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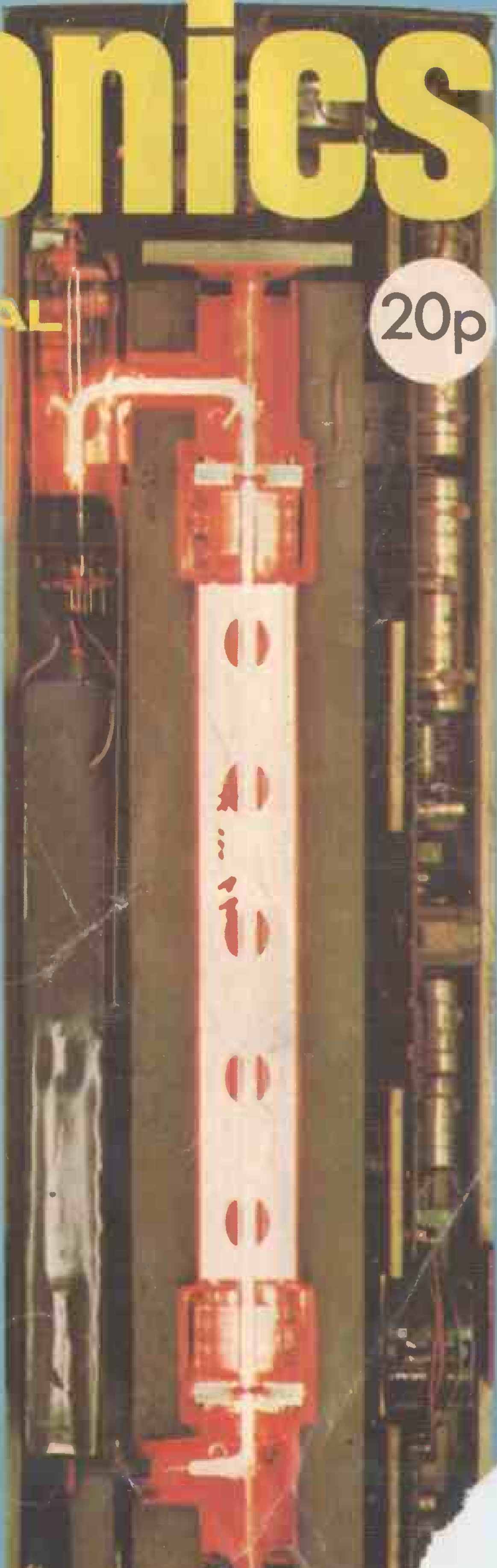

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AUGUST 1973 Vol 2 No.8

main features

projects

product tests

news & information

Cover: Picture shows internal view of Siemens' LG661 helium-neon laser. This generates 5mW continuous power and is used extensively in surveying and building work.

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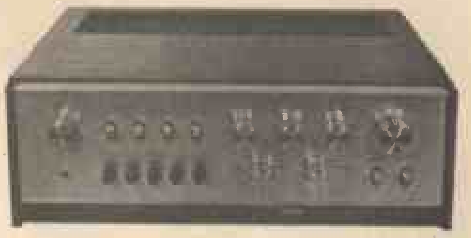

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36 Ebury Street, London SW1W 0LW
Phone: 01-730 2136/9

Published by WHITEHALL PRESS LTD

Printed in England by: Alabaster Passmore & Sons Ltd, London & Maidstone
INTERNATIONAL ASSOCIATES: Modern Magazines (Holdings) Ltd, 21-23 Bathurst Street, Sydney 2000. Phones: 26-2296 22-6129. ACP, Room 401, 1501 Broadway New York, USA. Bancho Media Service, 15 Sanyeicho, Shinjuku-Ku Tokyo, Japan. Distributed by: Argus Press Ltd

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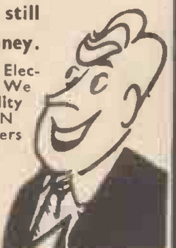

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36 Ebury Street
London SW1W 0LW
01-730 2136

International Editions

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lasers

THE current uses of lasers may seem dramatic enough, but they will pale into insignificance compared with what is about to come.

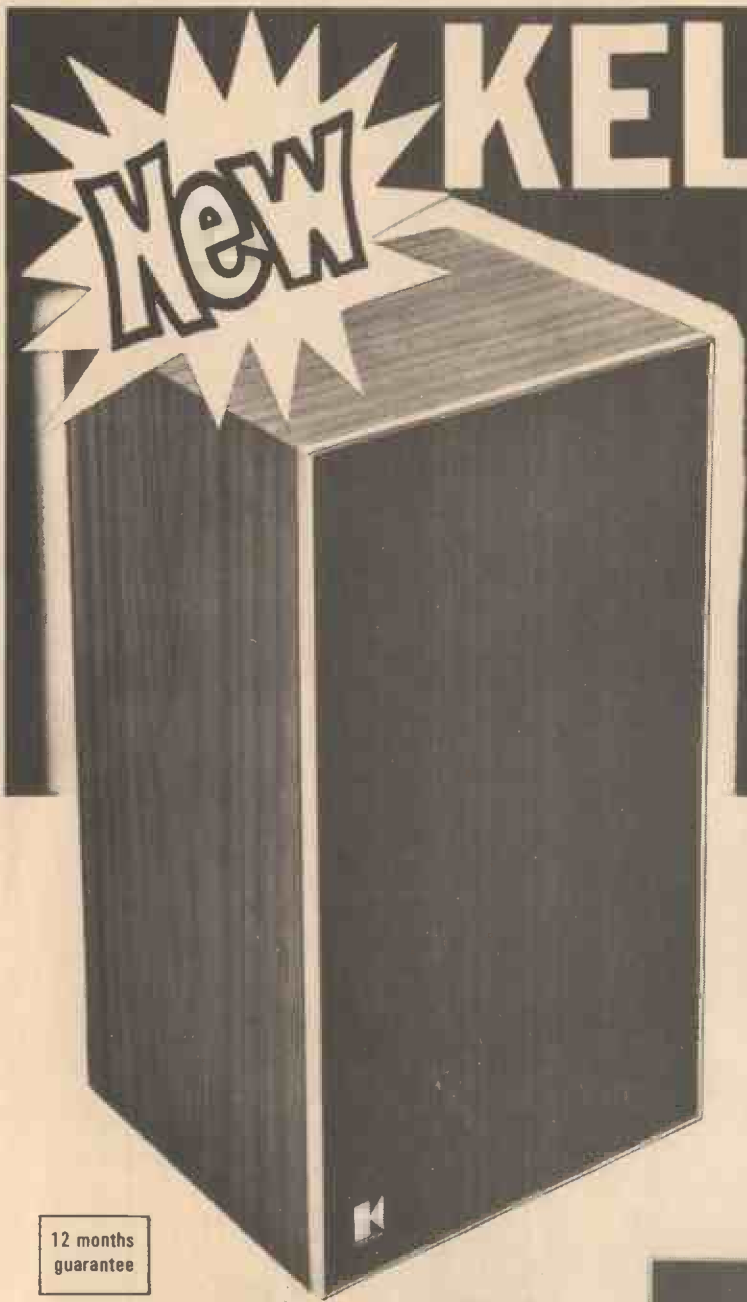
In communications, digital techniques combined with lasers will enable us to expand our transmission capabilities by an enormous amount — and virtually to eliminate noise and distortion. If a mere one percent of the visible and infra-red spectrum were to become available, we would have 150 times the channel space that is presently used in our entire communications spectrum — room for 500 000 TV channels, each 6 MHz wide!

In the generation of electrical energy, lasers may make atomic fusion reactors a reality. Fusion reaction takes place at extremes of temperature — 80 million degrees Celsius or more. At these temperatures the main problem is to contain the reactant gas plasma. Magnetic fields have been tried and largely failed. Now, it seems, high-powered lasers may be used to raise the temperature of nuclear fuel pellets almost instantaneously, without the need for a containing field — creating, as it were, a series of miniature H-bomb explosions in which the resultant energy is absorbed as heat within a container of lithium.

In physical research, X-ray holography is realistically expected to enable us to view the electron structure of matter. Similarly, it will be possible to view the structure of bio-chemical matter and thus greatly expand our understanding of life processes.

Holography, while still in its infancy, may enable us to construct optical computer memories with truly fantastic storage capability. It is also predicted that this technique will enable us to build three-dimensional colour television systems.

Laser technology is perhaps the most exciting of current fields of endeavour. It may even be true to say that lasers will, in the next decade or two, reveal more physical knowledge than the entire previous efforts of mankind. ●



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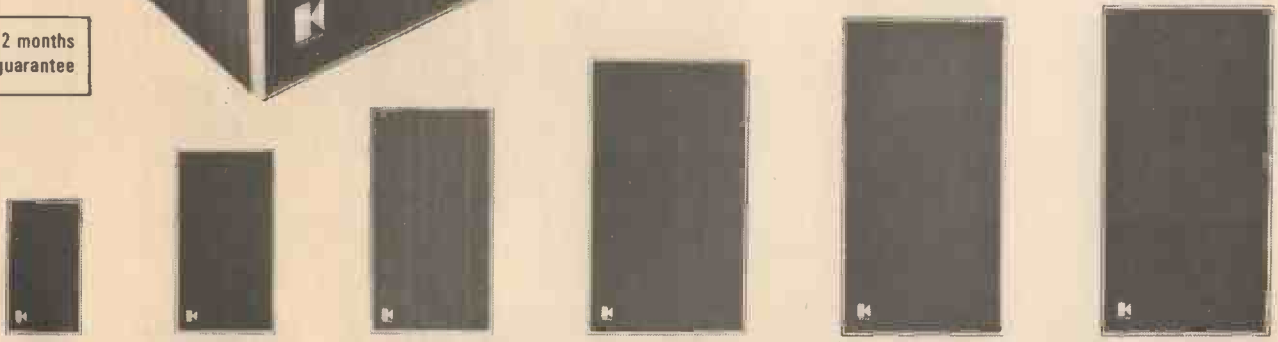

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news digest

CONGRATULATIONS!

Judging of the Hi-Fi Competition (featured in ETI April and May issues) has now been completed and first prize, a Rank Wharfedale System worth about £150 has been presented to **Sajad Jawad** of London NW6. Sajad is a Senior Production Engineer with Caps Microfilm Ltd and is a regular ETI subscriber.

"It was a complete surprise, I really didn't expect it" said Mr. Jawad when he was asked for his reaction on receiving the verdict even though this is not the first time he has won a major competition. Not long ago he won 3rd Prize in a competition organised by Heathkit and landed himself an amplifier.

No reader submitted a coupon identical to the order selected by the judges but Mr. Jawad's order was the closest and scored only eight 'difference points', the method selected for finding a winner. Four other readers scored 10 'difference points' and three of these won the remaining prizes as their explanations for the choice of order were considered the best.

Second prize, a pair of Keletron KS-20 speakers, went to **Mr. Guest** a student whose home is in Burton-on-Trent. The Teleton GA202 amplifier, the third prize, was won by **John Cardno** of Aberdeen, while the BASF tapes, the fourth prize, were won by **Brian Roberts** of Bournemouth.

The competition was a real success with the entries totalling about three times the expected number.

Mr. Jawad's order, which won him the prize, was 1: Low Distortion, 2: Smooth Frequency Response, 3: Wide Frequency Response, 4: Superior Transient Response, 5: High Power Handling Capacity, 6: High Efficiency, 7: Wide Polar Response, 8: Moderate Price, 9: Parts and Labour Warranty, 10: Attractive Appearance, 11: Reasonable Size.

The photograph shows Mr. Jawad being congratulated by Halvor Moorshead and Alex Mellon of ETI.

VIDEOTELEPHONE

Siemens have introduced a new videotelephone design, 'Videoset 101', which is now ready for series production. This device is a further development of the first European videotelephone for dial operation, which was presented by Siemens in 1967 and has been under test for two years in Germany. The new videotelephone is characterized by a larger screen, improved picture quality and simplified operation. It uses the internationally proposed standard video bandwidth of 1MHz.

Consistent use of the 1MHz bandwidth led to a noticeable improvement of the service features. The screen, for instance, has been enlarged to 128mm x 141mm. The number of lines, 267, guarantees a resolution at which even small details can be distinguished. For transmission of written texts, for example, a capacity of about 500 characters can be reckoned with. The frame frequency of 60Hz ensures a predominantly flicker-free picture, even in normal ambient brightness.

The new videotelephone retains the three original functional units: the telephone, the picture unit and an attachment box. There is a button for hands-free conversation and a volume control switch. The picture unit is rotatable, and its camera section can be tilted. A mechanical scissor aperture permits the use of plumbicon and silicon-vidicon type camera tubes, as well as the conventional vidicon.

The attachment box contains the power supply for the picture unit, as well as the video amplifier, the voice-switched amplifier for hands-free conversation and the associated relay assembly.

The videotelephone is likely to be used increasingly in PABXs in the next few years, but introduction of a videotelephone service in the public telephone network of the Federal Republic of Germany is not expected before 1980.

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(As featured in "Practical Wireless" May to August 1972)

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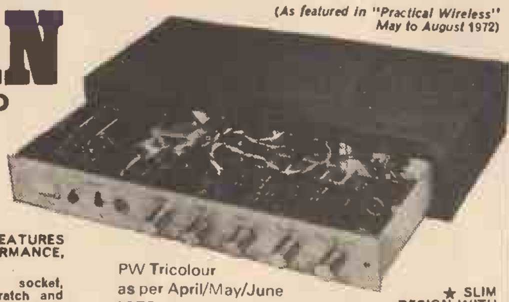

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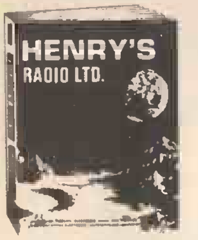

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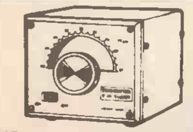

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SC40E	500	£1·20
10 AMP RANGE (TO48)		
SC45A	100	95p
SC45B	200	£1·00
SC45D	400	£1·25
SC45E	500	£1·45
15 AMP RANGE (TO48)		
SC50A	100	£1·25
SC50B	200	£1·35
SC50D	400	£1·65
SC50E	500	£1·85
DIAC D32		25p
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3 Amp T048

15 Amp T048

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Type	Volts P.I.V.	Price 1-11
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B1/05	50	25p
B1/10	100	25p
B1/20	200	30p
B1/60	600	35p
ONE AMP (G.I.) TUBULAR		
W005	50	30p
W01	100	35p
W02	200	40p
W06	600	45p
TWO AMPS ¼Hx⅝Lx⅛		
B2/05	50	35p
B2/100	100	40p
B2/200	200	45p
B2/600	600	50p
B2/1000	1000	60p
FOUR AMPS ¼Hx⅝Lx⅛		
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B4/200	200	65p
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B4/600	600	75p
B4/800	800	£1·00
SIX AMPS ¼Hx⅝Lx⅛		
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B6/400	400	90p
B6/600	600	£1·00

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CRS 1/10	100	30p
CRS 1/20	200	30p
CRS 1/40	400	35p
CRS 1/60	600	45p
THREE AMP (TO48)		
CRS 3/05	50	30p
CRS 3/10	100	30p
CRS 3/20	200	35p
CRS 3/40	400	45p
CRS 3/60	600	55p
FIVE AMP (TO66)		
CRS 5/400	400	60p
SEVEN AMP (TO48)		
CRS 7/100	100	60p
CRS 7/200	200	65p
CRS 7/400	400	70p
CRS 7/600	600	95p
SIXTEEN AMP		
SCR 16/100	100	65p
SCR 16/200	200	70p
SCR 16/400	400	80p
SCR 16/600	600	£1·00

1 Amp T05

3 Amp T048

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Type	P.I.V.	1-11
1 amp miniature		
IN4001	50	6p
IN4002	100	7p
IN4003	200	8p
IN4004	400	8p
IN4005	600	10p
IN4006	800	12p
IN4007	1000	15p
1.5 amp miniature		
PL4001	50	8p
PL4002	100	9p
PL4003	200	10p
PL4004	400	10p
PL4005	600	12p
PL4006	800	15p
PL4007	1000	16p

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Any one type.

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741C TO99	55p
741C D.I.L.	55p
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747C D.I.L.	£1·10
72741P D.I.L.	60p
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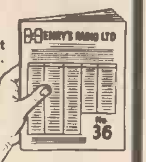

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news digest

PICTURES OF LUNAR MICRO-CRATER

A crater made on the moon by a micro-meteorite, and brought down to earth from the Caley plateau by the Apollo 16 astronauts as part of a specimen, is a mere three hundredths of a millimetre in diameter. NASA has put the moon-dust specimen containing this micro-crater at the disposal of the Max-Planck Institute for Nuclear Physics in Heidelberg, West Germany, from where it has been sent to the applications laboratory at the Siemens works in Karlsruhe for examination under a scanning electron microscope.

The specimen only measures about 2mm x 1mm and is, strictly speaking, not really moon material at all. Instead, it is an 'interplanetary traveller' itself, a nickel iron meteorite which is estimated to have crashed down on the moon some 3000 years ago. Normally such meteorites vaporize on impact and only very seldom leave behind fragments. This rare specimen of meteoric iron has, in turn, been hit by a micro-meteorite whose only remaining 'trace' is a crater of 0.03mm. diameter (the thickness of a human hair).

The scientists in Heidelberg have worked out that the micro-meteorite had a speed of about 25,000mph. What particularly struck the research workers at the Max-Planck Institute, however, was the presence of parallel structures in the immediate vicinity of the crater produced by the impact, this being a mineralogical peculiarity of meteoric iron. Two other and even smaller mini-micro craters to the right, which have a diameter of only two thousandths of a millimetre, are also noteworthy.

The Autoscan (Etec System) scanning electron microscope employed in this case is particularly well suited to examinations of this nature, which are performed to make the most minute surface structures visible with a very good depth of focus. The specimen is scanned line-by-line with a concentrated electron beam similar to the principle used for television. The secondary electrons produced on the specimen surface are amplified in a photomultiplier to form a video signal which then controls the electron beam intensity of a picture tube. The line deflection is synchronous to the primary electron beam, a scanning-pattern image being produced on the screen 'in the light' of the secondary electrons.

The meteorite photograph was taken at a beam voltage of 20kV with the specimen tilted at an angle of 80°. A total of 2048 lines were scanned at an exposure time of one second. The initial enlargement is 1000:1, the overall enlargement 3200:1.

NEW INTRUDER MOVEMENT DETECTOR

Security systems based on conventional sonar devices for detecting movement of intruders in premises, have often suffered from spurious alarms caused by inanimate objects flapping or swinging within their range such as curtains, doors, windows, shutters or signs.

To combat this particular problem, AFA-Minerva (EMI) Ltd., has introduced an advanced sonar detector which is able to reduce this rate of unwanted warnings by discriminating between different types of motion within its range. Its electronic 'memory' is able to ignore these typical wavering movements, which previously have triggered off security systems unnecessarily but able to identify the approach of an intruder and to sound the alert.

Known as the Fidela 3, this new general-purpose equipment is designed to detect intruders inside premises ranging from shops and offices, industrial and commercial buildings, to museums and art galleries. Measuring 11in long, 7in wide and 2¼in deep, the device can be fixed to most types of vertical surface.

NEW USES FOR THE CHAMELEON CHEMICALS

Chemicals which show brilliant colour changes when heated or cooled could soon be solving a wide range of problems. Called *Cholesteric Liquid Crystals,* they could be used almost anywhere that a fast visual indication of temperature levels is needed. Likely applications — some already at work — range from fault indication on electronic circuits, microwave detection and the non-destructive testing of engineering parts to such ideas as safety labelling of frozen foods and even mass screening for breast cancer.

Companies like Bendix and Raytheon, for example, are working on microwave detectors, where a thin film of CLC shows a pattern of colour according to the microwave energy falling on to it. Xerox is working on ideas for optical imaging and information storage using CLCs. Lockheed has developed ultrasonic field sensing equipment. Bell Telephone Laboratories has even come up with ideas for a large-screen colour television system called Cholophor which uses laser-beam scanning and a combination of CLCs with the phosphors like those in a normal colour TV.

Until now, most liquid crystals research has been concentrated on the nematic varieties, which are already being used for black-and-white numerical displays in desk calculators and watches. Cholesteric liquid crystals may eventually be more important because of their versatility.

CLC mixes can be adjusted to run through the complete spectrum of colours in as little as 0.2°C (0.36°F) or as much as 120°C (216°F). The material is normally used as a thin film on a black background. This looks like a sheet of black, flexible plastic. As it warms up it will go through red and yellow to a deep blue at the top of its range before turning black again.

ELECTRONIC SLIDE-RULE ON SINGLE "CHIP"

A single circuit now functioning in the laboratories of the Microelectronics Division of Rockwell International Corporation contains virtually all the mathematical functions of electronic calculators requiring five or more circuits.

The new circuits are expected to reduce substantially the price of hand-held, advanced mathematical calculators known as electronic slide-rules. The electronic slide-rule (ESR) circuit is the first of a new series of "extra powerful one-chip calculator circuits." The first ESR circuits are expected to be available sometime this summer.

(Continued on page 11)

news digest

Containing 14,200 transistors in a paper-thin chip of silicon smaller than a man's shirt button, the circuit is organized like a big computer with a central calculating unit controlled by a special program in a fixed memory.

The ESR circuits can be programmed to calculate sines, cosines, tangents and their inverses in degrees or radians, exponentials, numbers to any power, reciprocals of numbers, natural and base-ten logarithms, square roots, and the sum of squares. They also have constants such as Pi.

The basic ESR circuits can be reprogrammed inexpensively to produce a variety of specialized calculators. For example, a contractor's model would calculate construction formulas with single key depressions, or a business model would compute interest and other statistics.

In a scientific mathematical calculator, the ESR circuits provide an eight-digit display. The circuits also have a separate memory in which numbers ranging from .00000001 to 99,999,999 can be accumulated.

The ESR circuits join the division's line of one-chip calculator circuits which Rockwell Microelectronics is currently selling by the millions for basic machines. As an example of how much this circuit will reduce the cost, a machine with 15 to 20 professional functions will probably sell for under £100 by next year, and they will be sold by retail stores as well as by specialty sales organizations.

U.S. RETAILER TO HAVE 100% TERMINAL SYSTEM

The Hecht Company, the Washington-based American department store chain with 17 outlets in the Washington-Baltimore area, will be the first major U.S. department store group to convert entirely to electronic point-of-sale equipment.

Hecht's were the first chain to place orders, two years ago. for the NCR 280 retail terminal in a £1.2 million contract for 770 terminals covering its 10 Washington stores. These additional terminals will be installed this summer in Hecht's five major department stores and two outlet stores in and around Baltimore.

Benefits already experienced with the original equipment include much better control over credit business with a vast reduction in losses, plus a 40 per cent cut in sales audit staff since the need to key-punch sales information was eliminated.

WORLD'S FIRST TRANSPORTABLE ELECTRONIC EXCHANGE

The Post Office has taken delivery of Britain's first transportable electronic telephone exchange. Made by Plessey Telecommunications, the transportable electronic exchange is believed to be the first of its kind in the world.

The exchange, which will go into service at Padgate in Lancashire, is the first of 35 mobile exchanges — twenty-five 1,000 line and ten 2,000 line TXE2 units — ordered by the Post Office from Plessey for delivery over the next 18 months.

The mobile exchanges are easily transportable and will be moved around the country by the Post Office to provide telephone services quickly where they are most urgently needed.

Applications include extending the capacity of an existing exhausted exchange to relieve waiting lists for telephone service, temporarily replacing older exchanges and emergency replacement of out-of-action exchanges.

The picture shows the first TXE2 mobile electronic telephone exchange being taken from the Plessey Telecommunications factory at Beeston, Nottingham.

BOOM!

Figures recently released by the Department of Trade and Industry confirm the upward trend in the economy, discussed in last month's leader, at least as far as electronic capital equipment is concerned.

From the end of 1971 to the end of 1972, orders increased by 23%; exports performed even better and accounted for 39% of the total. These figures compare to the meagre rise of only 5% for the previous year which was largely due to inflation.

The electronic capital equipment industry last year was worth £738 million and everything points to an even larger figure for the current year.

BOOM, BOOM!

Considering that colour TV is still very young (it started about six years ago but did not of course catch on until two years ago) the growth has been truly staggering. Mullards, the largest British makers of colour TV tubes are manufacturing nearly 1½ million a year, 250,000 of these for export. This output has become possible because of the company's recently opened £10 million plant at Durham which is now fully operational.

NEW TV STATIONS FOR WALES

One main station and two relays have recently begun transmission in Wales. The main station is the IBA's *Moel-y-Parc* which is on Channel 49 and will serve 230,000 people in North Wales.

The relay stations are *Pontypool*, Monmouthshire, and *Bargoed*, Glamorgan both on Channel 24.

YUM, YUM

No, love, you're not meant to eat them. However we have got to admit that Athena have found new ways of publicising the components that they distribute. Susan Soames is the girl (and the components are capacitors if you hadn't noticed); she is featured in Athena's new quarterly newspaper 'Athena Connector' which was recently launched. It is a four pager designed for users of the large variety of components distributed by the company.

news digest

COMPUTER 'ON A CHIP' WITH CASSETTE TAPE

A new byte-orientated micro-computer with its own in-built cassette tape backing storage has been produced by Computer Electronics Ltd, of Saffron Walden, Essex, as part of its range of cassette tape data systems.

Believed to be one of the first 'processors on a chip' computers to be developed in this country, the complete computer fits on one of the company's standard printed circuit cards.

The 8-bit parallel CPU is designed to handle large volumes of data. It has a 48 instruction set, cycle time of 12.5μs and an 8 bit data and address bus.

Direct access to 16K bytes of memory can be provided, which may consist of random access, read only or a combination of both. The memory is expandable above 16K bytes and the CPU has 8 seven-bit registers and an interrupt facility. An assembler language has been developed for the CPU.

Other processors, each having their own in-built disks, communication multiplexors, etc. will be available shortly.

WHERE ARE YOU LADIES?

Despite our plea in the May issue for members of the gentler sex (females if you aren't too sure which is which) to contact the British Amateur Electronics Club and ourselves, neither of us have heard from anyone. Now there's no catch to this, there must be some ladies who are interested and, as an inducement to write to us, we will give a three month's subscription to the first (genuine) letter we receive— now what could be fairer than that?

The Hon. Secretary of the B.A.E.C., John Margetts, has just moved and anyone wishing to find out about the club should now write to: 11 Peartree Avenue, Ditton, Maidstone, Kent.

OPEN UNIVERSITY COURSE IN ELECTRONICS & CIRCUIT DESIGN

Electromagnetics and Electronics, a post-experience course by the Open University, aims to provide an understanding of the scientific basis of electronics and electronic circuit design.

The course is intended for those preparing for higher level university study in science and technology and for those who need a knowledge of electronics but who do not intend to study at a higher level.

It assumes little prior knowledge of electronics or electromagnetics but does assume a background of scientific or technical education beyond GCE 'O' Level.

The first part deals with the basic ideas of electricity, magnetism and electromagnetism, semiconductors and the properties of simple circuits. The remainder deals with electronic circuits, stressing the need to design circuits to meet specifications of noise, distortion, output voltage as well as gain and input and output impedance.

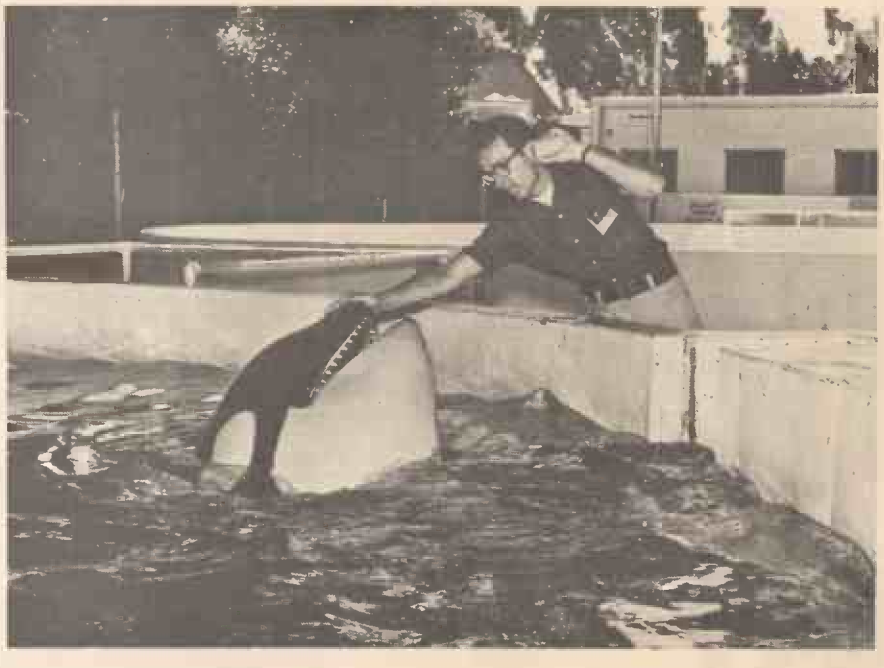
Applications are now invited for the course which starts next February and lasts until November. As with all post-experience courses, no formal academic qualifications are needed. They are self-contained courses designed to teach new developments or update knowledge of a subject.

The course consists of 17 written correspondence units linked to 17 television and five radio programmes. Students are required to attend a one week residential summer school and encouraged to attend evening or Saturday tutorial sessions. There are 12 assignments to complete and an examination at the end of the course.

A home experiment kit, including a cathode-ray oscilloscope and a signal generator, is sent to students who are expected to design and build circuits for checking at summer school.

Some elementary mathematics is required for the course. Students should know elementary calculus, the meaning of sine, cosine and imaginary numbers. A preparatory booklet is issued at the beginning.

The course tuition fee is £45 plus £37 for the residential summer school. Application forms are available from *The Post-experience Student Office, P.O. Box 76, Milton Keynes, MK7 6AA.*



William Flynn, curator of marine animals at San Diego's Sea World Park receives a message on his Multitone paging receiver as he gives a friendly pat on the nose to Shanu, a two-ton killer whale who is one of the star performers at the park.

A radio pocket paging system manufactured by Multitone Electric Co. Ltd., the London-based specialists, has been supplied to Sea World in order to provide instant and selective communication with key personnel whose work can take them anywhere on the 80 acre site.

Whenever a person is wanted, the switchboard operator is called. She simply presses a button on a control unit and a coded 'bleep' signal is radioed to the person's receiver. By pressing a button on the side of the receiver, the called person then receives a voice message from the operator. •

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AC113	0·20	AD161 &		BC149	0·12	BD138	0·50	BF194	0·12	OC20	0·63	2G371B	0·12
AC115	0·23	AD162 (MP)		BC150	0·18	BD139	0·55	BF195	0·12	OC22	0·38	2G373	0·17
AC117K	0·20		0·55	BC151	0·20	BD140	0·60	BF196	0·14	OC23	0·42	2G374	0·17
AC122	0·12	ADT140	0·50	BC152	0·17	BD155	0·80	BF197	0·14	OC24	0·56	2G377	0·30
AC125	0·17	AF114	0·24	BC153	0·28	BD175	0·60	BF200	0·45	OC25	0·38	2G378	0·16
AC126	0·17	AF115	0·24	BC154	0·30	BD176	0·80	BF222	0·95	OC26	0·25	2G381	0·16
AC127	0·17	AF116	0·24	BC157	0·18	BD177	0·65	BF257	0·45	OC28	0·50	2G382	0·16
AC128	0·17	AF117	0·24	BC158	0·12	BD178	0·65	BF258	0·60	OC29	0·50	2G401	0·30
AC132	0·14	AF118	0·35	BC159	0·12	BD179	0·70	BF259	0·85	OC35	0·42	2G414	0·30
AC134	0·14	AF124	0·30	BC160	0·45	BD180	0·70	BF262	0·55	OC36	0·50	2G417	0·25
AC137	0·14	AF125	0·25	BC161	0·50	BD185	0·65	BF263	0·55	OC41	0·20	2N388	0·35
AC141	0·14	AF126	0·28	BC167	0·12	BD186	0·65	BF270	0·35	OC42	0·24	2N388A	0·55
AC141K	0·17	AF127	0·28	BC168	0·12	BD187	0·70	BF271	0·30	OC44	0·15	2N404	0·20
AC142	0·14	AF139	0·30	BC169	0·12	BD188	0·70	BF272	0·80	OC45	0·12	2N404A	0·28
AC142K	0·17	AF178	0·50	BC170	0·12	BD189	0·75	BF273	0·35	OC70	0·10	2N524	0·42
AC151	0·15	AF179	0·50	BC171	0·14	BD190	0·75	BF274	0·35	OC71	0·10	2N527	0·49
AC154	0·20	AF180	0·50	BC172	0·14	BD195	0·85	BFW10	0·60	OC72	0·14	2N598	0·42
AC155	0·20	AF181	0·45	BC173	0·14	BD196	0·85	BFX29	0·27	OC74	0·14	2N599	0·45
AC156	0·20	AF186	0·45	BC174	0·14	BD197	0·90	BFX84	0·22	OC75	0·15	2N696	0·12
AC157	0·24	AF239	0·37	BC175	0·22	BD198	0·90	BFX85	0·30	OC76	0·15	2N697	0·13
AC165	0·20	AL102	0·65	BC177	0·19	BD199	0·95	BFX86	0·22	OC77	0·25	2N698	0·24
AC166	0·20	AL103	0·65	BC178	0·19	BD200	0·95	BFX87	0·24	OC81	0·15	2N699	0·35
AC167	0·20	ASY26	0·25	BC179	0·19	BD205	0·80	BFX88	0·22	OC81D	0·15	2N706	0·08
AC168	0·24	ASY27	0·30	BC180	0·24	BD206	0·80	BFY50	0·20	OC82	0·15	2N706A	0·09
AC169	0·14	ASY28	0·25	BC181	0·24	BD207	0·95	BFY51	0·20	OC82D	0·15	2N708	0·12
AC176	0·20	ASY29	0·25	BC182	0·10	BD208	0·95	BFY52	0·20	OC83	0·20	2N711	0·30
AC177	0·24	ASY50	0·25	BC182L	0·10	BDY20	1·00	BFY53	0·17	OC84	0·20	2N717	0·35
AC178	0·28	ASY51	0·25	BC183	0·10	BF115	0·24	BPX25	0·35	OC139	0·20	2N718	0·24
AC179	0·28	ASY52	0·25	BC183L	0·10	BF117	0·45	BSX19	0·15	OC140	0·20	2N718A	0·50
AC180	0·17	ASY54	0·25	BC184	0·12	BF118	0·70	BSX20	0·15	OC169	0·25	2N726	0·28
AC180K	0·20	ASY55	0·25	BC184L	0·12	BF119	0·70	BSY25	0·15	OC170	0·25	2N727	0·28
AC181	0·17	ASY56	0·25	BC186	0·28	BF121	0·45	BSY26	0·15	OC171	0·25	2N743	0·20
AC181K	0·20	ASY57	0·25	BC187	0·28	BF123	0·50	BSY27	0·15	OC200	0·25	2N744	0·20
AC187	0·28	ASY58	0·25	BC207	0·11	BF125	0·45	BSY28	0·15	OC201	0·28	2N914	0·14
AC187K	0·20	ASZ21	0·40	BC208	0·11	BF127	0·50	BSY29	0·15	OC202	0·28	2N918	0·30
AC188	0·22	BC107	0·09	BC209	0·12	BF152	0·55	BSY38	0·18	OC203	0·25	2N929	0·21
AC188K	0·20	BC108	0·09	BC212L	0·11	BF153	0·45	BSY39	0·18	OC204	0·25	2N930	0·21
ACY17	0·25	BC109	0·10	BC213L	0·11	BF154	0·45	BSY40	0·28	OC205	0·35	2N1131	0·20
ACY18	0·20	BC113	0·10	BC214L	0·14	BF155	0·70	BSY41	0·28	OC309	0·40	2N1132	0·22
ACY19	0·20	BC114	0·15	BC225	0·25	BF156	0·48	BSY95	0·12	P346A	0·20	2N1302	0·14
ACY20	0·20	BC115	0·15	BC226	0·35	BF157	0·55	BSY95A	0·12	P397	0·42	2N1303	0·14
ACY21	0·20	BC116	0·15	BCY30	0·24	BF158	0·55	Bu105	2·00	OCP71	0·43	2N1304	0·17
ACY22	0·16	BC117	0·15	BCY31	0·28	BF159	0·60	C111E	0·50	ORP12	0·43	2N1305	0·17
ACY27	0·18	BC118	0·10	BCY32	0·30	BF160	0·40	C400	0·30	ORP60	0·40	2N1306	0·21
ACY28	0·19	BC119	0·30	BCY33	0·22	BF162	0·40	C407	0·25	ORP61	0·40	2N1307	0·21
ACY29	0·35	BC120	0·80	BCY34	0·25	BF163	0·40	C424	0·20	ST140	0·12	2N1308	0·23
ACY30	0·28	BC125	0·12	BCY70	0·14	BF164	0·40	C425	0·50	ST141	0·17	2N1309	0·23
ACY31	0·28	BC126	0·18	BCY71	0·18	BF165	0·40	C426	0·35	TI843	0·30	2N1613	0·20
ACY34	0·21	BC132	0·12	BCY72	0·14	BF167	0·22	C428	0·20	UT46	0·27	2N1711	0·20
ACY35	0·21	BC134	0·18	BCZ10	0·20	BF173	0·22	C441	0·30	2G301	0·09	2N1889	0·32
ACY36	0·28	BC135	0·12	BCZ11	0·25	BF176	0·35	C442	0·30	2G302	0·19	2N1890	0·45
ACY40	0·17	BC136	0·15	BCZ12	0·25	BF177	0·35	C444	0·35	2G303	0·19	2N1893	0·37
ACY41	0·18	BC137	0·15	BD121	0·60	BF178	0·30	C450	0·22	2G304	0·24	2N2147	0·72
ACY44	0·35	BC139	0·40	BD123	0·65	BF179	0·30	MAT100	0·19	2G306	0·40	2N2148	0·57
AD130	0·38	BC140	0·30	BD124	0·60	BF180	0·30	MAT101	0·20	2G308	0·35	2N2160	0·60
AD140	0·48	BC141	0·30	BD131	0·50	BF181	0·30	MAT120	0·19	2G309	0·35	2N2192	0·35
AD142	0·48	BC142	0·30	BD132	0·60	BF182	0·40	MAT121	0·20	2G339	0·20	2N2193	0·35
AD143	0·38	BC143	0·30	BD133	0·65	BF183	0·40	MPF102	0·42	2G339A	0·16	2N2194	0·35
AD149	0·50	BC145	0·45	BD135	0·40	BF184	0·25	MPF104	0·37	2G344	0·18	2N2217	0·22
AD161	0·33	BC147	0·10	BD136	0·40	BF185	0·30	MPF105	0·37	2G345	0·16	2N2218	0·20

2N2219	0·20	2N3054	0·46	2N4059	0·10
2N2220	0·22	2N3055	0·50	2N4060	0·12
2N2221	0·20	2N3391	0·14	2N4061	0·12
2N2222	0·20	2N3391A	0·16	2N4062	0·12
2N2368	0·17	2N3392	0·14	2N4284	0·17
2N2369	0·14	2N3393	0·14	2N4285	0·17
2N2369A	0·14	2N3394	0·14	2N4286	0·17
2N2411	0·24	2N3395	0·17	2N4287	0·17
2N2412	0·24	2N3402	0·21	2N4288	0·17
2N2646	0·47	2N3403	0·21	2N4289	0·17
2N2711	0·21	2N3404	0·28	2N4290	0·17
2N2712	0·21	2N3405	0·42	2N4291	0·17
2N2714	0·21	2N3414	0·15	2N4292	0·17
2N2904	0·17	2N3415	0·15	2N4293	0·17
2N2904A	0·21	2N3416	0·28	2N5172	0·12
2N2905	0·21	2N3417	0·28	2N5457	0·32
2N2905A	0·21	2N3525	0·75	2N5458	0·32
2N2906	0·15	2N3646	0·09	2N5459	0·40
2N2906A	0·18	2N3702	0·10	28301	0·50
2N2907	0·20	2N3703	0·10	28302A	0·42
2N2907A	0·22	2N3704	0·11	28302	0·42
2N2923	0·14	2N3705	0·10	28303	0·55
2N2924	0·14	2N3706	0·09	28304	0·70
2N2925	0·14	2N3707	0·11	28305	0·84
2N2926 (G)		2N3708	0·07	28306	0·84
	0·12	2N3709	0·09	28307	0·84
2N2926 (Y)		2N3710	0·09	28321	0·56
	0·11	2N3711	0·09	28322	0·42
2N2926 (O)		2N3819	0·28	28322A	0·42
	0·10	2N3820	0·50	28323	0·56
2N2926 (R)		2N3821	0·35	28324	0·70
	0·10	2N3823	0·28	28325	0·70
2N2926 (B)		2N3903	0·28	28326	0·70
	0·10	2N3904	0·30	28327	0·70
2N3010	0·70	2N3905	0·28	28701	0·42
2N3011	0·14	2N3906	0·27	40361	0·40
2N3053	0·17	2N4058	0·12	40362	0·45

DIODES AND RECTIFIERS

AA119	0·08	BY133	0·21	OA10	0·35
AA120	0·08	BY164	0·50	OA47	0·07
AA129	0·08	BYX38/30		OA70	0·07
AAY30	0·09		0·42	OA79	0·07
AAZ13	0·10	BYZ10	0·35	OA81	0·07
BA100	0·10	BYZ11	0·30	OA85	0·09
BA116	0·21	BYZ12	0·30	OA90	0·06
BA126	0·22	BYZ13	0·25	OA91	0·06
BA148	0·14	BYZ16	0·40	OA95	0·07
BA154	0·12	BYZ17	0·35	OA200	0·06
BA155	0·14	BYZ18	0·35	OA202	0·07
BA156	0·13	BYZ19	0·28	SD10	0·05
BY100	0·15	CG62		SD19	0·05
BY101	0·12	(Eg) OA91		IN34	0·07
BY105	0·17		0·5	IN34A	0·07
BY114	0·12	CG651		IN914	0·06
BY126	0·14	(Eq) OA70-		1N916	0·06
BY127	0·15	OA79	0·06	1N414B	0·06
BY128	0·15	OA5	0·35	18021	0·10
BY130	0·16	OA58L	0·21	18951	0·06

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100v RMS	37p ,,
400v RMS	46p ,,

Size 15 mm × 6 mm.

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50	For	1·00
100	For	1·75
500	For	7·50
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40PIV(Min.)	100..1·50
Sub-Min.	500..5·00
Full Tested	1,000. 9·00

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VBOM	2A TO-1	6A TO-66	10A TO-88
	£p	£p	£p
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200	50	60	90
400	70	75	1·10

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T2	8	D1374	OC75
T3	8	D1216	OC81D
T4	8	2G381T	OC81
T5	8	2G382T	OC82
T6	8	2G344B	OC44
T7	8	2G345B	OC45
T8	8	2G378	OC78
T9	8	2G399A	2N1302
T10	8	2G417	AF117

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U 8	50	Sil. Planar Diodes DO-7 Glass 250mA like OA200/202	0·50
U 9	20	Mixed Voltages, 1 Watt Zener Diodes	0·50
U10	20	BAY50 charge storage Diodes DO-7 Glass	0·50
U11	25	PNP Sil. Planar Trans. TO-5 like 2N1132, 2N2904	0·50
U12	12	Silicon Rectifiers Epoxy 500mA up to 800 PIV	0·50
U13	30	PNP-NPN Sil. Transistors OC200 & 2S 104	0·50
U14	150	Mixed Silicon and Germanium Diodes	0·50
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U16	10	3 Amp Silicon Rectifiers Stud Type up to 1000PIV	0·50
U17	30	Germanium PNP AF Transistors TO-5 like ACY 17-22	0·50
U18	8	6 Amp Silicon Rectifiers BYZ13 Type up to 600 PIV	0·50
U19	25	Silicon NPN Transistors like BC108	0·50
U20	12	1·5 Amp Silicon Rectifiers Top Hat up to 1000 PIV	0·50
U21	30	AF. Germanium Alloy Transistors 2G300 Series & OC71	0·50
U23	30	MADT's like MHz Series PNP Transistors	0·50
U24	20	Germanium 1 Amp Rectifiers GJM Series up to 300 PIV	0·50
U25	25	300 MHz NPN Silicon Transistors 2N708, BSY27	0·50
U26	30	Fast Switching Silicon Diodes like 1N914 Micro-Min.	0·50
U27	12	NPN Germanium AF Transistors TO-1 like AC127	0·50
U29	10	1 Amp SCR's TO-5 can, up to 600 PIV CRS1/25-600	1.00
U30	15	Plastic Silicon Planar Trans. NPN 2N2926	0·50
U31	20	Silicon Planar Plastic NPN Trans. Low Noise Amp 2N3707	0·50
U32	25	Zener Diodes 400mW DO-7 case 3-18 volts mixed	0·50
U33	15	Plastic Case 1 Amp Silicon Rectifiers 1N4000 Series	0·50
U34	30	Silicon PNP Alloy Trans. TO-5 BCY26 2S302/4	0·50
U35	25	Silicon Planar Transistors PNP TO-18 2N2906	0·50
U36	25	Silicon Planar NPN Transistors TO-5 BFY50/51/52	0·50
U37	30	Silicon Alloy Transistors SO-2 PNP OC200, 2S322	0·50
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U40	10	Dual Transistors 6 lead TO-5 2N2060	0·50
U41	25	RF Germanium Transistors TO-5, OC45, NKT72	0·50
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U43	25	Sil. Trans. Plastic TO-18 A.F. BC113/114	0·50
U44	20	Sil. Trans. Plastic TO-5 BC115/NPN	0·50
U45	7	3A SCR. TO66 up to 600PIV	1·00

Code No's. mentioned above are given as a guide to the type of device in the pak. The devices themselves are normally unmarked.

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Pak No.			Price £p
Q1	20	Red spot transistors PNP	0·50
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Q5	4	OC 75 transistors	0·50
Q6	5	OC 72 transistors	0·50
Q7	4	AC 128 transistors PNP high gain	0·50
Q8	4	AC 126 transistors PNP	0·50
Q9	7	OC 81 type transistors	0·50
Q10	7	OC 71 type transistors	0·50
Q11	2	AC 127/128 Complementary pairs PNP/NPN	0·50
Q12	3	AF 116 type transistors	0·50
Q13	3	AF 117 type transistors	0·50
Q14	3	OC 171 H.F. type transistors	0·50
Q15	7	2N2926 Sil. Epoxy transistors mixed colours	0·50
Q16	2	GET880 low noise Germanium transistors	0·50
Q17	5	NPN 2 × ST.141 & 3 × ST.140	0·50
Q18	4	MADT'S 2 × MAT 100 & 2 × MAT 120	0·50
Q19	3	MADT'S 2 × MAT 101 & 1 × MAT 121	0·50
Q20	4	OC 44 Germanium transistors A.F.	0·50
Q21	4	AC 127 NPN Germanium transistors	0·50
Q22	20	NKT transistors A.F. R.F. coded	0·50
Q23	10	OA 202 Silicon diodes sub-min.	0·50
Q24	8	OA 81 diodes	0·50
Q25	15	1N914 Silicon diodes 75 PIV 75mA	0·50
Q26	8	OA95 Germanium diodes sub-min. IN69	0·50
Q27	2	10A PIV Silicon rectifiers 1S425R	0·50
Q28	2	Silicon power rectifiers BYZ 13	0·50
Q29	4	Silicon transistors 2 × 2N696, 1 × 2N697, 1 × 2N698	0·50
Q30	7	Silicon switch transistors 2N706 NPN	0·50
Q31	6	Silicon switch transistors 2N708 NPN	0·50
Q32	3	PNP Silicon transistors 2 × 2N1131, 1 × 2N 1132	0·50
Q33	3	Silicon NPN transistors 2N1711	0·50
Q34	7	Silicon NPN transistors 2N2369, 500MHz (code P397)	0·50
Q35	3	Silicon PNP TO-5, 2 × 2N2904 & 1 × 2N2905	0·50
Q36	7	2N3646 TO-18 plastic 300 MHz NPN	0·50
Q37	3	2N3053 NPN Silicon transistors	0·50
Q38	7	NPN transistors 4 × 2N3703, 3 × 2N3702	0·50

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The MK Slide Rule, designed to simplify Electronic calculations features the following scales:—Conversion of Frequency and Wavelength. Calculation of L, C and fo of Tuned Circuits. Reactance and Self-Inductance. Area of Circles. Volume of Cylinders. Resistance of Conductors. Weight of Conductors. Decibel Calculations. Angle Functions. Natural Logs and 'e' Functions. Multiplication and Division. Squaring, Cubing and Square Roots. Conversion of kW and Hp. A must for every electronic engineer and enthusiast. Size: 2 cm. × 4 cm. Complete with case and instructions. Price each: £3·35

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PIV	1A TO5	3A TO66	5A TO66	5A TO64	7A TO48	10A TO48	16A TO48	30A TO48
50	0·23	0·25	0·35	0·35	0·47	0·50	0·53	1·15
100	0·25	0·33	0·47	0·47	0·50	0·58	0·63	1·40
200	0·35	0·37	0·49	0·49	0·57	0·61	0·75	1·60
400	0·43	0·47	0·56	0·56	0·67	0·75	0·93	1·75
600	0·53	0·57	0·68	0·68	0·77	0·97	1·25	—
800	0·63	0·70	0·80	0·80	0·90	1·20	1·50	4·00

SIL. SECTS. TESTED

PIV	300mA	750mA	1A	1·5A	3A	10A	30A
50	0·04	0·05	0·05	0·07	0·14	0·21	0·60
100	0·04	0·06	0·05	0·13	0·16	0·23	0·75
200	0·05	0·09	0·06	0·14	0·20	0·24	1·00
400	0·06	0·13	0·07	0·20	0·27	0·37	1·25
600	0·07	0·16	0·10	0·23	0·34	0·45	1·86
800	0·10	0·17	0·11	0·25	0·37	0·55	2·00
1000	0·11	0·25	0·14	0·30	0·46	0·63	2·50
1200	—	0·33	—	0·38	0·57	0·75	—

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GENERAL PURPOSE GERM. PNP
Coded GP100. BRAND NEW TO-3 CASE. POSSIBLE REPLACE:—OC25-28-29-30-35-36. NKT 401-403-404-405-406-430-451-452-453. TI3027-3028, 2N250A 2N456A-457A-458A, 2N511 A & B. 2G220-222, ETC. VCBO 80V VCEO 50V IC 10A PT. 30 WATTS Hfe 30-170.

