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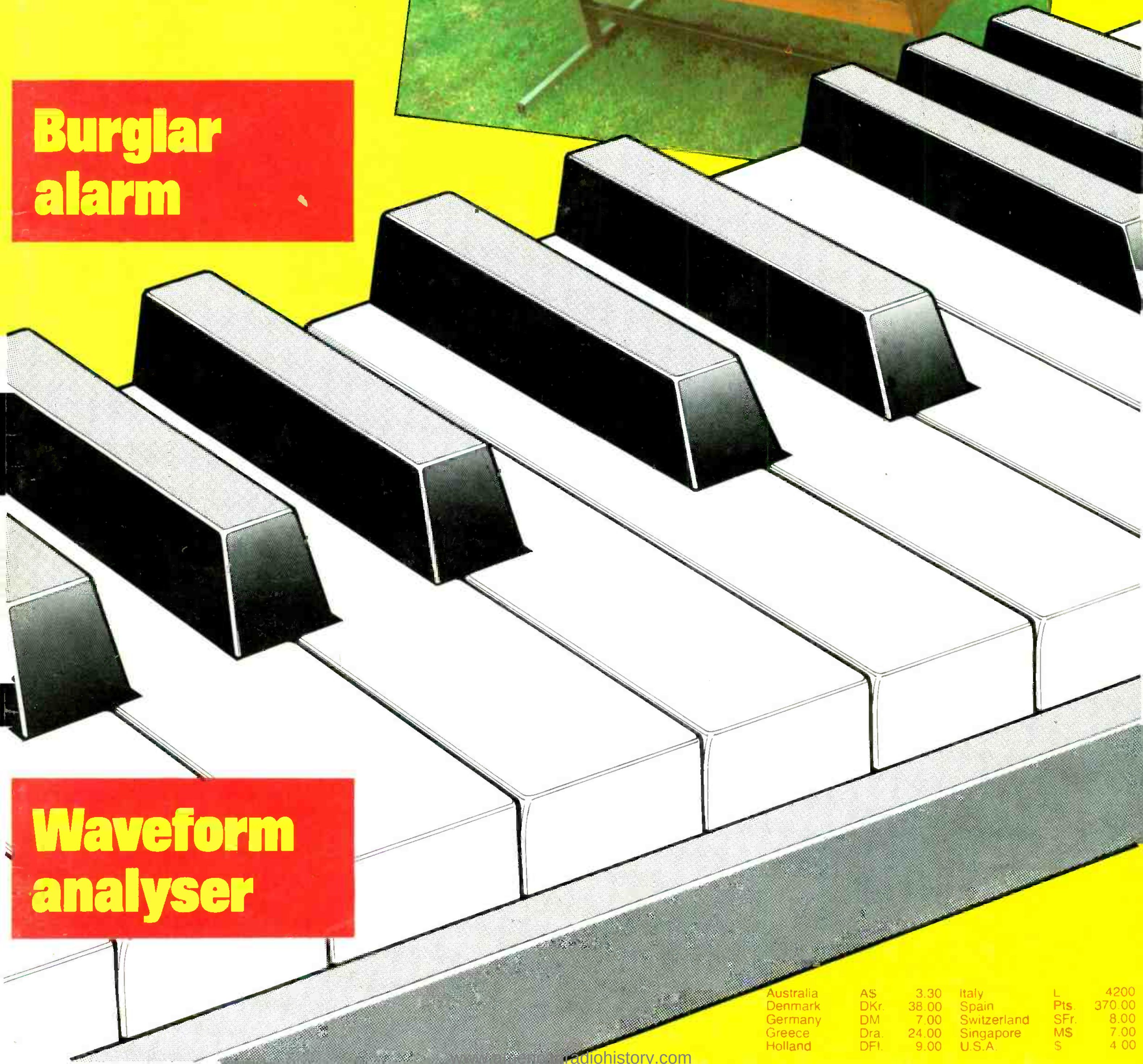

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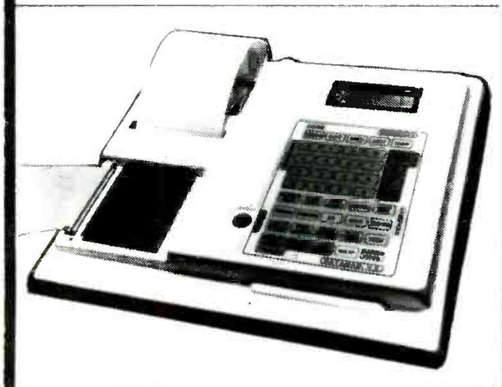

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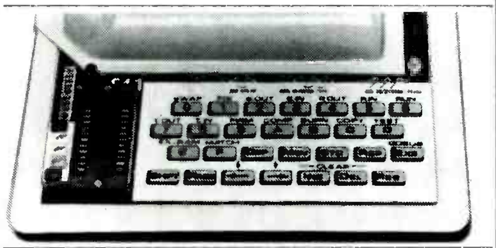

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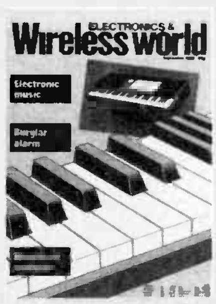

Front cover shows the digital, polyphonic keyboard, described on page 37. Cover design by Richard Newport.

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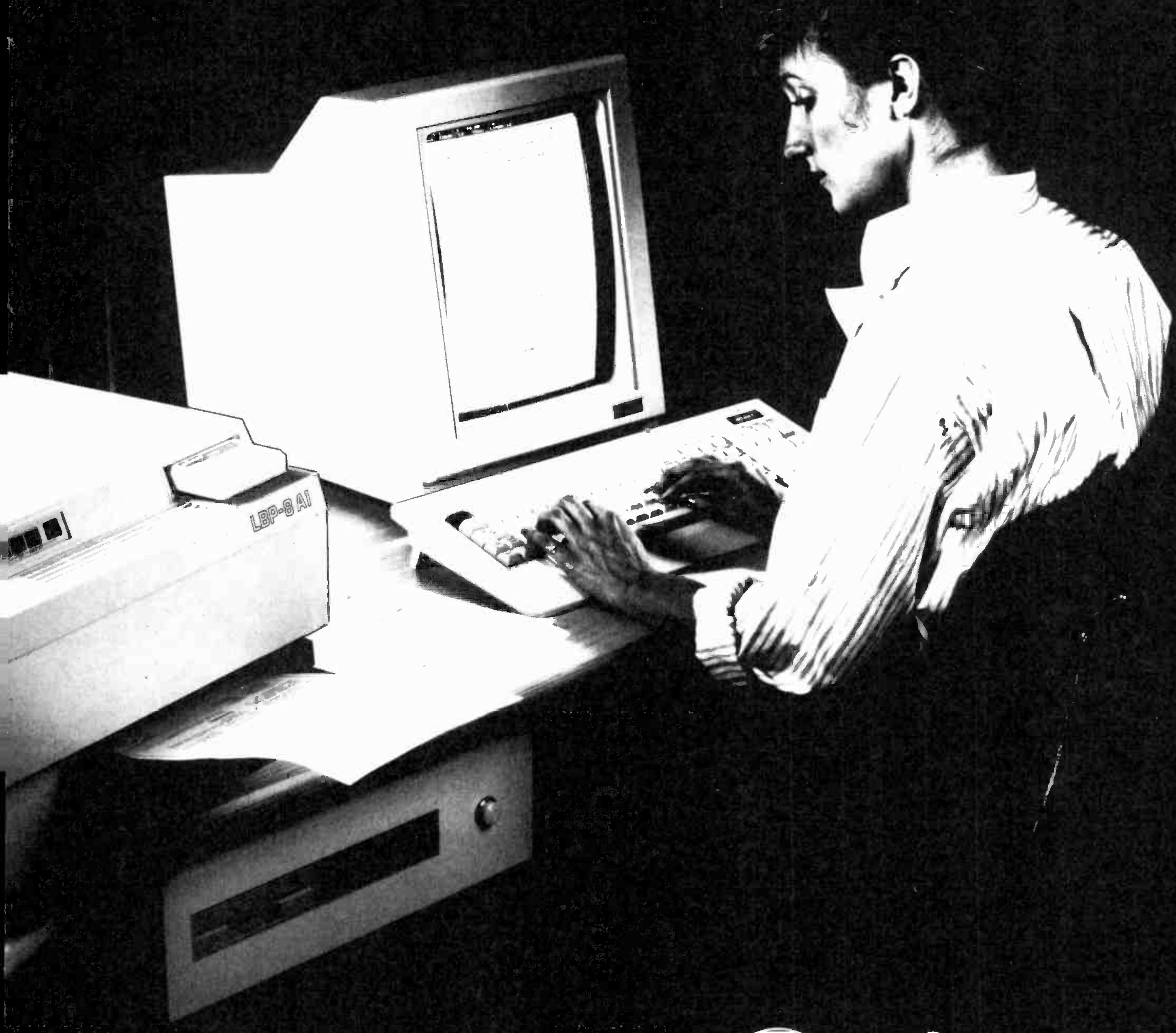

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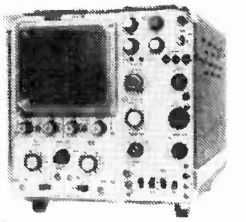

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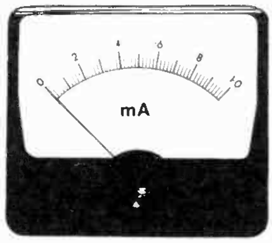

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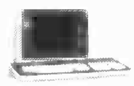

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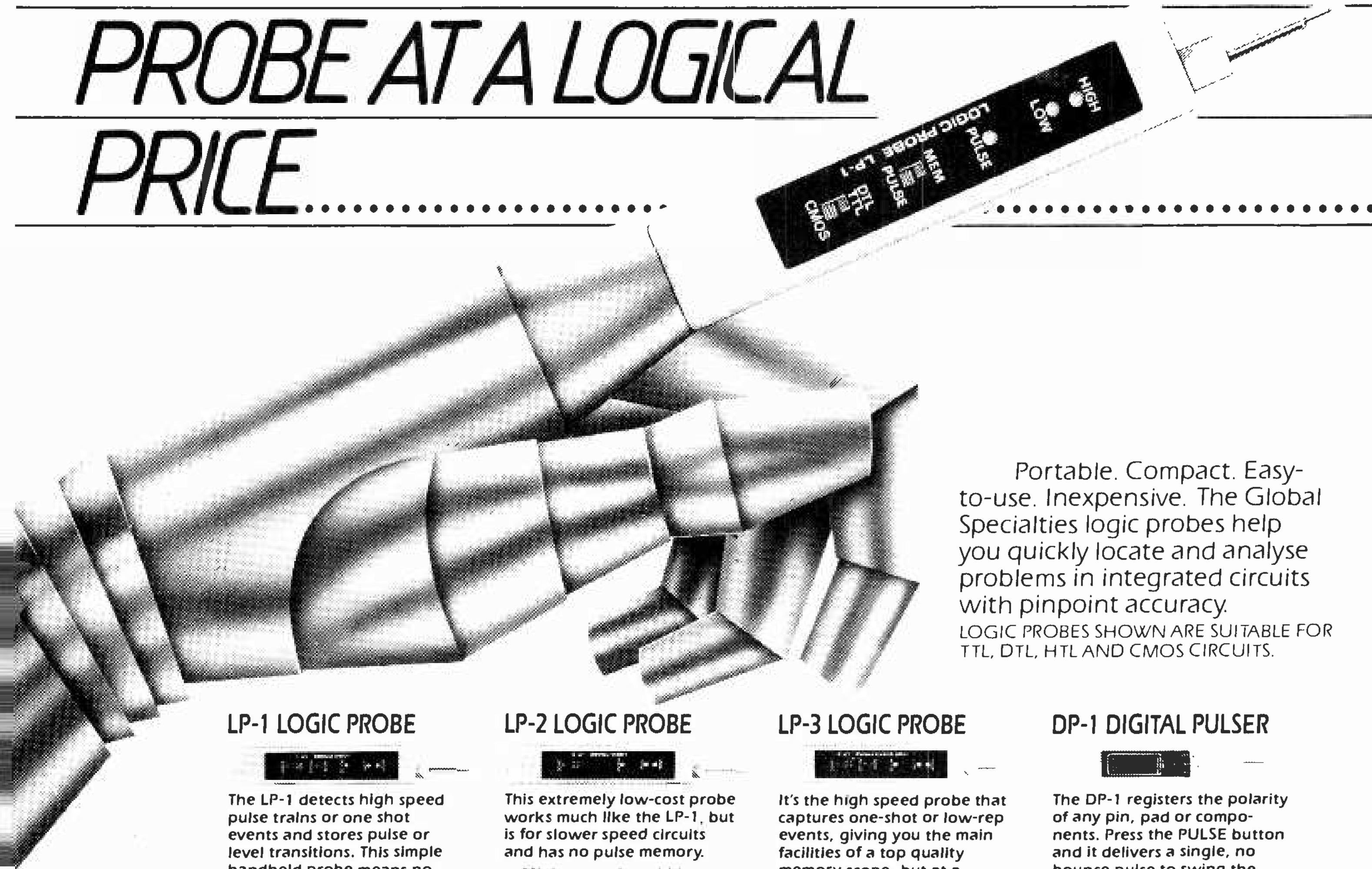

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Electronics, bread and games

If community radio is legalized in the UK, as seems likely, it will be a confirmation that electronic communications has something to offer even village-sized groups of people.

At the same time, electronic data communication is revolutionizing financial services like banking and stockbroking. As such it demonstrates its potential for any activity where quick decisions have to be made in response to rapidly updated information.

And now the electrical data sent via telecommunications systems is providing another kind of information beyond that of symbols written on v.d.us and printers — namely, video-conferencing over narrow-band links. Facial expressions, gestures and body-language are all meaningful components of human communication. The fact that video-conferencing is now commercially viable demonstrates the reality of the need for visual clues added to spoken words.
Undoubtedly this technology will help industry and commerce: it is a phenomenon of advanced capitalism — perhaps of the 'post-industrial' society so often discussed these days. A question worth considering, though, is whether it could also improve the quality of life in societies to which it is available. In particular, could modern data communications, with perhaps the addition of telemetry and telecontrol, allow more people to work either at home or very near their homes? This is not a luxury but an urgent social need in a rapidly industrializing world. Some big cities are rotting on the inside, some on the outside. Inner-city slums and outer-city shanty-towns are wretched places to live and bring up children. They are squalid, overcrowded, insanitary and violent. Yet people have actually migrated to them, in search of a better standard of living, because rural poverty was even harsher. This happened in Europe and North America in the 19th century and a similar process is occuring in Africa, Asia and Latin America in the present century. In some cities, like Calcutta, living conditions have become so bad that the migration is going into reverse, indicating a kind of equilibrium of rural and urban misery. With over a million people being added to the world's population every five days, this situation will not improve.

Slums, shanty-towns and the more salubrious but dreary suburbs all exist because workers have to live within reasonable distances of their places of work. If many work-places could be decentralized by the use of modern data communications, the wretchedness of urban poverty might be alleviated. In advanced industrialized countries the village could be rejuvenated. Instead of being virtually a dormitory suburb it could be once again a place for working as well as living. At one time economically based on rural crafts and industries, it would now support some inhabitants through the local 'mill' of a data communications station.

Who would pay for the extensive electronic systems needed? There would be considerable savings on the fuel at present wasted by daily commuting, and economies on health care, crime prevention, emergency services, urban land costs and big-city administration. People might even work better and hence more productively.

And the cities themselves would remain as centres of art and entertainment, learning and culture, sport and circuses, exhibitions, fairs and carnivals — in short, as places where people gather together because they want to, not because they have to.

Plasma etching at Harwell

Thought to be the key element in the manufacture of sub-micron integrated circuits, plasma etching is to be investigated at Harwell in an Alvey-backed programme. The system involves the selective removal of material by reaction with chemically active gases formed in a glow discharge.

Like all the Alvey projects, there is a close link between academic and industrial research and the process is to be studied using the latest laser and emission spectoscopy techniques by UKAEA at Harwell and by Oxford University. They will examine electrode materials, etching gas composition, resists and glow discharge characteristics. Special gases are to be provided by BOC Ltd, resists by Johnson Matthey Chemicals. Plama Technology Ltd. are to develop emmision spectroscopy techniques for monitoring and controlling the etchiing process and use the information to design new plasma etching machines. The major part of the work will be carried out in the Microelectronics Materials Centre of Harwell Laboratory.

BBC plans to save money

Thwarted in its attempt to get a much higher licence fee, the BBC has undertaken a 'fundamental re-examination' to provide the best service whilst staying within its income. The chief saving is to be made by "thorough reorganization and reduction of the central support services which, together with other economies, will permit a redeployment of resources and enhance the quality of programmes for listeners and viewers to network, regional and local services."

£6million more is to be spent on making BBC-1 an all-day service and cash for national and regional news and current affairs magazines is to be increased by 20%. Regional stations are to play a greater role in creating programmes for the networks, with some having their specialist areas strengthened. At present 20 hours of tv production a year is produced outside the BBC and it is planned that this be increased to 150 hours by 1988. Extra funds are also to be provided for tv drama.

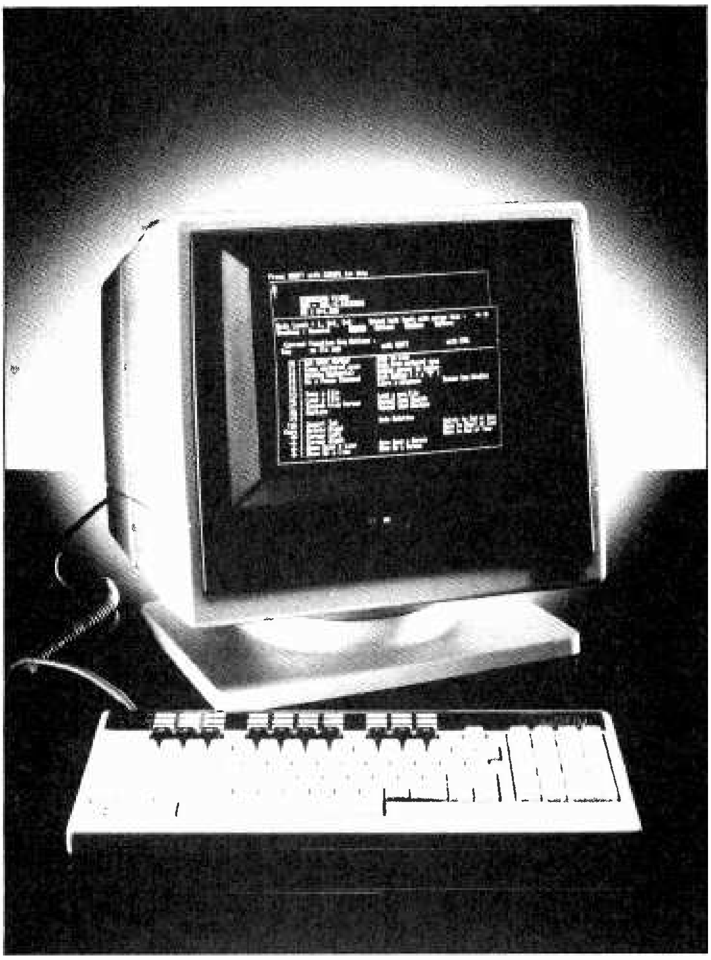
Radio services are looking urgently into providing a v.h.f. channel for Radio 1; the completion of the chain of local radio stations and the possible blending of Radio 2 with English local radio services, possibly sharing the schedules for evening programmes.

The principle source of saving is in cuts in permanent staff. The proposal is that there should be a ratio of 75:25 of permanent to contract staff, with 25% as a minimum for contract staff. Further savings are to be found in streamlining the administrative and support services, again a loss of jobs.

A comprehensive restructuring of the Schools and continuing education broadcast areas is proposed with the departments to be brought together on a single site as a unified multi-media group.

Output departments are to become more autonomous with the formerly central operations being devolved to them.

It was agreed amongst the Corporation's Board that the BBC should rely much more on standard equipment, rather than units made or modified to its special requirements. The design of equipment by the BBC will be reduced and its manufacturing facility will be closed. Studio planning, installation and architectural requirements will normally be carried out under external contract with a greatly reduced staff of BBC specialists acting as advisors. House and office services are to devolved to the specific departments that use them and all support areas such as catering, office cleaning, security and building amintenance may be contracted out if it is found to be economically advantageous. A target reduction of 10% is sought in secretarial and clerical effort. Out of a total of 25 000 staff it is though that a reduction of 4000 could be possible. Cuts are also planned in senior dining rooms, expence and hospitality costs. Travel and duty allowances are to frozen for the current licence period and canteen subsidies to be reduced.



The Acorn Cambridge Workstation, a 32-bit desktop computer with the power of a super-mini, it should help Acorn's financial recovery.

Acorn rescued again

Olivetti has bailed Acorn Computers out of financial trouble for a second time and now own nearly 80% of the company. Chris Curry and Herman Hauser, the co-founders of Acorn, remain on the Board. The new managing director is Canadian, Brian Long, who confesses that he knows little about computers. Alex Uboldi from Olivetti told us that their investment was chiefly in the Acorn R&D laboratories, which can add significantly to their pool of expertise.

Unix 4.2 programmes. Acorn claims that the software alone purchased for other workstations and mainframes would cost more than the whole workstation package.

In its simplest version at £1399 the workstation comes as a co-processor add-on for the BBC Micro, with 512KBytes of Ram. A complete 1MByte workstation without discs starts at £3595 and the top of the range is a 4MByte system for £7895 and that includes a 20Mbyte hard disc, a floppy disc and a high-resolution colour screen.

The workstation is fully compatible and can run any BBC micro application.

The announcements were made at the launching of a new product, the Cambridge Workstation which is a 32-bit computer designed for scientists and engineers.

Based around the 32016 processor, the computer is claimed to have the computational power of a super-mini computer such as the DEC VAX 11/750, and can run many mainframe applications. It comes packaged with Fortran 77, ISO Pascal, 'C', Cambridge Lisp and BBC Basic as well as 32000 Assembler. BCPL will become available soon and the operating system is Acorn's own PANOS which will also run

Weather satellite recovers

The recovery of the presumed dead NOAA-8 weather satellite will increase the odds for saving the lives of people whose planes have crashed or whose ships are in peril. The search and rescue (SARSAT) equipment on board the satellite will now be able to resume its operation of pickiing up distress signals from victims of aviation and navigational mishaps.

According to Gerald W. Longanecker, NASA's Meteorological Satellites Project Manager; "the restabilization of the satellite, which began tumbling out of control last June when an oscillation in the spacecraft's attitude control system failed, is now in full operation with the exception of one detector on an infrared radiometer that measures temperatures from the Earth's surface to 25 miles altitude. The instrument has three detectors, however, and the loss of one means only a minor loss of data."

The government/industry team of engineers reacted swiftly to stabilize the NOAA-8 satellite when a backup oscillator came back on line unexpectedly.

The satellite restabilization means that the search and rescue equipment will resume operations as part of an international program, begun in September 1983, which uses satellites to save the lives of people in downed airplanes or on ships in distress. Since the program began, nearly 400 lives have been saved. Principal participants in the international rescue program are Canada, France, the Soviet Union and the United States.

During the 11 months of NOAA-8 malfunction, three Soviet and one U.S. satellite have been circling the Earth picking up distress signals and relaying them to ground rescue stations.

The satellite recovery was the result of engineering teamwork aided by NASA and NOAA ground stations plus a French station at Lannion which provided data on the recovery as it developed.

Mobile radio on old tv Bands

The private mobile radio lobby has won the day, and will be granted the whole central section of Band III, made vacant by the demise of 405-line, black-and-white tv. The band will be used to establish private mobile radio on a nationwide basis.

Five small local networks are to licensed in London. Ten local networks in areas of greatest demand outside London will be allowed. There may be a limited degree of interconnection between the local networks and the PSTN. Other uses for the band are the business use of cordless telephones and the possibility of two-way mobile data systems is being investigated.

Only a limited number of frequencies have been allocated in Band I while other claims for use are being considered. The 50 to 50.5MHz band is to be set aside for amateur radio. 0.5MHz is allocated to on-site paging services. The 49.82 to 49.9MHz band will be used for low-power devices.

The same report was used to announce the extension of wide-area radio paging at 153 and 454MHz frequencies. British Telecom will not be allowed to apply for wide-area paging licences, in the interests of competition. Voice as well as tone and data is to be permitted on one of the 454MHz services.

In brief

Latest issue of *Which?* (July) includes a table listing portable colour tvs and monitors. Of the monitors listed — there are many ommissions — the Microvitec 1441 and the Novex 1416 are given as 'best' ratings, while the magazine identifies two tv/monitors as having 'best' picture quality and at the same time an adequate RGB rating — Philips 2007 and Grundig P40.

Cellular TACS could go

The full licences for the two cellular radio services, Vodaphone and Cellnet have been issued. There are a few differences between them and the draft licences issued last February: one addition allows the customer a choice in routing the calls over inter-connected public systems; another extends the obligation of both services to be useable with each other. Before erecting any new transmission masts, the licencees should investigate the possibilities of using existing masts or masts designed for joint use.

Tucked into Condition 37 of Schedule 1 is the provision for a mechanism to change the UK system from total access communication system (TACS) to European Community standards.

Cellnet has recently announced it 10,000th customer.

Electronic blue pencil

Apart from the headaches caused by hackers to electronic communications systems, there has been an increasing use of obscene words on bulletin boards and it is thought that this could offend. To the rescue comes Tim Clarkson, who has devised a naughty-words editor. This includes a glossary of all the forbidden words and automatically checks all messages. If an offensive word or phrase is encountered, the message is put into abeyance and may then be re-checked by an operator. The operation of the system is quite complicated as many rude words occur quite harmlessly within other words or phrases. So the glossary must include permitted contexts for the words as well as exclusions. The system is to be tried out on MicroLink, a nationwide bulletin board for micro users.

Londoners want community radio - but not pirates

The Greater London Council commissioned a poll of Londoners to find out what local radio services would appeal to them. A 62% majority said that they would like some form of community radio. A similar proportion was unhappy with the local services of the broadcasting authorities and would prefer that a local service should be run on a local basis by a committeē representing several interest groups. There was quite a high demand for radio stations that catered for specific sections of the community, such as ethnic minorities.

The only source for really local news was often found to be advertisements in news-agents' windows.

Advertising was thought to be the best way of paying for the services, but some form of non-commercial control should keep the service from being too commercial.

There are no plans for any specific services yet. The Government has announced the pilot launch of some community radio stations but these are very few in number and are unlikely to meet the demand.

Pirate radio gets a resounding thumbs down from the survey. The stations were thought to be too similar to ILR transmissions and covered too wide an area. Only 7% of those asked said that they listened to pirate stations most often.

The survey was carried out under the auspices of the Broadcasting Research Unit, a multi-funded body set up as an independant source of thinking and research into future broadcasting policies.

What future for BBC engineering?

In the present frenzy of cost-cutting at the BBC, it is sad to note that the principal casualty is to be the corporation's engineering division.

Design work by the BBC will be greatly reduced, studio planning and installation will be dealt with by outside contractors, whilst in-house equipment manufacture will cease altogether.

The BBC's need for home-grown technology is undoubtedly much less than it was in the days when there was no other customer in Britain for broadcast equipment. And indeed manufacturers already satisfy most of its requirements.

But much of the BBC' reputation for technical excellence depends on its having exactly the right tools for the job. And experience has shown that good tools cannot always be obtained off-the-shelf. Left to find its way in the commercial market-place, the BBC may have to put up with tape machines on which you can't edit properly, record-players with inaccessible controls and studio mixers where the transmission-mode switch is heart-stoppingly close to the one that turns off the mains.

As a major buyer, the BBC has up to now been able to tidy up such infelicities by discussion with the manufacturer, to the benefit of both parties.

Details of the cuts are still being worked out, it seems. But it is to be hoped that the BBC's administrators will use the axe with discrimination. For at present, it looks as if their engineering staff are in danger of being whittled away into little more than a maintenance crew.

In their first half-century, BBC engineers gained over 350 patents, many of them landmarks of their time: such as those relating to the slot aerial, the ribbon microphone, bandwidth compression, pulse-code and numberous other devices and techniques.

It is right that priority should be given to financing programmes rather than peripheral activities. But it will be a pity if, in its hasts to scrape together enough money to pay for daytime television, the BBC allows this distinguished record of engineering innovation to lapse.

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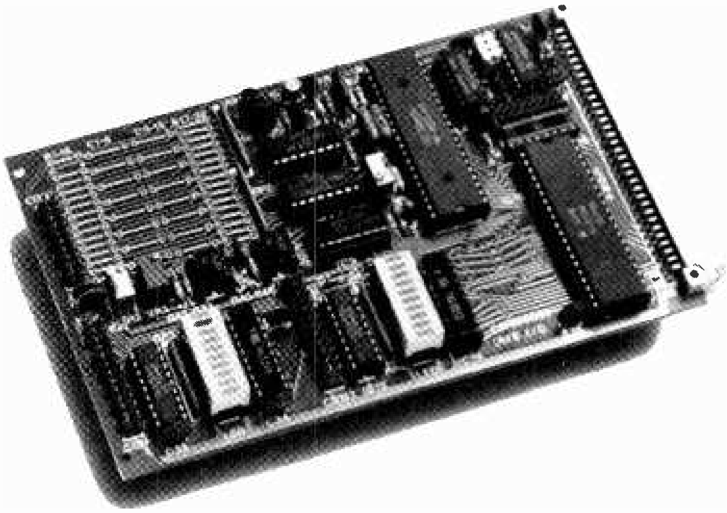

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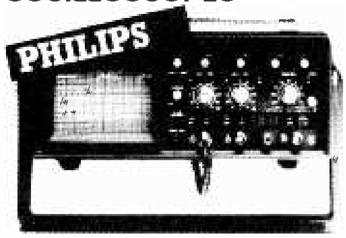

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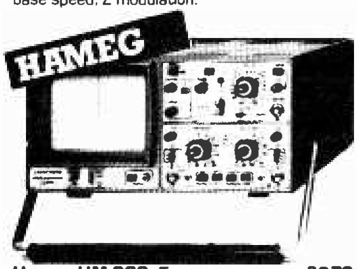

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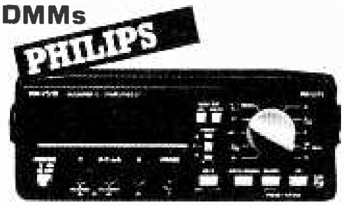

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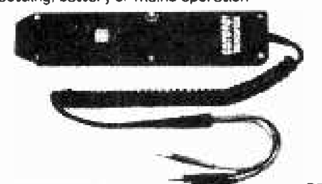

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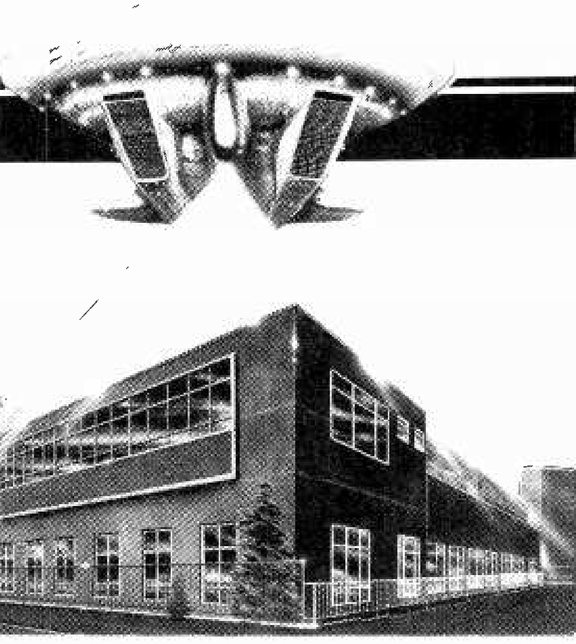

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AAY12	0.25	BC178	0.15	BD223	0.59	BFR88	0.30	RCA16335	0.80
AC125	0.20	BC182	0.10	BD225	0.48	BFR90	1.50	SKE5F	1.45
AC126	0.45	BC182LB	0.10	BD232	0.35	BFR91	1.75	TIP29	0.40
AC127	0.20	BC183	0.10	BD233	0.35	BFT42	0.35	TIP29C	0.42
AC128	0.28	BC183L	0.09	BD234	0.35	BFT43	0.35	TIP30C	0.43
AC128K	0.32	BC184LB	0.09	BD236	0.49	BFW92	0.85	TIP31C	0.55
AC141	0.28	BC204	0.10	BD237	0.40	BFX29	0.30	TIP32C	0.42
AC141K	0.34	BC207B	0.13	BD238	0.40	BFX84	0.26	TIP33C	0.95
AC142K	0.30	BC208B	0.13	BD242	0.65	BFX85	0.32	TIP34B	0.95
AC176	0.22	BC212	0.09	BD246	0.75	BFX86	0.30	TIP41A	0.45
AC176K	0.31	BC212L	0.09	BD376	0.32	BFX88	0.25	TIP41C	0.45
AC187	0.25	BC212LA	0.09	BD410	0.65	BFY50	0.21	TIP42C	0.47
AC187K	0.28	BC213	0.09	BD434	0.65	BFY51	0.21	TIP47	0.65
AC188	0.25	BC213L	0.09	BD437	0.75	BFY52	0.25	TIP120	0.60
AC188K	0.37	BC214	0.09	BD438	0.75	BFY90	0.77	TIP125	0.65
ACY17	1.15	BC214C	0.09	BD520	0.65	BLY48	1.75	TIP142	1.75
AD142	0.79	BC214L	0.09	BD538	0.65	BRY39	0.45	TIP161	2.95
AD143	0.82	BC237B	0.09	BD597	0.95	BR100	0.26	TIP2955	0.80
AD149	0.70	BC238	0.09	BD701	1.25	BR101	0.49	TIP3055	0.55
AD161	0.39	BC239	0.12	BD702	1.25	BR103	0.55	TIS91	0.20
AD162	0.39	BC251A	0.12	BD707	0.90	BRC4443	1.15	TV106/2	1.50
AD161/2	0.90	BC252A	0.15	BDX32	1.50	BT100A/02	0.85	2N1308	1.35
AF106	0.50	BC258	0.25	BF115	0.35	BT106	1.49	2N2219	0.28
AF114	1.95	BC258A	0.39	BF119	0.65	BT116	1.20	2N2905	0.40
AF115	2.95	BC284	0.30	BF127	0.39	BT119	3.15	2N3053	0.40
AF116	2.95	BC300	0.30	BF154	0.20	BT120	1.65	2N3054	0.59
AF117	2.95	BC301	0.30	BF158	0.22	BU105	1.95	2N3055	0.52
AF121	0.60	BC303	0.26	BF160	0.27	BU108	1.69	2N3702	0.12
AF124	0.65	BC307B	0.09	BF167	0.27	BU124	1.25	2N3703	0.12
AF125	0.35	BC327	0.10	BF173	0.22	BU125	1.25	2N3704	0.12
AF126	0.32	BC328	0.10	BF177	0.38	BU126	1.60	2N3705	0.20
AF127	0.65	BC337	0.10	BF178	0.26	BU204	1.55	2N3706	0.12
AF139	0.40	BC338	0.09	BF179	0.34	BU205	1.30	2M3708	0.12
AF150	0.60	BC347A	0.13	BF180	0.29	BU208	1.39	2N3733	9.50
AF178	1.95	BC461	0.35	BF181	0.29	BU208A	1.52	2N3773	2.75
AF239	0.42	BC478	0.20	BF182	0.29	BU208D	1.85	2N3792	1.35
AFZ12	3.75	BC527	0.20	BF183	0.29	BU326	1.20	2N4427	1.95
ASY27	0.85	BC547	0.10	BF184	0.28	BU407	1.24	2N4444	1.15
AU106	4.50	BC548	0.10	BF185	0.28	BU500	2.25	2N5294	0.42
AU107	3.50	BC549A	0.10	BF194	0.11	BU508A	1.95	2N5296	0.48
AU110	3.50	BC550	0.14	BF195	0.11	BU526	1.90	2N5298	0.60
BC107A	0.11	BC557	0.08	BF196	0.11	BU80Y	2.25	2N5485	0.45
BC107B	0.11	BC557B	0.08	BF197	0.11	BUY69B	1.70	2N5496	0.95
BC108	0.10	BC558	0.10	BF198	0.16	MJ3000	1.98	2SA715	0.60
BC108A	0.11	BCY33A	1.60	BF199	0.14	MJE340	0.40	2SC495	0.80
BC108B	0.12	BD115	0.30	BF200	0.40	MJE520	0.48	2SC496	0.80
BC109	0.10			BF241	0.15	MPSA13	0.29	2SC1096	0.80
BC109B	0.12	BD124P	0.59	BF245	0.30	MPSA92	0.30	2SC1106	2.50
BC109C	0.12	BD131	0.42	BF257	0.28	MRF237	4.95	2SC1172Y	2.20
BC114	0.11	BD132	0.42	BF258	0.28	MRF450A	13.95	2SC1173	1.15
BC116A	0.15	BD133	0.40	BF259	0.28	MRF453	17.50	2SC1306	1.00
BC117	0.19	BD135	0.30	BF271	0.26	MRF454	26.50	2SC1307	1.50
BC119	0.24	BD136	0.30	BF273	0.18	MRF455	17.50	2SC1364	0.50
BC125	0.25	BD137	0.32	BF336	0.34	MRF475	2.50	2SC1449	0.80
BC139	0.20	BD138	0.30	BF337	0.29	MRF477	10.00	2SC1678	1.25
BC140	0.31	BD139	0.32	BF338	0.32	OC16W	2.50	2SC1909	1.45
BC141	0.25	BD140	0.30	BF355	0.37	OC23	1.50	2SC1945	2.65
BC142	0.21	BD144	1.10	BF362	0.38	OC42	0.75	2SC1953	0.95
BC143	0.24	BD150C	0.29	BF363	0.65	OC44	0.75	2SC1957	0.80
BC147A	0.12	BD159	0.65	BF371	0.25	OC45	0.55	2SC1969	1.95
BC147B	0.12	BD160	1.50	BF394	0.19	OC70	0.45	2SC2028	1.15
BC148A	0.09	BD166	0.55	BF422	0.32	OC71	0.55	2SC2029	1.95
BC148B	0.09	BD179	0.72	BF457	0.32	OC72	0.85	2SC2078	1.45
BC149	0.09	BD182	0.70	BF458	0.36	OC81	0.50	2SC2091	0.85
BC157	0.12	BD183	0.70	BF459	0.36	OC171	3.50	2SC2098	2.95
BC158	0.09	BD201	0.83	BF467	0.68	R2008B	1.45	2SC2166	1.95
BC159	0.09	BD202	0.65	BF595	0.23	R2010B	1.45	2SC2314	0.80
BC174	0.09	BD203	0.78	BF597	0.25	R2322	0.58	2SC2371	0.36
BC174A	0.09	BD204	0.70	BFR39	0.23	R2323	0.66	2SD234	0.50
BC177	0.15	BD222	0.46	BFR40	0.23	R2540	2.48	3N211	1.95
				BFR81	0.25	RCA16334	0.90	3SK88	0.95

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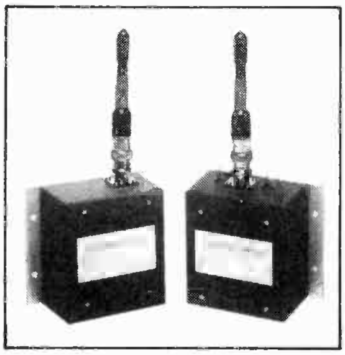

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Domestic microelectronic controller

Intarlec: intelligent alarm and partial control of the electrical installation.

by J.L. Gordon

Microprocessor-based alarm systems are now a popular addition to the many alarm control boards that are available from various sources. Generally it seems from conversations with some alarm installers, that electronic alarm control boards have been suspect as far as false alarms are concerned. However, more modern and perhaps expensive boards are indeed more reliable: some of the latest boards have microprocessor-controlled designs containing a processor that is rather under-worked in a domestic alarm system.

A microprocessor in such a system could service each alarm call through an interrupt network, the delay in servicing being only a few microseconds. However, there may be nothing for the microprocessor to be interrupted from, so a loop program can be chosen. Each contact or zone may be interrogated at regular intervals within a continuous loop, and decisions made as to the state of the system. Even this option provides for extremely rapid interrogation frequencies, which are not required. A pressure mat, for instance, would miss nothing if interrogated every 10 or even every 100 microseconds, as opposed to every 500 microseconds as should be possible in a domestic system.

The use of a microprocessor allows the advantages available in more expensive electronic systems, such as being able to take an average reading from peripherals so that noise may be eliminated and the ability to mask out faulty contacts under programmed criteria. In addition, the system would become more flexible, allowing functional modifications through programming.

Using a loop-type program, it should be possible to fit additional processing into the loop and still be able to interrogate contacts at a more than adequate frequency. The additional work should be related in cost terms to the cost of the alarm system. For example, it would make little sense to spend thousands of pounds on servo control equipment that would supplement an alarm system costing only a few hundred pounds. The servo control system would probably be self contained, and a separate alarm system chosen.

The unit described aims to provide control options that complement each other and extend the ability of the whole system. The control of certain lights in the premises can be effected through the microprocessor and be entirely automatic. This requires a light-level sensor but also enables the controller to simulate house occupation during holidays. The contact system could be extended to allow the controller to distinguish between rooms in the house. Additional internal sounders can be used as door bell repeaters and the door bell itself can allow silent access for the consumer when the alarm is armed.

The description that follows was intended for the operator and is not an extensive technical description. In the hardware and software descriptions that follow the unit is referred to as Intarlec, which with some poetic licence, is intended to represent "intelligent alarm and partial control of the electrical installation."

Intarlec is intended to provide the householder with a useful control and an alarm at a price that compares with other alarm systems. The system consists of a central control unit which is actually a small computer. Intarlec monitors peripherals located around the premises to detect the presence of a person. When the alarm mode is requested the information can be used by the computer to determine the appropriate action, given the input conditions. In this respect, it is little different from many other systems. However other systems have the alarm function as their only objective. Intarlec is useful in other ways, even when not operating as an alarm.

Intarlec will have conttrol of a small hunber of lights in the premises. This is essential to the main program. Suitable lights for control are those which serve a functional purpose such as hall, stairs, landing, kitchen and outside lights.

Taking the half light as an example, Intarlec monitors the outside light level and will therefore not activate the hall light during the day. However override facilities exist to allow for occasional events such as docorating where more light is needed during the day. During the evening it uses the same monitoring facilities that are used for the alarm, to detect the presence of a person in the hall. When programmed conditions are satisfied Intarlec will activate the hall light without any direct request from the consumer other than presence. Someone entering the premises by the front door will be greeted immediately by a well-lit hall and so avoid having to reach for a switch in the dark. Intarlec appears to provide character to an otherwise lifeless house. This kind of reasoning can be applied to other areas and lights. However the consumer is not advised to have this facility installed in areas such as living rooms, bedrooms etc., where lighting is not always functional and may depend on mood.

Three basic modes

— Mode 1. Normal mode as previously described.

— Mode 2. A request to arm the alarm but to inform Intarlec that house occupants are going to bed.

— Mode 3. This is maximum alert where all presence is interpreted as hostile.

Mode 2. When all householders are retiring for the evening mode two should be selected. Initially the alarm program is activated and then de-activated for about three minutes to allow people to clear hostile areas. During the deactivate period, hall and landing lights are turned on to allow safe passage to bed. When these lights go out, the consumer will know that Intarlec has re-activated the alarm program.

If the consumer needs to get up during the night. Intarlec deduces that it is not a burglar and promptly turns on hall and landing lights and deactivates the alarm for about five minutes. If the consumer stays for longer than this mode two should be cancelled and re-established when required. After five minutes, and presumably when the consumer is safely back in bed, Intarlec turns off the lights and re-activates the alarm. In the morning, mode one should be requested whilst the alarm is de-activated. If an intruder is detected in mode two, an internal alarm will sound, and all lights under computer control will be turned on.

Mode 3. When the consumer goes out, mode three should be selected. Intarlec allows about $1\frac{1}{2}$ minutes for the premises to be cleared and the alarm will then be armed. If an intruder is detected Intarlec initially responds by sounding an internal alarm and flashing all house lights to attract attention. During this time Intarlec establishes the validity of the call and when sure of an intrusion will add the external alarm. The alarm automatically resets and re-arms after about five minutes.

Mode three cannot be cancelled externally but entrance can be gained silently with programmed criteria (not discussed here). Mode three also offers a simulate facility for use when the premises remains unattended for

Communication unit operating instructions

Switch-on.
On power-up Intarlec starts in mode three, but will be deactivated to allow mode setting.

Mode 1. This is normal mode with no alarm. To select this mode, press button number one. A '1' will appear on the right hand display.

Mode 2. This is alarm request for occupied premises. To select this mode, press button number two. A '2' will appear on the right hand display.

Mode 3. This is alarm request, maximum alert. To select this mode, press button number three. A '3' will appear on the right hand display after a short delay. Simulate may be requested by holding in button number three until PP is seen on the display. After a short delay. 'S' will appear on the right hand display to show 'Simulate' has been activated.

The computer can be seen to be working normally by observing the rapid pulsing of any blank display segments.

When in mode one
All other key facilities are available:

Key 8 — override. Press key 8 then hold down the key for the light required until OK is seen on the display. Normal operation will be resumed.

Key 7 — set up. Key 7 re-starts the program as if power-up has just occurred. All edited registers will be set to normal.

Key 6 — lights out. Key 6 turns off any lights that are on.

Key 5 — edit. Key 5 is used to edit working registers. Pressing this key starts the editor. The following keys work in edit mode

1 — Increments address or data.
2 — Decrements address or data.
3 — Selects address of register.
4 — Selects content of register.
6 — Exit from edit mode to normal.
7 — Rapid test of simulate routine.

This facility should only be used after proper instruction, and with a register map.

When in mode two, the keyboard will not respond unless the alarm has been automatically deactivated. This prevents an intruder from cancelling the alarm.

Any mode request automatically cancels other modes.

When in mode three, the keyboard will not respond unless the alarm is deactivated by the user. If the alarm is activated by accident, it may be cancelled by a special procedure.

longer periods. When this routine is requested Intarlec controls internal lights when the premises are empty. Dusk initiates the simulate routine each day of absence. Lights then operate to simulate movement around the premises for as long as required. The consumer can determine the exact nature of this facility, so that the routine will be individually tailored to the consumer's needs. It is hoped that the simulate facility will deter breaks in so that the alarm function is not required. However, simulate in no way impairs Intarlec's ability to detect intruders.

When modes two or three are selected the last contact facility will read 0 unless a contact is operated. A non-zero reading means that a fault exists on that circuit or a door is open etc.

Other facilities

Lights under computer control will not normally have switches, and as Intarlec never forgets to turn lights off, electricity may be conserved.

The communications unit will normally show the mode of operation and the last point where a presence has been detected, on two displays. It is therefore possible to trace movement around the premises by studying the control panel.

Any lights under computer control may be turned on or off from the keyboard. Even when lights have been overridden in this way. Intarlec turns them off automatically after about two hours, in case you forget.

Some functions can be edited from the keyboard. However this requires more extensive knowledge of the system and is not recommended for the unpracticed. If editing wrong, the system may be easily re-set to normal. In the event of a power failure or other temporary problem, a separate electronic circuit monitoring computer functions automatically re-starts in maximum alert mode, but deactivates for a short period to allow correct mode selection.

Hardware description

Figure 1 shows the overall arrangement of the hardware required for a working system. A 12V d.c. power unit is required rated at about 2A; separate 5V regulators are used for the 6502 controller, the interface board, and the communication unit. This arrangement is not essential but has worked successfully in the prototype unit.

The controller board consists of a 6502 microprocessor, 1K of ram (2×2114), one 2716 eprom containing the system software, two 8154 p.i.as, chip select logic and a 1MHz clock provided for by the 6502. The original board was bought from Acorn Computers for £46, and was their System 1 board without monitor roms. Such a board may easily be constructed on a suitable i.c. breadboard if a commercial board cannot be found. The main feature of the Acorn board that prompted its use was the provision of two 8154 p.i.as for i/o and a 2716 2K eprom socket for the controller firmware. Although the construction of the controller is straightforward, one point of importance is that the 8154 and 6502 belong to different families of i.cs. The main problem is that the 8154 requires 'not read strobe', (NRDS) and 'not write strobe' (NWDS) lines, whilst the 6502 provides a 'read/not write' (R/$\overline{W}$) line for the same purpose. A solution is to split R/$\overline{W}$ with an inverter and then to nand each of the two new signals with 'Θ_2' (theta two) clock producing the required 'NRDS' and 'NWDS', which are onley low during 'Θ_2' and the correct level of R/$\overline{W}$.

All input to, and output from, the microprocessor is done through two 8154 p.i.as. These chips are useful because they allow single-bit read and write operations to any one of 16 bits, as well as two 8-bit port addresses. Single bits can be set or cleared through a unique address for each operation on each bit. The chip also contains 128 by 8 bits of ram, but has no timer. The timing of events is done within the main loop of the program.

It is possible to use a controller

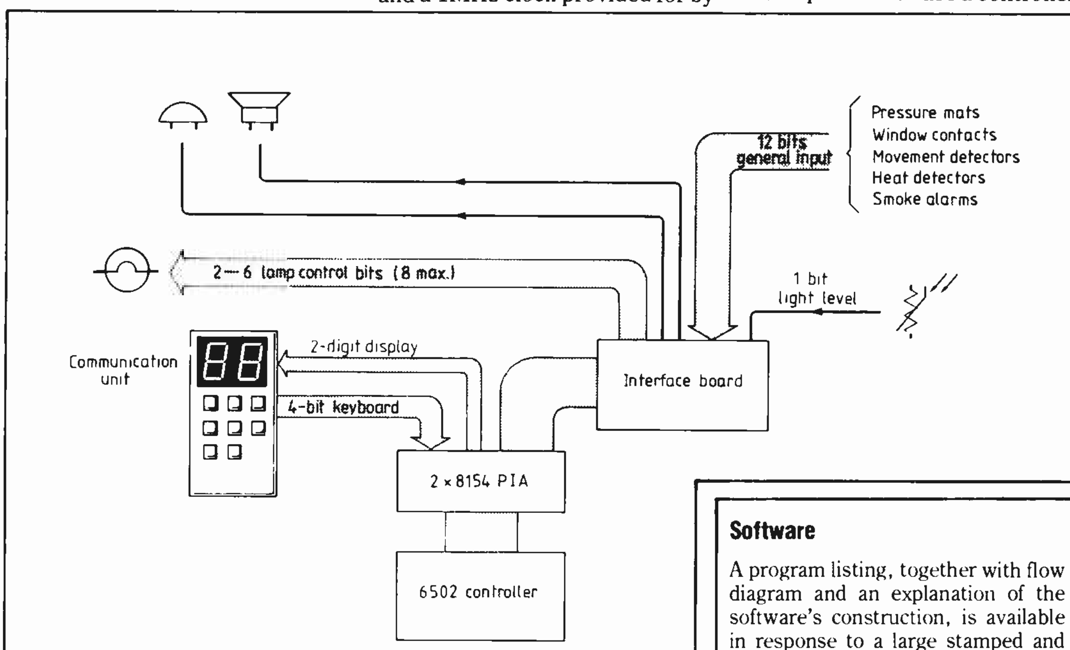


Fig. 1. The central controller can service up to eight mains lights, 12 inputs from various sensors, a five-tone internal sounder and special connections such as light level and auto reset prevention. Six port bits are used for user interface, allowing a reasonable length connection cable to the controller.

Software

A program listing, together with flow diagram and an explanation of the software's construction, is available in response to a large stamped and addressed envelope sent to the editorial office and marked 'Intarlec'.

board which includes the more common 6522 v.i.a. A simple arrangement using a minimal 6502, 2716 eprom, 2×2114 ram and 1×6522 v.i.a. has been built and tested successfully using an i.c. breadboard (such as RS 434-021). A working board would of course require two v.i.as, but it should be possible to include the extra one on the breadboard. The use of 6522s would reduce the cost of the unit but would not allow individual addressing of separate port bits.

