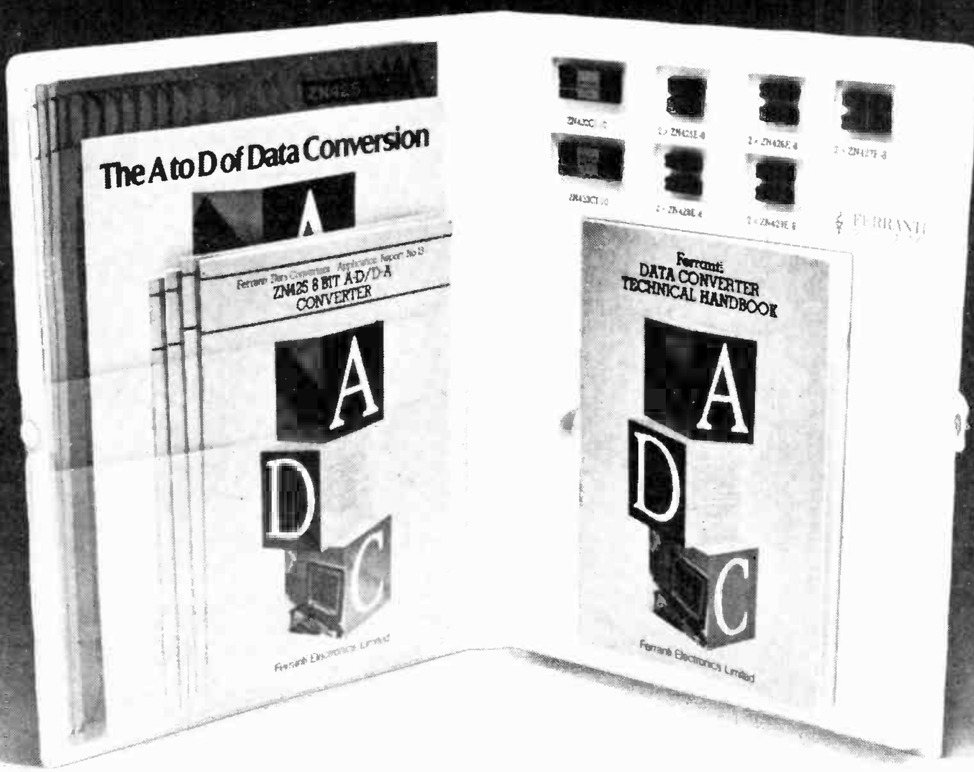

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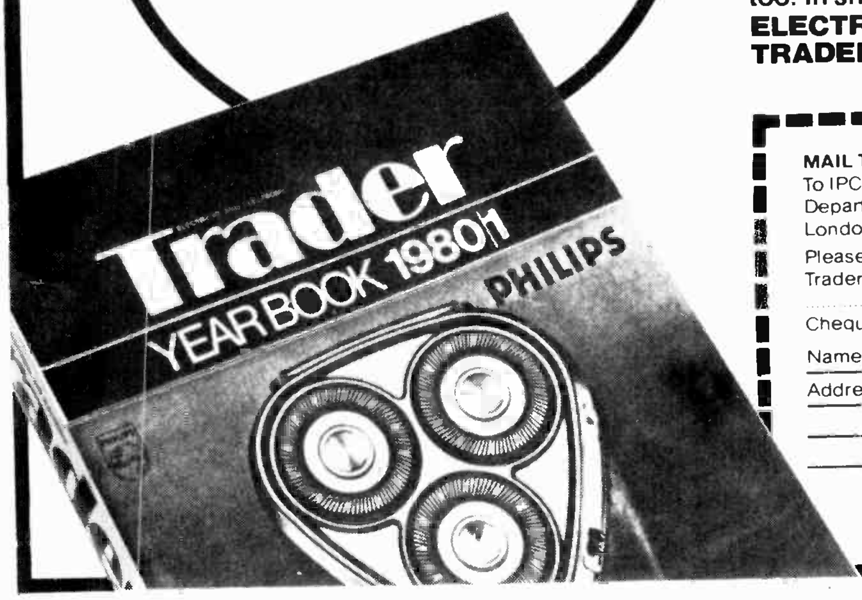

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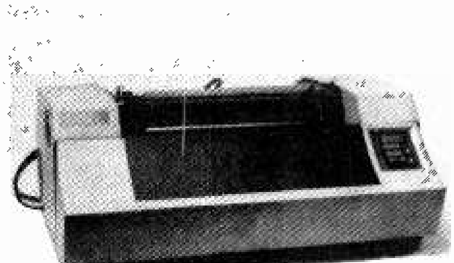
WW

Electronic Brokers

No.1 in Second User Minis & Peripherals

ASR 33 Teletype
Input/Output terminal incorporating paper tape punch and reader. 64 ASCII upper case character set, 110 baud operation, even parity keyboard, choice of RS232 or 20 mA interface. NOW ONLY £595.00.
Options: ICL-type keyboard **£50.00**, 8th level marking **£25.00**, remote reader control **£50.00**, reader step **£20.00**, Auto reader **£25.00**, pedestal **£30.00**



CENTRONICS 101A
Heavy duty Matrix Printer with 64 ASCII upper case character set, 165 cps operation, 132 print positions with adjustable tractor feed. 7×9 dot matrix, parallel input **£750.00.**

