ELECTRONICS &

Wireless world

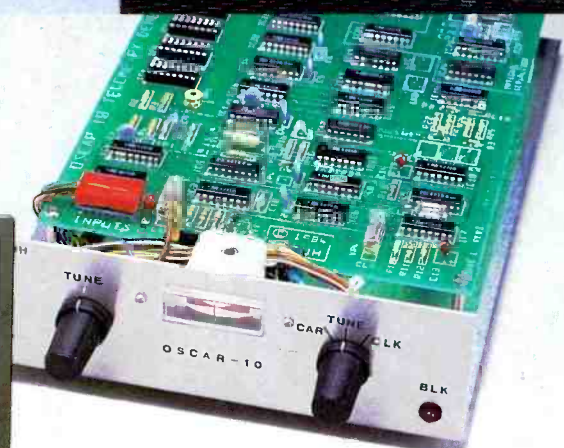
October 1984 85p

Oscar-10 demodulator

Digital multimeters

Modem autodialler

Lightning strike



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ELECTRONICS &
Wireless world
over 70 years in independent electronics publishing

October 1984 Volume 90 Number 1584

CONTENTS

FEATURES

REGULARS

Several articles have been held over this month, notably 'Music keys for the BBC micro', 'Stage lighting', 'Video playback', and 'Micro-controlled cassette recorder'.
We regret the need for this and will include them in the next issue, if possible.

Front cover is based on Jim Miller's piece on reception from Oscar-10

NEXT MONTH

John Adams describes his eprom programmer, which was designed for use with SC84 but which is equally suitable for others. It incorporates its own microprocessor.

Ian Kemp concludes his piece on the stage lighting system with a description of the remaining circuitry and some practical information.

Tor Knutsen describes a tape timing circuit with a real-time clock, which is independent of the recorder circuitry and needs only mechanical modifications.

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1983-84 MODELS

Editor: R. N. Wainwright, T. Eng (CEI), F.S.E.R.T.

This volume, like its predecessors, continues to provide the only comprehensive reference source for a large range of domestic entertainment products currently available from retail outlets.

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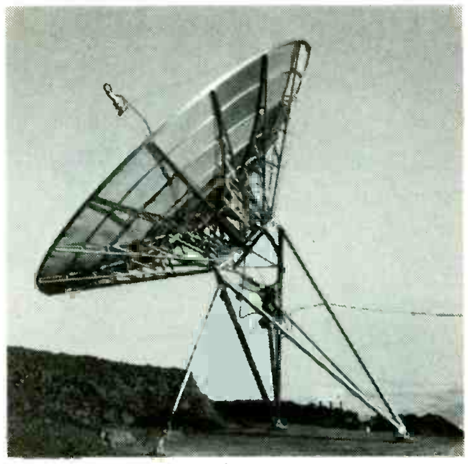

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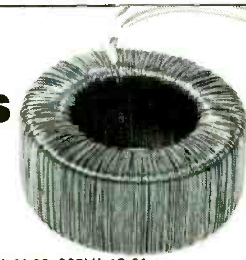

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CIRCLE 43 FOR FURTHER DETAILS.

Brains for IT

Despite the fact that the Government has espoused the cause of IT and promoted all sorts of awareness programmes for some years, thay have only now got to the stage where they officially recognise that there is an acute shortage of graduates and engineers working in computer technology. The first Report of the DTI IT Skills Shortage Committee (see News,) concentrating on university graduates, has devised all sorts of grand schemes to rectify the situation. We are already at the take-off point for some really important advances on computer technology design and one wonders if they are in time. With the formation of the Alvey directorate and the march towards the fifth-generation computer, we find that we are running out of people to produce the goods. According to the Committee, there is a five-year lag between the time when students decide to specialize in these areas until the time that they become graduates. However many decide now that this is what they want to do, there will be no positive result until five years have elapsed. The gap may partly be filled by graduates from other disciplines re-training — an electronics engineer would probably pick it up quite quickly, for example — but even that takes time.

The Committee pinned some hope on the Great Switch; to persuade students to study IT who might otherwise have gone into history or biology. Is this practical? Can someone with a natural leaning towards an arts course, or even a different science course, change so abruptly to a new field?

Even more hope was placed upon the New partnership between industry, the Government and Academia, but these wheels often grind exceedingly slow. Can a new gear ratio be slipped in and speed it all up to the rate of progress actually needed? The British have had a reputation for muddling through: "Something will turn up" is a common expression. This time we can't afford to wait for something to turn up because the Japanese, the Americans or the French will have beaten us to it. However laudable the Governments' plans are, they should have been thought of some time ago. Let us hope that they are not already too late.

A £300,000 c.a.d. centre for the design of hybrid microcircuit is part of a £3M investment programme by Welwyn Electronics Ltd, who are aiming to maintain their position as a leading manufacturer of custom hybrid circuits.

More efficient solar power

By use of clever control circuitry the power company, Solapak, have been able to increase the efficiency of silicon solar arrays by up to 25%. Traditionally the output from solar arrays has been intentionally limited to the voltages required to recharge batteries and there has been wasted energy representing the difference between the available output and the limited output. The Solomax controller has made it possible to convert this extra energy and make use of it. One practical outcome has been the production of a 50kW solar generating station for use in a remote telecommunications transmitter in Africa. The system has been designed to power the complete station with both a.c. and d.c. supplies. Alan Ditchler, who worked on Britain's largest solar generating station, BP's 30kW plant at Marchwood, before joining Solarpak as technical director, said that the system was highly reliable but not over-complex. "That is crucial for usage where the real needs are; in the developing countries".

Interference at the DTI

One consequence of the imminent privatization of BT is that the DTI has taken over the Radio Interference Service and renamed it the Radio Investigation Service. The service has about 260 staff in the field who investigate interference to authorised radio and tv broadcasts and, where possible, take action to stop it. They also try to keep track of illicit transmissions and prosecute offenders such as pirate radio operators or illegal CB users. The service will be taken under the wing of the Radio Regulatory Division.

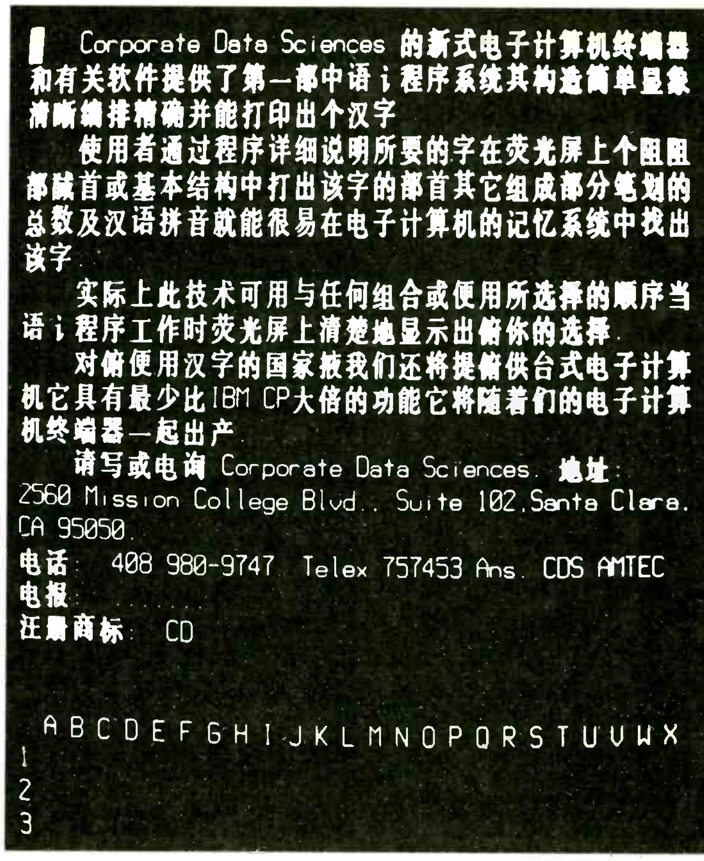
BT+IBM= SNA+PSS +OSI (PDQ)

British Telecom is planning a partnership with the computer giant IBM to launch a new national data network. The network will be based on IBM's Systems Network Architecture (SNA) protocols, but will be compatible with equipment from other manufacturers as well. A jointly-owned company to operate the network is expected to be set up shortly.

Besides offering customers a data network management service, the proposed company would provide 'value added' service such as electronic mail and database enquiry. And the data network management service would be available to other companies wishing to develop their own network applications.

The new venture is part of a general expansion of Britain's public data networks announced by BT. Investment in Packet SwitchStream, BT's existing packet-switched network, is to be doubled to £80M, and the system will be enhanced to include extra facilities for customers. These are to include direct access to the PSS via local switches and concentrators at up to 1 000 sites in the key business areas, providing extra data security at low cost. The system will also be accessible through standard dial-up viewdata terminals.

BT also intends to set up a data network based on the International Standards Organisation's Open Systems Interconnection (OSI) protocols. OSI is a hierarchy of communications standards devised to enable systems of different design to exchange data. At a later stage, hardware and software will be added to interconnect the OSI network with the SNA system.



A vast potentional market for computers in the People's Republic of China has been broken into by Corporate Data Sciences Inc. who have concluded agreements with the Amalgamated Computer Companies of Guangdong Province. Among their products is a high-resolution intelligent v.d.u. the Video Scroller Terminal with an internal microcomputer capable of receiving data at a rate of 12Mbyte/s and can print on the screen at 39Mpixels/s. The software includes Chinese character editing and processing system enabling a computer novice to carry out word processing in Chinese.

In Brief

The BBC Microcomputer is to remain the BBC micro for at least another four years. This follows the signing of a new agreement between Acorn and the BBC. It saves the BBC having to find another micro, although there were strong representations from Sir Clive Sinclair, and it also saves Acorn from having to find a new name for its product. Over 350 000 BBCmicros have been sold and it has overtaken all other computers for use in schools and colleges.

● Much greater insights into the magnetic map of the solar system will be found when Ulysses, the ESA/NASA spacecraft is flipped out of the ecliptic plane during a flypast of Jupiter. It is planned to take a polar orbit round the sun and send back information about the properties of solar wind, the interplanetary magnetic field, the sun's magnetic field, solar and galactic cosmic rays and cosmic dust. The craft is to be launched from a NASA Shuttle in May 1985. It will take 14 months to get to Jupiter, another two-and-a-half years to get over one of the poles of the sun and a further eight months to the other pole. The whole mission is due to last for five years.

● All those interested in receiving pictures from weather satellites are invited to send their names and addresses to H. Neale (G3REH) who is planning, with others, to initiate some form of organization. At first they are planning to correlate names and addresses, interests, skills and sources of advice and if there is sufficient interest, go on to form a Remote Imaging Group. H. Neale, Thornlea, Fishergate, Sutton St. James, Spalding Lincs PE12 0EZ.

● The Harlesdon records and video company which retails computers and hi-fi is called Lightning and during a thunderstorm recently was struck by lightning! The alarm system and telephone had been affected as well as some structural damage to the warehouse, but business was back to normal by 11a.m. the following day.

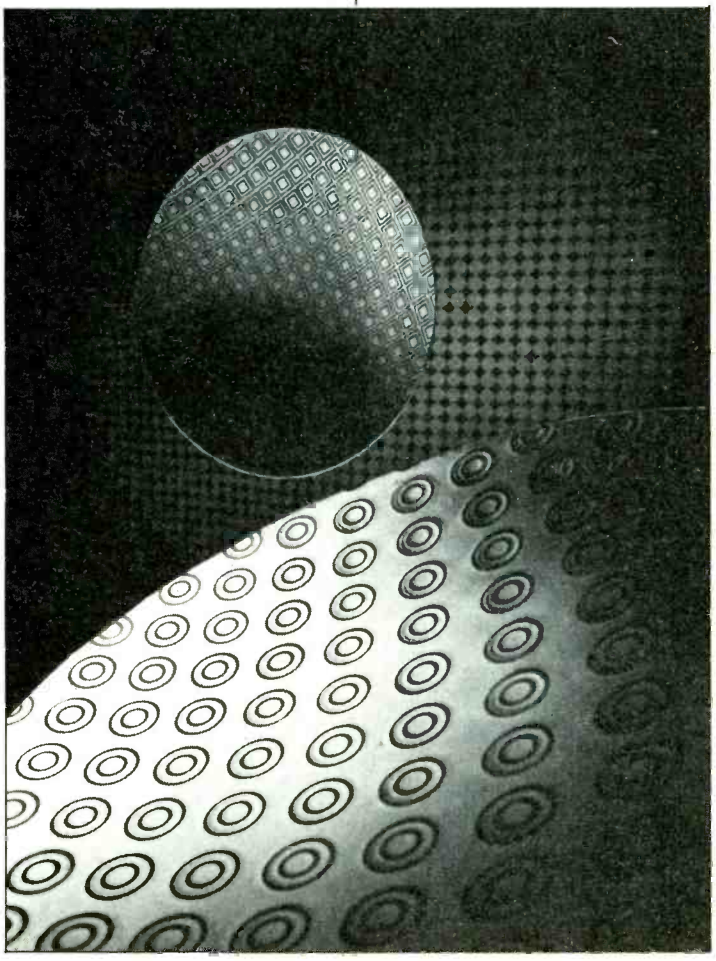
● Following research at the Frenchay Hospital in Bristol, it has been found that one of the best ways of promoting recovery in head-injured patients is to sit them in front of a computer. It seems that the logical thought needed to work with a computer helps to restore logic to the brain. A charity has been founded to buy (BBC) computers and displays etc, and to provide staff and accommodation. Details from, and donations to Councillor Mrs Anne Cummins, Head Injury Recovery Trust, Dept. of Neurosurgery, Frenchay Hospital, Bristol.

● A pan-European cellular radio service is now within reach, says Pye Telecom liason officer John Carlton, who is chairman of the EEA mobile radio committee and president of the European Conference Mobile Radio Group. At a recent mobile communications conference he said that the CEPT was planning to produce a European system specification for the 1990s, establishing the basic parameters by December 1986. More was needed than just harmonization of channels; an air interface standard must be common too if people were to use the same equipment all over Europe. The will and desire for such a service existed, said Mr Carlton, and it can now become a reality.

● Following the sucessful launch of Ariane 3 with the satellites ECS—2 and the French Telecom—1, the European Space agency has a full order book for future launches. Both satellites have been correctly positioned in geosynchronous orbit and are operational.

IT Brain shortage

Not an abstract picture by Vasareli but an illustration of parabolic refectors used in dual-band antennae. These were produced by plating copper onto a.b.s. plastic which is then vacuum formed into the required shape. The final product represents the overcoming of several problems; a.b.s. is a difficult material to plate and it is almost impossible to produce a bond strong enough to withstand the subsequent flexing during the forming operation. Chemists at Russell Laboratories in Ashford, Kent solved the plating problem and the material was forwarded to the Electronics Laboratories at Cambridge University, where the copper was etched and the reflectors formed for use in research into frequency-selective surface.



To investigate, and make proposals to rectify, the country's shortage of skilled people in the information technology field, the DTI set up an IT Skills Shortage Committee under the Chairmanship of Under-secretary John Butcher. The Committees' first report looks at the shortage of graduate skills. The Alvey directorate has estimated a current shortfall of some 1 500 graduates which is likely to escalate, if no action were to be taken, to 5 000 by 1988. The Committees' recomendations are to increase the number of first degree places in the appropriate areas, increase the number of IT conversion courses (where graduates from other disciples can learn about IT) and to expand the role of courses for updating or upgrading a student's IT skills.

The areas identified as being in particularly short supply of the right skills are: artifical intelligence, large-scale integrated circuit design, and software engineering. There is also a great shortage of teachers of these skills. In addition to increasing the number of university and polytechnic places, the committee has recommended the institution of the Great Switch by reducing the number of places in less-productive disciplines (the education spokesman on the Committee pointed out that we have a more than ample supply of historians and biologists). Another strategy is to attract brain-drain ex-patriots back with suitable tax and capital incentives. The major strategy is to encourage industry to provide equipment and expertise in the setting up of a new Partnership of collaboration with the Government and with academic institutions. This would involve the foundation of IT Training Companies; the commissioning of universities and colleges to provide contract courses such as conversion, updating developing and the like; for industry to provide key personnel as visiting professors and help with the supply of lecturers; to give or lend equipment to educational establishments and to provide access to 'leading edge' technology; for industry to provide consultancy and employment opportunities so that academics can enhance the town and gown relationship, increase the earnings of key individuals and provide students with practical work experience within their academic programmes.

The need for urgency is paramount, especially as it takes five years from the time that a 16 year old chooses which subjects in which to specialize to the time that a 21 year old emerges with a first degree.

Prestel in schools

Special educational microcomputing applications are to be included in an extension of BTs viewdata to be known as Prestel Education Service. The service has been developed by BT with the UK and Scottish Programme and many educational organizations will be contributing to parts of the service.

The service is aimed at secondary schools and among the special features will be School Link, a microcomputing service to be produced with Educational Computing magazine and allowing schools to receive telesoftware programs directly from the telephone line. Advice, support and ideas to enable schools to develop their uses of information technology will be provided, as will guides to further education courses and career opportunities. A system for ordering educational material and supplies is being developed.

Due to start at the beginning of next year, the deal to school will include a special low tarriff rate for Prestel and a low cost equipment package enabling schools to buy everything required to receive Prestel on their microcomputers at a substantial discount on commercial prices. Those schools who already receive Prestel will be eligible for the discounts from October this year.

British Space Agency?

A single body to coordinate the country's space efforts is needed, according to a pressure group led by the trade union TASS, many of whose members work in the aerospace industries. According to the union's aerospace organiser, Chris Darke, 'Britain's lead in the field of satellites and space technology is being overtaken by the French and the Japanese. We need to set up an agency similar to NASA in the United States or to ESA in Europe.'

He pointed out that many of the components used in satellite construction are bought in when they could be manufactured domestically and that there was little home research and development into the manufacture of launch vehicles and space stations. 81 MPs have signed a motion supporting the formation of such an agency and the union, along with other supporters, will be lobbying Parliment and in particular Kenneth Baker, the Minister with responsibilities for space activities, to press for its foundation.

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T1S43	0.43
ZS140	0.25
ZS170	0.21
ZS178	0.54
ZS271	0.23
ZS278	0.57
ZTX107	0.12
ZTX108	0.12
ZTX109	0.12
ZTX300	0.13
ZTX301	0.14
ZTX302	0.18
ZTX303	0.18
ZTX304	0.20
ZTX311	0.13
ZTX314	0.25
ZTX500	0.14
ZTX501	0.14
ZTX502	0.18
ZTX503	0.19

ZTX504	0.21
ZTX531	0.24
ZTX550	0.25
1N914	0.05
1N916	0.09
1N4001	0.06
1N4002	0.06
1N4003	0.06
1N4004	0.07
1N4005	0.09
1N4006	0.11
1N4007	0.12
1N4009	0.07
1N4148	0.04
1N5400	0.13
1N5401	0.13
1S44	0.04
1S920	0.08
1S921	0.09
2G301	1.00
2G302	1.00
2G306	1.00
2N404	1.30
2N696	0.32
2N697	0.32
2N698	0.32
2N705	1.25
2N706	0.25
2N708	0.25
2N930	0.25
2N1131	0.30
2N1132	0.30
2N1302	1.20
2N1303	0.80
2N1304	1.20
2N1305	1.00
2N1306	1.50
2N1307	1.10
2N1308	1.75
2N1309	1.20
2N1613	0.32

2N1671	5.00
2N1893	0.32
2N2147	4.00
2N2148	3.75
2N2218	0.32
2N2219	0.32
2N2220	0.20
2N2221	0.20
2N2222	0.20
2N2223	4.25
2N2368	0.25
2N2369A	0.25
2N2484	0.25
2N2646	0.50
2N2904	0.32
2N2905	0.32
2N2906	0.21
2N2907	0.21
2N2924	0.26
2N2925	0.22
2N2926	0.15
2N3053	0.26
2N3054	0.55
2N3055	0.65
2N3440	0.70
2N3441	0.85
2N3442	1.25
2N3614	2.20
2N3702	0.11
2N3703	0.11
2N3704	0.11
2N3705	0.11
2N3706	0.11
2N3707	0.11
2N3708	0.10
2N3709	0.11
2N3710	0.10
2N3711	0.10
2N3771	1.40
2N3772	1.60
2N3773	1.80

2N3819	0.30
2N3820	0.39
2N3823	0.60
2N3866	1.00
2N3904	0.17
2N3905	0.17
2N3906	0.17
2N4058	0.20
2N4059	0.20
2N4060	0.16
2N4061	0.16
2N4062	0.16
2N4124	0.16
2N4126	0.16
2N4286	0.15
2N4288	0.18
2N4289	0.18
2N4400	0.11
2N4401	0.11
2N4402	0.11
2N5457	0.32
2N5458	0.32
2N5459	0.32
2S017	10.00
2S019	12.00
2S026	25.00
2S103	1.50
2S302	2.00
2S303	1.50
2S322	3.50
2S324	3.50
2S701	2.00
2S745A	0.95
2S746A	0.95

CV Devices
Large stocks
Prices on
application

VALVES

A1834	9.00
A2087	13.50
A2134	17.50
A2293	16.00
A2426	27.50
A2521	25.00
A2900	15.00
A3343	45.00
AZ31	2.75
AZ41	2.60
BK448	114.90
BK484	155.35
BS90	58.00
BS810	60.00
BT5	58.95
BT17	151.00
BT19	44.05
BT29	349.15
BT69	354.80
BT95	129.90
CBL31	4.00
CL33	4.00
CY31	3.00
C1K	20.00
C3A	22.00
C3JA	22.00
DA41	25.00
DA42	18.70
DAF91	1.75
DAF96	1.75
DET22	35.00
DET24	49.00
DF91	1.75
DF96	1.75
DK91	1.75
DK92	2.00
DK96	1.75
DL92	2.00
DL94	1.75
DL96	1.75
DLS10	14.00
DLS15	12.50
DLS16	12.50
DLS19	12.50
DM70	2.00
DM71	2.00
DM160	4.75
DY87	1.50
DY802	1.50
E55L	45.00
E80CC	8.81
E80CF	11.27
E80F	14.19
E80L	13.73
E81CC	8.00
E81L	13.27
E810F	35.48
E82CC	8.10
E83CC	8.40
E86C	8.25
E88C	8.25
E88C	8.42
E90CC	9.47
E90F	9.90
E91H	6.25
E92CC	8.75
E99F	9.10

E130L	18.50
E180CC	10.50
E180F	10.20
E182CC	13.25
E186F	11.50
E188CC	8.91
E280F	22.51
E283CC	12.00
E288CC	17.50
EA52	125.00
EA76	2.50
EABC80	1.25
EAC91	3.50
EAF42	2.50
EAF801	2.00
EB41	4.00
EB91	1.50
EBC33	2.50
EBC41	2.50
EBC81	1.50
EBC90	1.25
EBF80	1.50
EBF83	1.75
EBF89	1.50
EBL31	10.00
EC90	1.25
EC91	8.00
EC92	1.75
EC157	410.00
ECC33	4.50
ECC35	4.50
ECC40	4.50
ECC81	1.75
ECC82	1.75
ECC83	1.75
ECC84	1.75
ECC85	1.75
ECC86	2.50
ECC88	2.10
ECC89	2.00
ECC91	8.93
ECC189	2.10
ECC807	1.75
ECC808	3.00
ECF80	1.55
ECF82	1.50
ECF86	2.50
ECH35	3.00
ECH42	3.50
ECH81	3.00
ECH83	2.50
ECH84	2.50
ECL80	1.50
ECL81	1.75
ECL82	1.50
ECL83	3.00
ECL84	1.50
ECL85	1.50
ECL86	1.75
EF37A	5.00
EF39	2.75
EF40	5.00
EF41	3.50
EF42	4.50
EF50	2.50
EF54	5.00
EF55	3.50
EF80	1.75
EF83	4.00

EF85	1.75
EF86	3.50
EF89	2.50
EF91	2.95
EF92	6.37
EF93	1.50
EF94	2.50
EF95	5.99
EF98	2.00
EF183	2.00
EF184	2.00
EF804S	12.00
EF805S	15.00
EH90	1.75
EK90	1.50
EL32	2.50
EL33	4.00
EL34MUI	4.00
EL36	2.50
EL41	2.80
EL42	2.50
EL81	5.25
EL83	6.00
EL84	2.25
EL86	2.75
EL90	2.25
EL91	9.69
EL95	2.00
EL156	30.00
EL360	8.50
EL500/504	3.00
EL509	7.00
EL821	13.00
EL822	13.97
EM34	5.00
EM80	2.50
EM81	2.50
EM84	2.00
EM85	2.75
EM87	2.50
EN32	17.46
EN91	6.50
EN92	6.96
EY51	2.75
EY81	2.50
EY83	2.50
EY84	9.24
EY86	1.75
EY88	1.75
EY500A	3.00
EY802	1.75
EZ35	1.75
EZ40	2.50
EZ41	2.50
EZ80	1.50
EZ81	1.50
EZ90	2.00
FW4-500	3.50
FW4-800	3.50
G1.371K	35.00
G551K	12.00
G180.2M	17.50
G240.2D	12.00
G400.1K	17.50
GN4	9.00
GN4A	9.00
GS16	16.00
GT1C	15.00
GU50	20.00

GU51	20.00
GXU1	15.35
GXU2	30.00
GXU3	25.40
GXU4	44.50
GXU50	20.00
GY501	3.00
GZ32	4.00
GZ33	4.75
GZ34	3.00
GZ37	4.75
KT61	5.00
KT66	12.00
KT77 Gold Lion	9.00
KT88	15.00
KTW61	2.50
KTW62	2.50
KTW63	2.50
M8079	12.34
M8080	8.25
M8081	9.82
M8082	9.69
M8083	8.58
M8091	10.43
M8096	6.80
M8097	8.10
M8098	8.15
M8099	8.00
M8100	9.52
M8136	10.23
M8137	10.23
M8140	6.00
M8141	6.50
M8142	8.75
M8144	7.50
M8149	6.50
M8161	9.35
M8162	10.40
M8163	8.25
M8190	5.00
M8195	10.85
M8196	7.50
M8204	7.05
M8212	11.37
M8223	6.00
M8224	6.30
M8225	4.50
M8248	14.03
MD2901	115.00
MU14	2.50
MX119	55.00
MX123	72.00
MX145	56.70
MX151	17.25
MX152	131.25
MX161	152.25
MX163	20.25
MX164	25.52
MX166	147.00
MX168	50.00
N78	15.00
OA2	3.25
OA3	2.50
OA4	6.00
OB2	4.35
OB3	2.50
OC2	4.35
OC3	2.50

OD3	2.50
OZ4	3.50
PC86	2.50
PC88	2.50
PC95	1.75
PC97	1.75
PC900	1.75
PCC84	1.50
PCC85	1.50
PCC88	2.00
PCC89	1.75
PCC189	2.50
PCC805	1.60
PCC806	1.60
PCE82	2.00
PCF80	2.00
PCF82	1.50
PCF86	2.50
PCF87	2.00
PCF200	3.25
PCF201	3.25
PCF801	2.50
PCF802	2.50
PCF805	1.70
PCF806	1.70
PCF808	1.70
PCL82	2.00
PCL83	3.00
PCL84	2.00
PCL85	2.50
PCL86	2.50
PCL805/85	2.50
PD500	6.00
PE06-40N	45.00
PFL200	2.50
PL36	2.50
PL81	1.75
PL81A	2.00
PL82	1.50
PL83	2.50
PL84	2.00
PL504/5	2.50
PL508	2.50
PL509	6.00
PL519	6.00
PL801	1.50
PL802	6.00
PY33	2.50
PY81	1.50
PY82	1.50
PY83	2.50
PY88	2.00
PY500A	4.00
PY800	1.50
PY801	1.50
QF451	82.50
QQV02-6	31.80
QQV03-10	23.50
QQV03-20A	48.38
QQV06-40A	75.00
QQV07-50	69.74
QQZ06-40A	75.00
QU37	12.50
QV03-12	6.80
QV04-7	3.50
QV08-100	171.20

QY3-65	63.24
QY3-125	68.64
QY4-250	70.14
QY4-400	76.20
QY5-500	190.00
QY5-3000A	450.00
QZ06-20	32.70
R10	6.00
R17	3.00
R18	3.00
R19	9.24
R20	2.50
RG3-250	32.68
RG3-250A	32.68
RG3-1250	59.50
RG4-1250	61.60
RG4-3000	99.45
RR3-250	40.00
RR3-1250	45.75
S11E12	65.00
S130	6.00
S130P	6.00
STV280-40	14.00
STV280-80	21.00
SU41	5.00
SU42	10.00
TD03-10	35.00
TD03-10F	35.00
TT15	50.00
TT21	30.00
TT22	37.50
TT100	60.00
TY2-125	65.00
TY4-400	80.00
TY4-500	105.00
TY5-500	214.00
TY6-800	210.00
TY6-5000A	490.00
TY6-5000B	395.00
TY6-5000W	425.00
TY7-6000A	525.00
TY7-6000W	525.00
TZ40	25.00
U18-20	3.50
U19	13.75
U25	2.50
U26	2.50
U37	12.00
UABC80	1.25
UAF42	2.50
UB41	3.00
UBC41	2.25
UBF89	1.50
UCC84	1.75
UCC85	1.85
UCF80	2.00
UCH42	2.50
UCH81	2.50
UCL82	1.75
UCL83	2.75

UF41	2.00
UF42	2.10
UF80	1.75
UF85	1.75
UF89	2.00
UL41	5.00
UL84	1.75
UM80	2.00
UY41	2.25
UY85	2.25
VLS631	15.00
XG1-2500	55.00
XG2-6400	141.90
XG5-500	26.60
XG2-6400	162.00
XR1-1600A	53.75
XR1-3200	81.97
XR1-3200A	
XR1-6400	165.00
YD1120	395.00
YD1240	490.00
Z759	25.00
ZM1000	8.00
ZM1001	8.00
ZM1020	9.00
ZM1021	9.00
ZM1022	9.00
ZM1023	9.00
ZM1040	19.36
ZM1041	16.66
ZM1042	17.77
1B3GT	3.00
1B24	25.00
1B35A	48.00
1B63	64.00
1R5	1.75
1S5	1.75
1T4	1.75
2AS15	11.50
2C39A	60.00
2C43	70.00
2D21	3.25
2E26	8.25
2J42	98.00
2J55	175.00
2J70A	383.00
2J70B	336.00
2K25	125.00
3-400Z	85.00
3-500Z	85.00
3A5	3.00
3B24	11.00
3B28	15.35
3B29	20.05
3B240M	17.50
3B241M	17.50
3C23	25.00
3C45	24.50
3CX100A5	47.00
3E29	45.00
3S4	2.00
3V4	1.75
465A	60.00
4-125A	60.00

4-250A	80.00
4-400A	87.00
4B32	20.00
4C35	78.00
4CX250B	45.00
4CX350A	80.00
4X150A	60.00
4X150D	56.00
5B254M	35.00
5B255M	35.00
5C22	160.00
5J180E	1650.00
5R4GY	3.50
5U4G	3.00
5U4GB	2.50
5V4G	2.50
5Y3GT	2.50
5Z3	4.00
5Z4G	2.50
5Z4GT	2.50
6-30L2	1.75
6AB4	1.75
6AB7	3.00
6AC7	3.00
6AF4A	4.25
6AG7	3.00
6AH6	5.00
6AK5	5.99
6AK6	2.50
6AL5	1.50
6AM4	4.00
6AM5	9.69
6AM6	6.02
6AN5	4.75
6AN8A	3.50
6AQ5	2.25
6AS6	8.66
6AS7G	8.75
6AT6	1.25
6AU5GT	5.00
6AU6	2.50
6AV5GA	4.50
6AV6	1.50
6AX5GT	3.00
6B7	3.25
6B8	3.25
6BA6	1.50
6BA7	5.00
6BA8A	4.00
6BC4	4.00
6BE6	1.50
6BH6	2.50
6BJ6	2.25
6BK4	4.50
6BL6	85.00
6BL7GT	4.50
6BM6	115.00
6BN6	2.00
6BQ7A	3.50
6BR7	6.00
6BR8A	3.50
6BS7	6.00
6BW6	6.00
6BW7	1.50
6BX7GT	5.00
6BZ6	2.75
6C4	1.25
6CB6A	2.50
6CD6GA	5.00

6CG7	2.50
6CH6	13.00
6CL6	3.75
6CW4	8.00
6D2	1.50
6DK6	3.00
6DQ6B	4.75
6EA8	3.00
6EB8	2.50
6EW6	2.25
6F6	3.00
6F23	1.60
6F28	1.60
6F33	33.50
6H1	14.00
6H2N	2.75
6H3N	2.75
6H6	3.00
6J4	5.50
6J6	8.93
6J7	4.75
6K4N	2.50
6K6GT	2.75
6K7	3.00
6K8	3.00
6KD6	7.00
6L6G	3.00
6L6GA	3.00
6L6GC	3.50
6L6GT	3.00
6L7	2.50
6N2P	2.50
6N3P	2.50
6N7	3.00
6P25	4.00
6Q7	3.75
6R7	3.25
6SA7	3.00
6SC7	2.75
6SF7	2.50
6SH7	3.00
6SJ7	3.25
6SK7	3.50
6SK7GT	3.00
6SN7GT	3.00
6SQ7	3.40
6SR7	4.00
6SS7	2.75
6U5G	3.50
6U8A	2.25
6V6GT	2.25
6X4	2.00
6X5GT	1.75
7B7	2.50
7C5	4.00
7C6	2.50
7H7	4.00
7R7	4.25
7S7	3.50
7Y4	2.25
7Z4	2.00
11E3	55.00
12AH8	5.00
12AT6	1.50
12AT7	1.75
12AU6	2.50
12AU7	1.75
12AV6	2.50
12AV7	3.50

12AX7	1.75
12AY7A	4.00
12B4A	3.50
12BA6	2.50
12BE6	2.50
12BH7	2.75
12BY7	3.00
12E1	20.00
12E11TT	28.00
12E14	65.00
13E1	170.00
19H4	27.50
19H5	47.50
24B9	67.25
30C15	2.00
30C17	2.00
30C18	2.00
30F5	1.60
30FL1/2	1.38
30FL12	1.80
30FL14	2.00
30L1	1.50
30L15	2.00
30L17	2.00
30P4	2.50
30P19	2.50
30PL1	3.00
30PL14	1.80
30PL15	1.80
35W4	1.00
50C5	1.50
75B1	6.05
75C1	4.50
85A1	7.50
85A2	6.45
90AG	12.96
90AV	12.96
90C1	6.00
90CG	14.54
90CV	15.45
92AG	20.00
92AV	20.00
95A1	8.45
150B2	6.50
150B3	8.35
150C2	3.25
150C4	6.00
211	35.00
723AB	125.00
803	25.00
805	45.00
807	3.75
811A	18.33
812A	29.50
813	125.86
833A	193.16
866A	20.03
872A	20.00
922	6.00
931A	18.50
1624	4.00
1625	3.50
2050	7.50
4212E	300.00
4212H	300.00
5544	81.97
5545	165.00
5551A	114.90
5552A	155.35

5642	9.00
5654	3.00
5651	4.45
5670	4.50
5675	28.00
5687	6.00
5696	4.50
5718	7.50
5725	5.50
5726	11.37
5727	7.05
5749	2.50
5751	4.00
5763	4.50
5814A	4.00
5840	4.00
5842	12.00
5876A	31.50
5879	5.00
5886	17.50
5963	2.50
5965	3.50
6005	2.25
6021	4.50
6057	10.23
6058	12.34
6059	6.00
6061	6.00
6063	3.75
6064	8.58
6067	10.23
6072	6.00
6080	14.00
6097A	235.00
6097B	200.00
6146A	8.25
6146B	8.25
6159B	19.00
6189	9.50
6201	11.40
6442	20.00
6883B	8.25
6973	4.00
7025	3.00
7551	6.25
7586	12.00
7587	18.50
7609	56.00
7868	6.00
7895	12.00
8005	110.49
8068	14.00
8122	90.00
8136	2.50
8417	6.00
18042	11.53
18045	10.49

Tested
Ex-Equipment
4CX250B 6.50
CV Devices
Large stocks
Prices on
application

BASES

B7G unskirted	0.25
B7G skirted	0.35
B9A unskirted	0.25
B9A skirted	0.35
Int Octal	0.35
Loctal	0.55
Nuvistor base	2.00
8 pin DIL Texas	0.10
14 pin DIL Texas	0.10
16 pin DIL Texas	0.10
Valve screening cans all sizes	0.40

CRTs

2AP1	8.50
2BP1	9.00
3BP1	12.00
3DP1	5.00
3EG1	10.00
3FP7	6.00
3GP1	6.00
3JP1	8.00
3JP2	8.00
3JP7	10.00
3KP1	15.00
3RP1	35.00
3WP1	20.00

5ADP1	55.00
5CP1	10.00
5CP1A	40.00
5FP15A	15.00
5UP7	25.00
DG7-5	63.32
DG7-31	58.07
DG7-32	58.07
DG7-36	65.00
DH3-91	56.83
DH7-11	113.12
VCR97	12.00
VCR138	12.00
VCR138A	12.50
VCR139A	8.00

VCR517B	10.00
VCR517C	10.00

Tube Bases
Prices on
application

INTEGRATED CIRCUITS

7400	0.16
7401	0.17
7402	0.17
7403	0.17
7404	0.18
7405	0.18
7406	0.43
7407	0.43
7408	0.20
7409	0.20
7410	0.17
7412	0.29
7413	0.32
7416	0.32
7417	0.32
7420	0.18
7422	0.20

7423	0.33
7425	0.30
7427	0.30
7428	0.43
7430	0.17
7432	0.30
7433	0.40
7437	0.32
7438	0.32
7440	0.32
7441	0.90
7442	0.72
7447AN	1.17
7450	0.18
7451	0.18
7453	0.18
7454	0.18

7460	0.18
7470	0.38
7472	0.33
7473	0.38
7474	0.38
7475	0.54
7476	0.42
7480	0.56
7482	0.75
7483	1.00
7484	1.05
7486	0.39
7490	0.60
7491	0.82
7492	0.60
7493	0.60
7494	0.82

7495	0.73
7496	0.82
7497	3.15
74100	1.54
74107	0.45
74109	0.73
74110	0.51
74111	0.71
74116	1.85
74118	1.00
74119	1.54
74120	0.83
74121	0.43
74122	0.62
74123	1.18
74125	0.58
74126	0.58
74128	0.63
74132	0.72

74136	0.51
74141	0.89
74142	2.30
74143	2.60
74144	2.60
74145	1.00
74147	2.00
74148	1.76
74150	1.80
74151	0.94
74154	1.80
74155	0.90
74156	0.90
74157	0.75
74159	2.20
74170	2.40
74172	4.40
74173	1.42
74174	1.60

74175	1.02
74176	1.16
74178	1.36
74179	1.36
74180	1.20
74190	1.90
74191	1.90
74192	1.90
74193	1.90
74194	1.25
74195	1.20
74196	1.35
74197	1.35
74198	2.70
74199	2.30
TAA570	2.30
TAA630S	3.50
TAA700	3.90
TBA480Q	1.84

TBA520Q	2.30
TBA530	1.98
TBA540Q	2.30
TBA550Q	3.22
TBA560CQ	3.22
TBA673	2.20
TBA700	1.52
TBA720Q	2.30
TBA750Q	2.07
TBA800	1.20
TBA920	2.90
TBA920Q	2.90
TBA990Q	2.90
TCA270Q	2.90
TCA760A	1.38

Terms of business: CWO. Postage and packing valves and semiconductors 50p per order. CRTs £1.50. Prices excluding VAT, add 15%.
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In some cases prices of Mullard and USA valves will be higher than those advertised. Prices correct when going to press.
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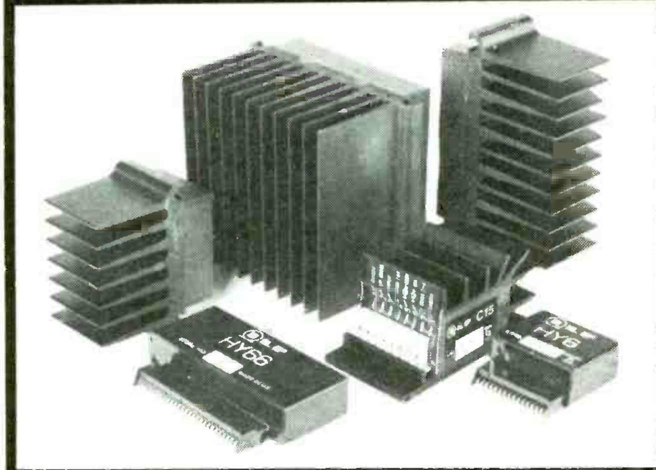
CIRCLE 31 FOR FURTHER DETAILS.

AMPLIFIERS

WHY ILP? Years of experience in audio, unique designs, world wide sales and outlets, reliable delivery and friendly service........



BIPOLAR MODULES

Ideal for Hi Fi, Full load line protection integral Heatsink, slew rate 15v/μs

Distortion less than 0.01%

Type	Output Power Watts (rms)	Load Impedance Ω	Price
HY30	15	4-8	£8.45
HY60	30	4-8	£9.95
HY6060	30+30	4-8	£19.45
HY124	60	4	£20.95
HY128	60	8	£20.95
HY244	120	4	£26.95
HY248	120	8	£26.95
HY364	180	4	£39.95
HY368	180	8	£39.95

MOSFET MODULES

Ideal for Disco's, public address and applications with complex loads (line transformers etc.). Integral Heatsink slew rate 20v/μs distortion less than 0.01%

Type	Output Power Watts (rms)	Load Impedance Ω	Price
MOS128	60	4-8	£30.45
MOS248	120	4-8	£39.95
MOS364	180	4	£45.95

PREAMPLIFIER MODULES

All modules are supplied with in line connectors but require potentiometers, switches etc. If used with our power amps they are powered from the appropriate Power Supply.

Type	Application	Functions	Price
HY6	Mono Pre Amp	Full Hi Fi facilities	£7.95
HY66	Stereo Pre-Amp	Full Hi Fi facilites	£14.95
HY73	Guitar Pre-Amp	Two Guitars plus Microphone	£15.95
HY78	Stereo Pre-Amp	As HY66 less tone controls	£14.45

MOUNTING BOARDS: For ease of construction we recommend the B6 for HY6 £0.95 B66 for HY66-78 £1.45.

POWER SUPPLY UNITS

Type	For Use With	Price
PSU212	1 or 2 HY30	£11.95
PSU412	1 or 2 HY60, 1 HY6060, 1 HY124	£13.95
PSU422	1 HY128	£15.95
PSU432	1 MOS128	£16.95
PSU512	2 HY128, 1 HY244	£17.45
PSU522	2 HY124	£17.45
PSU532	2 MOS128	£17.95
PSU542	1 HY248	£17.95
PSU552	1 MOS248	£19.95
PSU712	2 HY244	£21.95
PSU722	2 HY248	£22.95
PSU732	1 HY364	£22.95
PSU742	1 HY368	£24.45
PSU752	2 MOS248, 1 MOS368	£24.45

All the above are for 240v operation.

FOR FREE DATA PACK PLEASE WRITE TO OUR SALES DEPT.

Post to: ILP Electronics Ltd., Dept. 6
Graham Bell House, Roper Close,
Canterbury, Kent. CT2 7EP
Tel: (0227) 54778 Telex: 965780

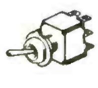
VISA Access

ILP

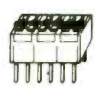
CIRCLE 50 FOR FURTHER DETAILS.

ELECTROVALUE

Your SPECIALIST SUPPLIERS for SWITCHES



Out of a very wide range of types, we show some of the more popularly demanded ones. The full range currently stocked will be found in our latest free A-Z price & products list. Please mention this journal when contacting Electrovalue.



MINIATURE TOGGLES, 7000 Series
250V/2A, 120 V/5A. Single, double, three and four pole configurations inc. Centre Off/On and biased.

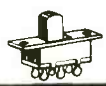
CK WAVECHANGE with adjustable stops. 1P/12 way, 2P/6W, 3P/4W, 4P/3W, 6P/2W.

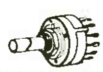
SWITCH KITS
RA Shaft Assemblies up to 6 wafers. DP Mains switch. Screens; Spacers.

PUSH BUTTON
Miniature
Single and Double Pole Changeover
Standard
Latching and momentary

SLIDERS
Miniature & Standard. SP and DP in 1, 2 or 3 positions.

Many other types such as for timing and other special applications.





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Tel: (0784) 33603. Telex: 264475. *North:* 680 Burnage Lane, Manchester (061-432 4945). *EV Computing Shop,* 700 Burnage Lane, Manchester (061-431 4866).

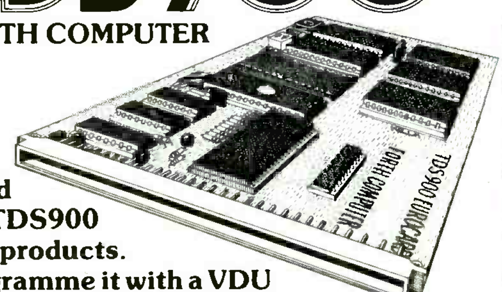
ACCESS AND BARCLAYCARD Phoned Orders Welcome

2

CIRCLE 47 FOR FURTHER DETAILS.

TDS900

FORTH COMPUTER



Build the TDS900 into products. Programme it with a VDU and your forecasts become fact.

Software costs are significant in all industrial applications of microprocessors. They cannot be amortised over the large quantities associated with personal computers and electronic games. This C-MOS embedded computer card aims at resolving this problem by including FORTH high level language programming and developmental facilities. The software can be written quickly and made to work correctly at lowest possible expense. Using a high level programming language rather than assembler gives a fast reaction time to market opportunities. Production products use the same board as employed in the prototypes.

No microprocessor development system is needed since the card contains a screen editor working with simple visual display units (VDUs). It also has the compiler for the FORTH source code. Debugging is inherent in the FORTH language and once the code is working, this can be output to a PROM programmer.

Use of C-MOS throughout has brought the power consumption down to 16mA, making the TDS900 especially suitable for portable and battery-driven applications.

Triangle Digital Services Limited
100a Wood Street, Walthamstow, London E17 3HX Tel: 01-520 0442

Visitors to our laboratories are welcome by appointment

CIRCLE 13 FOR FURTHER DETAILS.

Electronic Brokers Ltd

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Philips PM3207 15 MHz Oscilloscope £325
Compact, portable, lightweight oscilloscope designed for field and workshop use. 15MHz bandwidth with 5mV sensitivity. TV and auto triggering from either channel, with adjustable level. Add and invert facilities and X-Y mode. Large screen with internal graticule.

Hameg HM103 10MHz Oscilloscope £167
This small oscilloscope has been designed specifically for field service personnel and advanced electronic hobbyists. Single trace, 10MHz bandwidth with 2mV sensitivity. TV and auto triggering with adjustable level. Internal graticule and in-built component tester.

Philips PM3217 50MHz Oscilloscope £870
High 2mV sensitivity, dual trace, 8 x 10cm display with small spot size, high light output and illuminated graticule, auto trigger mode, TV triggering on line and frame. Full X-Y display facilities. Comprehensive second time base facility. Compact dimensions and low weight.
Philips PM 3215 Single time base £695

Hameg HM203-4 20MHz Oscilloscope £264
Designed for general purpose applications in industry and education. Versatile triggering performance to at least 40MHz. Dual trace X-Y operation, TV triggering, add and invert mode and component tester make the price/performance ratio of this scope most attractive.

Philips PM3219 Storage Oscilloscope £2675
Provides comprehensive, cost effective storage of single-shot transients and low frequency events. Variable persistence and variable storage. Auto erase between 1 and 10 seconds, and read button facility. Auto store up to 1 minute, up to 24 hours in 'baby sit' mode. 2mV sensitivity at 50MHz

Hameg HM204 20HMz Oscilloscope £365
High performance scope with peak value triggering up to 50MHz. Versatile triggering facilities and variable hold off control. Dual trace, delayed sweep mode, Z modulation, X-Y operation, internal illuminated graticule and component tester complete the attractive specification.

Philips PM3256 75MHz Oscilloscope £1325
Tough, light-weight ruggedised unit, with shoulder strap, that can be used in harsh service environments. Fast trigger circuits to over 100MHz. TTL triggering is standard. Trigger view third channel and full X-Y display. Dual trace with 2mV sensitivity and delayed time base.
Philips PM3254 Single time base £1218

Hameg HM605 60MHz Oscilloscope £515
Outstanding performance with versatile triggering to 80MHz. Sensitivity 1mV to 30MHz and 2mV above. Bright display from 14kV CRT. Switchable 1kHz/1MHz probe calibrator. Dual trace, delayed sweep, X-Y operation, Z modulation, internal illuminated graticule and component tester.

Philips PM3267 100MHz Oscilloscope £1250
Versatile and economic instrument designed for advanced electronic environments. Separate main and delayed time base controls with comprehensive triggering facilities and trigger view third channel. Dual trace, 2mV sensitivity, full X-Y display, Z modulation and internal illuminated graticule.

Hameg HM705 70MHz Oscilloscope £588
General purpose scope with multitude of operating modes and trigger facilities. Extremely bright and well defined displays, with 8 x 10 cm screen and internal illuminated graticule. TV triggering, Z modulation, X-Y dispaly facilities and sweep delay mode. Dual trace

ADD 15% VAT TO ALL PRICES Carriage and Packing extra

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CIRCLE 202 FOR FURTHER DETAILS.

U.K. RETURN OF POST MAIL ORDER
WORLDWIDE EXPORT SERVICE

BAKER LOUDSPEAKERS Post £2 each.

MODEL	INCHES	OHMS	WATTS	TYPE	PRICE
Disco/Group	10	8-16	50	PA	£18
Midrange	10	8	100	MiD	£25
Major	12	4-8-16	30	Hi-Fi	£16
Superb	12	8-16	30	Hi-Fi	£26
Woofer	12	8	80	Hi-Fi	£25
Auditorium	15	8-16	60	Bass	£37
Disco/Group	12	4-8-16	45	PA	£16
Disco/Group	12	4-8-16	75	PA	£20
Disco/Group	12	8-16	100	PA	£26
Disco/Group	15	8-16	100	PA	£35

REPAIR service to most Baker loudspeakers.
SPEAKER COVERING. Samples S.A.E.
CABINET WADDING 18in wide 35p ft.
SPEAKER CABINET Designs manual £3.50

MOTOROLA PIEZO ELECTRIC HORN TWEETER, 3¾in square **£5**
100 watts. No crossover required. 4-8-16 ohms, 7¾×3¼in. Flared Horn 60 watts **£10**
HORN BOXES, complete 200 watt **£30.** 300 watt **£35.** Size 16×6×6in. Black vinyl covered with handle and ¼in jack sockets Post £4.

CROSSOVERS. TWO-WAY 3000 c/s watt **£3.** 60W **£3.50.** 100W **£4.**
THREE-WAY 950 cps/3000 cps. 40 watt rating. **£4.** 60 watt **£6.** 100W **£8.**
LOUDSPEAKER BARGAINS. Please enquire, many others in stock.
4 ohm, 5in, 7×4in, **£2.50;** 6½in, 8×5in, **£3;** 8in, **£3.50.** 6½in 20W, **£7.50.**
8 ohm, 2½in, 3in, **£2;** 5×3in, 6×4in, 7×4in, 5in, **£2.50;** 3in, 10W **£4.** 8×5in, **£3;** 8in, **£4.50;** 10in, **£5;** 12in, **£6;** 8in 25W **£6.50;** 60W **£12.50.**
15 ohm, 2½in, 3½in, 5×3in, 6×4in, **£2.50.** 6½in 10W **£5.** 8in **£4.** 10in **£7.**
25 ohm, 3in, **£2;** 5×3in, 6×4in 7×4in. **£2.50.**
120 ohm, 3½in dia. **£1.**
EMI 13½×8in Bass & Tweeter 4 or 8 ohm 10 watt **£8**

FAMOUS LOUDSPEAKERS

MAKE	MODEL	SIZE	WATTS	OHMS	PRICE	POST
AUDAX	WOOFER	5in	25	8	£10.50	£1
GOODMANS	HIFAX	7½X4½	100	8	£30	£2
GOODMANS	HB	8in	60	8	£13.50	£1
WHARFEDALE	WOOFER	8in	30	8	£9.50	£2
CELESTION	DISCO	10in	50	8/16	£21	£2
GOODMANS	HPG	12in	120	8/15	£30	£2
GOODMANS	HPD	12in	120	8/15	£30	£2
GOODMANS	HP	15in	250	8	£72	£4
GOODMANS	HPD	18in	230	8	£84	£4

RCS STEREO PRE-AMP KIT. Inputs for high, medium or low imp volume control and PC Board. Can be ganged for multi-channel **£3.50**

SINGLE PLAY DECKS. 240v AC Post £2.

Make	Model	Cartridge	Price
GARRARD	6200	Ceramic	£22
BSR	P182	Ceramic	£26
BSR	P232	Magnetic	£28
BSR	P200	Magnetic	£34

BSR 12 DC P257 Ceramic **£24**

AUTOCHANGERS 240 VOLT AC

BSR	Budget	Ceramic	**£18**
BSR	Deluxe	Ceramic	**£20**
BSR	Deluxe	Magnetic	**£26**
GARRARD	Deluxe	Ceramic	**£22**

DECCA TEAK VENEERED PLINTH
Superior finish with space and panel for small amplifier and most record decks.
Board cut for BSR or Garrard 18¾in × 14½in. × 4in. **£5**
Black/chrome facia trim.
Suitable tinted plastic cover £5 Post £1

TINTED PLASTIC COVERS for Decks, Music Centres, etc. Post £1.

17⅞ × 13⅛ × 3¼in.	**£5**	18½ × 12½ × 3in.	**£5**
17½ × 9¾ × 3½in.	**£3**	14⅞ × 12½ × 2⅞in.	**£5**
16½ × 15 × 4½in.	**£5**	16⅞ × 13 × 4in.	**£5**
17 × 12⅞ × 3½in.	**£5**	14½ × 13½ × 2¾in.	**£5**
22⅞ × 13⅞ × 3in.	**£5**	17½ × 13¾ × 4¼in.	**£5**
21½ × 14¼ × 2½in.	**£5**	21 × 13⅞ × 4¾in.	**£5**
23¾ × 14 × 3⅞in.	**£5**	30¾ × 13⅞ × 3¼in.	**£5**

THE "INSTANT" BULK TAPE ERASER **£11.50** Post 95p
Hand-held. Compact unit. Suitable for cassettes and all sizes of tape reels. AC mains. Will also demagnetise small tools.
Tape Head Demagnetiser £5.

ALUMINIUM CHASSIS 2½in. deep 6×4 **£1.75;** 12×3 **£2.20;** 14×3 **£2.50;** 13×9 **£2.80.**
ALUMINIUM PANELS. 6×4 **55p;** 8×6 **90p;** 14×3 **90p;** 10×7 **£1.15;** 12×8 **£1.30;** 16×6 **£.30;** 14×9 **£1.75;** 12×12 **£1.80;** 16×10 **£2.10;**
ALUMINIUM BOXES. 4×4×1½ **£1.20;** 4×2½×2 **£1.20;** 3×2×1 **£1.20;** 6×4×2 **£1.90;** 7×5×2½ **£2.90;** 8×6×3 **£3;** 10×7×3 **£3.60;** 12×5×3 **£3.60;** 12×8×3 **£4.30;** 9×4×4 **£3;** 6×4×3 **£2.20;** 4×4×2½ **£1.60.**
POTENTIOMETERS 5k/2meg LOG or LIN. L/S **50p.** DP **90p.** Stereo L/S **£1.10.** DP **£1.30.**
Edge Pot 5K. SP **45p.**

DISCO MIXER 240V, 4 channels, 2 magnetic, 2 ceramic/tape, 1 mono mic channel, twin v.u. meters, headphones monitor outlet, slider conrols, panel or desk mounting, grained aluminium facia. Tape output facility £49. Post **£1.**
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As above but 7 Band Graphic £128.

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GROUP P.A. DISCO EQUIPMENT

BAKER AMPLIFIERS BRITISH MADE
PA.150 Watt MICROPHONE VOCAL and GROUP AMPLIFIER £129
4 channel mixing, 8 inputs, dual impedance, 50K-600 ohm, volume, treble, bass. Presence controls on each channel. Master volume control, echo, send return socket. Slave sockets. Post £3.
150Watt MIXER AMPLIFIER 4 Inputs £99
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100 Volt Line Model, 150 watt £114. MONO SLAVE. 150 watt £80.
Baker Stereo Slave 150 + 150 watt 300 watt Mono Heavy Duty Model £125. Post £4.

BAKER MOBILE PA AMPLIFIER. All transistor, 60 watt RMS, 12v DC & 240v AC, 4 inputs 50k Aux + 2 mics + 1 phono loudspeaker. Output 4-8-15 ohms + 100 volt line. **£89 Post £2**

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BAKER PORTABLE DISCO 150 watt. Twin console + amplifier + mike and headphones + twin speakers **£360.** Carr. £30. Console + decks + pre-amp **£135** Carr. **£6.**

PA CABINET SPEAKERS. Complete. 8 ohm 60 watt 17×15×9in. **£27. Post** £4. 4 or 8 or 16 ohm 75 watt 20×15×9in. **£52.** 90 watt 32×15×11in. **£71.** 150 watt **£80.** Carr. £10 Black vinyl covered.