Setting and clearing individual bits will require slightly more complex instructions in the firmware of a 6522-based controller:

For 8154

STA bit4set-porta/set bit 4
STA bit4clear-porta/clear bit 4

For 6522

LDA porta/to clear a bit
AND #%11101111/clear bit 4
STA porta
LDA porta/to set a bit
ORA #%00010000/set bit 4
STA porta

Reading a bit requires similar additions.

The Acorn board enabled its p.i.as at $0900 and $0E00. The rest of the text assumes that this is the case for any controller used.

Signal processing is done by the interface board, with the exception of the communication unit. It is possible to construct a controller board on suitable i.c. stripboard (eq.RS434-021). The design of such a board can not be included here but a simple arrangement using a minimal 6502, 2716 eprom, 2 × 2114 ram and a 6522 p.i.a. has been built and tested successfully using the board stated. A working board would of course require two p.i.as, but it should be possible to include the extra one on the strip board. The use of 6522s would reduce the cost of the unit but would not allow individual addressing of separate port bits.

The communication unit is connected directly to six bits of one of the p.i.as. The purpose of this unit is to permit the transfer of information between the user and the controller. Eight numbered keys are encoded by a 74LS148 to give three bits of data. A further bit (EO) is used to detect a key press. GS may also be used to detect a key press; this is active low which may be more secure if connecting wires are cut in that the servered keyboard will not be read when the port bit floats high.

To reduce interfacing cost and allow for the maximum number of bits on the 8154s to be used for control purposes, it was decided to use serial data transfer for the display. Two eight-bit shift registers are provided, which contain the information for the two seven segment displays. The information is shifted into the registers by a subroutine in the main program controlling the clock and data inputs to the shift register. The clock and data are not sent at the maximum frequency available to the program to allow for trailing leads connecting the communication unit. The clock frequency will be about 36kHz for the sub routine shown, and the information for the two digits of the display is sent about five times per second or once every 240 cycles of the main loop of the program.

The 74164 shift registers are used to drive common-anode displays through suitable resistor networks. Common-cathode displays may also be used with minor alterations to the drive subroutine.

As previously stated, other input and output is done through the interface board. The tone selector handles alarm sounding. The three control bits and the 74138 provide eight possible conditions. Address '0' is used as an off condition, '7' is also not connected to an alarm as it may be activated in the event of a fault if pins 1 to 3 on the 74138 float high during system reset. Address '6' is used to activate the outside alarm bell through the interface shown in Fig. 6. Lines 1 to 5 are used to provide five different tones for the internal sounders. These sounders are loud speakers driven from the output transistor shown. The tones are derived from a 7493 binary counter which divides the pulses from a 2096Hz oscillator. Each note is gated as shown using and logic. The lowest frequency note also provides reset pulses for the auto-reset circuit.

These pulses are independant of the microprocessor clock. The auto-reset circuit monitors the pulses provided by the processor; in the event of a failure of the pulses, the 74123 re-triggerable monostable will return to a low output, which in turn will allow the reset pulses to appear at the reset pin of the processor. The main program should provide a set pulse for the monostable within 200μs of the first reset pulse. This prevents any further reset pulses and the reset line remains high. Fig. 4 also shows a resistor-capacitor-diode circuit at the input of the inverter which allows reset at the earliest instant on power-up: reset will not have to wait for the timing of the monostable on this occasion. In the event of a fault on the controller board, it is likely that all lights will turn on and alarms off, due to the fact that the 8154's ports will reset as inputs and the gate inputs controlling lights etc. will tend to float high.

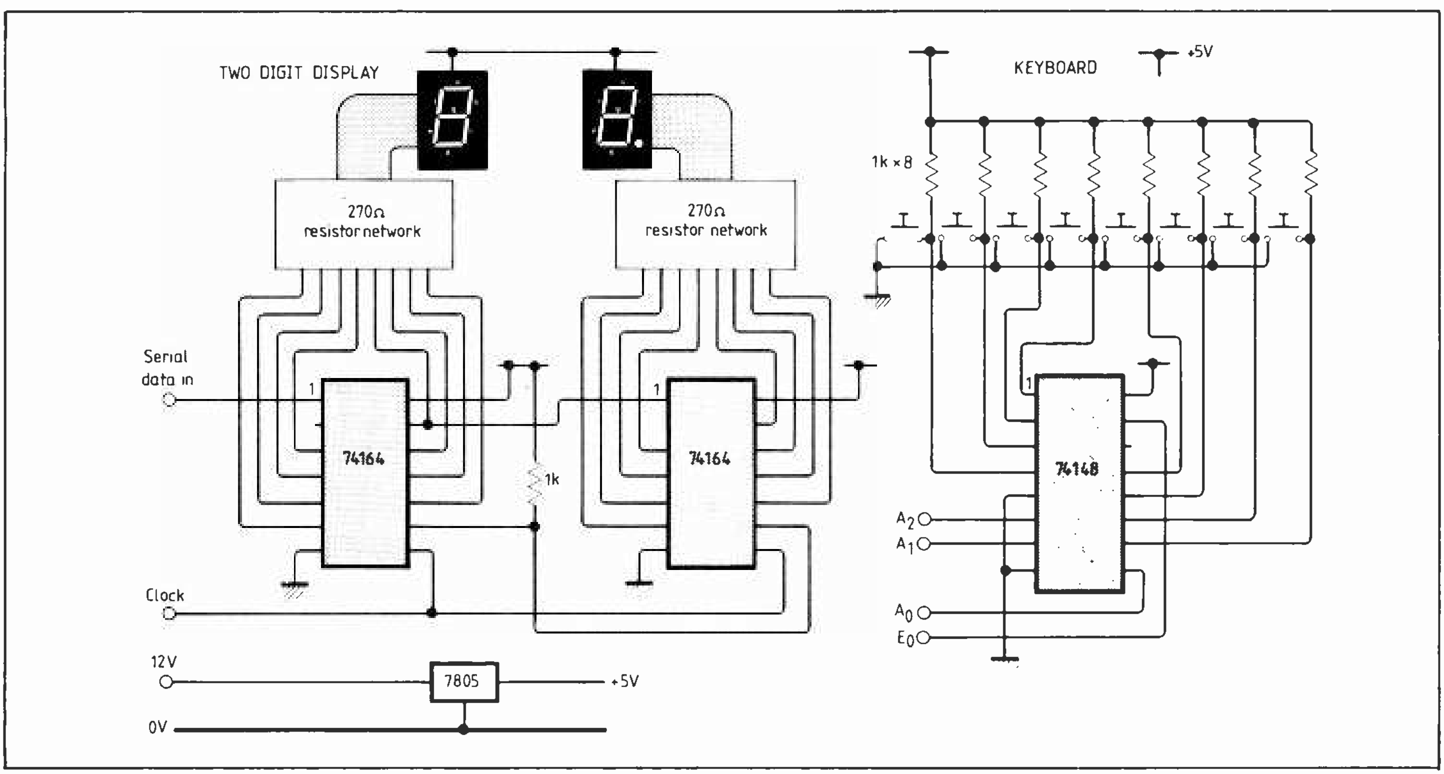
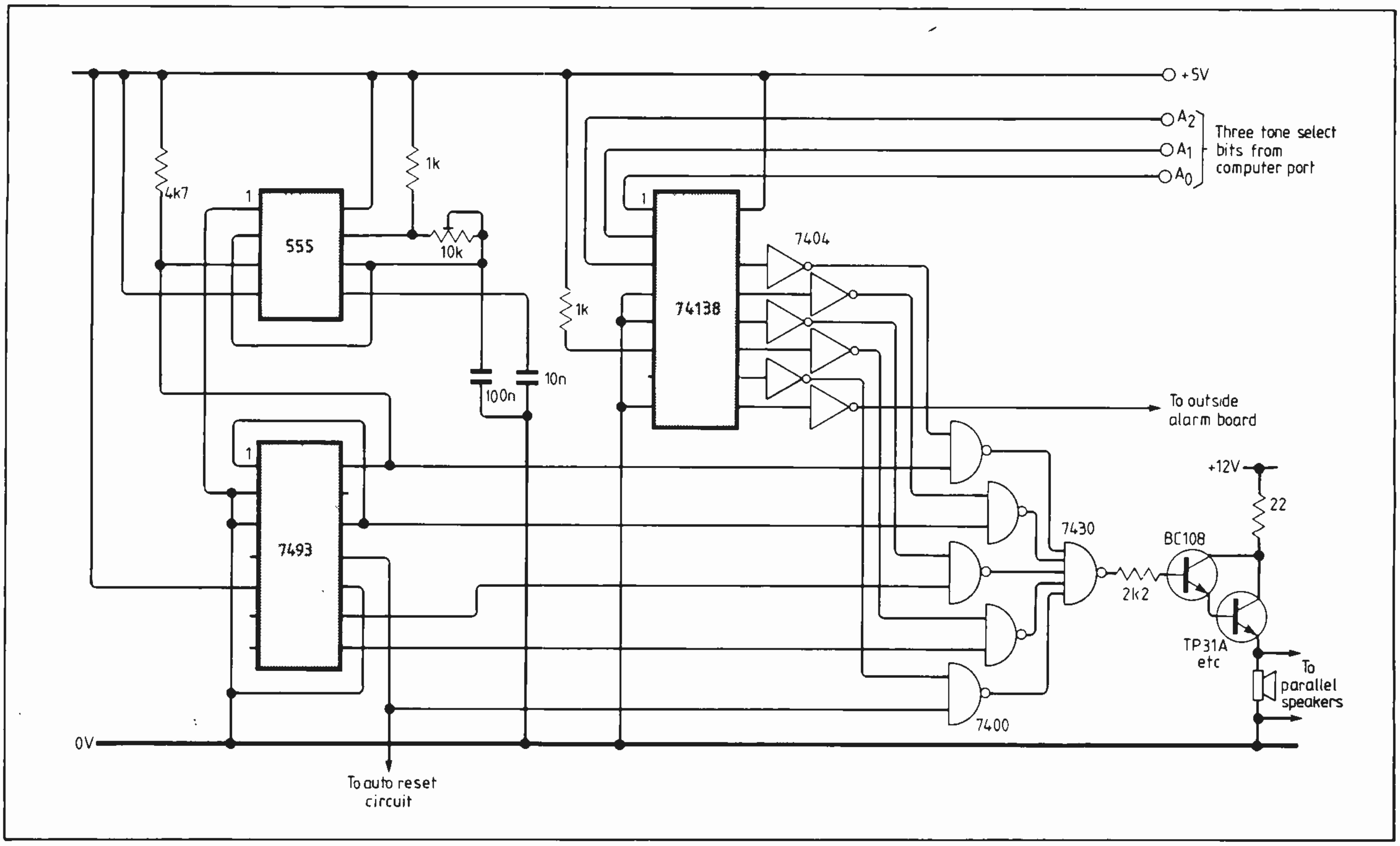


Fig. 2. **User interface should be as straightforward as possible. Only eight key inputs are provided but the system may be driven from just three keys for minimal operation 'Day' 'Sleep' and 'Out' ('1', '2' and '3'). Two seven-segment displays provide contact and mode of operation information which is frequently updated.**



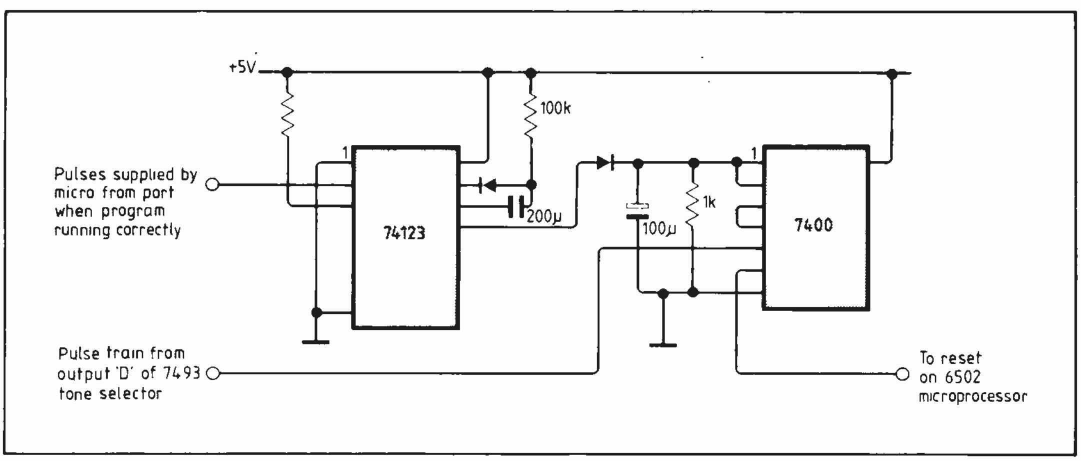


Fig. 3. Five notes may be generated from three port bit i/o lines allowing several types of warning sound. This sub-system also forms the route for outside alarm bell activation and an independent clock for auto reset.

Fig. 4. The failure of the central controller to provide retriggering pulses for the 74123 will allow a series of Reset pulses to be generated, which should re-start the system or at least cause it to fail safe.

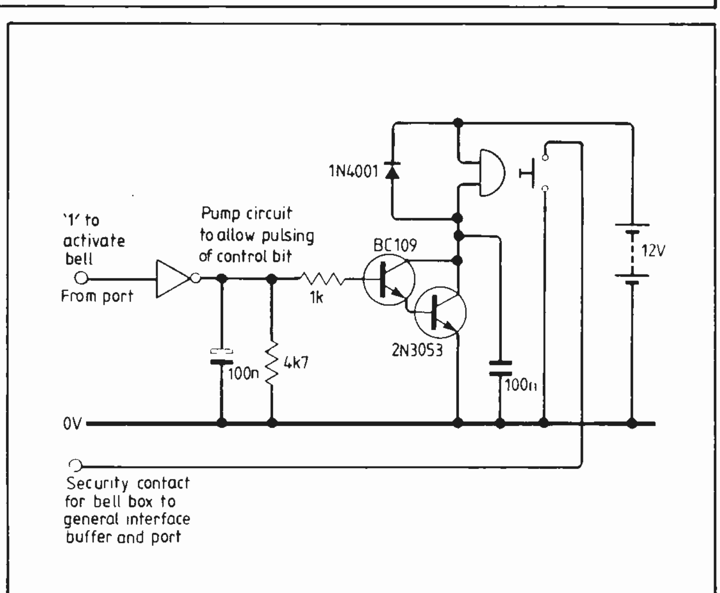


Fig. 6. Connection to an outside bell, incorporating a little pulse stretching and some inductive transient suppression.

General input and output buffers are shown in Fig. 5. Doors and windows using magnetic contacts are straightforward, pressure mat buffers are also simple, with 4.7kΩ resistors being used to limit peripheral-wiring current to about 1mA. Inputs have generally been arranged so that an active contact shows logic 1 to the controller. A number of light-level sensor circuits have been tried and most have proven successful. The circuit chosen is the simplest and allows signal processing at the interface board instead of the sender end. The sensor is an ORP12 which is housed in a transparent waterproof box outside the premises and where it will not be affected by artificial light or direct sunlight. When the light level is high, the ORP12 has a low resistance and the Schmitt nand is at logic 1. Some adjustment is provided by the 10kΩ pot. for a convenient change-over from 1 to 0. The Schmitt circuit provides about 800mV hysteresis about the change over point, although actual changes from 1 to 0 etc., are not inconvenient as each light has a timed on-period regardless of light level.

The door bell sensor is provided to read from the existing push at the front door. The circuit could easily be modified in case there is no existing bell. The simple pressure mat buffer of Fig. 5 would read from a push.

Fig. 6 shows a small circuit that is used to activate the outside alarm bell. Many bells available work on 6 to 12V and 300mA d.c. so the Darlington arrangement can drive the bell provided that protection is included from inductive transients. A pulse stretching circuit is also included because the bell will be sounded as well as the internal tone. As both internal tone and bell are activated through the 74138 of Fig. 3, they cannot be on together without this addition. This circuit, along with the battery supply to the bell, would be suitably housed in a box situated just inside the building near the bell.

Great care should be taken when installing the light switches. Safety precautions should be observed so that the mains supply remains entirely separate from the low voltage control circuit. In addition, it should be possible to arrange disconnection of the supply for maintenance to ceiling rose etc., and for changing lamps. The two circuits shown in Fig. 8 will both allow low voltage control of the lamps whilst isolating from the mains.

The opto-triacs were obtained from RS components. Their data sheet quotes an insulation resistance at 500V of 10E11 ohms. However the 15th Edition of the IEE Wiring Regulations states that semiconductor devices should not be used as isolators. One possible solution to this would be to fit a lock type switch and install the opto triac unit behind it. This would allow disconnection of the supply to an individual light whilst still giving the controller total control for much of the time. The relay switch circuit will provide the required isolation and comply with the regulations. The regulations would also require insulation to low voltage and barriers if the relay or opto-isolator is to be housed in the existing switch box or ceiling rose. The way that this is done is not specified and the local electricity board may be consulted. The relay shown in Fig. 8 from Diamond Electronics would have an insulating barrier and p.v.c. sleeving could be used where the control cable enters the box. If method 1 is used than the interface board will require a 7405, and if method 2 is chosen, a Darlington driver should be used. The UNL2003 etc. should be a suitable driver.

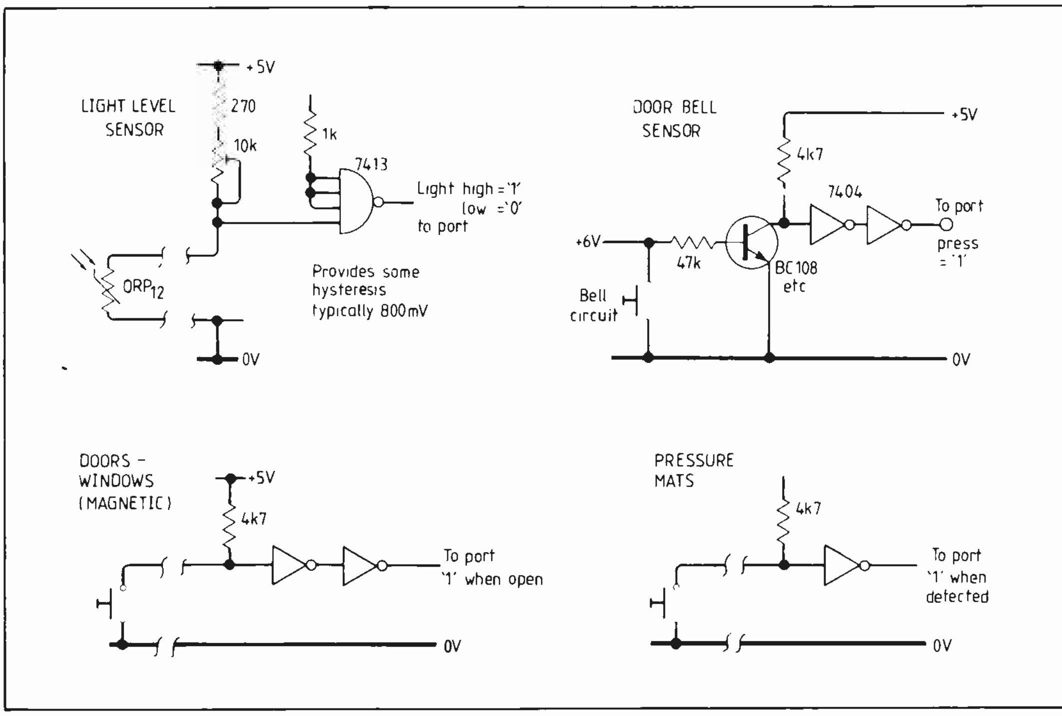


Fig. 5. **Several types of very simple interface are incorporated in the interface board which provide connection between controller and peripheral.**

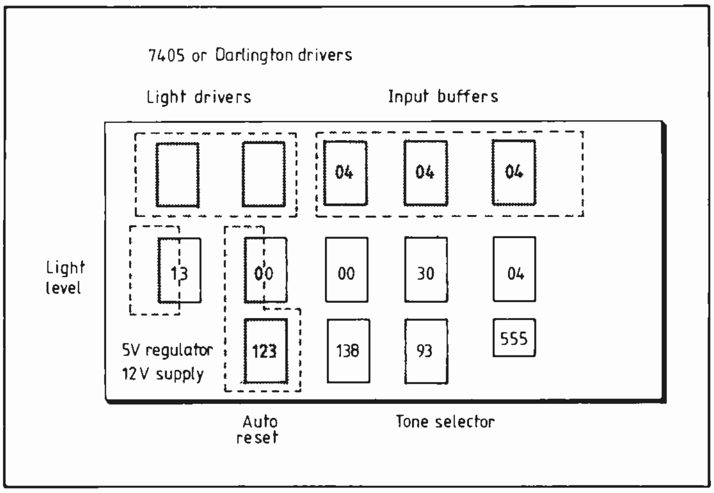


Fig. 7. **Interface buffering is accomplished by using several t.t.l. i.cs on a suitable i.c. patchboard such as those found in the RS or Maplin catalogue. The prototype was constructed on a 30-i.c. board from RS Components.**

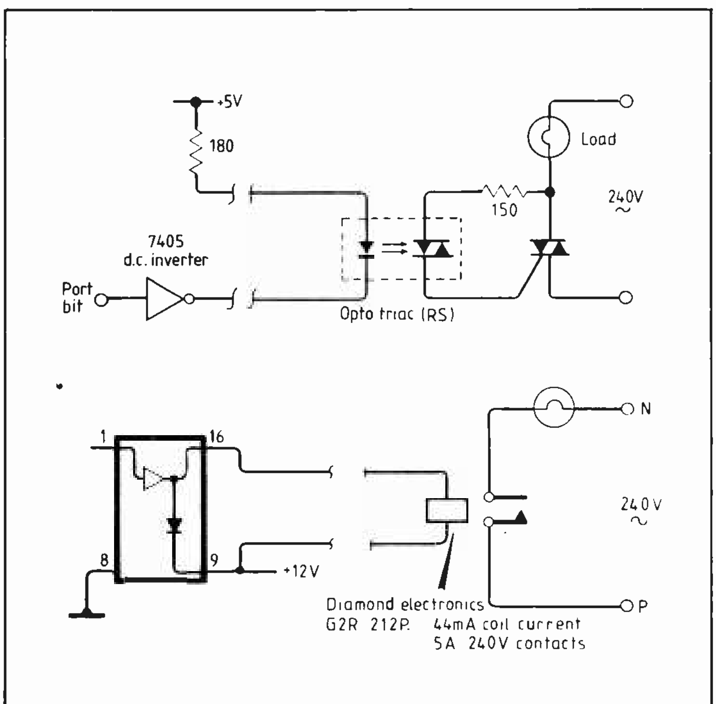


Fig. 8. **Mains light buffering must provide adequate electrical isolation and comply with the 14th edition of the IEE regulations. The use of an opto-triac provides isolation and simplicity of interface, whilst the use of a miniature relay removes the need to switch with a semiconductor device.**

Allowing the unit such total control of some lights may seem drastic, but if the software is implemented correctly and the hardware is reliable, no difficulties should be experienced. The original system implementation has in fact been moved to a different premises. Changing an original installation back to its normal state will prove easy if mains controllers have been installed at the light switch positions and blanking plates fitted instead of the switches. The change-over will simply involve removing the controllers and replacing the switches.

74 SERIES

7400	0.30
7401	0.30
7402	0.30
7403	0.30
7404	0.36
7405	0.30
7406	0.40
7407	0.40
7408	0.30
7409	0.30
7410	0.30
7411	0.30
7412	0.30
7413	0.50
7414	0.70
7416	0.36
7417	0.40
7420	0.30
7421	0.60
7422	0.36
7423	0.36
7425	0.40
7426	0.40
7427	0.32
7428	0.43
7430	0.30
7432	0.36
7433	0.30
7437	0.30
7438	0.40
7439	0.40
7440	0.40
7441	0.90
7442A	0.70
7443A	1.00
7444	1.10
7445	1.00
7446A	1.00
7447A	1.00
7448	1.00
7450	0.36
7451	0.35
7453	0.38
7454	0.38
7460	0.55
7470	0.50
7472	0.45
7473	0.45
7474	0.50
7475	0.60
7476	0.45
7480	0.65
7481	1.80
7483A	1.05
7484A	1.25
7485	1.10
7486	0.42
7489	2.10
7490A	0.55
7491	0.70
7492A	0.70
7493A	0.55
7494	1.10
7495A	0.60
7496	0.80
7497	2.10
74100	1.90
74107	0.50
74109	0.75
74110	0.75
74111	0.55
74116	1.70
74118	1.10
74119	1.70
74120	1.00
74121	0.55
74122	0.70
74123	0.80
74125	0.65
74126	0.55
74128	0.55
74132	0.75
74136	0.70
74141	0.90
74142	2.50
74143	1.30
74144	2.70
74145	1.10
74147	1.70
74148	1.40
74150	1.75
74151A	0.70
74153	0.80
74154	1.40
74155	0.80
74156	0.90
74157	0.80
74159	1.75
74160	1.10
74161	0.80
74162	1.10
74163	1.10
74164	1.20
74165	1.10
74166	1.40
74167	4.00
74170	2.00
74172	4.20
74173	1.40
74174	1.10
74175	1.05
74176	1.00
74178	1.50
74179	1.50
74180	1.00
74181	3.40
74182	1.40
74184	1.80
74185A	1.80
74190	1.30
74191	1.30
74192	1.10
74193	1.15
74194	1.10
74195	0.80
74196	1.30
74197	1.10
74198	2.20
74199	2.20
7474221	1.10
74251	1.00
74259	1.50
74265	0.80
74273	2.00
74276	1.40
74278	1.70
74279	0.90
74283	1.05
74742	3.20
74290	0.90
74293	0.90
74298	1.80
74351	2.00
74365A	0.80
74366A	0.80
74367A	0.80
74368A	0.70
74376	1.60
74390	1.10
74393	1.20
74490	1.40

74LS SERIES

74LS00	0.24
74LS01	0.24
74LS02	0.24
74LS03	0.24
74LS04	0.24
74LS05	0.24
74LS08	0.24
74LS09	0.24
74LS10	0.24
74LS11	0.24
74LS12	0.24
74LS13	0.34
74LS14	0.50
74LS15	0.24
74LS20	0.24
74LS21	0.24
74LS22	0.24
74LS24	0.50
74LS26	0.24
74LS27	0.24
74LS28	0.24
74LS30	0.24
74LS32	0.24
74LS33	0.24
74LS37	0.24
74LS38	0.24
74LS40	0.24
74LS42	0.50
74LS43	1.50
74LS47	0.80
74LS48	0.90
74LS51	0.24
74LS54	0.24
74LS55	0.24
74LS73A	0.30
74LS74A	0.35
74LS75	0.45
74LS76A	0.36
74LS78	0.42
74LS83A	0.70
74LS85	0.75
74LS86	0.35
74LS90	0.48
74LS91	0.90
74LS92	0.35
74LS93	0.54
74LS95B	0.75
74LS96	0.90
74LS107	0.40
74LS109	0.40
74LS112	0.45
74LS113	0.45
74LS114	0.45
74LS122	0.70
74LS123	0.80
74LS124	1.40
74LS125	0.50
74LS126	0.50
74LS132	0.65
74LS133	0.50
74LS136	0.45
74LS138	0.55
74LS139	0.55
74LS145	0.95
74LS147	1.75
74LS148	1.40
74LS151	0.65
74LS152	2.00
74LS153	0.65
74LS154	1.60
74LS155	0.65
74LS156	0.65
74LS157	0.50
74LS158	0.65
74LS160A	0.65
74LS161A	0.75
74LS162A	0.75
74LS163A	0.75
74LS164	0.75
74LS165A	1.10
74LS166A	1.50
74LS168	1.30
74LS169	1.00
74LS170	1.40
74LS173A	1.00
74LS174	0.75
74LS175	0.75
74LS181	2.00
74LS183	1.90
74LS190	0.75
74LS191	0.75
74LS192	0.80
74LS193	0.80
74LS194A	0.75
74LS195A	0.75
74LS196	0.80
74LS197	0.80
74LS221	1.00
74LS240	0.80
74LS241	0.80
74LS242	0.90
74LS243	0.90
74LS244	0.80
74LS245	1.00
74LS247	1.10
74LS248	1.10
74LS249	1.10
74LS251	0.75
74LS253	0.75
74LS256	0.90
74LS257A	0.70
74LS258A	0.70
74LS259	1.20
74LS260	0.75
74LS261	1.20
74LS266	0.60
74LS273	1.25
74LS279	0.70
74LS280	1.90
74LS283	0.80
74LS290	0.80
74LS292	9.00
74LS293	0.80
74LS295	1.40
74LS297	9.00
74LS298	1.00
74LS299	2.20
74LS321	3.70
74LS322A	3.90
74LS323	3.00
74LS324	3.20
74LS348	2.00
74LS352	1.20
74LS353	1.20
74LS356	2.10
74LS363	1.80
74LS364	1.80
74LS365	0.50
74LS366	0.50
74LS367	0.52
74LS368	0.50
74LS373	0.90
74LS374	0.90
74LS375	0.75
74LS377	1.40
74LS378	0.95
74LS379	1.40
74LS381	4.50
74LS390	0.60
74LS393	0.95
74LS395A	0.60
74LS399	1.00
74LS445	1.80
74LS465	1.20
74LS467	1.20
74LS490	1.50
74LS540	1.00
74LS541	1.00
74LS608	7.00
74LS610	19.00
74LS612	19.00
74LS624	3.50
74LS626	2.25
74LS628	2.25
74LS629	1.40
74LS640	3.00
74LS640-1	3.00
74LS641	2.00
74LS642	2.50
74LS642-1	3.00
74LS643	2.50
74LS643-1	3.00
74LS644	3.50
74LS645	2.00
74LS645-1	4.00
74LS668	0.90
74LS669	0.90
74LS670	1.80
74LS682	2.50
74LS684	3.50
74LS687	3.50
74LS688	5.50
74LS783	21.00

74S SERIES

74S00	0.50
74S02	0.50
74S04	0.50
74S05	0.50
74S08	0.50
74S10	0.50
74S11	0.75
74S20	0.50
74S22	1.00
74S30	0.50
74S32	0.60
74S37	0.60
74S38	0.75
74S40	0.50
74S51	0.45
74S64	0.45
74S74	0.75
74S85	3.00
74S86	1.00
74S112	1.50
74S113	1.20
74S114	1.20
74S124	5.50
74S132	1.00
74S133	0.60
74S138	1.80
74S139	1.80
74S140	1.00
74S151	1.50
74S153	1.50
74S157	2.10
74S158	2.00
74S163	4.00
74S169	7.00
74S174	3.00
74S175	3.20
74S188	1.80
74S189	2.25
74S194	3.00
74S195	3.00
74S196	3.50
74S200	4.50
74S201	3.20
74S225	5.20
74S240	4.00
74S241	4.00
74S244	5.00
74S251	2.50
74S257	2.50
74S258	2.50
74S260	1.00
74S261	3.00
74S283	2.70
74S287	2.25
74S288	2.00
74S289	2.25
74S299	5.50
74S373	4.00
74S374	4.00
74S387	2.25

74C SERIES

74C00	0.70
74C04	0.50/ 4069
74C08	0.70
74C10	0.70
74C14	0.50/ 40106 4584
74C20	0.70
74C32	1.00
74C42	1.50
74C48	1.50
74C73	1.00
74C74	1.20
74C76	1.00
74C83	2.00
74C85	2.25
74C86	0.50/40/ 70 4507
74C90	1.90
74C93	1.50
74C95	1.60
74C107	1.00
74C150	5.00
74C151	2.00
74C157	2.50
74C160	1.80
74C161	1.80
74C162	1.80
74C163	1.80
74C173	1.00/ 4076
74C174	1.50
74C175	1.50
74C192	1.50
74C193	1.50
74C194	1.50
74C195	1.50
74C221	2.50
74C244	2.00
74C245	2.25
74C373	2.25
74C374	2.25
74C902	1.20
74C911	9.00
74C912	4.50
74C922	6.00
74C923	6.50
74C925	6.50
74C926	7.50

74ALS SERIES

74ALS00	0.45
74ALS02	0.45
74ALS04	0.50
74ALS08	0.50
74ALS10	0.45
74ALS20	0.45
74ALS32	0.45
74ALS74	0.70
74ALS138	1.50
74ALS139	1.50
74ALS244	4.00
74ALS245	4.75
74ALS573	2.60
74ALS574	4.50
74ALS580	2.60

4000 SERIES

4000	0.20
4001	0.24
4002	0.25
4006	0.70
4007	0.25
4008	0.60
4009	0.45
4010	0.60
4011	0.24
4012	0.25
4013	0.36
4014	0.60
4015	0.70
4016	0.36
4017	0.55
4018	0.60
4019	0.60
4020	0.60
4021	0.60
4022	0.70
4023	0.30
4024	0.48
4025	0.24
4026	0.90
4027	0.40
4028	0.60
4029	0.75
4030	0.35
4031	1.25
4032	1.00
4033	1.25
4034	2.50
4035	0.70
4036	2.50
4037	1.10
4038	1.00
4039	2.50
4040	0.60
4041	0.55
4042	0.50
4043	0.60
4044	0.60
4045	1.00
4046	0.60
4047	0.60
4048	0.55
4049	0.36
4050	0.35
4051	0.65
4052	0.60
4053	0.60
4054	0.60
4055	0.80
4056	0.85
4059	4.00
4060	0.70
4063	0.85
4066	0.40
4067	2.30
4068	0.25
4069	0.24
4070	0.24
4071	0.24
4072	0.24
4073	0.24
4075	0.24
4076	0.65
4077	0.25
4078	0.25
4081	0.24
4082	0.25
4085	0.60
4086	0.75
4089	1.20
4093	0.35
4094	0.90
4095	0.90
4096	0.90
4097	2.70
4098	0.75
4099	0.90
4501	0.36
4502	0.55
4503	0.36
4504	0.95
4505	3.60
4506	0.90
4507	0.35
4508	1.20
4510	0.55
4511	0.55
4512	0.55
4513	1.50
4514	1.10
4515	1.10
4516	0.55
4517	2.20
4518	0.48
4519	0.32
4520	0.60
4521	1.15
4522	0.80
4526	0.70
4527	0.80
4528	0.65
4529	1.00
4531	0.75
4532	0.65
4534	3.80
4536	2.50
4538	0.75
4539	0.75
4541	0.90
4543	0.70
4551	1.00
4553	2.40
4555	0.36
4556	0.50
4557	2.40
4560	1.40
4566	1.40
4568	2.40
4569	1.70
4572	0.45
4583	0.90
4584	0.48
4585	0.60
4724	1.50
14411	7.50
14412	7.50
14416	3.00
14419	2.80
14490	4.20
14495	4.50
14500	6.50
14599	2.00
22100	3.50
22101	7.00
22102	7.00
40014	0.48
40085	1.20
40097	0.36
40098	0.40
40100	1.50
40101	1.25
40102	1.50
40103	2.00
40104	1.20
40105	1.50
40106	0.48
40107	0.55
40108	3.20
40109	1.20
40110	2.25
40114	2.25
40117	2.80
40163	1.00
40173	1.20
40174	1.00
40175	1.00
40192	1.00
40193	1.00
40194	1.00
40244	1.50
40245	1.50
40257	1.80
40373	1.80
40374	1.80
80C95	0.75
80C97	0.75
80C98	0.75

[illegible]

FND357	1.00
FND500/ TIL730	1.00
FND507/ TIL729	1.00
MAN74/ DL704	1.00
MAN71/ DL707	1.00
MAN3640	1.75
MAN4640	2.00
MAN6610	2.00
NSB5881	5.70
TIL311	6.50
TIL729	1.00
TIL730	1.00
MAN8910	1.50
MAN8940	2.50

DISPLAY DRIVERS

9368	4.50
9370	4.50
LM3914	3.50
LM3915	3.50
LM3916	3.50
UDN6118	3.20
UDN6184	3.20
ULN2003	0.90
ULN2004	0.90
ULN2068	2.90
ULN2802	1.90
ULN2803	1.80
ULN2804	1.90
75491	0.70
75492	0.70

OTHERS

2N5777	0.50
BPX25	1.80
BPW21	2.80
OCP71	1.80
ORP12	1.20
ORP60	1.20
ORP61	1.20
SFH205	1.00
TIL32	0.55
TIL78	0.55
TIL 31B	1.20
TIL 81	1.20
TIL 100	0.75

LINEAR ICs

AD7581	15.00
ADC0808	11.90
AM7910DC	25.00
AN103	2.00
AY-1-5050	1.00
AY-3-1350	3.50
AY-3-8010	4.50
AY-3-8910	4.00
AY-3-8912	5.00
CA3019A	1.00
CA3028A	1.10
CA3046	0.70
CA3059	3.25
CA3060	3.50
CA3080E	0.70
CA3086	0.80
CA3089E	2.10
CA3090AO	3.75
CA3130E	0.90
CA3130T	1.30
CA3140E	0.45
CA3140T	1.00
CA3146	2.25
CA3160E	0.90
CA3161E	2.00
CA3162E	6.00
CA3189E	2.70
CA3240E	1.50
CA3280G	2.70
CAD7002	12.10
D7002	6.00
DAC1408-8	3.00
DAC0800	3.00
DAC0808	3.00
DG308	3.00
HA1366	1.90
ICL7106	6.75
ICL7611	0.95
ICL76500	4.00
ICL7660	2.50
ICL8038	4.00
ICM7216B	22.00
ICM7217	7.50
ICM7555	0.90
ICM7556	1.40
LC7120	3.00
LC7130	3.00
LC7131	3.50
LC7137	3.50
LF347	1.20
LF351	0.60
LF353	0.90
LF355	0.90
LF356N	1.10
LF357	1.00
LM10CLH	4.50
LM301A	0.30
LM307	0.45
LM308CNI	0.75
LM310	2.25
LM311	0.60
LM318	1.50
LM319	1.80
LM324	0.45
LM334Z	1.15
LM335Z	1.30
LM336	1.60
LM339	0.40
LM348	0.60
LM349CH	3.60
LM358P	0.50
LM377	3.00
LM380N-8	1.50
LM380N	1.20
LM380	1.50
LM381AN	1.70
LM382	2.00
LM383	3.25
LM384	2.20
LM386N-1	1.00
LM387	2.70
LM389	1.80
LM391	1.80
LM392N	1.10
LM393	0.85
LM394CH	4.00
LM709	0.35
LM710	0.48
LM711	1.00
LM723	0.60
LM7245CN	3.00
LM733	0.65
LM741	0.22
LM747	0.70
LM748	0.30
LM1011	4.80
LM1014	1.50
LM1801	3.00
LM1830	2.50
LM1871	3.00
LM1872	3.00
LM1886	5.50
LM1889	3.50
LM2917	3.00
LM3302	0.90
LM3900	0.80
LM3909	1.00
LM3911	1.80
LM3914	3.50
LM3915	3.40
LM3916	3.40
LM13600	1.50
M51513L	2.30
M51516L	4.50
MB3712	2.00
MC1310P	1.50
MC1413	0.75
MC1458	0.45
MC1495L	2.50
MC1495	3.00
MC1496	0.70
MC3340P	2.00
MC3401	0.70
MC3403	0.65
MF10CN	3.00
MK50240	9.00
MK50398	7.90
ML920	5.00
ML922	4.00
MM6221A	3.00
NE529	2.20
NE531	1.20
NE544	1.90
NE555	0.22
NE556	0.60
NE564	4.00
NE565	1.20
NE566	1.50
NE567	1.25
NE570	4.00
NE571	2.50
NE592	0.90
NE5532P	1.50
NE5533P	1.60
NE5534P	1.20
NE5534AP	1.50
OP-07EP	5.00
PLL02A	5.00
RC4136	0.55
RC4151	2.00
RC4195	1.50
RC4558	0.55
S566B	2.20
S50240	9.00
SAA1900	16.00
SAD1024A	11.50
SFF96364	8.00
SL490	3.00
SN76033N	3.00
SN76477	6.00
SN76489	4.00
SN76495	4.00
SN76660	1.20
SPO256AL2	7.00
TA7120	1.20
TA7130	1.40
TA7204	1.50
TA7205	0.90
TA7222	1.50
TA7310	1.50
TBA231	1.20
TBA800	0.80
TBA810	0.90
TBA820	0.80
TBA820M	0.75
TBA920	2.00
TBA950	2.25
TC9109	5.00
TCA210	3.50
TCA220	3.50
TCA270	3.50
TCA940	1.75
TDA1010	2.25
TDA1022	4.00
TDA1024	1.10
TDA1170S	3.00
TDA2002	3.25
TDA2003	1.90
TDA2004	2.40
TDA2006	3.20
TDA2020	3.20
TDA2030	2.50
TDA2591	4.00
TDA3810	7.50
TDA7000	3.50
TEA1002	7.00
TL061CP	0.40
TL062	0.60
TL064	0.90
TL071	0.40
TL072	0.70
TL074	1.10
TL081	0.35
TL082	0.55
TL083	0.75
TL084	1.00
TL094	2.00
TL0170	0.50
TL430C	1.20
UAA1003-3	9.35
UA759	3.20
UA2240	1.20
UAA170	1.70
UCN4801A	5.50
ULN2003A	0.75
ULN2004A	0.75
ULN2068	2.90
ULN2802	1.90
ULN2803	1.80
ULN2804	1.90
URC575	2.75
UPC592H	2.00
UPC1156H	3.00
UPC1185H	5.00
XR210	4.00
XR2206	4.00
XR2207	3.75
XR2211	5.75
XR2216	6.75
XR2240	1.20
ZN404	1.00
ZN414	0.80
ZN419P	1.75
ZN423E	1.30
ZN424E	1.30
ZN425E8	3.50
ZN426E8	3.00
ZN427E8	6.00
ZN428E8	4.50
ZN429E8	2.25
ZN447E	9.50
ZN449E	3.00
ZN450E	7.50
ZN459CP	3.00
ZN1034E	2.00
ZNA1040	6.60
ZNA134J	23.00
ZNA234E	9.50
8703CJ	12.00

VOLTAGE REGULATORS

1A FIXED VOLTAGE PLASTIC TO220

+VE		-VE	
5V 7805	0.45	7905	0.50
6V 7806	0.50	7906	0.50
8V 7808	0.50	7908	0.50
12V 7812	0.45	7912	0.50
15V 7815	0.50	7915	0.50
18V 7818	0.50	7918	0.50
24V 7824	0.50	7924	0.50

1A FIXED VOLTAGE PLASTIC TO92

5V 78L05	0.30	5V 79L05	0.45
6V 78L06	0.30	12V 79L12	0.50
8V 78L08	0.30	15V 79L15	0.50
12V 78L12	0.30		
15V 78L15	0.30		

OTHER REGULATORS

Fixed Regulators		
LM309K	1A 5V	1.40
LM323K	3A 5V	3.50
78H05KC	5A 5V	5.40
78H12	5A 12V	6.40
78P05	10A 5V	9.00
VARIABLE REGULATORS		
LM305AH		2.50
LM317T	TO-220	1.50
LM317K	TO3	2.40
LM337T		2.25
LM350T	10A+VAR	4.00
LM396K	10A+VAR	15.00
LM723N		0.50
78HH05KC	5A 5V	5.75
78HGKC	5A+VAR	6.50
78GUIC	1A+VAR	2.25
79HGKC	5A−VAR	6.75
79GUIC	1A−VAR	2.50
SWITCHING REGULATORS		
ICL7660		2.50
SG3524		3.00
TL494		3.00
TL497		3.00
78S40		2.50
RC4195		1.50

OPTO-ISOLATORS

ILD74	1.30	TIL111	0.70
ILQ74	2.20	TIL112	0.70
MCT26	1.00	TIL113	0.70
MCS2400	1.90	TIL116	0.70
MOC3020	1.50	6N137	3.60
		6N139	1.75

LEDS

0.125"		0.2"	
RED TIL209	0.12	TIL220	0.15
GRN TIL211	0.16	TIL222	0.18
YEL TIL 212	0.20	TIL226	0.22
Rect LEDs (R/G/Y)	0.30		
CXQ (Bi Colour)	1.00		
10 LED BarGraph: Red	2.25		
Grn	2.25		

COUNTERS

74C925	6.50
74C926	6.50
74C928	6.50
7216B	22.00
ZN1040	6.70

COMPUTER COMPONENTS

CPU

1802CE	6.50
2650A	10.50
6502	3.50
65C02	12.00
6502A	5.50
6502B	8.00
6800	2.50
6802	3.00
6809	6.50
6809E	12.00
68B09	12.00
68B09E	16.00
68000-L8	36.00
8035	3.50
8039	4.20
8080A	4.20
8085A	3.00
8086	22.00
8088	17.50
8741	16.00
8748	18.00
TMS1601	12.00
TMS9980	12.00
TMS9995	12.00
WD55	14.50
Z80	2.80
Z80A	3.25
Z80B	
2651	12.00
3242	8.00
3245	4.50
6520	3.00
6522	3.50
6522A	5.50
6532	4.80
6551A	5.25
68B21	2.20
6829	12.50
6840	3.75
68B40	6.00
6850	1.60
68B50	2.50
6852	2.50
6854	6.50
68B54	8.00
6875	5.00
8154	8.50
8155	3.80
8156	3.80
8205	2.25
8212	2.20
8216	1.60
8224	P.A.O.
8226	4.25
8228	4.50
8243	2.60
8250	9.50
8251A	3.25
8253C-5	3.50
8255AC-5	3.00
8256	18.00
8256	24.00
8257C-5	4.00
8259C-5	4.00
8271	P.O.A.
8275	29.00
8279C-5	4.80
8284	4.60
8282	4.50
8283	4.00
8287	4.25
8288D	11.00
87755A	18.00
TMS9903	25.00
TMS9911	18.00
TMS9911	14.00
Z80B10	5.00
Z80P10	2.50
Z80CTC	2.50
Z80ACTC	2.75
Z80DART	6.50
Z80ADART	7.00
Z80DMA	7.00
TMS4500	14.00
TMS9901	5.00
TMS9902	5.00
Z80ADMA	7.50
Z80ASIO	7.00

MEMORIES

2016-150	4.00
2101	4.00
2102	2.50
2107B	5.00
2111A-35	4.00
2114-3	2.50
2147	4.00
4027-3	3.00
4116-15	2.00
4116-20	1.50
4118-3	5.00
41256-20	10.00
4164-15T	15.00
4164-15	3.00
4164-20	3.00
4416-15	4.00
4532-20	2.50
4816AP-3	2.00
5101	3.70
5514	4.50
5516	5.50
6116P-3	3.50
6116LP-3	4.00
6264P-15	22.00
6264LP-15	€6.00
6810	1.60
74S189	2.25
74S201	3.50
74S289	2.25
93415	6.00
93L422	9.50
93425	6.00

PROMs

28L22	4.00
24S10	2.50
18S030	2.00
18SA030	2.00
74S188	1.80
74S287	2.25
74S288	1.80
74S387	2.25
82S23	1.50
82S123	1.50
82S129	1.75

EE PROM

2816-30 2K×8	30.00
9306 256 bits (16×16)	4.50

EPROMs

2516+5V	3.50
2516–35	5.50
2532	4.50
2532	5.50
2564	8.00
2708	4.00
2716+ 5V	3.50
2716–35	5.50
2732	4.50
2732A–2	9.00
2732A–30	6.00
2732A-35	5.00
2764–25	2.60
27256–30	54.00
27256–25	60.00
27C64-25	10.00
27128–25	5.00
27128–30	8.00
27256-25	36.00
TMS2716	5.00

CRT CONTROLLER

CRT5027	18.00
CRT5037	12.00
CRT6545	9.00
EF9364	8.00
EF9365	25.00
EF9366	25.00
EF9367	36.00
MC6845	6.50
MC6845SP	6.50
MC6847	6.50
SFF96364	8.00
TMS9918	15.00
TMS9928	10.00
TMS9929	10.00

INTERFACE ICs

AD7581	15.00
ADC0808	12.00
AD561J	20.00
AM25S10	3.50
AM25LS2521	3.50
AM25LS2538	3.50
AM26LS31	1.20
AM26LS32	1.20
AM7910DC	25.00
DAC80-CB1-V	28.00
DM8131	6.00
DP8304	3.50
DS3691	3.50
DS8830	1.40
DS8831	1.50
DS8832	1.50
DS8833	2.25
DS8836	1.50
DS8838	2.25
D7002	6.00
MC1488	0.60
MC1489	0.60
MC3446	2.50
MC3459	4.50
MCS3470	4.75
MC3480	8.50
MC3486	2.25
MC3487	2.25
MC4024	5.50
MC4044	5.50
MC14411	9.00
MC14412	7.50
75107	0.90
75108	0.90
75109	1.20
75110	0.90
75112	1.60
75113	1.20
75114	1.40
75115	1.40
75121	1.40
75122	1.40
75150P	1.20
75154	1.20
75159	2.20
75160	5.00
75161	3.50
75162	4.00
75172	3.00
75182	0.90
75188	0.60
75189	0.60
75365	1.50
75450	0.80
75451	0.50
75452	0.50
75453	0.70
75454	0.70
75480	1.50
75491	0.65
75492	0.65
8T26	1.20
8T28	1.20
8T95	1.20
8T96	1.20
8T97	1.20
8T98	1.20
81LS95	1.40
81LS96	1.40
81LS97	1.40
81LS98	1.40
88LS120	3.00
9602	3.00
9636A	1.60
9637AP	1.60
9638	2.00

DISC CONTROLLER ICs

6843	8.00
8271	P.O.A.
8272	20.00
FD1771	20.00
FD1791	20.00
FD1793	20.00
8272	13.00
FD1797	22.00
WD2793	27.00
WD2797	27.00
WD1691	15.00
WD2143	8.00

CHARACTER GENERATORS

RO32513UC	7.50
RO32513LC	7.00
SN74S262AN	10.00

KEYBOARD ENCODERs

AY52376	11.50
AY53600	7.50
74C922	5.00
74C923	6.00

BAUD RATE GENERATORS

MC14411	7.50
COM8116	6.50
4702B	7.50

UARTs

AY31015P	3.00
AY51013P	3.00
COM8017	3.00
IM6402	4.50

MODULATORS

6MHZ	3.75
8MHZ	4.50

SOUND & VISION

12MHZ	12.00

CRYSTALS

32 768KHZ	1.00
1 00MHz	2.70
1.8432MHz	2.25
2.00MHz	2.25
2 45760MHz(L)	2.00
2 45760Mhz(S)	2.50
2.5MHz	2.50
2.662MHz	1.75
3.276MHz	1.50
3 5795MHz	1.00
4.00MHz	1.50
4.194MHz	2.00
4.43MHz	1.00
4 608MHz	2.50
4 9152MHz	2.50
5 00MHz	1.50
5 068	1.75
6 00MHz	1.40
6 144MHz	1.40
7 00MHz	1.50
7 16MHz	1.75
8 00MHz	1.50
8 867MHz	1.75
10 00MHz	1.75
10 50MHz	2.50
10 70MHz	1.50
11 00MHz	3.00
12.00MHz	1.50
14.00MHz	1.75
14 31MHz	1.60
14.756	2.50
15 00MHz	2.00
16 00MHz	2.00
17.734	1.50
18 00MHz	1.50
18 432MHz	1.50
19 969MHz	1.50
20 000MHz	1.50
24 000MHz	1.75
48.000MHz	1.75
116MHz	2.50
PXO1000	12.00

REAL TIME CLOCK

MC6818P	4.00
M5817AN	9.90
MSM5832RS	3.50

TELETEXT DECODER

SAA5020	6.00
SAA5030	7.00
SAA5041	16.00
SAA5050	9.00

LOW PROFILE SOCKETS BY TI

8 pin	9p	18 pin	16p	24 pin	24p
14 pin	10p	20 pin	18p	28 pin	26p
16 pin	11p	22 pin	22p	40 pin	30p

WIRE WRAP SOCKETS BY TI

8 pin	30p	18 pin	50p	24 pin	75p
14 pin	42p	20 pin	66p	28 pin	100p
16 pin	45p	22 pin	75p	40 pin	130p

TURNED PIN LOW PROFILE SKTS.