PRICE	1-24	25-99	100 up
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TO-3 case. G.P. Switching & Amplifier Applications. Brand new Coded R 2400 VCBO 250/VCEO 100/IC 6A/30 Watts. HFE type 20/fT 5MHZ.
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115 WATT SII POWER NPN 50p EACH.

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2N3820	50p	2N5459	40p
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2N3823	30p	MPF105	40p

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SN7400	0·15	0·14	0·12	SN7450	0·15	0·14	0·12	SN74123	£2·80	£2·70	£2·60
SN7401	0·15	0·14	0·12	SN7451	0·15	0·14	0·12	SN74141	0·67	0·64	0·58
SN7402	0·15	0·14	0·12	SN7453	0·15	0·14	0·12	SN74145	£1·50	£1·40	£1·30
SN7403	0·15	0·14	0·12	SN7454	0·15	0·14	0·12	SN74150	£3·00	£2·70	£2·50
SN7404	0·15	0·44	0·12	SN7460	0·15	0·14	0·12	SN74151	£1·00	0·95	0·90
SN7405	0·15	0·14	0·12	SN7470	0·29	0·26	0·24	SN74153	£1·20	£1·10	0·95
SN7406	0·35	0·31	0·28	SN7472	0·29	0·26	0·24	SN74154	£1·80	£1·70	£1·60
SN7407	0·35	0·31	0·28	SN7473	0·37	0·35	0·32	SN74155	£1·40	£1·30	£1·20
SN7408	0·18	0·17	0·16	SN7474	0·37	0·35	0·32	SN74156	£1·40	£1·30	£1·20
SN7409	0·18	0·17	0·16	SN7475	0·45	0·43	0·42	SN74157	£1·90	£1·80	£1·70
SN7410	0·15	0·14	0·12	SN7476	0·40	0·39	0·38	SN74160	£1·80	£1·70	£1·40
SN7411	0·25	0·24	0·23	SN7480	0·67	0·64	0·58	SN74161	£1·80	£1·70	£1·60
SN7412	0·35	0·31	0·28	SN7481	£1·20	£1·15	£1·10	SN74162	£4·00	£3·75	£3·50
SN7413	0·29	0·28	0·24	SN7482	0·87	0·86	0·85	SN74163	£4·00	£3·75	£3·50
SN7416	0·43	0·40	0·38	SN7483	£1·10	£1·05	0·95	SN74164	£2·20	£2·15	£2·10
SN7417	0·43	0·40	0·38	SN7484	£1·00	0·95	0·90	SN74165	£2·25	£2·20	£2·15
SN7420	0·15	0·14	0·12	SN7485	£3·60	£3·50	£3·40	SN74166	£3·50	£3·25	£3·00
SN7422	0·50	0·48	0·45	SN7486	0·32	0·31	0·30	SN74174	£2·30	£2·20	£2·10
SN7423	0·50	0·48	0·45	SN7489	£5·50	£5·25	£5·00	SN74175	£1·60	£1·50	£1·40
SN7425	0·50	0·48	0·45	SN7490	0·67	0·64	0·58	SN74176	£2·50	£2·40	£2·30
SN7427	0·45	0·42	0·40	SN7491	£1·00	0·95	0·90	SN74177	£2·50	£2·40	£2·30
SN7428	0·70	0·65	0·60	SN7492	0·67	0·64	0·58	SN74180	£2·00	£1·60	£1·40
SN7430	0·15	0·14	0·12	SN7493	0·67	0·64	0·58	SN74181	£5·50	£5·00	£4·75
SN7432	0·45	0·42	0·40	SN7494	0·77	0·74	0·68	SN74182	£2·00	£1·80	£1·60
SN7433	0·80	0·75	0·70	SN7495	0·77	0·74	0·68	SN74184	£3·50	£3·25	£3·00
SN7437	0·64	0·62	0·60	SN7496	0·87	0·84	0·78	SN74190	£1·95	£1·90	£1·85
SN7438	0·64	0·62	0·60	SN74100	£1·65	£1·60	£1·55	SN74191	£1·90	£1·85	£1·80
SN7440	0·15	0·14	0·12	SN74104	0·97	0·94	0·88	SN74192	£1·95	£1·90	£1·85
SN7441	0·67	0·64	0·58	SN74105	0·97	0·94	0·88	SN74193	£2·00	£1·80	£1·75
SN7442	0·67	0·64	0·58	SN74107	0·40	0·38	0·36	SN74194	£2·70	£2·60	£2·50
SN7443	£1·30	£1·25	£1·20	SN74110	0·55	0·53	0·50	SN74195	£2·00	£1·90	£1·80
SN7444	£1·30	£1·25	£1·20	SN74111	£1·25	£1·15	£1·10	SN74196	£1·80	£1·70	£1·60
SN7445	£1·80	£1·77	£1·75	SN74118	£1·00	0·95	0·90	SN74197	£1·80	£1·70	£1·60
SN7446	0·97	0·94	0·88	SN74119	£1·35	£1·25	£1·10	SN74198	£5·50	£5·00	£4·50
SN7447	£1·00	0·97	0·95	SN74121	0·40	0·37	0·34	SN74199	£5·50	£5·00	£4·50
SN7448	£1·00	0·97	0·95	SN74122	£1·40	£1·30	£1·10				

The AL50 HI-FI AUDIO AMPL
50W pk 25w (RMS)

0·1% DISTORTION! HI-FI AUDIO AMPLIFIER

- Frequency Response 15Hz to 100,000—1dB.
- Load—3, 4, 8 or 16 ohms. ● Supply voltage 10-35 Volts.
- Distortion—better than 0·1% at 1kHz.
- Signal to noise ratio 80dB.
- Overall size 63 mm × 105 mm × 13 mm.

Tailor made to the most stringent specifications using top quality components and incorporating the latest solid state circuitry conceived to fill the need for all your A.F. amplification needs.
FULLY BUILT—TESTED—GUARANTEED.

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STABILISED POWER
MODULE SPM80 £3·25

AP80 is especially designed to power 2 of the AL50 Amplifiers, up to 15 watt (r.m.s.) per channel simultaneously. This module embodies the latest components and circuit techniques incorporating complete short circuit protection. With the addition of the Mains Transformer MT80, the unit will provide outputs of up to 1·5 amps at 35 volts. Size: 63 mm × 105 mm × 20 mm. These units enable you to build Audio Systems of the highest quality at a hitherto unobtainable price. Also ideal for many other applications including:—Disco Systems, Public Address, Intercom Units, etc. Handbook available, 10p.

TRANSFORMER BMT80 £2·15 p. & p. 25p

NUMERICAL INDICATOR TUBES

MODEL	CD66	GR116	3015F Minitron
Anode voltage (Vdc)	170min	175min	5
Cathode Current (mA)	2·3	14	8
Numerical Height (mm)	16	13	9
Tube Height (mm)	47	32	22
Tube Diameter (mm)	19	13	12 wide
I.C. Driver Rec.	BP41/14 141	BP41 or 141	BP47
PRICE EACH	£1·70	£1·55	£2·09

All indicators 0·9 + Decimal point. All side viewing. Full data for all types available on request.

STEREO PRE-AMPLIFIER TYPE PA100

Built to a specification and NOT a price, and yet still the greatest value on the market, the PA100 stereo pre-amplifier has been conceived from the latest circuit techniques. Designed for use with the AL50 power amplifier system, this quality made unit incorporates no less than eight silicon planar transistors, two of these are specially selected low noise NPN devices for use in the input stages.
Three switched stereo inputs, and rumble and scratch filters are features of the PA100, which also has a STEREO/MONO switch, volume, balance and continuously variable bass and treble controls.

SPECIFICATION:

Frequency response	20Hz—20kHz ±1dB	Bass control	±15dB at 20Hz
Harmonic distortion	better than 0·1%	Treble control	±15dB at 20kHz
Inputs: 1. Tape head	1·25mV into 50KΩ	Filters: Rumble (high pass)	100 Hz
2. Radio, Tuner	35mV into 50KΩ	Scratch (low pass)	8kHz
3. Magnetic P.U.	1·5mV into 50KΩ	Signal/noise ratio	better than +65dB
		Input overload	+26dB
		Supply	+35 volts at 20mA
		Dimensions	292 × 82 × 35 mm

All input voltages are for an output of 250mV.
Tape and P.U. inputs equalised to RIAA curve within ±1dB from 20Hz to 20kHz.

SPECIAL COMPLETE KIT COMPRISING 2 AL50's, 1 SPM80, 1 BMT80 & 1 PA100 ONLY £23.00 FREE p.&p

only £13·15

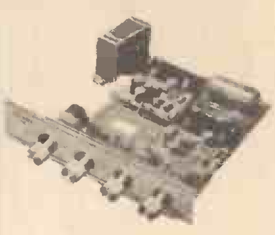
INTEGRATED CIRCUIT PAKS

Manufacturers "Fall Outs" which inclue Functional and Part-Functional Units. These are classed as 'out-of-spec' from the maker's very rigid specifications, but are ideal for learning about I.C's and experimental work.

Pak No. Contents	Price	Pak No. Contents	Price	Pak No. Contents	Price
UIC00=12±7400	0·50	UIC46=5×7446	0·50	UIC86=5×7486	0·50
UIC01=12×7401	0·50	UIC47=5×7447	0·50	UIC90=5×7490	0·50
UIC02=12×7402	0·50	UIC48=5×7448	0·50	UIC91=5×7491	0·50
UIC03=12×7403	0·50	UIC50=12×7450	0·50	UIC92=5×7492	0·50
UIC04=12×7404	0·50	UI351=12×7451	0·50	UIC93=5×7493	0·50
UIC05=12×7405	0·50	UIC53=12×7453	0·50	UIC94=5×7494	0·50
UIC06=8×7406	0·50	UIC54=12×7454	0·50	UIC95=5×7495	0·50
UIC07=8×7407	0·50	UIC60=12×7460	0·50	UIC96=5×7496	0·50
UIC10=12×7410	0·50	UIC70=8×7470	0·50	UIC100=5×74100	0·50
UIC13=8×7413	0·50	UIC72=8×7472	0·50	UIC121=5×74121	0·50
UIC20=12×7420	0·50	UIC73=8×7473	0·50	UIC141=5×74141	0·50
UIC30=12×7430	0·50	UIC74=8×7474	0·50	UIC151=5×74151	0·50
UIC40=12×7440	0·50	UIC75=8×7475	0·50	UIC154=5×74154	0·50
UIC41=5×7441	0·50	UIC76=8×7476	0·50	UIC193=5×74193	0·50
UIC42=5×7442	0·50	UIC80=5×7480	0·50	UIC199=5×74199	0·50
UIC43=5×7443	0·50	UIC81=5×7481	0·50		
UIC44=5×7444	0·50	UIC82=5×7482	0·50	UICX1=25 Assorted 74's	1·50
UIC45=5×7445	0·50	UIC83=5×7483	0·50		

Packs cannot be split, but 25 assorted pieces (our mix) is available as PAK UIC X1.

The STEREO 20



The 'Stereo 20' amplifier is mounted, ready wired and tested on a one-piece chassis measuring 20 cm × 14 cm × 5·5 cm This compact unit comes complete with on/off switch, volume control, balance, bass and treble controls. Attractively printed front panel and matching control knobs. The 'Stereo 20' has been designed to fit into most turntable plinths without interfering with the mechanism or, alternatively, into a separate cabinet.

Output power 20w peak	Input 1 (Cer.) 300mV into 1M
Freq. res. 25Hz-25kHz	Input 2 (Aux.) 4mV into 30K
Harmonic distortion typically 0·25% at 1 watt	Bass control ±12dB at 60Hz
	Treble con. ±14dB at 14kHz

£12·25 free p. & p.

NEW COMPONENT PAK BARGAINS

Pack No.	Qty.	Description	Price
C 1	250	Resistors mixed values approx. count by weight	0·50
C 2	200	Capacitors mixed values approx. count by weight	0·50
C 3	50	Precision Resistors 1%, mixed values	0·50
C 4	75	⅛th W Resistors mixed preferred values	0·50
C 5	5	Pieces assorted Ferrite Rods	0·50
C 6	2	Tuning Gangs, MW/LW/VHF	0·50
C 7	1	Pack Wire 50 metres assorted colours	0·50
C 8	10	Reed Switches	0·50
C 9	3	Micro Switches	0·50
C10	15	Assorted Pots & Pre-Sets	0·50
C11	5	Jack Sockets 3 × 3·5mm 2 × Standard Switch Types	0·50
C12	40	Paper Condensers preferred types mixed values	0·50
C13	20	Electrolytics Trans. types	0·50
C14	1	Pack assorted Hardware—Nuts/Bolts, Grommets etc.	0·50
C15	4	Mains Toggle Switches, 2 Amp D/P	0·50
C16	20	Assorted Tag Strips & Panels	0·50
C17	10	Assorted Control Knobs	0·50
C18	4	Rotary Wave Change Switches	0·50
C19	3	Relays 6—24V Operating	0·50
C20	4	Sheets Copper Laminate approx. 10" × 7"	0·50

Please add 10p post and packing on all component packs, plus a further 10p on pack Nos. C1, C2, C19, C20.

RTL MICROLOGIC CIRCUITS

	Price each 1–24	25–99	100 up
Epoxy TO-5 case uL900 Buffer	35p	33p	27p
uL914 Dual 2i/p gate	35p	33p	27p
uL923 J-K flip-flop	50p	47p	45p

Data and Circuits Booklet for IC's Price 7p.

DUAL-IN-LINE IC's. TWO Ranges PROFESSIONAL & NEW LOW COST.

PROF. TYPE No.	1–24	25–99	100 up.
TSO 14 pin type	30p	27p	25p
TSO 16 „ „	35p	32p	30p
LOW COST No.			
BPS 14	15p	13p	11p
BPS 16	16p	14p	12p

LINEAR I.C.'s—FULL SPEC.

Type No.	Price 1–24	25–99	100 up
BP 201C—SL201C	63p	53p	45p
BP 701C—SL701C	63p	50p	45p
BP 702C—SL702C	63p	50p	45p
BP 702—72702	53p	45p	40p
BP 709—72709	36p	34p	30p
BP 709P—μA709C	36p	34p	30p
BP 710—72710	44p	42p	40p
BP 711—μA711	45p	43p	40p
BP 741—72741	75p	60p	50p
μA703C—μA703C	28p	26p	24p
TAA 263—	70p	60p	55p
TAA 293—	90p	75p	70p
TAA 350	170p	158p	150p
S.G.S. EA1000 £2·63			

ROCK BOTTOM PRICES
LOGIC DTL 930 Series I.C's

Type No.	Price 1–24	25–99	100 up
BP930	12p	11p	10p
BP932	13p	12p	11p
BP933	13p	12p	11p
BP935	13p	12p	11p
BP936	13p	12p	11p
BP944	13p	12p	11p
BP945	25p	24p	22p
BP946	12p	11p	10p
BP948	25p	24p	22p
BP951	65p	60p	55p
BP962	12p	11p	10p
BP9093	40p	88p	35p
BP9094	40p	38p	35p
BP9097	40p	38p	35p
BP9099	40p	38p	35p

Devices may be mixed to qualify for quantity price. Larger quantity prices on application. (DTL 930 Series only).

SYSTEM 12 STEREO

Each Kit contains two Amplifier Modules, 3 watts RMS, two loudspeakers, 15 ohms, the pre-amplifier, transformer, power supply module, front panel and other accessories, as well as an illustrated stage-by-stage instruction booklet designed for the beginner. Further details available on request.

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SOLID ELECTROLYTE DEVICES

The name may sound uninteresting but these new components open up a vast new range of possibilities. Vivian Capel reports.

New developments in the field of semiconductors,leading in some cases to the appearance of completely new components is now becoming almost commonplace. Electtronic devices are now in everyday use which a few years ago were unheard of. Conventional components such as resistors and capacitors have also undergone development with new materials and manufacturing techniques, but the results have been far less spectacular.

One exception is the high-value capacitor which the makers, Gould Ionics of California, USA, used to call an *Energy Storage Device,* abbreviated to the initials ESD but now referred to as a *Solid Electrolyte Device.* Over the years we have seen an increase in the capacitance of electrolyte capacitors in common use from around 32μF, to 1,000μF and up to ten times that for certain modern equipment applications. These seem high values indeed, but they are dwarfed by the capacitance of the basic Solid Electrolyte Device which is 5 *Farads,* which if we express it in microfarads to show the magnitude compared with conventional capacitors is 5,000,000μF.

Lest one would naturally think that such a phenomenal capacitance needs a large bulk, the dimensions of the single cell is a disc, 1 inch in diameter by 1/3 inch high. The main drawback of the single cell is the operating voltage of 0.5V which is too low for most applications. With capacitances as high as this, it is possible to connect a number in series to increase the working voltage and still obtain capacitance values far higher than can be produced by other components. Packs of cells are therefore made to give operating voltages of 3.75V. The capacitance of the latter, which consists of 10 cells in series, is thus reduced.

PRINCIPLE OF OPERATION

The basic construction is a sandwich consisting of a carbon positive-electrode and a silver negative, with a solid electrolyte of rubidium-silver-iodide ($RbAg_4I_5$), which is highly conductive. Starting from the uncharged state, when a charging current is applied, there is a migration of positive silver ions from the immediate vicinity of the carbon electrode across the electrolyte toward the silver negative-electrode where they are deposited as silver metal.

The loss of these ions from the electrolyte that is in contact with the carbon electrode, produces a charge separation effect between the carbon and the electrolyte and a voltage difference appears. The property of capacitance depends on the close proximity of one conductor to the other as well as the area of proximation. The closer the conductors are, the higher the capacitance. This charge separation produces a spacing effect which is minute, being due only to the electrochemical action, with no interposing dielectric, solid or gas, as with conventional capacitors. It is this subnormal spacing that is responsible for the high capacitance. The silver electrode serves merely to attract the silver ions and does not form a separation

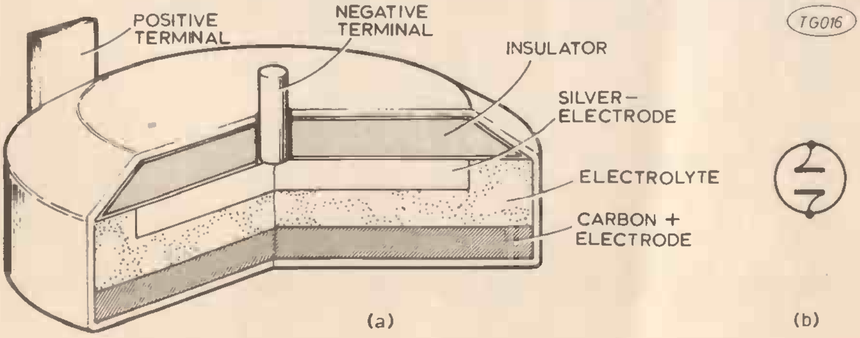


Fig. 1 (a) Cross-section showing construction of the Solid Electrolyte Device. (b) Circuit symbol layer or otherwise contribute to the capacitance of the cell. The charging voltage applied to each cell must not exceed 0.625V, but normal operation is up to 0.5V. Voltages in excess of these initiate chemical changes in the electrolyte and cause it to break down. This is what sets the voltage limit rather than any physical dimension as in the case of conventional-dielectric capacitors.

On discharging, the reverse process takes place; silver is given up by the positive electrode as the ions travel back through the electrolyte to restore equilibrium around the carbon electrode. The area of the carbon electrode determines the capacitance of the cell, and this is increased by giving it a rough surface.

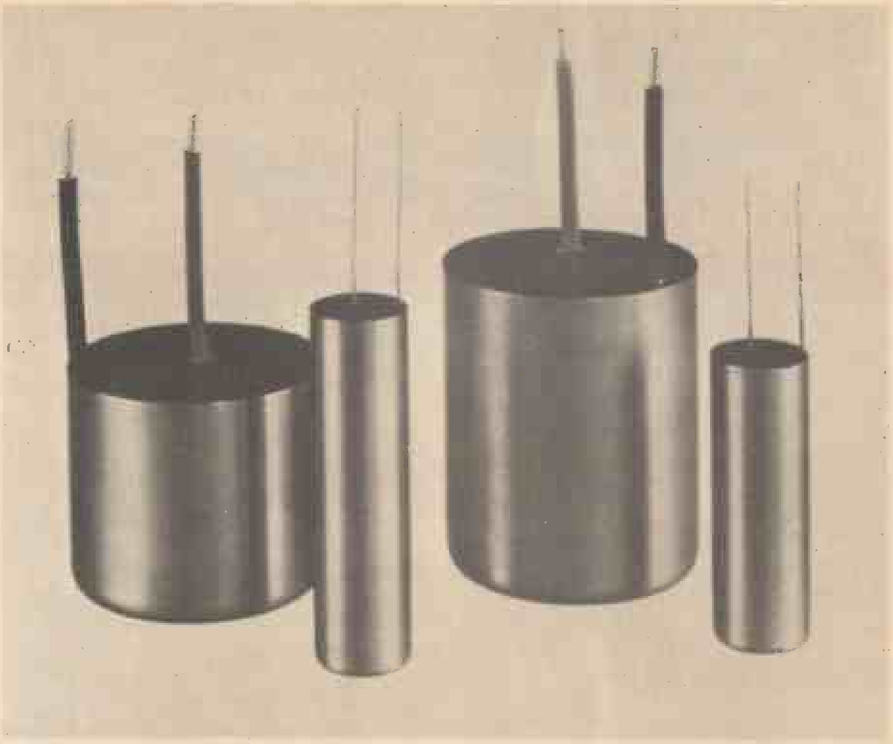
The capability of the cell to discharge its energy to an external circuit depends on the *Equivalent Series Resistance,* the value of which is quoted for each of the various types of cell. This is due to the area of the electrodes, a larger area giving a lower resistance. The single 1 inch diameter cell has an ESR of about 0.8 ohms, while the 10-in-series packs have a resistance of 8 ohms. The maximum charge and discharge rates are governed by this factor and they vary for different sized units. The smallest cells have a limit of 5mA, but the larger ones go as high as 50mA for normal operation and occasional higher currents being permittent for short durations.

LEAKAGE AND FAILURE

A special feature of the ESD is its very low leakage current. Resistance is around the value of 10,000 *Megohms,* which means leakage currents of only a few picoamps. Hence a charge can be held for a considerable period. One case is reported where the charge was found to be 97% of its original value 16 months after it was made!

Failure in conventional capacitors is usually due to the dielectric puncturing or deteriorating. As there is no such dielectric in the Solid Electrolyte Device, such a failure is theoretically not possible. The makers have claimed that they have no record of a single failure of any cell that has been operated within the prescribed limits, a zero failure-rate in fact. Even when overloaded by operating beyond the recommended values, the cells appear to be remarkably resilient and able to stand up to abuse. It seems that a considerable amount of energy is required to permanently damage an ESD.

A problem with some conventional capacitors, particularly those of the electrolytic type is the limited shelf life. If not used for a period, they can be found to be useless later. As the Solid Electrolyte Device is constructed of all solids, with no moist electrolyte to dry out or initiate corrosion, and the three solids are pressed together and sealed into the capsule, there is little to deteriorate. The makers estimate the shelf life to be well in excess of 10 years, although it has not been possible to prove this yet because of short time the devices have been available. During the development period of about six years, accelerated deterioration tests were made by cycles of extreme temperatures, but without ill effect.



Various versions of the Solid Electrolyte Devices

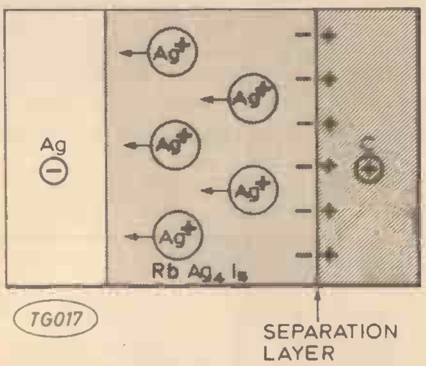


Fig. 2 (right) Positive silver ions migrate from the region of carbon and rubidium-silver-iodide electrolyte contact area toward the silver electrode, leaving a separation area of minute thickness across which the capacitance is produced.

APPLICATIONS

There are a considerable number of applications for these devices. As a high-value capacitor it can be used in timing circuits where a very long timing cycle is required. An additional feature for this application is that, unlike ordinary capacitors where the voltage increase across the component as it charges is not perfectly linear, the voltage/time curve is in fact linear. This being so, time can be measured as precisely as the voltage can be indicated. The device time relationships can be repeated many times over with an accuracy of better than 0.1%.

The low leakage currents combine with the high capacitance to make very long timing periods possible, up to a month or more being perfectly feasible. Generators with very low repetition frequencies can be designed to produce sawtooth or squarewave waveforms as desired. An example of such a generator is given in Fig. 3, which uses an IC operational amplifier plus a few extra components.

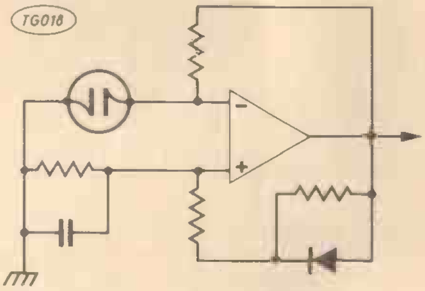


Fig. 3. Circuit of multivibrator for long timing cycles using the device with an operational IC amplifier.

One of the drawbacks with many subminiature electronic assemblies is the need to provide adequate decoupling. This involves high capacitance values, which with conventional capacitors has hitherto meant a fair amount of bulk. Thus we often have devices where the decoupling components take up a major share of the total space. The Solid Electrolyte Device could well see an end to this situation by providing decoupling without bulk. While decoupling capacitances of the order of several farads would not be required for the majority of applications, smaller capacitance version can be made with correspondingly smaller size. For example, one has been made with a conventional value of 500μF, but this was housed in a capsule only 0.032 inches in diameter and 0.02 inches high. While this was just a single cell with the usual voltage limitation of 0.5V operation, a pack of 10 to give 50μF at 5V working could still be accommodated in a device of the same diameter and 0.2 inches high, which is still far smaller than can be obtained with other types of capacitor.

COMPUTER APPLICATIONS

Its applications in computers for various purposes will be readily appreciated. For a digital memory unit, a small cell with a long charge-holding capability is eminently suitable. It can be used to store information in the logic binary code where the charged state represents 1 and the discharged state represents 0.

There are many circuits where momentary loss of power, even for a short period could prove very inconvenient, resulting in loss of information, switching data, and other problems. It is here that the Solid Electrolyte Device takes on its other application, that of energy storage. It can be permanently connected into circuits of a critical nature, where a standby supply would be very welcome. A storage capacity of 2.5mA-hours is quoted for some of the powerpack units, so with a moderate drain, a useful standby supply is ensured for all short-term power interruptions. The circuit for maintaining the standby power is quite simple and shown in the illustration. The Solid Electrolyte Device is connected directly across the load supply line, and a rectifier is included in series with the power supply to prevent it discharging back through the power circuits in the event of failure. As a bonus, the presence of

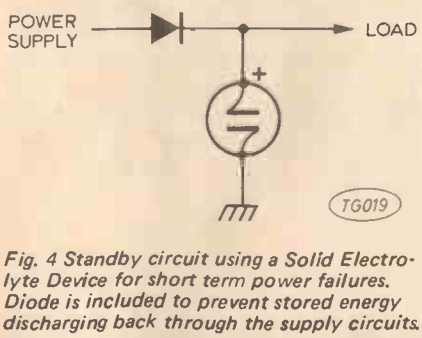


Fig. 4 Standby circuit using a Solid Electrolyte Device for short term power failures. Diode is included to prevent stored energy discharging back through the supply circuits.

the Solid Electrolyte Device will give a measure of voltage stabilisation to the circuit.

A further energy-storage use is to acquire energy from a low-output source over a long time period to make it available for shorter, high-current requirements. This is rendered possible by reason of the low leakage-current. Such currents in conventional high-value capacitors would dissipate all the energy from any low-output source before a usable quantity had a chance to accumulate. Examples of suitable low-output sources are: thermocouples, solar cells, and light generators. A light or heat operated personal radio is one possibility, or light-powered warning devices independent of battery or power supplies hence virtually maintenance-free, yet ready for use after protracted periods of inactivity, is another.

An application which is the converse of the above, is one where it is necessary to absorb large amounts of energy in a relatively short space of time to make it available for long low-current applications. As the Solid Electrolyte is capable of taking a fast charge, it is also well suited to this type of use.

As noted at the beginning of this article the normal operating voltage is 0.5V maximum per individual cell, and the linear portion of the charging curve extends only to this point. At just over this voltage, decomposition of the electrolyte starts, and this is accelerated by any further voltage rise until 0.66V where decomposition is rapid, and no further voltage rise can be obtained. However, the voltage can be taken up to 0.625V safely and the decomposition up to this point is reversible. In the initial stages of decomposition, that is between 0.5V and 0.625V, the capacitance of the cell is greatly increased.

Reference to the illustration where the characteristic of voltage across the cell is plotted against time shows how this occurs. As can be observed, the linear portion as previously stated ends at just over 0.5V, and above this the curve flattens out considerably. It follows from this that the time taken to reach 0.625V from 0.5V is much greater than that taken to bring the cell up to 0.5V from zero. As the charging current remains constant throughout the period, the quantity of energy in coulombs (time x current) that is stored is correspondingly greater than that stored in the earlier portion of the characteristic.

In actual practice, the energy stored is increased by some ten times by using this part of the cell's characteristic, which can be very useful. Of course if linear charging is needed as for timing and measuring applications, this portion would be unsuitable, but for straightforward energy storage, linearity

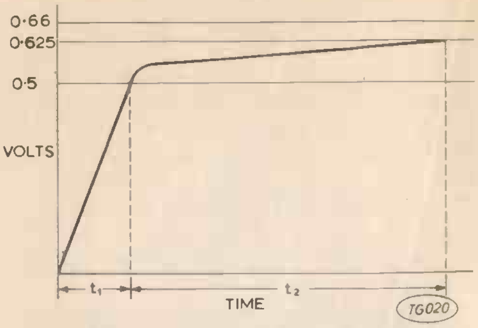


Fig. 5 Charging characteristic, time plotted against voltage. Linear portion up to 0.5V is used for timing and similar applications, for storage purposes 10 times more energy can be stored if the voltage is taken up to 0.625V, due to longer charging time above 0.5V.

is of little importance. The extra capacity available by using non-linear portion can be utilised in one of two ways. Either more energy can be stored, or the size of the cell can be reduced to obtain the same storage capacity.

USES WITH I.C's

We have mentioned before the anomaly of designing sub-miniature assemblies containing a large number of amplifying or other active circuit elements in a small space, yet having to use relatively large high-value decoupling capacitors. Solid Electrolyte Devices now provide the answer to this problem, but there is another application where even the normal-sized pack could be too large, and that is when used in conjunction with integrated circuits. The peripheral components used for I.C. circuits are always rather a nuisance because they impose a limit on the size of the equipment which otherwise could be much smaller.

Experiments by the makers would appear to herald an end to this problem. They have tried to deposit Solid Electrolyte Devices directly onto an I.C. substrate, and have been successful. Because of the inherent reliability of the devices, the overall failure risk of the chip would be virtually unimpaired by the inclusion of such capacitors, and because of the very small size of the cell elements needed to produce conventional capacitances, the chip size would be little affected. Thus truly sub-miniature equipment is now a possibility.

At present these devices are only used in professional and some top secret military circuits and are not available to the general public.

Prices for one-off units range from £39.90 for a device acting as a primary battery (3.6V, 250mA/hours) down to £3.40 for a 0.01F (10,000 F) device. The reason for not supplying the hobby market is due to the considerable degree of backup information that is necessary regarding circuit design and usage. ●

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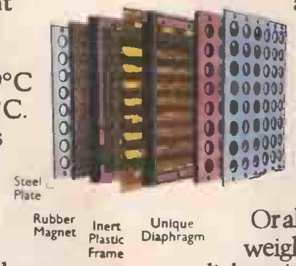

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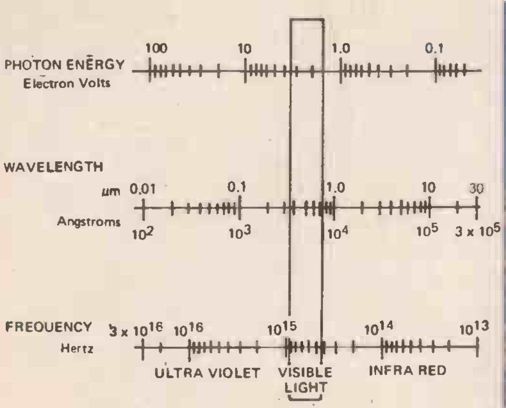
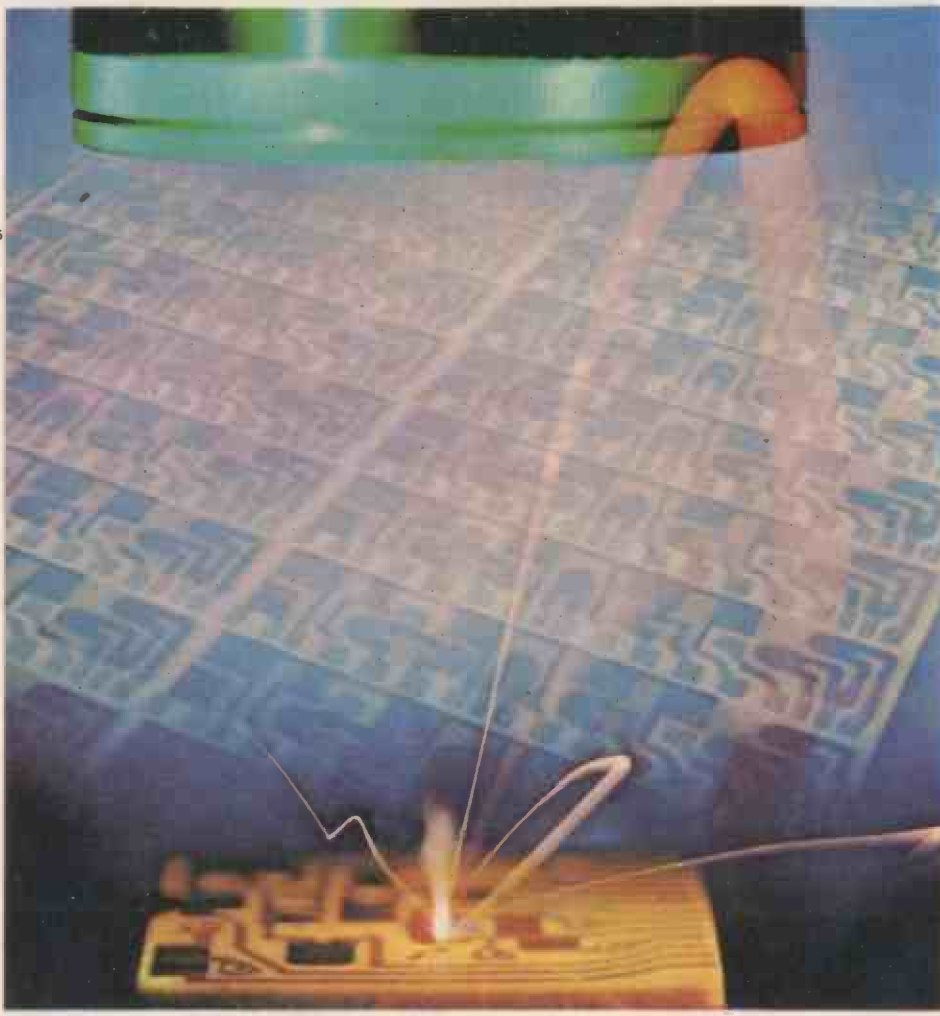


Fig. 1. Comparison of units used for electromagnetic radiation at optical frequencies. For example an energy change of 10 electron volts (ie $V = 10^{-19}$joules) produces radiation at 0.1 μmetres or 1000 angstrom, which is equivalent to a frequency of 2×10^{15} Hertz. Another SI preferred unit of wavelength is the nanometre = 1000 micrometres.



In the fabrication of multi-layer printed circuits, N/C machine tools with SINUMERIK controls adjust the resistances. The circuits are located on a co-ordinate table which is moved under a CO_2 laser beam by pulse motors. The resistance is varied by cutting into the layers until the desired value is obtained. The laser beam subsequently divides the substrate up into the individual modules.

LASERS

What they are, and how they work
Brian Chapman explains

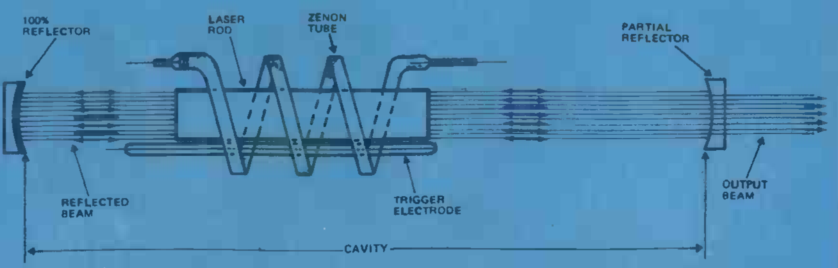


Fig. 2. In the ruby laser, as first developed by Theodore Maiman, pump light from a Xenon lamp raises the energy level of chromium atoms in a ruby rod until a pulse of coherent red light emerges from the partial reflector.

IN 1960 Theodore Maiman, then a scientist with Hughes Aircraft Corporation, successfully produced a beam of pure, red light by electronic means. Whilst the production of light in itself is not remarkable, the characteristics of the light produced by this new technique are remarkable indeed. The light is of a single frequency, the beam is coherent, in phase and very nearly parallel.

The new technique is yet another development based on quantum theory, the principles of which were first expounded by Einstein in 1917. The first application of these principles was the MASER – developed in 1954 by C. H. Townes and his students. (The word Maser is short for Microwave Amplification by the Stimulated Emission of Radiation.) The MASER operates, as the name implies, at microwave frequencies and makes low noise amplification possible at extremely high frequencies. The first MASER operated at 23 870 MHz but was of limited use as an amplifier as it could not be tuned. Nowadays tunable MASERs have been developed for

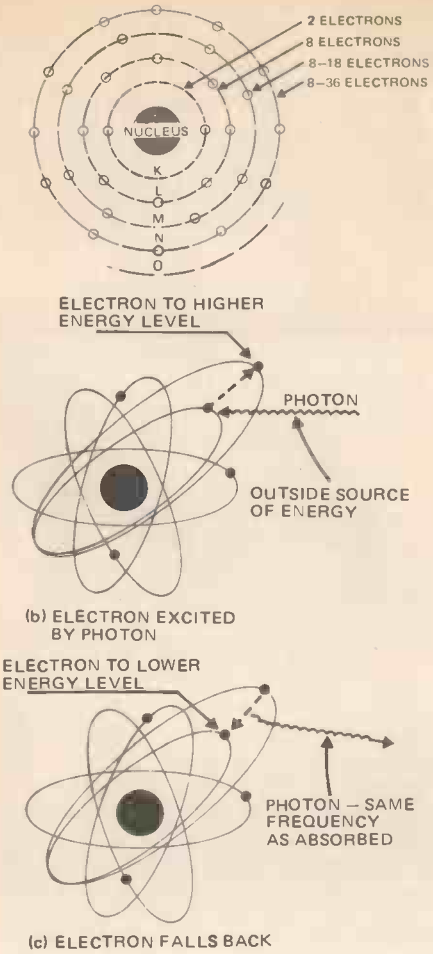


Fig. 3. (a) Simplified diagram (not typical of any particular element) of orbital levels of an atom. These levels are known as shells and are the only possible orbits.
(b) A photon of correct frequency will cause an electron to move to a higher shell.
(c) When the electron falls back to its original level in one jump it emits a photon of the same frequency as that which caused the initial excitation.

operation anywhere in the range 1-100GHz (1GHz = 10^9 Hz).

The extension of MASER action to the even higher optical frequency region was first achieved by Maiman who effected pulsed MASER action at 400 Tera Hertz (4×10^{14} Hz), i.e. a wavelength of 6943 Angstroms in a ruby rod pumped by a Xenon flash lamp. (Fig. 2). This new device was at first called an optical MASER but later this was changed to LASER (L for light).

The term LASER is somewhat of a misnomer as the majority of devices in use are oscillators not amplifiers. Hence at one stage LOSER was proposed as a name but this was soon dropped as it was thought no-one would invest money on a LOSER!

To understand LASER action it is necessary to review atomic theory to some extent. All other electronic systems make use of the energy of free electrons in the atomic system. Lasers, on the other hand, use processes within the atom itself to produce coherent radiation.

Figure 3 shows the now well known structure of the atom. This consists of a central nucleus orbited by one or more electrons. The complexity of the nucleus and the number of orbital electrons is unique to particular elements. The electron orbital paths are confined to discrete levels or shells (Fig. 3a), each shell corresponding to an energy level. An electron cannot exist in a stable state between shells and if subject to radiation that increases its energy it will jump to the next highest shell. The quantity of electromagnetic radiation necessary to just cause an electron to move to a higher shell is called a photon. Photons can be thought of as minute packets of energy which have the characteristics of both matter and electromagnetic radiation.

THE PHOTON

The photon is a fundamental concept in the quantum theory and the relationship of the photon frequency and the energy level to which the atomic system is raised is given by the equation:

$$E = h\nu$$

where

E= Energy level in ergs

h= Planck's constant (6.624×10^{-27} erg-sec)

v= Frequency of the photon

A photon *of the right frequency* is therefore required to raise an electron of a particular atomic system to a higher energy level. When an atom is in its lowest energy state it is said to be in the ground state and when its energy has been increased by a photon it is said to be in an excited state.

From the excited state, a number of possibilities exist for the return to ground state. Firstly the electron may fall to an intermediate level and then to the ground state. A photon will be emitted at *each* transition having a *lower* frequency than the incident photon (because each energy level jump is smaller) or alternatively it may jump straight to ground state and emit a photon of the same frequency as the incident radiation. These mechanisms are known as SPONTANEOUS PHOTON EMISSION and normally occur very rapidly (less than a microsecond after excitation).

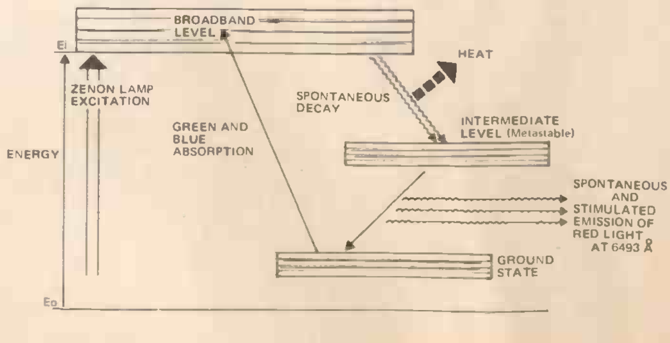
Siemen's stage laser as first used in a production of Mozart's "Magic Flute" in Munich's National Theatre (July 1970). Abstract light formations which turn and twist, flow apart and reconverge, take on new shapes, grow lighter and darker in innumerable shades are produced by laser interference patterns. One of the light forms, normally in colour, can be seen at the top of the photograph.

If a photon of the correct frequency is incident upon an atom already in the excited state, it will emit a photon having exactly the *same phase as the first photon, and travelling in the same direction.* This mechanism is known as STIMULATED EMISSION.

THE RUBY LASER

The original laser as built by Ted Maiman nowadays appears ridiculously simple. It consists of a ruby rod containing about 0.05% chromium (the chromium component gives the ruby its characteristic pinkish colour). The rod is surrounded by a Xenon flash lamp, as shown in Fig. 2. The purpose of the flash lamp is to provide excitation, called pumping, at 5600

Fig. 4. Energy level diagram for the ruby laser. The energy from the Xenon lamp takes the chromium atoms to the E_i level. They then decay in two steps back to ground state. The second transition provides coherent emission when population inversion has been achieved.



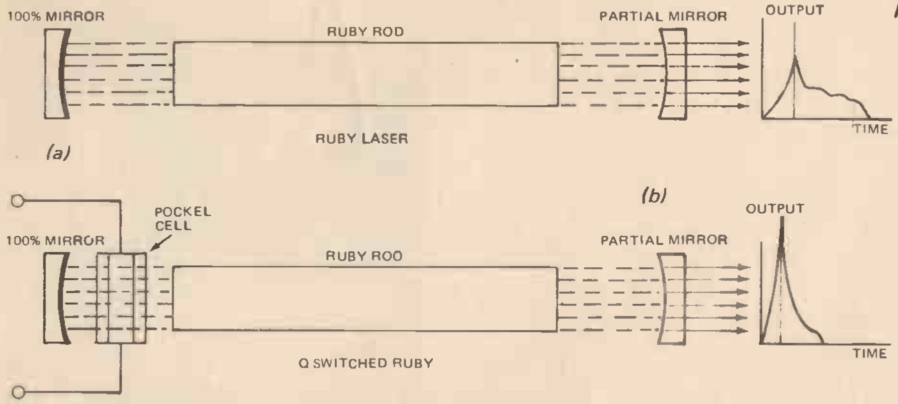


Fig. 5. The "Q" switching technique prevents emission of laser pulses until higher population levels have been achieved. (a) shows conventional ruby laser and its typical output pulse shape. (b) shows method of inserting Pockel cell and the resulting increased peak power of the pulse.

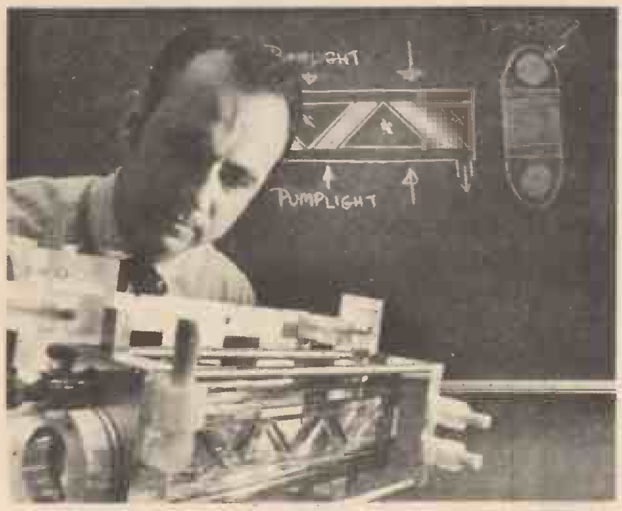


Fig. 6. The General Electric "Zig Zag" laser has eight slabs of neodymium doped glass arranged at the Brewster angle (57^o). This technique eliminates beam non-uniformity and allows very high-power, high-repetion-rate pulses to be generated.

angstrom (blue green light) to which the chromium atoms respond.

The chromium atoms, once excited, will spontaneously return to ground state in two steps, as shown in Fig. 4. They first return to an intermediate level, known as the metastable state, with the emission of heat, and then to ground state with the emission of red light at 6943 angstrom.

At this point the ruby rod will glow with red light. The flash lamp continues to pump energy to the chromium atoms pushing more of them to upper energy levels until, *there are more atoms at the higher energy level than at the lower.* This is known as population inversion and at this point the operation suddenly changes. Now photons begin to interact with excited chromium atoms to a significant extent, with a resultant stimulated emission of other *identical* photons which travel in the same direction as the incident photons.

The ruby rod, which is several centimetres long and half a centimetre in diameter, will have some photons travelling parallel to its axis, and these will be reflected at the ends back into the crystal where they produce still more photons. Those travelling in other directions emerge from the sides and are lost. The build up of photons parallel to the rod continues until, at a critical point, some of the coherent radiation bursts out through the partially reflective end face. Thus, a laser pulse is born. The pumping process continues generating further pulses of coherent red light each having a duration of about one or two milliseconds.

