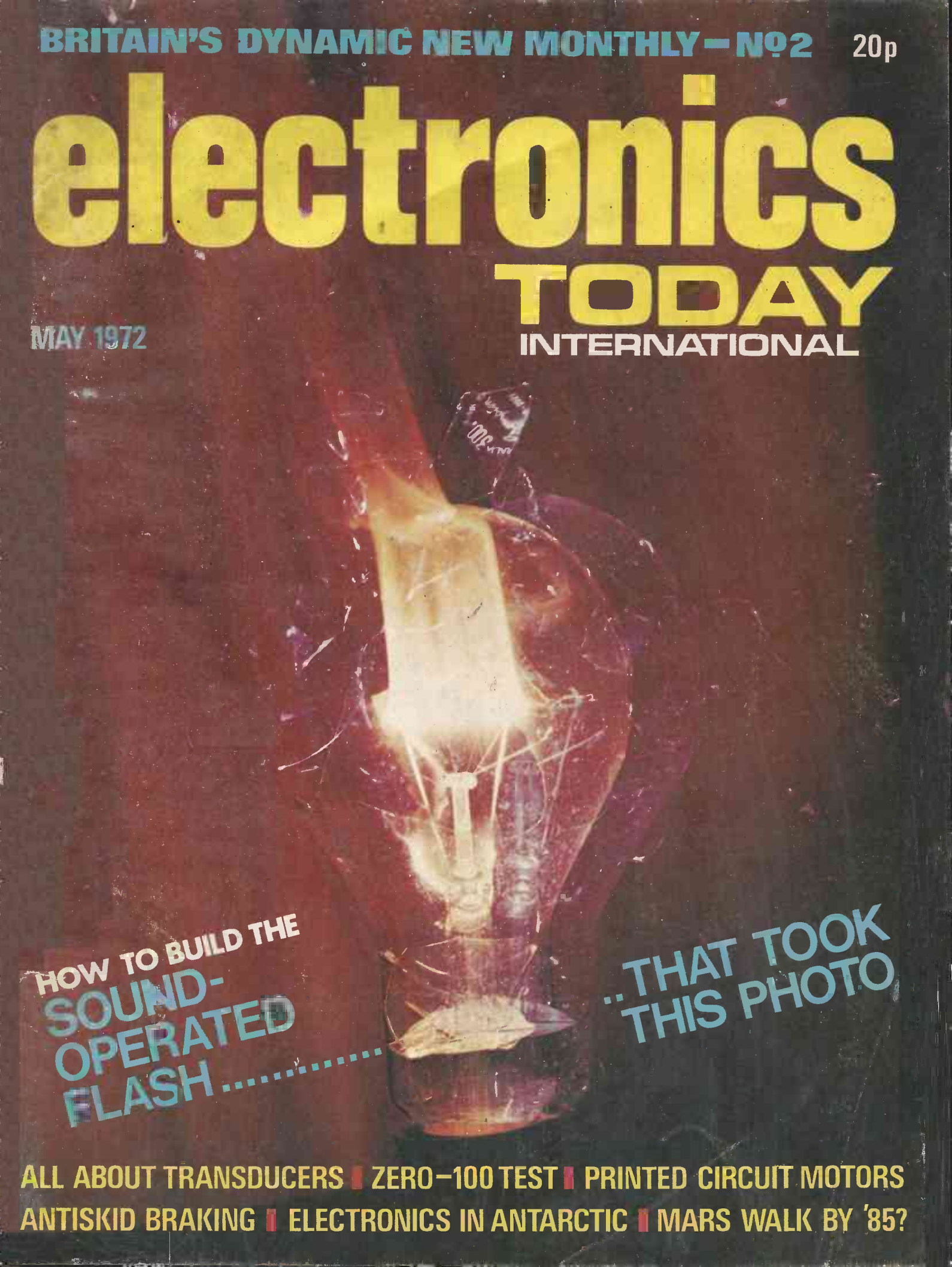
BRITAIN'S DYNAMIC NEW MONTHLY — No2 20p

electronics TODAY INTERNATIONAL

MAY 1972



HOW TO BUILD THE SOUND-OPERATED FLASH.....

..THAT TOOK THIS PHOTO

ALL ABOUT TRANSDUCERS ▮ ZERO–100 TEST ▮ PRINTED CIRCUIT MOTORS
ANTISKID BRAKING ▮ ELECTRONICS IN ANTARCTIC ▮ MARS WALK BY '85?

TTL 7400 SERIES INTEGRATED CIRCUITS

* MIX PRICES
* FULLY GUARANTEED
* LARGE QUANTITY PRICES ON REQUEST

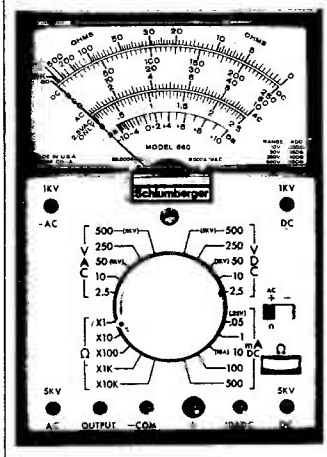
Type No.	1-24	25-99	100 Plus	Type No.	1-24	25-99	100 Plus
SN 7400	.18	.16	.14	SN 7491	1.00	.95	.90
SN 7401	.18	.16	.14	SN 7492	.75	.70	.65
SN 7402	.18	.16	.14	SN 7493	.75	.70	.65
SN 7403	.18	.16	.14	SN 7494	.80	.75	.70
SN 7404	.18	.16	.14	SN 7495	.80	.75	.70
SN 7405	.18	.16	.14	SN 7496	1.00	.97	.95
SN 7406	.30	.27	.25	SN 7497	6.25	5.50	5.00
SN 7407	.30	.27	.25	SN 74100	2.50	2.30	2.00
SN 7408	.20	.19	.18	SN 74104	1.45	1.35	1.20
SN 7409	.45	.42	.35	SN 74105	1.45	1.35	1.20
SN 7410	.18	.16	.14	SN 74107	.50	.45	.40
SN 7411	.23	.22	.20	SN 74110	.80	.70	.60
SN 7412	.42	.40	.35	SN 74111	1.45	1.35	1.20
SN 7413	.30	.27	.25	SN 74118	1.00	.95	.90
SN 7416	.30	.27	.25	SN 74119	1.90	1.78	1.65
SN 7417	.30	.27	.25	SN 74121	.60	.55	.50
SN 7420	.20	.18	.16	SN 74122	1.35	1.25	1.10
SN 7422	.48	.44	.40	SN 74123	2.70	2.55	2.47
SN 7423	.48	.44	.40	SN 74141	1.00	.95	.90
SN 7425	.48	.40	.35	SN 74145	1.50	1.40	1.30
SN 7427	.42	.39	.35	SN 74150	3.35	2.95	2.15
SN 7428	.50	.45	.42	SN 74151	1.10	.95	.90
SN 7430	.20	.18	.16	SN 74153	1.35	1.27	1.20
SN 7432	.42	.39	.35	SN 74154	2.00	1.75	1.55
SN 7433	.70	.61	.44	SN 74155	1.55	1.47	1.35
SN 7437	.65	.60	.50	SN 74156	1.55	1.47	1.35
SN 7438	.65	.60	.50	SN 74157	1.80	1.70	1.50
SN 7440	.18	.16	.14	SN 74160	2.60	2.40	2.25
SN 7441	.75	.72	.70	SN 74161	2.60	2.40	2.25
SN 7442	.75	.72	.70	SN 74162	3.60	3.40	3.25
SN 7443	1.00	.95	.90	SN 74163	3.60	3.40	3.25
SN 7444	1.75	1.60	1.45	SN 74164	2.75	2.30	2.10
SN 7445	2.00	1.75	1.60	SN 74165	4.00	3.50	3.00
SN 7446	2.00	1.75	1.60	SN 74166	4.00	3.50	3.00
SN 7447	1.75	1.60	1.45	SN 74167	6.25	5.60	5.10
SN 7448	1.75	1.60	1.45	SN 74170	4.10	3.55	3.05
SN 7449	1.00	.95	.90	SN 74174	2.00	1.75	1.30
SN 7450	.18	.16	.14	SN 74175	1.35	1.27	1.15
SN 7451	.18	.16	.14	SN 74176	1.60	1.35	1.20
SN 7453	.18	.16	.14	SN 74177	1.60	1.35	1.20
SN 7454	.18	.16	.14	SN 74180	1.55	1.30	1.20
SN 7460	.18	.16	.14	SN 74181	7.00	6.00	5.50
SN 7470	.30	.27	.25	SN 74182	2.00	1.80	1.60
SN 7472	.30	.27	.25	SN 74184	2.40	2.00	1.80
SN 7473	.40	.37	.35	SN 74185A	2.40	2.00	1.80
SN 7474	.40	.37	.35	SN 74190	2.95	2.85	2.75
SN 7475	.55	.52	.50	SN 74191	2.95	2.85	2.75
SN 7476	.45	.42	.39	SN 74192	2.00	1.90	1.80
SN 7480	.80	.75	.67	SN 74193	2.00	1.90	1.80
SN 7481	1.25	1.15	1.10	SN 74194	2.50	2.25	1.90
SN 7482	.87	.80	.70	SN 74195	1.85	1.70	1.60
SN 7483	1.00	.90	.85	SN 74196	1.50	1.40	1.30
SN 7484	.90	.85	.80	SN 74197	1.50	1.40	1.30
SN 7485	3.50	3.30	3.00	SN 74198	4.60	3.70	3.35
SN 7486	.45	.41	.38	SN 74199	4.60	3.70	3.35
SN 7490	.75	.70	.65	SN 74200	21.00	18.60	13.40

DON'T FORGET THE £1 VOUCHER ON PAGE 58

DAYSTROM
Schlumberger

NOW AVAILABLE FROM SEMICONDUCTOR SUPPLIES

'Drop-Proofed' VOMs



MODEL 660 SPECIFICATIONS

Accuracy	2% DC (1.5% on 50 ua range) 3% AC
Sensitivity	20,000 ohms/volt DC 5,000 ohms/volt AC
Dimensions	7"H X 5"W X 2¼"D
Weight	Less than 2 lbs. (Batteries included)
Ranges	
DC Millivolts	0-250
DC Volts	0-2.5/0-10/0-50/0-250/0-500/0-1000/0-5000
AC Volts	0-2.5/0-10/0-50/0-250/0-500/0-1000/0-5000
VAC Output	0-2.5/0-10/0-50/0-250
DC Microamps	0-50
DC Milliamps	0-1/0-10/0-100/0-500
DC Amps	0-10
Ohms	RX1(0-2K)20Ωcenter/RX10(0-20K)200Ω center/RX100(0-200K)2000Ωcenter/RX1000(0-2Meg)20KΩcenter/RX10K (0-20Meg) 200KΩcenter
dB Scales	(1 mw on 600 ohm line) −10 to +10/+2 to +22/+16 to +36/+30 to +50/+36 to +56

MODEL 660 FEATURES

- Completely drop-proofed
- Custom ruggedized self-shielded taut-band mechanism
- Temperature compensated
- Diode-protected meter movement
- Polarity reversal switch
- 1% precision resistors used in all critical circuit
- Special calibrated scales for dB measurement
- Externally replaceable fuse
- Single range switch
- Full range coverage

Price only £29-85

Use both vouchers for one order on this item

See the April issue of

ELECTRONICS TODAY INTERNATIONAL

for transistor prices or send for our catalogue as instructions below.

TRIACS

2 Amp	400v	- 75p
6 Amp	400v	- 95p
10 Amp	400v	- £1·25

DIACS

BR 100 — 36p

F.E.T. DEVICES

Type No.	1—24	25—99	100 Plus
UC 734E	.25	.21	.16
2N 3819	.28	.21	.17
2N 3823E	.40	.34	.26
2N 4302	.45	.38	.30
2N 4416	.88	.74	.64

LINEAR INTEGRATED CIRCUITS

Type No.	1—24	25—99	100 Plus
709C	.42	.36	.30
710	.60	.48	.42
711	.72	.65	.56
741C	.56	.48	.42
723C	.72	.65	.56

Please state T099 or D.I.L.

ZENER DIODES

BZY88 SERIES (400 mW)
3.3 volts to 30 volts

Prices:	1—24	25—99	100 Plus
	.15	.12	.08

E.F. Electronics

Dual-in-Line sockets

Beryllium Copper Contacts	1—24	25—99	100 Plus
8 pin	.26	.25	.20
14 pin	.28	.26	.21
16 pin	.30	.27	.22
24 pin	.90	.70	.60
40 pin	1.15	.95	.88

15 WATT IC
AUDIO AMPLIFIER
PRICE **£3.95** SEND 10p FOR BOOKLET

SMALL SIGNAL DIODES

Type No.	1—24	25—99	100 Plus
BAX16	.06	.05	.04
OA5	.30	.25	.20
OA10	.50	.42	.35
OA47	.08	.06	.05
OA90	.05	.04	.03
OA91	.05	.04	.03
OA200	.08	.06	.05
OA202	.08	.06	.05
IN914	.05	.04	.03
IN916	.06	.05	.04
IN4009	.05	.04	.03
IN4148	.05	.04	.03
IN4149	.06	.05	.04

PLASTIC RECTIFIERS

1 AMP RECTIFIERS

Type No.	1—24	25—99	100 Plus
IN 4001/SD 05	.05	.04	.03
IN 4002/SD 1	.06	.05	.04
IN 4003/SD 2	.07	.06	.05
IN 4004/SD 4	.08	.07	.06
IN 4005/SD 6	.09	.08	.07
IN 4006/SD 8	.10	.09	.08
IN 4007/SD 10	.12	.11	.10

SEND 5p FOR FREE!! CATALOGUE

Semiconductor Supplies

55, Whitehorse Road, Croydon, Surrey. CRO 2JG
Tel. 01-689 0676/7 DEPT. E.T.I/1

TRADE ENQUIRIES WELCOME

CASH and CARRY
COUNTER OPEN
9.30 – 5.30
MON – FRI

electronics TODAY

MAY Vol. 1 No. 2

main features

projects

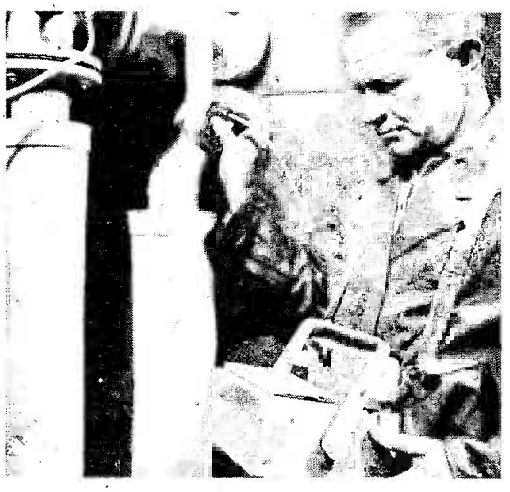
product tests

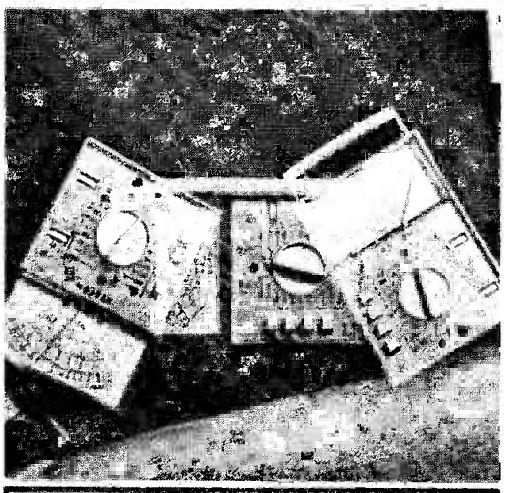
reviews

news & information

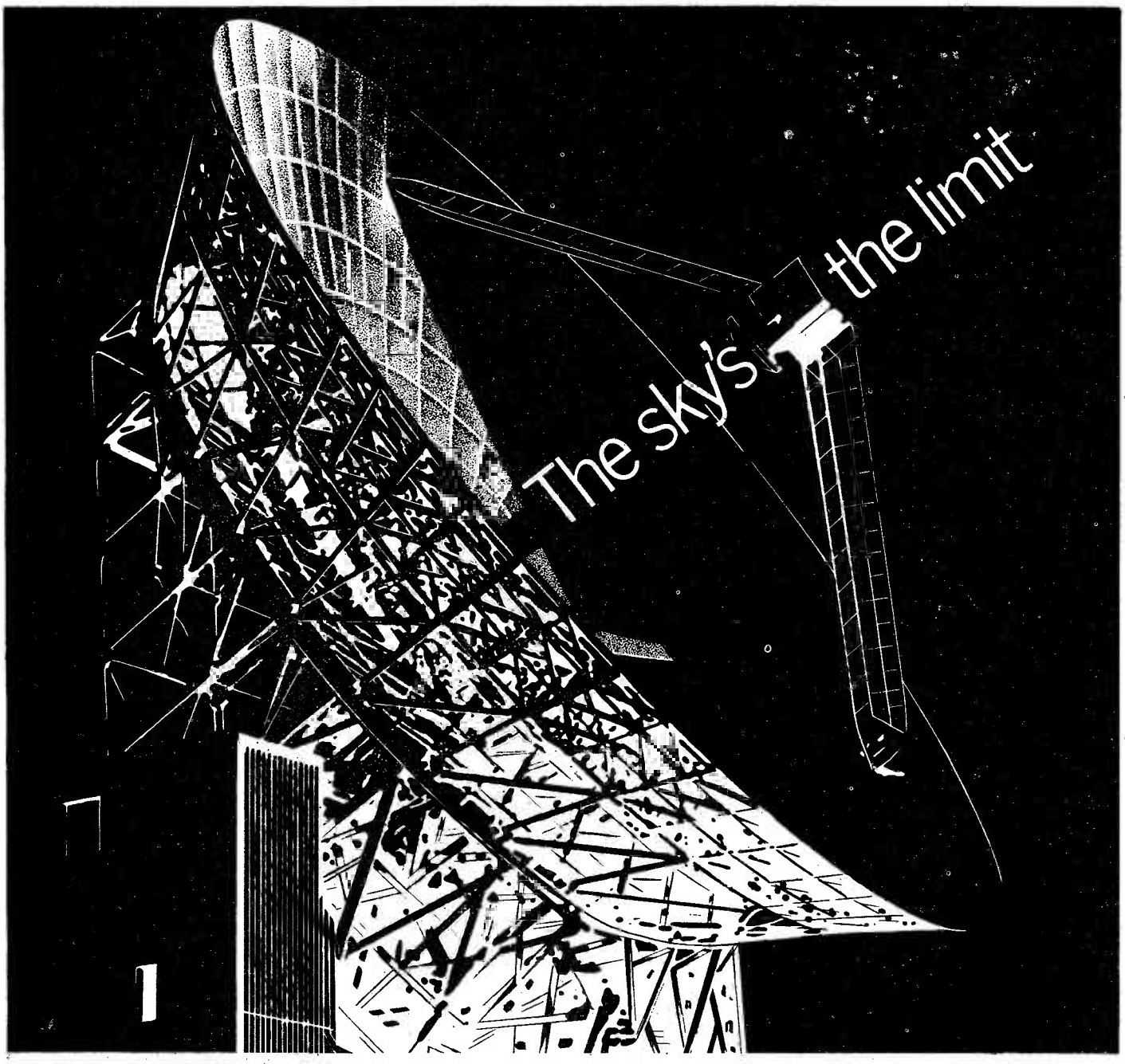
COVER: With bulb's glass envelope shot away, light filament is exposed to atmosphere, flares brilliantly for a few milliseconds before burning up. Action was stopped with sound-operated flash described this month.

JUNE ISSUE OF ETI ON SALE MAY 19TH 1972





ELECTRONICS TODAY INTERNATIONAL, 107 Fleet Street, London EC4. Phone 01-353 1040. Published by WHITEHALL PRESS LIMITED, 29 Palace Street, London SW1. Phone 01-834 0423/4. Australia: Modern Magazines (Holdings) Ltd, 21-23 Bathurst Street, Sydney 2000. Phones 26-2296, 26-6129. USA: A.C.P., Room 401, 1501 Broadway, New York. Japan: Bancho Media Service, Shinanomachi, Shinjuku-ku, Tokyo. Distributed by Argus Press Ltd. Printed in England by Alabaster Passmore & Sons Ltd, London and Maidstone.



International Instruments, Electronics, Automation Exhibition Olympia London 8-12 May 1972

Keeping up with developments in this fast moving industry can be difficult. That's why the IEA Exhibition was born and why you should seize this opportunity to visit the only international show this year to cover the field.

25% of the exhibitors come from 18 overseas countries and for the first time there will be special sections : one for process control instrumentation and one for electronic components.

Equipment and techniques need to be examined carefully, especially when they change radically and relentlessly.

The Intelsat project is a classic example. This project is big business – it costs $30,000,000 per match to blue touchpaper. 82 countries are involved and U.K. is the second largest contributor. The IEA Exhibition means business.

See you there.

The IEA Exhibition is sponsored by the 5 trade associations of the industry. Tickets available only from exhibitors or at 30p at the door.

Open : 10.00-18.00 daily (except Wed. and Thurs. open until 20.00)

For further information please return this coupon to : Industrial Exhibitions Limited, 9 Argyll Street, London WIV 2HA.

Please send me _____ catalogues 50p. each including p & p (published 3 weeks before opening day).

Name _____

Company _____

Address _____

Travel and Accommodation Arrangements

Official exhibition travel agents have been appointed. They can provide a complete travel service from the London office or through their representatives around the world : inclusive or individual rates for booking air, rail and sea journeys, vehicle hire, guides, accommodation and other services from their comprehensive range.

Please indicate the number of persons in your party and whether you wish to deal with London office or a local agent.

Number of persons _____

London office/local agent.

latest menace: electronic pollution!

Paul Godden
Editor, British Edition
Electronics Today International

Donn Donovan
Advertisement Manager,
British Edition
Electronics Today International

The word pollution already looms large in human affairs — and it will loom larger still as this twentieth century swings into its final quarter.

Scientists all over the world are raising the alarm; a typical comment — from biologist Barry Commoner — warns that "we are destroying this planet as a suitable place for human habitation."

With pesticides and herbicides filtering into our food, glass and plastic containers littering our countrysides and industrial detritus poisoning our rivers and oceans, we have more than sufficient cause for alarm.

And now, electro-magnetic spectrum is causing ever-increasing concern. There is a proliferation of equipment generating spurious radio frequency emission — diathermy units, induction heaters, plastic welders, and a wide range of high-powered equipment using phase control techniques.

In addition, early-warning tactical radar systems use ever-increasing average powers, and these are becoming a real hazard.

As witness to this, the Ministry of Defence warned recently that 'over the horizon' radar systems could cause sailors off Orford Ness to experience slight shock, accompanied by sparking from metal rigging or structures. It also warned that radio sets may be damaged, and some electrically-triggered devices might be accidentally energized. As if this were not enough, warning has been given that people intercepting the radar beam for any length of time may suffer injury.

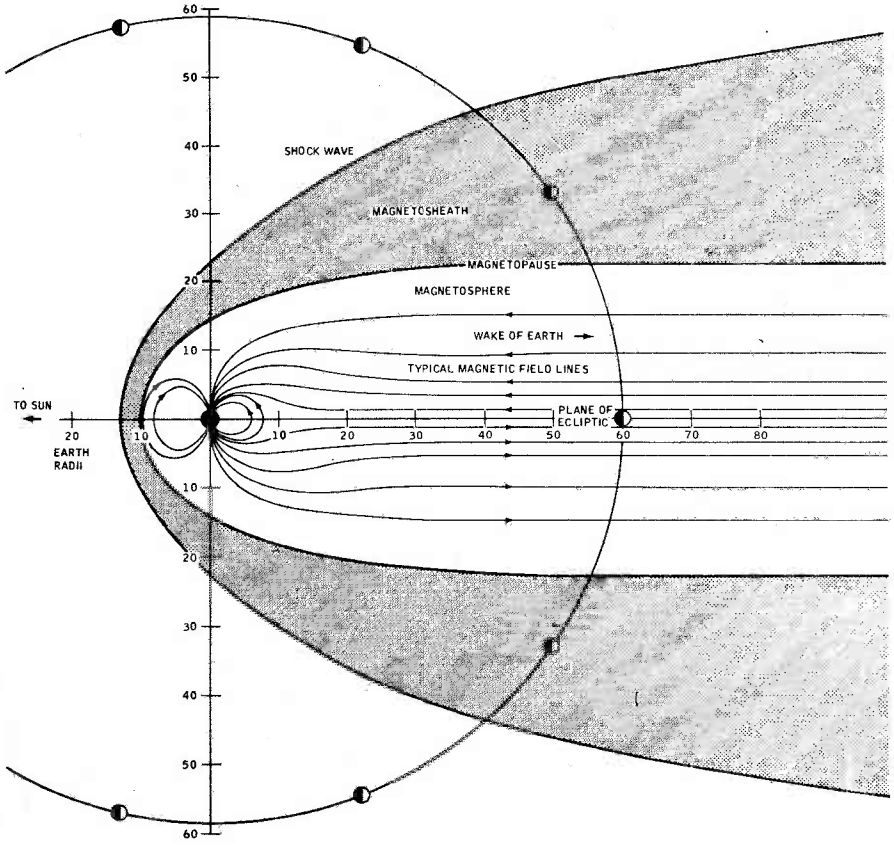
Surely the time has come when we must seriously consider international control of rfi-causing equipment.

Having got this off our chest, we want to thank you, one and all, for the great reception accorded the first issue of ELECTRONICS TODAY INTERNATIONAL — as indicated by sales reports from our distributors, and by numerous letters and phone calls of appreciation from readers.

It is all most encouraging — and reinforces our belief that there is a place for a magazine such as ETI, which covers the whole spectrum of electronics rather than concentrating on specialized areas.

news digest

EARTH'S MAGNETIC FIELD



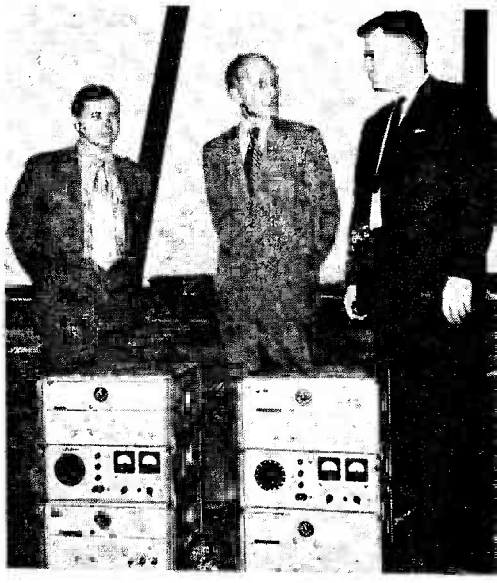
This recent drawing from NASA shows the observed magnetic field of the earth.

The solar wind 'blows' the magnetic lines towards the back side of the earth, thus forming the magnetosheath and the geomagnetic cavity. The geomagnetic cavity extends to at least 100 earth radii. In this drawing the Earth and Moon are not to scale.

TIME FLIES

Time dilation — the special part of Einstein's relativity theory that predicts more time will pass for stay-at-homes than for fast-moving space travellers returning to earth — underwent a new test recently; also tested by the experiment was the interaction of gravity and time, a part of the General Theory. It was the first known experimental demonstration of these effects using actual time-recording clocks. The preliminary results seem to support Einstein.