8 pin	14 pin	16 pin	18 pin	20 pin	24 pin	28 pin	40 pin
25p	32p	36p	40p	45p	55p	65p	90p

TRANSISTORS

AD161 2	45p
BC107 8	18p
BC109C	20p
BC169C	18p
BC172	18p
BC177 8	30p
BC179	30p
BC182 3	15p
BC184	16p
BC187	30p
BC212 3	16p
BC214	18p
BC237	16p
BC327	16p
BC337	16p
BC338	16p
BC461	40p
BC477 8	36p
BC516 7	50p
BC547B	20p
BC548C	16p
BC549C	16p
BC557B	18p
BC559C	24p
BCY70	30p
BCY71	36p
BD131	75p
BD132	80p
BD135 6	40p
BD139	40p
BD140	40p
BD189	60p
BD232	60p
BD233	75p
BD235	85p
BD241	60p
BD242	60p
BD379	60p
BD380	60p
BD677	40p
BF244B	40p
BF256B	50p
BF257 8	40p
BF337	36p
BFR39	32p
BFR40 1	32p
BFR79	32p
BFR80 1	32p
BFR96	180p
BFX29	45p
BFX30	45p
BFX84 5	30p
BFX86 7	30p
BFX88	30p
BFY50	30p
BFY51 2	30p
BFY56	33p
BFY90	90p
BRY39	45p
BSX19 20	30p
BU104	225p
BU105	190p
BU108	250p
BU109	225p
BU126	150p
BU205	200p
BU208	200p
BU406	145p
BUX80	600p
BUY69C	350p
E310	50p
MJ413	250p
MJ802	400p
MJ2501	225p
MJ2955	90p
MJ3001	225p
MJ4502	400p
MJE340	60p
MJE2955	150p
MJE3055	120p
MPF102	40p
MPF103 4	40p
MPF105	40p
MPSA06	30p
MPSA12	50p
MPSA13	50p
MPSA20	50p
MPSA42	50p
MPSA43	50p
MPSA56	30p
MPSA70	50p
MPSA93	40p
MPSU06	63p
MPSU07	60p
MPSU45	90p
MPSU65	78p
TIP29A	35p
TIP29C	40p
TIP30A	35p
TIP30C	40p
TIP31A	40p
TIP31C	45p
TIP32A	45p
TIP32C	40p
TIP33A	70p
TIP33C	80p
TIP34A	90p
TIP34C	120p
TIP35A	120p
TIP35C	140p
TIP36A	140p
TIP36C	150p
TIP41A	50p
TIP41C	55p
TIP42A	60p
TIP42C	65p
TIP54	160p
TIP55	180p
TIP120	75p
TIP121	75p
TIP122	80p
TIP125	75p
TIP126	80p
TIP142	120p
TIP147	120p
TIP2955	90p
TIP3055	70p
TIS93	30p
VN10KM	50p
VN66AF	90p
VN88AF	£1
ZTX108	16p
ZTX300	18p
ZTX452	45p
ZTX500	20p
ZTX502	20p
ZTX504	22p
ZTX552	55p
ZTX652	60p
ZTX752	70p
2N697	35p
2N698	45p
2N706A	36p
2N708	36p
2N918	45p
2N930	30p
2N1131 2	50p
2N1613	36p
2N1711	36p
2N2102	70p
2N2160	350p
2N2219A	30p
2N2222A	30p
2N2369A	30p
2N2484	30p
2N2646	50p
2N2904 5	30p
2N2906A	30p
2N2907A	30p
2N2926	12p
2N3053	36p
2N3054	60p
2N3055	55p
2N3442	140p
2N3553	240p
2N3584	250p
2N3643 4	48p
2N3702/3	25p
2N3704/5	25p
2N3706/7	25p
2N3708	25p
2N3773	200p
2N3819	40p
2N3823	30p
2N3866	90p
2N3904	22p
2N3906	22p
2N4036	65p
2N4037	65p
2N4123 4	27p
2N4125/6	27p
2N4401 3	25p
2N4427	90p
2N4871	50p
2N5087	27p
2N5089	27p
2N5172	27p
2N5191	90p
2N5245	40p
2N5401	60p
2N5459	30p
2N5460	60p
2N5485	45p
2N5875	250p
2N5883	375p
2N6027	30p
2N6052	300p
2N6059	325p
2N6107	65p
2N6247	190p
2N6254	130p
2N6290	65p
2SC1306	100p
2SC1307	150p
2SC1957	90p
2SC1939	150p
2SC2028	80p
2SC2029	200p
2SC2078	160p
2SC2335	200p
2SC2612	200p
3N128	200p
3N140	200p
3N141	200p
3N201	200p
3N204	200p
40290	250p
40361 2	75p
40595	120p
40673	90p
40871/2	100p

DIODES

BY127	12p
BYX36300	20p
OA47	10p
OA90/91	9p
OA95	9p
OA200	9p
OA202	10p
1N914	4p
1N916	7p
1N4148	4p
1N4001/2	5p
1N4003/4	6p
1N4005	6p
1N4006/7	7p
1N5401/2	12p
1N5403/4	14p
1N5404/5	14p
1N5404/7	19p
IS920	9p

BRIDGE RECTIFIERS

1A 50V	19p
1A 100V	20p

1A 400V	25p
1A 600V	30p
2A 50V	30p
2A 100V	35p
2A 400V	45p
3A 200V	60p
3A 600V	72p
4A 100V	95p
4A 400V	100p
6A 50V	80p
6A 100V	100p
6A 400V	120p
10A 400V	200p
25A 400V	400p

TRIACS PLASTIC

3A400V	60p
6A400V	70p
6A500V	88p
8A400V	75p
8A500V	95p
12A400V	85p
12A500V	105p
16A400V	220p
16A500V	130p
T2800D	130p
TIC206D	60p
TIC226D	75p
TIC246D	110p

THYRISTORS

3A400V	45p
8A600V	180p
12A400V	160p
16A100V	180p
16A400V	180p
C106D	45p
MCR101	36p
2N3525	130p
2N4444	180p
2N5060	30p
2N5061	32p
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CIRCLE 94 FOR FURTHER DETAILS.

by Martin Allard
B.Sc.(Hons)

Electronic mailbox

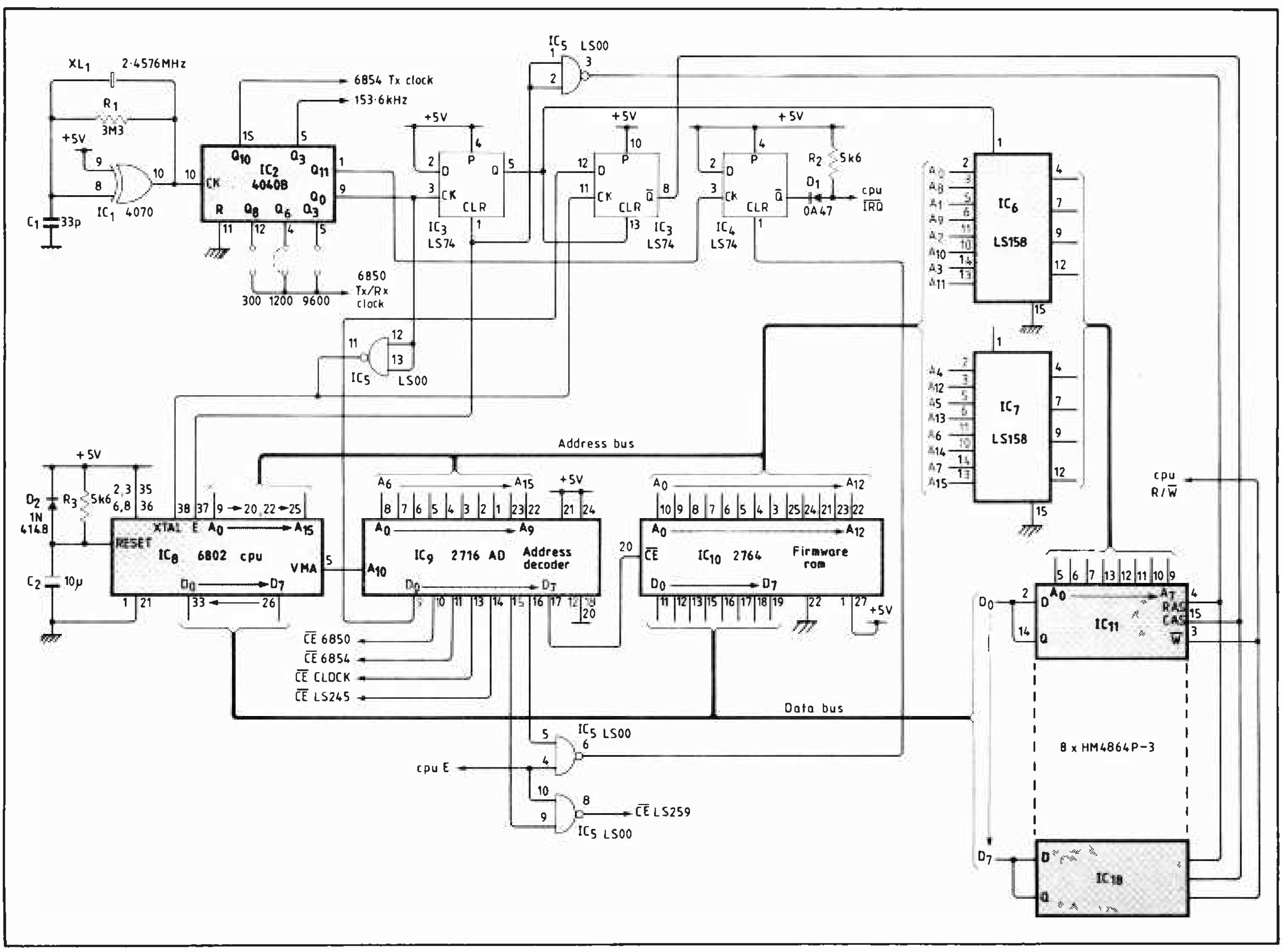
Circuits are the subject of this second article describing a self-contained electronic message system. Included in the microprocessor-based hardware is a novel digital modem design using a rom and latch.

Calls can be set up in a number of ways, but in all cases both a terminal circuit and a two-way mail circuit are opened, and any pending mail will be passed. There is a connect-to-line switch and a corresponding disconnect switch on the panel of the equipment. These are useful only if a call has been made manually and it is required to switch the systems to line without issuing a command from a terminal.

The 'o' command does the same thing. A connection will be established automatically by use of the 'c' command followed by a node name or a telephone number. A connection can be closed by typing ‹control-p› followed by 'c'. When mail is sent first class the call will be placed at once, but if one attempt fails the message will be reassigned as overnight mail.

It is central to the philosophy of this system that it does not interfere with normal use of the telephone. Considerable thought went into ways of achieving an economical and efficient service with no important disadvantages.

The solution is based on the use of a battery-backed real time clock in each node. Because it is essential that these should always be in step, they are left on GMT. When the telephone rings during normal hours, the mail system allows it to ring 20 times (about one minute) to give a reasonable opportunity for it to be



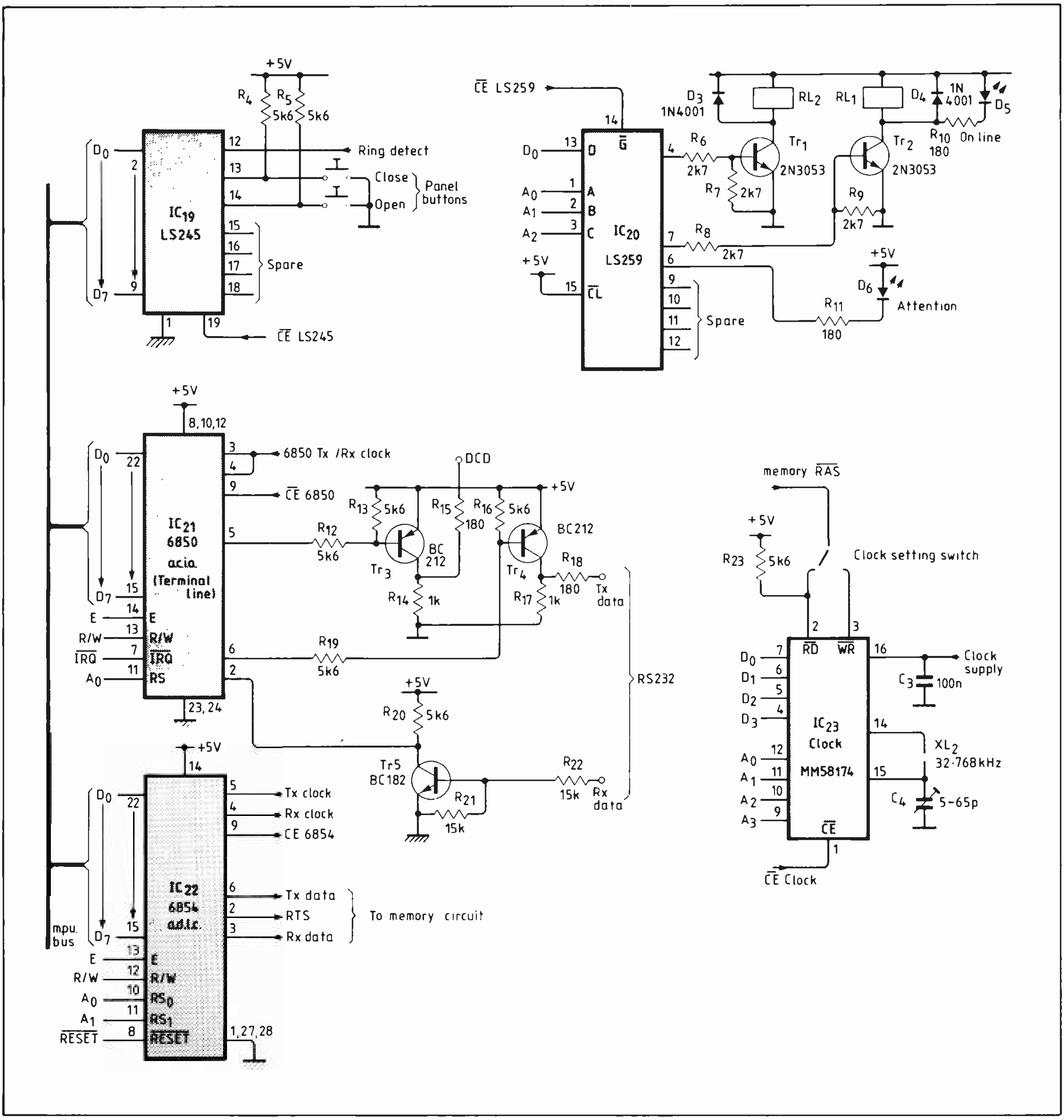
Processor section. An eprom address decoder is used to reduce the number of components.

answered if there is anybody at home, before answering itself.

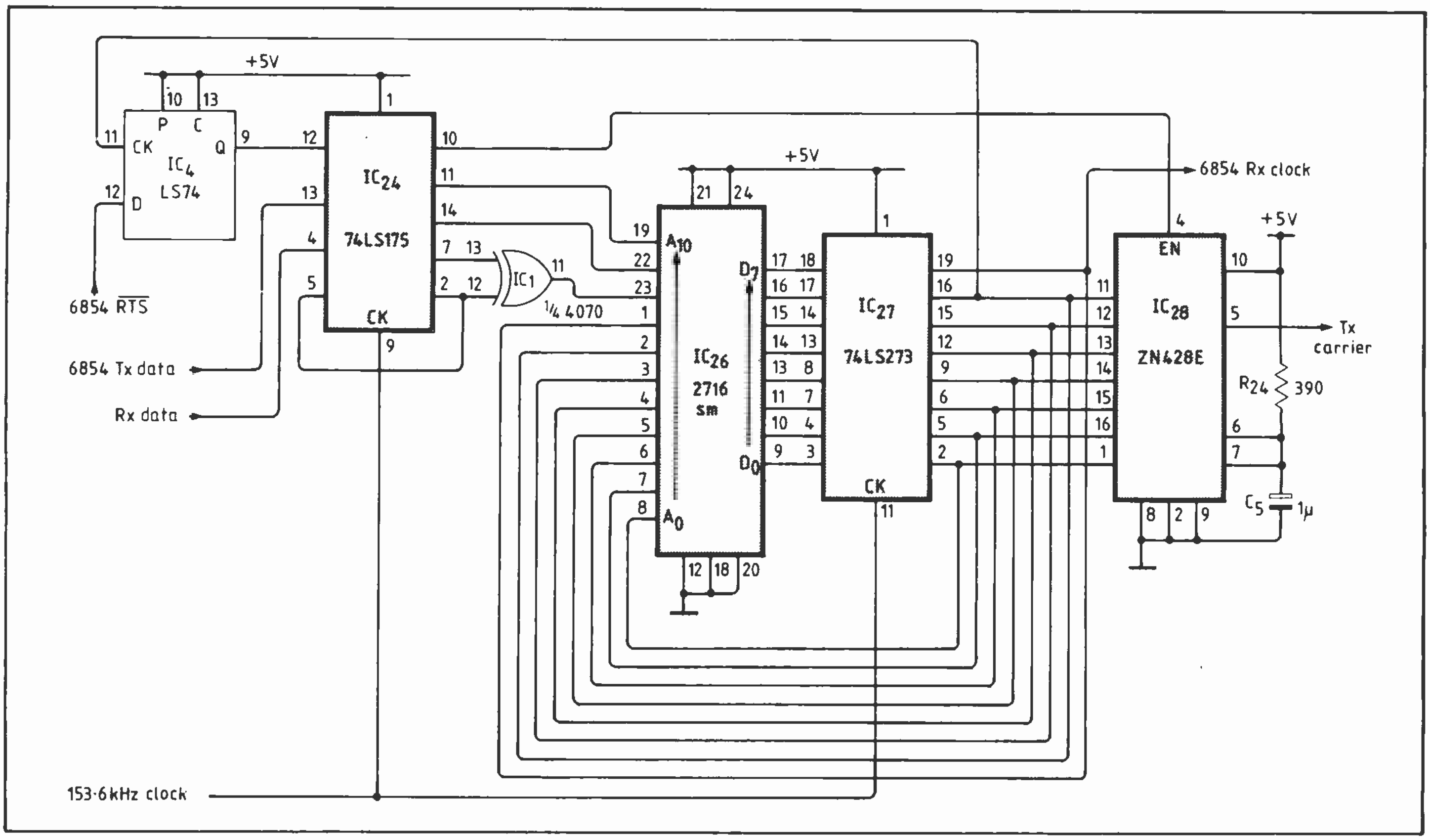
In order to take advantage of cheap rate telephone calls for non-urgent mail, this is sent at night. It is assumed that not many ordinary telephone calls are received between the hours of 4 and 5 a.m., so this period is used for mail transmission. To ensure that sleep is not disturbed, the mail system answers any call received in this hour immediately, within the first cycle of ringing current, and the telephone bell makes little or no sound.

Each node that has second-class mail to send starts making calls soon after 4 a.m. In order to reduce the risk of calls from two nodes to each other being attempted at the same moment and hence colliding, the first call is made at a random number of minutes past the hour, and further attempts are made at random intervals until 5 a.m. When this program was first written, it was with some dismay that I realized that I could only debug the code by staying up all night!

Not only is this arrangement compatible with normal use of the telephone, but it is also possible to leave an answering machine connected to the same line and still allow electronic mail to be received in the overnight mode as well. This feature relies on the fact that most telephone answering machines do not respond for



Digital interfaces. The asynchronous communications interface adaptor, a.c.i.a., is for data going to and from the computer or terminal used to enter the messages. A second serial interface device, the 6854 advanced data-link controller, is for modem communications. Time in seconds to leap years is counted by the 58174 clock.



The modem circuit includes a rom containing sinewave values. Each value in the rom represents not only the level of a sample to be sent to the 428 d-to-a converter but also the address of the next value in the eprom. Notice that the eprom data lines feed the eprom address lines through a latch.

at least two rings. This means that the machine will reply during the day, but the mail system will get there first during its own special hour.

Hardware

The MC6802 microprocessor used has the virtue of being cheap, and it is quite powerful enough for this application. If I were to start the project again I would use a more advanced processor just to make the program development easier, but now that the program exists (39 pages of assembly language) this is not an issue.

To reduce the amount of logic required, an eprom is used as an address decoder. The 64Kbytes of dynamic ram is refreshed every 2ms simply by an interrupt service routine containing 128 consecutive 'no-operation' instructions. Interrupts are also used for the terminal input, but terminal output and the line protocol are handled without them, using a simple form of process scheduling which has the side effect of generating random numbers.

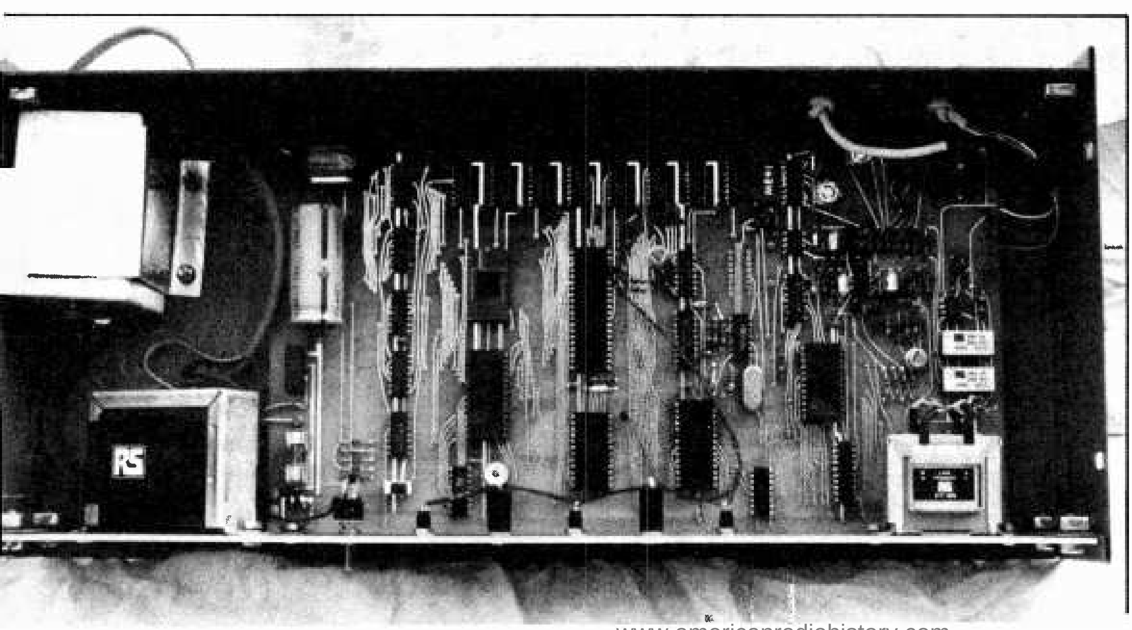
Apart from the real-time clock, which runs from its own 32.768kHz quartz crystal, all timings on the card are derived from a single 2.4576MHz crystal. This includes the processor clock, the line and terminal interface data rates, and the modem tones.

The real-time clock is operated from a small float-charged NiCd battery with an endurance of several weeks without power. This avoids the tedious task of resetting the clock when the system is moved. An internal switch must be operated to allow the clock to be set. Four spare inputs and four spare outputs are brought to a socket for future accessories.

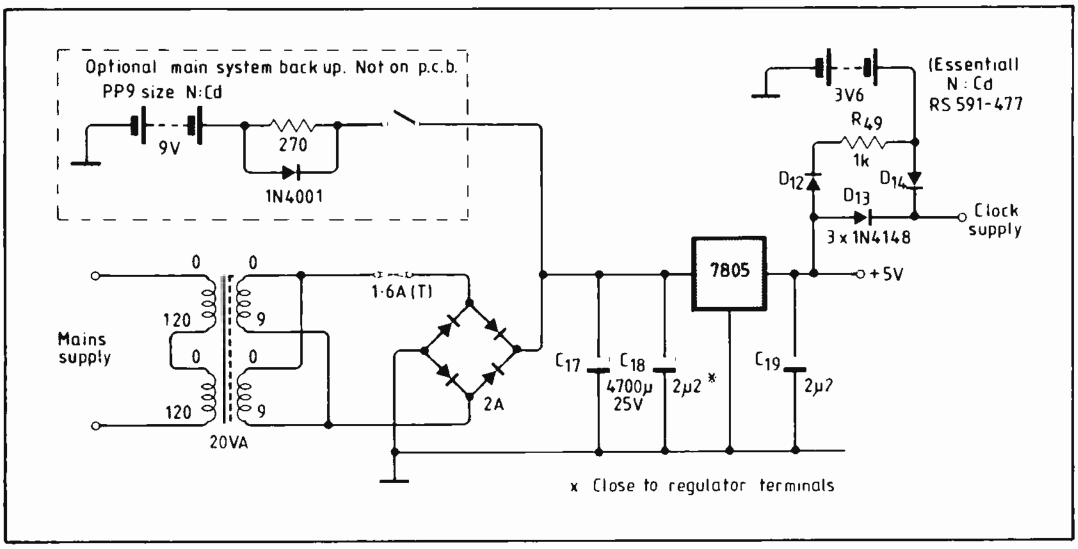
The mailbox is of course designed to be continuously powered. Three leds are fitted to the front panel; a green power indicator, a yellow one indicating line connection, and a red led marked attention. This attention led flashes when there is incoming mail which has not yet been read, and also if there has been a power failure since the mailbox was last used. It has a further function in that it comes on when a connection is made, and goes out as soon as the transport protocol has been established — a useful confirmation that the link is operating.

The heart of the modem is a finite-state machine with two purposes, consisting of a rom and a clocked latch, which is used in both transmit and receive modes. When transmitting, in conjunction with a d-to-a converter the state machine becomes a phase-continuous sinewave f.s.k. generator.

Consider the case of the transmitted data being continuously in



Both batteries and the power supply can be seen on the left of this prototype. Line interfacing is on the right and the processor/memory in the centre.



Two backup batteries are used in the power supply, one for the real-time clock and a larger one for powering the whole system for about 90 minutes in the event of a mains failure.

one state, so that a steady tone is produced. Each entry in the rom represents the level of the next sample to be output by the d-to-a converter in order to follow a sinewave at this tone frequency. This number is also used as the address in the rom of the next entry to be used. Unused addresses are filled with copies of the last valid entry in the addressing sequence. So if the latch starts with an arbitrary number, it will conform to the sequence within a clock period.

Since the same values will occur in both the ascending and descending half cycles it is necessary for an extra bit representing the half-cycle polarity to be used in the state machine but not taken to the converter. It is also essential that each sample is a different value, otherwise the machine would get stuck. In practice this necessitates a one-sample departure from the sine shape at the peaks of the cycle, which is easily removed by a subsequent RC filter.

When the data stream changes to the other state, it switches the rom address into a section containing a corresponding sinewave pattern for the other tone frequency. The starting point in this pattern is the voltage level and half-cycle polarity at which the first tone was interrupted, so any discontinuity is limited to the difference between two adjacent samples in the new tone sequence.

Use of a clock frequency of 153.6kHz permits the CCITT V23 standard tones of 1300Hz and 2100Hz to be reproduced to seven-bit accuracy with a frequency tolerance of 4Hz. The RTS signal from the h.d.l.c. serial interface i.c. is used to switch the direction of the half-duplex link. To avoid generating switching transients on the line it is arranged that the transmit tone always starts and ends on a zero-crossing point.

The receive side of the modem starts with a limiter, followed by a pulse generator and a pulse-counting discriminator. Where are the filters, you may well ask? Well there aren't any, and it works remarkably well. It is essential to preserve symmetry of the zero crossings through the limiter whatever the received signal level. Various experiments with multi-stage limiters led to the conclusion that the best approach was to use just one stage and to maximise its sensitivity by balancing out its offset.

After the limiter, a circuit using an exclusive-or gate generates pulses on both edges of the waveform. These are used to trigger a precision non-retriggerable monostable i.c., the pulse train from which is integrated and then sliced. The maximum data frequency is 600Hz, and it does not take an elaborate filter to separate the 1300Hz tone from this to an adequate extent.

The receiver clock-recovery system consists of the same state machine used in a different mode without the d-to-a converter. When there are no transitions in the incoming data stream the state machine 'free runs' and generates a simple incrementing count at the 1200Hz data rate, the most significant bit of which is used as the receiver clock.

Each transistion is detected by a circuit comprising a one clock-cycle latch delay and an exclusive-or gate. For one cycle following each data transition the rom address is changed to point into a table of numbers corresponding to the locking characteristics of a phase-locked loop. The amount by which the normal count sequence will be disturbed is determined by the contents of the entry accessed in this table. So if the loop happens to be in exact phase with the data stream there will be no change to the sequence, but otherwise the count will be altered by an amount proportional to the phase error. The exact characteristic is a compromise between noise immunity and a reasonably short worst-case locking time.

The interface to the telephone line (circuit follows in next article) is designed to comply with the requirements of BS6320, but it should be pointed out that approval cannot be given to a design, only to a complete apparatus. Shunt relay RL_2 is used to suppress bell tinkle at the opening and closure of a connection as well as during dialling. Transients on a telephone line can be substantial, and it is important that the line wiring is led straight out of the cabinet. The only operational problems experienced with the system have been traced to the line wires running too close to the 64K rams, with the result that the processor crashed during dialling.

Operation of the mail system is dependent upon the clocks remaining within a few minutes of each other. For this reason a float-charged NiCd battery is essential for the clock supply. Rather than making provision for the protection of memory in the event of a power failure, it is simpler to provide battery backup for the whole system, since it runs from one +5V supply.

The circuit shown is capable of sustaining full operation for about 90 minutes without mains. Whether it is needed or not depends upon local conditions, but power cuts of one or two seconds during the night are surprisingly frequent even in cities.

Because of the single +5V supply the terminal output levels are not strictly RS232. A voltage converter could be added to provide the correct rails, but there is a tacit understanding between designers of many pieces of equipment today that this is not worthwhile. Any terminal using an MC1489 or similar device as a line receiver will function correctly, and I have yet to find a terminal which fails to operate with these levels.

Construction and uses of the system are discussed in the next article.

Sampled data servos – a new analysis

by D.M. Taub, M.Sc., Ph.D.

Final instalment calculates response within the continuous-signal portion of the loop.

The method explained in July's article can be used to find the sample values at X (Fig. 21) which represents the input to the continuous-signal portion of the loop. Knowing the signal at this point it is straightforward to calculate the signal at other points in the continuous-signal portion, particularly the input and output signals of the plant at C and D respectively.

One way of making the calculation is to use the Fourier transform. If the samples at X at successive sampling instants have the values x(0), x(1), x(2) etc., this signal can be expressed in terms of frequency by taking its Fourier transform as follows (ref. 5, section 4.3):

$$X(j\omega) = x(0) + x(1)e^{-jT\omega} + x(2)e^{-j2T\omega} + \ldots$$

Suppose we are calculating the signal at D. The gain between X and D is the product of the hold-circuit gain $H_{XA}(j\omega)$ given by equation 3.2, the gain associated with the time delay $H_{AB}(j\omega)$ given by equation 4.1, the gain of any continuous-signal compensation $H_{BC}(j\omega)$, and the gain of the plant $H_{CD}(j\omega)$. Calling the overall gain between X and D $H_{XD}(j\omega)$ the signal at D as a function of frequency will be

$$D(j\omega) = X(j\omega).H_{XD}(j\omega) \quad \ldots 6.1$$

The corresponding time function d(t) is found by taking the inverse Fourier transform of $D(j\omega)$:

$$d(t) = \frac{1}{2\pi}\int_{-\infty}^{\infty} D(j\omega)\, e^{jt\omega} d\omega \ldots 6.2$$

(ref. 5, section 3.3). Unfortunately this method cannot be used under all circumstances, in particular when the output signal contains a d.c. component. The reason is that the plant will generally contain at least one stage of integration, so that its zero-frequency gain will be infinite; also the zero-frequency component of the signal at X will generally be zero. Therefore, applying equation 6.1 at $\omega = 0$ involves multiplying 0 by ∞, which gives an indeterminate result.

One way of overcoming the difficulty is to find the d.c. component of the output otherwise than through equation 6:1; for instance, we know that the d.c. component at D will be the same as at the input R. A more general way, however, is to use the Laplace transform instead of the Fourier transform. It is worth digressing for a moment to explain the difference between the two.

The Fourier transform of a signal represents that signal as a function of frequency; that is to say, the signal is regarded as the sum of a large number (ideally infinite) of sinusoids each of which has a constant peak value. With the Laplace transform, on the other hand, the signal is expressed as a function of complex frequency s, where s has a real part σ and an imaginary part $j\omega$. The signal can now be looked on as the sum of a large number (again ideally infinite) of sinusoids whose peak values are changing exponentially with time as shown in Fig. 30. The interesting feature here is that there is an infinite number of ways in which a given signal can be built up from components of this kind.

Consideration of the complex-frequency plane (Fig. 31) makes this point clearer. The Fourier transform of a signal represents that signal as a function of points along the $j\omega$-axis: at each point along this axis the function will have some value $D(j\omega)$ which will in general be complex.

To convert this back to a function of time, we apply equation 6.2 which can equally well be written

$$d(t) = \frac{1}{j2\pi}\int_{-\infty}^{\infty} D(j\omega)\, e^{jt\omega}\, dj\omega \quad \ldots 6.3$$

in other words, integrating the product $D(j\omega).e^{jt\omega}$ along the $j\omega$-axis.

The Laplace transform of a signal, on the other hand, represents it as a function of all points on the s-plane; at every point s, the function will have some value D(s), which will again be complex. These points of course include the $j\omega$-axis, and so in a sense the Laplace transform contains the Fourier transform within it.

To convert the signal back to a time function we apply the inverse transformation:

$$d(t) = \frac{1}{j2\pi}\int_{-\infty}^{\infty} D(s).e^{ts}ds \quad \ldots 6.4$$

This is very like the inverse Fourier transform, 6.3, except that the path of integration is no longer confined to the $j\omega$-axis. The path has to conform to certain conditions (see ref. 8, chapters 5 and 7), but even within these conditions the number of permissible alternatives is infinite. The path chosen determines the particular elements that are added to form the time function;

Fig.31. Path of integration in the s-plane.

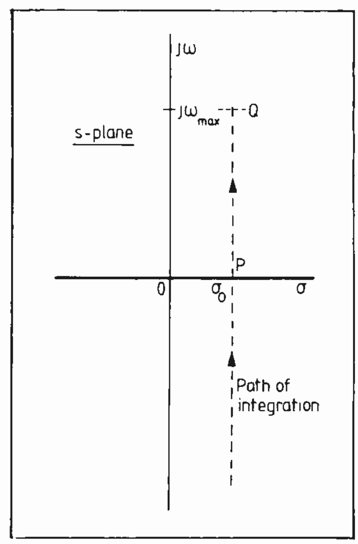


Fig.30. Exponentially decreasing and increasing sinusoids

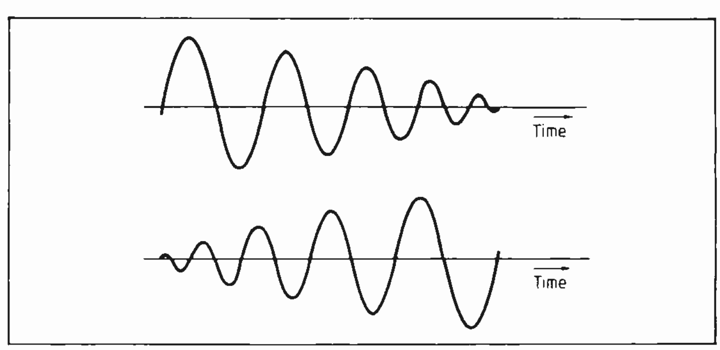


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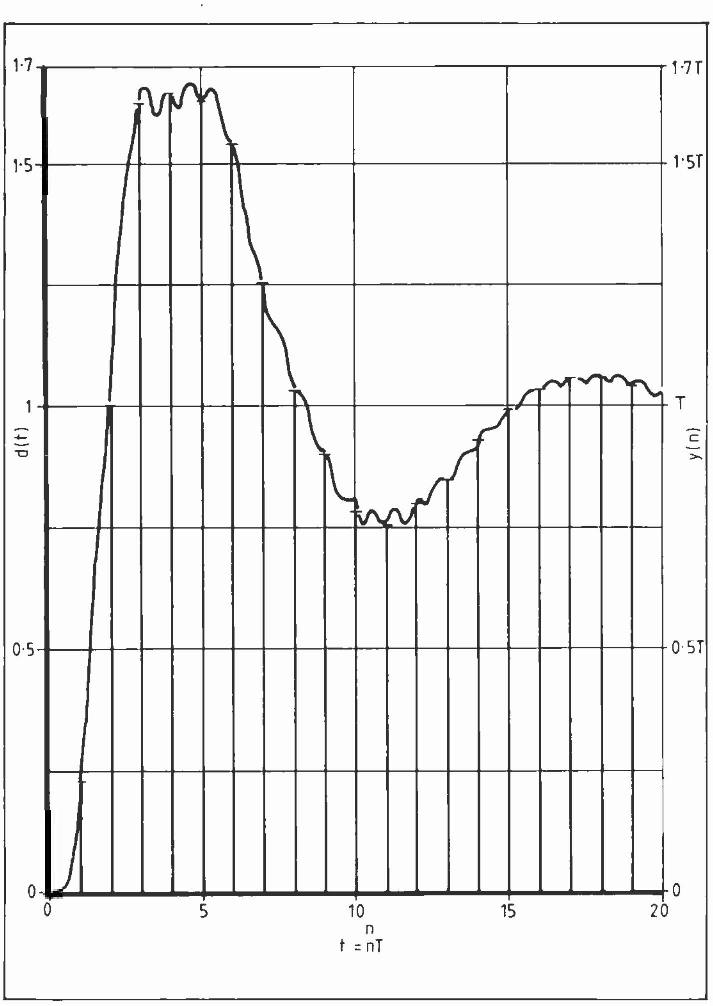
Fig.32. Response at D and Y to step function input.



we could choose a different path, implying that different elements are being added, but the result would be the same.

Now to return to the practicalities of computing the plant output d(t), the same general considerations applying also to the plant input c(t). As regards the path through the s-plane it is permissible, and convenient from a computational point of view, to choose a path parallel to the $j\omega$-axis and lying to its right. The real part of s is thus held constant at a positive value σ_0, as shown by the dashed line in Fig. 31. Strictly, the integration in equation 6.4 should be carried out for values of s between $\sigma_0 - j\infty$ and $\sigma_0 + j\infty$, but in practice D(s) falls to such a low value when the imaginary part of s exceeds 2 or 3 times $j\omega_s$, that the integration can be truncated. The value of ω at which it is truncated is denoted by ω_{max}.

A further point concerning the integration in (6.3) is that values of the integrand at equal distances above and below the real axis are the complex conjugates of one another. Therefore, instead of integrating between $\sigma_0 - j\omega_{max}$ and $\sigma_0 + j\omega_{max}$, we need only cover the region $\sigma_0 + j0$ to $\sigma_0 + j\omega_{max}$ as follows:

$$d(t) = \frac{1}{j2\pi}\int_{\sigma_0 + j0}^{\sigma_0 + j\omega}\{\, D(s).e^{ts} + $$

$$+ \text{conj}\,[D(s).e^{ts}]\,\}\,ds$$

When a complex quantity is added to its conjugate, the imaginary parts cancel and we are left with twice the real part. The integration therefore becomes

$$d(t) = \frac{1}{j\pi}\int_{\sigma_0 + j0}^{\sigma_0 + j\omega} \text{Real}\,[\,D(s).e^{ts}\,]\,ds \qquad \ldots 6.5$$

Procedure for computing d(t)

1. A set of points is chosen equally spaced δs apart along the line PQ in Fig. 31. These points represent the values of s at which the computation will be carried out; the closer the spacing, the more accurate the result. Choice of $_0$ is a compromise. Making it too small introduces errors in the integration of equation 6.5 because of the rapid variation of D(s) with s near the real axis, while making it too large introduces errors at large values of t because the terms being added in the integration are increasing rapidly with time. A good compromise is to make σ_0 numerically equal to 3 times δs.
2. $H_{XD}(s)$ is computed for all the above values of s. This is the product of the hold-circuit gain $H_{XA}(s)$ given by equation 3.1, the gain of the time delay, $H_{AB}(s)$, $(= e^{-s\Delta\tau})$, and the gains of any continuous-signal compensation and the plant, $H_{BC}(s)$ and $H_{CD}(s)$ respectively.
3. The Laplace transform of x(t) is computed from the expression (ref. 5, section 4.3)

$$X(s) = x(0) + x(1)e^{-Ts} +$$
$$+ x(2)e^{-2Ts} + \ldots + x(n)e^{-nTs}$$

X(s) is a periodic function like $X(j\omega)$, and so there is no need to apply this at all the chosen values of s. It is applied at the values from $\sigma_0 + j0$ to $\sigma_0 + j\omega_s/2$, and the remainder of the function obtained as explained in the April article, page 58.
4. Corresponding values of X(s) and $H_{XD}(s)$ are multiplied together to give D(s) at the chosen values of s.
5. Equation 6.5 is applied at the desired values of t, to give the time function d(t).

Example

The procedure has been applied to the system used in the earlier examples (in the June and July issues). ω_{max} was set at 3ω, δs at $j\omega/50$ and σ_0 at $3\omega_s/50$. The input to the system (point R in Fig. 21) was assumed to be a step function of unit height, so that, bearing in mind the properties of the sampler (April article), the sample values at U will be equal to the sampling period T, as they were in the July example. d(t) was computed at intervals of T/5, giving the time response plotted in Fig. 32. Also shown in this Figure, for comparison, are the sample values at Y copied from Fig. 28. The effect of the 2750Hz plant resonance can be clearly seen; also, the values of d(t) at the sampling instants and the sample values at Y are seen to correspond closely, confirming the accuracy of the method. The relevant programs are presented in ref. 9.

Software availability

These articles have developed a way of analysing linear sampled-data servos based on theory and concepts with which electrical engineers will be familiar, and are complemented by programs in a companion paper [ref. 9]; readers may find them useful in the development of sampled-data servos generally. They are available from the author at IBM UK Laboratories Ltd, Hursley Park, Winchester, Hampshire.

Corrections

Part2 equations, April. The upper-case phi (Φ) is to be taken as the lower-case form (φ), to agree with the text. But in Fig.6 caption please substitute zero for phi. In the appendix, 'Sampled cosine wave:' should be inserted prior to equation U2.6.

Part 4 appendix, June, should show the variables as $(j\omega)$ and $(m\omega_s + \omega_0)$ respectively.

Part 5. The left-hand side of equation 5.6, accidently ommitted, should be $H_{UY}(z)=$, and the greek characters gamma and xi should have been shown as multipliers and not as superscripts in this and equations 5.7 and 5.8. In the expression for y(n) on page 61 please substitute u for v and for the word 'points' in column 3 please read 'poles'.

by J.C. Kanaar

Bubble memory interface

This three-i.c. interface allows a 128Kbyte bubble memory kit to run on SC84's Z80 bus. Being non-volatile, wear-free and suitable for use in hostile environments, bubble memory is an alternative to disc storage in many applications.

Bubble memories have been around since the late sixties but prices have precluded their use by many. Their main attraction is their non-volatility, but bubble memories also have no moving parts and offer immunity to hostile environments (dust and vibration). Articles appear from time to time outlining operation and applications of these memories[1] but very little practical information is published.

A bubble memory requires quite complex support circuits, as Fig. 1 shows, and because low-level signals are in close proximity to high-level drive signals, careful design of circuit boards is required. These problems are overcome by using a prototyping kit from Intel known as the BPK72A. This is a 1Mbit unit, i.e. 128Kbyte, designed to operate at ambient temperatures between 15 and 35°C. Its cost is about the same as that of a double-sided 5¼in disc drive.

The kit comes with a wealth of information about bubble memories, starting with a primer on the subject[2] and progressing through the operation of all parts of the support circuits. Design considerations for multiple bubble-memory units and their printed circuit boards are also included. In the past this was a true kit which the buyer had to build and test but it now comes completely assembled and tested, although the useful assembly instructions are still included.

Interfacing to a microprocessor, information for which is supplied in the kit, requires a few additional components depending on which data-transfer method is chosen. Data transfer can be carried out through direct memory access, which requires use of a separate controller, or by using interrupt or polling systems.

The easiest to implement of these three methods — the method used here — is polling which relies entirely on software to control data transfer. Only a simpl hardware interface to SC84 is needed to decode two i/o ports and provide switching and buffering for the data lines. Operation of the bubble memory unit as an SC84 peripheral is transparent to the user because of the support circuits and operating program.

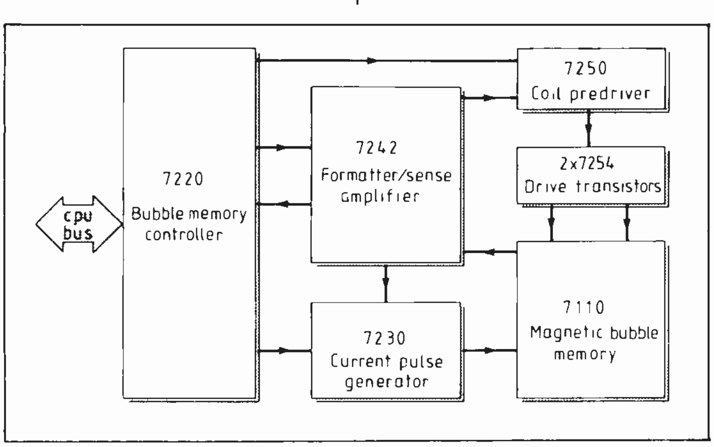


Fig. 1. **Elements of the 128Kbyte bubble-memory kit. Data passes to and from the computer through a simple parallel interface, Fig. 2, mainly under control of software within the computer. Data inside the bubble memory unit is transferred in serial form using what is called a major-track/minor-loop architecture — hence the need for controlling and formatting circuits.**

Bubble memory communication

All communication with the bubble memory is carried out through the 7220 bubble-memory controller which has one 8bit bidirectional port allowing access to internal registers. One port address line is used to select either command/status or parameter/data registers. Instructions to initialize, read and write data to and from bubble memory are issued by the command register; information about the execution of commands and the state of the controller is provided by the status register.

The parameter registers are used to determine how the controller will respond to these commands, i.e. the amount of data to be transferred, if error correction is to be applied and which bubble memory to use. The data register is a first-in-first-out data buffer used in conjunction with the 8bit port to transfer data to and from the bubble memory. It is necessary in order to reconcile timing differences between the parallel data transfer used by the microprocessor and the serial data transfer employed in the bubble memory.

In the 7110 bubble memory, a 'major-track/minor-loop' architecture is used in which magnetic bubbles are propagated along the major input and output tracks and are stored in minor loops. This design gives good manufacturing yields and permits creation of redundant storage loops. Defective loops are detected during manufacture; one loop, called the boot loop, is used to store a record of the usable loops.

During read operations, low-level signals from the bubble detectors are amplified by the 7242 formatter/sense amplifier. During write operations, this amplifier supplies control signals to the current-pulse generator. It also formats data passing between the controller and memory, handles error correction if instructed and arranges storage in usable loops of the memory by reference to the boot loop information.

The 7230 current-pulse generator is controlled by the formatter/amplifier during write operations and sends current pulses to the memory to generate magnetic bubbles with the aid of timing signals supplied by the controller. Power supply monitors are included to carry out an orderly shutdown without loss of data if either supply falls below a certain threshold level.

Current required to form the magnetic field responsible for moving the bubbles is supplied by the 7250 coil predriver and 7254 v-mos drive transistors under control of the controller and formatter/amplifier.

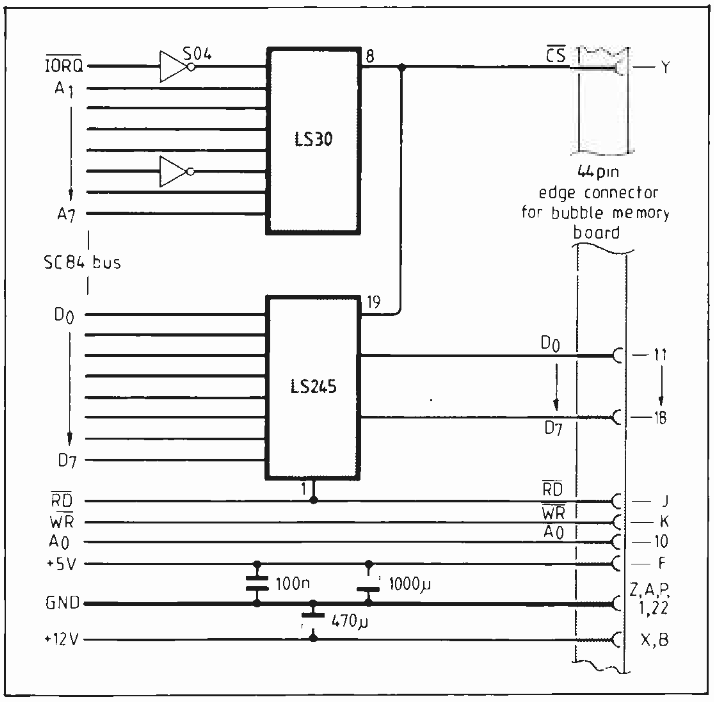


Fig. 2. Complete bubble-memory unit interface consisting of i/o port decoding and a bidirectional data buffer. Using a polling technique allows the interface to remain simple.

Interface circuit

Figure two shows the circuit for linking SC84 to the bubble memory unit. Unfortunately, the memory unit is too large to be mounted conveniently on a single Eurocard but it can be mounted horizontally if space is available. I used a piece of 150mm^2 Veroboard to mount the memory unit connector and interface i.cs. This board plugs into a connector supplying the necessary bus signals mounted horizontally above the SC84 boards.

Since the kit is built and tested, any problems that you encounter will probably be due to timing or interface circuit malfunctions. Using a 4MHz clock in the SC84 should not present any problems. There are enough instructions in the kit to allow you to write programs for verifying that it is possible to write and read to and from the bubble memory. This should be done first.

Having reached this stage you will have to determine how the memory unit is to be used. Mounted in a pluggable container it could form part of a remote data acquisition system. The memory unit containing information would then be transferred to the computer for data processing. Alternatively, a number of memory units could be used instead of disc drives in a compact portable system.

My computer uses disc drives and so I decided to incorporate the memory into the disc operating system, designating it unit 'D'. Again, there is enough information in the literature to allow a bubble driver program to be assembled in Z80 code.

The software consists of a bubble-memory installation program, used at the start of every disc boot, which is patched into the operating system cold-start address. Subroutines are used for loading the parameter registers, resetting the first-in-first-out memory and for bubble-memory reading/writing.

Space is also required for patching the existing disc functions. Some functions are not required by the bubble memory and Read and Write Disc functions need to transfer operation to the appropriate bubble memory when unit 'D' is called. Before either of these functions takes place, it is necessary to convert the track and sector number to a bubble-memory page number and place it in the parameter block. This is simplified by using the bubble memory in error correction mode. In this mode each page contains 64 bytes which multiplies easily into the existing operating system's 512 byte sectors.

After allowing for some error messages in the event of a failure in the bubble-memory system, the additional code was incorporated in the disc operating system so that it loads from DD00 to E000 when the disc is booted. One point to bear in mind if this path is followed is that the bubble memory should be loaded with E5. The operating system will produce some irregular output if the directory area is not so loaded.

John Kanaar is a keen electronics enthusiast with a C&G Full Technological Certificate earned through a correspondence course. He enjoys building circuits most — he started constructing just after the war when most of the effort was in making holes for valve holders and avoiding lethal operating voltages. An interest in RTTY led to his study of computers. At work, John is involved with administration and accounts in the food industry.

Copies of the author's machine-code can be obtained by sending a large s.a.e. to our editorial offices. Please mark your outgoing envelope with bubbles.

Rapid Recall Ltd. is offering the BPK72A bubble-memory evaluation kit to *E&WW* readers at special price of £126 excluding v.a.t. To take advantage of this offer, fill in the coupon on page 92.