MAINS TRANSFORMERS

		Post
250-0-250v 80mA, 6.3V 3.5A, 6.3V 1A	**£7.00**	£2
350-0-350V 250mA, 6.3V 6A CT	**£12.00**	£2
220V 25ma 6V lamp	**£3.00**	
220V 45ma 6V 2 Amp	**£4.00**	£1
250V 60mA, 6V 2A	**£5.00**	£1

Step-Down 240V to 115V 150w **£9.** 250W **£12.** 500W **£14** post £2 Isolated 240v to 110v 660 watts **£20** post £4

GENERAL PURPOSE LOW VOLTAGE
Tapped outputs available

	Price	Post
2 amp, 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 25 and 30V	£6.00	£2
1 amp 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£6.00	£2
2 amp, 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60	£10.50	£2

	Price	Post		Price	Post
5-8-10-16V. ½ amp	£2.50	£1	0-8-12V.5 amp	£5.00	£1
6V. ½ amp	£2.00	£1	15-0-15V 1 amp	£4.00	£1
6-0-6V. 1½ amp	£3.50	£1	15-0-15V. 2 amp	£5.00	£1
9V. 400ma	£1.50	£1	20V. 1 amp	£4.00	£1
9V. 3 amp	£4.00	£1	20-0-20V 1 amp	£3.50	£1
9-0-9V. 50ma	£1.50	£1	0-12-27V. 2 amp	£4.00	£1
9-0-9V. 1 amp	£3.50	£1	20-40-60V. 1 amp	£3.50	£2
10-0-10V. 2 amp	£4.00	£1	25-0-25V 2 amp	£5.50	£1
10-30-40V. 2 amp	£5.50	£1	24V. 5 amp Twice	£12.00	£2
12V. 100ma	£1.50	£1	30V. 1½ amp	£5.00	£1
12V. 750 ma	£2.50	£1	30V. 5 amp and 17-0-17 2a	£4.50	£2
12V. 3 amp	£4.50	£1	12-0-12v lamp	£3.50	£1
12v. 5 amp	£5.00	£1	35V. 2 amp	£4.00	£1
12-0-12V. 1 amp	£3.50	£1			
12-0-12V. 2 amp	£4.50	£1			

55-0-55 6amp + 17-0-17v 1 amp £20 £4

LOW VOLTAGE ELECTROLYTICS
500mF 12V **15p;** 25V **20p;** 63V **40p,** 1200mF 76V **80P**
1000mF 12V **20p;** 25V **35p;** 50V **50p;** 100V **£1.20.**
2000mF 30V **42p;** 40V **60p;** 100V **£1.40;** 1500mF 100V **£1.20.** 2200/63v **£1.30**
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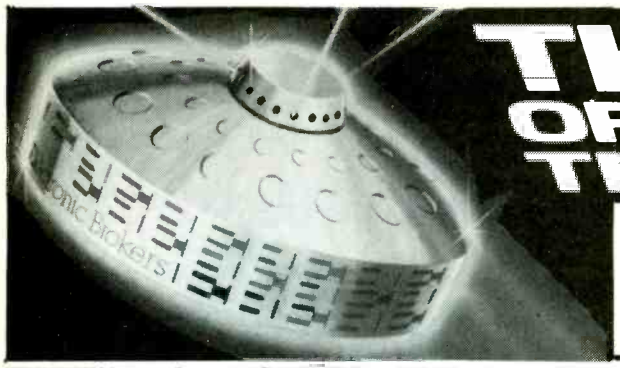

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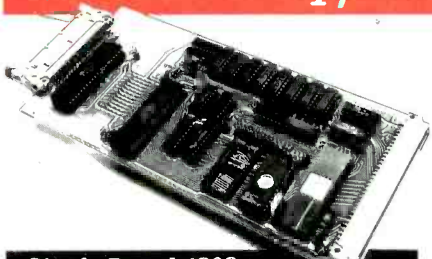

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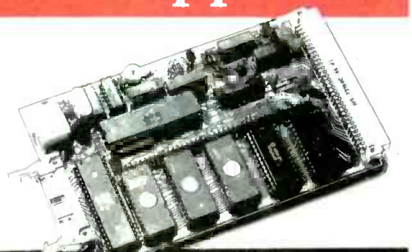

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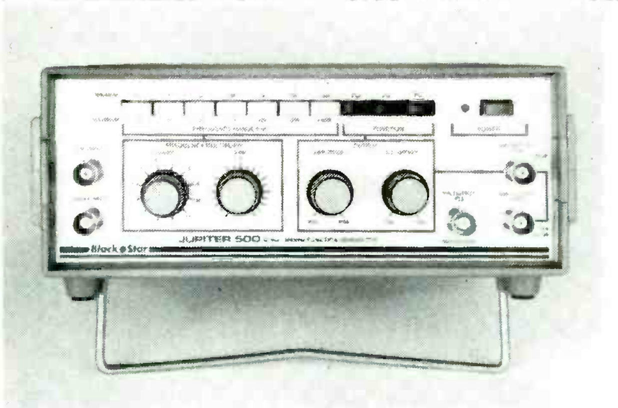

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SC84 microcomputer

by J. H. Adams, M.Sc.

Software loaded from eprom into ram at switch-on is a machine-code programming tool and a link for higher level programs and the disc-operating system.

Resident software, i.e. software present when SC84 is switched on, is described this month. It consists of a 'kernel' providing links between the computer's hardware and software loaded from outside (e.g. from disc), and the resident machine-code operating system. This operating system — MCOS — uses the kernel and is capable of working at an even more basic level, providing a range of facilities for program testing, development and operation. Although this software is stored in eprom, it is correct to call it resident software since it is used in ram.

Within the eprom there are 14 bytes of machine code which are never accessed by the user but which copy the resident software into ram and pass control to MCOS upon reset. The first act of MCOS is to remap system memory so that the eprom, whose entire 64Kbyte content has been copied into ram, is permanently locked out of the map. A potential disadvantage of this is that the computer's fundamental software is now in volatile memory and so may be corrupted — but this is also a great advantage. Not only can you modify the operating system to suit your own requirements, but you can also keep completely different operating kernels on disc, or on different discs, giving a great degree of flexibility. Different kernel facilities can be provided for different applications programs.

MCOS and the kernel take just under 2Kbyte, around 50% of which is MCOS, 35% is the kernel and 8% an area of 'scratch-pad' ram for interrupt-vector tables, system variables, stacks, etc. As mentioned in the first article (May issue) SC84 starts up at machine-code level and progresses upward, which is the reverse of most microcomputers. This allows the user far more contact and familiarity with the machine code. Most system software, including all software for SC84, was written using assembly language (discussed later), but the argument for knowing some fundamental machine code is similar to and as strong as the need for basic numeracy, despite the range of calculators available.

While MCOS is powerful on its own, SC84's primary use will probably be as a disc-based computer. As the computer is advanced to the next level by say initiating SciDOS from MCOS, or by loading and entering Pascal from SciDOS, additional software is loaded into memory, each extra layer passing information through previously loaded ones as each task is broken down into simpler and simpler forms. It is important that all of these layers of software can communicate with each other in a way that is relatively anonymous so that should one part be rewritten, the others remain usable. For example, suppose that the block of software inside the kernel which

- — sets the cursor flashing
- — waits for a key depression
- — reads the keyboard character into a memory buffer
- — stops the cursor flashing
- — reads and clears the keyboard buffer
- — returns the keyboard-buffer content

starts at address 0FC14. When the next layer, MCOS or SciDOS, wants this function it could execute it with the assembly-language instruction CALL 0FC14. However if the kernel is rewritten so that the subroutine starts a byte earlier, all references to 0FC14 must be changed to 0FC13. Such a commonly used routine would be called from many different points so making these changes would be unsatisfactory. There are several possible solutions to this problem.

- ○ The kernel could start with a series of jump instructions to each of the kernel functions. Providing the start of the kernel doesn't alter, system software can call these entry points to pass control to the desired function.
- ○ A call to just one location could be made with one of the Z80 registers containing a parameter to indicate which function is required. The kernel then analyses the contents of the register and passes control to the requested section of the kernel.
- ○ A call could be made with the program location immediately following the call instruction containing the parameter of the required function. This would be processed as the above register call, its advantage being that it wouldn't use up a Z80 register.

The first option has been chosen for SC84; details of entry addresses and their functions are shown in Table 1. This option gives the fastest response as the function pointers do not need decoding and, for the small number of functions required of the kernel, it uses least memory. SciDOS uses this method for communication between its constituent parts, and a modified form of the second option for interfacing with applications software. This modified form operates by the applications program making a call to memory address 00005 with the function number in the Z80 C register. SciDOS will have

Table 1. Kernel functions.

Address	Function name	Description
0F800	HRESET	Completely reinitializes system and returns to MCOS.
0F803	SRESET	Reenters MCOS without resetting RSTs to default values.
0F806	VDUA	Sends the character in A (the accumulator) to the v.d.u. Can process all ascii characters (020 to 07E) as well as certain control characters, escape sequences and reverse-video ascii characters.
0F809	KEY1	Waits for a character to appear in the keyboard buffer, clears the buffer and returns the key code in A. Processes the paging key.
0F80C	PARIN	Reads an 8-bit byte from the parallel input port to A.
0F80F	PAROUT	Sends the contents of A to the parallel output port.
0F812	PRINT	Sends the character in A to the serial output port.
0F815	VDUON	Switches the v.d.u. into the memory map at 08000 to 09FFF.
0F818	VDUOFF	Switches the v.d.u. out of memory map.
0F81B	KEY2	Tests keyboard buffer, returning 000 if empty or clearing the buffer and returning the key code if not.
0F81E	KEY3	Similar to KEY2, but processes the paging character and does not clear buffer.
0F821	KEY4	Tests the keyboard buffer, returning 000 if empty or 0FF if not. Does not clear the buffer.
0F824	RESDSK	Resets (to track 00) and selects the specified disc unit.
0F827	RDDSK	Reads from the specified disc unit, track and sector to memory.
0F82A	WRDSK	Writes to the specified disc unit, track and sector from memory.
0F82D	STEPR	Sets the stepping rate for disc seek and restore operations by supplying code 018 to 01B in the A register. These four codes correspond to stepping rates of 3, 6, 10 and 15ms respectively when the interface is in the 8in mode, double these times in 5.25in mode. The slowest speed is the system default.
0F830	PSCROL	Sets the number of screen lines to take part in v.d.u. scrolling. Scrolling always occurs from the bottom of the screen, but this function can be used to keep a number of lines at the top of the screen stationary for applications such as mixed graph plotting and data output, applications progam menus and/or instructions. The number of scrolling lines is supplied in register A.
0F833	TIME	Creates a 10ms time delay.
0F836	SETUP	Sets standard v.d.u. mode (32 lines of 96 characters).

written a jump to its function-identifying entry point at this memory location. The benefit of having a disc-system entry point which is independent of the computer system and the size of the operating software explains the phenominal success of CP/M and the large amount of software for use on CP/M compatible computers.

MCOS operation

Machine-code operating system MCOS provides facilities for listing the contents of memory, loading and altering memory contents, finding specified bytes, comparing areas of memory, and other functions necessary for working directly in machine code. When the computer is switched on or the reset button pressed, MCOS clears the top v.d.u. line and prompts you for input on this line with the READY message and cursor. MCOS commands are given in English, which may seem odd to readers who have used other computers for machine-level operations. Each command consists of a word followed by a space and up to four parameters, depending on the function. Command syntax was detailed last month using Backus-Naur notation, i.e. expressions in between less and greater-than signs <> indicate what should be typed at that point, and expressions in square brackets are optional. As you type in the parameters, MCOS will space them out on the top line. Note that the only space that you type is the one after the command word. All functions execute immediately and all but ALT and LOAD return the system to READY mode after execution.

At any time, unless MCOS is corrupted, a 'soft reset' may be brought about by pressing the control and at-symbol keys (CTRL @) to return to MCOS command state. If MCOS has been corrupted, the hardware reset button must be used. From the command-state only, to avoid accidental use, two other commands are also available. These are CTRL S to initiate a single-density SciDOS disc and CTRL D for initiating double-density discs.

CP/M's i/o specification is primitive — it was designed so that features of a mechanical teleprinter would meet it — and as a result, many applications packages can be modified to make better use of the computer's display. This makes the software package incompatible with CP/M but can greatly enhance the operation of the program. This is one reason why it is difficult to write a disc-operating system which complies with all so-called CP/M-compatible software; the expression is much abused. In practice, SciDOS and MCOS offer v.d.u. facilities way beyond the requirement of CP/M compatibility.

Some software packages such as Wordstar provide a disassembled listing of parts of the program so that you can extensively modify their i/o routines to, for instance, directly use particular types of memory-mapped v.d.u. This type of modification is particularly applicable to SC84 and results in a superb implementation of Wordstar. Other programs, particularly spreadsheet, 'calc' and planning programs, can be modified for full-screen editing by running a utility program supplied with the package. This program, often called Install, offers you options for standard terminals (which your computer is or matches) or the option of supplying terminal-control sequences otherwise known

List 1. Extracts from MCOS.

```
0060             LINE    EQU    96                      ;VDU chars per line
0020             FRAME   EQU    32                      ;VDU lines per frame
9400             VDU1    EQU    0A000H - LINE * FRAME   ;set VDU start
0014             CRTH    EQU    HIGH VDU1 AND 03FH      ;high byte of VDU start
0000             CRTL    EQU    LOW VDU1                ;low   "   "   "   "
                 ;
00E0             CONTRL  EQU    0E0H              ;set basic port address for I/O
00F0             IDR     EQU    CONTRL + 010H           ;MK3801 direct ports
00F1             GPIP    EQU    CONTRL + 011H
00F2             IPRB    EQU    CONTRL + 012H
00F3             IPRA    EQU    CONTRL + 013H
00F4             ISRB    EQU    CONTRL + 014H
00F5             ISRA    EQU    CONTRL + 015H
00F6             IMRB    EQU    CONTRL + 016H
00F7             IMRA    EQU    CONTRL + 017H
00F8             PVR     EQU    CONTRL + 018H
00F9             TABCR   EQU    CONTRL + 019H
00FA             TBDR    EQU    CONTRL + 01AH
00FB             TADR    EQU    CONTRL + 01BH
00FC             UCR     EQU    CONTRL + 01CH
00FD             RSR     EQU    CONTRL + 01DH
00FE             TSR     EQU    CONTRL + 01EH
00FF             UDR     EQU    CONTRL + 01FH
0000             SCR     EQU    0                       ;MK3801 indirect ports
0001             TDDR    EQU    1
0002             TCDR    EQU    2
0003             AER     EQU    3
0004             IERB    EQU    4
0005             IERA    EQU    5
0006             DDR     EQU    6
0007             TCDCR   EQU    7
                 ;
FA71   F8 06     STITAB: DEFB   PVR,DDR           ;set GPIP bit 1 as O/P
FA73   F0 02             DEFB   IDR,002H
FA75   F1 02             DEFB   GPIP,002H         ;and set it high (RX disabled)
FA77   F8 02             DEFB   PVR,TCDR          ;set baud rate (RX)
FA79   F0 02             DEFB   IDR,002H
FA7B   F8 01             DEFB   PVR,TDDR          ;set baud rate (TX)
FA7D   F0 02             DEFB   IDR,002H
FA7F   F8 07             DEFB   PVR,TCDCR         ;select prescale of 4 on both
FA81   F0 11             DEFB   IDR,011H
FA83   FC 98             DEFB   UCR,098H          ;set 8 bit, 2 stop
FA85   FD 01             DEFB   RSR,001H          ;enable RX
FA87   FE 01             DEFB   TSR,001H          ;enable TX
FA89   F8 03             DEFB   PVR,AER
FA8B   F0 C0             DEFB   IDR,0C0H          ;rising edge for FDC ints
FA8D   F7 C0             DEFB   IMRA,0C0H         ;unmask FDC ints
FA8F   F6 01             DEFB   IMRB,001H         ;unmask keyboard int
FA91   F8 05             DEFB   PVR,IERA          ;enable FDC ints
FA93   F0 C0             DEFB   IDR,0C0H
FA95   F8 0C             DEFB   PVR,IERB+008H     ;enable keyboard int
FA97   F0 01             DEFB   IDR,001H          ;and set S bit
                 ;
FECE   F5        PRINT:  PUSH   AF                ;save register and flags
FECF   DB F1     PRINT1: IN     A,(GPIP)          ;wait for handshake ready
FED1   CB 57             BIT    2,A
FED3   20 FA             JR     NZ,PRINT1
FED5   DB FE     PRINT2: IN     A,(TSR)           ;wait for UART ready
FED7   CB 7F             BIT    7,A
FED9   28 FA             JR     Z,PRINT2
FEDB   F1                POP    AF                ;restore register and flags
FEDC   D3 FF             OUT    (UDR),A           ;output byte
FEDE   C9                RET
                 ;
                 ;
                         .DEPHASE
                         ORG    007F9H
                         .PHASE 0FEE7H
                 ;
FEE7   9400      INIT1:  DEFW   VDU1              ;default VDU start
FEE9   20 20             DEFB   FRAME,FRAME       ;default scrolling window
FEEB   9400              DEFW   VDU1              ;default cursor position
FEED   00                DEFB   000H              ;dummy
FEEE   00                DEFB   000H              ;default line position
FEEF   1B                DEFB   01BH              ;default step rate (slowest)
                 ;
                 ;
                 ;
FEF0   7F 60 68 38 CRTC: DEFB   07FH,LINE,068H,038H,021H,007H,FRAME,FRAME
FEF4   21 07 20 20
FEF8   50 08 08 08       DEFB   050H,008H,008H,008H,CRTH,CRTL,000H,000H
FEFC   14 00 00 00
                 ;
FF00   FEA0 0000 STIVEC: DEFW   AF674,0000H,0000H,0000H,0000H,0000H,0000H,0000H
FF04   0000 0000
FF08   0000 0000
FF0C   0000 0000
FF10   0000 0000         DEFW   0000H,0000H,0000H,0000H,0000H,0000H,INTRQ,0000H
FF14   0000 0000
FF18   0000 0000
FF1C   FE96 0000
                 ;
FF20                     DS     020H              ;reserved for expansion
                 ;
                 ;
FF40   0000      WINDOW: DEFW   00000H            ;VDU start address
FF42   00        SCMAX:  DEFB   000H              ;scroll limit
FF43   00        SCNOW:  DEFB   000H              ;lines scrolled/scroll flag
FF44   0000      CURSOR: DEFW   00000H            ;cursor position
FF46   00        KEYBUF: DEFB   000H
FF47   00        LPOS:   DEFB   000H              ;line position (00-5FH)
FF48   00        STEP:   DEFB   000H              ;disc stepper rate
FF49   00        CURDRV: DEFB   000H              ;image of CONTRL port
FF4A   10 20 11 21 DRVTAB: DEFB 010H,020H,011H,021H
                 ;
                 ;
FF4E             KBF:    DS     010H              ;keyboard buffer
                 ;
                 ;
FF5E   F855 0000 IF000:  DEFW   AF02A,00000H,00000H,00000H
FF62   0000 0000
FF66   0000 0000         DEFW   00000H,00000H,00000H,AF2?4
FF6A   0000 FA15
                 ;
                 ;
FF6E   00 00 01  SDEN:   DEFB   000H,000H,001H  ;single density bootstrap data
FF71   0080              DEFW   00080H
FF73   00 00 01  DDEN:   DEFB   000H,000H,001H  ;double density bootstrap data
FF76   F600              DEFW   0F600H
                 ;
FF78   0000      DF76F:  DEFW   00000H
                 ;
FF7A   49 58 20 49 TF3EC: DEFB  "IX IY HL DE BC AF HL'DE'BC'AF'SP AT S  S  S
FF7E   59 20 48 4C
FF82   20 44 45 20
```

as escape sequences. These sequences make it easier for non-technical users to modify programs. They always begin with the standard control character ESC (CTRL [) and continue with non-control characters which the v.d.u. software interprets. Dbase II is a good example of a data-management program which is greatly enhanced by use of the escape sequences provided on SC84.

A complete source list of MCOS can be supplied on the Sci-DOS system disc if requested. The source code takes 32 pages so it is not practical to publish it in *E&WW*, but extracts are shown in List 1 to illustrate how to adapt the system for other printers, how to modify display parameters and what is stored in the work area. For readers not familiar with source listing and assemblers, the following notes will be of use.

Assemblers

Conversion of a file of assembly-language statements into code which the microprocessor can directly execute — or at least into a form which is relatively easy to modify for direct execution — is done by a program called an assembler. It is better to write all but the simplest programs in assembly language.

The assembler will allow you to use alpha-numeric labels and symbols to represent addresses and values used in the program rather than having to put in the actual values; the assembler works out these values during assembly. As label values are not implicit in the unassembled assembly-language file, inserting extra statements, and thus altering program locations of all the following code, does not entail a major sequence of alteration. Using symbols to represent values and declaring the values of those symbols at the start of the program makes it easier to alter the symbol value. As an extra aid, the assembler checks the list of statements for syntax errors, e.g. values or jump addresses out of range, and reports them. Details of assembly-language statements are available in the various Z80 manuals.

Assemblers produce object-code files which are files of executable or near-executable code. They also produce listing files, which are copies of the source file appended with values of the program counter (the address at which the code will be) and the actual code produced by the assembler. List 1 is extracts from a listing file. In this listing along with the lines of assembly language are lines of 'pseudo ops', i.e. statements which give instructions to the assembler. The EQU statement assigns a value to a symbol. A byte may be defined directly using DEFB and DEFW allows definition of a 16-bit word. A space of the left in the program may be defined using DS.

Not so often found is the DEPHASE/ORG/PHASE sequence which allows code to be assembled at one address and run at another. This sequence means drop back to the actual code pointer (this will be pointing into the MCOS eprom), set it to 007F9 and then continue with assembly, dumping code into locations starting at this address but assembling it as though it was at locations starting at 0FEE7.

In List 1, the first section is part of the symbol definition area showing how definitions for the v.d.u. and i/o facilities are built up from simple values. For instance, if a line width of 88 characters is chosen, the base of the v.d.u. area would automatically be reset from 09400 to 09500 and the start address loaded into the c.r.t. controller (HD6845SP) to 01500. Similarly, mapping of all the i/o-board ports is defined by the symbol CONTRL. Symbols used for the i/o ports allocated to the MK3801 are those given in the manufacturer's data sheet.

On reset the MK3801 is loaded with a series of parameters which define most of the system i/o characteristics. All of these parameters are stored in a table labelled STITAB which starts at address FA71 in ram. Data in this table consists of pairs of bytes, the first of which is the address of the STI port and the second data to be written to it. Note that to write to the indirect port requires four bytes in the table. The first two write the indirect port address into the pointer/vector register (PVR) and the next two write the value to the required register by writing to the indirect register (IDR) — a dummy name for the selected indirect register.

To alter the printer rate from 9600 baud to your requirement, alter the data byte at location 0FA7E. To calculate the value you want, divide the required into 19200. To alter the serial format from eight bit data with two stop bits, change the UCR (uart control register) data byte at location 0FA83. The significance of bits in the UCR is shown in Fig. 1.

Keyboard, v.d.u. and disc facilities

Paging is operated by the key-code CTRL]. The default condition is paging on, i.e. VDUA will halt after receiving the number of line-feed characters equal to the scrolling window size since the last key-press occurred. During a paging pause, a full size flashing cursor is displayed at the bottom left of the v.d.u. Any key pressed will release the function and another screen of information will be shown. The key code used to release the paging pause is discarded.

KEY1 and KEY2 clear the keyboard buffer, KEY3 and KEY4 do not. KEY1 and KEY3 process CTRL] as a paging function toggle and do not return the code. If an application program requires CTRL], KEY2 and KEY4 must be used.

VDUA passes ascii characters (020 to 07E) and reverse video ascii characters (0A0 to 0FF — i.e. the normal ascii character with the eighth bit set) directly to the v.d.u. also recognizes the following control characters.

CTRL G (BEL)	causes a 'beep'
CTRL H (BS)	backspaces the cursor one place without deleting.
CTRL J (LF)	moves the cursor down one line, scrolling the screen if necessary.
CTRL L (FF)	as for LF.
CTRL M (CR)	returns the cursor to the leftmost position of the current output line, clearing any characters to the right of the original cursor position, providing it was not already at the left margin.
DEL (hex. 07F)	backspaces the cursor one position, deleting the character onto which the cursor moves.

VDUA also recognises the following ESCAPE sequences (ESCAPE being the hex. character 01B, decimal 27 or CTRL [).

ESC F	selects reverse video display of subsequent ascii codes.
ESC G	selects normal video display of subsequent ascii codes.
ESC H	moves the cursor to the top left corner of the v.d.u.
ESC J	erases from cursor position to end of screen
ESC K	erases from cursor position to end of line
ESC Y l c	sets the cursor position to line l, column c. l and c are single hex. characters equating to the desired value plus 01F, i.e. the top left corner of the v.d.u. is 020, 020 and the bottom left corner (in mode 0) is 03F, 07F.

Data is passed to the disc function (RESDSK, RDDSK and WRDSK) by setting the IX register to point to a five byte area of memory, the significance of which is that

—the first byte is the drive code, 00 for drive A, 01 for B etc.
—the second byte is the track number required
—the third byte is the sector number required
—the third byte is the lower half of the memory address
—the fourth byte is the upper half of the memory address

The memory address referred to is the start of an area in memory to/from which the data transfer is to take place.

These functions return an error code (00 for no error) in the A register which is based upon the completion code returned by the floppy disc controller. These codes are summarized below but for fuller details of these codes, see the manufacturer's data sheet.

Bit 6	set if disc is write-protected
Bit 4	set if sector, track or side not found
Bit 3	set if a read or write error occurs
Bit 1	set if a verify of a write fails

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AA117	0.09
AA119	0.09
AAY32	0.09
AC107	0.28
AC126	0.17
AC127	0.15
AC128	0.15
AC128K	0.23
AC141K	0.23
AC142K	0.22
AC153K	0.23
AC176	0.18
AC176K	0.20
AC187	0.15
AC187K	0.20
AC180	0.17
AC188K	0.23
ACY18	0.48
ACY19	0.48
AD142	0.60
AD149	0.45
AD161	0.22
AD162	0.22
AF124	0.25
AF125	0.25
AF126	0.25
AF127	0.25
AF139	0.22
AF239	0.22
AL112	0.70
AL113	0.80
ASZ15	1.00
ASZ17	1.00
AU110	1.10
AY102	1.80
AY106	1.80
BA145	0.10
BA148	0.10
BA154	0.06
BA157	0.12
BB101	0.13
BB103	0.16
BB105B	0.18
BB205B	0.24
BC107	0.07
BC108	0.07
BC109	0.07
BC115	0.10
BC118	0.11
BC140	0.19
BC141	0.19
BC142	0.19
BC143	0.19
BC147	0.05
BC148	0.05
BC149	0.05
BC157	0.05
BC159	0.05
BC182	0.06
BC182L	0.06
BC183	0.06
BC183L	0.06
BC184	0.06
BC184L	0.06
BC212	0.06
BC212L	0.06
BC213	0.06
BC213L	0.06
BC214	0.06
BC214L	0.06
BC237	0.07
BC238	0.07
BC300	0.16
BC301	0.18
BC302	0.18
BC303	0.18
BC327	0.06
BC382	0.06
BC337	0.06
BC328	0.06
BC557	0.06
BCY32	1.50
BCY33	1.50
BCY34	1.50
BCY42	0.20
BCY56	0.16

BCY70	0.16
BCY71	0.16
BCY72	0.16
BD115	0.26
BD124P	0.50
BD124	1.10
BD128	0.35
BD131	0.25
BD132	0.25
BD135	0.20
BD136	0.20
BD137	0.20
BD138	0.20
BD139	0.20
BD140	0.20
BD144	0.90
BD150	0.30
BD157	0.38
BD158	0.38
BD166	0.30
BD175	0.30
BD177	0.30
BD179	0.32
BD181	0.45
BD201	0.33
BD202	0.38
BD203	0.42
BD204	0.42
BD222	0.31
BD225	0.31
BD232	0.31
BD237	0.21
BD238	0.24
BD433	0.28
BD437	0.28
BD535	0.38
BD536	0.38
BD537	0.40
BD538	0.40
BDX32	1.00
BDX65	0.80
BF180	0.16
BF181	0.18
BF183	0.20
BF184	0.20
BF185	0.20
BF194	0.05
BF195	0.05
BF196	0.06
BF199	0.06
BF200	0.16
BF257	0.18
BF258	0.18
BF259	0.18
BF336	0.20
BF337	0.20
BF338	0.20
BF362	0.30
BF422	0.21
BF458	0.19
BF459	0.19
BFX29	0.20
BFX84	0.20
BFX85	0.20
BFX87	0.15
BFX88	0.15
BFY50	0.14
BFY51	0.14
BFY52	0.14
BFY56	0.25
BYF57	0.25
BFY64	0.25
BR100	0.14
BSX19	0.15
BSX20	0.15
BSX21	0.16
BSX26	0.16
BSX29	0.19
BZX76	0.18
BT106	0.90
BT109	0.90
BT116	0.80
BT119	1.00
BT120	1.00
BU104	1.00
BU106	0.80
BU108	1.00
BU110	1.10

BU111	1.40
BU126	0.70
BU204	0.75
BU205	0.70
BU208	0.75
BU208A	0.80
BU208D	1.20
BU326	0.85
BU406	0.85
BU407	0.75
BU408	1.00
BU500	1.10
BU526	0.80
BY126	0.06
BY127	0.08
BY133	0.08
BY164	0.22
BY176	0.85
BY179	0.35
BY182	0.32
BY184	0.32
BY187	0.32
BY196	0.20
BY206	0.11
BY207	0.11
BY223	0.72
BYX10	0.15
CA270	0.40
CA3086	0.25
CA3089	1.50
CA3240	0.90
C106D	0.23
MC1327	0.70
MJ2500	1.00
MJ2501	1.10
MJ2955	0.55
MJ3000	1.15
MJ3001	1.15
MJE29A	0.30
MJE30A	0.30
MJE340	0.25
MJE350	0.80
MJE520	0.30
MJE2955K	0.90
OA47	0.06
OA90	0.04
OA91	0.04
OA200	0.07
OA202	0.07
OC28	1.00
OC29	0.80
OC35	1.00
OC45	0.50
OC71	0.30
OC72	0.50
OC200	1.80
OCP71	1.00
ORP12	1.00
ORP60	1.00
ORP61	1.00
R2008B	0.80
R2010B	0.80
SAS560	1.10
SAS570	1.10
SN76003N	1.40
SN76013N	1.40
SN76023N	1.40
SN76033N	1.50
SN76110N	0.70
SN76115	0.70
SN76226	0.90
SN76227	0.80
T2800D	0.52
TAG06-60	0.42
TAG521-200	0.72
TAG4443	0.76
TAG4444	0.76
TAA550	0.16
TBA120S	0.45
TBA395	0.60
TBA396	0.60
TBA520	0.75

TBA530	0.75
TBA540	0.75
TBA560	0.70
TBA800	0.35
TBA810S	0.60
TBA820	0.75
TBA920	0.80
TBA950	0.80
TBA990	0.80
TCA800	0.80
TCA940	0.85
TDA1170	0.90
TDA1412	0.60
TDA2002	0.80
TDA2003	1.50
TDA2020	1.40
TDA2030	1.40
TDA2522	0.80
TDA2530	0.80
TDA2532	0.75
TDA2540	0.70
TDA2560	0.70
TDA2593	0.80
TDA2690	0.70
TIP29	0.15
TIP29A	0.22
TIP29C	0.25
TIP30	0.16
TIP31A	0.24
TIP32	0.24
TIP32A	0.24
TIP33	0.50
TIP34	0.50
TIP41A	0.22
TIP41C	0.25
TIP42A	0.22
TIP42C	0.25
TIP47	0.40
TIP48	0.40
TIP49	0.40
TIP110	0.47
TIP112	0.54
TIP115	0.45
TIP117	0.56
TIP120	0.43
TIP121	0.46
TIP122	0.47
TIP125	0.47
TIP126	0.56
TIP127	0.56
TIP2955	0.34
TIP3054	0.38
TIP3055	0.34
TIS61	0.15
TIS90	0.15
TIS91	0.18
2N 2904	0.20
2N 2905	0.20
2N 2906	0.18
2N 2907	0.18
2N 2926	0.08
2N.3019	0.28
2N.3063	0.18
2N 3054	0.35
2N.3055	0.32
2N 3055H	0.38
2N 3440	0.58
2N 3442	0.85

2N.3771	0.85
2N.3772	0.90
2N.3773	1.00
2N.4031	0.25
2N.4036	0.25
2N.4037	0.25
2N.4443	0.76
2N 4444	0.76
2N 5061	0.20
2N 5294	0.30
2N 5296	0.30
2N 6106	0.40
2N 6107	0.40
2N 6109	0.40
3N 128	0.55
3N 143	0.65
IN 914	0.02
IN 4001	0.04
IN 4002	0.04
IN 4003	0.04
IN 4004	0.04
IN 4005	0.04
IN 4006	0.04
IN.4007	0.06
IN 4148	0.02
IN 5400	0.09
IN.5401	0.10
IN 5402	0.10
IN.5403	0.11
IN.5404	0.11
IN.5405	0.12
IN 5406	0.13
IN.5407	0.13
IN.5408	0.13
VOLTAGE REGULATORS	
7803	0.35
7812	0.35
7815	0.35
7818	0.35
7824	0.35
7905	0.35
7912	0.40
7915	0.40
7918	0.40
7924	0.40
78L05	0.28
78L12	0.28
78L15	0.28
74L18	0.28
74L24	0.35
LM309K	1.00
LM317K	2.20
LM317T	1.80
LM323K	4.20
LM723	0.32
78HGKC	5.70
78H05KC	5.20
78GU1C	1.90
79GU1C	2.15
79HGKC	6.70

JAPANESE TRANSISTORS	
2SA73	0.30
2SA104	0.32
2SA198	0.22
2SA203	0.30
2SA473	0.37
2SB54	0.25
2SB77	0.32
2SB337	1.20
2SB405	0.22
2SC460	0.21
2SC495	0.60
2SC733	0.40
2SC1161	1.10
2SC1172Y	1.50
2SC1279	0.24
2SC1306	1.00
2SC1307	1.00
2SC1520	0.25
2SC1969	1.30
2SC2029	1.20
2SC2078	1.20
2SC2122A	2.00
2SC2952	0.27
2SD234	0.37
2SK135	4.00
MB3712	1.50
TA7205	1.50
UPC575	1.00
ICS SOCKETS	
8 pin	0.06
14 pin	0.08
16 pin	0.09
18 pin	0.12
20 pin	0.14
22 pin	0.16
24 pin	0.18
28 pin	0.20
40 pin	0.25
VALVES	
DY87	0.53
DY802	0.45
ECC82	0.40
ECC83	0.43
ECC83	0.40
ECC85	0.40
ECH81	0.49
ECH84	0.52
ECL80	0.57
ECL82	0.25
ECL84	0.57
ECL85	0.57
ECL86	0.49
EF80	0.31
EF85	0.34
EF89	0.43
EF183	0.45
EF184	0.53
EL34	1.90
EY86	0.31
EY87	0.31
PC97	1.00

PCC85	0.42
PCF80	0.58
PCF200	1.35
PCF801	1.10
PCF802	0.57
PCF806	1.15
PCH200	1.00
PCL81	0.54
PL519	4.50
PCL82	0.63
PCL84	0.50
PCL85	0.55
PCL86	0.55
PCL805	0.55
PFL200	0.85
PL36	0.80
PL504	0.95
PL508	1.90
PY81	0.70
PY88	0.48
PY500A	1.60
ZENERS	
400MV BZY88 Range 2V7 to 39V0	060
13W Zeners BZX61 Range 2V7 to 39V0	120
MEMORIES	
2114	2.00
2716	3.00
2532	4.00
2732	4.00
2764	7.00
4116	0.75
6116	6.00
LM324	0.30
LM380	0.50
LM381	1.00
LM709 Oil	0.30
LM723	0.32
LM741 Oil	0.15
LM741 Met	0.45
LM3900	0.25
NE555	0.15
NE556	0.40
BYX55/350	0.30
BYX55/600	0.30
BYX55/600	0.30
BYX55/800	0.32
BYX70/500	0.29
BYX70/500	0.31
BYX70/800	0.36
BYX71/600	0.80

LED	
LED 3mm RED	0.05
LED 3mm YELLOW	0.10
LED 3mm GREEN	0.10
LED 5mm RED	0.05
LED 5mm YELLOW	0.10
LED 5mm GREEN	0.10
BRIDGE RECTIFIERS	
1A/50V	0.16
1A/100V	0.18
1A/200V	0.19
1A/400V	0.21
1A/600V	0.23
1A/800V	0.28
2A/100V	0.35
2A/200V	0.36
2A/400V	0.42
2A/600V	0.54
2A/800V	0.58
3A/200V	0.66
3A/400V	0.68
3A/600V	0.78
6A/200V	1.00
6A/400V	0.80
25A/100V	1.60
ELECTROLYTIC	
4700UF-16V CAN	0.20
TRIPLERS	
LP1195 (4000Ser)	2.25

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CIRCLE 74 FOR FURTHER DETAILS.

The printer routine waits for the RS232 line to indicate that the printer is ready for a character, waits for the STI u.a.r.t. to indicate that it is ready to be loaded and then writes the character into the UDR (u.a.r.t. data register). The routine is intentionally the last in MCOS so that any spare space in MCOS immediately follows it and is thus available for an expanded routine to suit your printer. A user printer routine must begin at address 0FECE and not extend beyond 0FEE6, giving 25 bytes in all. The routine must wait for a 'printer ready' indication and then send the contents of register A to the printer. For readers using a parallel printer, the parallel ports and the now unused RS232 handshake lines may be used for communication with the printer. Note that your routine must not alter any of the Z80 registers.

Once a working routine has been established by experimentation it should be stored in eprom permanently or, if programming facilities are not available, in a file called PRINTER.COM. To create PRINTER.COM, load at address 0100 (using the MCOS LOAD command) the hexadecimal series 21 0C 01 11 CE FE 01 xx 00 ED B0 C9, followed by your routine, setting xx to the number of bytes in your routine. Boot a disc and save this program using SAVE 1 PRINTER.COM. This is one case where it is quicker to write directly in hexadecimal, the program consisting of just five instructions and some data.

```
LD HL,0010CH   ;source address
LD DE,0FECEH   ;destination address
LD BC,000XXH   ;set transfer count
LDIR           ;transfer BC types
RET            ;return to SciDOS
data...
```

Data loaded into the c.r.t. controller after every soft or hard reset is stored at the 16 locations beginning at 0FFF0. The values are, in order, horizontal total*, horizontal displayed, horizontal-sync. position*, sync. widths, vertical total*, vertical adjust, vertical displayed, vertical sync. position*, control, vertical dots-per-character, cursor top, cursor bottom, start-address high and low byte and cursor-address high and low byte. The unit for horizontal values is characters; for vertical values it is character rows. Values marked with an asterisk represent the required value − 1 so the horizontal total is actually 128 (denary).

For the effect of altering some of the values you should make reference to the manufacturer's data sheet. Altering horizontal-sync. position acts as a horizontal shift control. Altering the upper four bits of sync. widths alters the length of the vertical sync. pulse. This will act as a vertical shift as well as correcting for any tendency for the top of the picture to slant or cramp.

Following the c.r.t. controller data table is a page used for interrupts, system parameters and system stack. Organisation of the page is shown in Table 2.

General points

The BEL output is pin 19 of IC_{205}. When Control G is sent to the v.d.u. a 100ms burst at approximately 1.2kHz is generated at that pin. Many programs generate BEL to signal that something requires your attention — usually an error. In SC84, BEL is used to indicate that the keyboard buffer is full and characters being typed are being ignored. In the various versions of EDIT, BEL indicates unrecognized commands. BEL is also generated, of course, by typing Control G in MCOS or SciDOS. A suitable sounder would be one of the piezo or crystal types generally available. If a low impedance sounder is used instead, the sounder must be coupled to IC_{205} through a 10μF capacitor.

Correct settings for S_{301-4} are off-off-on-on.

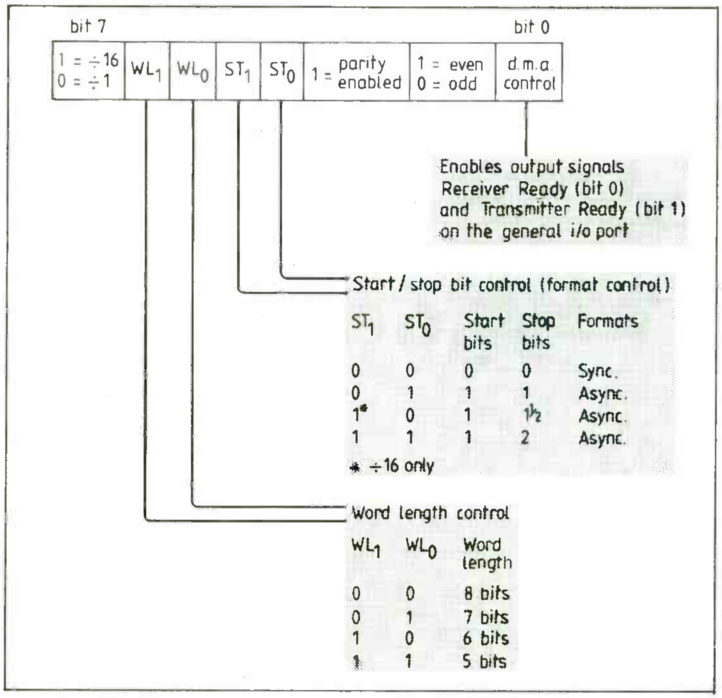


Fig. 1. UART control register bits are in the byte at memory location FA83. Being in ram, these bits may easily be altered.

Table 2. Interrupt, system parameter and stack organization.

0FF00-0FF1F	Interrupt address vector generated by STI (see p66, July issue).
0FF20-0FF3F	Reserved for future interrupt vectors.
0FF40-0FF4D	Holds system parameters. In particular the last four hold default drive allocations for drive codes A: to D: respectively. Swapping the contents of locations 0FF4A and 0FF4B swaps assignments of drives A and B. This might be done if drive A was faulty.
0FF4E-0FF5D	Keyboard buffer. SCIDOS has a 16-key type-ahead facility. Characters are stored here while awaiting processing.
0FF5E-0FF6D	Eight addresses written into the RST jumps on reset.
0FF6E-0FF77	Two IX data blocks used during booting of system discs.
0FF78-0FF79	Store of the last LISTed address in MCOS. Used during relists using the ALT command.
0FF7A-0FFA9	Heading for MCOS register-display routine.
0FFAA-0FFFF	Used for system stack operations and for storing the string of bytes used in MCOS FIND.

John's next project is a stand-alone eprom programmer with its own processor. It interfaces with SC84 and any microcomputer with an RS232 interface.

PAPAYA TV

With regard to the article "Television" reception with papaya tree antenna in the July 1984 issue: you might be interested to know that this is not the first time that the use of trees has been suggested for the reception of radio signals. In 1905, Major George O. Squier of the United States Signal Corps. conducted a series of such experiments between Alcatraz Island, San Francisco Bay and Fort Mason, a distance of about one and a half miles. Later, the Naval transmitter at Yerba Buena island was used, the signals being received at Fort Mason, a distance of over three miles.

His various experiments are reported in detail in the references 1 and 2 but, briefly, his transmitter consisted of an induction coil producing a 4in spark together with a vertical wire antenna, the frequency being about 3.27 MHz. The receiver was a carbon-granule coherer used in conjunction with a battery and a telephone. One side of the receiving circuit was connected to a nail hammered into the tree trunk at some suitable height, the other side being connected to the tree at earth level. The leads were all carefully screened to ensure that it was indeed the tree which was acting as the receiving antenna, not the connecting wires. He found that as long as the upper and lower connections were greater than about three feet apart, signals were received. As the height from the ground of the upper connection was increased the signal strength also improved up to the point where the branches diverged, after which no increase was found. It was also discovered that an equally effective upper contact could be made by putting the nail into the smaller twigs of the tree, or even by simply pressing the wire against leaves or flowers.

The initial experiments used eucalyptus trees, but a more extensive set of trials reported success with willow, pine, spruce, oak and others. Not surprisingly, a dry, unhealthy tree was found to be less effective than a strong sappy specimen. In the course of his measurements, he also made some observations on the naturally occurring e.m.f.'s generated in trees, and noted some interesting correlations with the periods of sunrise and sunset.

Another experimenter, J.M. Blake, reported success in receiving signals at a distance of 80 miles using an elm tree as the antenna[3].

The comment of the Editor of the 'Electrician'[4] is of some interest:

'If, as the writer of the report contends, every living tree acts as an aerial absorbing Hertzian waves in its path, a forest would have great influence in impeding, if not in staying altogether, the transmission of signals over its surface, more especially in an untuned system, but on the other hand we believe that the majority of workers have found that the action of vegetation has been to improve conditions'.

V.J. Phillips
University College of Swansea
University of Wales

References
1. *Electrical World and Engineer* V45, p90. Jan 14, 1905.
2. *Electrician* V54, pp836-9, March 10, 1905.
3. *Electrical World and Engineer*, V45, pp307-8, February 11, 1905
4. *Electrician* V54, p822, March 10, 1905.

We were delighted to read of the success in using papaya trees as tv antennas, the results confirming our own experiments with indoor plants as a replacement for set-tops.

There are however one or two snags, notably the need to prune daily for optimum reception above 800 MHz, and the dangers of working without safety capacitors. Experiments with rubber plants are looking encouraging since these will, we believe, meet the relevant BS5373.

A N V Pedersen
Marketing Director
Communications Division
Antiference

Readers may be interested in my own experiments using organic antennas.

We have a 100ft oak which produces considerable gain at 1.3 Ghz compared to a wet Players No 6 — a pity it's deciduous. Nevertheless we have managed to solve the beam-steering problem by uprooting the tree and immersing it in a million-gallon pool.

The rotation problem caused us a lot of headaches but, in this no-expense spared project, we finally (and inevitably) succeeded by using a much-modified fairground 'big wheel'.

Winds above about 10 mile/h force us to guy the whole system rigid. However we are presently obtaining quotes for a full Dacron-covered radome which, when installed, will allow the beam to be moved even in 100 mile/h winds.

The easiest means of matching the leaf/tree configuration turned out to be trimming the roots.

I.J. Dilworth
Capel St Mary
Suffolk

MARITIME MOBILE AND SOLAS

Surely it is time that something was done about the British Amateur Maritime Mobile Licence. After many years of paying between three and four times the normal amateur licence fee to hold both my normal amateur licence and my maritime mobile licence, the last straw came from the Home Office in October 1982 when I was sailing on SS Oriana as 1st Radio Officer. A group of American radio amateurs were given written permission by the Home Office to operate from SS Oriana, a British ship, using their American licences. Apparently permission had originally been granted by the Home Office for American amateurs to operate with their American Licences from MV Island Princess, also a British ship, in 1980. It may be possible to imagine my annoyance at this situation when I, as a British radio amateur and a Radio Officer employed by the company which owns both of these ships, had to go through all the procedure of letters of permission, forms filled in, DTI inspection arranged and passed and an extra licence fee of approximately three times the normal fee paid, to obtain my maritime mobile call.

Surely there can be no more worthy reason for an amateur Radio Station than when it is used on board ship where it can be used as a 'Safety of Life At Sea' back-up for the ship's main radio installation. In all of the ships I have sailed in, which include two of the world's largest passenger vessels, each carrying more than 2,500 souls, all the radio equipment is installed in one radio office. Should this radio office be put out of action by fire, collision, flood etc., the vessel would lose all of its long range communication facilities. Apart from the radio office there is the bridge v.h.f. but its 40-50 mile range would not be of much use in the middle of the South Pacific. Passenger vessels also have one or two lifeboats fitted with radio but usually it is impossible to raise the masts and rig the aerial when the boat is in the stowed position.

An amateur radio station set up away from the Radio Office and with its own aerial could be an invaluable back up on any ship. As most modern amateur transceivers will operate from 12V d.c. the station could also be easily made independent of the ships mains in an emergency. For these reasons one would think that amateur radio at sea would be actively encouraged but in fact quite the reverse is true. The small handful of British /MM licences in existence bears witness to the tortuous path of red tape and heavy expense that has to be trodden by the intending seagoing radio amateur. Incidentally, while I was on Oriana, my annual /MM licence fee was approximately three times as much as the normal ship's radio station licence fee even though the ship's station included some £100,000 worth of equipment and had six R/Os to man it.

Surely a simple letter of permission from the Master of the vessel would suffice without any extra licence or fee being necessary. Most radio amateurs with /MM licences are also the ship's Radio Officer; however, when this is not the case, perhaps there should be a ruling that the amateur installation be checked by the ship's R/O to ensure that no serious interference to the ship's normal radio communications was caused.

Maybe it would be easier if I applied to the FCC for an American amateur licence, which would allow me to operate on British ships.

Paul Barry
CRO MV Sea Princess
EX G3RJS
EX G3JS/MM

COMBINATION LOCK

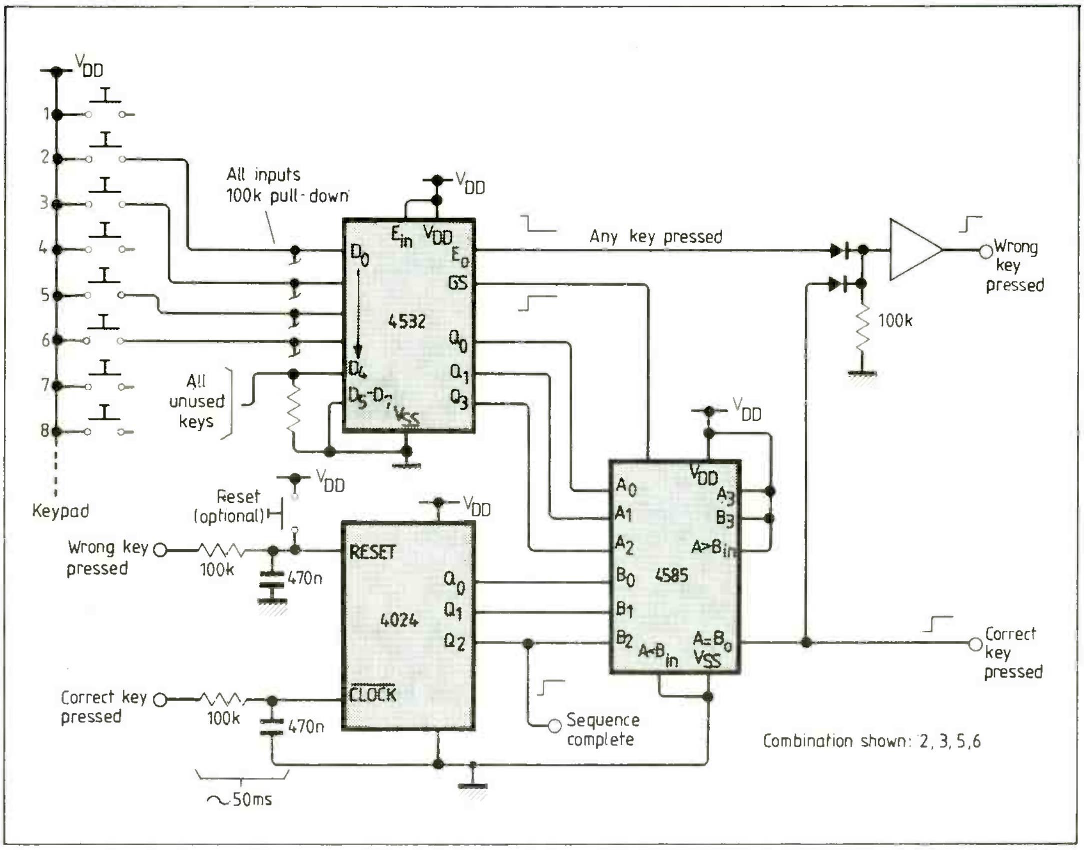
Referring to the combination lock with deterrent in May Circuit Ideas, the techniques used in the enclosed simplified circuit may be of interest.

As shown, the 4532 priority encoder generates a binary output code and true and inverted 'and key pressed' signals when any key is pressed. The 4024 counter is incremented each time the next key in the 0,1,2.. sequence is pressed and released. The counter is reset if an incorrect key is pressed, the key 4585 comparator A=B output is used to provide the 'correct key pressed' signal which increments the counter.

For the original application, a sequence length of four was required, so that the output from the third stage of the counter, Q_2, was used as the 'sequence complete' output. However, other sequence lengths may be generated by decoding the appropriate counter state.

The circuit may readily be modified, and may be extended to any length of sequence. As shown, the maximum sequence length is eight.

D. Protheroe,
Forest Hill
London



BEHIND THE MICRO

Ronald G. Young's letter (*WW*, Letters, March 1984) prompts me as both microcomputer owner and technical writer to relate my own experiences with my system, and at the same time say a word in defence of my profession.

I don't really believe that the literature is deliberately written to discourage experiment. Firstly, it is often difficult to get informed (sensible) answers to enquiries in many shops, particularly when the salesman gets the feeling that you are not reaching for your chequebook. Secondly it is very probable that the writers, due to the non-availability of hard/software, and under pressure of time and/or cost perhaps, have neither been able to obtain reliable information nor to try things out for themselves, and therefore do not include doubtful information — if in doubt, leave it out. It is often difficult to get preliminary information on a product at all, even when you are writing the handbooks for the manufacturer himself.

The compatibility question raised by Mr Young does not stop at asking 'will I get a cloud of smoke': the answer to this is — probably not. No, the compatibility question is far more subtle, and extends through the hardware, and the firmware, through the operating system and often deep into the software. A more appropriate question is — will you get the expected or desired result, when you connect various units and run the software?

I took delivery of my microcomputer system just over one year ago, and am still trying to solve certain totally unexpected (in) compatibility problems, one involving the printer and the word processing programs I use (both programs — I can't blame the software, nor the hardware, directly), the other involving strange software interactions with the multi-user operating system. The printer prints, the micro works fine, as does the terminal, but... when they are all connected together and the software is loaded, I occasionally get some very odd and unexpected results.

Before I ordered my system I spent two years (!) studying microcomputer literature, and had very clear ideas of what I wanted. I visited (pestered?) many dealers to obtain information, and rapidly gained the impression that I knew more about micros than many of the salesmen, who just seemed interested in a quick sale, and rapidly lost interest when I presented them with my requirement which did not correspond with one of their 'off-the-peg' systems. I followed the advice to choose my software first, and then choose suitable hardware to run it on. Even so, I still have problems with incompatibility, partly because I was not able to try out the complete system with the software for a few months before I bought it, partly because I didn't become my own expert soon enough, and partly because the hardware did'nt quite work as expected.

Of course you CAN join together gadgets from six different manufacturers; that's what the interface outlets are for, but even if they are fully compatible in practice or on paper, the results may still be extremely unpredictable. (For example, one of the problems with my system lay neither in the computer nor in the printer, but in an 'incompatible' RS-232C connecting cable between the two!.)

I sympathize with Mr Young, and others who are bewildered by the relatively young art of microcomputing. The lack of standards in microcomputer interfacing is lamentable, and leaves the would-be purchaser in a dilemma far worse than that of building up his own 'personalized' high fidelity system. At least here most items are standardized, more or less...

My advice is to read as many test reports as possible, and compare different opinions, particularly with software, but also hardware. If possible, try out things for yourself (difficult, when the label say 'Customers are requested not to touch..'), and don't rely on the manufacturer's statement that the product is compatible. Some 'gadgets' are more compatible than others.

F.J. Deall
Karlstad
Sweden

TV CAMERAS

After reading Pat Hawker's sad news (June, 1984) about the way we have lost our lead in the field of automated tv cameras, I cannot help wondering whether our national broadcasting organisation has done all it might to help British manufacturers in one way or another.

For many years now I have been accompanying parties of final-year degree students on conducted tours of the Television Centre at White City, but I have never seen a Marconi Mark VIII in use there, or its even more sophisticated successor. A further surprise for me on my most recent visit was in the News studio, where the pre-automatic British cameras have now been replaced by German equipment.

I know that it is not the function of the BBC to act as a shop-window for British manufacturers, and I know that they claim to always buy the most suitable apparatus for the job regardless of its origin. Surely, however, they have some obligations in this respect by virtue of their high international profile, which makes a visit to White City a 'must' for all visitors from foreign broadcasting organizations. What is so special about the News studio that its requirements could not have been met by either of the two home manufacturers? The great publicity boost of having Fernseh cameras on display at our most prestigious television complex is all the more regrettable when one remembers the notorious chauvinism and penetration-difficulty of the German broadcasting market.

I have not been to Washington for many years. Maybe the British Ambassador is now using a Mercedes. (Or is it a Datsun?)

E.J.Stocks,
Senior Lecturer,
Polytechnic of North London

ROOTS OF RELATIVITY

Four letters referring to Special Relativity theory appeared in the July issue of *Wireless World*. Three of these admit or imply that serious imperfections exist in the theory, while the fourth is neutral. Equally interesting is the spectrum of attitudes of the four contributors.

C.B.V. Francksen of Farnborough provides an excellently balanced and informative review of the status of Einstein's second postulate (that the velocity of light is the same for all observers despite their mutual relative motions), and the logical difficulties that the postulate failed to overcome concerning media for electromagnetic wave propagation, that is, "aethers". He points out correctly that "Einstein raised his 1905 paper in an attempt to show that we can have as many aethers as we like"; this is the opposite of the popular legend that Einstein "abolished" the luminiferous aether. (He just refused to mention it). Not least of Mr Francksen's virtues is that he advocates *practical experimental tests* in five areas of fundamental concern, which he identifies. The sting of his letter lies at its tail.

G.Blondeau of Ottawa affirms that Special Relativity as a theory is incomplete, and that "since it is basically a correction to classical electrodynamics" it does not have a microbasis. He than warms my heart further by concentrating on *physics* rather than mathematics or mythology, and asks six questions in physics to which the theory, if it is a physical theory, ought to be able to provide answers. Many of us will no doubt be watching in amused anticipation to see whether any Relativist will try to answer those questions, and how credible his answers will be.

J.G.D.Pratt of Leatherhead takes the soft line that we ought not to expect much from our fundamental theories anyway: "their truth cannot be inferred from other theories and facts". But he goes on to say (with Sir Karl Popper) that a fundamental theory nust be refutable by established facts. The idea is that what distinguishes a scientific theory from a faith or dogma is that it can be *disproved*.

Mr Pratt then goes on to say that "It is not a valid objection to a fundamental theory to say that it embraces a concept which clashes with your old preconceived ideas, or that it cannot be derived from something else". I'm sure every scientist will agree with that. Fortunately, many students of physics won't accept that Special Relativity can contain gross logical inconsistencies within itself and still be valid as a theory in physics. If some person says to me, "Black is the opposite of white, while at the same time black is the same as white", I will believe that person to be mistaken; my own ideas, whether preconceived or otherwise, don't enter into that argument. A group of propositions ("theory") may carry the seeds of its own disproof. If it does it should not survive.