GE TERMINET 1200 RO
High-Speed typewriter-quality Impact Printer with switch-selectable print speeds of 30, 60 and 120 cps 80 print positions with adjustable pin-feed paper tractor Full upper and lower case ASCII character set Current loop (20mA) Interface NOW ONLY **£495.00.** (optional extra — parity card **£50.00**)

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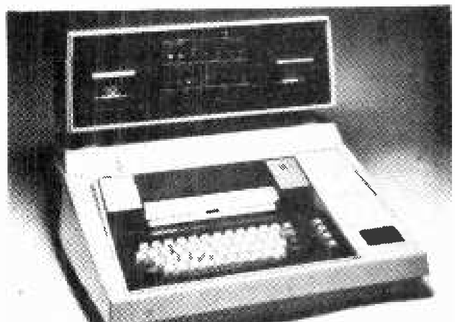
HAZELTINE THERMAL PRINTER
80 column 30cps Receive-only printer with parallel TTL input. Ideal hard copy attachment for Hazeltine 2000 VDU users. **£395.00**

TERMIPRINTER 7075 RO
Typewriter quality output printer providing full upper and lower case character set. Switch-selectable print speeds of 10, 15 & 30 cps. 118-column print line with 12.85" pinfeed platen RS232 Interface. NOW ONLY **£395.00** (optional Extra-Interface cable & connector **£15.00**).



TEXA[illegible]SR
Input/output terminal incorporating twin cassette/drive for high-speed transmission Silent operation at 10, 15 & 30 cps 64 upper case ASCII character set RS232 Interface **£1375.00**
Also available Texas 725 KSR Portable Terminal with integral acoustic coupler **£625.00**

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KW11P Programmable Clock. **£345.00**

LA 11-PD Matrix Printer complete with Unibus Controller **£1500.00**

MF11L 8KW Parity Core including 9-slot system unit. **£975.00**

MM11DP 16KW core — brand new surplus — only **£875.00**

MM11LP 8KW Parity Core. . . **£750.00**

PDP 11/40 Processor with 48KW parity core, KT 11D Memory Management, DL 11 Asynchronous interface and 6ft cabinet. **£5250.00.**

PDP 11/04-MD 9-slot 5¼" Processor with 28KW Core and DL11W Interface. BRAND NEW SURPLUS. **£4500.00**

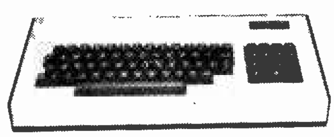
PDP8E Series Modules — large stocks of option modules, add-on core, CPU boards, etc. all at reduced prices.

HEWLETT PACKARD
9830A Programmable Calculator 8K memory, extended I/O Rom, string variables ROM, 4 peripheral interfaces (1 serial, 3 parallel).
PRICE £2750.00

NEW ASCII KEYBOARDS — NEW LOW PRICES

KB 771 Superb 71-station ASCII Keyboard incorporating separate numeric/cursor control pad and installed in custom-built steel enclosure with textured blue enamel finish Ideal for the VDU builder. Case dimensions 17¼" × 7½" × 3⅝" Total weight 4kg. PRICE **£89.50**

(mail order total £108 10).



		Mail Order Total
KB756 56-station ASCII Keyboard mounted on P.C.B.	£45.00	**£53.48**
KB756MF As above, fitted with metal mounting frame for extra rigidity	£49.50	**£58.65**
KB710 10-key numeric pad, supplied with connecting cable	£8.00	**£9.78**
KB701 Plastic enclosure for KG756 or KB756MF	£12.50	**£15.24**
KB702 Steel enclosure for KB756 or KB756MF	£18.00	**£23.00**
KB2376 Spare ROM Encoder	£12.50	**£15.24**
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DC-512 DC convertor to allow operation at 5V only (plugs in to P.C.B.)	£7.50	**£9.20**
DB25S Mating connector for KB771	£4.25	**£5.46**
PERK 56-station ASCII Keyboard for PET Complete with PET interface, built-in power supply and steel enclosure	£145.00	**£172.50**

Discounts available for quantities

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BALL MIRATEL 9" Monitor with case including space for keyboard **£95.00**

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NOW AVAILABLE further large stocks of the popular Hazeltine H1000 and H2000 VDUs.

H1000 (from) **£225.00**
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Electronic
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A.C. Voltmeter 400E	£225
A.C. Voltmeter 400F	£195
A.C. Voltmeter 400EL	£225
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Valve Voltmeter TF 2604	£250
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HEWLETT PACKARD	
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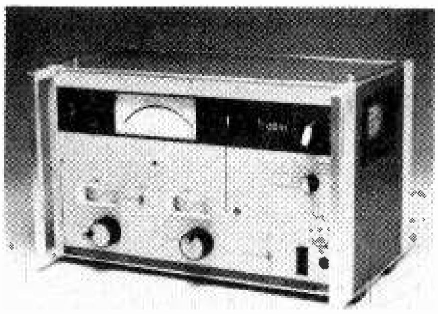
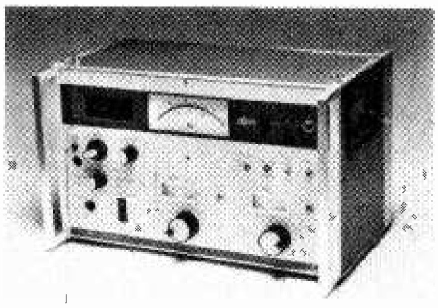


LEVEL OSCILLATOR W2007



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Carrier-Frequency Level Test Set.
6KHz-18.6MHz.
W2007 + D2007 **£1750**