Professor Joseph C. Hafele of Washington University, St. Louis, Mo., and Richard Keating of the U.S. Naval Observatory, Washington, D.C., flew a set of four Hewlett-Packard precision atomic clocks around the world. They flew the route once eastward and once westward, measuring how much time the clocks recorded during their trips, relative to the time observed on earth by the ensemble of Hewlett-Packard atomic clocks at the Naval Observatory which are the United States' official timekeeper. The experiment was funded by the Observatory. Preliminary, uncorrected results for the experiment indicate a slight loss for



Professor Hafele, L. Walker of Hewlett-Packard, and Richard Keating of the U.S. Naval Observatory, with atomic clocks flown round the world to test a key part of Einstein's theory of relativity.

the eastward trip and a definite gain for the westward trip, as Einstein's theory would predict for paths similarly flown.

To test the theory, the results of the experiment must be compared with the results the theory would predict. To predict the results, two aspects of relativity theory must be considered. One of these treats the interaction of velocity and time, the other the interaction of gravity and time. Both must be considered in predicting the results of the Hafele-Keating experiment. The expected results depend on the actual paths, velocities, and altitudes during the flights. For a total flight time of about 38 hours at 650 miles an hour, at an altitude of 35,000 feet around the equator, the predicted results are a loss for the eastward flight of about 110 nanoseconds relative to the clocks on earth, and a gain of about 300 nanoseconds for the westward flight. The only quantity man can measure with anything like this precision is, fortunately, time.

The experiment was made possible by the availability at the Naval Observatory of compact, extremely precise cesium beam atomic clocks and frequency standards (Model 5061A manufactured by the Hewlett-Packard Company in Santa Clara, California). Portable versions of the same instruments were carried around the world on both trips. Time comparisons of nanosecond precision were made possible with the Hewlett-Packard Computing Counter (Model 5360A). So far has the art of time measurement advanced, not one of the instruments used in the test was of special laboratory construction. All are standard and commercially

available. Hundreds of the Hewlett-Packard atomic clocks are in regular use. They keep many nations' official time, and maintain their standards of frequency. They are also widely used in navigation, communication systems, and the Apollo tracing network. A miniature version has been developed and is being tested now for the Air Transport Association's newly-approved aircraft collision avoidance system.

AMPEX QUITS CONSUMER MARKET

Possibly demonstrating the truth of the old adage that those who make money in any particular field are rarely the pioneers — Ampex, the first company in the USA to make tape recorders, is to quit the domestic market.

The move has been forced onto the company due to inadequate profitability. Ampex has produced a broad range of reel-to-reel and cassette recorders and these will gradually be phased out.

The semi-professional AX300 unit will remain in production and the company will continue to supply both prerecorded and blank tapes and will honour warranties and supply parts for all products.

Also remaining in production is Ampex's range of professional audio and video recorders. Work will still continue on the development of the Instavideo cartridge-type colour TV recorder

FUEL CELL LATEST

In the USA the Lockheed Aircraft Corporation are currently developing a new type of fuel cell that they expect will produce up to 100 times more power than existing lead-acid batteries.

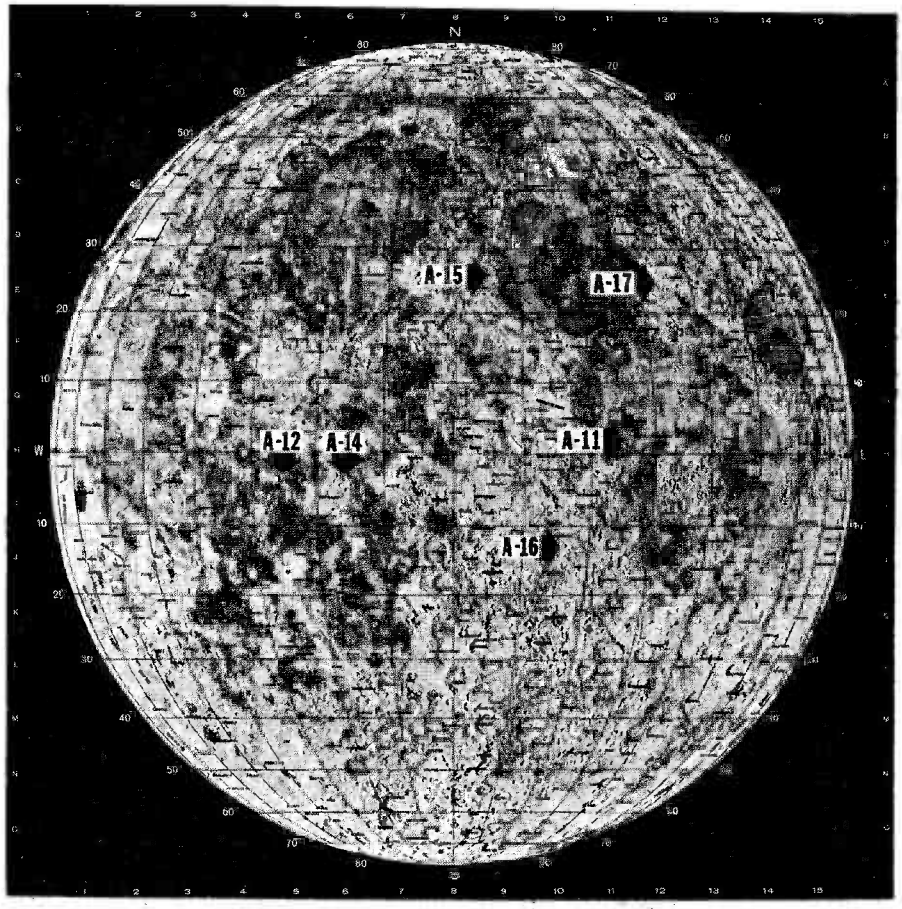
The Lockheed cell is fueled by water and an alkali metal such as sodium or lithium. The company claim to have developed methods of controlling the violent reactions that are normally produced when such materials are brought into contact, yet still extracting large quantities of electrical energy.

The cell is claimed to be pollution free, the only by-product being hydrogen which is collected and used as a secondary source of energy.

GOODBYE MYSTERE CHIPS

Our Paris correspondent tells us that following problems with a recent batch of integrated circuits a well known French aircraft manufacturer is looking for another supplier.

APOLLO 16



Due to blast off (about one week after the printing date of this issue) the Apollo16 lunar spacecraft will land in the Moon's Descartes area, in latitude 15.5°E and longitude 9.0°S.

This map shows the landing sites of all lunar probes from Apollo 11 through the projected Apollos 16 and 17.

NEW COLOUR TUBE

In Japan, Toshiba has developed a new type of colour TV picture tube. Unlike the conventional shadowmask tube in which round holes are formed through the shadowmask, the new Toshiba tube has an array of rectangular holes arranged in a vertical pattern.

Three electron guns are used — arranged horizontally in-line.

Advantages claimed for the new tube include higher level of brightness, better resolution and contrast, and freedom from convergence and deflection adjustments.

First commercial TV receiver to use the new tube is the 9" Sharp currently available in the US at a list price of $300.

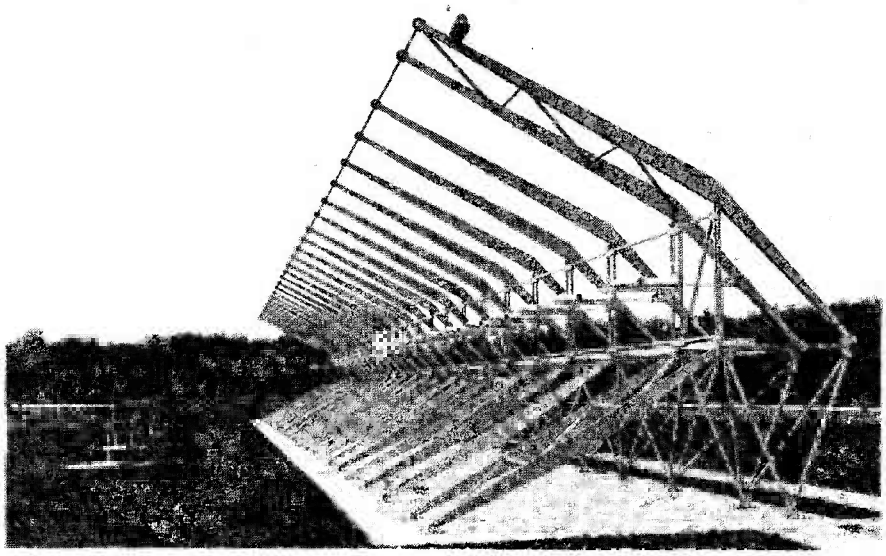
PLESSEY ROLA MANAGER OVERSEAS

Plessey Rola business manager, Mr. Maurice Smith, has begun a world tour during which he will visit other Plessey operations in the U.S., U.K., Europe and South Africa.

Although the trip was scheduled before the announcement of the starting date for colour television transmissions in Australia, its purpose is to assess the latest developments in the electronics components field particularly in relation to colour television.

Whilst in New York, Mr. Smith will attend the IEEE Exhibition where Plessey Rola is to exhibit loudspeakers, loudspeaker enclosures, professional quality printed circuit boards and magnetic materials.

BRITISH INSTRUMENT LANDING SYSTEM



The highest performance rating in the world for an instrument landing system (ILS) has so far been granted only to Britain's most advanced system, the Plessey STAN 37/38. This is for its performance in its role as the ground guidance element for automatic landing systems planned to operate in the near zero visibility conditions classified as Category 111. Early this year a STAN 37/38 installation at London's Heathrow Airport was the first to be officially promulgated as Category 111 and a second promugation has just been made for a similar installation at Dulles International Airport, Washington, DC.

The installations at Heathrow and Dulles mark a further important step forward in the programmes being carried out in both Britain and America to enable aircraft to land fully automatically in all weathers. In the past two months enquiries for over 50 STAN 37/38 ILS systems have been received by Plessey and the company expects further interest to be shown in it as a result of its recognition by both the British and American governments.

ANTI-MATTER UNIVERSE?

Probably the most fundamental premise of physics is that physical laws are universally valid. But astronomical discoveries made in recent weeks are now causing many astrophysicists quite seriously to doubt even this.

Reason for their doubt is a number of observations — based on red shift — of objects that seem to be moving very considerably faster than the speed of light, meanwhile emitting energy at greater levels than previously considered possible.

Speeds more than ten times the speed of light have been reported.

Faced with this great kink in the curve of previously accepted learning, some very radical theories are now being given serious attention. The most prominent — and most startling — of these is the 'black hole — white hole' theory put forward by Dr. Robert M. Hjellming of Green Bank, West Virginia's National Radio Astronomy Observatory.

Basic premise of the 'black hole' theory is that inward pressure of very large masses of matter could produce objects of enormous density — several billion tons per inch — and with a gravitational field so intense that even light could not escape (Hence the term 'black hole').

But Dr. Hjellming goes beyond this and postulates universes other than our own, existing in other space-time frames of reference.

He contends that matter existing within our universe may be entering a 'black hole' to emerge — via a 'white hole' — into another space-time continuum. Matter could enter our universe in the opposite fashion.

However close to science-fiction this may appear, Dr. Hjellming's theories accord with Sir Fred Hoyle's concept of a steady-state universe. They may explain how new matter can be supplied to maintain Hoyle's concept of a universe that is expanding but internally unchanging.

The theory also resolves the apparent 'one-sided' nature of our universe, in which matter is more in evidence than anti-matter. The concept of 'black hole — white hole' links between differing universes may resolve this apparent physical contradiction.

Dr. Hjellming suggests our universe may be considered as galaxies on the outer surface of an expanding balloon that represents the four-dimensional curvature of space and time. Thus, as the 'balloon' expands, the galaxies become further apart. However, states Dr. Hjellming, on the inner surface of this balloon there is another, matching universe. The two are linked by 'black holes' and 'white holes'. Matter falling into a 'black hole' in our universe will reappear as antimatter which is entering via a 'white hole' in a complementary universe.

The complementary universe is predominantly of an antimatter nature — thus balancing the converse state of our own.

Dr. Hjellming's theories are by no means accepted by all astro-physicists; but if he is correct — as many reputable scientists believe him to be — he will put the science-fiction publishers out of business once and for all.

NEW VIDEO RECORDER

Two of Europe's leading manufacturers of television broadcasting equipment, Philips and Fernseh, have joined forces to develop a new professional colour video tape recorder.

The first joint development — a helicalscan format video recorder — was presented to European broadcasters during the end of February in Germany and Holland. One demonstration took place in Munich at the German Institute of Broadcast Engineering, and was attended by more than 80 representatives of German broadcasting organisations.

The second demonstration, at Hilversum, was attended by members of the European Broadcasting Union who came from all parts of Europe.

The Philips-Fernseh recorder has an omega-loop tape path and uses a single

video head for recording and playback. Two independent sound tracks are provided. This will allow stereo programmes to be broadcast in the future. In addition to the control track there is an auxiliary track available for cue and address code purposes.

Simplicity of operation and low capital capital investment have been two prime objectives of the new development. The Philips-Fernseh colour recorder is considerably less expensive than today's quadruple-head recorders. Tape consumption is reduced to about one-third.

Design has been made relatively simple by employing a single video head and the recorder can be operated after a minimum of training. The new recorder is designed for production and presentation purposes.

The first versions will be available for both PAL and SECAM systems.

MEASUREMENT BREAKTHROUGH

Technicians at the Commerce Department of the U.S. National Bureau of Standards have successfully measured the frequency of infra-red light, emitted by a helium-neon laser, as 88,376,245,000,000 Hz.

This is the highest frequency measurement ever made; it is, in fact, two orders of magnitude higher than was previously possible four years ago.

As the wavelength of infra-red light is already known to a high order of accuracy, it will now be possible to establish a very precise figure for the speed of light. This will be of immense value in fields such as space science, astronomy, chemical analysis, etc., and may well result in an interchangeable method of measuring both length and time.

SYSTEM STUDIES EARTH RESOURCES FROM SPACE

A sophisticated image processing system developed by The Bendix Corporation has been delivered to the National Aeronautics and Space Administration's Goddard Space Flight Centre, Greenbelt, Maryland.

The system will be used to process thousands of electronic "photographs" taken every week from the Earth Resources Technology Satellites (ERTS). The first Earth-orbiting spacecraft, ERTS-A, is scheduled to be launched this spring followed by ERTS-B in 1973.

The ERTS programme is concerned with studies of the natural resources of the Earth and man's management of them.

The Bendix image processing system was developed under a $10 million subcontract from the General Electric Space Division, NASA's prime contractor for ERTS.

Now being installed into the Goddard Space Flight Centre's Data Processing Facility for ERTS, the system converts images of the Earth taken with high resolution vidicon cameras and multispectral scanners into film and computer-compatible tapes useful to scientific investigators in a wide variety of disciplines. These include agriculture, forestry, oceanology, geology, hydrology and mapmaking.

Information relayed by the ERTS satellites to ground receiving stations will essentially consist of electronic "photographs" of 100-nautical-mile-square patches of the Earth's surface. Each image will be recorded in digital form on magnetic video tape.

Nearly 10,000 images, each containing 72 million bits of information, must be processed each week to keep up with satellite data transmission.

The Bendix image processing system is composed of three subsystems: bulk, precision, and special processing.

The bulk processing subsystem converts original magnetic video tape to positive images on a 70-millimetre film by means of an electron beam recorder. Corrections to accommodate satellite orientation and sensor calibration, as well as any distortions produced by communications and video recording operations, are applied to the video data simultaneously with image recording. Selected images will then be enlarged, printed, catalogued and distributed by NASA to ERTS users. False colour composite prints can be made from the enlargements of the black-and-white images produced by bulk processing.

The precision processing subsystem, on request by ERTS users, is used to apply further corrections to the 70 mm. film produced by the bulk processing subsystem. Precision location and scaling of images relative to map co-ordinates is also performed.

The special processing subsystem converts digitized, user-selected scenes to computer-compatible tape. This enables all ERTS users who have access to a general-purpose digital computer and the capability of reading a standard computer tape format to process and experiment with digitized ERTS video data. Another service provided by the special processing subsystem is production of selected sections of the original 100-square-mile images on digital computer tape.

All latest images generated by either bulk or precision processing are developed in the initial photographic processing element using stringent material and process controls. Three products – 70-millimetre, 9½-inch black-and-white and 9½-inch colour composites – are used as inputs to the production photo processing element for mass-production of the imagery and subsequent distribution to the users.

SONEX '72 – BOOM IN OVERSEAS TRADE

Reports on the Sonex '72 Exhibition show that buyer interest from overseas is greater than ever before. Exhibitors say they have been overwhelmed by the response from visiting buyers and those seeking agencies for British audio and Hi-Fi equipment.

Reasons for this interest are, firstly, that the quality and technological engineering of British-made products in this field are so high, and secondly, that Britain's forthcoming membership of the Common Market has sparked off an unusual degree of flurry to secure agencies for British products.

"We have had a host of visitors from France, Belgium and Portugal," said a representative of Highgate Acoustics, "and I think this is due to a large extent to the fact that we are so competitive."

From Richard Allan comes a similar story: "60% of our production is already exported and the percentage will increase again this year. This is because of the quality of our goods and because the prices remain so acceptable. We are even getting buyers from Japan for high-quality equipment!"

"A bookful of enquiries for sound installations" – that is the message from Grampian Reproducers. "Now we will have to follow these up and quote." Commenting on the flow of overseas visitors, Grampian have had a steady stream through their exhibition rooms. "We are currently exporting 25% of our production, and this figure will go up into the thirties during 1972. The whole calibre of enquiries this year is better even than in 1971."

From the Garrard exhibition rooms comes news of a "pretty hefty order for our new modules. Zero 100S and the AP76 are proving to be of keen interest to all visitors. The acceptance level has been very high indeed."

First time at SONEX – Bang & Olufsen. The story here is very much the same as elsewhere: "There has been a very great interest from overseas buyers, but, of course, we ourselves are importers, so visitors from overseas are not of particular importance to us. Home trade is another matter. U.K. trade visitors have flocked to see our equipment and they have been more than impressed.

"What they look for in Bang & Olufsen is quality and design. Our sales were up 97% in 1971 over the previous year and the line of the graph is confidently expected to continue in the same, steep direction. Although we have been looking more or less at the top 6% of the market in this country, our research statistics have come up with facts that show a deep interest across a very wide section. The show stopper has been the new Beocenter 3500, and we expect great things from this unit."

BSR have had very good trade days at SONEX, but the response from the general public seemed to be quieter. "We have had a mass of overseas buyers through the exhibit, but we don't really go after overseas business. Already some 92% of our production is exported and sold through our existing network of agents, so there isn't much more room for expansion."

Decca "expected very big interest, and we got it. We haven't been disappointed at all. We have had a lot of really good orders from overseas buyers."

BENDIX WINS CONTRACT FOR EXPERIMENTS ON MARS

The Bendix Corporation's Aerospace Systems Division here has been awarded a $5,206,755 contract to design and produce three scientific experiment packages which will be carried to the planet Mars in 1975.

The contract was awarded by the Martin Marietta Corporation, prime contractor to the National Aeronautics and Space Administration for the two identical unmanned Viking spacecraft which will be soft-landed on the surface of Mars.

The purpose of the Viking mission is to study the physical characteristics of Mars and to determine if life can exist on the planet.

"The information from the scientific investigations on Mars will greatly increase our knowledge of the 'Red Planet' and consequently lead to a better understanding of the origins of the Earth," says Joseph F. Clayton, general manager of the Bendix Aerospace Systems Division.

The Division is also the prime contractor to NASA for the Apollo lunar surface experiment packages (ALSEP) set up on the Moon during each Apollo mission.

The Bendix experiments for the Viking programme are a seismometer, an upper atmosphere mass spectrometer and a retarding-potential analyser.

The seismometer will monitor seismic activity on Mars to determine if there are movements in the structure of the planet, whether it has a crust and a core and if its mantle is similar in composition to that of the Earth.

The instrument will also relay to Earth the rate at which meteorites strike Mars and information on the mechanical properties of the material near the Viking lander vehicle.

The Viking seismometer is a miniature device consisting of electromechanical inertial transducers and associated electronics that condition the seismic signals for presentation to the lander's data system.

The upper atmosphere mass spectrometer, operating while the lander vehicle is passing through the upper atmosphere of Mars on its descent to the surface, will provide information on the composition and abundance of gases such as carbon dioxide, nitrogen, oxygen, argon and helium.

The instrument is a double-focusing electrostatic/magnetic mass spectrometer that ionizes the atmosphere gases and then determines the type and concentration of the gas constituents.

The retarding potential analyser will determine the concentration and energy distribution of ions and electrons in the Martian upper atmosphere during the descent of Viking lander to the surface of the planet.

Recent developments in the theory of planetary atmospheres has increased interest in information of this nature.

The instrument consists of a sensor head and associated electronics. The sensor head contains planar grids and a collector. The collector is connected to an automatic range-changing linear electrometer.

In addition to the Bendix instruments, each Viking lander will carry instruments concerned with biology, meteorology and soil analysis.

The experiments aboard the Viking landers will be powered by nuclear generators (SNAP 19) and information will be relayed to Earth via the tracking stations of NASA's manned space flight network.

The long, nine-month trip to Mars puts critical limits on the Viking spacecraft's weight and power consumption. Bendix will use such light-weight materials as magnesium and berylium in constructing the instruments as well as the latest state-of-the-art in micro-miniature electronic components, including large-scale integrated circuits.

Two identical Viking spacecraft are scheduled to be launched from the Kennedy Space Center between mid-August and mid-September, 1975. Nine months later they will arrive in orbit around Mars.

AS RIGBY SEES IT!

"Oops! Yet another bite from the OTH electronic pollution!"

ELECTRONIC PAIN KILLER

New electro-medical discovery could mean relief for victims of chronic pain

HUNDREDS of thousands of people suffer from pain so intense that they can neither work nor sleep. And whilst drugs provide some temporary relief, the amounts and side effects may be of such magnitude that the palliative may be little better than the pain.

But a recently developed electronic stimulator may be able to control chronic pain in patients for whom other measures have not been effective. Whilst the technique is still under active development it has proved very successful and over 60% of several hundred experimental patients found that chronic pain was substantially reduced. Of the failures, a substantial proportion had complicated psychiatric problems.

The technique operates by electrically stimulating the dorsal surface of the spinal cord.

The spinal cord consists of a bundle of nerve tissues which carry messages to and from the brain. Pairs of peripheral nerves leave the spinal cord to be distributed throughout the body. Messages travel along these nerves as electrical impulses, and whilst the original input to the nervous system may have been mechanical, electrical, thermal, chemical, osmotic or whatever, the actual signal media will always be electrical.

Nerve tissues consist of numerous cells (called nerve cells) with branching, thread-like extensions. Every nerve cell is in contact with others by means of these extensions. The points where nerve cells make contact are called synapses.

The long extension of a nerve cell is called an axon, and it is by means of the axons that the electrical signals are transmitted. The conduction and insulation efficiency of axons is very poor – about a million times worse than copper wire of the same cross-sectional area.

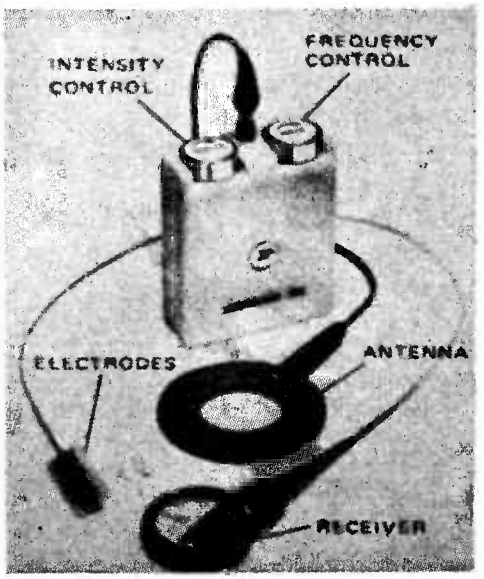
To compensate for this electrical inefficiency, each axon acts as an amplifier with approximately unity gain, i.e., the signal leaves the axon at about the same signal level at which it entered the axon.

Axons will not transmit any signal less than a certain minimum level. Either the input signal is strong enough to trigger off the axon's firing, or it is not. It is in fact a digital, rather than an analogue system.

More than this in fact, for the pulse 'generated' by an axon is always of approximately the same length. Unlike the Morse code the system can only transmit dots – there are no dashes. The dots are all of the same length and all of the same magnitude. The only way in which the intensity of a stimulus can be increased is by an increase at which the frequency of the axons fire. In human beings this upper limit is somewhere around 100 pulses a second.

The speed at which the electrical impulses travel to the brain is, by normal electrical practice, very slow indeed – at the very highest it is less than 300 feet a second – at the slowest it may only be a few feet per second. The speed of propagation is

ELECTRONIC PAIN KILLER



This neuro-stimulator unit is made by Medtronics Inc., in Minneapolis USA. Unlike most implanted medical devices, both the Medtronics and the Avery units use an external power source – thus obviating further operations for battery replacement.

The receiver of the Avery unit is encapsulated in epoxy resin.

Transmitter of neuro-stimulator made by Avery Laboratories at Farmingdale, New York. Power is radiated to the implanted receiver by the circular antenna.

largely a function of the diameter of the nerve fibre; the larger the fibre – the quicker the speed. A higher velocity is also produced by a myelin (fatty) layer.

It has been discovered that if an electrical stimulus is applied to the large fast-conducting fibres, this will block (or gate off) the transmission of impulses from the slower fibres. And it is these slower fibres that predominantly carry pain-causing impulses.

In the pain killing experiments the fast-conducting fibres are stimulated by injecting an electrical square wave that is variable in voltage, frequency and pulse width. The action connection to the nerve fibre is made via a number of platinum discs bonded to a layer of dacron mesh coated with silastic (Fig. 1).

Wires from the electrodes are taken, beneath the skin, to an RF receiver implanted just below the rib cage. As with a crystal radio set, power is supplied to the implanted RF receiver by a small battery powered transmitter carried in the patient's jacket or shirt pocket.

The patient can energise the transmitter whenever he requires. He is also able to adjust the voltage from 0.3V to 30V and the frequency from 9 to 550 Hz. The pulse width can be altered, but only by the physician, from 100 microseconds to 800 microseconds. In use the patient adjusts the controls to achieve

HOW THE SYSTEM IS IMPLANTED

(A medical description)

The preoperative evaluation consists of history, physical and psychiatric examination, roentgenograms of of previous areas of spinal trauma or surgery. Myelograms in those patients having had or suspected of having intraspinal disorder, complete urological evaluation including cystometrograms and intravenous pyelography.

The electrode is implanted via a high dorsal laminectomy for pain in the lower part of the body, and in the cervical region for arm pain.

optimum pain reduction. Usually this is obtained with the voltage set between 0.5 and 3V; frequency between 15 and 100 Hz and a pulse width of 200 microseconds. The parameters vary from patient to patient and also within the same patient from day to day, depending upon the degree of pain and the efficiency of the battery used to power the stimulator.