Although such action is possible with a simple ruby rod having both ends polished and perfectly parallel to each other, it is far better to use external mirrors to do the reflection. These are specially constructed multilayer (dichroic) mirrors such that they reflect the frequency of interest with high efficiency. One of them is made partially transmissive to allow the laser pulse to emerge. For the laser to operate at maximum efficiency it is desirable to get as much light as possible into the ruby rod. For this reason the flash lamp is wound around the ruby in a helix.

Since Maiman's first laser began pulsing, some 13 years ago, enormous strides have been taken in the development of laser technology. Many new lasing techniques have been developed and both peak and average power have been increased to staggering levels. Average power of 100kW and a peak power of 10^{14} watts have been obtained in laboratory experiments, according to recent reports. And even these levels may well have been exceeded at the time of writing. Space does not allow a coverage of all types in detail but the following survey describes the major types currently in use or under development.

Before passing on to the survey of the different types of laser, we should mention two methods of increasing the peak pulse-output power. The first method, known as *"Q" switching* or "Q" *spoiling,* is achieved by interrupting the optical cavity, thus reducing losses due to lasing until a much higher population inversion is achieved, typically 70 to 80%. The Q switch then suddenly restores the normal cavity and a much more powerful and shorter pulse than usual is achieved.

The device used to interrupt the cavity is usually a Pockel cell. This cell is a crystal of ammonium or potassium dihydrogen phosphate cemented between two crossed sheets of polarizing material. Due to the cross polarization, light cannot normally be transmitted through the cell. The Pockel cell is inserted in the laser cavity, as shown in Fig. 5b.

When an electric field is applied to the crystal it rotates the plane of polarization of the incident light by 90^o allowing it to pass through the cell. The "Q" of the lasing cavity is now suddenly increased and a very short, high peak-power pulse is produced.

The GIANT PULSE technique, although very similar, uses a cell containing a solution of any one of several metal-organic compounds known as phthalocyanines in place of the Pockel cell. The solution strongly absorbs red light and prevents laser action until a higher population inversion is achieved — just as for "Q" spoiling.

As the energy emitted by the ruby increases, the absorbing solution suddenly becomes perfectly transparent, and all the energy is emitted as a giant pulse. The cell then returns to its absorbent state until the ruby energy again rises to the critical point.

THE LASER FAMILY

The ruby laser belongs to a general class of lasers known as SOLID STATE (not to be confused with semiconductor lasers). These lasers are characterized by a crystalline or glass

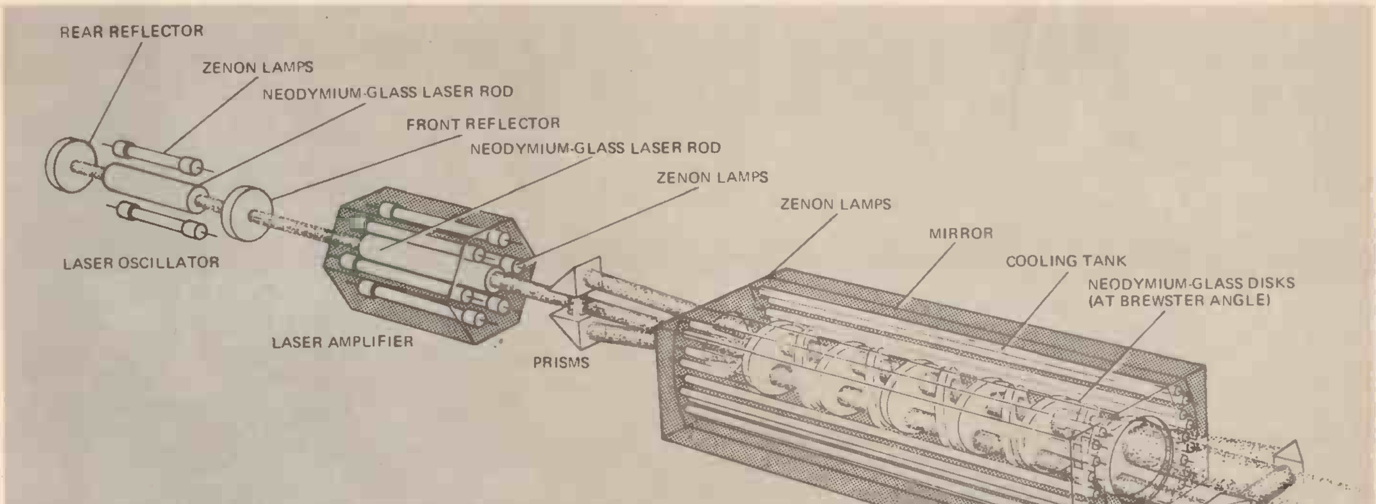


Fig. 7. A three stage system such as is required to provide the enormous peak powers required for the generation of power by atomic fusion. Current systems provide focused power densities of 10^{17} watts per square centimetre.

base material in rod form containing up to 2% of another impurity material which produces the laser action.

Ruby — Chromium doped aluminium oxide.

Nd:Yag — Neodymium doped Yttrium Aluminium Garnet.

Nd:Glass — Neodymium-doped glass.

Yalo — $YACO_3$ Yttrium Aluminium Oxide.

Nd:$CaWO_4$ — Neodymium-doped Calcium Tungstate.

Other dopants such as dysprosium and uranium have been used together with base crystals of yttrium gallium and gandolinium gallium.

Pumping limitations due to characteristics of Xenon lamps, and heat dissipation problems limited available output power and prevented continuous operation in early solid state lasers. In fact it was not until 1962 that a CW laser was constructed with neodymium doped calcium tungstate at Bell Telephone Laboratories. This was followed in 1964 by the Neodymium YAG laser which operates at 10.6μM (infra red). Nowadays there are many Nd:YAG lasers available commercially and one model from Holobean Inc., is capable of 1100 watts CW.

General Electric has developed what is known as a 'zigzag' laser. In the original prototype, eight neodymium-doped slabs are arranged in a zigzag pattern at the Brewster angle (approx. 57°). The assembly is cooled and is optically pumped by flashlamps (Fig. 6). The beam of a smaller laser is passed through the zigzag where it undergoes amplification thus producing an output of 30 nanosecond wide, 50-80 joule pulses. Although this power output is not tremendous, the technique is expected to provide average power levels of 100kW and a peak pulsed output of the order of 100GW (100 000 megawatt) in scaled up versions.

The technique of using one laser to amplify the output of another is commonly used to achieve higher output powers (see Fig. 7). Additionally some unusual pumping techniques have been used in an effort to further increase power. One method, devised by RCA in 1962, used a 12 inch hemispherical mirror to

Cloth being cut at high speed to complex patterns by a computer controlled laser beam.

Fig. 8. Construction of a typical helium-neon laser. The gas mixture is contained in a glass tube and is excited by RF at 28 MHz or by a high voltage dc supply.

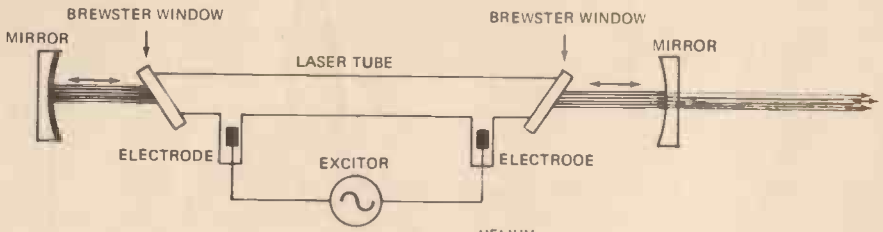
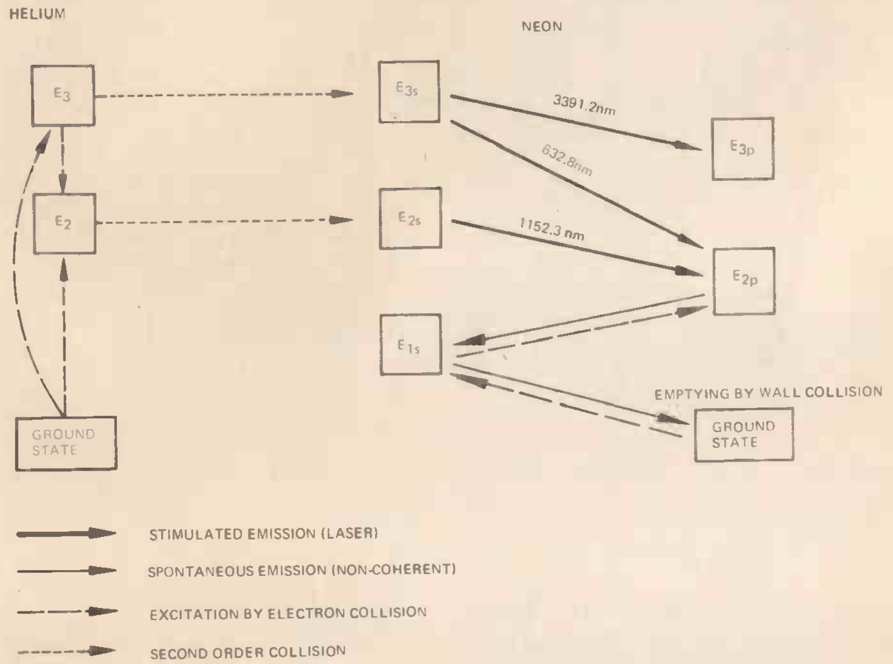


Fig. 9. Energy level diagram of helium-neon laser.



focus sunlight onto a laser crystal of calcium fluoride immersed in a bath of liquid neon. The laser produced a continuous output of 50 watts at 2.36 microns directly from solar energy and is thus particularly suited for satellite communication applications. This was the first device, ever, to use sun power direct without conversion to another form of energy, such as heat or electricity.

Another method of eliminating electrical power supplies is to use what is known as chemical pumping. In this method a chemical reaction or explosion is used to generate light in a flash tube which then drives the laser in the conventional manner. A typical light-producing reaction is that of aluminium and sodium perchlorate. In the explosion method the shock wave generated by a charge is made to travel through an argon filled box which has three sides silvered and one transparent. The resultant compression of the argon gas causes it to emit intense radiation in the ultraviolet region. This is then focused onto the laser rod.

A further method is to pass gas at high speed over aerodynamic surfaces which produce shock waves in the gas and hence population inversion.

The lower power applications of solid state lasers include optical ranging, materials processing (IC resistor trimming), microwelding and microdrilling. High power applications include satellite tracking, metal cutting and other stringent materials processing requirements. One very important area of application is in the heating of plasma for fusion reactions. Experiments have indicated that fusion reactions can be initiated and to some extent controlled *without a confining magnetic field* by focusing a powerful laser pulse onto a pellet of thermonuclear fuel. The pellet temperature must be raised to the vicinity of 80 million degrees Celsius for fusion to take place. Pilot plants have already shown encouraging results and the economics of the process are good.

GAS LASERS

Gas lasers may be subdivided into three categories:

(1) Neutral (atomic) gas
(2) Ionized gas
(3) Molecular gas

The neutral gas lasers, sometimes called atomic noble gas lasers may use helium, neon, argon, krypton or zenon. The most common laser is that using helium and neon. Indeed, it is the most prolific of all laser types.

The first helium-neon laser contained a mixture of 90% neon and 10% helium at a pressure of 1 to 2 millimetres of mercury in a quartz tube approximately 80 cm long and 1.5 cm in diameter. It emitted radiation at five coherent infrared frequencies, the strongest of which was at 11 530 angstroms. This laser was constructed at Bell laboratories in 1961. Helium-neon lasers have since been constructed to operate at two other prime wavelengths 6328 angstrom (red) and 3.39μm (infra red) Outputs range from 0.01 mW to one watt.

The operation of the helium-neon laser may be understood with reference to Figs. 8 and 9. The main difference between solid-state and gas lasers is the way the latter are pumped. In the gas laser an electric discharge is produced, within the tube, either by an RF generator (at typically 28 MHz) or, by a high voltage dc supply. Helium electrons and ions are accelerated between the electrodes and the faster moving electrons collide with other atoms and ions of neon increasing their energy to level E_3 as in Fig. 9. After colliding with the neon atoms the helium atoms fall back to

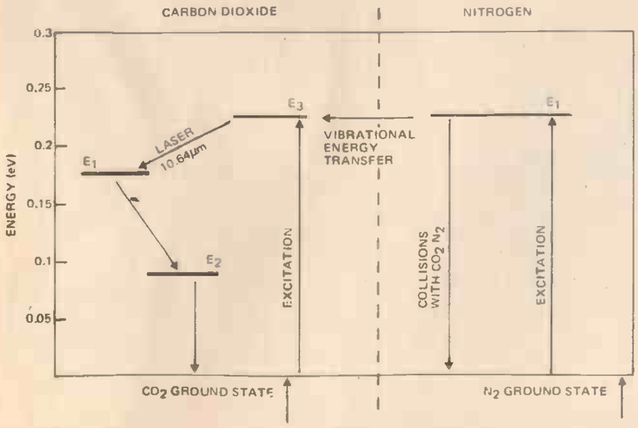


Fig. 10. Energy levels of a CO_2 laser.

ground state — having imparted all their energy to the neon. The neon atoms then fall to the metastable level E_2 emitting photons of coherent radiation. The other falls, from E_2 to E_1, and E_1 to ground state, produce incoherent radiation which is visible as the characteristic red glow of neon.

Since the level E_2 has ten possible energy levels very close together there are many different transitions possible and helium-neon lasers therefore have a wide line spectrum (several frequencies generated simultaneously in a narrow band). However since gas lasers as a whole can be made very frequency stable they are the most monochromatic light sources available.

Gas lasers have been constructed using 29 different neutral elements and have produced radiation at more than 450 frequencies within the waveband 0.41μm to 216.3μm.

ION LASERS differ from neutral gas lasers mainly in design and operating procedure, the emission being due to a drop between two energy levels of an ion rather than a whole atom. The most commonly used gas is argon with neon, krypton and zenon also being used. Outputs of an argon-ion laser may be in the region of tens of watts but the efficiency is very low — of the order of 0.001%. The most important emission being argon-ion lasers occur at 4880 angstrom (blue) and 5145 angstrom (green).

The most outstanding example of a MOLECULAR LASER is the CO_2 laser which currently provides the highest available CW power. Emission is in two groups of oscillation at 9.6 and 10.6μm. Maximum theoretical efficiency is 40% and efficiencies of from 10 to 33% have been obtained in commercial lasers.

Improved power output and efficiency may be obtained from CO_2 lasers by the inclusion of small quantities of nitrogen and helium. The energy level of a CO_2/nitrogen laser is shown in Fig. 10. In operation the nitrogen and CO_2 are both excited by an electric discharge. The E_1 level of nitrogen corresponds very closely to the upper laser level of the CO_2 and a rapid interchange of energy between the two takes place. The nitrogen thus provides additional excitation to that already given to the CO_2 by the discharge. The lower laser level E decays to ground via E_2 and, as E_2 lies very close to the ground state, it is possible for this level to be populated due to heat. The helium is present because it has a high thermal conductivity and thus helps to cool the gas. But further cooling may be necessary to prevent population of the E_2 level which would limit power output and decrease efficiency.

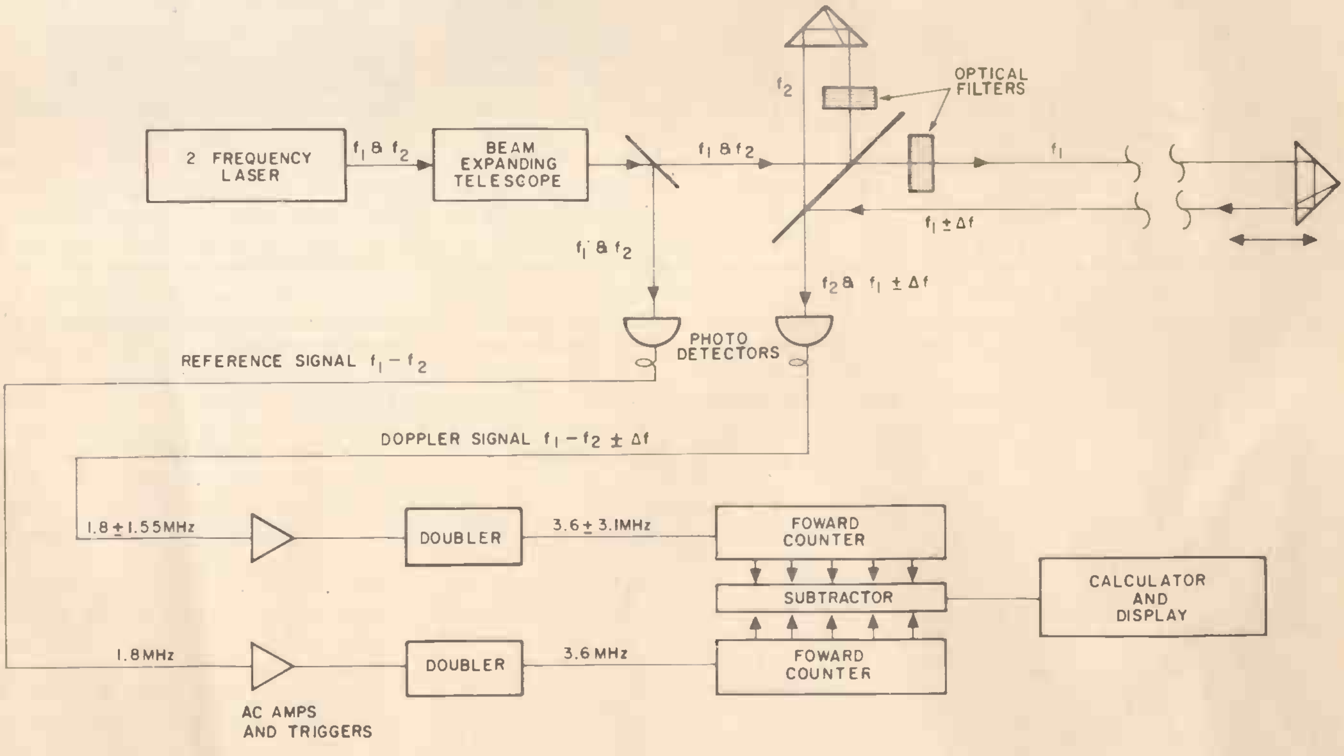
Conduction cooling is limited by the thermal conductivity of the gas mixture and to increase power output it is therefore necessary to remove the waste energy of the laser by flowing the gas through the tube. The structure of a conventional electrically excited CO_2 laser is shown in Fig. 11. The output, which is independent of tube diameter within the range 1.5 to 5cms, is proportional to length, and is about 70 watts per metre for lengths up to 10 metres. Above 10 metres the output falls to about 40 watts per metre. Obviously a 200 metre long laser would be somewhat impractical so the tubes are usually folded, using mirrors to bend the optical path. A commercial laser using this technique has five tubes, each 2.6 metres long, and produces 500 watts of continuous power.

Still higher powers may be achieved by increasing CO_2 pressure and flow. The flow characteristics may be improved by passing the gas through the laser transversely, as shown in Fig. 12. This results in better efficiency at low flow rates.

Much work is also underway on chemically excited gas lasers, where a chemical reaction supplies the energy required to achieve population inversion. No external energy source is required with a chemical laser, apart from pump power to achieve the fast gas-flow rates required. The main disadvantage is that the gases are corrosive, expensive and non-recyclible.

SEMICONDUCTOR LASERS

The semiconductor laser (also known as the injection laser) promises to be of great importance in the field of optical communications. Other lasers



An important application of helium-neon lasers is in distance and velocity measurements by interferometric techniques. This system, the Hewlett Packard model 5525A is capable measuring length with an accuracy of ±0.000 001 inch over 200 feet.

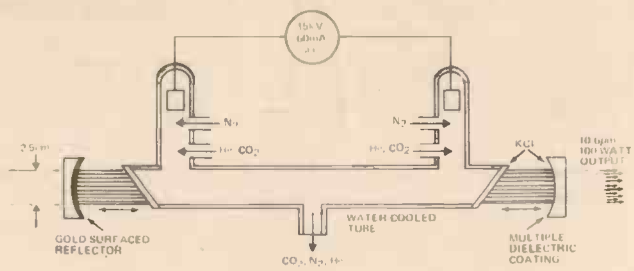


Fig. 11. Typical 100 watt CO_2 laser removes heat by flowing gases through the laser tube.

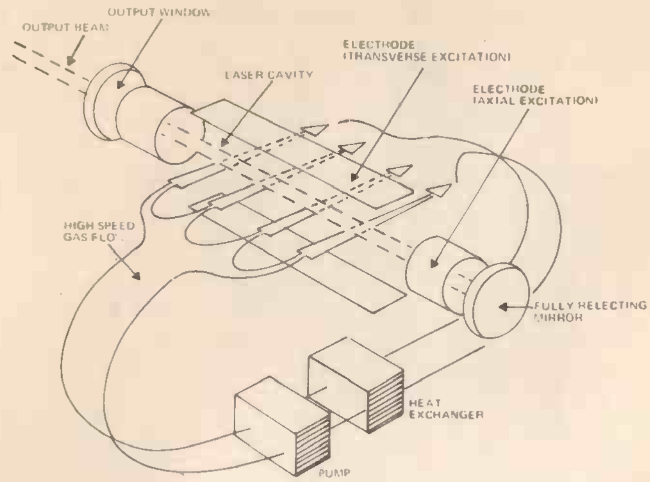


Fig. 12. Transverse gas flow reduces gas transit time and allows higher efficiency at low flow rates.

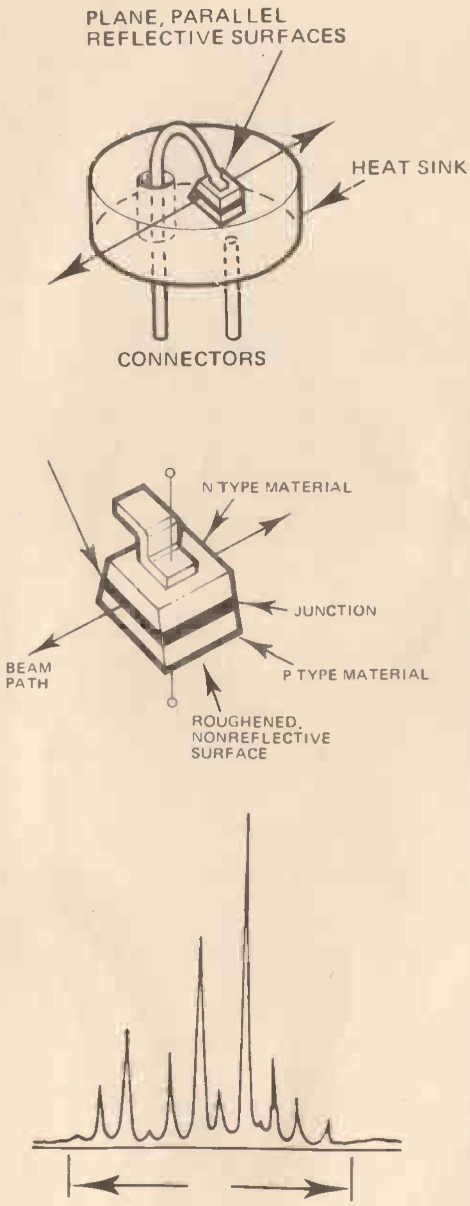


Fig. 13. Typical semiconductor laser
(a) The laser diode mounted on its heat sink
(b) Detail of the laser diode structure
(c) Output is composed of many narrow spikes

are not readily modulated at optical frequencies but semiconductor lasers are — quite easily — and over very large bandwidths. Power outputs are not high (about 1 watt with gallium arsenide) but efficiencies are the highest obtainable (between 40 and 70 percent) and materials are available which lase over a greater wavelength range than with any other type. In fact the wavelength coverage is from 0.33 micrometres (ZnO) to 31.2 micrometres (PbSnSe).

The gallium arsenide laser is one of the most commonly used types and consists of a semiconductor diode having "N" type (GaAs doped with tellurium) and "P" type (GaAs doped with zinc) layers as in conventional diode. When a forward bias is applied to the diode a large number of electrons and holes are forced towards a very narrow region (about 1/10 000 inch thick) on the "p" side of the junction known as the active region. The holes and electrons recombine in this region with each recombination giving rise to the emission of a photon in the 8400 and 8500 angstrom region. These photons in turn stimulate the emission of more photons which are in the same direction and have the same phase as the first. Coherent radiation is therefore produced in a plane parallel to the junction.

The first semiconductor lasers had to be operated at cryogenic temperatures. That is, they operated immersed in liquid helium, hydrogen or nitrogen which removes heat very rapidly from the crystal. Operation at room temperatures in CW mode has now been obtained by improved construction methods.

As it is small, light weight and of greater efficiency than any other laser, the injection laser is ideally suited to space communication systems and terrestrial short-distance communications. It could also be used in computers to transmit enormous quantites of data at super speed between sub-assemblies. It has even been suggested that semi-conductor lasers may be integrated into large scale microcircuits as communication links within the chip. (For example in extra large scale integration of CMOS on spinel).

The main disadvantages of injection lasers are their low power output and wide beamwidth of a few degrees. This is a disadvantage in many applications as the received power intensity falls off very rapidly with increased beamwidth.

LIQUID LASERS

Liquid lasers are inexpensive and have characteristics similar to solid state lasers. Higher average powers are possible than with the solid state type, but liquid expansion with heat is a severe problem which must be allowed for.

There are two main types — the rare-earth chelate laser and the organic dye laser. The dye laser has the particular advantage of tunability within the visible spectrum and either CW or pulsed capability.

The coverage presented here is of the main types only. There are many others either available commercially or at an advanced experimental stage which we have been unable to cover in a necessarily brief article such as this.

Sufficient to say that lasers will have a profound impact on the technology of the future. At one time it was said that lasers were an interesting phenomenon awaiting application. This of course is no longer true as lasers have found countless applications in industry, medicine and as tools for fundamental physical research. It is still true to say however that laser technology is in its very early infancy and it is therefore impossible to forsee the marvels due to laser applications of the future. ●

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AC 156	0·20	BC 207	0·10	BSY 95A	0·10	2N 2369	0·12
AC 176	0·18	BC 208	0·1[illegible]	BU 105	2·25	2N 2369A	0·15
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ACY 17	0·25	BC 258	0·10	C 425	0·35	2N 2894	0·35
ACY 18	0·20	BC 259	0·13	C 426	0·25	2N 2904	0·20
ACY 19	0·20	BC 268	0·15	C 428	0·25	2N 2904A	0·25
ACY 20	0·20	BC 300	0·42	C 449	0·30	2N 2905	0·25
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ACY 39	0·50	BC 304	0·40	OC 20	0·65	2N 2907	0·20
ACY 40	0·20	BCY 30	0·25	OC 22	0·40	2N 2907A	0·12
ACY 41	0·20	BCY 31	0·30	OC 23	0·40	2N 2923	0·12
ACY 44	0·30	BCY 32	0·50	OC 24	0·60	2N 2924	0·12
AD 140	0·50	BCY 33	0·25	OC 25	0·35	2N 2925	0·12
AD 142	0·45	BCY 34	0·30	OC 26	0·30	2N 2926R	0·10
AD 143	0·45	BCY 39	0·65	OC 28	0·40	2N 2926G	0·10
AO 149	0·40	BCY 42	0·20	OC 29	0·40	2N 29260	0·10
AD 150	0·65	BCY 43	0·20	OC 35	0·42	2N 2926Y	0·10
AO 160	0·35	BCY 70	0·16	OC 36	0·50	2N 29206B	0·10
AD 161	0·35	BCY 71	0·20	OC 41	0·20	2N 3053	0·20
AD 161/2	0·55	BCY 72	0·15	OC 42	0·25	2N 3054	0·50
AD 162	0·35	BCZ 11	0·40	OC 44	0·15	2N 3055	0·50
AD M/PR	0·55	BO 115	0·75	OC 45	0·15	2N 3133	0·30
AF 114	0·20	BD 121	0·65	OC 57	0·50	2N 3391	0·20
AF 115	0·20	BO 123	0·80	OC 70	0·12	2N 3390	0·25
AF 116	0·20	BD 124	0·60	OC 71	0·15	2N 3393	0·15
AF 117	0·20	BD 130	0·50	OC 72	0·20	2N 3394	0·12
AF 118	0·45	BD 131	0·75	OC 74	0·30	2N 3404	0·25
AF 124	0·25	BD 132	0·75	OC 75	0·25	2N 3405	0·25
AF 125	0·20	BD 133	0·65	OC 76	0·15	2N 3414	0·10
AF 126	0·20	BD 135	0·40	OC 77	0·40	2N 3415	0·10
AF 127	0·20	BD 136	0·45	OC 81	0·20	2N 3416	0·15
AF 139	0·40	BD 137	0·45	OC 81D	0·20	2N 3417	0·20
AF 178	0·45	BD 138	0·55	OC 82	0·25	2N 3440	0·85
AF 179	0·55	BD 139	0·60	OC 82D	0·20	2N 3563	0·15
AF 180	0·50	BD 140	0·75	OC 83	0·23	2N 3564	0·18
AF 181	0·42	BDY 20	1·00	OC 84	0·25	2N 3565	0·13
AF 186	0·45	BF 115	0·25	OC 139	0·25	2N 3566	0·20
AF 239	0·43	BF 117	0·45	OC 140	0·55	2N 3572	0·95
AL 102	0·65	BF 119	0·58	OC 169	0·25	2N 3692	0·17
AL 103	0·60	BF 121	0·25	OC 170	0·25	2N 3702	0·10
ASY 26	0·30	BF 123	0·27	OC 171	0·30	2N 3703	0·10
ASY 27	0·30	BF 125	0·25	OC 200	0·40	2N 3704	0·10
ASY 28	0·30	BF 127	0·27	OC 201	0·75	2N 3705	0·10
ASY 29	0·30	BF 152	0·21	OC 202	0·80	2N 3706	0·10
ASY 50	0·20	BF 153	0·30	OC 203	0·50	2N 3707	0·10
ASY 56	0·25	BF 154	0·16	OC 204	0·40	2N 3708	0·10
ASY 57	0·25	BF 158	0·15	OC 205	0·75	2N 3709	0·10
ASY 58	0·25	BF 159	0·30	OCP 71	1·00	2N 3710	0·10
BC 107	0·10	BF 160	0·23	ORP 12	0·50	2N 3711	0·10
BC 107B	0·10	BF 161	0·35	ORP 60	0·40	2N 3714	0·10
BC 108	0·10	BF 163	0·20	ORP 61	0·40	2N 3773	3·00
BC 108B	0·10	BF 166	0·35	2G 301	0·20	2N 3790	2·00
BC 109	0·10	BF 167	0·20	2G 302	0·20	2N 3794	0·15
BC 109B	0·10	BF 173	0·20	2G 303	0·20	2N 3819	0·25
BC 113	0·15	BF 177	0·25	2G 306	0·35	2N 3820	0·50
BC 114	0·15	BF 178	0·25	2G 309	0·35	2N 3866	0·65
BC 115	0·15	BF 179	0·30	2G 371	0·15	2N 3903	0·20
BC 116	0·15	BF 180	0·30	2G 374	0·15	2N 3904	0·18
BC 117	0·15	BF 181	0·32	2G 381	0·20	2N 3905	0·20
BC 118	0·10	BF 182	0·35	2G 417	0·20	2N 3906	0·20
BC 119	0·30	BF 183	0·40	2N 404	0·20	2N 4033	0·75
BC 125	0·15	BF 184	0·20	2N 696	0·15	2N 4058	0·12
BC 126	0·20	BF 185	0·20	2N 697	0·15	2N 4059	0·12
BC 132	0·25	BF 194	0·15	2N 698	0·25	2N 4060	0·12
BC 134	0·20	BF 195	0·15	2N 699	0·30	2N 4061	0·12
BC 135	0·12	BF 196	0·15	2N 706	0·10	2N 4062	0·12
BC 136	0·15	BF 197	0·15	2N 706A	0·12	2N 4143	0·25
BC 137	0·15	BF 200	0·35	2N 708	0·13	2N 4236	1·35
BC 138	0·25	BF 224	0·35	2N 709	0·40	2N 4248	0·10
BC 140	0·30	BF 244	0·18	2N 718	0·20	2N 5172	0·10
BC 141	0·40	BF 257	0·40	2N 718A	0·30	2N 5457	0·30
BC 142	0·25	BF 258	0·45	2N 916	0·18	2N 5458	0·33
BC 143	0·20	BF 259	0·50	2N 918	0·30	2N 5459	0·35
BC 144	0·25	BF 270	0·25	2N 929	0·15	2S 301	0·50
BC 145	0·20	BF 271	0·20	2N 930	0·15	2S 302	0·42
BC 147	0·10	BF 272	0·50	2N 1131	0·20	2S 303	0·55
BC 148	0·10	BF 273	0·25	2N 1132	0·20	2S 322	0·50
BC 149	0·12	BF 274	0·29	2N 1302	0·16	2S 324	0·95
BC 153	0·20	BFS 61	0·27	2N 1303	0·16	2S 502	0·35
BC 154	0·20	BFS 98	0·25	2N 1304	0·20	40360	0·45
BC 157	0·13	BFW 10	0·25	2N 1305	0·20	40361	0·50
BC 158	0·13	BFX 13	0·25	2N 1306	0·22	40362	0·45
BC 159	0·13	BFX 29	0·25	2N 1307	0·22	40408	0·50
BC 160	0·12	BFX 30	0·60	2N 1308	0·25	40636	1·10
BC 167	0·12	BFX 34	0·70	2N 1309	0·35		

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IS 021		BY 114	0·15
IS 44	0·15	BY 124	0·15
IS 113	0·15	BY 126	0·15
IS 120	0·15	BY 127	0·20
IS 121	0·11	BY 164	0·65
IS 130	0·11	BYX 10	0·35
IS 131	0·11	BYX 38/30	0 45
IS 132	0·13	BYZ 10	0·35
IS 4148	0·07	BYZ 11	0·35
IS 920	0·10	BYZ 12	0·35
IS 922	0·10	BYZ 13	0·30
IS 923	0·15	BYZ 16	0·45
IS 940	0·06	BYZ 17	0·40
IS 951	0·06	BYZ 18	0·40
AA 119	0·10	BYZ 19	0·30
AA 120	0·10	BZY 78	1·00
AA129	0·10	OA 5	0·25
AAY 30	0·12	OA 9	0·12
AAY 42	0·15	OA 10	0·20
AAZ 13	0·12	OA 47	0·10
AAZ 15	0·15	OA 70	0·08
AAZ 17	0·15	OA 79	0·08
BA 100	0·15	OA 81	0·10
BA 102	0·25	OA 85	0·10
BA 110	0·25	OA 90	0·08
BA 115	0·08	OA 91	0·08
BA 116	0·25	OA 95	0·08
BA 126	0·25	OA 200	0·10
BA 141	0·35	OA 202	0·10
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7409	0·20	7497	6·50
7410	0·18	74100	1·80
7411	0·25	74104	1·00
7412	0·40	74105	1·00
7413	0·30	74107	0·45
7416	0·40	74110	0·60
7417	0·40	74111	1·30
7420	0·18	74118	1·10
7421	0·25	74119	1·40
7422	0·50	74121	0·45
7423	0·50	74122	1·50
7425	0·50	74123	2·85
7426	0·35	74141	0·80
7427	0·45	74145	1·60
7428	0·60	74150	3·50
7430	0·18	74151	1·10
7432	0·45	74153	1·30
7433	0·80	74154	2·00
7437	0·60	74156	1·50
7438	0·60	74157	1·50
7439	0·60	74160	2·00
7440	0·18	74161	2·00
7441	0·70	74162	3·75
7442	0·70	74163	3·75
7443	1·20	74164	2·50
7444	1·20	74165	2·50
7445	2·00	74166	4·00
7446	1·20	74167	7·00
7447	1·20	74170	5·00
7448	1·20	74174	2·50
7450	0·18	74175	1·50
7451	0·18	74176	2·00
7452	0·23	74177	2·00
7453	0·18	74180	1·80
7454	0·18	74181	6·00
7460	0·18	74182	2·25
7470	0·30	74184	3·00
7472	0·30	74185A	3·00
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7480	0·70	74194	2·75
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7482	1·00	74196	1·75
7483	1·10	74197	1·75
7484	1·00	74198	5·00
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YAMAHA CA 700 AMPLIFIER

MEASURED PERFORMANCE OF YAMAHA CA-700 AMPLIFIER

Frequency Response:	20Hz to 20 kHz ±1 dB		
Power Output for Rated Input:	47 watts		
Channel Separation (at Rated Ouput of 60 watts):	100Hz	1kHz	10kHz
	76dB	50dB	45dB
Signal to Noise Ratio with respect to Rated Power (Auxiliary Input):	Unweighted		75dB
	Weighted		85dBA
Total Harmonic Distortion (at Rated Output):	100Hz	1kHz	6.3kHz
	0.25%	0.25%	0.2%
Tone Controls:			
Bass	9dB boost at 50Hz		
	10dB cut at 50Hz		
Treble	7dB boost at 10kHz		
	10dB cut at 10kHz		
Loudness Control	6dB boost at 50Hz		
	4dB boost at 10kHz		
Low Pass Filter	4dB cut at 10kHz		
High Pass Filter	4dB cut at 50Hz		
Dimensions:	400mm wide by 140mm high by 300 mm deep		
Recommended Resale Price:	£141.19 inc. VAT		

THE Yamaha Company of Japan started production of pianos back in the 1880's. Since then they have extended their range to include all orchestral instruments, and ten years ago commenced production of electronic equipment for the domestic market.

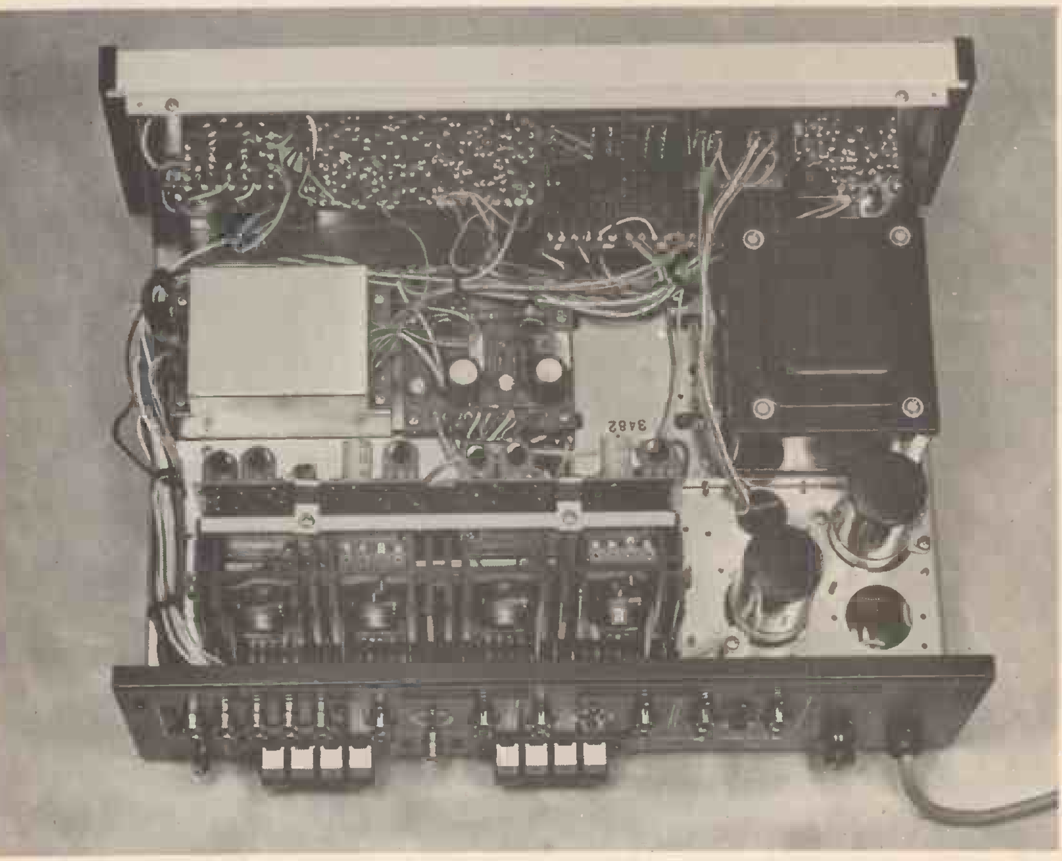
Yamaha have companies throughout the world. They are the largest single manufacturer of orchestral instruments, in particular, pianos, for which they are world renowned. The company also manufactures hi-fi equipment for other prominent audio organizations.

In this article we review the company's Yamaha CA 700 Amplifier.

The CA 700 amplifier has a very neat external appearance. It is housed in an oiled timber enclosure. The front panel is brushed aluminium with a black edging strip on each end, and has a small black panel across the bottom. The front panel controls are arranged in two rows consisting of the following:–

On the top row, left to right, we have:

(a) microphone input level control.
(b) two speaker-select toggle switches for speaker systems A and B.
(c) two filter toggle switches, one for the low-pass filter and one for the high-pass filter.



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product test

(d) bass tone control knob with five boost and cut positions.
(e) treble tone control knob with five boost and cut positions.
(f) balance control knob.
(g) volume control knob.

On the bottom row we have:
(a) a small orange bezel light.
(b) a set of five push on and off buttons for auxiliary 1 select, auxiliary 2 select, phono 1 select, phono 2 select, tuner select.
(c) tape monitor select switch with five positions, (i) dubbing A-B, (ii) A play (iii) source monitor, (iv) B play and (v) dubbing B-A.
(d) mode select switch with five positions for left channel, right channel, left and right channels, stereo and stereo reverse.
(e) two toggle switches, one for audio muting – providing a 20dB cut, and the other for loudness control.

On the left hand end of the black strip, across the bottom, we have a push on/off power switch, ring tip and sleeve headphone socket, and two tip and sleeve microphone sockets.

On the rear, we have input and output facilities, and these include 11 pairs of phono sockets for tuner input, phono 2 input, phono 1 input, auxiliary 2 input, auxiliary 1 input, tape B play, tape B record, tape A play, tape A record, preamplifier output and main amplifier in. The phono 2 input is for moving coil cartridges only, and is fitted with a preamplifier to suit. Both tape record A and B also have DIN recorder playback sockets. The preamplifier and main amplifier may be separated by throwing a switch.

Speaker outputs are made via two groups each of four spring loaded terminals. A single phono socket is also provided for mono output.

YAMAHA CA 700 AMPLIFIER

Some of the facilities on the amplifier are worth noting, firstly because they are not normally included on amplifiers in this price bracket, and secondly, because they are features that, we feel, are very worthwhile on any amplifier. The first of these features is the microphone input level control which makes mixing of dialogue on to a tape with other source material a simple process controllable from the amplifier. Other mixing combinations are also possible using this control.

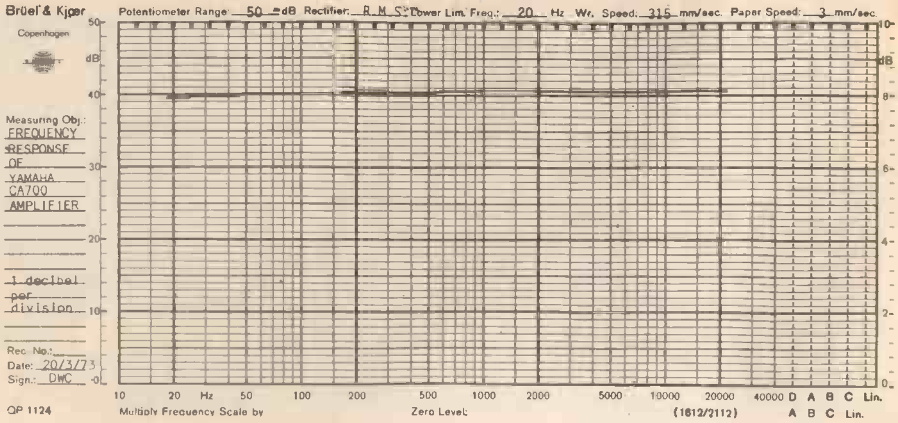
A second feature is the tape monitor switch which allows dubbing from one recorder to another.

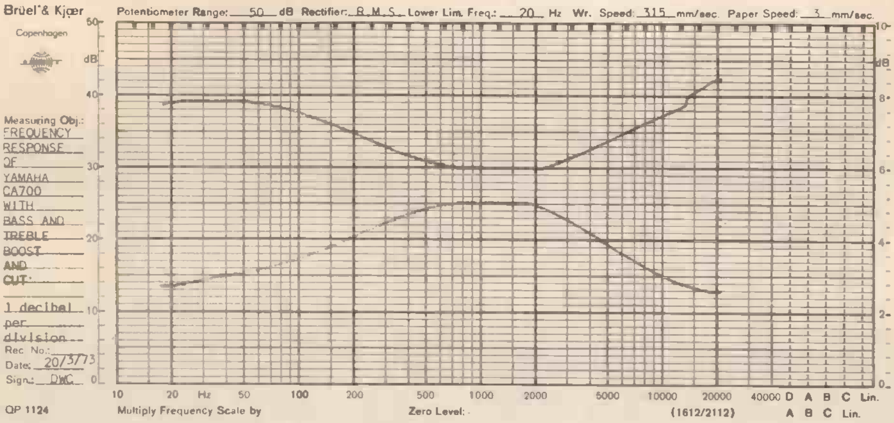
The internal layout is good with each circuit having its own printed circuit board. The filter circuits, tone control circuits and microphone preamplifier circuits are each mounted on the back of their respective front panel controls. The two power amplifier boards slide into multipin edge connectors. The four power transistors are on a common heatsink, mounted just inside the back cover. A large plastic grille is fitted into the top of the timber enclosure to allow adequate ventilation over the heatsinks. Two thermistors are also fitted on the heatsink to provide protection. As a circuit diagram was not supplied with the unit, we could not determine exactly how they operate, or what degree of protection was provided.

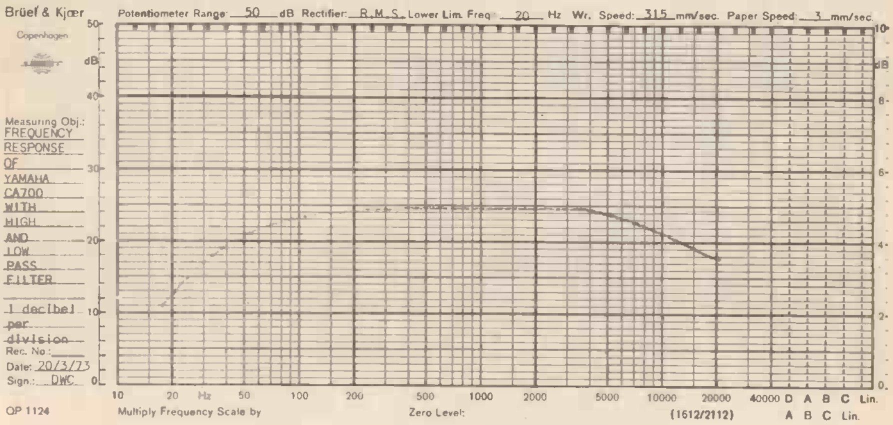
An instruction manual was supplied with the unit and gave basic information on the front panel controls and rear panel facilities. In addition, three pages gave information on various wiring connections.

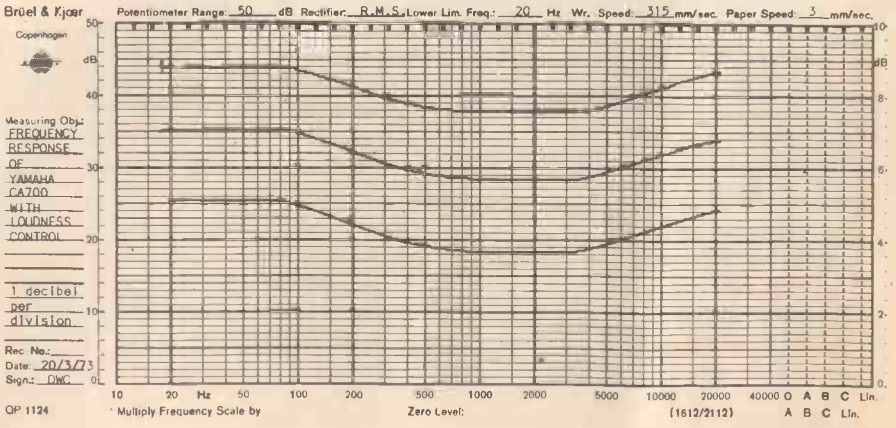
The laboratory measurements were quite interesting. The signal to noise ratio was very good at 75dB. Total harmonic distortion was also more than adequate and dropped to less than 0.1% at 50 watts. The loudness control was unusual because the bass and treble boost did not diminish with an increase in volume, as is the general trend. The low and high pass filter characteristics were rather disappointing providing only 4dB cut at 10kHz and 50Hz respectively.

The Yamaha CA-700 combines a balanced performance specification with a number of worthwhile features not seen on most amplifiers. Its power output is more than adequate to drive most speakers, even low efficiency ones, to realistic listening levels in the average lounge.