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Autoranging D.M.M. PM 2527	£400
SCHLUMBERGER	
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Microprocessor D.M.M. 7065	£1150
As above with processor option	£1450
Microprocessor D.M.M. 7055	£975
As above with processor option	£1300

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250MHz Multifunction Counter 1911A-01	£380
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Counter Timer 1953A opt. 15 & 16	£850
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1GHz Timer Counter PM 6615	£695
80MHz Universal Counter PM 6611/02	£350
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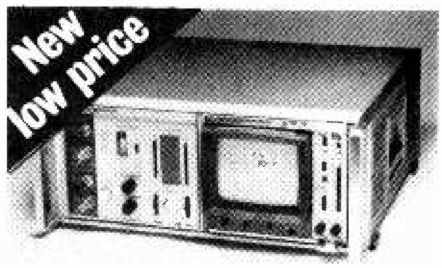
4 Track. DC to 20KHz, 7 Speeds,
4 or 14 Channels **£1950**



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8407A + 8412A (110MHz) **£2500**

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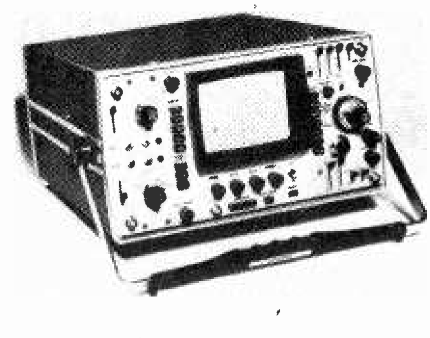
1707B Scope. 75MHz Dual Trace and Sweep Delay **£925**



COSSOR
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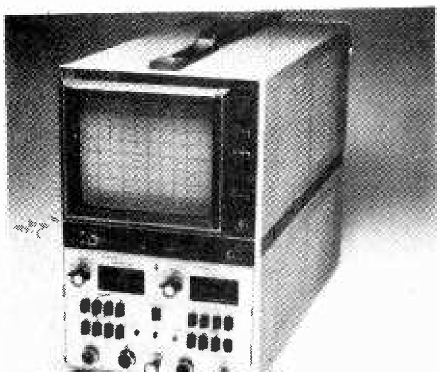

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15MHz to 18GHz **£2500**

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with PUNCH & READER. Upper case ASCII with V24 Interface. 240 volt operation.

£125 each

INFRA RED IMAGE CONVERTER type 9606 (CV 144)

1¾" diameter. Requires single low current 3KV to 6KV supply. Individually boxed. With data

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200 Steps — 20-oz/in. torque. 12/24 volt input 4-wire.
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Size 3x2½x2" high with 12 Alma Reed Switches. Blue keys marked in green 0-9 and a star with one blank.
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24V invertor version
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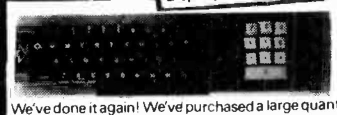

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During the last year we have sold professional broadcast television equipment and systems to more than 90 organisations in 20 countries. Now further planned expansion of both our domestic and international markets has created the following vacancies:-

Regional Sales Managers

Although we have now recruited Regional Sales Managers for Africa, the Middle East and Eastern Europe, we still have vacancies for similar posts in other parts of our market area, in particular North and South Europe.

The successful applicants for these positions will be qualified television engineers with several years' experience in sales, marketing and other relevant commercial activities.

Extensive travel will be necessary and a knowledge of at least one European language apart from English is desirable. These positions offer the opportunity for substantial career development as part of a talented and highly motivated team.

Manager Audio Department

Reporting to the General Manager, Sales, the successful applicant will be responsible for giving product planning advice to the various international design groups. Qualifications to degree level or equivalent in electronics or a related discipline and several years' experience in the development of professional audio products are desirable. Experience in digital audio processing would be a great advantage.

Travel to Japan and Europe for product briefing and technical support would be necessary.

Lecturer

The successful candidate would conduct theoretical and practical training courses on our major products, be able to write circuit descriptions and produce training manuals with lucid block diagrams.

Ideally, candidates should have in-depth experience of video tape recording, digital circuitry and a practical up-to-date knowledge of the broadcast industry, especially measurement techniques, plus an ability to present ideas clearly and answer the most difficult and unexpected technical questions. Knowledge, or an ability to master the techniques of video cameras, digital audio equipment and the application of microprocessors to broadcast equipment will be an advantage, although we are prepared to provide the necessary additional training. Promising young graduates will be considered.

Assistant Product Managers and Product Engineers

We have vacancies for Assistant Product Managers and Product Engineers in each of our four equipment groups; TBC and Editing Systems, Cameras, 1 inch VTR's and U-matic VTR's.

Candidates for the Assistant Manager posts will ideally be Graduate engineers with some years of experience in video technology, whereas as applicants for the Product Engineers vacancies will probably be less experienced. However, at both levels, we are willing to consider the right kind of experience in lieu of formal qualifications.

Successful candidates will receive suitable in-house training to enable them to provide technical product support both within Sony Broadcast and externally to customers.

Marketing Promotions Manager

The successful candidate will be responsible for formulating and implementing all aspects of corporate and product image. In particular, this will include mounting effective product advertising campaigns, organising Sony Broadcast's presence at major international exhibitions, preparing product literature and press liaison.

The post will also involve collaboration with other Sony companies in jointly promoting broadcast equipment products throughout the market area.