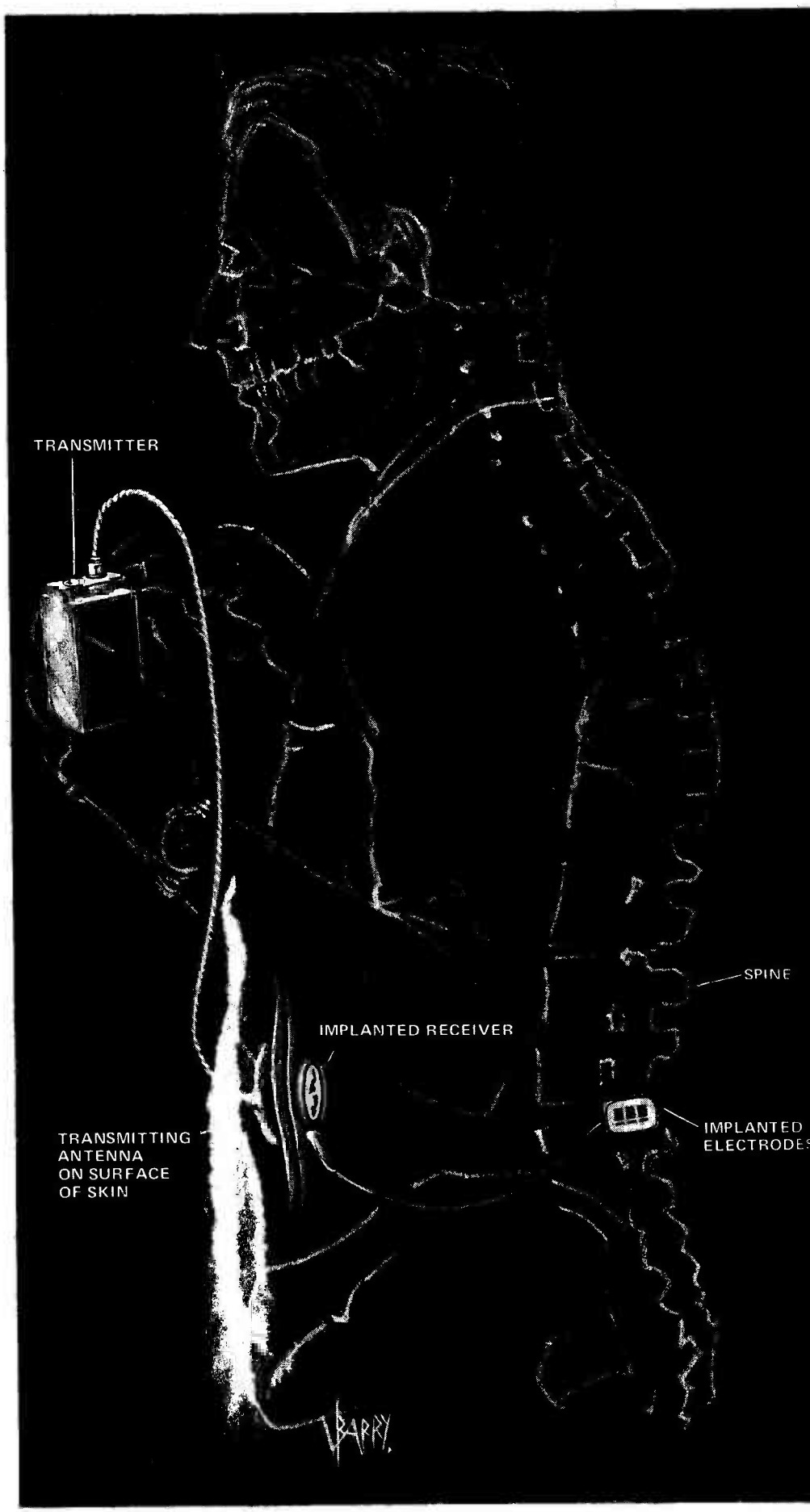
Patients differ widely in the amount of stimulation required to obtain pain relief. Some have excellent relief with a constant stimulus during the waking hours, others require intermittent periods of stimulation lasting from fifteen to sixty minutes with pain relief outlasting the stimulation from one to five hours.

The sensation described by the patient is usually a very mild continuous electric shock — many describe this as a mild tingling feeling — when the stimulator is being used at therapeutic levels. One patient described the feeling as being similar to that on the surface of a cat's throat when it purrs.

The technique does not completely reduce pain, but for the 60 to 65% of people for whom it has been proved to work it does reduce it to a level at which the patient can live a normal comfortable life. It is especially effective for patients with spinal and back problems.

At the present time the technique is limited to fairly simple applications but it is quite probable that cancer victims may be helped within the near future.

The system is however regarded as experimental and whilst neurosurgeons see the technique as 'the answer to chronic pain not responsive to other known treatment' it is seen as a last resort rather than a routine practice.



This sketch — by one of our staff artists — shows how the receiver and electrodes are implanted. The patient is shown adjusting the transmitter — normally carried in the patient's coat or shirt pocket.

THE PRINTED CIRCUIT MOTOR

This article, written exclusively for Electronics Today International by R.M. Evans M.I.E.E., C. Eng. of the National Research and Development Corporation, explains the principles and operation of the printed circuit motor. ETI makes due acknowledgement to the staff and management of Printed Motors Ltd., without whose co-operation and assistance this article would not have been possible, and to the National Research and Development Corporation for permission to publish.

THE printed circuit motor was invented during the late 1950s. It is generally attributed to J. Henry-Baudot, employed at that time by the Societe d'Electronique et d'Automatisme in Paris. The printed circuit motor arrived on the industrial scene at a time when printed circuit techniques were being generally applied to a host of applications that had previously used solid conductors. Before the technique could be used for an electric motor, a suitable form of construction had to be found, and here the inventor dug deep into history to utilise the Faraday disc principle discovered in 1831 and which was the forerunner of all electric machines.

PRINCIPLE OF OPERATION

One big drawback of the original Faraday disc motor was that, because in essence the armature consisted of a single turn, it required the supply of very high currents at low voltages. This was unwieldly, consumed a lot of power and required the brushes to pass very heavy currents.

Although the principle of the Faraday disc has recently been resurrected for high current generators, traction motors and superconducting machines, it fell into disuse for a long period, during which the drum type machine as we know it today was developed. The excitation flux in a conventional dc machine is usually produced by energising coils located on the stator. The rotor has a multiturn winding arrangement with end connections brought out to a commutator and this allows considerable freedom of choice in deciding rated values of current and voltage. Because the excitation flux would otherwise have to cross the relatively large air gap presented by the bore of the machine it becomes necessary to locate the armature or rotor conductors in a magnetic core to minimise the reluctance of the flux path. This increases the bulk, cost and inertia of the armature and magnifies the commutation problems.

The essence of the printed motor is that it combines the advantages of both disc and drum type constructions without the disadvantages of either. By an ingenious design of armature which allows the printed circuit motor to be made in thin pancake form, the flux air gap is reduced to a minimum and no iron is required in its construction. And by having a multipole arrangement it becomes possible to design for practical levels of rated voltage, keeping current to manageable proportions.

A simplified diagram showing the basic principle at the printed motor is shown in Fig. 2. As can be seen by

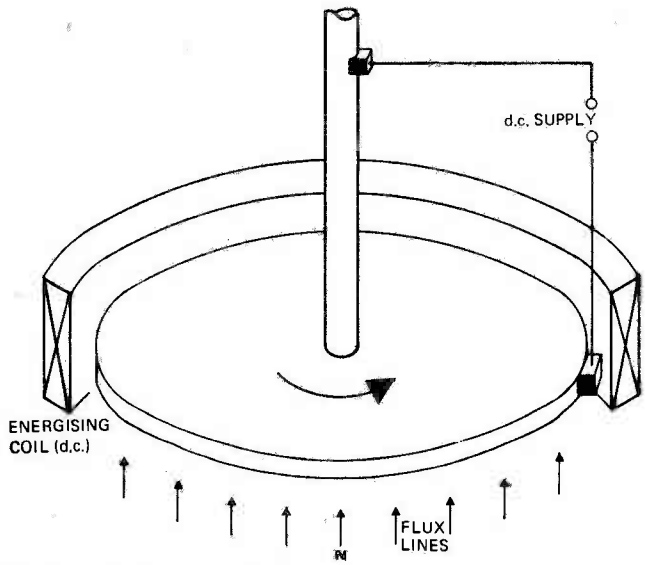


Fig. 1. Basic Faraday disc motor.

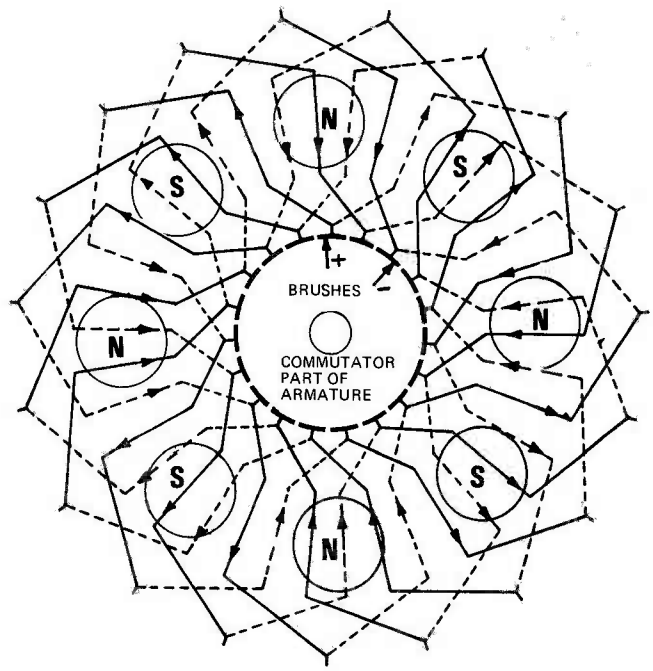


Fig. 2. This drawing shows the basic principle of the printed motor. The solid lines represent conductors on the front face of the armature; broken lines represent conductors on the rear face. The commutator is part of the armature.

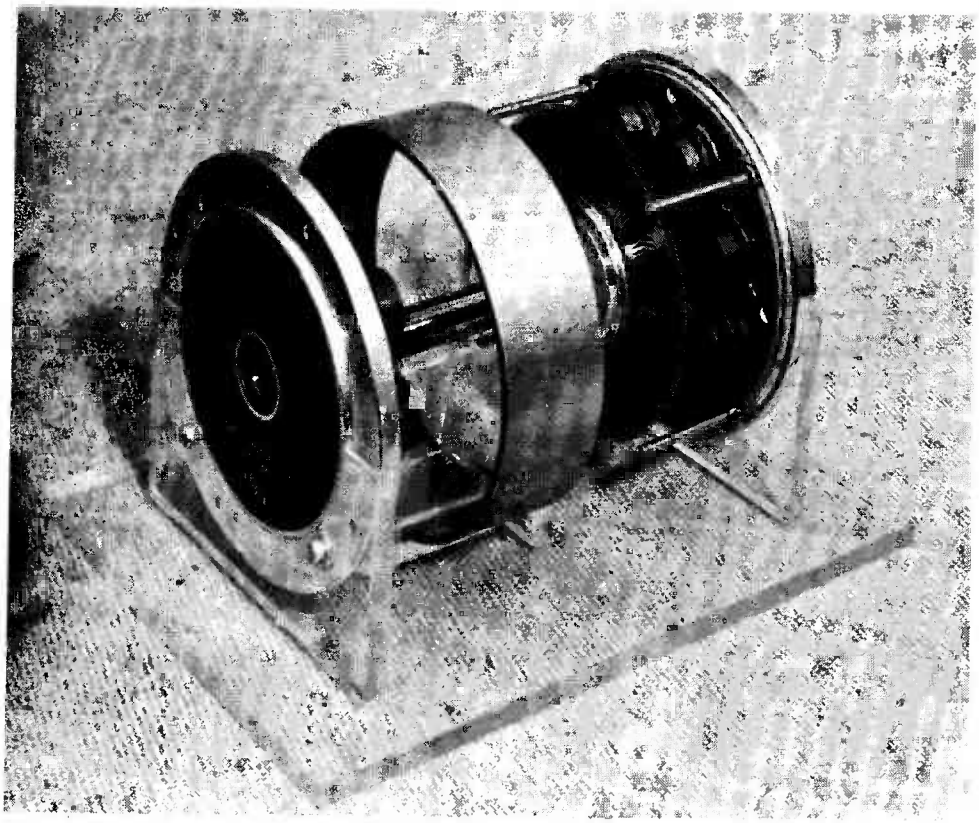


Fig. 3. Exploded view of a printed circuit motor. The windings wrapped around the pole pieces are used only for the initial magnetization. They are subsequently sealed off and left in position to avoid disturbing the magnetic circuit.

alternating the polarity of adjacent pairs of poles it becomes possible to connect the conductors under each pole in series, in a classical wave-wound arrangement in which the voltage rating V of the motor will approximate to:—

$$V \triangleq e \times \frac{n}{2}$$

Where e = induced voltage per conductor at rated speed

n = total number of conductors.

For simplicity only a small number of conductors per pole have been shown whereas in practice there will be a far greater number — the end connections between conductors are arranged geometrically to provide a running surface for the brushes which deliver the supply power to the motor thus dispensing with the need for a separate commutator.

CONSTRUCTION

The pole pieces which are made from Alcomax 3 are generally cylindrical in construction. They are located rigidly to their respective end plates as shown in Fig. 3 which gives an exploded view of one type of motor.

To achieve the best magnetic characteristics it is desirable to magnetise the motor after it is assembled into final form. The magnetisation is carried out by injecting the requisite dc current through the winding shown wrapped around the pole pieces. These windings are then sealed off and left in position as it would be impossible to remove them without disturbing the magnetic circuit.

When these motors first appeared on the industrial scene the armatures were formed using printed circuit techniques, i.e. copper foil on an insulation backing piece etched to give the requisite conductor layout. This was later superseded by a mechanical system of punching and the armature shown in Fig. 3 has had the notches between conductors produced by this process. Although no longer truly descriptive of the method of construction, the term 'printed circuit' motor has remained.

The armature starts off as two, four or six copper discs punched out in the manner described. With alternate discs reversed, they are then cemented together in pancake form with a circular wafer of insulation interposed between them.

CONNECTION

Electrical connection is made between the ends of the conductors on one face and the ends on the other so that a wave winding is formed. The 'chevron' part of each conductor is the "useful" portion which passes under the poles — all the 'forward' conductors, (shown with heavy lines in Fig. 2) are on one face whilst the "return" conductors (dotted) form the face on the reverse side.

The conductor contour of the armature is computer designed for optimum performance. The geometry ensures that the end connections align when placed back to back, and the curved portion forms a track on which the brushes run — the armature is thus provided with its own inbuilt commutator.

The remainder of the construction is fairly straight-forward, the armature is clamped to the main shaft which is located in bearings in the end plates, Brush housings are provided in one of the end plates though which special silver graphite brushes make contact with the armature.

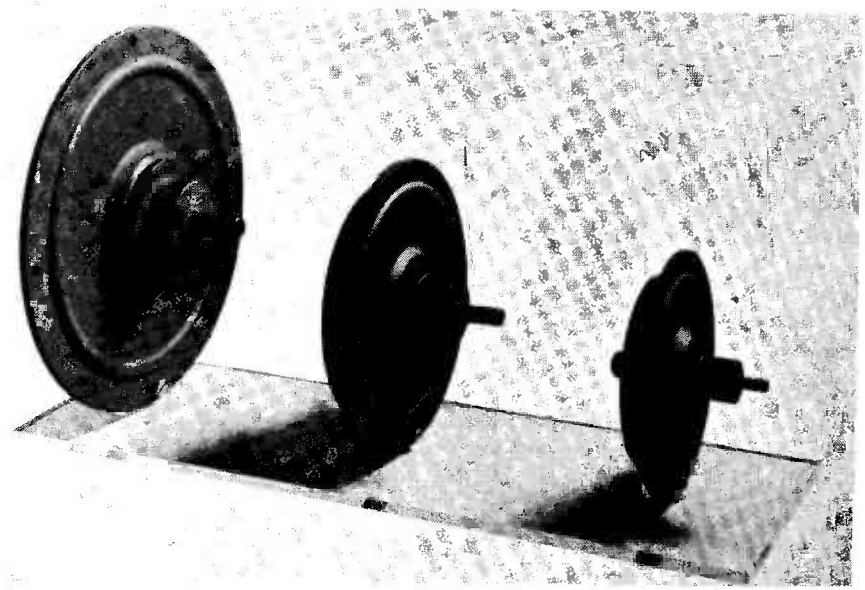


Fig. 4. Typical 'general purpose' printed circuit motors with ratings from 12 to 350 Watts at speeds of up to 4000 rpm. Rated voltage is from 12 to 47 volts.

THE PRINTED CIRCUIT MOTOR

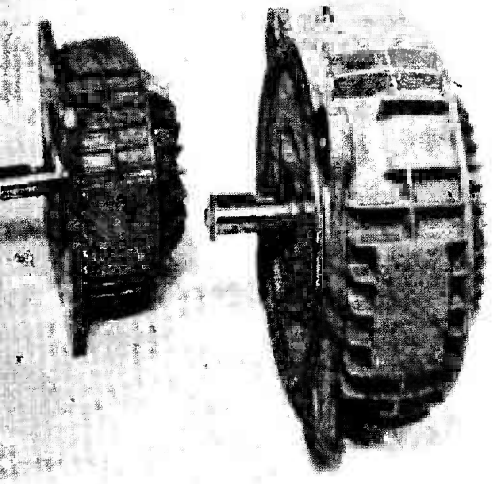


Fig. 5. These high power servo-motors are rated 1000 to 5000 Watts.

Because of its unique construction the printed motor has several advantages to offer over the more conventional machine.

The armature contains no iron in its magnetic circuit, therefore armature reactance is negligible. This is a particularly important feature especially in regard to commutation, as the high coil voltages induced in conventional machines (due to the rate of change of current during the commutation cycle) are not present. Commutation is thus virtually sparkless and the motor will accept very high current surges without damage. These characteristics are ideal for fast accelerating duties – in fact by suitable current injection a starting torque five times normal may be obtained.

Again, because of its negligible armature reactance, the motor has a virtually pure resistive input impedance. Changes in supply voltages almost instantaneously reflect a current change in the windings, and this, together with the low rotor inertia, make the printed motor eminently suitable for control applications.

A printed circuit motor runs smoothly at all speeds and being of a slotless construction and having a relatively large number of conductors (and thus commutator segments), cogging is eliminated. All armature conductors are exposed to the cooling medium enabling high current densities to be employed. Since the only insulating medium is that of a simple disc between armature faces, the cost of insulating for a higher working temperature category is not very great.

Table 1[1] shows a dimensional comparison between conventional and printed motors.

PERFORMANCE

Figs 4 and 5 show typical printed circuit motors; those in Fig. 4 are termed 'General Purpose' and are available with outputs from 12 to 350 watts at speeds up to 4000 rpm, rated voltage varies between 12 and 47 volts dc. The high power servo motors shown in Fig. 5 are available in powers from 1000 to 5000 watts at speeds of 3000 rpm and rated voltage varying between 90 and 150 volts dc.

The absence of magnetic material in the armature also means that the torque output is directly proportional

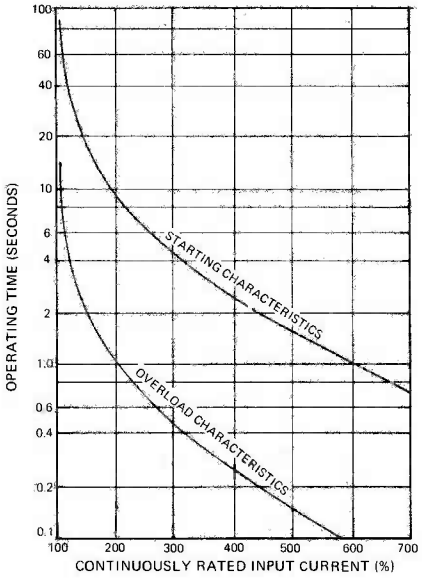
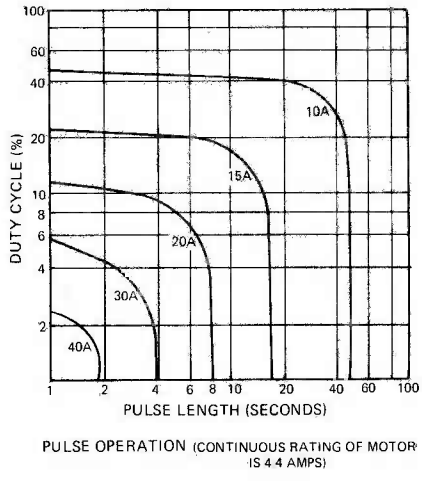


Fig. 6. Permissible motor overload current for short running times.



PULSE OPERATION (CONTINUOUS RATING OF MOTOR IS 4.4 AMPS)

Fig. 7. This graph shows how a printed circuit motor, normally rated at 4.4 amps, can be used with pulsed operation.

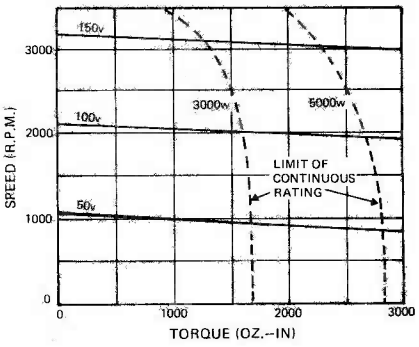


Fig. 8. Torque/speed characteristics of 3000 and 5000 Watt printed circuit motors.

to the armature current and is not limited by saturation. This allows a pulse torque of up to five times the normal full load figure to be developed, but the motor must be derated as shown in Fig. 6.

A further important feature of the printed circuit motor arising from the linear relationship between current and torque is the fact that there is no degradation at high currents as a result of magnetic saturation. And as previously stated currents up to five times the continuously rated level can be handled, the only practical limitations being the design of the associated drive circuit. The armature, which has a relatively small thermal capacity, heats up quickly whereas the rest of the motor has a much longer time constant. The peak temperature reached by the motor after a number of current pulses is therefore the sum of these two effects, one proportional to the duty cycle and the other to the pulse duration. This relationship is shown in Fig. 7.

Typical torque speed characteristics of the 3000 and 5000 watts printed motor are shown in Fig. 8.

APPLICATIONS

Printed circuit motors first made an impact on the industrial scene in computer peripheral applications, where their compactness, high current capacity and low inertia made them eminently suitable for tape drives. There has since been a steady inroad into the machine tool drive, graphic art, tape transport and traction fields and their introduction to the process industry as part of a packaged controller unit is imminent.

The high power/weight ratio of the printed motor combined with its compactness and high starting torque and overload capability make it eminently suitable for traction duties. Some thousands have been sold for electrically driven golf club carriers – Figs. 9 and 10 show lawnmower and tricycle applications. Fig. 10 brings

home the ease with which the motor may be adapted as the hub of a wheel taking up very little extra space in an application where space is at a premium.

Printed motors have been applied to the paper drive of U.V. recorders with some success. To record transient events which occur in mass spectrometry, it is necessary to use very high paper speeds, and to avoid wastage (the sensitised paper is costly) the recording speed must be reached in the shortest possible time. Utilising the rapid response of a printed motor to a pulsed supply, a roll of paper can be accelerated up to five metres per second in 0.3 seconds. The ease with which the speed of the motor can be controlled has also eliminated the expensive gearbox (with its attendant noise), making it possible to attain a continuously variable range of paper speeds of 5000:1.

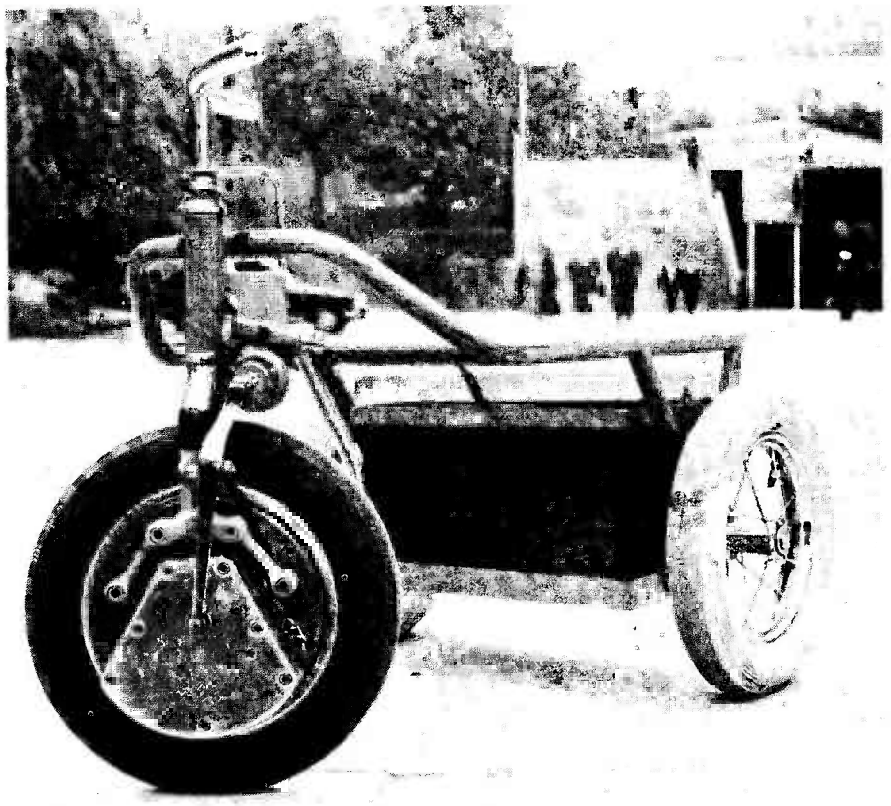
Another major demand for printed motors has been for servo applications, i.e. where precise control of the output shaft speed is required. This is generally obtained by using a feed-back loop so that any errors in the speed are automatically compensated for by adjusting the supply feeding the motor.

Magnetic and paper tape capstan drive servos are an ideal application where the tape speed is required to be held within closely defined limits so that analogue signals are faithfully recorded on and reproduced by the tape. A most accurate control method is the phase lock servo system marketed by Printed Motors Ltd., the block schematic of which is shown in Fig. 12.

In this system a high precision radially ruled optical disc is mounted directly on the motor shaft. The frequency of signal produced from the pick-off unit is compared with the reference frequency which represents the desired speed of the machine. If too slow, the dc amplifier increases the voltage supply to the motor, and reduces it if too fast, until the desired speed setting is reached. By this method motor speeds may be controlled to within an accuracy of 0.1%.

Fig. 9. This electrically powered lawnmower uses a printed circuit motor drive.

Fig. 10. The printed circuit motor of this electrically powered tricycle forms the hub of the front wheel.



An instrument tape transport system using printed circuit motors would have typical performance figures as follows:—

Start Time	4 sec at 120 i.p.s.
Stop Time	2 sec at 120 i.p.s.
Tape Accuracy	0.1% of nominal speed
Cumulative Flutter (peak to peak)	.25% at 120 i.p.s. (Bandwidth .1Hz to 10 kHz. 1.7% at $\frac{15}{16}$ I.P.S. (bandwidth 1Hz to 200 Hz)

Although the servo capstan provides the tape drive, the tape still has to be wound and unwound onto the spools and to avoid stretching or breaking it is essential that the spool speeds be compatible with that of the capstan. This is accomplished by monitoring the tension in the tape and feeding back a proportional signal to the spool drive to ensure constant tension is maintained. Due to the relatively large inertia of its load, and the rapid excursions in acceleration torque that are required, the printed motor is ideally suited to handle the spool drive duty.

In data logging systems where the input is in digital form, the capstan drive speed requirements, (although in some respects similar to those for instrument tape transports), are not so onerous, tolerances between ± 4% being generally acceptable. Where the input is delivered in an intermittent

Table 1 shows a dimensional comparison between conventional and printed motors.