References

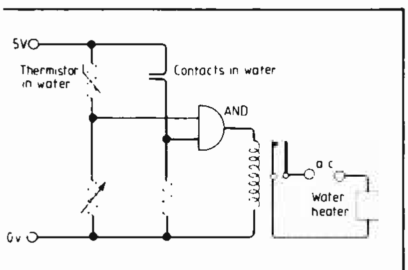
1. A review of magnetic bubble memories and their applications, K.F. Baker, *The Radio and Electronic Engineer*, March 1981.
2. Memory components handbook, Intel Corporation, 306 Bowers Avenue, Santa Clara, CA95051, USA.

SAFETY LAST

The Midland Examining Group, which includes some very senior exam boards, has recently produced its syllabus for the new GCSE physics exam. The section dealing with electronics first establishes that the thermistor shown below is of the usual negtempco variety (p. 30). Indeed, no other type is discussed. Then the following is offered, as a safety-conscious circuit for a water heater.

If there is no water, the contacts are open circuit, and there is no heating. What happens if there is water is rather more interesting. One might spend a pleasant lunchtime raising questions for the examiners. Would they, for example, propose to call the fire brigade before or after switching on the above circuit? And how far, in their estimation, might this safety-conscious circuit blow its constructor?

I. Pepperpot
Steam Bomb Company
(address supplied — Ed).



LIGHT, DISTANCE AND TIME

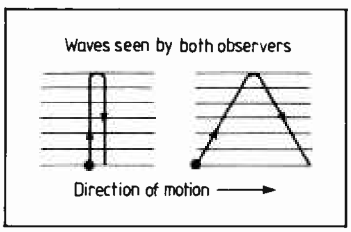
The origin of the controversy about the Special Theory of Relativity lies with the absurdity that was contrived in 1887*. This initial absurdity was further extended by Einstein in 1905 when he contrived to distort Nature in a manner which would have had Dr Frankenstein green with envy. As far as I can tell none of your contributors has identified the errors.

I would start by asking author Scott-Murray, correspondents C.F. Coleman and A. Watson, and James Burke, who recently demonstrated Michelson's Monster on television, a simple question: "How do I use an interferometer to measure the difference in the arrival time of two rays of light?" In the explanation which follows I assume c to be a physical constant but I lay great stress on the fact that I do not consider it to be a velocity; that was a major error which I shall explain in a moment.

If I walk round a source of monochromatic light, say a sodium flame, then I see the same frequency from all directions. Had it been otherwise then surely I would have seen a beat frequency at the M.M. interferometer. Since I did *not* see a beat frequency then I think I am entitled to assume that, within a specified distance, there will be a certain number of waves in any particular direction; numerical isotropy. That is the view of the observer who is at rest with respect to the M.M. experiment.

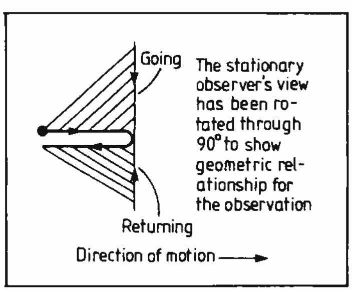
There was now introduced a second observer who was to be at rest relative to the aether (this was assumed, quite improperly, to be a 'rest frame' associated with the sun). What both observers saw was to be compared and we must never lose sight of the fact that in each axis both observers were to look at an unique thing, the same ray of light.

The relativity of observation between the two observers in the transverse axis is



and we see instantly that whilst the number of waves for both observers is invariant, the wavelength for the stationary observer is extended by an amount that conforms to the Lorentz transform.

In the longitudinal axis the relativity of the observation is



and for the stationary observer the wavelength is extended by the Lorentz factor as recommended by Einstein ('Einstein's universe' by Nigel Calder).

Because of the colour invariance of a sodium flame there can be no doubt that physical length is velocity-invariant. Had it been variant then M.M. would have seen their desired result for all of the wrong reasons. But there is one further thing to consider about this experiment.

The transverse axis treats with the phenomenon of aberration, and without the presence of an aether the phenomenon of aberration cannot occur.

Putting to one side M.M.'s personal error we must surely accept that the experiment showed (a) the additive theory to be true (in any case any other alternative runs counter to common sense), (b) the aether to exist and (c) that light moves at constant velocity to the aether.

This leaves us with what, at first sight, seems to be an ambiguity.

How can c be constant for all observers and yet constant with respect to the aether? To avoid this confusion I shall give light a dual aspect and we shall see Einstein's great mistake emerge — he simply did not understand what he was doing when he applied some of his mathematical symbols to Nature.

The term v/c is a hybrid, rather like mixing apples and pears. As there is unit time both above and below the line this may be cancelled. We are left with what at first sight seems to be a simple quotient of two distances. So it is *on paper*, but when we come to use it to predict the behaviour of moving objects we find that our predictions go horribly wrong.

On the top of the term we have a distance that may extend to infinity. On the bottom we have a choice; we may say that the length is simply part of the infinite scale of the upper line, in which case we must accept that the term v/c is just a specification as to the magnitude of the units of velocity in an infinite Newtonian scale of possible velocities (this is the length that is involved with the velocity of propagation of light: it is part of the scale of human anticipation). The alternative view of the lower term is to differentiate between the limited length that *was* constructed within unit time and the distance *within* which it was constructed. The *was* is finite, whereas the *within* implies potential infinity.

By failing to distinguish between a Euclidean abstract distance and the length of a physical entity Einstein did science no service at all because, when it is *applied* to Nature, the term v/c is ambiguous. Hence the paradoxes of relativity.

I am sure that at this point some defender of relativity is likely to suggest that the two lengths for c are numerically the same so how can they be ambiguous. I would agree about the distance but the ray of light is a physical thing that has things attached other than simply distance.

Firstly, because inertia, gravity and the strong force are a simple consequence of the radiation pressure of light, in unit time no physical interaction may occupy a distance greater than c; this is due to Doppler.

Secondly, because the radiation pressure of light is in direct proportion to the frequency, all physical interactions vary linearly if judged by the light-related scale of motion.

The Lorentz transform removes the ambiguity from v/c by adjusting v into conformity with the light-related scale which is linear and finite. It is the mathematical escape from the inevitable error inherent to the admixture of light, distance and time. We see that all Hafele and Keating did was to show that the pi meson decayed in a distance that was in direct proportion to its light-related velocity. If *any* relativist thinks otherwise then I will show him a pair of clocks that do not allow him to follow Einstein into error.

If the transform is assigned to any place other than the proper one, say to time, then a paradox such as the 'twins' will appear because v/c is inevitably released back into ambiguity.

Here stand I at rest in the aether (heresy?) and I see a ray of light that has been constructed in unit time rushing toward me. I note, after it has passed, that it comprised N waves of wavelength D the

product of which is the distance c. Knowing by now that c + v and c − v are going to cause me confusion I say "I shall move toward the source and away from the source half the distance c in unit time in each case to find out what happens". In each case I see both N and D vary but find that the product ND is always c. I find that I *can* have addition, subtraction and constancy all at the same time but, only if I avoid the Newtonian scale of velocity and stick to light as the basis.
Alex Jones
13 Little Street
Alderney

*Michelson and Morley, *Philosophical Magazine* December 1887.

ROBOTS

With reference to your August 1985 issue and the article entitled "Robots for learning and fun", I would like to point out a couple of errors regarding the software for the Cyber 310 Educational Robot.

The article states that our applications package is "small", and costs £150. Not at all: the software is supplied free with the Cyber 310, and is far from small. Apart from the Towers of Hanoi routine mentioned in the article, the applications software also allows automatic zeroing of the robot, Cartesian input , polar cylindrical input, and direct steering and programming of the robot to emulate industrial learning boxes . Coupled with the Forth and RoboForth control software, this adds up to a very powerful free program package.

The only extra software not supplied free is the demonstration package that accompanies our Robotics Course, and the cost of this entire course is only £50.
David Atkinson
U.K. Sales & Marketing Manager
Cyber Robotics Ltd

LOGIC SYMBOLS

Mr Hayward's letter (May 1985) rings like a resonant bell in a swamp of grinding and grating. Whereas I am *not* a circuit designer (which I presume Mr Hayward is) and therefore must sit on the fence regarding the adoption of the new logic symbols, his comments regarding Government committees and the growing madness to re-invent heiroglyphics are poignant to say the least.

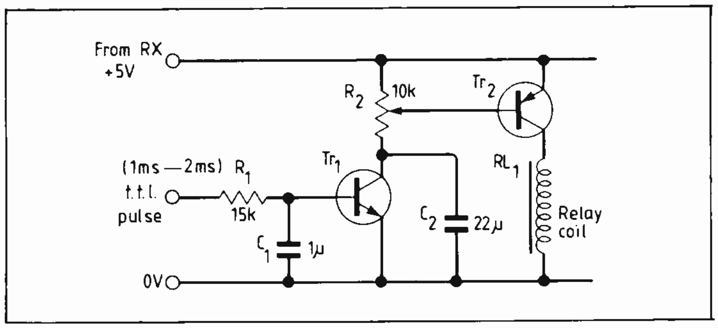
It seems to me that today there is a lemming-like tendency on the part of power-wielding bodies to attempt to impose arbitrary standards on all and sundry to a point of stupidity, to a stage where what an engineer does becomes subordinate to the units and terms he uses to describe it. In this country, for example, we have a Bureau of Standards which seems to have only two concerns: that we write everything in Afrikaans as well as in English, and that we write, for example "m^2 rather than "sq. metres" I am employed by a major water supply authority, which is absolutely soaked in this sort of nonsense.

Is it too late to call for reason? To suggest that the most important feature in, say, a specification for a mobile radio system, is that the system works, and not just that the currently fashionable terms dreamed up by a combination of university academics and Government bureaucrats are used to describe the coating on the surface of a mast? I have coined two terms: ACACRAT and BUREAUDEMIC, to describe this sort of nonsense. I hasten to shrink from suggesting that they become standard (!) terms but I think your readers will know what I mean.
P.L.J. Allcock
Kempton Park
Transvaal
South Africa

BATTERY-SAVING RELAY SWITCH

The circuit shown on p. 66 of the July issue seems to be overly complicated. This circuit is designed to operate a relay (for forward/reverse) from a radio control proportional channel, using minimum component count. The response time is about ¼ second, which is adequate for many applications.

Time constant R_1, C_1 prevents Tr_1 turning on at minimum pulse-width input, allowing C_2 to charge via R_2, holding Tr_2 and therefore RL_1 off. (R_2 is adjusted to achieve this.) At maximum pulse-width input, Tr_1 is turned on by the input pulse removing sufficient charge from C_2 (current-limited by R_1) to turn on Tr_2 and RL_1. The hysteresis of the relay avoids instability.



Tr_1 collector will follow the input in a reasonably proportional manner and could be used for (say) a simple "proportional" speed control, if Tr_2 was replaced by an emitter follower.
D. Hutchinson
Harlow
Essex

RELATIVELY BORING?

H. Morgan of Tonbridge, in your issue of July 1985, asks you to try to find the most respected scientific figure in the world and get him to pronounce once and for all a verdict on arguments about relativity.

I gave a brief and simple account of special relativity mathematics in 1963 in a routine textbook "Physics for Engineers", although at that date there was very little interest in the subject. Most people — including myself — did not *really* understand pressure of radiation and the relativistic increase of mass of the electron when travelling very fast, both of which phenomena were apparently measurable, according to then-current scientific literature; and there was also to be considered the subject of energy derived from mass loss in nuclear reactions. The non-relativistic explanation of radiation pressure seemed completely unsatisfactory at that date.

As the " most respected scientific figure" I would humbly suggest Professor D.A. Bell, a perservering and long-established contributor to your columns. I remember with interest that when I was his laboratory partner in 1931, studying then-electronics consisting of 900 volt oscillators, Lecher lines, etc. in the late Professor Townsend's electrical laboratory, he was much enamoured of a magazine which I had not then heard of, called *The Wireless World*, most of which also I could not understand, though his abounding enthusiasm induced me to buy it occasionally to try to get up to date in "wireless", then an up-and-coming subject. Professor Townsend, as he will remember, was a noted disbeliever in Quantum theory. Whether he believed in relativity perhaps Professor Bell would know.
George Lewin
South Ascot
Berks

I can well understand Mr Morgan's objections (*EWW* 85-7 p. 79) to the "continuous welter of statement and counter-statement, argument and bad-tempered knocking" on subjects of theoretical physics. He might have added objections to writers who often show inability or unwillingness to listen to argument.

But why is it published in *Electronics and Wireless World?* Simply because this unwillingness to listen has led editors of possibly more suitable publications to refuse to print the ideas of scientists they do not agree with. I am happy that *EWW* has not been so narrow-minded.

Science is not religion; there is no divine revelation in science. There is no way to establish facts but observation and experiment, experiment and observation. That is why all 'thought experiments' should be viewed with great suspicion. They leave no room for the emergence of the unexpected and the unknown. That is also why the authority of a "respected scientific figure" cannot provide a resolution. I'm afraid that the editor with his comment, valid as it was, did not really strike at the heart of Mr Morgan's letter.

Every theoretical and practical physicist would do well to remind himself of two things. One is that we do not really know much: we have no understanding of the things we are playing with; what is time; what is gravity; what is matter? The other is that even an accepted and well tried theoretical system (as far as it goes) is no more than a model of the reality that we are part of. The map is not the territory.
P.G. van Dijk
Zwolle
Netherlands

I have followed the articles and letters on relativity and the rest of the 'modern physics' circus since the article by L. Essen in October 1978, which so impressed me that I started buying *Wireless World* instead of reading it in the library.

I would like to see more of the subjects which bore H. Morgan (Letters, July). You ask who is competent to decide who is right. I ask where else we can read open debate on these matters if you go back to being just another electronics magazine, printing inoffensive S-level 'physics for electronics engineers' — in New Scientist?

If I was a professional physicist, I think I would be ashamed to admit it to a lay person whose idea of what I did might well have been formed from television programmes full of starry-eyed academics quoting from T S Elliot and a background of loud jarring music. . . Why do all the worst BBC science programmes have this? Is it to drown the words? I might have claimed to be a psychologist and hoped to be taken for a tough behaviourist.

Of course the truth always comes out eventually. Where are the reputations of Freud, Cyril Burt and Lysenko now? Remember, all founded powerful, seemingly unchallengeable orthodoxies. Humpty Dumpty has a great fall. . .
Roderick Saunders
Birmingham

Some time ago I formulated two maxims which recent correspondence in your journal reminded me of.

1) Everyone with a superficial understanding of relativity and electromagnetism or quantum mechanics will construct their own versions, complete with all paradoxes resolved, the elimination of 'unnecessary axioms' and thoroughly tested by 'thought experiment'.
2) These people will either
   a) continue to study and develop a deeper understanding,
   b) forget it, or
   c) try to persuade the Establishment of its errors by writing lots of letters.

A couple of years ago I had the pleasure of meeting a man who was not only a specialist in relativity but had also appeared on television from time to time. I enquired as to whether he ever got eccentric letters as a result of this exposure. It transpired that he had and initially spent much time writing detailed replies. In spite of valiant efforts, at last sheer volume had swamped him. His solution was to pair up authors of similar viewpoint and send each a copy of the other's letter with a covering note suggesting that they correspond with each other. The result was invariably an aggrieved reply from each wanting to know why on earth he had suggested that they discuss their ideas with "that nutcase".
Charles Williams
University of Durham

WIRELESS?

I have been a reader of *Wireless World* for about 55 years, and must gently complain that your title doesn't appear to justify the content as precisely as was its wont.

There is little in the magazine now which is 'wireless' or radio and any reader picking the title up for the first time could be forgiven for thinking that the paper is for computer buffs. I have used computers longer than anybody on your staff and still cannot see why they generate so much excitement. After "Three Mile Island" I would have thought that a serious review of the uselessness of computers was apparent and that the enormous risks in the vulnerability of military computers should prohibit the use thereof. Nor do I acknowledge the hightech minds which are accorded to children: sure they can solve computer problems; they can also do Monopoly and play cards better than I can.

My interest in radio is stronger than ever and I am amazed at the sangfroid shown by the young in the easy acceptance of the technical miracles which are handed to them on a golden plate. Generally, the young have not the deeper technical interests in the technology which previous generations had. Not for them the taking care not to have a wiped dry joint, or chasing an intermittent capacitor fault somewhere. Or second or third-channel break though via a whisker of wire which resonates, or a girl's necklace which heats up when she operates an r.f. welder, or power which leaks along a work bench and appears on the top as a r.f. spark a foot long.

Modern radio receivers are not a bit as good as the older valve types. It is unusual to hear a radio which does not have high background hiss. It is unusual to hear a commercial radio with adequate selectivity: this is avoided by using after filters with a cutoff. There is not a commercial receiver available with the all round performance of the GEC BRT400, or its predecessor. I had one with pushpull outputs via two PX4s, driven by MHL4s, and the range was from 9metres to 5,500 metres without a break in the range at all. I once heard a ham transmitter from Moscow one November who was using two watts aerial power. Alas the set was sold when I was an expat. abroad. If I could get the specs I would rebuild that set myself. The tonal quality even on shortwave reception was marvellous. I would suggest that you could generate radio interest in radio if you republished the set with diagrams and constructional details. I am using A Sanyo, a Panasonic, a Bush, a homebrew, an Eddystone, a Pioneer, a Vega and all because I havn't got my old GEC!!!

John D. Beud
Whitchurch
Cardiff

CORRESPONDENCE

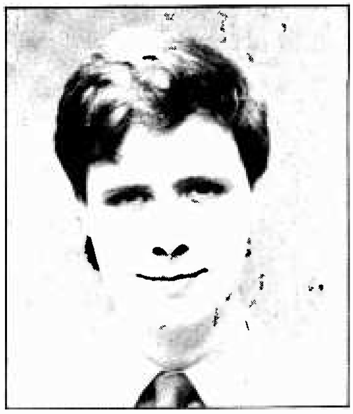
May I suggest that the insoluble "paradox" of Mr Michael resides solely in his head. Our brain does not perform "triangulation", using as base-line lateral or time separation of sensor images, to determine the spatial relationship of objects within a visual field. Intelligently, since it is a skill learnt by practice, we perform in analogue neuron networks an almost immediate weighing process using techniques similar to Probability theory (not geometry), combined with Flicker-comparator-like matching processes, to memory-map image sets to determine whether or not an object exists, and then further to determine whether or not the same found object really exists where it appears to exist in a single or a multiple-image field. Two quite separate tests! Should one test fail or should conflict arise between test results we invariably then have an illusion, but not an insoluble one. Indeed if the "paradox" is insoluble, we could then be continually bumping into each other.

Fortunately for us, Mr Michael has now quite brilliantly presented the proof of this prospect. He proposes that object-to-sensor distance is a prime paralogism in the Correspondence problem when performing or trying to perform "triangulation" to analyse a multiple image field; in that, until one object is identified (for example by an infant) as being unique within a multiple-image field, then it is impossible to instruct limb motor centres to "triangulate" and grasp the object, even with a stereoscopic image pair — sadly this is not his digital Quantum Leap.

Perhaps Mr Michael, after correcting his input-output algorithm could further amplify his intriguing proposition. Can we start bumping or not? I eagerly await his reply. Work on Mr Michael; I could be wrong.
A.J.P. Ferro F.C.T.
London N4

Digital polyphonic keyboard

by D.J.Greaves B.A.



David Greaves is a postgraduate research student at St John's College Cambridge working with new computer architecture, in particular on natural language processing algorithms.

David is three time a winner of the Esso-sponsored Design Technology competition, holder of an IEE Jubilee Scholarship and a former contestant on BBC tv's Young Scientist of the Year programme. He plays the guitar and, being a lover of most types of music, is fascinated by anything that combines electronics, music and computer algorithms.

His many designs include a digital spectrum analyser, several digital sound effect units and an ever growing computer which he started building in 1977. This 200Kbyte computer with hard disc drives runs home-written software including a Basic interpreter, BCPL compiler and assemblers.

Digipoly is a versatile keyboard instrument capable of producing many electronic organ, piano and synthesizer sounds. It is entirely digital, with a Midi interface, and includes an 8088-based control processor and a high-speed t.t.l. signal processor with other potential applications.

Most current electronic keyboard instruments use a combination of digital and analogue circuits. Output of these instruments is typically generated by sixteen conventional analogue oscillators whose frequency, and subsequent filtering/ amplification, is digitally controlled.

Digipoly is the outcome of an investigation into the possibilities of producing a musical instrument using entirely digital note generation techniques. The result is a useful piece of equipment capable of synthesizing many conventional electronic organ sounds and also many synthesizer and electonic-piano sounds. However, the basic instrument is not capable of producing any voice for which the harmonic structure of the sound changes during the note.

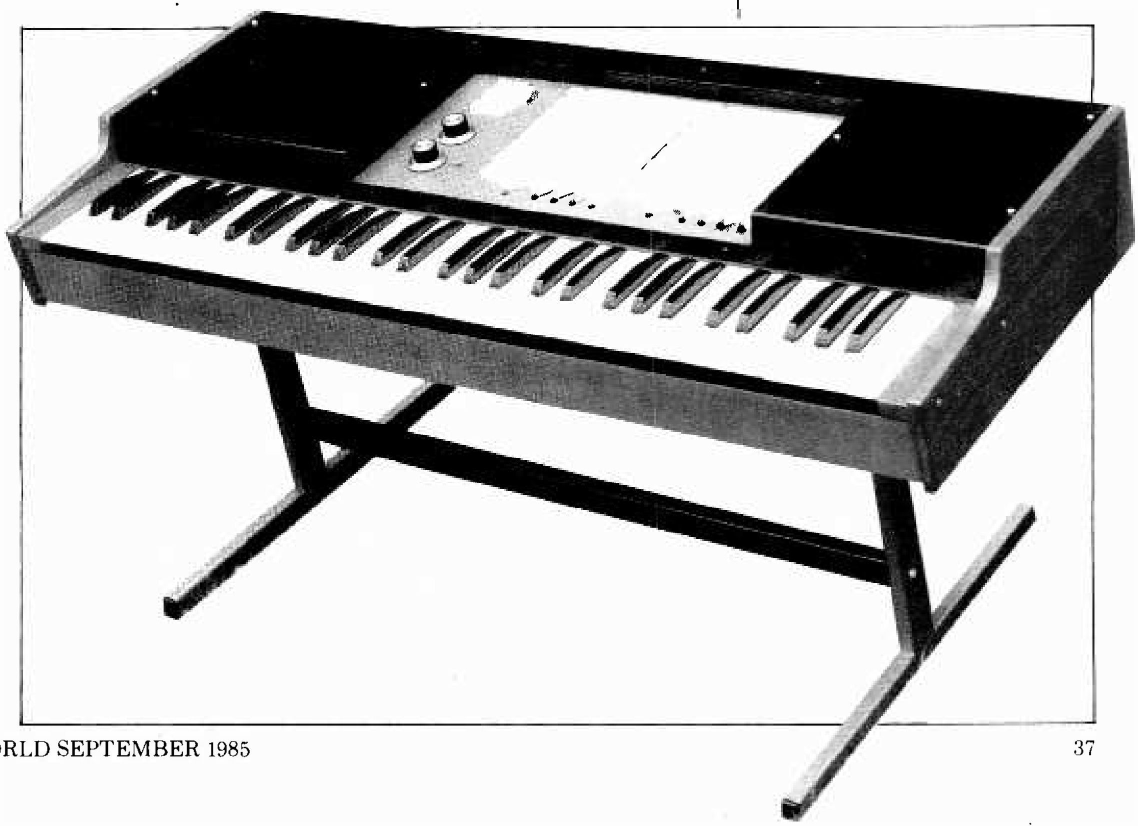
The main advantage of Digipoly over older analogue designs is the simplicity and versatility of its digital circuits. A standard Midi (musical-instrument digital interface) bus connection is included so that Digipoly can be used with other instruments, sequencers and under remote computer control.

Figure one shows the interconnection of Digipoly's various parts. On its own board at the heart of the system is an 8088 microprocessor which controls all instrument functions. It has an 8Kbyte eprom for its program and look-up tables and 2Kbyte of cmos ram with battery back-up to retain user settings for user-defined voices when the main power source is removed.

The 8088 microprocessor controls all of the instrument through 16 eight-bit parallel i/o ports. This means that for development and debugging purposes, the complete microprocessor board can be removed from the instrument and replaced by a cable to a microcomputer which addresses the same 16 ports. Software for Digipoly was developed in this way on an 8088-based computer.

Front panel controls of the instrument are polled by the microprocessor. For economy, I chose a simple front panel with push buttons and leds, Fig.2. Two rotary controls are also used, one for the master volume setting and the second, connected to the a-to-d converter, whose function depends on the push-button selection.

The sprung-action keyboard is a standard 61-note C-to-C plastic one. It is scanned every 2ms by the microprocessor and appears as an array of 61 ones and zeros reflecting the state of



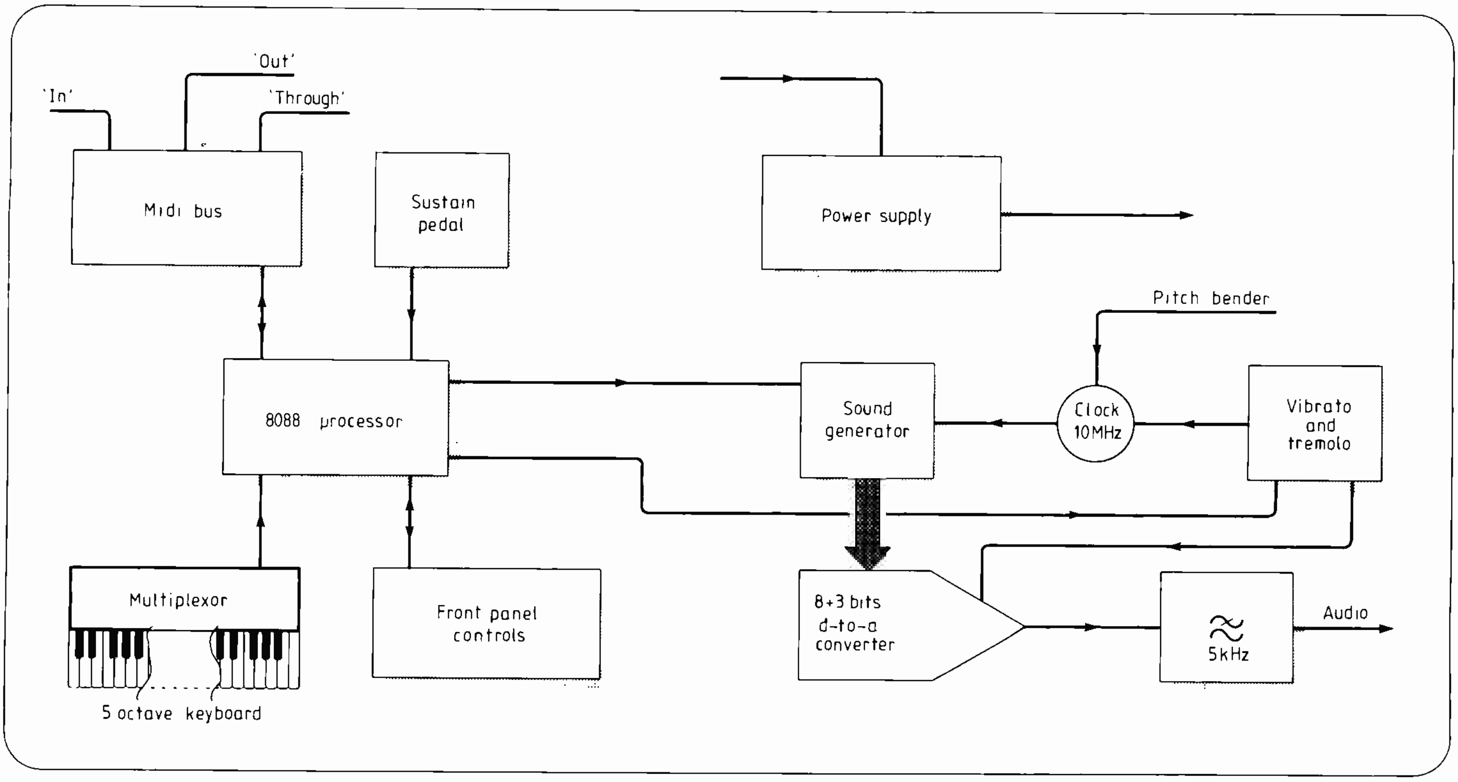


Fig. 1. **Block diagram of the digital polyphonic keyboard instrument. All control functions are handled by the 8088 microprocessor.**

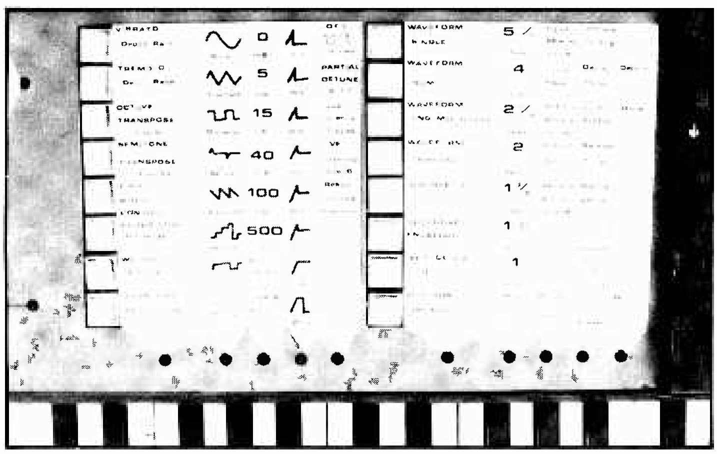


Fig. 2. **Front panel legend. There is a variable-context button by each row in the two legend sections. A led under each column indicates when a column is in use.**

the keys. Front-panel controls allow keyboard pitch to be stepped up or down over six octaves and also transposed up and down by six semitones. Absolute pitch can be varied over one semitone to allow tuning to other instruments.

Digipoly is equipped with a midi interface which is a fast serial data link to other instruments. Bit serialization is performed by the 8088 microprocessor and timed using software delays from the processor's 15MHz crystal. Received-data start bits are used to interrupt the microprocessor whose interrupt routine then assembles a byte which is stored in a queue in memory. This queue is polled by the main program for new commands which are then interpreted according to the Midi standard.

Sound generation is performed by a microcode program running on a simple processor built from discrete t.t.l. i.cs. This processor, performing around five million instructions each second, simulates eight asynchronous oscillators whose frequency can be varied in 0.5Hz steps from zero to 16kHz. Waveforms of these oscillators are stored digitally in a 129-by-256 element array and their amplitude is adjustable over 64 linear steps. Each oscillator sends a new value to the output digital-to-analogue (d-to-a) converter at about 35kHz.

Having eight separate note channels within the instrument means that it is normally possible to hold eight keyboard keys together and hear all eight notes polyphonically. The 8088 microprocessor automatically assignes a new channel for each key. In 'double-up' mode, which is selected from the front panel, two channels are used for each key so only four keys may be used together. Reduction in the number of channels available is also sometimes caused by the automatic arpeggio effect, the Midi bus and the sustain pedal.

Output from the d-to-a converter is fed through a three-pole low-pass filter with a 5kHz cut-off frequency which remove steps from the digital waveform and sums the eight oscillators. The d-to-a converter is eight bits wide and used eight times for each sample, giving an effective dynamic range for all voices of 66dB; when no key is pressed, converter output is zero so the signal-to-noise figure is generally better than this figure. Filter output is fed through the volume control to a ¼in jack output socket.

Figure 3 shows some of the envelope possibilities. A variable 0.1 to 5Hz sinewave oscillator is included to apply vibrato and tremolo modulation to the output; speed and depth of these effects are controlled digitally by the 8088 microprocessor.

Frequency synthesizer

Figure 4 shows a notegeneration channel. Eight such channels are implemented by the t.t.l. microprocessor in microcode and each channel has two sixteen-bit registers, P and F. Frequency of the oscillator is determined by the F register and is set by the 8088 processor before a note starts. In each channel, the P register holds the current phase of the oscillator and has the contents of the F register added to it at regular intervals of 28μs.

The rate at which the P register overflows and returns to zero is the fundamental frequency of the note being produced by the channel. Being 16bits, the P register can count up to 65536; if the F register holds unity then the synthsized frequency is (1/0.000028)/65536 which is 0.5Hz. Hence the frequency of the channel is 0.5Hz multiplied by the value in the F register.

Indexing of the waveform table is carried out by the P register's eight most-significant bits. The waveform table, held in an array in the t.t.l. processor address space,

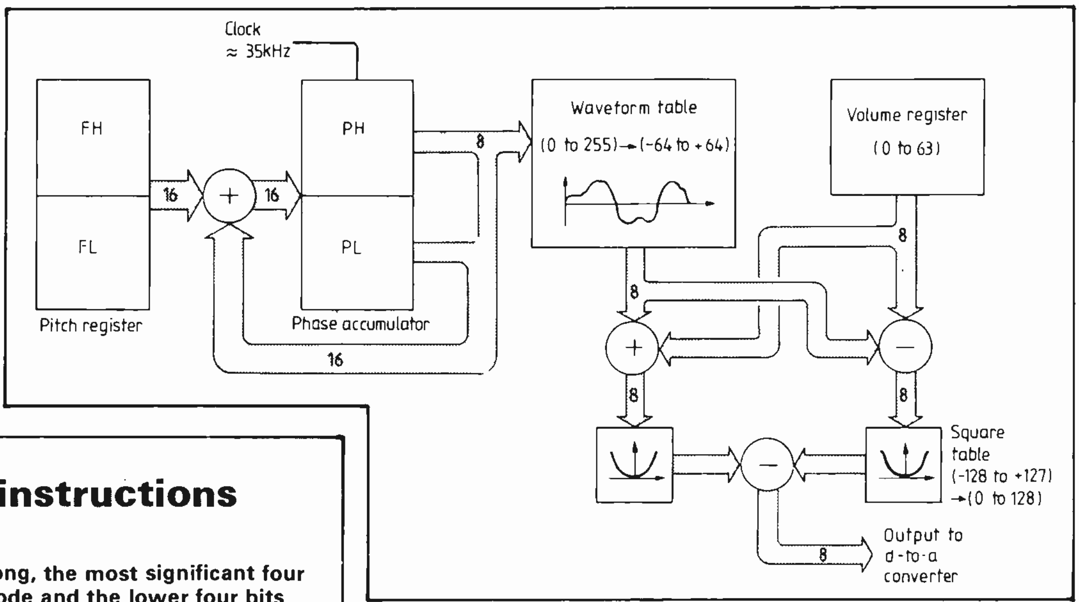


Fig. 4. Note generating system. Microcode in the t.t.l. processor runs eight of these systems. A pitch register is repeatedly added to an accumulator which is used to index a stored waveform. The waveform is multiplied by a volume factor using the 'quarter squares' method and then sent to the output d-to-a converter.

T.t.l. processor instructions

All Instructions are one byte long, the most significant four bits giving the instruction opcode and the lower four bits giving the addressing mode where pertinent.

For instructions that do not specify an m value, the low-order four bits of the opcode should be zero. The INCV instruction adds one to the V register modulo n where n is the number of sound channels that the Digipoly has. This is set by links to eight. The INCV instruction has the same opcode as the HOST instruction so that the two can be performed at once. Other unused opcodes are decoded in hardware and so can easily be used to add new features to the instruction set.

Bit patterns for the opcodes are

0000	LOAD m	load m into the accumulator
1000	STORE m	store the accumulator at m
0001	ADD m	add the m into the accumulator
0101	ADC m	as add but include the carry bit in the result
0110	SUB m	subtract m from the accumulator
0011	CLEAR	zero the accumulator
1010	LOOP	execute the next instruction and jump to zero
1011	INCV	increment the V register
1011	HOST	enable 8088 d.m.a. into memory
1111	NOP	no operation

The addressing mode bit patterns (m) are

0000	PL,V	Low order byte of the P array using V
0001	PH,V	high order byte of the P array using V
0010	FL,V	low order byte of the F array using V
0011	FH,V	high order byte of the F array using V
0100	VOL,V	volume array using V
0101		Not used
0110	DAC0	DAC0
0111	DAC1	DAC1
1000	SQ,A	square table indexed by the accumulator
1010	WV,A	waveform indexed by the accumulator
1100	E0	register E0
1101	E1	register E1
1110	E2	register E2
1111	E3	register E3

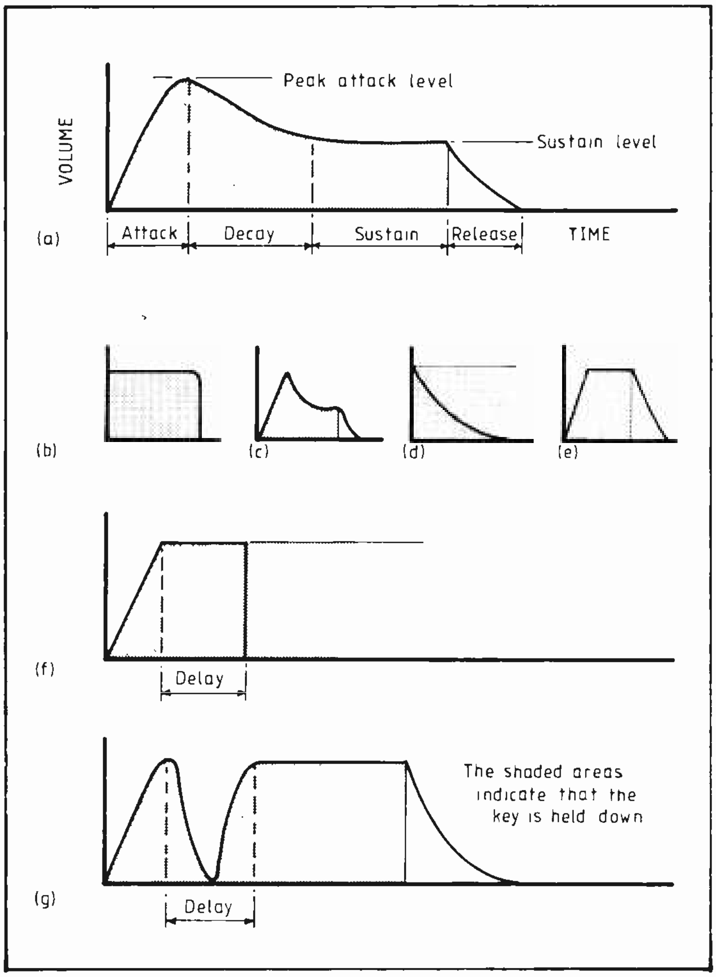


Fig. 3. Envelope profiles. The general a.d.s.r. (attack-decay-sustain-release) envelope is shown in (a), preset envelope profiles are shown in (b-e), and (f) is a non-a.d.s.r. profile which produces pulses. A pre-echo profile similar to the general a.d.s.r. form but with two attacks is shown in (g). Shaded portions indicate the time that a key is held.

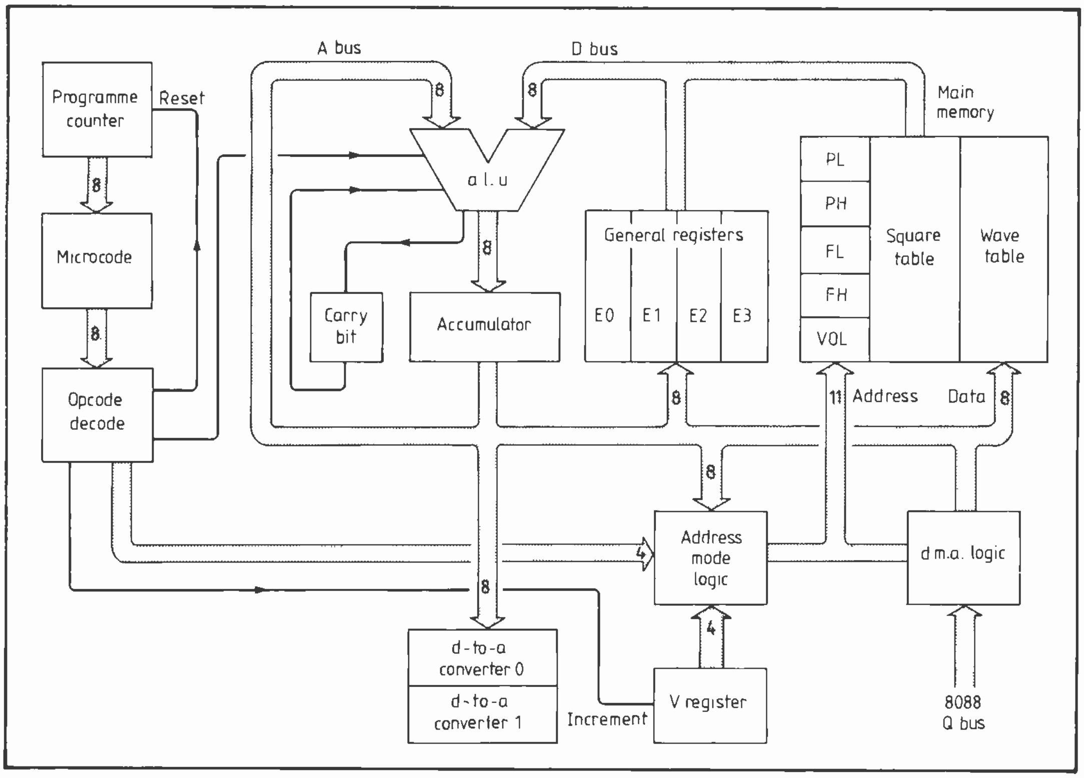


Fig. 5. **Architecture of the t.t.l. processor which has ten instructions. The accumulator is used for all arithmetic results and there are four extension registers for temporary results. The main memory is partitioned in hardware and is accessed using several different addressing modes.**

contains values in the range −64 to +64. Contents of the array are initially loaded by the 8088.

Each channel has a volume register holding a value between zero and 63. It is necessary to multiply values from the waveform table by the volume value to control output-signal amplitude. This multiplication is performed using the 'quarter-squares' method. Use of a simple look-up table to multiply a seven-bit number by a six-bit number to produce an eight-bit result would take eight Kilobytes of memory; with the quarter-squares method, only 256 bytes are needed. The identity

$A \times B \times 4 = (A+B)^2 - (A-B)^2$

is used. Values from the waveform table and volume register are summed and differenced, then the difference between the squares of these values is computed. In order to keep the number of bits under control, the square table actually contains the function.

$SQ(X) = X \times X/128$

which gives results in the range 0 to 128. When two values from the square table are differenced, a full eight-bit value is produced and this is the result of the computation.

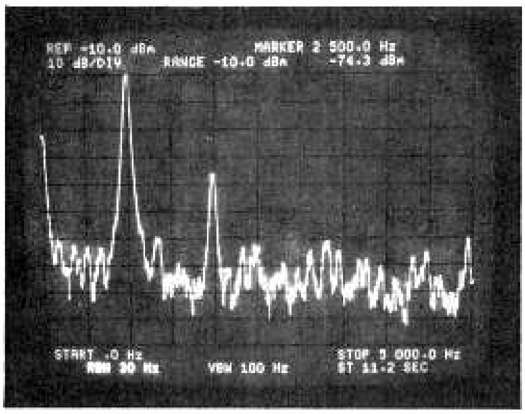
Figure five shows the t.t.l. processor architecture. This processor was specifically designed for Digipoly but is general enough for use in many other applications. Different address spaces are used for the program and data so that the hardware can be more easily 'pipelined'.

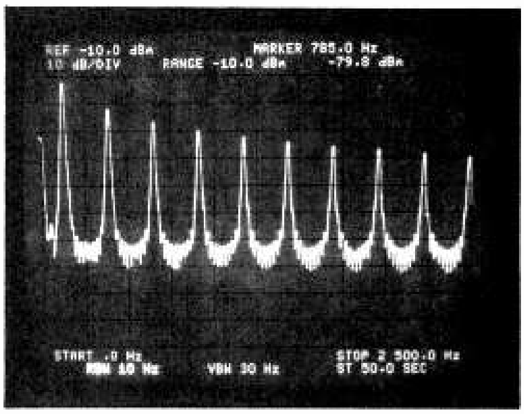
A prom holds the microcode program and sequential execution is controlled by the eight-bit program counter register. All data manipulation instructions use the eight-bit accumulator either as a source or destination (or both) of one of the operands. There are four general-purpose extension registers E0-E3 and an index register V which is normally used to select which synthesizer channel is being processed.

Main memory is partitioned in hardware into several regions. There are five arrays which are always indexed by the V register — PL, PH, FL, FH and VOL. These arrays contain eight-bit bytes and are 16 locations long. They are used for the low and high-order bytes of the P, F and volume registers respectively.

There are also two arrays of 256 bytes, the square table SQ and the waveform table WV, which are indexed by the accumulator. Output from the t.t.l. processor is achieved by writing to one of two locations, DAC0 and DAC1. Only DAC0 is used on the present Digipoly. Input to the processor is always performed by direct memory access (d.m.a.) to the processor memory under the control of an external device.

Descriptions of the 8088 processor section and Midi bus are included in the next article.





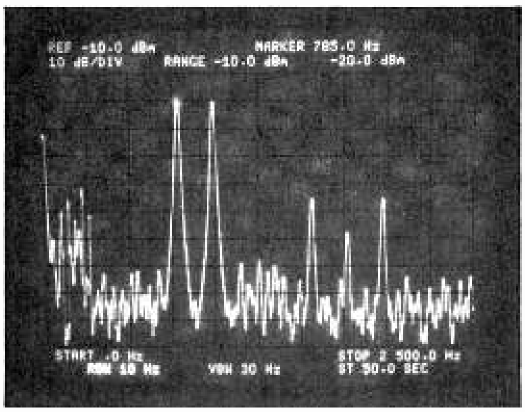


Fig. 6. **Second harmonic at 36dB and sampling noise at 65dB of a 1kHz sinewave (a), two sinewaves at 750 and 1000Hz with intermodulation product −50dB at 1750Hz (b), and 120Hz squarewave with its spectrum of odd harmonics (c).**

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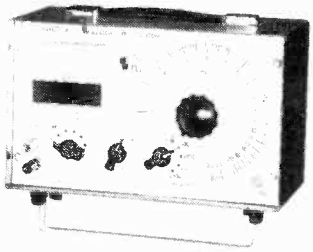

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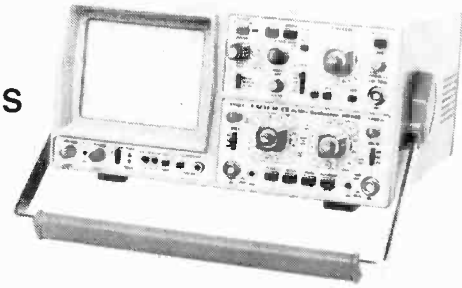

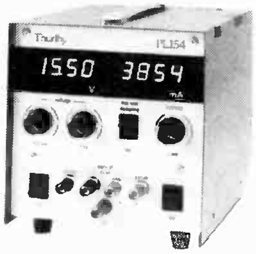

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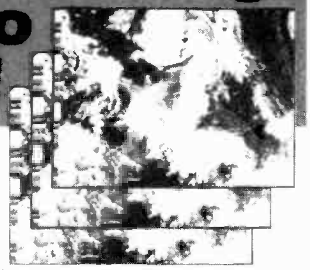

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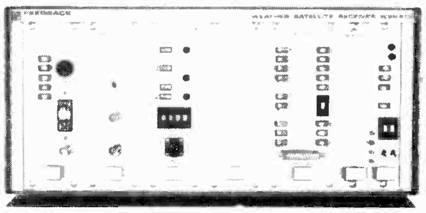

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Communications receivers

A survey of general-coverage sets

A generation ago, a communications receiver was for countless engineers, whether amateur or professional, the pride of the workbench. Not so long ago, electronics *was* radio, and a high-performance general-coverage set was one of the most complex pieces of electronics it was possible to own.

Today, when there is a digital watch on almost every wrist and a computer-controlled washing machine in quite a few kitchens, radio equipment has lost its pre-eminence. But communications receivers continue to retain their usefulness.

For keeping in touch with the world, their value is greater than ever. International broadcasting is big business and the thousands of high-frequency transmitters now in operation around the world are added to every year. And investment in receiving equipment grows correspondingly.

Even the smallest and poorest countries feel the need to make their voice heard abroad. The largest may broadcast hundreds of hours of programmes every day in dozens of languages, from Afar and Albanian to Yoruba and Zulu. Their transmission schedules are listed annually in that short-wave listener's bible, the World Radio TV Handbook, which now runs to no less than 600 pages of small print. To cope with the growing babel, additional frequency allocations were agreed in 1979 and are gradually taking effect.

Some countries use the international airwaves merely for political propaganda, but by no means all. So for anyone who can put up with the lack of pictures and with a sound quality that is inevitably rather less than hi-fi, short-wave radio can be a fascinating source of news, entertainment and information.

However, in recent years many non-broadcast users of the h.f. spectrum have moved to alternative methods of transmission. International telephone traffic, for example, is carried now mostly by satellite or cable. But there remains a great deal of other activity: for example, clandestine transmissions, data, radio-teleprinter code from foreign news agencies, military transmissions and, of course, radio amateurs.

For many years an apprenticeship served before an h.f. receiver, possibly of the war-surplus variety, was considered an indispensable qualification for obtaining a transmitting licence. But besides its use as an adjunct to an h.f. transmitter, a communications receiver has its place in the modern amateur station as a building block for operations on much higher bands. Converters are available to extend coverage into the v.h.f. range and even into the microwave bands, where the tuning and accuracy and stability of the basic receiver can give important performance advantages.

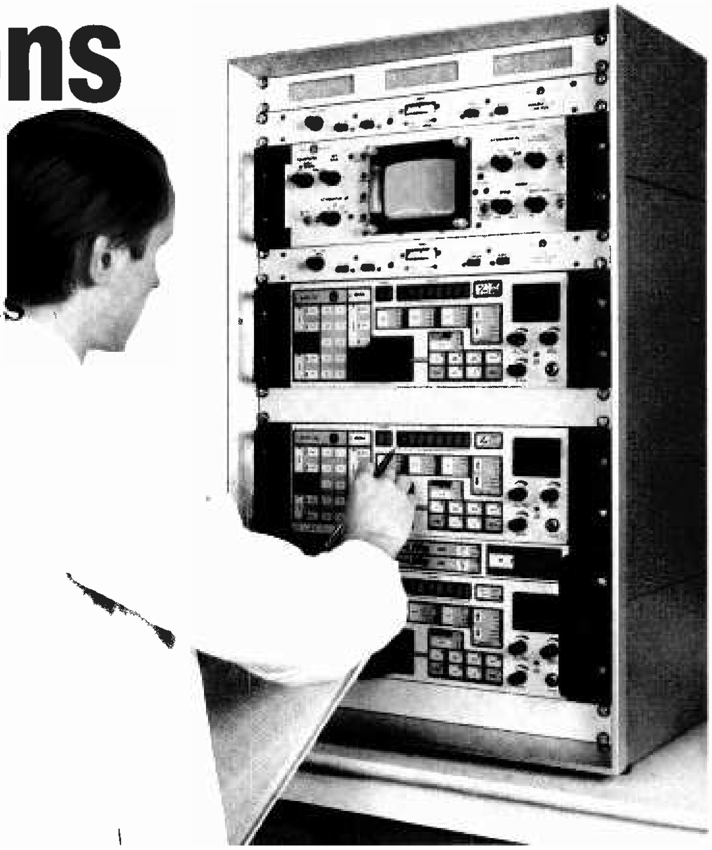
In addition, the communications receiver can make a useful piece of test equipment in its own right as a tunable r.f. microvoltmeter. Digital frequency meters read only the largest signal present; but a receiver can detect sidebands and harmonics over several octaves and may be as much help as a spectrum analyser. To check its accuracy, you need do no more than tune in to one of the standard frequency and time stations maintained by the world's observatories and standards authorities.

Virtually all the receivers listed in the accompanying table incorporate synthesized tuning, the introduction of which in recent years has led to greatly improved convenience in use — at a cost, in lower-priced sets at least, of some sacrifice of r.f. performance. The synthesized oscillator may be noisy and so provoke spurious responses; whilst an untuned front-end is prone to overloading by unwanted strong signals.