Candidates will need to demonstrate a sound knowledge of the broadcast industry, a keen organisational ability, initiative and a degree of artistic flair.

Sales Engineers

We require competent engineers who are experienced in video cameras and/or VTR's to supplement our sales force. A considerable amount of travel overseas and in the UK will be involved. Experience in selling would be an advantage, but the main requirements are a pleasant personality, dedication and ability.

Senior Proposals Engineer

Reporting to the General Manager, Marketing, the successful applicant will have a technical background, preferably in the broadcast industry, and be able to demonstrate an overall systems capability. He/she will enjoy working with the minimum of supervision and will function happily under pressure.

The work will include the making and assessment of technical proposals to meet specific customer requirements, and will hence require an understanding of Contract Law. A knowledge of foreign languages would prove useful, though not essential.

Service Engineers

Two openings exist, one at a more senior level, for engineers with broadcast television engineering experience in operations and maintenance.

The positions will entail responsibility for the repair and test of sophisticated broadcast television equipment, together with minor development work. Some travel will be necessary.

Candidates for the senior appointment should preferably be qualified to HNC, or equivalent in a related discipline, and be conversant with modern digital techniques.

The second position should appeal to engineers with limited appropriate experience now seeking a progressive environment in which to broaden their knowledge.

Q.A. Engineers

Candidates should be experienced in the repair of modern television equipment and also be familiar with digital circuitry.

Activities will include the testing and commissioning of advanced broadcast television equipment for which occasional travel may be required. A relevant HNC level qualification is desirable.

All these posts carry excellent salaries and fringe benefits normally associated with a large international company, in some cases a motor car and relocation expenses where appropriate. The above appointments are open to both male and female applicants.

Write in strict confidence to Barry White, Personnel Manager giving full details of qualifications, experience and present salary.

SONY® Broadcast

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom

(456)

Radio Telecommunications Engineers

£6,500 TO £8,500

An international company, involved in the provision of sophisticated communications systems, is able to offer stimulating careers to engineers in the United Kingdom in our Telecommunications Division.

Are you experienced in the installation and testing of broadband radio link and associated equipment, and/or have you spent time in a planning/estimating office? We are looking for:

INSTALLATION PLANNING ENGINEERS

To translate systems design concepts into detailed practical terms, to produce drawings, charts and schedules of equipment installation and testing instructions to brief the field engineer.

INSTALLATION ENGINEERS

UK-based field engineers to manage the installation and commissioning of telecommunications systems overseas or in UK. You would be working as a member, or take charge of, a team translating the efforts of the planning engineer into working systems.

Applications are invited from engineers with several years' relevant experience, three of which have been in a supervisory capacity. Academic qualifications are an advantage.

Salaries are negotiable and dependent upon experience and qualifications. Overseas travel is necessary, and excellent allowances are paid for such duties.

Benefits include 4 weeks' holiday plus bonus, relocation expenses where appropriate and a pension and life assurance scheme, restaurant, social club and free car park being some of the amenities.

To apply phone or write quoting ref. K/174 to Sue Dillon, IAL, Aeradio House, Hayes Road, Southall, Middx. Tel: 01-574 5134.

IAL THE HIGH TECHNOLOGY TASK FORCE
COMMUNICATIONS SYSTEMS
COMPUTER SYSTEMS AND SERVICES
AVIATION SYSTEMS AND SERVICES - WORLDWIDE

1976

(453)

UNIVERSITY OF LIVERPOOL

INSTITUTE OF CHILD HEALTH ALDER HEY CHILDREN'S HOSPITAL

TECHNICIAN

(Grade 5)

To assist with research. Work includes assistance with design and development of medical electronics instruments and operating the Institute's digital computer. Applicants must possess ONC or equivalent as minimum qualification and be experienced in fault diagnosis and use of digital and analogue integrated circuits. Knowledge of programming an advantage. Salary in a range £4,257-£4,974 p.a.

Application forms may be obtained from The Registrar, The University, P.O. Box 147, Liverpool, L69 3BX. Quote Ref: RV/446/WW. (458)

NATIONAL HEART AND CHEST HOSPITALS, Brompton Hospital. Medical Electronics Technician required to undertake work involving maintaining, installing and developing medical electronics equipment. Applicants should have a good general knowledge of electronics. Previous hospital experience not essential. Salary, which will depend on experience, will be within the range £4,280-£6,350 inclusive, with a pay rise pending. Further information available from the Physicist in Charge, Mr R. B. Logan-Sinclair, tel 01-352-8121, ext 4252. Application forms available from Miss J. A. Jenks, Personnel Manager, Brompton Hospital, Fulham Road, London SW3 6HP, tel as above, ext 4357. (421

LONDON BOROUGH OF NEWHAM. East Ham College of Technology, High Street South, London E6 4ER. Principal: K. R. Bishop, B.Sc. (Econ.) FRSA, Department of Electrical & Electronic Engineering. Technician Grade T2 required to be responsible for both the Elementary and Advanced Electronic laboratories. Relevant theoretical and practical experience in electronics essential. Ability to service test gear an advantage. Salary: £4,380-£4,620 p.a. inclusive. Application forms may be obtained by writing to the College Administrative Officer enclosing an addressed envelope. Completed forms should be returned within 14 days of the appearance of this advertisement. (440)

ONE IN A MILLION?

Among the million or so leaving school or university this year there is a chance that one — perhaps two — is destined to make a significant development in audio.