Continuous rated output at 3000 rpm (watts)	Length of motor (excluding length of shaft extn.) (inches)		Motor diameter (inches)		Weight (lb.)	
	Printed motor	Conventl. motor	Printed motor	Conventl. motor	Printed motor	Conventl. motor
230	2½	10	7	6½	16	34
1000	4¼	12	8¾	7½	30	68
1600	4¼*	15	8¾*	10	30*	150
3000	5½	18	12¼	13	66	240
5000	5½*	23	12¼*	13	66*	290

* Force cooled

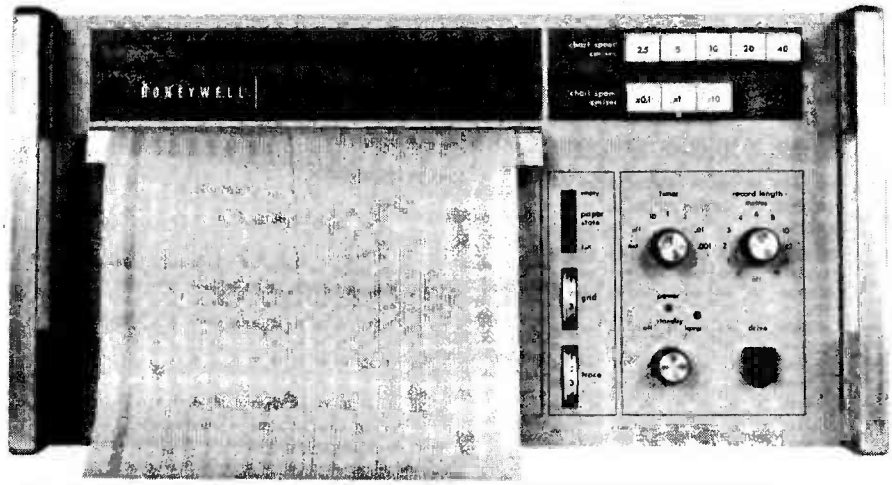


Fig. 11. This Honeywell ultra-violet recorder uses a printed circuit motor for the paper drive mechanism.

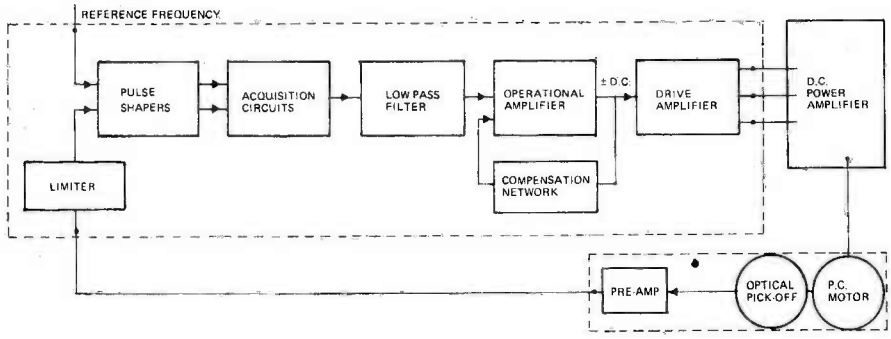


Fig. 12. This phase-locked loop servo system provides precise control of motor speed.

fashion it is desirable to have the tape driven discontinuously to save tape and storage space. An incremental mode of operation is therefore adopted, so that just before the digital information is required to be recorded, a command signal sets off the capstan drive. Obviously the speed of run up of the capstan motor is of a prime importance as this will determine the repetition rate at which information may be recorded. Typically the capstan is required to advance the tape in small discrete steps of about 0.001" so that packing densities of 1,000 bits per second may be achieved. An illustration of an incremental tape transport using printed motors is shown in Fig. 13.

In an entirely different field is the use of printed motors for operating large control valves where torques in excess of 10 lb.ft. are required. Fast operating time is required and by using a reduction gear in conjunction with a screw and nut arrangement piston speed travels in the region of 1" per second have been achieved. This is much faster than has been obtained using a conventional motor. A typical example is shown in Fig. 14. The printed motor in this illustration has a continuous rating of 25 oz. inches. The motor may be supplied directly from the process controller pulsed output, and an added advantage is that its high torque characteristics is invaluable in overcoming the valve stiction.

The virtually sparkless commutation action of the printed motor has been used to advantage in electron beam welding, where a drive was required for a work table which had to be fitted within a vacuum chamber under conditions of 10^{-4} mm Hg. Because of its inaccessibility it was necessary for the drive motor to be maintenance free for considerable periods. By fitting special brushes maintenance free life of up to 1,000 hours was obtained.

CONCLUSIONS

Although first invented during the '50s the printed motor has only gained acceptance as a reliable piece of electrical equipment over the past few years. But now the motor is making inroads into applications which have long been the preserve of conventional motors and there seems no reason why the high growth rate which has been achieved over the past few years should not be maintained, if not accelerated, in the future. ●

REFERENCES

1. B. E. Hall: 'Printed Motors in Control' Instrument and Control Engineering, December 1969.

Fig. 13. The printed circuit motors used in the tape transport system of this data logging recorder advance the tape in 0.001" increments.

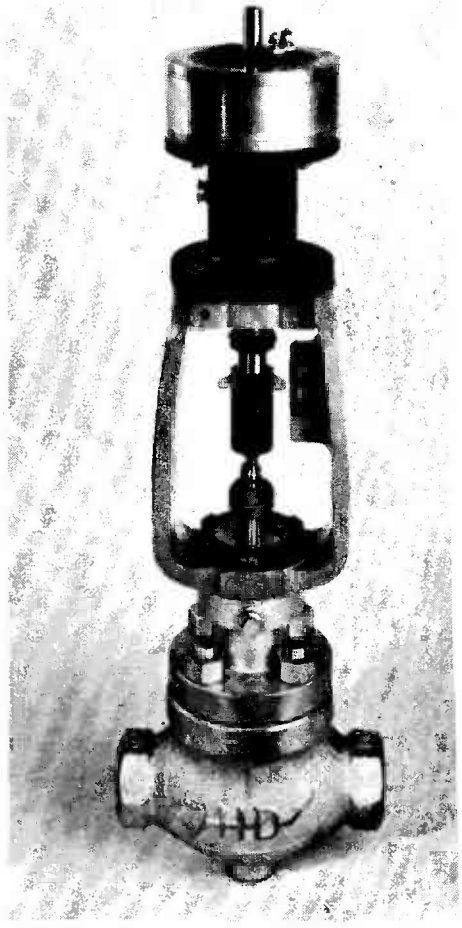


Fig. 14. This large control valve is powered by a printed circuit motor capable of sustaining 25 oz. in. torque.

We won't compromise on quality

But you can compromise on price

Garrard's Zero-100 is a product of superb engineering.
It costs over £50.
You needn't compromise if you can't afford it.
The same unsparing attitude to precision is behind the AP76
at about £29 and the SP25 Mk III at under £17.
And there are other Garrard decks costing more or less.
They are in the finest 'ready-made' Hi-Fi systems.
Or you can put them in yourself.
Either way you can't lose, if it's a Garrard deck.
Send now for range brochure.

Garrard

A PLESSEY QUALITY PRODUCT

Garrard, Newcastle Street, Swindon, Wiltshire

Bases illustrated
available July 1972

ELECTRONICS IN

Iceberg, near Davis, Antarctica (ANARE photograph by W. Dingle)

Field camp on the Antarctic Plateau near Mawson (ANARE photograph by A. Williams)

The remoteness and environmental severity of inland Antarctica presents an unusual challenge to the engineering of scientific instrumentation.
This article by Ian Bird and Alan Humphreys of the Antarctic Division of Australia's Dept. of Supply describes the problems involved in constructing a totally unmanned observatory to operate at temperatures as low as -100°C.

THE ANTARCTIC

by Ian G. Bird, AMIREE, FRMT., and Alan Humphreys, AMIREE

Engineers at Australia's Antarctic Division of the Department of Supply have designed and constructed an automatic, unmanned geophysical observatory about fifty miles south of Casey Base, on the coast of Antarctica, about 2500 miles south of Perth W.A.

The installation, which is now in service, has instruments for recording auroral displays, magnetic micro-pulsations, ionospheric opacity (riometer), wind direction, barometric pressure and air temperature.

The equipment, designed to run unattended for up to one year, consumes only 1.5 watts average power.

Data is recorded both on magnetic tape and photographic film: operations are programmed from a crystal chronometer. Data relating to magnetic micro-pulsations are logged continuously; other data such as night-time auroral photographs are taken at five minute intervals, whilst meteorological observations are made hourly.

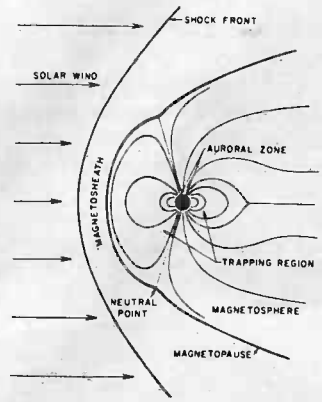
THE PURPOSE OF THE INSTALLATION

The observatory is primarily intended for the study of solar terrestrial physics, and for research into the upper atmosphere.

One of the effects currently being studied by the observatory is the interaction between the "solar wind" and the earth's magnetosphere.

The sun constantly ejects streams of charged particles into space. This emission is termed the "solar wind". The earth's magnetosphere (see Fig. 1) captures these particles and guides them towards the earth's surface in the polar regions surrounding the geomagnetic poles. The effects of the interaction between the solar wind and the upper atmosphere of the earth is dramatically illustrated by magnetic storms, ionospheric disturbances (causing radio blackouts) and auroral displays.

Study of these phenomena is of importance to fundamental physics and has great practical significance to space travel. It has always been of concern to HF radio communicators as the solar emissions cause sudden fades and radio blackouts and many other effects.



Configuration of the Earth's magnetic field, showing the distortion produced by the solar 'wind'.

Knowledge of the meteorology and glaciology of Antarctica is intrinsically important not only for itself but also to the greater understanding of world weather.

POWER CONSIDERATIONS

For inland Antarctica, conventional remote-station power systems such as wind-driven generators, propane thermoelectric generators or primary cells are of dubious reliability; radio isotope thermoelectric generators provide a feasible power source but at high cost. To provide even a few watts can be difficult and costly.

A design criterion therefore, was to limit power requirement by devising low-power instrumentation capable of operation at low temperatures, and it was apparent at the outset that no power could be provided specially for thermal control of the instrument shelter.

Precharged storage batteries provide the bulk of the 1.5 watt requirement of the prototype observatory; additional capacity is provided by solar and special wind-powered generators.

LOW TEMPERATURE BATTERIES

Energy around 40 watt hours per pound weight is commonly available from primary cells at moderate temperatures; however, as temperature falls, so chemical reactivity is reduced, and at $-40^{o}C$, almost no power may be drawn from primary cells (Figure 2).

Secondary batteries (lead-acid and nickel-cadmium), have a known performance to $-30^{o}C$. For specific low temperature application, modifications to the electrolyte will optimize performance. At the 50-hour charge and discharge rate, a special lead-acid battery showed 45 percent charge – discharge cycle efficiency at

The design and development phases of the observatory were carried out in the Antarctic Division's Melbourne laboratory. (ANARE photograph).

ELECTRONICS IN THE ANTARCTIC

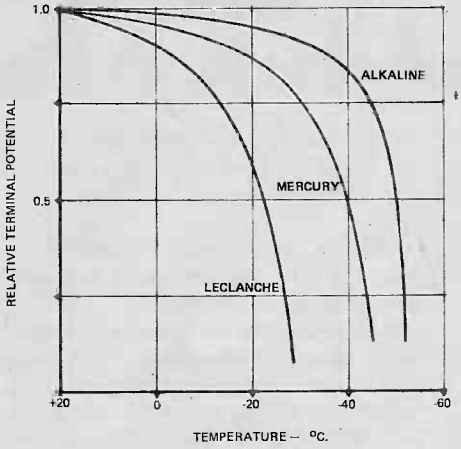


Fig. 2. This graph shows the terminal potential of primary cells discharged at the 100 hour rate.

-60°C, and 20 percent at −65°C.

For lead-acid cells, excess electrolyte and a fully charged specific gravity of 1.310 are used to maintain near optimum conditions: these procedures allow for efficient operation to −60°C. Nicad Cells are optimized at a specific gravity of 1.230 which is constant with state of charge; efficient operation to −50°C results.

The prototype observatory uses both lead-acid and Nicad batteries for comparative assessment.

CHARGING TECHNIQUES

(i) Solar

For six months of the year, energy is available from the Sun. For moderate outlay a silicon solar cell array provides worthwhile power in average sunlight.

(ii) Wind

Worthwhile energy can be obtained at wind speeds around five metres second with ability to survive gusts of 75 metres second. Antarctic experience with propeller-driven generators has shown moderate reliability under these conditions in coastal regions but the low inland temperatures provide added problems. Development is continuing in this area. A variety of small generators has been developed and during 1963 Antarctic Division developed a five watt turbine generator for operation in rugged conditions. This generator, (Fig. 3), has performed well at remote sites south of Mawson station and could be scaled to provide greater power. The predominantly constant wind direction allows fixed orientation.

(iii) Radio Isotopes

Light-weight isotope power generators using the alpha emitter, Plutonium 238, provide about one watt per pound weight of generator. Cost is typically $150,000 for a five watt generator. A five watt strontium-90 powered generator costs about $30,000 but requires heavy biological shielding. Strontium 90 generators have been used reliably in various remote station applications including Antarctica.

One advantage of thermo-electric conversion is that due to conversion inefficiencies, heat is available for elevating the temperature of batteries and instruments.

Fig. 3. This five Watt turbine generator has been specially developed for rugged conditions. (ANARE photograph).

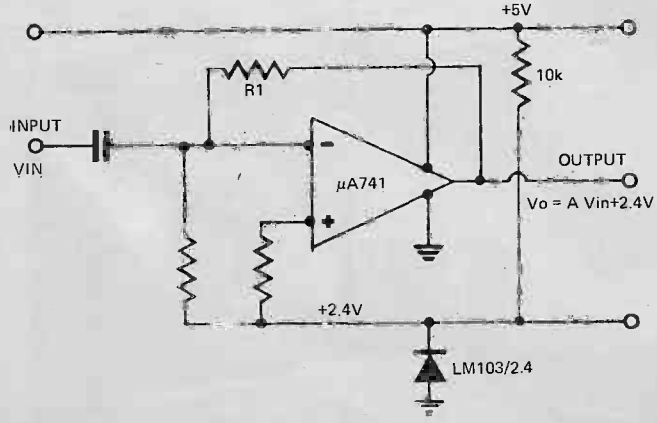


Fig. 4. Micro-circuit biasing arrangement for a single 5V supply.

MINIMIZING THE POWER REQUIREMENT

Power consumption, far lower than ordinarily achieved with standard components, was achieved as follows:

Supply Voltage

A nominal six volt power system regulated to five volts was chosen as being the minimum generally to operate solid state and other devices. Operation at this voltage is the main factor contributing to the efficiency of the circuitry.

Logic Components

TTL logic consuming 2.5 milliwatts per gate was used; standard 54 series logic requires 10 milliwatts. Recently released complementary-symmetry metal-oxide semi-conductor (COSMOS) logic is under evaluation; its quiescent consumption of 50 nanowatts per gate shows the future trend.

Linear Microcircuits

Amplifiers of the uA741 type were used to give 90 dB gain at 2.5 milliwatts consumption (Figure 4). Micropower circuits such as RM4132, with a gain of 108 dB at 5 volts and 0.1 milliwatts consumption, offer future advantage.

Discrete Component Circuits

The high gain of some transistors at microamp collector currents, opens a

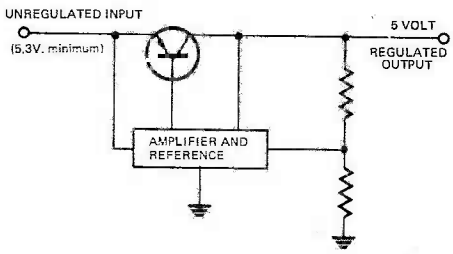


Fig. 5. Basic circuit of low-loss regulator.

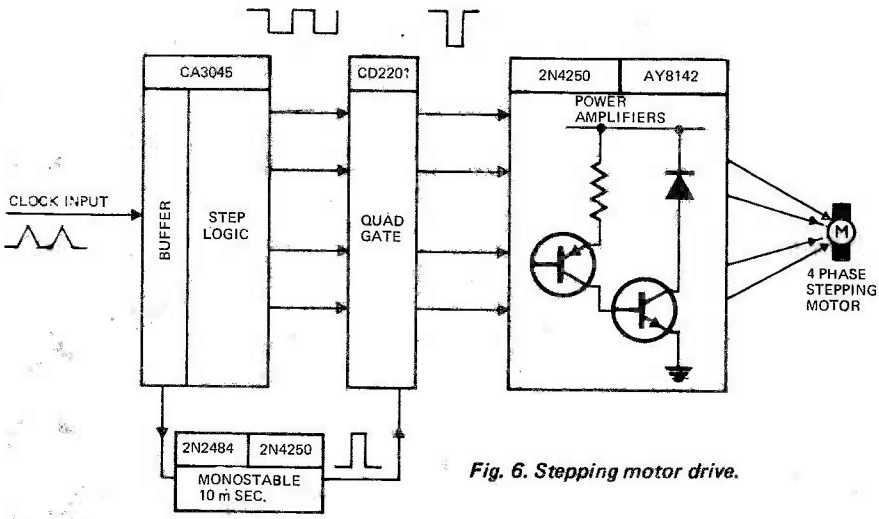


Fig. 6. Stepping motor drive.

field for low-power design. This principle was used for continuous loads such as the Chronometer to attain a power advantage of 1000 over conventional microcircuits. (Cosmos MSI will remove this advantage.) Standby power is limited by low quiescent current circuits.

Voltage Regulator

The regulator (Figure 5) differs from the usual arrangement by application of a PNP series control transistor: this allows regulation down to a series voltage drop just above collector saturation voltage.

Motors

Precision dc motors and stepping motors are required to drive the tape and film transport mechanisms; power requirement is limited by pulse-powering the tape capstan stepping-motors (Figure 6) and minimizing the duty cycle of the dc motors (1:300 for tape deck).

Thermal Control

Although the observatory instrumentation has been specifically designed to operate at low ambient temperatures — the chronometer quartz crystal reference requires a stable environment. Power to achieve this has been limited to 100 milliwatts.

DATA ACQUISITION

Station scientific data are recorded (currently) on paper chart, magnetic tape and film; some routine analysis is completed at the station but the bulk is done by computer-aided processes in Australia. The proposed automatic stations offer a similar facility for the annual return of data for processing in Australia.

In the long term, as complexity and time resolution requirements increase, on-site recording capacity will prove inadequate and regular read-out will need to be considered; this could be to a satellite.

DATA SAMPLING RATES

At manned observatories, chart speeds of 15 cm per hour are typical for the common geophysical instruments (riometer and magnetometer), the resulting time resolution being about fifteen seconds. Examination shows that data-scaling rarely exceeds one-minute intervals, except for magnetic micropulsations. Hence a sampling rate of 40 per hour was decided upon, with an auxiliary rate of one per hour for meteorology and housekeeping. This allows 9000 hours of operation to a single 2400 ft. tape reel. Magnetic micropulsations are monitored continuously and recorded on a separate analogue tape recorder.

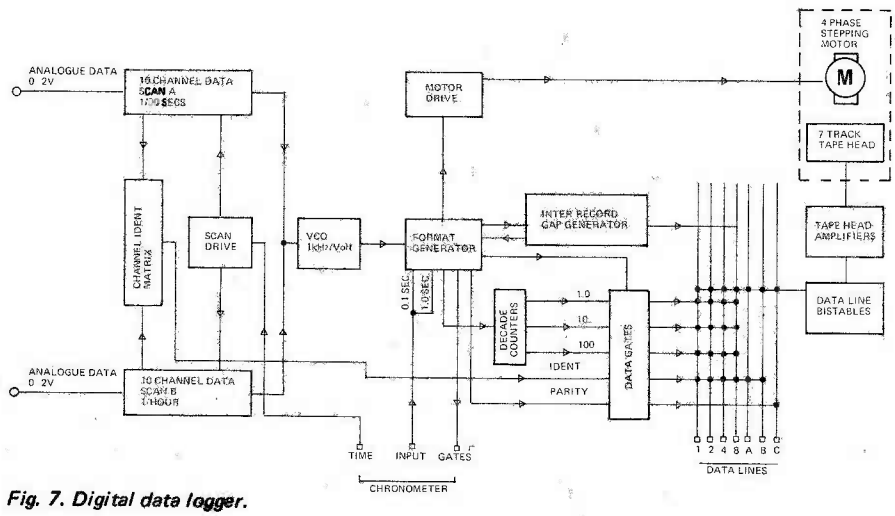


Fig. 7. Digital data logger.

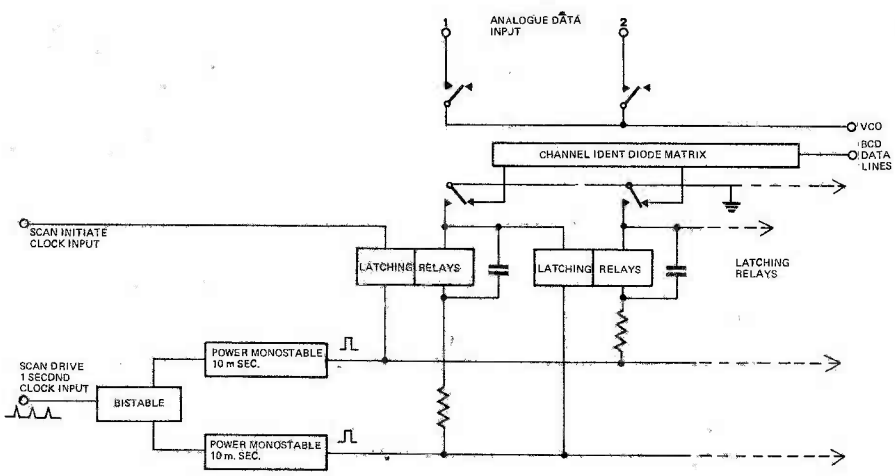


Fig. 8. Analogue multiplexer.

ELECTRONICS IN THE ANTARCTIC

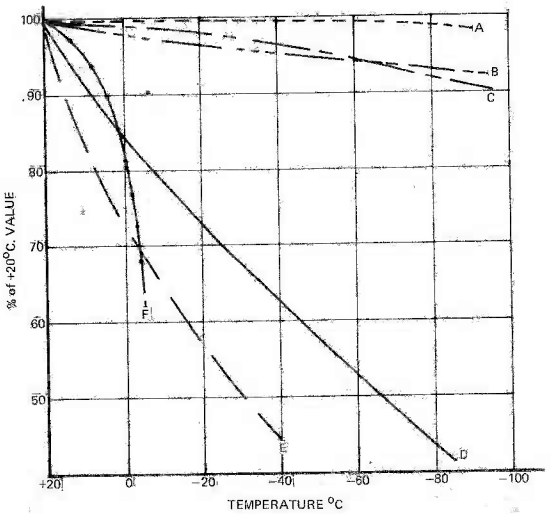


Fig. 9. These curves illustrate the low temperature performance of various components.

A: Polycarbonate capacitor
B: Solid tantalum capacitor
C: Polyester capacitor
D: Silicon transistor (current gain)
E: Germanium transistor (current gain)
F: Etched aluminium foil electrolytic capacitor

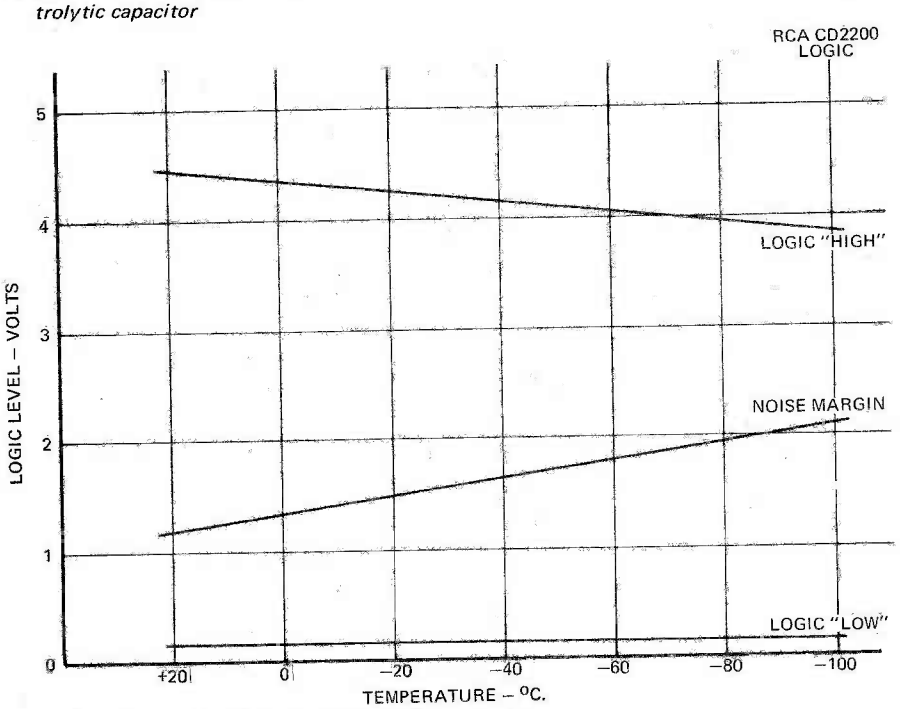


Fig. 10. Variation of logic level voltage with temperature.

RECORDING TECHNIQUES

Digital

To obtain high reliability, low power consumption, large data storage capacity and ease of subsequent data processing, magnetic tape was chosen as the recording medium.

To record the primary data directly in computer format is advantageous; digital recording also makes optimum use of the tape. The data logger is shown in Figure 7. Maximum input rate is one measurement per second recorded on ½ inch computer tape, 556 bits per inch, 7 track NRZ1 logic to include the various tape gaps and spaces is provided. A stepping motor drives the capstan, and dc motors power the tape tension control; a pinch roller is avoided to minimize tape skew.

The input scan is provided by a shift register of latching relays (Figure 8); programming is controlled by the chronometer. The logger operates at 90 second intervals for 30 seconds, average power consumption is 450 milliwatts and test operation is satisfactory at –70°C.

Analogue

Direct slow speed analogue recording on ¼" tape has been used widely in magnetic micro-pulsation equipment. For a tape speed of 2¼ in. per hour, frequencies to 2Hz can be recorded, however some data is lost to tape "drop out". The analogue tape deck capstan is pulsed at five steps per second, thus sampling the analogue signal at the recording head. A fair reproduction of signals to 1.5 Hz is recorded. A single 2400 ft reel of tape provides 12,000 hours of continuous recording. Average power consumption for continuous operation is 50 milliwatts.

COMPONENTS AT LOW TEMPERATURES

Most components show some parameter change as temperature varies; Military Standard Specification 202 rates components to –55°C. but performance below this temperature is not usually stated by manufacturers. Antarctic Division investigations to –100°C are illustrated in Figure 9.

This work shows the feasibility of selecting resistors and capacitors for stable operation at very low temperatures; high gain silicon transistors have current gains of around 100 at -80°C – adequate for most requirements.

INTEGRATED CIRCUITS

Operational amplifier parameters; gain, output voltage swing, and input offset are all temperature dependent. For amplifier uA741, using a single 5 volt supply, temperature variation from 0°C to –80°C causes about 4 dB reduction in open-loop gain, and output voltage swing falls to about 60 percent of the 0° value – 2.5 volts; these variations are not unduly restrictive on design. However, effects of the input offset drift, limit the practical closed-loop gain; for a gain of 45 dB the output voltage drifts 10 percent for a temperature fall of 80°C and one percent for 25 dB closed-loop gain. For higher gains, low drift amplifiers such as uA725 may be used.