E.R.R.Holmberg of Barnes finds my articles embarrassing; I'm sorry about that, because I have no wish to give anybody offence. But I am, unashamedly, trying to wake people up and encourage them to think with their heads. Any conscientious Natural Philosopher nowadays *ought* to be embarrassed by the abysmal situation that fundamental physics has been allowed to get into, partly through negligence and partly through unprotested intellectual dishonesty. "It is true that there are serious imperfections in both Relativity and Quantum Mechanics" admits Dr Holmberg, "and if Dr Murray confined himself to explaining tham to your readers one could not object". Perhaps he would care to join me in listing, for your readers, a few more of the logical crimes that these theories continue to perpetrate so glaringly? My surveys have not been exhaustive!

I think Dr Holmberg summarizes the difference in our attitude most aptly when he says, by way of throwaway, "...but then common sense has never been of much help in theoretical physics". That is probably true of the mathematically-dominated physics which has grown up since 1905, when the mystical rot set in, but would Sir Isaac Newton, Dr Holmberg's hero (and mine), have accepted it as criticism of his approach? I hold that the self-disciplines of common sense and logic *do* count, and that nobody has ever proved the contrary; hence I can manage without quarks, tachyons, virtual photons, time that runs backwards, black holes, and multiple parallel universes. Flights of fancy of that kind, when they are trotted out seriously in public as the latest "discoveries" that our theoretical physics has to offer, are what embarrass *me*.

W A S Murray
Kippford
Galloway

ROOTS OF RELATIVITY

NO, Dr Murray (May, 1984) is wrong. AM′ is not equal to BM′. Dr Murray forgets that the coordinates of distant events are not directly observed but are based on mathematical reference. He also, unfortunately, presents the problem in a way which suggests an a priori causal connection between events A and B where there is none. The only link between them is the *a posteriori* observation of the simultaneous arrival of their signals at M and M′ when both observators lie precisely midway between the milestones struck by the lightning flashes. There is no contradiction here.

If M registers the events at ±X and their signals reach him at t=0 then, according to the Lorentz transformation, M′ places them at

$$x'_A = -X\sqrt{\frac{c-v}{c+v}}.\ t_A = -\frac{x}{c}\sqrt{\frac{c-v}{c+v}}$$

$$x'_B = X\sqrt{\frac{c+v}{c-v}}.\ t_B = -\frac{x}{c}\sqrt{\frac{c+v}{c-v}}$$

from where their signals reach him simultaneously at t′=0. Meanwhile milestone A is moving away from M′ at speed v and milestone B towards him at the same speed, so that at t′=0 the positions of the milestones are

$$S'_A = -X\sqrt{\frac{c-v}{c+v}} - \frac{vx}{c}\sqrt{\frac{c-v}{c+v}}$$

$$= -X\sqrt{1-\frac{v^2}{c^2}}$$

$$S'_B = X\sqrt{\frac{c+v}{c-v}} - \frac{vx}{c}\sqrt{\frac{c+v}{c-v}}$$

$$= X\sqrt{1-\frac{v^2}{c^2}}$$

N.B.Taylor
Camberley
Surrey

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CIRCLE 78 FOR FURTHER DETAILS.

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Merlin Way, Bowerhill, Melksham,
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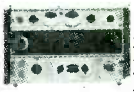

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TF2002. As above but AM only. **£450**
MARCONI TF1066B. AM/FM Generator. 10-470MHz. 0.2uV-200mV output. FM Deviation up to ±100kHz.
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CENTRIFUGAL BLOWERS 'TORIN' part no 2448. Extremely powerful blowers with outlet dimensions of 6×7". Actual cfm not known but would be suited to office/factory air extraction/ventilation etc. Little used condition..**£35**+vat. Carr £4.

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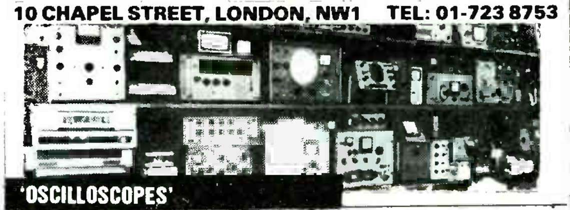

'OSCILLOSCOPES'

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HEWLETT—PACKARD 1707A dual trace 75MHz £750
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TELEQUIPMENT S61 — see display below
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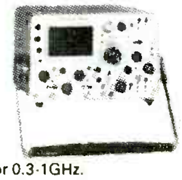
★★ TEST EQUIPMENT ★★



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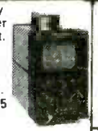
TELEQUIPMENT D61 SCOPES



A bulk purchase of these quality oscilloscopes enables us to offer them for sale for just £100 +vat. Specification as follows. Bandwidth DC-5MHz Sensitivity 5mV/div. Sweep speeds from 500ms/div to 1us. 8×10cm CRT. External X & Z-mod inputs. £115 inc vat & inc handbook Zerox.(Carriage £10)

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PLEASE NOTE. All the pre-owned equipment shown has been carefully tested in our workshop and reconditioned where necessary. It is sold in first-class operational condition and most items carry a three months' guarantee. For our mail order customers we have a money-back scheme. Repairs and servicing to all equipment at very reasonable rates. PLEASE ADD 15% VAT TO ALL PRICES. EQUIPMENT WANTED. PLEASE WRITE OR PHONE.

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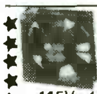

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CIRCLE 46 FOR FURTHER DETAILS.

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PERTEC Model PCC2000 COMPUTER/WORD PROCESSING SYSTEM. Comprising. 64kbyte 8085 based processor with green 24 × 80 display, detached keyboard with numeric & function keypads, twin 8" double or single density floppy disc drives (IBM compatible), RS232 & Centronics interfaces, NEC Model 5500 Spinwriter (55cps daisy wheel printer). Software included in the price — CP/M, WORDSTAR, BASIC, DATASTAR etc. BRAND NEW **£1,100.00**
DICOLL LSI11 SYSTEM comprising, processor with 64bytes, BA11 backplane & PSU (DEC manufactured), DLV11J quad serial interface, dual PERTEC double density floppy disc drives. Contained in compact, attractive portable box. Software includes RT-11 & many interesting bits & pieces **£750.00**
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TRANSAM 'TUSCAN' S100 MICROCOMPUTER Z80 based machine with 64kbytes of static RAM, twin 5¼" floppy disc drives, NEC green phosphor monitor, RS232 & 8 bit parallel interfaces. S100 software includes CP/M etc. **£750.00**
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CBM Model 8027 daisy wheel printer (Olympia 'Scripta') for PET. 25cps, IEEE interface. BRAND NEW **£250.00**
CBM Model 8024 high speed matrix printer (Tally 1200) for PET. IEEE interface. BRAND NEW **£250.00**
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CENTRONICS Model 702 matrix printer. 132col. 165cps. bidirectional printing with self test. In good ex-demo condition **£225.00**
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DEC boxes & power supplies. Various models available (BA11MF, SB11AA, BA11LX) all with 22 bit addressing or easily modified & with various optional processors etc. .... **P.O.A.**
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Please note: • VAT & Carriage extra on all items • Visitors by appointment, please. • Technical manuals are available from us for many items stocked.

CIRCLE 67 FOR FURTHER DETAILS.

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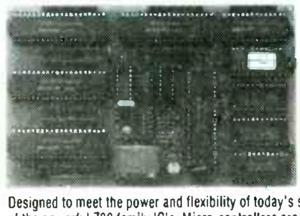
CIRCLE 39 FOR FURTHER DETAILS.

Z80A MICRO-CONTROLLERS



- 4MHz Z80A CPU
- 4K EPROM — 2K supplied with MCV2.0
- 4K Battery backed RAM — 2K supplied
- 4 × Z80A PIO's (64 I/O lines)
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- Standard 100mm × 160mm Eurocard
- Cost effective prices (£94.04-10 off) includes all connectors, manual etc.

Designed to meet the power and flexibility of today's stand — alone micro-controllers, the GNC CUB makes full use of the powerful Z80 family IC's. Micro-controllers are available with up to 64K RAM, 8K EPRDM, RS232 etc. Manuals include circuit diagrams and assembly language listings. No ULA's, PAL's or other funnies.
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PRICES

CUB (built & tested)	£103.44
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Please add £1.00 for P&P plus V.A.T.

GNC ELECTRONICS
Little Lodge, Hopton Road,
Thelnetham, Diss, Norfolk. IP22 1JN.
Tel; Diss (0379) 898313.

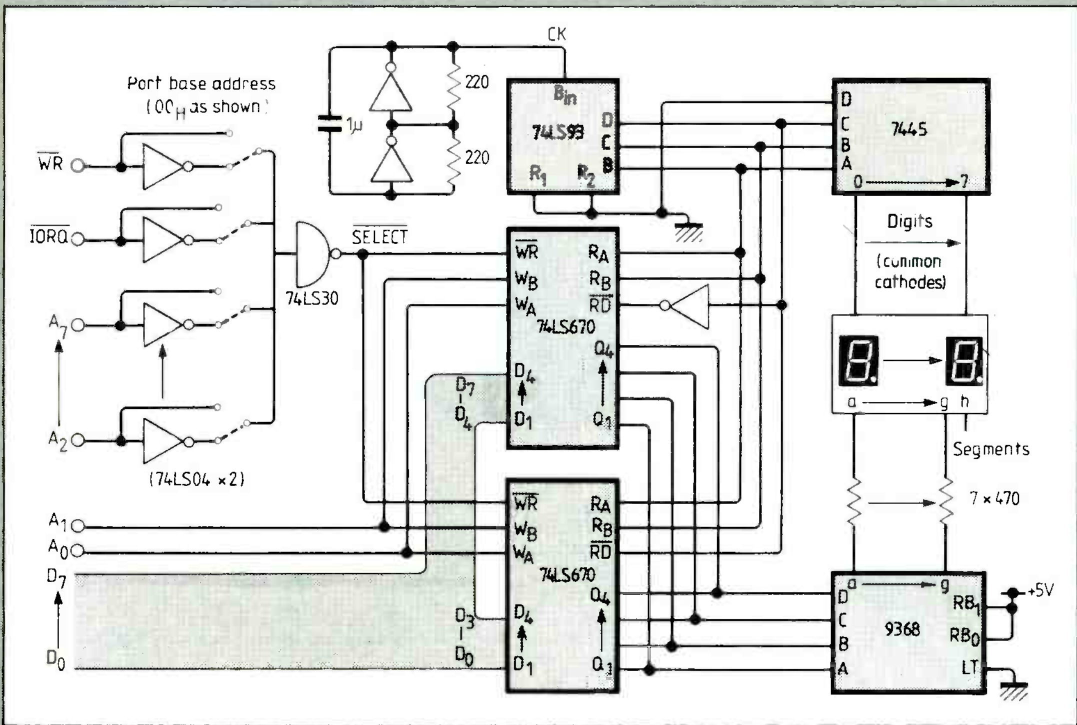
CIRCLE 21 FOR FURTHER DETAILS.

8-digit hexadecimal display for Z80

Occupying only four Z80-microprocessor output ports, this eight-digit hexadecimal display allows a microcomputer to be operated without a v.d.u. and requires only simple driving software. It is especially useful for displaying register contents, addresses and data when using machine code.

Links shown set the display's base address. A data byte written into one of the four ports used is stored and displayed as a pair of hexadecimal digits. If only decimal digits are needed, a 74LS48 can be used in place of the 9368 (but with pin three high). The beauty of 74LS670 four-by-four registers is that data can be written in one side as four eight-bit numbers and read at the other side as eight four-bit numbers.

J.C.W.Newell
Oxford University



Microprocessor failure detector

I originally designed this reset and 'watchdog' timer for use in a basic 6502/6532 design, but it may be applied to any microprocessor control system where processor failure must be detected before damage to the controlled load can occur. Built from cheap components, it provides a defined reset period at power up and monitors processor activity after reset.

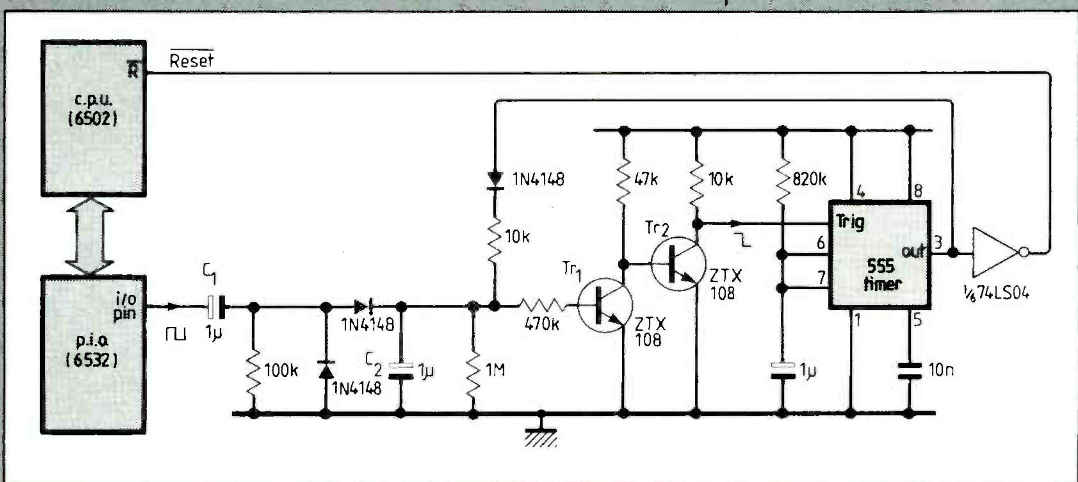
When power is applied, C_2 is discharged so Tr_1 is off and Tr_2 on. This pulls the 555 trigger input low and starts the reset timer. Timer output being high charges C_2 through the diode and keeps it charged until the end of reset, when C_2 starts to discharge, and the processor is released from the reset state. As long as the processor operates within software control the i/o pin continues to change state, keeping C_2 charged through C_1, and the processor reset input remains high.

If a supply transient or interference causes the system to lose control, the i/o pin may stick in either the low or high state. Now, C_2 discharges and the 555 issues another reset pulse. If the system does not respond to reset, the circuit becomes astable and issues a string of pulses. Software to drive the i/o pin is simple.

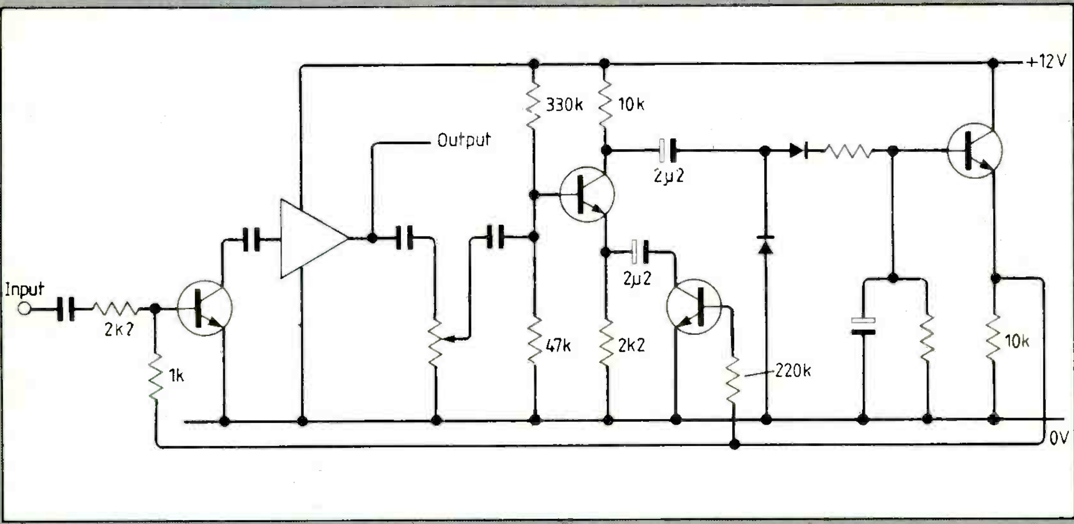
```
.TOGGLE LDA PORT
        EOR£ %00000001
        STA PORT
        RTS
```

Output of the 555 may be used to switch a clamp transistor on the system output to provide an inhibit during reset.

P.D.Hutchings
Devizes
Wiltshire



DON'T WASTE GOOD IDEAS
We prefer circuit ideas with neat drawings and widely-spaced typescripts, but we would rather have scribbles on 'the back of an envelope' than let good ideas be wasted. Submissions are judged on originality or usefulness — not excluding imaginative modifications to existing circuits so these points should be brought to the fore, preferably in the first sentence. Minimum payment of £30 is made for published circuits, normally early in the month following publication.



Audio a.g.c.

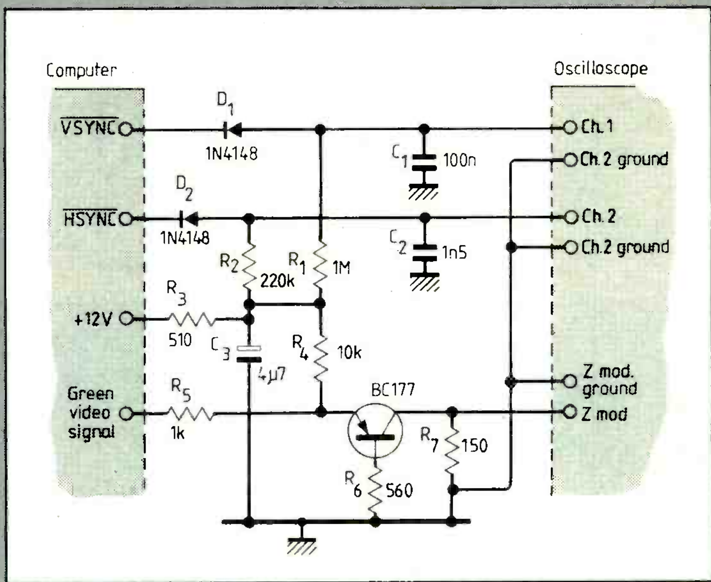
Output of most automatic gain-control circuits using the shunt configuration rises with input to a certain extent. With this circuit, by applying positive feedback, I have obtained a <1dB change in output over a >20dB change in input. The system eventually runs out of steam but it provided me with over 26dB of a.g.c. range and the subsequent linear rise in output with input was also useful. Time constants should be tailored to suit your needs.

K. Wong
London

Oscilloscope as video monitor

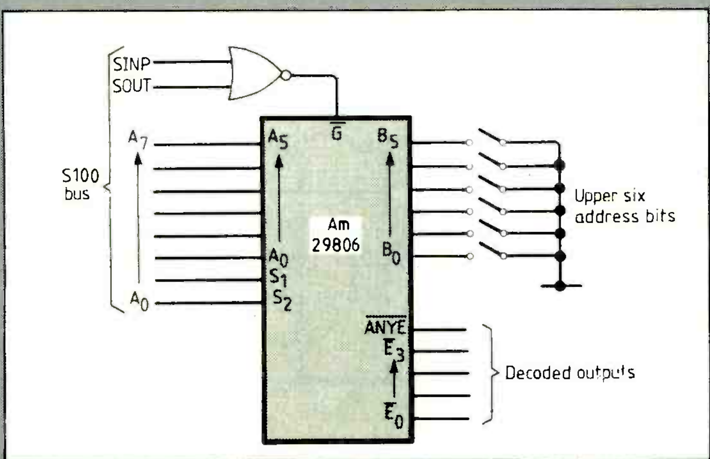
Designed to display video from a computer on an oscilloscope, this simple interface produces a sharp picture provided that all probes are grounded on the interface and all lines are well shielded. Diode D_1, R_1 and C_1 change VSYNC pulses to a vertical ramp for driving channel one of the oscilloscope and D_2, R_2 and C_2 do the same with horizontal sync. pulses for channel two. The green signal of RGB output is limited and buffered by the transistor and fed to the oscilloscope Z modulation input. I made and tested this circuit using a Casio FP1100 microcomputer and Hameg 412 oscilloscope.

Vafa Ghaffarian
Tehran
Iran



Artificial daylight

In this idea on page 51 of the July issue, the unmarked fet source resistor is 1kΩ and R_2 is 2W.

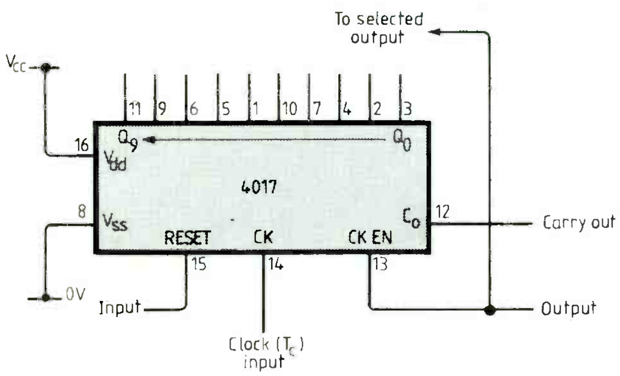


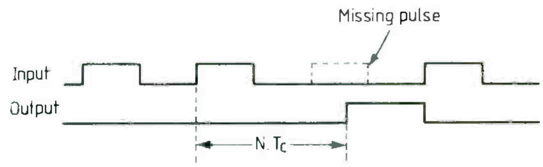
I/O port decoder for S100 microcomputers

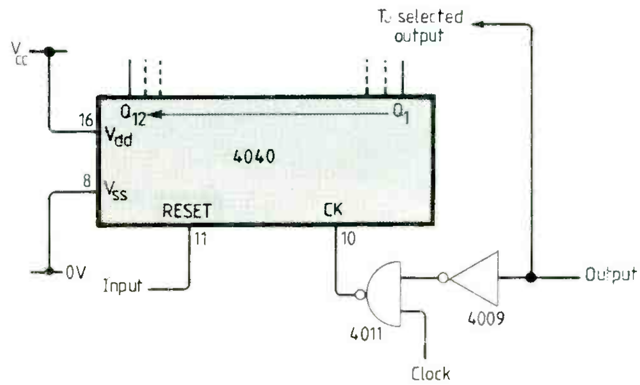
In S100/IEEE696 systems, i/o port decoding is usually done by 74LS85 comparators or random logic. This circuit minimizes components by using an AMD 29806 chip-select decoder, which is intended for Multibus use but is suitable for many other applications.

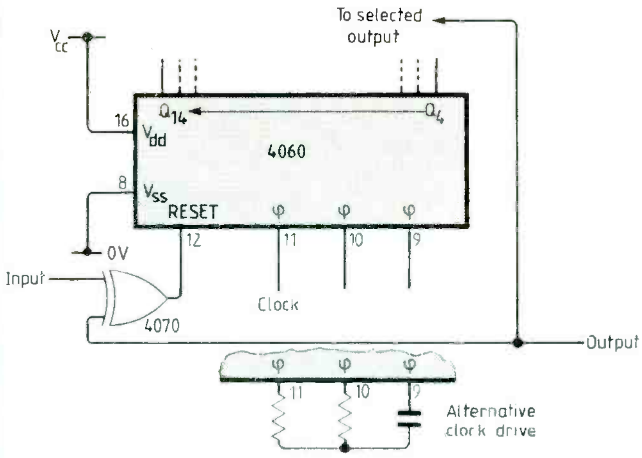
To decode a block of four contiguous i/o ports, address-bus lines $A_{2\text{-}7}$ are connected to comparator A inputs, and lines $A_{0,1}$ to the select inputs. Switches connected to the comparator B inputs set the code for the upper six address bits; pull-up resistors are included in the i.c. When the upper six address lines coincide with the switch settings and a SINP or SOUT signal is received, the lowest two address bits are decoded to select one of four active-low outputs ($\overline{E_{0\text{-}3}}$). An 'any-enable' output ($\overline{ANYE}$) is also available.

J. MacMillan
University of Leeds









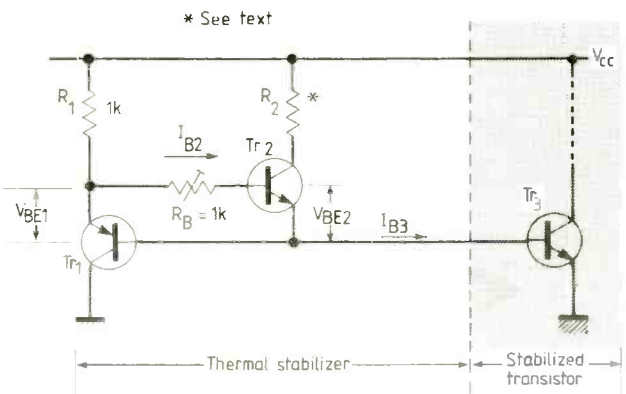
Digital missing-pulse detector

A digitally timed missing-pulse detector requiring one active device is shown. While input is high, the 4017 is reset. When input goes low, counting commences until one of the outputs goes high, inhibiting the clock. The number of clock pulses in the time-out period is selected by connecting the clock-enable line to the appropriate output.

In the timing diagram $N.T_c$ represents the time-out period, where N is the count length and T_c the period of the input clock. Since the input and the clock are not synchronized, a one clock period uncertainty exists in the time-out period. This can be reduced by increasing the count length and clock frequency. Further 4017 counters can be cascaded to achieve this, using the carry output as the clock input to subsequent counters. Alternatively a 4040 counter may be used but external clock gating is required.

The second variation uses a 4060 counter whose output is a pulse recurring with a period equal to the time-out period. This device has gate outputs suitable for a crystal oscillator but since these are gated by the reset line, the time-out period is affected by the crystal start-up time. The alternative CR oscillator shown does not have this limitation.

L.D.Thomas
Nuneaton
Warwickshire



Thermal stabilizer

Unlike some other circuits, this stabilizer for high-power transistor amplifiers has no instability. To stabilize Tr_3 with temperature, I_{B3} must be held constant. For this circuit,

$$I_{C1} > I_{C2}$$

so

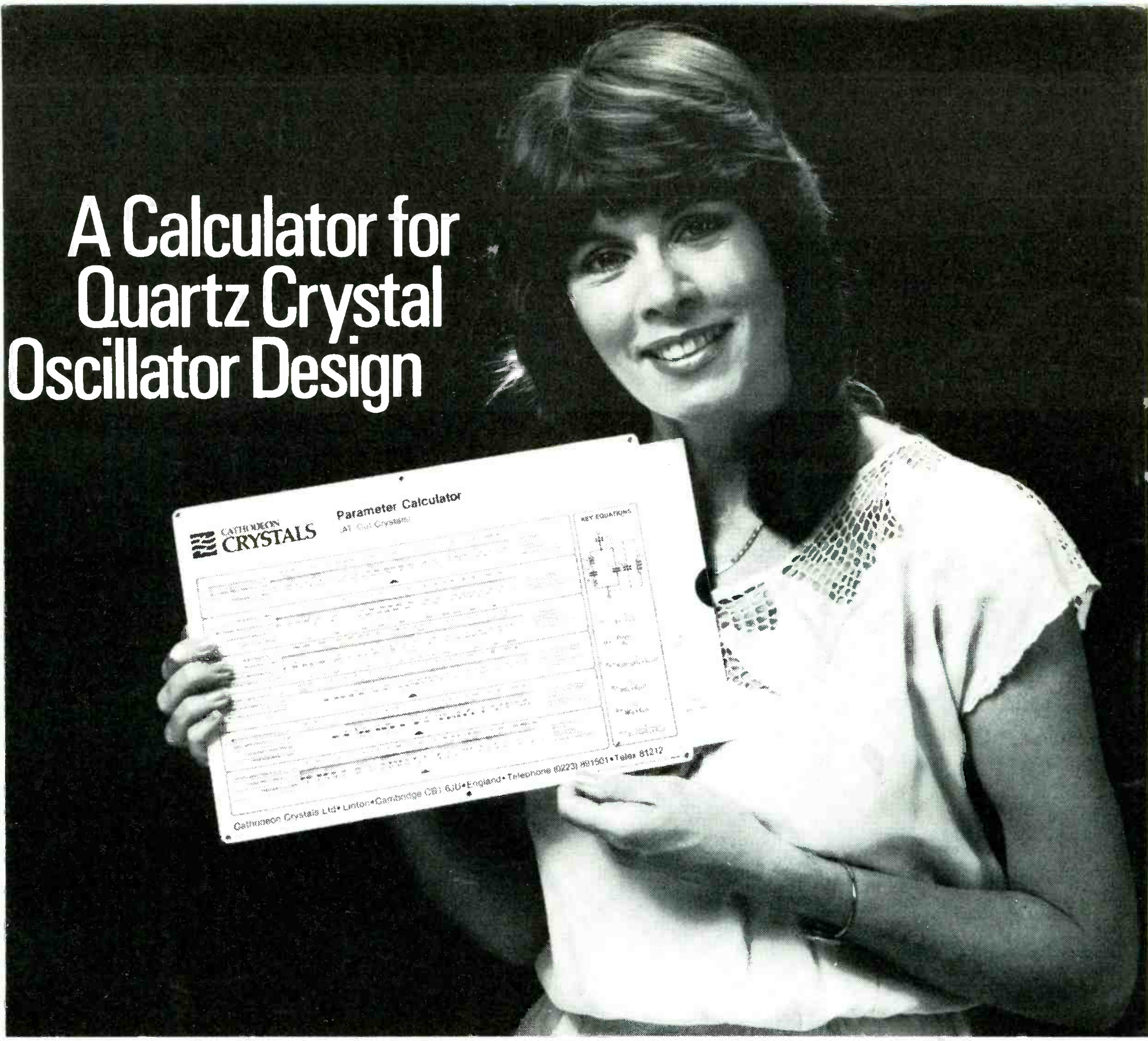
$$I_{B2} = (V_{BE1} - V_{BE2})/R_B$$

Since both V_{BE1} and V_{BE2} decrease as temperature increases, I_{B2} and hence I_{B3} remain constant. The collector/base junction of Tr_1 also provides some diode compensation for Tr_3.

Quiescent current through Tr_3 is set by R_3 and R_2 reduces dissipation in Tr_2 with high values of V_{cc}. Transistors $Tr_{1,2}$ are flat-pack types such as the TIP32 and TIP32. By adjusting the mica washer under TR_2 it is possible to decrease I_{C3} as temperature increases.

L.V.Gibbs
Lower Hutt
New Zealand

A Calculator for Quartz Crystal Oscillator Design



A crystal has only got two legs so it must be simple. Just how wrong can you be! Let's take Motional Capacitance for example. The Motional Capacitance of the Nth order mode can be calculated from the crystal admittance:

$$Y_N = \frac{4b\ell i\omega\varepsilon_{22}}{2h}\,(1+\hat{k}^2_{26}) + \frac{4i\omega\varepsilon_{22}.4\hat{k}^2_{26}\,\mathrm{Sin}^2\,\bar{\xi}_{N\gamma}\,\ell\,\mathrm{Sin}^2\,\bar{\nu}_{N\varepsilon}\,b}{[(\omega^2_{N\gamma\varepsilon}/\omega^2)-1]\,N^2\pi^2\bar{\xi}^2_{N\varepsilon}\bar{\nu}^2_{N\varepsilon}L_{N\gamma\varepsilon}h}$$

After a little interesting manipulation, this reduces to:

$$C_N = 16\varepsilon_{22}\,\hat{k}^2_{26}\,\mathrm{Sin}^2\,\bar{\xi}_{N\gamma}\,\ell\,\mathrm{Sin}^2\,\bar{\nu}_{N\varepsilon}\,b/N^2\pi^2\,\bar{\xi}^2_{N\gamma}\,\bar{\nu}^2_{N\varepsilon}\,L_{N\gamma\varepsilon}\,h$$

This fun equation can then be evaluated for C_1. Similiar procedures are required for the other components of the equivalent circuit.

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CIRCLE 80 FOR FURTHER DETAILS.

Telemetry decoder for Oscar-10

by J. R. Miller, B.Sc.

Connect this decoder to a home computer and an amateur-band receiver and you can monitor data and messages from Amsat's latest spacecraft. Suitable for any computer with an RS232-compatible port.

Oscar-10 is the latest transponding satellite for radio amateurs. It was launched by Ariane rocket on 16 June 1983. Its period is just under 12 hours and its orbit very elliptical (e=0.6); this makes it appear quasi-stationary. Much of the time its range exceeds 35 000km which means nearly a hemisphere is within its view, and for many hours on end. The satellite enables amateurs with modest equipment to communicate at some time or other with stations almost anywhere on the planet[1].

Oscar-10 carries two linear transponders, at u.h.f. and in L-band. Mode U accepts 70cm uplink signals and has a 2m downlink; mode L is 23cm up and 70cm down.

Associated with each mode are two alternative telemetry transmissions: from a general beacon (GB) or an engineering beacon (EB). Of these the 145.810MHz general beacon is used predominantly, and will be a familiar sound to most users of the two-metre amateur band. The other frequencies are 145.987MHz (EB), 436.04MHz (GB) and 436.02MHz (EB).

Transmissions are continuous: on the hour and half-hour UTC there is a five-minute morse code bulletin, followed by 25 minutes of p.s.k. telemetry. At the time of writing two spells of 50 baud r.t.t.y. are proposed, five minutes each on the odd quarters of the hour.

Telemetry from Oscar-10 is transmitted in 512-byte blocks, preceded by a four-byte synchronisation code (hex 39 15 ED 30) and followed by a two-byte cyclic redundancy check (c.r.c.c) and then a run of about 200 padding bytes (hex 50). A byte comprises 8 bits and is transmitted serially, most significant bit first, at a rate of 400 bit/s. So a new block is sent every 14.3s and lasts for 10.3s. The interval before the next block can be used for computer processing of the telemetry.

There are several different kinds of block, but Q, Y and M blocks are the most common. Their first two characters are always an Ascii identifier, for example: M <space>. Line feed and carriage return are in general not used.

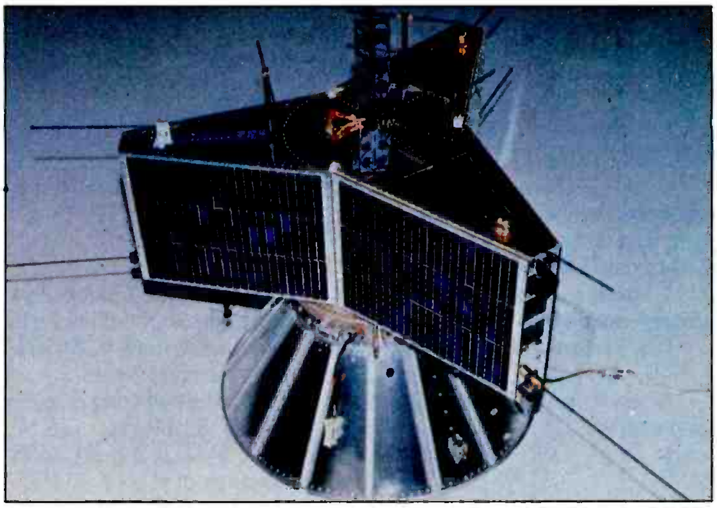


Fig.1. **Oscar-10 satellite. Picture by courtesy of AMSAT.**

M Blocks are plaintext messages, comprising eight lines of 64 Ascii characters. They are at present used for routine communications between command stations.

Y Blocks are entirely Ascii telemetry (Fig. 2). The first line contains the time (UTC) and Amsat day number (0=January 1, 1984). Lines 2 and 3 are command and control status information. Lines 5-8 are 64 selected telemetry values which may be converted using the equations published in the Oscar-10 operating manual[2]. At the time of writing, minor format changes have been proposed.

As an example, columns 3, 7, 11 and 15 represent temperatures, which decode as T=(N-127)/1.82. The first entries in columns 3 and 7 are the mode U

```
Y  HI. THIS IS AMSAT OSCAR 10                      10:53:03  2308
#034D   #0020   #019E
64  7   0   0   13  225 0

204 0   156 0   199 0   185 126 212 51  152 7   103 47  159 56
0   37  138 31  29  36  140 128 0   0   135 133 111 0   135 13
64  137 141 192 179 170 139 149 118 150 139 13  238 138 148 13
198 140 126 177 198 152 139 0   11  142 141 0   11  137 133 0

Y  HI. THIS IS AMSAT OSCAR 10                      11:08:30  2308
#034D   #0020   #019E
64  7   0   0   13  225 0

204 0   157 0   199 0   185 111 212 51  152 10  103 48  159 56
0   37  139 0   30  36  140 130 10  0   135 146 110 0   135 13
66  137 142 186 177 170 139 96  213 150 140 13  239 138 148 13
199 140 126 10  220 153 139 0   11  142 141 0   11  137 133 0
```

Fig.2. **So-called Y blocks from Oscar-10 are entirely in Ascii code. First line contains the day number (2308 is 27 April 1984); then come two lines of command and control status information followed by 64 telemetry values.**

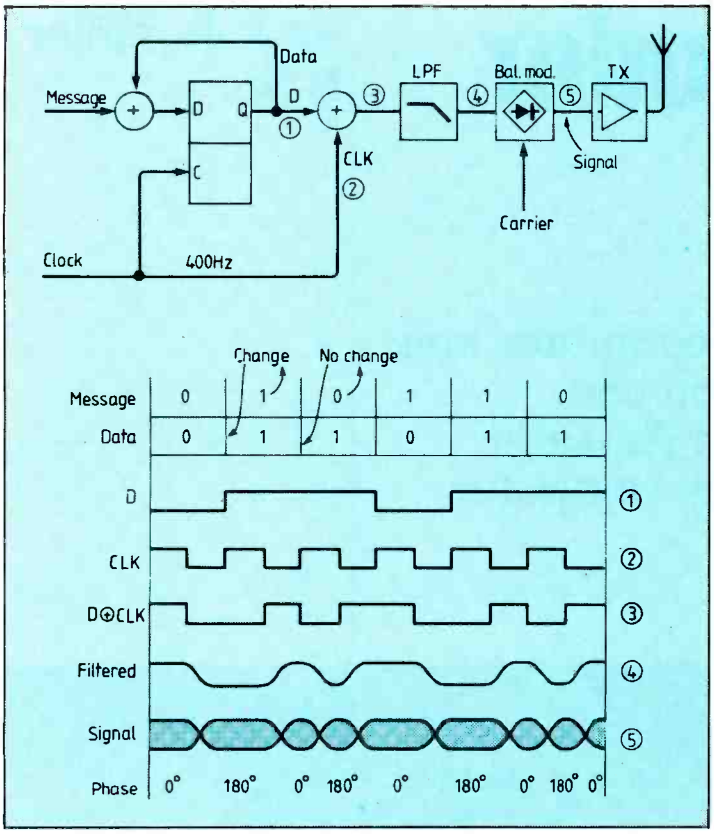


Fig.3. **Spacecraft's p.s.k. telemetry modulator. Message is first differentially encoded: 0 becomes 00 or 11 (that is, no change in data), while 1 is represented by a change (01 or 10). Data is then multiplied (ex-or) with a 400Hz clock, filtered and modulated on to the carrier.**

transponder receiver and transmitter temperatures, 16°C and 32°C respectively.

Q Blocks begin like Y blocks (excepting the letter Q) but lines 5 to 8 contain the full suite of 256 hexadecimal telemetry bytes.

The schedule of transmission is generally 32 blocks; one M, one Y and 30 Q. It repeats every eight minutes of so.

Modulation

The digital information stream at 400bit/s (called the message) is first differentially encoded such that a 1 is represented by a change in the output data stream (i.e. 01 or 10) while a 0 is denoted by no change (00 or 11). This data is next exclusive-ored with a 400Hz clock, low-pass filtered to restrict its bandwidth (third order Bessel, 560Hz) and then balance modulated on to the transmitter carrier (Fig. 3).

This modulation is called antipodal phase-shift keying (p.s.k.). Carrier phase is either 0° or 180° according to the data. Because of the low pass filtering there is also some amplitude modulation at bit or clock transitions.

The signal spectrum for random data is shown in Fig. 4. Note the absence (on average) of a carrier or other line components; these would waste transmitter power.

In the following sections, note the distinction between 'message' and 'data'. The data is the stream which represents the message. Let us use the following notation:

M_n—bit n of the original message,
D_n—bit n of the data, derived from message
S, S(t)—transmitted signal
A(t)—signal amplitude
Clk—the 400 Hz data clock
Car—carrier
* —means exclusive Or (A*A =0, 0*1=1, 1*0=1)
±A—means 'either A or its inverse'

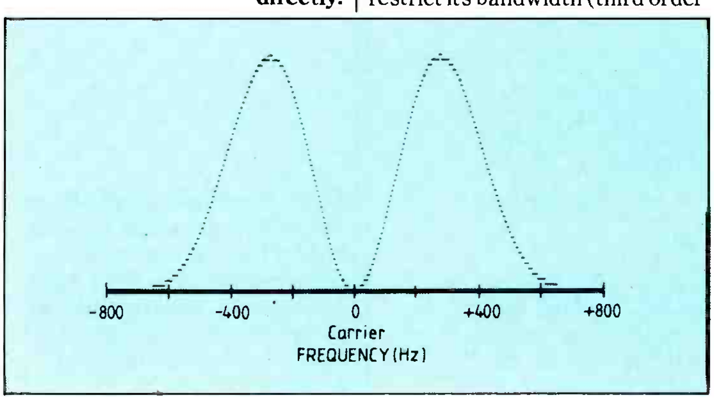


Fig.4. **Telemetry power spectral density. Vertical scale is linear. Note the absence of any line components, which would waste power and which would also make it impossible to lock on to the 'carrier' directly.**

It is useful to remember that if we associate the numeric value +1 with logic 1, and the value −1 with logic 0, then the ex-or operation is (sign excepted) equivalent to multiplication.

Some features of this modulation scheme that facilitate the demodulation process are:

- the signal can be described as $S(t) = A(t) \sin(\omega t)$
- ignoring amplitude modulation, the signal can also be thought of as the ex-or of data, clock and carrier: $S = D_n * Clk * Car$
- message stream is related to data stream by $M_n = D_n * D_{n-1}$
- differential message encoding is used to enable a decoder to deal with the unavoidable 180° phase ambiguity in recovered carrier
- all data bits have a mid-bit transition, but not always an inter-bit transition.

Demodulation

Essentially this reverses the modulation operations. The receiver will be set to c.w. or s.s.b. mode so that the carrier is translated down to audio frequency for input to the decoder. (Fig. 5).

The signal carries neglible information in its amplitude variations, so it may first be limited. This has a great advantage that all subsequent processing can be digital.

First a carrier and clock (denoted by CarR and ClkR) are recovered from the signal (S) and then ex-ored with the signal, giving a product (P):

$$P = S * [CarR * ClkR]$$

Provided the local carrier and clock are (excepting possible inversion) replicas of the originals,

$$CarR = \pm Car \text{ and } ClkR = \pm Clk,]$$

this product simplifies to:

$$P=[D_n*Clk*Car]*[\pm CarR*\pm ClkR] = \pm D_n$$

which is the original data. If the signal were noise free, the data D_n would be perfectly usable at this point. Noise however perforates the bits and so mid-bit sampling would lead to random errors. Instead, D_n is integrated over the bit interval and the resulting accumulation sampled at its end, a process called integrate-and-dump. The system as a whole is a matched filter.[4]

Note that in order to clock the data and time the integration properly, a means must be provided of resolving the ClkR 180° phase ambiguity. (The information to do this is implicit in the signal.)

The message M_n is next found from $\pm D_n$ by differential decoding. The present data bit is exored with the previous data bit. The possible inversion of D_n is of no consequence, for $-D_n * -D_{n-1}$ and $D_n * D_{n-1}$ are both the same.

The message stream is now available for processing, by either hardware and/or software.

A truly optimum matched filter would take account of the sinusoidal nature of the signal and its amplitude modulation. The hardware required to do this involves deconvolution and is not trivial. The penalty for using a limiter and binary processing is less than 2dB which in actual on-the-air practice is insignificant.

Decoder operation

The receiver should be set to s.s.b. mode; the normal 2.4kHz bandwidth is more than adequate, and can with advantage be reduced to around 1kHz before decoding loss becomes apparent.

Because of the decoder's limiter, unnecessarily wide bandwidths reduce performance.

If the signal is tuned into the middle of the receiver's passband then the carrier frequency will typically be 1500Hz. The actual frequency is not important, but there is a lower limit caused by the onset of aliasing, when the lower sideband folds round 0Hz and into itself. This sets in at a carrier frequency of about 500Hz. The upper limit is set only by the performance of the logic family; if t.t.l. were used the carrier could well be at 455kHz, i.e. at intermediate frequency.

Carrier recovery (Fig.6): a phase locked loop cannot be used to extract the carrier directly as there is no carrier line component in the spectrum of an A(t) sin(ωt) signal where A(t) = random data.

However if the signal is subjected to a nonlinear process such as self-multiplication, the ± is eliminated, and line component at 2ωt is generated. A simple digital way of achieving this is to ex-or the signal with itself delayed by a quarter-cycle. Every zero-crossing of the carrier creates one new cycle of twice the carrier frequency, which can be regenerated with a phase locked loop (p.l.l.) and followed by a divide-by-two circuit. This division does however result in the 180° phase uncertainty previous noted.

The carrier p.l.l. must accommodate receiver frequency instability, noise and changing doppler shift (-250Hz/hour at 145MHz, u.s.b. If the loop bandwidth is too small the p.l.l. is difficult to tune in initially, has only a small tracking range and is generally fussy. If it is wide, with little noise, the loop will hold lock over a wide tuning range, but it will constantly jump out of lock on noiser signals. So a fixed loop bandwidth will not suit every situation. A few experiments will show what is wanted in practice: the value will lie between 10 and 100Hz.

Clock recovery: This is accomplished in exactly the same way as carrier recovery, by multiplying the data by itself delayed by a quarter-bit. This generates an 800Hz proto-clock, which is regenerated with a p.l.l. and then divided by two. Since the clock frequency is constant, the loop bandwidth can be 1Hz, even with cassette tape signals. As with the carrier loop, the clock at this stage also has a 180° phase ambiguity.

James Miller, who is 39, discovered electronics at an early age with a crystal set. Later he obtained a B.Sc. (Hons) in electronic engineering at the Univetsity of Birmingham and then worked for Marconi and Sperry Gyroscope. Eight years ago he joined Cambridge Consultants to work on design and development in signal processing, electronics, computing, optics, non-impact printing and manufacturing technology. He left CCL recently to take up freelance work as an engineer and technical writer. His interest in wireless continues through amateur radio (G3RUH) and he combines a passion for satellites with cooking, eating, Wagner, the city of Cambridge and other fine things.

Clock ambiguity resolution (Fig.7): as long as there are 01s and 10s in the data, which means that the inter-bit transitions will be absent, a second proto-clock of 400Hz can be generated by ex-oring the data with itself delayed by half a bit. Although somewhat sparse (trace 3) this extra clock has the virtues of correct phase, and coherence with the ambiguous clock.

If these two are now ex-ored together, the smoothed result is a net high or low. This signal can then be used to invert (or not invert) the ambiguous clock to the correct sense.

In fact the second 400Hz proto-clock could be used to excite a p.l.l. However, with the signals encountered in practice, the effective loop gain and bandwidth are caused to vary constantly, which makes the loop rather fragile — though it does work.

A particular feature of the clock and carrier recovery circuits is their aperiodic, digital design, involving no tuned circuits. So their operating frequency can be modified simply by changing the v.c.o. centre frequency.

Block sync detection: hex 39,15,ED,30 is the pseudo-random sequence generated by the

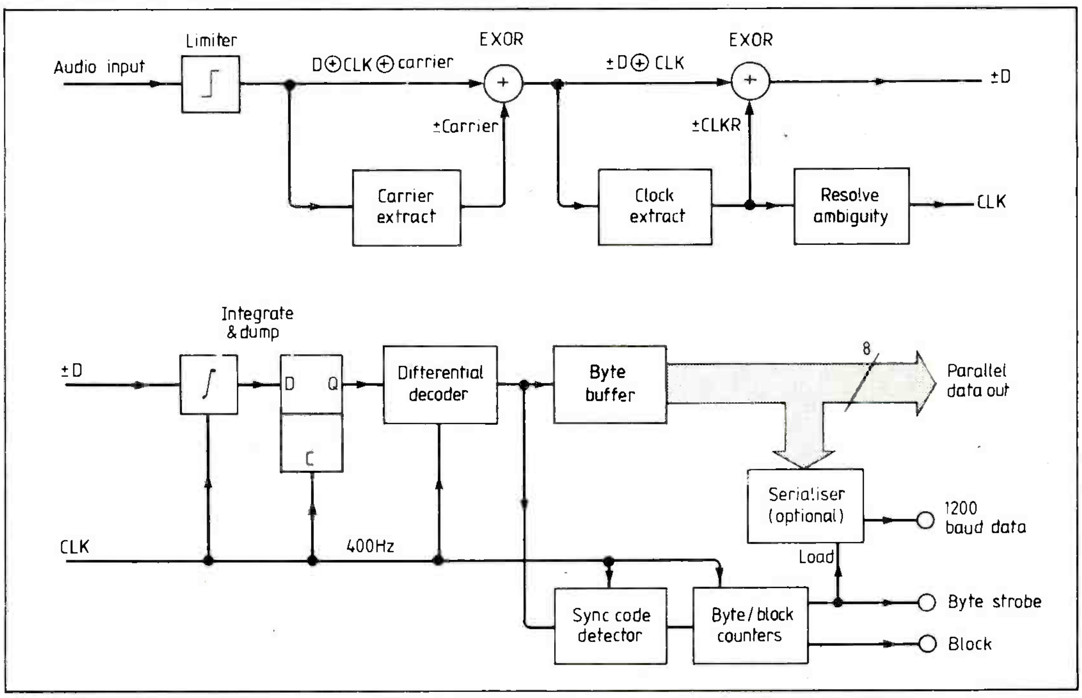


Fig.5. **Audio input to the decoder comes from a two-metre amateur band receiver. The output is available in parallel or serial form to suit the user's computer.**

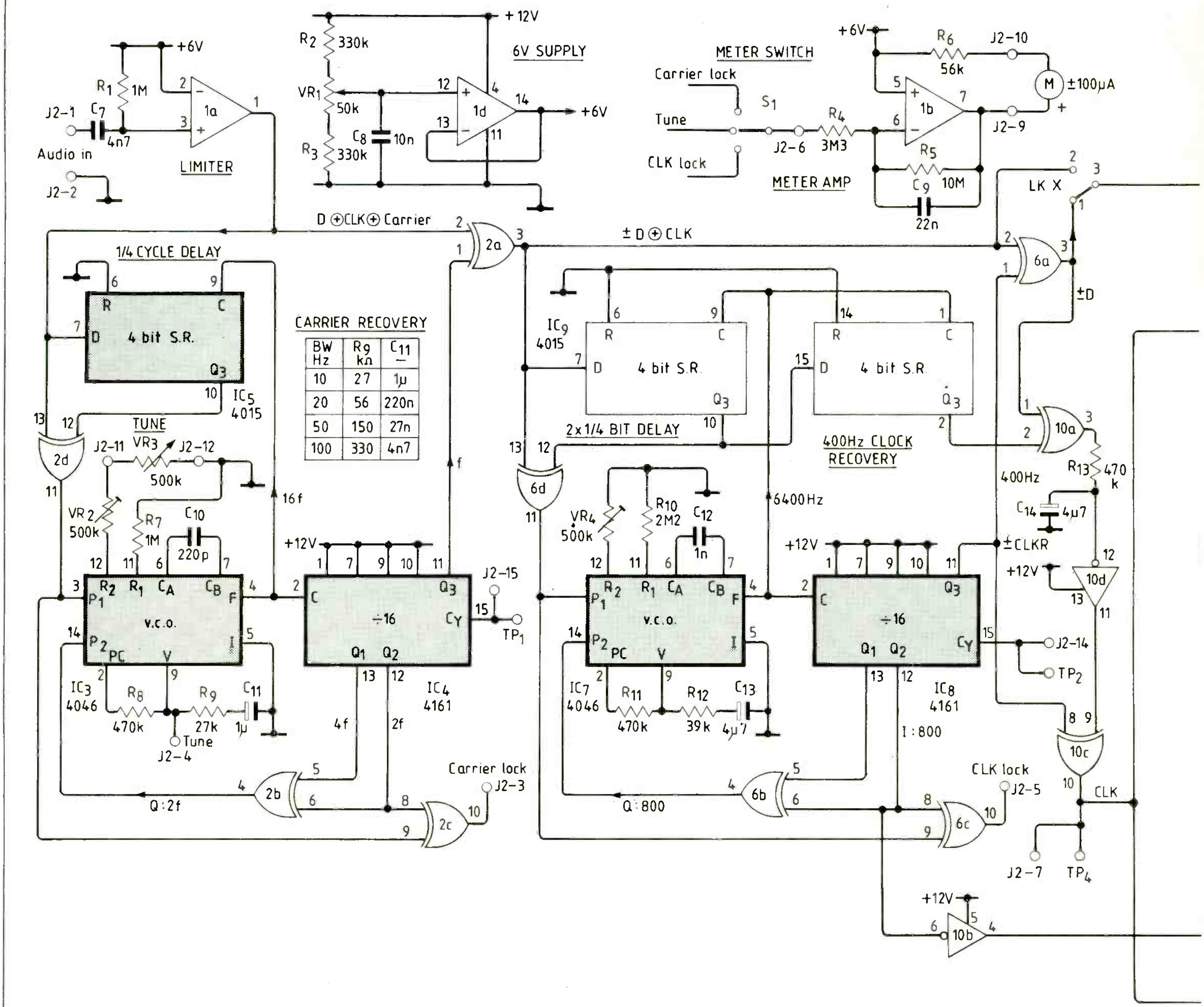
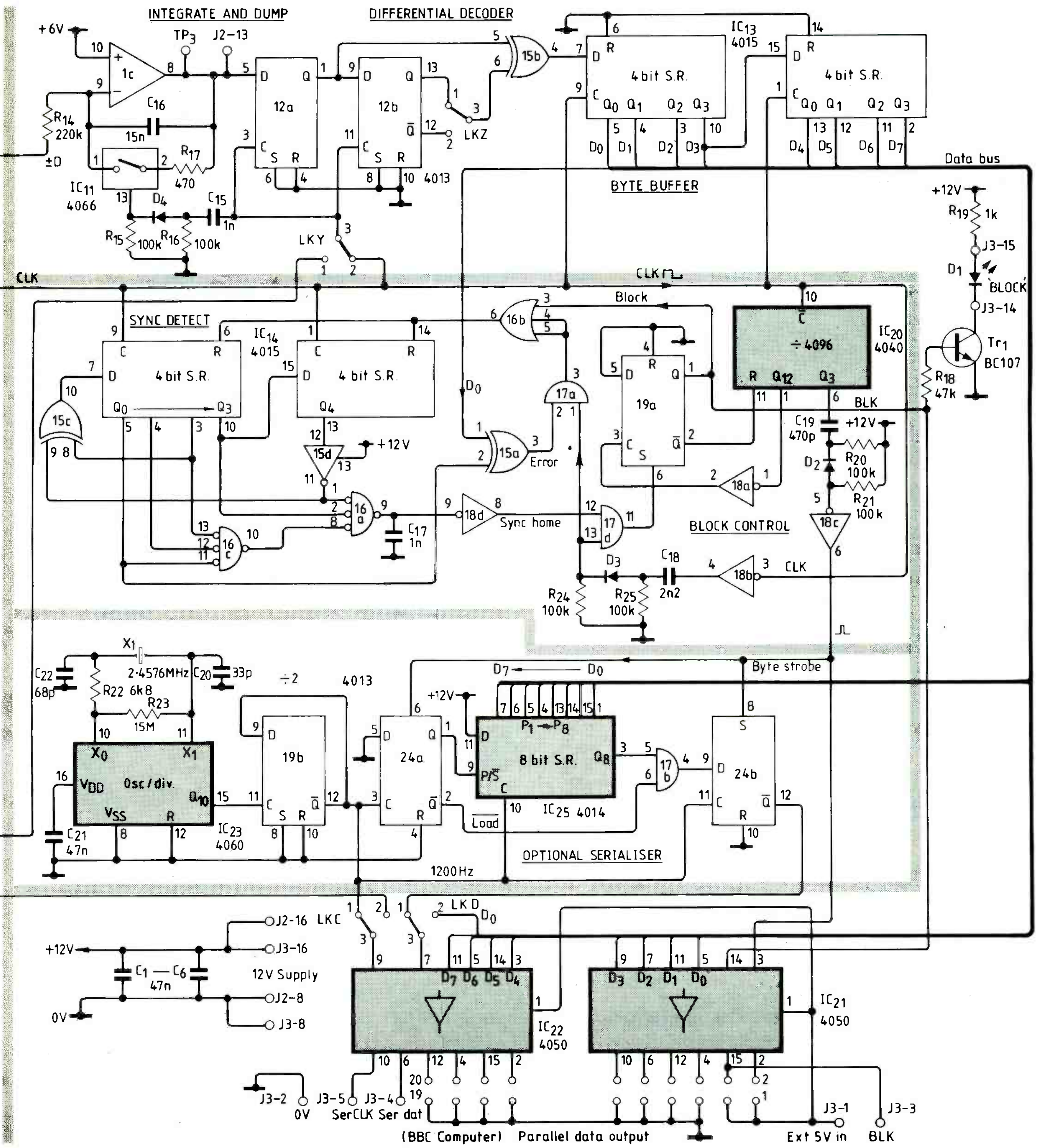


Table A. connection details

J_2 — inputs	
1 Audio in	16 +12V
2 0V	15 TP1
3 Car. lock	14 TP2
4 Tune to	13 TP3
5 Clk lock S_1	12 Tuning, VR_3
6 Meter amp.	11 Tuning, VR_3
7 Tp4/Clk	10 Meter −
8 0V	9 Meter +

J_3 — outputs	
1 +5V in/oout	16 +12V
2 0V	15 Led +
3 Block	14 Led −
4 Ser.data	13 —
5 Ser.clock	12 —
6 —	11 —
7 —	10 —
8 0V	9 —

Complete circuit diagram of the decoder. A ready-made printed circuit board for this project is available direct from the author or through Amsat-UK. For details see the reference list.