That person's first decision might well be to join QUAD in Huntingdon. At school, he or she will have realised that amplifier design is not just a matter of having a listen or a fiddle with standard circuits and their variations. Later will have come an adolescent stage of great discoveries. "Increase the rise time to eliminate TIM". "Regulate the power supply for better imaging".

Following on from such childish things will have come an ability to distinguish between the characteristic impedance of the medium and the third row of the dress circle and between peak flux density and the rather gooey substance fed by spoon to small children. He or she will, nevertheless, be sufficiently down to earth to know that one newton is about the weight of the average apple.

1 in 10^6?

Well, drop us a line anyway.

Mr. P. J. Walker

THE ACOUSTICAL MANUFACTURING COMPANY LIMITED

30 St. Peters Road, Huntingdon, Cambs. PE18 7DB

(403)

ELECTRONIC NEWS GATHERING

A Major Overseas Television News Organisation based in London has a vacancy for a Suitably Qualified Assistant to work with a Senior Cameraman covering Worldwide News Events.

ESSENTIAL QUALIFICATIONS

A good understanding of the principles involved in Electronic Picture Generation and Recording, together with a proven background in "NEWS" or similar operations. The ability to work with a small team under pressure.

CONDITIONS OF SERVICE

GOOD SALARY with excellent employee benefits including non-contributory pension scheme. London-based with a considerable element of foreign travel.

Please reply to Box No. WW380

(380)

Electronic Engineers

Important new projects in the defence field have created a number of interesting vacancies for engineers in our laboratories at Bracknell.

You could work at the forefront of new technology on equipment for combat aircraft, helicopters, tanks and other applications if you have experience in:—

* Digital and/or analogue circuit design
* Real-Time microcomputer control
* Microwave techniques in the short centimetric wavelengths
* Flight control

We would particularly like to hear from engineers with a working knowledge of MSI, LSI and CMOS circuits design.

Vacancies are open to male or female applicants at all levels, some to form the nucleus groups being set up to meet the challenge of developing entirely new equipment.

We also have vacancies for graduate engineers seeking their first appointment this year.

We believe that we can offer exceptional opportunities for you to exercise your technical skills in an unusually attractive working environment. The laboratories are situated within Lily Hill Park in surroundings well suited to research and development.

Bracknell is in rural Berkshire and offers an extensive range of housing and facilities in and around the new town. Relocation assistance will be provided where appropriate.

Please write giving brief details, or asking for an application form, to Mrs Josie Hunt, Ferranti Instrumentation Limited, Aircraft Equipment Department, Lily Hill House, Bracknell, Berkshire. Telephone: Bracknell 24001. Please quote reference number A/236/WW.

FERRANTI

Selling technology

468

RADAR DISPLAYS EXPERIENCE?

There's at least £16,500 tax free on the screen for you

Sophisticated modern radar systems form one part of Lockheed's involvement in Saudi Arabia and one of Lockheed's most important maintenance functions is to make sure that all the displays and associated interface equipment is working at peak efficiency all the time.

If you're formally qualified in radar displays, that experience could earn you a key place in one of Lockheed's maintenance teams – and at least £16,500 tax-free over the next two years.

In addition, you'd enjoy the full Lockheed benefits package – free food, laundry and bachelor accommodation, free medical care and life insurance, excellent recreational facilities, three paid leave periods a year with free flights home together with local leave.

To join Lockheed, you'll need at least three years' experience in radar display systems which use both CRT digital, and scanning displays. If you have some knowledge of radar transmitter/receiver and signal processing equipment, that's a big advantage.

If you'd like more information on working in Saudi Arabia with Lockheed, drop a line, giving brief career details, to the Senior Recruitment Executive (Lockheed), IAL, Personnel Consultancy, Aeradio House, Hayes Road, Middlesex. Or phone him on 01-574 5000. Please quote ref. L164

(346)

IAL LOCKHEED INTERNATIONAL

ROYAL NATIONAL INSTITUTE FOR THE BLIND

ELECTRONICS ENGINEER

Circa £7000+ p.a. (review July)

This post is for a practical, creative man or woman, genuinely interested in keeping abreast of rapid development in electronics with a lively appreciation of their application rather than high academic qualifications. You should have had experience in semi-conductor technology in order to design and construct prototype aids for use by blind people, to initiate projects in external research establishments and manufacturing concerns, and to maintain familiarity with international research in this specialised field of work. Ability to provide accurate verbal and written reports essential. Staff receive free lunch in our own restaurant, and there is an excellent RNIB Pension Scheme with transferability. Applications giving full c.v. including present post and salary to: Personnel Officer, RNIB, 224 Great Portland Street, London W1N 6AA.

B(423)

UNIVERSITY COLLEGE CARDIFF

Applications are invited for the post of

TECHNICIAN

(Grade 5)

in the

FACULTY OF SCIENCE

Applicants should possess an HNC or equivalent and have a good knowledge of analog and digital techniques, experience with microprocessor controlled instruments and interface would be an advantage. Salary range £4257-£4974 p.a. Duties to commence as soon as possible.

Application, together with the names and and addresses of two referees, should be forwarded to the Vice-Principal (Administration) and Registrar, University College, P.O. Box 78, Cardiff, CF1 1XL. Closing date: June 30, 1980. Reference 2052. (1492)

TRENT POLYTECHNIC

LECTURER GRADE II/SENIOR LECTURER IN ELECTRICAL/ ELECTRONIC ENGINEERING

Candidates should preferably possess teaching and/or industrial experience. Research experience and a continuing interest in research work are preferable requirements for the post. Some knowledge of the application of computing to electrical engineering desirable.