It is nevertheless a surprise to find so few synthesized sets among the mass-market portables, since inevitably there must come a point at which silicon becomes cheaper than the mechanisms it replaces. By contrast, tv set makers seem to have had no difficulty in making the switch to electronic tuning — with a little help from the semiconductor industry.

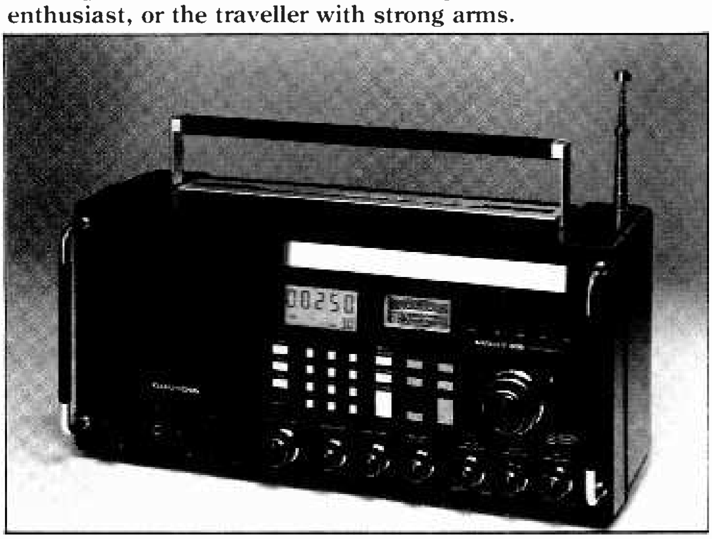
In a synthesized set, it is a fairly simple matter to include remote control of the main receiver functions. Thus even some of the relatively low-priced sets aimed at the amateur are now offered with a computer interface, enabling the enthusiast to automate his routine band-scanning.

Remote control is widely used in professional receiving installations, where it is common practice to station the operators in an office or listening room and to group the receivers out of sight in racks elsewhere. In extreme



This professional monitoring set-up from Eddystone includes three model 1650 receivers and a panoramic display module.

Grundig's Satellit 600: a multi-feature portable for the enthusiast, or the traveller with strong arms.



Vigilant's Micon receivers, designed to meet the 1983 MPT specification, offer automatic scanning of 200 stored channels.

cases, the receivers may even be in another country. Sets designed for this purpose may be offered by with dedicated remote-control units or with interfaces for control by serial port or by GPIB or IEEE-488 bus.

Certain receivers for professional applications are too highly specialized in nature to warrant detailed coverage in a feature such as this; however, we have included a few in the table for the purposes of comparison. Among them are measuring receivers (some more were listed in our GPIB feature last December), surveillance receivers and military sets.

Finally, for those with shallow pockets, or of an adventurous turn of mind, it may be worth noting that the home design and construction of short-wave receiver is still possible - although it would take a lot of ingenuity and experiment to match the performance and facilities of the average commercial set.

A recent published design was the RX-80 s.s.b.-c.w. receiver by A.L. Bailey, which appeared in *Radio Communication* (Radio Society of Great Britain) in 1981. One kit we have come across is the FCR-130 from Comutech (see address list): intended for the beginner, this four-stage t.r.f. receiver gives a.m., c.w. and s.s.b. reception.

In the table, filled blocks denote features offered with the standard model; empty blocks or entries in square brackets relate to optional extras.

Price: does not include v.a.t.

H.f. range: tuning range of the basic receiver. Many models have, or can be fitted with, further ranges not shown here.

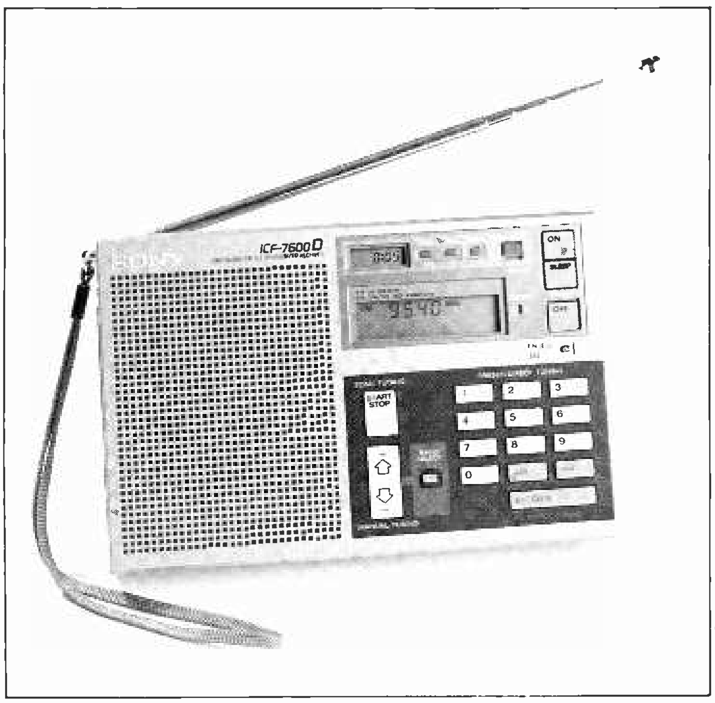
Modes: the column headed 'fm' refers to narrow-band frequency modulation. Wide-band f.m. capability is indicated separately.

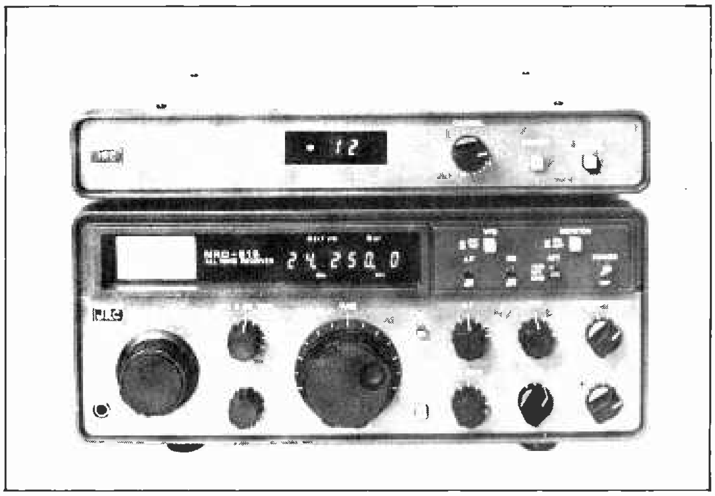
Mems: the number of memory locations available for storage and recall of receive frequency and any associated settings.

Sensitivity: figures relate, as far as possible, to a normal a.m. signal in the h.f. band giving a signal-to-noise ratio of 10dB. Many sets can be supplied with built-in r.f. amplifiers for more gain.

Power: note that a few d.c.-powered sets require a 24V supply rather than 12V.

This compact synthesized portable by Sony gives full h.f. and v.h.f. coverage and even has a digital clock.





For the DX-er: JRC's synthesized set with traditional-style rotary controls. The memory unit is optional.

The sets

AOR (sold also as **Regency**): Japanese v.h.f.-u.h.f. keypad-controlled scanners covering in addition the upper h.f. range. Optional converter extends coverage to 1.2GHz. Available from A.R.E. Communications, Lowe Electronics, South Midlands Communications and others.

Bearcat: range of scanners from Uniden includes the multi-mode DX-1000 for the short-wave enthusiast. Available from Radio Shack, E.M.A. etc.

Drake: popular non-synthesized amateur radio work-horse, still available from Radio Shack. Accessory board provides up to eight additional crystal-controlled frequencies. Optional digital readout.

Eddystone: now part of Marconi Communications Systems. High-performance sets for monitoring,

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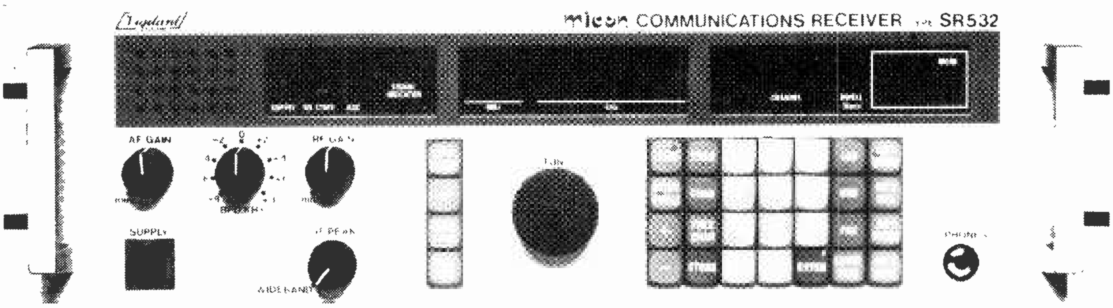

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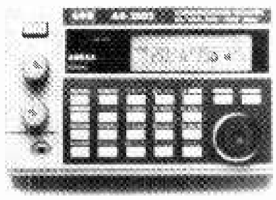

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Maker, model	Basic price	hf range, MHz	Modes am	cw	ssb	isb	fsk	fm	other	Mems	Sens. a.m.	Display	Computr i/face	Power ac	dc	Comments
AOR AR-2001	295	25-550	■					■	wbfm	20	0.5µV	l.c.d.		□	■	low-cost v.h.f./u.h.f. scanner
Bearcat DX-1000	300	0.01-30	■	■	■			■		10	1µV	led		□	■	portable/table-top scanner
Drake R7A	1387	0.01-30	■	■	■		■			[8]	<1.2µV	[led]		■	■	available while stocks last
Eddystone 1650/1	2750	0.01-30	■	■	usb		□			99		led	□	■	■	MPT-approved maritime receiver;
1650/3		0.01-30	■	■	■	■	□			99		led	□	■	■	commercial, profess'l, military
1837/2		0.1-30	■	■	■		□				1.5µV	led		■	■	gen'l purpose, marine reserve
1995/1	5500	20-470	■	■	■		■	■	pulse	99	1.5µV	led	□	■	■	rebroadcast, surveillance;
1995/2	7100	20-1100	■	■	■		■	■	pulse	99	1.5µV	led	□	■	■	available at end of 1985
Grundig																
Yacht Boy 700	96	1.5-26[30]	■	■	■							dial/l.c.d		■	■	portable with lw/mw/fm bands
Satellit 300	113	3.9-22	■							35		l.c.d.		■	■	portable with lw/mw/fm bands
Satellit 600	304	1.6-26.1	■		■					60		l.c.d.		■	■	portable with lw/mw/fm bands
Icom R70	547	0.1-30	■	■	■		■	□			<0.5µV	fluor		■	□	
R71A	634	0.1-30	■	■	■		■	□		32	<0.5µV	fluor		■	□	options include voice synthesizer
JRC NRD-515	839	0.1-30	■	■	■		□			[99]	<2µV	led		■		gen'l purpose; memory unit, £230
Panasonic RFB600	415	1.6-30	■	■	■					9	~2µV	fluor		■	■	portable with lw/mw/fm
RFB3100	212	1.6-30	■	■	■							fluor		■	■	portable with lw/mw/fm
Phase Track																
Liniplex F1	525	2-26.5	■		■					9	1.5µV	none		■	■	portable model; see text
Liniplex F1-2	1222	2-26.5	■		■					18	1.5µV	none		■		dual version; rebroadcast uses
Plessey 2282		0.01-30	■	■	■	□	■			100	3µV	led	[GPIB]	■		high-performance modular system with remote control options
Racal RA1792		0.1-30	■	■	■	□		■		100	3µV	l.c.d.	[GPIB]	■	□	high performance, transportable
RA1794		2-512	■	■	■			■	■	100	1µV	led	□		■	military transportable
RA1795		20-512[1000]	■	■	■			■	■	100	~1.3µV	led	[GPIB]	■		military/surveillance uses
RA1796		2-1000	■	■	■			■		100	1µV	led	□		■	electronic warfare, transportable
Regency MX7000	347	25-550	■					■	wbfm	20	1.5µV	l.c.d.			■	opt. converter for 800-1300MHz
Rohde & Schwarz																
ESM 500A		20-1000	■		□	□		■	□	99		led	GPIB	■	■	panoramic monitoring option
EK 070		0.01-30	■	■	■	■	■	■		30		led	GPIB	■	■	panoramic option
Sony ICF-7600D (in US, ICF 2002)	156	0.153-30	■		■					10		l.c.d.		■	■	compact portable; unusually wide f.m. broadcast range, 76-108MHz
ICF-2001D (in US, ICF-2010)	287	0.15-30	■	■	■					32		l.c.d.			■	synchronous detector on a.m.; air band; 76-108 f.m.; 4-event timer
Trio R-600	260	0.15-30	■	■	■						<5µV	led		■	□	basic table model
R-2000	417	0.15-30	■	■	■			■		10	<4µV	fluor		■	□	full-feature model; optional con- converter (£111) for 118-174MHz
Uniden CR-2021	165	0.15-30	■	■	■					6		l.c.d.		■	■	portable; f.m. band 76-108MHz has six more memories.
Vigilant SR502		0.05-30	■	■	■		□			6	1µV	decade switches		■	■	low cost, high performance
Micon SR530		0.05-30	■	■	usb		■			200	1.5µV	led		■	■	MPT-approved marine receiver
Micon SR532		0.05-30	■	■	■		■			200	1.5µV	led		■	■	similar model for static use
SR721		0.05-30	■	■	■		■			200	1µV	decade switches		■		remote-controlled receiver; three other models
Yaesu FRG8800	486	0.15-30	■	■	■			■	[wbfm]	12	4µV	l.c.d.	□	■		gen'l purpose; optional converter (£78) for 118-174MHz
FRG9600	413	60-905	■		■			■	wbfm, acssb	100	1µV	fluor	□	□	■	mobile receiver; optional NTSC video i.f. unit

rebroadcast, maritime, commercial and military use. Options include panoramic frequency display, remote control etc.

Grundig: large range of portables includes three models for the enthusiast. Yacht Boy is not synthesized but has a digital frequency display.

Icom: Japanese receivers for the enthusiast. Options for the R71A include infra-red remote control, additional filters, voice-synthesizer for frequency indication. From Thanet Electronics, A.R.E. etc.

Japan Radio Co. (JRC): table-top synthesized receiver for the keen s.w.l. Options: memory unit storing 96 channels in groups of 24, c.w. filters for improved reception of morse code. From Lowe, SMC and others.

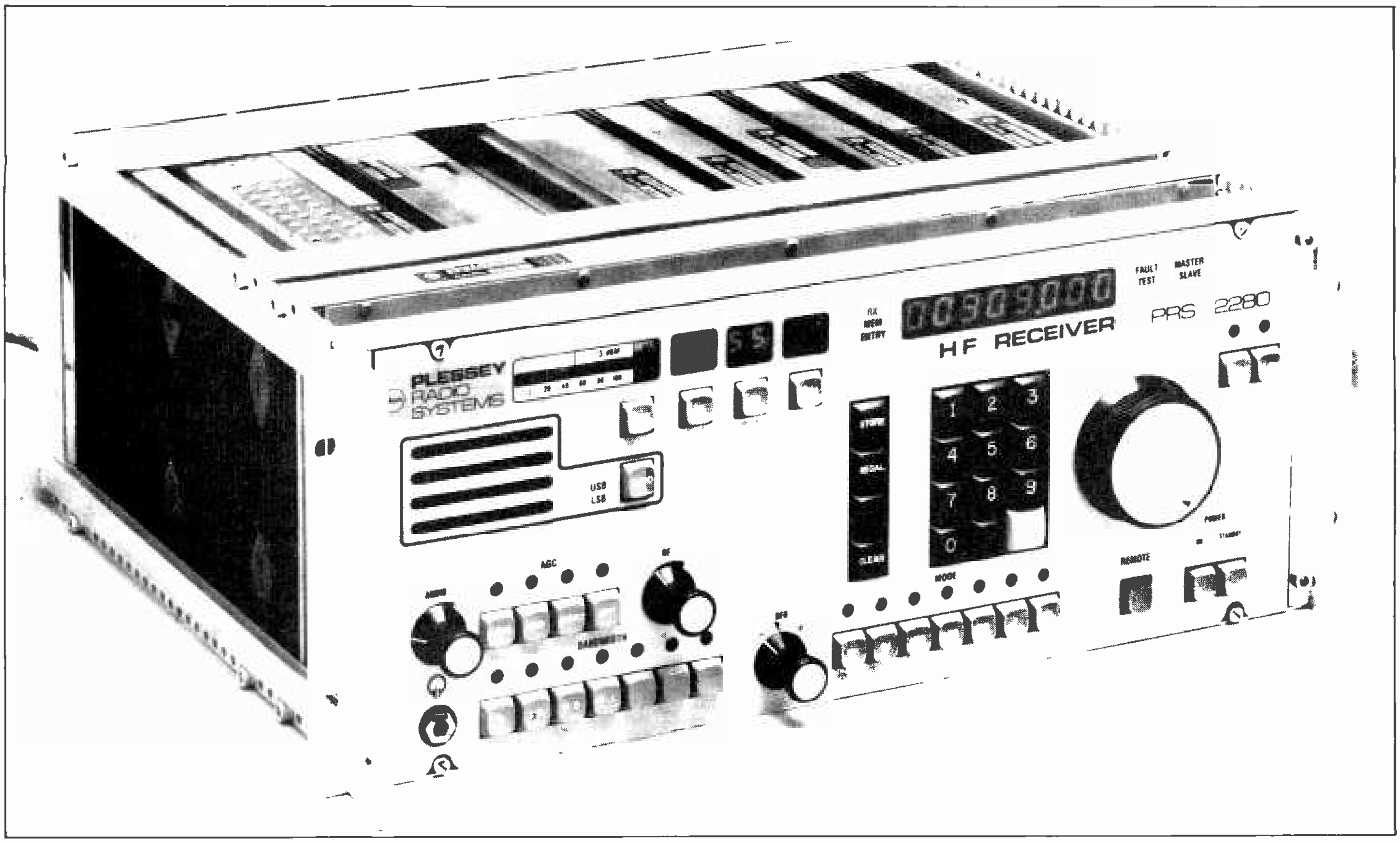
Panasonic: audio range includes two multi-band synthesized portables for the enthusiast.

Phase Track: unusual, easy-to-use portable receiver for the traveller. Crystal-controlled for optimum front-end performance. Frequencies supplied are selected to give round-the-clock reception of the BBC World Service; alternatives can be provided on request. Special tracking phase-locked demodulator gives exceptional audio quality on s.s.b., d.s.b. and a.m. Dual rack-mounted version for broadcast relay applications allows pre-fade monitoring without interruption of the programme being relayed. M.f. versions available.

Plessey: high-performance receiver family for monitoring, surveillance, rebroadcasting, direction-finding and coastal radio services. Modular construction for easy upgrading. Options include diversity operation.

Racal: complex, high-performance receivers for civil and mili-

Sacrificing coverage to gain audio quality: the unique Liniplex portable h.f. receiver from Phase Track.



For servicing, receivers from Plessey's PRS2280 family can be stripped of all their modules leaving only the case.

tary uses. Options include panoramic frequency display, remote control.

Rohde & Schwarz: comprehensive range of monitoring, direction-finding and analysing receivers, of which two examples are listed here. The company has published an attractive illustrated booklet describing the design and use of test receivers: it is available to professional readers under the title Special 1, Signal strength and interference measurements.

Sony: range of multi-band portables includes an exceptionally compact synthesized model.

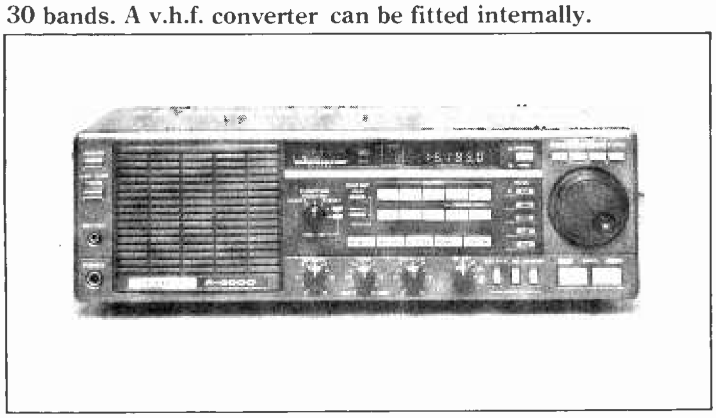
Trio: (sold overseas as Kenwood): two Japanese-made receivers for the keen amateur. Accessories for the R-2000 include a v.h.f. converter and c.w. filter.

Uniden: portable set resembles the earlier Sony ICF-2001.

Vigilant: high-performance, general-purpose sets. Options include remote control, RS232/RS423 control, dual-diversity operation.

Yaesu: Japanese-made sets for the keen amateur. Interfaces available for Apple II and NEC PC-8001 computers or for any computer with an RS-232C-compatible serial port. Options for the FRG8800 include an active antenna. Available from several amateur radio dealers, including Amateur Electronics, A.R.E. Communications and South Midlands Communications.

This all-mode set from Trio covers 150kHz to 30MHz in 30 bands. A v.h.f. converter can be fitted internally.



Addresses

Amateur Electronics, 510 Alum Rock Road, Birmingham B8 3HX.

A.R.E. Communications Ltd, 38 Bridge Street, Earlestown, Newton-le-Willows, Merseyside WA12 9BA.

Comutech (Devon) Ltd. 12 Edgecumbe Way, St. Anne's Chapel, Gunnislake, Cornwall PL18 9HJ.

Eddystone Radio Ltd, Alvechurch Road, Birmingham B31 3PP.

E.M.A. Telecommunications Engineers, Orford, Woodbridge, Suffolk IP12 2LX.

Grundig International Ltd, Mill Road, Rugby, Warwickshire CV21 1PR.

Lowe Electronics, Chesterfield Road, Matlock, Derbyshire DE4 5LE.

Panasonic U.K. Ltd., 300 Bath Road,. Slough, Berkshire SL1 6JB.

Phase Track Ltd, 127 Queens Road, Reading, Berkshire RG1 4DG.

Plessey Radio Systems, Martin Road, West Leigh, Havant, Hampshire P09 5DH.

Racal Communications Ltd, Bracknell, Berkshire. RG12 1RG.

Radio Shack Ltd, 188 Broadhurst Gardens, London NW6 8AY.

Rohde & Schwarz UK Ltd., Roebuck Road, Chessington, Surrey KT9 1LP.

Sony (U.K.) Ltd. South Street, Staines, Middlesex TW18 4PF.

South Midlands Communications Ltd. (SMC), Rumbridge Street, Totton, Southampton SO4 4DP.

Thanet Electronics, 143 Reculver Road, Herne Bay, Kent.

Uniden (UK) Ltd., Uniden House, Parnell Court, East Portway Industrial Estate, Andover, Hampshire SP10 3LX.

Vigilant Communications Ltd, Unit 5, Pontiac Works, Fernbank Road, Ascot, Berkshire SL5 8JH.

Further information

World Radio TV Handbook, 39th edition by J.M. Frost. Billboard A.G., soft covers, 600 pages. Available in Britain through Pitman Publicaions, £17.95.

Wireless World Guide to Broadcasting Stations, Newnes Technical Books, 1983, £7.50.

The Radio Society of Great Britain, Lambda House, Cranbourne Road, Potters Bar, Hertfordshire EN6 3JW.

European DX Council, P.O. Box 4, St. Ives, Huntingdon PE17 4FE.

International Short Wave League, 88 The Barley Lea, Coventry CY3 1DY.

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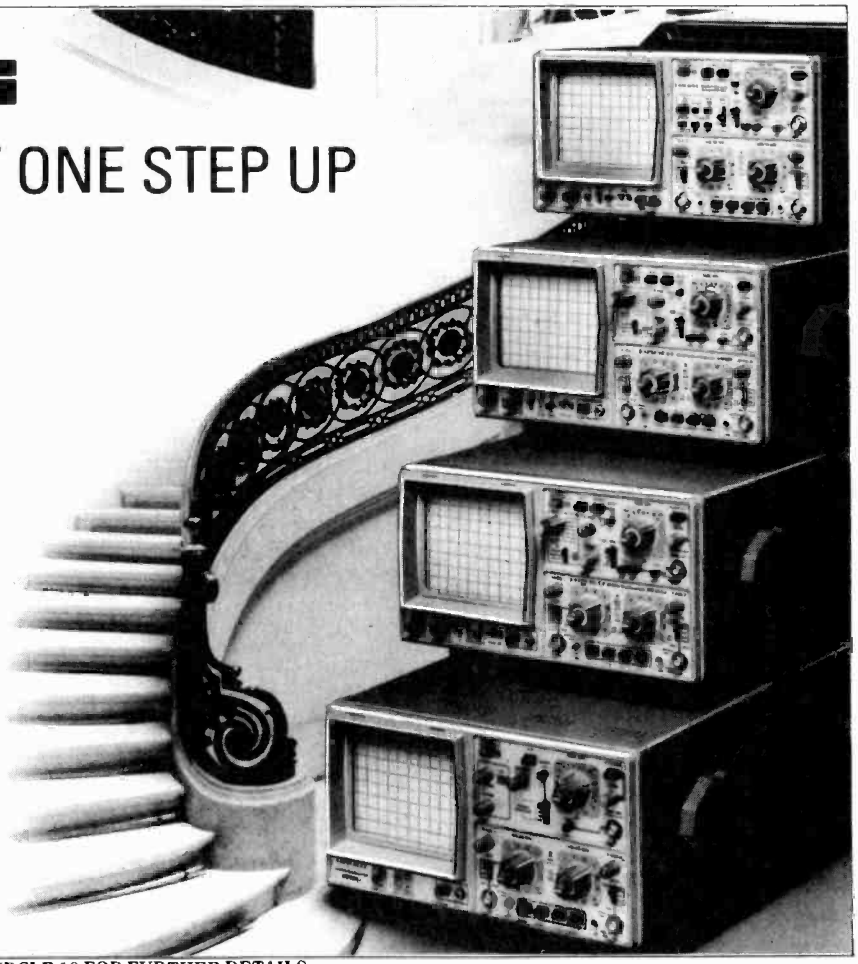

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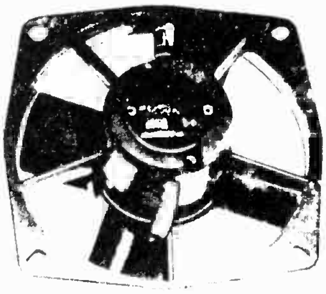

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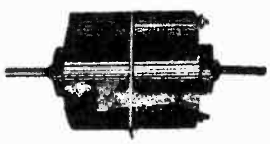

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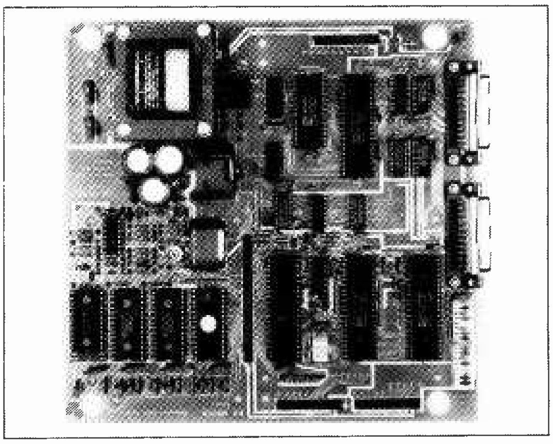
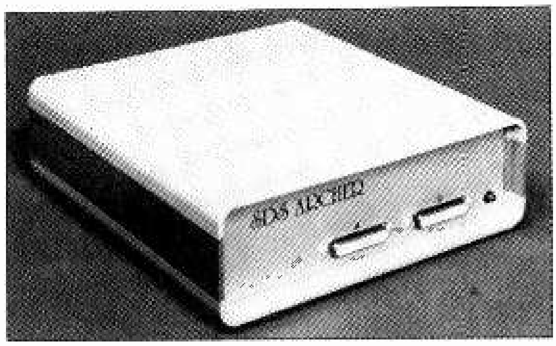
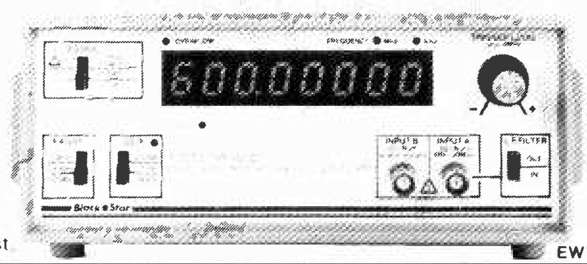






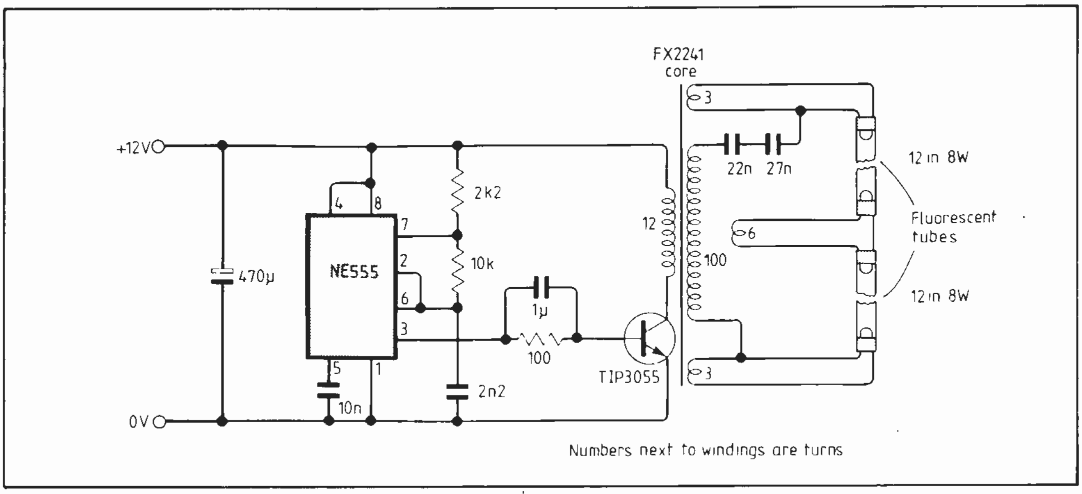
Fluorescent lamp inverter for 12V supply

Rather than using the usual power oscillator, my fluorescent lamp inverter has a 2N3055 power transistor driven by a 555 timer acting as an oscillator with a 1:1 mark/space ratio. This makes the circuit simple, efficient and easy to adapt for different tubes up to 20W. As shown, the inverter drives two 8W, 300mm tubes.

The transformer is wound on an FX2241 pot core with the 12-turn primary next to the core. Next is the main 100-turn secondary winding in three or four neatly-wound layers, followed by three cathode heating coils, two of three turns and one of six. A small paper 'air' gap should be formed between the core segments and adjusted to give maximum lamp brightness. Larger cores such as the FX2242 should work equally well.

To run other sized lamps, just alter the number of secondary turns and the size of the ballast capacitor, while keeping an eye on current consumption, light output and ease of starting. As shown the circuit takes about 1.6A. A Thorn-EMI 16W 2D lamp could also be used with its starter and capacitor removed, but at £7.50 they are rather expensive.

P.G. Bennett
Bristol



Bandpass filter

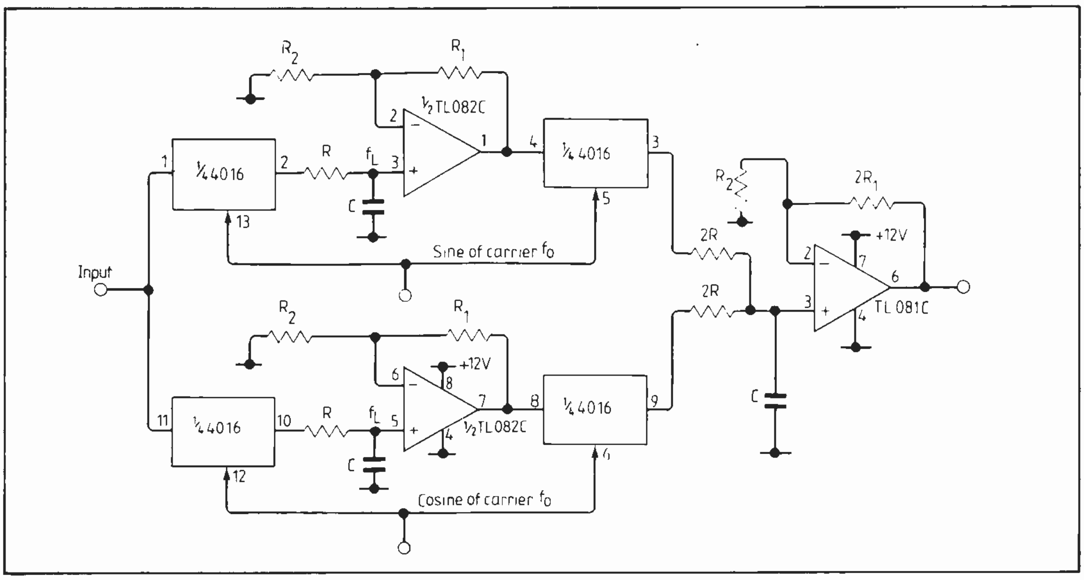
Many telecommunications systems require bandpass with a Q factor which can be set to a desired value without changing the circuit. This solution is a quadrature amplitude modulator consisting of two identical balanced mixers which operate under control of sine or cosine-related carriers of the desired pass-band centre frequency, f_0.

Operation of the circuit is similar to that of an n-path filter, Q-factor is around 100 and small variations in Q due to changing f_0 are negligible.

Two low-pass filters with cut-off frequency f_L only pass, unattenuated, input components from the mixers within $\pm f_L$ of centre frequency f_0. After low-pass filtering, each signal is remodulated by the same carrier frequency f_0 in quadrature. Another low-pass filter at the output of the summing point removes higher harmonics resulting from the second mixing.

Hence bandwith Δf is determined by cut-off frequency f_L and the Q factor can be set by the choice of f_0 only. For example, choosing an f_L of 10kHz and f_0 of 10MHz yields $\Delta f = 2f_L = 20$kHz, resulting in $Q = f_0/\Delta f = 500$. The value of Q is thus controlled by f_0 with Δf fixed. Values of R and C determine the pass bandwith.

Kamil Kraus
Rokycany
Czechoslovakia



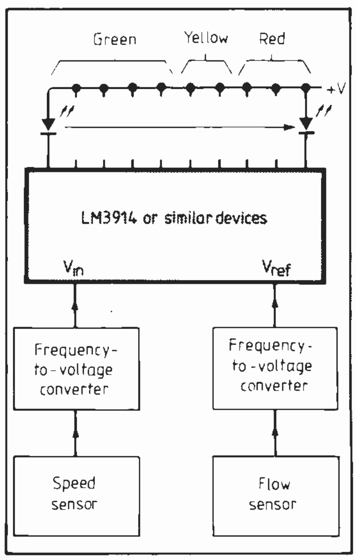
Rate indication using LM3914 bargraph i.c.

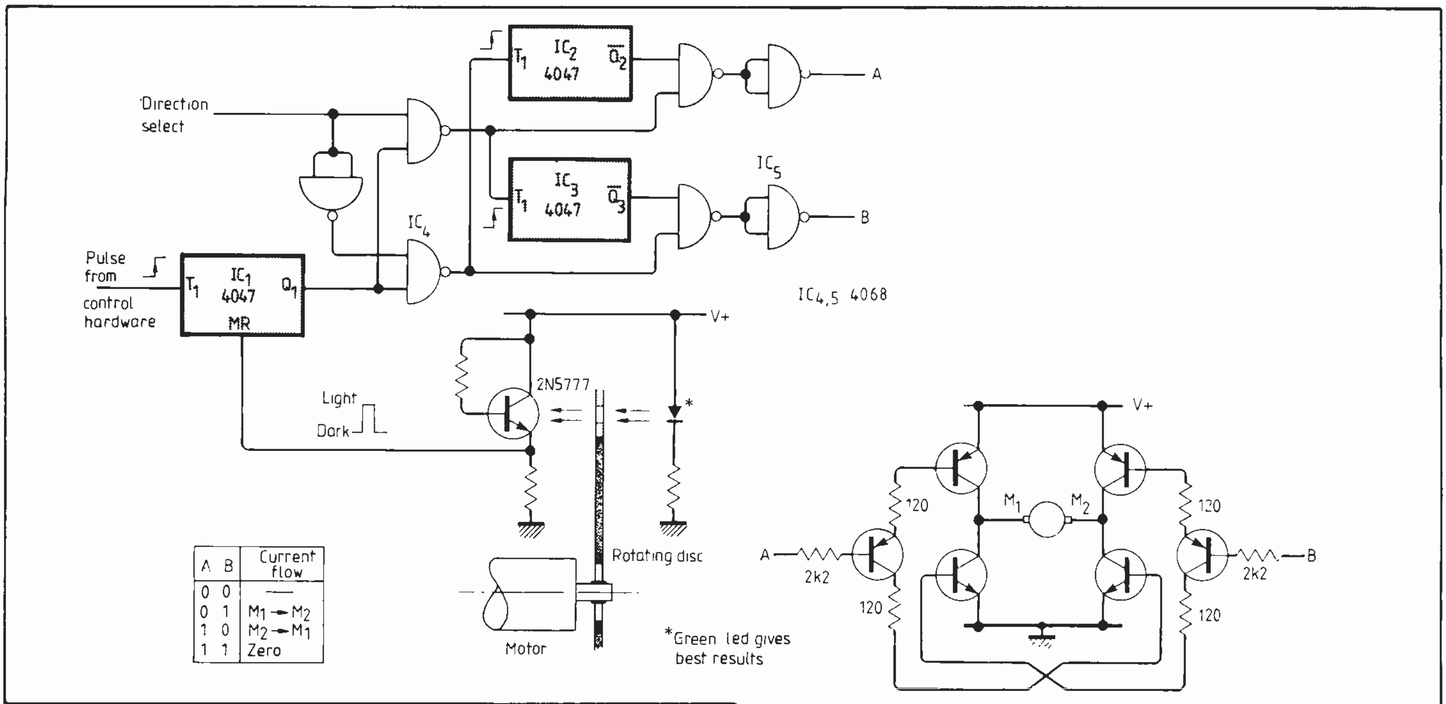
In some applications it is desirable to indicate a product or ratio. The popular LM3914 bargraph can be used for this purpose, the number of leds lit being proportional to V_{in}/V_{ref}.

Displaying petrol consumption directly in a car is inconvenient, possibly even a dangerous distraction; a bargraph indication using different colours can be noticed even when one is not looking directly at it.

Feeding, say V_{in} with a voltage representing km/h and V_{ref} with a representation of l/h, the bargraph could indicate km/l. I have tried the principle by feeding the two inputs with variable voltages and it works fine.

Bart Scholten
Lerenskog
Norway





Stepping a d.c. motor

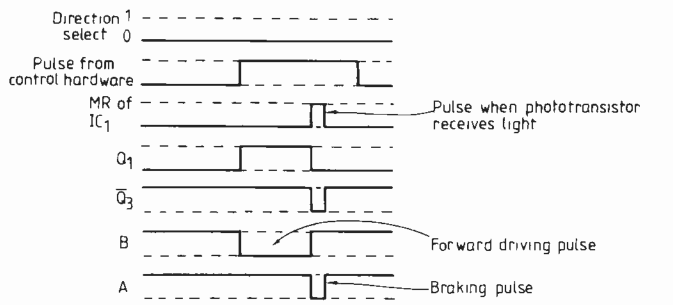
Using a digital control circuit, a d.c. motor can be made to act as a stepping motor provided that it has the requisite high starting torque, low armature time constant and high braking torque — features that usually go hand in hand. This single-supply control and drive circuit allows stepping in both directions.

Time taken for the motor to rotate through a given angle depends on the load so drive pulses have to be load dependent. This is difficult to implement directly so I used rotational position feedback with the aid of a disc with equally-spaced radial holes (a dark X-ray plate will do). Light through the disc holes is sensed by a fixed photo-transistor.

Output from the sensor feeds the master reset input of a monostable device, IC_1. As a hole passes the sensor, the reset input of IC_1 goes high. The Q output of IC_1 goes low, forcing the outputs of $IC_{4,5}$ high, and IC_2 is triggered to give a short low pulse, assuming that the direction select input is zero.

Pulse width at A depends on the motor used and is determined by trial and error. The pulse from IC_1 should be wide enough to rotate the motor through the desired angle (i.e. a single step) with the greatest load. I used a 15V supply and cmos digital i.cs.

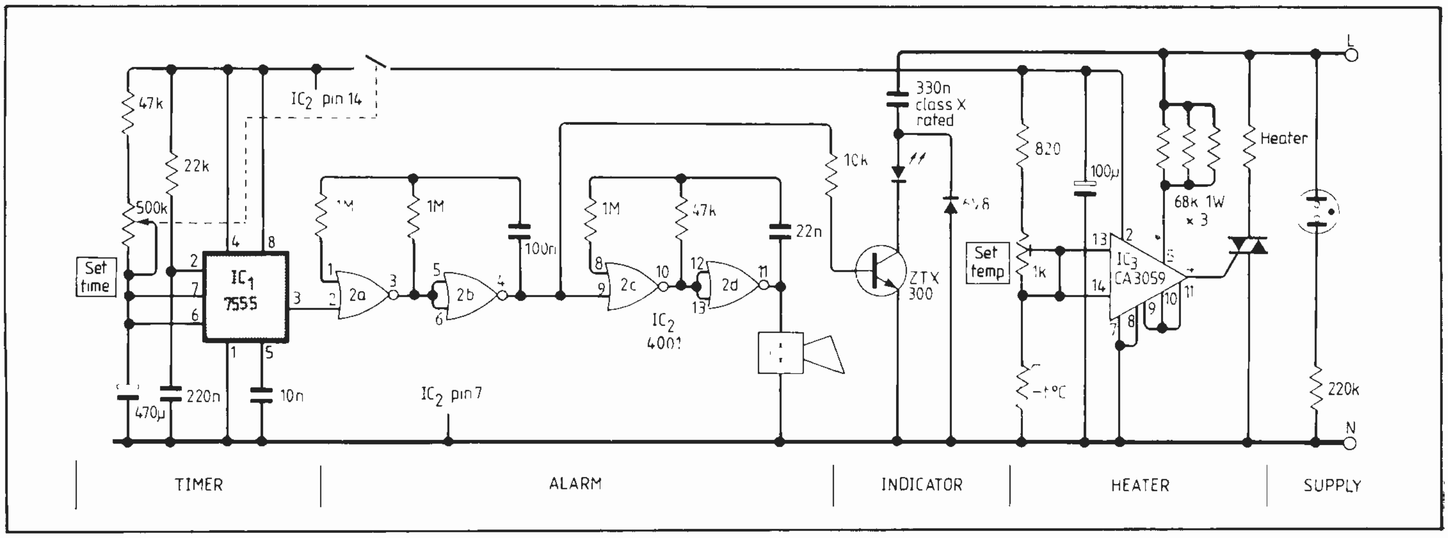
S. Mitra
West Bengal
India



Oven timer/alarm

Using the CA3059 zero-voltage switch as the basis of a circuit for controlling the temperature of a small oven is a conventional application. However, using the regulated d.c. output of this device to supply low-power i.cs for timer and alarm facilities means that no additional power supply components are required.

M.R. James
Sherborne
Dorset



Economical oscilloscope timebase

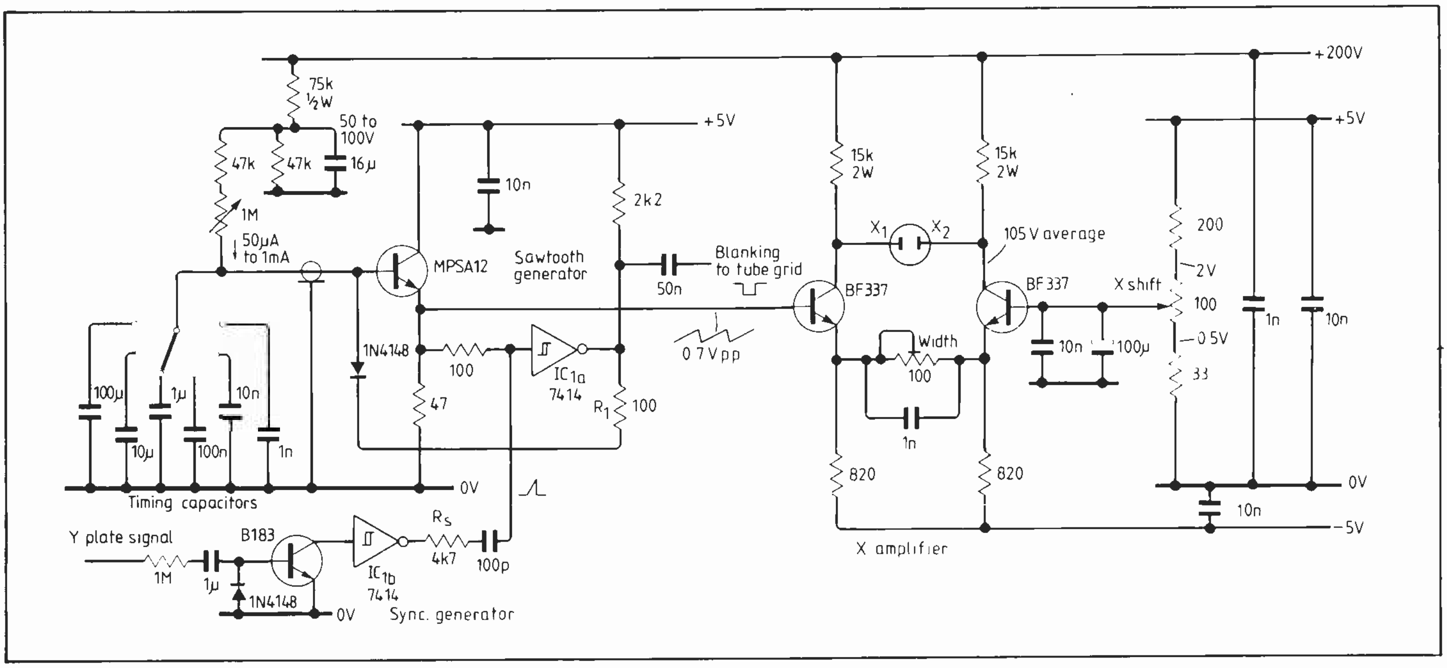
In this timebase for small cheap oscilloscope tubes, sawtooth waveforms are generated by a relaxation oscillator which uses hysteresis of a t.t.l. Schmitt trigger. The circuit provides up to 350V pk-pk at sweep frequencies rising to a few hundred kilohertz. Owing to the small amplitude required and the high voltage on the sweep potentiometer, charging of the timing capacitor is quite linear.

Feedback resistor R_1 slows down flyback so that the deflection amplifier can follow it at the highest speeds. This reduction in flyback discharge current also eliminates voltage steps on the capacitor due to series resistance. The width control is shunted by a compensating capacitor which affects operating speed.

Synchronization comes from a simple wave squarer fed by a signal from a Y plate. The 100pF capacitor and 4.7kΩ resistor feed a small fast pulse to IC_{1a} which causes a slightly early flyback if the sweep is nearly finished, but otherwise has no effect. A 5V signal is also available for flyback blanking.

The transistors do not require heat sinks. With stage gains of 400, reasonable care is needed with layout.

D.H. Potter
Axminster
Devon



Phase sequence network

An ideal three-phase supply has three voltages of equal magnitude and separated in phase by 120°. Although only balanced voltages are generated, unbalanced loads and faults can cause unbalance in voltage magnitude or phase at the consumer terminals. Such imbalances have little or no effect on single-phase supplies, but they can cause overheating in three-phase motors.

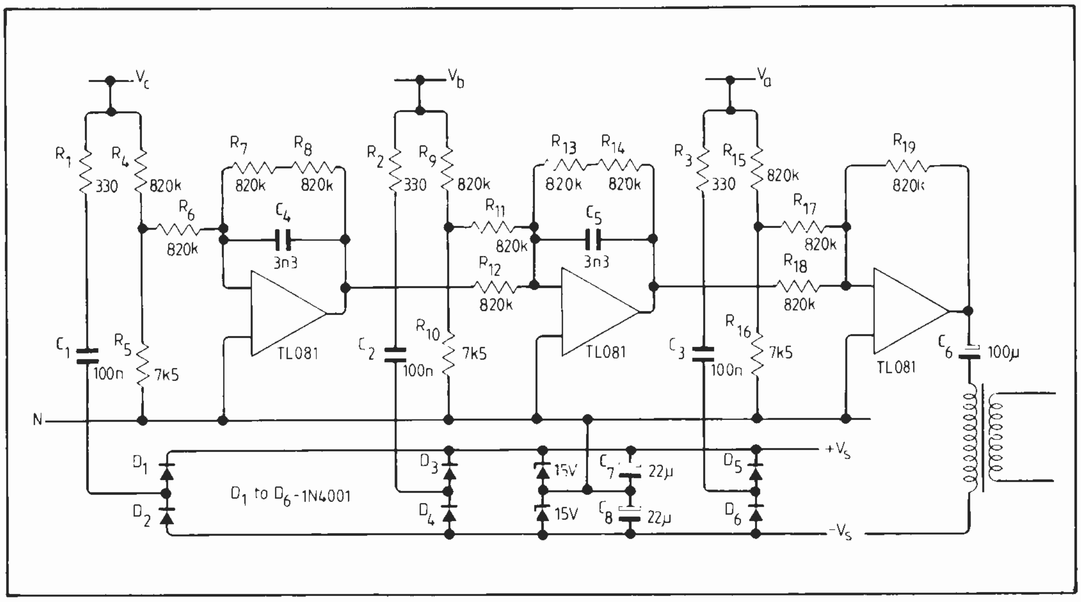
Output of this circuit can be made proportional to either to positive or negative phase-sequence of the three-phase supply. The positive phase sequence is a kind of vectorial mean of the three-phases that do useful work in a motor. The negative phase sequence is the main cause of overheating during loss of a line connection. Reversing any two inputs switches the circuit from one function to the other.

The three-phase voltages are divided and fed to three op-amps connected in series to produce output voltage,

$$V_o = -k(V_a + a(V_b + aV_c))$$

where a is the phasor

$$a = \exp(j.2.\pi/3).$$



Since each op-amp introduces inversion or 180° phase shift, a capacitor bridging the feedback resistor can be selected to introduce a further 60° phase shift at 50Hz. This makes total phase shift 240° lagging or 120° leading, as required by the second equation.

Power supply for the op-amps is taken from the mains through capacitors C_{1-3}. In principle, the circuit requires a neutral connection but it works without one. A small transformer isolates output from the mains-connected circuit.

A. Refsum
Queen's University of Belfast

Loudspeaker impedance measurement

Impedance of a low-frequency loudspeaker is represented by output voltage of this constant-current audio power amplifier with bridge output.

Amplifier IC_1, connected as a straightforward non-inverting circuit, amplifies test signal V_{in} to about the supply-rail level. If the non-inverting input of IC_2 is taken as ground, this amplifier operates as a standard inverting circuit, maintaining a virtual ground at its input. The portion of IC_1 output across R_4 must then also appear across R_7, the input resistor of IC_2, and output of IC_2 varies oppositely and in proportion to Z_m, its feedback impedance.

But for the small drop across R_7, Z_m is connected between the complementary outputs of amplifiers $IC_{1,2}$, making a signal of nearly twice the supply voltage available for measurement. Since

$V_{oa1} = V_{ia}((R_4 + R_5 + R_6)/R_6)$,

where V_{oa1} is output voltage of IC_1 and V_{ia1} is input voltage of IC_1,

$V_{ia2} = V_{oa1}((R_4/(R_4 + R_5 + R_6))$

and

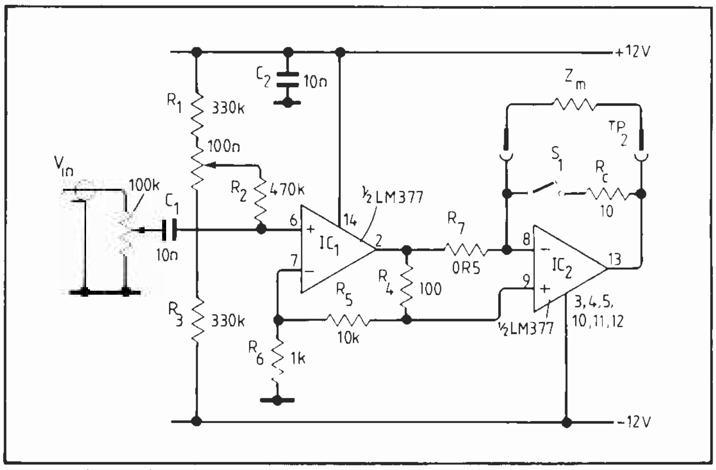
$$V_{oa2} = V_{ia2} \times (Z_m/R_7)$$

then

$V_{oa2} = V_{in} \times (R_4/R_6) \times (Z_m/R_7)$,

or, if the offset potentiometer is adjusted for $V_{in} = 0.5V$,

$$Z_m = 10V_{oa2}.$$



In practice, with the switch momentarily closed, the input potentiometer nulls the tester output with no input then the offset potentiometer is adjusted so that there is 1V across calibration resistor R_c with a signal present.