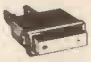
MINIATURE WAFER SWITCHES

2 pole, 2 way—4 pole, 2 way —2 pole, 3 way—4 pole, 3 way—2 pole, 4 way—3 pole, 4 way—2 pole, 6 way, 1 pole, 12 way. All at 22p each.

TOGGLE SWITCHES

Metal, all standard types with metal dolly 240v. 3 amp: SP, ST 17p SP, DT, 22p DP, ST 22p DP, DT, 28p less 10% for ten of same type.

ROCKER SWITCH



13 amp self-fixing into an oblong hole. Size approximately 1in. x ½in., 9p each, 10 for 82p.

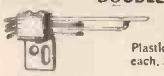
SLIDE SWITCHES

Slide Switch, 2 pole change over panel mounting by two 6 BA screws. Size approx. 1" x ½" rated 250v lamp. 8p each, 10 for 72p.

Ditto as above but for printed circuit 7p each. 10 for 63p.

Sub Miniature Slide Switch. DPDT 19mm (¾" approx.) between fixing centres. 14p each or 10 for £1·26.

DOUBLE LEAF CONTACT

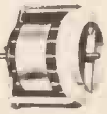


Very slight pressure closes both contacts. 8p each, 10 for 72p. Plastic push rod suitable for operating. 6p each, 54p for 10

LIGHT CELL

Almost zero resistant in sunlight increases to 10 K. Ohms in dark or dull light, epoxy resin sealed. Size approx. 1 in. dia. by ¼ in. thick. Rated at 500 MW. wire ended. 61p. Suit most circuits.

PAPST MOTORS



Est. 1/20th h.p. Made for 110–120 volt working, but two of these work ideally together off our standard 240 volt mains. A really beautiful motor, extremely quiet running and reversible. £1·65 each. Postage one 23p, two 33p. 230 V. mod 1 £3·30

MINIATURE SEALED RELAY

American made. Our Ref. No. REL A1. Measures only ½" wide x ½" thick and ½" high and it's a double change over, we don't know the contact rating but estimate this at 3/5 amps. The coil resistance is 600 ohms and 9–12 volt will close it. Ideal for models and miniaturised equipment. It's a plug in relay but we supply complete with base. Price 28p including base.

COMBINATION SWITCH

This comprises of 12 miniature change-over micro switches. Joined in banks of 3 and mounted on frame with four digital numbered thumb wheels and a removable lever for locking the thumb wheel—the thumb wheel operates 3 banks. Over 4,000 combinations are possible but rewiring the switch connections underneath then thousands more variations are possible. If you are making equipment which you don't want switched on accidentally or without authority then this is a switch to consider—this can also be used as a coding switch for many other operations. Very neat and compact and measuring approx. 4" x 1½" x 1¼" deep. Priced at £2·75.

MAGNETIC CLUTCH

XEROX 1215494—J/N 10-1110 PN866-10. We have no information on this but it appears that the main section with coil fits to the spindle of the machine and there is a contact plate to fit on a stationary part. It appears also that the clutch can be used as a partial break by putting reduced voltage into it, as a normal brake with normal voltage or as emergency stop by putting increased voltage into it. American made and very well made at that. Price £1·65.

DRILL CONTROLLER

New 1kW model.

Electronically changes speed from approximately 10 revs. to maximum. Full power at all speeds by finger-tip control. Kit includes all parts, case, everything and full instructions £1·65, plus 13p post and insurance. Made up model also available £2·50 plus 13p p. & p.

BAKELITE INSTRUMENT CASE

Size approx. 6¼" x 3¼" x 2" deep with brass inserts in four corners and bakelite panel. This is a very strong case suitable to house instruments and special rigs, etc. Price 50p each. Paxlids 11p extra.

15A ELECTRICAL PROGRAMMER

Learn in your sleep: Have radio playing and kettle boiling as you awake—switch on lights to ward off intruders—have warm house to come home to. All these and many other things you can do if you invest in an electrical programmer. Clock by famous maker with 15 amp. on/off switch. Switch on time can be set anywhere to stay on up to 6 hours. Independent 60 minute memory jogger. A beautiful unit. Price £2·15 + 20p p. & p. or with glass front chrome bezel 83p extra.

WATERPROOF HEATING ELEMENT

26 yards length 70W. Self-regulating temperature control. 55p post free.

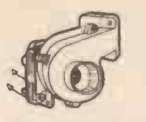
HIGH ACCURACY THERMOSTAT

Uses differential comparator I.C. with thermistor as probe. Designer claims temperature control to within 1/7th of a degree. Complete kit with power pack £6·15.

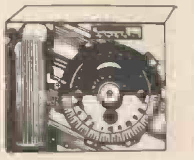
TREASURE TRACER

Complete Kit (except wooden battens) to make the metal detector as the circuit in Practical Wireless, August issue. £3·30 plus 20p post and insurance.

CENTRIFUGAL BLOWER



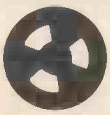
Miniature mains driven blower centrifugal type blower unit by Woods, powerful but specially built for quiet running—driven by cushioned induction motor with specially built low noise bearings. Overall size of blower is approx. 4¼" x 4¼" x 4". When mounted by its flange air is blown into the equipment, but to suck air out mount it from the centre using a clamp, ideal for cooling electrical equipment, or fitting into a cooker hood, film drying cabinet or for removing flux smoke when soldering etc., etc. A real bargain at £2·05.



ELECTRIC TIME SWITCH

Made by Smiths these are a.c. mains operated. NOT CLOCKWORK. Ideal for mounting on rack or shelf or can be built into box with 13A socket. 2 completely adjustable time periods per 24 hours. 5 amp changeover contacts will switch circuit on or off during these periods. £2·75 post and ins., 23p. Additional time contacts 50p pair.

COMPUTER TAPE



2,400 ft. of the Best Magnetic Tape money can buy. Some users claim good results with Video and sound. 1in., wide. £1·10 plus 30p. post. Spare spools and ½" Scotch tape. Brand new. Suits most video recorders. £3·30 for 3,600 ft.

GOOD COMPANION I.C. MODEL

We can now offer this fine receiver but in I.C. version, using Ferranti ZN414 and Mullard AF Module 1172. Cabinet size approx. 11in. wide x 8in. high x 3in. deep. Complete with excellent 2 tone cabinet with assembly instructions £5·75.

ERGOTROL UNITS

These units made by the Mullard Group are for operating and controlling d.c. motors and equipment from a.c. mains.

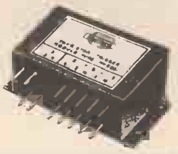
Thyristors are used and these supply a variable d.c. resulting in motor speed control and operating efficiency far superior to most other methods.

The units are contained in wall mounting cabinets with front control panel on which are fuses—push buttons for on/off and the variable thyristor firing control.

4 models are available—all are brand new in makers cases:

Model 2410 for up to 5 amps £19·25
Model 2411 for up to 10 amps £30·25

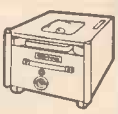
MULLARD THYRISTOR TRIGGER MODULE



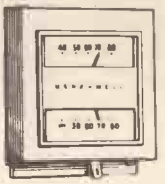
This produces pulses for phase control triggering, it has two isolated out-puts, so one thyristor or two thyristors (in separate arms of bridge) may be controlled by one module. The timing circuit is synchronised to the mains frequency and control is by an external variable resistor or from a voltage or current source. Provision is made for feedback where automatic control is required. Price £4·95 each or 10 for £45·00.

THIS MONTH'S SNIP

TAPE PLAYBACK UNITS



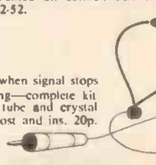
Mains operated. Made by Rediffusion the famous "music in background people." These are complete units ready to work and we understand that they are in good going order. We have not tested them but would exchange any that do not work properly. These have a superior motor driven flywheel to control the tape through the capstan and also an even equally useful valve amplifier with EL84 output. In a steel case with carrying handle. Two models offered, good as new £6·50 and somewhat used at £3·50. 75p carriage up to 200 miles then 50p per 100 miles extra.



THERMOSTAT WITH THERMOMETER

Made by Honeywell for normal air temperatures 40°–80°F. (5–25°C.). This is a precision instrument with a differential which can be adjusted to better than 1·5°F. A mercury switch breaks on temp. rise—the switch is operated by coiled bi-metal element and an adjustable heater is incorporated for heat anticipation. Elegantly styled and encased in an ivory plastic case with clear plastic windows, thermometer above and switch setting scale below. Size approx. 3·8" x 3·2" x 1·4" deep. Can be mounted on conduit box or directly on wall. Price £1·38 each or 10 for £12·52.

RADIO STETHOSCOPE



Easiest way to fault find—traces signal from aerial to speaker—when signal stops you've found the fault. Use it on Radio, TV, amplifier, anything—complete kit comprises two special transistors and all parts including probe tube and crystal earpiece. £2·20—twin stethoset instead of earpiece 83p extra—post and ins. 20p.

HORSTMANN "TIME & SET" SWITCH

(A 30 Amp Switch.) just the thing if you want to come home to a warm house without it costing you a fortune. You can delay the switch on time of your electric fires, etc., up to 14 hours from setting time or you can use the switch to give a boost on period of up to 3 hours. Equally suitable to control processing. Regular price probably around £5. Special snip price £1·65. Post and ins. 23p.

SUB. MINIATURE MICROSWITCH

Made by Burgess, their Ref. V4T6—our ref. MS. A1. These measure only ⅝" x ⅜" x ¼" thick—have change over contacts and tag connection. Price 16p each or 10 for £1·44.

MULLARD AUDIO AMPLIFIERS

All in module form, each ready built complete with heat sinks and connection tags, data supplied.

Model 1153 500mW power output 72p.
Model 1172 750mW power output 94p.
Model EP9000 4 watt power output £1·60.
EP9001 twin channel or stereo pre amp. £1·98.
10% discount if 10 or more ordered.

DISTRIBUTION PANELS

Just what you need for work bench or lab. 4 x 13 amp sockets in metal box to take standard 13 amp fused plugs and on/off switch with neon warning light. Supplied complete with 6 feet of heavy cable. Wired up ready to work. £2·50 plus 25p P. & P.

INSTRUMENT RACKS WITH DRAWERS

These extremely well made racks measure 6ft. high, 22in. wide, 23in. deep, they comprise four drawers each of which is on ball bearings for easy withdrawal, but is of very solid construction to hold equipment in a rigid mode. Originally, these held computer equipment and must have cost £50–£60 each. We have only 10 and offer these at £11 per rack with drawers. You must collect.

SATCHWELL DUOTRONIC CONTROLLER

These are big wall mounting panels containing transformers, relays, valves etc. Used for the control of ducting (through ZPM modulation motor which we can supply). Their primary use of course is in air conditioning, but no doubt other applications are available. These panels cost £50–£60 each. Our price £16 each. Quantity price by negotiation.

6V D.C. POWER MOTOR MADE BY REDMUND

For driving a bilge pump and similar applications. This motor we understand develops on ⅛ H.P. It is extremely powerful and although rated at 6v, this operates up to 12v. for short periods with very much increased power, (probably at least ¼ H.P.) We understand that from the makers they cost over £5. We have a limited stock at £2·20 each plus 25p post on one and then 15p each.

TRANSMITTER FOR BLEEPERS

Mains operated, simply needs a single copper conductor to surround the bleeped area then any bleep receiver may be called at will. 2 only of these. Price £15 each. Not new but believed to be in good order.

RACK AND CHARGER FOR BLEEPERS

Receivers are stored in this over night and charged at the same time. 2 only available. Not new but believed in good order. £10 each.

8 AMP VARIACS

These are variable voltage transformers. British made by the famous Zenith Co. Fully enclosed for bench use and fitted with calibrated scale and control knob. Zenith model No. 100 LM. 220–240v. A.C., output 0–240v. up to 8 amps. This model is listed at over £20. We have a limited quantity only, absolutely brand new, still in maker's cartons, offered to you at £13·75 each plus £1 carriage and insurance up to 400 miles.

MOTOR GENERATOR

Made for Admiralty. 24 volt d.c. input, 240v. 50 cps. output. Admiralty rating 80 watts but we have tested this to 50% overload voltage regulated so suitable to operate TV or instrument. In case with metal cover, controls on front include voltmeter. Unused. Probably cost £200 each to make. Our price only £25 each plus carriage £2 up to 200 miles. £4 up to 400 miles.

150 WATT PEARL LAMPS

230v. Best makes, Mazda etc. Balance of G.P.O. contract £1·20 per box of 25 Plus 25p post, 5 boxes post free.

POWER RHEOSTAT

61 ohms at 11·5 amps. This is a large rheostat. 1 only. Good order, ex equipment. £6·60 plus £2 carriage.

POWER RHEOSTAT

·78 amps 399 ohms. Price £3·50 plus 75p carriage.

9 VOL GRAMAPHONE UNIT

Battery operated with pick-up on unit plate. Speed auto-stop turnover cartridge. Price £2·50 plus 40p post and insurance.

BUY TIME SLOT METER

Made by Sangamo Weston. 3 types, one for each coin 2½p, 5p, or 10p. Price £1·75 each plus 25p post and ins.

4 STATION TRANSISTORISED INTERCOM

Solid State three transistor printed cct. meter and three sub station push button/press talk system. 200mW output, complete with installation accessories and 9v. Ever-ready power pack approx. 3 x 1½ x 4in. Price £8·50 plus 20p.

PHOTO ELECTRIC KIT

Contains photo cell, relay, transistor and all parts to make light operated switch. Limited quantity. £1·75 plus 20p post and ins.

AC/DC MILLIAMETERS 3 RANGE

Moving iron mirror scale laboratory instalate. Ranges 52 and 50 and 100mA by selection switch (coil resistance marked) size 7½ x 5 x 3½in. type 35999/1. Price £6·60.

GALVOMETER 20–0–20 F.S.D.

Moving coil precision laboratory instrument of extremely high sensitivity (3x10-7 A per division), size approx. 6½ x 2½ x 2ins. Price £5·50.

ACOS. 'G' METERS

For use with transducers and accelerometers. These are precision instruments they measure "g" in three steps, 0–10, 0–100 and 0–1000 directly on a large clear meter scale 0–1. Two Modules available:— Standard Module (IDOOL) price £12 and Auto cutout model (IDOOL) which has an inbuilt circuit with relay to trip the external circuit (trip level is adjustable by a control which is virtually linear with the meter scale). The trip load may be up to 2a. Once the circuit has been tripped it can be restored by a reset button. Price of this model is £18.

PARMEKO NEPTUNE SERIES C CORE TRANSFORMERS

These transformers are beautifully made, steel encased stove enamelled black, upright mounting. All have normal 50cps. primary 230/240v. with primary screen and are new and unused. Small quantities only of each type available as follows:

Model 6000/79 275-0-275v. at 330mA. and 6·3v. at 4·6a. Price £6·60. 50p post.
Model 6000/71. 290-215-0-215-290 at 125mA. and 2 at 6·3v. 6a. Price £5·50. 40p post.
Model 49 250v. at 10mA. 6·3v. at 3a., 5v. at 0·75a. Price £2 plus 30p post.
Model 47 620-0-620 at 9mA. 4v. at 1a. Price £6·60 plus 40p post.

Parmeko Neptune C Core Chokes. These are encased and match the transformer above.

Model 6000/73 4H at 560mA., £2·75 plus 40p post.
Model 35 10H at 1mA. £2·75 plus post 40p.
Model 49 10H at 70mA. £1·75 plus 30p post.
Model 69 10H at 110mA. £2·20 plus 40p.

Electric Car Ignition. In addition to the kits for 12v. cars we can also supply systems for 6v. cars. These are not kits but made up and ready to work. Price £5·50 plus 30p post.

VARIABLE INDUCTANCE CHOKE

Has three windings. Two of them rated to carry 8A. a.c. The third a control winding needs current of up to 75mA d.c. In an unsaturated state that is with no or very low control current flowing the volts dropped across the a.c. windings will be high but as the control current increases the reactance of the main windings decreases and the voltage dropped by them would become less and less. Uses of this inductor are for voltage regulation, current control, lamp dimming etc. Weighs approx. 60 lbs. Price £12 each plus £2 carriage up to 200 miles. £3. 300 miles. £4. 400 miles.

Where postage is not stated then orders over £5 are post free. Below £5 add 20p. S.A.E. with enquiries please.

J. BULL (ELECTRICAL) LTD.

(Dept. E.T.) 7, Park Street, Croydon, CR0 1YD
callers to 102/3, Tamworth Road, Croydon

TRACKING WEIGHT -how it affects record wear

LAST YEAR we commissioned our acoustical consultants to determine whether or not gramophone records lose their 'brilliance' after a number of playings.

The results – published in our February 1973 issue – interested, and surprised many of our readers. So much so, in fact, that we asked our consultants to conduct further tests – this time on a very controversial subject indeed – the effect on record wear of different tracking weights.

Once again, the results were surprising, for whilst we have always held that too low a tracking weight will cause the stylus to bounce and perhaps damage the record groove, we did not realize just *how* much wear this causes.

Our tests proved conclusively that when a record is played at the lowest recommended tracking weight, the rate of wear is even higher than occurs at the highest recommended tracking weight.

At the lowest tracking weight wear is even higher than at the highest weight.

A second and most interesting finding was that the cleanest sound is *generally* obtained when the tracking weight is set somewhere between the nominal centre and the highest value of the recommended tracking weight range.

If your stylus is dirty as this one (unretouched photograph) then the wear caused by incorrect tracking weight is the least of your problems!

This finding was less surprising because a cartridge's compliance is a function of its tracking weight, and generally, all things being equal, the higher the tracking weight the more easily the stylus follows difficult passages.

A mediocre cartridge has best tracking at highest recommended weight.

A very good cartridge can achieve this in the lowest region of the range – but only when fitted to a first class arm. An average cartridge achieves it at a tracking weight about the middle of the recommended range, but a mediocre cartridge will only reach its maximum trackability at the maximum recommended weight.

For both records we set up an automatic record changer to play the centre 7" section of one side of the record, monitored in an A-B test against a new record after 2, 5, 10, 20 and 100 playings. You may ask why an A-B test? The A-B test was required because we found that even after 100 playings, a dust and scratch free record played with a good stylus, still sounds normal and acceptable, until compared with a *new* recording of the same record. Our testing demands such techniques in order to provide valid results.

In playing each of these two records over and over again at 'normal' tracking weights we found it impossible to discern any difference in the sound between two sequential playings. The reason for this is quite simple; loss of signal level in even one harmonic component is far less than 1 dB, and this is by and large below the smallest change in signal that the human ear can detect. Even the difference in audible content between 20 and 100 playings, except under the worst possible conditions, is difficult to discern, for what you hear are subtle changes in the relative component intensities of the higher order harmonics as well as a small drop in total signal level that is almost impossible to detect, even in an A-B test.

But where significant changes did occur were on the multiple playings with the stylus tracking pressure set at the lowest level. Then it was quite possible to detect what we can only describe as a general numbing or deadening of the clarity. This was evident even on the second playing, and resulted in a complete lack of listening ease after ten playings.

After 100 playings of the lowest tracking weight, the record sounded almost as if it had been made in a different studio and had utilised another orchestra! By contrast, the record that had been played at what we will loosely term the optimum tracking weight, sounded fairly normal and, apart from surface wear and signal to noise ratio, was by and large acceptable.

Having completed our subjective appraisal we were then faced with the difficult task of devising a set of instrumented tests which would allow us to qualify in precise terms that which we had heard.

Trackability measuring has plagued the technical press for years. In an article in "Electronics World" (June 1967), James Cogan of Shure Brothers in the U.S.A. dealt with this subject in some depth. He proposed a number of techniques for measuring trackability, including the use of variable speed turntables in order to provide any level of velocity that is desired so that the point at which mistracking occurs may be measured. The basic problem is that a cartridge that can track at a given velocity – such as 20 cm per second at a frequency of say 100Hz – may not be able to track at the same velocity at a frequency of 6000Hz or higher. This is because the dynamic behaviour of the stylus assembly varies so greatly with the range of frequencies over which it is expected to perform. The tracking ability of a cartridge should in fact really be specified over a wide range of frequencies.

Most commercial discs have average

Tracking weight may be set very accurately using a stylus balance.

recording velocities well below 10 cm per second, and only a few records have momentary peak velocities that exceed levels over 15 cm per second. Unfortunately, these high peak levels tend to occur at the highest frequencies, which are the most difficult for a cartridge to track. Whilst the trackability can be improved by using a higher stylus force. this in itself is not a solution, for trackability should be *designed* into the cartridge, not *forced* into it.

Most records designed for testing trackability are not really designed for multiple playings, and even so the technical information they provide does not give a unique scale of merit completely suitable for what we had in mind. For that matter, however, neither does any record that we are aware of.

What we sought to achieve was to be able to measure the rate of change of the harmonic components on a record whose average velocity was in the range 5-10 cm per second, and to be able to monitor the small changes in harmonic content that occurred during many playings. Eventually we decided to use a square-wave test record.

This was a 7", 45rpm disc tnat has on one side two bands of a 1kHz square wave recorded at 7cm/sec. This record was played 100 times and we recorded the output during the first, fifth, tenth and hundredth playing on to tape using as a preamplifier a Bruel and Kjaer type 2409 voltmeter terminated on the input in 47 kΩ and recording the signal on a Kudelski Nagra 3B tape recorder onto Scotch type 206 tape. We then formed a small tape loop on which we performed a narrow-band analysis using a filter with 30Hz band width, (we could have used a narrower band width, but this would have meant that the subsequent analysis time would have been ten times as long). A typical example of the recordings is shown in Fig. 1 where the dramatic difference between the first and 10th playing at 0.8 grams is clearly evident.

The results were particularly interesting. The first was that after 100 playings the fundamental signal level can drop by as much as 3 dB (at optimum tracking weight) and by as much as 6 dB with the tracking weight set at one extreme or the other.

At the maximum tracking weight the most noticeable feature is the attenuation of the higher order odd harmonic components above 13 kHz. These are directly attenuated and are modified by either the shape of the groove or by the stylus.

Providing the record is kept clean and the stylus is well profiled, the rate of change in wear rate for velocities below 10 cm per second (at maximum tracking weight) is neither excessive nor really a matter for concern. However, when the tracking weight is set anywhere between one half of the lowest level and the the lowest level *recommended* by the cartridge manufacturer, changes occur in a somewhat different manner. Firstly, the harmonic components rise due to the asymmetry of motion of the stylus in the groove, and over only ten playings, these components could rise by as much as 5dB. However, it should be noted that these components are not readily audible even though the record is being rapidly worn out. Over 100 playings, the damage is extensive and the record is far from what it was originally in terms of the loss of high frequency components, and the very significant increase in the even order harmonics.

The cleanest sound is obtained . . . near the nominal centre of the tracking weight range.

At twice the nominal optimum tracking weight, the rate of wear is *less than observed at half the recommended weight.* There is no significant increase in the even order harmonics, but there is still a significant loss of the odd order harmonics above 11 kHz. The rate of change of harmonic components between the third and ninth is not particularly high, and the record sounds very similar to when it was initially played, except for a slight loss of brilliance and lustre.

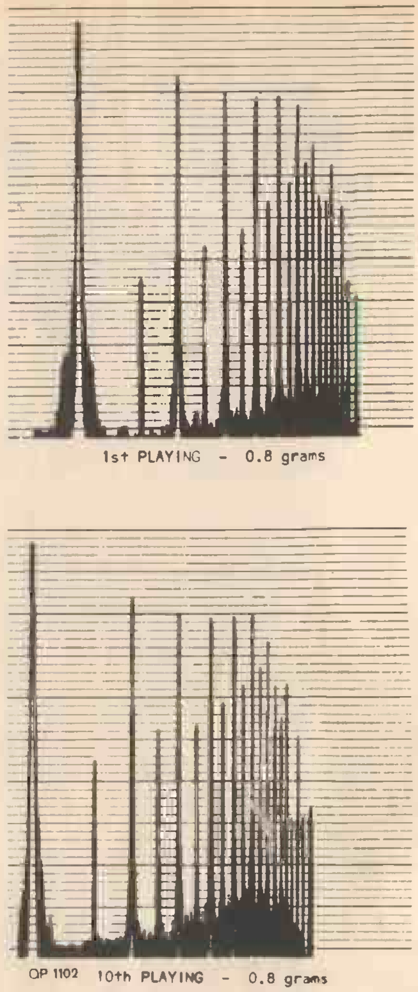


Fig. 1. Narrow Band Spectra of Square Wave Test Record on 1st playing and 10th playing with tracking weight of 0.8 grams.

The conclusions that we have drawn from this are as follows:—

1. To minimize record wear and to obtain quality reproduction, do not set any cartridge tracking weight below the *middle* of the range recommended by the manufacturer.
2. It is preferable to track at a slightly higher tracking weight than optimum, if the tone arm is not one of the best available.
3. The damage done to a record by dust in the grooves or by a dirty stylus, or by a poorly profiled or badly worn stylus, is far greater than that which will result from playing the record under optimum conditions. ●

GET A 4th TV CHANNEL NOW

Last month we described how to improve reception on UHF. Keith Pitt now concludes with this UHF aerial preamplifier that you can build yourself.

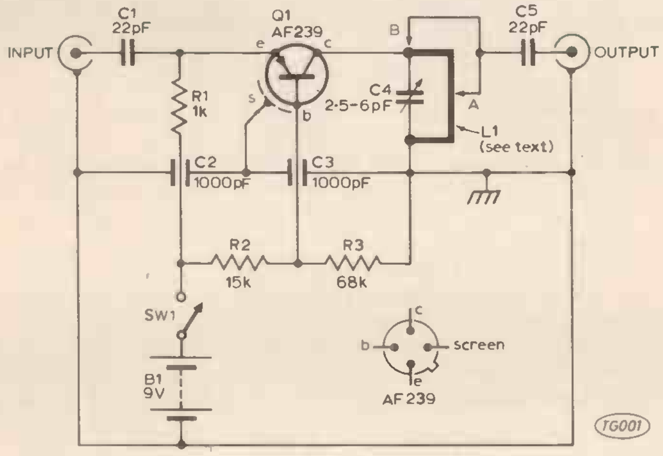


Fig. 1. The circuit diagram of the UHF preamplifier

As described previously in this issue, a preamplifier can raise a low television signal input to a level where a useable picture is obtained. Most modern sets are extremely sensitive and the minimum useable signal is quite close to the background noise. However, in many cases, extra gain from a preamplifier can help to make results more acceptable. The first necessity is a good aerial with as short a run of UHF cable as possible. Ideally, the preamplifier should be at, or close to, the aerial. This, however, is generally a professional installation job. Nevertheless some benefit is usually obtained even when the amplifier is close to the set. This article contains constructional details for a self-contained preamplifier that can be mounted on the back of the television set. The cost of components including VAT is probably about £2, but prices vary between suppliers.

CIRCUIT

Although modern silicon NPN transistors can have very high cut-off frequencies in the lower gigahertz range, allowing low-noise broadband common emitter amplification, they are expensive and often difficult to obtain. For these reasons the germanium PNP AF239 is preferred. The price is usually under 50p. It operates well up to the top of the UHF bands when connected in common base. The emitter receives the input via a ceramic capacitor C1. The output is taken via a similar circuit in the collector lead. The base is at chassis potential to R.F. via a feed-through capacitor C3. The resistor network, R1, R2, R3, provides the bias for the transistor. The battery supply is decoupled by a second feed-through capacitor, C2.

All the components except C1 and C5 are mounted on a small tinplate sub-chassis which can be soldered. This is then bolted into an aluminium box. The chassis is connected to the negative side of the battery. At UHF stray capacitance and inductance from the leads can upset the operation of the circuit, hence all connections are made as short as possible. Careful separation of output and input to avoid instability is also needed. The sub-chassis divides the space in the box into three parts; the largest contains the on/off switch and battery. The two smaller screened sections contain the majority of the circuit except R2 and R3. The input region is made very small to minimise stray inductance. The size of the box was chosen to enable a PP6 battery to be used with a long life on the very small current drain of the preamplifier. This results in the output enclosure being larger than would otherwise be necessary.

The collector, while at D.C. chassis potential, is maintained above this to R.F. by the coil, L1. The circuit is tuned by a small trimmer, C4. This is Henry's Radio type "C2", nominally 2.5-6pF. Most other trimmers have too high a minimum capacitance to allow tuning of the top of band 5. If trouble is experienced here, then type "C1", slightly lower in value, can be used instead for channels 5-68 only. The maximum will not tune the lower channels. The length of collector lead soldered to the coil produces the correct inductance for the UHF bands. The trimmer is soldered from earth to the junction of collector and coil.

The output is taken from a tapping on the coil via C5. The impedance of the output will vary according to the position of the tapping. It will always be a mismatch to the 75 ohm output.

PARTS LIST

R1	Resistor	1k	5%	¼W
R2	,,	15k	,,	,,
R3	,,	68k	,,	,,
C1	Capacitor	22pF	ceramic	
C2	,,	1000pF	ceramic feed-through	
C3	,,	1000pF	ceramic feed-through	
C4	,,	2.5-6 pF	trimmer (see text)	
C5	,,	22pF	ceramic	

Q1 AF239

L1 See Fig. 4. Made from 1 3/16ins of inner conductor of coaxial cable.

SW1 Single pole on/off switch.

2 coaxial sockets, battery connector, aluminium box (Norman AB8) 22swg tinplate sub-chassis, 3¾in x 2 5/8in, low-loss coax (for lead to set).

This mismatch is deliberate in order to broaden the bandwidth and make the amplifier cover more channels without altering the setting of C4.

Two alternative tappings are shown in the circuit diagram. Tapping A is approximately half way along the coil. High gain results but only over one or two adjacent channels for any setting of C4. This is acceptable where the preamplifier is required for only one particular channel such as a neighbouring ITV station. For more general use a tapping at B where the trimmer, coil and collector lead join is better. In the prototype this broadened the bandwidth sufficiently to give above unity gain over about 15 channels. If instability should result on any channel, then a resistor from about 2.2k ohms down to about 100 ohms connected across the output socket should effect a cure. The value should be as high as possible compatible with a cure.

No direct measurements of gain were made, but connected at B, the preamplifier gave a very visible signal increase on all the channels available in the author's district, 24-63. If the higher channels do not show a similar gain, a change to trimmer type "C1" should solve the problem.

CONSTRUCTION

An aluminium box type AB8 from the widely available "Norman" range, (Norman Rose Ltd), was chosen to permit the use of a PP6 battery. Input and output coaxial sockets are located in convenient positions near the top of the box to allow as much room as possible for the components. The output socket is positioned so that a hole can be drilled alongside it in the case wall to allow a screwdriver to trim C4 while the amplifier is operating. The box measures 4 in x 4 in x 1½ in. A tin-plate sub-chassis holds all the components, 22s.w.g. is convenient, but any solderable sheet that can be cut and bent to shape is acceptable. Although the position of the holes is not critical, the dimensions in Fig. 2 are those found suitable in the construction of the prototype. The transistor is mounted in a 5/16 in hole in the chassis with its emitter and base leads in the input compartment and the collector in the output section. The screen is folded back at 180° to its original position and is carefully soldered to the chassis using a heat sink, such as a pair of pliers. The size of the holes for the feed-through capacitors must be determined for the components used as they vary from type to type. (One of these decouples the power rail and the other grounds the base to R.F.). After the holes have been drilled, the

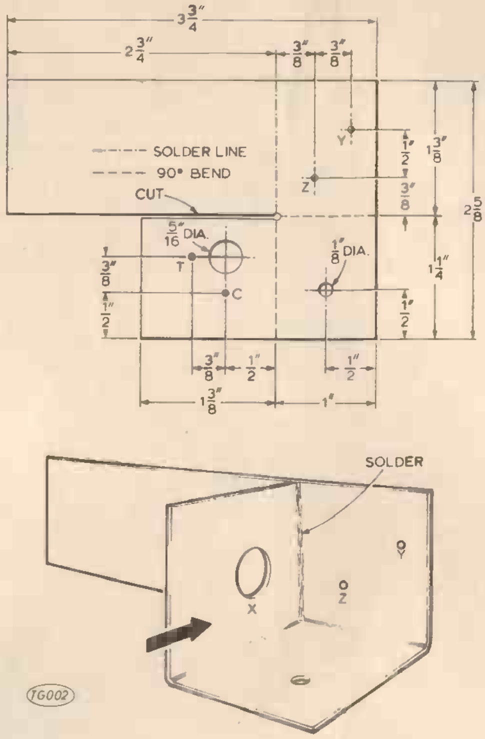


Fig. 2. Construction of the sub-chassis. Any solerable sheet can be used (even a tin can!)

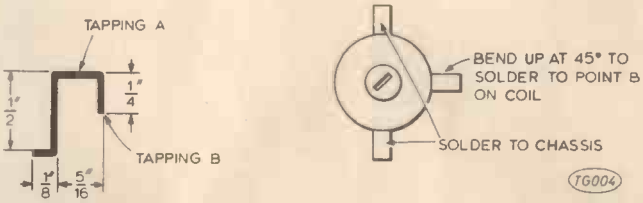
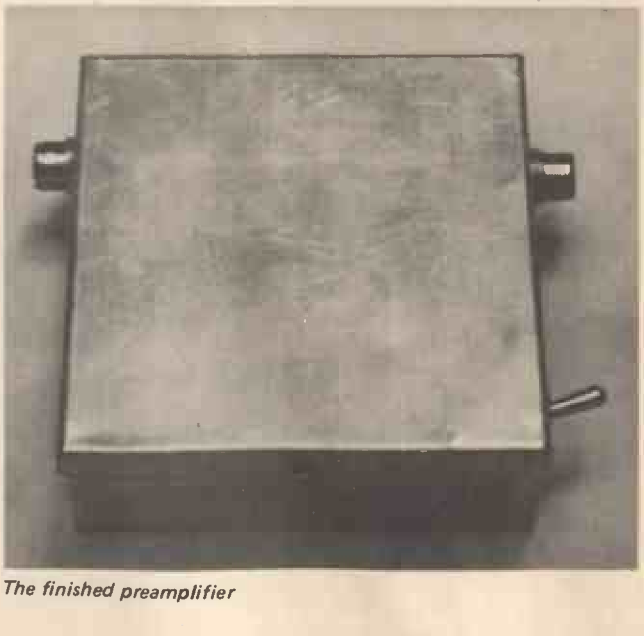


Fig. 4. The construction of the coil, made from a 1 3/16in length of the inner conductor of coaxial cable. On the right is shown the preparation of the trimmer, C4, which is soldered above the transistor



The finished preamplifier

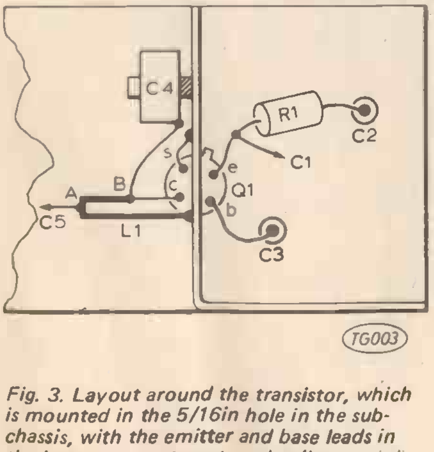


Fig. 3. Layout around the transistor, which is mounted in the 5/16in hole in the sub-chassis, with the emitter and base leads in the input compartment, and collector and screen to the output compartment

GET A 4th TV CHANNEL NOW

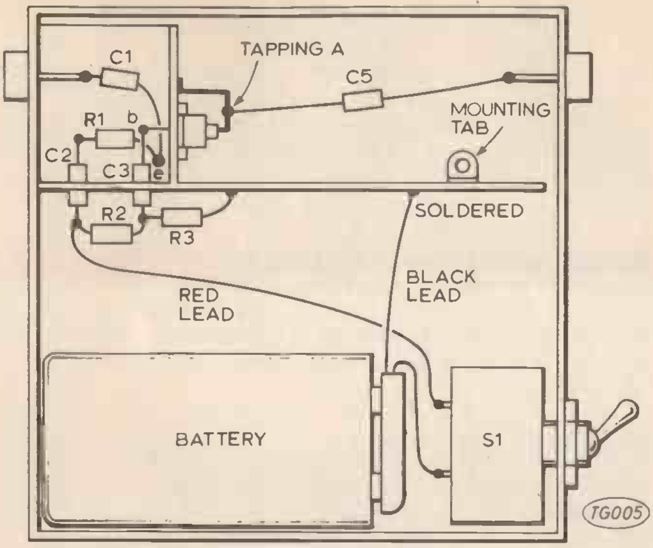


Fig. 5. Complete layout, with C5 connected to tap A (for high gain on a narrow bandwidth)

chassis is cut and bent as shown in Fig. 2. The bent-up wall of the input section is soldered to the long wall to give mechanical stability. The chassis is bolted to the case by two 6BA screws, One goes through both the box bottom and the tin plate at any convenient position in the input area. The other locates a small tab of tin-plate which is then soldered to the unsupported back wall of the chassis to give further strength. All these holes should be drilled and a trial assembly made before removing the sub-assembly to mount the components.

ASSEMBLY OF COMPONENTS

Fit the two coaxial sockets to the case and also mount the on/off switch. In the prototype this was a dtdt type used as a single pole on/off switch so that the battery with its clip just pushed snugly in place without any other support. However, any convenient switch may be used and double-sided tape used to hold the battery down.

Returning to the sub-chassis, first solder the two lead throughs, C2 and C3, and the two resistors R2 and R3 which go on the outside. R2 joins C2 to C3 and R3 is soldered from C3 to ground as close to the post as possible. Next mount the transistor. Always use a heat sink on the lead to avoid the risk of damage due to overheating. Fig. 3 shows how the leads are bent. As shown the base is soldered directly to the inner tag of C3. R1 is taken as directly as possible from the end of the emitter lead to the post of C2. The collector lead is bent so that it is vertical to the mounting wall. The coil made as shown in Fig. 4, is soldered down so that its ¼ in length is in the same line as the collector. The collector lead is cut so that the two form a butt joint, point B. The trimmer C4 has its central lead bent up at 45° to the other two feet. It is soldered to the chassis by these feet so that the bent up tag exactly joins the butt joint of coil and collector. C1 and C5 are not attached until the sub-chassis has been mounted in the main box. C1 has very short leads cut to suit the locations of the socket and the joint of R1 and the emitter. One end of C5 is soldered to the output socket and the other to either position A or B on the coil. The values of C1 and C5 are not critical, they only need to be low impedance to R.F. The first prototype used 1000pF ceramic, but the version in the photograph employs 20pF tubular ceramics with no visible difference in performance.

*The photograph shows the inside of the finished preamplifier. Here **C5** is connected to tap B (for reasonable gain on a wide band-width).*

When propagation conditions are right it is possible to pick up more than one extra TV station. This picture shows a transmission from Holland on UHF picked up in Southern England, using a good aerial in conjunction with an aerial preamplifier almost identical to the one described here

Output to the set is taken by way of a low loss coaxial lead. The length is not critical but it should be at least 1 ft. long.

Figure 5 shows a general view of the preamplifier with the lid removed.

RESULTS

The prototype gave a very visible gain on all the channels available at the author's location. Using tapping A, for any given setting of C4, above unity gain was only obtained on one or two adjacent channels. Using tapping B a reasonable gain appears probably over all the channels of a given transmitter with the possible exception of some of those requiring an exceptionally broad bandwidth.

AVAILABILITY OF COMPONENTS

The Norman range of aluminium boxes is widely available from component stockists. The AF239 transistor is also widely available. ●

SURVEY OF COMMERCIAL PREAMPLIFIERS

Not all of our readers will want to build their own preamp. There are a number of models available from commercial manufacturers at reasonable prices. Four examples are illustrated below. When required to specify the relevant channel group, quote 'A' for channels 21-33, 'B' for channels 39-51, and 'C-D' for channels 51-68.

THE TDL 'KING' TELEBOOSTER

This is a set side preamp, mains or battery powered (2.3mA consumption). Specify range 'A', 'B', or 'C'. Prices £6.50 (mains) and £4.17 (battery) plus 9p p&p.
From *Transistor Devices Limited, Claremont House, 6 Orchard Gardens,, Teignmouth, Devon.*

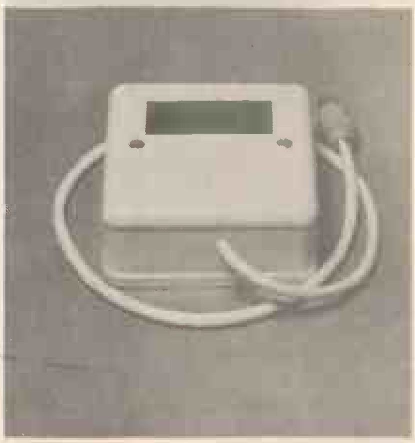
THE LABGEAR (PYE) CM6000

This is a masthead preamp, operating from a 16V 3mA supply (from the CM6001/PU). There is also a set-side version (CM6017). There are three models for 'A', 'B' and '**CD**', giving 17dB gain. The wideband preamp, CM6019, covers all UHF channels with 10dB gain. Prices £5.25 (CM6000) £4.62 (CM6001/PU), £4.18 (CM6017) and £8.40 (CM6019 with CM6020/PU) From *Labgear Ltd. Abbey Walk, Cambridge.*

THE ANTIFERENCE MA101

This is the masthead version, operated from the PU101 supply. The BSA201 contains the preamp from the MA101 and mains power supply in one housing for set back mounting. The respective gains for the models 'A', 'B', and 'CD' are 17dB, 15dB, and 13dB. The Prices £5.24 (MA101), £4.62(PU101) and £7.00 (BSA201); these prices are exclusive of VAT. Available from *Antiference Ltd., Aylesbury, Bucks.*

THE VELCO B45



(Similar in appearance to the model illustrated). This preamp is tunable over the UHF band, and is powered by a PP3 battery. The price is £3.25 plus 10p p&p.
From *Electronic Mailorder Ltd., 62 Bridge St., Ramsbottom, Lancs.*

PROCESSORS, PROGRAMS AND PERIPHERALS

John Talbot continues his introduction to computers

PAGING

The most straightforward way of addressing locations in a core store is to give each location a unique reference number and to use that same number when gaining access from any point in the program. This is not practicable in a small machine because of the conflicting requirements of restricting word length, for economy reasons, and including operational information in the same word as the address. Some shorthand method of addressing is needed.

Using a computer for scientific work at the Pressed Glass Division of Pilkington Bros. Limited. The plant is manufacturing face photos for television picture tubes, (Courtesy Digital Equipment Co. Limited.)

It is customary to break up the memory into 'pages' of a few hundred words; one bit of each word is used to select either the current page (the page which the program is working through at the time) or a *common* page (the first page of the store), so one instruction can contain the address of any location on either of these pages. Each location on the common page contains the full address of another location on any other page to which the program might require to jump. Thus a jump from page 2 to page 4 is carried out by *indirect addressing* via page 0. The incidence of snakes and ladders often calls for machine-level gymnastics involving many pages so that linkages between pages must be introduced during high to low level program translation.

LIBRARY, OR STANDARD, ROUTINES

Allowances must also be made for the insertion of library routines. These are low-level sub-programs that are complete in themselves, yet have been designed as appendages for high-level programs. When the FORTRAN programmer wants to find the square root of a number he simply writes one statement, SQRTF (X). This is easy for the man but impossible for the machine, which requires a score of instructions to enable it to solve this one simple problem. This set of instructions is generated automatically by the square root library routine when called by its name, SQRTF.

A full set of library routines is provided with the computer and, in the case of many small machines, is read from punched tape during the translation process. The source program is checked automatically and the relevant routines are extracted and attached to the main program, while others are ignored.

As the source program is fed into the machine initially the need for certain library programs is detected automatically. But the software system has no means of knowing the length of the source program until the end is reached and therefore cannot know where in the computer's memory the library routines will finally be placed. So how can the user's program find its way around the library? At the top of page one of the computer's memory one address is reserved for each of the available library routines *before* the source program is taken in. As the source program demands each library it is given the appropriate address on page one, although at the time that address contains nothing. When the program is safely in store another special program, called a linking loader, accepts the library routines and notes the address of the first instruction in each. It then places this address in the appropriate page one address. This means that the main program, whenever it needs a library routine, must look on page one to discover where that routine has been stored and then go to this indirect address in order to continue working. (See Figure 3). Of course, the main program must 'write down' where it has got to in order that the computer does not get lost at the end of the library routine and knows the point to which it must return.

This description of the FORTRAN translation process provides a clue to the way in which programs at different levels may be linked together. The programmer working in assembly language does not have a set of library routines provided as a matter of course, but as time passes he can accumulate his own library of subroutines. These enable him to deal with common programming situations without the need to devise a new set of instructions for each occasion. Later, if he is writing in a high-level language but feels the need to introduce an especially useful machine-language subroutine then he can do so.

At the present stage in the development of software there is no likelihood of low-level languages being ousted by high-level, or vice-versa. The slow speed of operation and poor memory utilisation of high level programs was mentioned earlier. Even if speed is unimportant to a particular user a program in ALGOL, say, as opposed to assembly language, may necessitate the purchase of extra core storage at considerable extra expense. However, this may be preferable to the long-winded and expensive process of writing a lengthy, special purpose program in assembly language. Again, if a low-level program that can be adapted to meet the new requirement is already in existence and can be purchased from the originating computer bureau or software company at reasonable cost then this would be the best approach.

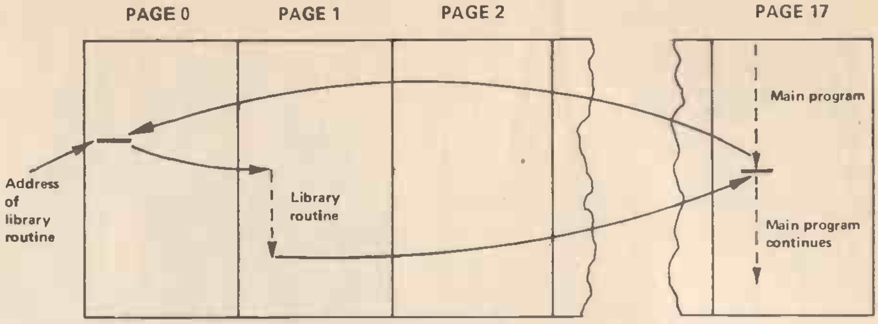


Fig. 3 Illustrates how access is gained to library routines from the main program — a method employed in a number of popular small machines

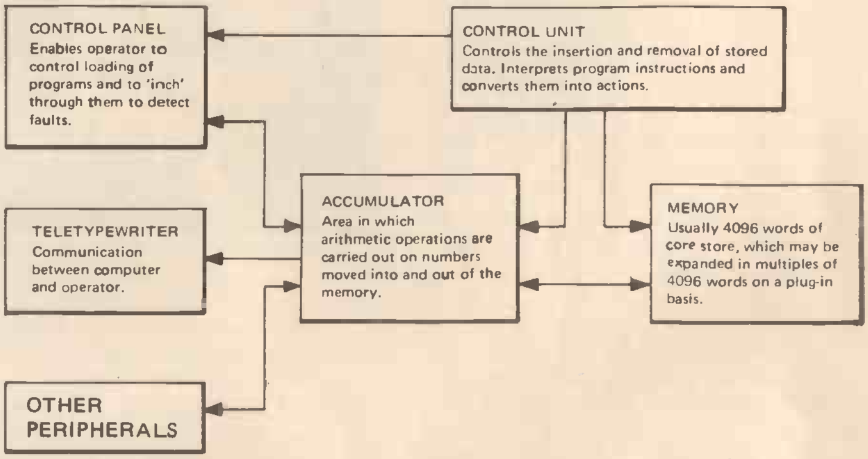


Fig. 4 Simplified block diagram of a mini-computer

This computer, installed at a large car showroom in Glasgow, is used to correlate spare parts stocks with counter sales and workshop spares consumption.
(Courtesy Digital Equipment Co. Limited.)

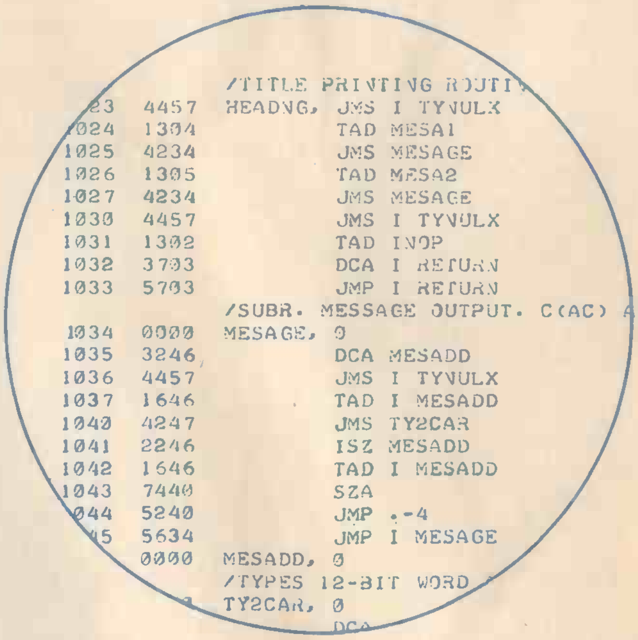


Fig. 5 An assembly language program as it appears on the computer print-out following compilation, with (left column of figures) addresses and (right) coded instructions

INTERRUPTS

There is one key factor that may tip the scales heavily in favour of low-level and this is the need to handle interrupts. This requirement often arises when data is being accepted from or fed to a peripheral machine, such as a teletypewriter, whose maximum operating speed is dictated by mechanical factors. Most teletypewriters work at

10 characters per second whereas a digital computer takes, typically, 3 microseconds per instruction. It is clear that most of the computer's time will be wasted in waiting if a long sequence of characters is to be printed out. This can be overcome by placing a character to be printed in an output buffer (a temporary store) which the teletypewriter can interrogate, while releasing the computer to do some other work. When the output machine is ready it energises a wire (*'sets a flag'*, in computer parlance) to request the next character. The computer detects the interruption, shelves its secondary task, issues the required character and then returns to its secondary job. We say that the output device has *'generated an interrupt'* and the interrupt has been serviced. A similar process takes place if the operator has received a message from the computer requesting data. In reply, he strikes a key which energises the interrupt line, the computer completes the current instruction and then reads the character.