Salary: £5229-£9822 (salary award pending).

Further details and form of application from The Assistant Director (Administration), Trent Polytechnic, Burton Street, Nottingham, NG1 4BU. Forms to be returned as soon as possible. (448)

INNER LONDON EDUCATION AUTHORITY

Learning Materials Service, Television Centre, Thackery Road, London SW8 3TB

The Television Centre produces a range of educational programmes distributed in the form of 16mm film, videocassettes and sound cassettes. The sound section of five members works with professional equipment (Neve, Studer, Sandor ITC etc.) to provide an audio component of high standard.

Vacancies exist for

(1) HEAD OF SOUND (ST4)

To lead the section and also to mix and process many of the programmes. He/she will be responsible for training new staff, and with the chief engineer and others will also undertake responsibility for the equipment and for its purchase and maintenance.
Applicants should have suitable theoretical qualifications, with at least 10 years of relevant experience at senior level. A good working knowledge of all sound operations associated with television and film is essential.
Salary is within the scale £7 901 64 to £8,375 64 (this is under review from July 1980)

(2) SOUND ASSISTANT (ST2)

The work is largely film recording using the Nagra, but with periods of studio duty (rigging, boom operation, tape and grams etc). Working hours are based on a flexible 35-hour week exclusive of meal times. Travel to locations is involved. Occasional overnight stops are required.
Although applicants should have a thorough knowledge of sound techniques in a film and television environment, consideration will be given to those who are willing to learn, have appropriate technical qualifications, and experience elsewhere in the sound recording field.
Salary is within the scale £6,170 64 to £6,896.64 (this is under review from July 1980)

Further information and application forms from EO Estab 1C, Room 365 The County Hall, London SE1 7PB. Telephone 01 633 7456 8848

Closing date 14 days after the appearance of this advert

(463)

CAMBRIDGE AREA HEALTH AUTHORITY (TEACHING)

AUDIO VISUAL ENGINEERING TECHNICIAN

(Medical Physics Technician III)

An experienced technician is required to provide engineering and technical support to a wide range of audio-visual equipment in the Cambridge Health District and the Cambridge University School of Clinical Medicine.

The successful applicant will have experience in the service of colour and black and white CCTV systems, including cameras and VCRs and be competent to support a wide range of AV equipment. Applicants must be able to work without supervision and should, for preference, have an appropriate HNC or equivalent qualification.

Salary scale £4605-£5952.

Further information, application forms and job description available from:

P. E. Ward
Medical Physics Department
ADDENBROOKE'S HOSPITAL
Hills Road, Cambridge, CB2 2QQ
Telephone: 0223-45151, Ext. 606

(457)

VIDEO ENGINEERS DUPLICATE SHOWBIZ FOR TOP MONEY

Europe's largest distributor of pre-recorded video entertainment programmes require top-class operators for our multi-format video cassette duplicator facility located in West London. Must have experience with ½'', ¾'' and 1'' C format systems. Front line maintenance experience an advantage.

Shift working.

Please write or telephone **Richard Lees, Technical Manager, Intervision Video Limited, 102 Holland Park Avenue, London, W.11. Telephone (01) 727 1453.**

UNIVERSITY OF LIVERPOOL
DEPARTMENT OF MECHANICAL ENGINEERING

SENIOR EXPERIMENTAL OFFICER

Newly created post concerned with measurement and instrumentation problems in broad area of Stress —Analysis and Vibrations of engineering structures and components. Applicants should possess degree or equivalent qualification (e.g. Chartered Engineer Status) in Engineering or Physics and minimum five years' relevant experience with reasonable vareity of recording instruments, transducers, etc. Candidates with less experience may be considered initially for appointment as Experimental Officer.

Salary in the range S.E.O. (£5052-£8769) or E.O. (£4402-£7410), depending on qualifications and experience.

Application forms available from the: **Registrar, The University, P.O. Box 147, Liverpool L69 3BX.** Quote Ref. RV/414/WW.

(398)

DIGITAL EXPERIENCE?

FIELD, SUPPORT AND PRODUCTION. VACANCIES IN COMPUTERS, NC, COMMS, MEDICAL, VIDEO, ETC.

For free registration ring
01-464 7714, ext. 502

LOGEX

ELECTRONICS RECRUITMENT SERVICE
309 HIGH ROAD, LOUGHTON, ESSEX. IG10 1TD
01-502 1589/0937 01-464 7714 EXT. 402 (321)

Broadcast Transmission Engineers

Through our network of Transmitting Stations, the IBA is responsible for the transmission of all Independent Television and Local Radio services throughout the United Kingdom. Vacancies now exist for Shift Engineers to be employed in the operation and maintenance of high power UHF television transmitters, transposers and MF, VHF radio transmitters.

The successful applicants will be required to carry out monitoring duties, performance test measurements and preventive and corrective maintenance on all transmitting station equipment. This will include scheduled and emergency mobile maintenance work at unattended stations. Some weekend and evening work will be required.

Candidates should be qualified to HNC (or equivalent) level in Electrical or Electronic Engineering and have at least three years experience with broadcasting equipment. A valid, full driving licence is essential.

Starting salary will be within the range £5,880-£7,280 with provision for movement, subject to qualifications and experience, onto a higher range rising to £8,202. Salaries will be reviewed on 1st July 1980.