N.J. Dennis
Ontario
Canada

1Hz to 30MHz voltage to frequency converter

For an input of 0-5V, this circuit produces frequencies from 1Hz to 30MHz with ±0.08% linearity error, approximately 20ppm/°C drift and a zero error of 0.3Hz/°C.

Using charge-feedback allows the amplifier to close the loop around the entire converter which enhances linearity and stability but introduces loop settling time into the overall system step response. Main elements of the circuit are a chopper-stabilized op-amp, the LTC1052, and a switched-capacitor 'building block', the LTC1043 (both Linear Technology).

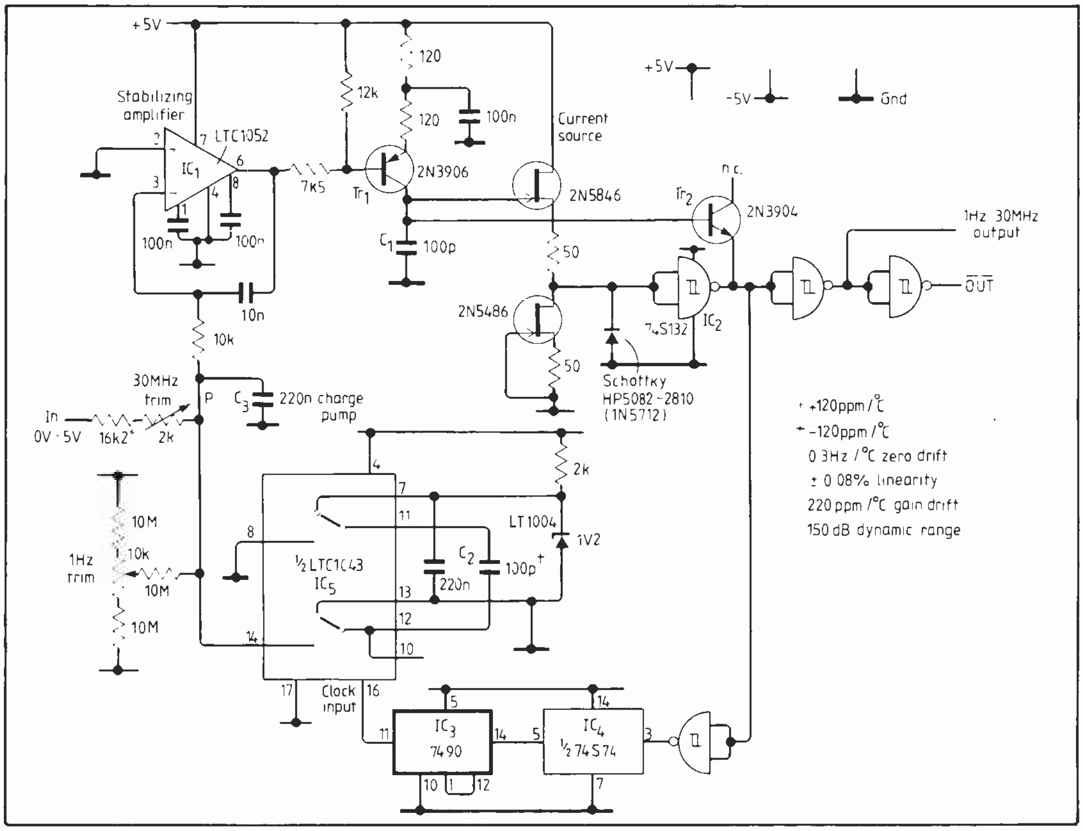
Positive V_{in} sends output of IC_1 negative, causing current source Tr_1 to charge C_1 positively. Schmitt-trigger inverter IC_2 changes state when the ramp passes the upper threshold, thereby removing charge from C_1 through diode-connected Tr_2. Input-voltage hysteresis of this gate sets the limits which the oscillator will run between. Circuits $IC_{3,4}$ provide a division by 20 to make the feedback frequency range acceptable to the LTC1043.

During the oscillator ramping interval, IC_5 pins 11 and 12 are connected to pins 7 and 13, charging C_2 to the LTC1004 1.2V reference voltage. When output of IC_3 goes low, charged capacitor C_2 appears at pin 14 of IC_5. Thus each time that IC_3 pulses, a fixed charge is dispersed into junction P with a polarity which opposes the positive input current.

Capacitor C_3 integrates the discrete charge dumps and amplifier IC_1 controls Tr_1 to run the oscillator at a frequency necessary to force the non-inverting input of IC_1 to 0V. In this way, drift and non-linear response in the oscillator section are compensated for by the closed-loop control.

This mode of control results in very low output jitter and noise over the whole 150dB operating range. Jitter stays below 0.01% down to 20kHz, rising to 1% at 30Hz and 10% at 1Hz. As operating frequency decreases towards IC_1 feedback-loop roll-off, the loop dominates jitter characteristics. In the higher frequency ranges, the loop poles are not a factor and current source and schmitt-trigger noise dominate.

To trim the circuit, input should be grounded and the 1Hz-trim potentiometer adjusted to the point where oscillation occurs. Apply 5.000V and set the 30MHz-trim potentiometer for 30.00MHz output. Repeat this procedure until both end points are fixed.



Keith Williams
Microcall
Thame
Oxon

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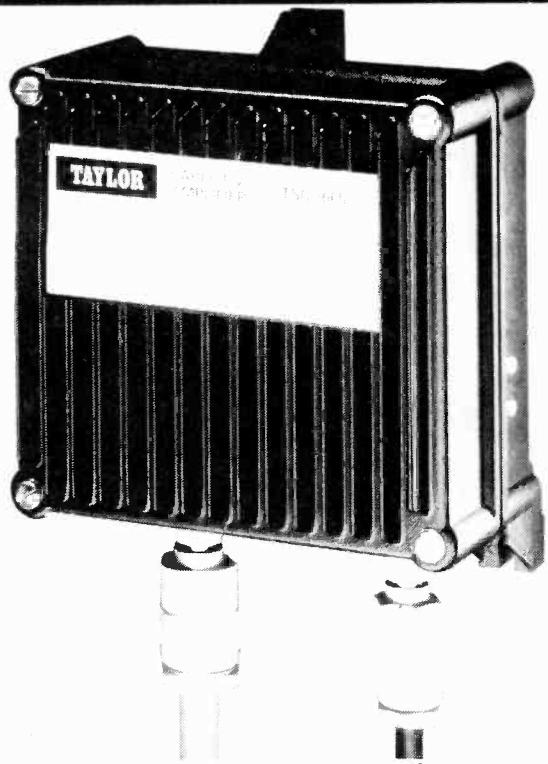

Application other than Cable T.V. includes C.C.T.V. (up to 26 Channels 8MHz wide on V.H.F. Repeaters, and up to 65 Channels 8MHz wide on U.H.F./V.H.F. Repeaters). Suitable for outdoor mounting.

TYPE	FREQUENCY RANGE MHz	GAIN dB ADJUSTABLE	MAXIMUM OUTPUT dBmv	FREQ RESPONSE FLATNESS	INTERNAL SLOPE ADJUSTMENT	POWER REQUIREMENT
TSC3060	40-300	10-30	60dB (1000mv)	+ or – .5dB	5dB	27-42V 10VA~
TSC3060SM	40-300	10-30	60dB (1000mv)	+ or – .5dB	5dB	25-45V 7VA~
TSC3660	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv)	+ or – .5dB	5dB VHF — UHF	27-42V 18VA~
TSC3660SM	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv)	+ or – .5dB	5dB VHF — UHF	25-45V 13VA~
TSC3665	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv) VHF 65dB (1800mv) UHF	+ or – .5dB	5dB VHF — UHF	24-42V 24VA~
TSC3665SM	40-300 470-860	10-30VHF 16-36UHF	60dB (1000mv) VHF 65dB (1800mv) UHF	+ or – .5dB	5dB VHF — UHF	25-45V 18VA~

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TYPE	FREQUENCY RANGE MHz	ATTENUATION 40MHz	ATTENUATION 300MHz	TYPE	FREQUENCY RANGE MHz	ATTENUATION 470 MHz	ATTENUATION 860MHz
EZV6	40-300	6dB	1dB	EZU6	470-860	6dB	1dB
EZV9	40-300	9dB	1dB	EZU9	470-860	9dB	1dB
EZV12	40-300	12dB	1dB	EZU12	470-860	12dB	1dB

	TYPE	COAXIAL CABLE CONNECTORS
A	SCP14	Screw on coaxial plug for 14mm Outside Diameter cable.
B	SCP10	Screw on coaxial plug for 10mm Outside Diameter cable
C	SCP	Screw on coaxial plug for 5 - 9mm Outside Diameter cable
D	SAC	Screw on right angled connector
E	SFC	Screw on female line connector
F	SMC	Screw on male line connector
	HS1/14	Heat shrink sleeve for SCP14
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Dawe	6292A	Soniclean Automatic Generator. 25Khz High Intensity o/p. £150.00
Tektronix	106	Square wave Generator 10Hz-1MHz r.r.p. £175.00
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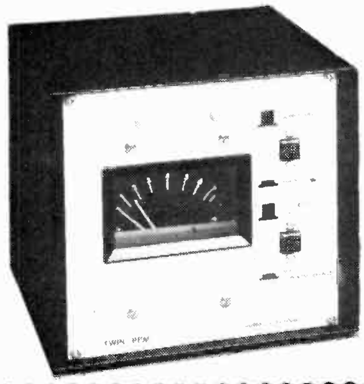

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Oscilloscope display of mean, peak or r.m.s. values

Simultaneous display on a single-channel oscilloscope

When working with random signals such as audio or white noise, it is often difficult to estimate from an oscilloscope screen their mean, peak or r.m.s. values. However, these are just those quantities required when developing circuitry that filters or manipulates such signals.

This compact instrument provides a display of all, or any combination of V_{in}, V_{peak}, $V_{r.m.s.}$ as horizontal lines on the oscilloscope simultaneously with the input voltage, while using only a single oscilloscope channel. As an optional extra a low-cost, built-in d.v.m. can provide a numerical readout of the mean, peak or r.m.s. value of the input voltage, from 20mV to 20V f.s.d.

A block diagram of the instrument (Fig.1), shows that it separates neatly into three sections: analogue signal processing; digital channel switching; and a digital voltmeter. The analogue section produces the four required voltages at the input to a four-channel multiplexer. To keep the digital circuitry as simple as possible, a mechanical switch is used to select either $+V_{peak}$, or $-V_{peak}$. The digital section sequentially selects any combination of the input signals that have been chosen by the user from four push buttons. If the button is pushed the corresponding signal is displayed; another push turns the signal off.

A separate, three-push-button unit selects which signal the d.v.m. measures.

Analogue circuit

The incoming signal is buffered by IC_{1a}, (Fig.2) with an input resistance set by R_1 to 1MΩ, matching that of a standard oscilloscope input, so ordinary oscilloscope probes can be used with the instrument. A straight-forward RC low-pass filter with a one second time constant gives the mean signal value, buffered by IC_{1b}. The positive and negative signal peaks are captured by conventional op-amp peak detectors, IC_2, with a decay time constant set to one second. This allows the peak value of a signal whose average amplitude over time is changing to be followed. R_4, R_6 could be switched out to provide the peak voltage over a much longer time, set by the input bias current of $IC_{2b,c}$ and the reverse leakage of $D_{2,4}$. The value of C_4, C_6 is a compromise between catching fast peaks, as set by the maximum output current capability of $IC_{2a,c}$ and the droop rate. D_1, D_3 clamp the outputs of $IC_{2a,c}$ when the input signal is less than the currently held peak value, reducing the voltage slew rate required from the op-amps and minimizing reverse-bias-caused leakage currents through D_1, D_3.

An Analog Devices true r.m.s. i.c. (AD536) calculates the r.m.s. values of V_{in}, using the implicit

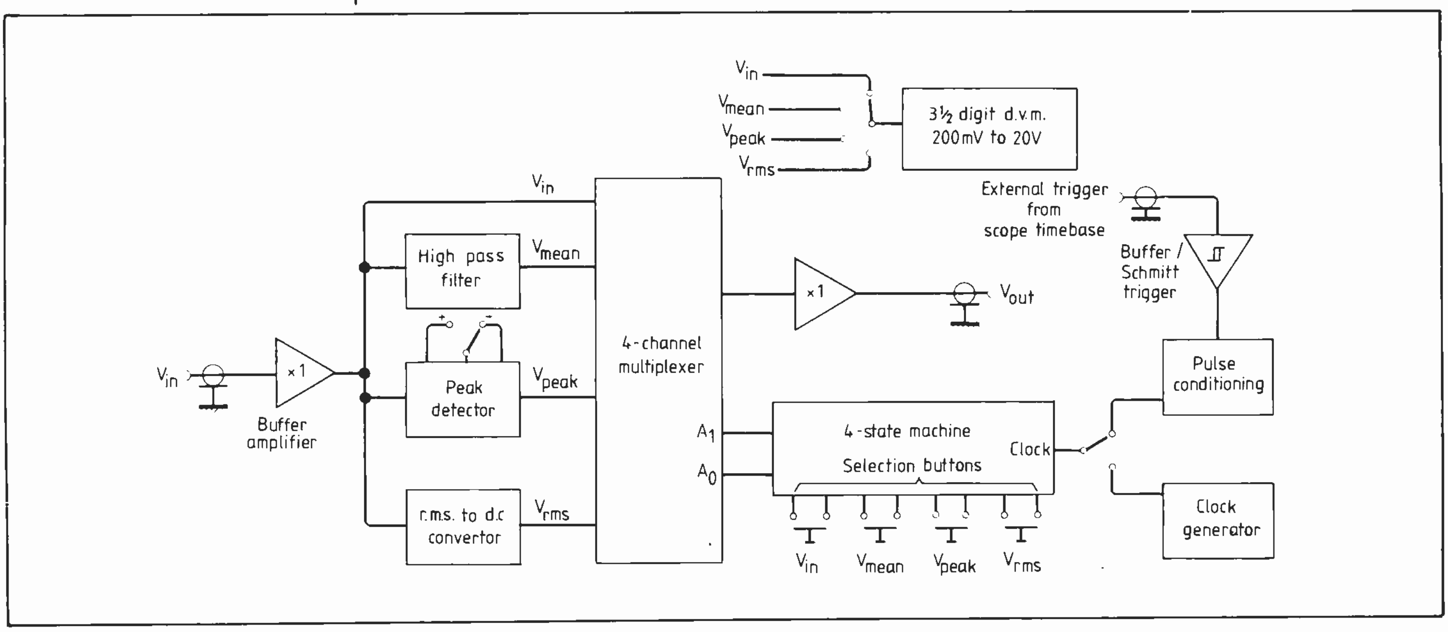


Fig. 1. **System block diagram of signal analyser.**

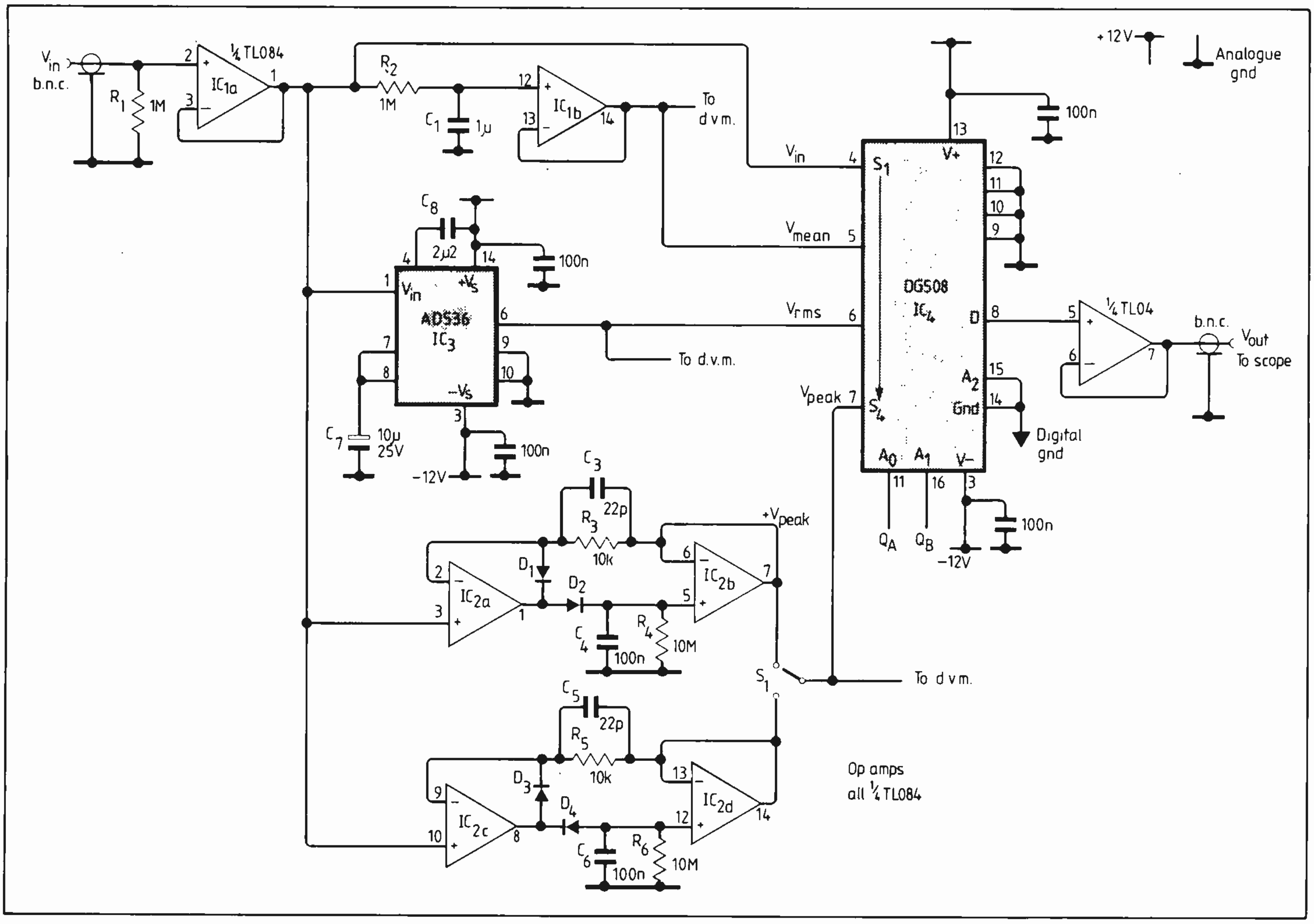


Fig. 2. **Circuit diagram analogue sub-section.**

computation method, shown schematically in Fig.3. The low pass filter output is the r.m.s. value, feedback to the multiply/divide stage to scale down the V_{in}^2 product by V_{out}, so avoiding potentially very large square term products (e.g. $V_{in}^2 = 100$ if $V_{in} = 10V$). The output settles to the r.m.s. value of the input, averaged over a time period set by RC (the "mean" in root mean square). The AD536 works internally in a current mode, but the principle is identical to that shown here.

There are two sources of error in the r.m.s. calculation; static error and dynamic error. Static error is due to non-idealities in the XY/Z operation, offset errors i.e. $V_{rms} = 0$ when $V_{in} = 0$, and absolute gain errors, i.e. $V_{rms} = K\sqrt{V_{in}^2}$, where K is not unity. Offset and gain errors can be trimmed out. Even without these trims, the AD536J version is specified to have a combined total maximum error of 0.5% of the r.m.s. value ±5mV, quite adequate for the oscilloscope display. Static errors occur for all frequencies of V_{in}; dynamic errors depend on the waveshape, (particularly the crest factor $= V_{in(peak)}/V_{r.m.s.}$ and the input signal frequency relative to the period over which the mean is taken.

If V_{in} is a sine wave, for example, then $V_{in}^2/V_{r.m.s.}$ has a double frequency ripple component (see Fig.3) which is low-pass filtered below a corner frequency of $1/(2\pi RC)$Hz. To reduce the magnitude of this ripple (or drop for pulse-type waveforms) it is necessary to increase RC. This, however, increases the time required for $V_{r.m.s.}$ to settle to its true value following a step change in the magnitude of V_{in}. A better compromise is to place another first-order low-pass filter external to the implicit feedback loop.

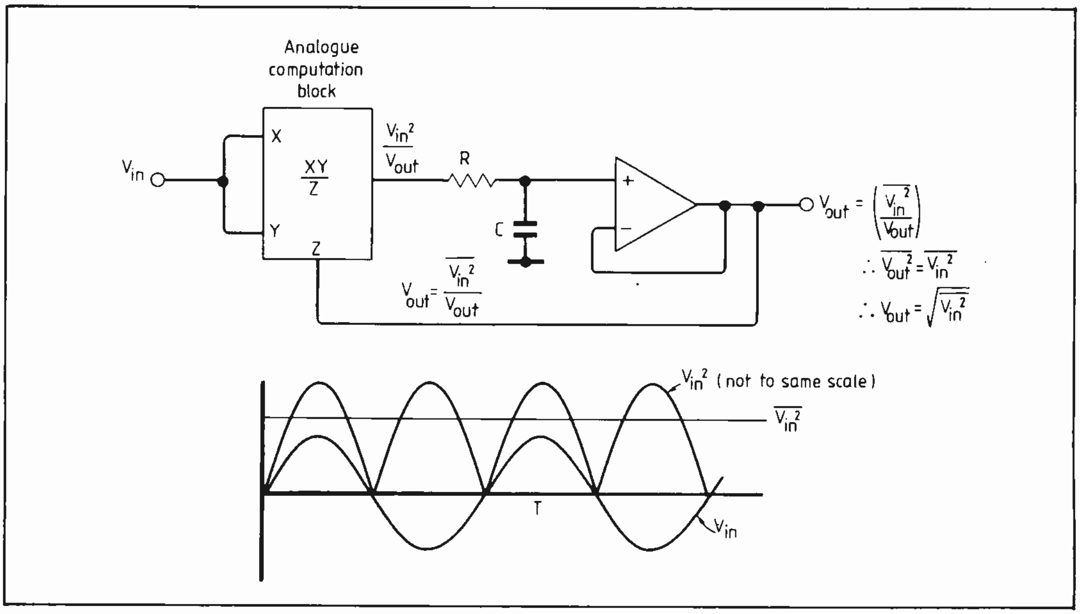


Fig. 3. **Root-mean-square calculating i.c.**

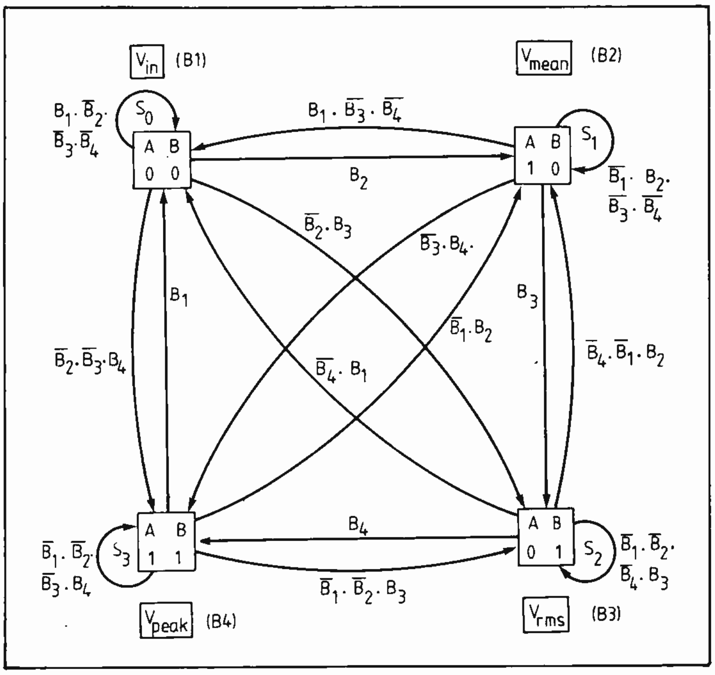


Fig. 4. **State table for sequential four-state machine.**

This reduces the magnitude of the ripple, without proportionally increasing the settling time. For the values of C_{av} and C_7 (Fig.2) used here the settling time to 1% of the step change input amplitude is about 3 seconds. The lowest frequency sine wave that can be measured to within 1% of the true r.m.s. is 10Hz, compatible with the overall 0.1 second time constant of the instrument. Many other compromises and configurations are possible: Analog Devices has a booklet available describing the various trade-offs involved. Note that the AD536 is able to cope with ±20V peak transient inputs without damage, but the nominal full scale r.m.s. output is 2V, i.e. $V_{p-p} = 5.6V$. The quoted accuracy is maintained to well over 1MHz.

All four derived voltages are sent to an 8-to-1 multiplexer IC_4, which has a fast switching time, and approximately constant on resistance of 60Ω, plus a wide range of input signal voltages, easily coping with the design range of ±10V. The channel-select logic inputs are t.t.l. compatible and the output is buffered by IC_{1c} to provide a low-impedance drive to the oscilloscope.

Digital section

The digital section's function is to sequentially switch one of the four voltage inputs through to the oscilloscope, if and only if the button corresponding to that input has been activated. For this a logical four-state machine is used, the state switching diagram for which is shown in Fig.4. Each button toggles a flip-flop, ($IC_{12,13}$, Fig.5), which are all cleared on power up. The first push of a button sets the flip-flop Q output high, denoted on the state diagram by variables B_n; another push sets it low, shown as $\overline{B}_n$. If only a single button was set (indicated to the user by the l.e.d. in the button coming on), e.g. V_{in}, the four-state machine would cycle continually through a single state, A = 0 and B = 0 in this example. These internal state variables A and B are also used as output variables: they are simply the two-bit binary code selecting which input is switched through to the output in IC_4.

When the user wishes to display more parameters of the input signal, e.g. V_{rms}, the r.m.s. button is pushed, B_2 set, and the machine cycles between states S_0 and S_2. The machine changes state on every clock pulse, which comes either from an oscilloscope time-base synchronous pulse, giving an alternate sweep display of V_{in} and V_{rms}, or from a free-running oscillator, giving a chopped display. The labels on the arrows show the state of the button flip-flops for that particular path to be taken. All possible paths must be indicated on the diagram. From these change of state paths the set and reset conditions for the state machine internal variables A and B (which electronically are the Q outputs of the J-K flip flops in IC_{11} are derived:

Set $A = S_0.B_2 + S_2.B_2.\overline{B}_1.\overline{B}_4 + S_2.B_4 + S_0.\overline{B}_2.\overline{B}_3.B_4$
Reset $A = S_1.B_1.\overline{B}_3.\overline{B}_4 + S_3.B_1 + S_3.\overline{B}_1.\overline{B}_2.B_3 + S_1.B_3$
Set $B = S_1.B_3 + S_0.\overline{B}_2.B_3 + S_1.\overline{B}_3.B_4 + S_0.\overline{B}_2.\overline{B}_3.B_4$
Reset $B = S_3.B_1 + S_3.\overline{B}_1.B_2 + S_2.\overline{B}_4.\overline{B}_1.B_2 + S_2.\overline{B}_4.B_1$

These equations can be tidied up to:
Set $A = S_0.(B_2 + B_4.\overline{B}_3.\overline{B}_2) + S_2.(B_4 + B_2.\overline{B}_1.\overline{B}_4)$
Reset $A = S_1.(B_3 + B_1.\overline{B}_3.\overline{B}_4) + S_3.(B_1 + B_3.\overline{B}_1.\overline{B}_2)$
Set $B = S_0.(B_3.\overline{B}_2 + B_4.\overline{B}_2.\overline{B}_3) + S_1.(B_3 + B_4.\overline{B}_3)$
Reset $B = S_2.(B_1.\overline{B}_4. + B_2.\overline{B}_1.\overline{B}_4) + S_3.(B_1 + B_2.\overline{B}_1)$

And the internal states are defined as: $S_0 = \overline{AB}$, $S_1 = A\overline{B}$, $S_2 = \overline{A}B$, $S_3 = AB$.

Following Zissos in Ref. 1 the set and reset equations for a JK type flip-flop with outputs A and $\overline{A}$ are:

$$\text{Set } A = \overline{A}.JA$$
$$\text{Reset } A = A.KA$$

So when AB values are substituted for S_0 then the set and reset conditions for the two flip-flops can be derived by simply dropping the A and $\overline{A}$ (or B and $\overline{B}$) from the appropriate expression. When this is done we get:

Set $A = \overline{B}.(B_2 + B_4.\overline{B}_3) + B.(\overline{B}_4 + B_2.\overline{B}_1)$ 1
Reset $A = \overline{B}.(B_3 + B_1.B_4) + B.(B_1 + B_3.\overline{B}_2)$ 2
Set $\overline{B} = (B_4 + B_3).(B_2 + A) = \overline{B}_4.\overline{B}_3 + B_2.\overline{A}$ 3
Reset $\overline{B} = (B_1 + B_2).(\overline{B}_4 + A) = \overline{B}_1.\overline{B}_2 + B_4.\overline{A}$ 4

The gating shown in Fig.5 derives these functions. Expressions 1 and 2 can be recognised as a selection depending on B between two combinatorial functions, implemented with a 4053 multiplexer. The negated form of 3 and 4 has been derived so that a dual, four-input And-Or-Not gate 4085 IC_{10} can be used to drive JK B IC_9. The complete four-state machine can be made up with only five i.cs and has been found completely reliable and glitch free in use.

The clock source for the four state machine comes from a dual comparator IC_5 used as a free running 20kHz oscillator with a t.t.l. compatible output, and as a level comparator with hysteresis to bring the oscilloscope time-base gate or flyback pulse to a standard t.t.l. level. The 1k preset R_1 should be adjusted to suit the oscilloscope used, and the input 10k/1k attenuator may need altering. Note the four-state machine changes on the rising edge of the clock pulse. Front panel switch S_2 selects alternate or chop.

The displayed parameter select push buttons are debounced by IC_{11}, whose outputs drive four D-types wired to toggle. The four red leds mounted on the push buttons give a clear indication of exactly what is being displayed. Of course this is all, perhaps, an electronic over-indulgence: a simple mechanical toggle switches could be used instead, with invertors to provide true and complement outputs.

Digital voltmeter. Having gone to some trouble to derive mean, peak and r.m.s. values of a waveform it seems worthwhile to include a voltmeter in the instrument to give a digital readout of their long term values. Note that the oscilloscope display is even more versatile than an analogue meter; quite short term trends in the three parameters (depending on the time constants used) and their causes can be observed simultaneously.

The dynamic range of the input signals of interest in audio work is liable to be quite large. A d.v.m. has, therefore, been selected with a capability of resolving down to 100μV levels. The i.c. chosen, the Ferranti ZN451, has 3½ digits, based on a charge-balancing circuit, with a digital auto-zero and external amplifier offset cancellation facilities. With careful design it is able to work at a remarkable 2mV f.s.d., i.e. a resolution of 1μV. Here the ranges selected are 19.99V, 1.999V and 199.9mV f.s.d. The single-chip d.v.m. directly drives a 3½-digit liquid-crystal display.

A rotary switch S_7 selects an output from the 100k input attenuator, which is buffered by op-amp IC_{1d}. The ZN451 cancels the offset voltage of this op-amp by regularly reversing the polarity of signal the chip voltage-input pins see, using a cmos switch IC_{14}. First, the chip measures $V_{in} + V_{offset}$, then $-V_{in} + V_{offset}$, digitally adds the two together, and divides by two, so the offset voltage is cancelled.

The ZN451 runs from a single +5V rail, and the common-mode input voltage range is ±1V centred on +2.5V. To measure bipolar signals of ±20mV range the chip power rails are shifted to nominally −2.5V (using a simple single-transistor regulator) and +2.5V (using the on-chip +5V regulator, which maintains a 5V differential between V_{cc} and V_{gnd}). The cmos switch control signals PH1 and PH2 hence run between ±2.5V, which is sufficient to activate them, as they have a +1.4V t.t.l.-compatible logic input threshold.

A second section of the switch together with the Ex-Or gates in IC_{15} (for backplane a.c. drive) set the decimal point position on the display, and a third switch section controls two leds for "V" or "mV" indication.

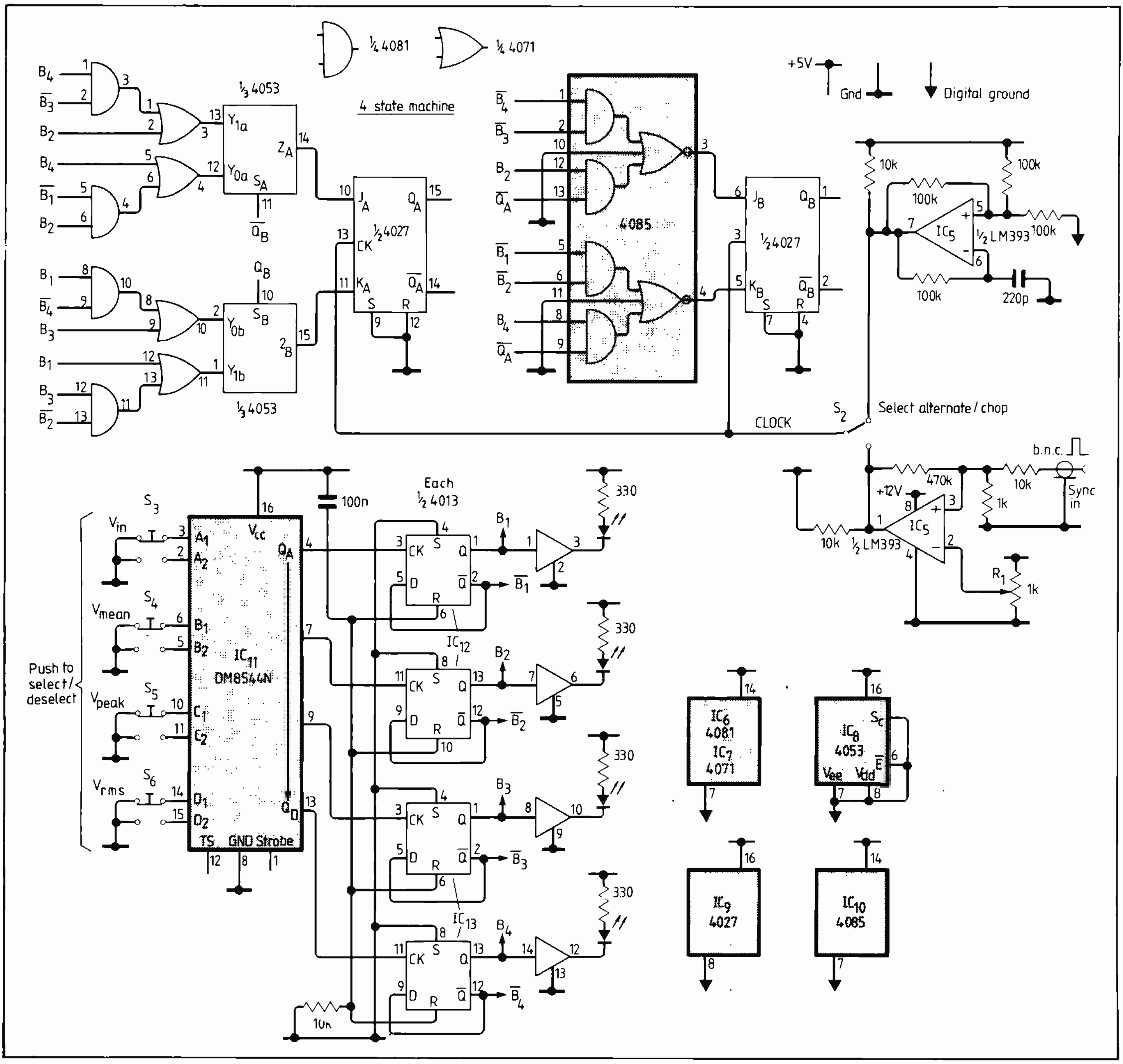
Calibration of the d.v.m. is quite straightforward if a current source with a very high output impedance (>10MΩ) such as that in Fig.7 is used. The bottom resistor is nominally 1k. Adjust R_2 in the current source so that 199mV is dropped across it, preferably measured by an external $4\frac{1}{2}$ digit d.v.m. Do not alter R_2 subsequently! Switch S_7 to the 199.9mV range and adjust R_3 for a 199mV reading. Using the changeover switch S_9 you can check for a −199mV reading. Now switch to the 1.999V range, and adjust R_4 for a 1.99V reading on the ZN451; do not alter R_3. Similarly switch to the 19.99V range and adjust R_5, leaving R_3 and R_4 alone.

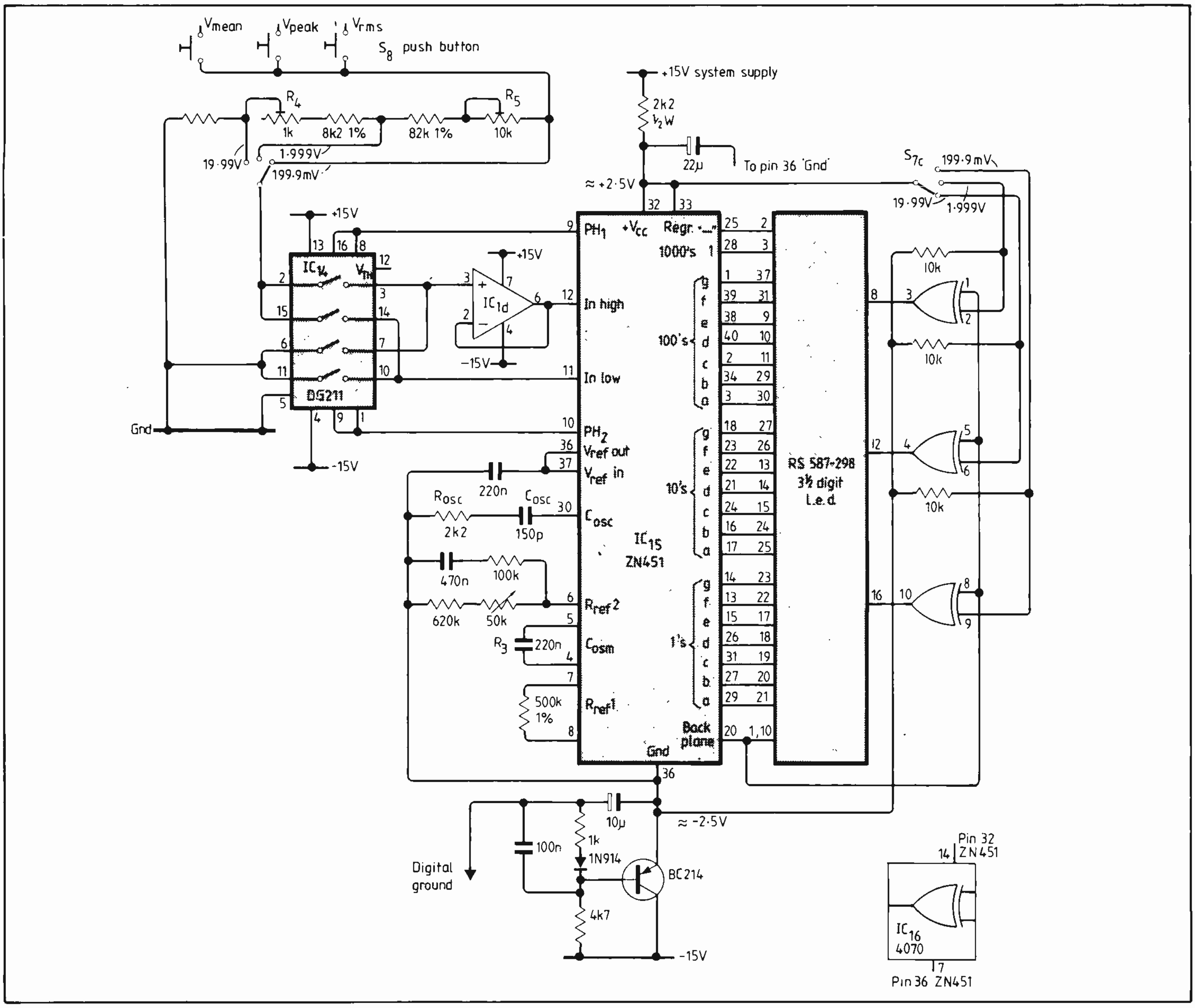
The meter incorporates internal digital auto-zero, so with the attenuator input shorted to ground there should be no bottom-digit flicker. If a range is overloaded the display is blanked, except for a leading "1". The internal oscillator clock rate is set by R_{osc} and C_{osc} so that the measurement interval is 500ms, a whole number of mains 20ms cycles for mains pick up rejection. R_{osc} could be trimmed if necessary. Note that for 100μV resolution decoupling and wiring layout around the ZN451 should be carefully attended to.

Use and construction

The prototype of the instrument

Fig. 5. **Digital sub-section circuit diagram.**





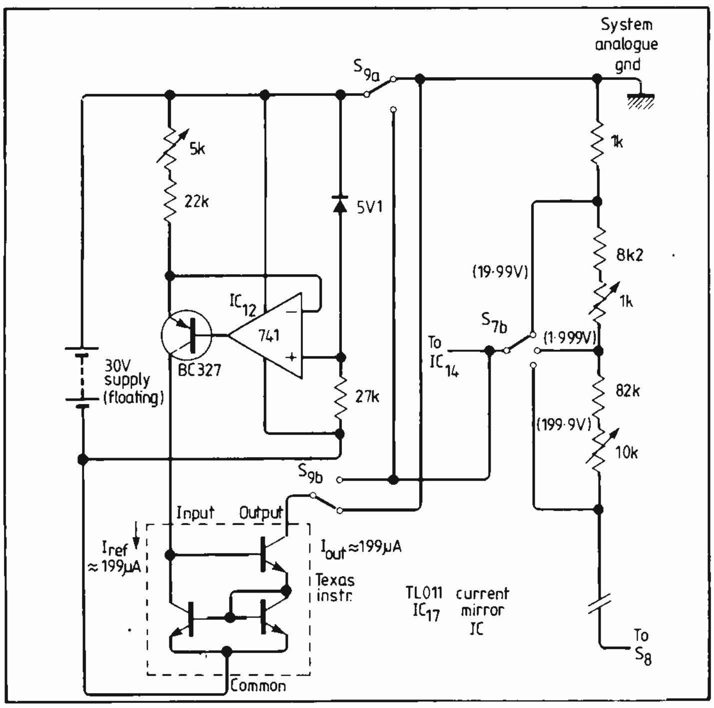


Fig. 6. **Digital voltmeter circuit diagram, previously published in *Electronic Product Design*, Dec. 1984.**

Fig. 7. **Calibration current source.**

was constructed in a 180×120×70mm plastic Vero case, on square-pad Veroboard, using point-to-point wiring. A mains to ±15V and +5V p.s.u. is included, using the 6VA slim-line 15-0-15V transformer available from RS Components Ltd. (RS 208-282). The usual 78/79 series regulators were used, only a small heat sink being necessary as the circuitry is generally designed around low-power devices. The front panel switches are of the piano-key type, drilled to accept sub-miniature leds. The d.v.m. range switch is placed on the rear panel.

The instrument is very easy to use: the signal source is routed to the input rear panel BNC, output going to one oscilloscope channel. On some instruments there may be problems with triggering, expecially in chop mode when it is easiest to run the input signal directly to the external trigger, as well as to the analyser. No input overvoltage protection is provided and the user may wish to add Zeners/resistors as necessary. The linear range is nominally ±10V, with a 1% accuracy. The r.m.s. chip is, however, limited to peak-to-peak swings of 5.6 volts, before the accuracy falls off.

Reference

1. Zissos, D., Duncan, F.G., Problem and Solutions in Logic Design. Oxford Science Publications, Oxford University Press, 1979.

Eliminating stereo hiss?

A major problem for listeners and broadcasters has existed since 1961, when the FCC officially adopted the Zenith/ General Electric (pilot-tone) system of stereo broadcasting. This is the significant difference, amounting to a penalty of some 25dB, between the signal that needs to be applied to a receiver or tuner to receive noise-free stereo, compared with the much lower signal strength required for satisfactory mono reproduction. In engineering terms it is UK practice to designate the 60dB (μV) field strength contour as the limit of stereo coverage and 48dB for mono, and to advise listeners that at least a two-element outdoor antenna is recommended for good stereo.

For national networks it is possible, although costly, to plan for a minimum field strength of 60dB in all areas, but for local stations there will inevitably be large areas where only mono reception is satisfactory. This can mean that in some topographic situations noise-free stereo is achieved over only about a quarter of the mono coverage area, unless listeners are prepared to install multi-element roof-top antennas.

Over the past decade a number of techniques for stereo noise reduction have been proposed by Dolby and others, but these have highlighted the problem of introducing new techniques into broadcasting services without affecting the quality of reception on existing high-quality receivers. European broadcasters, in particular, have tended to reject signal-processing techniques in much the same way as they have, in the past, given thumbs down to extra channels carried piggy-back on stereo transmissions, despite the widespread use of s.c.a. (subsidiary communications authorization) in the USA. Interest in s.c.a. techniques, however, is currently reviving in the UK and a new series of tests are planned. The problem of compatibility is closely related to multipath distortion.

Meanwhile in the USA, the CBS Technology Centre, in collaboration with the National Association of Broadcasters (NAB), has developed a new noise-reduction technique for stereo ("FMX extended range stereo system") claimed to provide. with the North American pre-emphasis of 75 microseconds, a noise reduction of up to 23dB, while maintaining full compatibility with the existing pilot-tone stereo transmissions. This employs linked compression and expansion techniques (i.e. similar to Lincompex) by using the main 38kHz d.s.b.s.b. signal as a decoding reference for processing a second heavily-compressed 38kHz sub-carrier radiated in phase-quadrature to the first. Existing receivers, it is claimed, simply ignore the quadrature signals but FMX decoders automatically expand the companded stereo signal and so overcome stereo hiss. At the transmitter, a re-entrant compressor reduces the compression ratio at high signal levels and so prevents overmodulation resulting from summation of the two 38kHz signals.

It is claimed that in large-quantity production a suitable FMX decoder chip could cost less than £1. New circuitry in the encoder would add around £2500 to the cost. Field trials at WPKT, Meriden, Connecticut were held earlier this year and the system was originally described at the June 1985 International Conference on Consumer Electronics. More trials by a number of American broadcasters are planned.

Potentially such a system could be a major step forward for v.h.f. stereo, but European broadcasters would need to be convinced that the heavily compressed quadrature signal would have no effect on existing tuners and receivers even under pronounced multipath conditions.

DTI to "specify" CB radios

In a written reply on June 28, Geoffrey Pattie, Secretary of State at the DTI, revealed that illegal forms of CB radios and cordless telephones would be "specified" later this year. This will have the effect of prohibiting sale, manufacture, hire and importation of equipment not in accordance with British regulations. However an exception is to be made for f.m. C.B. equipment designed to operate in the band 26.960 to 27.410MHz which is expected to become available in 1987 as part of the move towards "harmonization" with Europe, and where the equipment otherwise meets the UK technical specification.

S.s.b. broadcasting

Details of Japanese-developed experimental receiver-adaptors suitable for use on transmissions having the carrier reduced by up to 12dB have been published by M. Ohara of NHK in the *EBU Reveiw-technical* of April 1985. These have included the use of phase-locked loop synchronous detection and also the use of two-phase synchronous detection with a crystal filter to extract the carrier. Such systems can also be used as interference-rejection demodulation of double-sideband a.m. transmissions by providing sideband selection. The p.l.l. detector seems to be slightly the more effective.

Using Bands I and III

In a separate answer, Mr Pattie described the initial plans for the use in the UK of the former v.h.f. "television" Bands 1 and III, and forecast that some frequencies would be allotted for mobile s.s.b. radio telephones. Broadcasters will be relieved to have confirmation that six blocks each 0.7MHz wide will be made available in Band III, and two of 0.35MHz in Band 1.

It was also confirmed that British radio amateurs will soon be given 24-hour access to 50 to 50.5MHz subject only to some restrictions intended to prevent interference to European television. This move has been warmly welcomed by the RSGB who point out that the band is suitable for new forms of propagation research. 49.82 to 49.90MHz will be available for the use of general low power devices which have minimal potential for causing interference, such as toys and telemetry equipment. Wide-area paging will be permitted about 153MHz and 454MHz.

Jutland and Room 40

The first casualty of war, it is often said, is truth. Churchill believed that in war truth has to be surrounded by a bodyguard of lies. Fair enough, but unless one is careful, some wartime "deceptions" become firmly established as "history".

The 1914 Russian troops "with snow on their boots", the 1941 carrot-eating night-fighter pilots, and most of the many "sibs" that were officially put into circulation have long been discredited. But the recent IEE "50th anniversary of radar" seminar provided at least one example of fiction long regarded as fact, capable of misleading even such a distinguished historian of radio technology as Professor Charles Susskind of the University of California.

In his interesting "Who invented radar?" paper, he included in passing the well-established story of how the naval battle of Jutland on May 31, 1916 was brought about by the d/f stations (built by H.J. Round of the Marconi company) detecting a tiny change in bearings of the transmissions of the German warships in the Jade estuary near Wilhemshaven over 300 miles away, representing a change of bearing of only about one degree: This story has been widely accepted even since the end of the Great War. It was not until recently that the true story emerged in Patrick Beesly's "Room 40".

Whereas the success of Alan Turing in 1942 in cracking the four-rotor German enigma cipher remained secret for 30 years, the astonishing degree to which Admiral Hall's "Room 40" cryptanalysts were able to read German naval ciphers virtually throughout the first World War remained hidden for over 60 years.

Patrick Beesly shows that the intention of the German fleet to put to sea was obtained from a series of messages from May 28, 1916 onwards, including traffic via Bruges informing German U-Boats to reckon with their own ships being at sea on May 31 and June 1. There can be no doubt that it was the decoding of the messages rather than super-accurate d/f bearings that provided the intelligence that led to the Grand Fleet sailing to intercept the German warships and so bringing about the last major clash of battleships — 35 British and 21 German — in an action in which no less than 248 vessels were involved. Although British naval losses were the higher, the main German fleet returned to port and never ventured out again during the Great War.

This amended story does not deny due credit to H.J. Round, since his sensitive receivers were used for interception as well as d/f.

At the seminar I mentioned this to Dr Susskind and he graciously admitted that he had long had reservations about the d/f story. His wife also found my version credible as she was actually involved in decoding German naval traffic in World War 2.

Wireless World and radar

Professor Susskind also suggested that possibly the last reference to radar techniques in the open literature until the end of WW2 was the *Wireless World* description of the crude collision-avoidance system fitted (not entirely successfully) to the crack French passenger-liner Normandie in 1935. This encouraged me to check library copies and, sure enough, I found in the June 26, 1936 issue, pages 623-4, "'Feelers' for ships — new micro-wave equipment described" a detailed follow-up to a news item "Ratio feeler" in the issue of November 8, 1935.

It was prophetically noted that: "Any device which may serve to increase the security of ocean travel deserves special notice and the micro-wave apparatus described here seems to offer great possibilities in this field." It was claimed that the 16cm (1875MHz) continuous-wave system could "discover the presence of an obstacle in its path, such as an iceberg or another vessel which, by reason of fog or other obstruction to vision, might otherwise not be detectable."