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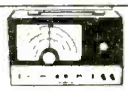

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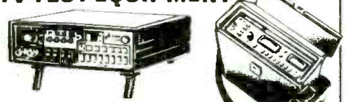

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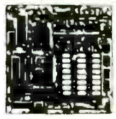

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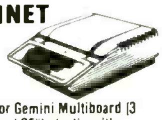

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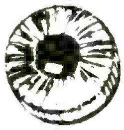

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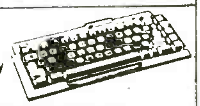

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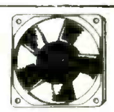

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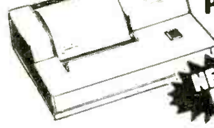

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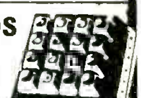

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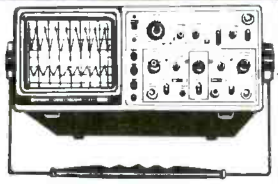

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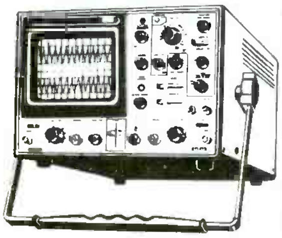

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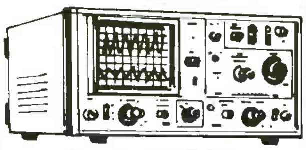

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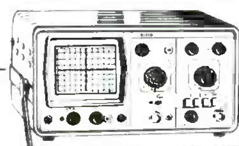

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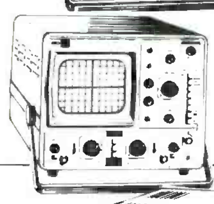

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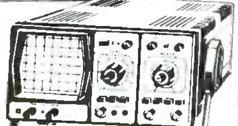

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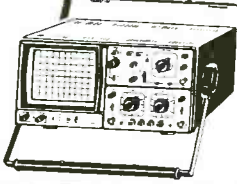

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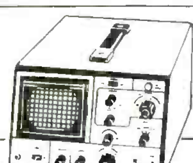

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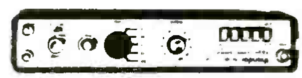

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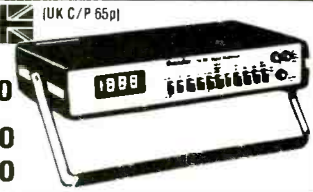

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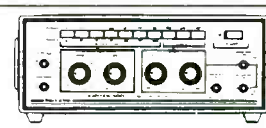

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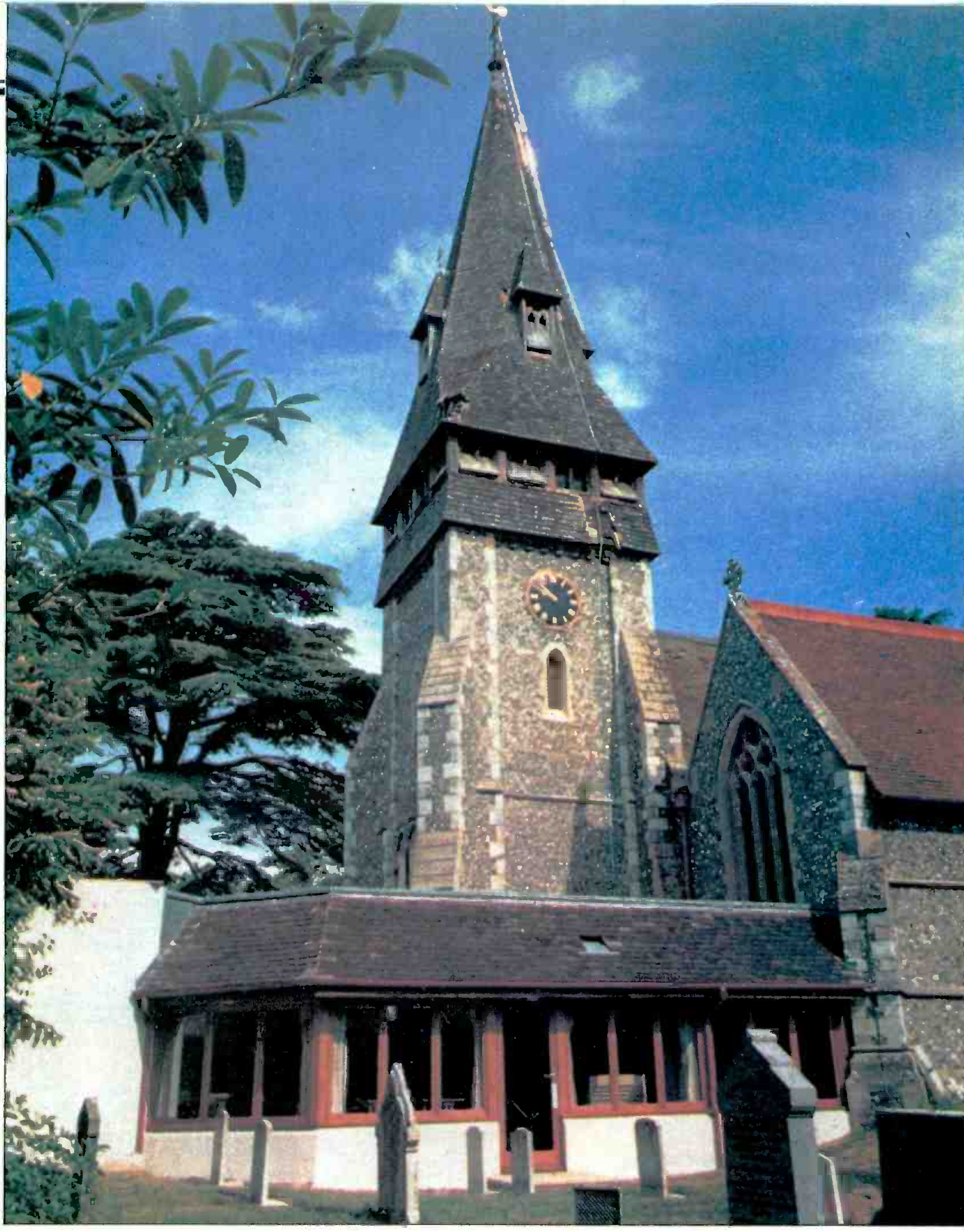
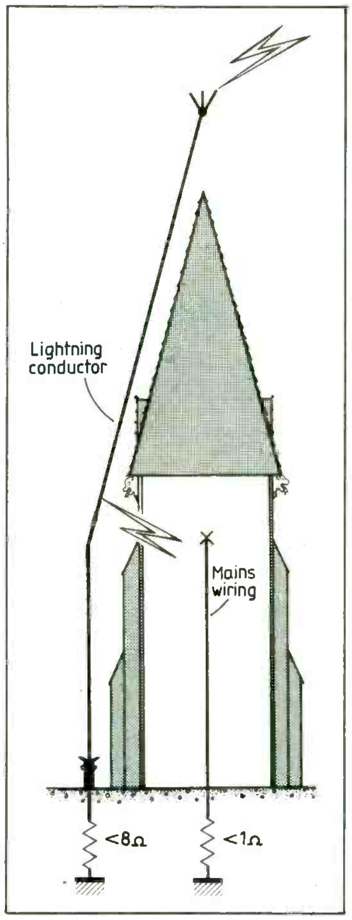
CIRCLE 7 FOR FURTHER DETAILS.

by John Wilson



A) After the strike. Damage can be seen above and to the right of the clock and on the roof corner.



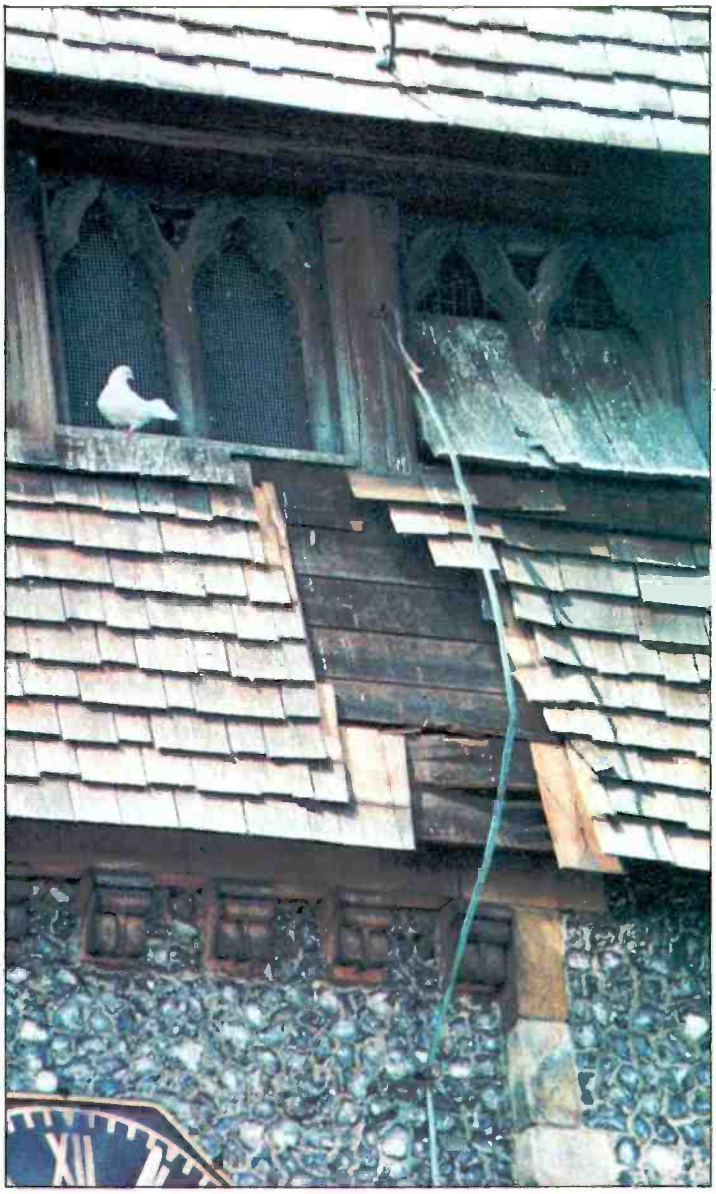
Lightning strike

When does a lightning conductor fail, and what happens when it does?

To arrive at the scene soon after a massive lightning strike is undoubtedly the best time to arrive. I don't of course refer to such base considerations as personal safety but rather the opportunity to study a rare phenomenon. As with much in the world of engineering, a modest amount of 'hands on' experience is worth a mountain of theory and therefore worth reporting. The events I describe took place in early May when I was called in to have a look at the damage to a range of audio, video and musical equipment at a local parish church (location undisclosed for security reasons). The following description contains no new insights into the behaviour of electrical discharges but will, I hope, offer a few practical tips to others who (like myself) always assume that accidents happen to others.

Background

The church in question is a favourite haunt of tv producers, a possible explanation for the sense of déjà-vu that the heading picture may provoke. It was built in 1830 and sticks about 30m above the top of a low ridge of hills. Such a structure, being an obvious target for lightning strikes, was well protected by a modern lightning conductor. This was professionally maintained and had only recently been tested for earth resistance — about 8 ohms and well within the limits considered acceptable by the industry. Yet a single stroke of lightning stripped off the conductor, vaporizing it in several places and setting the church tower on fire. Several square metres of roofing lead were ripped of as if by a giant hand and a 20 cm by 20 cm timber beam split in two. Total faith in the protective value of lightning conductors may be comforting, but it's clearly not the whole story!



B) Closer view of the damage shown in the heading picture.

Electrical damage

When I examined the electrical and electronic systems throughout the church complex (various halls and committee rooms), it soon became obvious that considerable amounts of energy had been diverted indoors. Mains cables were shorted, fused or simply missing! Telephone wires as far as 50m from the point of strike had their insulation ripped off and were melted in several places.

Closer examination showed that the lightning had jumped from a point about half-way down the lightning conductor to a section of mains wiring about 2m away inside the church tower. The diagram shows the set-up and suggests a probable explanation. Mains earths are nearly always (or should be!) better than the ground stakes of lightning conductors and will therefore offer a preferential path for the discharge. The fact that such wiring is quite separate from the lightning conductor appears to be irrelevant unless the two are physically separated by more than about 3m. Distances smaller than this merely represent low impedance discharge paths for megavolt pulses. (A good rule of thumb in the trade suggests that mains wiring should be kept clear of lightning conductors by at least a foot for every ohm of the latter's earth resistance.)

A quick study of the mains wiring around the church buildings showed a type of damage which is instantly distinguishable from that caused by conventional electrical overloads. The cable in the tower (2.5mm T & E) was parted in several places and stripped of its insulation in others. All these places were at 90 degree bends where presumably the electric field was greatest and where the prime mode of failure would have been insulation breakdown to the air around. Another interesting feature was the tendency, elsewhere in the building, for M.I.C.C. cables to develop internal shorts, either at the ends or at random points along the way. This may simply be the result of the cable failing at its weakest points, but it may also be explicable in terms of standing waves resulting from a high-energy pulse being sent along an unterminated transmission line. I simply don't know.

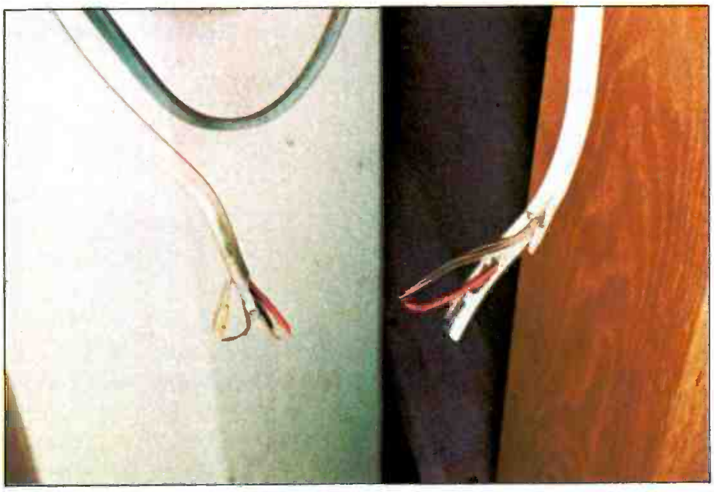
Electronic equipment

With one solitary exception (the failure of a BF907 mosfet in a radio microphone receiver), all the damage of electronic equipment could be explained in terms of voltage surges transmitted through the mains. About half a dozen pieces of audio, video and musical equipment suffered widespread destruction of semiconductors and power supply components, this including over a thousand transistors and diodes in a solid-state pipe-organ action mechanism. There was, however, a common factor linking this motley collection of electrical equipment: each was plugged in or otherwise directly connected to the mains wiring. None was actually switched on at the time of the storm and virtually every fuse was left intact. Here again, it seems, the voltage was doing the damage.

Further evidence that damaging spikes had come through the mains wiring was provided by a number of otherwise similar electronic units which at the time were physically disconnected. These included two commercial cassette decks which were sitting in boxes right at the base of the tower. Although surrounded by a graveyard of wrecked equipment and externally scorched by molten cables, neither of these decks developed any fault at all. When a storm is expected it therefore seems, on the basis of this experience, good advice to unplug everything of value and to remove the mains lead at least a couple of metres from the nearest permanent wiring. The same must obviously be true of antennas

Lightning strikes Hotel: Woman Hurt

Woman guest hurt when Penzance hotel struck by lightning. Top floor window of hotel blown in and masonry damaged. Woman treated at hospital and later discharged.



C) Internal twin-and-earth cable parted and stripped.

D) Some of the blown semiconductors.

and other metal work in buildings.

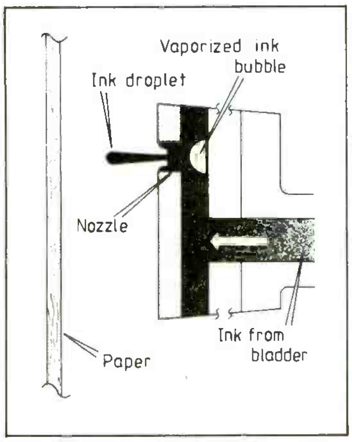
Components in details

In view of the varied nature of the equipment, few general principles emerge. I was surprised, however, at the number of components that failed in a short-circuit mode. These included about 200 transistors with complete c.b.e. shorts and about a dozen dead-short Zener diodes. Four different 3-terminal regulators also failed with input/output shorts. Not surprisingly, therefore, shunt stabilized sub-circuits survived better than circuits powered by 78XX and 79XX devices. One mains-connected unit to emerge completely unscathed was a 12-channel audio mixer fitted with a 10-watt crowbar zener (to protect against power unit failure or misconnection!)

Summary

Although this brief investigation was hardly very scientific, a few useful guidelines do emerge:

- Don't assume that anything can protect against a direct lightning strike.
- Sensible physical separation of lightning conductors from mains wiring (and plumbing) will minimize damage.
- Direct and induced voltage strikes can bypass fuses and antenna leads when a storm is imminent. Remove the plug at least 2 metres from the socket.
- Shunt protection of d.c. rails does seem to give equipment a greater degree of protection from mainsborne insults.



Resistive heaters propel ink jet

This disposable printer head uses thick-film resistors as heating elements to force ink through 12 microscopic nozzles onto plain paper. When current is passed through one of the 12 resistors, surrounding ink rapidly vaporizes and the resulting 'explosion' forces liquid ink through the nozzle and onto the paper to form a dot. Ink is replenished by capillary action.

Developed at Hewlett Packard's Califonia laboratories, the plug-in head — costing under £6 — can print around 500 pages before it needs replacing. It can produce 2400 dot-rows each second but the printer designed to use it, the HP2225, runs well within this rate, producing up to 150 chars/s in an 11-by-12 matrix at a noise level of around 50dB and at a cost of £400.

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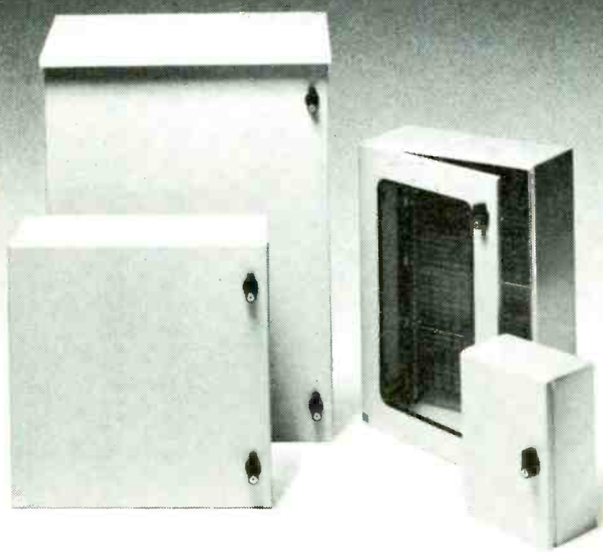

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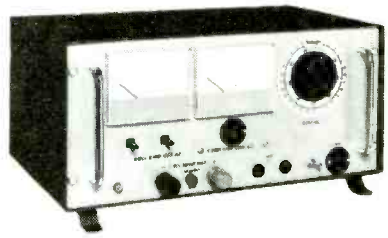

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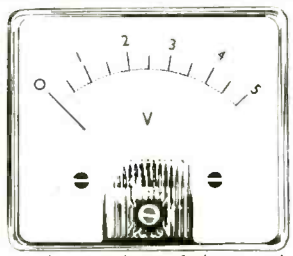

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CIRCLE 56 FOR FURTHER DETAILS.

by Ivor Catt*

Fundamentals of energy transfer

Ivor Catt continues his discussion of basic weaknesses in e.m. theory, proposing a new model.

Maxwell's difficulty with the anomaly disappears, and his fudge factor, displacement current, traversing the capacitor from top to bottom and creating magnetic field in the horizontal, forward, direction, becomes an embarrassment because by generating forward magnetic flux (which is why Maxwell invented it,) it contravenes the requirements of a TEM wave, that all magnetic field should be transverse. Once it is realised that a capacitor is a transmission line[23], we have to conclude that the traditional treatment of the capacitor (i.e. displacement current, generating forward magnetic flux) is incompatible with the traditional treatment of the transmission line (i.e. the TEM wave). We are forced to removed the concept of displacement current from our theory to prevent it from undermining the important concept of the TEM wave.

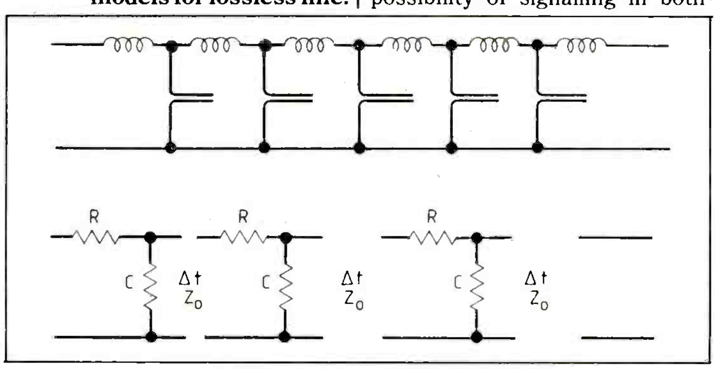
Repeated LC model for transmission line.

It is traditional to offer the LC model (Fig.10) as a good way of understanding the operation of a transmission line, with inductors either in the top line or in both lines. This is a disastrous model for a number of reasons: the series L induces the student to think that a lossless transmission line has a high frequency cut-off, which is untrue; it outlaws the possibility of signalling in both directions at the same time, and is largely to blame for the general tendency to only half-use the capacity of long, expensive lengths of coax. or twisted pair cables; my erstwhile co-author Malcolm Dividson has pointed out that since a capacitor *is* a transmission line, the model is absurd — modelling something in terms of itself.

My erstwhile co-author Dr D.S. Walton has proposed a new model (Fig10), for the lossy transmission line, where losses R and G remain as discrete resistors periodically along the length, but each section is a delay unit with a certain characteristic impedance (i.e. resistance). According to this model, a signal passes alternately through resistive loss segments R—G, and delay segments. There are no reactive components. Dispersion will arise from repeated partial two-way reflections at each R—G element, and will of course be more apparent for 'high frequencies'.

*Watford College

Fig.10. **Old (1) and new (b) models for lossless line.**



Displacement current

I have argued that free space had at least one innate characteristic — inpedance. In this section, written by F. David Tombe of Belfast College of Technology, another argument is presented for space having at least one innate characteristic, which he suggests is 'polarization', or paired poles.

Maxwell's displacement current is introduced in modern textbooks using the following argument.

Ampere's circuital law can be written:

$$\text{curl}\,\underline{B} = \frac{4\pi}{c}\underline{J} \quad (1)$$

$$\text{div curl}\,\underline{B} = \frac{4\pi}{c}\text{div}\,\underline{J} \quad (2)$$

Since the div of a curl is always zero, we arrive at

$$\text{div}\,\underline{J} = 0 \quad (3)$$

But the equation of continuity states that

$$\text{div}\,\underline{J} = -\frac{\delta\rho}{\delta t} \quad (4)$$

This dilemma results in the conclusion that equation (1) only holds for static situations and that a modification is required for time varying *B* fields. The additional modification term must be such that

$$\text{div (the additional term)} = +\frac{\delta\rho}{\delta t} \quad (5)$$

so as to always cancel out with div $\underline{J}$. The result is that the 'displacement current' is added on and the equation now looks like this;

$$\text{curl}\,\underline{B} = \frac{4\pi}{c}\underline{J} + \frac{1\delta \underline{E}}{c\,\delta t} \quad (6)$$

But this extra term must surely contradict the original derivation of equation (1), since taking the curl (spatial differentiation) has no relevance to the time dependent aspect of B.

The 'displacement current' can in fact be justified another way simply by viewing it is a polarisation current component implicit in the original $\underline{J}$ term. If we define the vector $\underline{D}$, having direction of current, such that

$$\underline{J} = \frac{\delta \underline{D}}{\delta t} \quad (7)$$

Then

$$\text{div}\,\underline{J} = \frac{\delta}{\delta t}(\text{div}\,\underline{D}) \quad (8)$$

From the equation of continuity

$$-\frac{\delta\rho}{\delta t} = \frac{\delta}{\delta t}(\text{div}\,\underline{D}) \quad (9)$$

therefore, integrating, we get

$$-e + \text{constant} = \text{div}\,\underline{D} \quad (10)$$

Now

$$\text{div}\,\underline{E} = 4\pi\rho \text{(Gauss's Law)} \quad (11)$$

Combining (10) and (11) we see that

$$\underline{D} = -\frac{\underline{E}}{4\pi} + \underline{D}_2 \quad (12)$$

Hence using (1) and (7),

$$I = \frac{\delta D_2}{\delta t} - \frac{1}{4\pi}\frac{\delta E}{\delta t} \qquad (13)$$

$$\text{curl } \underline{B} = \frac{4\pi}{C} I_2 - \frac{1}{C}\frac{\delta E}{\delta t} \qquad (14)$$

Such a derivation implies that electromagnetic waves cannot possibly exist in the absence of a medium in which polarisation is linked to displacement current. The minus sign means that the displacement current is in the opposite direction to the opposing electric field caused by the linear ether stress of polarisation. This is identical in principle to Lenz's Law for torsional aether stress which occurs in Faraday's Law.

TEM wave

The conventional wisdom on electromagnetism contains two mutually contradictory versions of the Transverse Electromagnetic Wave. The first, the Rolling Wave, is the view of 90% of academics. Opposed to this view, the second, correct version, called the Heaviside Signal, attracts the remaining 10% of academics. It is remarkable that the contradiction has never been noticed[24].

Rolling Wave. Kip[25] describes the Rolling Wave;

> "...Our demonstration involves the use of the first two Maxwell equations to show that such a postulated time and space variation of E gives rise to a similar time and space variation of H (but at right angles to E) and that this H variation cuts back to cause the postulated variation in E. Thus, once such a wave is initiated, it is self-propagating."

The two relevant Maxwell Equations are

$$\frac{\delta E}{\delta x} = -\frac{\delta B}{\delta t} \text{ and } \frac{\delta H}{\delta x} = -\frac{\delta D}{\delta t}$$

Heaviside Signal. Opposed to the Rolling Wave is what we shall call the Heaviside Signal. The most highly developed form of this view is that at any point in space, an electromagnetic signal always contains one kind of energy only. The energy density is equal to the product of D and B at that point. The rate of flow of energy, which travels at the speed of light ©, through unit area is equal to the product of E and H at that point. E, H and © are always mutually perpendicular. E/H = $\sqrt{\mu}$ and © = $1/\sqrt{\mu}$. There is no interaction between E and H, which are co-existent, co-substantial, co-eternal[3].

Beyond Theory H

For the last century, the lost debate in electromagnetic theory as between Theory N (Fig.1), that current and charge in/on wires cause fields, and Theory H (Fig.2) that the electromagnetic field travelling down between two conductors is the cause and electric current and charge in the wires are effect of that cause. I call the debate 'lost' because some 70 years ago the wrong theory, Theory N, won the debate and suppressed all evidence of the existence of the (energy current) alternative, Theory H. (The recent assertion of Prof. Ziman FRS, that 'The aim of science is to achive consensus' gives the seal of approval to this suppression.)

Fundamental to all three theories, N, H and C, is the principle of conservation of energy. The measure of energy flow is the electromagnetic field E × H (i.e. the Poynting Vector). In the case of Theory N, the current and charge in the wires *cause* the field, which field transports the energy. A theory which is energy based must retain the energy carrier, E × H. It must also retain the *cause* of the energy carrier, i and

In the case of Theory H, the energy carrier E × H is the *cause*, and i and , being secondary effects of that cause, are not essential to the transport of energy. Heaviside failed to notice that in Theory H, i and were outside the path of the theory from (a) prime mover E × H to (b) effect, the flow of energy. He never questioned the need for i and in his revoluntionary Theory H.

Although the Catt Anomaly was discovered after Theory C, it shows us that major problems arise when electric charge tries to play its part properly in the passage of TEM wave guided between two conductors. The way out of the dilemma is to excise i and from Theory H, leaving us with a non-dualistic theory, Theory C.

Theory C

In 1873 Maxwell wrote[26]

> "Since ...the theory of direct action at a distance is mathematically identical with that of action by means of a medium, the actual phenomena may be explained by the one theory as well as by the other, provided suitable hypotheses be introduced when any difficulty occurs."

This statement led Hertz to say, "Maxwell's Theory is Maxwell's set of equations."

If we allow ourselves Maxwell's extraordinary licence, we find that Theory C is also Maxwell's Theory. Even though in Theory C, charge and current have been excised from the theory of a TEM wave propagating down between two conductors, Maxwell's Equations still serve us by making us able to manufacture instruments, i and , since they have been found to be useful constructs in the past, although now they lack physical reality (in the say way as acceleration lacks physical reality, being merely a mathematical manipulation of physically real distance and physically real time).

Numerous well known (but very confusing) theoretical bodies of knowledge are transformed by the change of view caused by Theory C. In the case of a transistor or thermionic valve, the problem is no longer one of how the charge (electrons) travels from emitter (cathode) to collector (anode). Now, all movement is in a different direction. Energy current, guided by the two conductors, (Fig.11), enters sideways into the critical interface between emitter (cathode) and base (grid), gradually accumulating as it vacillates to and fro along the junction. After a time, the density of the energy reaches a critical value (0.7V) and this causes other energy current, travelling towards the transistor (valve) guided between the emitter wire and the collector wire, to see a shot circuit (instead of the earlier open circuit) by when it reaches the far side of the component. Whereas before, the incident energy current arriving between emitter and collector wires reflected without inversion, it is now inverted before it reflects back towards the +5V supply. Electric charge is not involved — it would collide with the Catt Anomaly.

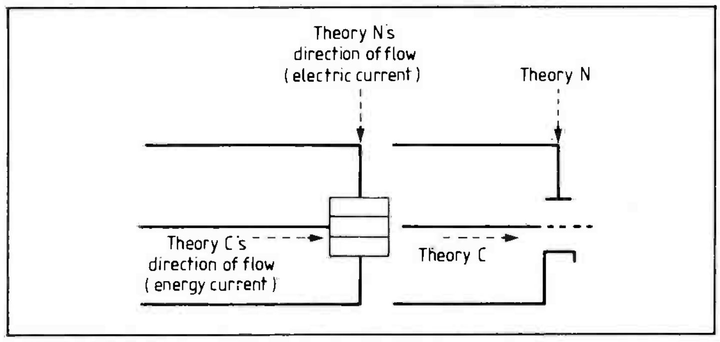


Fig.11. **Theory C turns e.m. through 90°.**

The lower 'Fig.8' of the first part of this article should have been labelled Fig.9 and captioned 'Today's view of Maxwell's problem'.

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23. Catt, I., et al., 'Displacement Current', *Wireless World*, p51, December 1978
24. Catt, I., 'Electromagnetic Theory Vol.1', C.A.M. Publishing, p18, 1979
25. Kip, A.F., 'Fundamentals of Electricity and Magnetism', McGraw-Hill, p320, 1962
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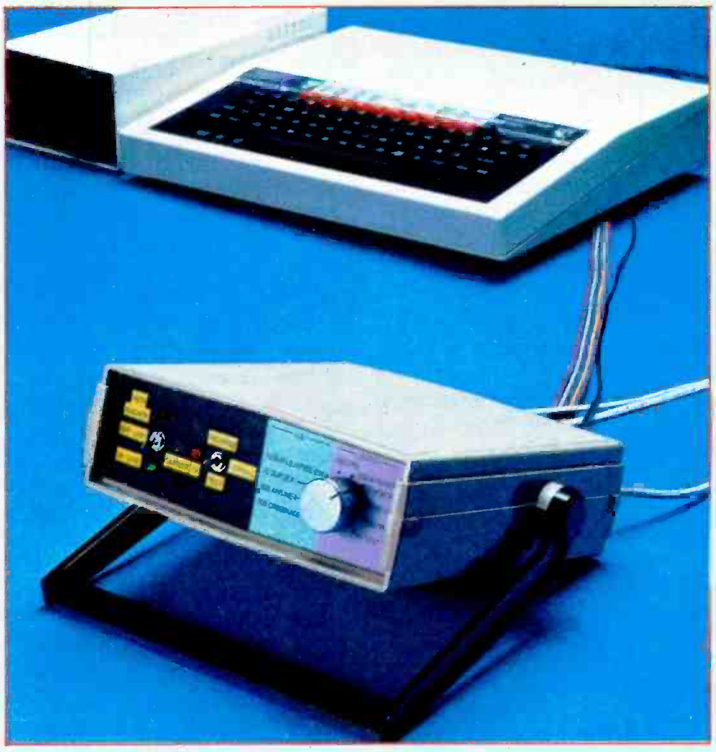
27. ref.(1), p29

Multi-standard modem

Some additional notes and a software auto-dialler



by Richard Lambley

I hope later on to provide an auto-dialler board to pair with the modem; but in the meantime here is an impulse auto-dialler in software for the BBC Microcomputer. Users of other computers will no doubt be able to adapt it if they wish to.

The program drives the three relays in the modem via the computer's user port. A fourth line in the user port enables the computer to monitor the carrier-detect pins of the modem i.c. and so recognise that a call has been set up successfully.

A small hardware addition is required (Fig.1): nevertheless, this part must be one of *Wireless World's* cheaper constructional projects. The transistor is needed to allow the computer to close the line-seize delay (RL_1) and the inverters are to give the correct sense of operation. The user port is bi-directional; and when the computer is first switched on, the port's eight lines are configured as inputs. Without the inverters, all three relays would become energised straight away and would remain so until the program was running.

To dial a telephone number, the sequence of operations is as follows. First the line-seize relay must close. Then, when dialling tone is received from the exchange, the first digit must be sent. The DON relay closes, and after an interval of 7ms the IMP relay opens to create the first of a series of impulses. These impulses are transmitted at a rate of ten per second, with a 2:1 mark-space ratio. That is, the IMP relay opens for 66ms and then closes (between impulses) for 33ms. When the final impulse in the group has been sent, there is a pause of a few milliseconds before the DON relay opens again. An interval of 80ms separates successive digits.

In the program I have used a machine code routine to drive the user port, with the aim of adhering to these timings as closely as possible: every telephone user will know, however, that in practice fairly wide tolerances seem to be allowable. For an interval timer, I have used timer 2 in the user v.i.a. This is clocked by the system at a rate of 1MHz, whereas the only timers accessible from Basic count at 100Hz.

Timer 2 may be pre-set with any 16-bit number and can therefore give delays of up to 65ms. To pulse the IMP relay it seemed

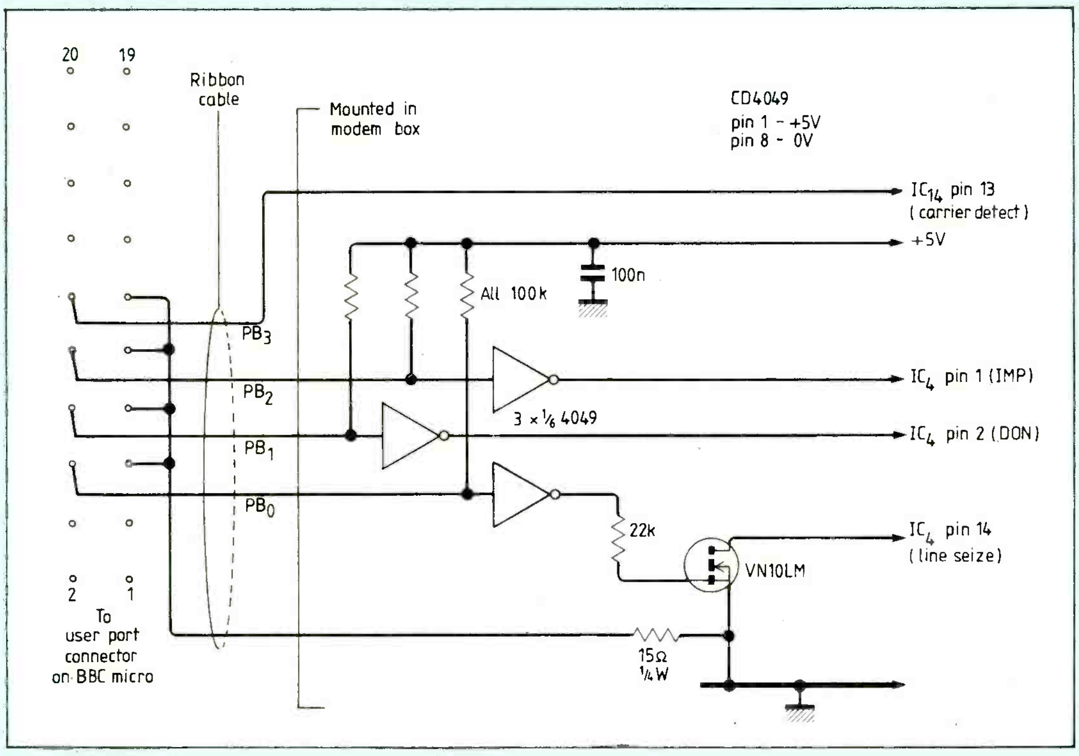


Fig.1. **Interfacing the modem to the BBC Micro's user port. The fet is a low-cost plastic-encapsulated type, but any switching transistor with enough gain could be used instead.**

```
   10 REM ******** AUTODIALLER *********
   20 REM
   30 REM Electronics and Wireless World
   40 REM
   50 REM          October 1984
   60 REM
   70 REM ******************************
   80 REM
   90 REM User port=&FE60:
  100 REM line-seize relay=bit 0;
  110 REM DON=bit 1; IMP=bit 2.
  120 REM 0V at user port energises
  130 REM relays, 5V releases.
  140 REM Data direction register=&FE62
  150 REM Set bits 0-2 as outputs...
  160 *FX151,98,7
  170 REM ...and initialise...
  180 *FX151,96,7
  190 ON ERROR GOTO 680
  200 osbyte=&FFF4:oswrch=&FFEE
  210 timerlo=&78:timerhi=&79
  220 DIM telephone$(26,2):DIM dial 20
  230 MODE7:PROCassemble
  240 A%=&EB:X%=&FF:Y%=0
  250 speech%=(USR(osbyte)AND &FF00)DIV &1
00
  260 PROCheading("Electronics and Wireles
s World")
  270 PROCheading("auto-dialler")
  280 PRINTTAB(0,23)CHR$134;CHR$157;CHR$13
2;CHR$136;"Press a key to get dialling ton
e...";
  290 line%=GET:*FX151,96,6
  300 PRINTTAB(0,23)CHR$132;CHR$157;CHR$13
4;" Enter a letter - or press <space>  "'C
HR$132;CHR$157;CHR$134;" for more, or <TAB
> to key direct:";
  310 VDU28,0,21,39,5:choice%=FNmenu
  320 VDU28,0,24,39,5
  330 IF choice%=0 THEN CLS:PRINTTAB(0,5)C
HR$131;"Enter the number, then press <RETU
RN>:"':INPUT" "dial$ ELSE dial$=telephone$
(choice%,2)
  340 V%=VPOS-(J%-choice%)-1
  350 PRINTTAB(2,V%)CHR$135;CHR$136;teleph
one$(choice%,1);TAB(22)CHR$134;
  360 VDU26:PRINTTAB(0,23)CHR$135;CHR$157;
CHR$132;" Dialling...";SPC(23)'SPC(38);
  370 PRINTTAB(15,23);CHR$129;
  380 IF speech% THEN PROCtalk
  390 $dial=dial$:CALL start
  400 PRINTTAB(0,23)CHR$133;CHR$157;CHR$13
5;CHR$136;"Awaiting a carrier...";SPC(12);
CHR$7;
  410 TIME=0:VDU28,0,21,39,5
  420 PRINTTAB(2,V%)CHR$135;CHR$137;CHR$26
  430 REM
  440 REM Read bit 3 of user port; hand
  450 REM control of line-seize relay
  460 REM to the modem when a carrier is
  470 REM detected.
  480 REM
  490 REPEAT:X%=&60:A%=&96
  500   carrier%=((USR(osbyte)AND &80000)D
IV &80000)EOR 1
  510   UNTIL carrier%=1 OR TIME=3000
  520 VDU7,26:CLS:*FX151,96,7
  530 IF carrier%=0 THEN END
  540 *FX21,0
  550 REM
  560 REM Set-up commands for the
  570 REM communications package
  580 REM can be inserted into the
  590 REM keyboard buffer using
  600 REM *FX138,0,x thus:
  610 REM
  620 *FX138,0,35
  630 *FX138,0,67
  640 REM Call comms package, e.g....
  650 *COMMSTAR
  660 REM
  670 REM ++++++++++++++++++++++++++++++
  680 CLS:*FX151,96,7
  690 END
  700 REM ++++++++++++++++++++++++++++++
  710 DEFPROCheading(heading$)
  720 FOR I%=1 TO 2
  730   PRINTCHR$132;CHR$157;CHR$134;CHR$1
41;TAB(20-LEN(heading$)/2);heading$
  740   NEXT
  750 ENDPROC
  760 REM ++++++++++++++++++++++++++++++
  770 DEFPROCassemble
  780 DIM code 230
  790 FOR pass%=0 TO 2 STEP 2
  800   P%=code
  810   [ OPT pass%
  820   .zero LDY #&3A \ for 0, dial 10
  830   JMP continue
  840   .again INX
  850   JMP read
  860   .exit PLA:TAY:PLA:TAX:PLA:PLP
  870   RTS            \ finished
  880   .start PHP:PHA:TXA:PHA:TYA:PHA
  890   .timer LDA #&96 \ set up timer 2
  900   LDX #&6B
  910   JSR osbyte    \ read v.i.a. reg.11
  920   TYA
  930   AND #&DF
  940   TAY
  950   LDA #&97
  960   JSR osbyte    \ timer mode control
  970   LDY #&A0
  980   LDX #&6D
  990   JSR osbyte    \ clear i.f.r. bits
 1000   LDY #&20
 1010   LDX #&6E
 1020   JSR osbyte    \ disable t2 i'rupts
 1030   LDX #0
 1040   .read LDY dial,X \ get next digit
 1050   CPY #&D
 1060   BEQ exit
 1070   CPY #&30      \ validate...
 1080   BMI again
 1090   CPY #&3A      \     ...input
 1100   BPL again
 1110   TYA
 1120   JSR oswrch    \ display digit
 1130   CPY #&30
 1140   BEQ zero
 1150   .continue TXA
 1160   PHA           \ push char. number
 1170   TYA
 1180   SEC
 1190   SBC #&30
 1200   .pulse PHA    \ push digit value
 1210   LDA #&97
 1220   LDX #&60
 1230   LDY #4
 1240   JSR osbyte    \ close DON relay
 1250   LDA #&1B      \ 7ms, high byte
 1260   STA timerhi   \ stow it
 1270   LDA #&58      \ 7ms, low byte
 1280   STA timerlo   \ stow it too
 1290   JSR delay
 1300   LDA #&97
 1310   LDX #&60
 1320   LDY #0
 1330   JSR osbyte    \ pulse IMP relay
 1340   PHA:TXA:PHA
 1350   LDA #&82      \ 33ms, high byte
 1360   STA timerhi
 1370   LDA #0        \ 33ms, low byte
 1380   STA timerlo
 1390   JSR delay
 1400   JSR delay     \ twice, for 66ms
 1410   PLA:TAX:PLA
 1420   LDY #4
 1430   JSR osbyte    \ release IMP
 1440   JSR delay     \ 33ms delay
 1450   PLA
 1460   SEC
 1470   SBC #1
 1480   CMP #0        \ finished digit?
 1490   BNE pulse
 1500   LDA #&10      \ 10ms, low byte
 1510   STA timerlo
 1520   LDA #&27      \ 10ms, high byte
 1530   STA timerhi
 1540   JSR delay
 1550   LDA #&97
 1560   LDX #&60
 1570   LDY #6
 1580   JSR osbyte    \ open DON
 1590   LDA #40
 1600   .iloop PHA
 1610   LDA #&13
 1620   JSR osbyte    \ inter-digit pause
 1630   PLA
 1640   SEC
 1650   SBC #1
 1660   CMP #0
 1670   BNE iloop     \ ...until 800ms
 1680   PLA           \ retrieve char. no.
 1690   TAX
 1700   INX
 1710   JMP read      \ get next digit
 1720   .delay LDX #&6B
 1730   LDY timerlo
 1740   LDA #&97
 1750   JSR osbyte    \ load t2c-low byte
```

easiest to set the timer to 33ms and to call it twice to obtain the 66ms interval.

Some well-heeled readers may by now have second processors for their BBC computers, and to achieve compatibility with these I have addressed the user port not directly but with the FX/osbyte calls recommended by Acorn. Page &FE can be written to with A%=151 and read with A%=150.

When a carrier has been received from the remote computer, the program hands control of the line-seize relay over to the modem and lastly calls the user's communications software.

The user can insert his own choice of numbers in the data statements at the end. Dashes, spaces and so on can be included in the telephone numbers if required: the dialler routine will ignore them.

Modem notes

Finally, one or two points left over from last month's article. The receiver section of the Am7910 is very sensitive, in fact much more so than it needs to be for ordinary purposes. Under some circumstances it may show a tendency to detect a carrier when no carrier exists. If this happens, try reducing the signal input at pin 5 by increasing the ratio to R_{61} to R_{67}. The input resistance at this pin is about 50kΩ.

One of the reasons why some of the 1200/75 baud systems I listed may not be compatible with Prestel terminal software is that the Viewdata carriage-return character indicated as '#' is actually the Ascii underline character, number 95. If one of these systems fails to recognise your carriage returns (this applies to part of the Open University system illustrated here), it may be worth trying a control-M instead.

Also in the software department, Computer Concepts now have an updated version of their *Termi* terminal emulator package for the BBC Micro. This incorporates many of the features of the rather more expensive *Communicator* rom. The other BBC rom I mentioned, Pace's *Commstar*, has also been improved: the previous restriction on file-length can now be overcome by spooling direct to, or from, disc.

I should perhaps remind the reader that connecting non-approved equipment to the public network is frowned on by the British telecommunications authorities. The modem described in these articles, being a design for home construction, is not approvable.

Addresses

Computer Concepts, Gaddesden Place, Hemel Hempstead, Hertfordshire HP2 6EX; 0442 — 63933.
Pace Software Supplies Ltd, 92 New Cross Street, Bradford BD5 8BS; 0274-729306.

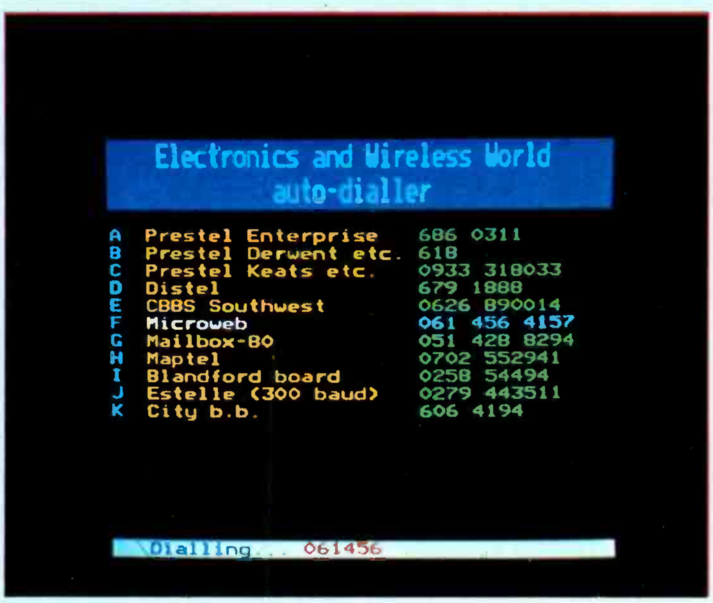
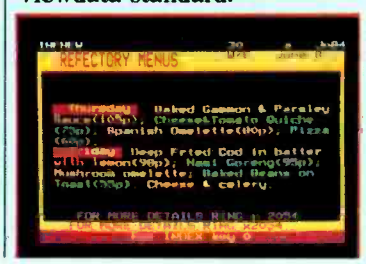


Fig.2. Lunchtime at the Open University. In part, this 1200/75 baud system follows the Viewdata standard.




```
1760 LDY timerhi
1770 LDX #&69
1780 LDA #&97
1790 JSR osbyte    \ load t2c-high byte
1800 .delayloop LDA #&96
1810 LDX #&6D
1820 JSR osbyte    \ read flag register
1830 TYA
1840 AND #&20      \ mask off t2 flag
1850 CMP #&20      \ timed out yet?
1860 BNE delayloop
1870 RTS
1880 ]
1890 NEXT
1900 ENDPROC
1910 REM ++++++++++++++++++++++++++++++
1920 DEFPROCtalk
1930 FORI%=1 TO LEN(dial$)
1940 T$=MID$(dial$,I%,1)
1950 IF T$<"0" OR T$>"9"THEN T$=CHR$128
1960 IF T$="0" THEN T$="0"
1970 SOUND-1,ASC(T$),0,0
1980 NEXT
1990 ENDPROC
2000 REM ++++++++++++++++++++++++++++++
2010 DEFFNmenu
2020 REM seize line
2030 menu%=0:*FX151,96,6
2040 REPEAT
2050   menu%=menu%+1
2060   FOR I%=1 TO 2
2070     READ telephone$(menu%,I%)
2080   NEXT
2090 UNTIL telephone$(menu%,1)="ZZZ"
2100 REPEAT:CLS:J%=0:RESTORE 2250
2110   *FX202,32
2120   REPEAT
2130     REPEAT
2140       J%=J%+1
2150       PRINTCHR$134;CHR$(J%+64);CHR$131;" ";telephone$(J%,1);TAB(24)CHR$132;telephone$(J%,2)
2160     UNTILJ% MOD 16=0 OR J%=menu%-1
2170     REPEAT
2180       key%=GET
2190       IF key%=9 THENkey%=0
2200       IF key%=32 THENkey%=-1
2210       IF key%>32 THEN key%=key%-64
2220     UNTILkey%>=-1 AND key%<menu%
2230   UNTILkey%<>-1 OR J%=menu%-1
2240 UNTILkey%>=0
2250 DATAPrestel Enterprise,686 0311
2260 DATAPrestel Derwent etc.,618
2270 DATAPrestel Keats etc.,0933 318033
2280 DATADistel,679 1888
2290 DATACBBS Southwest,0626 890014
2300 DATAMicroweb,061 456 4157
2310 DATAMailbox-80,051 428 8294
2320 DATAMaptel,0702 552941
2330 DATABlandford board,0258 54494
2340 DATAEstelle (300 baud),0279 443511
2350 DATACity b.b.,606 4194
2360 REM ** Add further data here; **
2370 REM alter line 220 if necessary.
2380 DATAZZZ,ZZZ
2390 =key%
```

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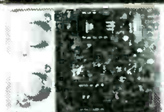

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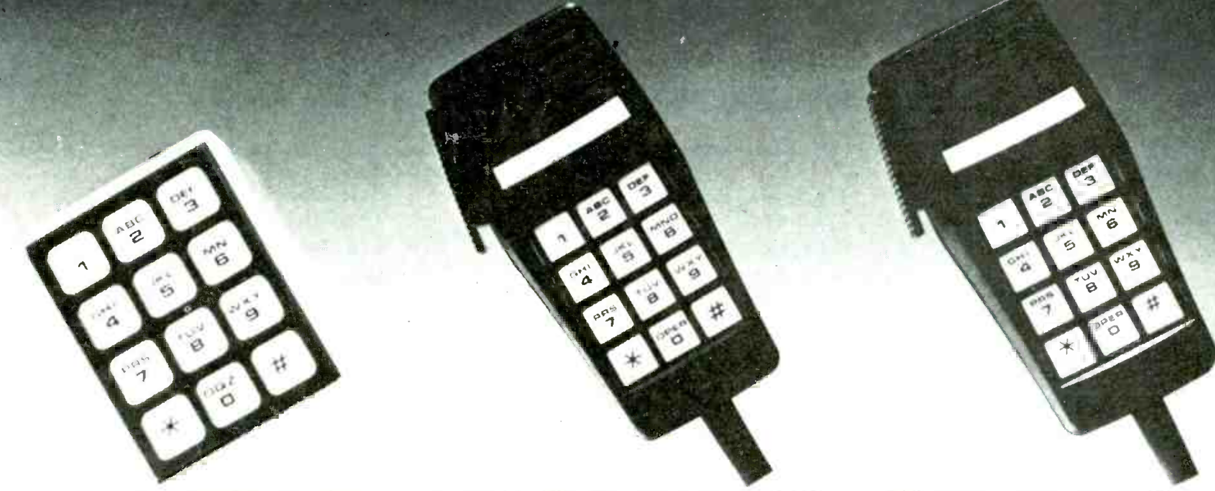

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Digital links

A two-day National URSI colloquium, organized by the British National Committee for Radio Science at Leeds University on July 5-6 attracted some 75 delegates. This was a follow-up to the one-day meeting last year in London under the auspices of the Royal Society and designed to bring together those working in both the pure and applied radio sciences, either in conjunction with the URSI commissions or the CCIR study groups.

This year, the emphasis seemed rather more on the work of such establishments as the Rutherford Appleton Laboratory and by academic staff and research students at British universities. Some 45 short presentations also explored the organization and funding of British research; there seemed much less emphasis that in 1983 on industrial research other than a paper relating to microwave propagation by British Telecom Research, and a survey of 'Monolithic Microwave Circuits' by Dr M.J. Howes (Leeds University).

Of special interest were several papers on current projects aimed at providing more information on wideband propagation of high-speed digital signals. It has already become clear that 140 Mbit/s transmission on terrestrial microwave links is subject to significantly more multipath outages that anticipated a few years ago when, for example, British Telecom made the decision to aim for early digitalization of its main inter-city trunk routes.

A significant number of outages are being recorded on experimental 140 Mbit/s digital links due to anomalous propagation, in particular multipath echoes and selective fading due to tropospheric propagation. The number and duration of outages vary from year to year and cannot be accurately predicted: unlike analogue systems there is no 'graceful' degradation of signals. Deep fades can cause complete loss of synchronization. British Telecom appear to be regretting their commitment to reduced-bandwidth q.p.s.k. digital modulation. In bad selective-fading conditions, two-channel diversity does not overcome the multipath problems. On an experimental link in one day on June 1983 there were 450 seconds of outage in three hours to ducting: diversity did not help.

Interaction between the direct ray, ground reflections and the tropo signal has been shown in Australia to be one of the mechanisms causing deep fading: the combination of direct and tropo signal results in what has been termed defocussing of the main signal, with the result that an antiphase terrain reflection can result in very deep fades. Multipath also results in time-dispersal of the signal, giving rise to intersymbol distortion.

While the practical effects of broadband digital systems have to be seen in perspective. British Telecom have already been obliged to redesign microwave aerials to minimize sidelobes and improve cross-polarization performance. Clearly the rush to digits is not proving easy.

Mobile fading

Mulitpath and ground-reflected signals have long been accepted as a problem for mobile radio communications (particularly for s.s.b.) and v.h.f./f.m. broadcasting.

A recent article by T. Bossert of the German Institut für Rundfunktechnik, Munich (EBU Review — Technical, June 1984, pp.11-116) examines in detail the effects of multipath propagation in built-up areas on car radio reception and outlines a novel form of stereo receiver designed to give optimum protection against multipath disturbances.

This receiver abandons conventional techniques for protection against ignition interference, as these can cause problems under conditions of selective fading. Improvements, however, involve the inclusion of a system based on a parallel a.m. demodulator which automatically and immediately reduces channel separation during deep fades, driving the decoder into a mono mode when the received signal is low. In effect, the de-emphasis circuits are made adaptive, so that the technique can also be used to provide effective suppression of ignition pulses by briefly restoring the de-emphasis to its maximum value during pulses. In order that spurious pulses should not affect the phase of the stereo pilot tone, phased-locked loop decoders are used. Time dispersal of the pulses is minimized by providing sufficient bandwidth to cope with the saturation state.

Such a design, it is suggested, would cope with the frequent signal drops of 20 to 30dB below average level, causing a sudden increase in noise even when the signal remains above the f.m. threshold, caused by selective fading due to the interaction of direct and reflected signals.

Digital h.f.

A $6.5-million order for over 1000 h.f. communications receivers placed by the Canadian Department of National Defence with Rockwell-Collins looks set to initiate an era of digital signal processing in the intermediate-frequency stages of high-grade receivers.

Collins are claiming their HF-2050 receiver as the first production model to adopt digitized i.f., although it is clear that digital designs have been developed elsewhere. At Racalex 82, for example, a number of presentations were made on the application of advanced digital signal processing in receiver, direction-finding and spectrum analysis for radio surveillance, and an experimental digital spectrum analyser was shown.

Collins have not disclosed full details of the HF-2050 but it uses either four of five microprocessors to perform i.f. filtering and frequency conversion, digitizing a 3 MHz signal at 12 million samples per second; after processing, a digital-to-analogue converter with a sampling rate of 16,000 per second provides the a.f. output. The front end of the receiver, other than the frequency synthesizer, remains analogue.

Advantages claimed for digital processing and the elimination of the usual crystal selectivity filters include a 40 per cent reduction in the component count, 30 per cent reduction in board area and enclosure dimensions, a specified mean time between failures of 5000 hours (more than double that of a comparable conventional receiver) and easier manufacture due to the use of more component suitable for automatic insertion.

Key features in any high-performance receiver are the shape factor, dynamic range and time delay ('ringing') distortion of the crystal or mechanical filters. Collins claim the digital filtering results in a major reduction in time delay distortion and variable bandwidths under software control.

Recent years have seen a marked revival of interest in h.f. communications for defence purposes owing to what is now accepted as the greater vulnerability, despite the more consistent signal propagation, of satellite communications. The USA Army have recently placed several development contracts for digitized transceivers.

Amateur Radio

Laboratory tests

In recent years, with most equipment now factory-built, there has been increasing interest in evolving satisfactory methods of evaluating and specifying the performance of equipment based on laboratory measurement. This is particularly difficult for equipment used in the amateur service since the actual conditions under which it may be used can vary enormously. The flexibility of designs, made suitable for several very different modes, has also inevitably introduced compromises that can be less than ideal for the user who may require low-cost equipment for only one mode, but under extremely competitive conditions. It can be argued, for example, that transceivers designed for s.s.b. are seldom ideal for still-popular narrow-band c.w. (morse) operation.