Employment benefits include free Life Assurance and Personal Accident Scheme, a Contributory Pension Scheme, generous relocation expenses and subsidised mortgage facilities.

IBA INDEPENDENT BROADCASTING AUTHORITY

If you are interested in the above, please write or telephone for an application form to: Personnel Officer – Engineering Regions, IBA, Crawley Court, Winchester, Hants. SO21 2QA. Tel: Winchester 822273.

Sales Engineer
For the industry of the future

Few would deny that semiconductor technology is the industry of the future. And now your mixture of technical knowledge and commercial flair could put you firmly in that future as Internal Sales Engineer with RCA's talented sales and marketing team.

Based at Sunbury, you will be advising our many customers on the varied uses of RCA integrated circuits and power devices. You will also provide assistance to field sales engineers in maintaining important commercial customer contact.

The salary will reflect the status which we attach to our salesmen and women, and there will be good early promotion prospects plus all the benefits of an internationally successful corporation.

If you're ready for the industry of the future, call Nick Blake, our Sales Manager, on Sunbury-on-Thames 85511. Or write to the Personnel Department, RCA Limited, Lincoln Way, Windmill Road, Sunbury-on-Thames. (449)

RCA Solid State

ELECTRONIC MARINE SYSTEMS FIELD ENGINEERS

Hunting Surveys & Consultants Limited requires Electronic Engineers to work on both theoretical and practical aspects of a variety of instrumentation systems associated with Marine Surveys.

They must be qualified to at least HNC with emphasis on modern digital circuitry, but having also a broader electronics background. Some software experience would be advantageous.

Applicants will need to be physically fit and must be prepared to undertake periods of operational work in the North Sea and Overseas.

Applications to

**The Personnel Manager,
Hunting Surveys
& Consultants Limited,
Elstree Way, Borehamwood,
Herts, WD6 1SB.**

(363)

PROTOTYPE WIREPERSON

to build analogue and digital automatic test equipment and prototype PCBs. We design and make intrinsically safe instrumentation for the petrochemical and allied industries and need someone with a good knowledge of electrical, electronic and mechanical engineering practice plus the ability to work from engineering drawings and sketches.

Salary range **£5,000-£5,700,** depending on age and experience

Apply to Janet Hutcheon

**Measurement Technology Ltd.
Power Court, Luton, Beds.
Tel. 0582 23633**

(390)

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.

Registered disabled people may be considered.

Pay scales for Radio technicians start at £4640 per annum, rising to £6525, 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

(9483)

ELECTRONIC SERVICE ENGINEER

ATTRACTIVE SALARY
EARNINGS RELATED BONUS
VEHICLE

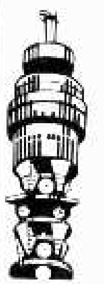
In order to maintain our current growth rate we urgently need an additional Service Engineer.

Lee Engineering market high technology equipment employing digital and analogue technique and for the vacancy a Service Engineer with broadbased practical experience and initiative is required. The positions will be primarily based at Walton-on-Thames but periodic service visits to customers is envisaged.

Please apply, by phone or in writing, to:

C. E. Welsh
LEE ENGINEERING LIMITED
Napier House, Bridge Street
Walton-on-Thames, Surrey KT12 1AP
Tel: Walton-on-Thames 43124/5/6

(368)



CAPITAL
APPOINTMENTS LTD

CAPITAL HOUSE
29-30 WINDMILL STREET
LONDON W1P 1HG
TEL: 01-637 5551

THE UK's No. 1 ELECTRONICS AGENCY

Design, Dev and Test to £9,000
Ask for Brian Cornwell

SALES to £12,000 plus car
Ask for Ken Sykes

FIELD SERVICE to £8,000 plus car
Ask for Maurice Wayne

We have vacancies in ALL AREAS of the UK

Telephone: 01-637 5551 (3 lines)

(291)

SENIOR R.F. DEVELOPMENT ENGINEER

UP TO £9000 P.A. **NORTH KENT**

Our client, a well-known electronics manufacturer, requires a Senior Development Engineer to participate in, and to co-ordinate, the development of a new generation of two-way radio equipment right through from specification to production stage.

Age is not important and some 'trade-off' between qualifications and experience is acceptable but, for guidance, the ideal candidate will have:

A degree, or equivalent, in electronic engineering or a related discipline.

A minimum of 5 years experience in R.F. design.

A thorough working knowledge of contemporary techniques in circuit design from audio through to U.H.F. plus an understanding of digital techniques.

Sufficient familiarity with manufacturing methods to appreciate the effects of design philosophy on ease of production, test and service.

The company, which was established nearly sixty years ago, is situated in North Kent and is within easy reach of London, the countryside and the coast. Career prospects are excellent. Additional benefits include a first class pension scheme and, where necessary, assistance with relocation.

All applications will be treated in the strictest confidence and will be acknowledged immediately.

Apply in writing or telephone for an application form (you are welcome to reverse the charge) to:

TJB

RONALD C. SLATER
TJB ELECTROTECHNICAL PERSONNEL SERVICES
12 MOUNT EPHRAIM, TUNBRIDGE WELLS, KENT TN4 8AS
TELEPHONE TUNBRIDGE WELLS (0892) 39388

469

SOUTHERN ELECTRICITY

Littlewick Green, Maidenhead

SECOND ENGINEER (TELECOMMUNICATIONS)

CHIEF ENGINEER'S DEPARTMENT
HEAD OFFICE
Salary within the range £8,231-£10,846 per annum

Applications are invited for the above post in the Technical Services Section of the Chief Engineer's Department.