The equipment was made by the Société Française Radio-Electronique and known as the SFR obstacle detector. Unfortunately, as other papers at Savoy Place made clear, it use on the Normandie was less successful than during earlier trials in the English Channel and it was subsequently taken off the vessel.

By 1936 several teams of engineers were furiously working in secret on radar systems for the detection of aircraft. The open publication of this article must have come as a shock to such teams, although the idea of using radio reflections from ships dates back to about 1906.

Car electronics

The vulnerability of the increasing amount of electronic equipment in modern vehicles to strong local signals, circulating electric currents, switching transients, etc. is at last attracting the attention and concern of the industry. High-power mobile transmitters with r.f. outputs of over 100 watts, as used legally by some radio amateurs and illegally by some c.b. operators with linear amplifiers, can cause severe e.m.c./r.f.i. problems not only in the vehicle in which they are carried but also to the electronics of nearby vehicles, including vital vehicle control systems. Part of the trouble is due to cost-cutting exercises which leave the electronics unshielded, with interconnections unfiltered or with leaky connectors. Some engineers see a future solution in the use of fibre-optics within vehicles. Electronic braking systems also now face increasing competition from improved hydraulic systems that imitate the "pumping" of electronic anti-skid systems by regulating the flow of braking fluid in step with the angular momentum of the wheels — and do this at lower cost than electronics. Guidance, navigational and terrain-mapping systems are still found more in laboratories than on the roads.

The possibility of failure or inducing latch-ups in some c.mos memory devices by the light from photographic flash-guns or lasers has been investigated by British Telecom research engineers at Martlesham. In extreme cases an intense photographic flash has been shown to result in destructive latch-up while output latching can occur at much lower light levels when using inadequately protected c.mos uveprom devices.

Amateur Radio

Old-style rigs

The vast majority of amateurs now use modern transceivers, some of them hybrid (valve/semiconductor) designs but increasingly all-solid-state. Yet at the same time there is a revival of interest in the simple, classic type of crystal-controlled transmitters that were popular in the 1930s, including their use with simple wire antennas supported by trees and/or houses.

Recently on 3.5MHz I contacted Phil Evans, GW8WJ, who has the distinction that since he acquired his licence in October 1937 he has never used a transmitter exceeding 10 watts input in conjunction with an 84 ft end-fed antenna with counterpoise (the W3EDP design of the mid-thirties). Yet his "tritet" crystal oscillator plus power amplifier (6L6 formerly 42E) still puts out a useful signal that has brought him a fair share of long-distance contacts, including Australia and New Zealand on 3.5MHz. His antenna is strung up to a neighbours chimney and the 17 ft counterpoise, with a switch at 6.5 ft for some bands, is run around the skirting board of his upstairs "shack". Receiver is a wartime HRO. Phil Evans, who is 70 years old this month, says "I can't understand this mania for big antennae-support towers that run into so many local-authority planning problems."

On h.f. at 5 w.p.m.

Proposals for a new class of UK amateur licence that would permit Class B (v.h.f. only) licensees to operate c.w. on a restricted basis on the 1.8, 21 and 28MHz bands after passing a five words per minute Morse test have been submitted by the RSGB to the DTI and are currently being considered.

The RSGB do not regard their proposals as constituting a "novice" licence since they still require the applicant to pass the Radio Amateurs' Examination. The new permit would allow the use of transmitter powers of up to 9dBW output and it is interesting to speculate how such a limit, which is significantly below the minimum output of most widely available h.f. transceivers, could be effectively enforced.

Nevertheless many c.w. enthusiasts will welcome this new incentive in the belief that those who gain experience of manual Morse in this way will find it an attractive mode and continue to use it after acquiring a Class A licence by taking a 12 w.p.m. morse test.

The DTI have been set something of a poser by Tom Maclean, whose exploits on lonely Rockall have included "unlicensed" amateur radio operation under the self-assigned callsign GR1TM. Apparently the Radio Investigation Service decided, wisely enough, to wait for his return to the mainland before making official enquiries — and so forfeiting an attempt themselves to effect a landing to obtain firm evidence of his radio activities.

In brief

Forthcoming mobile rallies include: August 25, Preston rally at Lancashire University, BARTG rally at Sandown Park, Esher and Torbay rally at STC Social Club, Old Brixham Road, Paignton. September 1, Lincoln Hamfest at Lincolnshire Showground 4 miles north of Lincoln. September 8, Galashiels Open Day, Focus Centre, Livingstone Place. September 15, Vange rally, Nicholas School, St Nicolas Lane, Basildon also Peterborough rally, Wirrina Sports Stadium, Bishops Road. September 21, Amateur Radio Car Boot Sale at Shuttleworth Collection, Old Warden Aerodrome, nr Biggleswade. September 22, Harlow Sports Centre, Hammarskjold Road, Barlow.

PAT HAWKER, G3VA

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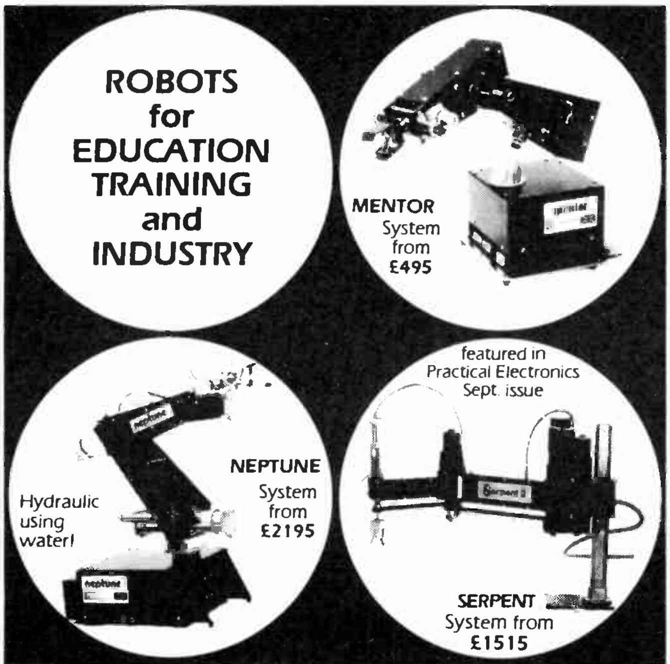

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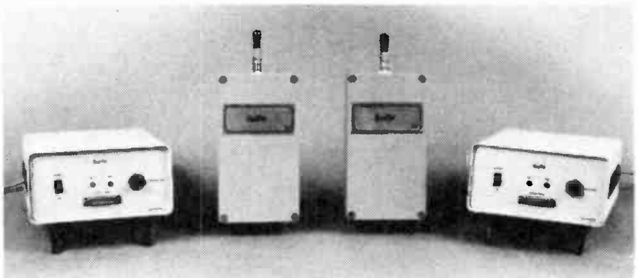

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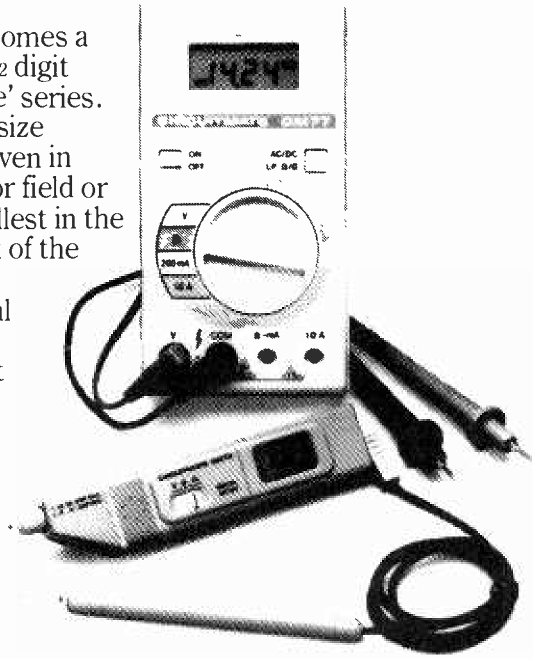

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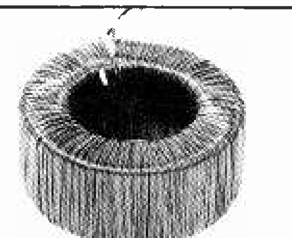
CIRCLE 71 FOR FURTHER DETAILS.

Toroidal Transformers



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CIRCLE 93 FOR FURTHER DETAILS.

NiCd cells — part 4

by Rod Cooper

A practical assessment together with hints on construction

The charging system has been operational for almost two years, during which time 15 NiCd D-cells, three F-cells and variable numbers of C-cells have circulated through it. Most of my own instruments have had their 6 or 9V batteries, whether primary or secondary replaced by single NiCd cells and d.c./d.c. converters. The lower cost of single cells relative to the previous miscellany of batteries permitted a reservoir of cells to be held permanently in the charger on a 15½day cycle, sometimes extended to 31 days, without increasing the budget. Besides being used in single-cell d.c. converter combinations, cells taken from the charger stock were used in batteries in two pieces of domestic gear equipped with low-voltage cut-outs.

None of these cells have shown any symptoms of dendrite formation or any other recharge-related symptom. The failure rate prior to this over a similar period using a conventional constant-current battery charger accounted for nearly half the available NiCd capacity.

Some of the improvement must be credited to the different way in which the cells are discharged most of the time, i.e. with d.c. converters, and this should be taken into account as like is not being compared with like.

However it can be said without qualification that the technique of holding a stock of cells in a guaranteed minimum state of charge for instant replacement of discharged cells, instead of waiting for recharge, does work extremely well in practice.

If this record of reliability continues, the extra cost of the charger will be recouped very shortly. The pay-back time obviously depends on the rate of use of cells, higher rates of use reducing the pay-back time, and it also helps if the number of cells held in the charger, and thus the size and cost of the charger itself, is tailored to suit one's needs. Having two banks of four cells each will not make economic sense if the usage is only one or two cells a month, but the design is highly adaptable and the charger shown in the photograph for example has only two banks of two cells each.

To my surprise, a charger situated in a well-insulated garage indicated that the temperature cut-out operated several times during the winter months. This occurred despite the fact that the garage shared a common warm wall with the house, but a check with a maximum-minimum thermometer confirmed that the cut-out was justified. This leaves me to wonder what would have happened without such a cut-out.

Building a practical charger

The following table gives values of R_a and R_b for the circuit shown on page 35 of the July issue.

R_a (Ω)	R_b (Ω)	cell size	comment
82 or 91	8.2	AA	uses a C/3 charging rate
68 or 75	6.8	C	
47	3.9	D	
33	2.2	F	replace D_{10} with 3A diode

Resistor b should be a generously rated power resistor, such as a four or seven watt type from RS Components ceramic range. R_a can be a two-watt carbon type. These two resistors must be mounted in a position where they cannot set up strong convection currents inside the case. Do not, for example, mount them near the bottom of the case. To reduce the effect of convection, a screen can be interposed between the resistors and the sensing diode strings. These two sensors must be placed as close together as practical construction will allow, and remote from the heat sources such as the mains transformer and these resistors.

There are two critical components in the charger system, namely the cell holder and the mains transformer. Unfortunately RS Components do not stock a full range of single-cell holders, but the reference numbers for those that are stocked are

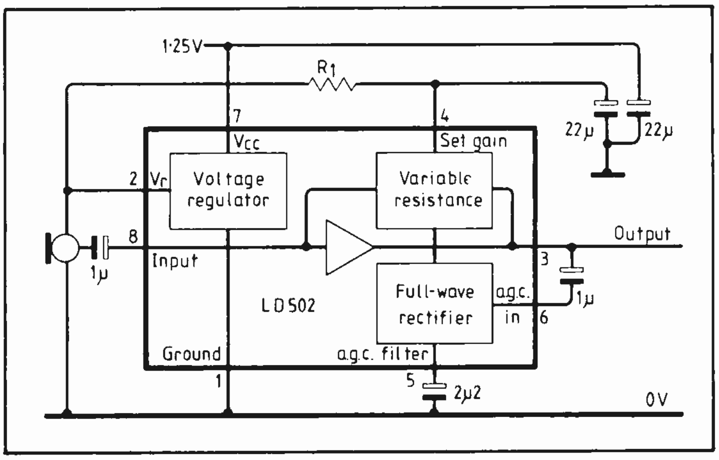
cell size AA: ref. 507-551
cell size D: ref. 507-539
transformers: 12VA ref. 207-627
20VA ref. 207-122
50VA ref. 207-239

To solve the problem, and for those would-be constructors without access to RS Components, a full range of single-cell holders including C and F sizes, the mains transformers, a suitable metal case and a set of printed circuit boards are available from J. Biles Engineering, 120 Castle Lane, Solihull, West Midlands B92 8RN.

Single-cell working

In response to enquiries about the LD502 i.c. mentioned in the May article, here is some more information about this little-known device.

The LD502 in an a.g.c. audio pre-amp in an 8-pin Minipac. The supply voltage range is 1.05 to 3V, open-loop gain 60dB and the a.g.c. range up to 65dB. Suitable applications are in microphone amplifiers, tape recorder equalization circuits and voltage-controlled amplifiers. The block schematic is shown below in a typical buffered electret microphone application.



The LD502 can be used with other devices in the range such as the LC507, which is a three-stage linear class-A amplifier operating from 1.0 to 3V, to form recording and playback circuits for cassette recorders. (Record circuit available on request.)

The i.cs are manufactured by Linear Technology Incorporated of Canada (not to be confused with Linear Technology Corporation of California) and are distributed by Steatite Microelectronics, Hagley House, Hagley Road, Birmingham B16 8QW. There are more than 20 devices listed which operate from 1.0V. There is no doubt that these low-voltage i.cs will cause radical changes in the way designers specify circuits for portable equipment. Although they cost more than standard i.cs, this is outweighed by the technical and economic merits of avoiding batteries, as highlighted in the May and June articles.

Corrections

Two errors occured in the articles, neither the author's fault, the first on page 60 of the June issue, when the words "Even charging 10C can result in a doubling of the usual overcharge pressure" did not refer to 10 × capacity, but should have read 10°C. And the second was in the July issue, page 35, when diode D_4 was shown connected the wrong way round. (An omission in the page 35 circuit has since been discovered — connect Tr_7 collector to the l.e.d. cathode.)

by John Lidgey†

†Dr F.J. Lidgey is Principal Lecturer in Electronics, Department of Engineering, Oxford Polytechnic

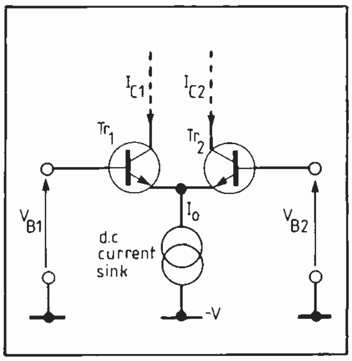
The tale of the long-tail pair

The operation and applications of the extremely versatile long-tail pair circuit are examined in two articles. In this first article the characteristics of the pair are analysed and applications in op-amp and high frequency circuits reviewed.

Probably the single most important circuit in analogue electronics is the emitter-coupled pair, often referred to as the long-tail pair. It is the basis of many circuits, most notably the input stage of operational amplifiers, high-frequency voltage-controlled amplifiers, analogue logarithmic and antilog circuits, full four-quadrant multipliers, and emitter coupled logic (e.c.l.)

In this article the main features and operation of the emitter coupled amplifier will be reviewed with the objective of obtaining a sound understanding of these circuits. The results of this exercise are then used to analyse a number of important applications.

Fig. 1. **Elements of the long-tail pair. The tail was originally a large-value resistor.**



Static characteristics

The emitter-coupled amplifier is termed a long-tail pair when connected as shown in Fig.1. The name 'long-tail' was coined many years ago when the current sink, I_0, was realised using a large-value resistor connected between the emitters of Tr_1 and Tr_2 and the negative voltage supply.

In the forward active region the collector current of a bipolar junction transistor (b.j.t.) is related to the base-emitter voltage by the empirical relationship,

$$I_C = I_S\,(e^{V_{BE}/V_T} - 1) \qquad (1)$$

where I_S, typically 10^{-13}A, is a constant for a fixed temperature and dependent upon the device geometry and structure, and V_T is the thermal voltage, which is linearly related to absolute temperature and about 25 mV at a nominal 290°K room temperature.

When used with a value of V_{BE} significantly higher than V_T, (1) reduces to

$$I_C \simeq I_S e^{V_{BE}/V_T} \qquad (2)$$

This exponential relationship holds for about six decades of collector current and is the basis of analogue logarithmic and exponential (antilog) circuits.

Returning to the circuit of Fig.1, assuming that both transistors are well matched in device parameters and of exactly the same temperature (e.g. a single chip pair) if $V_{B1} = V_{B2}$, then $I_{C1} = I_{C2}$ as both transistors have identical values of V_{BE}. Clearly, a common base-to-ground potential $V_{B1} = V_{B2} \neq 0$ will not alter the collector currents as long as the current siink, I_0, is not affected and Tr_1 and Tr_2 both have sufficient reverse bias on V_{CB} to keep them in the active region.

However, if $V_{B1} \neq V_{B2}$, then the share of emitter current between the two transistors will no longer remain equal at half of I_0. Using (2) we may obtain the expression,

$$V_{B1} - V_{B2} = V_{BE1} - V_{BE2}$$
$$= V_{T1} \ln\left(\frac{I_{C1}}{I_{S1}}\right) - V_{T2} \ln\left(\frac{I_{C2}}{I_{S2}}\right) \qquad (3)$$

However, since the transistors are a single-chip pair, which for convenience shall be denoted as $Tr_1 \equiv Tr_2$, the additional horizontal line on the normal three equivalent sign implying precise temperature matching as well as device matching, then

$$V_{T1} = V_{T2} = V_T$$
and
$$I_{S1} = I_{S2} = I_S$$

and (3) reduces to

$$\left(\frac{V_{BE1} - V_{BE2}}{V_T}\right) = \ln\left(\frac{I_{C1}}{I_{C2}}\right) \qquad (4)$$

But the current sink at the emitter node forces the sum of the two emitter current to equal the constant current I_0.

Alternatively in terms of collector current,

$$I_{C1} + I_{C2} = \alpha\, I_0 \qquad (5)$$

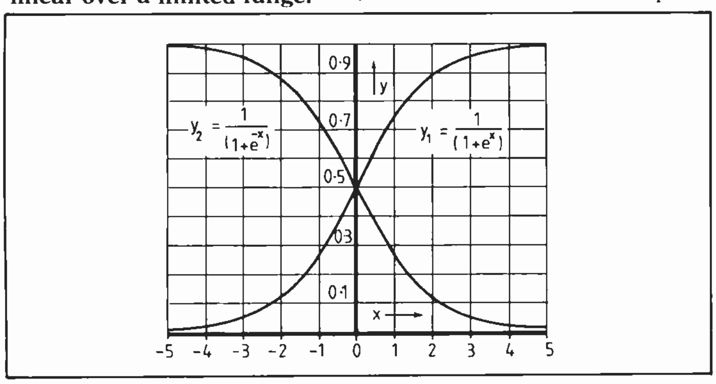
and so (4) may be separately solved for I_{C1} and I_{C2}, giving

$$\frac{I_{C1}}{\alpha I_0} = \frac{1}{(1 + e^{x})} = y_1 \qquad (6)$$

and $$\frac{I_{C2}}{\alpha I_0} = \frac{1}{(1 + e^{-x})} = y_2 \qquad (7)$$

where $x = (V_{B1} - V_{B2})/V_T$. These equations are best illustrated graphically and are shown plotted in Fig.2.

Fig. 2. **Collector currents are linear over a limited range.**



The transconductance of a circuit is the ratio of output current change in response to an input voltage change. If the input voltage of the long-tail pair is $(V_{B1} - V_{B2})$ the output current change may be taken from either Tr_1 or Tr_2 or the difference between them. It is interesting to note from (5) that the change of collector current, though not always linearly related to input voltage change, is always equal and opposite in the two transistors. One can see from the curvature of the characteristics of Fig.2 that, if x ranges outside ±1 then significant non-linear distortion occurs. Translated to input voltage changes, if $|V_{B1}-V_{B2}| \leq 25mV$, then the circuit operates reasonably linearly. If $V_{B1} \geqq (V_{B2}+4V_T)$ then Tr_2 is effectively cut-off and Tr_1 collector current reaches a maximum of I_0, this current limiting not being the same effect as taking a b.j.t. into saturation by forward bias on V_{CB}. Similarly if $V_{B2} \geqq (V_{B1}+4V_T)$ the reverse effect occurs, Tr_1 being cut-off and Tr_2 collector current limiting at I_0. In these extremes it can be seen from Fig.2 that there is no longer any change of collector currents outside the range $|V_{B1}-V_{B2}| \leq 4V_T$; the circuit behaving as a current limited switch and not an amplifier.

Transconductance

Temperature stability. One of the most significant features of this circuit is that the transconductance, given by the slope of Fig.2 at any particular bias point, is almost temperature independent and not at all strongly dependent upon the exact charactertistics of the particular b.j.t.s used. The maximum transconductance is clearly obtained when the circuit is biased about $V_{B1}=V_{B2}$ and is given by

$$\left|\frac{dI_c}{d(V_{B1}-V_{B2})}\right| = |g_m|_{max} = \frac{I_0}{4V_T} \qquad (8)$$

Although the circuit of the long-tail pair responds to a difference in potential between the bases it may be used as a single-ended input stage simply by connecting one base to ground. To fully appreciate the merits of the long-tail pair circuit, one should consider a simple directly coupled common-emitter stage, such as is shown in Fig.3.

Ignoring any practical difficulties of obtaining a bias battery of value V_{BEQ}, from (2) the quiescent collector current is given by,

$$I_{CQ} = I_S e^{V_{BEQ}/V_T}$$

and it can be shown that in order to maintain a constant value of I_{CQ} then V_{BEQ} should be reduced by about 2.5 mV per degree centigrade temperature rise.

If V_{BEQ} is held at a constant value then the quiescent collector current will rise by a factor of $e^{0.1} \approx 1.1$ for each degree centigrade temperature rise. The transconductance g_m is given by

$$g_m = I_{CQ}/V_T$$

Thermal voltage V_T is directly proportional to absolute temperature and consequently increases by around 0.33% per degree centigrade at room temperature; however, this increase is much less than the increase in I_{CQ} and, as a result, g_m will rise by about 10% per degree centigrade temperature rise. Returning to the long-tail pair, (8) shows that, provided that the current sink I_0 is designed to be almost temperature independent, then the long-tail pair transconductance will be much less temperature-dependent than that of a single common-emitter amplifier.

Related to the relative stability of g_m when comparing the long-tail pair amplifier with a simple common-emitter circuit, such as that shown in Fig.3, is the fact that for zero-point signal, the quiescent collector currents in the long-tail pair remain almost at $I_0/2$, whereas the single common-emitter collector current increases by about 10% per °C. Inputs to both these circuits may be directly coupled for operation down at d.c. However, as the collector-base potential must be positive to keep the b.j.t.s active, it is necessary to use some form of d.c. voltage-level shifting circuit to enable either to be used with directly coupled loads. Because of the strong temperature dependence of I_{CQ}, the single common-emitter amplifier is almost impossible to use in practice. Figure 4, shows a typical long-tail pair amplifier with a voltage level shifting circuit based on an emitter-follower buffer Tr_3, with a constant current sink bias, I_0'.

The output of this circuit can now be taken to a grounded load. The long-tail pair is not really being used to maximum advantage in this amplifier as collector current changes in Tr_1 do not contribute to the voltage gain of the system; the next circuit of Fig.5 overcomes this limitation.

Applications

As stated earlier the applications are many, ranging from linear amplifiers through to high-speed logic gates. We will now review arguably the most important application of the long-tail pair as the differential input stage of an operational amplifier.

Basic op-amp input stage. The circuit shown in Fig.4 is typical of the early, first-generation op-amp structures. However, a significant improvement in open-loop voltage gain is achieved by the circuit of Fig.5, which is typical of commercial op-amp designs such as the LM324 and others.

Tr_1 and Tr_2 are a p-n-p long-tail pair and Tr_3 and Tr_4 present an active current-mirror type load to the collector of Tr_1 and Tr_2. The output is taken from the collector of Tr_2 to a second gain stage shown schematically. On the diagram are the currents flowing in response to an input signal which makes the potential of the base of Tr_2 greater than the potential of Tr_1. The collector current of Tr_1 rises by δI and Tr_2 falls by δI. Tr_3 is connected as a diode and Tr_4 mirrors the collector current of Tr_3. The net result is that the current changes of both Tr_1 and Tr_2 are summed at the output node X and drive the second gain stage with current $2\delta I$. This configuration achieves the maximum voltage gain for the input stage, which is important for good signal to noise ratio as well as high open-loop (before negative feedback) gain.

High-frequency 'triple' circuit. The circuit of Fig.6(a) is the basic arrangement of a high-frequency tripe such as the LM3026/

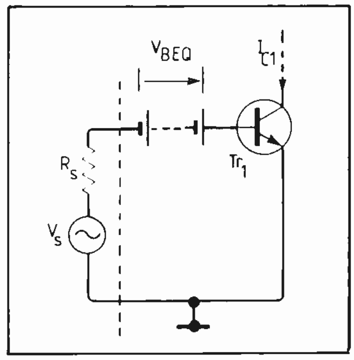


Fig. 3. **Simple d.c.-coupled common-emitter stage.**

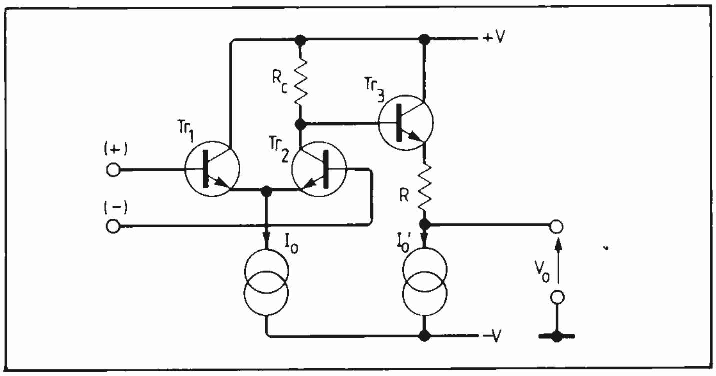


Fig. 4. **Voltage-level shifter allows long-tail pair to drive a directly coupled load. Only half the circuit contributes to stage gain.**

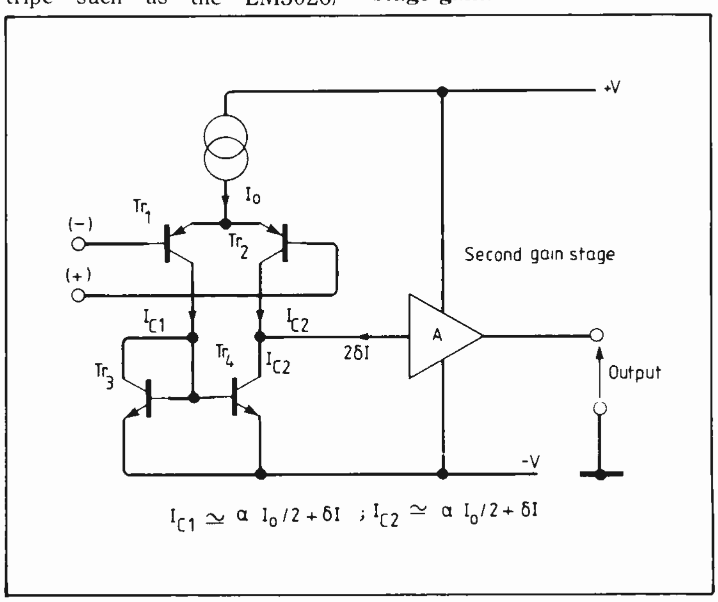


Fig. 5. **Typical op-amp version of long-tail pair, both Tr_1 and Tr_2 contributing to stage gain.**

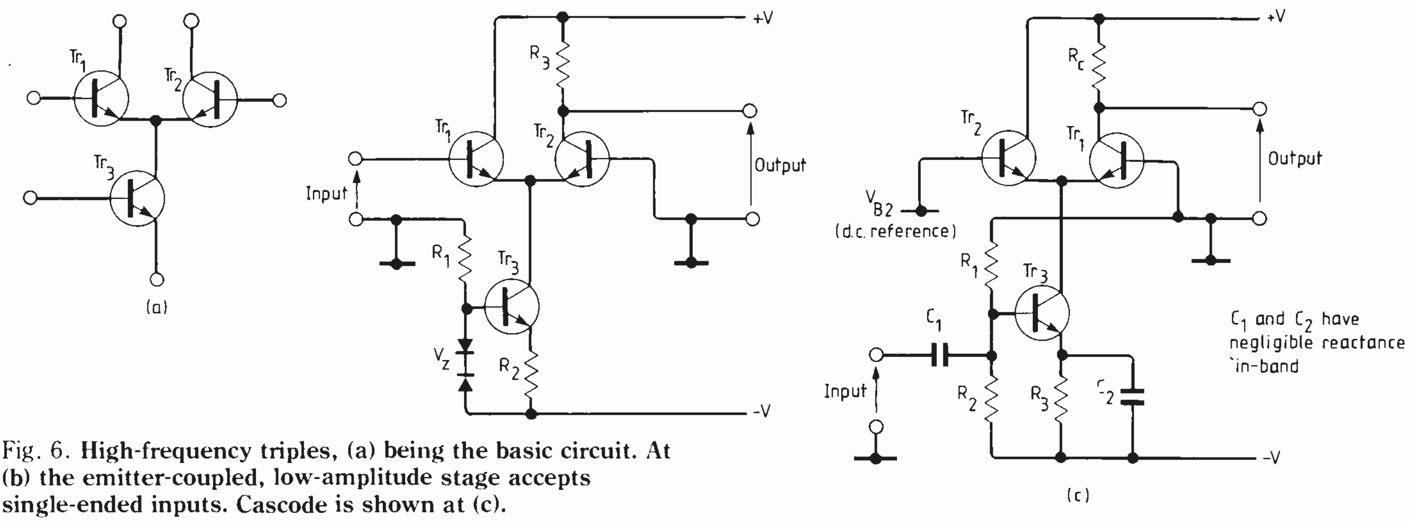


Fig. 6. **High-frequency triples, (a) being the basic circuit. At (b) the emitter-coupled, low-amplitude stage accepts single-ended inputs. Cascode is shown at (c).**

LM305H. Possible application configurations for useful high-frequency performance are shown in Fig.6(b) and (c). The first circuit of Fig.6(b) is referred to as an emitter-coupled amplifier and is used for low-amplitude single-ended (one side common ground) inputs. It is essentially that of a two-stage amplifier comprising a common-collector stage feeding a common-base stage. It can be shown fairly easily[1] that the high-frequency performance of this pair is extremely good, compared with a common-emitter, mainly because neither the common-collector nor the common-base produce the same Miller capacitance multiplication that occurs for the common-emitter.

The long tail current is given approximately by:-

$$I_0 = \alpha . V_Z / R_2$$

$$\text{where } \alpha = \beta/(\beta + 1)$$

As drawn, the input needs to be directly coupled to the base of Tr_1. Alternatively, a bias network of two equal valued resistors, connected in series between the power supplies with the centre connection taken to the base of Tr_1 can be used if the input is to be a.c. coupled through a series capacitor.

The voltage gain of the stage is given by,

$$A_V = + \alpha . R_3 . I_0 / 2V_T$$

Gain is the same magnitude as that of Fig.4, which is half the full differential gain of a long-tail pair.

If, instead of grounding the base of Tr_2 it is taken to a variable direct voltage of low impedance, then altering this voltage will change the quiescent current share between Tr_1 and Tr_2, resulting in a variation of gain. Clearly, if the base potential of Tr_2 is sufficiently high, then although Tr_1 will be active with quiescent collector current of I_0, Tr_1 will be cut-off and the voltage gain is therefore reduced to zero. Similarly, if the base potential is too low Tr_2 will become cut-off and again the voltage gain falls to zero.

The graph of Fig.7 shows this gain variation as a function of base potential on Tr_2, the gain being a maximum for the configuration shown in Fig.6(b). Thus, the circuit may be used as a high-frequency voltage-controlled gain stage, suitable for applications such as automatic gain control in receivers where the d.c. potential of the base of Tr_2 is controlled by the average signal amplitude obtained following the detector stage.

A similar application of the high-frequency 'triple' is shown in Fig.6(c), where the input signal is a.c.-coupled into the base of Tr_3. This circuit is often without Tr_2 and is known as a cascode amplifier. It is essentially a common-emitter, feeding directly into a common-base stage operating with the same collector current as Tr_3. The common-emitter operates into the relatively low input impedance of the common-base stage, yielding a voltage gain of only −1, hence Miller multiplication effects are minimized. Of course, the common-emitter provides high current gain and the common-base stage, which cannot give a gain of greater than unity, provides the voltage gain of the two transistor amplifier. The net performance is almost the same power gain as a single common-emitter but operating over a much broader bandwidth. This increase in gain-bandwidth produce is very significant and the circuit has many useful application at high frequencies.

The additional transistor Tr_2 can be used as a signal-robbing common-base circuit. As the d.c. base potential of Tr_2 is increased with respect to the base of Tr_1 then the current share between Tr_1 and Tr_2 alters and the gain of the amplifier falls. Figure 8 shows the voltage gain as a function of the control potential. Unlike Fig.7 the curve is not symmetrical, as the gain maximizes not when the base potentials are equal but when Tr_2 is cut-off.

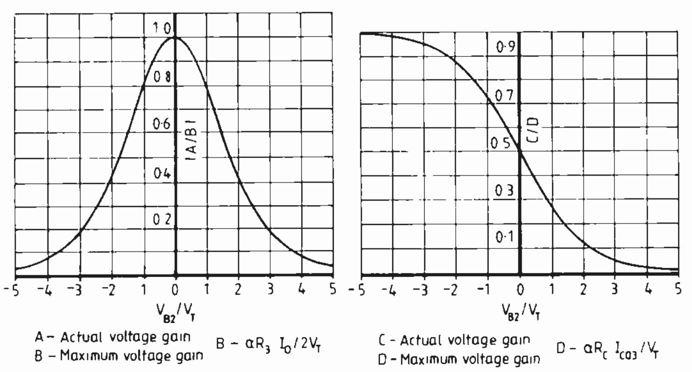


Fig. 7. **Gain variation with base potential on Tr_2 for circuit of Fig. 6(b).**

The remainder of the tail

In the second article four further important applications of the long-tail pair will be reviewed; these being log and antilog circuits, linear differential transconductive amplifiers, the full four-quadrant multiplier and emitter coupled logic gates.

Reference

1. Gray P.R. and Meyer R.G., "Analysis and Design of Analogue Integratal Circuits", John Wiley, 1977, 1984. Chapter 7.

Fast Fourier transforms using a microcomputer

by Terje Larsen and Gisle Dyrik

Personal computers make spectral analysis of periodic wavetrains feasible for a much wider audience than hitherto

Gisle K. Dyvik followed his masters degree from the department of applied physics at the Technical University of Norway in 1954 by post-graduate studies at Birmingham College of Advanced Technology. He has since worked as a development engineer in Norway and research physicist in the USA. In 1961 he joined the teaching staff at Horten Ingeniorhogskole, Norway, where he now lectures in electronics. He has published papers on dielectric properties of polymers in relation to molecular structure and authored didactic books on physical topics.

Terje Larsen graduated as an electronics engineer at Horten Ingeniorhogskole. Previously educated as an electronics technician, he has been working in various related activities, including service and maintenance of electronic equipment, the last few years in the department of medical electronics at Haukel and Regional Hospital, Bergen. He has developed an extensive interest for, and knowledge of, the BBC Micro as a versatile electronics tool, and is presently commercializing a flexible terminal emulator of his own design, packaged as a paged rom for the BBC.

There is one field where the impressive computational power of the modern PC/home computer can be put to a particular demanding test: the spectral analysis of periodic waveforms. When such a train of pulses has been sampled and digitized appropriately, the data can be treated with the Fourier transform technique to yield an equivalent sum of sinusoidal waves. This involves the calculation of a large number of amplitudes corresponding to the fundamental frequency occurring in the signal as well as higher the higher harmonics. To achieve a reasonably good resolution the number of samples representing a given signal should be as high as possible. The computational work involved, however, increases rapidly — with the square of the number of samples to be treated — therefore some kind of practical compromise is needed.

The present work is a program designed to take advantage of the speed and power of the BBC Micro, as applied to 256 sample points. By the application of the straight Fourier transform technique this would imply the calculation of no less than 264,144 multiplications — a cumbersome process, even on the BBC Micro! Fortunately, such digitized sample values lend themselves to being treated by a simplified variety of the Fourier technique: the fast Fourier transform, developped to take advantage of inherent redundancies, and thus reducing the computational effort drastically*. In the present case this means that the number of multiplications is reduced to some 16,384.

Even, so, the time lapse involved remains a factor of considerable interest. We have sought to optimize our program as far as could reasonably be done on the basis of the BBC Basic. And in particular we draw attention to the machine code routine labelled "mirror", generated by PROCassemble (List 1). As part of the FFT treatment the amplitude terms of the arrays have their array numbers changed (scrambled) to resemble their own binary mirror images: thus 1 translates into 128 because the mirror image of 00000001 is 10000000 for example. This could be achieved by means of a BBC Basic exponential expression, but there was considerable time to be saved in using machine code for this important routine.

```
   10 REM ******************************
   20 REM *                            *
   30 REM`*   FAST FOURIER TRANSFORM   *
   40 REM *          (FFT)             *
   50 REM *           by               *
   60 REM *                            *
   70 REM  Terje Larsen & Gisle K Dyvik
   80 REM *  Horten Ingeniorhogskole   *
   90 REM *                            *
  100 REM ******************************
  110 DIM mirror 20
  120 PROCassemble:MODE 0
  130 PROCinitiate: TIME=0
  140 PROCgetdata
  150 PROCscreen
  160 FOR I%=1 TO L%
  170 Q%=0 : R%=J%
  180 FOR K%=1 TO P%
  190 X%=Q%/J% : S%=USR(mirror)DIV &FFFF
 AND &FF
  200 Z1=R(S%):Z2=S(S%)
  210 FOR M%=Q% TO R%-1
  220 A1=D(M%): A2=E(M%): U%=M%+J%
  230 B1=Z1*D(U%)-Z2*E(U%): B2=Z2*D(U%)+
Z1*E(U%)
  240 D(M%)=A1+B1: E(M%)=A2+B2: D(U%)=A1
-B1: E(U%)=A2-B2
  250 NEXT
  260 Q%=Q%+2*J% : R%=R%+2*J%
  270 NEXT
  280 PRINTTAB(42+I%,18)"-": J%=J%DIV2:
P%=2*P%
  290 NEXT
  300 B%=0
  310 FOR X%=0 TO N%DIV2
  320 Y%=USR(mirror)DIV &FFFF AND &FF
  330 Q(X%)=SQR(D(Y%)*D(Y%)+E(Y%)*E(Y%))
  340 IF Q(X%)>B% THEN B%=Q(X%)
  350 NEXT
  360 PRINTTAB(15,18)STRING$(40," "):T%=
60
  370 VDU5:O%=2^(11-L%):K=100/B%
  380 FOR Z%=0 TO N%DIV2
  390 H%=INT(Q(Z%)*K +.5)
  400 MOVE T%,160: PLOT 1,0,4.2*H%
  410 IF H%>LIM THENPLOT 0,-20,40:PRINT
H%
  420 T%=T% + O%
  430 NEXT
  440 PROCkeyboard
  450 END
  460
  470
  480 DEFPROCinitiate
  490 REM============
  500 L%=8:N%=256:P%=1:J%=N%/2:F%=N%-1:H
%=F%DIV2:G%=H%DIV2+1
  510 DIM D(F%),E(F%),Q(J%),R(H%),S(H%)
  520 VDU23,248,24,24,24,24,24,126,60,24
  530 INPUTTAB(10,10)" Which data file t
o be used? (<RTN> gives F.EXAMPLE)  "N$
  540 CLS: IF N$="" THEN N$="F.EXAMPLE"
  550 INPUTTAB(10,10)" Lower limit for p
er centage ?  (<RTN> gives 10)  "LIM
  560 CLS: IF LIM=0 THEN LIM=9
  570 VDU 23;8202;0;0;0;
  580 ENDPROC
  590
  600 DEFPROCassemble
  610 REM============
  620 P%=mirror
  630 [OPT 2
  640 CLC
  650 TXA
  660 STA &70
  670 LDX #8
  680 .LOOP
  690 LDA &70
  700 ROL A
  710 STA &70
  720 TYA
  730 ROR A
  740 TAY
  750 DEX
  760 BNE LOOP
  770 RTS
  780 ]
  790 ENDPROC
  800
  810 DEFPROCgetdata
  820 REM==========
  830 A=OPENIN N$
  840 INPUT#A,f:M=0:FOR Z%=0 TO F%
  850 INPUT#A,D(Z%):M=M+D(Z%):NEXT:CLOSE
#A
  860 MEAN=M/N%
  870 FOR Z%=0 TO F%:D(Z%)=D(Z%)-MEAN:NE
XT
  880 FOR I%=0 TO G%:R(I%)=COS(I%*PI/128
): NEXT
  890 FOR I%=0 TO G%:S(I%)=R(G%-I%):NEXT
  900 FOR I%=G% TO H%:R(I%)=-S(I%-G%):S(
I%)=R(I%-G%):NEXT
  910 ENDPROC
  920
  930 DEFPROCscreen
  940 REM==========
  950 @%=&020207:F= f/N%
  960 PRINTTAB(21,2)"***  FAST FOURIER T
RANSFORM  ***"
  970 PRINTTAB(21,3)"   (BBC BASIC/HYBRI
D VERSION)"
  980 MOVE 50,150: DRAW 1100,150: MOVE 5
0,150: DRAW 50,650
  990 PROCframe(0,0,1279,1023)
 1000 PROCframe(255,703,1024,831)
 1010 PRINTTAB(69,27)"FREQ."
 1020 PRINTTAB(1,11)"AMPL.          Freq
.  at  "CHR$(248)" :"
 1030 PRINTTAB(17,18)"COMPUTATIONS IN PR
OGRESS:"
 1040 PRINTTAB(43,18)STRING$(L%+1,"*")
 1050 VDU5: MOVE 50,142 : PRINT"FREQUENC
Y INTERVAL: ";F;"Hz"
 1060 VDU4: MOVE 256,768
 1070 FOR X%=0 TO F%
 1080 DRAW X%*3+255,768+D(X%)
 1090 NEXT
 1100 @%=&0302
 1110 ENDPROC
 1120
 1130 DEFPROCframe(r%,s%,t%,u%)
 1140 REM======================
 1150 MOVE r%,s%: DRAW r%,u%
 1160 DRAW t%,u%: DRAW t%,s%:DRAW r%,s%
 1170 ENDPROC
 1180
 1190 DEFPROCkeyboard
 1200 REM============
 1210 VDU4: PRINTTAB(53,11)"Time: ";TIME
/100"s"
 1220 VDU5:X%=200:Y%=200:*FX4,1
 1230 *FX11,5
 1240 *FX 12,1
 1250 *FX229,1
 1260 MOVEX%,Y%: GCOL3,7: VDU248
 1270 REPEAT: K%=GET: VDU8: VDU248
 1280 IF K%=9 THEN GCOL0,1: VDU8: VDU248
: PROCprintout:ENDPROC
 1290 IF K%=136 THEN X%=X%-2 ELSE IF K%=
137 THEN X%=X%+2
 1300 IF K%=138 THEN Y%=Y%-2 ELSE IF K%=
139 THEN Y%=Y%+2
 1310 IF X%<54 THEN X%=54 ELSE IF X%>107
8 THEN X%=1078
 1320 IF Y%<200 THEN Y%=200 ELSE IF Y%>6
30 THEN Y%=630
 1330 MOVE X%,Y% : VDU248
 1340 VDU4 : PRINTTAB(30,11)INT((X%-54)/
8*F+.5)" Hz": VDU5
 1350 UNTIL FALSE
 1360 ENDPROC
 1370
 1380 DEFPROCprintout
 1390 REM    Insert your screen-dump
 1400 REM     routine here, e.g.
 1410 *GDUMP
 1420 REM    To call it, press <TAB>.
 1430 ENDPROC
```

*The Fast Fourier Transform by E. Oran Brigham. Prentice Hall, Englewood Cliffs, New Jersey.

The remarkable ease with which the BBC Micro allows such hybridization of 'bottle neck' segments is very commendable. The result is that the program now runs in some 38 seconds, as opposed to the original time lapse of about 98 seconds for our first Basic version, written in a fairly traditional manner. Just how well the BBC Micro serves is perhaps best illustrated by the observation that a similar program written in Applesoft needed some eight minutes to execute!

When run, the program first asks for the name of a data file to be used, and then for the lower limit of percentage numbers to be printed out. Pushing ‹RTN› when asked for the data file will load the default F.EXAMPLE. ‹RTN› for the percentage number will set the lower limit at 10%. If the default file F.EXAMPLE is chosen, the percentage should preferrably be set to 100, which will suppress percentage printout altogether. As supplied, this file consists of data sampled and digitized from the output of a heart simulator (the typical cardiogram shape of the curve will be recognized by many). The vertical lines shown represent the amplitudes of the various sinusoidal components in the original signal (Fig.1). By means of the cursor keys, a little arrow can be moved around, showing the frequency represented by any particular frequency line. The spectrum is crowded, with a fairly complicated overall shape. Quite possibly, the presence of an abnormal heart condition might be betrayed by the appearance of characteristic patterns, superimposed over the normal spectrum.

In strong contrast to this, loading F.EX2DATA and pushing ‹RTN› for the percentage number, gives a strikingly different result (Fig.2). This file contains data for five periods of an ideal sinusoidal wave — samples at a rate of 256 points per second (meaning that the window shown represents a total time of one second). The FFT analysis gives the logical result that this particular curve only contains one single component wave: i.e. itself at 5Hz!

Next, F.EX3DATA represents five periods of a rectangular wave train, sampled at the same rate of 256 points per second (Fig.3). The line spectrum found contains a sinusoidal component at the fundamental frequency of 5Hz, as expected, but also higher harmonics at 15Hz, 25Hz, 35Hz. . . This is in complete agreement with the Fourier transform theory, as are indeed the amplitude values printed out (normalized in relation to the maximum value). Theory predicts that the amplitudes should fall off successively in the ratios 1/1, 1/3, 1/5, 1/7, 1/9. . . — which is exactly what we see.

In F.EX4DATA five periods of a corresponding sawtooth wave train have been included (Fig.4). This type of pulse is much richer in higher harmonics than the square-wave type, and the FFT analysis bears this out in a rather striking manner: all the spectral lines are seen to be present, but with additional lines in between — just as predicted by the Fourier theory. The amplitude ratios now expected are 1/1, 1/2, 1/3, 1/4, 1/5, 1/6, 1/7. . . — again confirmed by the computational results found.

Finally, data for an interference pattern generated by mixing three sinusoidal waves of equal amplitudes but different frequencies are given in F.EX5DATA. From Fig.5, the three component waves at 8Hz, 16Hz and 32Hz are completely resolved by the program.

The frequency-dependent representation thus found is strictly complementary to the original time-dependent signal input. The logical extension of this — but in the opposite direction — is that only slight modifications are necessary in the present program to make it remove one or more of the sinusoidal components present in such a periodic signal. The components that remain can then be superimposed again, thus reproducing the original pulse train with the unwanted components digitally filtered away.

In our quest for speed and efficiency we came to wonder what could be gained from using Forth as the programming language instead. We have therefore made a version of the FFT program for Skyway's Multi-Forth 83. To our great suprise we found that it took a considerably longer time than the BBC Basic! In spite of the fact that the same degree of machine code hybridization has been introduced, the Multi-Forth 83 version is definitely slower, needing 46 seconds of running time after the compilation stage has first been completed. A corresponding version for the J.W.B. Forth V2.5, also with machine code hybridization, was

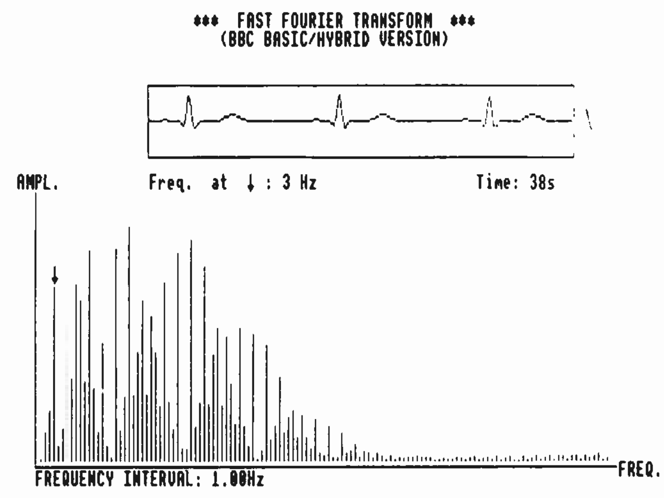


FIG. 1

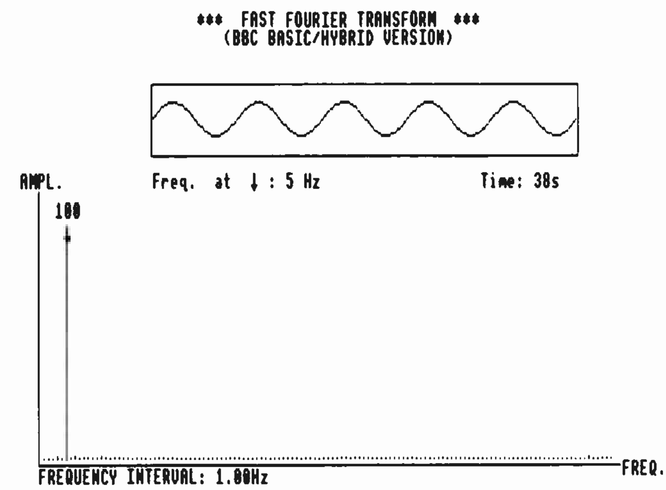


FIG. 2

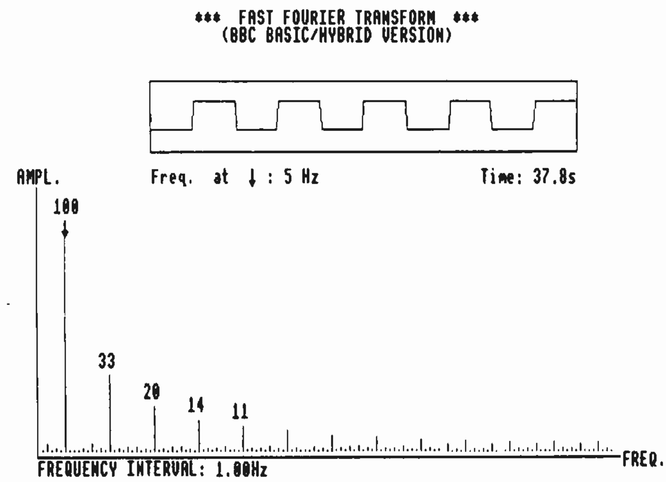


FIG. 3

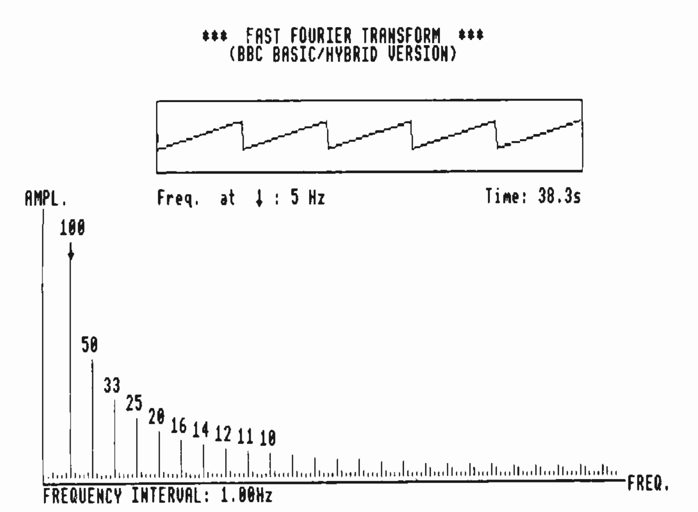


FIG. 4

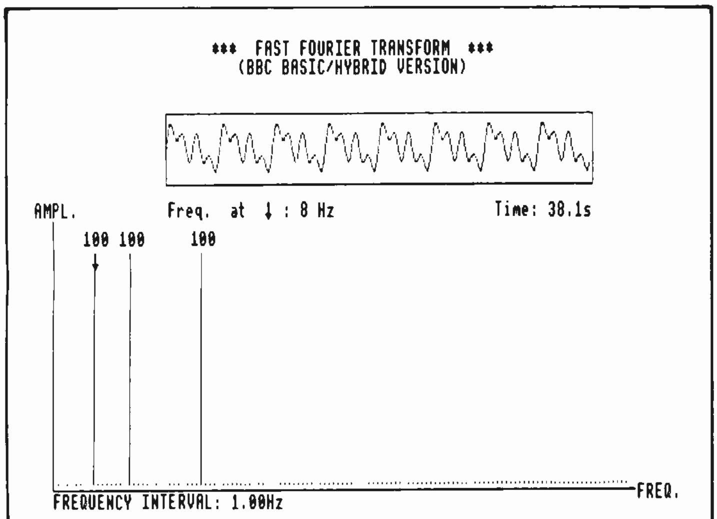


FIG. 5

a little faster (36s), but still surprisingly close to the BBC Basic.