Amateurs have also been encouraged to seek the widest possible dynamic range and strong-signal handling capabilities to counter the signal emanating from h.f. broadcast stations, yet at the same time have come to expect the use of digital frequency synthesizers with their relatively poor spectrum purity. The case for using digital p.l.l./v.c.o. synthesizers on h.f. is not a strong one in view of the phase noise of low-cost designs.

There is a tendency to design equipment that shows up well in laboratory tests, whether or not this is reflected in on-air performance. For example, with measurements conventionally made at 14 MHz, the value at lower frequencies of pre-mixer selectively, formerly provided by up to three mechanically tracked tuned circuits plus oscillator circuit using a four-gang variable capacitor, passes unnoted. Measurements made using two signals space 20 kHz or more apart conceal the considerable reduction in narrow-band dynamic range with signals about 2 to 5 kHz off-tune, rising from the fact that non-linearity of any stage up to and including the product detector can degrade performance. Envelope demodulation in unbalanced product detectors adds to the problem.

For several years Robert Sherwood, WB0JGP of Sherwood Engineering Inc. of Denver, Colorado had been emphasizing that the key to improved receiver performance lies in more attention being given to the gain distribution and the use, if necessary, of narrow-band selective filters in more than one stage of the receiver.

Professional models often use an initial 'roofing filter' but this tends to have a bandwidth of 12 kHz for i.s.b. operation, with a range of more selective filters later in the i.f. chain. Robert Sherwood has shown that the c.w. operator, by fitting a 600 Hz filter as a roofing filter in a Drake R4C receiver can obtain 2 kHz dynamic range measurements (85dB) equal to those at 20kHz, spacing. With some current designs the difference can be over 25dB, Often it is virtually impossible to make narrow-band measurements due to the effect of synthesized oscillators.

Dynamic range is particularly important on 7 MHz due to the continued operation in the 'exclusive' amateur band of Chinese (7010, 7020, 7025, 7085 kHz) and Albanian (7065, 7080, 7090 kHz) broadcast stations. IARU Region 1 societies have been urged to press for the closure of these transmissions.

Under a footnote to the 1979 Radio Regulations, China reserved the right to continue to use non-broadcast frequencies until the establishment and implementation of the h.f. broadcasting plan (due to be agreed at the 1986 WARC). Albania is not a member of the ITU.

Legalities

The coming into force of Part VI of the Telecommunications Act on July 16 gives the DTI new powers to combat spectrum abuse, including seizure of equipment without having to wait for a Court order, even where no criminal charges are brought. However the important sections relating to the 'marking' and 'restriction' of specific types of apparatus still, in early August, await the necessary Orders from the Secretary of State defining the 'restricted' apparatus. It seems likely that the first Order will relate to amplitude-modulated CB transceivers.

An interesting section that has perhaps not received the attention it deserves is Section 78. This inserts a new section 12A into the 1949 Wireless Telegraphy Act empowering the Secretary of State to make regulations imposing requirements 'on wireless telegraphy and related apparatus with respect to their ability to resist interference by rejecting unwanted signals'. Sale of non-complying equipment is made an offence.

In view of the large amount of domestic electronic appliances that is unduly susceptible to local r.f. fields due to ineffective shielding or filtering, there would seem to be wide scope for new regulations. However, for example, it is difficult to imagine the DTI banning the sale of many current types of v.c.r. machines, the new 'electronic' telephones, microprocessor-controlled petrol pumps, etc. etc. For instance, does the 'related apparatus' definition legally include such products? One wonders if anyone has thought through the implications of this Section which could have far-reaching consequences for amateurs faced with e.m.c. problems.

Then again, despite rumours to the contrary, there appears to be no intention of attempting to ban the use by listeners of h.f. transceivers, even where these are installed and ready for immediate use at any time.

A letter from DTI is answer to an enquiry from a listener confirms that the test is 'the use to which the apparatus is actually put' there being no reference in law to the purpose for which the apparatus is designed or its capabilities. The DTI is not concerned that a transceiver may contain facilities for transmitting or for receiving transmissions other than those authorized, so long as it is used only in accordance with the terms of Regulation 3 of the Wireless Telegraphy Regulations 1970. DTI add: 'Indeed if this were not the case it would be illegal to use most ordinary transistor radios without a licence simply because they are capable of picking up transmissions — such as the emergency services — which are not covered by the exemption regulations.'

This all suggests that it will be difficult for the DTI to restrict 'illegal' transmitting equipment by Order if it can also serve a 'legal' purpose.

Packet radio

Several British amateurs are now experimenting with 'packet' high-speed data systems on 144 MHz. A 'packet switching satellite' is also under development in the USA for a possible Space Shuttle launching in 1986.

Packet systems provide high-speed data with automatic repetition of errors, as with AMTOR , but with the advantage that each 'packet' of information is self-contained, including callsigns, so that no two stations require the exclusive use of a channel. Thus, despite the greater bandwidth required for the much higher data rate, many packet stations can share a signal channel.

At present UK licences restrict the use of high-speed data to v.h.f. and above but the system has been investigated on h.f. in North America. If a concession is granted by DTI it would surely be helpful if a precedent could be established in restricting packet operation to specified segments of the h.f. bands. One notes that with growing popularity of electronic (computer-based) and high-speed electronic morse, non-manual telegraphy is at times already occupying almost half of the 14 MHz c.w. band. The use of amateur radio to exchange computer software has attracted unfavourable comment from firms who believe that software copyright may be infringed. In some cases it seems as though home-computer enthusiasts are infiltrating amateur radio rather than vice-versa!

In brief

Watson Peat, CBE, former president of the Scottish National Farmers Union and broadcaster, has become 'national governor for Scotland' of the BBC. He lists his hobbies as 'amateur radio and flying'. In *alter ego* he is GM3AVA and his photograph appeared in a 1982 *Wireless World* article on 'Clandestine Radio' as a young Special Communications wartime operator. Poacher turned gamekeeper?... The FCC have rejected an ARRL petition to keep cable television operators from using amateur-band frequencies but have reminded the cable industry that it has an obligation to prevent and remedy leakage problems affecting radio services... Tom Laidler, VK5TL has related the unfortunate story of the owner of a Yaesu FT7 solid-state transceiver who temporarily replaced a fuse with a piece of wire. Repairs cost 165 Australian dollars, including replacement of two power amplifiers transistors, the driver transistor, audio i.c. device, etc... American amateurs living within 75 miles of the Canadian border have been banned from using 420 to 430 MHz, allocated in Canada to commercial mobile operation... Space Shuttle 'amateur radio' astronauts now include Ron Parise, WA4SIR a NASA scientists due to make his first flight in 1986. Astronaut Anthony England, WORE, due in space next April is to be guest speaker at the Welsh Amateur Radio Convention, Blackwood, Gwent on September 30... A considerable number of RAE courses and a few Morse classes due to start in September in local education centres, etc.

PAT HAWKER, G3VA

first stage of a five stage shift register having its middle and last outputs ex-nored and fed back to its input, starting off at all 0s.

Using such a feedback shift register, 100% sync detection can be effected by comparing the message stream bit serially with the output of the first stage. if there is a disagreement, the shift register is reset to zero; otherwise it is clocked on. If the full sequence is successfully checked the register will reach its last state, which can be detected with a five-bit and gate and used to set a start-of-block flag. The flag then inhibits the shift register.

Byte counting: the block flag releases a byte/block counter. Every eighth count signals that a byte is available, and when the counter matures at 8 × 512 = 4096, the block flag is cleared and sync code testing resumes.

Outputs: parallel data output is buffered to t.t.l. level, and consists of an eight-bit byte, positive-going mid-bit strobe, and the block flag. These are brought out to a 20-way p.c.b. connector. Pin-out is compatible with the BBC microcomputer user port, which will also provide a 5V supply for the output buffers.

The optional serialiser gives an RS232-type output at 5 volts, 1200 baud, with one start, eight data and many stop bits (50 characters per second). This could be used to drive a printer direct, but the hexadecimal, non-Ascii data with Q blocks will cause unpredictable results — weird characters and reams of waste paper! using a v.d.u. or the serial port of a computer is tidier.

Circuit notes

The complete circuit diagram is shown in Fig. 9. A printed circuit board is available[2,5] all other parts may be obtained from RS Components.

A half V_{dd} bias is incorporated to 'float' the op-amps. The 12V supply is not especially critical.

There is no channel filter built into the design because the receiver will provide one. The simple limiter IC_{1a} will be effective on a few millivolts of signal. The meter circuit (IC_{1b}) is primarily intended to aid tuning; but with an external switch S^1 it can be used to monitor other signals, in particular the state of lock of the two p.l.l.s.

The main p.l.l. IC_3 runs at 16 times the carrier frequency. This drives a four-bit shift register IC_5 to give a quarter-cycle delay. The v.c.o. IC_3 is followed by a divide by 16 counter IC_4 and some logic to generate the local Q:2f signal and the recovered carrier CarR which translates the signal to baseband in IC_{2a}. The loop bandwidth is 10Hz; component values for other bandwidths are shown in the table.

Extraction of the 400 Hz clock is similar to the carrier loop; the v.c.o. IC_7 runs at 6400Hz and has a 1Hz loop bandwidth. Note the additional quarter-bit delay IC_{9b} which provides the overall half-bit delay needed for the ClkR ambiguity resolution performed by $IE_{16a,c}$ and R_{13}/C_{14}. The clock extraction circuits were originally devised for a Uosat data demodulator[3] and the integrate-and-dump IC_{1c}, IC_{11}, and IC_{12a} is taken from that source too.

The block sync code detector consists of the feedback shift register code generator IC_{14}, IC_{15c} and a final state (00001) tester $IC_{16a,c}$. The shift register is released when the block bistable IC_{19a} is clear. Incoming data (bit D_0) is tested against the code generator in ex-or gate IC_{15a}. A high state indicates a disagreement, and a $\overline{Clk}$ pulse resets the shift register.

If the shift register reaches its last state, a Clk pulse at and gate IC_{17d} sets the block bistable IC_{19a}, which also lights a led. The shift register is reset and inhibited, while the bit/byte counter IC_{20} is released.

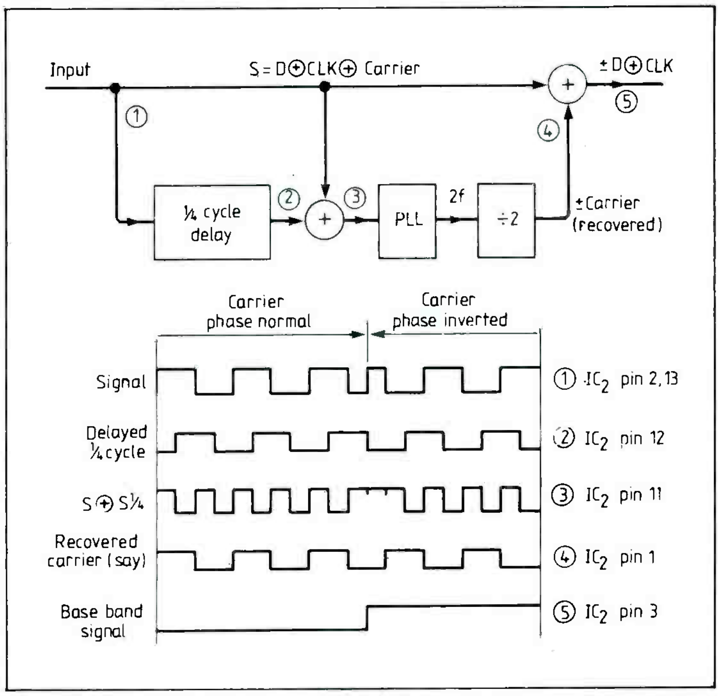

Fig.6. **Carrier recovery and conversion to baseband. Clock recovery is identical: simply add 4 to the i.c. numbers.**

Every eighth count generates a positive, mid-bit byte strobe from the shaper circuit IC_{18c}. This pulse signals external equipment to read the byte in buffer IC_{13} via buffers IC_{21} and IC_{22}.

The optional serialiser works as follows. The rest condition has the start bistable IC_{24b} permanently clocking out 'stop' which is cascading through from the shift register DS input, IC_{25} pin 11. When the decoder has a byte ready, byte strobe sets the control bistable IC_{24a} pin 1 to 'load'. This prepares the start bistable IC_{24b} to go to 'start' and the shift register IC_{25} to load with bits D_0-D_7 from the decoder buffer. This

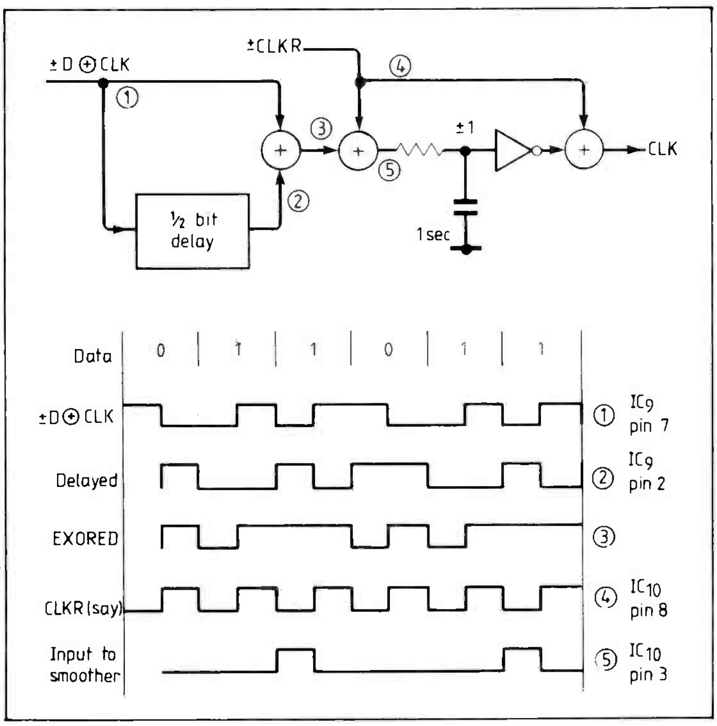

Fig.7. **Resolving clock ambiguity: input to the smoother results in a net low on the capacitor, so ex-or inverts ClkR to the correct phase, Clk. If Clk had been correctly phased in the first place, then the capacitor would hold high and ex-or would not invert.**

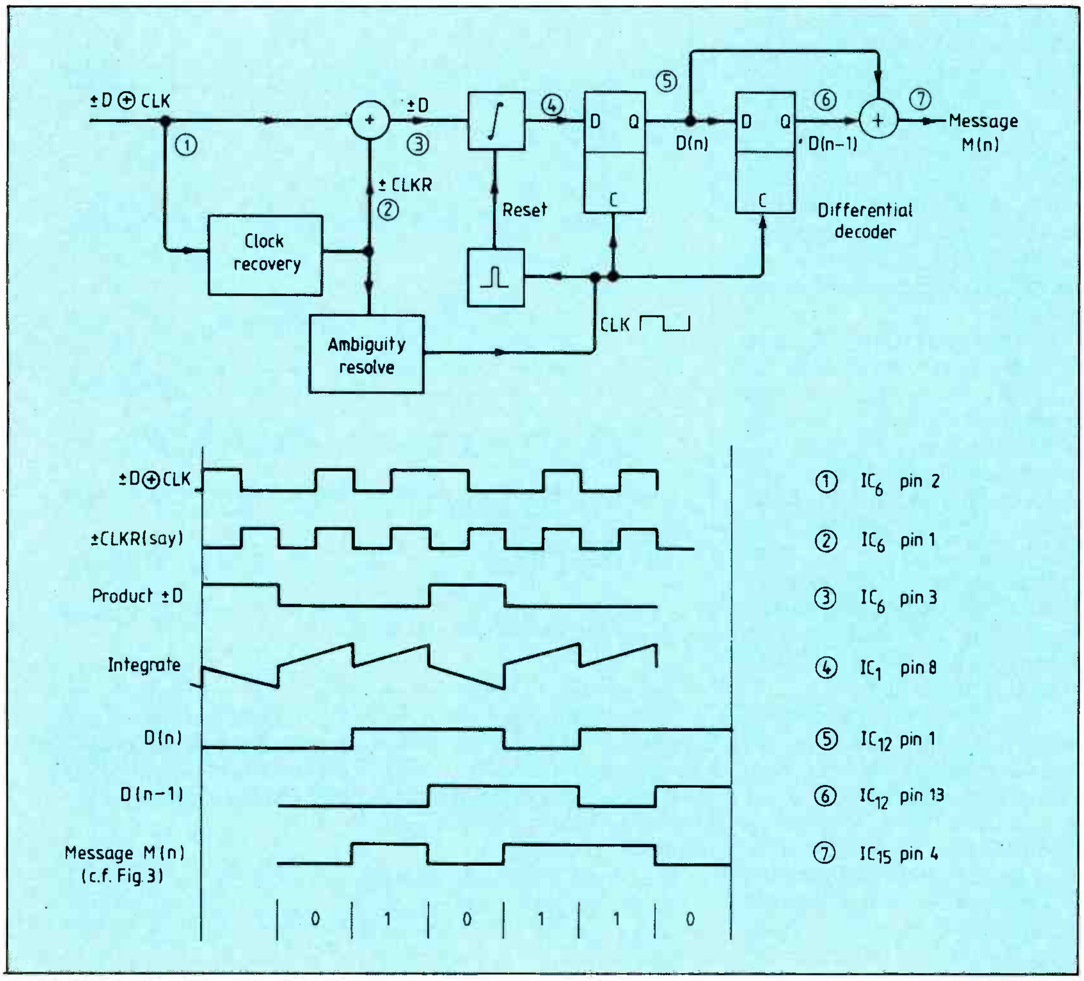

Fig.8. **Message recovery: with noise present, the product ±D will be perforated and the triangles in trace 4 will become ragged. The differential decoder compares present data with the previous bit: if they are the same, the message bit is 1, if different 0. Thus the polarity of data is unimportant.**

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1. Davidoff, M.R. The Satellite Experimenter's Handbook, American Radio Relay League, 1984. (from Amsat-UK or the Radio Society of Great Britain.)
2. Amsat-UK, London E12 5EQ, England. Oscar-10 Operating Manual, £3; The Satellite Experimentor's Handbook £9.90 (members £8.50); Oscar-10 telemetry test data tape, £6 (members £5); telemetry decoding software for the BBC microcomputer, on cassette £6 (members £5); p.c.b. £15. Prices include packing and UK postage; overseas postage costs extra. A stamped addressed envelope should accompany *all* enquiries. Amsat-UK depends on donations.
3. Miller J.R. Data Decoder for Uosat, *Wireless World*, May 1983.
4. Viterbi, A. Principles of Coherent Communication, McGraw-Hill 1966.
5. A good quality double sided, legended, plated-through, printed circuit board is available for £15 including packing and UK postage, from the author at 3 Benny's Coton, Cambridge, CB3 7PS, England, (or from Amsat-UK).

happens on the next high-going edge of 1200Hz clock, which also clears the load condition. Subsequent 1200Hz clock pulses shift the data out of the serialiser.

Outputs have the following conventions: the parallel data output byte is 1 high, 0 low. D_0 is the least-significant bit. 'Block' is high true. Byte strobe is a high going 20 microsecond pulse, and begins mid-bit.

The serial 1200 baud data format is Start and Data 0 high, Stop and Data 1 low, eight data bits, l.s.b. sent first. The 1200 baud square-wave clock goes low mid-bit. Note that not all data is Ascii, in particular the last 256 bytes of Q blocks.

400 bit/s serial data and Clk may be selected as the serial output by changing link D and link C. Square wave Clk goes low mid-bit. The data is *not* in start/stop telegraphy format.

Setting up

An audio generator, oscilloscope and multimeter will be needed. A telemetry data test tape will be invaluable: this can be recorded off-air or obtained via Amsat-UK[2]. The satellite itself can be used for live testing, but is not always available when you want it. The signal is also noisy, which may confuse matters.

Receiver: the first job is to decide what carrier frequency will be used. Trigger the scope at 200Hz (or 50Hz if available), tune the receiver to Oscar-10's beacon and display the audio. Amplitude modulation should be discernible. Experiment with tuning and bandwidth until the signal looks healthy with the mid-bit cross-over clear and sharp. Now trigger the scope with the signal, estaimate and note the carrier frequency, say f_c. Any frequency exceeding 800Hz will be satisfactory.

Carrier Loop: the objective is to set the loop mid-frequency to the measured carrier frequency (f_c) and achieve a total frequency swing (f_{sw}) at the output of the divide-by-16 (TP1) of f_{sw} = 800Hz. This is slightly complicated by the fact that a 4:1 spread in oscillation frequency between different samples of a 4046 v.c.o. is quite typical.

Start with the v.c.o. swing, nominally given by $f_{sw} = 1/(R_7 \times C_{10})$. Apply V_{dd} and then 0V to pin 9 of the p.l.l. chip IC_3, measure high and low frequencies at TP_1 and subtract. If the difference f_d, is within 25% of 800Hz, then all is well. Otherwise, change C_{10} pro rata for the correct swing.

Calculate and note the desired v.c.o. upper frequency, $f_u = f_c + f_d/2$. Again, connect V_{dd} to pin 9 of the 4046. With the main tuning potentiometer VR_3 at mid-position, adjust trimmer VR_2 to give frequency f_u. If this cannot be achieved, then change C_{10} and R_7 (in inverse proportion to each other, so as to preserve f_d) and start again.

Now inject f_c at the audio input. Check that the loop locks on this signal. The lock meter should indicate to one side. Slightly vary the input frequency and the main tuning control VR_3 and observe the tuning meter centre-zero response. The loop should stay in lock over a range of $\pm f_d/2$.

Clock loop: in the same way as for the carrier loop, check that the available frequency swing at TP_2 is about 100Hz in total. if necessary, change C_{12} to achieve this. Then adjust VR_4 so that the mid-frequency is 400Hz.

Temporarily ground IC_{2a} pin 1. Inject 400Hz at the audio input. The loop should lock up correctly; this will show on the lock meter. Next inject 200Hz, which simulates data 010101... (message 11111....). Verify that the loop locks again. Examine the ambiguity signal at IC_{10d} pin 12. This should be either high or low and should not dither about $V_{dd}/2$. Now examine the Clk signal at IC_{10c} pin 10. The low-going edges should coincide with the transitions of the input signal.

Disturb loop lock a number of times by removing the 200Hz input signal for a few seconds. Each time this is done the ambiguity signal will assume a random state, but Clk should always resolve itself to the correct phase.

$V_{dd}/2$ supply. Remove the temporary ground from IC_{2a} pin 1. Apply receiver random noise to the system input. Connect an analogue meter (on volts d.c.) across pins 1 and 2 of the bistable IC_{12a}. Adjust the half-supply control VR_1 for zero reading.

Decoding. The system is now adjusted and may be checked out live or with a test tape.

To be continued

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For use with any BBC Micro 'B' with 1.2 MOS or later issue.
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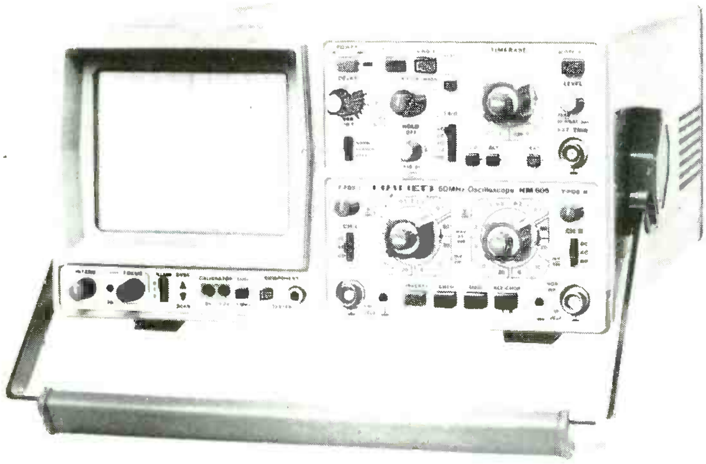

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CIRCLE 40 FOR FURTHER DETAILS.

D.C. Supplies from A.C. Sources

by K.L. Smith, P.h.D.*

Linear supplies — the transformer

Late last century the great battle between Edison's d.c. distribution system and Tesla's proposal to use a.c. was decisively won by the proponents of the a.c. system. The surprise (to the writer, at least) was how widespread d.c. mains supplies were in Britain, even after the second World War. I can remember during one of my first jobs as a youth, running around with a rather grumpy old van driver visiting numerous East London dwellings, collecting old d.c. radios and radiograms, 'for conversion to the new a.c. mains being installed...!'

The one device that ensured success for the a.c. system was, of course, the static transformer. This device, with up to 98% efficiency of conversion (on large sizes) enabled voltage level changes to be carried out with such ease that all argument from the opposition fell on deaf ears. Only the frequency and final voltage of the supply and decisions about number of phases were left to argument: as is well known we ended up with 230 volts r.m.s. at 50Hz for the normal single phase supply — and the Americans with 115 volts at 60Hz. From here on, our tiny transformers come into their own.

Small power transformer l.f.

Many authors on this subject have stated that after a user has ordered a transformer to yield the required voltage output at the appropriate VA rating, a heavy item turns up — much too big, or else one that gets far too hot and might affect the circuitry nearby. Many designers simply state that "I glance at a similar design, note the transformer size, then ask for one to be made about the same size".

This a very hit-and-miss approach and one's feeling is that there must be a slightly better way of arriving at the volt-ampère rating and turns-per-volt requirement on the copper side, together with an appropriate area and weight of iron. (There ought to be, since we possess experience going back to 1831!)

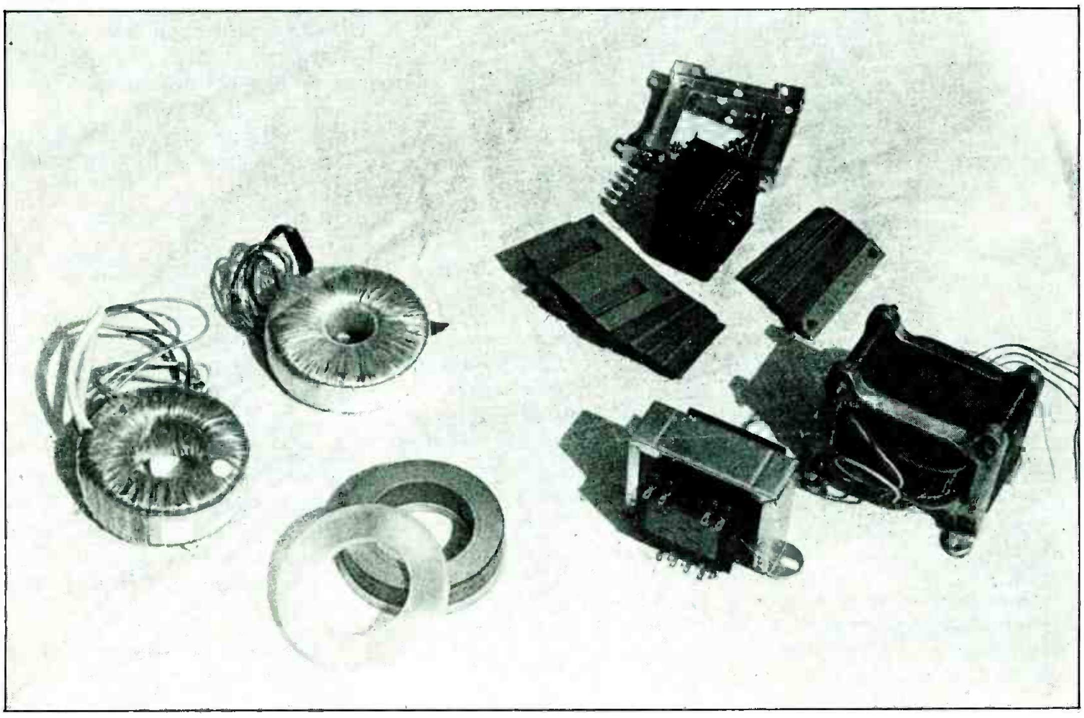
Nevertheless, transformer design does seem to be as much an art as science — with those 'rules of thumb' thrown in. The commercial field seems to have a number of small firms networking in the production of various 'lines' — with a slick business in 'lams' and 'bobbins' going on between them...

The fashions have changed too. It was not long ago that primary and various secondary windings were piled one on top of the other, with paper inter-leaving between layers and electrostatic screening between windings. Much more common now is the sectional bobbin of moulded plastic with random windings in side by side sections. Modern wires are much more tough, with polyurethane* enamels on them. This may account for the more direct winding. Also, electrostatic screens have decreased in use, on the grounds no doubt, that interwinding capacity is now

*e.g. 'Covar'

*University of Kent at Canterbury

Fig.1. **Typical small transformers found in domestic and laboratory electronic equipment. From left to right; (a) a 50VA toroidal transformer from ILP Electronics; (b) a similar device with the same rating produced by Cotswold Electronics; (c) E and I laminations and the part-wound core available from RS Components for your own secondary design, winding and assembly — also rated at 50VA; (d) an assembled transformer on what would appear to be the same lamination size as (c), kindly supplied for test by Clairtronic; (c) the author's 'home made' 60VA step-down transformer, the design of which is discussed in this article. Later, some experimental temperature rise curves are given for these transformers with their rated throughput load applied. Also shown is a typical rolled-strip ('clock spring') silicon steel core for the toridals.**



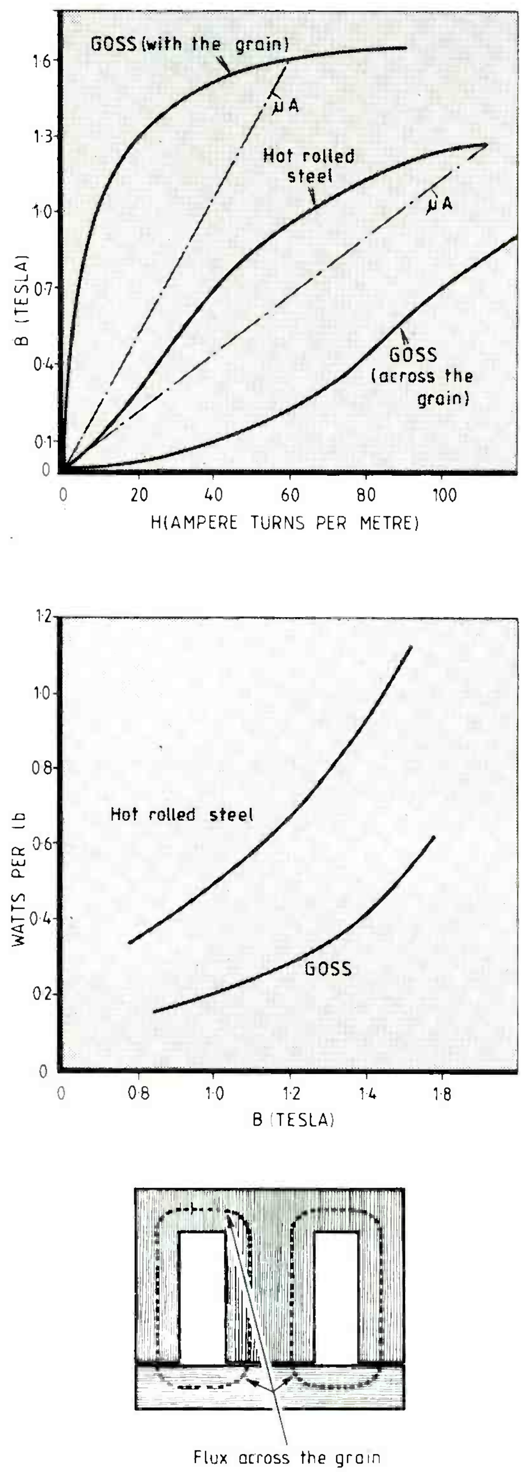


Fig.2. **The advantages of using grain oriented 3 silicon cold rolled steel (goss) with the flux in the direction of the grain, is well brought out in (a) which shows the small magnetizing force required to reach the high flux density (~1.6 tesla) before saturation sets in. (b) illustrates the lower watt-loss per pound weight of core because of hysteresis and eddy current dissipation. For comparison, the performance of 'ordinary' lamination material, 4% silicon hot-rolled steel, is shown to be inferior on both counts. The performance of goss with the direction of the flux across the grain is worse than either — a difficulty with laminated cores where some steel must be in the non-preferred direction, see (c).**

much less. Recently, many problems of winding toroidal transformers appear to have been overcome and glowing claims are made for their performance.

Designing small transformers

An essential point is to get all the magnetic flux produced by the primary to link with the secondary. To do this, a low-reluctance magnetic circuit common to all the windings is necessary. The high permeability core making up this magnetic path means that only a relatively small magnetizing current I_m is required to produce a magnetizing force H amps per metre, sufficient to generate a near-saturation flux density B teslas, according to $B = \mu H$, where μ henries per metre is the permeability. of course, it is well known that μ for iron is anything but constant, so there are problems. For instance, the initial permeability μ_i is different to the amplitude permeability μ_a. For power transformers, the value of μ_a is the appropriate one. The variable μ means that the magnetizing current ceases to be sinusoidal, even though the voltage across the winding remains so. usually this distortion can be neglected. Of some interest is that although the current distortion means harmonic generation, if only a sinusoidal voltage is present there cannot be any power in the harmonics, as there are no corresponding in-phase voltages to multiply by I_m is relatively small for large transformers, but can be as much as 30% of the load current in small examples, up to a few tens of VA rating.

The start of transformer design rests squarely on Faraday's law:

$$E = 4.44\Phi N f$$

for a sine wave supply, see Appendix.

E is the induced voltage, Φ is the maximum allowed magnetic flux in webers, N is the coil turns and f is the requency in Hz. Therefore for a constant Φ, a higher frequency means less turns for a given E. That is one reason why high-frequency switching supplies and inverters have such small wound components for a relatively large VA. $\hat{B}$ is the *flux density*, Φ/A_{core}

Iron core and turns-per-volt. $\hat{B}$ depends on the iron chosen for the core. Hot-rolled iron laminations might reach 1.3 teslas. 4% silicon steel with aligned grain can be taken up to 1.6 tesla before saturation sets in. But laminations stamped out of this material might have up to 40% aligned in the wrong direction (see Figure 2) and 1.3 tesla might be all that can be reached again.

I remember using the rule, 'one square inch of core needs 8 turns per volt — together with $T^2 = \sqrt{VA}/5.38$' This expression is that given by Langford-Smith[1] and relates the (square) limb section of side length T (inch), required for the VA rating. You might ask at this point, 'What about the ferrite materials now available?' Unfortunately they have a low saturation flux density, about 300 milliteslas and only start to come into their own at high frequencies. At low frequencies, modern steels allow a performance a little better than the above expression predicts.

From Faraday's law at 50Hz and a flux density of 1.3 teslas we have:

$$E = 4.44 \times 1.3 \times T \times S \times 50 \times N \times 0.9 \times 10^{-6}$$

$$\text{or } \frac{N}{E} = \frac{3.47 \times 10^{-3}}{T \times S \times 0.9 \times 10^{-9}}$$

$$= \frac{3.86 \times 10^{3}}{T \times S} \text{ turns per volt.}$$

In this equation, T is the tongue width, S the stack height, in millimetres. For a limb cross section 645 mm^2, $N/E = 6.0$ turns per volt, which is rather less than the 8 turns per volt required on the old 1 sq. in cores with a maximum B of 10 000 gauss (= 1 tesla). The '0.9' originates in the 'stacking factor' or reduction in iron area because of the insulating layer on the lamination.

Volt-ampere rating. Exceeding the $\hat{B}$ for the iron will result in a peaky distorted current wave and high I_m (r.m.s.), with subsequent large heating loss. The 'copper loss' varies with load current as expected, but the iron losses remain constant for a given $\hat{B}$. This is because the flux remains constant in the core, on or off load. If a load current is drawn from the secondary, a flux is immediately set up in the core by the secondary ampere-turns, but an opposite current (with equal ampere-turns) appears in the primary to cancel it. The greater the secondary current, the more the primary current: so Φ remains constant. Arguments are often made for equalizing the iron and copper losses at full load, but this condition may not be optimum for core-saturation-limited operation. Small mains transformers are often designed for copper-to-iron loss ratios of about 2 or 3 : 1.

Maximum current in the winds is set by the allowable copper loss heating effect (and as we have just seen, the smaller contribution from the hyteresis loss in the core). Small transformers lose heat more readily that large devices (that is, the surface-area-to volume ratio is favourable in the small ones). For transformers up to about 100VA, a current density of 3.1 amps per square millimetre is satisfactory in the copper. For larger designs (to ~700 VA) a density of 2.3 Amm^{-2} is assumed. For a few kVA, 1.6 Amm^{-2} is a common figure, unless special cooling, such as oil filling or forced air cooling, is used. The Appendix includes a justification of these values.

In all cores, there is an available 'window area' to take the windings (including the central hole in a toroid). The fraction of this space actually filled with copper is called the *filling factor*, F_W, which can be surprisingly small and is even worse in toroids where the winding shuttle has to link the window right up to the last turn.

Typical E and I laminations still used for open-frame transformers are based on 'no-waste' dimensions, where the I_s are punched out of the window in a pair of Es. If we use general dimensions for the moment, as defined in Fig. 3, then the window area is L × H mm^2. The thickness of the bobbin and insulation takes up about 0.8 of these dimensions, so the available window area is 0.64LH. A strict application of BS800 regarding 'creepage' would reduce the available window area even further in small transformers. Under this standard, 8 mm (4 mm each end) must be left between the mains voltage windings and 'user accessible' windings and/or 'dead metal' (core). Even the less stringent IEC380, 435 or VDE 0730 specifications (3 mm creepage clearance) would make a large reduction in area — especially in very small (high-frequency) transformers.

If the earlier neat layers with paper interleaving method of winding is used, then the situation shown in Fig. 4(a) applies. Each turn takes up a cross sectional area of D(d′+p). The linear winding length per turn D is usually taken as 1.11 times the overall diameter d′. Paper thickness is about a third of the wire diameter, therefore p = 0.33d′ and the copper diameter ranges between 0.9 and 0.935 times the overall diameter, according to the gauge and relative thickness of enamel. Therefore, the area taken up per turn is

$$1.11 \times \frac{d}{0.9} X \left(\frac{d}{0.9} + \frac{0.33d}{0.9}\right)$$

$$= 1.82d^2$$

The area of copper available to carry current is $\pi d^2/4$, so the ratio of copper area to winding area is:

$$\frac{\pi d^2}{4 \times 1.82d^2} = 0\text{-}432$$

But the window area is already down to 0.64LH, which means that the total copper area is 0.64 × 0.432 × LH = 0.276LH. You can see this is much less than half.

Random winding improves this by about 1.25 times. Without interleaving paper, the wire tends to lay according to Fig. 4(b) and the area taken up per turn is about $d'^2\cos 30°$. The ratio of areas now becomes

$$\frac{\pi(0.9)^2}{4\cos 30°} = 0.735.$$

The improvement will hardly be more than 80% of this in practice, therefore a factor of 0.735 × 0.8 = 0.59 can be taken as 'near the mark'. 0.64 of this is 0.38, which is some improvement on 0.276.

For efficient operation, half the copper is arranged to be taken up by the primary and half by the secondary winding, because the VA handled under load is nearly equal in each winding. Thus the area of copper to apportion to the primary becomes 0.19LH. The 0.19 could be termed the *half winding filling factor*, $F_{W/2}$.

If you think about it, we now have the volts per turn from Faraday's law and the total current in one 'filled turn' of primary copper, so that the VA handling capacity is now known from:

VA = ampere-turn × volts per turn

$$= \frac{I_d F_{W/2} LH \times 4.44 B_m}{TSf \times 0.9 \times 10^{-6}}$$

VA is therefore proportional to the current density attained in the copper, the filling factor, the window area, maximum flux density in the core, the cross section of the central limb and the frequency of the a.c. supply. In particular, VA is proportional to the product of the iron and copper areas. As an example, the 'no-waste' laminations working at 1.3 teslas and 50 Hz with $I_d = 3.1$ Amm^{-2} the VA is:

$$VA = 4.44 \times 1.3 \times 50 \times 3.1 \times 0.19 \times 0.9 \times 10^{-6} \times LHTS$$

$$= 1.53 \times 10^{-6} \times LHTS$$

'No-waste' laminations have dimensions as shown in Fig. 5 related as, L = 1.5T, H = 0.5T and for a square section core, S = T, so that

$$LHT = 0.75T^4$$

$$\therefore\ T^2 = \frac{\sqrt{VA}}{1.07 \times 10_2}$$

Entry in Faraday's notes, dated 29 August, 1831.

1. **Expts. on the production of Electricity from Magnetism etc. etc.**
2. **Have had an iron ring made (soft iron), iron round and 7/8 inches thick and ring 6 inches in external diameter. Wound many coils of copper wire round one half, the coils being separated by twine and calico — there were three lengths of wire each about 24 feet long and they could be connected as one length or used as separate lengths. By trial with a trough each was insulated from the other. Will call this side of the ring A. On the other side, but separated by an interval, was wound wire in two pieces together amounting to about 60 feet in length, the direction being as with the former coils; this side call B.**
3. **Charged a battery of 10 pr. (pairs of) plates 4 inches square. Made the coil on B side one coil and connected its extremities by a copper wire passing to a distance and just over a magnetic needle (3 feet from iron ring). Then connected the ends of one of the pieces of A side with battery; immediately a sensible effect on needle. It oscillated and settled at last in original position. On breaking connection of side A with battery again a disturbance of the needle.**
4. **Made all the wires on side A one coil and sent current from battery through the whole. Effect on needle much stronger than before.**

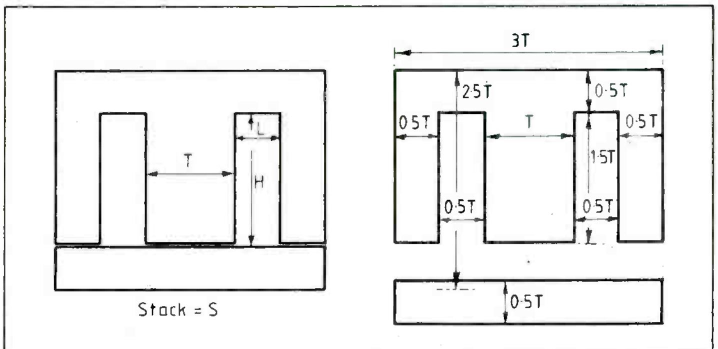


Fig.3. **Typical 'core'-type lamination shape for small transformers. The 'T' and 'U' form has virtually disappeared.**

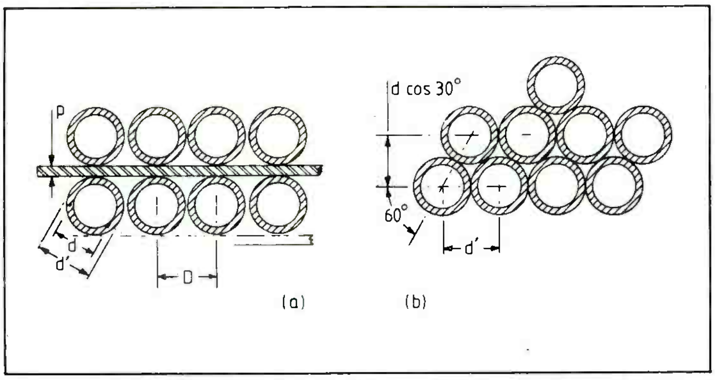


Fig.4. **The 'lay' of winding turns shown in (a) takes up most space. The increased toughness of modern wire enamels indicates that 'random lay' or the method more resembling (b) might be seen in contemporary transformer design.**

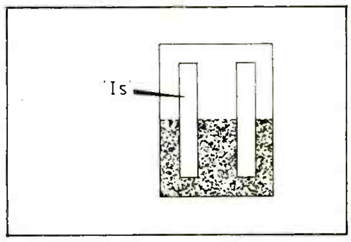


Fig.5. **Nearly all available laminations of the kind shown in Fig.3 have relative dimension as shown here. The 'Is' are punched out of the window spaces in a par of 'Es', hence the term 'no-waste' or 'scrapless' describes them.**

Fig.6. **The temperature rise of transformers means that designers have to keep a close eye on the insulation materials, as well as the effects inside enclosures — on other circuit components, etc. The author carried out the measurements shown here, and certainly found that the toroids dissipated less heat than the open frame transformers.**

where T is the limb width in mm*

Size and weight. 50 and 60 Hz mains transformers are bulky items. Because of this interest arises in the way linear size and weight vary with VA rating.

If A is a cross sectional area of either copper or iron, then the linear dimensions vary as $A^{\frac{1}{2}}$. As shown above, VA varies as A^2, which means VA rating varies as the linear dimensions to the 4th power. More relevant (usually) is the weight, as this sets the cost and whether we can lift the equipment!

Weight varies as the cube of the linear dimensions:

$$\text{weight} \propto (A^{\frac{1}{2}})^3$$
$$\therefore \quad VA \propto A$$
$$VA \propto (\text{weight})^{\frac{4}{3}}$$

*Converting this result to inches, $T^2 = \sqrt{VA/6.9}$, which is somewhat 'better' than Langford-Smith's result. This means that 1sq.in core area using modern 'no-waste' iron can handle nearly 50VA, which is a value suitable for small laboratory power supplies. The two commercial laminated transformers in Fig.1 both use exactly this core stack and they are rated, 'Max load 50VA by the makers.

Thus if VA is doubled, the weight must be increased by a factor $2^{\frac{3}{4}}$ = 1.68, in other words, by 68% — other parameters remaining constant.

What limits performance?

The hint so far is that magnetic saturation limits the power throughput of a transformer, given the core cross section. This is only true over a certain range of frequencies, including the mains frequency we have discussed.

Energy lost as heat in cycling round the hysteresis loop of the core material is proportional to the area of the loop. Core material for a.c. use should therefore, have thin loops. This effect predicts that the power dissipated in a core should increase with the frequency.

Some time ago, Steinmetz derived an empirical relation between core loss, frequency f and the peak flux density in the core, $\hat{B}$. He found:

$$\text{Core loss (watts)} \propto f\hat{B}^n$$

where n lies between about 1.9 and 2.9 according to the material. Now for a given sine of square-wave voltage drive and core:

$$\hat{B}N \propto \frac{1}{f}$$

where the peak value of the flux density is that for maximum allowable temperature rise. These relationships indicate that for a fixed core loss $\hat{B} \propto 1/f^{\frac{1}{n}}$ so that as the frequency is lowered, both $\hat{B}$ and N will have to be increased to maintain core losses constant. At relatively high frequency the core losses will be limited by the maximum allowable value of $\hat{B}$, and we are in the *core loss limited* region. Looking at the division of losses between core and windings gives designers a degree of freedom regarding choice of greatest efficiency, or least volume for a given throughput of power — and so on.

As the frequency is lowered, $\hat{B}$ goes up on the B-H curve towards the saturation level, $\hat{B}_{sat}$. If the core is driven into saturation, the primary current will rise rapidly at the peaks. At frequencies lower than $\hat{B}_{sat}$ the transformer is designed such that it is *saturation limited.* This means that the number of turns N has to go up inversely with f to keep $\hat{B}_{sat}$ constant, and the winding loss will increase. The total power loss will still set the temperature rise and is the limiting factor in the design.

At the very lowest frequencies, the leakage inductance and high resistance of the large number of turns required for the voltage, mean that temperature rise is no longer the major issue. The *regulation* requirements take over and the transformer design is then said to be *regulation limited.*

Practical example

It is always salutory to carry out construction of something to see if the design theory works.

Some nondescript 'T' and 'U' stampings that had been 'put away in case they might be useful' were pressed into service. They must have gone back to the 1930s, considering the old choke they had come from. The material for the stampings was probably Stalloy. A fairly low maximum flux density was decided upon for this poor old iron.

The design proceeds as follows:

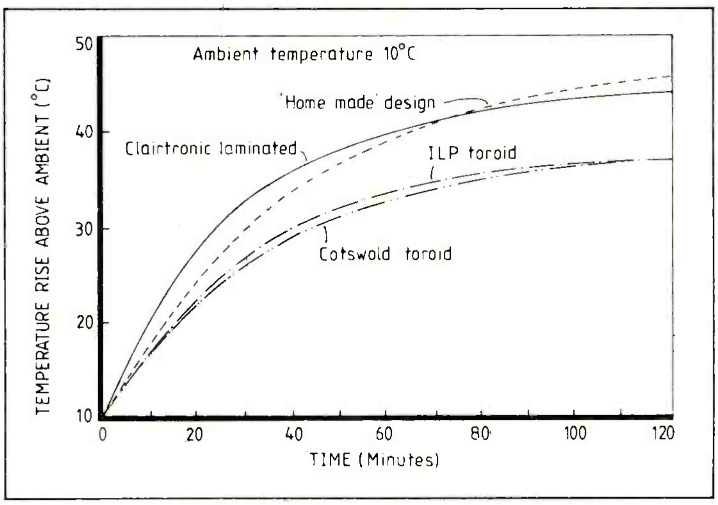
T = 24mm
S = 39mm
L = 28mm
H = 22mm

with a stacking factory of 0.9. The geometry was far from 'no-waste'. B was taken as 1.0 tesla and current density was assumed to be 3.1 Amm^{-2} in the copper at full load.

Volt-ampere rating. Inserting the values into the VA equation gives:

$$VA = 4.44 \times 1.0 \times 50 \times 3.1 \times 0.17 \times 0.9 \times 10^{-6} LHTS$$

$$= 61\ VA$$



Turns per volt. On putting the values into the formula:

$$\frac{N}{E} = \frac{1}{4.44\times1.0\times50\times0.9\times10^{-6}\,TS}$$

$$= 5.3 \text{ turns per volt}$$

Therefore 5.3 × 230 = 1219 turns are required on the 230 volt primary. The ampere-turns to yield 61VA is $1/5.3 \times NI_p$ or NI_p = 323 ampere-turns. This shows that the current at full load in the primary winding is given by:

$$\frac{323}{1219} = 265 \text{ mA}$$

Assuming that the magnetizing current is ~ 30% of this, then I_m = 80 mA as I_m flows at all times and is in quadrature with the load current, the total current at full load is $\sqrt{I_{load}^2 + I_m^2}$ = 275 mA.

30 s.w.g. copper wire has a current-carrying capacity of 242 mA, at the density assumed here. This is a little on the low side but was nevertheless chosen, (i.e. was on hand...)

Does it fit? The area available for the copper of the primary is 0.17LH, in other words, 105mm². Enamelled 30 s.w.g. wire has a copper diameter of 0.315 mm and the cross sectional area of 1219 turns is 95 mm², within the 105 mm² area available. From the earlier ideas about winding factors, the overall winding area required is about 1.11 × 0.35 × 0.35 × 0.8 × 1219 = 132.6 mm². Again, well within the geometry available.

For a 'lab supply' range I chose two 15 volt secondaries. Each can carry 2A for the projected VA. 20 s.w.g. is just right for this. The number of turns for 15 volts works out at 5.3 × 15 = 80. The 160 turns of 20 s.w.g. has a copper area of 105 mm². The overall winding area required is calculated as before — 1.11 × 0.98 × 0.98 × 0.8 × 160 = 136.5 mm²

These figures shown that about half of the copper — and the corresponding winding area — is taken up by the primary, the other half by the secondary, as required. The inside bobbin dimensions are about 0.7H and 0.8L, so that the geometrical area available is 0.7 × 0.8 LH = 345 mm². Half this is 172 mm², which indicates a comfortable margin in the window. With some satisfaction, the windings were built up to these predicted values.

The magnetizing current was measured as 89 mA, and the temperature rise on load is shown as curve (b) in Fig. 6.

Toroidally-wound transformers

These go back to Faraday's original shape — although he did not use a.c. drive, and therefore paid no attention to eddy current problems in a solid core. They do have advantages over the open-frame designs, mainly because grain-oriented steel can be used in its 'preferred' direction all the way round the magnetic circuit. The air gap where flux has to cross core members still exists (the core is a spiral...) but is now distributed and has hardly an effect on the reluctance. The magnetizing current is small and the flux density large (~1.6T), so a smaller device for the same VA should be possible. The multi-winding advantage of laminated transformers, has now switched to multi-winding of the cores. The individual laminating in the one has become individual winding of the other. It is this mastery of toroid coil winding that has made them economically viable recently. To see the coil shuttle going through the closed toroidal core and the turns rapidly advancing round the circumference, is a fascinating sight.

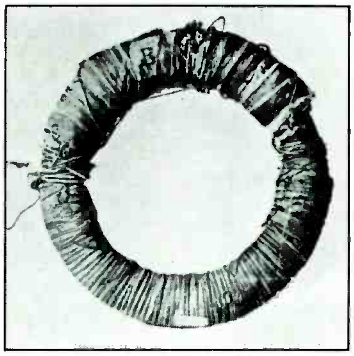
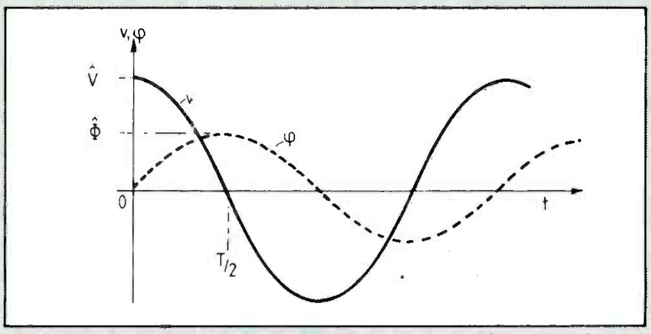


Fig.7. **Faraday's 'ring' (toroidal) transformer — 1831.**

Appendix

Voltage induced by changing magnetic flux

A look at Faraday's Law, $e = N d\phi/dt$ shows us that an applied voltage e is equal to the rate at which the magnetic flux changes ($d\phi/dt$), through a coil of N turns.



If you glance at Fig. A1, this relationship is shown for sinusoidal variations. The flux has a peak value $\hat{\Phi}$ and changes at a frequency f Hz as

$$\phi = \hat{\Phi}\sin\omega t$$

The rate of change of this is

$$\frac{d\phi}{dt} = \omega\hat{\phi}\cos\omega t$$

So e is

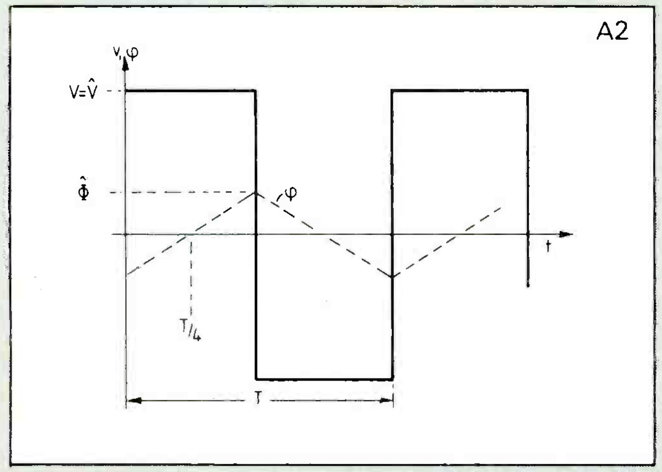
$$e = \omega N\hat{\Phi}\cos\omega t$$

Therefore the peak value of the voltage is $\hat{V} = \omega\hat{\Phi}N$. If the coil has a ferromagnetic core, it is the peak flux density $\hat{B}$ that must not be exceeded, either for core loss considerations or magnetic saturation limits. Therefore $\hat{\Phi} = \hat{B}A$, which sets the core cross sectional area we need for a required peak flux.

You can easily write down the r.m.s. value of the alternating voltage across the coil

$$V = \frac{2\pi N\hat{B}Af}{\sqrt{2}} = 4.44\hat{B}NAf$$

This important transformer designer's formula always crops up in con-



sidering sine wave operation — such as the design of mains transformers. But a good deal of modern circuitry will be found to use anything but sine waves. For a square wave supply, the voltage is flat topped. This means $d\phi/dt$ is constant. In other words, the changing flux ramps up and down, as I have tried to show in Fig. A2. The slope of the ramp is $4\hat{\Phi}/T$ or, saying the same thing, $4\hat{\Phi}f$,

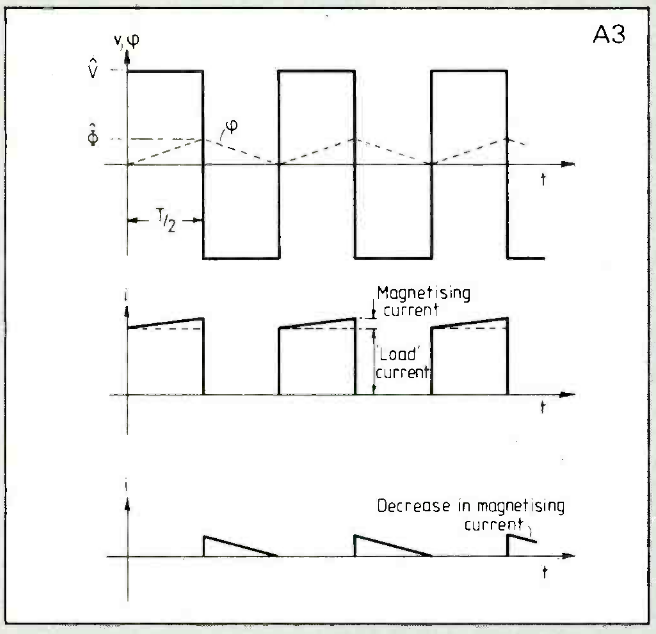
$$\therefore\quad V = \hat{V} = 4N\hat{B}Af$$

...for a square wave balanced about zero volts.