Variation of logic levels with temperature is also of concern (Figure 10), at –80°C there obviously is adequate margin for satisfactory

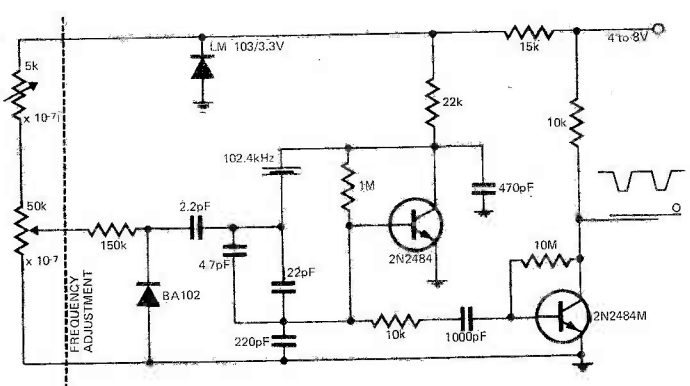


Fig. 11. Chronometer reference oscillator.

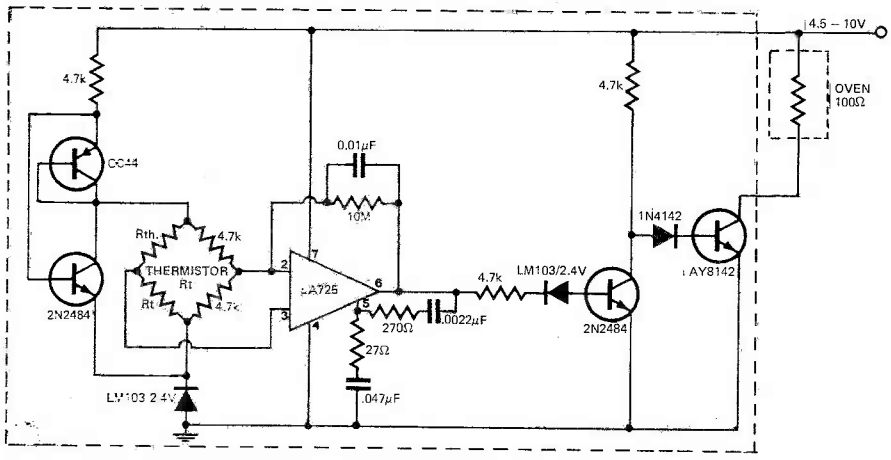


Fig. 12. Basic circuit of oven temperature controller.

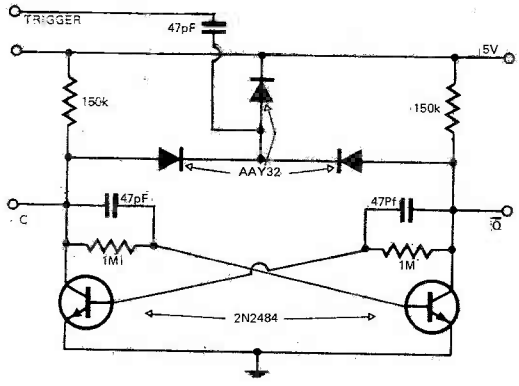


Fig. 13. Basic binary circuit.

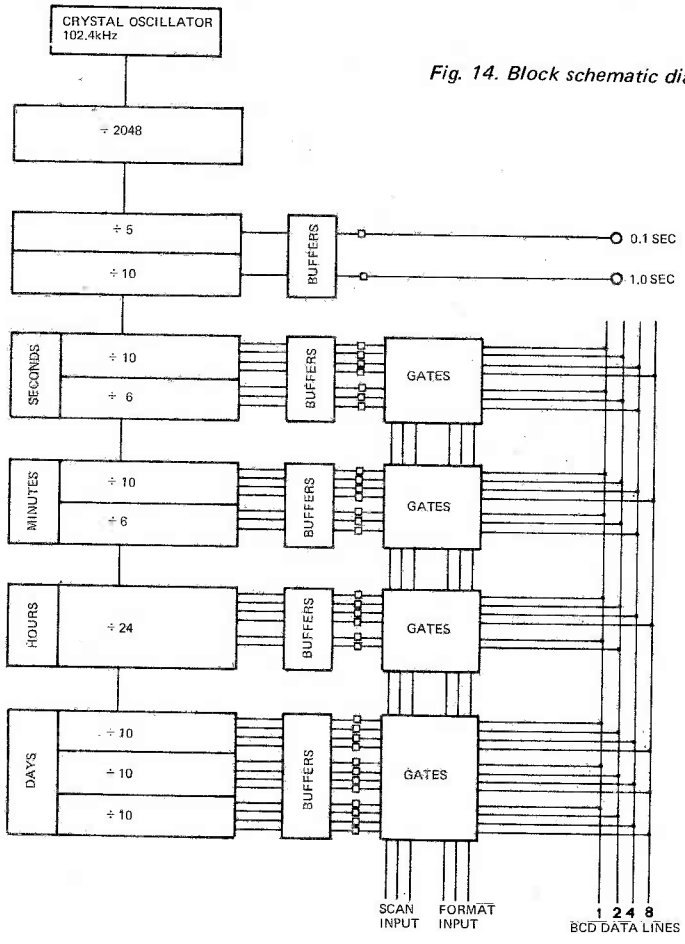


Fig. 14. Block schematic diagram of chronometer.

operation; the increased noise immunity is useful.

MECHANICAL COMPONENTS

For efficient mechanical design, friction must be minimized; lubricants play an important part in this. The viscosity of conventional low-temperatures lubricating oil increases about 1000 times for a temperature fall from +20°C to −60°C; silicone oil viscosity increases about 10 times, dry bonded lubricants such as "Molykote 88" (molybdinum disulphide in vinyl butyral resin) have excellent low temperature performance and are ideal for lubricating ball races and small gear reducers. Teflon coating also has been used for reducing friction in slow-moving gear trains and geneva drives.

Springs increase in brittleness at low temperatures and require careful design. It has proved desirable for all mechanical drives to be positive, that is, not to rely on friction, and to avoid rapid acceleration of mechanical components.

ELECTRICAL CABLE

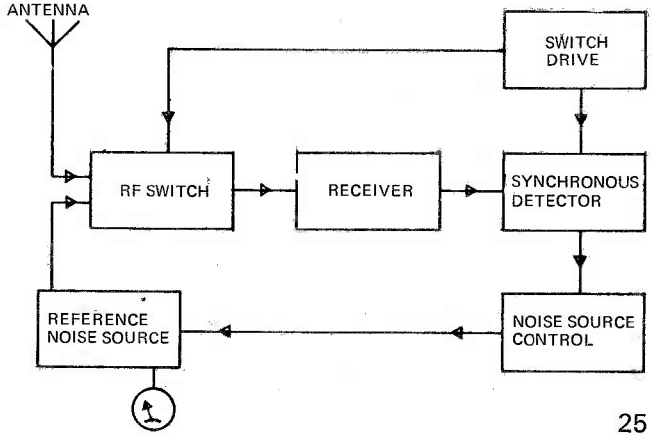
Commonly used flexible cables of PVC are liable to fracture below 0°C; polythene cables are moderately flexible to −40°C; teflon cables are flexible at −100°C; silicone rubber also has good low-temperature performance. For the observatory, requirement for flexibility was eliminated. Polythene dielectric and sheathed coaxial cables to antennae are fully protected; all equipment wiring is teflon-insulated and fixed in position.

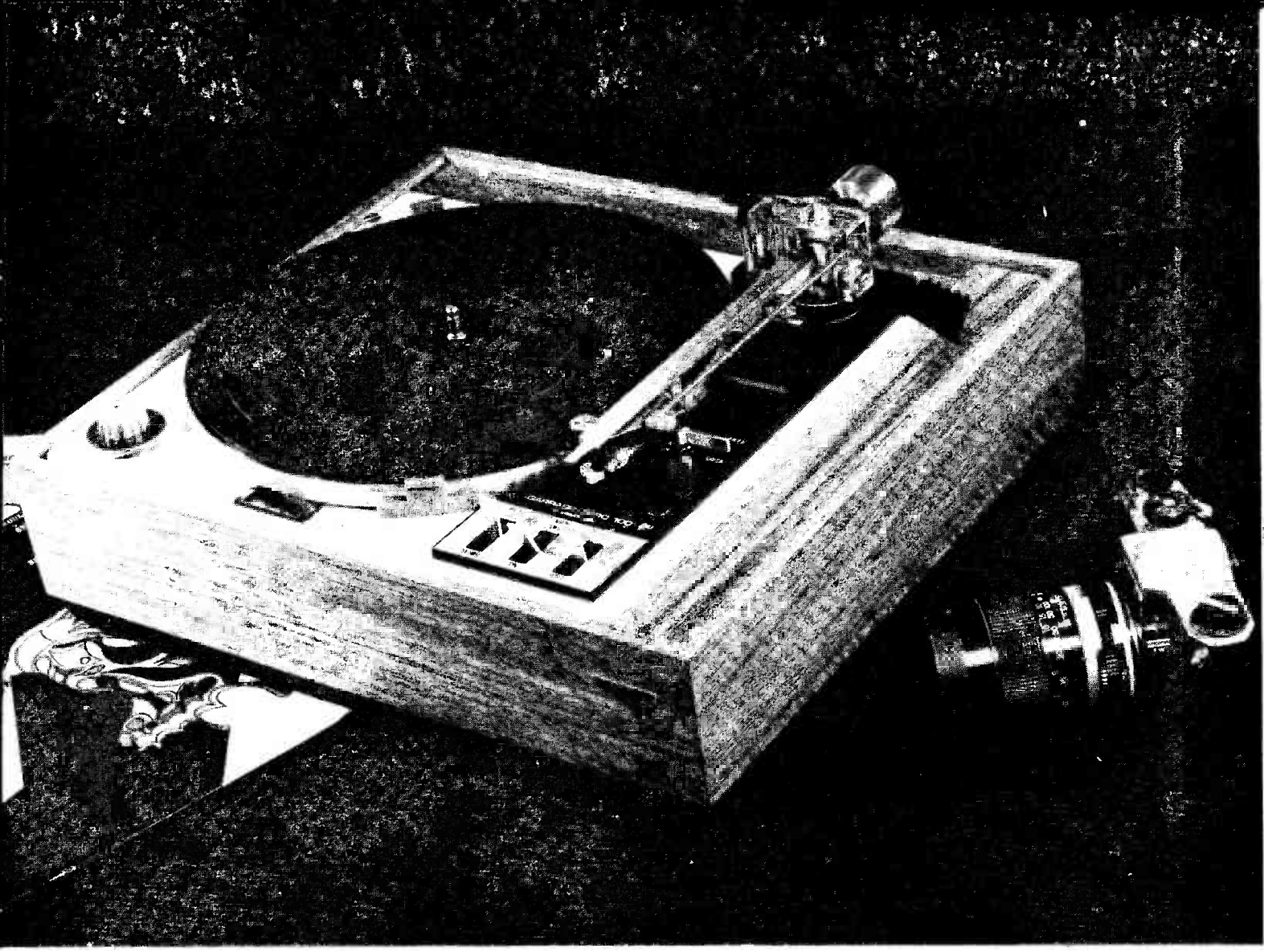
FILM AND TAPE

Measurements of the mechanical strength of photographic film shows that, while the tensile strength may increase about 30 percent for a

Continued on page 71

Fig. 15. Riometer – block schematic drawing.





ZERO TRACKING ERROR

Garrard Zero-100 Automatic Turntable.

electronics TODAY INTERNATIONAL
product test

THE CONCEPT of a pick-up that will track a record in a linear fashion is as old as disc reproduction. The reason for wanting it is to enable the playback system exactly to reproduce the mechanical characteristics of the record cutting system.

Ideally, the pickup arm should track the record on a radial line. The stylus should be wedge shaped and be connected to the cartridge by a bar at 15° to the plane of of the record. If this can be arranged, the playback system will exactly match the characteristics of the recording system.

The wedged stylus shape has been approximated by the elliptical stylus to a satisfactory degree, and most cartridges professing high fidelity have the 15° rake angle.

The one remaining weakness is non-linear tracking.

From time to time linear tracking arrangements have been designed, but mostly they suffer from one serious weakness. This is friction caused by complex bearing arrangements.

There are two basic ways of obtaining linear tracking. The first is to have an arm which slides horizontally across a bar located at the rear of the turntable. This system, whilst provided perfect tracking, has bearings that introduce a lot of friction. The second system is that used in the Garrard Zero – 100. This consists of two parallel arms connected to the headshell, each fixed at two pivot points. With correct geometry this system provides almost totally accurate tracking. However, this requires four bearings instead of one and hence approximately four times as much friction.

Errors in tracking angle introduce second-harmonic distortion, and since the best that one can hope for with a conventional pickup arm is perfect tracking only on two positions on the record, it automatically follows that at every other point on the record, distortion will be introduced by the tracking error. This distortion is given by the equation.

$$THD(2nd) = k\,\phi\frac{V}{v}$$

where V is the velocity of the groove modulation
v is the groove velocity
and ϕ is the tracking error in degrees.

It will be seen, therefore, that the possible methods of decreasing the distortion are either:–

(i) to increase the grove velocity, (ie, use 45 rpm or 78 rpm instead of 33-1/3 rpm),

(ii) decrease the groove modulation,

(iii) reduce the tracking error

The first method has the obvious disadvantage that there will be less recording time per record. Some special records are made like this, such as our 12" diameter, 45 rpm Bruel and Kjaer test records. The second method would result in a degraded signal-to-noise ratio, and this would therefore be just as unacceptable as the generation of second harmonic distortion. The only remaining method is the use of linear tracking arms.

Before considering in detail the raison d'etre of the Garrard Zero-100 design, it is necessary to consider the subjective effect of distortion. Generally it can be said that the higher the order of the harmonic the more sensitive the ear is to it. If it is supposed to be there – then it will be pleasing, and will add colour. If harmonics are there unintentionally, such as from an overworked pocket transistor radio they are very unpleasant indeed. Thus even a fairly critical ear will happily tolerate some 3% harmonic distortion, but only about 1% third harmonic distortion. Another important subjective effect is that the average adult can hear little above 16kHz, and since modulation velocity is proportional to frequency as well as amplitude, the most severe distortion for given amplitude will occur at high frequencies. However, harmonic distortion at frequencies above 8kHz will not be audible as even the *second* harmonic will be 16kHz.

MEASURED PERFORMANCE OF GARRARD ZERO-100 SERIAL NO. 75100/004

Turntable

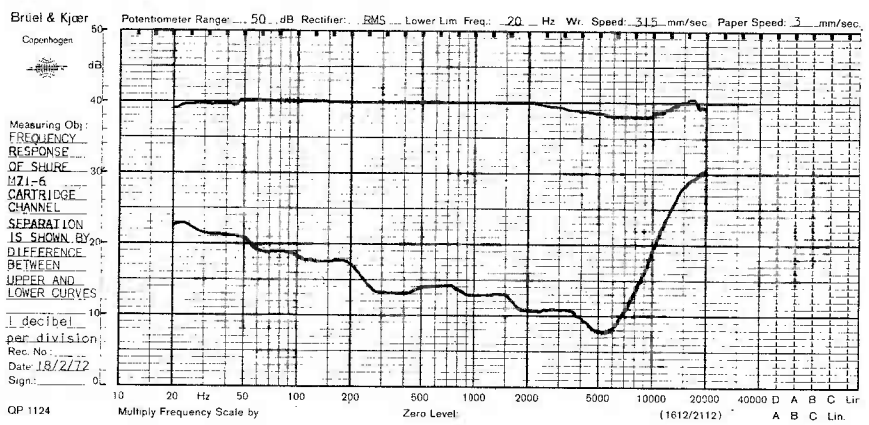
Wow and Flutter	= 0.15% rms
Hum & Rumble Equalized But Unweighted re 1kHz at 5cm/sec	= –44dB
Speed Variation	= ± 3%
Turntable Weight	= 3½ lbs

Pick Up Arm – Friction Measured at the Head.

Transverse Friction	= 200 mgs
Vertical Friction	= 30 mgs.

Cartridge Supplied – Shure type M71-6

Tracking Force	= 2 grams
Frequency Response	= 20 to 20kHz ± 1 –2dB
Channel Separation at 1kHz	= 27dB
Channel difference at 1kHz	= 1dB
Output re 1kHz 5 cm/sec	= 4.4mV
Cartridge Impedance	= 47 k Ω
Cartridge Weight	= 6 grams.



MECHANICAL CONSTRUCTION

The Garrard Zero-100 player has an appearance that could be described as "professional". The base plate is white enamelled pressed steel and has a raised section on the righthand side containing the pick-up arm and its controls. In the centre is an escutcheon for viewing an illuminated stroboscope image. On the left hand side of the deck are a pair of concentric aluminium knobs. The inner knob provides speeds of either 45 rpm or 33-1/3 rpm, and, for automatic operation, sets the changer mechanism for the correct record size. The outer knob provides a variation of ±3% of the nominal operating speed. The pick-up control levers on the righthand side of the deck provide for automatic operation, manual on/off and pick-up cueing, respectively.

These gold-anodized vertical control levers are well spaced to allow easy operation.

The cueing lever provides a very fast lift, but is nevertheless positive and free of lost motion to ensure that the stylus can be lowered back into the same groove. The lowering action is slow and extremely smooth in both the manual and automatic modes.

The main feature of the Zero-100, is of course, the tone arm.

ZERO TRACKING ERROR

The Garrard Zero- 100S is the non-automatic version of the unit tested.

The rather large main gymbal bearing of this arm is enclosed in a clear rectangular perspex frame.

The 'universal' bearing of the secondary arm consists of a spherical head resting in an indentation. This is located in the perspex frame, approximately one inch from the centre line of the main bearing. It is constrained against rough handling or shipping, by a cage. This gives the impression of looseness when the head shell is moved. Nevertheless the bearing is very positively located while playing records.

On the top of the main gymbal is a small ceramic magnet; this is directly beneath a similar magnet attached to the perspex frame. These magnets provide the anti-skating force. The strength of this force is adjusted by sliding a piece of steel between the two magnets, thereby decreasing their mutual repulsion. The position of the steel shield is visible through the perspex frame and this has calibration marks (in grams) corresponding to the tracking weight of both conical and elliptical stylii.

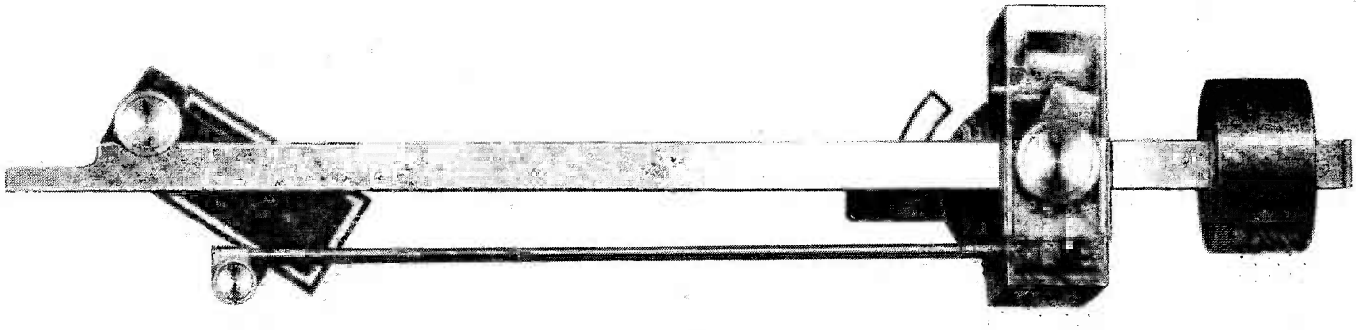
The counter weight is made of lacquered brass. It screws onto the arm by means of a central plastic spider and is locked by a nylon ratchet under the main arm. This is designed vibrationally to isolate the mass of the counterweight from the tone arm, in an attempt to reduce low frequency excitation of the system consisting of the tone arm mass and stylus compliance. The tracking force is provided by a small brass weight under the tone arm. This will provide tracking weights of up to 3 grams.

It is at the head shell that one appreciates the complexity of the parallel tracking arrangement. The head shell is pivoted to the main tone arm and the secondary arm via ball bearings. The main arm bearing is designed to be loaded in either direction, while the one on the secondary arm is preloaded to remove play.

These bearings are a very important part of the Zero-100 unit, and to a large extent determine its performance. We found that there was no measurable play in either bearing, but we felt there was probably more stiction than was desirable. Measurements showed that whilst the vertical stiction was a very respectable 30 mg, the horizontal stiction was 200 mg. These figures clearly show the increased stiction caused by using four bearings for horizontal movement as against two for vertical movement.

To find out the actual effect of this sideways friction we set up the arm using an Ortofon MI5E cartridge tracking at 1 gram. We found that the tracking over some of our audio obstacle course test records was exemplary on the outer channel, but slight mistracking occurred on the inner channel and this was largely due to the arm's friction. Using the Shure M71-6 cartridge supplied to us with the unit, we obtained excellent performance at a tracking weight of 2 grams. This is the maximum recommended for this particular cartridge.

While Garrard claim that much lower tracking weights are possible, we do not see any point in reducing second harmonic distortion by reducing



the error in the tracking angle, and then replacing it by far more annoying and objectionable third and higher harmonics on high level transients. We would therefore recommend that a heavier tracking cartridge such as the Shure M71-6 or Ortofon MF15 be used.

While the arm is possibly "state of the art", the turntable drive system is far from it, and is similar to that used on some of the earliest turntables. It consists of a pulley driving onto a pressed steel rim. We found that although the turntable rumble figures are quite low, subjectively, they seem to be higher, due to the higher frequency components that are caused by the ringing of the steel rim.

Although the turntable weighs 3½lb, the drive rim is very light. A far better performance would most probably be obtained by eliminating the steel drive rim and incorporating it in the main aluminium diecasting.

The drive motor is a combination induction and synchronous motor providing an operating speed as accurate as the mains frequency, and independent of voltage fluctuations.

Fine speed adjustment is obtained by varying the height of an idler wheel on a conical stepped pulley. The provision of speed adjustment brings with it the need for some form of speed measurement. This is provided in the form of a stroboscope on the underside of the turntable. The stroboscope is illuminated by a neon-light mirror, enabling it to be viewed from above.

A simple but well designed feature is the spring loaded pick-up arm. This enables the pick-up to rise against a spring without straining the actuating mechanism should the unit be inadvertently started with the arm in the locked position.

One point which arose during the testing is the need for a good earth between the turntable deck and the amplifier. If this is not provided or inadequate, the signal-to-noise ratio may not exceed 20 dB.

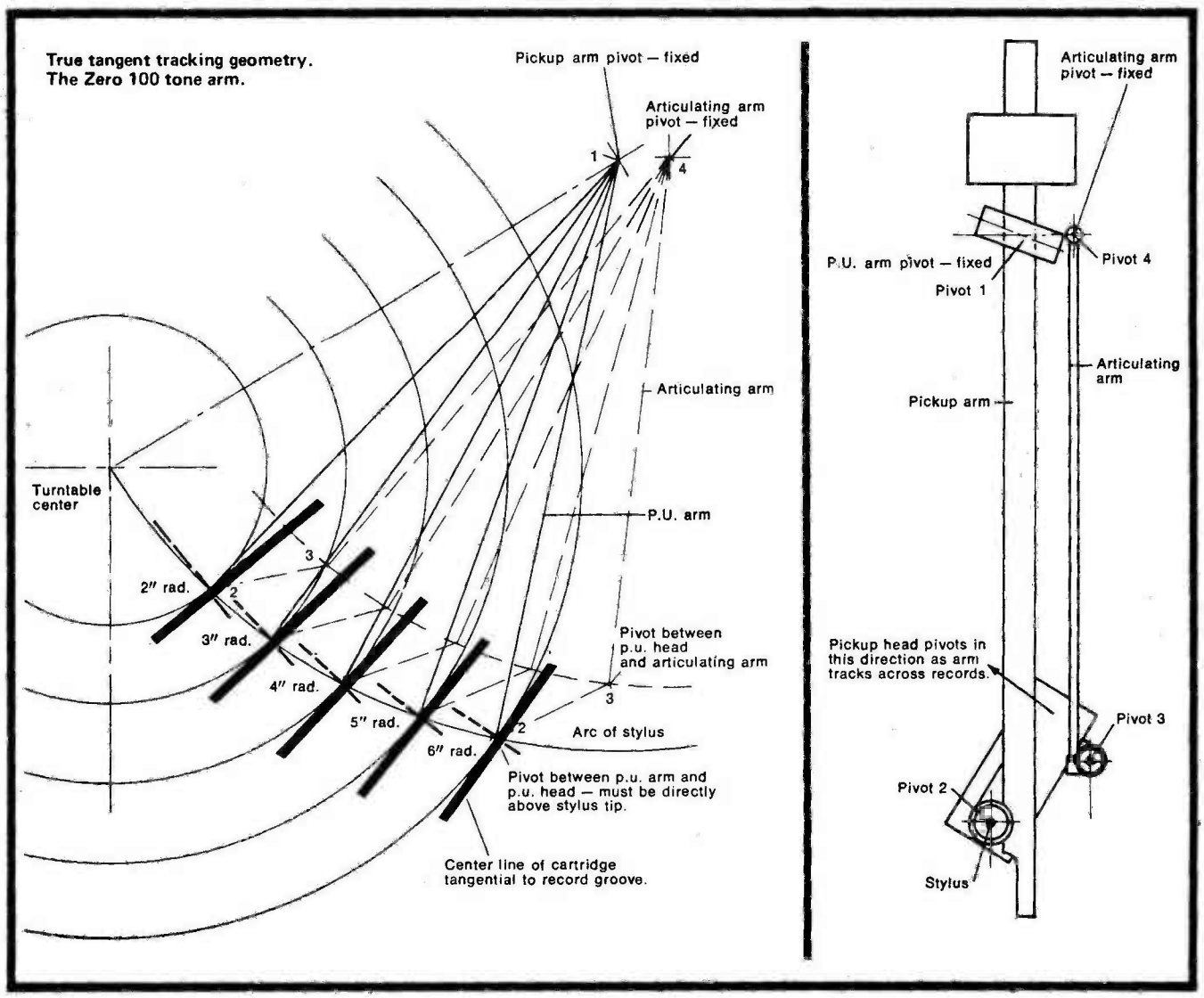
The handbooks supplied with the Garrard Zero-100 provide detailed information on the turntable's operating principles, construction, installation and use.

The Zero-100 arm is extremely well designed, but the same degree of refinement has not been extended to the rest of the turntable.

With a suitable cartridge, the Zero-100 performs well. However, despite the complexity of the arm mechanism there is no measurable difference in performance between the Zero-100 arm and other *top quality* conventional arms. Nor could we detect any subjective improvement on most programme material.

The Zero-100 unit is well constructed, and while it does not achieve all the aims it strives for, it is the best unit that we have seen that will provide linear tracking without severely compromising the other requirements of a good pick-up arm. ●

True tangent tracking geometry. The Zero 100 tone arm.