An especially important interrupt is the mains failure interrupt. Additional hardware is added to the computer which can detect an impending mains failure in about a millisecond — before the computer power rails begin to collapse. In that millisecond the machine must shut down in a properly organised manner; it must hastily shove all volatile data into store (where it can be found again!) and then go to a prescribed address from which it can emerge, without loss or corruption of the program, when the power returns.

The program may have to accept interrupts from many sources — teletypewriters, measuring instruments in a process plant, even other computers. A small computer may have to service 50 or more interrupts from peripheral machines and, in theory at least, they could all request or present data simultaneously. Just as an adept juggler attempts to keep all of his balls and clubs in the air at all times so the computer program must be organised so that as many devices as possible are used efficiently and are not kept waiting.

The housewife and mother establishes an interrupt-priority routine when the front and back doorbells, the telephone bell and the cooker alarm all sound simultaneously when she is changing the baby. She completes the current instruction (changing the baby), stores the fact that this is the point that she has reached in the daily program, then services the interrupts in turn according to their likely urgency.

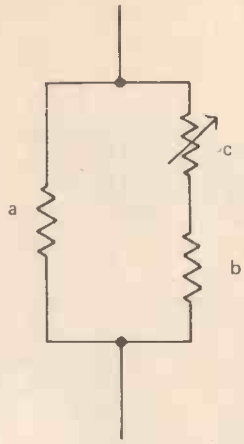
The use of interrupts implies that two programs must be in use at once, sharing the available time. This is incompatible with the high-level philosophy of serial processing. In general, only the more advanced forms of FORTRAN can operate in an interrupt environment and even then some compromise is necessary. There are no instructions that can handle inputs and outputs directly: these services are only available via library routines. An anomalous situation can arise if the interrupt demands a library routine which is already in use, perhaps overwriting data relating to the main program.

The importance of the interrupt fa-

A Minic Computer in use at the laboratory of the Government Chemist. For analysis of the weight and moisture content of cigarettes and tobacco. This all-British computer was one of the first to use the "firmware" concept, in which the programming is simplified

A Minic microprogrammed computer being tested for an installation in Germany. Here the operator communicates with the machine via an IBM 'Golf-ball' Typewriter. (Courtesy Micro Computer Systems Limited.)

Equipment for experimental work on photo-elastic models at the University of Surrey, including a 'Minic' mini-computer and, above the computer control panel, a magnetic tape storage device using an improved version of the familiar domestic cassette mechanism.
(Courtesy University of Surrey and Micro-Computer Systems Limited)



Minimum resistance = $L = \frac{ab}{a + b}$

Maximum resistance = $H = \frac{a(b + c)}{a + b + c}$

Fig. 6.

Fig. 7. A BASIC program which choses values for the resistors a) and b) in Fig. 6. given the value of variable resistor c) and the desired resistance of the network at the two extremes of adjustment of c)

```
10  PRINT "INPUT MIN RES, MAX RES, POT RES (OHMS)"
20 INPUT L, H, C
30 LET D=SQR((C*(L-H))↑2+4*(H-L)*C*L*H)
40 LET B=(-C*(H-L)+D)/(2*(H-L))
50 LET A=B*L/(B-L)
60 PRINT
70 PRINT "MAIN R";A,"POT SERIES R";B
80 PRINT
90 PRINT"IF FURTHER DATA TYPE1, ELSE 0"
100 INPUT V
110 IF V=1 THEN 10
120 END
```

cility becomes yet more apparent as we examine another essential feature of the modern digital computer-expandability.

THE SIGNIFICANCE OF ACCESS TIME

Core storage has the virtue of random access: any location on the current page can be reached with equal facility within one machine cycle (typically 3 microseconds) and any location in the memory can be reached within 2 cycles. Most small machines can be expanded from the normal minimum of 4096 words (4K, for short) in blocks of 4K up to 32K, but this can be a costly business. At some sacrifice in flexibility mass storage devices such as magnetic tape, discs or drums can be used instead. A 2400ft reel of tape recorded on 9 tracks at 800 bits per inch stores 80 million bits, approximately. This is equivalent to over 6 million words of 12 bits each on a reel of tape which may be only one of many in a library.

Magnetic tape has several shortcomings — notably it has long access time. It may take several minutes for the computer to search through the reel for the information it seeks. However, other work may be undertaken while the search is in progress, the tape interface requesting an interrupt when the data becomes available.

Data may also be stored on the surface of a magnetic drum revolving at 7000-25000 r.p.m., the longest access time being the time taken for one revolution of the drum. Similarly, a magnetic disc can store over 200 million bits of data with a maximum access time of 70 milliseconds. In general, the type of work to be carried out dictates the choice of additional storage devices. Even if a program contains full interrupt facilities it would be foolish to allow lengthy direct transfers between peripherals having incompatible transfer rates. To take an extreme example, the transfer of the entire contents of a disc to a teletypewriter would take over 70 hours! However, one computer could make use of these two devices quite efficiently if the disc was used to store a large amount of statistical data from which a few facts were to be extracted and printed at 10 characters per second.

The design of computers is ever changing and the advent of compact memory modules fabricated by the use of integrated circuit techniques has reduced the space occupied by a minicomputer by about 70% in five years. Magnetic tape storage is being influenced by the development of low-cost cassette recording systems, based upon the less robust but very simple domestic cassette tape recorder. The relatively expensive, unreliable and complicated keyboard/printing devices are an obstacle to wider computer usage, but the solution to this problem will come in time.

There is (or should be) a rider to Parkinson's Law, stating that the work presented to a computer expands to occupy fully the facilities and hours available. Once a machine has been installed and set to work it is not long before people's imagination is captured and all sorts of investigations previously considered impractible suddenly assume a new importance. After a few months have elapsed the new user finds himself at the end of a long queue and the machine time he is allocated falls between 2 and 4 a.m.! If, as often happens, some time after installation an unforseen combination of circumstances occurs and reveals a defect in the software then the programmer will find that everyone wants him to modify the program yet no-one wants to allocate him any machine time in which to do it! ●

eti INPUT GATE

LETTERS FROM OUR READERS

BUGS

I wonder if you could send me addresses of firms which can supply bugging devices and also where do these companies advertise? —M.Y. Lancs

Sorry, but we will not supply such information; we do not want to encourage any form of bugging and passing on such information would, in a small way, be encouraging such practices. As a magazine we do not accept advertisements for such devices.

There are a number of companies in this country, operating quite legally, who either manufacture or import (usually from the United States) various bugs; however the use of these devices is nearly always illegal and where it is not it is usually immoral. We have from time to time inspected a number of these devices; they are almost invariably designed to operate on illegal frequencies, have a very limited range (usually only a few feet) and are very expensive.

If you want to know something, why not ask rather than rely on eavesdropping, you probably won't get an answer (you wouldn't have to use a bug otherwise) but if this is case, surely the person has a right to their privacy.

OH DEAR!

I bought the May issue of Electronics Today International and didn't understand a word of it. —F.O'D. Dublin

We all have our problems.

OVERSEAS EDITIONS

I see from your leader page that there are ETI editions in France and Australia. I would be interested to know if these magazines are identical to your magazine or is only the name the same? —R.G. Chelmsford

Each of the ETI editions operates independently but within a pretty close framework. The British edition carries a number of features prepared by the overseas editions and they in turn use some of our articles.

A number of articles are planned internationally with each edition contributing to the feature. We are unique in this aspect as we have far more sources of information to draw on than any other electronics magazine. One feature, which will be published in the near future, has contributions from all three editions plus information from ETI's correspondents in the USA and Japan. Although we have this international flavour, each edition carries a substantial proportion of material only applicable to the home country, in fact we only carry each others features when the article is of a truely international nature.

AMPLIFIER KITS

I plan to build my own amplifier for an electric guitar. Ideally this should be not more than 10W power.

However I have very little knowledge of electronics and so I would like to know if you can help me by giving me details of any companies which offer amplifier kits for beginners. —D.P. Co. Durham

There are very few companies who offer kits of modern amplifiers but there are some, such as Heathkit. However there are a large number of companies who sell amplifier modules, which are usually the output stage which requires between 100mV and 1V in. The reason why there are few is because of the problems that can occur; modern circuits are excellent but many have the disadvantage that they are d.c. connected throughout and the smallest error can lead to every transistor blowing.

Companies offering these amplifier modules (which usually require a separate power supply) include Bi-Pak, Bi-Pre-Pak, Sinclair and Henry's Radio.

ETI P.C. BOARDS

May we through your columns offer our sincere apologies to those of your readers who have placed orders with our company for printed circuit boards, for the delays in delivery they have suffered.

Whilst nothing is less interesting than someone else's problems, a few words of explanation are, it is felt, in order. The poor service has been due to 4 prime causes:— (1) Initially some raw material supply problems. (2) Removal of premises. (3) Senior staff leaving — in fact the engineer responsible for E.T.I. boards. (4) The response to the advertisement.

Probably one or two of the above would have made no real difference — but all taken together . . . . The patience of your readers has astonished us, and we would like to thank them for this. We do know how disappointing it is to be delayed in the completion of a project by a missing part.

Readers will, however be pleased to note that the situation is now rapidly normalising, and no delay is anticipated on future orders. The total backlog should have been caught up by the time the current issue of the journal is in print.

—John Schofield, Schofield Electronics

WOW AND FLUTTER FIGURES

I hope we are not approaching a situation parallel to R.M.S. watts!! I quote from the instruction books of three cassette recorders:— (1) 'Wow & Flutter . . . Less than 0.12% W.R.M.S.', (2) 'Wow & Flutter . . . ⩽ ± 0.4% measured with EMT 420', (3) 'Wow & Flutter . . . 0.6% DIN'.

I can only hope these are different ways of saying the same thing! But are they? I always understood Wow and Flutter to be a measure of the deviation from the ideal. I presume W.R.M.S. is a weighted figure. I have met these weighted figures in relation to signal to noise ratios, and in this case they are never so good as the normal S/N ratio, so I assume quoting a weighted figure will have a considerable effect on the Wow and Flutter specification. If this is so, perhaps there is a rule of thumb for converting weighted to unweighted W & F figures.

I do not understand the other two ways I found W & F to be specified — as the percentage measured by the EMT 420 and as a percentage DIN.

May I take this opportunity to express my appreciation of your journal, as a retired Radio Engineer, it keeps me abreast with the times.—A.C.W. Staines

It has been suggested that the DIN figure is an old African unit. One DIN is the noise generated by 100 average drummers (available on loan from Bush Telegraph Co.), so 0.6% DIN is slightly louder than one drummer with one hand tied behind his back. ●

TWO MAJOR FEATURES IN NEXT MONTH'S ETI

BUILD THE ETI

Electronic Transistorised Ignition

A thoroughly tested project which is going to be a winner. This new, economical design will give the definite advantages of easy cold starting, very long life for plugs and points, freedom from oil fouling of plugs, plus worthwhile improvements in engine smoothness, performance, m.p.g. and pollution. Modern plastic power transistors and a specially designed inverter transformer are used in a thyristor capacitor-discharge circuit which is compatible with both positive and negative chassis cars and features an "all-well" lamp, easy switchover to conventional ignition plus a built-in burglar foiling facility.

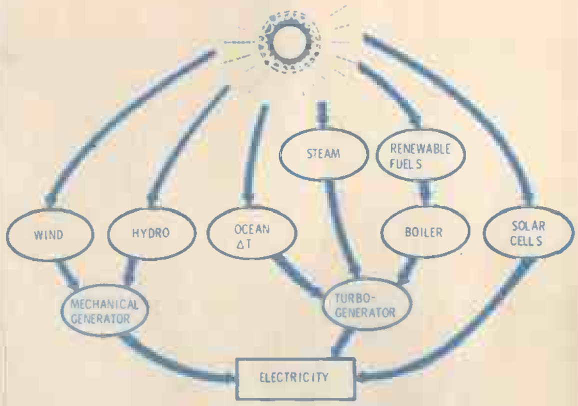
And there's more! We have arranged for a complete kit to be available at less than £8 but for ETI readers only there will be a £2 voucher, available for a limited period, enabling you to buy this for less than £6 including postage and VAT! And there's more! A built, tested, guaranteed model will also be available, again at an unbeatable price using the special voucher. These offers are genuine and will last for a limited period.

THE

SOLAR SOLUTION

—IS IT THE ANSWER TO THE ENERGY CRISIS?

SOLAR ELECTRIC POWER



In the last few months it has dawned on the world that oil is running out. Even optimistic forecasters now believe that oil will cease to be our main source of energy within 15 years. Vast new reserves of energy will be required to satisfy our continually increasing appetites.

What is the solution? There is plenty of coal but this is also a diminishing resource and presents problems. Nuclear power will probably take over eventually, but very serious problems remain; although nuclear power stations have been used for 20 years they have still to prove themselves.

Could sun power step into the gap after the oil runs out and before nuclear power takes over? ETI have been compiling a major feature for months — and we will be reporting on a variety of schemes being tried around the world.

Proposed methods vary enormously for harnessing the power of the sun; these range from a vast satellite to the redesign of our homes.

Next month we take an overall look at these problems and possible solutions.

PLUS TIMTRONIC

A DIGITAL ALARM CLOCK PROJECT

Advances in LSI technology have brought about the introduction of inexpensive clock chips. Next month we describe a project using one of these latest chips which not only gives the time but is an alarm clock complete with a "snooze circuit". If you doze off after it sounds, it will give you a reminder after 7 minutes, and again after another seven minutes until you get up.

A complete kit, including p.c. board and case will be available to make a superbly styled digital alarm clock that will grace any home.

WHAT TO LOOK FOR IN SEPTEMBER'S

electronics today INTERNATIONAL

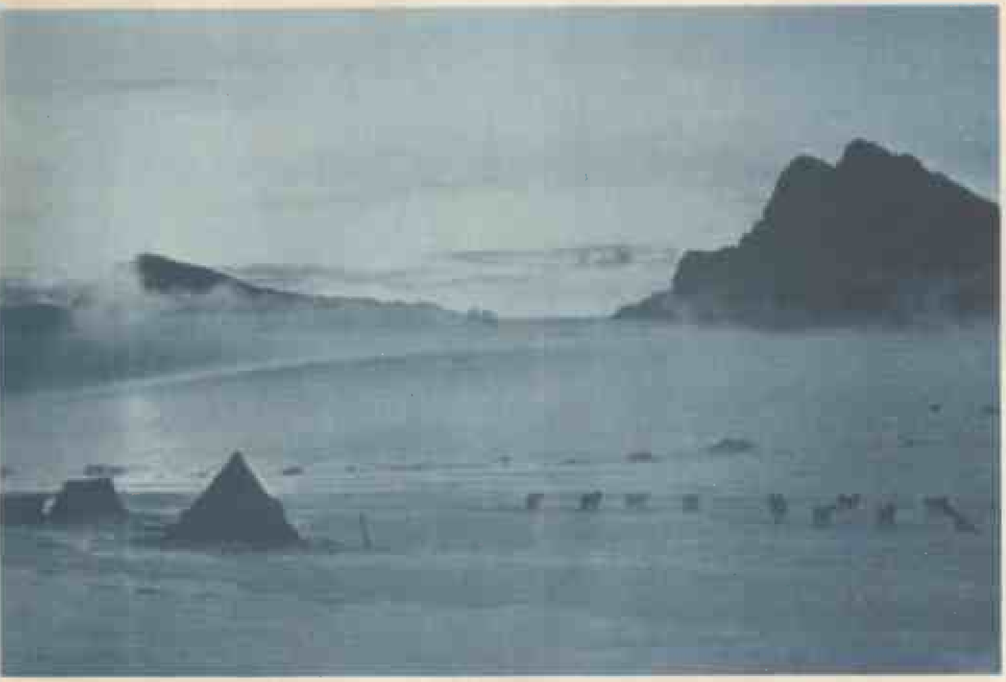
ON SALE MID-AUGUST — 20p

ETI TAKES A PRIDE IN BEING REALLY UP-TO-DATE, SO WE OURSELVES DO NOT ALWAYS KNOW WHAT WILL BE IN THE NEXT ISSUE SO THE FEATURES MENTIONED ON THIS PAGE ARE ONLY SOME OF THOSE THAT WILL BE INCLUDED.

Cryogenics and superconductivity

THE SEARCH FOR THE COLDEST COLD.

by Dr. Peter Sydenham Ph.D., M.E., M.Inst. MC.



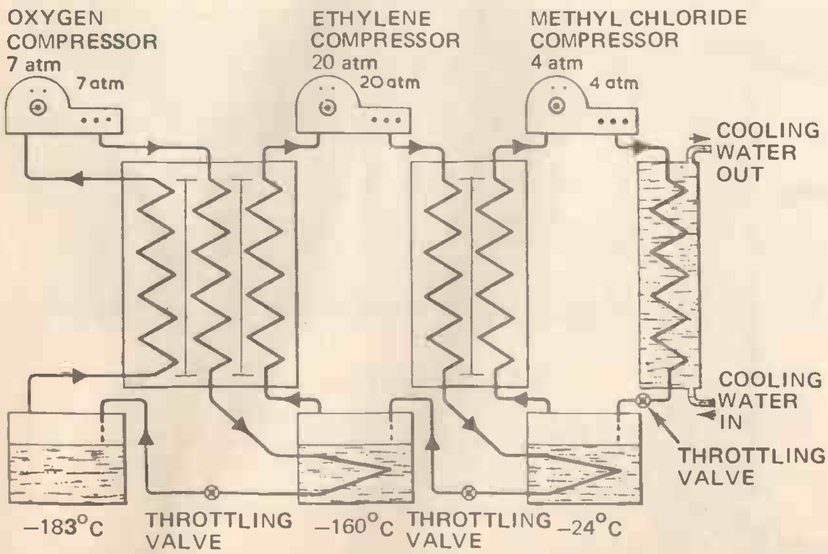
PURE RESEARCH involves expeditions into the unknown — to be somewhere or do something never accomplished before always carries with it the chance of a significant discovery that will eventually alter the current practice for the better.

The story of cryogenics and the quest for the coldest cold is such a tale. Its commerical benefits, many of which were discovered without expectation of the remarkable and useful effects found near absolute zero, are just being realised after a century or two of patient and devoted research by many scientists. They each investigated some aspect of science not knowing the full implications of the collective nature of the whole.

Lavoisier, Cailletet, Charles, Amontons, Boyle, Maxwell, Boltzmann, Carnot, Claude, Wroblewski, Faraday, Kelvin, Onnes, Van der Waals, Andrews, Dewar, Plank, Einstein, Nernst, Joule, Thomson, Dulong, Petit, Weber, Debye, Bohr, de Broglie, Heisenberg, Born, Fermi, Dirac, Bose, Sommerfeld, Giaque, Curie, Mendelssohn, Simon, Shubnitkov,Kazarev, Meissner, de Hass, Voogd, Frolich, Bardeen, Cooper, Schrieffer, Bogolyubov, London, Keesom, Kapitza, Landau (apologies to those others omitted), each in his own way assisted the development of what was once pure research — the search for the coldest temperature — into a group of knowledge enabling technological science-fiction devices to be realised.

The uses of techniques that provide extremely low temperatures near the absolute zero are widespread, but it is only recently that far-reaching applications have been seriously considered. Fast logic for computers, suspension systems for high speed trains, magnets of enormous field strength for research, scope to build large capacity but smaller size power generators, determination of physical constants to increased precision, improved particle accelerators, a

Fig. 1. The method of cascades devised by Pictet can produce liquefied oxygen.



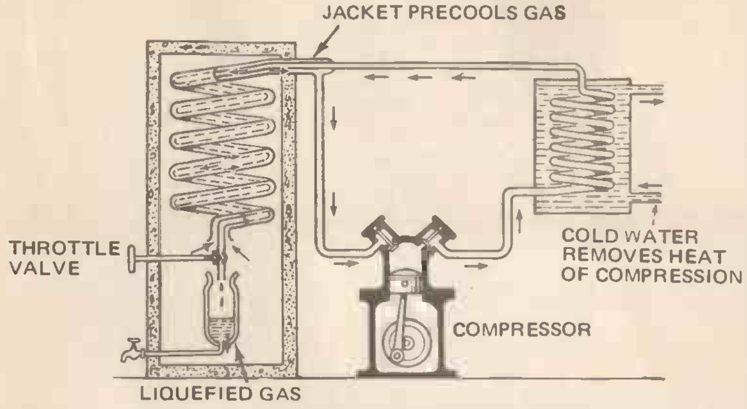


Fig. 2. Liquefaction obtained by the cooling of the release of pressure in the Linde-Hampson process is based on a principle devised by Joule and Thomson. They used a wad of silk instead of the modern expansion valve shown.

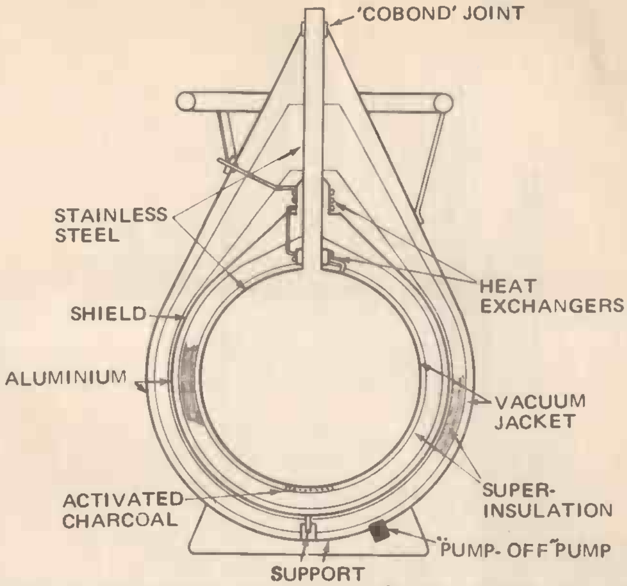


Fig. 3. A modern helium dewar. It holds 35 litres and loses only 1% per day.

suspension system for a gravity meter, low-loss small-size dc transmission lines, greater detection in missile seeking trackers, cauterizing and incising in medicine — these examples each make use of cryogenic techniques originally devised and improved by scientists and engineers.

COLDER AND COLDER AS THE DECADES PASS

In the 18th century Lavoisier (the scientist who demonstrated that teams of horses could not part two half-spheres held together by the effect of an internal vacuum) predicted from intuition that gases could be liquefied as the temperature was lowered. He was unable to prove this experimentally — that was the accomplishment of Cailletet and, independently, Pictet in 1877. Previous to this, most attempts to liquefy gas had been by increasing the pressure — not an easy method. Cailletet discovered the cooling effect of a gas expanding suddenly from a high pressure condition. Pictet devised a method, known now as cascade cooling, by which a liquefied gas was used to pre-cool another (with a lower boiling point) before the pressure was increased. Both Cailletet and Pictet managed to liquefy oxygen and thereby obtain 119°C of cold. This was a big step from the freezing mixtures that produced only 60°C of cold.

The cascade method is shown in Fig. 1. Compressed methyl chloride is cooled by a water jacket; it then expands through a throttle, cooling down to -24°C. This is then used to extract the latent heat of compression of the next, ethylene, cycle that in the same way produces a liquid at -160°C. Finally oxygen is used, being liquefied at -183°C. The method cannot be continued, for there is no substance having the necessary critical temperature and triple points to span to hydrogen.

Even before this time, Amontons, in the 17th century, had realised from observations made with an air thermometer (in which volume is related to temperature), that there seemed to be a lower temperature that could not be exceeded by any method.

It was a century before the concept was accepted after being formulated by Charles and Gay-Lussac. This lowest value was shown to be —273°C, and was subsequently called 'absolute zero'. A temperature scale — the Kelvin scale, starts with zero at this point and has the same subdivision sizes as the Celsius scale. Because this degree of cold had not been realised — liquefied oxygen was the best so far at around 90K — the search for means to liquefy other gases continued. However, it is doubtful that anyone expected to find the extraordinary behaviour of electrical conductors when the temperature came with a few degrees of absolute zero. At around 5K many conductors lose all trace of resistance to current flow and become superconductors.

A little time before the liquefication of oxygen, Joule and Lord Kelvin (Thomson) had conducted experiments in which a highly compressed gas was allowed to lose its pressure by passing through a porous plug. An apparatus using the principle is shown in Fig. 2. They found the gas flow emerged from the plug at a reduced temperature — this is now known as the Joule-Thomson effect. The extent of the cooling for each pressure change is not large, but by continued recycling of the gas it becomes progressively cooler. Linde and Hampson realised this in 1895 and Linde separated oxygen from liquefied air shortly after.

In this period — the late 19th century — the interest in cold was mainly for commercial reasons — refrigeration in ships (-40°C) for the Australian-British meat trade. Liquefaction of air (-185°C is needed) by Claude in 1902 and Linde was for the oxygen needed mainly in acetylene welding and cutting. In the 1920s Claude-designed expansion engines produced temperatures of -200°C, leaving only 73 degrees to go to absolute zero.

Mendelssohn — (whose book provided much of this historical detail — (see reading list) said that even in the 1930s there was little scientific application of these engines in industry. By 1946, however, the lowest critical temperature gas, helium (5K) succumbed to the expansion method at the Massachusetts Institute of Technology in the United States. This achievement followed the liquefaction of hydrogen at 33K. But this was not the first time helium had been liquefied. That honour goes to Professor Kamerlingh Onnes of Leiden for in June 1908 he produced a test tube containing a little liquid helium. The attempt used 75 litres of liquid air to liquefy 20 litres of hydrogen that in turn was used to precool helium producing 60 cubic centimetres of liquid.

The work of another scientist, James Dewar, paved the way to absolute zero by providing an efficient container for these cold liquids. Prior to 1892, when Dewar demonstrated the first evacuated jacketed flask, scientists had to put up with the rapid evaporation of their liquefied gases. Before this, liquid ethylene was used as a jacket around liquid oxygen — such containers became known as cryostats and the science of cold production as cryogenics. The vacuum flasks are now called Dewars in science. The cross

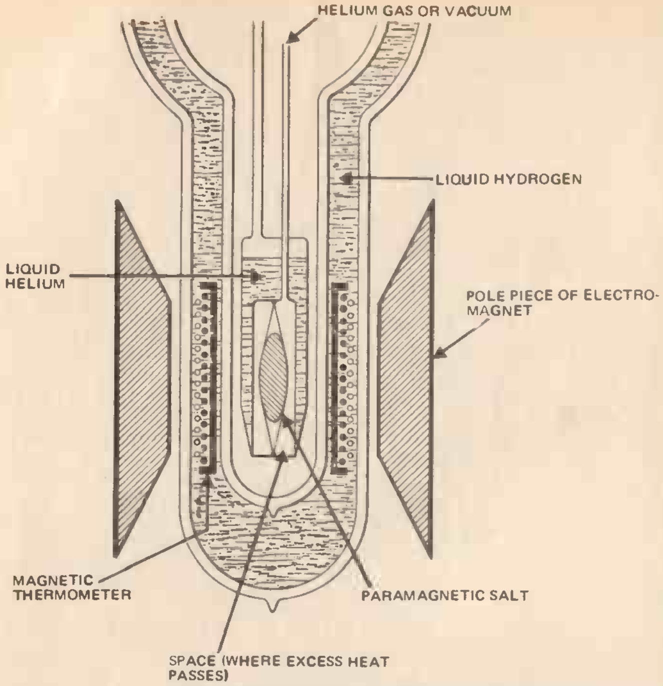


Fig. 4. Arrangement used in magnetic cooling. The salt and gas-surround are allowed to cool to liquid helium temperature. Magnetic field is applied aligning the electron spins. The gas is evacuated to remove excess heat. The field is then removed.

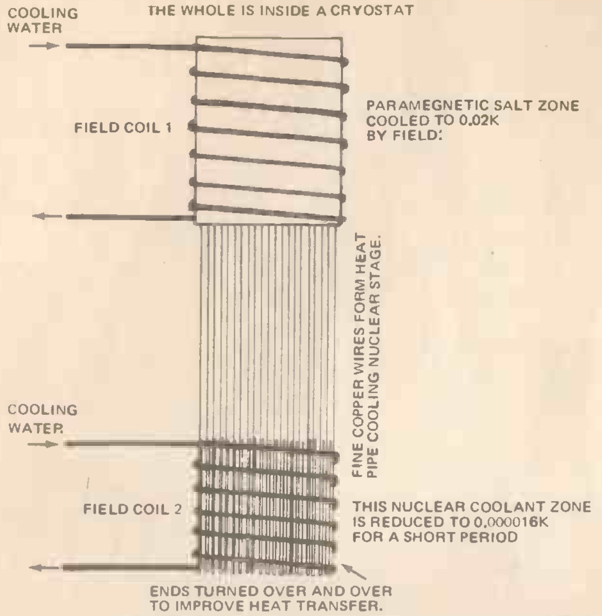


Fig. 5. Schematic of cooling method in which the spins of the nuclei are aligned (as devised at Oxford). The top stage is the electron-spin cooling stage; this cools the lower to 0.02K in readiness for nuclear cooling. The fine copper wires act as the cooling link. The second field is applied to align the nuclei spins.

section of a modern unit incorporating heat exchangers to further reduce the heat loss to only 1% per day, is shown in Fig. 3.

By the start of this century it was well established that OK was the lowest temperature attainable, and with only 5 degrees to go, many pure scientists continued their excursions into the unknown. Actually Onnes had obtained 1K by reducing the pressure on his small quantity of liquefied helium but he did not know it at the time. The unexpected property of superconduction had been observed but the lack of theory to predict such a departure must have deterred many a scientist from reporting his findings. Before considering superconductivity let us first complete the history of the search for ways to produce colder temperatures.

By reducing the pressure of helium its boiling point is lowered. In this way, using massive vacuum pumps, Onnes obtained 0.83K in 1922. This, most people thought, was the end for no lower boiling point gas exists. Onnes, however, did not hold that view, and he was soon proven correct. While Onnes was on his death bed in 1926 (and unbeknown to him), Giaque was experimenting at the University of California with an entirely new way to further reduce the temperature. It is now known as magnetic cooling.

MAGNETIC COOLING

In essence, magnetic cooling involves aligning the spins of the electrons orbiting the nuclei to obtain a more than usual degree of alignment. Salts of rare earths are suited to this; examples being gadolinium sulphate, cerium fluoride, iron ammonium alum, chromic methylammonium alum (CMA for short) and manganous ammonium sulphate (MAS). As shown in Fig. 4, the bath of salt is immersed in liquid helium which is held in a hollow enclosure that can be evacuated. The pole pieces of a powerful electromagnet are placed on each side, and the field used to align the spins. Theory predicts that heat must be liberated by the salt when the electron spins are so aligned for this is a state of less entropy (the degree of state of disorder). The spare heat goes into the gas around the jacket containing the salt; pumping then removes the gas and therefore the heat. The field is then removed and the evacuated chamber now acts as a cryostat holding the salt that is cooled to around 10^{-2}K or a little less. The method is also known as paramagnetic cooling after the magnetic property of salt.

In 1936 Shubnitkov and Kazarev discovered the existence of a similar paramagnetism involving the nuclei as well as the electrons. The effect is minute, so great effort was needed to invoke nuclei spin alignment as well, thereby obtaining even lower temperatures. In 1956, 2.10^{-5}K was reached with apparatus using the principle shown in Fig. 5. In 1969 a temperature of 5.10^{-7}K was obtained by Professor Abragram.

THE SUPPLY OF HELIUM

Where does helium come from? It is an inert gas that got its name from the method of its discovery. In 1868 Lockyer realised it existed from his studies of the optical spectrum of the sun's corona or helios. It is distributed uniformly in the atmosphere but only at some five parts per million by volume; the low concentration makes it expensive to concentrate from this source. There are a few natural wells containing it in the United States, Canada and U.S.S.R. but even these sources are dwindling to such an extent that sales are restricted. For this reason processes needing helium aim to use recirculation systems to reliquefy the same gas.

Its common non-reuseable uses are as a mix gas (with oxygen) in deep-sea diving breathing supplies, as a gas-shield in welding, in lamps and as the non-inflammable gas for balloons.

Helium, as well as other liquid gases such as nitrogen, is invaluable as the cooling medium for extremely sensitive photo detectors used in infrared thermal sensing and missile trackers: cooling the detector element reduces the thermal Johnson noise, thereby increasing the signal-to-noise ratio. Helium is the coldest liquid gas available but the comparative difficulties of supply and storage restricts its use to applications where the higher temperatures of other liquid gases will not suffice.

Today, liquid helium is used in vast quantities. The nuclear research plant

CERN at Geneva, produces an average 40 000 litres/year for research purposes. Plants to liquefy it are reasonably common — the one shown in Fig. 6. is installed at the Division of Chemical Physics of the CSIRO in Australia.

Fig. 6. Helium liquefier plant. Helium is recovered from experiments. Note the dewars on the right.

SUPERCONDUCTIVITY AND SUPERFLUIDITY

The disappearance of resistance in electrical conductors at a temperature of 5K, or thereabouts, was not expected. Many gases had been liquefied without departing from the normal laws of resistance. Only helium produces a low enough temperature for the phenomenon to occur.

SUPERCONDUCTIVITY

After Kamerlingh Onnes liquefied helium in 1908, scientists were able to investigate the properties of materials at lower temperatures than before. In what was a most routine kind of test — the measurement of the electrical resistance of mercury — the Onnes team found that at 4.2K its resistance dropped sharply to an extremely low value, near enough to zero resistance in fact. This change is shown dramatically in Fig. 7. It would have been thought that the resistance would have reduced gradually, being zero only at the absolute temperature zero ($10^{-\infty}$K). Dewar also noticed this peculiarity but did not follow it up.

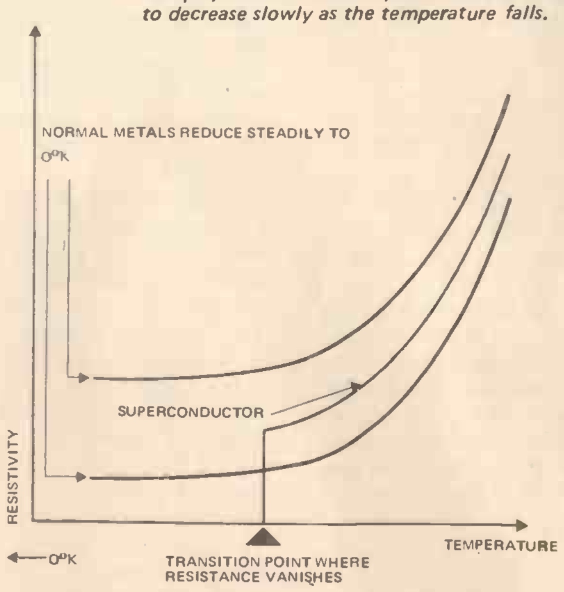
Onnes continued the research and devised a way to measure the incredibly small resistance — quite out of the range of resistance bridges in use. The method chosen was to set a current going in a loop of superconducting metal deep in a liquid helium bath and then monitor the decay of field strength of the magnetic field thus produced. There was no detectable reduction after many hours, the duration of the test being limited by the then scant supply of liquid helium. Other experimenters since then have suspended a ball in the field of a superconducting loop. One such ball remained supported for two years — only dropping when the helium supply failed and the loop lost its superconducting condition. (This is not perpetual motion: but is simply a system where energy is not lost).

When superconductivity was first noticed there was little interest in the phenomena. No theory existed to explain it, so many scientists probably concluded that there was a fault in their apparatus. It was only in 1957 that a reasonably adequate theory was put forward. (Many had been proposed). This is called the BCS (after Bardeen, Schrieffer and Cooper) theory. These scientists shared the 1973 Nobel prize for Physics for this achievement. In essence, it is believed that the vibrations of the lattice become so ordered that electrons can flow freely through without being impeded by random vibrations. Fortunately, to understand the applications of superconductivity there is no need to be familiar with the complicated physical theory.

Magnetic field strength depends upon the product of amperes and turns, so the higher the current the stronger the field, provided the medium does not saturate magnetically. At first sight this implies the production of unlimited strength fields, for enormous currents can be caused to flow in a superconducting ring. But a limitation was soon found, for the field so produced in fact inhibits the current flow and the superconductivity is degraded. The main problems, therefore, have been to discover metals with a high superconductivity transition temperature, and to realise means by which large field strength can be obtained in a stable manner.

Over thirty metal elements and hundreds of alloys have been found to be superconductors. At liquid-helium temperature there is lead, mercury, tin, vanadium, thallium and indium.

Fig. 7. In a superconductor the electrical resistance vanishes abruptly at the transition point. Normal conductors continue to decrease slowly as the temperature falls.



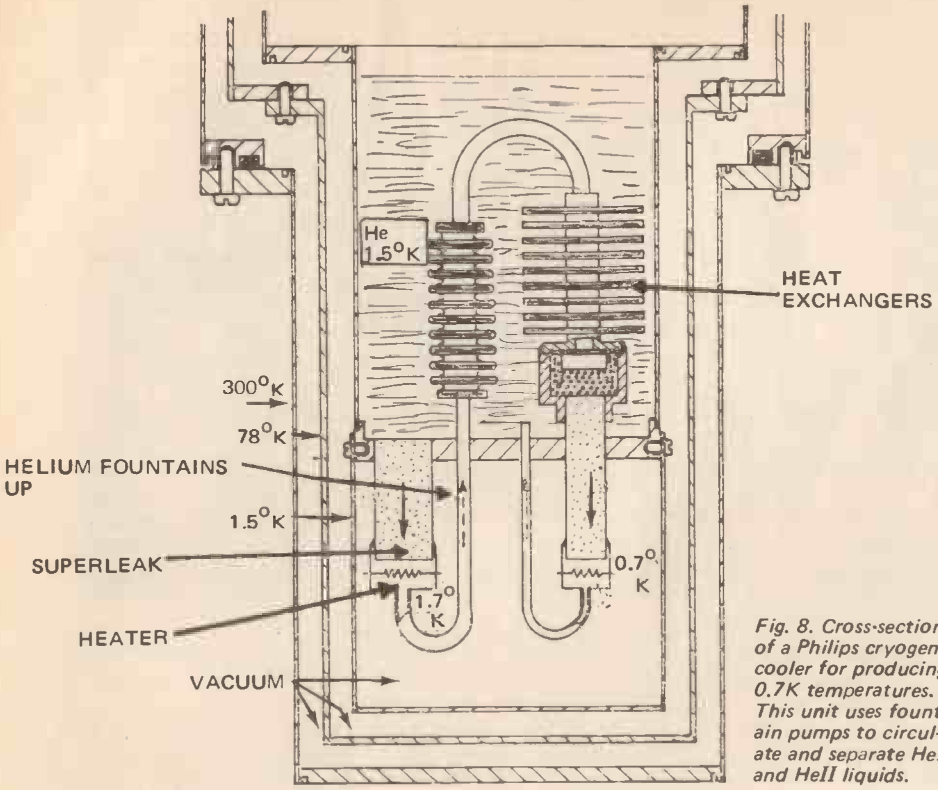


Fig. 8. Cross-section of a Philips cryogenic cooler for producing 0.7K temperatures. This unit uses fountain pumps to circulate and separate HeI and HeII liquids.

Aluminium, zinc, cadmium, iridium and titanium are superconducting at temperatures in the magnetic cooling region around 1K. The metal with the highest transition temperature is techetium at 11.2K. (Nb_3Sn, a compound, has a critical temperature of 18.2K). There appears little likelihood of superconductors existing at room temperature.

Over the years, patient research and development has steadily produced ways to obtain greater field strengths. In 1934, Heinz London published calculations leading on from the work of others showing that in certain alloys the magnetic field penetrated to a very small depth, and, within this depth, it did not destroy superconductivity. The distance is only 10^{-7}m so wires have to be extremely fine. By 1937, fine wires of lead had been made and tested, with the gratifying result that increased field strengths were obtained that also agreed with calculations predicting them.

Today, superconducting magnets use mainly niobium-titanium and niobium-tin wires and tapes. The Imperial Metal Industries' Niomax, has 61 filaments supported in a normal metal matrix, the whole wire being 0.5mm in diameter. This wire can pass currents to 7.10^6 A/mm^{-2} (in this case, therefore, roughly 10^6 amps) and produce a field strength of 50kG (the new metric unit, the Telsa, equals 10kG) before the field degrades itself. Other forms are thin tubes to enable the liquid helium to be pumped through, thereby obtaining more efficient cooling. Plessey produced a niobium-tin tape which has been used to build a magnet producing a 100kG field. Iron circuits are not used, for the iron would saturate well before this value is reached. A copper matrix for the filaments is not satisfactory in alternating current work; instead cupro-nickel is used as a support. It is the lossless field generation that attracts technological interest for, in the design of electromagnet devices — transformers generators, motors and magnetic suspension systems — this characteristic can be used to reduce the size of the machines without loss of output capacity.

SUPERFLUIDITY:

Another unexpected property of liquid helium occurs as it is cooled through 2.17K (called the λ point). Below this point the fluid loses all evidence of normal fluid behaviour. The heat conductivity rises enormously, conducting heat a million times better than helium above 2K. Above the transistion point, the helium is called HeI, below, HeII to distinguish between them. In the region below 2K, helium takes on extraordinary properties.

Firstly, in the film transfer effect the liquid will rise up the outside of an empty flask floating in HeII, pass over the top and keep filling. Secondly, a small source of heat placed in a tube filled with the liquid gas will pump the helium around. This is scientifically called the thermo-mechanical effect. It is, however, often referred to as the fountain effect, for when a porous plug is placed in the flow of this type of pump, the HeII actually fountains from the top in a spectacular manner. Curiously, the finer the pores or tubes used in the plug (a super leak) the easier the liquid flows — quite the opposite to normal viscous fluid flow laws.

In Fig. 8. is a diagram of a cooler for producing 0.7K temperatures that exploits the behaviour of superfluid helium. It uses a fountain pump to circulate the helium. (All that is needed is the porous plug, a small chamber and a heater.) Cooling occurs by continuously circulating the mixture of the HeI and HeII. The superfluid will be pumped around, but not the normal and higher temperature fluid. In this way there is a gradual increase in the amount of HeII in the chamber, resulting in a colder temperature.

Conversely, if HeII is allowed to flow by gravity through a porous plug it will lose heat, emerging cooler. This is the mechano-caloric effect. These two processes show there is a reversible process between heat and the flow of mass.

To date, technological interest has been with the superconductivity aspects. In the next part, the now many applications of cryogenic methods will be discussed.

FURTHER READING:

"The Quest for Absolute Zero"
K. Mendelssohn, World University Library, Weidenfeld, London, 1966. (A highly interesting book describing this development amongst scientists; many personal details enhance the description. Mathematical explanation has been avoided).

"For Explaining away Resistance"
P. Stubbs, New Scientist 1972, 56, 817, p212.

"Intrinsically Stable Conductors"
Rutherford High Energy Laboratory, Reprint No. RPP/A43. 1968.

"Expansion Engines for Low Temperature Processes"
S. C. Collins and R. L. Cannaday, Oxford University Press, 1958, London.

"Low Temperature Techniques"
F. Dinand A. H. Cockett, Newnes, 1960, London.

"An Introduction to Liquid Helium"
J. Wilks, Clarendon Press, 1970, Oxford.

"Superconductivity"
E. A. Lyton, Methuen, 1969, London. (Has extensive bibliography).

FROM THEORY TO PRACTICE

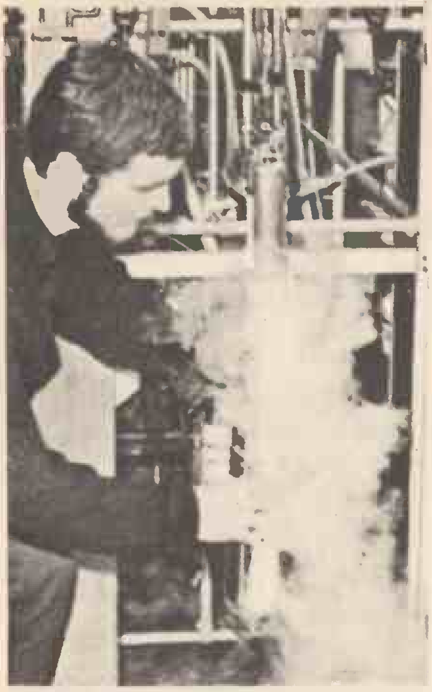


Fig. 9. Cryogenic research equipment in use at the University of Southampton.

There is naturally, a lapse of time before applied scientists, engineers and technologists start to use new principles discovered by pure scientists. In the case of low temperature physics, many years passed. It is only in the last two decades that the use of superconducting effects have been considered for large-scale technological applications. There are many explanatory factors for this delay.

Onnes discovered superconductivity in 1911, but at that time the need for its modern uses was not so apparent, nor had low-temperature techniques advanced sufficiently for designers seriously to consider using them in day-to-day practice. An application must wait for suitable economic conditions – the costs of development, building and running the new way must be less than the old – it is, therefore, not surprising that superconductivity has only recently emerged from the science laboratory.

Cryogenics is the technology concerned with providing and applying low temperature devices working below 200K (73°C of Cold). Superconductivity is part of cryogenics, and is the most striking phenomena, but the use of cryogenic methods, in general, has enhanced the quality of many disciplines without the exploitation of superconductivity.

CRYOGENIC APPLICATIONS

Separation of Gases

The need for oxygen as an industrial commodity has steadily increased – from comparatively nil in 1900 to literally millions of cubic metres in 1973. Other gases stored and transported as liquids in large industrial quantities include nitrogen, helium, methane, acetylene and hydrogen.

British road regulations limit tanker sizes to the liquid equivalent of 10 000 cubic metres capacity, but larger units are permitted in other countries. Methane storage plants of 2 000 000 cubic metres have been built. Today oxygen liquefier plants can produce 100 tonnes of liquid gas per day.