If the ‹ESC› button is pressed, the FFT program expects to find a suitable machine-language screen dump routine called PRINTER on the disc. As Mode 0 is used by our program, it will need some kind of memory expansion to be run in the given form (like the Aries B-20 a.o.). It is completely compatible with the 6502 second processor, and will then execute in 26 seconds. However, for the program to be run on any standard Model B, we have also produced a compacted version, which we will be happy to make available.

With a little practice in random file technique you should have no trouble in generating data files for testing and demonstration purposes. But note the following points.

- The program expects to find as the first item of such a data file a number giving the sampling frequency (for instance 256, corresponding to 256 samples per second — if that would be the case). Then all the 256 numbers constituting the actual sample points follow.
- After reading the data in from disc, the average of all the sample values is subtracted from each: the d.c.-component is thus 'filtered' off. This makes the data generation easier, as only the a.c.part of the signal will matter anyway.

As an extension of the present program, one of us has recently been working on and started testing out a machine code version of it, that actually executes in about 1 second. This means that it is now feasible to do on-line signal spectral analysis, practically in real time on a shoestring budget. We hope that the publication of this BBC Basic program might serve as the starting point and source for similar inspirations to many of your ardent readers.

Literature received

The instruments catalogue from Keithley covers their range of hand-held and bench multimeters and includes programmable IEEE and systems models. There are current/voltage sources, Nanovoltmeters and the DAC500 Data Acquisition and Control system used in conjunction with Apple IIe or IBM personal computers. Keithley Instruments Ltd, Boulting Road, Reading, Berks RG2 0NL. EWW250

The Rifa range of subminiature, high power d.c./d.c. converters are detailed in leaflets from Campbell Collins Ltd, 162 High Street, Stevenage, Herts SG1 3LL. The PKA range of converters fit in a square package only 76mm wide and 17mm high and yet can provide up to 40W of power conversion. different versions cater for input voltage ranges. EWW251

A technical manual that describes the KD32-AA and KD42-AB central processing units used in the Microvax I system is available free from distributors Rapid Recall. The *Microvax I CPU Technical Description* includes a system overview and sections describing the programming interface and module configuration. Other chapters deal with data path microcode, and the data pack module, memory controller microcode and module and the Q22 bus controller. There are a number of appendices. Rapid Recall Ltd, Denmark Street, High Wycombe, Bucks HP11 2ER. EWW252

A data acquisition manual includes an introduction to the products of Maxim, which include a-to-d converters, op-amps, display drivers and more. All the products are fully compatible with the 71xx range and with c-mos amplifiers Maxim Integrated Products UK Ltd, Whitchurch Road, Pangbourne, Berks RG8 7BP. EWW253

A useful stock and price list of Japanese semiconductor products comes from Impulse who hold franchises from Hitachi, Mitsubishi, NEC and Toshiba. The products are listed, together with a brief description and prices. Featured are the c-mos eproms from Mitsubishi– Impulse Electronics Ltd, Hammond House, Caterham, Surrey CR3 6XG. EWW254

A brochure from Rendar introduces the Spikebloc mains protector which has been developed for the protection of sensitive electronic equipment, particularly microprocessor-based, from the hazards of electrically noisy environments. The devices offer protection against surges, spikes and r.f.i. Rendar Ltd, 7 High Street, Ringwood, Hants BH24 1AB. EWW255

Used test equipment can be bought from Carston, who have produced a leaflet describing the available equipment. The company has expanded into the computer field and have a number of development systems, terminals and peripheral equipment. All second-hand instruments are guaranteed for 12 months. Carston Electronics Ltd, 99 Waldegrave Road, Teddington, Middlesex TW11 8LL. EWW256

A wide range of solid-state relays are produced in California by Opto 22 and are detailed in a catalogue from the UK distributors System Devices Ltd, 26 Such Close Ind. Estate, Works Road, Letchworth, Herts SG6 1JF. EWW257

Printer buffer memory i.cs

Mike Catherwood's printer buffer, described in the May and July issues, is designed to give a 2ms dynamic-ram refresh cycle (ras-only refresh). Texas Instruments 64Kbit d-rams require a 4ms refresh cycle and will not work with the printer buffer as it stands.

There is a modified version of the software giving a 4ms refresh cycle in the top half of the eprom supplied by Technomatic. This software is brought into play by tieing address line A_{10} high; it should work with Texas rams, although it has not been tested. Normally the software is in the lower half of the eprom.

Access time of the 2716 eprom was quoted as 250ns, but more readily available 350ns devices should suffice. On many types of eprom, pin 21 should be tied high and not left floating as it is on the boards supplied by Combe Martin Electronics.

Radar in retrospect — correction

Readers baffled by the picture of the 'cavity magnetron' on p.75 of the August issue will be relieved to know that *WW* is not trying to change history. The device shown is the Caracal sine-wave inverter, mentioned on p.78, where the magnetron was transferred in error. Apologies to Tom Ivall, Caracal and any readers who didn't happen to spot the mistake.

Human communications - the new discipline

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

R.E. Young's seventh article in his series on British invention, innovation and electronics looks at the progress made in communications between people, especially with regard to mental handicap.

Articles in this series

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

By its very nature, and by the way in which it developed, 'Human Communications' would almost certainly lose rather than gain by formal definition. Also when the recognition of its constituting a "New Discipline" was put on record in the first article of this series[1], much of the original work contributing to the final concept had already been carried out and reported. For example, in a previous article on Human Communications[2], it was shown how interchange of vital information was built up between the fields of mental handicap (hyperautism) and that of control under extreme emergency conditions.

It is relevant to compare this with the radar and television case as given in the second article in this series. Two points of special interest arise here. The first is that unique conditions existed for them in the UK which almost certainly could not have been found elsewhere. Thus, for example, personnel with extensive training and experience were available for transfer from television to radar at the beginning of World War II.

A number of factors entered into the success achieved with this transfer, notably British adaptability; and this quality can be seen fully in the parallel case with transfer of technological thinking to the field of mental handicap, particularly to research into "this most mysterious of all human complaints".

A programme of technologically-based research in this field was introduced in the two-part article on Crisis Control[2]; and is at the centre of a companion article on mental handicap which appeared in the September 1983 issue of *Wireless World*.

As will be seen, this issue had two linked features, additional to the article itself, which made a significant contribution to it, not only in the immediate context of the transfer of technological thinking to mental handicap, but also in that of the even more fundamental matter of throwing light on the mental handicap condition — the second point of interest mentioned earlier. Thus this aspect of throwing light is embodied almost literally in the special cover picture of this issue. With remarkable insight — which justifies being called inspired — the artist has caught the person living underneath the handicap, and usually revealed, if at all, by only a 'flash glance'. As indicated in the article, that people, as isolated individuals, had recognized that this was a 'false handicap' is indeed difficult to believe; but, in a sense, the foundations of the research programme lay in finding this to be so which thereupon continued as a 'bringing-together' of people and evidence.

This process has, of course, continued and developed over the past two years; but by the start of this period it had already been put forward and had become accepted that ". . . even the most severely handicapped autistic has a latent capability and can be assisted to break the shell (of hyperautism) by a deeply understanding approach — one which recognizes that communication is the basic problem and that removal of stress and help in carrying out even simple actions to achieve some kind of pride in performance are beneficial, particularly when previously considered to be impossible".

This extract from the Editorial in the *Wireless World* for September 1983, and under the heading 'Technology and people', represents an invaluable summary of the basic — humanitarian — approach described in the accompanying article on mental handicap.

The artwork for the cover of *Wireless World* in which "the artist has caught the person living under a handicap, and usually revealed by only a 'flash glance'."

cap associated with the ultimate establishment of the research care unit approved in principle for Warwickshire[4].

It is particularly encouraging and rewarding to find similar endorsement coming some two years later in 1985, but from an entirely different type of source. This was in connection with the general approach put forward for research care, initially for the mentally handicapped.

Although on a small scale, development of research care has been maintained over this period, either essentially on the voluntary basis as noted in the earlier article[2] or from 'supported' units within the voluntary ambit; and endorsement has come from both of these areas, and outstandingly, in terms of human communications, from a Centre falling into the latter category. In a note summarizing progress made with the 'new thinking' (human communications) approach to care, in its widest sense, the Head of this Centre reports on the success which they have achieved in "transporting" the thinking and methods evolved for mental handicap to ". . . several (other) fields". With the unit set up originally to provide care for the physically handicapped, this had been the first of these fields in which these ideas had been tried out; but within a surprisingly short time mental handicap has been added together with certain aspects of geriatric care.

The importance of these statements arises on several counts. Foremost amongst them is the confirmation (endorsement) of its being possible to bring together, as it were, the two kinds of handicap by taking advantage of the common ground of human communication. Such possibilities had been shown to exist by the project work described earlier in the September 1983 article, with the salient points brought out in the project flow chart for the specialized Research Care Unit. Specific examples include the reference to correlation with 'outside' areas (relative to mental handicap) such as geriatric care made on the chart for 'Phase 4'.

Another relevant reference is made at the end of that article to the aim of obtaining information which would be of value in fields such as ordinary autism and geriatric care (helping with ability to speak). It may be noted that these possibilities as exemplified by geriatric care were introduced in the first article on crisis control in relation to interchange of information.

A brief digression should be made here. It will be noted that the term 'Human electronics' is used in the quoted article. This ante-dated the recognition that this whole subject represented a new discipline, and the suggestion that it demanded a title commensurate with the breadth of the fields covered. That this is a wide subject will be seen from the section headings in the rest of the article; but this introduction is made almost exclusively in relation to mental handicap because the advances that had been made and have led to this recognition were in this field with the bulk of the work having been carried out in it; and full acknowledgement must be made to all those who — either as individuals or in groups — have contributed so much to it.

Reverting to the note dealing with the progress made with 'common ground' care of the handicapped, one of the greatest services it does is to show how utterly vital it is to establish communication with the handicapped, that every effort should be made, and continue to be made, to do this whatever the degree of handicap; and that, with full understanding, and the right conditions, the person under the handicap will be revealed. The difficulties are not underestimated, rather the reverse; but it comes out quite clearly that this is a team with a quite unusual capacity to absorb — and act upon — new ideas, and, in this case, to persist with the task of bringing out the concealed person whatever the odds.

This is, of course, an expression of a major principle which has been built up, and consolidated particularly over the last two years. It is embodied in the four letters M H S M. These initial letters, standing for 'Mentally Handicapped (of) Sound Mind', coming from an acute and penetrating observer, give an objective assessment of this condition. This is at variance with the conventional view of these disadvantaged people based on the admitted lack of knowledge[3] of the nature of the complaint and the understandable confusion with the defined mental (stress) illnesses, but has found more than an answering chord in a number of people with interest in, and experience of, mental handicap.

High technology and hyperautism

As indicated in the first article on Crisis Control, and subsequently, interchange of information has been going on for some time between the two areas of mental handicap care and technologicallly-based analysis of this 'completely intangible' human problem. Even by early 1983 it had become clear that this interchange had developed to the point where technological thinking was giving an entirely new picture of the hyperautistic condition; and, furthermore, that it offered not only engineering techniques for tackling the problem, but also that it gave explanations of the mechanisms involved. Much of the latter were derived from 'system modelling', and this forms the subject of a later section in this article; but as shown in the 1983 publication containing the project flow chart, it had become accepted by then that these explanations were valid and could be used to form part of the foundations of a coordinated research programme.

That this programme has continued in what can only be called a typically British way, with contributions coming from both technical and non-technical 'associates' and organisations, has been indicated in the preceding section; but it is perhaps even more significant that the period of consolidation of the last two years has shown that high technology ideas and concepts generally can be adapted and applied successfully to practical use in the care and development of the mentally handicapped.

'High technology' has been adopted here to give depth and meaning to this new — composite — approach. The definition "Advanced engineering permeated by electronics", as evolved for complex system and comparable development engineering activity, has severe limitations when faced with the intangibilities of mental handicap. On the other hand it offers a basic 'terms of reference' title, familiar to most, which can be given to this overall approach. Thus by substituting 'human communications' for 'electronics' (the importance of this original substitution in relation to the concept of a new discipline has already been noted) and with expansion, the defining title becomes 'System research engineering permeated by human communications'.

This may seem to be a statement of the unimportant, but as already indicated, experience shows that acting upon 'half-a-story' can be dangerous to the point of producing failure when embarking upon a new technologically based project. Thus, as in the case where the work is undertaken by a team with a variety of backgrounds and training, it is utterly vital to lay down lines of action in words which are without ambiguity and are *fully understood* by all.

To a certain extent this process corresponds to 'separating-out the factors' with a project where the fact has to be faced that progress is not being mantained; and that this is due to the existence of one — or probably more than one — obscure faults which are, in effect, completely concealing the true position. Classic examples of this, quoted earlier[1] are the radar installation which appears to be working, and yet is actually 'blind', and the fault on a piece of instrumentation which is literally hidden by its failure to provide information. Also, although the individual fault — when finally found — is almost invariably simple in the extreme, reaching the solution is a complex and protracted task which in essence depends on achieving this segregation of factors.

Now, with the final clearance of trouble, it should be possible, in this instance, to produce a clear statement which gives the staff a picture, hitherto denied to them, of the state of the project; and which, if suitably drafted, should result in much more effective project flow being achieved by virtue of "everyone being informed" and — quite vital in such cases — being informed in the 'same language'.

These principles, seen from the R & D Management point of view, take on even more importance for this Human Communications research programme. Apart from anything else, this was a true research project with every aspect of it being new; and on this score alone, it is essential that all those taking part be given a picture of the position reached with the programme of such a nature that they are helped to take the right technical decision on the course to be followed when presented with one of the so-called minor problems which arise almost every day in this work. This is, of course, one of the main aims of endeavouring to make sure that staff are enabled to feel that they are being kept fully informed of any developments which may bear upon the work of the team; and are being put to them in such a manner that the way ahead is being cleared to the maximum for them to 'get it right'. This does, of course, represent an ideal world; but with projects like the one under discussion, the chances of a false trail being followed are so high that a close management/staff understaning is vital for this to be avoided. A corollary is that with a fully integrated team, interchange and the general contact which is maintained can prevent more than one variable being altered at a time. Violation of this ground rule i.e. for members of a team to make major technical changes in isolation, can pose a very real threat to the project.

Although it has been pointed out that a period of consolidation has been reached in the programme, this does not mean that the scale of research and investigation in this sphere should be reduced — there is still an enormous amount of ground to be covered as shown e.g. in the proposals for a new Research Care Unit for the mentally handicapped[4].

There is, in fact, one area in particular where a great deal of progress has already been made — that of explanation of the hyperautism of mental handicap — but where expansion of effort and resources would be well justified. This explanation has a dual character where high technology has been applied in two widely different ways; the first, developed over the years, may be called 'direct' and is fundamentally observational, while the second, an indirect approach, is based on specialized Human Communications (advanced engineering) techniques produced as part of the natural evolution of the project.

Two divisions therefore exist coming under the headings of 'Observation and the build-up of evidence' and, slightly over-simplified, 'System modelling'. These two divisions, under these headings, are examined in more detail in the next two sections; but it is felt that it would be valuable to refer at this point to a far-reaching principle which has come out of this work, that underlying the correlation of observation and system analysis to give increased insight into the hyperautism of mental handicap.

'Hyperautism' is used here because of its technical connotation. As many will know from experience, the whole issue of reduced, and especially of no, communication is usually totally obscured by the consequent lack of tangible evidence (of the existence of the 'concealed person'). As has been shown the initial strength of the project lay in the quality of the observers and of their evidence, and in the fact that it was possible to gather and collate this information over a long period. As the number of those taking part increased so did the speed of acquisition, but the basic problem of the long intervals between 'sightings' of the concealed person always remains; and it was not until results from work on communication parallels became available that a practicable programme of research with (at last) a finite time scale could be envisaged.

Actually as soon as the transfer of (comparison) information had become established, it rapidly turned into a two-way interchange with 'spin-off' in both directions. It was not long before definite project lines could be discerned, but it also became abundantly clear that this was a classic example of a project where 'separating-out the factors' was imperative for the maximum advantage to be taken of the data that was beginning to be accumulated. Of even greater significance was that if 'separating-out' could be done in the right way, this would mean that acceptable sub-project divisions could be identified within the informal organisation which is still maintained on this basis as a background to this work.

That this process was carried out successfully and the correct divisions selected was due in great measure to the strength of the contributions made by associate coupled with the way in which the overall project was built up. Thus, looking at this as a conventional R & D project in the UK, many of its (constituent) elements fell into place almost naturally; but, as seen in the other examples, the 'hidden strengths' in the country came into the picture. One of these, quoted earlier[3], becomes especially significant in this instance. The facilities which already existed in Britain, and had been set up by the medical authorities with such sound judgement, provided an environment which, as a minimum gave the equivalent of a flying start to this work.

Again, it may seem that undue emphasis is being put on an issue which is less than crucial. However as with the design development of any complex control system, this question of identifying the unknowns and establishing the divisions in which they will fall *is* crucial; and it will be realised that with 'human' and technological investigations and analysis being carried out simultaneously, this requirement becomes over-riding. This process, which can be described as one of sorting-out and allocation, is perhaps best illustrated in terms of a typical sub-project which made itself manifest during the course of the programme.

The sub-project concerned — 'delay in response'[3] — is associated with 'thinking fatigue' which has been written up in an

A shared viewpoint reinforces a cooperative approach in a complex environment as here, and with helpers and patients.

earlier article on crisis control[2], so that a separation had been affected between the two. It should be pointed out that this separation was only in time to begin with and that it was followed in the form of individual recognition somewhat later. This order of events was controlled and the major principle emerges that if this order had been reversed, at best an appreciably longer term would have elapsed before identities became clear, and at worst, the two issues would have obscured each other to the extent that they could have remained unrecognised for an indefinite period. This is, of course, a danger which always exists and — it will be realised — increases progressively with the complexity of the project. When, as in this instance, there is a strong possibility that spin-off contributions can be made to other fields (delay in response and thinking fatigue are not confined to the mentally handicapped), failure to evolve what amounts to a correctly 'marshalled' management structure can result in losses, particularly of time, which are impossible to assess. The word 'marshall' is used here advisedly, and because it leads into the concept of data marshalling[2,3] and its relevance to the whole question of the new (technological) approach offered by human communication to problems in the 'ordinary' world, and in particular to that of mental handicap. From the next two sections, and from the reference already given, it will be seen that data marshalling, defined as the separation, streaming and systematic presentation of 'masses of data', is a key concept in this work and as exemplified by system modelling and the process of collection of evidence which preceded, and then became coordinated with it. Also, and as a concluding statement it can be said that it is equally true that the same applies to data marshalling in the various areas of research control which were covered earlier.

Observation and the build-up of evidence

Although, by force of circumstances and events, the great part of the work on human communications has been done in the general context of the hyperautism of mental handicap, its origins in the personal observation of human behaviour under the stress of unexpected emergencies, specifically with the operational control of what can fairly be called high technology systems, mainly in World War II. That such systems were involved meant that these observations were made under 'multi-channel thinking' conditions which linked in with the results of later work and also provided an elementary form of reference standard for evaluation purposes. One aspect of this has been covered in the *WW* article on crisis control where two categories of behaviour (Conditions A and B) are introduced in relation to comparable effects seen with the mentally handicapped.

The most important conclusion reached from these observations and from comparison which followed was that when the non-handicapped went into condition B — where the ability to take action virtually disappears, they returned comparatively quickly to the A condition as soon as the emergency had passed. (Condition A is when, despite severe stress, the person thinks and takes action — as far as outside appearances are concerned — exactly as before the incident occurred.)

Now the other main observation made under full crisis conditions was that the change to Condition B was accompanied by a change in facial expression to the blank look of mental handicap. Obviously a number of inferences can be drawn from these observations, and this has been done progressively as more evidence became available. Equally obviously, one is heavily dependent on this evidence when reaching conclusions, and considerable caution has to be exercised in doing this. Methods of obtaining uninfluenced evidence developed e.g. for investigating obscure radar faults have been used; but, as indicated earlier, it has been possible to ensure that evidence comes from a number of independent sources, while the dependability (quality) of the observers has already been stressed. Also a number of forms of cross-checking do exist or have been set up, in this case, among them the fact that information (and thinking) come from two entirely different fields. Another form of cross-checking has been provided more recently — by the system modelling of the next section.

It will be realised that this facility of cross-checking is only one element in the general process of interchange between the two fields of full crisis control and the research care and education of the mentally handicapped. The scope and influence of this interchange can be seen in an illustration based on the human communications aspect of control room design for emergency conditions (Ref. 5) stemming in turn from the observations made of actual incidents.

A feature which comes to be common to all these incidents is the way in which the operating staff almost sub-consciously arrange themselves in a 'two-tier' control structure as shown in several publications notably on the front cover of the *Wireless World* containing the first part of the crisis control article, and — of still more immediate interest in relation to mental handicap — in the photograph taken at CEGB's Nuclear Power Training Centre. Notice the positions taken up by the staff where they are alongside each other and are looking at a common point. It may seem more than strange that this advanced work can be brought into the context of hyperautism; but this general disposition of two people in particular has been found to be especially favourable to establishing communication between the mentally handicapped and, say, an instructor. Surprisingly good results can be obtained with this technique, even with the severely handicapped, and it serves as an example of how the alternative — 'confrontation' — approach is to be avoided, something which appears to be of value to conventional education.

In passing, it may be noted that the degree of success obtained in communicating with the hyperautistic (in both directions) has two major implications: it represents confirmation of the existence of the 'concealed person'; and also shows that this whole subject is of an extremely complex nature, and not something which should be dismissed as not requiring attention of the highest calibre.

Finally, in this connection, there have been clear indications of a marked correspondence between the 'subliminal' methods of teaching found to be effective with the mentally handicapped and those suggested for the training of personnel in preparation for dealing with unforeseen emergencies[2]. Yet again this may seem surprising, but it emphasises to an even grater extent the complexity of the thinking mechanisms (and interactions) lying underneath mental handicap.

System modelling is, in a sense, self defining as a means of providing technological explanations of effects such as 'thinking fatigue' and 'delay in response' and even in predicting, for example, the 'inversion' of speech — seen in the non-handicapped in the transposition of syllables (the Spoonerism) or of individual digits in a telephone number. The number of ramifications of this work are clearly near-infinite; so it is proposed to take one example only to show how, information can be brought together to produce a desired 'model'.

As part of an examination of the problems of 'fast sampling' of pulse waveforms[6], Poole has found that the uncertainty (indeterminate element) resulting from the sampling action is dependnent upon the position along the original signal waveform at which the sample is taken. (Other factors, of course, enter into this.) It is understood that as part of this research, Poole found that the uncertainties in 'search sampling' were reduced in some circumstances by reversing the direction of sampling in time — colloquially by sampling 'backwards' in time and not moving forwards increasingly with it. Now system modelling has shown that sampling and 'back-comparison' effects appear in hyperautism and this has been seen in other pieces of system modelling, and as part of the associated theoretical work it does appear that the results obtained by Poole can be linked with speech inversion as quoted above.

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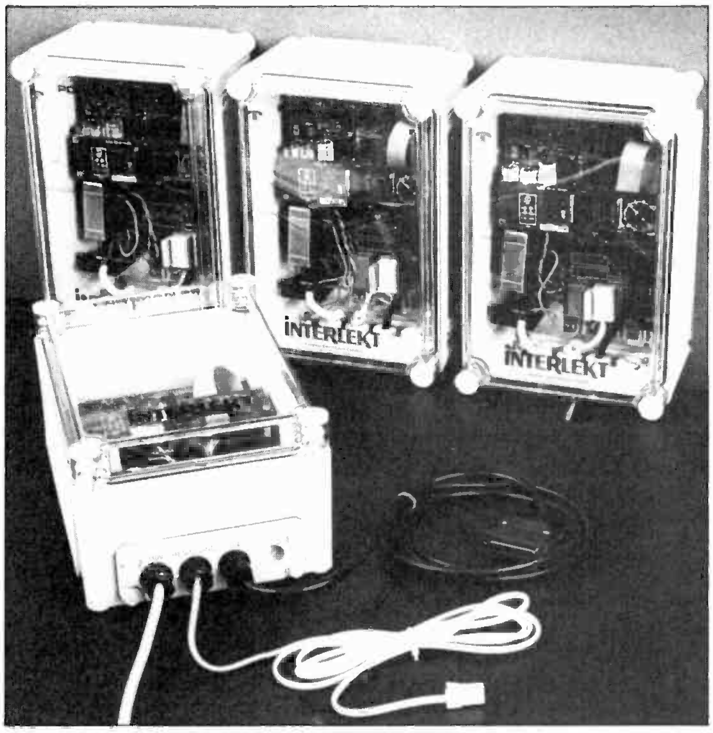
4. R.E. Young; Mental Handicap — proposals for South Warwickshire Specialised Unit, Communication to the South Warwickshire Health Authority.
5. R.E. Young; Control in Hazardous Environments, Peter Peregrinus, Stevenage 1982.
6. Poole, S; Telemetry sampling phenomena, *Electronic Engineering*, May 1964.

Modem for the wet

The first waterproof modem to receive BABT approval is Interlekt's Portman 66, which comes in a sealed plastics box and is built on p.c.bs coated with fungicidal varnish. The first buyer is the Department of Transport, which will install it in roadside cabinets as part of a national system for the automatic collection of traffic data.

Other products from Interlekt include a range of more conventiional high-speed and low-speed modems. Prices begin at £125 (plus v.a.t.), which buys a multi-speed V.21/ V.23 modem suitable for home or business use. Interlekt Electronics Ltd, 24 Portman Road, Reading RG3 1LU. EWW211



Calculator/dialler

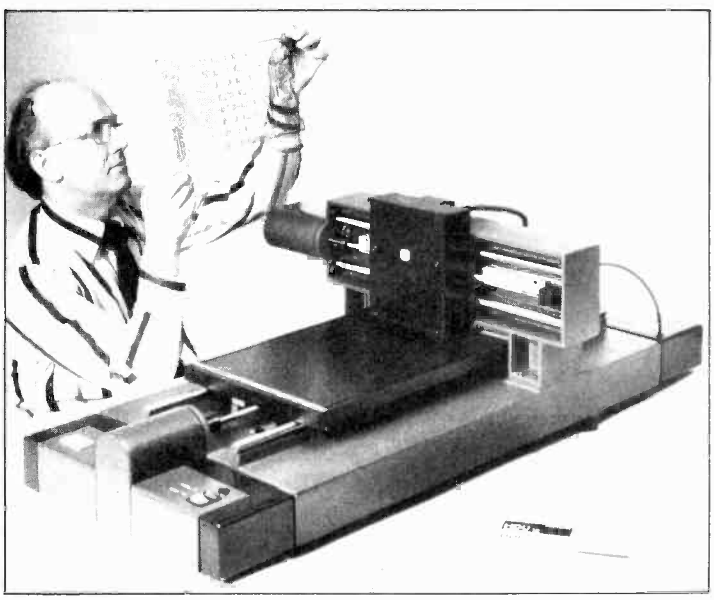
This pocket calculator not only adds up your expenses — it also helps you 'phone the office. Inside is a tone dialler which activates a box connected to your company's switchboard. By keying the right code, you get an instant connection to the extension you want without waking up the operator. And if the extension is busy, you can try another.

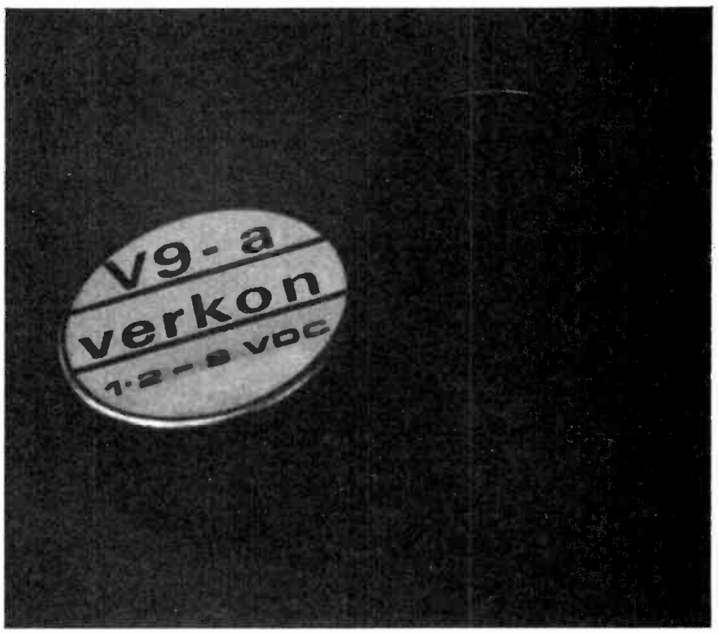
The IQD Phonethru unit is available from IQD Ltd, North Street, Crewkerne, Somerset TA18 7AR. A basic system costs £445. IQD have a range of other products using telephone d.t.m.f. signalling, including radio auto-patch units and devices for the supervision and control of remote equipment. EWW210

Pcb photoplotter

Artwork for printed circuit boards up to a size of 300 by 500mm can be produced automatically on the Flashcan photoplotter system. The design does not use aperture discs and slides or analogue variations in the light intensity. Instead it has a processor which controls the variable aperture lens and the flash rate of a xenon lamp. The basic image projected onto the film is octagonal and the flash rate controls overlap between successive octagons to produce lines. Servo positioning, using feedback from optical gratings parallel to the axes, ensures a resolution of 0.01mm and an accuracy of of less than 0.005mm.

With u.v.-sensitive paper it is possible to produce a plot rapidly without development. The overall plotting speed is 150mm/s including flashing octagonal pads 'on the fly'. The system can be used with many of the recognised c.a.d. formats or through an RS232C port, from disc or from tape or even remotely through a modem. At £22 000 it is claimed to be less than half the price of comparable systems. Cescom Electronics Ltd, Harrow Road, Leytonstone, London E11. EWW209





Dc power source

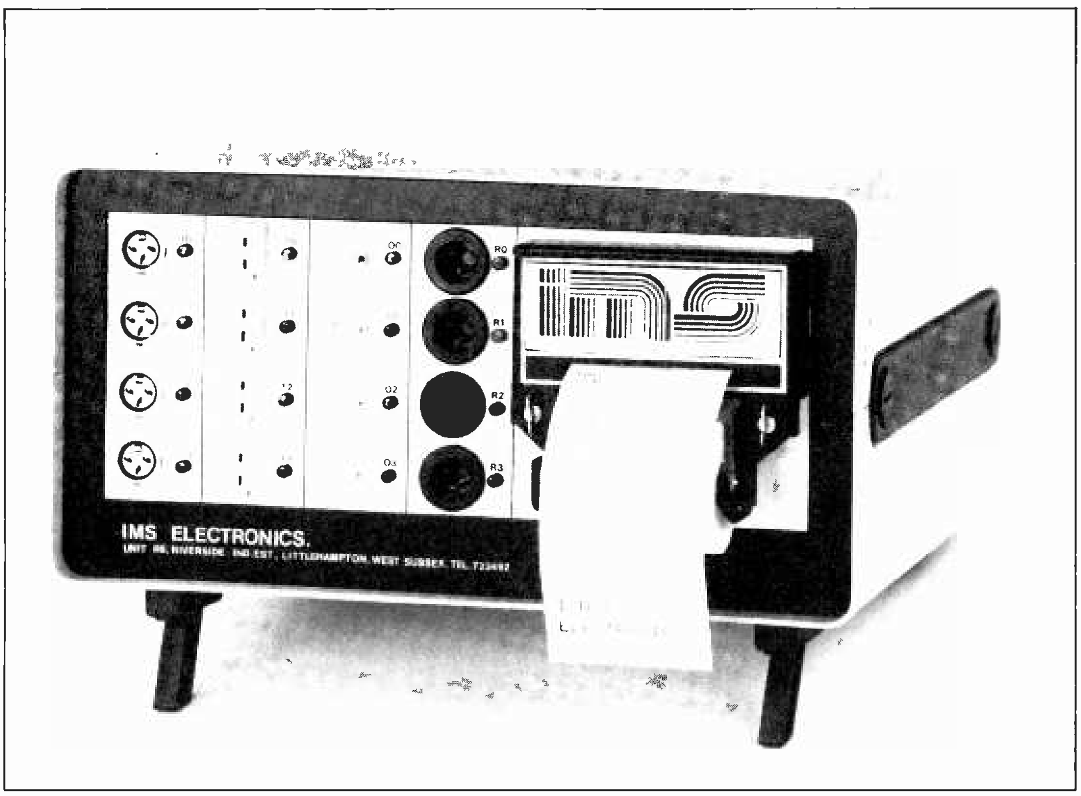
Used in combination with a sealed single NiCd cell, the Verkon V9-a provides a 9V d.c. output with a current rating up to 100mA. The V9-a is designed to replace PP9, PP7 and other batteries as the power source for low-power electronic circuits, small motors and other applications.

In a diameter of 31mm and a height of 16mm, there is packaged a variable drive switch-mode step-up d.c. to d.c. converter. The circuit is fully encapsulated in resin and housed in a steel case and is therefore screened and very rugged. The use of Schottkey semiconductors results in low conversion losses and obviates the need for heat sink. The single cell NiCd has the advantage of not suffering from reverse charging, over-charging, dendrite formation or electrolyte leakage, and can achieve up to 2000 charge/ discharge cycles; so there are several good reasons for using single cells in combination with a V9-a, in place of a NiCd battery. £5.25 (inc. v.a.t.) from J. Biles Engineering, 120 Castle Lane, Solihull, W. Midlands B92 8RN. EWW201

IEEE 488 interface

Full GPIB controller functions are available on the BBC Microcomputer by using the Electroplan interface. The unit is self-contained, with its own power supply, and plugs into the 1MHz bus port on the micro. The computer can be linked to 14 independently addressed peripheral units, including data acquisition systems, A.t.e. stations and programmable instrumentation. Full talk/listen/control functions are allowed, including multiple controller with 'pass' control. A maximum data transfer rate of 64Kbytes/s is possible.

A library of software routines is provided along with a comprehensive tutorial manual enabling the software to be tailored to a specific function. Electroplan Ltd, PO Box 19, Orchard Road, Royston, Herts SG8 5HH. EWW205



Thermocouple logger

Up to 16 thermocouples may be monitored at once on the CM1600 measurement and control interface. Cold junction compensation and linearization are performed automatically and the readings are transmitted through an RS232C link to a host computer.

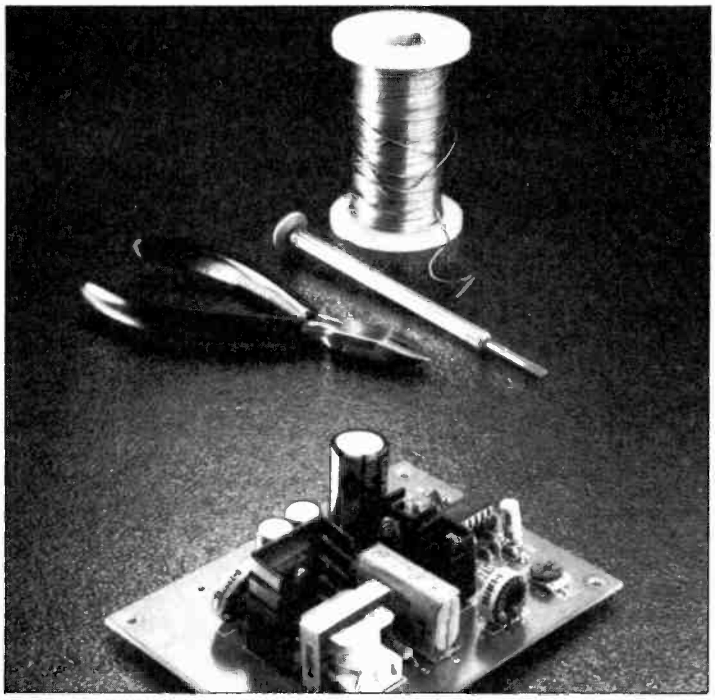
If all 16 thermocouples are not required then it is possible to reconfigure any channel as a voltage input or output or a switching relay for up to mains voltage. Optional extras include the dot matrix panel printer fitted into the instrument as shown, and a 32K ram expansion. An IEEE488 interface may be fitted instead of the RS232C at no extra cost, which works out to around £795 for an average set-up. IMS Electronics, Unit R6, Riverside Industrial Estate, Littlehampton, W. Sussex BN17 5DF. EWW206

CP/M development package

For some of the newer low-cost computers able to run CP/M operating systems, such as the Tatung Einstein and the Amstrad CP464, HiSoft have developed a suite of development software at a similarly low price. Devpac80 comes as three packages: ED80 is a fast full-screen editor that has a number of help screens instantly available and permits 'cut and paste' editing,wild card search and replace, the recovery of deleted text and many other features. GEN80 is a two-pass assembler that can handle over 4000 source lines a minute. The disc includes library files, full textural macros, conditional assembly and full mathematical functions. MON80 is single-stepping monitor and debugger. It can disassemble onto disc, to produce a file ready for ED80 or GEN80, multiple breakpoints may be set, patterns may be found either as bytes or mnemonics and there are many more features. The whole suite is available in CP/M 2.2 format for £39.95 inclusive. HiSoft, 180 High Street, Dunstable, Beds LU6 1AT. EWW207

150kHz switcher kit

This kit of components for a switching power supply offers an introduction to high-frequency switching techniques. The supply is based around the Siliconix PWM125 controller i.c. and the kit includes a p.c.b. and all the components necessary to build the supply. Although the controller is switched in this circuit at a frequency of 150kHz, there is provided a separate oscillator sync terminal and can be used over a range from 100 to 500kHz. The circuit has adjustable deadtime control, internal soft-start, input undervoltage lock-out, latching p.w.m. to prevent multiple pulses and works over a range of 8 to 35V output. Dage (GB) Ltd, Eurosem Division, Rabans Lane, Aylesbury, Bucks HP19 3RG. EWW202



Rent a meter

A 7$\frac{1}{2}$-digit multimeter may be more precise than is needed for day-to-day use, but could be helpful at the development and prototyping stages of a project. Such an instrument is the Datron 1081 which has a short-term stability of 0.25ppm and a linearity of 0.5ppm. Measurements to 10nV resolution are possible. The 10 to 100kHz a.c. range uses true r.m.s. for measurement and can accommodate a dynamic input range of 1 to 200%. A Bessel active filter extends the low-frequency range down to 0.1Hz. The instrument may be calibrated through the front panel and there is a button to re-standardize all functions to the internal reference circuitry or a prime reference source. The instrument along with a range of other instruments may be hired on a weekly basis from Microlease plc, Forbes House, Whitefriars Industrial Estate, Harrow, Middlesex HA3 5SS. EWW203

Interference simulator

Designed to perform tests in accordance with existing and proposed standards, the Schaffner NSG 200 is capable of simulating almost all kinds of interference encountered in both a.c. and d.c. power lines. It simplifies the task of checking the susceptibility of equipment and systems to interference and also the effectiveness of suppression devices.

The instrument consists of two sections; a main unit and a number of plug-in modules, one of which may be used at a time and each of which is capable of generating a different type of interference. With these supply voltage variations and interruptions or superimposed pulses of various type can be generated. Schaffner EMC Ltd, 1 Ashville Way, Molly Millar's Lane, Wokingham, Berks RG11 2PL. EWW208

Improving your Epson

The print quality of dot-matrix printers has improved greatly in the past four or five years, and many owners of earlier models must be regretting bitterly that they hadn't waited a little longer before buying.

But if you have one of the popular Epson FX, JX or RX+ printers you can now upgrade to the latest standards by adding Epson's Special Font Set. The two p.b.bs fit inside the printer case without soldering and provide 'near letter quality' (NLQ) characters with a resolution of up to 15 dots by 18.

Several permutations of size and style are possible (we've used the roman face in emphasised mode to print the FFT program listing in this month's issue) and the software permits fine adjustment of the spacing between characters or words. The proportional spacing mode gives access to italics, superscript and subscript characters and an attractive sans-serif font. There are variants for 11 languages or countries.

A 6K ram buffer helps reduce delays in printing and part of it can be used to store NLQ character sets downloaded by the user (as seen in our table on page 47). All functions and modes of the basic printer remain accessible under software control.

The Special Fonts Set is available with parallel or serial interfacing and costs about £130 plus v.a.t.

For the current FX80+ and FX100+ printers, a word-processing card (£113) offers similar NLQ options plus some formatting commands: text can be centred or right-hand justified by the printer itself. Epson UK Ltd, Dorland House, 388 High Road, Wembley, Middlesex HA9 6UH. EWW213

More talk from the BBC

The Acorn speech upgrade for the BBC Micro gives the most realistic-sounding speech to be heard from any microcomputer. The sounds it produces come from a real voice — that of Kenneth Kendall, the former BBC-tv newsreader, frozen on silicon. But through lack of rom space his vocabulary is inevitably rather sparse: it's limited to about 150 words of computerese plus the names of the characters on the keyboard.

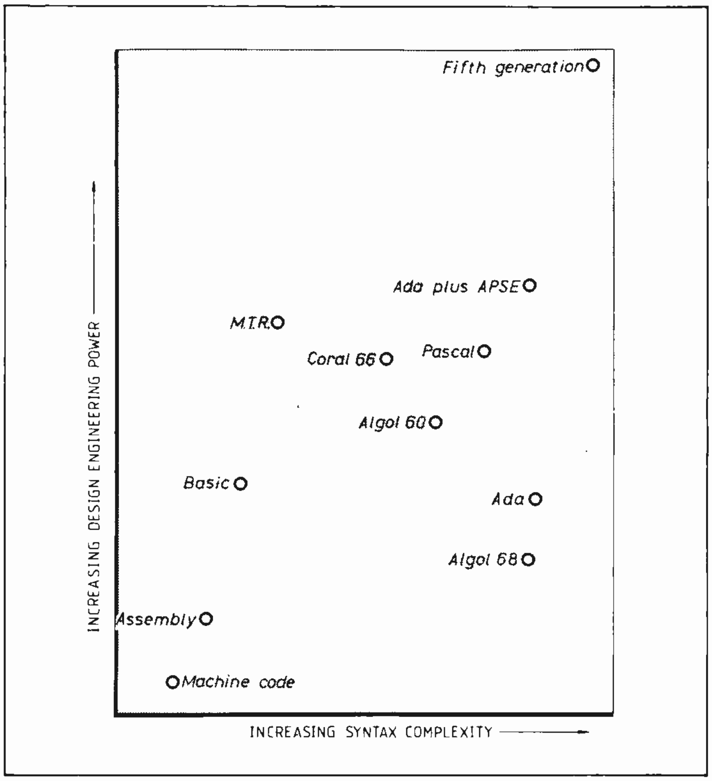
But now this restriction can be overcome by the addition of some firmware from Computer Concepts. The Speech Rom plugs into one of the computer's paged rom sockets and controls the Texas speech processor chip directly.

It uses the phoneme system — phonemes are the units of sound which speech is composed. Southern English has 54 of them and each is represented in the rom's command list by a single letter or a two-letter group. The speech quality is good (the voice is not Kenneth Kendall's, but is male and sounds English rather than American) and programming it is surprisingly easy to learn:

*UTTER <1> W I UH L e S W ER L D

The command allows much subtlety of emphasis and intonation and with a little experience you can obtain excellent results: a good ear is helpful!

The Speech Rom cannot be used at the same time as Kenneth Kendall, though it can be synchronised with the computer's sound generator. It can even sing along in the key of C, though it cannot manage sharps and flats. The price is £33.35 including v.a.t. and postage. Computer Concepts, Gaddesden Place, Hemel Hempstead, Hertfordshire HP2 6EX. EWW212



Multi-language compiler

A small UK company called Space, known for its Intel development system rental service, is producing a range of software which allows programs to be developed, written and compiled into any one of a number of high or low-level languages. Once source code is written using the new language, called MTR, one simply selects the working language required from a menu. The package is intended for software engineers working in military, industrial and scientific design fields.

Initial products in the range are the MTR language for writing source programs and the MTR compiler for converting source code into Coral 66, Ada, 'C', Pascal or ASM80. New compiling options promised during 1985 at the rate of one per month are Fortran, Basic, ASM86 and PL/M.

Future releases of the compiler will include options for producing logic maps for superimposing on commercially available u.c.l.as. The compiler currently runs on any Intel series three or four development system. Vax and IBM p.c. versions are promised and the licence fee is £2900 per site.

According to the designers, syntax of the minimum textual representation language, MTR, is almost as simple as Basic. Currently, MTR can be compiled into Coral 66, Ada, Pascal or ASM80 and a further five target languages are promised for this year. Space, Old Coach House, Court Road, Upton upon Severn, Worcests. EWW219.

Bubble memory — special offer

(see article, Page 32)

Cut out this coupon, fill in your name and address and send it with a cheque for £144.90 to Tony Greco, Rapid Recall, Rapid House, Denmark Street, High Wycombe, Bucks HP11 2ER.

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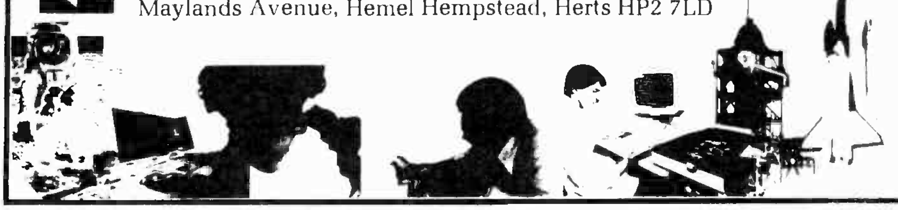

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EWW/3/85

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London Borough of Bromley

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School of Television and Broadcasting

Current Course developments and the introduction in September 1985 of a new B/TEC HND course in Television Programme Operations have created the following staff appointments:

1. SENIOR LECTURER IN TELEVISION BROADCAST ENGINEERING

The Senior Lecturer will be responsible for teaching most aspects of video engineering technique in current use for broadcasting. The successful applicant is likely to have specialist knowledge of one specific aspect of television engineering with a good background knowledge of other areas.
A working knowledge of digital and micro-processor techniques is essential since the applicant will be responsible for their development in the curriculum.
Applicants should hold an advanced level engineering qualification to at least HND level. This requirement may be waived if considerable broadcast experience is offered. An essential requirement of the post is that the person appointed is capable and interested in developing their interestss and skills as part of the continuing course development.

2. SENIOR ELECTRONICS MAINTENANCE TECHNICIAN

An Electronics Maintenance Technician is required to maintain the broadcast equipment in use by the Department. Duties will include major fault finding in all types of studio equipment and some supervision of part-time technicians together with some administration duties. The postholder will report to the Board of Studies.
The successful applicant should offer several years' experience in the maintenance of electronic systems including techniques involving micro processor systems and digital techniques. Some television experience would be useful but, if a good electronics ability is demonstrated, the postholder should quickly develop the required skills for television engineering. It is expected that the successful applicant would hold an advanced level qualification in telecommunications or electronic engineering to at least HNC level or equivalent.

SALARIES (including London Weighting):
Senior Lecturer: £11,853 to £14,739
Technician (Scale 6) £9,189 to £9,771
Starting salary will depend upon qualifications and experience.

Application forms and further details from The Registrar, Ravensbourne College of Art and Design, Walden Road, Chislehurst, Kent BR7 5SN. (25)

Inner London Education Authority

LEARNING RESOURCES BRANCH,
Production Division,
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Thackeray Road,
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Television Camera Operators (ST1/2) (Two Vacancies)

Salary Range £6222 to £9327 plus £1419 London Weighting Allowance.

The Television Centre produces a range of educational programmes distributed in the form of videocassettes, sound cassettes and 16mm film. It has a colour studio equipped to professional standards (Link 110 cameras, Cox mixer, Neve sound mixer, Ampex VPR2's etc.) a mobile unit and battery portable camera.

Two vacancies have arisen for television camera operators to work principally in the studio but also on location video recording, the mobile unit and, on occasion, with other technical sections.

Full job description and application forms from EO/Estab 1B, Room 366, The County Hall, London SE1 7PB. (Please enclose S.A.E.).

Further details of the posts are available from the Chief Engineer's Office at the Television Centre (622 9966).

The closing date for completed application forms is 25 · 10 · 85.

Suitable for Job-share.

ILEA IS AN EQUAL OPPORTUNITIES EMPLOYER (8)

Appointments

Inner London Education Authority
LEARNING RESOURCES BRANCH,
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Television and Publishing Centre,
Thackeray Road, SW8.

Television Maintenance Engineer (ST1/2)

Salary Range £8238 - £9327 + £1419 London Weighting Allowance. Plus £192 shift allowance.

A maintenance engineer is required to work at the Television and Production Centre which is equipped to professional colour TV broadcasting standards. The engineer will work in a section of four which is responsible for maintaining a high level of performance of a wide range of sound and vision equipment.

Full job description and application forms are available from EO/ Estab 1B, Room 366, The County Hall, London SE1 7PB. Please enclose S.A.E.

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Re-advertisement.

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GRADE III

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Application form and job description available from District Works Office, St. James' Hospital, Exton's Road, King's Lynn, Norfolk. Telephone: King's Lynn (0553) 766266 ext. 764/798. Closing date for applications: 6th September 1985. (23)

West Norfolk & Wisbech Health Authority

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Requires Technician. Duties involve the maintenance and repair of a wide variety of interesting equipment. Considerable electronics and mechanical expertise necessary, or a willingness to learn. Previous NHS experience relevant study.

Salary scale (dependent on experience) £6488 - £9367 pa inclusive.

Job descriptions and application forms from the Personnel Department, The Hospital for Sick Children, Great Ormond Street, London WC1N 3JH. Tel: 01-405 9200 ext 266.

Closing date 2nd September (30)

SYSTEM PLANNING ENGINEERS

Newbury, Berkshire

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(17)

Inner London Education Authority

LEARNING RESOURCES BRANCH,
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TELEVISION ENGINEER

for Master Control Section (ST1/2)

This post is involved with the bulk production of colour videocassettes from 1" Ampex submasters. The successful candidate will be expected to operate the 1" machine, cassette machines (VHS, Betamax and U-matic) and label and check copies. He/she will have a good working knowledge of colour television principles and suitable experience and/or technical background.

Salary within the scale £6222 to £9327 + £1494 London Weighting Allowance.

Further details, including full job description and application forms from EO/Estab 1B, Room 366, The County Hall, London SE1 7PB. (Please enclose S.A.E.) The closing date for completed application forms is 30 · 9 · 85.

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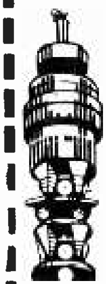

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The successful applicant must have a flexible approach and be able to fit into a busy working studio. There is a requirement for some overtime and weekend working to meet recording studio deadlines.

Applicants should have a degree or HNC in a relevant discipline.

Please send a detailed C.V. with covering letter to:

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For further information, please contact Michael Trand (Chief Electronics Technician) on Ext 2385.

Brent Health Authority working for Equal Opportunities. (11)

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