TWO BATTERY-

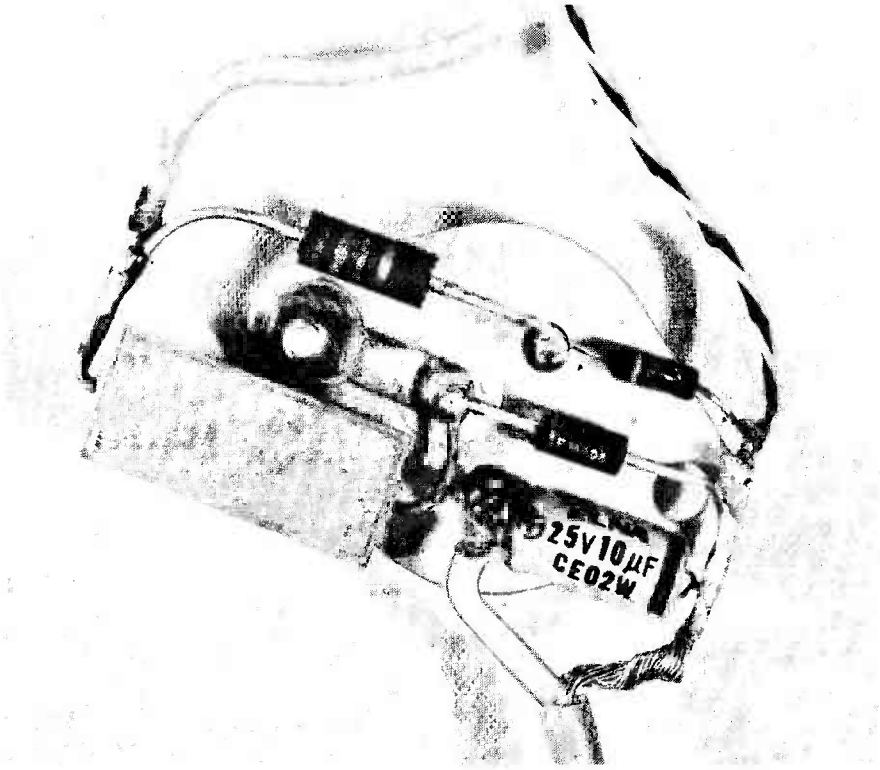
ETI PROJECT

511

These simple 'battery savers' will provide 9 volts at up to 250 mA.

The 12 volt unit – before encapsulation.

Fig. 1. This shows a simple way of constructing the 12 volt version.



MANY battery operated portable appliances are provided with a socket to enable them to be connected to a suitable external dc power supply.

This article describes the construction of two external power supplies, or 'battery savers', that may be used to energize many different types of tape recorders, record players, transistor radios, etc.

One unit is mains operated and is intended for use in the home – the second unit is intended for use in cars or trucks and operates from the vehicle's electrical system.

Both units are very simple to construct, provide adequate regulation and have sufficient power handling capacity to operate practically any small domestic (normally battery operated) appliance.

As the majority of battery operated appliances use a nine volt supply, both units described here have been designed for a nominal nine volt output. However for some purposes a six volt or a four and a half volt

SAVERS

POWER UNITS FOR BATTERY OPERATED APPLIANCES

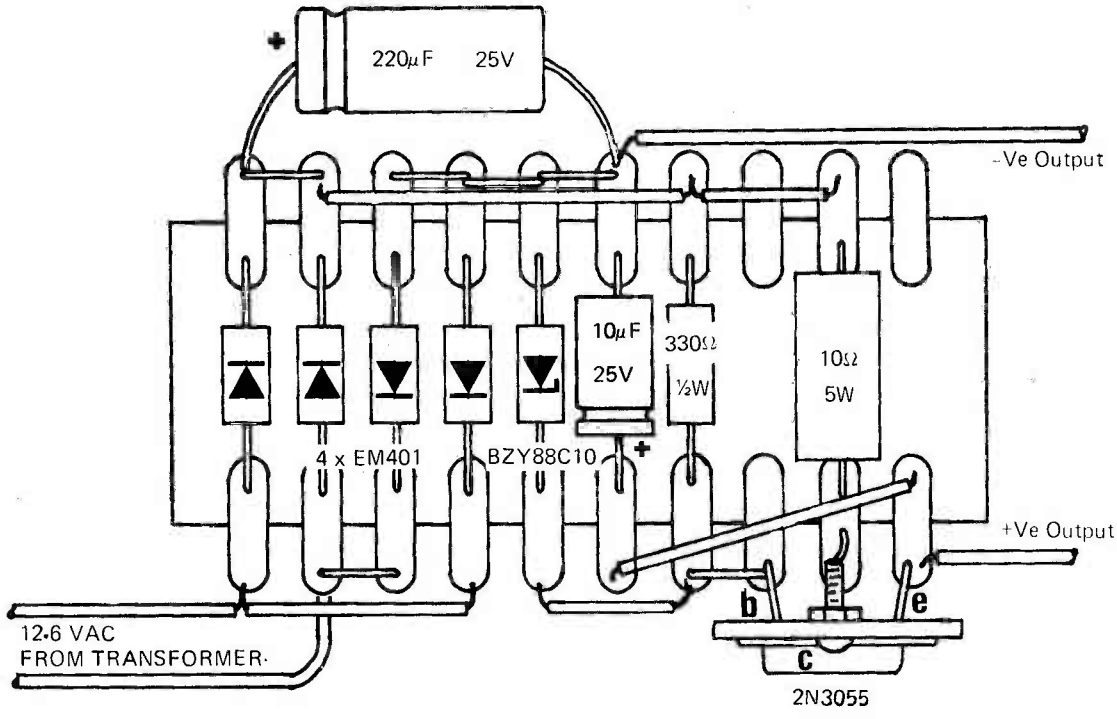


Fig. 2. Layout of mains operated unit.

PARTS LIST

Twelve volt version

1 – transistor, 2N 3055
1 – zener diode, BZY88C10
1 – diode, EM 401
1 – resistor, 10 ohm, 5 Watt, 10%
1 – resistor, 220 ohm, ½ Watt, 10%
1 – capacitor, 10μF, 25 volt electrolytic
1 – plastic box
Sundries, epoxy resin, cable, solder lug, plug.
(Note, components quoted above are for nine volt output. See Table 1 for alternative output voltages)

TABLE 1

Output Volts	ZD1	R1 (12V) ohms	R1 (240V) ohms
9	BZY88C10	220	330
7.5	BZY88C8V2	330	470
6	BZY88C6V8	470	680
4.5	BZY88C5V1	470	680

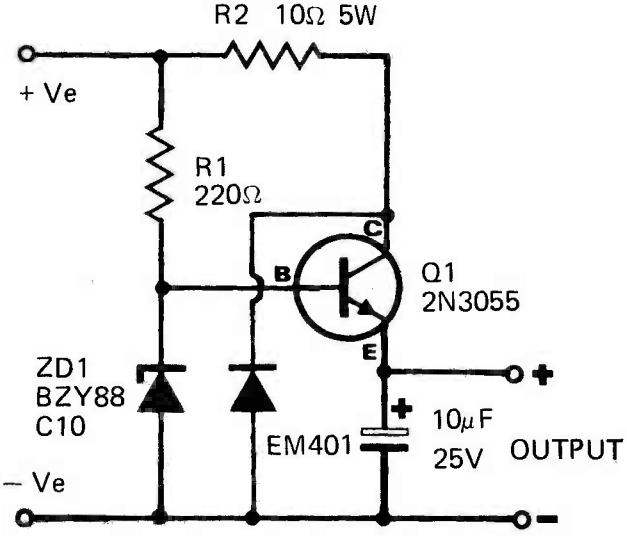


Fig. 3. Circuit diagram of 12 volt operated unit.

output may be required. This may be readily achieved by replacing the components ZD1 and R1 by those shown in Table 1.

CONSTRUCTION

The 12 volt version has few components and the simplest method of construction is that shown in Fig. 1. As can be clearly seen, all components are soldered directly onto the power transistor.

After checking that it operates satisfactorily and that all joints are properly soldered, the complete unit may then be placed in a small plastic box and encapsulated in epoxy resin.

A cigarette lighter adaptor is fitted to the input lead and an appropriate power plug to the output.

The mains-operated version is larger than the simple 12 volt operated unit. This unit should be constructed using tag strips or matrix board.

A layout showing tag strip construction is shown in Fig 2. The completed unit when finished, should be mounted in a suitable box.

THE UNITS IN USE

Both units have been designed so that they will not be damaged if the output is accidentally short circuited. Nevertheless a continual short circuit must not be applied as this will cause excessive heat to be generated within the 10 ohm resistor.

If the appliance already has a socket for an external power supply this will almost certainly be of a type in which the plug cannot be accidentally shorted. If no socket is fitted then an external power supply socket should be installed. Standard plug/sockets for this purpose are readily available from most parts suppliers, but note that plugs/sockets intended for nine volt use are not interchangeable with those intended for six volt use – the centre pins are of different diameters.

The socket should be of the type which has a contact for disconnecting the internal battery when the power supply is plugged in. ●

PARTS LIST

1 – transformer, 240 volt to 12.6 volts (100 mA minimum)
1 – transistor, 2N 3055
1 – zener diode, BZY88C10
4 – diodes, EM 401
1 – resistor, 10 ohm, 5 Watt, 10%
1 – resistor, 330 ohm ½ Watt, 10%
1 – capacitor, 10μF, 25 volt electrolytic
1 – capacitor, 220μF, 25 volt, electrolytic
Sundries, plug, tag strips, cable, solder lug etc.
(Note, components quoted above are for nine volt output. See Table 1 for alternative output voltages)

HOW THEY WORK

Twelve volt unit

Q1 is a 'series pass' transistor and drops the supply voltage to the required regulated output voltage.

The output of the transistor is controlled by the Zener diode ZD1. Resistor R1 supplies current for the correct operation of ZD1 and also provides base current for Q1.

The 10 ohm series resistor prevents damage to the transistor if the output of the unit is accidentally short circuited.

The EM 401 diode prevents reverse polarity of the supply voltage. If a polarized plug is fitted to your vehicle, this diode may be omitted. Again if there is no possibility at all of accidentally shorting the output – the 10 ohm resistor may be replaced by a link.

The 2N 3055 'series pass' transistor is much larger than required. We have specified this device as it provides very good overlead capability and is readily available at low cost (under £1.50 from many suppliers).

MAINS OPERATED UNIT

The mains operated version is complicated only by the addition of a power transformer, diode bridge, and a smoothing capacitor. The EM 401 diode used to protect against reverse polarity is obviously not required. Operation is otherwise as described above.

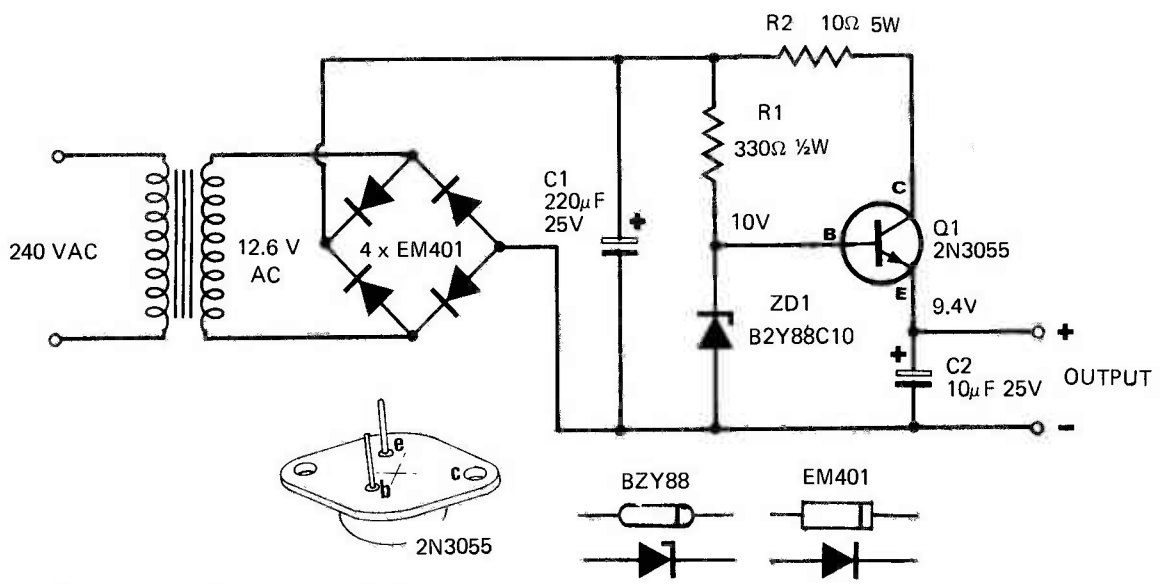


Fig. 4. Circuit diagram of mains operated unit.

POCKET ELECTRONIC CALCULATOR

This new broad-range calculator can fit into a shirt pocket.

A powerful new electronic pocket calculator, the HP-35, has been introduced by the Hewlett-Packard Company.

The new calculator is designed for a broad range of applications in science, engineering of all types, statistics, mathematics, education, business and finance. Customer deliveries are expected to begin in July or August of this year.

The calculator weighs only nine ounces (complete with rechargable nickel-cadmium battery) and fits into a shirt pocket. The new battery-powered unit can be likened to a "fast, extremely accurate electronic slide rule, with a solid-state memory similar to those used in computers", says Hewlett-Packard.

The HP-35 bears little resemblance to other pocket calculators, is said to offer many features previously found only on large desk-top machines costing several times as much.

All trigonometric and logarithmic functions, square root, addition, subtraction, multiplication and division, together with several other mathematical operations, are performed by the HP-35 in a fraction of a second. Each of these operations is carried out with a single stroke of one of the unit's 35 keys.

The unit has an "operational stack" of four registers, plus a data storage register for constants. The stack holds intermediate answers, and, at the appropriate time, automatically brings them back for further use. This eliminates the need for making notes or re-entry of intermediate answers when performing chains of calculations such as sums of products or products of sums.

HANDLING CAPABILITY FROM 10^{-99} TO 10^{99}

Answers appear automatically on the calculator's bright red light-emitting-diode display, which can show numbers having up to 10 digits plus two-digit exponents and appropriate signs. The HP-35 features automatic decimal point placement and automatic scientific notation for very large or very small numbers. Like larger, more expensive calculators, the HP-35, is accurate to 10 significant digits, and has the ability to handle numbers as small as 1×10^{-99} or as large as $9.999999999 \times 10^{99}$ (that's almost a 1 followed by a hundred zeros).

The size (approximately 3" x 6" x 1"), convenience and power of this calculator should change present patterns of calculator usage. With the HP-35, intricate calculations that are currently handled only with larger calculators in the laboratory or office will now be performed on the spot, in the field, in meetings, at home or whilst travelling, state Hewlett-Packard.

LARGE-SCALE INTEGRATED CIRCUITS (LSI)

The HP-35 has especially designed MOS/LSI (Metal-Oxide-Semiconductor/Large-Scale Integration) circuits using a new low-power, high-performance ion-implant process. These circuits are believed to be the largest presently in volume production in the world. Each is equivalent to 6,000 transistors — a total of 30,000.

The new calculator comes with a sturdy travel case, a soft leather personal carrying case, a battery pack, an AC adaptor and battery recharger, foil name tags and an instruction manual. Additional battery packs are available as optional accessories. The calculator carries a 12-month warranty. ●

THE HARMON-KARDON CAD5 CASSETTE RECORDER

electronics TODAY INTERNATIONAL
product test

Although Harmon-Kardon is an American company, their new Dolbyized cassette recorder is built in Japan. Louis Challis reports . . .

THE Harmon-Kardon cassette recorder is one of the smallest stereo recorders we have seen to date, and certainly the smallest of those that incorporate the Dolby noise reduction system.

The external appearance is attractive. Imitation timber panelling is used on the top and front of the recorder, both side panels are timber with imitation edge strips, and the splayed control panel is finished in matt black. All controls are mounted on a splayed panel at the front of the recorder, with the exception of the two microphone inputs. These are located on the front panel. This panel has a rocker-type stereo-mono mode select switch at the left hand end adjacent to six small key switches. These key switches provide the following functions:—

a) record interlock
b) fast rewind
c) stop and cassette eject
d) play or record

e) fast forward
d) pause

Four small bezel indicators are mounted below the key switches. These indicate:—

a) record mode
b) drive motor 'on'
c) record level overload
d) Dolby 'on'

These are inadequately illuminated for medium to bright room conditions, with the exception of the overload light which was extremely bright when operative.

To the right of the key switches are dual VU meters, two slide-type record level potentionmeters, the Dolby "in" rocker switch and the power "on" rocker switch. The dual VU meter is clearly marked and easily read from a distance, although calibration is slightly inaccurate.

The cassettes are drop loaded onto the loading platform, which is raised by operating the "stop-cassette eject" key switch. The loading platform and cassette may then be pressed into the operating position without closing the smoked perspex dust cover. However, the manufacturers do recommend closing the dust cover to guarantee correct location of the cassette.

A small tape counter, which may be used for cueing, is located just behind the cassette well.

Four holes on the rear panel provide access to tab potentiometers so that the record and playback levels may be correctly adjusted before making Dolbyized tapes. The playback level potentiometers are normally preset in the factory and should not require further adjustment. In fact, if one does wish to check their setting it is necessary to obtain a Dolby level setting tape which is pre-recorded with a Dolby test tone of standard intensity. The record level potentiometers should be adjusted to provide optimum bias for each type or brand of recording tape, and the handbook explains how this should be done. A "hold-on" pushbutton is located on the back panel so that a Dolby test tone may be recorded on the desired brand of tape for adjusting the record level potentiometers. Adjacent to this pushbutton is a second push button for bias selection for chromium dioxide tape.

All inputs and outputs are effected via three pairs of R.C.A. coaxial sockets located on the rear panel. Two pairs of sockets are for inputs, one pair is for high level inputs (typically 600mV) and one pair is for low level inputs (typically 200mV). The third pair is for the output (950mV for 0VU output level).

For the subjective tests we recorded some of our favourite records on Advocate Crolyn CrO_2 and on BASF Low Noise cassettes and compared the recorded tapes with the original recordings in an A-B type test.

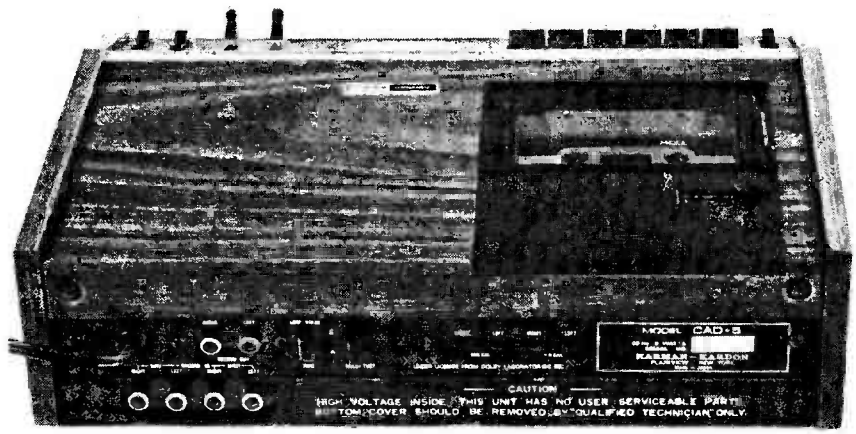
With the chromium dioxide tape the difference between it and the original was impossible to detect, except for a slight loss in the very high frequencies. (On many recordings there is negligible high frequency content above 12kHz and no difference would be discernible between an original and a recording on chromium dioxide tape). The loss is more apparent with the BASF Low Noise tape which on this recorder, rolls over at a frequency of approximately 10kHz. However, as many speaker systems roll over above 12kHz, the frequency response of the BASF tape will be more than adequate for most domestic hi-fi installations.

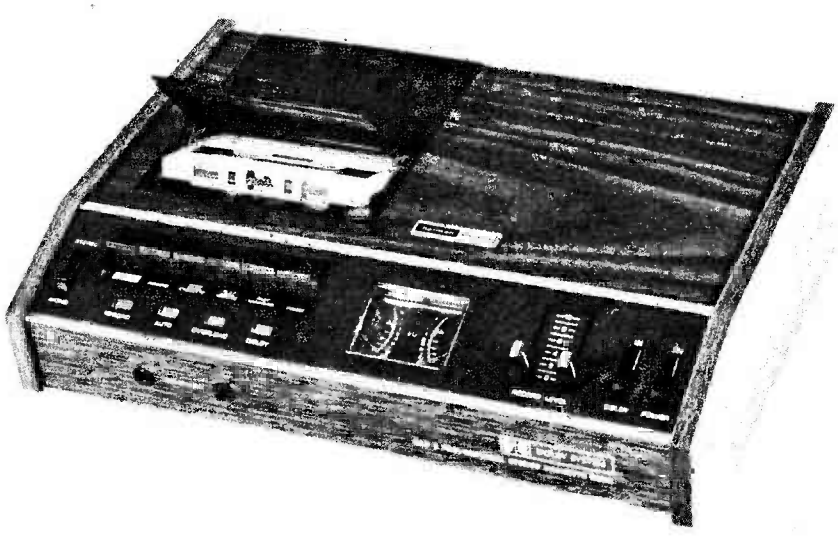
The measured performance confirmed our subjective appraisal. The record to replay frequency response extends to 13kHz with chromium dioxide tape. During the subjective and laboratory measurements we found the force required to operate the key switches rather excessive, particularly the record/replay switch. Admittedly we were continually changing from record to rewind to playback modes, which tended to accentuate the force required.

On a machine described by the makers as a *professional* stereo cassette, we expected to find a tape sensor of some form that would release the pinch roller and stop the drive motor when a tape fault occurred, but were dismayed when we realised that should a tape break, particularly during a recording session, the drive motor is kept operating and the only visible indication that a fault has occurred is that the feed hub has stopped rotating.

PRINTED CIRCUIT BOARDS

The electronic circuitry is contained on six printed-circuit boards. The main board, located under the cassette chamber, is fitted with three multipin plugs to facilitate removal for repairs.



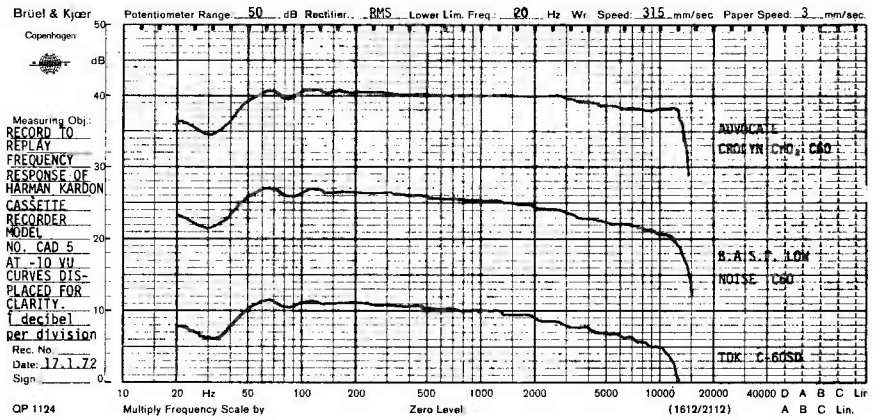


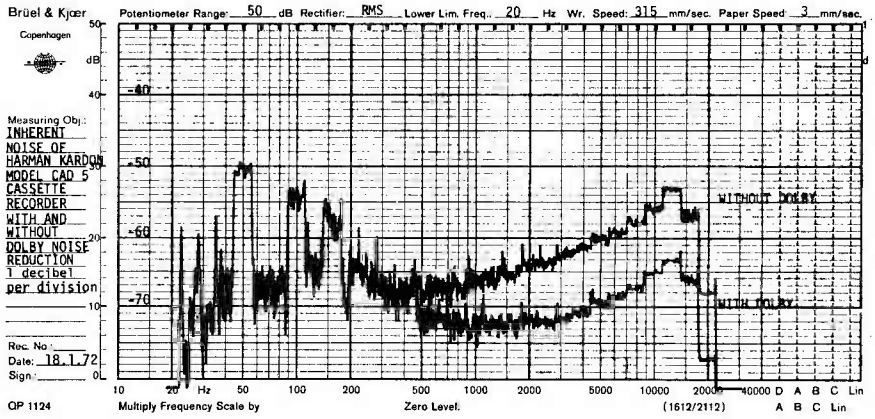
THE HARMON-KARDON CAD5 CASSETTE RECORDER

An intriguing, but excellent feature of the main printed circuit board is the addition of pieces of insulated wire approximately ½" long soldered to the various test points on the board. The free end of these wires are bared and looped so that alligator clips can be fixed to them for testing and adjustment purposes.

Another unusual feature of the circuitry is the 6 volt dc drive motor which eliminates the need to change drive pulleys for 50Hz or 60Hz operation and eliminates the high level of hum associated with dc motors.

The take-up spool sensor consists of a reed switch and a rotating magnet located under the tape counter. The mains transformer, which is mounted in a large compartment at the right hand end, is fitted with two primary windings which may be wired in parallel or series for 110V or 220V operation respectively. It would appear from the size of this compartment, and the use of a 6V dc motor, that the unit could be readily modified for battery operation. This would improve the signal to noise ratio





MEASURED PERFORMANCE OF HARMON KARDON MODEL NO. CAD5

CASSETTE RECORDER (WITH DOLBY) SERIAL NO. 088669

RECORD TO REPLAY FREQUENCY RESPONSE:

	Record level 0VU	Record level -10VU
BASF low noise C60	40Hz to 5kHz $^{+2}_{-3}$dB	40Hz to 7kHz $^{+2}_{-3}$dB
TDK C-60SD	40Hz to 4kHz $^{+2}_{-3}$dB	40Hz to 6kHz $^{+2}_{-3}$dB
Advocate Crolyn C60	40Hz to 8kHz $^{+1}_{-3}$dB	40Hz to 13kHz $^{+1}_{-3}$dB

TOTAL HARMONIC DISTORTION RE 1kHz SIGNAL AT

	0VU	-10VU
	1.5%	0.4%

INTERMODULATION DISTORTION

Combined with signals of	0VU	-10VU
1kHz & 960Hz	0.6%	0.4%

CROSS TALK AT 0VU

100Hz	36dB
1kHz	34dB
10kHz	30dB

SIGNAL TO NOISE RATIO RE 1kHz SIGNAL AT 0VU

Unweighted	= 46dB
Without Dolby (A scale) weighted	= 55dB
With Dolby (A scale) weighted	= 58dB

WOW AND FLUTTER 0.2% rms

SPEED ERROR, RECORD TO REPLAY Typically +0.4% to +0.8%

Dimensions 12½" wide x 9" deep x 3¼" high

Weight 10lbs.

(with Dolby) by as much as 10dB and would make the unit fully portable. A 12V battery wired in after the rectifier would appear to be the only modification required.

The unit was supplied with a complete set of RCA patchcords for record and replay. An 11" x 8½", 12 page Instruction Manual was also included. This very adequately describes the recorder's operations, but is inadequate in terms of maintenance instructions for fault finding. A circuit diagram is not supplied.

This recorder again highlights the advantages of incorporating the Dolby 'B' Noise Reduction system with a cassette recorder capable of utilizing the full capabilities of chromium dioxide tape.

This test report, graphs and measured specifications show that the Harmon Kardon recorder is a well-made unit with good performance. But it is a pity that the manufacturers describe it as a 'professional' unit. 'Professional' is a reasonably precise term and we feel that gimmicks such as this are out of keeping with the standards that we expect from *truly* professional equipment. But intending purchasers should appreciate that this is a criticism of the promotion rather than the unit itself. ●

The black vehicle has electronically controlled braking.

Electronic Anti-Skid Braking

Electronically controlled braking system ensures optimum deceleration regardless of surface conditons.