It was in 1956 that the first British plant capable of producing several tonnes of liquid oxygen per hour was built. Today the capacities available have been increased tenfold. Smaller plants of different design are used to separate the rare gases from the air (argon, krypton, xenon, helium and neon). In the oxygen plants, the air is first compressed to six atmospheres and cooled by water sprays. It is then reduced in temperature, by heat extracting refrigerators, to 100K. This cold air has two fractions, one rich in oxygen and heavy, the other rich in nitrogen and light. They are subsequently separated in a column as gases, with liquid oxygen also being available. (More details of the processes used are to be found in

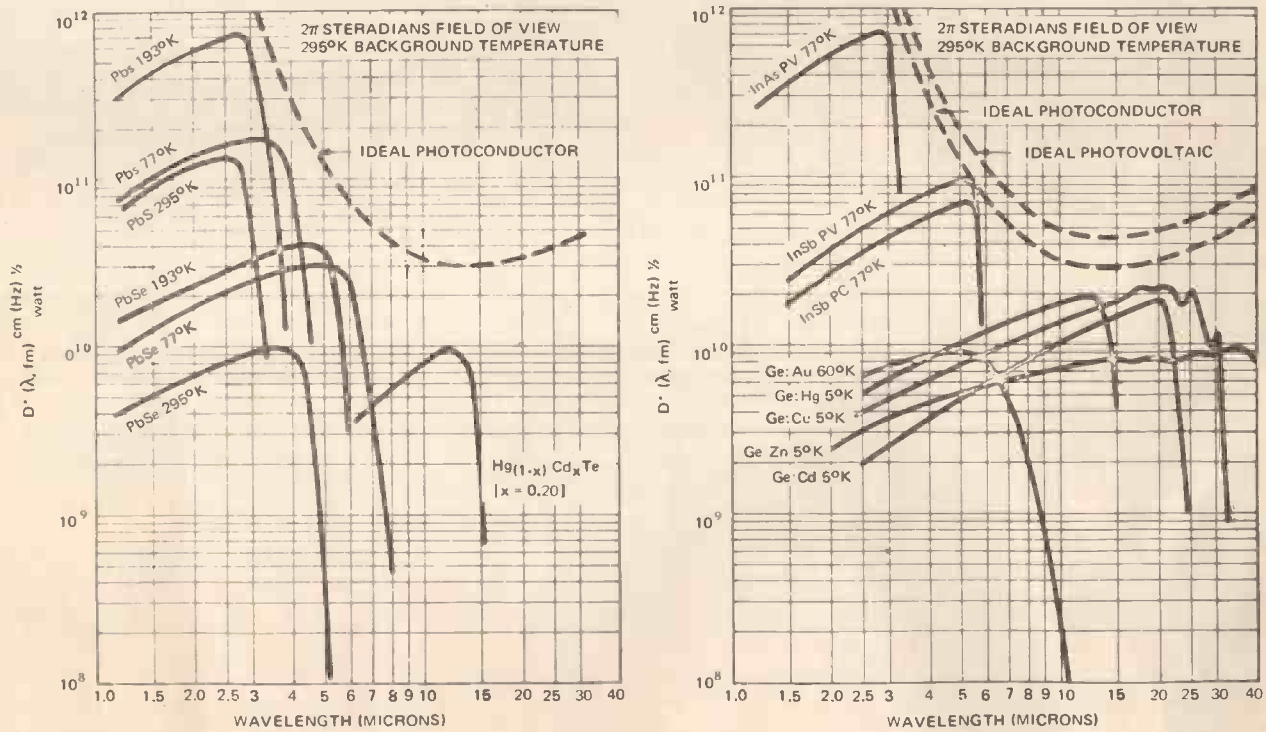


Fig. 10. Sensitivity of infrared detectors depends upon the temperature of the element as shown by these curves

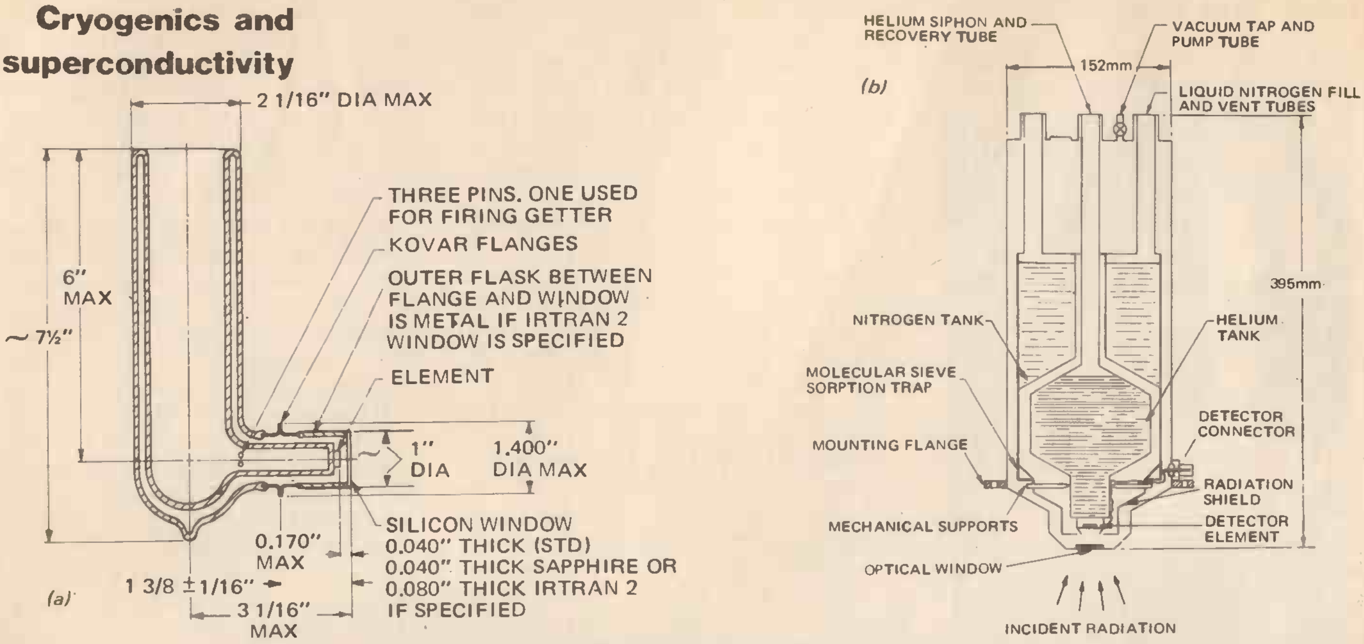


Fig. 11. Dewars used to cool infrared detectors: (a) A style 60A glass dewar (b) Cross section of a Mullard stainless steel unit using helium

"Low-Temperature Techniques" by Din and Cockett, Newnes 1960).

It can be seen that the technological ability to produce large quantities of liquid gas is now highly developed enabling the use of cryogenic techniques to be seriously considered in a big way.

Measurement of Material Properties

Application of cryogenic techniques requires knowledge of the behaviour of materials at the temperature proposed. For example, stainless steel must be used for the inner wall of cryogenic containers as mild steel becomes too brittle. In the superconducting region (below 20K) there is need for more data on materials. At CERN, for example, a test facility has been built to test the tensile strength, to 8000 kg, of superconducting material whilst it is carrying 12 000 amps in a magnetic field of six Tesla. (60kG). In Fig. 9. a member of the Southampton University of Cryogenics Group is shown working on the measurement of the specific heat of solids in the superconducting region.

Infrared Detection Systems

The detectivity of many infrared detector elements can be enhanced by cooling them to varying degrees of coldness, as shown by the curves given in Fig. 10. Cooling also enables a different response peak to be obtained. Generally, but not always so, the cooler the element the higher the detectivity. Cold shields are also used to limit the field of view: the detector sees a virtually non-radiant surface away from the viewing aperture.

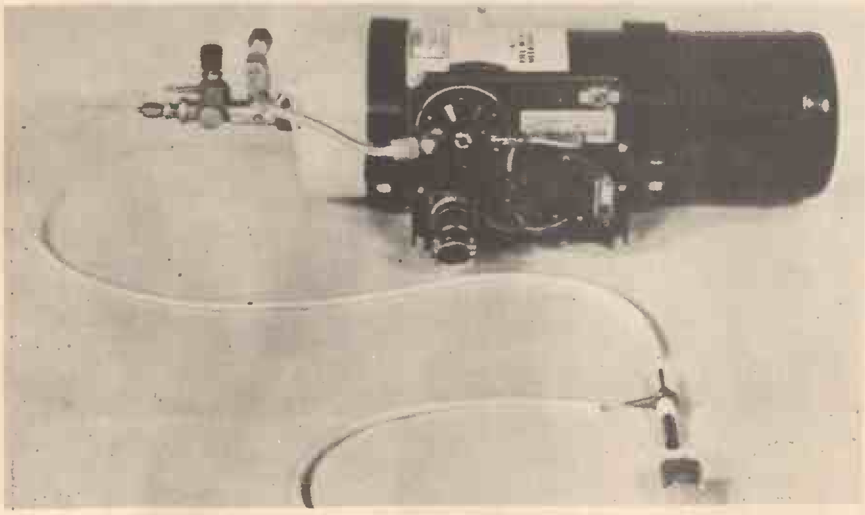


Fig. 12a Liquid nitrogen transfer system. The standby time is 60 hr enabling a detector to be used virtually on demand.

Elements needing cooling range in size from 0.05mm to 10mm. Because of the convenience they are used at temperatures of commonly available liquid gases. To keep the detector cool for considerable periods, (the hold or dwell time) it is mounted in close thermal contact with one of a number of cooling methods.

For laboratory work a special glass dewar is satisfactory: they come in many shapes and sizes. In the one illustrated in Fig. 11a, liquid nitrogen will hold the detector at 77K for four hours. Metal dewars are also made with similar hold times. Larger units like that shown in Fig. 11b can hold at 5K (liquid helium) for 12 hours.

Longer hold times in small dewars can be achieved by maintaining the liquid gas level with a transfer system. That shown in Fig. 12a uses nitrogen (stored in the cylinder) to provide cooling for eight hours. Alternatively a cryostat cooled by the Joule-Thomson principle can be .inserted into the dewar. Compressed gas is fed to the cooling head, (one is shown in Fig. 12b) and expansion cools the body to the liquid gas temperature. The helical coils are the heat transfer link between the body and the contents of the dewar.

Thermo-electric coolers, using the Peltier effect, are also used to cool detectors, but only where moderate cooling is needed. They are able to provide up to 80 degrees of cold.

Medical Applications

Some medical operations require a device that can destroy a specific area of tissue on a very localised basis. In the treatment of Parkinsons disease a cluster of brain cells must be cauterized; the removal of tumours is another example where an intensive burning probe is required. Radio frequency heating is one way to destroy cells but intense cold can also perform the task.

A probe, designed for neurological operations is shown in Fig. 13a. High-pressure nitrous oxide loses pressure in the orifice, producing cooling at the tip. This cryosurgical instrument will stay at -180°C when immersed in water. The same company also manufactures a urilogical probe for the removal of tumours. To obtain a greater degree of cooling, liquid nitrogen is used in this probe. The nitrogen (see Fig. 13 b) is contained under pressure in the dewar flask. A solenoid valve controls the flow through the tip. This system will hold the probe of the unit at -180°C in tissue. A miniature heater is provided in the tip for rapid defrosting.

Heat Pipes and Switches

The concept of transferring energy via pipes is common in hydraulic engineering. The same idea can be used in heat transfer. A simple way to conduct heat is to use a solid copper (or silver) rod with one end at the source and the other at the sink. There is, however, a better device called a heat pipe. This can be as much as 500 times more efficient than a solid rod. A cross section of one is shown in Fig. 14 The tube has an outer capillary structure that acts as a wick. Inside this is a vapour space. In the evaporator section the heat input from the component to be cooled vaporises the fluid in the wick. This vapour automatically flows back to the other end where it condenses. A typical pipe might be 10mm across and 300mm long. The concept works at all

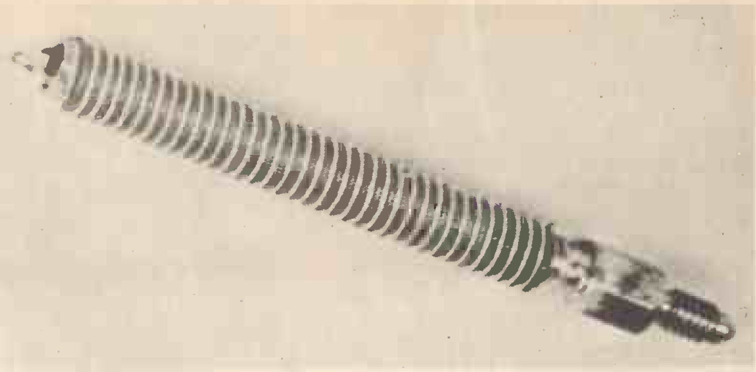


Fig. 12b A Joule-Thomson cryostat head. Cooling is by pressure release of argon or nitrogen gas.

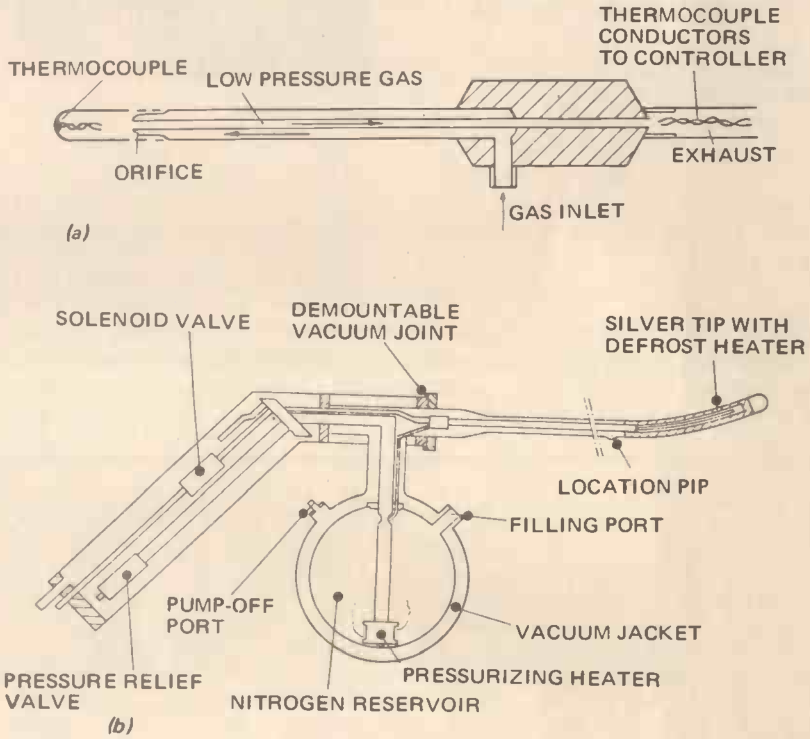


Fig. 13 Cryosurgical instruments by Spembly Products: (a) Neurological probe having a small active volume. (b) Urological probe for the removal of tumours.

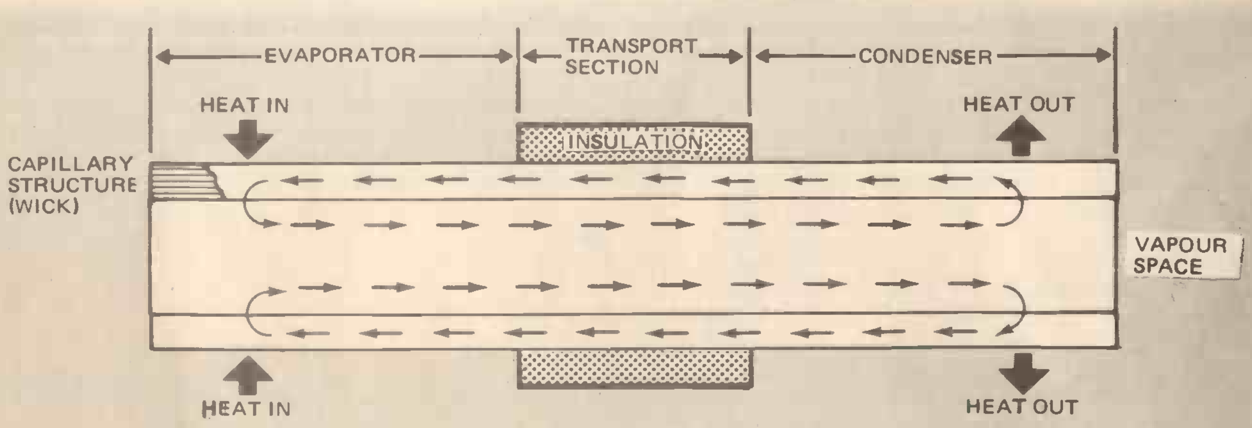


Fig. 14 Schematic of a two-phase heat pipe.

temperatures and cryogenic versions have been studied at the Goddard Space Centre for cooling detectors mounted remote from the central cooling unit.

In many cryogenic experiments it is necessary rapidly to isolate the stages of a cascaded cooling arrangement. Thermal switches have been proposed to do this. One form uses a conducting rod in a tube immersed in a lubricant of liquid helium. Pulling the rod up into the hotter end changes the thermal conductivity of the thermal path. Another switch makes use of the significant change in thermal conductivity of a superconductor when it changes from superconducting to the normal state. Altering the temperature of the field intensity will switch the rate of heat conduction.

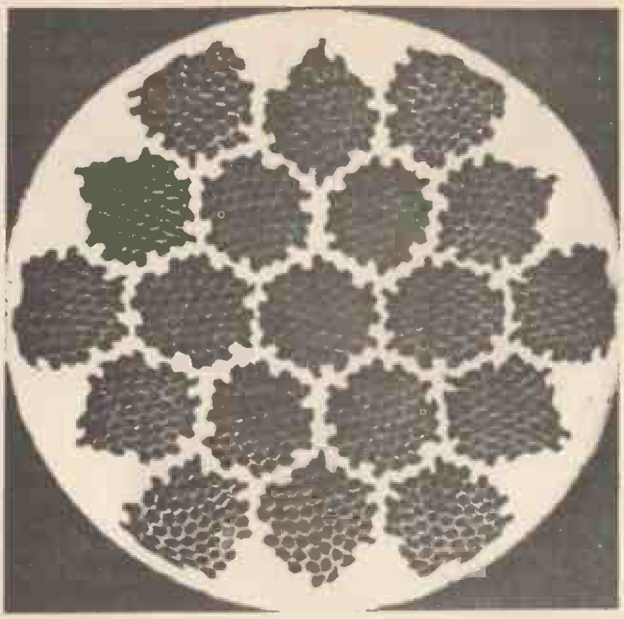


Fig. 15 Cross section of Imperial Metals Industries superconducting cable. It has 1045 filaments held in a copper matrix.

APPLICATIONS OF SUPERCONDUCTIVITY

Applications of superconductivity mainly exist where lossless current flow is an advantage. There are, however, others that make use of the altered physics of the conductor lattice.

Power Transmission

With few exceptions electric power is transmitted as an alternating current at high voltage. Transformers enable extra high voltages to be used on the lines with a proportional drop in the current carrying capacity needed. As power losses in a conductor are proportional to the square of the current flowing, the lowered amperages result in great cost savings. Voltages in the megavolt region are, however, quite unsuited for industrial and domestic use, so transformers are used to lower the voltage again. Now, new developments in efficient solid-state inverters and converters have stimulated considerable research into the use of extra-high voltage dc systems, as well as the ac method.

If cable had no resistance, there could be no losses, and thus current density could be high. Hence a smaller area of conductor could be used. Superconducting cables offer this feature. At present the location of a power station is largely decided by the line losses of the distribution network – these can amount to as much as 50% of the generated power. Lossless lines would enable the power stations to be located in remote areas. In the United States, the Tennessee Valley Power Authority recently started a research programme to test extra high voltage underground superconducting power lines. Their commonplace use will, however, be a while yet, for there are many practical problems to be overcome.

In all heavy-power applications the need is for mechanically strong, easy to manufacture cables that have a large degree of superconducting stability. (The field produced by the current flow, if too great, can turn the cable back to a normal conductor.) It is, therefore, obvious that a fault on the line could potentially vaporize the conductor unless protective measures are incorporated. To reduce this disadvantage, the superconducting filaments (they are fine to enable large field strengths to exist without destroying superconduction) are bonded to a heat and electrical conducting matrix such as copper. A cross-section of a multi- filament composite cable is shown in **Fig. 15.** Each filament is of niobium-tin sheathed in cupro- nickel.

Ensuring the supply of liquid helium is another major problem. HeII, the superfluid form of helium is preferred, as its thermal conductivity is thousands of times greater than copper. At present refrigeration plant is most inefficient; around 1kW of energy input is needed to produce 1W of cooling at liquid helium temperature (4.2K). The weights of the units are approximately 140 kg/watt. Well designed insulation methods fortunately gain very little heat, so the cooling load is small.

High-Field Magnets in Power Generation.

The problems discussed above apply equally well to the design of high field strength magnets, but solutions have been forthcoming and electromagnets of superstrength have been made using superconducting coils. Important heavy engineering applications are in power generation, nuclear research plants, motors and in vehicle suspension proposals.

Electric power is generated by using an energy source to move conductors across a magnetic field. The more intense the field, the greater the output power that is available. The limit in ac generation is more or less set at machines in the 1000 MW region. One way to improve efficiency is further to increase the size of the generator but manufacturing and transport difficulties have imposed limits.

Although the excitation of the field in a generator consumes only a small proportion of the output, the use of superconducting field-coils can reduce this loss, boosting the machine efficiency by about 1%. (99.6% compared with the present 98.6% is the estimate given by Westinghouse).

There is talk of 2500MW machines using superconducting windings but to date prototypes of only 5MW are being tested (see **Fig. 16.**). Weight may also be reduced by as much as one half.

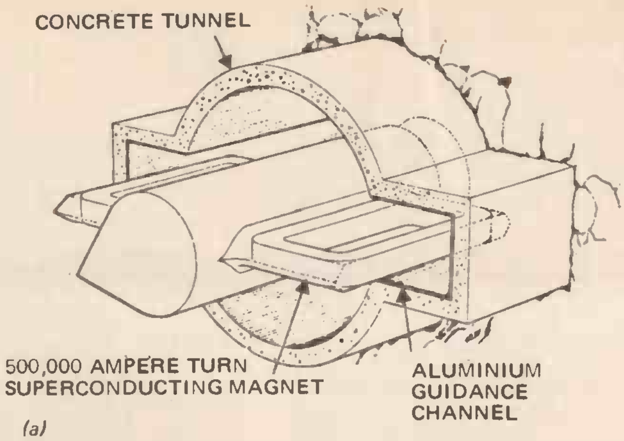
Superconducting dc machines are also being investigated. Applications include a 1MW naval motor-generator set, and industrial generators for smelting, plating and— electrolysis plants. It is predicted that superconducting machines will be used in ships during this decade, and in power-stations in the next.

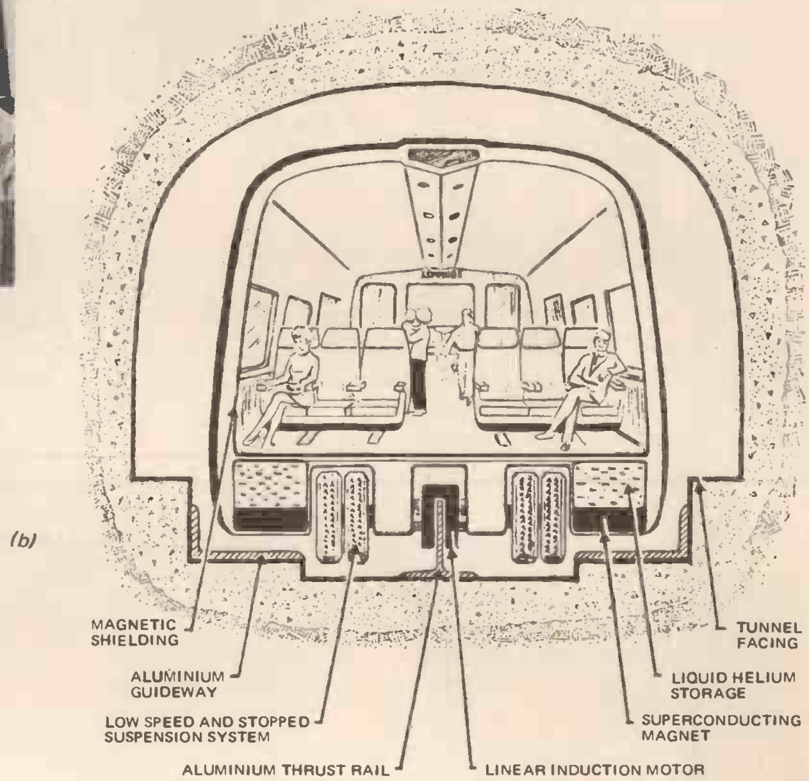
Magnetic Suspension Systems

High-speed trains have been developed that run on air cushion suspensions. Equally viable, but less promoted are the maglev, (magnetic-levitation) suspension schemes. These make effective use of

Cryogenics and superconductivity

Fig. 16 Prototype 5MW superconducting rotor of a power generator made by Westinghouse.





superconducting field-coils to provide the lift needed. The principle of maglev is simple to demonstrate. If a permanent (or electric) magnet is moved across the surface of a good electrical conductor such as aluminium, it will be repelled by the field created by currents induced in the sheet. (It is as though there is an identical bipole magnet below the sheet that is interacting with the source magnet.) The faster the relative velocity the greater the lift.

Full-size vehicles using normal magnets have been built to demonstrate the maglev principle, but the probable cost savings of superconducting magnets cannot be overlooked for future transport systems. Superconducting magnets allow a higher field strength to be used and this ensures greater clearance for a given speed. In turn, the track tolerances can be relaxed, cutting costs. Another advantage is that a superconducting field cannot collapse at speed so a fault would lower the vehicle gently onto auxilliary wheels installed for such a purpose.

A number of vehicular ideas are being tried, see Fig. 17. Various institutions such as the Siemens Research Centre in Germany, the Cryogenic Group of the University of Warwick in England, Sandia Laboratories in New Mexico and the

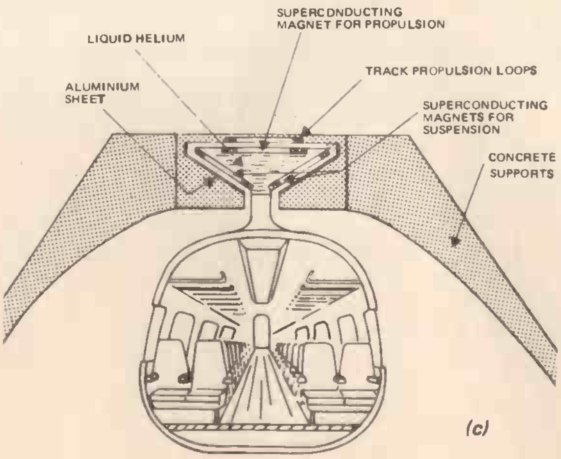
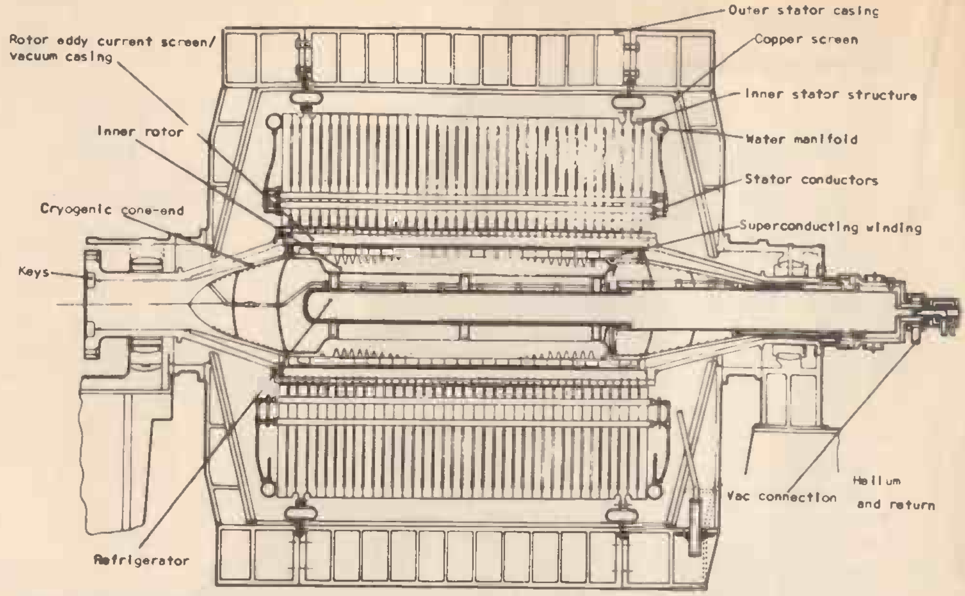


Fig. 17 Superconducting suspension arrangements of proposed maglev vehicles. (a) A high-speed rocket at 5000 m/s.
(b) The Stanford concept for a 600 km/hr train.
(c) University of Warwick proposal.

Cryogenics and superconductivity



500 MW superconducting AC generator designed at IRD.

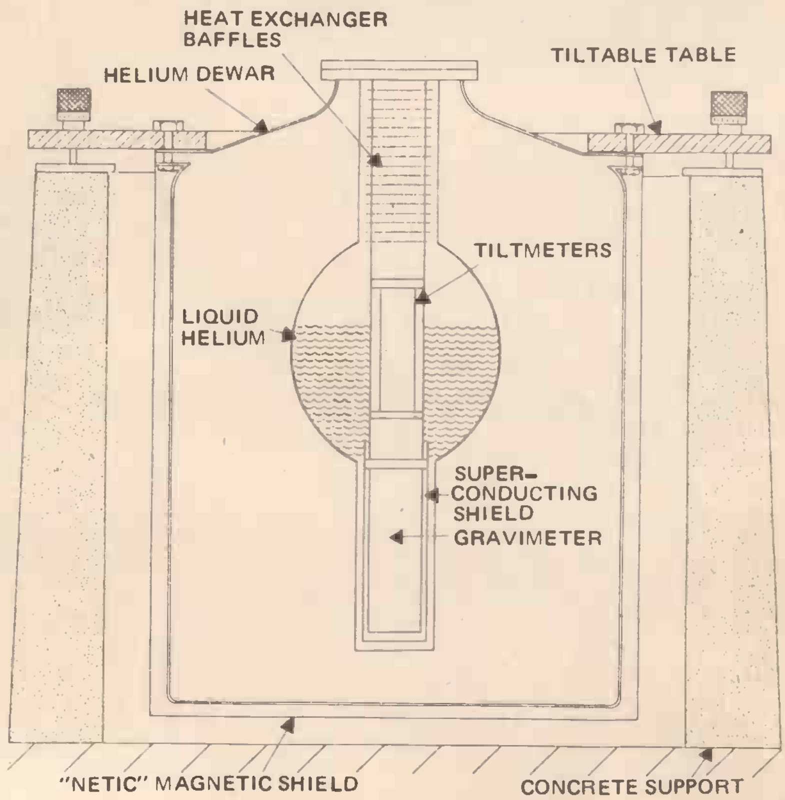


Fig. 18 Cross-section of a superconducting gravity meter installation. The tilt meters are used to correct records for inclination

Stanford Research Institute in California are concerned with maglev vehicles.

Other uses of superconducting magents include magnetic field "crucibles" to contain extreme temperature plasmas (ionised gases) without a physical container, frictionless bearings in gyroscopes, suspension of a gravity meter mass, and in nuclear accelerators. At present, the normal magnet designs in such accelerators need magnet ring diameters of hundreds of metres. Superconducting magnets will reduce this size and enhance the resolution.

The advantage of superconducting derived suspension in instruments is that the persistent currents are less susceptible to external noise and an improved signal/noise ratio is obtained. In the superconducting gravity meter a 1 inch diameter superconducting ball is suspended between the fields of two loops. The vertical position of the ball is sensed with capacitance micrometry. Drift of this instrument is of the order of parts in 10^{10} per day. A cross-section of the superconducting gravity meter installation is given in Fig. 18.

Superconducting loops are not perfect-joins and ac currents waste some of the energy — so with time the current decays and the magnet loses strength. It will be necessary in continuous-use applications to charge up the field periodically. Flux pumps are one possible way to do this. If a superconducting loop is made smaller, the same total magnetic flux must move into the smaller area presented by the loop. The field strength therefore rises. A simple way to achieve flux pumping is to successively slide shorting bars along a U-shaped loop. Each stroke will add more flux to the end of the loop. The limit is reached when the field begins to degrade the superconductivity.

So much for the power applications of superconductivity. Now considered are devices making use of superconductivity in other ways.

Computer Logic

In 1956 Buck invented the Cryoton computer logic element. This is a miniature superconducting switch that can be triggered by passing a control current through it. It consisted of a 0.25mm diameter tantalum wire with a 0.1mm diameter niobium wire wound around it. Field provided by the niobium wire is used to quench the superconductivity of the other, both wires being normally superconducting. The important feature of the Cyroton is that it consumes no power in its normal state. Speed is limited by the inductance-resistance time constant to about 10^{-5} sec in the wire-wound version. This is rather too slow for computer logic so research workers have developed deposited layer equivalents that can switch in 10^{-9} sec. The basic switch can be compounded to perform more complex logic.

A current induced in a superconducting loop persists without the need to supply energy. It is therefore, capable of acting as a memory element in a computer. These have also been developed. One cell that has found favour is the Crowe cell shown in Fig. 19. A drive wire is used to establish the current. The sense wire is used to interrogate whether there is, or is not, a current flowing, this determining the state of the memory bit.

Cryogenics and superconductivity

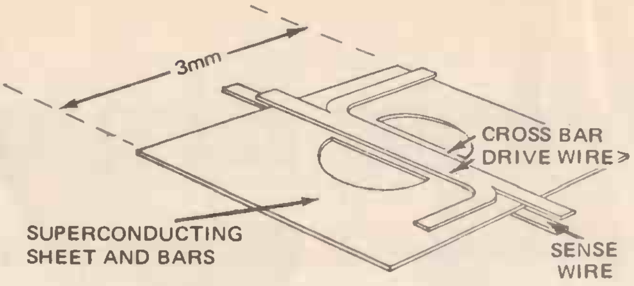


Fig. 19 The Crowe superconducting memory cell. The main disc is lead and all elements are superconductors.

Superconductivity and Standards Metrology

In 1962, Josephson, at Cambridge University, predicted that an alternating current would flow between weakly connected superconductors. This is known as a dc supercurrent. The significance of the effect to standards determination is that the frequency of this supercurrent is proportional only to the voltage across the junction, the constant of proportionality being the basic physical ratio 2e/h (e is the electron charge, h is Planck's constant). Experiment has shown that the relationship holds to at least a part in 10^7. Another discovery was that the voltage-current relationship for such a junction is a series of steps when the junction is irradiated by microwaves. The steps occur at certain integral ratios of the supercurrent frequency and the irradiating frequency.

This effect is able to provide a new way to define voltage that will eventually overshadow the Weston standard cells used at present. An added advantage of the method is that the voltage function occurs as a frequency that is easier to measure than an analogue voltage level. This constant has been measured by various groups in relation to the standard-cell voltage definition and is 483.59 megahertz/microvolt.

Assuming the voltage standard is satisfactory, the junction can be used to determine the e/h ratio with a precision 20 times better than that obtained by X-ray measurements used prior to this discovery.

In some determinations a point contact junction is formed within a cryostat by moving a niobium point away from a niobium block. A junction holder is shown in Fig. 20a. The holder is mounted in the end of X-band waveguide that is cooled to liquid helium temperature. The characteristic voltage- current curve obtained is shown in Fig. 20b. Experiment has shown that the temperature used matters little – results at 2.2K and 4.2K are identical.

The Josephson effect is an excellent example of how the realisation of radically new and highly useful techniques can often result from the tireless pursuit of pure science having no immediate purpose or intention.

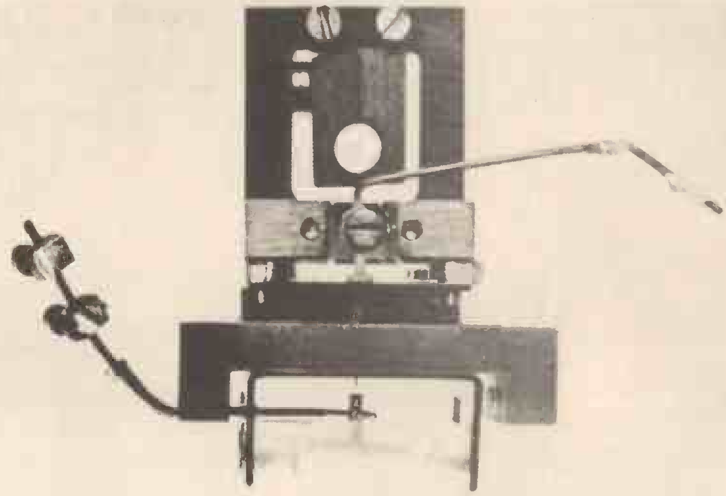
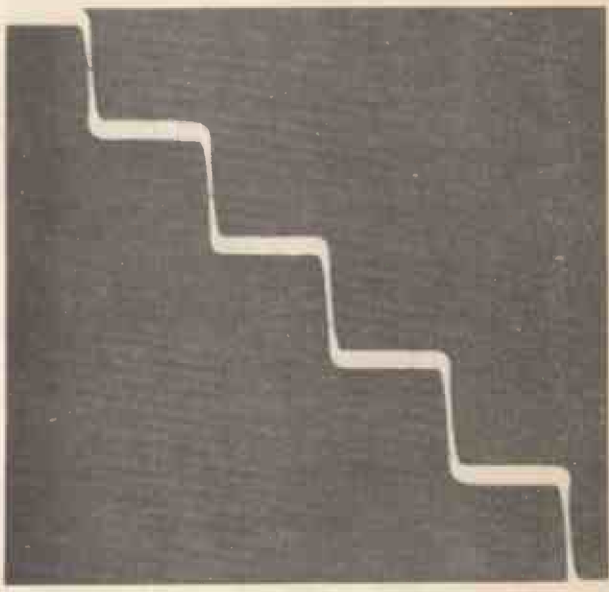


Fig. 20 (a) This niobium point contact is used to determine emf by the ac Josephson method (b) Voltage-current signal at 1mV levels



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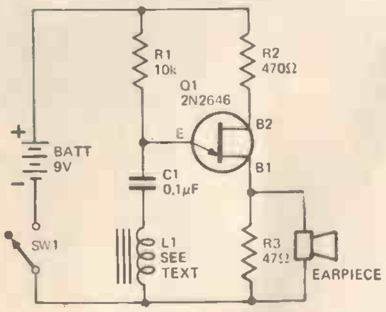
The Revealer

PROJECT 213

Beat the crooked car-dealer at his own game with A.J. Lowe's metal detector.

Fig 1. The completed unit together with earpiece and search coil.



UNIJUNCTION TRANSISTOR

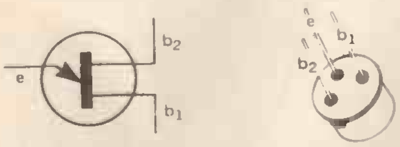


Fig. 2. Circuit diagram illustrates the simplicity of the unit.

'HONEST JOE', down at the used car lot, knows *all* the tricks, and uses as many as need be, to make his vehicles appear better than they really are.

Patching up rust holes, and filling up the dents from collisions — with putty, fibreglass, epoxy and paint, are just a few of the tricks for disguising the poor condition of bodywork. As bodywork is very costly to repair properly its condition is of vital importance to a used-car buyer.

Here's a little gadget — THE REVEALER, which will help to even up the game, by detecting what goes on below that beautiful but oh-so-thin coat of paint.

WHAT IT DOES

The revealer is an electronic test device to determine whether or not there is steel below the paint work. It comprises three elements — a search coil, the electronics, which are in a tin box, and an earpiece. The circuit generates a tone in the earpiece. When the search coil is placed over, and close to, steel, the tone changes significantly.

A would-be buyer of a used car can carry the tin box in his pocket, the earpiece in his ear, and the search coil discreetly in his hand. Tests can be made on door panels and mudguards and other places where rusting or filling is likely to exist. The best way to check a door panel, for example, is to hold the search coil at the top of the panel, where rust is unlikely, and then quickly transfer it to the bottom — where rust is more likely. If the note starts off — 'eeeeeee' and finishes up — 'mmmmmmmm', — look out! the bottom of the door panel has been filled with something that's not steel.

Of course a test can be made by simply moving the search coil over suspect areas, and listening for any change in pitch and tone.

Thus by listening to the frequency of the oscillator one can tell whether there's steel — or something else — under the coat of paint on a car.

While moving the search coil over the body work, the note should remain steady. If it fluctuates — take heed, all is not well.

THE SEARCH COIL

The search coil used in the prototype is a 1.5 henry choke of 85 ohms resistance and 10 mA rating, which happened to be on hand. The iron core is made of E and I laminations, with all the Es facing one way. After removing the choke from its mounting

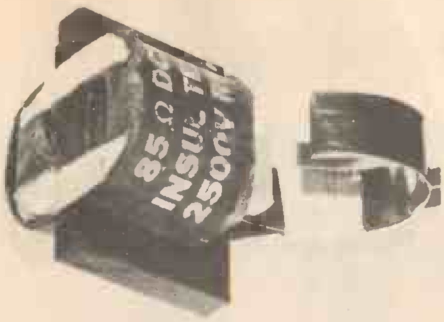


Fig. 3. The search coil may be constructed from an iron-cored coil having an inductance of 1.5 Henry and dc resistance of 85 ohms.

frame, the Is are discarded, thus leaving the choke with open-ended Es only.

The sensitivity of the search coil is increased by discarding about half of the E laminations, so that when the open ends of the remaining laminations are brought near any steel, then this steel makes a significant change in the inductance of the coil, and hence in the frequency of the oscillator.

On the prototype the remaining laminations were wedged securely with a wooden wedge, which also held a suitable small steel handle. See Fig. 3.

Constructors who do not have a similar choke on hand should experiment with similar chokes, or small transformers. An old transformer with one winding open-circuited would do, as long as the coil in use is continuous. Practically any small transformer will work; just try whatever is to hand. Naturally the smaller the search coil the better able it is to locate small flaws beneath paint.

HOW IT WORKS

The tone is generated by a unijunction transistor relaxation oscillator. This oscillator is quite conventional except – that, in addition to the usual capacitor between the emitter and negative rail, there is an inductor in series with the capacitor. (Fig. 2.).

The value of this inductance determines the frequency and tone of the note generated.

The inductor is actually the search coil, and its inductance is varied by the proximity of steel to the open ends of its iron core.

When the inductor search coil is close to steel the frequency of the note decreases, when there's no steel there it remains high.

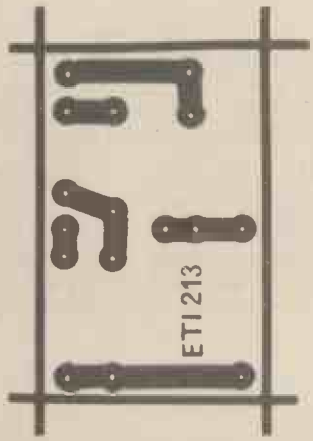
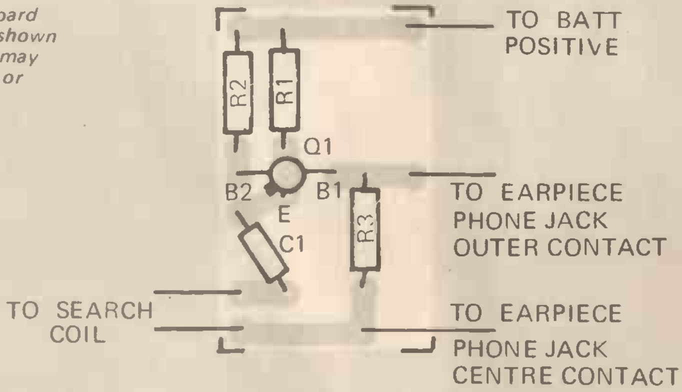


Fig. 5. A printed circuit board may be used (foil pattern shown here full size), or the unit may be assembled on tag strips or Veroboard.

Fig. 6. Component overlay



CONSTRUCTION

Construction is not in any way critical. In the original model the components were mounted on a printed circuit board measuring 1 7/8" x 1", and assembled with the battery in a small tin box which once held throat tablets.

The jack used for the earpieces was of the type used in some transistor radios, with three terminals, and fitted with a normally-closed switch. Before use, this was adapted, by bending the fixed contact of the switch, so that the switch became normally-open, and was closed by the insertion of the earpiece plug. Figure 4 shows the jack after adaptation. The battery negative lead goes straight to one of the terminals of the jack.

Fig. 4. The jack must be bent as shown so that the switch makes contact when the earpiece is inserted.

This switch is used as the battery on-off switch, SW1 in Fig. 2, so that the device is switched on simply by inserting the earpiece plug.

If constructors use a choke different from that in the original then they should experiment with the value of the capacitor C1 to adjust the frequency of the oscillator to a satisfactory value. The layout of the copper side of the printed circuit board is shown in Fig. 5. Fig. 6 shows the component positions on top of the pc board.

Constructors who are not equipped to make a little pc board could easily mount the components on a tag strip or on Veroboard.

Well there it is — a one evening low cost project, but it could save its maker a small fortune on his next car deal. ●

Transducers in measurement and control

Dr. Sydenham discusses the continuing need for new types of transducers.

WE have looked at many ways by which the common physical variables are sensed and transduced into equivalent electric signals. The methods that we have described are well developed and are reliable and often extremely precise. Because of this it might be thought that there is a sensor available to monitor any possible variable and that the sensor design aspect of measurement systems engineering is now simply a case of applying commercially available devices in a routine manner. This is not the case — many highly desirable sensors are still not developed sufficiently to use, some have not even been realised; the need for inexpensive small transducers is paramount.

The task of the transducer designer continually includes the creation of new sensors (in-use tyre wear, leaf area increase rate on a tree, grass height monitor for automatic lawn-mowing, an education effectiveness monitor, an elasticity modulus meter for structural foundation bore-holes — these are all current problems awaiting solutions). The task is not always to provide a parts per million precision. As illustrations of these difficulties, two areas of measurements are now outlined: the first being an old discipline where progress has been slow — photometry — and the other, viscosity, a relatively new automatic measurement need.

PHOTOMETRY

Photometry is the science of measuring visible radiation in relation to its ability to produce visual sensation. (Sometimes the definition is extended to include radiation bordering on the visible, namely, infrared and the ultraviolet regions). This is a psychophysical parameter, for determinations are related to the human eye and what it appears to see. Therein lies the difficulty — a standard average eye response is needed to allow for the biological variation in eyesight between observers.

We have already dealt with a better way to measure a radiation variable when black body radiation was discussed. These radiometric measurements do not rely on psychophysical factors. Photometry had its birth in the days before the work of Plank when scientists wished to quantify the effects of light. They created their own standards of brightness and illumination intensity using firstly standard size candles and later standardised flames in which the gas jet orifice, the gas pressure and composition were carefully specified so that different constructors obtained much the same standard. The response of the eye varies with wavelength and the individual, so attempts were made to define a standard observer as the average of a large number of people. In 1951 this became accepted reality. A graph showing the agreed response is given in Fig. 1.

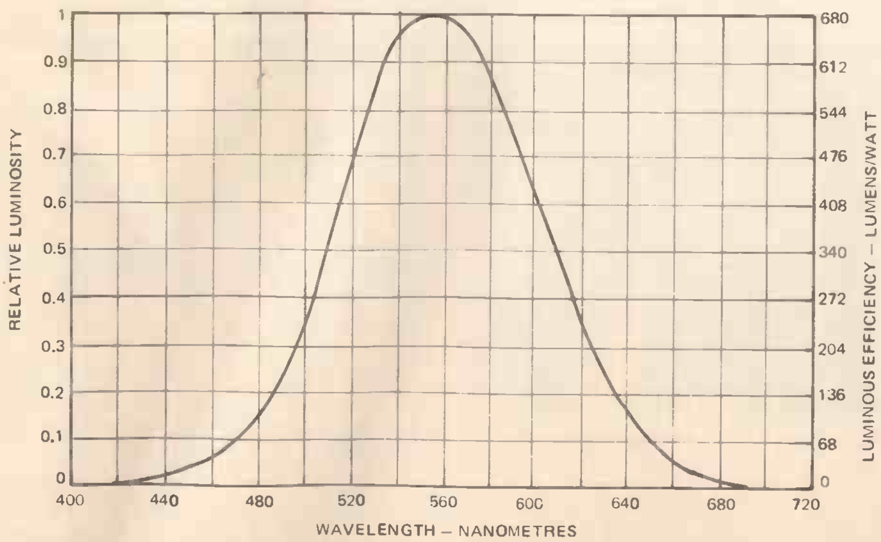


Fig. 1. Response curve of 'standard eye .

It is not feasible to employ a person with such a standard eye response, so photo detectors are used, in conjunction with fresh liquid-filled optical filters to modify the response accordingly. Coloured glass filters are avoided as these degrade with time. Detectors used include phototubes and selenium cells. But even with careful filter design, agreement with the standard response cannot be made accurately so a residual error curve is

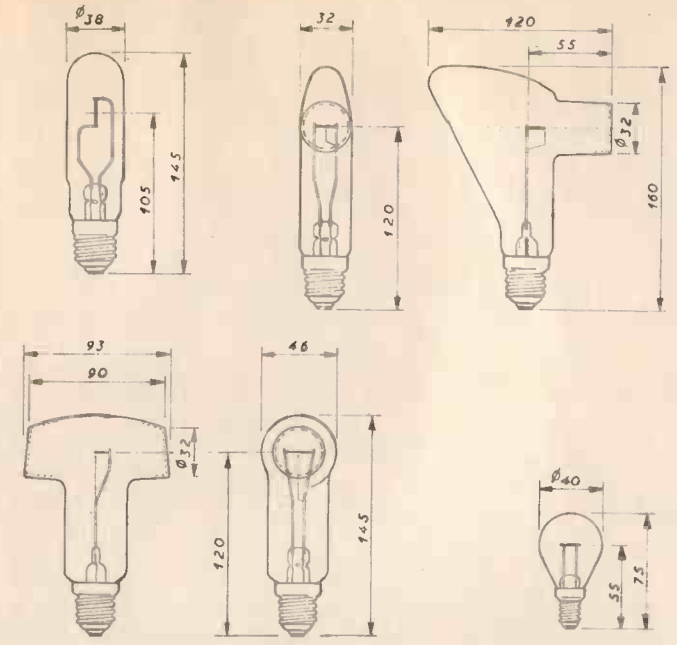


Fig. 2. Tungsten ribbon lamps especially designed to produce a uniformly radiating surface. The windows are ground plane-parallel from quartz or heat-resisting glass and must have their spectral energy transmission calibrated before manufacture.