If you drive the winding with a unidirectional pulse train, the core will be magnetised in one direction only. Now, as Fig. A3 shows, the flux rises to its peak $\hat{\Phi}$ in a time T/2, so that $d\phi/dt = 2\hat{\Phi}/T = 2\hat{\Phi}f$ and the voltage becomes:

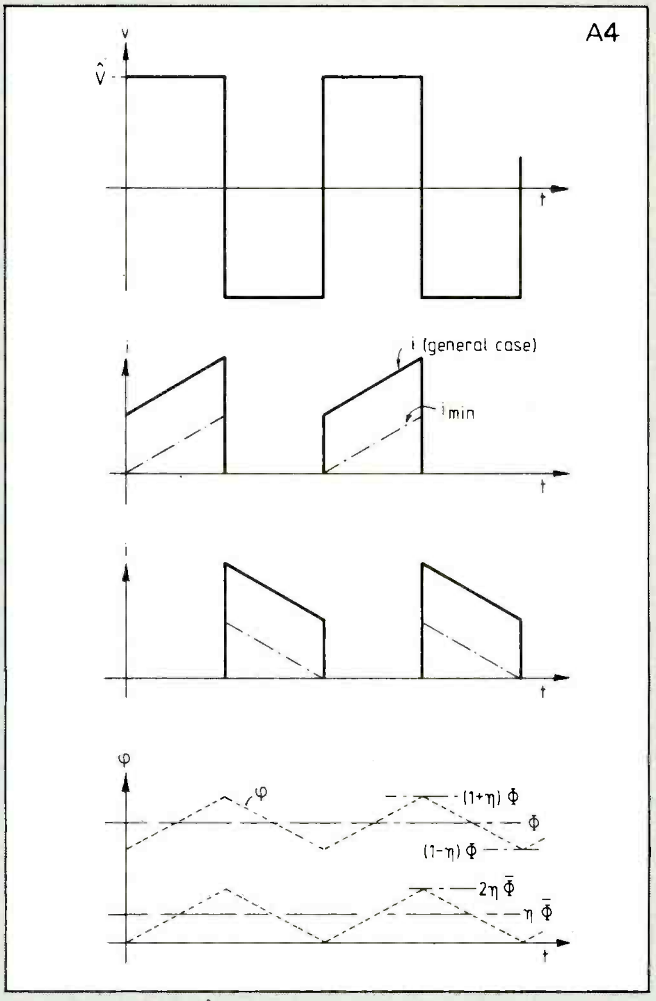
$$\hat{V} = 2N\hat{B}Af$$

This time the voltage is the (unidirectional) peak value across the coil. The r.m.s. value V, is now less than $\hat{V}$ (it is in face $\hat{V}/\sqrt{2}$), so the voltage levels are now much less. Or, saying it another way, to get the same levels and for the same throughput of power, a much bigger transformer is required.



A little though shows that the last example is just a simple case of a more general one-sided, or biased-core operation. Figure A4 illustrates a situation where in general the flux never reaches zero. The limiting case is the one just described, where the flux in the core does make it to zero for an instant. This (Fig. A3) situation is redrawn on Fig. A4.

The usual procedure is to take the ratio of the mean values of flux and call it, say, η. The peak flux reached in the limiting case is therefore $2\eta\hat{\Phi}$, while that in the general case is $(1+\eta)$. This means that the total change



in flux in time T/2 is $\hat{\Phi}\,2\eta/1+\eta$ so that the rate of change of flux is

$$\frac{d\phi}{dt} = \frac{4\eta}{1+\eta}\hat{\Phi}f$$

$$\text{and } \hat{V} = \frac{4\eta}{1+\eta}\,N\hat{B}Af$$

is a peak value, on the relevant half cycle. To get this situation, you would have to steer the currents and voltages appropriately by diodes. Also, the assumption that V is constant while the current flowing in the 'output' is linearly falling means that a further complication is required — namely, a smoothing capacitor to hold up V at the constant level assumed. It looks more and more as if these last two examples are highly contrived and that we are getting rather remote from the simple ideas of transformer operation. Nevertheless, they form a central discussion in how two common switching mode power supply circuits works. These are the 'forward converter' and 'flyback converter' circuits.

Current density in the copper

The resistance of the windings is inversely proportional to the cross sectional area of the wire, (s.w.g. is the measure of this...) and directly proportional to the length. The constant of proportionality is called the *resistivity* of copper, ρ_c.

We can use this factor to derive an expression for the resistance of a winding. For instance, a primary coil would have a resistance R_p given by:

$$R_p = \frac{\rho_c m N_p l_\omega}{\left(\frac{A_\omega F_{\omega/2}}{N_p}\right)} = \frac{\rho_c m N_p^2 l_\omega}{A_\omega F_{\omega/2}}$$

where N_p is the primary turns, l_ω is the mean turn length, A_ω is the window area, $F_{\omega/2}$ is the filling factor for the primary and m is the fractional increase in resistance of the copper with temperature rise.

In a similar way the secondary winding resistance is:

$$R_s = \frac{p_c m N_s^2 l_\omega}{A_\omega F_{\omega/2}}$$

with the appropriate subscript.

In a properly designed transformer, the primary ampere-turns equals the secondary ampere-turns and the copper is shared between them such that the losses in them are equal.

$$P_{\omega(p)} = I_p^2 R_p = \frac{p_c m N_p^2 I_p^2 l_\omega}{A_\omega F_{\omega/2}} = P_{\omega(s)} = I_s^2 R_s = \frac{p_c m N_s^2 I_s^2 l_\omega}{A_\omega F_{\omega/2}}$$

The equality above means that the current density, I_d in each winding is the same and is given by:

$$I_d = \frac{I_p N_p}{A_\omega F_{\omega/2}} = \frac{I_s N_s}{A_\omega F_{\omega/2}}$$

$$\therefore \quad P_\omega = I_p^2 R_p + I_s^2 R_s = 2 p_c m I_d^2 A_\omega F_{\omega/2} l_\omega$$

Finally as a substitution $F_{\frac{\omega}{2}} = \frac{1}{2} F_\omega$

$$\therefore \quad P_\omega = p_c m I_d^2 A_\omega F_\omega l_\omega$$

If the value of P_ω is such that $P_{TOT} = P_{CORE} + P_\omega = P_{\frac{\omega}{2}} = P_\omega$

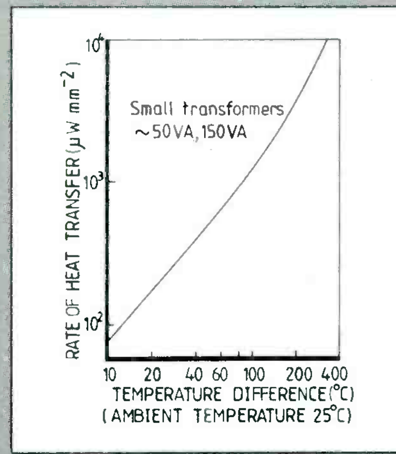
Then:

$$P_{TOT} = \frac{3 p_c m I_d^2 A_\omega F_\omega l_\omega}{2}$$

$$= A_c P_h$$

where A_c is the *cooling surface* and P_h is the *specific rate of heat transfer* of the surface. This is often taken as 500 $\mu W\ mm^{-2}$, (see Fig. A5).

Finally $$I_d = \sqrt{\frac{2 A_c P_h}{3 p_c m a_\omega F_\omega l_\omega}}$$



A5

A representative range of m at a few temperatures is given in Table A1. Armed with a list of known values for the qualtities in the expression for I_d, an estimate for the current density can be found. As an example, we can take the dimensions of a 'no-waste' lamination pile, as shown in Fig 5. of the text. The estimated value of A_c is found on the assumption that the vertical sides of the transformer are much more effective in convective removal of heat than the horizontal surfaces. Doing the calculation:

A_c $5t^2 + 15t^2 + 3t^2 = 23t^2$

Also $l_\omega = 6t$, $A_\omega = \frac{3}{4}t^2$, $p_c = 1.7 \times 10^{-5}\Omega mm$, $F_\omega = 0.3$, $m = 1.2$

$$\therefore \quad I_d = \sqrt{\frac{4 \times 2 \times 23t^2 \times 500 \times 10^{-6}}{3 \times 1.7 \times 10^{-5} \times 1.2 \times 3t^2 \times 0.3 \times 6t}} = \frac{16.7}{\sqrt{t}}$$

It looks as though t (the tongue width) acts as a kind of 'characteristic length' for this purpose. If $t^2 = 645.16$mm (1 sq. in.) then the value of I_d works out at 3.31 amps per square millimetre, which is quite close to the 'rule of thumb' value already assumed. Going to a core four times this area (VA about 700) the density works out at 2.34 Amm^{-2}. For a few kVA (5000 VA), the estimate is 1.8 Amm^{-2}.

LITERATURE RECEIVED

The new components catalogue from MS Components is even bigger than its predecessors and the company looks set to rival the other two-initial component distributor. MS have a retail counter and are willing to sell to private buyers without a minimum order charge. The catalogue now includes, bench power supplies, a wide range of power supply units, increased ranges of instruments, more tools, a wider range of integrated circuits, toroidal transformers. EWW250

Sub-minature electron devices for hybrid i. cs is the title of a catalogue from NEC Electronics (UK) Ltd which contains information on their Mini-mold devices, Power Mini-Mold devices, mini flat i.cs (c.mos devices) and solid tantalum chip capacitors. The catalogue includes dimensions for all products and details of the tape packaging methods for automatic insertion machinery. NEC Electronics (UK) Ltd, 116 Stevenston Street, New Stevenston, Motherwell, ML1 4LT. EWW251

Tracker ball controllers are explained and detailed in a technical brochure (F3051) from Marconi. Twelve pages describe applications and circuit operation, supported by functional layout and quadrature-phase diagrams. Marconi Electronic Devices Ltd., Power Division, Carholm Road, Lincoln LN1 1SG. EWW 252

All manner of plugs and connectors for use in computers and communications are detailed in the *Amp Connectors for the Data System Industry catelogue*. It covers all the major connection types including ribbon cable, mass terminated, Eurocard, coaxial, D-type. edge, disc drive as well as I.c. sockets and programmable switches. Ampliversal claim that the grouping together of these products makes ordering and selection easy, with fast delivery on all stock items. Ampliversal, Amp of Great Britain Ltd, Terminal House, Stanmore, Middlesex HA7 4RS. EWW 253

A new edition of the booklet issued by the British Amateur Television Club to its new members has been published. It reflects the increase of the use of video in amateur tv circles and offers introductions to many of the techniques used in amateur tv, including transmitting and receiving and slow-scan tv. It includes a glossary of those terms that will be new to a first-time user. All this is packed into a dozen pages! Details from The membership Secretary, B.A.T.C. Grenehurst, Pinewood Road, High Wycombe, Bucks HP12 4DD EWW254

A cross reference list to identify and corelate their power mosfets against those of other manufacturers has been issued by Ferranti. The list is intended as a guide to the selection of a direct or near-equivalent device from the Ferranti range. The alternatives referred to are functional sustitutes which meet or are close to the critical ratings BV_{dss}, $R_{DS(on)}$ and $I_{D(on)}$. In many cases better devices are available. Ferranti Electronics Ltd, Discrete Components marketing department, Fields New Road, Chadderton, Oldham, Lancs OL9 8NP. EWW255

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QS1215	2.10
QS1218	5.00
QU37	9.50
QV03-12	4.95
QV05-25	1.75
QV06-20	29.50
QV08-100	145.00
QV2-250	45.00
QY3-125	49.50
QY4-250	65.00
QY4-400	71.95
R10	4.00
R16	12.00
R17	1.50
R18	2.50
R19	2.50
R20	1.20
R1169	55.00
RG1-125	4.95
RG1-240A	14.50
RG3-250A	3.50
RG3-1250A	35.00
RK2K25	62.50
RG4-1000	10.00
RK-20A	12.00
RL16	1.50
RPL16	12.00
RPY13	2.50
RPY43	2.50
RPY82	2.50
RR3-250	15.00
RR3-1250	33.50
RS613	45.00
RS685	54.95
RS688	52.15
S6F17	5.95
S6F33	28.95
S11E12	38.00
S30/2K	12.00
S104/1K	10.00
S109/1K	15.00
S130	5.95
S130P	5.95
SC1/800	5.00
SC1/1100	6.00
SC1/1200	5.00
SC1/1300	6.00
SC1/2000	9.00
SD6000M	45.00
SP2	1.50
SP41	5.00
SP42	3.00
SP4B	4.95
SS501	35.00
ST11	1.50
STV280/40	11.95
STV280/80	19.95
SU42	4.95
TB2.5/3000	85.00
TB2-300	45.00
TB3/2000	3.95
QS1206	395.00
TBL-2-300	275.00
TD1-100A	25.00
TD03-10F	28.00
TD3-12	4.00
TDD4	5.50
TP25	1.50
TSP4	7.00
TT11	1.50
TT15	34.95
TT21	29.00
TT22	29.00
TT100	57.00
TTR-31MR	0
Q	65.00
TY2-125A	60.00
TY4-400	70.00
TY7-6000A	365.00
TY8-600W	365.00
TYS2/250	375.00
U18-20	2.75
U19	11.95
U24	2.00
U25	0.90
U26	0.90
U37	9.00
U41	6.95
U50	2.00
U82	3.00
U191	0.70
U192	1.00
U193	0.65
U251	1.00
U801	0.75
UABC80	0.65
UAF42	1.00
UBF80	0.60
UBC41	2.95
UBC81	1.50
UBF89	0.60
UBL21	1.75
UC92	1.20
UCC84	0.70
UCC85	0.60
UCF80	1.00
UCH21	1.20
UCH41	1.20
UCH42	1.35
UCH81	0.65

UCL82	1.75
UF85	1.20
UF41	1.15
UF42	1.15
UF80	0.80
UF89	2.50
UL44	3.50
UL84	0.85
UU5	3.50
UU7	8.00
UU8	9.00
UY41	3.50
UY85	0.70
V235A/1K	250.00
V238A/1K	295.00
V240C/2K	225.00
V241C/1K	195.00
V2464A/2K	315.00
V339	3.50
V453	12.00
VLS631	10.95
VP4B	4.50
VP133	2.00
VR75/30	3.00
VR101	2.00
VR105/30	1.50
VR150/30	1.15
VT52	2.50
VU29	4.50
VU39	1.50
W21	4.50
W77	5.00
W729	1.00
W739	1.50
X24	1.00
X66/X65	4.95
X76M	1.95
XC24	1.50
XC25	0.50
XFW47	1.50
XFW50	1.50
XG2-6400	35.00
XG5-500	22.50
XL1-5V	1.50
XL628FT	7.50
XNP12	2.50
XP1002	29.00
XR1-1600A	49.50
XR1-3200A	79.50
XR1-6400A	99.50
Y503	25.00
Y65	6.95
Y602	12.00
YD1100	75.00
YJ1060	265.00
YL1020	29.00
YL1070	115.00
YL1071	109.00
YL1290	65.00
Z77	1.20
Z302C	12.00
Z359	9.00
Z505S	15.00
Z520M	4.00
Z521M	8.00
Z700U	3.00
Z749	0.60
Z759	19.85
Z800U	3.00
Z803U	18.95
ZA1000	12.50
ZA1001	1.50
ZA1002	1.50
ZC1040	8.00
ZM1005	8.00
ZM1020	8.95
ZM1021	8.00
ZM1023	7.95
ZM1041	14.00
ZM1082	9.00
ZM1084	10.00
ZM1177	9.00
ZM1202	55.00
ZM1263	4.00
ZM1612	3.00
1A3	4.50
1AC6	1.20
1B3GT	1.95
1B22	10.00
1B24	14.95
1B35A	29.50
1BC2A	2.50
1C1	2.50
1C5GT	2.50
1D5	2.50
1FD1	2.50
1G3GT	2.50
1K3GT	2.50
1L4	0.60
1L6	1.00
1LA6	1.00
1N2	4.50
1N5GT	2.50
1P28	25.00
1S2	0.55
1S5	0.70
1T4	0.70
1U5	1.00
1X2B	1.40
1Z2	8.95
2B7	1.50
2B22	69.50
2C21	1.00
2C39A	23.50
2C39BA	39.50
2C40	37.00
2C40A	55.00
2C42	29.50
2C51	0.75
2C53	32.00
2CY5	1.50
2D21	0.95
2D21W	2.50
2E26	7.95
2J42	93.00
2K25	24.95

2K25 Raytheon	75.00
2K26	95.00
3A/107B	12.00
3A/108A	9.00
3A/109B	11.00
3A/110B	12.00
3A/141K	11.50
3A/147J	7.50
3A/167M	10.00
3A2	3.95
3A3A	3.95
3A4	1.10
3AL5	0.95
3AT2	3.35
3B2	3.00
3B4	7.00
3B7	4.50
3B24	10.00
3B26	24.00
3B28	12.00
3BZ6	1.50
3C4	1.00
3C45	24.00
3CB6	1.50
3CN3A	2.50
3CS6	0.95
3CX3	2.50
3CY5	1.50
3D6	4.50
3D21A	29.50
3D22	19.50
3E22	49.50
3EH7	1.95
3EJ7	1.95
3W4GT	2.50
4B551B	115.00
4-65A	59.00
4-250A	65.00
4B32	19.50
4BQ7A	1.75
4BZ6	1.95
4C27	25.00
4C28	25.00
4CB6	1.95
4CX250B I.T.T.	37.50
4CX250B EIMAC	49.00
4CX250B surplus ex-government	12.50
4CX250B tested ex-equipment	6.00
4CX250BM EIMAC	75.00
4CX250K EIMAC	95.00
4CX350A	71.50
4D26	75.00
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4GV7	2.25
4J52	75.00
4JC6A	2.95
4X150A	25.00
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5A152M	9.00
5A163K	10.00
5A170K	6.25
5A-180M	9.00
5A-206K	10.00
5AMB	2.15
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5AR4	2.00
5AU4	1.50
5B8	2.50
5B.110M	10.00
5B-254M	14.50
5B-255M	19.50
5B-256M	9.00
5B-257M	9.00
5B-258M	14.50
5C22	69.00
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5R4GY	2.80
5T4	5.95
5U4G	1.95
5U4GB	2.50
5V4G	1.25
5Y3GT	1.95
5Z4GT	0.85
6/30L2	0.70
5A/203K	9.00
6A7	4.95
6A8G	1.50
6AB8	0.66
6AC7	2.00
6AF4A	2.50
6AF9	4.15
6AG5	1.50
6AG7	1.95
6AH6	1.50
6AJ4	2.00
6AJ7	2.00
6AK5	1.00
6AK6	2.00
6AL5	0.60
6AM4	3.25
6AM5	6.00
6AM6	1.50
6AN5	2.65
6AN8A	2.65

6AQ5	1.50
6AQ8	0.85
6AR8	3.95
6AS5	1.50
6AS6	1.50
6AS7G	4.50
6AT6	0.75
6AT8	1.75
6AU4	2.00
6AU6	0.95
6AV6	0.75
6AW8A	2.50
6B8G	1.50
6BA6	0.95
6BA7	4.50
6BA8A	3.50
6BC8	1.00
6BD4	1.50
6BD6	1.00
6BE6	0.72
6BF5	1.60
6BG6G	3.00
6BH6	1.95
6BH8	1.50
6BJ6	1.20
6BK4	4.00
6BK7A	1.95
6BM8	0.58
6BN4	1.65
6BN6	1.65
6BN7	4.50
6BN8	2.35
6BQ5	0.75
6BQ7A	0.72
6BL7GTA	3.95
6BL8	0.65
6BR5	0.70
6BR7	4.95
6BR8	2.15
6BR8A	2.15
6BS7	5.50
6BS8	2.50
6BW4	1.50
6BW6	5.35
6BW7	1.50
6BW8	4.00
6BX6	0.48
6BX7GT	3.50
6BZ6	2.50
6BZ7	2.95
6C4	1.10
6C5	1.95
6C6	2.50
6C8G	1.50
6C11	2.50
6C15	2.50
6C18	2.50
6CA4	0.60
6CA7	3.50
6CB5	3.95
6CB6	1.95
6CD6GA	4.50
6CF6	1.50
6CH6	6.95
6CL3	3.95
6CL6	3.25
6CL8A	2.00
6CM5	1.60
6CM7	2.95
6CS6	0.75
6CW4	6.50
6CY5	1.00
6CY7	2.50
6DC6	2.35
6DK6	1.15
6DQ5	3.35
6DQ6B	2.50
6DW4	2.15
6EA4	4.95
6EA7	2.50
6EA8	2.50
6EB8	1.75
6EM5	2.50
6EM7	2.50
6EU7	1.95
6EU8	1.75
6EV7	2.95
6EW6	1.50
6EW7	4.50
6F1	2.00
6F5	4.95
6F6G	2.00
6F7	5.50
6F12	1.50
6F13	3.00
6F14	1.00
6F17	2.75
6F21	2.50
6F22	0.70
6F23	0.60
6F24	1.25
6F25	1.25
6F28	1.25
6F32	1.25
6F33	17.00
6FG5	1.95
6G6G	5.50
6GH8A	0.80
6GK5	1.50
6GK6	1.95
6GS7	2.15
6GV7	2.50
6GW6	2.50
6H1	9.50

6H3N	1.10
6H6	1.35
6H6GT	1.95
6HS6	4.95
6J4	1.10
6J4WA	3.15
6J5	2.50
6J6	0.65
6JB6A	3.95
6JE6C	4.95
6JU8	2.50
6JS6C	4.95
6J7	4.15
6K7G	0.70
6K8Y	3.95
6KD6	5.50
6KM8	2.50
6KT8	2.95
6L1	2.50
6L15	3.15
6L19	3.95
6L6GC	2.95
6L6GC(GE)	3.95
6L6GT	1.15
6LD20	0.60
6LF6	4.50
6LJ8	2.50
6LQ6	4.95
6N7	2.50
6N7GT	2.50
6P15	1.50
6P25	4.00
6P26	4.00
6P28	2.00
6Q7	1.20
6Q7GT	1.20
6R7G	3.15
6S4A	1.50
6S7	1.10
6SA7GT	1.00
6SC7	1.50
6SG7	1.20
6SH7	1.20
6SJ7GT	1.20
6SK7	0.80
6SK7GT	1.20
6SL7GT	0.85
6SN7GT	0.95
6SQ7	0.80
6SS7	1.95
6U4GT	1.75
6U8	0.85
6U8A	1.50
6V6GT	0.85
6X2N	1.00
6X4	1.50
6X5GT	0.55
6X5GTY	1.00
6X8A	2.25
7A6	4.50
7A7	2.00
7AD7	1.75
7B7	2.50
7C6	2.50
7E7	2.50
7AU7	1.50
7J7	5.50
7Y4	1.95
8B8	2.50
8B10	2.50
8BQ5	1.95
8FQ7	1.95
10D2	1.25
10DE7	2.50
10F1	0.75
10GK6	1.95
10P14	2.50
10P18	0.78
10LD11	1.00
10LD12	0.65
11E2	16.50
11E3	55.00
12A6	3.95
12AD6	1.50
12AG8	1.50
12AL5	1.00
12AT6	0.95
12AT7	1.15
12AT7WA	2.50
12AU6	1.50
12AU7	0.55
12AV6	0.80
12AX4GT	1.00
12AX7	0.65
12AX7WA	2.50
12AY7	3.95
12AZ7A	1.95
12B4A	3.50
12BA6	1.50
12BE6	1.05
12BH7A	2.50
12BL6	1.75
12BY7A	2.75
12BZ6	4.95
12CA5	1.95
12CX6	1.20
12DQ6B	3.50
12DW4A	3.50
12DW7	2.50
12E1	17.95
12E14	28.00
12GN7	3.95
12HG7	4.50

12HG7A	4.50
12J7GT	0.70
12J7GT	3.50
12K5	1.00
12K7GT	0.60
12K8	1.10
12SA7GT	1.00
12SG7	4.75
12SH7	1.00
12SK7	1.00
12SJ7	0.60
12SN7GT	1.85
12SQ7GT	1.50
13D3	3.20
13D7	3.20
13DE7	2.50
13DR7	2.95
13EM7	3.50
14S7	1.00
17EW8	0.95
17JZ8	2.75
18D3	1.60
19AU4GT	2.50
19G3	17.00
19H4	23.95
19H5	33.50
19Q6	9.00
20A2	10.50
20D1	0.70
20LF6	3.50
20L1	0.95
20P1	0.55
20P3	0.60
20P4	1.95
20P5	1.15
21LU8	2.50
24B1	39.50
25L6GT	1.75
25BQ6	1.75
29C1	19.50
30C17	0.40
30C18	1.48
30F5	0.95
30FL1	1.00
30FL2	1.35
30FL12	0.95
30FL13	1.10
30FL14	1.25
30L1	0.45
30L15	0.60
30L17	0.60
30P4MR	1.00
30P12	1.00
30P18	0.60
30P19	1.00
30PL1	2.50
30PL13	0.60
30PL14	1.75
31JS6A	5.50
33A/158M	19.50
35A5	4.50
35L6GT	2.00
35W4	0.70
35Z3	1.85
38HE7	4.50
40KD6	5.50
42	6.95
47	6.00
50A5	1.50
50C5	0.95
50CD6G	1.15
50EH5	1.50
50JY6	2.95
52KU	2.00
53CG	15.00
61SPT	4.50
75B1	2.50
75C1	2.50
83	8.50
84	3.00
85A1	6.50
85A2	1.50
90AV	10.00
90C1	2.70
90CG	13.50
91AG	9.00
92AG	19.50
92AV	12.50
95A1	6.50
108C1	1.50
150B2	6.95
150C2	1.50
150C4	2.15
155UG	25.00
185BT	1.50
274A	15.00
307	5.00
328A	15.00
388A	17.50
425A5	8.00
431U	2.00
572B	35.00
705A	8.00
708A	8.00
715A	6.00
715C	45.00
725A	275.00
803	14.95
805	39.00
807	1.60
810	45.00
811A	12.95
813	18.50
813USA	45.00

829B	14.50
833A	60.00
866A	3.50
872A	19.00
873	60.00
884	5.50
930	9.95
931A	13.95
954	1.00
955	1.00
958A	1.00
1299A	0.60
1619	2.50
1625	3.00
1626	3.00
2050W	4.50
2050	2.75
3545	4.00
404A	10.95
927	15.00
1927	25.00
4313C	4.00
4328D	9.00
5642	9.50
5651	2.50
5654	1.95
5663	1.95
5670	3.25
5672	4.50
5687	4.50
5692	3.50
5696	2.75
5704	3.50
5718	6.15
5725	2.50
5726	2.50
5727	2.50
5749	2.50
5750	1.85
5751	2.95
5763	4.95
5814A	3.25
5829WA	6.50
5636	5.50
5678	7.50
5840	3.50
5842	11.00
5847	10.95
5879	8.50
5886	13.95
5894	39.50
5899	4.50
5963	1.75
5965	2.25
6005	1.85
6012	16.00
6021	3.65
6057	2.50
6058	2.50
6059	3.75
6060	2.25
6062	4.50
6063	2.00
6064	3.25
6067	1.95
6072	4.20
6080	4.75
6080WA	8.50
6096	2.85
6132	10.00
6136	2.50
6146B	7.50
6157	2.50
6158	3.20
6201	6.45
6205	6.95
6211	2.50
6267	1.50
6350	2.00
6360	4.50
6386	14.50
6545	8.50
6550A	8.00
6688	6.50
6870	11.50
6887	9.50
6883B	9.95
6973	4.50
7025	2.50
7027A	4.50
7032	2.00
7059	2.50
7167	3.95
7189	2.50
7189A	2.35
7193	7.50
7199	4.95
7233	7.95
7239	17.50
7247	2.00
7360	8.95
7462	15.00
7475	5.00
7486	75.00
7551	5.45
7558	9.45
7586	11.00
7587	26.95
7591A	4.95
7609	47.00
7733	5.50
7788	18.50
7868	3.95
8012	15.00
8042	45.00
8102	3.95
8106	2.95
8136	1.00
8156	10.95
8245	107.50
8298A	6.50
8417	5.95
9001	1.50
9006	0.90
18042	10.00
18045	10.00

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VA1056S	0.23
VA1104	0.70
VA8650	0.45
VA1097	0.25

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CIRCLE 24 FOR FURTHER DETAILS.

Digital multimeters now

As a result of progressive circuit integration, sales of digital multimeters are now well ahead of their analogue counterparts

Newcomers to digital multimeters may be forgiven for showing bewilderment at the surfeit of these instruments now on the market. From a choice of 16 or so over a decade ago the market now contains at least 50 different brands world wide, and that doesn't include single-function digital meters that are now proliferating — capacitance meters, thermometers, decibel meters, as well as voltmeters. (For this survey, we've taken 'multimeters' to mean instruments that can measure three or more different quantities, excluding the component 'bridge type of instruments.)

Most of the activity has been at the low-cost end of the market — the 3½ digit hand-held and the portable bench-type instruments — and has been largely due to increasing circuit integration and, from about 1977, the use of microprocessors. The recent economic climate has meant that cost has become a more important factor in the choice of meter and dmms, like other products where circuit integration has made inroads, have fallen in price whereas analogue meters have at least followed inflation.

The effect of integration can be gauged from the simple digital voltmeter circuit shown on this page. The making of a low-cost multimeter is little more than adding signal conditioning circuitry — an ideal candidate for assembly in the Far East.

The result in the USA has been that the market for digital multimeters has risen to eight times that for analogue meters, with the hand-held share up to about 20%. But in Europe, digital meters are only just on the point of double the analogue turnover, and this large difference leads one instrument marketer to identify the low-cost end as "a tremendous and virtually untapped market".

Chip technology has sincealso allowed development in 4½digit models as well as 3½, though less successfully feels Stuart Thompson of Thorn-EMI Instruments, "probably because the accuracy of field service jobs is already met by 3½digits."

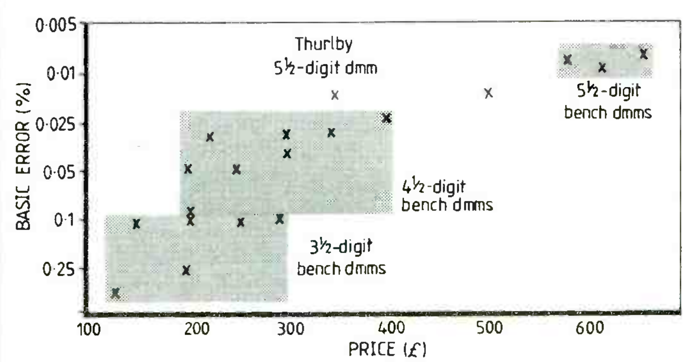
Cost is a major factor in the servicing business as each technician needs a meter, and the frequent outside visits mean robustness and portability are requirements in addition to a desire for better accuracy than the analogue meter offers. These factors are leading buyers to look closely at handhelds; last year a tv rental company decided to go digital to the tune of 2,500 meters — claimed to be the largest order ever placed by a tv rental company.

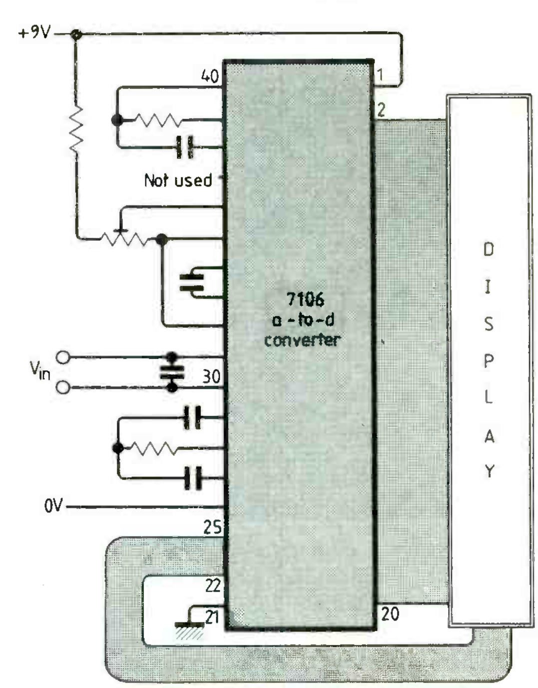
But the middle and top-end markets havn't been standing still, with competition as keen as ever at offering value for money to get a bigger share of the market (reckoned to be worth £14 millon in the UK last year). In the traditional area for benchtype dmms, in r & d labs, meter prices are falling in real terms and performance increasing, aided by the widespread use of microprocessors. John Nicholls, Thurlby's managing director, says that despite heavy inflation it is possible to buy a 4½digit multimeter now for much the same price as a 3½digit multimeter five years ago. "4½digits is establishing itself as the standard for general purpose lab. bench meters" he finds "with 3½ digits confined primarily to lower cost, mainly hand-held, products".

As Mr Nicholls' chart shows, (reproduced on this page) there is some overlap between the 3½ and 4½digit product areas, with some 3½digit meters going up to £200 or more, whilst a few 4½digit meters, Thurlby's 1503 included, are available for as little as £150. But there is still a big jump from the 4½digit meters, and a still larger jump to those with calculating ability. This gap restricts most engineers wanting a mulitmeter for general bench use to the 4½digit area, but there is a wide range of models available from under £200 to over £450 depending on resolution, accuracy and features. "Although offering better value for money than those of a few years ago", he points out, "most of these products provide

Bench dmm price performance distribution reveals overlap in 3½/4½ digit area. The large gap between 4½ and 5½ digit pricing may mean that many engineers will have to contend with a 4½. Thurlby's 5½ digit meter falls in this price range, though it hasn't the accuracy of most 5½ digit meters.

Circuit integration has led to a flood of low-cost 3½ digit multimeters from the Far East based on this simple $3 voltmeter design from Intersil.





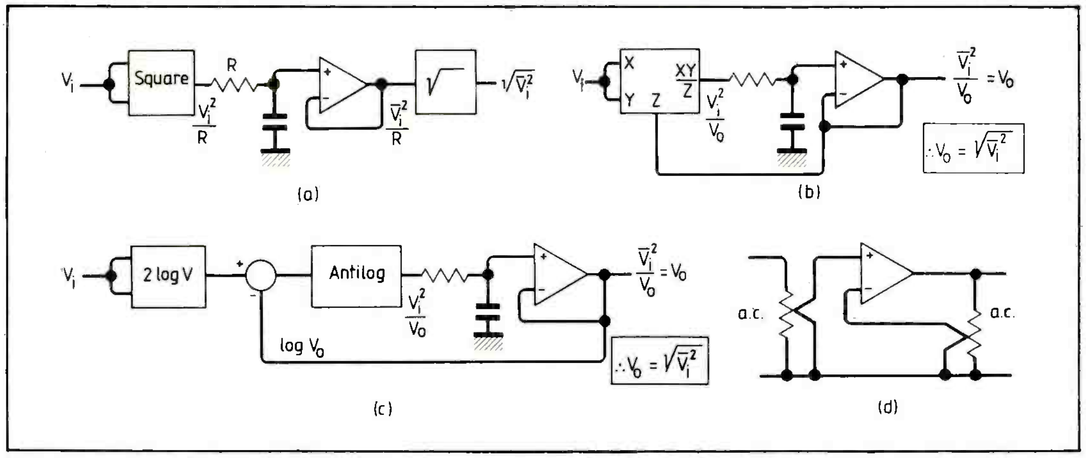


Fig.1. Because subsequent circuitry is subject to the square of the input signal magnitude (a), thus limiting dynamic range, scheme (b) is preferable, though the logarithmic approach of Datron, Solartron and others has better linearity.

A solution to the problem is the 'implicit' method which uses feedback to perform the square root function indirectly, Fig.1(b). Simpler and cheaper, this has greater dynamic range because average signal levels vary with r.m.s. level and not as the square. In the logarithmic approach, first used by Datron, block A is replaced by log/antilog circuitry, Fig. (c). A particular virtue of this scheme lies in its balancing of temperature drifts and linearity down to 0.01% of full scale.

The table below indicates the

Waveform	Mean modulus	Mean meter	r.m.s. value	Form factor	Crest factor	Error
Sine	0.637	0.707	0.707	1.11	1.42	–
Triangle Sawtooth	0.5	0.55	0.577	1.16	1.73	−3.8%
Pulse, 50%	1	1.11	1	1	1	+11.1%
Rectified sine 90° chopped	0.318	0.353	0.5	1.57	2	−29%
Pulse, 10%	0.18	0.199	0.3	1.66	3	−34%
Pulse, 1%	0.02	0.022	0.1	5	10	−78%

little more in terms of capability than their more expensive predecessors."

In production testing, a major area for dmms, long-term accuracy and stability are of paramount importance Here, fast automated and recordable measurements are required and the meter may be a vital link in a process control chain. These 'systems' meters have a facility for serial or parallel data bus operation, and additionally may need calculating and limit-testing facilities.

The most demanding application as far as accuracy is concerned is the calibration lab, where stability, absolute accuracy and high resolution are of the highest attainable so that standards can be confidently transferred and measurements related to national standards.

Basic multimeter

In its simplest form a digital multimeter consists of an input divider, function converter (omitted for dvms), analogue-to-digital converter, clock & counter display and drivers. The input divider is a resistive ladder to reduce the analogue input to a fixed voltage range of 2V or 200mV with a ×10 buffer. (The range is actually 1.999V, the 1 digit indicating overrange inputs.) Range may be manually selected by pushbutton or rotary switch, or automatically selected by an autorange level-sensing circuit.

The circuit loading that occurs when a measuring meter is added in parallel is always a source of error. The rule of thumb is that multimeter impedance should be a factor of ten times the source impedance for each significant digit to maintain the rated sensitivity. For example, if you want to measure across a 10kΩ source resistance with 3 digit accuracy then input resistance should be at least 10MΩ.

Functions other than direct voltage measurement require converters. A current converter usually consists of low-value resistors in the input network switched in as shunts at the a-d converter input, and the voltage developed across the shunt measured and displayed as current. Resolution can be limited by low values of shunt producing low voltages. Usually the drop across the shunt, the 'voltage burden', has a negligable effect on the circuit, but in low voltage high current circuits it may be significant and accuracy will suffer.

The a.c. converter may be simply a transformer and rectifier arrangement to give a direct voltage equivalent to the average alternating input. More commonly it will be an op-amp feedback diode rectifier, but whichever it is it will only give accurate r.m.s. readings for sinusoids. Because non-sinusoidal waveforms are so widespread, more manufacturers are adding a 'true r.m.s.' feature. This may use an r.m.s.-to-d.c. converter that squares the input voltage, averages with a low-pass filter and then takes the square root. But because the circuitry following the squarer cannot handle a wide (squared) dynamic range, it is limited to a 10:1 input range, though this is otherwise a competent method with a potential error of less than ±0.1% and good bandwidth, Fig.1(a).

horrendous errors that could be made by using a meter that simply senses mean values yet is scaled to read r.m.s. The limitation in dynamic range of r.m.s.-sesing converter is usually specified by quoting a maximum crest factor that the circuit will handle and still give correct r.m.s. readings. Fluke, for instance, specify their true-r.m.s. meters only for waveforms with a crest factor of up to three, and for anything significantly greater recommend a thermal-converting type. The other point to watch over measuring high crest-factor waveforms is bandwidth because of the appreciable amounts of harmonic energy contained in switching waveforms (and, of course, noise as well).

Though thermal conversion is perhaps the simplest way of getting an r.m.s. value and can be reasonably accurate with distorted waveforms (crest factors of 3:1 or more) it has its difficulties. The method involves a pair of heaters and thermocouples arranged so that the applied voltage heats one couple connected to an amplifier. The d.c. output drives another heater/couple wired so that equal temperatures indicate the d.c. output is equivalent in heating effect to the applied a.c., Fig (d). Unfortunately the time constant limits the l.f. response and dynamic range is restricted because of the square-law problem and non-linearity.

Analogue—digital conversion

One of the most straightforward methods of converting from analogue to digital signals is the binary ramp, using a comparator to control clocking of counter, Fig.2(a). The comparator's output stops the clock when the fed back signal equals the input signal and the accumulated count, which is the digital equivalent of the input, held in a register. The comparator input has to be fed from a digital-to-analogue converter, so the whole thing is not the simplest of converters. And it requires the addition of input filters to prevent mains-related interference affecting reading.

An idea that is simpler to construct and which has the advantage of rejecting mains-related noise is the ramp intergrator, in effect a very cost-effective replacement for the d-to-a converter in the binary ramp. Here, Fig.2(b), the ramped output of an integrator feeds a comparator which stops a counter when its two inputs are equal. The output is $V_{ref}t/RC$ after time t and is proportional to the ratio of the input to the reference. But its weakness is that accuracy depends on both the clock and the integrating capacitor — the resistor is not so much of a problem — (as well as V_{ref}).

First used by Solartron back in 1963, the intergrating technique has since become the most important technique for digital voltmeters in its dual or triple-ramp form. Patents on the technique held by Fairchild, Weston and Solartron gave the Schlumberger group a powerful patent pool to manage, but now are they on the point of expiring. Perhaps partly in an effort to avoid paying patent royalties, manufacturers turned their attention to variants of the dual-slope technique to increase its accuracy. To understand how these helped it is necessary to know the workings of the basic dual-ramp idea.

In the integrator, a feedback capacitor C is changed through resistor R for a known time t, Fig.2 (c), at which its voltage is

$$V_x = \frac{1}{RC}\int_0^{t_1} V_{in}\,dt = \frac{V_{in}t_1}{RC}$$

which simply means that the accumulated charge is proportional to the average value of the input over a fixed period. The integrator input is switched to the opposite-polarity reference voltage after the counter has reached its predetermined count, representing t_1, triggered by an overflow pulse. The capacitor discharges until the comparator senses it has reached zero, that so

$$0 = V_x - \frac{1}{RC}\int_{t_1}^{t_2} V_{ref}\,dt$$

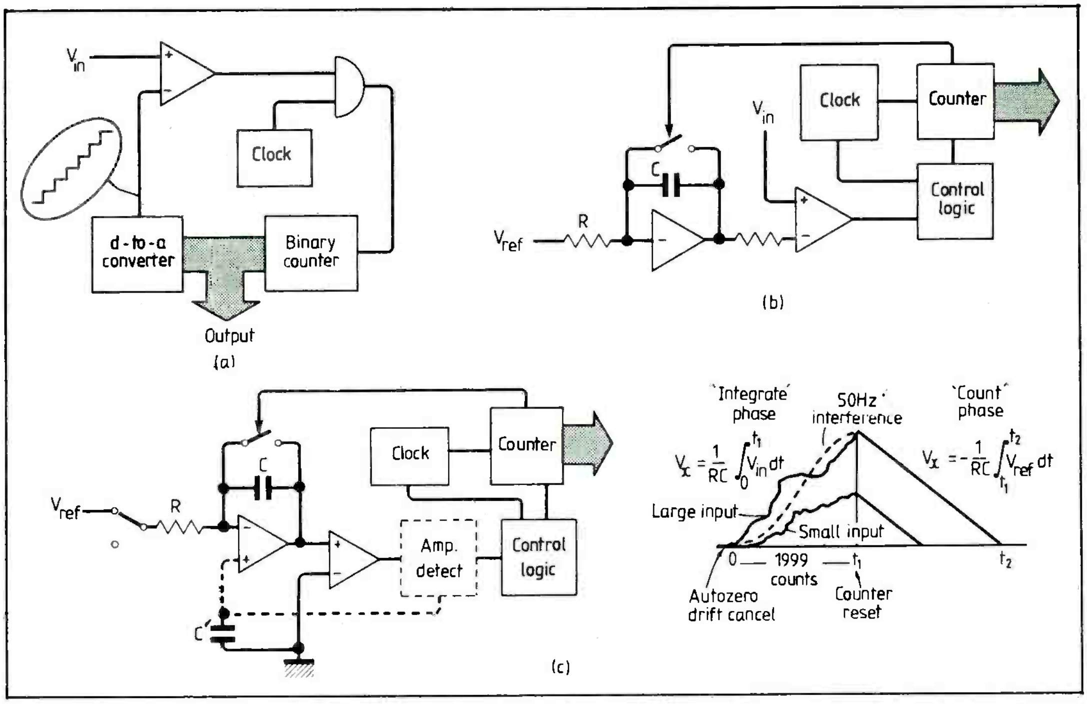
and if $t_1 = T_1$ and $t_2 - t_1 = T_2$, then

$$0 = \frac{V_{in}T_1}{RC} - \frac{V_{ref}T_2}{RC}$$

$$V_{in} = \frac{T_2}{T_1}V_{ref}\ (=kT_2)$$

which not only means that T_2 is directly proportional to V_{in} — it is the *discharge* time or count that is displayed in dual-slope integrator — but that it is independent of R, C and clock values. The reference voltage, which does need to be accurate, is chosen to give a suitable basic range, typically two volts (though only 1.999 is indicated as the first digit is an over-range feature).

The initial measuring period t_1 is chosen to contain one period of 50 or 60Hz so that a superposed mains interference will be averaged out and rejected along with its harmonics.



Though the integration is independent of clock frequency the effectiveness of series-mode rejection depends on its accuracy. It is the counter timing that fixes the integration period, and for an error of Δt per mains cycle the rejection will be 20log(Δt/t), so that a 0.01% error limits rejection to 80dB.

This ability to reject mains-frequency voltages together with low errors of between 0.25 and 0.001%, good temperature stability and low cost have made dual-slope integration the most widely used of techniques. It is the basis of many a-to-d converter dvm chips, including Intersil's highly successful three-dollar derivative of the 7303 (see Table).

A shortcoming in the dual-slope method is that errors at the integrator input show up as error in the digital word. Input errors can be clearly reduced by introducing a third phase of the cycle in which the input is grounded and a capacitor charged with zero plus drift errors. This charge is then applied with opposite polarity during integration, thus cancelling the effect of errors.

When the dual-slope technique is applied to the design of five or six-digit voltmeters other errors begain to appear. According to Solartron these are due to

- dielectric storage in the integrator capacitor which gives 'zero' error and non-linearity even with the best capacitors
- clock variations during up or down slopes

Fig.2, depicting the chief contenders for digital-to-analogue conversion, continues on pages 76,79 & 80.

A decade of Intersil dvm chips

Year	Device	Digit	Features
1975	8052/8053	3½	Two chips, dual slope, no logic, p-mos
1976	8052/7101	3½	Two chips, with logic, b.c.d. out, p-mos
1977	7103	3½/4½	Supersedes 7101, multiplexed b.c.d. out
	8068	3½	Similar 8052, low noise for 10μV/count
1978	71C03	3½/4½	C-mos version of 7103
	7106	3½	Single-chip derivative of 7303, l.c.d. drive, auto zero, reference, $3
	7107	3½	Similar 7106 but l.e.d. drive
	8052/7104	—	Two chips, 12, 14, 16bit versions for μP
1979	7109	—	Single chip, 12bit, parallel output, $10
1980	7116	3½	Similar 7106, with l.c.d. hold
	7117	3½	Similar 7107, with l.e.d. hold
1981	7126	3½	Low power version of 7106, 100μA
1982	7135	4½	Single chip, multiplexed b.c.d. out
	7136	3½	Similar 7126+fast overrange recovery
	7137	3½	Similar 7136 but for l.e.d. display
1983	7129	4½	Triplexed l.c.d., 10 μV/count, two-cycle conversion, 5½digit res., cont. test
1984	7139	3¾	Single-chip autorange mulitmeter, display up to 3999 to reduce range
	7115	—	14bit post-package prom corrected, successive approx. (40μs), R/1.8R ladder
1985	?	—	16bit version of 7115 likely

- transistor delays varying with time and temperature
- mismatching of integrator and reference switches
- mismatching of high and low references in multislope converters
- difficulty in trading resolution for speed
- input voltages not being monitored during the down slope.

These problems have led Solartron to pursue other avenues — first successive approximation (1977) then later pulse width conversion — though some schemes have been devised to reduce the effect of such errors. One compensation, used in Racal Dana's 6000 series, builds a more complete representation of the integrating capacitor in a attempt to accurately maintain the RC product. It achieves this by placing the network Fig. 2(d) in the non-inverting input of the integrator, at C, in (c).

All of these higher-order effects are worthless of course if stability of the voltage reference isn't maintained. This leads some designers to place a zener reference diode within a controlled oven, others to use a reference bridge. Dana for instance to achieve an error of as little as 3p.p.m., a temperature coefficient of 1p.p.m. per deg. C and 6p.p.m. over three months, using this last-mentioned arrangement. In the cheaper instruments the i.c.s used didn't include zener references, and a mercury use is sometimes used instead. Later instruments, e.g. Fluke's 70 series, make use of an off-chip band-gap device.

Multislope techniques

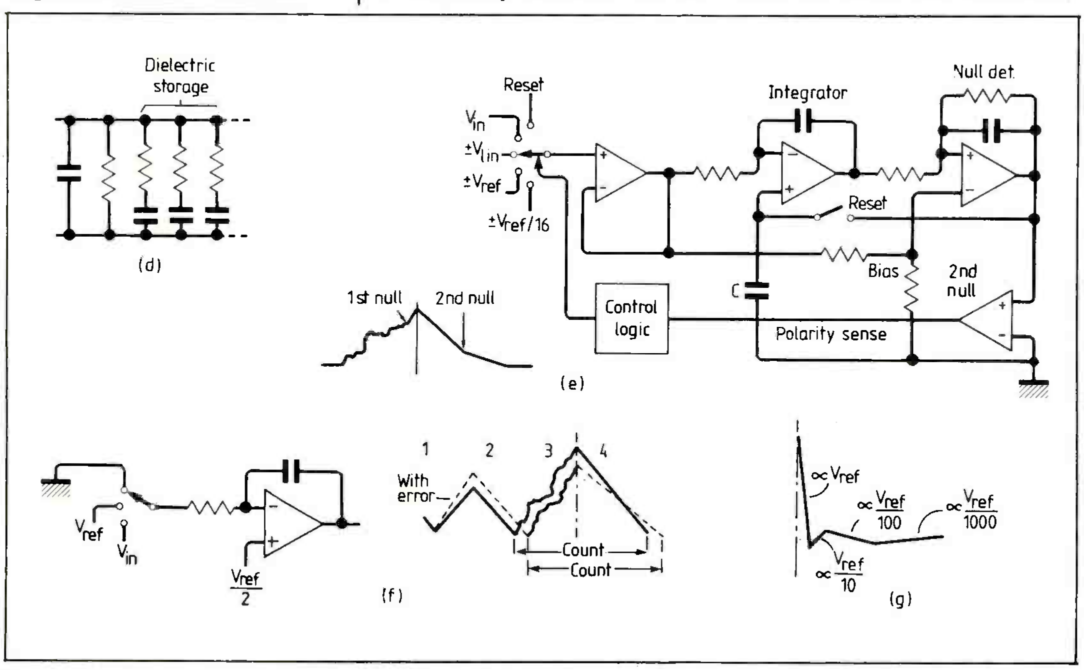
An interesting extension of the dual-slope technique is the triple or multislope conversion in which there is an initial fast 'ramp-down' for a partial conversion followed by a slow but accurate ramp-down for the final answer. In the 'triple-slope' method of Datron, a reference voltage is applied for a short time after integration with the *same* polarity as the signal, Fig.2(e). This provides a finite integrator charge even if the signal is zero. At the end of this linear period the opposite-polarity reference voltage is applied and the null detection biased by an amount less than the linear charge. The integrator discharges until the biased null is reached, when the main null detector activates the control circuitry and switches the reference to $V_{ref}/16$, also removing the third slope bias. The integration discharges at 1/16 of its original rate with the digital circuitry also counting at 1/16 of it previous rate, toward the final null. (As the effect is of delay in the 1/16-rate period are reduced by 16 the bandwidth may be reduced by the same amount, giving four times lower noise.) Normally, the integrator capacitor imperfections limit the resolution to 10p.p.m., but with this particular adaptation Datron have produced instruments with 1p.p.m. linearity and resolution, with an effective null detector resolution of 3μV in 100ns.

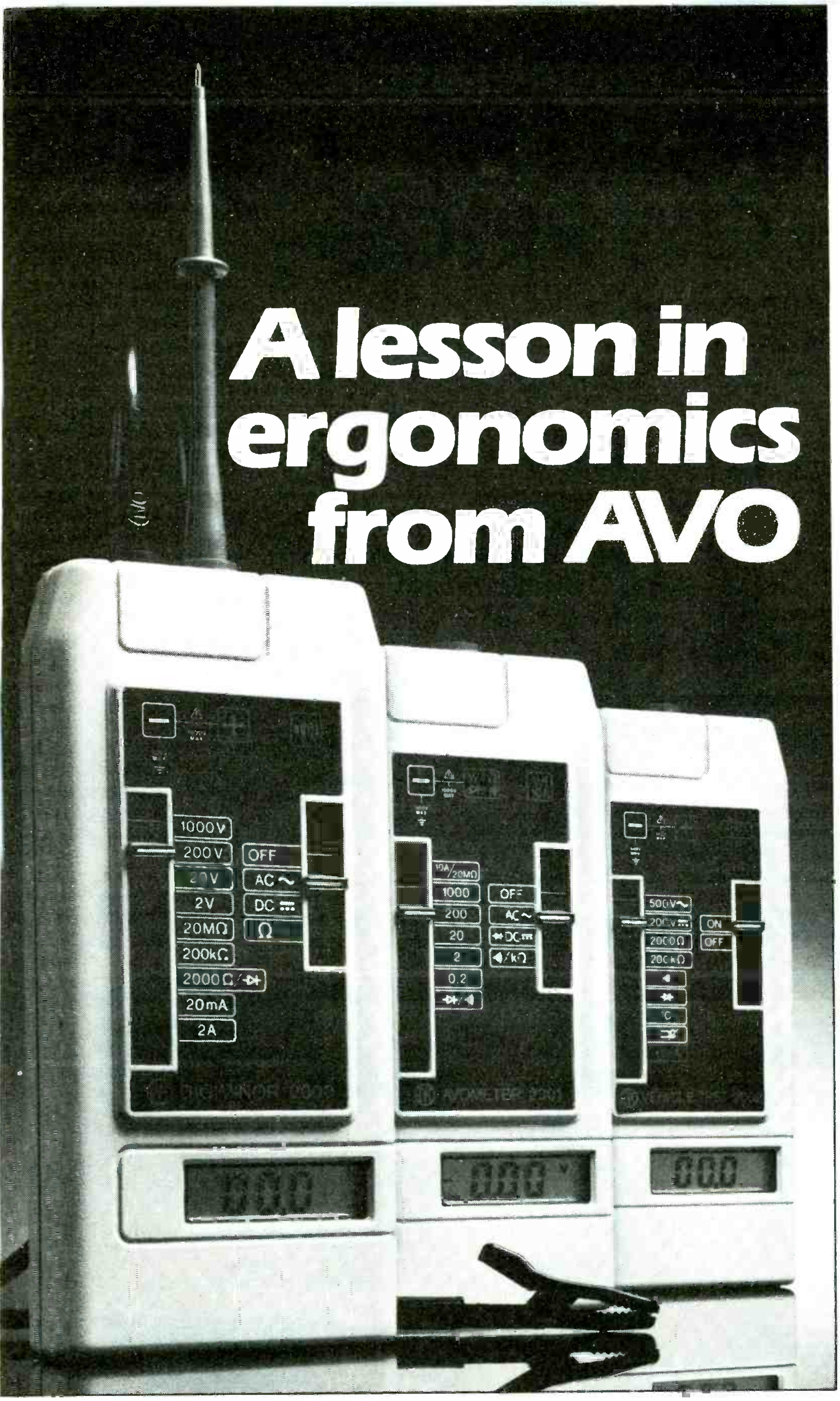
A large proportion of the development cost of Thurlby's 5½digit 1905 meter went into the design of a high-linearity triple-slope converter, in which a microprocessor provides for 'intelligent' control of the converter as well as de-integration time measurement, and data manipulation. It does this with a large number of c-mos transmission gates switched under microprocessor control to provide a number of refinements. An auto-zero phase following each measurement charges two capacitors with zero offsets, then applied in opposing polarity during integration to remove the offset errors during measurement. Shifting the zero-crossing voltage allows a brief increase in integration slope and also the input level to be interrogated. Thurlby say the converter is capable of a 6½digit result, but because of other limitations the last digit is suppressed.

In the quad-slope integrator of Analog Devices, drift and gain temperature coefficients are reduced to 1p.p.m./deg.C at reasonable conversion speeds, though still slow for some applications (40Hz). A 13bit converter AD7550 goes through two cycles of dual-slope conversion, once with zero input and once with signal input. Errors determined during the first cycle are subtracted digitally from the result of the second cycle Fig.2(f).

One of the most refined of all the multislope techniques is that used in Hewlett Packard's 3456 dmm. The run down period has four slopes, the first steep and with a finite overshoot, the next with a tenth of the slope but of opposite polarity and with overshoot, the third with the polarity of the first but a hundredth of the

Fig.2 continued – see text





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CIRCLE 5 8 FOR FURTHER DETAILS.

slope, and the last of opposite polarity and a thousandth of the original slope. A clock starts at the beginning of each slope and stops when it crosses zero for that slope, and the charge left on the integrator capacitor at the end of each slope represents what is left to digitize. The four least significant digits are then derived sequentially from these stored counts. The sensitivity of this technique is largely determined by the last zero-crossing for the l.s.b., where the crossing is shallowest and consequently most precise.

But that's not all. In one conventional multislope variant a sawtooth approach keeps the integration capacitor charging at a fast rate by switching in an opposite-polarity reference to ramp down at intervals during the integration phase. As the number of switchings varies with input level — a high level input produces a steep slope and most switchings — this makes it impossible to accurately compensate for variations in switching times. Not only that but the average capacitor voltage is kept high being most sensitive to dielectric absorbtion.

What the HP method does is to maintain a high charge rate with the sawtooth idea, keeping the average voltage on the integrating capacitor lower in both run up and run down, as well as breaking up the run into equal periods that do not vary with input.

Actually, the first two most significant digits are established during the run-up when the instrument's charging rate is set for 100,10 or 1 cycles of mains frequency. For 0.1 cycle resolution reduces from six to five 6½ to 5½ digits with only the m.s.b. established in run-up, and for 0.01 cycle and 4½ digit resolution the integrating period isn't used for measuring. Two later HP models also use this multislope technique, 3468 and 3478, but these lower cost types do not include selectable integration periods.

Yet another multislope technique is in Fluke's latest 70 series hand-held dmm. The instrument, which Fluke call a 'third generation' type, uses two c-mos i.cs, one the a-d converter and the other a microcomputer programmed to control the a-d c., switch function and range, format the display and drive both analogue 'bar graph' and digital display up to a count of 3200. Because the usual dual-slope reading rate of 2½ per second isn't fast enough for the bar display and gives slow autoranging, and because its usual range of 1999 counts leads to low resolution of many common voltages for example 28V, 2.2V cells, 240V, a faster reading rate was sought. A series of ten short conversions are made at 25/s each made up to 40ms and without auto-zeroing in between. These 'samples' are used to update the bar and for autoranging, but a summation of the ten is used for the full-resolution digital display.