Automotive experts have been predicting for some time that an electronic anti-skid braking system for motor vehicles would be in production in the near future.

This has now happened, and a system basically similar to early forecasts will be available as an option on Mercedes-Benz commercial vehicles, buses, and their 350SL passenger car as from April this year.

Despite the recent introduction of twin hydraulic circuits, practically fade-free disc brakes and anti-rear wheel locking valves, Mercedes-Benz felt that too much reliance was placed on the driver to assess and remain within the confines of the physical laws of friction.

Locked wheels do not have directional stability. Their braking efficiency is also less than with wheels braked to within a fraction of locking.

OPTIMUM BRAKING

The co-efficient of adhesion of a tyre – which, when multiplied by the wheel load gives the braking power – is dependent on tyre slip. If the tyre turns freely in relation to vehicle speed, the slip is zero and the transferable braking power is zero.

With a slip of 10 to 15% (that is to say, when the wheel turns 10 to 15% slower than the corresponding vehicle speed), the coefficient of adhesion, and therefore the braking power reach a maximum.

If the slip is higher, the co-efficient of adhesion decreases, and with 100% slip, i.e. when the wheel is locked, it is generally at a minimum.

Only on ice is the co-efficient of adhesion curve generally horizontal.

With these facts in mind, Mercedes-Benz considered that further improvements in braking performance could only be achieved through an automatic system that ensured the optimum application of braking effort for all road and tyre conditions during an emergency stop.

HOW THE SYSTEM WORKS

As soon as a wheel begins to lock up as a result of excessive pressure on the brake pedal, the automatic control system reduces the braking force to such an extent that the gripping capacity of the tyre is not exceeded even if full brake pedal pressure is applied.

The components of the system are shown in Figs. 1 and 2.

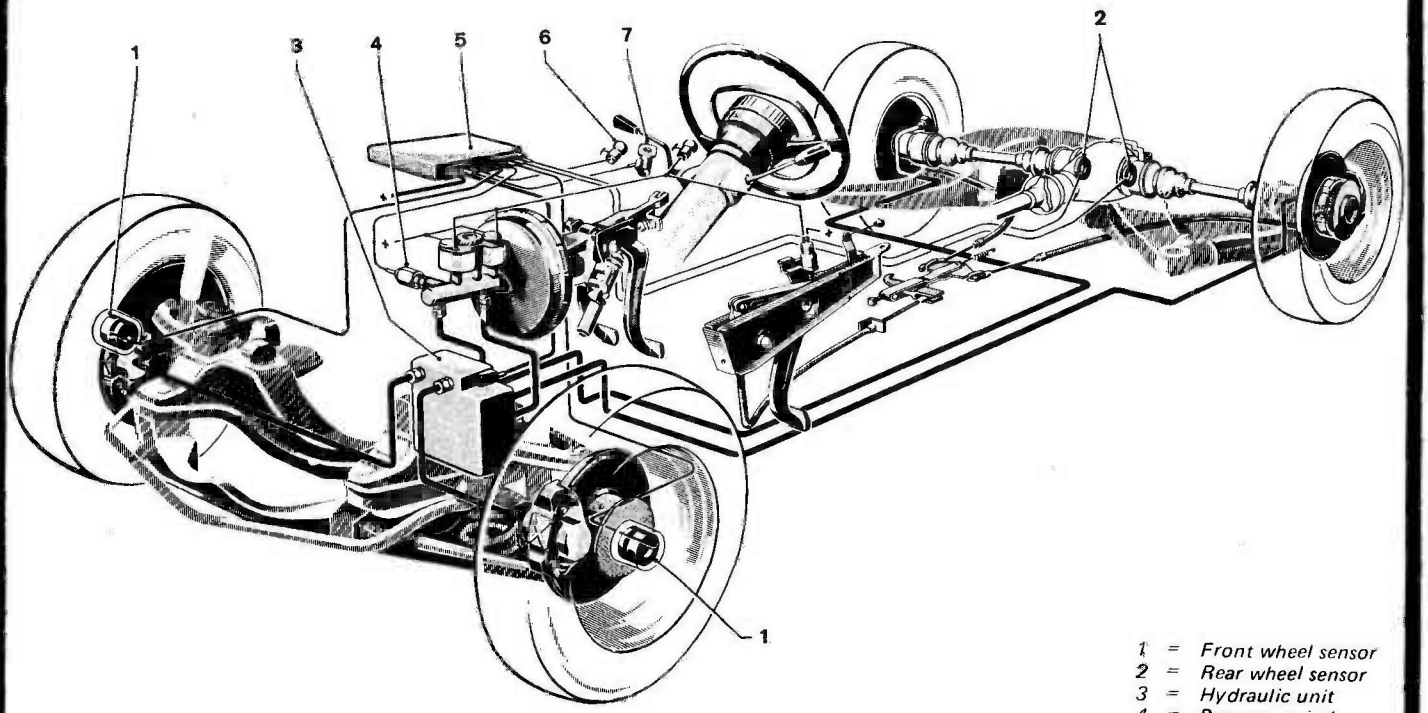
Fig. 1 shows the arrangement of the electronic sensing and control circuits. The schematic diagram (Fig. 2) shows the layout of the hydraulic part of the system.

If a wheel tends to lock up as a result of excessive pressure on the brake pedal, its rotational speed decreases very rapidly. A digital signal, proportional to wheel velocity, is sent by a digital transducer in each wheel to an electronic control unit. A differentiating circuit within the control unit converts this digital (velocity) signal into a voltage proportionate to deceleration.

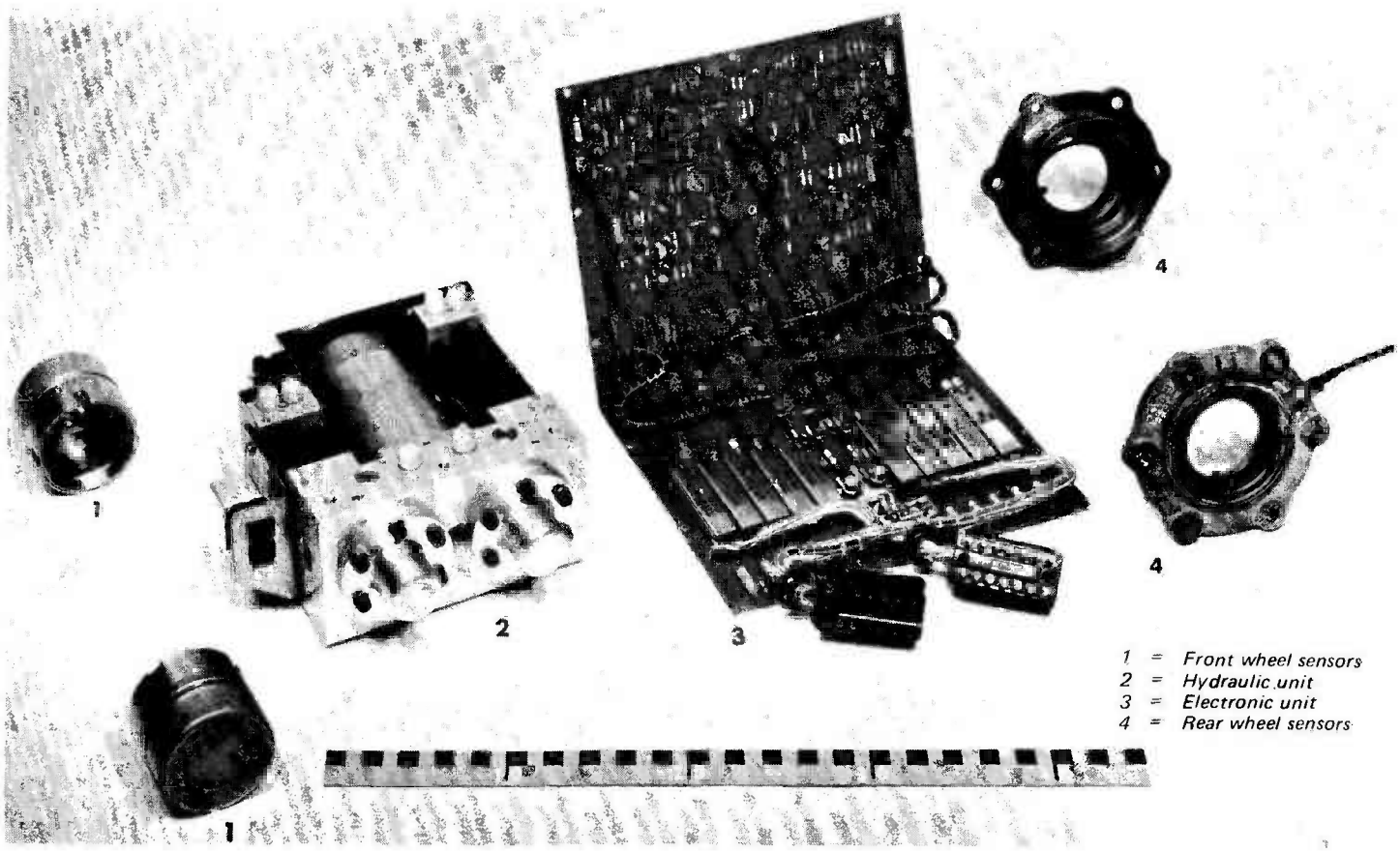
This voltage is then compared with a predetermined highest permissible value (roughly proportional to a *wheel* deceleration of 1.3G). If this level of deceleration is exceeded, a control signal is instantly transmitted to an electro-magnetic valve that in turn reduces the pressure of the brake fluid on the appropriate wheel.

As soon as this happens, the wheel,

FIG. 1 HOW THE ELECTRONIC SENSING AND CONTROL SYSTEMS ARE INSTALLED



1 = Front wheel sensor
2 = Rear wheel sensor
3 = Hydraulic unit
4 = Pressure switch
5 = Electronic unit
6 = Warning light
7 = Starter switch



1 = Front wheel sensors
2 = Hydraulic unit
3 = Electronic unit
4 = Rear wheel sensors

now receiving less braking power, accelerates again. This is registered by the wheel's sensor, and again the control unit reacts and brake line pressure is re-applied until speed drops once again and the cycle begins anew.

To fully appreciate the operation of this system it should be clearly understood that the wheel sensors are monitoring *wheel* deceleration and not necessarily vehicle deceleration. At low braking efforts the two levels of deceleration will be virtually the same, but the instant that the wheel begins to lock, the wheel deceleration becomes many times greater than the vehicle deceleration and this is registered instantly by the electronic control unit. This technique ensures that the optimum level of deceleration will apply regardless of the co-efficient of friction of the road surface.

THE CONTROL SYSTEM IN ACTION

With conventional brakes, a car can be stopped from 60 mph within 160 feet. Using the Mercedes system the same car on the same road can be stopped within 138 feet. The reduction by 24 feet corresponds to a 16% increase in braking efficiency.

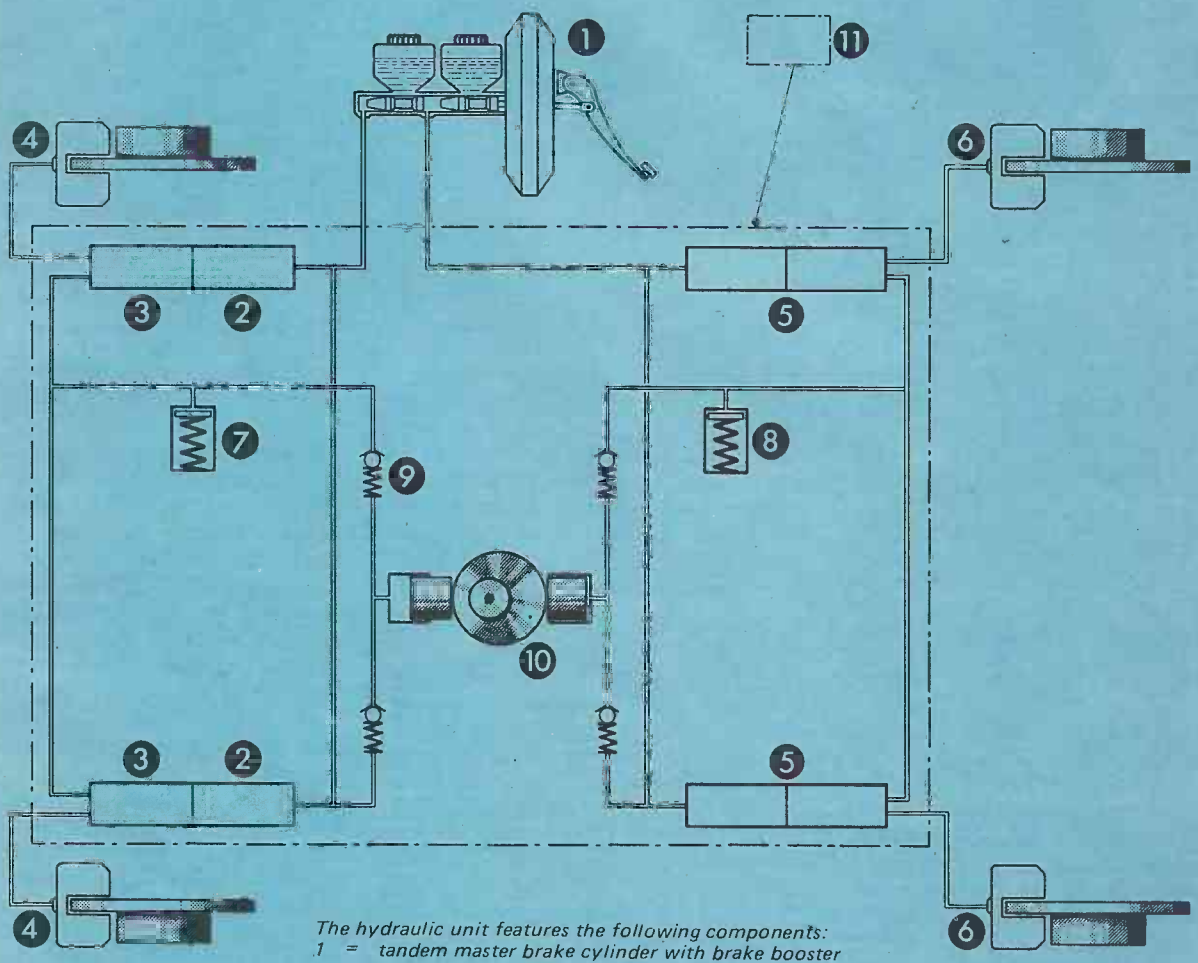
But this does not tell the whole story, for when braking, speed does not decrease in a linear progression; retardation increases towards the end of the stopping distance. At the point where the car equipped with the electronic system has stopped from 60 mph, the conventionally braked car would still be doing 25 mph.

On wet roads, the differences in stopping distances are even more dramatic. For example, on wet concrete a conventionally braked vehicle travelling at 90 mph recorded a stopping distance of 543 feet, whereas another vehicle, identical except for electronic braking control, stopped within 336 feet. At the point where the 'controlled' vehicle had stopped, the 'uncontrolled' vehicle's speed was still 53 mph.

More important still is the fact that with the automatic system the vehicle remains steerable — this is dramatically illustrated in our lead photographs where vehicles with the electronic system are seen maintaining their cornering line despite heavy braking, whilst conventionally braked vehicles have left the track.

It is greatly to Mercedes-Benz' credit that despite their very heavy development costs they have agreed to make the system available to other motor manufacturers. ●

FIG. 2 THE HYDRAULIC SYSTEM



The hydraulic unit features the following components:
1 = tandem master brake cylinder with brake booster
2 = inlet valve, front wheel
3 = outlet valve, front wheel
4 = caliper, front wheel (disk brake)
5 = valve set, rear wheel
6 = caliper, rear wheel (disk brake)
7 = brake fluid reservoir, front axle
8 = brake fluid reservoir, rear axle
9 = check valve
10 = dual-circuit floating-piston eccentric pump, driven by electric motor
11 = hydraulic unit

We test the Drake R-4B and SPR-4 communicati receivers.

DRAKE'S

electronics TODAY INTERNATIONAL
product test

The largest and most energetic fraternity of amateurs in the world is that of the United States.

There, amateurs enjoy greater freedom than elsewhere and have the ability to buy some of the best radio equipment manufactured in the world. Regretably, most of this equipment is not readily available in this country as by comparison the market is small, and the prices are higher than locally made receivers.

The little equipment that is imported is usually sold on indent or before it is even landed and so is seldom available for testing. Fortunately, two Drake communications receivers became available for review just before we went to press and although we were short of time we decided that it was an opportunity not to be wasted, for the R. L. Drake Company is well known and respected and their reputation stands high.

The two receivers tested were an R-4B, a hybrid valve/transistor receiver intended primarily for amateur use; and the newer SPR-4, a fully transistorised receiver intended both for communication and amateur use.

THE R-4B

The R-4B was the first receiver of the two that we put through the hoops. It is a compact double-conversion receiver with a host of operational features calculated to please the most sophisticated amateur (or professional).

The front panel is divided by a bold two colour treatment into two areas, the upper being light grey and the lower dark grey.

The upper area contains a large illuminated S meter, a function knob for *off/standby/on/external mute/noise blanker/calibrate,* a passband selector lever for 0.4, 1.2, 2.4 and 4.8 kHz bandwidths and a concentric knob for upper and lower sideband. A precision geared drive on the right-hand side controls a 500 kHz bandwidth tuner. This is calibrated in 1 kHz but divisions can be accurately read to 250 Hz.

The lower section of the front panel has controls for selecting any of five crystal controlled amateur bands, 3.5-4, 7.0-7.5, 14.0-14.5, 21.0-21.5 and 28.5-29.0 MHz (for which crystals are supplied), and a control for selecting ten additional but optional crystals for 500 kHz ranges between 1.5 and 30 MHz (except between 5.0 and 6.0 MHz).

Other controls are a preselector, an RF gain, variable notch filter, a mode selector *(for AVC off, fast AVC, slow AVC, SSB/CW, and AM)* an RF gain control and AF gain control.

A control on the side of the receiver enables fixed frequency crystal operation to be selected. Also on the side is an S meter zero adjustment, a notch filter adjustment, and a phone jack.

On the rear of the receiver, sockets are provided for accessory power output. There is also an injection socket for transceiver operation, a mute jack for transmitter controlled operation, an Anti-Vox socket for use with transmitters whereby voice

transmission can be inhibited, a speaker output for impedances down to 4 ohm, and an RCA coaxial type antenna connector.

The internal circuitry of the R-4B is both unusual and practical. The receiver uses ten valves, ten transistors, and seventeen diodes. There are also two JK flip-flop integrated circuits in the double binary division of the frequency calibrator.

INPUT STAGE

The input stage consists of a permeability-tuned transformer, tuned pre-selector, and associated RF amplifier. This is followed by a transistorized permeability-tuned V.F.O. (variable frequency oscillator) a crystal controlled oscillator, and a pre-mixer valve.

The variable frequency oscillator is tunable from 4955 kHz to 5455 kHz whilst the crystal frequency is selected so that the difference obtained by heterodyning the output of the V.F.O. will always be 5645 kHz higher in frequency than the desired signal frequency.

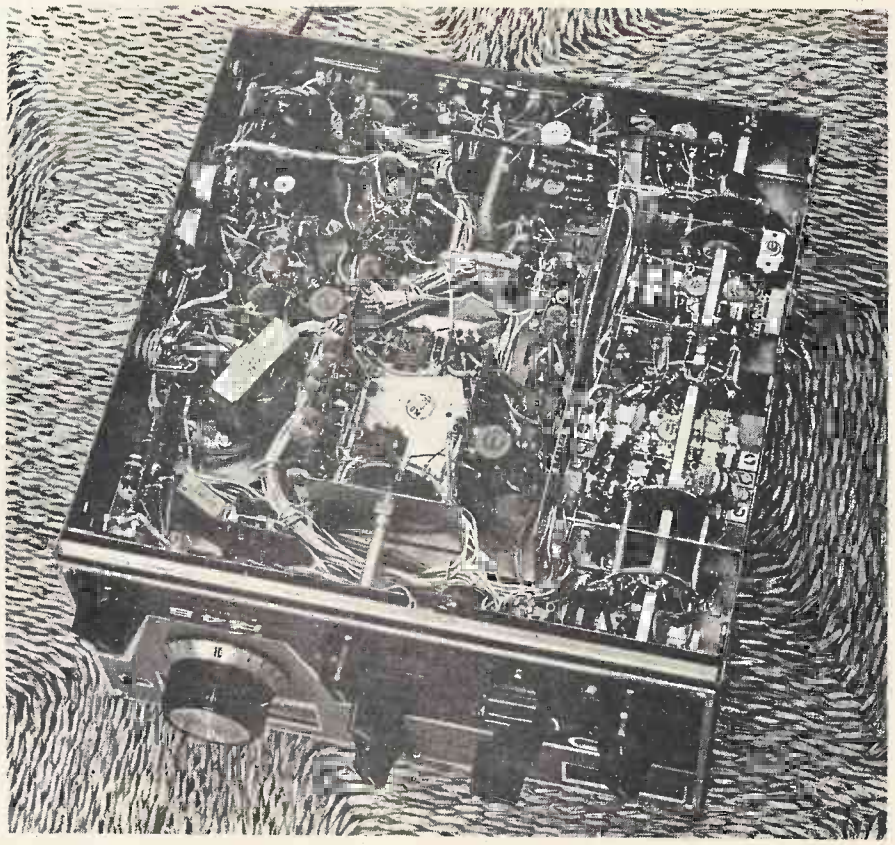
The first mixer is coupled through the permeability-tuned pre-mixer output coils and is heterodyned with the RF amplifier to provide the difference frequency of 5645 kHz which is passed through a crystal filter to the second mixer.

The second mixer control and screen grids are connected as a Pierce type oscillator which is crystal controlled to operate at 5595 kHz, the resulting output is then the 50 kHz difference frequency.

The 50 kHz output is fed via permeability-tuned T notch filter to the first IF amplifier. The IF amplifier has an IF tuner incorporating four high Q, LC circuits which utilise gauged permeability-tuning to obtain four bandwidths of 0.4, 1.2, 2.4 and 4.8 kHz at the 6dB points.

The second IF amplifier is followed by a fixed tuned transformer stage and the detection circuits.

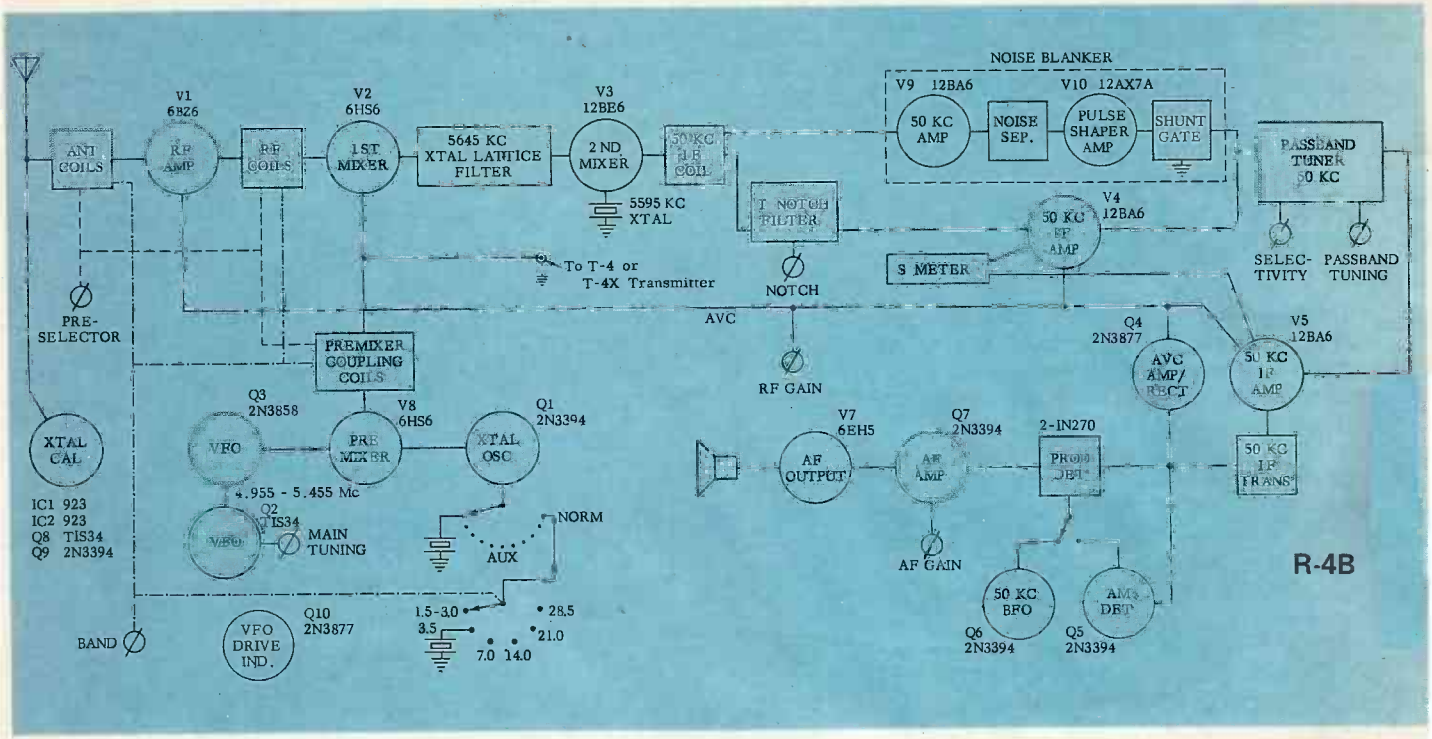
When in either the SSB or CW positions, the beat frequency oscillator is activated. This produces a 50 kHz signal which is applied to a product detector and heterodynes with the 50 kHz signal from the second IF output stage. With the receiver in the AM mode the beat frequency oscillator is off and an AM detector and amplifier is activated.



ABOVE:
Underside view of the R-4B shows excellent accessibility of all components.

LEFT:
Drake R-4B receiver — the speaker to the left of the receiver is standard equipment.

DRAKE'S PROGRESS



The automatic volume control system uses two transistors to provide a fast actuating circuit with a time constant of approximately 25 milliseconds and a slow actuating circuit with a time constant of approximately 750 milliseconds.

The output of the second mixer is also coupled into an effective noise blanker circuit which when actuated by a noise pulse, significantly above the received signal level, shunts the output of the first IF amplifier to ground whilst the level of the noise pulse is maintained.

To provide accurate frequency calibration on each revolution of the main dial the 100 kHz signal is divided by the two micro-logic 923 JK flip-flops to provide a clean 25 kHz square wave with harmonic output suitable for calibrating to beyond 30 MHz.

The audio output stage is a class A amplifier valve arrangement with an output transformer wound for a 4 ohm load.

The receiver comes complete with a detailed 38 page handbook and excellent circuit diagram and crystals for the amateur bands. An added feature is the inclusion of a set of cable marking tags for attaching to each end of the cables used in any possible set up.

THE SPR-4 RECEIVER

The SPR-4 receiver has many similarities to the R4-B including permeability-tuning but has been designed with a different end user in mind.

Firstly, it is all solid-state from the new dual gate MOS FETs (field effect transistors) to the audio output transistors. Secondly, it has the ability to tune from 150 kHz to 30 MHz (depending on the crystals selected) for marine, general purpose amateur or communication work. Thirdly, it is designed for mains or battery powered operation and on 12VDC only needs 2 watts of power (when the dial lights are switched off).

The two colour treatment on the front panel of the SPR-4 is similar to that of the R-4B.