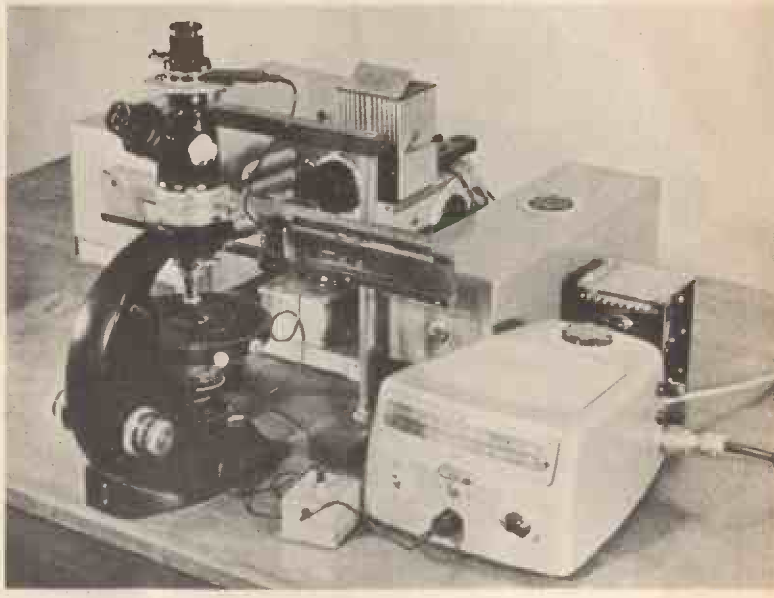


Fig. 3. EEL apparatus for measuring the reflectivity of ore minerals (using microphotometry).

used to correct readings when extreme accuracy is required.

An alternative method to obtain the response disperses the broad band white light source separating out the colours. These are then passed through a shaped aperture allowing the correct amount of light through at each wavelength. The colours are then recombined. It can be seen that these procedures require a high skill content and a lot of tailoring to obtain accurate results. Where feasible, photometric measurements are made on a relative basis as the eye is more sensitive to differences in brightness than to the absolute level of radiation. Radiometric measurements, not being based upon a subjective test, are usually to be preferred, but the extensive use of the photometric units in applications such as illumination engineering, in visually used optical instruments, in astronomy and in television prevents the total abandonment of the latter in favour of a radiometric alternative.

Luminous intensity, the 'candle-power' of a source, is now standardized as the candela (dc) a unit defined in terms of the luminous intensity of black-body radiation. To make life easier in day-to-day measurements, secondary standards — tungsten lamps of special design like that shown in Fig. 2 — are used. Luminous flux has units of lumens (lm) and relates to the flow of light fluxing away from the source. The candela is ideally a point source radiating into a spherical space around it. Allowing for this, a candela source emits 12.57 lumens of light flux. Illumination is the luminous flux falling on a surface and is expressed in lumens per square metre, units called lux (lx). The fourth unit, luminance, is similar to the lux except that this is the luminous intensity of an extended surface — not a point source. Its unit is the nit (nt) which is candelas per square metre.

Numerous other photometric units exist from the past (lambert, foot-candle, apostilb, phot, skot, talbot, metre-candle) but only the four, candela, lumen, lux and nit are to be used in future (Definitions and conversion factors for these units were published in ETI, October 1972). As both radiometric and psychophysical measures relate to the same thing it is possible to equate luminous flux with radiated power once the standard eye is defined. In Fig. 1. the luminous efficiency of a source is represented on the right-hand axis. For example, a source radiating at 0.56μm will produce 680 lm/watt.

The practical difficulties of creating a standard eye response, the primary standard black-body and secondary standard lamps are considerably greater than those encountered in many other forms of standard. The best precision attainable is barely better than one part in 100. Similar problems exist in ultra-violet and infrared 'photometry'.

Creating and maintaining photometric standards are seldom the tasks of the transducer user: acquaintance is more likely to be with photometer instruments of one kind or another. The microphotometer is an instrument incorporating photometric measurements with microscopy in order that the light magnitudes of very small areas can be measured. A common use of these is to determine the degree of blackening of photographic emulsion records from a spectrograph, a field of stars or interferometer fringes. In the automatic scanning photometer a narrow beam of light is passed through the emulsion to impinge on a photodetector. The photographic plate is then slowly moved across, recording the detector output with position.

Another application of the microphotometer is for measuring the reflectivity of mineral grains in order to investigate the composition and nature of an ore. One such equipment is shown in Fig. 3. Light of constant amplitude and wavelength composition is directed onto a cut and polished specimen held on the microscope stage. The reflected radiation is first viewed visually through the eyepiece to identify the area being measured; a thin slide containing a flat photocell is then inserted under the eyepiece to measure the light flux reflected. The cell is connected to the galvanometer via a preamplifier in order to amplify the microampere signals. Added sensitivity

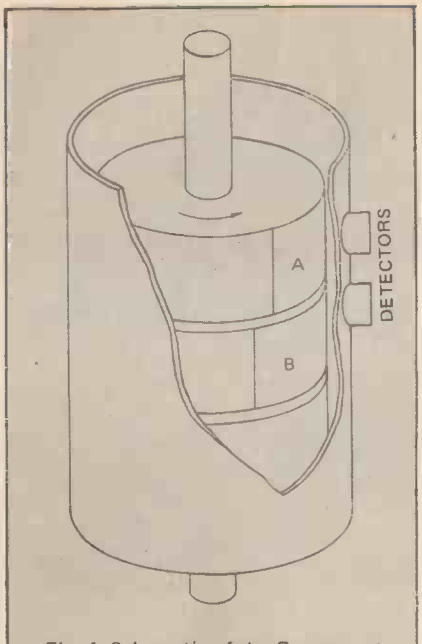


Fig. 4. Schematic of the Rosemount on-line rotating viscometer.

Transducers in measurement and control

can be obtained with a split-photocell position-sensitive detector arrangement. This is clipped onto the scale of the galvanometer to amplify the movements of the light spot. The same apparatus can also be used to determine exposure times in microphotography. This example shows how a seemingly simple measurement can become impossible as precision is increased, if the basic principles are inappropriate.

VISCOSITY

A fluid's resistance to the tendency to flow is called its viscosity. Instruments for measuring it are called viscometers or rheometers. Most viscometers make use of the viscous drag upon a rotating or oscillating cylinder turning in the fluid. In the unit shown diagrammatically in Fig. 4. the upper and lower cylinders are solidly connected and turn in the container filled with the fluid to be measured. The central bob, as it is called, is connected to the outer two by a taut ligament that allows it to lag behind the outer pair depending upon the viscous drag on its surface. External detectors sense some form of mark on the cylinders producing two pulse trains whose phase will depend upon the angular difference. Fluids fall generally into two classes of viscosity, those in which it is constant with shear rate (called Newtonian fluids) and those in which viscosity depends on shear rate (the non-Newtonian fluids). Examples of the latter are paints, creams, polymers and emulsions. In the illustrated viscometer, the pulse rate is a measure of shear rate so it can also be used to investigate the change of viscosity with speed. (In viscosity measurements it is vital to control the temperature of the fluid as viscosity depends on it).

Until the recent adoption of the SI systems of units, viscosity was measured in poise (after the 19th Century scientist Poiseuille). The SI unit to be used in future is the Pascal.second (Pa.s). One centi-poise is equal to 10^{-3} Pa.s.

An unusual challenge arose in the on-line measurement of the viscosity (regarded as consistency in this case) of bread dough, sponge batter and pastry fat used in automatic baking production by the J. Lyons catering company in London. In the chosen solution, see Fig. 5. the highly viscous dough (5.10^2 Pa.s compared with 10^{-3} Pa.s. for water) is forced from a mixing stage out of a proportioning batching head. Resistance to shear within the dough is determined by the torque needed to continuously rotate a paddle immersed in the dough. A differential gear unit is used to sense the torque exerted by the paddle. This mechanical computing element provides a turning moment on the output shaft when a torque exists on the paddle being driven at constant speed. A strain-gauge load-cell converts the output torque into an electrical signal. It is appropriate in this industry to refer to the 'tightness' of 'slackness' of the dough, so they use a special off-line instrument called a Farinograph to calibrate the consistency meter in their own kind of units. It is able to handle products with viscosities in the range, 500 to 0.1 Pa.s. when suitable paddles are used.

This example well illustrates the need for inventive designers in transducer development.

TRANSDUCERS AND PROCESSES

Automatic measurement and control of processes could not be realised if transducers did not exist. They are the essential communication link between the physical attribute of interest and the recorder or controller. The number of applications for sensors is infinitely large, ranging over disciplines such as medicine, power generation, marine survey, weapons, food-stuffs processing, oil refining, scientific research, pollution control, television and communications.

In many cases the need is for a large

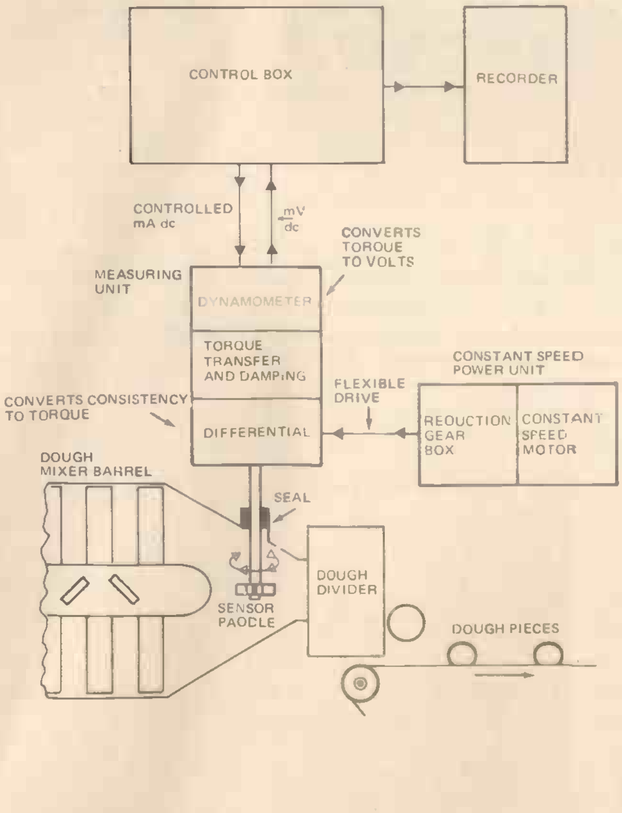


Fig. 5. Basic system components of consistency measuring instruments used in automated bread making.

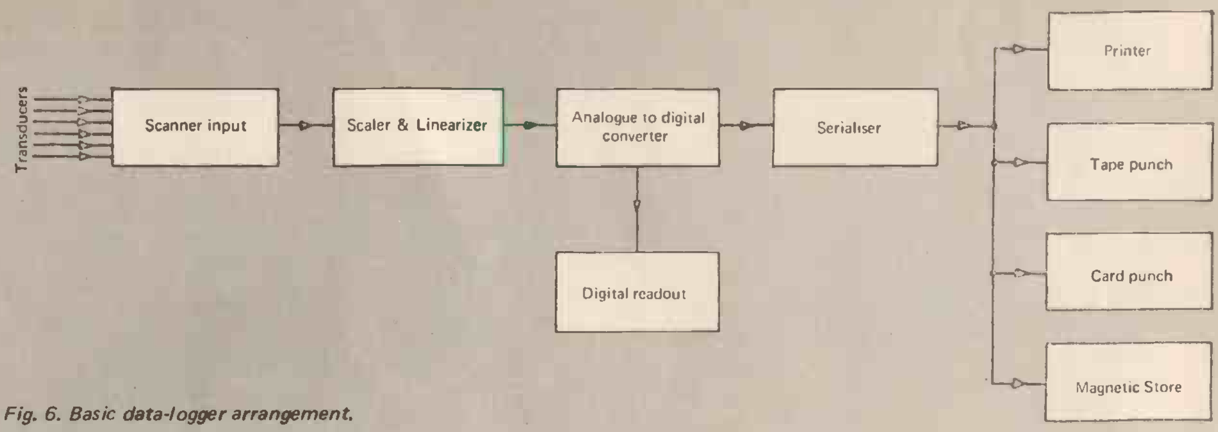


Fig. 6. Basic data-logger arrangement.

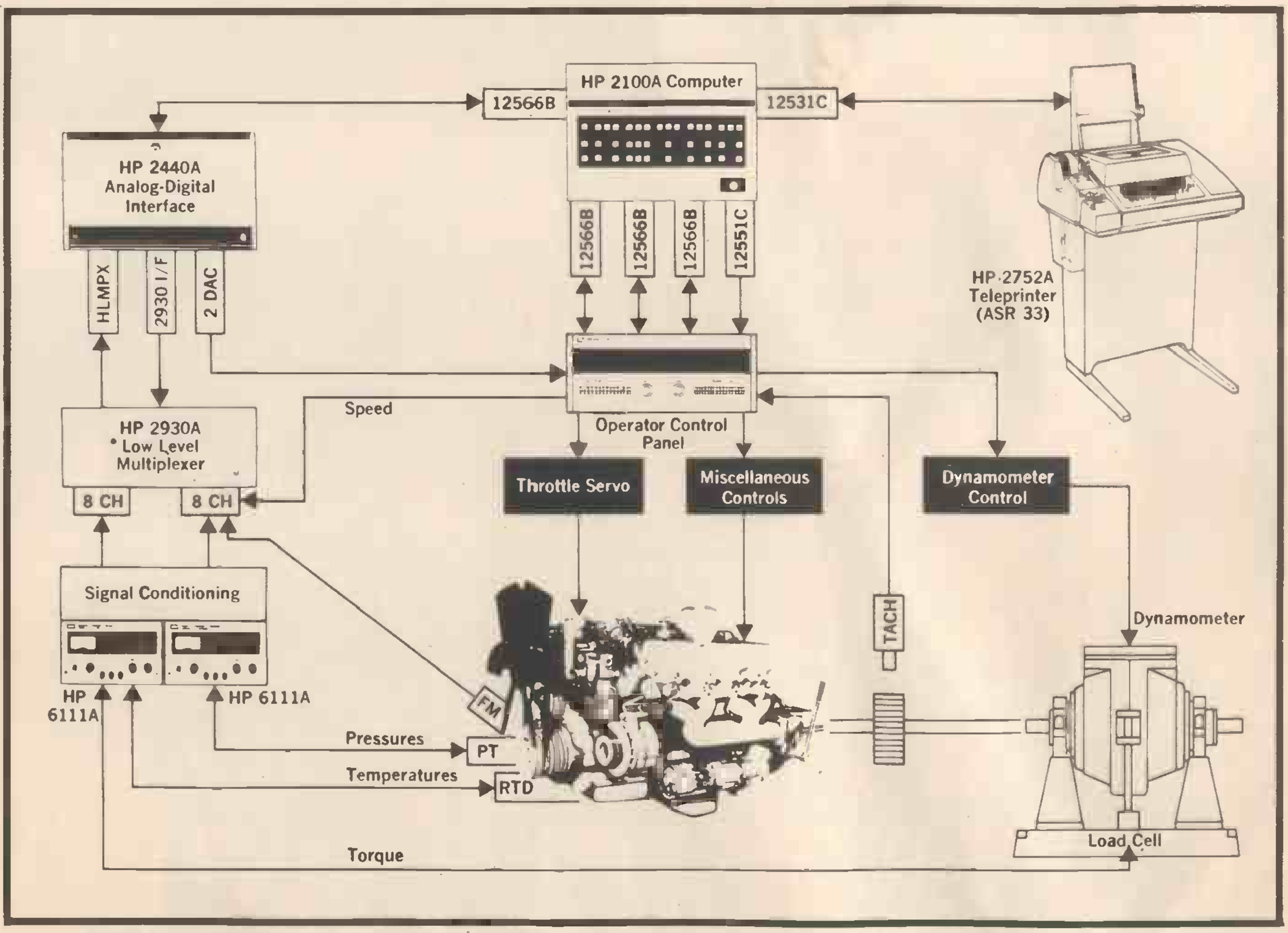


Fig. 7. HP9600 data acquisition and control system applied to engine testing.

Transducers in measurement and control

number of parameters to be monitored requiring the use of a diverse arrangement of sensors as we have seen exist. Sometimes they are of the same kind but at different locations, for instance, as in the structural testing of a ship at sea using strain gauges, or they may be of different kinds as in a process plant where temperatures, pressures, moisture content etc., must be monitored. When data from each is not needed continuously, they can be switched sequentially onto a common line feeding a single time-shared recorder — as shown in the data logger schematic of Fig. 6. When automatic data processing is used, a digital form of output is preferred — some transducers are designed to produce digital signals directly. For visual monitoring, analogue chart records are best. It is common practice to use

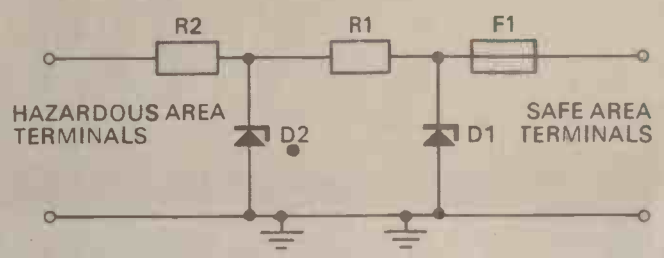


Fig. 8. Circuit used in a Zener barrier.

Transducers in measurement and control

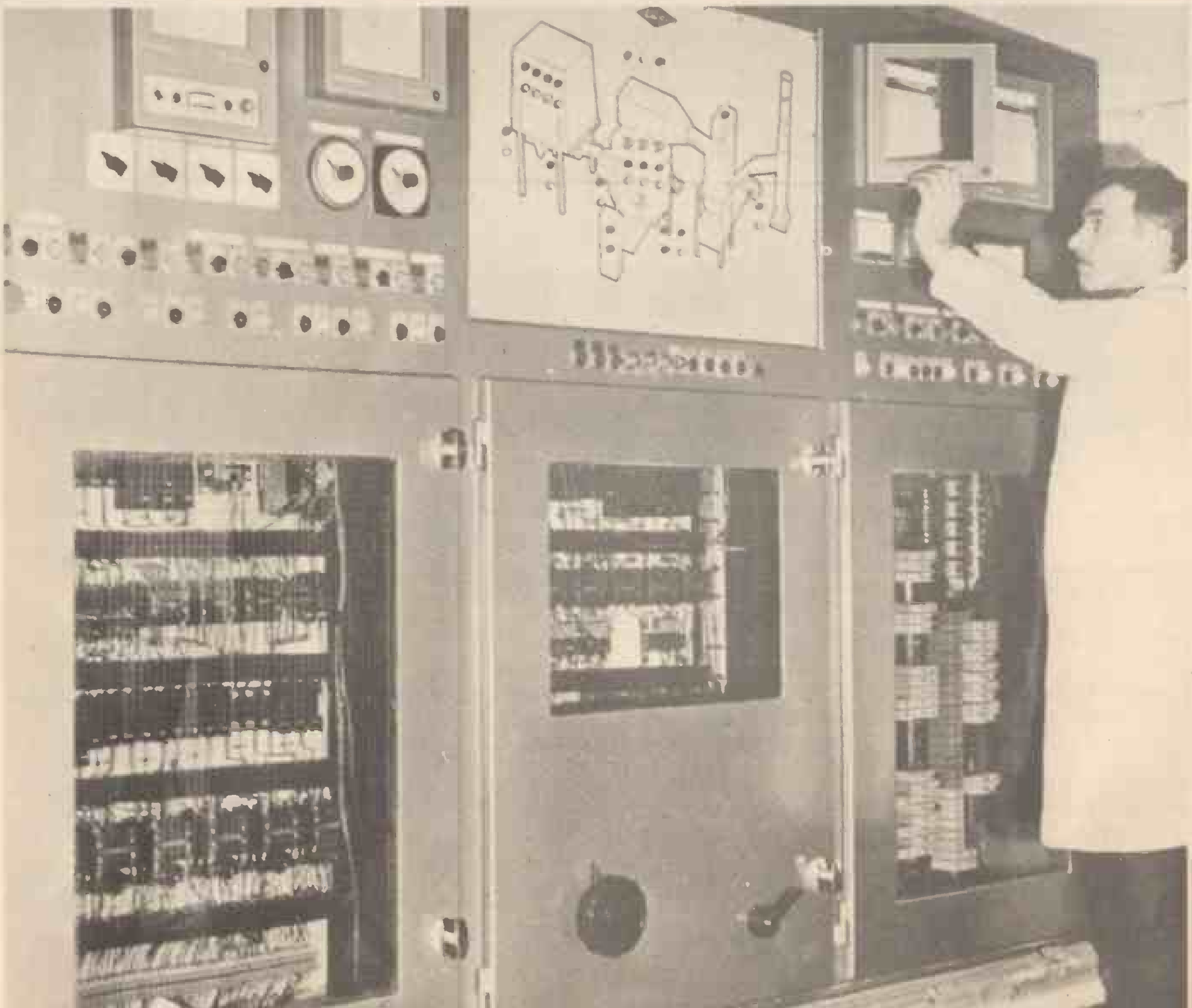
Fig. 9. Control console of Lucas automatic incinerator features indicating mimic panel.

both to satisfy both needs. An essential requirement in large-scale development is that each sensor delivers signals that are compatible and uniformly ranged to make best use of the dynamic range of the recorder. Many instrument manufacturers now list data acquisition systems as product lines: the Hewlett Packard 6900 system is shown in Fig. 7.

To assist the design of large, complex process-control systems, makers of transducers and controllers use a number of standardised transmission signal ranges, examples being the 4-20 mA dc and 0-10 mV dc systems, but these are not universally adhered to; recalcitrant manufacturers claiming that their particular output range is more satisfactory.

SAFETY MEASURES

Often sensors must be situated in hazardous areas where explosion could result from a spark or excessive heating of the sensor circuits. The obvious way to reduce this risk is to contain everything in flameproof enclosures of great strength. There are disadvantages to this method, namely, that the cost is high, and that testing and maintenance are made difficult,



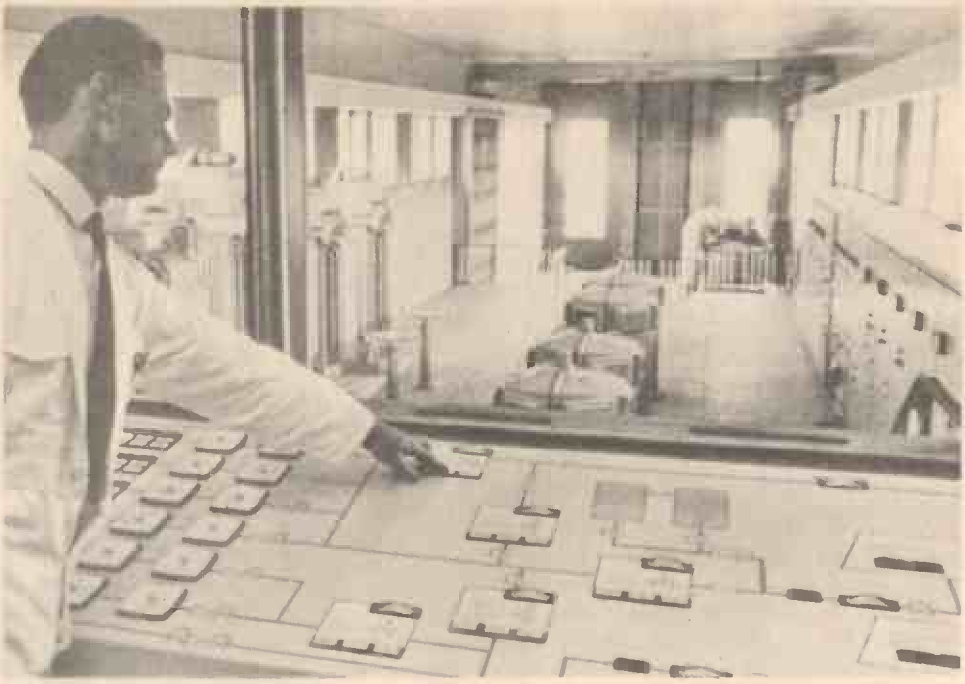


Fig. 10. Human engineered control panel of computer-controlled water distribution station – controls are laid out in the mimic diagram.

for the power must be shut-off when the enclosures are opened.

The alternative, and more recently adopted method, is known as intrinsic safety. Inflammable vapours require a specific level of energy to bring them to the flash point. Limiting the amount of power available from a sensor circuit under any condition will eliminate this risk. No enclosures are needed and the sensor can be adjusted with the power on.

Originally the concept was implemented by ensuring that the circuit could not draw or give up greater than a specified power in the event of a fault. (This amount is found by testing in a special test chamber filled with inflammable vapour). A marketed Philips pressure transducer system is maintained intrinsically safe by limiting the inductance to 33 mH (at the most) and the capacitance to 180 nF. It uses the 4-20 mA standard (representing 0-100% signal swing) to provide power from the quiescent 4 mA value. This method works but suffers from the need to individually check each circuit for safety. A plant having hundreds of transducers would take a considerable time to inspect.

A recent improvement (it was introduced around 1960) is to use a circuit placed on the boundary of the hazardous area and the non-hazardous area that can ensure that all electronic circuits connected after it in the unsafe zone are isolated with regard to high power levels. The Zener barrier does just this. Basically it uses a Zener diode connected across the two-wire line and a fuse in series on the unearthed safe side line. A power surge attempting to pass the barrier (perhaps as the result of a sensor or wiring fault or a fault at the supply end) and thus attempting to raise the voltage at the sensor, is diverted to earth by the diode. Faults of long duration that might destroy the Zener diode are eliminated by the fuse blowing. In practice, a Zener barrier uses a pair of diodes, (see Fig. 8.) to reduce the risk of losing protection by an open-circuit diode (that would not be detected). Zener barriers, complying to Standards, are available commercially as ready-made units. As yet, their use is not internationally accepted. For further details consult the article listed in the suggested reading.

CONTROL ROOMS

Today, extremely complex processes and large power plants can be operated by a staff of only two or three people. This is achieved by monitoring all essential parameters with transducers feeding their signals back to a control room. By making the controllers and recorders small enough and of standard shape it is possible to mount them together on a control console.

Well designed layouts are the result of considerable thought, for the operator must instinctively know what to do in an emergency. Two basic arrangements are as follows: The layout can contain a schematic or mimic diagram of the plant on which lights operate to show failure or correct action. The console of a computerised refuse disposal system is shown in Fig. 9. Alternatively, the controls themselves can be placed in the mimic layout covering the whole panel as shown in Fig. 10. Row after row of exactly similar knobs and dials are to be avoided if each has a different purpose. Often a multi-channel closed-circuit television monitor is incorporated to enable the operator to view the proceedings at selected places.

SOURCES OF INFORMATION AND SERVICES

Anyone who has had to select or make a sensor for a specific task will know the frustrations involved – does such a sensor exist on the market; where does one buy it; are the specifications realistic in light of current technological achievement? Often a sensor is built from scratch (at great cost) because the task of researching the literature and manufacturers' catalogues for information appears prohibitive. Because the sensor may be cheap does not imply easy purchasing. It is, therefore, appropriate to outline where assistance is available in this regard.

If the sensor is known to be in common useage, the relevant Standards Association leaflets, kept in most libraries, will describe what is accepted and attainable practice, for the Standards are reached by considering current *practice, not future hopes.* This study may also reveal specifications of the sensor that may have been overlooked. Manufacturers' data sheets also assist

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in understanding the pros and cons of a device, but read more than one maker's literature for it is not totally unknown for a manufacturer to be biased in favour of his own product!

If you are not fortunate enough to have a good technical literature library at your disposal, assistance may be available from places such as the Standards Laboratory (NPL in Britain, NSL in Australia, NRC in Canada, NBS in the States, etc.) of the country concerned, and also from the government laboratories.

To help ensure that marketed instruments (and other products) are up to specification, each country has a national testing authority that inspects and registers testing laboratories who have the necessary facilities. In Britain the British Calibration Service, BCS. In Australia this is the National Association of Testing Authorities, NATA. Only laboratories maintaining the required standard of equipment and excellence of use can obtain registration. Consequently, a study of the index listing the certificated laboratories may reveal a manufacturer in the field of interest. These laboratories can test equipment for buyers as well as manufacturers, at a reasonable charge.

Specialized services exist in technological sophisticated countries. The association in Britain concerned with instruments being the Scientific Instrument Research Association (SIRA). They operate a service called SIRAID on behalf of their numerous member companies. Enquiries regarding makers, suppliers and data of instruments are attended to promptly, free of charge. a phone call, letter or telegram asking for a list of potential suppliers of a named transducer will result in a letter by return. The service goes further, for reasonable rates, to provide assistance in design and testing, consultation services, and for specific research into instrument problems. SIRAID is not confined to British residents; their address is South Hill, Chislehurst, London, U.K.

Some countries have a peculiar problem due to the high content of imported equipment — this is the task of locating the agent representing the manufacturer. A simple way is to contact the respective Embassy or special office of each country, such as the British High Commission for British products. The staff are well informed and usually maintain an up-to-date library of products and trade journals supplied by air mail.

Sources of aid often disregarded are Universities and Technical Colleges. It is a common feature in many countries that industry shuns consulting the academics. It is true that some tertiary research is esoteric and not relevant to day-to-day problems, but in general these institutions contain a wealth of free information. The staff are usually willing to assist for this is one of their roles in society.

If the interest is research orientated, it might pay to subscribe to one of the personal abstracting services such as iSi (Institute of Scientific Information). For a modest fee they will regularly supply selected abstracts, from numerous journals, in which the title includes key words chosen by the subscriber. iSi also publish the Science Citation Index, a series of volumes in which authors referred to by writers of articles are listed. This rapidly assists the reader to find out who else is working in the same field, and thus find other information on a technique.

We have now reached the end of this series. It has been our intention to promote awareness of the many techniques and their limitations. No *universal* sensor appears to exist, so the task of selection will continue to be a matter of careful consideration. There will, however, always be a universal need for sensors to convert the real-world phenomena into a language suited to our automatic communication methods.

FURTHER READING

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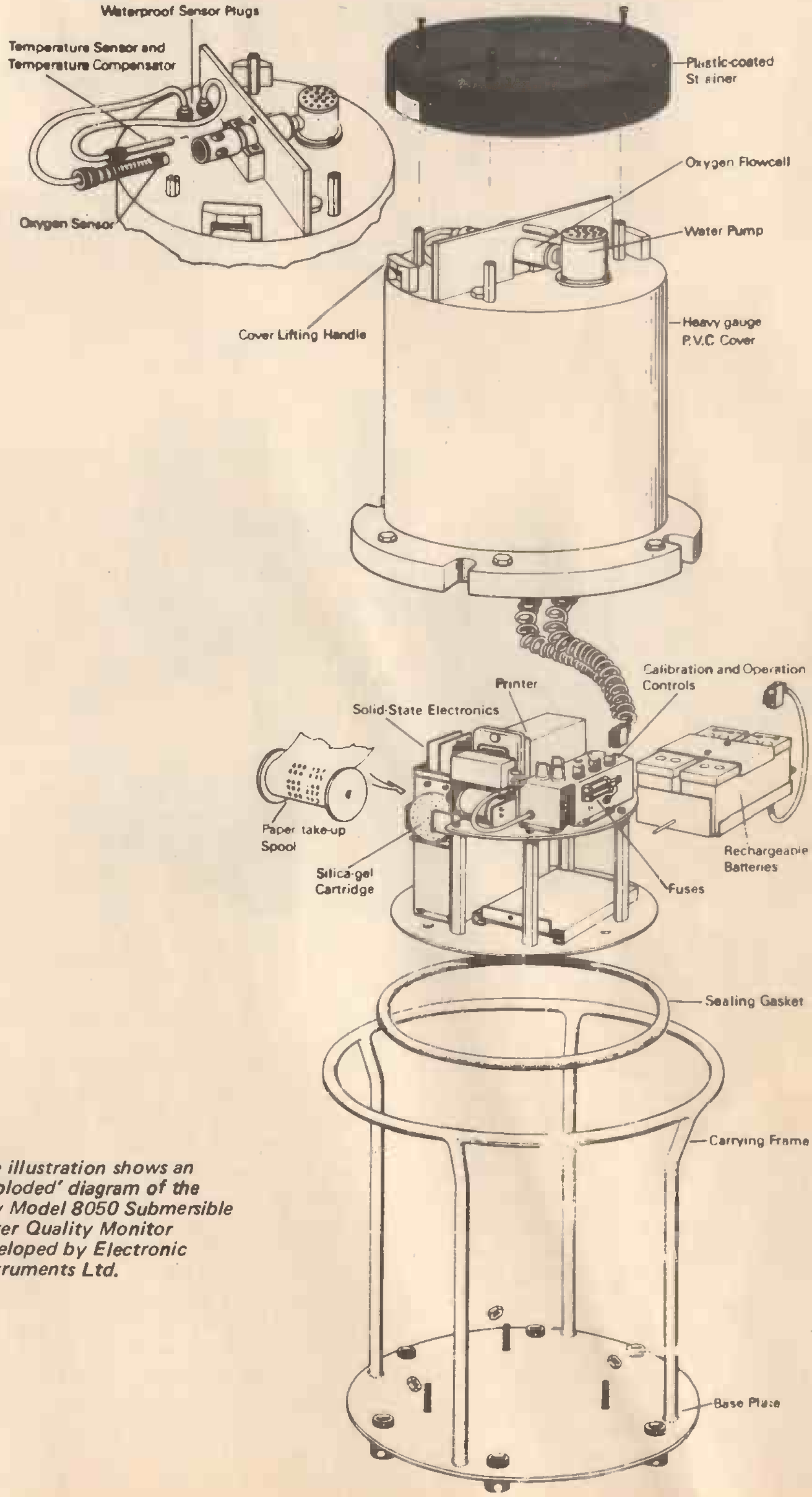
automatic pollution monitor

Submersible Water Quality Monitor Model 8050



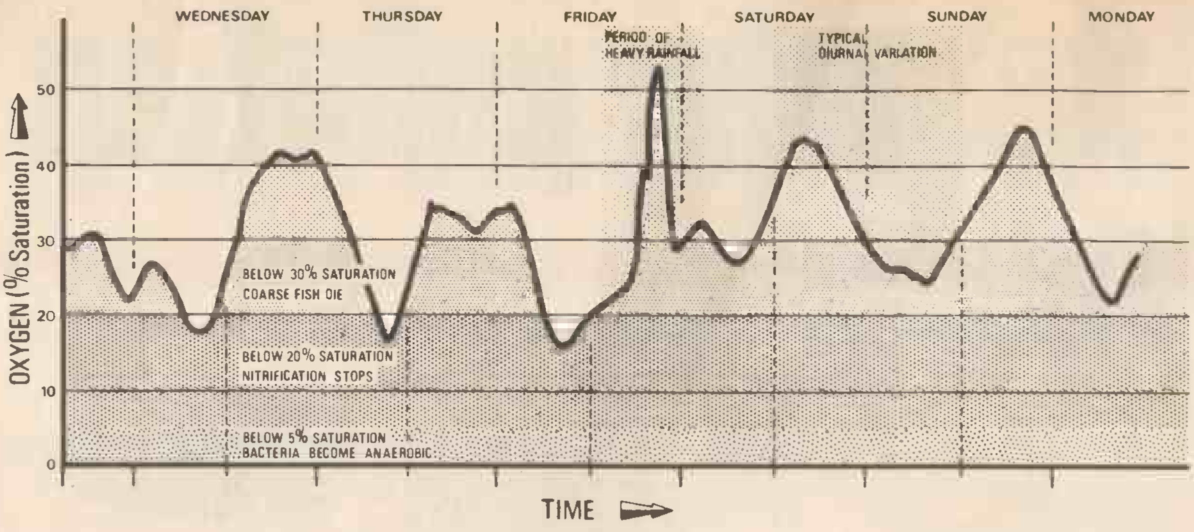
The illustration shows an 'exploded' diagram of the new Model 8050 Submersible Water Quality Monitor developed by Electronic Instruments Ltd.

A few months ago the PLA (Port of London Authority) who are responsible for the lower reaches of the Thames River offered three £500 prizes for the first three salmon to be caught in the Thames in their area. The fact that this prize will probably be won in *less* than five years illustrates perfectly the massive strides that have been made in cleaning up our rivers. Ten years ago they were amongst the filthiest in the world; now they are among the cleanest in the industrialised areas. Unpolluted water has a dissolved oxygen content of 100% but ten years ago, for a six mile stretch of the Thames, the figure was nil. At that time just a few eels managed to survive and the Thames was a complete barrier to all fish.. Today several dozen species can be caught in this same stretch.

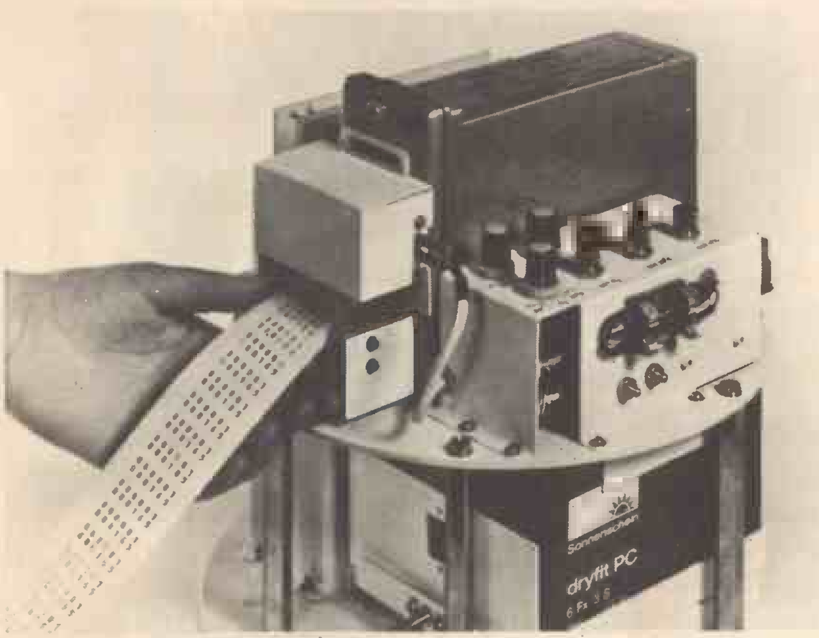
This cleaning up operation began years before the current "pollution consciousness" took hold and has been going on quietly. The cost has been enormous but the process has not yet finished.

One problem that has been facing those responsible for the cleaning up of our rivers is that of monitoring.

The Model 8050 is a portable, self-contained, 'round-the-clock' monitor using solid state electronic circuitry housed in a rugged waterproof case. The equipment will operate for up to 6 weeks at depths down to 30 metres.



Analogue plot of digital recordings on paper tape of dissolved oxygen level during a six-day period in a small river containing a high proportion of treated sewage. This graph contains the data obtained from 500 discrete samples. The Model 8050 clearly shows that there are periods when the sewage load is more than either the sewage plant or the river itself can purify. There is an obvious difference between the amount of pollution during the week and that at the weekend.



The output is printed in real values upon a paper tape which is stored within the instrument. Each pair of readings represents the Dissolved Oxygen and Temperature in the water at sampling rates which are variable from 1 minute to 2 hours.

Until recently the only method of checking on the state of the water has been to take samples and have these checked out in a laboratory. This is expensive and laborious. In addition, it leaves large gaps in the records for the dissolved oxygen content is not a stable factor—it varies enormously from hour-to-hour as well as from day-to-day.

ETI was recently invited to a demonstration on the Thames, right beside Tower Bridge, of a new automatic water quality monitor.

This instrument, developed by Electronic Instruments Limited, a member of the George Kent Group, can be suspended in the water or rested on the river bed for up to six weeks and will provide a continuous series of readings on the state of the water.

The new unit—the Model 8050 Submersible Water Quality Monitor was developed from an original idea of the Water Pollution Research Laboratory at Stevenage.

The 8050 is portable, automatic, self-powered by rechargeable batteries and designed for operation at depths of up to 100 ft. In addition to recording the oxygen content it also provides a record of the water temperature.

Up to 500 readings can be taken before the batteries require recharging and the time intervals between these readings can be selected from 1 minute to two hours.

A major advantage is that the readout, which is printed onto paper tape is in real form: the oxygen content is shown as an actual percentage as is the water temperature; systems of this type often require the information to be returned to the lab. for analysis.

At the demonstration we saw a unit submersed from a PLA launch and another unit, which had been immersed for a week, brought up to investigate the readings. Both operations are done quickly and do not require skilled operators.

The paper tape showed immediately the need for a constant monitor of the water's condition. At its low point the oxygen content had been as low as 8% (but only for very short periods) but reached a peak of 67%. Fish such as salmon and trout require a minimum of 10% for survival. The divergence of the figures depends on the tides (this part of the river is tidal) but also on the day of the week. Fridays show the maximum pollution (this gave the low 8% reading) while on the following Sunday the minimum reading was 25%.

The sensors are based on existing types and are housed in a plastic coated steel strainer on top of the unit. An impeller is fitted on top to provide the correct amount of water for the reading (one litre).

The 8050 sells for considerably less than models so far available at £750, putting it well within the range of the various water authorities. It is the first such unit available and a massive export market is predicted. So far some 30 units are in operation. ●

IMPROVED A-D CONVERTER

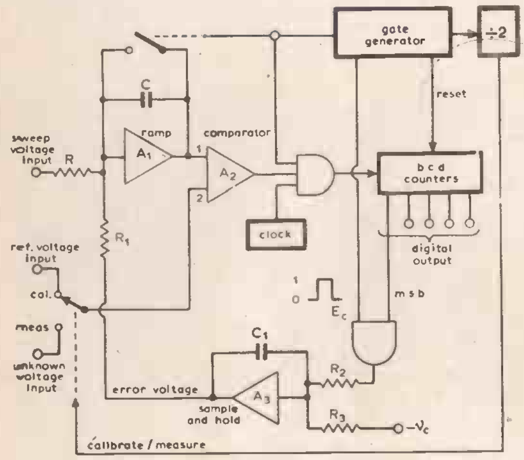


Fig. 1. Block diagram of A-to-D converter

A CIRCUIT has been designed by Jim Barnes of the Applications Department of Motorola, Phoenix, which allows greater accuracy to be obtained from single-ramp A-to-D (analog-to-digital) converters. The converter, for which a patent is pending, uses alternate Measure and Calibrate cycles to obtain 0.01% or 4½ digit accuracy.

A known analog input is measured and the resulting digital number is compared to the correct answer. If this digital number is not correct, the converter is automatically adjusted so that the correct answer will be produced. Since this calibration cycle is interlaced with cycles which measure the unknown analog voltage, compensation for all but the most rapid variations in converter accuracy is provided.

This new conversion method requires only one precision part which is the reference voltage used in the calibration cycle. This voltage must be maintained to within $\pm \frac{FS}{2\,(n+1)}$ where n is the number of bits of accuracy if ±½ least significant bit accuracy is to be expected, and FS is the full scale value of the converter.

In the conventional circuit, the output of a ramp generator is

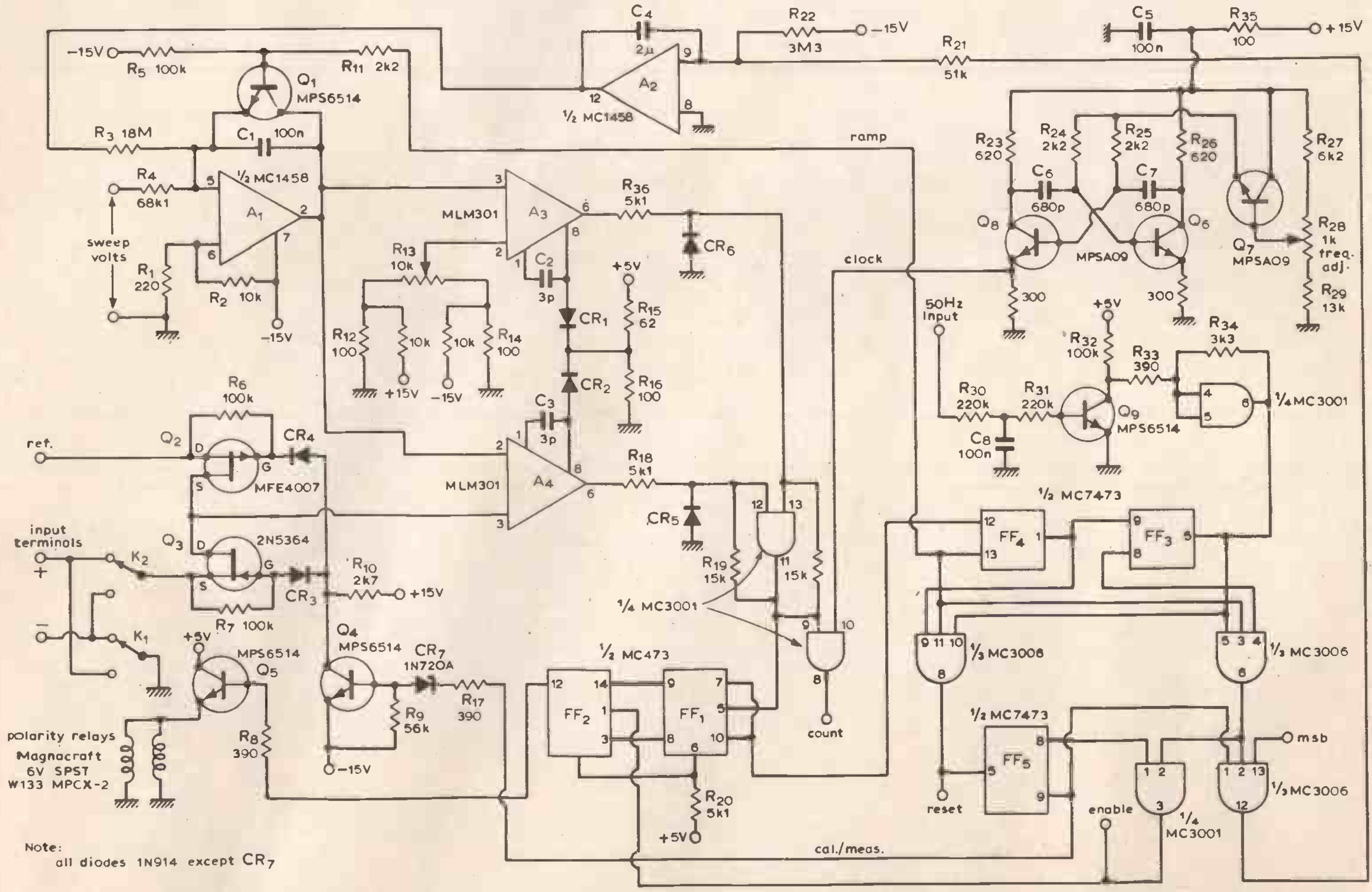


Fig. 2. Circuit diagram.

compared with the unknown analog input voltage. At the start of the ramp a gate is opened and, when the ramp voltage is equal to the analog input voltage, the gate is closed. It follows, therefore, that the gate is open for a time proportional to the magnitude of the analog voltage. When open, the gate allows constant frequency pulses through to a counter. After each gate cycle, the counter holds a number which is proportional to the input voltage; the contents of the counter can then be converted into a code to suit the particular application.

The prime cause of inaccuracies is the ramp generator which can suffer from two defects, incorrect slope, and wrong starting time. If the ramp starts late, too few check pulses will be registered. If the slope of the ramp is too steep, it will reach the unknown voltage too soon, with the same result. The clock frequency, of course, has the same effect on accuracy as the ramp slope — if the clock is too slow it will not produce a sufficient number of pulses during the gate interval.

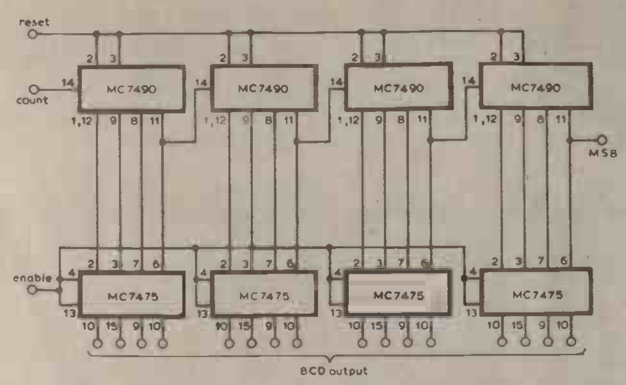


Fig. 3. Logic layout

Circuit alternates measure and calibrate cycles to obtain 0.01% accuracy.

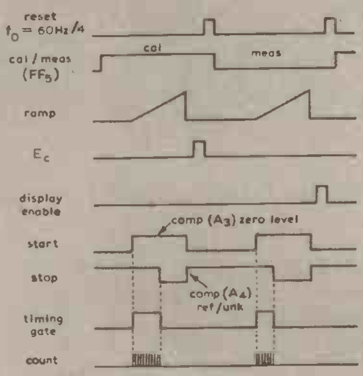


Fig. 4. Circuit waveforms.

AUTOMATIC CALIBRATION

Figure 1 shows a block diagram of the system. The voltage reference is exactly 80% of the full scale value of the converter because, in a BCD counter, this corresponds with the switching of the most significant bit in the counter.

In operation, the comparator is switched alternately between the unknown voltage and the reference voltage. The most significant bit of the BCD output number is examined during the calibrate cycle, by means of pulse E_C so it can be decided if the ramp slope is too steep or too shallow, and to derive a dc control voltage which is used to vary the ramp slope. Since the error voltage is only present during the E_C pulse, a means must be provided to store the control voltage value when the signal is not present. In the system shown, an integrating operational amplifier is used in a sample and hold circuit. The capacitor and charging resistor values are selected so that the error voltage obtained during each calibrate cycle will correct the ramp slope an amount corresponding to the least significant bit divided by four.