A point of difference with conventional dual-slope integrations is the overshoot past the zero baseline of the run down after the first sample, so the second and subsequent sample integrations start from a non-zero baseline. A correction is applied in those cases where overshoots from adjacent samplings are not the same: twice the nominal overshoot interval is subtracted from the value in the read register, and the result multiplied by the indicated polarity. Ideally this algorithm results in a maximum error of one count for any sample. A summation of samples results in a full resolution display (with the ½count uncertainty of the a-d conversion process, of course).

Pulse conversion method

With the progress that linear large-scale integration was making it was perhaps inevitable that attention would turn to techniques more complicated than dual-slope integration, particularly in view of its speed limitation. The advantages of 'quantized feedback' couldn't be ignored any longer, according to manufacturers. The first two-chip sets available, one analogue and one digital, were only suitable for 3½ and 4½ digit resolutions, and for 5digit operation Racal-Dana designed their own digital l.s.i. circuit which they used in their 6802-controlled µ5000 series of multimeters. The conversion method intrinsically provides auto-polarity selection, auto zero and ratiometric operation, while high resolution performance isn't required of either the integrator or comparator, only the voltage reference being critical.

Dubbed a 'second generation' device, the first c-mos single-chip quantized feedback converter was produced in 1977 by Siliconix (LD130). It required only a reference and three external capacitors to complete a converter and sold for $4 in quantity. Both its price and its relatively low power consumption made it suitable for portable use. Quantized feedback performs the 'measure' and 'count' phases at the same time. As integration takes place, digital control circuitry feeds quantized charge back to the integrator capacitor in response to the sampling of a comparator, Fig.2 (i). The charge units are produced by adding or subtracting a reference at the integrator input for periods that are counted and accumulated, the integrator output being kept near to the reference level. In effect, the converter measures the charge required to balance that on the integrator capacitor; though it is the time the reference takes to achieve that which represents the input.

Unresolved charge at the end of the count period limits resolution to four digits, and to achieve five digits, the cycle can be extended to include an override interval, Fig.2(j), as in Dana's 5000 series of instruments. During this override the input buffer is grounded so that the remaining capacitor charge is integrated to establish the final digit.

As convesion is done with the input applied, drift in the clock affects path signal and reference charges equally, unlike the dual-slope techniques. The measure and count time can be expanded without needing wider dynamic range in the integrator. And dielectric absorption isn't a problem.

The term multislope convers ion appears to get used in two ways, confusingly. Originally, it

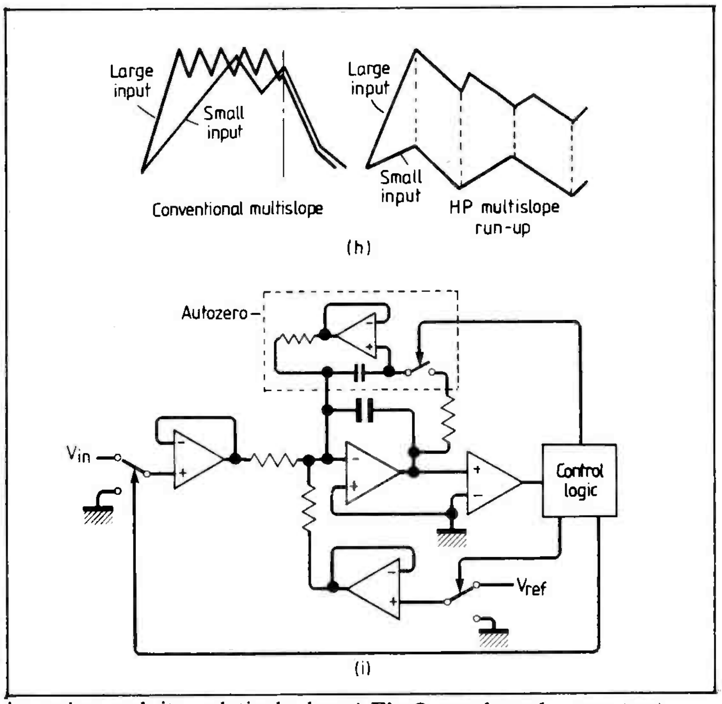

Fig.2 continued – see text

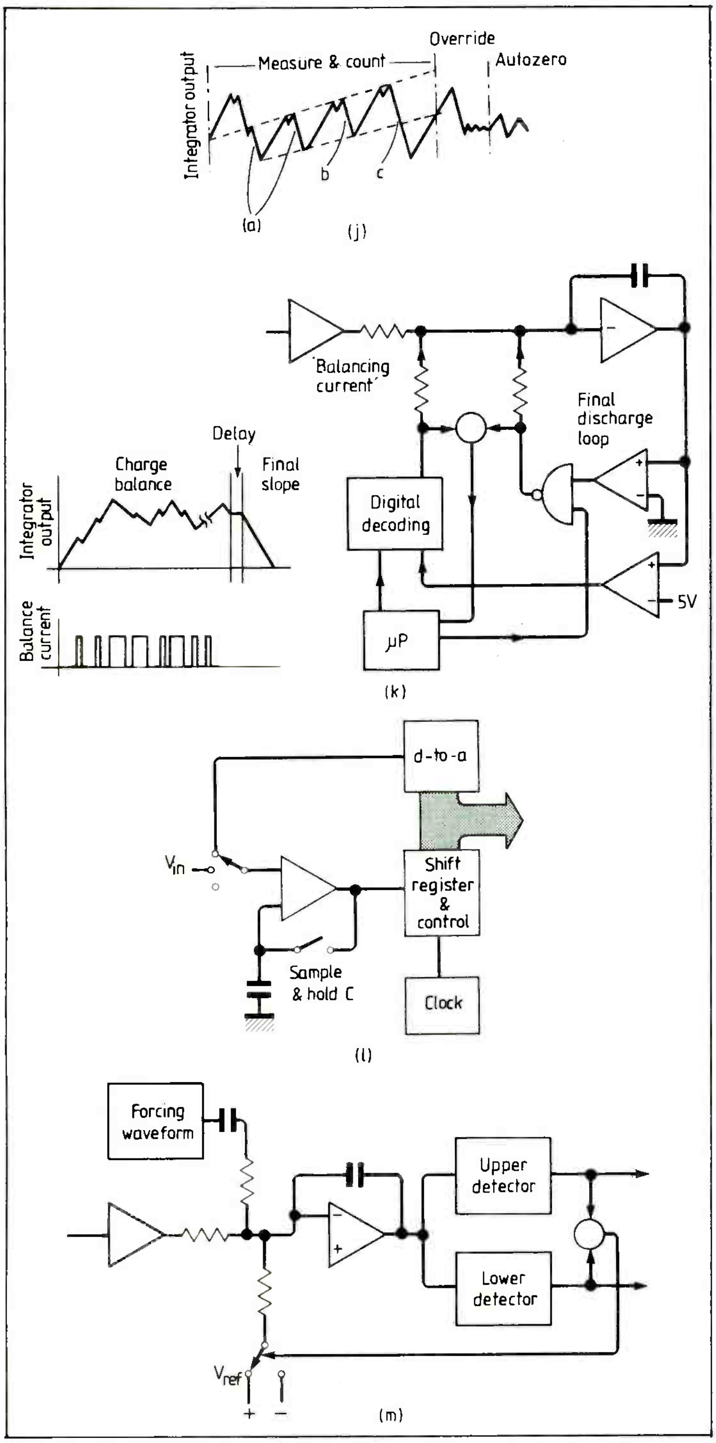

Fig.2 continued – see text

Further details of currently-available digital multimeters will appear in next month's issue.

applied to those variants of the dual-slope method that broke the ramp-down or discharge phase into sections. By decreasing the slope of the run-down, the aim was to increase the accuracy with which the charge on the integrator capacitor could be determined, and so improve the techniques resolution. The input signal is disconnected during this phase. Examples are Figs.2 (e) and (g). But it is also used for the class of integrator where discharges are made during the integration period, such as the saw-tooth scheme which keeps the capacitor charging rapidly; some of the digitization takes place in this period Fig2(h). H.P's term Multislope II helps to distinguish it.

But in another class by far the most of the signal is determined in the early part of cycle, as in 'quantized feedback'. A similar approach is made in Keithley's 191 and 192 models, where the 'charge balancing' period (chosen to minimize mains pick-up) consists of a ramp-up followed by partial constant current discharge for 2μs, after which the reference or balancing current is switched off and the cycle repeats, each time a pulse being generated. The number of pulses is proportional to the integrator output and to the input voltage. With only 4,000 counts in this period the resolution is restricted so a final phase which extracts the remaining charge at reduced current is timed using a fast clock to allow resolution to 6½ digits.

The technique is administered by a microprocessor in Keithley's latest 5½-digit model 197. While the integrator output is below the comparator switching level (5V) a constant-frequency pulse train switches the reference of balancing current with a duty cycle of 12%, Fig2(k). When the integrator output reaches the 5V comparator level the duty cycle is changed to 60% and causes ramp-down, until below the threshold level. The microprocessor counts the time that the balancing current is high. High-speed operation would be needed to get 5½-digit resolution — incompatible with the low speed required for mains-frequency rejection — so again use is made of the charge remaining at the end of the integration cycle. Using a second comparator enabled by the microprocessor timer, the time required to remove the remaining charge is counted, weighted and added to the main count.

Perhaps the oldest method for a-d conversion is that of successive approximation, for it was used in the first three-digit dvm to be sold in Europe by Solartron 25 years ago. In the s.a. technique, which is still widely used and is the basis of a number of integrated a-d converters, an output is held on a capacitor and amplifier switched to a reference, the difference being converted to binary which is successively compared with the unknown input in accurate steps, Fig.2 (l). With error reduction methods, s.a. can produde a good five digit or a poor six-digit converter. Though faster than multislope methods there is no inherent averaging of mains-frequency interference and filtering is essential. But to be as effective as the integration methods at rejecting 50 or 60Hz components a combination of both digital and analogue filtering is necessary, as in the 4½-digit Fluke 8502A, which achieves 100dB of noise rejection at 50Hz.

Nevertheless, Solartron were first to produce a five-digit dvm using s.a., though with the help of a patented 'digit carry' technique. But in the search for greater resolution they went on to develop what they call pulse width conversion, first used in the seven-digit 7075 meter (1977). Now, all Solartron's multimeters use the technique on account of its "superiority over all other systems for precision measurement. And we have used all other systems', says Umar Qureshi, Marketing Manager for dvms. It relies on a balanced dynamic integration that is continuously measuring input voltage and is related to previously lined methods. An l.f. rectangular wave Fig.2(A) wave drives the integrator above and below two detection levels to establish a fixed frequency of operation and reduce the capacitor storage problem. When the integrator output crosses the upper level a positive reference is applied to the feedback path and switched off when the output goes below. With zero input the feedback is a balanced square wave with no d.c. content Detector drift is automatically compensated by this 'calibration balance'. The width of this l.f. waveform is adjusted by the detectors to a net positive or negative level to balance the input. The two detectors gate up and down counters to accumulate a value that represents the digitized input. Integration time is easily varied by gating one or more balance cycles, providing a continuous integration over any selected period.

With this 'calibration balance' and dynamic integration Solartron achieve a non-linearity of less than 0.5 parts per million, with positive and negative reading correlating perfectly. Scale lengths can easily be varied from three to eight digits to suit the application. Fast input changes are followed with p.w.c. and even minor overloads are detected and the circuit protected by fast autorange.

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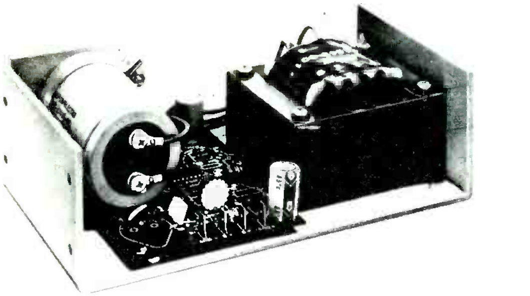

- * DUAL INPUT 110/240 VAC 50/60Hz
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MODEL NO.	VOLTAGE/CURRENT RATING.		DIMENSIONS (mm)	PRICE *
12 A 5	5v	1.2A	96 × 77 × 45	£4.75
12 D 5	5v	12A	229 × 120 × 80	£12.75
12 A 12	12v	0.75A	96 × 77 × 45	£4.75
12 C 12	12v	3A	143 × 124 × 65	£8.75
12 D 12	12v	6.5A	229 × 120 × 80	£12.75
12 A 15	15v	0.5A	96 × 77 × 45	£4.25
12 B 15	15v	.3A	124 × 102 × 45	£6.50
12 C 15	15v	2.8A	134 × 124 × 65	£8.75
12 A 24	24v	0.4A	96 × 77 × 45	£4.25
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MAINS ISOLATORS
Pri/Sec 120V×2

VA	Price	P&P
*20	5.82	1.60
60	9.49	1.80
100	11.08	2.00
200	15.69	2.25
250	18.97	2.64
350	23.47	2.70
500	29.23	2.95
750	41.28	3.70
1000	53.00	4.00
1500	68.37	4.70
2000	82.27	5.10
3000	115.35	OA
6000	203.65	OA

*115 or 240V sec only.

400/440V ISOLATORS
400/440 to 200/240V CT

VA	Price	P&P
60	9.50	1.80
100	11.08	2.00
200	15.68	2.25
250	18.97	2.40
350	23.47	2.70
500	29.23	2.95
1000	52.98	4.00
2000	82.27	5.00
3000	115.37	OA
6000	228.75	OA

24/12V or 12-0-12V
2×12V Secs. Pri. 240V

12V	24V	Price	P&P
0.3A	.15	2.41	.90
1	.5	3.19	1.20
2	1	4.25	1.20
4	2	4.91	1.60
6	3	7.69	1.60
8	4	8.98	1.60
10	5	9.82	1.80
12	6	10.89	1.90
16	8	12.97	2.12
20	10	17.46	2.44
30	15	21.69	2.64
60	30	44.45	OA
83	41	51.20	4.50

(AMPS)

96/48V. Pri 2×120V
Secs 2×36/48V

72/96-	36/48V	Price	P&P
0.5A	1	5.37	1.20
2	4	14.69	2.20
3	6	17.79	2.40
5	10	32.23	3.20
6	12	40.36	3.50
8	16	44.03	3.75

(AMPS)

50/25V or 25-0-25V
2×25V Tap Secs. 5, 7, 8, 10, 13, 15, 17, 20, 25, 30, 33, 40, 20-0-20 or 25 0-25V

50V	25V	Price	P&P
0.5	1	4.13	1.40
1	2	5.03	1.50
2	4	8.69	1.84
3	6	10.36	1.90
4	8	14.10	2.12
6	12	18.01	2.20
8	16	24.52	2.70
10	20	30.23	3.00
12	24	36.18	3.20

(AMPS)

60/30V or 30-0-30V
Pri 2x120V. 2×30V Tap Secs 6, 8, 10, 12, 16, 18, 20, 24, 30, 36, 40, 48, 60, 24-0-24 or 30-0-30V.

60V	30V	Price	P&P
0.5	1	4.70	1.50
1	2	7.15	1.50
2	4	9.20	1.90
3	6	13.31	2.00
4	8	15.15	2.20
5	10	19.16	2.20
6	12	21.86	2.65
8	16	30.72	3.00
10	20	35.76	3.30
12	24	41.22	3.50

(AMPS)

MINIATURES

Sec V	Amp	Pri	P&P
3-0-3	.2A	3.11	.90
6×2	1A×2	3.45	1.20
9-0-9	.1	2.59	.90
9×2	.33×2	2.41	.90
8,9×2	.5×2	3.36	1.20
8,9×2	1A×2	4.27	1.40
15×2	.2A×2	2.41	.90
12-0-12	.05	3.11	.90
20×2	.3×2	3.39	1.20
20×2	.15×2	1.50	.50
20,12,0			
12,20	.9	4.13	1.30
15,20-2	1A×2	5.60	1.60
15,27×2	.5×2	4.83	1.40
15,27×2	1A×2	7.30	1.60

TOROIDALS
Wound to spec.
30VA to 5KVA

EXPORT ENQUIRIES WELCOMED

30/15V or 15-0-15V
2×15V Tap Sec. Volts 3, 4, 5, 6, 8, 9, 10, 12, 15, 18, 20, 24, 30 or 15-0-15V

30V	15V	Price	P&P
0.5A	1	3.19	1.20
1	2	4.32	1.40
2	4	6.99	1.60
3	6	8.10	1.85
4	8	9.67	1.90
5	10	11.95	2.00
6	12	13.52	2.00
8	16	18.10	2.26
10	20	20.88	2.26
12	24	23.20	2.50
15	30	26.60	3.00
20	40	35.64	4.83

(AMPS)

AUTOS
105, 115, 220, 230, 240V
For step-up or down

VA	Price	P&P
80	4.84	1.40
150	6.48	1.60
350	11.84	2.00
500	13.30	2.24
1000	24.14	2.80
1500	28.17	3.20
2000	42.14	4.00
3000	71.64	4.80
5000	108.30	OA

CASED AUTOS
240V to 115V USA skts.

VA	Price	P&P
20	7.21	1.50
80	9.35	1.60
150	12.10	1.90
250	14.73	2.00
500	24.14	2.20
1000	33.74	2.80
2000	60.47	4.50

EDUCATIONAL METERS
Front finger screw terminals
78×98mm
0—10A
0—2A £3.98each
0—30V+ .50 p&p

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12/24 V DC-240V AC

100W	£59.27
250W	£154.93
500W	£239.50
1000W	£350.00
2000W	£709.00

CONSTANT VOLTAGE TRANSFORMER 1%
Spike-free stable mains

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500VA	£196.69
1KVA	£338.40
2KVA	£594.50
3KVA	£957.73
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5KVA	£1531.00
6KVA	£1743.00
7.5KVA	£2073.00
10KVA	£3347.00

AVOs & MEGGERs

8Mk5	£126.00
8Mk6(latest)	£138.70
DA211 LCD	£68.40
DA116 LCD	£154.50
DA117 Auto	£157.00
Megger Gen	£116.40
Batt Megger	£85.50
DA 2000	£72.80

P&P £2 VAT 15%

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Transformers T1, T2
£5.70 inc VAT

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Accurate metering of voltage & current is provided, with electronic fold back current limiting to give fast, safe protection to both power supply & external equipment.

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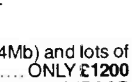
Lynwood GD1 VDUs: Intelligent Green micro controlled, RS232, printer port, 101 key k/b. Full Video enhancements. ONLY **£149** + £15 P&P (S/H)

Burroughs MT686/7/TD710: Intelligent Green 12" VDU with 3 micros and 64K store. RS232. Programmable... Only **£199** new or £149 S/H + £15 P&P

Videcom Apollo VDUs: Stylish 15" Green Z80 controlled VDU with printer port and lots of very advanced features. Only **£399** new or £249 S/H £15 P&P



Centronics 306 Line printers: Professional fast (120 cps), superb quality 80 column printer. Parallel i/f..... ONLY **£99** + £15.00 P&P

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Diablo 630 Daisywheel printer. OEM i/f NEW **£599** + £15 P&P
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SAE for LIST and enquiries

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SHUGART DISK DRIVES. Cabinet containing 2 × 801 Disk Drives with PSU & FORMATOR. Un-used £250
DIOBLO HITYPE 11 Daisy Wheel Printer 1355WP £250
GE TERMINET PRINTER with Keyboard. Upper & Lower Case £100
DATA DYNAMIC 390 (Teletype ASR33) — Printer, Keyboard, Punch & Reader in Sound Proof enclosure) £50
AZTEC 20in MONITOR Black & White. Composite Video £40

Item No

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89 EH PULSE GEN 139L 1KHZ-20MHZ Single/Double Pulse £200
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99 TEK TIME MARK GEN 180 £40
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104 MARCONI Q METER TF329G 50KHZ-50MHZ £150
106 MARCONI UNIVERSAL BRIDGE TF1313 0.25% £200
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114 WAYNE KERR COMPONENT BRIDGE B521 (CT375) L 100uH-500kH; C 1pF-5F; R1 milliohm-1000 Mohm £35
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169 KINGSHILL STAB PSU Model 500 0-60V 0.5A. Current limiting. Metered P&P £7 £40
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281 H.P. LOGIC STATIC ANALYSER 1602A £450
286 AVO VALUE CHARACTERISTIC METER VCM 163 £275
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297 MARCONI DIFFERENTIAL DC VOLTMETER TF2606 0-1100V £225
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CIRCLE 66 FOR FURTHER DETAILS.

01-208 1177 TECHNOMATIC LTD 01-208 1177

BBC Micro Computer System OFFICIAL DEALER

ACORN COMPUTER SYSTEMS:
BBC Model B Special offer .... £320 (a)
BBC Model B + Econet .... £389 (a)
BBC Model B + DFS .... £409 (a)
BBC Model B + DFS + Econet ...... £450 (a)

UPGRADE KITS
A to B Upgrade Kit .... £75 (c)
DFS Kit .... £95 (c)
Econet Kit .... £45 (c)
Speech Upgrade Kit .... £47 (c)

ACORN ADDON PRODUCTS:
Z80 2nd Processor .... £265 (a)
6502 2nd Processor .... £175 (b)
Teletext Adaptor .... £190 (b)
IEEE Interface .... £282 (b)
Prestel Adaptor .... £99 (b)
RH Light pen .... £39.50 (c)

BBC FIRMWARE:
1.2 Operating System Rom .... £7.50 (d)
BASIC II ROM .... £22.50 (d)
VIEW Word Processor Rom .... £48.00 (c)
WordWise Word Processor Rom .... £34.00 (d)
BCPL ROM/Disc .... £86.00 (c)

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EXMON/TOOLKIT ROM .... £20 ea (d)
Printmaster (FX80)/GraphicsROM .... £28 ea (d)
ULTRACALC spreadsheet ROM £69 ea (c)

COMMUNICATION ROMS:
Termi Emulator .... £28 (d)
Communicator .... £59 (d)
Commstar .... £29 (d)

For detailed specification on any of the BBC Firmware/Peripherals listed here or information on our complete range please write to us.

DISC DRIVES

These drives, fitted with high quality slim line Japanese mechanisms are supplied in attractive cases with BBC matching colour and come complete with data and power leads, manual and formatting disc. The 40/80T switching is supplied as standard on TEAC 80T drives. Single drives are supplied with or without power supply. All dual drives are supplied with integral switch mode power supply. TEAC & MITSUBISHI drives are compatible for both single and double density operation. These drives can also be used with any other micro with a Shuggart A400 interface.

1 x 100K TS55A (40T) TEAC .... £120 (b)
1 x 200K TS55E (40/80T) TEAC .... £160 (b)
1 x 400K TS55F (40/80T) TEAC .... £198 (b)
2 x 100K TD55A (40T) TEAC with PSU .. £300 (a)
2 x 200K TD55E (40/80T) TEAC with PSU £390 (a)
2 x 400K TD55F (40/80T) TEAC with PSU £420 (a)
CS55A TEC with PSU .... £135 (a)
CS55E TEC with PSU .... £175 (a)
CS55F MIT with PSU .... £215 (a)
40/80T Switch Module .... £30 (c)
3" Hitachi 100K Drive .... £120 (b)
TD55M (80T) Mitsubishi .... £420 (a)

DISCS & ACCESSORIES

The 3M discs with a life time warranty provide a reliable and error free performance at economical prices. Floppiclene head cleaning kit is an ideal way to ensure optimum performance of your drives.

3M DISCS in packs of 10
40T SSDD **£16 (c)**; 40T DSDD **£22** (c);
80T SSDD **£24** (c); 80T DSDD **£27** (c);
10 Disc Library Case **£1.95** (c);
30 Disc Case **£6 (c)**;
3" Maxell DS Disc **£4.50 ea** (d);
FLOPPICLENE Kit (20 disposable discs) **£14.50** (c);
Drive Cables: Single **£6.50** Dual **£8.50** (d);
30/40 Disc Lockable Case **£14.50** (c);
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Our wide range of printers offer a choice of printer for every requirement at competitive prices. We have the full EPSON range which sets the industry standards for reliability, flexibility and versatility. The new KAGA TAXAN range provides the NLQ printing fonts and other new exciting features. For those wanting the correspondence quality printing we have the BROTHER and JUKI printers. To support our range of printers we also carry a wide range of printer interfaces, accessories and consumables.

EPSON: RX80FT **£240** (a); FX80 **£325** (a); FX 100 **£480** (a):
KAGA TAXAN: KP 810 **£269** (a); KP910 **£369** (a);
BROTHER: HR15 **£350** (a); EP44 **£199** (a):
JUKI 6100 **£359** (a).
3 Col Graphics Plotter/Work Stn **£490** (a)
3 Col Graphics Plotter only **£270** (a)
Grafpad Graphics Tablet .... **£120** (b)

ACCESSORIES

EPSON Serial Interface: 8143 **£35** (b); 8148 with 2K buffer **£50** (b).
EPSON Paper Roll Holder **£17** (b); FX80 Tractor Attach **£37** (b); RX/FX80 Dust Cover **£4.50** (d).
EPSON Ribbons: MX/RX/FX80 **£6.50**; MX/RX/FX100 **£12.50** (d).
JUKI: Serial Interface **£60** (a); Tractor Attach. **£99** (a); Sheet Feeder **£199** (a); Ribbon **£2.50** (a).
BROTHER HR15: Sheet Feed **£199**; Ribbons - Carbonor Nylon **£3**; Multistrike **£5.50** (d); 2000 Sheets Fanfold with extra fine perf. 9.5" - **£13.50**; 15" **£17.50** (b).
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MICROVITEC 14" RGB
1431 Std Res **£195** (a); 1431AP std Res PAL/Audio **£215** (a);
1451 Med Res **£295** (a); 1441 Hi Res **£399** (a);
2031 20" Std Res **£360** (a); Plinth for 14" Monitors **£8.50**.
Microvitec Monitors with TTL/Linear Inputs also available.

KAGA VISION III
Super Hi Res 12" RGB **£358** (a);
Green Screens: KAGA 12G **£106** (a); SANYO DM8112CX **£99** (a);
Swivel Stand for Kaga Green **£22.50** (b);
BBC Leads: KAGA RGB **£5** Microvitec **£3.50**; Monochrome **£3.50** (d).

TORCH Z80 PACK

The proven Z80/CPM upgrade for the BBC with Z80 CPU/64K RAM/CPN ROM 2 × 400K Disc Drive and PERFECT software Package — **£675** (a); ZEP100 Z80CPU/64K RAM/CPN ROM & PERFECT software package — **£290** (a); Torch UNICOM Communications Package — **£161** (b). **GRADUATE** The card to convert your BBC into an IBM PC. To be available early September. Send for details.

ATTENTION

All prices in this double page advertisment are subject to change without notice.

ALL PRICES EXCLUDE VAT
Please add carriage 50p unless indicated as follows:
(a) £8 (b) £2.50 (c) £1.50 (d) £1.00

TIME WARP Real Time Clock/Calendar for the BBC.

A low cost unit with built in battery back up opens up numerous applications like electronic dairy, display of time & date, document dating, precise timing and control in scientific experiments. Simply plugs into the user port. Send for full details. .... **£29 + £2 p&p.**

SMARTMOUTH The original speech synthesis for the BBC: still the best.

Attractively packaged self contained speech synthesiser with built in speaker and AUX socket. Allows creation of any English word with ease and economical memory usage. Simply plug into the user port, simple software means no need for ROMs. Supplied with software instructions and demo/development programs. ..... **£37 + £2 p&p.**

EPROMER II PROGRAMMER

Our current version of the highly popular Eprom programmer is now being enhanced to provide more and better facilities for easy programming by the user. The software will maintain its superiority over all currently available similar programmers. The range of eproms handled has been widened, to include the eproms with lower programming voltage and eproms which can be programmed using algorithm. Control of all operations has been moved to the keyboard. The screen display has been improved to give more information. The screen editing facilities have also been modified to simplify the data entry.

- The new Eprom Programmer will now program 2516, 2532, 2564, 2716, 2732, 2764, 27128 and 27128 + 5v eproms, and all but the 27256 in a single pass.
- The programmer will be supplied with integral power supply, and interfaces with the BBC via the 1MHz bus. It is fully buffered and complies with Acorn protocols. There is no power drain from the computer.

Please telephone for further details.

PRINTER SHARER & BUFFER

This printer sharer/buffer provides a simple way to upgrade a multiple computer system by providing greater utilisation of available resources. The buffer offers a storage of 64K. Data from three computers can be loaded into the buffer which will continue accepting data until it is full. The buffer will automatically switch from one computer to next as soon as that computer has dumped all its data. The computer then is available for other uses. LED bargarph indicates memory usage. Simple push button control provides REPEAT, PAUSE and RESET functions. Integral power supply. £245 (a).

MODEMS

BUZZ BOX Full spec pocket sized with Originate & Answer modes. BT Approved. Confirms to CCITT V21 300/300 Baud Battery/Mains powered £65 (b).
TELEMOD2 Full & Half duplex operation: BT Approved: CCITT V23 std: 1200/75 or 1200/1200 Baud operation, Mains powered £65 (b).
MINOR MIRACLES WS 2000 One package that provides almost all international communication standards: CCITT V21/23, BELL 103/113/108/202, (BT Appr. exp) 300/300, 600/600, 1200/75 & 75/1200 Baud. Mains powered £129 (b).

SOFTY II

This low cost intelligent eprom programmer can program 2716, 2516, 2532, 2732, and with an adaptor, 2564 and 2764. Displays 512 byte page on TV — has a serial and parallel I/O routines. Can be used as an emulator, cassette interface.
Softy II .... **£169.00 (b)**
Adaptor for 2764/2564. **£25.00**(c

UV ERASERS

UV1T Eraser with built-in timer and mains indicator.
Built-in safety interlock to avoid accidental exposure to the harmful UV rays.
It can handle up to 5 eproms at a time with an average erasing time of about 20 mins. **£59 + £2 p&p.**
UV1 as above but without the timer. **£47 + £2 p&p.**
For Industrial Users, we offer UV140 & UV141 erasers with handling capacity of 14 eproms. UV141 has a built in timer. Bother offer full built in safety features UV140 **£61**, UV141 **£79**, **p&p £2.50**.

PRODUCTION PROGRAMMER

P8000
P8000 provides reliable gang programming of up to 8 EPROMS simultaneously with device sizes up to 16K × 8 bytes rail versions. Simple menu driven operation ensure easy eprom selection and reliable programming in minimum programming times. **£695 + £6 carriage.**

EP8000
This CPU controlled Emulator Programmer is a powerful tool for both Eprom programming and development work. EP8000 can emulate and program all eproms up to 8K × 8 bytes, can be used as stand alone unit for editing and duplicating EPROMS, as a slave programmer or as an eprom emulator **£695 (a).**

CONNECTOR SYSTEMS

I.D. CONNECTORS

(Speedblock Type)

No of ways	Header Plug	Receptacle	Edge Conn.
10	90p	85p	120p
20	145p	125p	195p
26	175p	150p	240p
34	200p	160p	320p
40	220p	190p	340p
50	235p	200p	390p

D CONNECTORS

No. of ways

	9	15	25	37
MALE				
Solder	80p	105p	160p	250p
Angled	150p	210p	250p	365p
FEMALE				
Solder	105p	160p	200p	335p
Angled	165p	215p	290p	440p
Hoods	90p	85p	90p	100p

IDC 25-way plug 385p. Socket 450p.

TEXTOOL ZIF

SOCKETS 24-pin £5.75
28-pin £8.00 40-pin £9.75

DIL SWITCHES

4-way 90p 6-way 105p
8-way 120p 10-way 150p

JUMPER LEADS

24" Ribbon Cable with Headers

	14-pin	16-pin	24-pin	40-pin
1 end	145p	165p	240p	350p
2 ends	210p	230p	345p	540p

24" Riboon Cable with Sockets

	20-pin	26-pin	34-pin	40-pin
1 end	160p	200p	280p	300p
2 ends	290p	370p	480p	525p

Ribbon Cable with D Conn
25-way Male 500p Female 550p

RS 232 JUMPERS

(25 way D)

24" Single end Male £5.00
24" Single end Female £5.25
24" Female Female £10.00
24" Male Male £9.50
24" Male Female £9.50

DIL HEADERS

	Solder	IDC
14 pin	40p	100p
16 pin	50p	110p
24 pin	100p	150p
28 pin	200p	—
40 pin	200p	225p

AMPHENOL CONNECTORS

36-way plug Centronics Parallel Solder £5.25 IDC £5.25
36-way socket Centronics Parallel Solder £5.50 IDC £5.50
24-way plug IEEE Solder £5 IDC £4.75
24-way socket IEEE Solder £5 IDC £4.75

PCB Mtg Skt
Any Pin 24 way Solder 600p
36 way ZOC 650p

RIBBON CABLE

(grey/metre)

10-way	40p
16-way	60p
20-way	85p
26-way	120p
34-way	160p
40-way	180p
50-way	200p
64-way	280p

EURO CONNECTORS

DIN 41612

2 × 32 way St Pin	230p	275p
2 × 32 way Ang Pin	275p	320p
3 × 32 way St Pin	260p	300p
3 × 32 way Ang Pin	375p	400p
IDC Skt A + B	275p	
IDC Skt A + C	350p	

For 2 × 32 way please specify spacing (A + B, A + C).

TEST CLIPS

14-pin 375p 16-pin 400p
40-pin £10.30

EDGE CONNECTORS

	0.1"	0.156"
2 × 6-way (commodore)	—	300p
2 × 10-way	150p	—
2 × 12-way (vic 20)	—	350p
2 × 18-way	—	140p
2 × 23-way (ZX81)	175p	220p
2 × 25-way	225p	220p
2 × 28-way (Spectrum)	200p	—
2 × 36-way	250p	—
1 × 43-way	260p	—
2 × 22-way	190p	—
2 × 43-way	395p	—
1 × 77-way	400p	500p
2 × 50-way(S100conn)	600p	—

FIVE-FINGER EXERCISE

A keyboard add-on for the BBC Micro enables it to be operated with one hand, moreover because the keys are all multi-function and not marked, the keying sequence has to be learned and by its very nature the user is touch typing even before he/she realises it. Such is the claim for the Quinkey alternative keyboard for the micro. There are only six keys; one for each right-hand finger and two for the thumb. The fingers are only ever used on their own keys. The second thumb key acts as a shift or control key and enables the keyboard to access all the keys of the normal keyboard. The Quinkey comes with an adaptor which plugs into the analogue input of the Beeb. Software on cassette, easily transferred to disc, programs the computer to interpret the Quinkey input into ASCII characters. To cater for multi-user school applications up to four Quinkey keyboards may be plugged into the adaptor and all four can use the computer at the same time, the screen being divided into different-coloured windows. Included in the software is a program that coordinates the Quinkey with Wordwise or View word processor programs.

On a trial run with the Quinkey, your correspondent found that it was quite easy to learn the alphabet, following the very clear instructions in the manual, but that the control functions and special characters were more difficult to pick up. It may be some time for speed to be acquired before the Quinkey entirely replaces the traditional keyboard, but one instinctively feels that such an approach is right and is worth persevering with.

Microwriter, who produce the Quinkey, tells us that even left-handed users are happy with the right-handed keyboard, but a left-handed version is available to special order. The Quinkey costs £49.95 inclusive and includes the adaptor, manual and the cassette software. An educational pack for £148.80 includes four keyboards, a users' guide and special software on a cassette tape. Microwriter Ltd, 31 Southampton Row, London WC1.
EWW 205

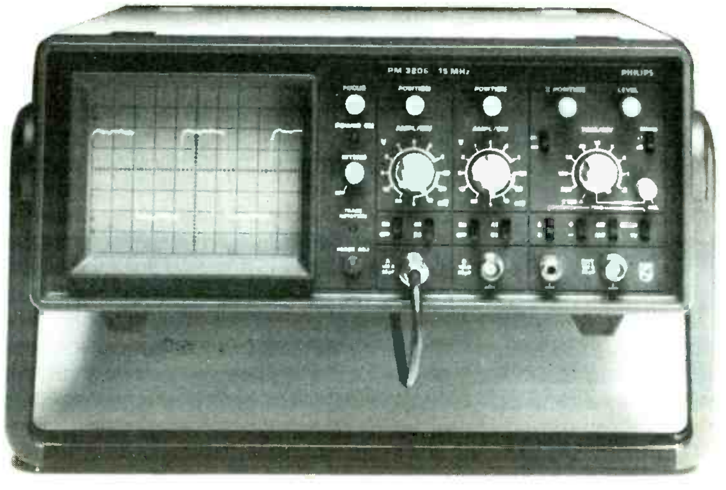
MONITOR CONSULTANCY

A design consultancy specializing in colour and monochrome monitors enables companies to commence monitor production quickly and inexpensively. As an example, a monochrome design for either 9 or 12in tubes, powered from a +12V supply can have a video bandwidth of over 20MHz and can accept either composite sync. or separate line and field syncs. in addition to a t.t.l. video circuit. It can have a very low component count and built onto a p.c.b. measuring only 100 by 160mm.

Similar design criteria are used for the colour monitors, resulting in compact, high performance units at low cost; even in small batch numbers. Special versions can be designed to suit virtually any application, civil or military. Existing or special designs are available on a manufacturing licence basis, with royalties payable on actual production levels. This approach can eliminate research and development costs and minimize production delays. Combe Martin Electronics, King Street, Combe Martin, North Devon, EX34 OAD.
EWW 210

LOW COST 15MHz OSCILLOSCOPE

A new dual-trace oscilloscope from Philips offers a high standard of performance and reliability and yet costs only £275. The PM3206 has all the facilities expected of a general-purpose instrument that may be used for field engineers, educational and industrial laboratories. These include a wide sensitivity range, 5mV to 20V/cm, a bright c.r.t. with a built-in graticule, and a variety of triggering facilities including tv triggering. X and Y amplifiers are provided and the instrument is capable of Z modulation on the display. The case is constructed from tough a.b.s. plastic and the oscilloscope has been given a full environmental testing for durability against vibration, temperature and humidity extremes. The front panel controls are clearly labelled and conveniently spaced. Internally, the use of integrated circuits has led to neat, compact circuitry which makes it easier to manufacture and may account for Philips' ability to produce a high specification instrument at a comparatively low cost. They have called it a 'ProAm' device to indicate that it might bridge the gap between amateur and professional equipment. Having chosen this label, perhaps there will be other instruments in this class. Pye Unicam Ltd, York Street, Cambridge CB1 2PX.
EWW 206



To get further information on any of the products mentioned in these columns, circle the appropriate number on the reply card.

LINSLEY-HOOD 300 SERIES AMPLIFIERS

35 Watt Complete Kit. MosFet O/P £79.50
45 Watt Complete Kit. MosFet O/P £83.50
Reprints of Original Articles from 'Hi-Fi News' .... £1 no VAT.

LINSLEY-HOOD 100-WATT MOSFET POWER AMPLIFIER

The very latest amplifier design, published in 'Wireless World' by the renowned John Linsley-Hood. This may now be taken as the standard by which the rest are judged! Our kit, approved by the designer, has massive heat sinks and power supply and includes all components needed to build. Case size 412mm wide, 254mm deep and 145mm high. Automatic switched speaker protection is included as standard. Cost of all parts is over £120. Our complete stereo kit price £105.50.

LINSLEY-HOOD CASSETTE RECORDER CIRCUITS

Complete record and replay circuits for very high quality low noise stereo cassette recorder. Circuits are optimised for our HS16 Super Quality Sendust Alloy Head. Switched bias and equalisation to cater for chrome and feric tapes. Very easy to assemble on plug-in PCBs. Complete with full instructions.
Complete Stereo Record/Play Kit £25.26
VU Meters to suit .... £2.30 each
Reprints of original Articles .... 75p. No VAT.

STUART TAPE RECORDER CIRCUITS

Complete stereo record, replay and bias system for reel-to-reel recorders. These circuits will give studio quality with a good tape deck. Separate sections for record and replay give optimum performance and allow a third head monitoring system to be used where the deck has this fitted. Standard 250mV input and output levels. Full details are in our lists.
Reprint of Original Articles .... £1.30. No VAT.

SET OF 4 SUB-MINIATURE IF TRANSFORMERS for high quality AM tuner. THE SET ONLY 38p!
Application circuit if required 10p
Suitable ferrite rod antenna 85p

AM VARICAP DIODE BARGAIN Due to a fantastic bulk purchase we are now able to offer the super SMV2012 varicap diodes at unvelievable prices. These are a wide range diode for use in AM tuner applications. They are also supplied in matched sets to eliminate tracking errors!. Matched pair only **25p.** Matched 4 only **60p.**

AM TUNER COIL SET Set of 4 cols for long medium and short wave AM tuner. Coils are LW Osc. MW OSc, SW Osc and SW Aerial. Normally **30p** each. OUR PRICE FOR THE SET ONLY **55p.**

Application circuit using coils and matched pair of SMV2012 varicaps 35p
Suitable PC Board £1.50
PC Mounting Wavechange Switch £1.60

STEREO CASSETTE DECK

Following the runaway sellout of our last cassette deck we have now obtained a small quantity of an even nicer one. Main features are full auto-stop, Chrome/Ferric Switch, Manual record level control (invaluable for computer use), twin VU meters and 3-digit counter. Complete with all record and replay circuitry, control keys and cassette carrier/door. Very good quality and only **£21.80** inc Vat and Post. Circuit diagram and Noies 35p.

ALPS FF317U FM FRONT END

Beautiful, precision made High Quality variable capacitor tuned FM Front End with Dual-gate MosFet. The tuning capacitor also has 2-AM Gangs and built in 3:1 reduction gear. Covers full FM range of 87 to 109MHz. Supply needed is 12V at only 30mA Max. Inputs are provided for AGC and AFC signals. These have recently been on special offer from another supplier at £4 plus VAT. **OUR PRICE IS ONLY £3.99 INCLUDING VAT AND POSTAGE!** Circuit if required 35p.

COMPLETE STEREO TUNER MODULE

Three band LW/MW/FM Stereo Tuner fully assembled on PCB 165 × 85mm. Supplied with Ferrite rod aerial and band switch fully wired. Facility provided to drive tuning meter and stereo LED. Only needs 12v DC supply. FM sensitivity. 2.5uV. **Price only £7.99 inc. VAT and post.**

'STEREO AMPLIFIER MODULE'

Ready built and tested quality power amplifier module complete and ready to use. Mains input 220/240v with power to spare for tuner and tape deck. Size 190 × 110 × 65mm.

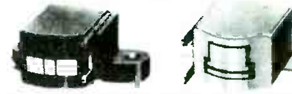
TUNER AND PRE-AMP MODULE

Matching unit to above. Contains Long, medium and short wave AM tuner. Stereo FM tuner and pre-amp with switched inputs for tuners, tape and pickup. Complete with flywheel drive and cord assembly. Size 400 × 220 × 63mm.
Special offer for both items only **£16.90.**

COMPONENTS

We now list a wide range of individual components many of which are not available elsewhere. Send for your copy of our latest list which also gives further information on our Kits.

HIGH QUALITY REPLACEMENT CASSETTE HEADS



Do your tapes lack treble? A worn head could be the problem. Fitting one of our replacement heads could restore performance to better than new! Standard mountings make fitting easy and our TC1 Test Cassette helps you set the azimuth spot-on. We are the actual importers which means you get the benefit of lower prices for prime parts. Compare us with other suppliers and see! The following is a list of our most popular heads, all are suitable for use on Dolby machines and are ex-stock.

HC20 Permalloy Stereo Head. This is the standard head fitted as original equipment on most decks £5.11
HM90 High Beta Permalloy Head. A hard-wearing, higher performance head with metal capability £8.06
HS16 Sendust Alloy Super Head. the best head we can find. Longer life than Permalloy, higher output than Ferrite, fantastic frequency response £9.91
HQ551 4-Track Head for auto-reverse or quadrophonic use. Full specification record and playback head £9.73
Please consult our list for technical data on these and other Special Purpose Heads.
MA481 Latest version Double Mono (2/2) Record/Play head. Replaces R484 .... £8.90
SM166 Standard Mounting 2/2 Erase head. Compatible with above or HQ551 4 Track head £5.90
ME151 Non Standard Mounting 2/2 Erase head £4.25
H524 Standard Erase Head. Semi double gap, high efficiency £1.50
H561 Metal Tape Erase Head. Full double gap £4.90

HART TRIPLE-PURPOSE TEST CASSETTE TC1

One inexpensive test cassette enables you to set up VU level, head azimuth and tape speed. Invaluable when fitting new heads. Only £4.66 plus VAT and 50p postage.

Tape Head De-magnetiser. Handy size mains operated unit prevents build up of residual head magnetisation causing noise on playback £4.54
Curved Pole Type for inaccessible heads £4.85

Please add part cost of post, packing and insurance as follows:

INLAND	OVERSEAS
Orders up to £10 – 50p	Please send sufficient to cover
Orders £10 to £49 – £1	Surface or Air Post as required.
Orders over £50 – £1.50	

ALL PRICES EXCLUDE VAT UNLESS STATED

Personal callers are always very welcome but please note that we are closed all day Saturday

(0691) 652894

HART ELECTRONIC KITS LTD
PENYLAN MILL
OSWESTRY, SHROPSHIRE
SY10 9AF

1.5GHz testing problems?

Use a TECHTEST Model 260 1.5GHz Up-Converter

— it works with any 240-350 MHz generator

The Model 260 has been designed to provide a very economical signal source for testing 1.5 GHz communication equipment. It is a linear heterodyne up-converter that employs advanced techniques to generate very clean and stable signals in the 1440-1550 MHz band from signal generator inputs 1200 MHz lower. Since it has zero insertion loss the input signal generator controls are used directly to set the output signal level and all modulation conditions. Full accuracy and stability is ensured by phase-locking the internal 1200 MHz local oscillator to the signal generator standard. Find out more from:

Techtest Ltd, Street Court, Kingsland, Leominster, Herefordshire HR6 9QA England. Telephone: KINGSLAND (056881) 744 Telex 837264.

CIRCLE 79 FOR FURTHER DETAILS.

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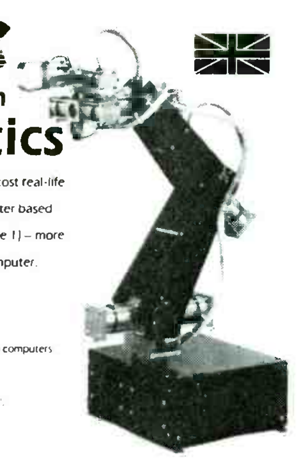
neptune

for low-cost training in

real-life robotics



The advanced design of the Neptune 2 makes it the lowest cost real-life industrial robot.
It is electro-hydraulically powered, using a revolutionary water based system (no messy hydraulic oil!)
It performs 7 servo-controlled axis movements (6 on Neptune 1) – more than any other robot under £10,000.
Its program length is limited only by the memory of your computer.
Think what that can do for your BASIC programming skills!

And it's British designed, British made.

Other features include:
- Leakproof, frictionless rolling diaphragm seals
- Buffered and latched versatile interface for BBC VIC 20 and Spectrum computers
- 12 bit control system (8 on Neptune 1).
- Special circuitry for initial compensation
- Rack and pinion cylinder couplings for wide angular movements
- Automatic triple speed control on Neptune 2 for accurate 'homing in'.
- Easy access for servicing and viewing of working parts
- Powerful – lifts 2.5 kg. with ease.
- Hand held simulator for processing (requires ADC option)

Neptune robots are sold in kit form as follows:

Neptune 1 robot kit (inc. power supply)	£1250.00	ADC option (components fit to main control board)	£95.00
Neptune 1 control electronics (ready built)	£295.00	Hydraulic power pack (ready assembled)	£435.00
Neptune 1 simulator	£45.00	Gripper sensor	£37.50
		Optional extra three fingered gripper	£75.00
Neptune 2 robot kit (inc. power supply)	£1725.00	BBC connector lead	£12.50
Neptune 2 control electronics (ready built)	£475.00	Commodore VIC 20 connector lead and plug-in board	£14.50
Neptune 2 simulator	£52.00	Sinclair ZX Spectrum connector lead	£15.00

All prices exclusive of VAT and valid until the end of 1984.

mentor

desk-top robot

This compact, electrically powered training robot has 6 axes of movement, simultaneously servo-controlled. It gives smooth operation, and its rugged construction makes it ideal for use in educational establishments. Other features include long-life bronze and nylon bearings, integral control electronics and power supply, special circuitry for inertial compensation, optional on-board ADC, and hand-held simulator as the teaching pendant. Like Neptune, Mentor's program length is limited only by your computer's memory. Programming is in BASIC.

Mentor is all-British in design and manufacture and comes in kit form at an astonishingly low price:

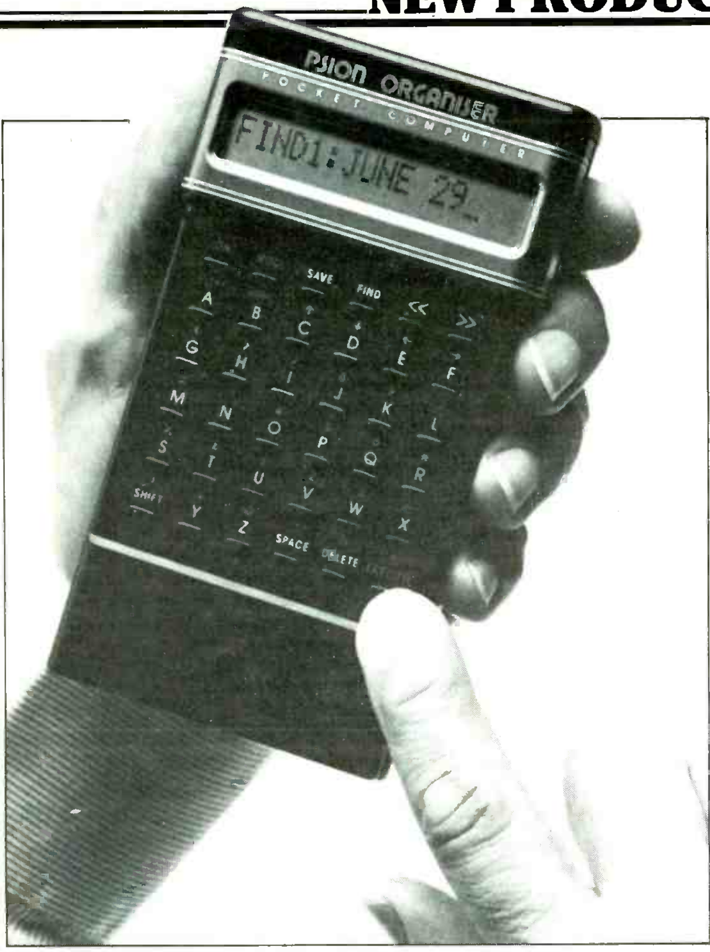
Mentor robot kit (inc. power supply)	£345.00
Mentor Control electronics (ready built)	£135.00
Mentor Simulator (requires ADC option)	£42.00
ADC option (Components fit to control electronics board)	£19.50
BBC connector lead	£12.50
Commodore VIC 20 connector lead and plug-in board	£14.50
Sinclar ZX Spectrum connector lead	£15.00

All prices exclusive of VAT and valid until the end of 1984.

Cybernetic Applications

CYBERNETIC APPLICATIONS LIMITED
PORTWAY TRADING ESTATE, ANDOVER, HANTS SP10 3PR
TEL: (0264) 50093 Telex: 477019

CIRCLE 61 FOR FURTHER DETAILS.



POCKET COMPUTER

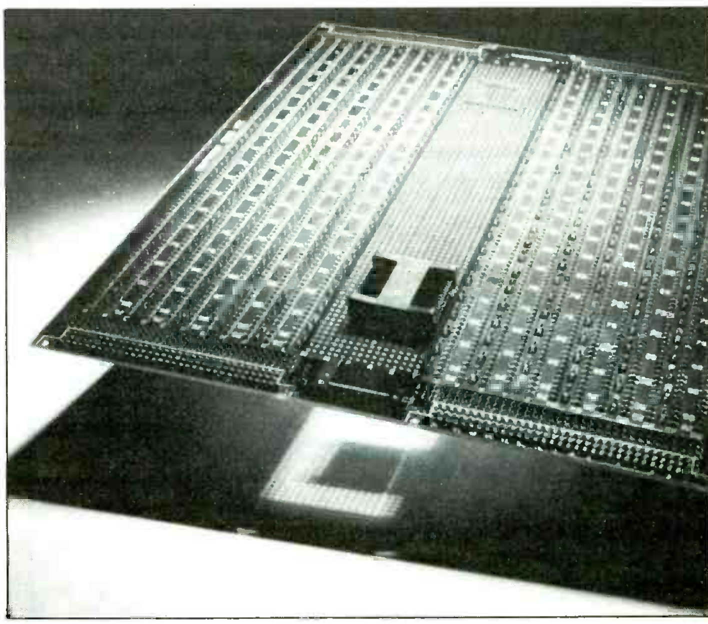
Eproms may be programmed from within the Psion Organiser which gives this miniature pocket computer instant access to mass storage. Based around the Hitachi 6301X c.mos processor, the computer includes 4K of rom which is internal to the processor, 2K of ram and each 'datapak' eprom can hold 8 or 16K. The computer was designed to form a pocket filing system and some accent has been placed on its database facilities. If two 16K datapaks are used together up to 44 000 characters may be stored. Software is also available on plug-in eprom modules and include mathamatics, finance, science and engineering packages. Also available is an easy-to-understand programming language, POPL, compiled by Pion especially for the Organiser. It is built around a set of simple commands and includes mathematical, scientific and generalized functions for use within programs. Data can be edited during entry and can even be 'erased' from the eprom by clever use of software which will ignore an entry which has been changed or deleted. Of course the whole eprom can be cleared by exposure to u.v. light and Psion have provided an eraser for this purpose. Each eprom can be re-cycled up to 100 times.

By far the biggest space inside the Organiser is taken up by a standard PP9 battery (which will last for about six months in normal use). A power module converts to the six power rails needed internally, including the 21V needed to 'write' to the eprom. A trickle current is used to keep the real-time clock going when the computer is switched off. The Organiser can switch itself off automatically if it is not used. The calculator-style keyboard is arranged in alphabetical, not qwerty, order which would not make it very suitable for such applications as word processing. Add-ons announced but not available at the time of writing are an RS232C interface which can be used as a printer output or to communicate via a telephone and modem. The Organiser costs £100 and datapaks are £12.95 for 8K or £19.95 for 16K and each program pack costs £30. Psion Processors, 22 Dorset Square, London NW1 6QG.
EWW 207

CIRCUIT ANALYSIS ON AN APPLE

Software programs on Circuit Analysis 2.0 enable an electronics engineer to analyse circuit with up to 60 components and 30 nodes or a d.c. circuit with up to 80 components and 40 nodes. In the a.c. program single frequency calculations of gain/phase performance, or frequency sweeps of up to 30 steps on a linear or logarithmic basis, are provided. The impedance versus frequency of input, output or intermediate points can be established, and circuits may be optimised for specific characteristics. The d.c. program calculates the voltage on all circuit nodes and all branch currents, and powers in one step. Any node may be examined for 'worst case' limits, or optimised to a specific level.

The software comes with a comprehensive handbook detailing all options together with guidance for drawing up the necessary equivalent circuit on which the circuit analysis will be based. The programs are fully menu driven. The programs have been developed by Key Electronics in collaboration with the American author of Circuit Analysis 1.0, which has now been withdrawn. Errors in the original program have been corrected and the whole process speeded up. In particular the 'worst case' analysis in both a.c. and d.c. programs is a valuable feature. The programs are retailed through P & P Micro Distributors Ltd, New Hall Hey Road, Rossendale, Lancs. BB4 6JG.
EWW 208



PROTOTYPE CARD

Designs using a mix of surface-mounted and through-board components can be prototyped on the EQC—UV series of quick-connect boards from Dage. The 233 by 280mm cards have 80% of their area free for conventional components with a standard pattern for mounting dual-in-line i.cs. A strip running down the centre of the board provides the rest of the area devoted to the positioning of surface-mounted devices. At each end of the board are mounting positions for DIN connectors which may be already fitted, if required. 0 and 5V grids are provided throughout the board to enable the design of high-speed, low-noise designs. The card can be made with tin or gold-plated contacts. The quick-connect system offers a simple point-to-point wiring with insulation-displacement connection. Other sizes of the board are available.
Dage (GB) Ltd, Eurosem Systems Division, Rabans Lane, Aylesbury, Bucks HP19 3RG. EWW 209

LOW—PROFILE TRIMMER—POTS

The Mepco Electra range of cermet trimming potentiometers is now available from Greenwood Electronics. They are available in both circular (8014 series) and rectangular (8035 series) styles; the single turn circular trimmers can be supplied in three different pin formats and in versions for vertical or horizontal mounting. Resistance values for both styles range from 10 ohms to 5 megohms. Both series trimmers are low profile components, the circular trimmers having dimensions of 0.25in p.c.d × 0.175in high; the rectangular types are 0.25in high. The 8014 models are constructed with yellow rotors to facilitate identification of adjustment points on p.c.bs

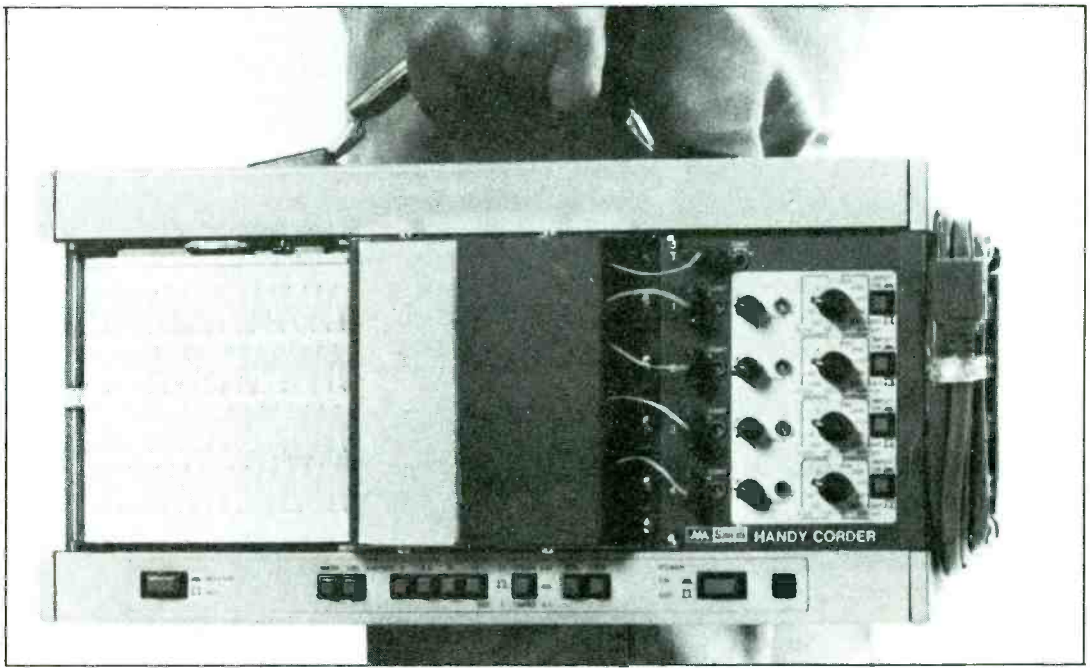
8035 series trimmers offer the designer very smooth continuous adjustment giving infinite resolution over the entire resistive track; the low temperature coefficient of 100ppm/°C is also maintained over the full operating range of the track

Both series feature a sealed construction and can be used in both solder and cleaning baths. Greenwood Electronics, Portman Road, Reading, Berks. RG3 1N. EWW 211

ON-CHIP MEMORY

An innovation in gate-array technology combines the bipolar macrocell array logic concept and high-speed random access memory (ram) in a common l.s.i. circuit.