The successful applicant will be part of a team engaged in the design, commissioning, and subsequent maintenance of telecommunications systems throughout the Southern Electricity Board, and must be able to spend periods away from Head Office when carrying out these duties.

Schemes in progress include telecontrol, data communications, medium capacity microwave links, multi-channel line circuits and radio and line telephony systems. Applicants should have had experience in some of this work and preferably be in possession of suitable technical qualifications.

The successful candidate will be required to drive a motor vehicle which may be either a private car or a Board owned car.

Relocation assistance will be provided in appropriate circumstances.

Applications on forms obtainable from the Secretary, Southern Electricity, Southern Electricity House, Littlewick Green, Maidenhead, Berkshire SL6 3QB and returned to him quoting 31/80 by not later than July 4, 1980.

(436)

AMPEX

World leader in Magnetic Recording, seeks

ENGINEERS

to join small teams responsible for designing and producing Mobile and Studio Broadcasting Television Systems in an expanding international market.

The key requirement is to demonstrate experience and achievement in the design of Television Systems. A valuable additional qualification would be a degree or HNC in electronics or a related discipline.

Good Salary, Pension, Life Assurance and Permanent Health Schemes. Staff Restaurant.

Please write or phone for an application form from Clive Legg or Maureen Brake, Reading (0734) 85200, Ampex Great Britain Limited, Acre Road, Reading.

(466)

Sultanate of Oman

TELEVISION ENGINEERING VACANCIES

Due to expansion of the service, several vacancies have arisen and applications are invited from suitably qualified persons.

Those applying for the Engineering vacancies should have full C and G certificates, dip. Tech. or HNC and not less than six years' relevant experience. In most cases a knowledge of Arabic — although not essential — would be useful.

Contracts of employment will be for two years in the first instance and renewable for one year at a time by mutual agreement.
Married accommodation is provided together with free air passage at beginning and end of contract for family. Air tickets are also provided for leave after the first year of service.
Applicants should state age, nationality, qualifications and full details of experience.

TRANSMITTER ENGINEERS

For maintenance of high power VHF TV transmitters and low power UHF transposers. The work will involve travel and in some cases overnight stops away from base. The Transmitters operated within the Sultanate are manufactured by Siemens and Philips.

VTR ENGINEERS

For maintenance on Ampex VR 1200 B and Bosch Fernseh BCM40 machines. There will also be some operational work. In addition some planning and installation work is likely as during the forthcoming year it is intended that 1" VTR machines will be installed.

STUDIO ENGINEERS

For maintenance on cameras vision mixers, S.P.G.S., vision distribution systems, telecine machines and video monitors etc. There will also be operational work, particularly on outside broadcasts and some occasional planning and installation work during the course of the year.
The equipment employed are Philips LDK15 Cameras, Bosch Fernseh, Telecine by rank Cintel and Bosch Fernseh.

MAINTENANCE ENGINEERS

To maintain a wide range of high quality sound broadcasting equipment. Some planning and installation work will arise as new equipment is installed.

LIGHTING ELECTRICIAN

To carry out maintenance on TV studio and film lighting equipment including Dimmers, Luminaries, Batteries, etc. Some lighting work might be involved.

FILM CAMERA MECHANIC

To carry out maintenance on eclair and ARRI 16 MM cameras and other film equipment including Synchronisers, Steenbeck Editing Tables, Tripods, etc.
Applications should be sent to:

Director General of Radio and Television
Ministry of Information and Youth Affairs
P.O. Box 600, Muscat, Sultanate of Oman

(439)

REQUIRED: SENIOR AND JUNIOR SERVICE ENGINEERS

The senior engineer should have at least five years' experience of audio equipment and knowledge of A/V systems would be an advantage.

Excellent salary for the right person

Please contact

Mr. Roger Brown
Fraser-Peacock Associates Limited
94 High Street, Wimbledon Village
London SW19 5EG
Telephone: 01-947 7551

(355)

Customer Engineers Electronics

Register now — and let us help you in your search for a suitable job

CONNECTION PERSONNEL CONSULTANTS LIMITED

193 FLEET STREET LONDON E C 4 Tel 01-404 5858

Computer Maintenance Engineers

The Job covers the installation and maintenance of a wide range of computer equipment which includes:

* 3 large scale (B6800) computer systems and peripherals
* 4 medium scale (B1800) computer systems and peripherals
* 24 small scale (B90) computer systems and peripherals
* over 150 terminals linked to the above.

Qualifications should ideally be to Degree level but emphasis will be on ability.

Salary will not be a limiting factor in the selection of suitable candidates.

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.

All necessary training on mainframes and peripherals will form part of the successful candidates personal development.

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Further details and application forms from the **Personnel Officer, Brighton Polytechnic, Moulsecoomb, Brighton BN2 4AT. Telephone: Brighton 693655 Ext. 2536. Closing date: June 27th.**

(400)

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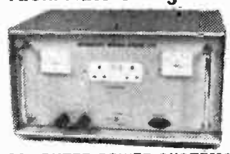

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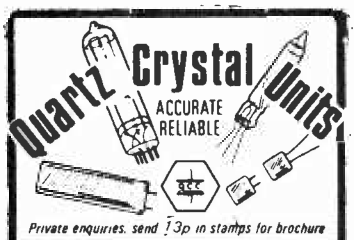

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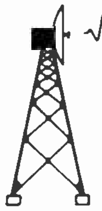

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