Figure 2 is the circuit diagram of the converter employing the calibration method just described and Fig. 3 shows the counter and logic control circuits.

To avoid the need for precision parts in the loop, a potentiometer is used to adjust the frequency of the oscillator. This allows the oscillator to be set so that even if the ramp has been driven by the control voltage to its most shallow slope, no more than 10 000 clock pulses can reach the counter during the calibrate cycle before the ramp reaches the eight volt reference. The error signal will hence always be of the correct polarity to drive the ramp up until the proper 8000 pulses are reached when the ramp crosses the eight volt reference, at which point the loop locks.

The ramp generator (component B) and the integrating amplifier (component D) which provides the error control voltage are shown in Fig. 2. The error input to the integrating amplifier is single-ended, i.e. error pulses are supplied only when the gate count is too high, control in the other direction being provided by a fixed bias. With no error pulses, the integrated error signal drifts slowly positive, while with continuous error pulses, it steps more negative at the same average rate. Figure 4 shows the waveshapes generated for control of the A/D converter.

The error voltage changes rapidly during the E_C pulse and drifts slowly between pulses. With large errors, such as might be present for a short time when the unit was first turned on, a staircase error waveshape would be produced, but at near zero error, the most significant bit error decoder output will be toggling between a plus and minus value to produce a sawtooth wave.

The electronics to accomplish polarity sensing are implemented as follows (see Fig. 2): polarity is indicated by a J-K flip-flop, S, connected so that it will change state every time it receives a negative going pulse. The timing gate is connected to its input so that each occurrence of a timing gate signal will trigger the flip-flop.

In operation, the flip-flop changes state at the end of each measurement of a positive voltage. The timing gate pulse, which is always present during the calibrate cycle (because the reference voltage is always positive), returns the flip-flop S to its original state, ready for the next measurement. However, if the input is negative or zero, only the calibrate cycle timing gate pulse will be present, so the state of flip-flop S would alternate for each cycle.

A second J-K flip-flop, T, is connected to flip-flop S in such a way that its state is forced to be the same as that of flip-flop S at the time of the display enable pulse. With two flip-flops connected in this way, the polarity relay (and readout) will only be activated under the conditions that the unknown input is either negative or exactly zero voltage. ●

electronics tomorrow

NEW SERIES

THIS IS THE FIRST of a series in which we intend to discuss new products of interest to, and available to, the amateur and small professional constructor. It is intended to be more than a product review in as much as we hope to be able to give short constructional examples of some of the products, this approach gives a better insight to the capabilities of the product than one gets with a data sheet.

Before launching into the first reviews a few points are worth mentioning about obtaining these devices. As the products are normally new (so new that some may not even be released yet) they will not normally be obtainable from your usual component supplier. They will only be obtainable from the manufacturers or their franchised distributors, some of these are not willing to deal with individuals and most of them have a minimum order charge of £2-3, £25 or even £100. There are a few firms now filling this gap, they will deal with individuals, schools, firms, etc. and do not usually have a minimum order charge, especially for CWO transactions. Some of these firms are independent and others are subsidiaries of larger distributors, the former may be willing to chase virtually any device for you whereas the latter will be restricted by their franchises. Most manufacturers will not sell direct although it is to them or their distributors that one should write for data. For each product reviewed we will give one reference to approach for data and another for the component. When asking for data or components be sure to give a clear description and a component reference and if possible send a stamped, self-addressed envelope. Please also mention ETI as in case of problems it can be used as a common reference point.

This series of articles depends of course on data being available to the author from manufacturers and distributors. Anybody is welcome to send data or comments to us and everything will be considered for inclusion.

Although the intention is normally only to mention new products, we will cover some products that are not new to the industry but may well be new to the amateur constructor, this even includes surplus devices. Again we would point out that most of these products are new and as such supplies may be limited or there may be delays in supply, so be prepared for this. Wherever possible we will try to obtain a special offer to readers of ETI, only this will probably be a special price for a limited quantity so get your orders in quickly.

NEW RADIO CHIP DATA SHEET

Remember the Ferranti ZN414 radio chip? It was the subject of articles and a special offer in ETI at the end of last year. The sort of projects at that time were simple earpiece receivers for the medium wave only. Ferranti have now issued a new data sheet and booklet describing the device and its use in the following projects: Earphone radio, Domestic portable, Model radio control receiver, Direction finder, AM superhet and Frequency standard receiver. Unfortunately Ferranti have copyrighted the data sheet so we cannot reproduce any of the circuits here. Price of the ZN414 is £1.20 one off. Data: 1. Component: 2.

SOCKETS FROM JERMYN

Most IC manufacturers and distributors guarantee their products *only* if the IC can be returned for testing unsoldered, thus the additional price of a socket for expensive ICs can pay dividends in the end.

One of the foremost socket manufacturers in the country is Jermyn Industries and, although some of their sockets are expensive compared to those obtainable in the shops, they are designed for industrial applications and are not likely to pack up after a few insertions. Four interesting products from Jermyn are:

a. Large IC sockets, 24, 28, 30, 36, 40 and 50 pin DIL sockets for LSI devices. As some LSI devices are very prone to destruction by fingers or faulty irons, a socket is a good investment.

b. Pin Headers. These are plugs which fit into standard 14 or 16 pin sockets with solder tags to which cable or components may be attached. Two types are available, low-profile for use with cable as interconnecting plugs (16 way flat cable is also available) and high-profile for use with discrete components to effectively make your own ICs. Both types have holes in the caps through which a permanent potting compound can be inserted for temperature or physical stability.

c. Test Sockets. These are high quality panel or PCB mounted sockets with very low insertion force. They are ideal for IC test panels as the ICs can be easily inserted, tested and removed without the slightest possibility of harming the pins.

d. Test Probe. A 16 pin probe that fits over the IC *in situ* for testing whilst in operation. The probe can be connected with 16 way cable to a test board or 16 LEDs.

Jermyn catalogue: 3, Components: 2 or 3.

DIGITAL ALARM CLOCK CHIP

National Semiconductors have announced an addition to their MM5311 range of clock chips with the MM5316 digital alarm clock chip. The interesting thing about this chip is that it interfaces directly with RCA or Siemens Liquid Crystal displays. The chip features 4 digit 7 segment outputs, AM/PM outputs, 1Hz output and switched outputs for alarm and a "sleep" feature. Power requirements are 8-29V D.C. at 2-5mA as the supply does not have to be regulated the power supply circuitry can be very simple and small.

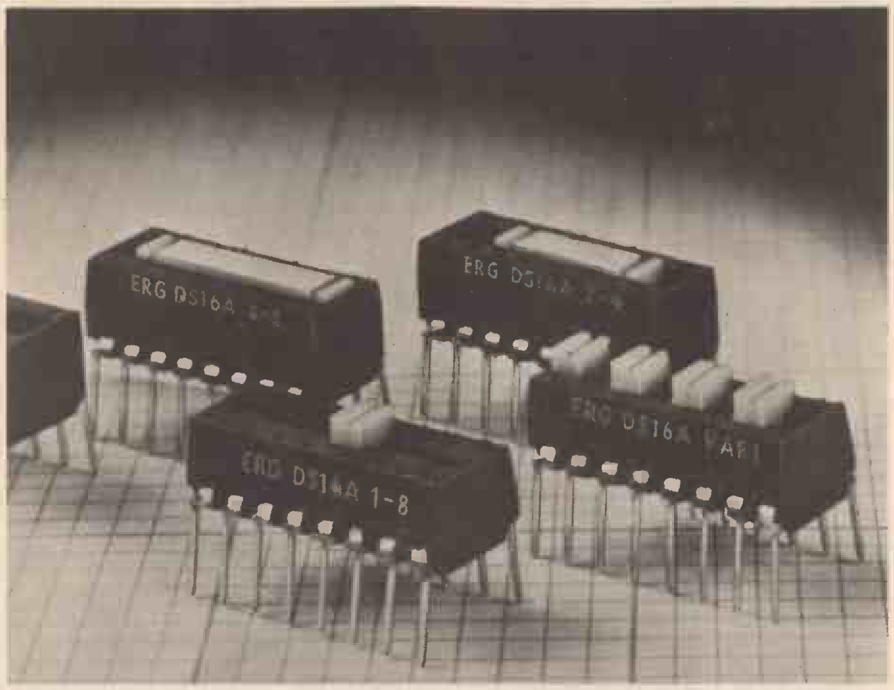
Data MM5311-5316: 4, RCA L/c: 12, Siemens L/c 9. Components MM5311-5316 - small quantities: 3, large quantities: 5 or 9. Liquid Crystal - RCA: 2 or 12, Siemens: 9.

555 TIMERS

The Signetics 555 timer reviewed a few months ago in ETI has been "second sourced" by two manufacturers. This means that the 555 has become an industry standard all three devices now available have similar specifications. The two new devices are the Motorola MC1455 and the National Semiconductor LM555. This extremely versatile device has been described in most electronics magazines so data sheets are probably not required, however they can be obtained from Signetrics: 6, Motorola: 7 and National: 4. The prices vary slightly but one-off are just under £1. Small quantities (manufacturer depends on stocks) from 2, large quantities Signetics: 8. Motorola: 3, National: 5.

MINIATURE SWITCHES

New LSI chips and miniature LED displays mean that sizes of clocks, digital meters, calculators, etc. can be considerably reduced. Unfortunately some parts of the finished unit are still large, these usually being the transformers, the case and the switches. ERG of Dunstable have solved the switch size problem (transformer and case manufacturers please note) by announcing a range of slide switches based on a 16 pin DIL package. The alternative to the switches is usually a large rotary switch, so these switches show a space saving of 10:1. The range is the DILI-8 one-pole eight-way, DILI-6 one-pole, six-way, DIL2-4 two-pole four-way, DIL4-2 two-pole four-way and the DILVARI four one-pole two-way switches in the one package. Prices are 75-90p for one offs. Data: 10, Components: 2



Erg Dilswitches. These high quality miniature switches are made to fit into standard DIL sockets, PCBs and Veroboard. They are rated as: Maximum voltage 28V d.c. at 250mA; Life (minimum) 20,000 contact wipes. They are available in the following types: DIL 1-8, 1-pole 8-way at 75p; DIL 2-4 2-pole 4-way at 80p; DIL 4-2 4-pole 2-way at 85p; DILVARI 4 times 1-pole 2-way at 90p; DIL1-6 1-pole 6-way (To Order).

RED AND GREEN LEDS

The fallacy that LEDs are red has long been supported by the fact that green LEDs have cost about £4 each compared to about 40p for the red. FR Electronics have recently announced the SLA15 green LED at about £1.20, this matches the SLA5 red LED. These LEDs are the subject of our first special offer, we have 1000 pairs (one red and one green) available at £1 per pair (recommended price £1.60). To take advantage of this offer fill in the coupon below.

Please note that for trade and export reasons prices quoted exclude VAT. UK purchasers should add 10% when ordering.

ELECTRONICS TODAY INTERNATIONAL
August 1973

I would like to take advantage of the special offer for a pair of red and green LEDs mentioned in the feature Electronics Tomorrow. I enclose a cheque/P.O for £1.10.

Name ....

Address ....

....

....

....

Orders should be sent direct to:
BYWOOD ELECTRONICS
181 Ebberns Road,
Hemel Hempstead,
Herts.

Offer is limited to first 1000 orders.

-----CUT-----

To finish up with, a list of firms specialising in the supply of up-to-date devices to the small quantity market. Where the firm is a subsidiary of a distributor the distributor's name is in brackets.

Arrow Electronics Ltd. (LST Ltd). 7 Coptfold Road, Brentwood, Essex.
Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts.
Northern Electronics, 9 Montreal Street, Oldham, Lancs.
SCS Components (Semicomps), PO Box 26, Wembley, Middlesex.
Trampus Electronix, PO Box 29, Bracknell, Berks.

REFERENCES

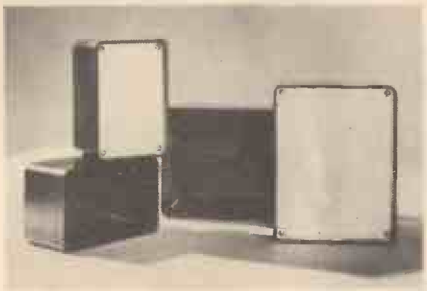
1 Ferranti Ltd, Gem Mill, Chadderton, Oldham, Lancs.
2 Bywood Electronics, 181 Ebberns Road, Hemel Hempstead, Herts.
3 Jermyn Industries, Vestry Estate, Sevenoaks, Kent.
4 Atlantic Components, 143 Loughborough Road, Leicester.
5 National Semiconductors, The Precinct, Broxbourne, Herts.
6 Signetics Corp., Yeoman House, Croydon Road, London SE 20.
7 Motorola, Semiconductors Ltd. York House, Empire Way, Wembley, Middlsex.
8 Semicomps Ltd. Northfield Ind. Est., Beresford Way., Wembley, Middlesex.
9 Semiconductor Specialists, Premier House, Fairfield Road, Yiewsley, West Drayton, Middlesex.
10 ERG Industrial Corp., Luton Road, Dunstable, Beds.
11 FR Electronics, Wimbourne, Dorset.
12 REL Equipment & Components, Croft House, Bancroft, Hitchin, Herts.

eti component news

WEST HYDE 'MINOS'

The MINOS case from West Hyde is intended as an alternative for manufacturers of small instruments who may have previously used die cast boxes (which required painting). Where total screening is not imperative, the low cost and attractive finish makes these little cases an obvious choice.

Available in two sizes (100mm x 65mm and 130mm x 100mm and both 50mm deep) they are moulded in ABS which provides a gloss finish of intense black and a box of high strength/weight ratio.



Built-in P.C. guides will carry either screens, dividers, or printed circuit cards, up to five in the small case and seven in the large one. Chassis or P.C. Cards may also be supported on 'P' clips from internal pillars.

The front panels are fixed by plated steel screws and are in white PVC coated steel, or plain aluminium, both of which contrast well with the polished ABS to give an attractive appearance.

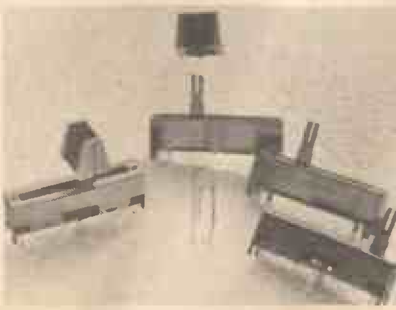
One-off prices are 40p for the small unit, 50p for the large. Postage etc. is 7p and 8p respectively. (Add VAT to all orders).

West Hyde Developments Ltd., Ryefield Crescent, Northwood Hills, Northwood, Middx. HA6 1NN.

SLIDER POTENTIOMETERS

Guest Distribution Division now have available a range of new slider potentiometers for mono and stereo application.

These potentiometers are constructed with a metal case, ensuring good electrical screening and robustness. The moving parts are made of nylon and lubricated for life during manufacture to give smooth consistent action.



A dual wiper system on the carbon tracks gives good electrical contact and low noise operation. Mounting for these 45mm slider potentiometer can be via threaded fixing holes in metal case or by the P.C. solder tags.

Availability is from stock in a selection of ohmic values in log and lin. A balance control is included and there is also a metallic finished knob to fit this range.

Guest International Ltd., Redlands, Coulsdon Surrey, CR3 2HT.

MICROMINIATURE SYNCHRONOUS MOTOR FROM IMPEX

Impex Electrical Ltd have announced a breakthrough in extreme miniaturisation with the production of a new synchronous motor - the 9904 110 09601 series. This motor will be of considerable interest to manufacturers of such products as domestic timers, industrial counting instruments and, in fact, any equipment where the physical size of both the motor and of the complete equipment is of prime importance.

The microminiature motor measures only 13mm x 19mm (approx), has good low noise characteristics and will give long and reliable service even in ambient temperatures as high as 85°C. It is designed to operate at 375 r.p.m. at 50Hz, delivering 0.8g cm at spindle speed with a power consumption of 200 mW.

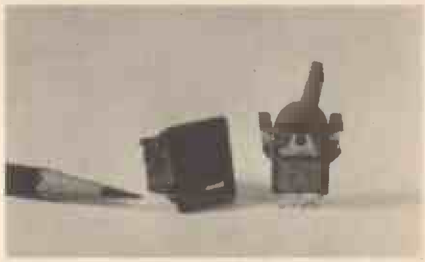
Impex Electrical Ltd., Market Road, Richmond, Surrey.

PHOTODIODE ONLY NEEDS STARLIGHT

Even the light of the stars on a moonless night is sufficient for the new Siemens photodiode BPX 63 to operate as an opto-electronic receiver, for example, for photographic exposure meters. The photo-sensitivity of the diode is 10nA/lux. The threshold sensitivity of earlier photoconductive cells is not just equalled, it is actually bettered. At an illuminance of 10^{-2} lux (10^{-3} lux behind the matching filter), the component supplies an output voltage exceeding 0.5mV without thermally generated charge carriers excessively interfering with the useful current. A circuit for a photographic exposure meter designed in the Siemens Applications Laboratories also ensures that the aperture setting can only be affected by the useful signals and not by the noise signals.

NEW MINIATURE SWITCHES

Roxburgh Electronics Ltd. have added two new miniature switches to their range of paddle and rocker switches. The new switches type MJ, are designed for snap-in fittings for ease of assembly and fit into a panel cut out



of only 12.7mm x 15.0mm. Available in 1, 2, 3 or 4 pole double throw configurations, they have a switching capacity of 5A @ 120V a.c. The switches have stainless steel bodies and are available with a variety of terminations.

Roxburgh Electronics Ltd, 22 Winchelsea Road, Rye, Sussex.

FLEXIBLE PERMANENT MAGNET

Magnetic material in strip form which can be bent, twisted or flexed without loss of magnetic properties has been introduced by 3M.

Available with or without pressure-sensitive adhesive backing, Plastiform permanent magnet strip is supplied in 0.5in, 0.75in and 1in widths, and is, says 3M, suitable for a wide range of applications - from pure electrical, where it can be employed in reed relays, thermostats, FHP motors, loudspeakers and galvanometers, to fixing and holding functions on domestic appliances, hinged and sliding doors, security devices, dictating machines - even as coupling on toy trains!

Produced by a special process which orientates the barium ferrite both before and during magnetisation for a stronger magnetic field, Plastiform magnet strips have greater resistance to demagnetisation than most conventional magents, and may be machined, cut, slit, punched, stamped, drilled or milled.

3M, 3M House, Wigmore Street, London W1A 1ET. ●

There's no such thing as the perfect Hi-fi system.

That's why we made the 810.

There is no one Hi-fi system which is perfect for everybody.

Rooms, like wallets, are different sizes. And musical reproduction requirements vary.

So we've made the ultra-flexible, supremely compatible, highest quality turntable.

The BSR McDonald 810.

For the man who wants to choose separate amplifier and speakers to build up his own perfect Hi-fi system.

It costs £44·25. It's a transcription unit weighing $16\frac{1}{2}$ lbs. The diecast turntable alone is $6\frac{3}{4}$ lbs. – solid and dynamically balanced.

A pitch control gives accurate turntable speed, using stroboscopic centre plate.

The low mass aluminium pick-up arm is gimballed for virtually friction free movement in all planes.

It has a slide-in cartridge holder, minimum tracking pressure of $\frac{1}{2}$ gramme and decoupled one piece counter-balance.

Its 4-pole dynamically balanced synchronous motor compensates for any fluctuation in mains voltage or record load.

There's hydraulically actuated viscous cueing on manual and automatic, and a unique anti-skate device.

The 810 is a two-speed player, 45 or $33\frac{1}{3}$ – all that's needed on a modern turntable.

It operates by featherweight push-button for start/stop and selection of record size.

A rigid smoke-tinted styrene dust cover and a polished wooden plinth are available as extras.

For a preview just return the coupon, or ask to see and hear the deck at your local dealer.

BSR Limited, McDonald Division, Monarch Works, Cradley Heath, Warley, Worcs.
Tel: Cradley Heath 69272.

Please send me your illustrated brochures of the complete range of turntables.

Name____________________

Address____________________

ET15

It's a sound start

BSR McDONALD

EQUIPMENT NEWS

TELEPHONE DATA TERMINAL FROM ITT

The need for a low cost data terminal has focused attention on the widely available telephone. ITT, with experience of manufacture and development of communications equipment for the world's postal authorities, have now included in their range a new telephone with integrated data features. Subject to the normal regulations of the national postal authorities, the ITT 7012 telephone terminal is available for use with ITT System 710 voice/data systems.

Providing all the features of a modern push button telephone, the ITT 7012 has in addition a visual data display, plastic badge and punched card reader and a printer. Special features, including a line seizure key for 'hands free' operation and a loudspeaker for audible response, are provided to assist input of data from the dial push buttons.

The new telephone terminal can give computer access to areas previously precluded by high terminal costs. Typical of such an application is the collection of project control data with an ITT System 710 integrated voice/data system. When work on a specific project or activity starts, the telephone terminal is used to dial access to ITT System 710 and input identifying badge card together with variable project or cost centre data for storage and future processing. This telephone terminal can operate with most modern push button signalling systems. including multi-frequency and d.c. The terminal has a 14-character visual display and a reader for Hollerith-coded cards and plastic badges. The ITT 7013 printer provides optional hard-copy facilities, giving a permanent record of data input.

S.T.C. Ltd., Foots Cray, Sidcup, Kent.

TWO DIGITAL MULTIMETERS

Two new 5-digit machines from Dana Electronics Ltd, spearhead the launch of a family of machines whose qualities are going up-market as fast as their prices are coming down.

Model 5000 DVM has five digits plus 100% over-ranging, and is the first integrating voltmeter with this capability. It is in fact the lowest-priced five-digit machine ever offered by Dana, thanks largely to their use of an LSI silicon-gate MOS IC. Nevertheless, neither quality nor reliability has been sacrificed. Solid-state silicon circuitry is used throughout, and each instrument is subjected to severe quality-control checks. All ICs are tested before installation, and every instrument is given a 120-hour run-in at 50°C, a 2.5 g vibration test, and a 168-hour run-in at elevated temperature.

The 100% over-ranging facility, which is unique for a 5-digit integrating voltmeter, is made possible by a brand-new technique: delayed dual-slope integration. This is a technique used in the Model 5000 to reduce noise and increase linearity, by reducing the bandwidth of the axis-crossing detector by means of a filter.

The basic instrument has five d.c. ranges (with 1μV resolution), complete auto-ranging, internal auto-zero without kickback, 10^{10} ohms input resistance, 100% over-range, a large LED display with zero blanking, function annunciators, cam interlocks to prevent improper range selection, and a switchable filter with 30ms response time. Optional accessories include four full-scale a.c. volts ranges (from 1 to 1,000V), six kilohm ranges, 4-wire ratiometric ohms measurements, d.c./d.c. ratios and a.c./d.c. – ohms/d.c. ratios.

The Model 5000 DVM replaces the Model 5300, but an £80 price reduction accompanies the improved performance: £515 for the basic model.

Model 5900 Digital Multimeter is complementary to the 5000 DVM and has the same rugged and highly-tested qualities. However, it is super-stable and accurate: ± (0.001% of reading + 0.001% of full scale) for 90 days, on the 10V range. Dana say that in spite of this there is no competitor offering anything like it at anything like its price.

It is a 5-digit instrument, with 60% over-ranging, boasting greater than 10,000MΩ input resistance, and delayed dual-slope integration. To get the best performance from the dual-slope integrator a 200-count delay is inserted between the signal integration and reference integration periods. This results in extremely high linearity, coupled with a bandwidth-limited null detector with very low noise. In addition the integrator has automatic zeroing circuitry to further ensure 0.001% accuracy.

There are five d.c. volts ranges, with full-scale readings from 0.1 to 1,000V, giving a maximum resolution on the lowest scale of 1μV. Settling time is only 5 milliseconds (10 milliseconds on the 100V range). With an external d.c. reference voltage connected to a rear-panel terminal the Model 5900 is given full 3-wire ratio capability: d.c./d.c., a.c./d.c., and mV/d.c. True 4-wire ratio measuring is available as an option.

Dana Electronics Ltd, Bilton Way, Dallow Road, Luton LV1 1UY.

TOUCH TERMINAL

A new concept in computer terminal communications – the touch terminal – has been developed by Ferranti Limited and Plessey Radar.

The touch terminal comprises a composite display and touch wire system through which unskilled operators may gain access to a computer memory store on a question and answer basis.

Touch communication is made possible by the use of touch points incorporated into a mask on the front of a C.R.T. display. When an operator is required to make a decision the computer presents a set of choices on the display, each one being associated with an appropriate touch point. The choices can be displayed as letters, symbols, words or sentences. To make a selection, the operator merely touches the appropriate touch point and a coded signal informs the computer of the choice. The computer then acts on that choice and presents the operator with the next set of choices and so on until the required data is presented.

Up to thirty-two touch points can be fitted to the mask in any layout which suits the customer's requirements. Connections to the touch points are made by a flexible printed circuit which forms part of the mask. Most Ferranti displays can be supplied as touch terminals and only a minimal amount of reprogramming is needed for the computer to use this system. In many cases touch terminals can be used without keyboards as the computer re-annotates the touch points for each set of selections, thus providing the effect of an almost infinite keyboard on the screen of the display. By making full use of the computer power available the operator's task can be significantly reduced.

Touch communication using the Touch Terminal is invaluable in areas where untrained operators with no typing experience have to communicate quickly and without error with a computer. Typical user areas are information retrieval, process control, air traffic control, reservation systems, simulation, education and many other military and commercial applications.

Ferranti Ltd., Simonsway, Wythenshawe, Manchester M22 5LA

STATISTICS CALCULATOR

Researchers who analyze data to generate histograms, or calculate mean and standard deviations, fit curves, or many other statistical calculations, now have a small desktop calculator to do their jobs quickly, easily, and at lower cost. The new Hewlett-Packard Model 9805A Stat Calculator system is claimed to solve most basic statistical calculations with one keystroke.

A built-in impact printer uses standard adding machine paper tape. Long lists of data entries and calculations are easily checked on its tape printout. Results are labelled for easy identification. A total of 10 digits plus the sign, and up to 6 places to the right of the decimal point can be printed.

A basic system plus four variations is available. Two of these versions are compatible with an optional plotter. All five systems:

1. Calculate a complete histogram on a data sheet. The resulting printout includes the cell number, lower bound of the cell, number of occurrences in the cell, and the relative percent frequency of the cell.
2. Compute a straight line fit using the least squares technique, along with correlation coefficient.
3. Compute a parabolic curve fit using the least squares technique, along with correlation coefficient.
4. Calculate mean and standard deviation and print number of entries.
5. Calculate *t* or both paired and unpaired data.
6. Calculate correlation coefficient for two-variables.

In addition, the standard four arithmetic functions are included. Other built-in calculations include %, 1/x, x/12, In x, log x, e^x, raise a number to a power, and grand total accumulation. Two expanded versions of the Model 5 provide additional statistical computations.

An algebraic notation is used for all calculations. Parenthesis operation is built in.

Called the Model 5, Option 001, the basic unit is a complete statistical calculator with the built-in printer. Model 5, Option 002 is the basic system with a solid-state, 10-character display added. Keyboard entries and results are displayed as well as printed on the tape.

Plotter compatibility is added on the Model 5, Option 003. This system plots curves and histograms with calibrated axes on the optional Hewlett-Packard Model 9862A Plotter at a keystroke.

Additional statistical calculations added on the Model 5, Option 004 are calculation of least squares power curves, least squares exponential curves, least squares logarithmic curves and calculation of one-way analysis of variance. Model 5, Option 005 adds plotter compatibility and plots these curves as well as normal curve overlays for histograms.

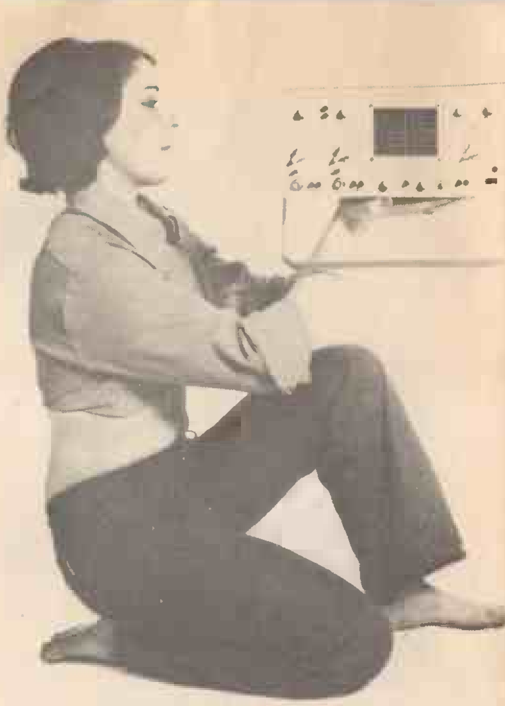
Hewlett-Packard Ltd, 224 Bath Road, Slough, Bucks SL1 4DS.

NEW PORTABLE SCOPE

Scopex Instruments was formed at the end of 1971 to meet what was felt to be the need in the market for a low-cost precision oscilloscope.

The design philosophy from the outset was to produce an oscilloscope which was easy to use, whilst maintaining a high degree of performance. The first model to be introduced was the 4D-10, with a vertical amplifier bandwidth of 10MHz. The uncalibrated variables which have often been a liability in the hands of students and semi-skilled operators were removed. To further the philosophy Scopex introduced the "easy where it counts" triggering where the triggering point and the polarity are selected on just one control. As far as is known, the 4D-10 was the first oscilloscope in the low cost area to offer this facility, and at a price of £98.

Scopex have now introduced the 4D-25, which incorporates the basic philosophy of performance with simplicity. The bandwidth is 25MHz, which can be displayed over the full display area, plus signal delay for investigating the leading edge of the displayed waveform. To meet the requirements of a 25MHz 'scope the trigger' circuit has a Tunnel Diode circuit but retains the "easy where it counts" trigger control which is now being widely accepted as a winner.



The 4D-25 is a precision instrument offering 3% accuracy at all times, the accuracy associated with much higher-cost designs, and providing that degree of reliability not commonly associated with oscilloscopes in this classification.

The 4D-25 sells for £175.

Scopex Instruments Ltd, Pixmore Industrial Estate, Pixmore Avenue, Letchworth, Herts SG6 1JJ.

AUTORANGING COUNTER TIMERS – THREE FROM ONE BASIC UNIT

Electroplan have been appointed by Schlumberger to distribute a new range of frequency counter timers. The distribution agreement is on an exclusive basis and adds further products to the comprehensive Schlumberger low cost instrumentation range now held in stock by Electroplan.

The new 2600 series of frequency counter timers are built on a basic unit with one 50MHz module allowing direct frequency and multiple period measurements with 30mV sensitivity. With the addition of a further 50MHz module time interval measurements can be taken with 100nS resolution. The third variation uses a 50MHz module plus a 520MHz module to give high frequency measurement with 50mV sensitivity.

All the counter timers feature 7 digit LEDs with a brightness adjustment, autoranging on all functions, optional battery operation and serial BCD operation. Parallel BCD is also available as an option. The counter timers cost from £250.

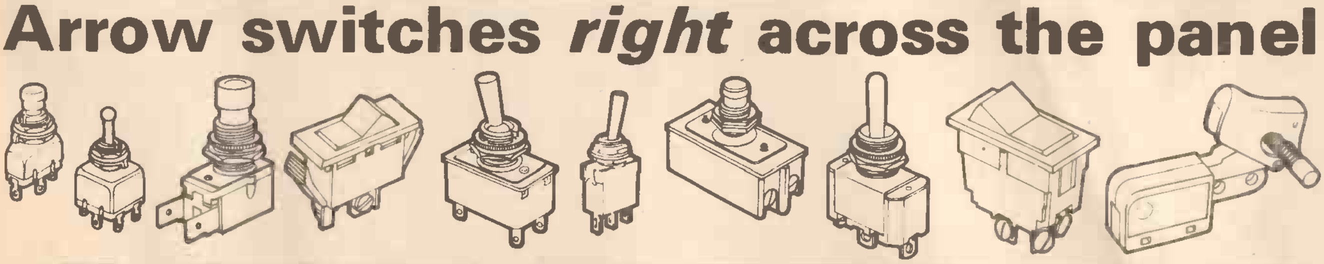
Electroplan Ltd., P.O. Box 19, Orchard Road, Royston, Herts SG8 5HH. ●

In subminiature switching, low cost *needn't* mean low quality! That's the message that British-made Arrow CT series carries round the world—gaining ready acceptance wherever it goes. Those rugged little lever switches pack maximum performance into minimum size and weight. Single and double pole versions with 2 or 3 way action, give a choice of levers in bright chrome or seven colours. They meet ratings up to 2A at 250V ac, and with their C.S.A. and U.L. approvals they'll help you show the flag.

Get the full data on hardy, home-grown Arrow CT sub-mins.

ARROW-HART (EUROPE) LTD.
PLYMBRIDGE ROAD, ESTOVER,
PLYMOUTH PL6 7PN, ENGLAND.
TEL: 0752 701155 Telex: 45340 Cables: ARROWHART PLYMOUTH

Arrow switches *right* across the panel



Scottish Office
13 MURRAY PLACE, STIRLING FK8 1DQ
Telephone: 0786 3823

U. K. Distributors ITT ELECTRONIC SERVICES HARLOW - 027-96 26777 RENFREWSHIRE - Johnstone 23457 LEIGH - Leigh 5211/2/3 SUTTON COLDFIELD - 021-355 4511 BRISTOL - 0272 290125
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JERMYN INDUSTRIES. SEVENOAKS - 51174

Overseas Agents in Arabian Gulf, Belgium, Ceylon, Denmark, East Africa, Eire, Finland, France, Greece, Holland, Hong Kong, India, Israel, Italy, Kuwait, Federation of Malaysia, Norway, Philippines, Portugal, Singapore, South Africa, Spain, Sweden, Switzerland, Trinidad and Western Germany.

Why take the risk?

of damage to expensive transistors and integrated circuits, when soldering?

Use Antex low-leakage soldering irons

Model X25
220-240 Volts or 100-120 Volts

The leakage current of the NEW X25 is only a few microamps and cannot harm the most delicate equipment even when soldered "live." Tested at 1500v. A.C. This 25 watt iron with it's truly remarkable heat-capacity will easily "out-solder" any conventionally made 40 and 60 watt soldering irons, due to its unique construction advantages. Fitted long-life iron-coated bit 1/8".

2 other bits available 3/32" and 3/16".

Totally enclosed element in ceramic and steel shaft Bits do not "freeze" and can easily be removed.

PRICE: £1.75 (rec. retail)

Suitable for production work and as a general purpose iron

Model CCN
220 volts or 240 volts

The 15 watt miniature model CCN. also has negligible leakage. Test voltage 4000v. A.C. Totally enclosed element in ceramic shaft. Fitted long-life iron-coated bit 3/32".

4 other bits available 1/8", 3/16", 1/4" and 1/16"

PRICE: £1.80 (inc. retail)

OR Fitted with triple-coated, iron, nickel and Chromium bit 1/8"
PRICE: £1.95 (rec. retail)

A SELECTION OF OTHER SOLDERING EQUIPMENT.

MODEL CN
Miniature 15 watt soldering iron fitted 3/32" iron-coated bit. Many other bits available from 1/16" to 3/16". Voltages 240, 220, 110, 50 or 24
PRICE. £1.70 (rec. retail)

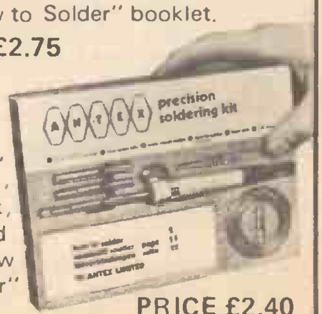
MODEL CN 2
Miniature 15 watt soldering iron fitted with nickel plated bit 3/32". Voltages 240 or 220.
PRICE: £1.70 (rec. retail)

MODEL G
18 Watt miniature iron, fitted with long life iron-coated bit 3/32". Voltages 240, 220 or 110.
PRICE. £1.83 (rec. retail)

MODEL SK.1 KIT

contains 15 watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32", heat sink, solder, stand and "How to Solder" booklet.
PRICE: £2.75

MODEL SK.2 KIT



contains 15 watt miniature iron fitted with 3/16" bit, 2 spare bits 5/32" and 3/32", heat sink, solder, and booklet. 'How to Solder"
PRICE £2.40

MODEL MES. KIT Battery-operated 12v. 25 watt iron fitted with 15' lead and 2 heavy clips for connection to car battery. Packed in strong plastic wallet with booklet "How to Solder" **PRICE: £1.95**

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DX MONITOR

Compiled by Alan Thompson

An interesting letter from FRANK JERVIS, of Chesterfield, starts the "feed-back" to DXM with a query that's an oldie to those experienced at DXing — Frank's problem is that he wonders how DXers manage to measure transmitter frequencies accurately when the dial of most receivers is, at best, calibrated in 50kHz steps and the frequencies on which he hears programmes, according to his receiver, aren't those announced by the station. This, of course, is the experience of most DXers unless they are fortunate enough to have a receiver with digital read-out of the frequency to which it is tuned, or it is a professional-type Communication receiver which has an accurate dial and means of checking the accuracy of it against a frequency standard, such as a crystal marker giving 'peeps' every 100kHz along the dial. Such equipment is the exception rather than the rule in DXers shacks, so what's to be done to achieve accurate frequency measurement which certainly makes for good DXing. If you don't know the exact frequency to which you are tuned you haven't much chance of hearing the weak and rare station that you are looking for.

Most DXers have to make do with receivers whose dials are marked in arbitrary divisions in metres or kilohertz (or kilocycles, which are the older name for the same thing). Here, the only real answer is to acquire a heterodyne Frequency Meter and, although they aren't cheap, they make frequency measurement both easy and accurate. In simple terms, a heterodyne Frequency Meter is a very weak and tuneable transmitter which can be set to any desired frequency, often to an accuracy of something like 0.1kHz. The word 'heterodyne' is an emotive one for radio listeners since it, normally, indicates an annoying whistle marring the clear reception of a station but a heterodyne Frequency Meter puts that whistle to good use. The meter is tuned until a heterodyne is heard on the station, indicating that you are within a few kilohertz of the required frequency and is then carefully adjusted until the heterodyne just disappears — i.e. it is 'zero-beat' with the required signal. These meters are provided with an individual calibration book and the meter reading is referred back to the calibration book and the precise frequency read off. As one might expect, these meters are not at all cheap, and the most commonly encountered type, the ex-Service BC221, costs about £25 in really good condition, complete with its individual calibration book. BC221's are to be found at prices as low as £7 or £8, but they are useless — unless you have access to accurate frequency measuring equipment *and* have days to spend on its re-calibration without the *individual* calibration book that goes with the instrument. Always check that the serial number of the BC221 and the serial number of the calibration book agree. There are other heterodyne Frequency Meters available, and the commonest is the Class D Wavemeter which does not possess the same accuracy nor the same frequency range as the BC221 — however, if funds are limited, a 'Class D' is a well worthwhile acquisition.

If your receiver is fitted with some form of calibrated bandspread then you are well on the way to accurate frequency measurement, within a few kilohertz, at quite low cost. Various versions of the Crystal Calibrator are available from radio dealers specialising in equipment for the amateur and the DXer, and the simplest version is one fitted with a 100kHz crystal which will give a piercing note every 100kHz of the radio spectrum up to 30MHz, or even above. The usual form of bandspread features a dial which is marked from 0 to 100, with the individaul points marked on the scale. Assuming that you wish to calibrate the range 4800 to 4900kHz, the drill is to set the bandspread dial on the '100' mark and, using the crystal calibrator, adjust the main tuning until 4900kHz falls slap on that '100' setting. Without adjusting the main tuning, tune down the bandspread dial until the next 100kHz point is heard by another ear-piercing note — make a note of the reading (let's say it is '25' on the bandspread dial). That means that 75 marks on the bandspread dial equals 100kHz, so each space on the bandspread dial equals 1.333kHz and you can calculate the frequency of the station you've logged with a fair degree of accuracy. To avoid awkward calculations, you can transfer the readings to a sheet of graph paper and a straight line graph will enable you to read-off the frequency just by noting the bandspread reading and checking it against the graph. It is an easy evening's work to plot graphs for each of the bands that interest you and they will always be accurate, within 2 or 3 kHz, so long as you always remember to re-set the bandspread dial to '100' with the main dial on the same frequency. Usually, the tracking of the receiver will not be exactly linear but the deviations will not be too large over any 100kHz range.

Recent developments in the field of integrated circuits have brought a range of frequency standards onto the market and within the reach of Mr Average DXer. Briefly, a common type of IC 'standard' will provide you — at the flick of a few switches — with 'markers' every 1MHz, 500kHz, 100kHz, 50kHz, 25kHz and 10kHz along the dial, and this is accurate enough for you to interpolate the frequency between 10kHz points. This is somewhere between the laboratory standard of the BC221 and the rough accuracy of the simple crystal calibrator in accuracy, and the price, too, falls into that field. Just a word of warning: if you are doing your DXing on a 'domestic' receiver, this kind of frequency marker is not recommended for you since the scale of the domestic receiver is normally so short that is just does not lend itself to accurate measurement of frequencies using this method. I'm afraid that it is a BC221, or the Class 'D' wavemeter, that is needed in such cases — a 'marker' will simply not have enough dial space available for you to be able to recognise the individual 'pips'.

Nobody could describe July and August as the zenith of the DXing year but currently there's quite a lot of geomagnetic activity taking place at fairly frequent intervals, which means that African and Latin-American stations are often heard at good strength. A few to try in the next month include: (frequencies in kHz, times GMT).

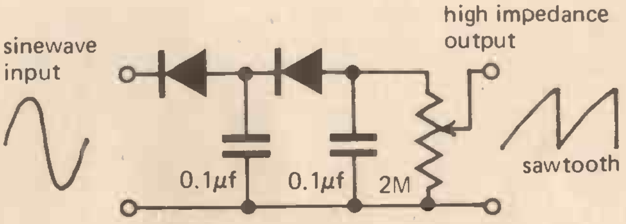
4805	Jakarta	Note the new official simplified spelling of Djakarta! From 2200 with its Home Service in Indonesian
4820	Radio Gambia	Often good throughout the evening, from about 1900 until sign-off at 2300. Watch you have this, not the Angolan on same frequency.
4980	Ecos del Torbes, Venezuela	Four LA stations on which to cut your teeth if you are new to LA DXing. You ought to hear at least 2 of the 4 most evenings after 2300. Brazil Central in Portugese: the others in Spanish.
4990	R Barquisimeto, Venezuela	
4995	R Brasil Central, Brazil	
5010	R Cristal, Dominican Rep.	
6144	R Calabar, Nigeria	Both are 10kw and carry NBC's regional programmes until 2300 when they have English news from Lagos. Fairly easy in gaps between some of the European powerhouses from (say) 2000, in vernaculars and English.
6195	R Sokoto, Nigeria	
7230	R El Aaiun, Spanish Sahara	A so-and-so of a frequency! Try from about 1930 up to 2300 or so — broadcasts in Hassania (a dialect of Arabic) and Spanish, and has Radio Nacional Espana news at 2100-2130 (approx), in Spanish. More difficult: try 4627 for its PTP relay from El Aaiun to Villa Cisneros at same times.

September marks the start of the DXing year and major International broadcasters will be making their seasonal frequency changes on the first Sunday in the month. An interesting Autumn and winter seem in prospect, DX-wise, with the lowest sunspot numbers for years — next month, I shall concentrate on some *real* DX that ought to be available through the dark evenings, so make sure that all the gear (not forgetting the aerials!) gets a going over before the fun really starts.

Any "feedback" will be welcomed, by the 14th of each month, and the address is — Alan Thompson, 16 Ena Avenue, Neath, Glamorgan SA11 3AD. If you want a personal reply, please enclose a s.a.e. Until next time, 73 and may all your listening yield new DX catches (well! we can but hope, hi!).

TECH-TIPS

SIMPLE SAWTOOTH GENERATOR

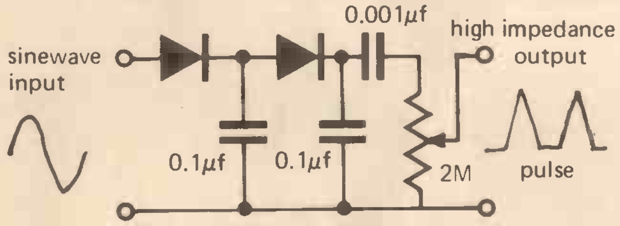


Here is a circuit that can be used in simple oscilloscopes or RF sweep generators. It works best with low frequency sinewave inputs.

The high impedance output ensures its suitability for CROs.

Almost any diodes of a suitable PIV rating can be used but high back-resistance diodes are preferable.

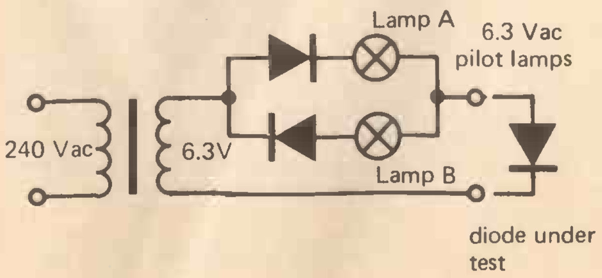
SIMPLE PULSE GENERATOR



This circuit is useful in adjusting noise blankers for producing time marker pulses for a CRO or chart recorder.

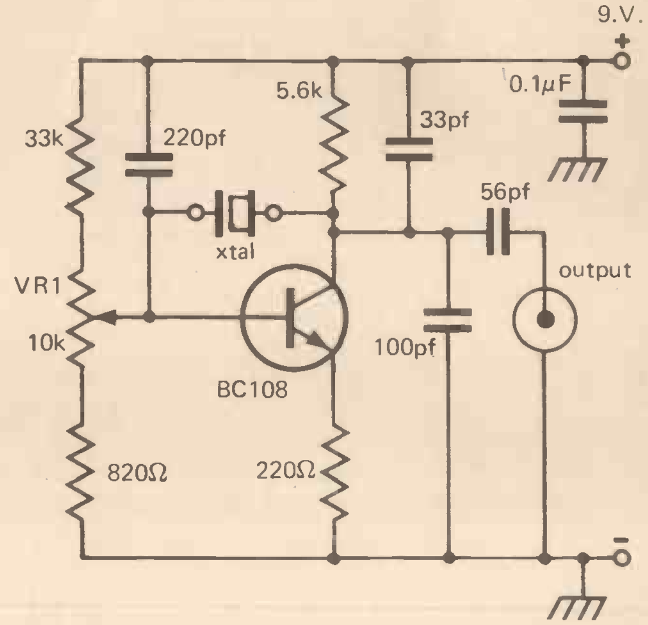
The high impedance output is adjustable by the 2 Megohm potentiometer. Peak inverse rating of the diode should be high enough for input voltage used.

GO/NO-GO DIODE TESTER



If lamp A or lamp B is illuminated the diode is serviceable. If both light the diode is short circuit. If neither light, diode is open circuit.

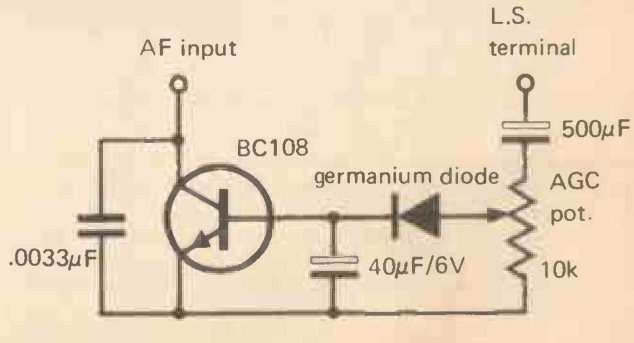
UNCRITICAL CRYSTALS



Surplus crystals are very useful in a variety of applications. But it is sometimes difficult to obtain reliable oscillation in many standard circuits.

This circuit overcomes this problem. It will provide reliable oscillation and provides an output close to one volt peak-to-peak. Power consumption is around 1mA from a nine volt supply.

SIMPLE AGC



Audio derived automatic gain control is one of the simplest methods of obtaining signal compression in a radio receiver. It is of particular value with short wave receivers used in areas where deep fading is prevalent.

The simple circuit shown here requires a minimum of components and may be used with both valve and transistor receivers.

In use, the main volume control should be set for the desired signal strength whilst the radio is tuned to a weak station, the radio is then tuned to a strong station and the AGC potentiometer adjusted to a comfortable listening volume. ●

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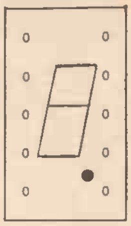

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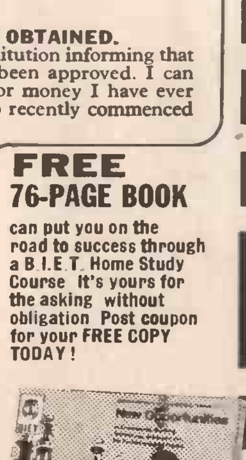

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