The MCA1500M is an addition to the National Semiconductor MCA family of subnanosecond, bipolar gate arrays. With 1464 equivalent gates of logic, the chip also carries on-board memory consisting of 1280 bits of user-configurable ram. National Semiconductor claim novelty for the five-nanosecond, on-chip memory access time, and mixed e.c.l./t.t.l. I/0. National Semiconductor, Industriestrasse 10, D-8080 Fürstenfeldbruck, W. Germany. EWW 212

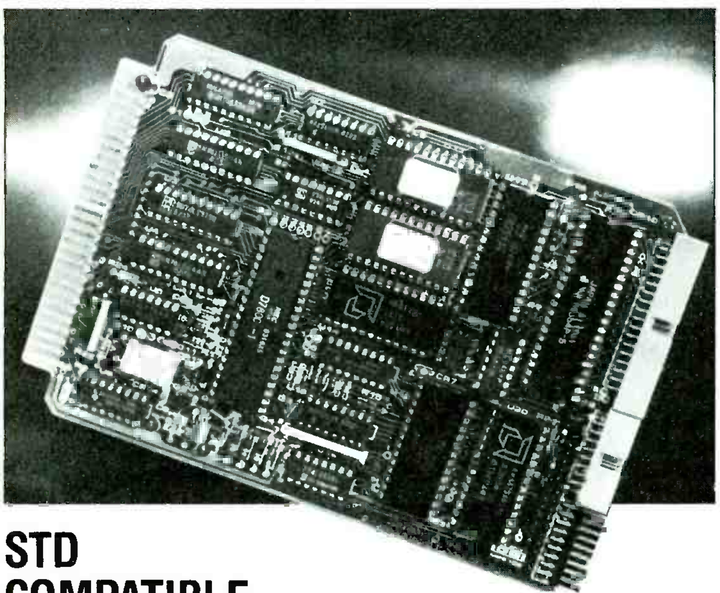


FOUR CHANNEL PORTABLE OSCILLOGRAPH

The 8K32 four-channel, portable oscillograph, from Rostol is compact, provides permanent inkless thermal-writing traces and weighs less than 8kg. Power supply requirements are a.c. mains or 12 Vd.c.

Switched input-sensitivity ranges are from 10mV/cm to 50V/cm, frequency response of 0—100Hz, and chart speeds are from 1mm/s to 100mm/s. Up to 66 hours of continuous use can be obtained from the 40 metre Z-fold chart.

This recorder offers crystal-controlled time marker with an accuracy of 0.05%, external voltage-proportional chart-speed control, remote signal and chart drive on-off, signal limiters and built-in calibration facility. The pust-button event marker can also be operated by external control. Rostol Limited, Lyson Avenue, Ash Vale, Nr Aldershot, Hants, GU12 5QF. EWW 213



STD COMPATIBLE, ONE-BOARD COMPUTER

A Z80A-based computer board from Burr-Brown, the MP6WZ is designed to operate either in single-processor or master/slave modes for multiprocessor environments. It may eliminate the requirement for additional serial or parallel I/0 cards, counter/timer card or a separate interrupt controller, since these functions are all included on the board.

Program memory is formed by fuse link prom which allows changes to be made in both the d.m.a. control and the memory timing cycle. A Z80A-CTC provides a three channel user-definable counter/timer with one channel being dedicated to the serial RS232C I/0 port, which can operate at up to 9,600 baud in a variety of communication protocols.

The MP6102 can be used in conjunction with separate ram cards, also available from Burr-Brown. 2Kbytes of ram are available on the card. On-board memory may be deactivated, while the eprom- based monitor/BIOS firmware may be unconditionally asserted.

The MP6102 features a programmable power on/reset jump, and an AM9516 universal interrupt controller is used to provide management and priority resolution for up to eight maskable interrupt inputs. Parallel I/0 is provided by an I8255A peripheral interface which supplies 24 bits of multiple mode input or output. Burr-Brown International Limited, Cassiobury House, 11-19 Station Road, Watford, Herts WD1 1EA. EWW 214

WELL WORTH A SECOND LOOK...

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No — you're not seeing double, just the Crotech 3132's Component Comparator in action. This unique feature, using two Crotech component testers, gives you the benefit of checking an active or passive component against a known standard. Complete circuits can also be checked using signature techniques.

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CIRCLE 48 FOR FURTHER DETAILS.

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Pantechnic present the most adaptable high-powered amplifier ever.

FET SYSTEM AMP

Features:
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- VERSATILE. Delivers more than 1kW into ½ to 8 ohms

OR 2 × 600W into 2 to 8Ω
OR 4 × 300W into 2 to 4Ω (200W into 8Ω)
OR { 1 × 600W into 2 to 8Ω; 1 × 300W into 2 to 4Ω; 1 × 150W into 4 to 8Ω }
Etc., etc.

Having been closely involved in a wide variety of OEM applications of their amp boards. Pantechnic became aware of numerous implementation problems often left untackled by other amp board manufacturers. These problems specifically of size and thermal efficiency became particularly aggravated at high powers and considerably lengthened OEM product development time.
By including thermal design in the totality of board design it has been possible to reduce the size of the electronics, and increase the efficiency of the transistor to heatsink thermal circuit. The combined effect of this has been to dramatically increase the volumetric efficiency of the amplifier/heatsink assembly. The **SYSTEM** Amp offers 1.2kW of power in a space of 180mm x 102mm × 77mm, excluding PSU and Fan.
The basis of this considerable advance is the PANTECH 74 Heat Exchanger, designed and manufactured by us. By eliminating the laminar air flow found in conventional, extruded heatsinks, heat transfer to the environment is greatly enhanced.
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As ever Pantechnic offer a full range of customising options including DC coupling, ultra-high slew, etc. Contact Phil Rimmer on 01-361 8715 with your particular application problem.
P.S. Specs, as ever, are exemplary.

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O.E.M. POWER SUPPLIES

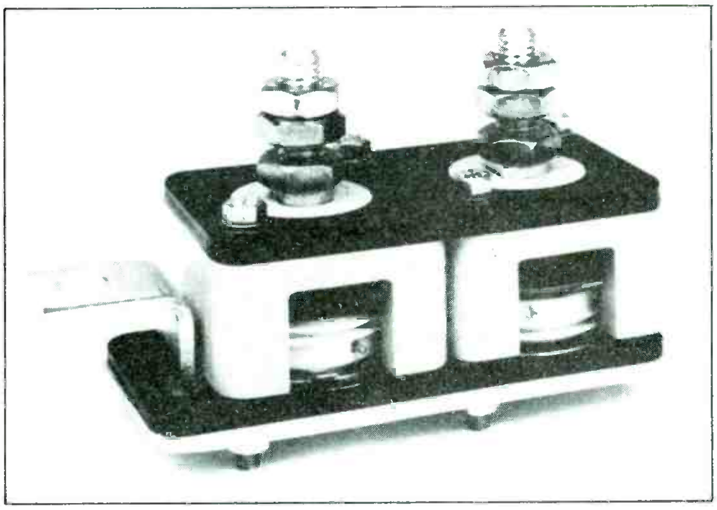
Farnell instruments Limited have recently announced details of new 55 watt, multi-output, open-card, switched-mode power supplies, in the N55 series. These units, designed for the o.e.m. market, have a reduced component count, which has resulted in lower price and increased reliability.

As well as the open-card format, N55 units can also be supplied mounted on a chassis for standard open-frame mounting or fully enclosed in ventilated safety covers. Customised enclosures, incorporating, for example, a power switch and CEE power input socket, can be supplied to special order. Three and four output (optional 4th and 5th outputs respectively) models are available. The first of these models, measuring 100×160×50mm, is Eurocard size and its three outputs consist of +5V, 3.5A; +12V, 3A and -12V, 1A (or +24V, 1A). The four output model, measuring 188×115×50mm, offers +5V, 6A; +12V, 3A; 12V, 2A floating and 24V, 1A (or 5V, 1A) floating outputs. All models operate from a field selectable 115/230a.c.input.

A range of options includes a power fail monitor, output monitor and a choice of regulated or semi-regulated output combinations. Full IEC, VDE, BS and UL approvals are pending. Farnell Instruments Ltd, Sandbeck Way, Wetherby, West Yorkshire LS22 4DH EWW 215

ALUMINIUM-COATED PLASTIC

Aluminium-coated plastic sheeting from Jayco Plastics is not only decorative, but gives valuable r.f. shielding. The aluminium coating is 15 microns thick, enough to give good r.f. attenuation, on a choice of p.v.c., polycarbonate, polystyrene or acrylic sheet which is available in thicknesses 200, 400, 600 or 800 microns. Apart from the r.f. shielding, the material is useful for making base panels where earthing is required and is very suitable for screen printing. Jayco Plastics Ltd, 29/43 Sydney Road, Watford WD1 7PY. EWW 216



POWER SEMICONDUCTOR MOUNT

A power semiconductor mounting module, which can accommodate any two TO-200 AB or DO-200 AA outline capsule power semiconductors, has been introduced by Westcode Semiconductors Co Ltd, part of the Hawker Siddeley group.

The PowerMod comprises a pair of electrically isolated capsules on a common baseplate and requires only four fixing screws to mount on to a suitable heatsink. It has been designed so that the capsules are held at the correct mechanical pressure when the four screws are fully tightened. Any Westcode device having either a TO-200 AB or DO-200 AA outline can be fitted in the module, thus allowing any thyristor-diode, thyristor-thyristor or diode-diode combination to be realised, including fast-switching-device combinations such as the R216 thyristor and the CXC170 diode.

Thermal impedance (junction to baseplate) for each semiconductor is the discrete device value as given in the Westcode data sheet for that device plus 0.095°K per watt. The mounting thermal impedance, baseplate to heatsink, for each semiconductor is typically 0.0114°K per watt. Westcode Semiconductors Co Ltd, Langley Road, Box 57, Chippenham, Wiltshire, SN15 1JL. EWW 217

POWER CRIMPER

An air-powered bench-mounted press from AB Engineering, the AB4500, will crimp all types of loose terminals up to 25 sq. mm.

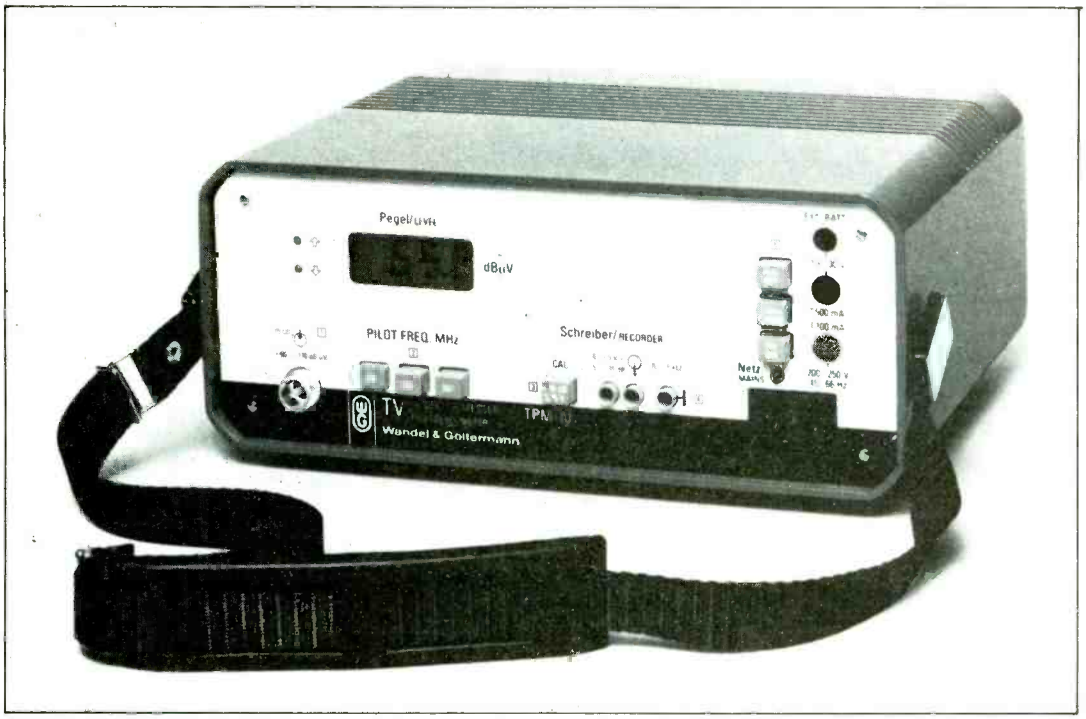
It has a C-type, open crimping head, controlled by foot pedal and protected by a safety guard, or may be supplied with an H-type closed head; the design permits fast interchangeability of heads and dies.

With an operating power of four tons at 80 p.s.i. or 4½ tons at 100 p.s.i., the press will crimp copper tube terminals and cut copper stranded wires up to 35 sq. mm. Two lower-powered models are also available, the AB2500 and the AB 3500, giving respectively 10 sq. mm and 25 sq. mm capacity from 2½ tons and 3½ tons operating power. AB Engineering Company, Timber Lane, Woburn, Milton Keynes MK17 9PL. EWW 218

PHOTODIODE

Photodiode type GM/7 by GPD has an active area of 7mm² and finds application in laser detecting devices in optical communication systems, measurement of optical power or fibre attenuation, pyrometry, etc.

It has an active element 3mm in diameter, dark current only 30 micro-amps and responsivity 0.7 amps A/W. The GM/7 is available in TO-8 package and for special applications the chip is available mounted close to the window. Germanium Power Devices Corporation, P.O. Box 3065, Shawsheen Village Station, Andover, MA 01810-0865, USA. EWW 219



LEVEL METER FOR BROADBAND CABLE SYSTEMS

W & G Instruments announce the TPM-10 TV Pilot Level Meter, a new product designed for measurement on broadband cable systems carrying tv and business data communications.

In these systems, the pilot signals are used for control and automatic correction of signal levels (a.g.c.) and the frequency response (TILT). In a typical (sub-split) system, pilot signals below and above v.h.f./u.h.f. band are used; the TPM-10 has been designed to measure one low frequency pilot and two above band.

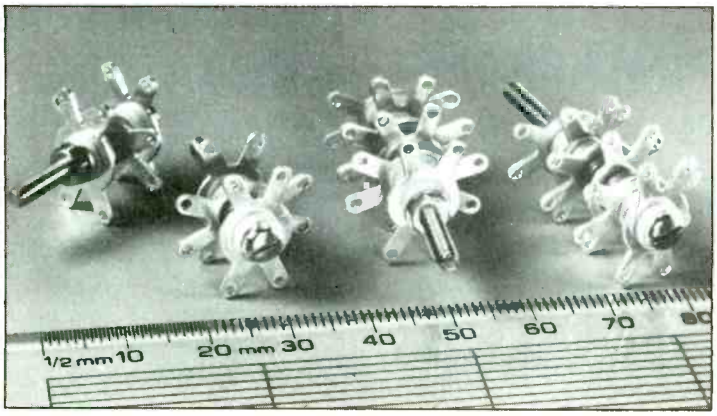
The instrument is designed that the signal to be measured may either be a continuous-wave pilot or an actual tv signal. Measurement of the line-sync. level ensures that the accuracy is not reduced by video content or adjacent channel modulation. These features make the TPM-10 ideally suited to the in-service monitoring of installed systems as well as for commissioning and fault finding applications. A recorder output is provided for long term monitoring.

Measurement accuracy is enhanced by the built-in automatic self-calibration feature, and the 3½ digit, auto-ranging digital display gives a resolution of 0.1dB over a wide dynamic range. W & G Instruments Limited, Progress House, 412 Greenford Road, Greenford, Middlesex UB6 9AH. EWW 220

MULTIPLE TAG INSULATORS

A range of multiple tag insulator assemblies from Oxley, the 6.X series, can accomodate up to six banks of insulator tags. High-dispersion grade p.t.f.e. is used as the insulation medium and each bank can be supplied with the insulator in a different colour, standard colours being black, brown, red, orange, yellow, green, blue, violet, pink, grey and white. Each bank includes a special internal eyelet that inhibits rotation of the complete assembly. Maximum current per terminal is 5A and working voltage is 3kV d.c.: maximum capacitance to chassis or between banks is 2pF.

Terminations are silver plated brass; the mounting screws are nickel plated brass; and the 6.X series meet the 56 day damp heat climatic category of IEC68 (IEC68: 55/200/56). Operating temperature range is —55°C to +200°C. Oxley Developments Co. Ltd., Priory Park, Ulverston, Cumbria. LA12 9QG.
The E3 audio cassette interface from Elan Digital Systems Limited is designed to provide an easily operated interface for the digital data storage of EPROM'S. Utilising standard I/0 connectors, the E3 gives complete data integrity during transfer, with a high recording rate. EWW 221



AUDIO CASSETTE INTERFACE

The E3 audio cassette interface from Elan Digital Systems Limited is designed to provide an easily operated interface for the digital data storage of eproms. Utilising standard I/0 connectors, the E3 gives complete data integrity during transfer, with a high recording rate.

It can be used with most systems which incorporate a standard bidirectional RS232 facility, and can be run either from internal batteries or connected to the mains supply via a mains adaptor. When powered by batteries, the E3 continues to function reliably down to 30% below nominal battery voltage.

Data can be transmitted at up to 2400 baud with clock synchronization to good quality tape recorders. At this speed, 4K of data may be loaded every minute, typically allowing the storage of more than two hundred 2708 eproms or fifty 2732 eproms on one C60 tape cassette. Considerable savings can thus be made by storing master program data on cassette rather than holding it on individual master eproms.

The interface is designed to ensure complete data integrity during transfer. Phase-lock-loop tracking ensures that data integrity is still maintained with lesser quality tape recorders, without clock synchronization and at a somewhat lower transfer rate. Both storing data on tape, and loading data from tape, have been made extremely simple operations. Audible instructions may be dictated before new data is loaded, with a change in tone indicating recording or playback mode.

Industry standard 25-pin 'D' type connectors are used for the serial I/0, and a standard 5-pin DIN connector for cassette recorders. Led indication on the front panel of the instrument gives advance warning that batteries need changing, shown by the failure of the led to light. The only controls needed are also located on the front panel, for off/on and play/record modes. Elan Digital Systems Limited, 16-20 Kelvin Way, Crawley, West Sussex: RH10 2TS.
EWW 222

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3	EH Research Labs Pulse Generator Type 139MB	1
4	H.P. Rx Meter Type 250B	1
5	Airmec Millivoltmeter Type 301A	3
6	Airmec Millivoltmeter Type 301	3
7	Data Dynamics Terminal	1
8	Marconi Timebase Delay Generator Type TF 1415	1
9	Marconi FM/AM Modulation Meter Type TF2300	1
10	AIM Electronics Variable Function Generator	1
11	Pye VHF Signal Generator Type SG2V	1
12	Pye HF Transceiver 6 channel Type SSB130	1
13	Pye Signal Generator Type SG5U	1
14	Pye Battery Chargers Type FC0 9 volt.	96
15	Pye Modulation Meter Type MM1	3
16	H.P. Wave Analyser Model 302A	1
17	Tektronix Oscilloscope Type 545A Less Plug ins.	2
18	KSM Electronics Pulse Generator Type T18/D	2
19	EMI Electronics Oscilloscope Plug — ins Type T7/6	2
20	EMI Electronics Oscilloscope Plug — ins Type T7/1	6
21	Pye Motophone Portables Mid Bano	6
22	Dynamco Oscilloscope Type D7100	1
23	Wayne Kerr Universal Bridge Type CT375	2
24	Decwriter Terminal	1
25	Ferro-Mag 3ph 240v 5.4kva Transformer	1
26	Tektronix Oscilloscope Plug-ins Type G.	4
27	Marconi RF Power Meter Type TF 1020A	1
28	Marconi 100 Watt 7db Attenuator Type TM 5280	1
28	Advance Oscilloscope Type OS 2000R	1
30	Marconi VHF Signal Generator Type TF 1064B	2
31	Rohde & Schwartz Power Signal Generator BN 41001	1
32	Ferranti Computer Terminal Type WDM 2000	1
33	Pye IF Signal Generator	4
34	Marconi Oscilloscope Type TF 1331A	1
35	Bruel & Kjoer Microphone Amplifier Type T 2604	1
36	Tektronix Oscilloscope Type 531A C/W Type H Plug-in	1
37	Tektronix Oscilloscope Type 547 C/W Type 1A2 Plug-in	1
38	Advance Signal Generator Type C2	4
39	Marconi 25 Mhz Pulse Generator Type 2025	1
40	Rhode & Schwartz Power Test Adaptor Type BN 413116	1
41	Marconi Frequency Covertor Type TF2400/TM7164	1
42	Solartron Recorder Drive Unit Type A295	1
43	Marconi UHF FM Signal Generator Type TF 2012	1
44	Wandel & Goltermann Filter Unit Type LDEF-2	1
45	Rhode & Schwartz Wavemeter Type BN 15221	1
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47	H.P. Signal generator Model 606A	1
48	Avo Signal Generator	1
49	Rhode & Schwartz Polyskop Type oA 2090B	1

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55	H.P. DC Power Supply 0-43v 3amp	1
56	H.P. VTVM Model 400D	2
57	Jerrold Field Strength Meter Model T7048	1
58	Marconi Universal Bridge Type TF868A	2
59	Marconi Standard Signal Generator Type TF867	3
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61	Solartron Digital Voltmeter Type LM 1420 2	1
62	Marconi Programmable FM/AM Modulation Meter Type TF 2301A	1
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67	Eddystone Communications Receiver Type 680X	1
68	Sanders Microwave Oscillator Type CLC 2-4	1
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70	Telequipment Oscilloscope Type D43	1
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73	Marconi Programmable Voltmeter Type TK 2607	1
74	Electro International UHF Pre Amp Type Ap501R	1
75	Honeywell Power Line Test Set Type PLT-1	1
76	Tekelec Digital Voltmeter Type TE313 03	1
77	BPL Super Megohmmeter Type Rm170	1
78	Chart Recorders Various	3
79	Marconi AF Power Meter Type TF2500	1
80	Rhode & Schwartz Signal Generator Type BN 41409	1
81	Trendata Test Set No.5	1
82	General Radio VHF Oscillator Type 1363	3
83	Tektronix Oscilloscope Type 545B less Plug-ins	1
84	Nargard Oscilloscope Type 311 C/W 3 Plug-ins	1
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88	Electrohome 9in Video Monitors	4
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90	Telequipment Oscilloscope Type S 51B	2
91	Sony Emty Video Tape Reels Type RH7V	33
92	Electronics Instruments Ltd. Chronotron Type 25E	1
93	Belix Power Supply Unit Type TSS 76	1
94	Advance Millivoltmeter Type 77A	5
95	Roband Double P S U Type T104	1
96	Marconi Output Power Meter Type TF893	3
97	H.P. Storage Oscilliscope Type 181 Complete with Manuals.	1
98	Marconi AF Power Meter Type TF893A	3
99	Marconi Valve Volt meter Type TF1041	3
100	Telequipment Oscilloscope Type S54A	3

Lot No.	Description	Qty
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102	Tektronix Oscilloscope Type 551 C/W Plug-ins & Trolley	1
103	Rhode & Schwartz Microwave Power Meter Type BN2412	1
104	Marconi Microwave Sweep Oscillator Type 6600A	1
105	Marconi Signal Generator Type TF995A	1
106	Schomandl Modulator MAF Type BN B41962	1
107	Schomandl Decade Signal Generator 300Hz-100Mhz Type ND 100M	1
108	Rohde & Schwartz Decade Signal Generator Type BN 41104	1
109	Telequipment Oscilloscope Type S32A	4
110	Marconi AM Signal Generator Type TF801D/8S	1
111	Marconi VHF Signal Generator Type TF 1064B/6M	1
112	Marconi Universal Bridge Type TP 868B	2
113	Marconi Tx & Rx Output Test Set Type TF 1065	2
114	H.P. SHF Signal Generator Model 618B	1
115	Marconi Noise Generator Type TF1106/2	2
116	Marconi Signal Generator Type TF995A/5	2
117	Marconi Signal Generator Type TF995B/5	2
118	Marconi VHF Alignment Oscilloscope Type TF1104/1	1
119	Marconi Signal Generator Type TF 1066B/6S	1
120	Tektronix Oscilloscope Type RM17	1
121	Telequipment Oscilloscope Type S31R	1
122	Telequipment Oscilloscope Type D52	1
123	Marconi Audio Tester Type TF894A	1
124	Telequipment Oscilloscope Type S43	2
125	Marconi FM Signal Generator Type TF2006 10-220 Mhz	1
126	Philips Millovoltmeter Type GM6012	1
127	Pye W30 Westminster Low Band 24 volt	14
128	Racal Communications Receiver Type RA17	1
129	Advance Oscilloscope Type OS 25A	1
130	Marconi UHF Signal Generator Type TF 1060/2	2
131	Lan-Elec Ltd. Stablised P.U. Type LP 401T	1
132	SE Labs Oscilloscope Type SM 111	1
133	Advance Oscilloscope Type OS220	2
134	Rhode & Schwartz UHF Test Receiver Type BN 1523	1
135	Tektronix Oscilloscope Type 647 less Plug-ins.	1
136	Aztec 19in Video Monitor Type VM 2047S	4
137	Airmec Modulation Meter Type 409	2
138	Marconi RC Oscillator Type TF 1101	2
139	Marconi Semsitive Valve Voltmeter Type TF1100	2
140	Foster Oil Filed Variac 0-270volt 40amp	1
141	Hewlett Packard Sweep Oscillator Type 692D	1
142	Tektronix Time Mark Generator Type RM 181	1
143	Tektronix Time Mark Generator Type 180A	1
144	Telequipment Oscilloscope Type S54AR	1
145	Telequipment Oscilloscope Type S31R	1
146	Sony Video Tape Type V-30H	108
147	Telequipment Oscilloscope Calibrator Type C.1	1
148	Marconi 20 Mhz Sweep Generator Type Tf 1099	2
149	Transistors Type 2N3740	750
150	Venner Digital Counter Type TSA 663A/2	2

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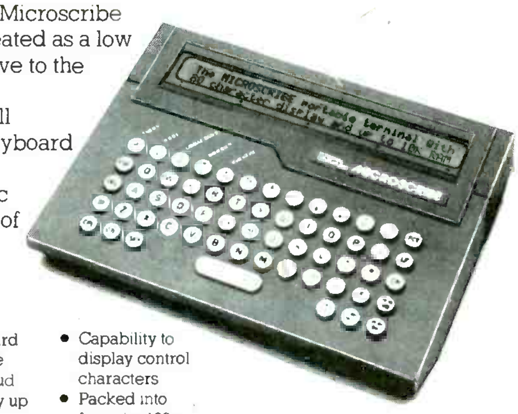
CIRCLE 29 FOR FURTHER DETAILS.

MICROSCRIBE

THE VDU ALTERNATIVE

The new Microscribe has been created as a low cost alternative to the dumb VDU.

It has a full QWERTY keyboard with an alphanumeric LCD display of 16, 40, or 80 Characters.



Features:

- Links to Standard RS232 interface
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FOR MORE DETAILS CONTACT NEWPORT TEL: (0633) 841381

TERMINAL TECHNOLOGY
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Telex: 498118 SECTOR

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subject to space available

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LINE advertisements (run on): £4.00 per line, minimum £25 (prepayable).
BOX NUMBERS: £5 extra. (Replies should be addressed to the Box Number in the advertisement, c/o Quadrant House, The Quadrant, Sutton, Surrey SM2 4AS).
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TEST ENGINEERS

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A good working knowledge of digital and analogue electronics is essential. Applicants should have a suitable technical qualification and/or 3 years test experience.

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BOOK EDITOR

The Radio Society of Great Britain is the national body representing UK radio amateurs. An important part of its activities is the production of books, the turnover of which is currently approaching £300,000 per annum.
The Society requires an experienced desk editor to play a major role in expanding its list in the field of amateur radio and associated topics. Applicants should be able to assist with the planning of the book programme, the procuring of manuscripts and their processing ready for printing. They would be expected to have a knowledge of radio and electronics: an interest in, and a capacity to write on, the topic of amatuer radio would be an advantage.
The position is an excellent opportunity to take up a creative and expanding role with a headquarters employing twenty-five people. The salary will be commensurate with age and experience.

Applications with full cv should be sent to David Evans, General Manager, Radio Society of Great Britain, Alma House, Cranborne Road, Potters Bar, Herts. EN6 3JW.

(2710)

Electronics Engineers £9561

Communications Design in High Tech Country

At H.M. Government Communications Centre we're using the very latest ideas in electronics technology to design and develop sophisticated communications systems and installations for special Government needs at home and overseas.

With full technical support facilities on hand, it's an environment where you can see your ideas progress from initial concepts through prototype construction, tests and evaluation, to the pre-production phase, with a chance to influence every stage. Working conditions are pleasant, the surroundings are attractive, and the career prospects are excellent.

Ideally we're looking for men and women who have studied electronics to degree level or equivalent and have had some experience of design, whether obtained at work or through hobby activities. Appointments will be made as Higher Scientific Officer (£7149-£9561) or Scientific Officer (£5682-£7765) according to qualifications and experience.

For further details please write to the address given below. As our careful selection process takes some time, it would be particularly helpful if you could detail your qualifications, your personal fields of interest and practical experience, and describe the type of of working environment most suited to your career plans.

The Recruitment Officer, HMGCC, Hanslope Park, Buckinghamshire MK19 7BH. (2448)

AMPEX is a company at the forefront of magnetic recording technology, which manufactures Professional Video Equipment, Instrumentation Recorders, Disk Drives, Terminals and Magnetic Media.

AMPEX INTERNATIONAL TRAINING, based in Reading, England, is currently expanding and there are several vacancies for Instructors to conduct quality maintenance courses on AMPEX products.

Applicants should be men or women who have experience in one or more of the following areas:

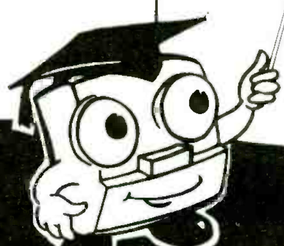
Digital Processing, Professional Video Recording, Digital Magnetic Recording, Microprocessor Based Equipment.

Teaching experience is not essential, as appropriate training will be given.

An attractive salary is offered, together with the usual large company benefits.

For application forms, please contact:
Maureen Brake, Personnel Department,
or John Watkinson, Training Manager.

AMPEX
INTERNATIONAL
TRAINING



Reading (0734) 875200

AMPEX, ACRE ROAD,
READING RG2 0QR.

(2723)

Electronic Engineers – What you want, where you want!

TJB Electrotechnical Personnel Services is a specialised appointments service for electrical and electronic engineers. We have clients throughout the UK who urgently need technical staff at all levels from Junior Technician to Senior Management. Vacancies exist in all branches of electronics and allied disciplines - right through from design to marketing - at salary levels from around £5000-£15000.

If you wish to make the most of your qualifications and experience and move another rung or two up the ladder we will be pleased to help you.

All applications are treated in strict confidence and there is no danger of your present employer (or other companies you specify) being made aware of your application.

TJB ELECTROTECHNICAL PERSONNEL SERVICES,
12 Mount Ephraim,
Tunbridge Wells,
Kent. TN4 8AS.

TJB

Tel: 0892 39388
(24 Hour Answering Service)

Please send me a TJB Appointments Registration form:

Name . . . .

Address . . . .

. . . .

(861)

University College of Swansea

ELECTRONICS TECHNICIAN

Applications are invited for the vacancy of **Electronics Technician Grade 4** at the University College of Swansea, in association with the Department of Electrical and Electronic Engineering. The successful candidate should have a sound knowledge and experience of digital and analogue circuitry. Preference will be given to candidates familiar with microprocessor hardware and software.

The salary will be on the scale £6,106 — £7,024 per annum

Application forms may be obtained from the Personnel Office, University College of Swansea, Singleton Park, Swansea, SA2 8PP, to which office they should be returned by Thursday 13 September 1984

(2708)

Systems Engineers

Outstanding opportunities for pragmatic Systems Engineers to become Senior Systems Engineers, Technical Managers or Project Managers, dealing from scratch with one of several new, exciting, large high technology projects.

Up To £20K+

Several unique opportunities affording excellent career prospects with a large, expanding, performance orientated company exist for engineers with a degree or HNC in Physics or Engineering (preferably Electronics or Systems Engineering, but possibly Mechanical Engineering). Candidates should have acquired good systems experience whilst working in the Electronics or Defence Industries and ideally will have practical knowledge of prototype production or trials.

Your task will be to assist our client, who has developed an enviably secure base in the development and manufacture of complex weapons systems, to develop new business areas for high technology systems in both the defence and commercial sectors. The number of persons ultimately involved in a project will vary from 20 to 750 and the development costs will range from £20M to £200M and consequently there will be tremendous opportunities for you to progress to the control of the running of very large projects as well as to higher levels of management. By proposing, developing and evaluating systems and design options, producing prototypes and arranging for all necessary trials and tests, your team's objective will be to produce complete technical and cost proposals for complex, state-of-the-art systems whose technical excellence and competitiveness will ensure that large contracts are secured. To have acquired the necessary skills and experience to meet this formidable challenge you will probably be at least 30 to 35 years old; have management experience especially of dealing with people outside your direct control; have experience of customer liaison and project planning; and will have developed commercial and business awareness.

These important new positions offer excellent rewards and conditions with first class future prospects in the thriving division of a leading company in the High-Technology and Defence Industries that is part of a highly successful, major international group. The division has an order book which takes them potentially beyond the year 2000, is committed to developing several new business areas, and is poised to move into the world market in a big way.

TO FIND OUT MORE and to obtain an early interview, please telephone JOHN PRODGER in complete confidence on HEMEL HEMPSTEAD (0442) 47311 during office hours or one of our duty consultants on HEMEL HEMPSTEAD (0442) 212650 evenings or weekends (not an answering machine). Alternatively write to him at the address below.

Executive Recruitment Services

THE INTERNATIONAL SPECIALISTS IN RECRUITMENT FOR THE ELECTRONICS, COMPUTING AND DEFENCE INDUSTRIES

25-33 Bridge Street, Hemel Hempstead, Herts., HP1 1EG.

(2721)

Junior Radio Officers

The Royal Fleet Auxiliary has a number of vacancies for Junior Radio Officers. These appointments are for short term engagements of 6 months duration, (with the possibility of extension) and offer recently qualified personnel the opportunity to gain the required seatime.

Minimum qualifications: MRGC and DTI Radar Maintenance Certificate. Applicants should preferably be under 25. Apply, in the first instance, by telephone to: — Gil Parsley on 01-385 1244 ext. 3102.

(2707)

ROYAL FLEET AUXILIARY RFA

SALES ENGINEERS

London & Home Counties

Listed below are just a sample of the vacancies that ATA London are currently looking to fill:

	1st year Earnings
Electronics Industry enclosures, connectors, p.c.b.'s to B.T., Marconi, Pye, British Aerospace etc	£13,000
High technology speciality adhesives	£10,500
Intruder alarms/security systems	£9,500
Chemicals to electronics industry	£10,000
Lithium/wet cell batteries	£12,000
Fire alarm/escape lighting	£12,000
Fibre Optic developments	£15,000
Electronic systems/modules	£12,000
Circuit protection/accessories	£9,000
Electronic Wafer devices/semi-conductors	£16,000
Trainee Electronic Passive Components	c£9,000

All the above positions include a company car, expenses, pension, paid holidays.
For further information, telephone:
01-637 0781 (9am—6pm)
(out of hours answering service)

211 Great Portland Street, London W1N 5HA

ata Sales Recruitment
A Division of ATA Selection and Management Services Ltd

(2735)

Service Engineers

Opportunities in Professional Broadcast Engineering

As one of the market leaders in the broadcast television industry, we provide engineering support for some of the most sophisticated professional equipment in use today. Our wide range includes cameras, VTRs/VCRs, editing control systems and professional audio equipment. Applications are now invited from well qualified engineers to be appointed at all levels in the Service Department. Full product training will be given, and there are considerable prospects for personal development.

Base Service

Located at our prestigious engineering complex in North Hampshire, the successful candidates will join an engineering team engaged in the maintenance and repair of our video product range. Applicants should have HNC Electronics (or equivalent) together with a background in electronics. For senior positions broadcast experience is essential.

Field Service (London Operations)

To provide a comprehensive service support to our customers based in London.

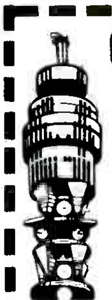
Aged 24 plus, applicants should have HNC Electronics together with several years broadcast experience, gained either in operational TV or its allied manufacturing industry. Knowledge of VTRs and cameras is essential.

We offer attractive salaries and first class conditions of employment. If you are looking for a new career move please contact David Parry, Assistant Personnel Officer.

SONY Broadcast

Sony Broadcast Ltd.
City Wall House
Basing View, Basingstoke
Hampshire RG21 2LA
United Kingdom
Telephone (0256) 55 0 11

(2717)



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THE UK's No. 1 ELECTRONICS AGENCY

If you have HNC/TEC or higher qualifications and are looking for a job in design, test, customer service, technical sales or similar fields:

Telephone now for our free jobs list
We have vacancies in all areas of the UK
Salaries to £15,000 pa

01 808 3050
(24 hours)

CAPITAL APPOINTMENTS LTD
76 WILLOUGHBY LANE, LONDON N17 0SF

(291)

Appointments

Senior Technical Officer
Telecommunications

Vital to the efficiency of British Airways' worldwide operations is an extensive U.K. communication network between airports and provincial towns.

To further expand and enhance our sophisticated voice networks and logging systems nationwide, we are now seeking an additional experienced telecommunications engineer.

Managing a variety of projects from inception through to completion, you will consult with users, assess their needs and recommend appropriate technical solutions, often liaising with British Telecom and other equipment suppliers.

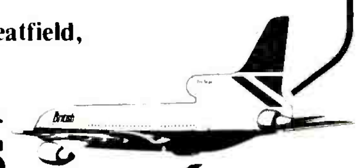
For this important role, you should have a City and Guilds and/or HNC in Telecommunications, or an equivalent, recognised qualification. You must also combine excellent interpersonal skills with several years' experience with small call-connect or PABX telephone systems. Previous experience of working closely with BT and other suppliers would be a distinct advantage.

Although based at Heathrow, you should be prepared to spend approximately 20% of your time away from home, occasionally using your own car for business purposes.

A starting salary of circa £9,000 p.a. is offered together with advantages such as a contributory pension scheme, favourable holiday travel opportunities, holiday bonus and profit sharing.

Interested applicants should send a detailed CV to Kris Streatfield, Recruitment and Selection (S7), British Airways Plc, PO Box 10, Heathrow Airport (London), Hounslow, Middlesex TW6 2JA, marking the envelope KS2511.

British airways



(2722)

AUDIO/ELECTRONICS ENGINEER

Based London area, for company servicing educational audio systems and audio visual equipment. Practical experience of electronics essential, ideally with microprocessor and mechanical knowledge.
We are looking for someone with drive and independence, who will be able to assume management responsibilities and contribute to the growth of a small organisation.
Salary to match experience and potential, car included, with opportunity to participate if successful in the Company.

BELLNORGIS LIMITED
9/11 KENSINGTON HIGH STREET, LONDON W8 5NP

(2731)

Dolby

Dolby Laboratories Inc. manufacture and market Audio Noise Reduction equipment which is used by major recording companies, recording studios, the film industry and broadcasting authorities throughout the world.

Due to increased sales and the introduction of new products we have the following vacancies:—

Printed Circuit Board Assembly Operators (£100 pw NEG). We need experienced PCB Assemblers who are able to demonstrate a high level of practical skill and who enjoy working to a high standard.

Electronic Test Technicians (£135 pw NEG) We need people educated to HNC level (or equivalent) with the potential to develope test and fault finding skills (to component level) in a semi-automated test environment.

Electronic Test Engineer (£8000 pa NEG) We need experienced Test Engineers educated to HND to equivalent level who can demonstrate a practical knowledge of Analog testing and rapid "trouble-shooting" to component level.

For further information contact: Sarah Kennedy, Dolby Laboratories Inc. 346 Clapham Road, London SW9 9AP. 01-720 1111

(2724)

UNIVERSITY OF YORK

Department of Electronics

Applications are invited for the following three year Research appointments.

A. Research Assistant in Avoinic Systems

To investigate the development of asynchronous multiprocessing techniques for aircraft flight control systems. The project forms part of an expanding team effort covering various aspects of avionics in collaboration with British Aerospace PLC, Brough, N. Humberside. Candidates should have a working knowledge of microprocessors, computer interfacing and software development. A basic knowledge of modern control theory and sampled-data techniques would be an advantage. Applicants should hold a good honours degree or higher qualification in Electronic Engineering or Control Systems.

B. Research Assistant in Plasma Processing Technology for VLSI

This project is an investigation of Plasma-Enhanced Deposition and Dry Etching of refractory metals and silicides for the advanced processing of the very small device structures required for VLSI circuits. The project is supported by the Alvey Directorate for Information Technology and is running in collaboration with Plasma Technology (UK) Ltd, British Telecom, Plessey and STL. Applicants should have a thorough knowledge of solid state physics and semiconductor device theory, and an interest in semiconductor device and integrated circuit fabrication techniques. An interest in practical electronics would be an advantage. Applicants should have a good honours degree or a higher qualification in either Electronic Engineering or Physics, with a strong electronics content.

Successful candidates for both posts will be able to register for a higher degree, paying a nominal fee. The salary will be in the range £6310—£8530 (under review) with USS. Three copies of applications with full curriculum vitae and naming two referees, should be sent by 20 October 1984 to Registrar's Department (Appointments), University of York, Heslington, York Y01 5DD. Further details are available on request. Please quote reference number 7/7127 A or B. (2732)

Antenna Test Specialists

Marconi Space Systems at Portsmouth has recently commissioned the UK's most advanced satellite Near Field, Far Field Antenna Test Range and there is an immediate requirement for Test Leaders to control and implement customer requirements working up to 20 GHz.

Test Leaders will institute test runs and be responsible for range personnel, test procedures, safety, the integrity of test equipments, and will also contribute to the development of the test range facility. Applicants should have an HNC as a minimum qualification and at least 5 years' experience of R.F.and antenna testing utilising computer based systems.

Excellent salaries and comprehensive range of benefits are offered, together with relocation assistance if required.

Telephone Portsmouth (0705) 674019 for an application form or send c.v. to Jack Burnie, Marconi Space Systems Limited, Browns Lane, The Airport Portsmouth, Hants PO3 5PH quoting reference BL 212.

(All posts are open to men and women).

Marconi
Space Systems

(2706)

ELECTRONICS TECHNICIAN GRADE III

Required for maintenance of electro medical/industrial electronic equipment.
Applicants should have been time served tradesmen within the electronics field or with equivalent training and be experienced in electronic maintenance and fault finding.
Applicants should preferably have ONC/HNC or City and Guilds full technical certificate in electronics.

SALARY: **£5868 — £7584**

Job Description and application form obtainable from Personnel Officer, (H.Q. Services), **Royal Victoria Hospital, D.M.T. Offices, Shelley Road, Bournemouth. BH1 4HX. Tel: Bournemouth 303581 Ext. 234.**

CLOSING DATE FOR COMPLETED APPLICATIONS

10th October, 1984.

(2709)

NORTH MIDDLESEX HOSPITAL, STERLING WAY, EDMONTON, N18 1QY

MEDICAL PHYSICS TECHNICIAN GRADE III/IV

The Medical Physics Department at the above hospital is responsible for providing electronic maintenance service for the Haringey District Hospital. The work load includes maintenance of equipment used in the Intensive Care Unit, Theatres, Labour Wards, together with Radiotherapy and Nuclear Equipment.
You should preferably be experienced in electronic maintenance and some experience of design work would be an advantage but that should not deter newly qualified persons from applying.
QUALIFICATION: ONC/HNC or equivalent. Entry into Grade II requires three years experience in a relevant subject.
SALARY FOR GRADE IV: £5794 p.a. rising to £7421 p.a. inclusive of London Weighting.
SALARY FOR GRADE III: £6755 p.a. rising to £8549 p.a. inclusive of London Weighting.
For further details contact MR D.W. Bailey, (Senior Physicist) on 01 807 3071 ext 678.
Application forms and job descriptions are available from the Personnel Department at the above address, or telephone 01 807 3071 ext 571.
CLOSING DATE: 5th October, 1984.

Haringey
HEALTH AUTHORITY

(2719)

CAPITAL RADIO 194

ELECTRONICS ENGINEER

Capital Radio has a vacancy for a Maintenance Engineer within its Engineering Department. Candidates should be qualified to HNC or degree level in a relevant subject and be experienced in maintaining modern studio and radio broadcasting equipment to the highest engineering standards. The successful applicant will be required to work on a shift rota — which includes weekends — and on operational duties such as outside broadcasts. He/she would normally be working on the instructions of the Maintenance Supervisor but would also be expected to work for periods unsupervised. The opportunity may arise for some development work. Candidates should posses a current UK driving licence.

Starting salary will be dependent upon qualifications and experience and will include shift enhancement. For candidates with experience and qualification as above, salary will be not less than £10,139 per annum. Any appointment made on a trainee level would attract a salary of not less than £8,212 per annum.

Applications to be received no later than Friday 28th September 1984, and should be sent to: Sue Davies, Head of Personnel, Capital Radio Limited, PO Box 194, Euston Road, London NW1 3DR. Please quote reference number ENG/206 on all applications. Previous applicants need not apply.

(2730)

Telecommunications Maintenance Staff

for the New Mercury Network
up to £13,500 + allowances

Mercury is creating a digital network based on the most up-to-date techniques. We will be supporting our service with a maintenance organisation capable of responding quickly and effectively to our customers' requirements.

As part of our expansion we require Maintenance Staff at our London, Manchester and Bristol service centres. We also need, Maintenance Engineers for our satellite earth stations in the London Docklands – standard B and in Oxford – standard C.

Field Maintenance Engineers
London, Manchester, Bristol

£10,000 – £13,500 + car + allowances

Qualified to ONC, City & Guilds or TEC level in telecoms, you must have a detailed knowledge of digital and analogue techniques applied in this field. At least three years experience of maintenance and repair to <u>component level</u> in the following areas is essential:-

★ Microwave point to point links

★ PCM/TDM multiplex systems

★ Digital communications systems

Ref: MTEO 8

Earth Station Maintenance Engineers
London, Oxford

£10,000 – £13,500 + £2,003 shift allowance

You must have experience of maintaining telecommunications equipment and ideally have worked on standard B or standard C earth stations. Shift work will be necessary.

Ref: ESMO 1 – quote either London or Oxford

Maintenance Support Engineers
London, Bristol £7,500 – £10,500

You must have experience of maintaining and installing microwave or digital telecommunications equipment, be committed and prepared to progress to the role of Maintenance Engineer.

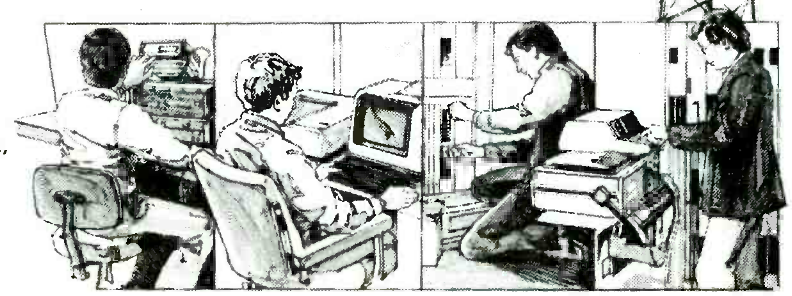
Ref: MSSO 1 – quote either London or Bristol

Salaries will be on the scales quoted. The exact point will depend on the experience and qualifications of the successful applicants. Benefits include non-contributory pension and a generous meals allowance. Relocation expenses will be paid, where appropriate.

Applicants for Bristol and Oxford will be required to work in London for a short period to familiarise themselves with company systems and maintenance procedures, prior to taking up their posts. The company will meet lodging expenses. London positions qualify for a £1,266 London Allowance.

Please telephone or write for an application form, quoting the appropriate reference, to

Jeremy Webster,
Mercury Communications Ltd.,
28/30 Theobalds Road,
LONDON WC1X 8NC.
Tel: 01-404 5155, ext. 242.



Mercury COMMUNICATIONS

Appointments

BANK OF ENGLAND

The bank has a vacancy for an Assistant Electrician to work in the Telecommunications Section of the premises division.

Applicants should have workshop experience and should possess, or be studying for, or be prepared to study for electronic qualifications.

Benefits include generous leave entitlement, assistance for house and season ticket purchase and a non-contributory pension scheme. Salary according to scales commencing at £8,263PA including London Allowance.

Application forms are available by ringing 01-601 4732 between 9am and 5pm.

(2737)

TRANSMITTER ENGINEER

Transmitter Engineer required with all round broadcast experience on audio, transmitters and antenna systems both AM and FM. Experience essential on BBC, IBA or other. Qualifications an advantage Salary £15,000 negotiable + car. Southern Ireland.

Write to:—

Radio Nova, Scholarstown Road, Stocking Lane, Dublin 14.
or Telephone:—
Chris Cary on Dublin 932 167,
or
Irene Hare 01-441 2922

(2701)

ARTICLES FOR SALE

UNUSED OLD STOCK. DC convertors input 50V output 20V 3A and 24V 2A. Telecom type 62 equipment practice. Normal price £387 each. £50 collected or £60 delivered. Cash with order. To D.H. Wilson, 33 Farwig Lane, Bromley, Kent. BR1 3RE. 290 0200. (2661)

BRIDGES waveform/transistor analysers. Calibrators, Standards. Millivoltmeters. Dynamometers. KW meters. Oscilloscopes. Recorders. Signal generators — sweep, low distortion, true RMS, audio, FM, deviation. Tel. 040 376236. (1627)

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ELECTRONICS ENGINEERS

If your career is stagnating, if you are unemployed, or just starting your career in the most dynamic industry this country has to offer, then Capital Appointments can help. Our client companies have immediate and long term requirements throughout the UK for most categories of staff including:

TECHNICAL MANAGEMENT, DESIGN, SOFTWARE, TEST, FIELD SERVICE, SALES, ETC.
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For immediate attention to your career requirements, complete the form below now and post to:
CAPITAL APPOINTMENTS LTD, 76 WILLOUGHBY LANE LONDON N17 0SF
If you would prefer to telephone us to discuss your situation in more detail, one of our consultants will be pleased to help.

TELEPHONE: 01-808 3050 CUT FORM AND RETURN

CONFIDENTIAL

NAME .... ADDRESS ....

....

Tel. (Home): .... (Office): ....

Date of Birth: .... Place of Birth: .... Nationality now: ....

If not British, is a Work Permit required? ....

Marital Status: .... Car Driver: .... Car Owner: ....

Type of Position required: .... Approx. Salary level ....

Please indicate areas in which you are prepared to work:					
Cent. London		S. Coast		E. Midlands	
S.E. London		West Country		W. Midlands	
S.W. London		N.E. England		E. Anglia	
N.E. London		N.W. England		Wales	
N.W. London		Scotland		Overseas	
Home Counties: N.W.		N.E.	S.W.	S.E.	

Are you a houseowner?	Are you willing to relocate?
Are you prepared to travel — In UK?	Overseas?
State of health:	
Notice Period required:	Availability for Interview:

EDUCATION:
Secondary School Qualifications: ....
College or University Qualifications: ....
Any Professional Membership: ....

CAREER HISTORY

From/To	Company	Job Title/Description	Salary

Please indicate any Companies you do not wish us to contact.

If you wish to detail further aspects of your experience or job requirements, please continue on a separate sheet.

(2450)

ARTICLES FOR SALE

OPTOELECTRONICS DATA BOOK 1984

Price by Texas £6.00

DIGITAL ELECTRONIC CIRCUITS & SYSTEMS by N.M. Morris PRICE: £5.45

MICROELECTRONICS: A PRACTICAL INTRODUCTION by R.A. Sparkes PRICE: £8.50

SOLDERING IN ELECTRONICS by R.J. Klein Wassin Wassink PRICE: £51.00

OPTICAL FIBER COMMUNICATIONS BY G. Keiser PRICE: £9.50

DIGITAL IMAGE ANALYSIS by S. Levialdi PRICE: £26.00

SEMI-CUSTOM IC DESIGN & VLSI by P.J. Hicks PRICE: £13.50

INTRODUCTION TO MOS LSI DESIGN by J. Mavor PRICE: £18.50

HANDBOOK OF BATTERIES & FUEL CELLS by D. Linden PRICE: £63.00

THE DESIGN & DRAFTING OF PRINTED CIRCUITS by D. Lindsey PRICE: £41.50

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(2245)

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MICROWAVE FILTERS 3.7 — 4.29Hz Bandpass 1dB loss 0.3dB ripple. 30dB rejection at 3.4GHz and 4.7 GHz £85. Phone 02605 2549 for data sheet or quote for your spec. M.M. Electronics. 12 Daisyfield Terrace, Horwich, Lancs. (2720)

Film processor (oscillograph & other films) **£89.** Precision Hygrometer Ni head and bridge amplifier **£35.** Joyce/Gevaert Recording Densitometer **£175.** Oscilloscopes. Oven Control Unit **£25.** Tek plugins **£25-£35.** Hewlett-Packard 1750.B., **£59.** Anemometer/air flow meter, dial indication **£35.** Dial-less utilises pulsed light **£25.** Dial type may also be additionally operated with pulsed light. Fibre-optic light source **£35.** 20.A., variac I" recording tape. Centrifuge **£49.** Sweep generator. Wow meter. EHT meter. FM/AM Generator. Balance & weights. Philip's EHT Supply i-5KV. Sirect Proportional Temperature controller **£35.** Alternator Control Unit, **£35.** Enlarger for 16mm — 4¼×2¼. Mutual/Self Inductance Bridge. Cartridge Nail Gun **£65.** Keyboards **£10.** Variacs. Microscope. Cameras, lemses, various. Tektronix Oscilloscope (TV) with markets & time delay **£98.** 100MHz Tektronix **£175.** Tektronix Calibrator.

040-376236. (2016)

Design Engineers

S.E.ENGLAND

Up to £18,000

If you are keen to gain the maximum benefit from working in an Applied Research Technology Environment, our client can offer you the finest resources coupled with the most up to date computer facilities and they will help and encourage you to develop your professional skills to their fullest.

We are confident there are few companies who can match their record of growth and innovation over the past few years. They can offer excellent opportunities for you to work in a wide range of advanced circuit/device development. Because of their expanding order book which now runs into the next century they will also give you early opportunities to use your abilities to control and manage teams and projects.

As a member of one of several small teams of professional engineers you will work in generously equipped modern laboratories devising some of the most sophisticated defence systems yet known.

We are able to offer progressive openings at all levels for ambitious engineers to establish themselves in advanced electronics design and development. Our client provides an excellent salary package, full company benefits, five weeks holiday, generous relocation expenses and they will be particularly interested if you can contribute experience to the following:

Power Engineering – development of ultra-sonic transmitters and high power switch mode supplies using the very latest FET systems and power hybrids.

VLSI Device Design – for digital signal processing applications using in-gate arrays, semi-custom and full-custom and employing some of the best CAD circuit, logic simulation and auto-placement technology available.

Analogue Circuit Development – very low noise broadband amplifier design at LF and VLF using thick film hybrids together with programmable attenuators and active filter techniques.

Digital Signal Processing – using FFT and Advanced Digital Technology in sophisticated micro processor controlled systems which also use the very latest DSP chips.

TO FIND OUT MORE and to obtain an early interview, please telephone JOHN PRODGER in complete confidence on HEMEL HEMPSTEAD (0442) 47311 during office hours or one of our duty consultants on HEMEL HEMPSTEAD (0442) 212650 evenings or weekends (not an answering machine). Alternatively write to him at the address below.

Executive Recruitment Services

THE INTERNATIONAL SPECIALISTS IN RECRUITMENT FOR THE ELECTRONICS, COMPUTING AND DEFENCE INDUSTRIES

25-33 Bridge Street, Hemel Hempstead, Herts., HP1 1EG.

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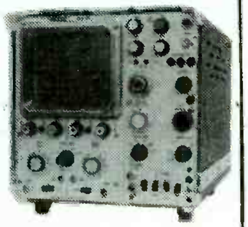

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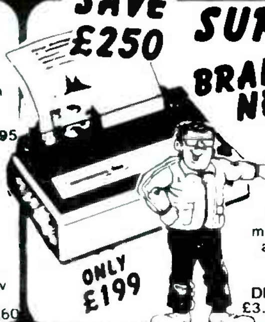

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