The upper section of the front panel contains the S meter, a frequency preselector range switch for selecting the crystals and which simultaneously indicates the preselector position and range switching, the main tuning dial and the preselector.

The lower section contains the range switch for tuned circuit adjustment, the concentric RF/AF control, the mode selector and the concentric function selector and the notch filter.

The circuitry is almost the same as that of the R-4B receiver including the crystal filters and permeability-tuning. Transistors are used for all operational functions including those difficult tasks of mixing where ordinarily transistors seem to be at a disadvantage. To compensate for this normal deficiency, Drake have made use of dual gate FETs (MFE 3007's) which they claim have improved cross modulation, intermodulation, and AGC performance. We found their claim to be justified.

The circuitry makes clever use of MOS FETs to duplicate the grid control performance and impedances of valves. Whilst a long tail pair is used for the first mixer, the other mixers and IF amplifiers are all dual gate FETs.

The major difference between this receiver and the R-4B is the audio amplifier which uses 7 transistors in a 'single ended' push-pull circuit. The main receiver uses 28 transistors and 21 diodes, an additional two transistors and 2 diodes are used to plug in 100 kHz calibrator and 14 transistors and 2 diodes in the plug-in 5-NB noise blanker.

The handbook supplied with the SPR-4 is only 13 pages in length and is too brief to be of real technical value.

The receivers drift when initially switched on. This is to be expected and despite the drift both the receivers are immediately usable. The initial rate of drift is typically at a rate of 100 Hz per 15 minutes but this drops to 80 Hz per hour for the R-4B after two hours warm up and 75 Hz per hour for the SPR-4 after one hour warm up. The frequency stability of the SPR-4 is slightly better for intermittent mobile use and its total drift in the first hour of operation was only 300 Hz. This is particularly good.

The sensitivity of both receivers is good and well within the

communication receiver class:

Receiver Signal to Noise Ratio on AM at 1μV

Frequency:	R-4B	SPR-4
3.750 MHz	8dB	14dB
7.075 "	7dB	13dB
14.100 "	7dB	14dB
21.250 "	8dB	14dB
28.750 "	7.5dB	13dB

The SSB sensitivity of both receivers provided better than 9dB signal to noise ratio at all frequencies for 0.25 μV signal level.

The noise factor of both receivers is better than most communications receivers, being typically 4dB on AM at 4.8 MHz for the SPR-4, and 5dB for the R-4B.

The term *Noise Factor* is often misunderstood as it is a measure of the added noise provided by the internal circuitry of the receiver. Most other communications receivers which we have tested have been unable to provide an overall noise figure of less than 4dB.

The IF selectivity is excellent and both receivers had the following basic performance:

Nominal bandwidths	Actual bandwidths at the 6dB points	& 60dB points
4.8kHz	4.8kHz	10kHz
2.4kHz	2.4kHz	7.2kHz
1.2kHz (R-4B)	1.2kHz	4.9kHz
400Hz	400Hz	2.7kHz

The image rejection of both receivers is 80dB for both the first IF and second IF, whilst the handbook conservatively claims "over 60dB".

The S meters for both receivers were checked out and whilst the SPR-4 was in order the R-4B was not correctly adjusted. The actual adjustment is not complex but we didn't attempt to play with it.

Measured Results for DRAKE SPR-4 S/N 493 and R-4B S/N 10865 R

	SPR-4	R-4B
Frequency Coverage As supplied	150 – 500kHz .5 – 1MHz 1 – 1.5 " 6 – 6.5 " 7 – 7.5 " 9.5 – 10 " 11.5 – 12 " 17.5 – 18 " 21.5 – 22 "	3.5 – 4 MHz 7.0 – 7.5 " 14.0 – 14.5 " 21.0 – 21.5 " 28.5 – 29.0 "
Selectivity 6dB Bandwidths	400Hz, 2.4kHz, 4.8kHz	400Hz, 1.2kHz 2.4kHz & 4.8kHz
Sensitivity AM	0.5μV for 8dB S/N	1μV for >7dB S/N
SSB	0.25μV for 10dB S/N	0.25μV for >9dB S/N
Spurious Rejection	Image Rejection 80dB	Image Rejection 80dB
Spurious Signal	Less than 0.25μV equivalent signal on all ranges tested for both receivers.	
Frequency drift after 1 hour warm up	less than 75Hz/hour	less than 100Hz/hour
A.V.C.	effective above 6μV	effective above 5μV
Audio output at A.V.C. threshold for 30% modulated signal	0.75 watts	0.55 watts
Power consumption 240V	19 watts	58 watts
Size and weight:	10.75" wide x 5.5" H. x 12.5" deep 18 lbs	10.75" wide x 5.5" High 12.5" deep 16 lbs

The S Meters sensitivities were as follows:

	SPR-4	R-4B
S1	1 μV	1 μV
S2	5 "	1.8 "
S3	9 "	2.5 "
S4	14 "	4 "
S5	22 "	5.6 "
S6	32 "	10 "
S7	50 "	20 "
S8	70 "	40 "
S9	100 "	70 "
+20dB	1 mV	
+40dB	22 mV	
+60dB	120 mV	

The A.G.C. action on both receivers was very good. For the SPR-4 it commences at 6 μV and holds the output within 3dB up to 100 mV and to within 6dB up to 560 mV input. For the R-4B the A.G.C. commences at 5 μV. It holds the output within 3dB up to 5 mV, and 8dB up to 500 mV.

Neither receivers has any vices in tuning in SSB, AM or CW and in each case the notch filter nulls out single frequency carriers as if they didn't exist.

During field trials out of Sydney both receivers proved to have excellent performance on both the amateur bands and the marine bands. There are only a few features which we didn't like.

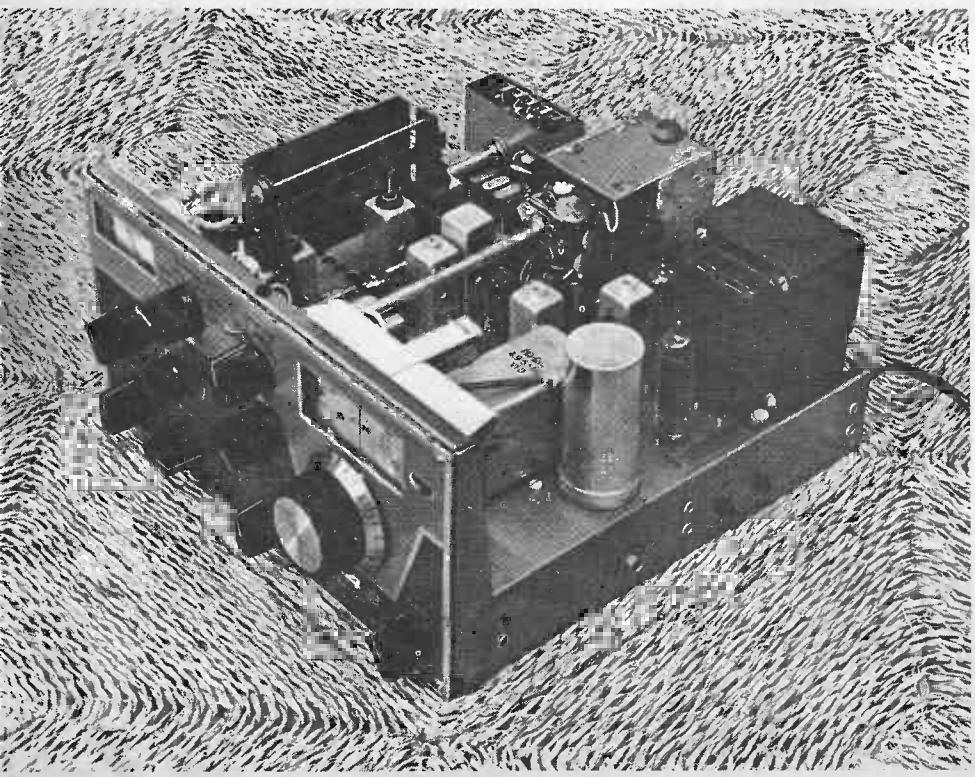
Firstly we do not feel that double concentric controls are practical. The early Collins 51J4 receivers featured a lever control similar to that used by Drake and this proved to be troublesome.

Secondly the application of a concentric audio/RF control as found on the SPR-4 does not please most users searching for a low level signal.

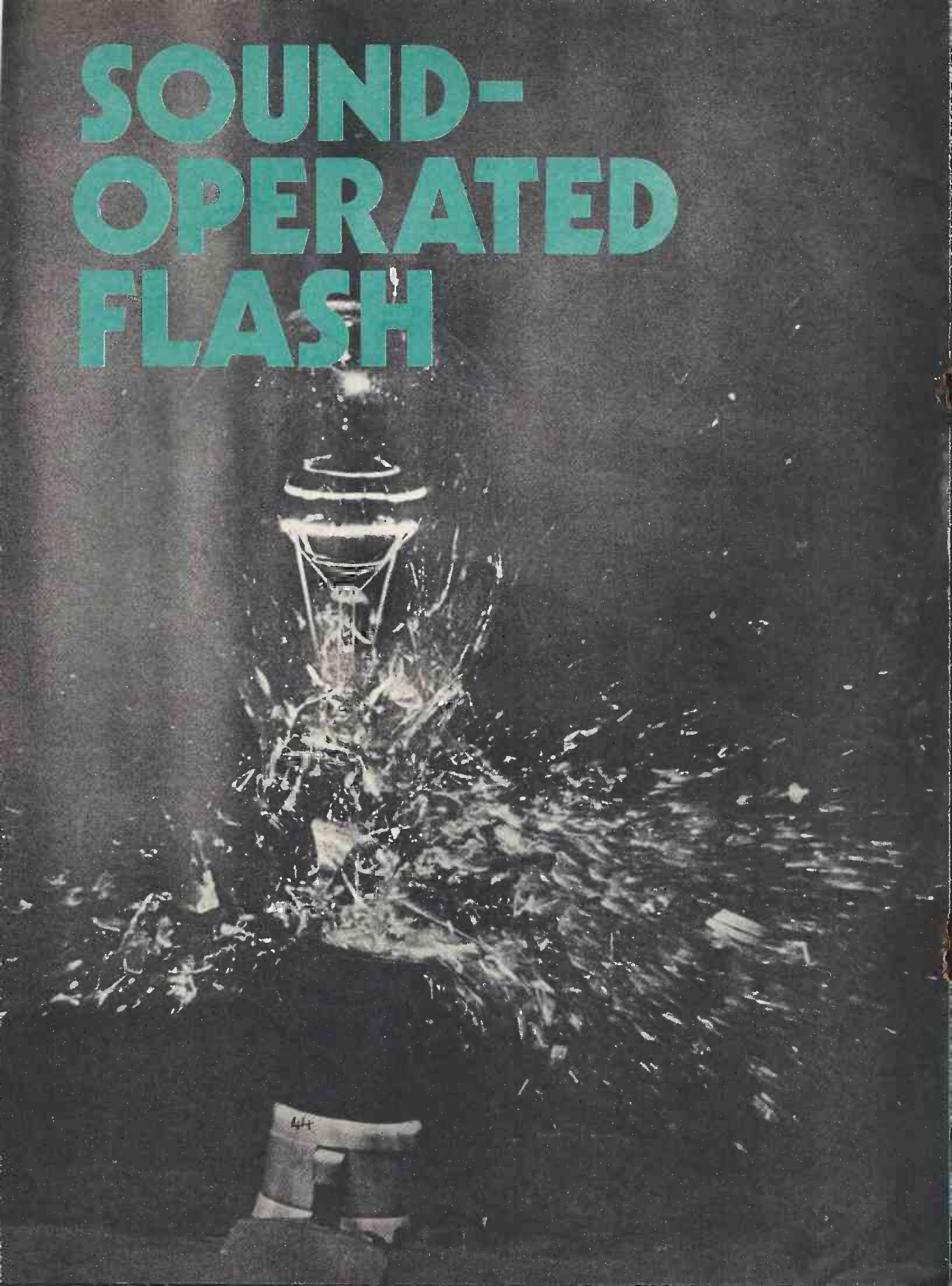
Thirdly when used at high levels the internal speaker on the SPR-4 caused microphonics in the permeability tuners, so it was obvious that the use of an external speaker, or phones is essential.

There may be better receivers around, but these receivers would undoubtedly be two of the best general purpose tuneable receivers that we have yet seen for amateurs, coastal radio or general purpose communication work. ●

The sheet metal cover of the R-4B is easily removable.



SOUND-OPERATED FLASH



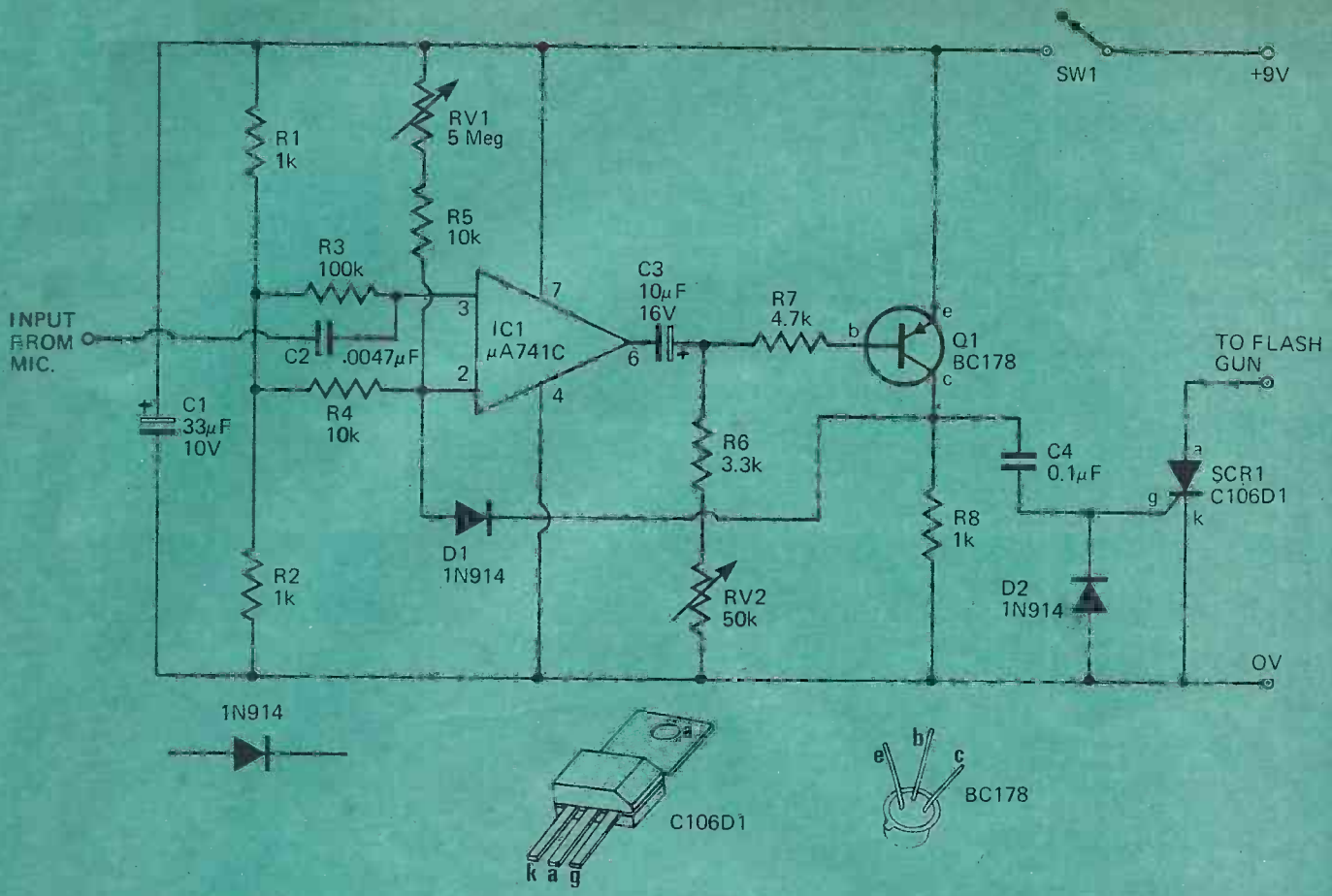


Fig. 1. Circuit diagram of complete unit.

ET PROJECT 514

Photograph a bursting balloon — or shattering light globe — by using this sound operated device.

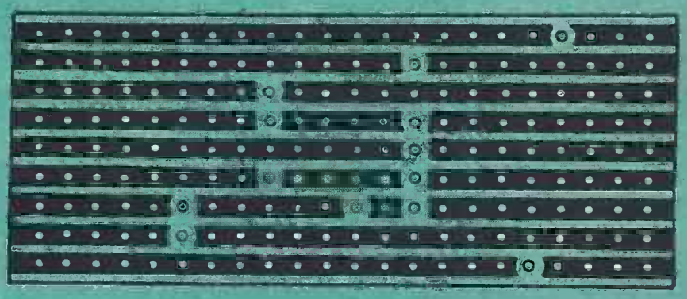


Fig. 2. This is the foil pattern of the Veroboard. The breaks shown in the copper tracks should be made using a sharp-pointed drill.

THIS month's dramatic front cover picture — and the photograph sequence reproduced in these pages — were taken using the sound operated flash described in this article.

The unit triggers any standard electronic flash gun a predetermined (and adjustable) time after any specific sound. The sound level at which the unit will trigger is adjustable by potentiometer RV1.

The unit is intended to photograph practically any fast (sound causing) transient phenomena — a surprisingly large number of uses can be found in specialized photography, science, and industry. The ability to delay the flash from five milliseconds to 200 milliseconds after the onset of the event increases the unit's versatility very considerably.

CONSTRUCTION

The unit is very simple to make — and for this reason we decided to build it onto Veroboard rather than go to the expense of a special printed circuit board.

Figure 2 shows the foil pattern of the Veroboard, Fig. 3 shows the component layout.

Cut the Veroboard to size and use a sharp pointed drill to break the copper tracks as shown. Locate and solder the components onto the board, paying particular attention to the polarity of capacitors and diodes, and to the pin connections of the integrated circuit.

The unit is physically quite small and may be housed within any suitable box or plastic container.

Assembly should be completed to the level shown in Fig. 4 and the unit fully tested before final assembly into the box.

OPERATION

The unit is designed for use with electronic flash guns using the capacitive discharge firing system.

To use, simply connect a high output

SOUND-OPERATED FLASH

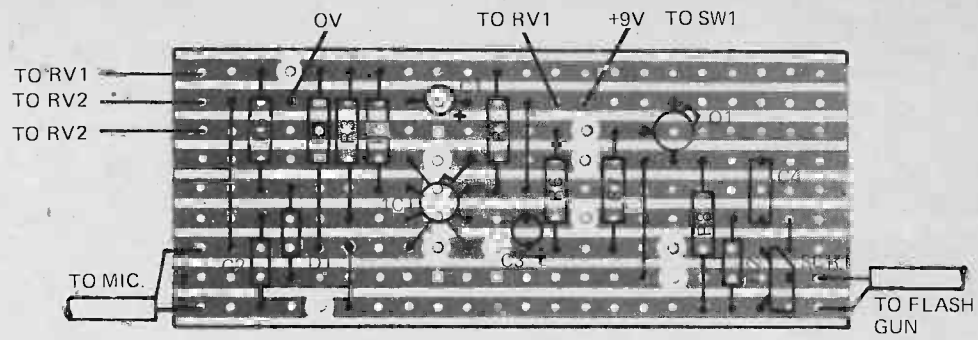


Fig. 3. How the components are located on the Veroboard.

PARTS LIST ETI514

R1 – resistor 1k ohm ½ Watt 10%
R2 – " 1k " " "
R3 – " 100k " " "
R4 – " 10k " " "
R5 – " 10k " " "
R6 – " 3.3k " " "
R7 – " 4.7k " " "
R8 – " 1k " " "
RV1 potentiometer 5M log
RV2 " 50k "
C1 Capacitor 33 uF 10V electrolytic
C2 " 0.0047 uF 100V
C3 " 10 uF 16V
C4 " 0.1 uF 100V
Q1 Transistor BC178 or similar
D1, D2 diode 1N914 or similar
1C1 Integrated circuit uA 741C (metal can type only)
SCR1 C106D1
SW1 Switch single pole single throw
9V battery
Plug for flash and or an extension cord
Microphone jack
Microphone – High output crystal
Veroboard (0.15").

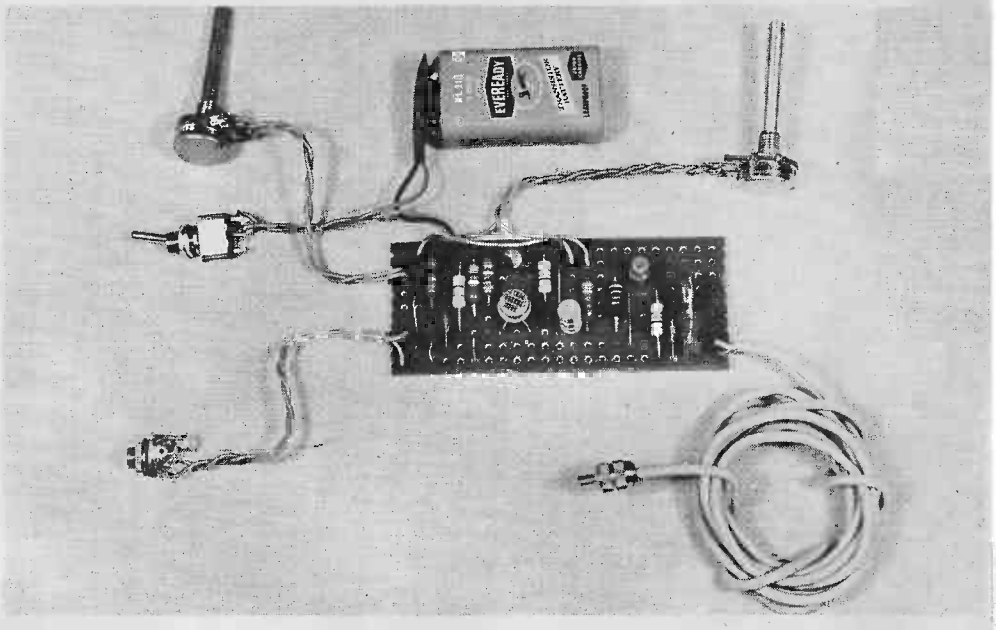
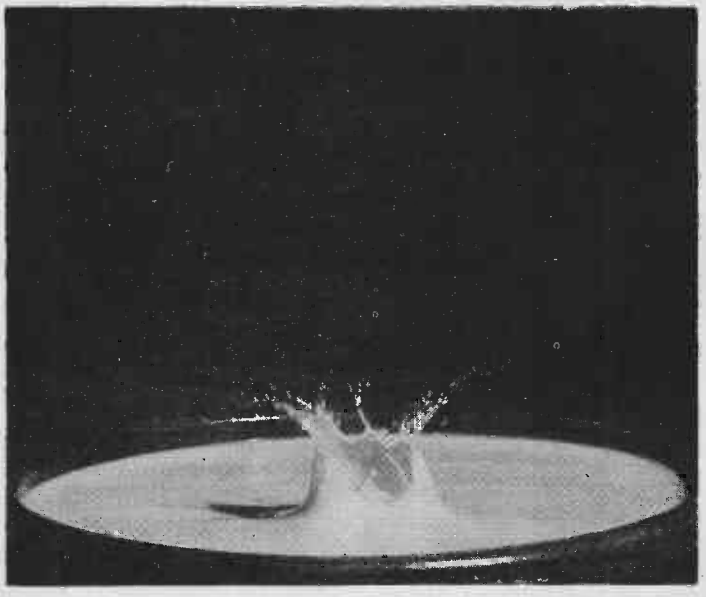
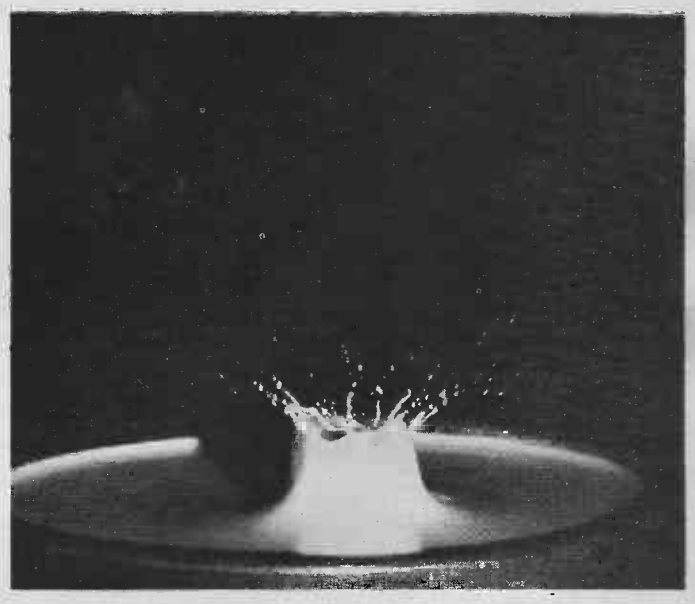


Fig. 4.

These pictures show how the variable time delay facility can be used to capture the effect of a ball bouncing in a container of fluid. The pictures were taken with the sound operated flash unit set at time delays between 50 milliseconds and 200 milliseconds.





crystal microphone (these are cheap and readily obtainable) into the mic. input socket on the unit, and plug the unit's flash lead into the flash gun.

Switch on SW1 and adjust RV1 so that the flash is not triggered by ambient noise, but will be triggered by the event to be recorded – i.e., a gun firing, hands clapping, glass breaking, etc.

In most circumstances the stop-action photography must be done in a dark room with the camera shutter open, or if only black and white film is used – using a red photographic safe-light. Assume for example, that we wish to photograph a bottle at the instant of being broken by a stone from a catapult. The equipment, catapult and bottle are set up initially in the light and tested to confirm correct function and sequence.

A test run is then performed, using an arbitrary setting of the delay, in the now darkened room. This is done by opening the shutter, firing the catapult and then closing the shutter before turning on the lights. (Although shooting a bottle in the dark may seem very difficult – with a little practise it is surprisingly easy – our front cover picture was taken just this way. It is of course potentially dangerous and it is essential to wear eye protection.)

Subsequent development of the film will show whether the chosen delay was correct. If too short, the bottle will be photographed before actually breaking up – if too late the action will have progressed further than required. Further pictures should then be taken varying the time delay to 'bracket' the actual delay that is now estimated as correct. With a little experience the user will be able to estimate the required delay within close limits.

As the flash duration is typically of the order of one or two thousandths of a second, quite high-speed activity can be frozen – as our own pictures show. ●

HOW IT WORKS

Basically the microphone triggers the IC monostable circuit which subsequently triggers an SCR, and hence the flash, after a time delay. This delay is adjustable – by varying a monostable on-time – from 5 milliseconds to 200 milliseconds.

Integrated circuit IC is an μA741C. This is a dc differential amplifier with a high gain – typically 25,000. The output swing of the IC with a 9 volt dc supply is of the order of 6 volts, and this is obtained with an input swing of only 240 microvolts. This makes the IC ideally suited for use as a comparator and is the mode of operation utilised in our circuit.

Due to the very high gain and the relatively large input signals normally encountered, the IC is almost always either fully cut off or fully saturated. The linear region is very narrow and is not utilized in this circuit.

The two inputs of the IC (pins 2 and 3) would be at the same potential were it not for the bias current supplied through RV1. This raises the voltage at pin 2 of the IC by 10mV or more above pin 3 depending on the setting of RV1. The IC will therefore normally be fully saturated and the output voltage will be low.

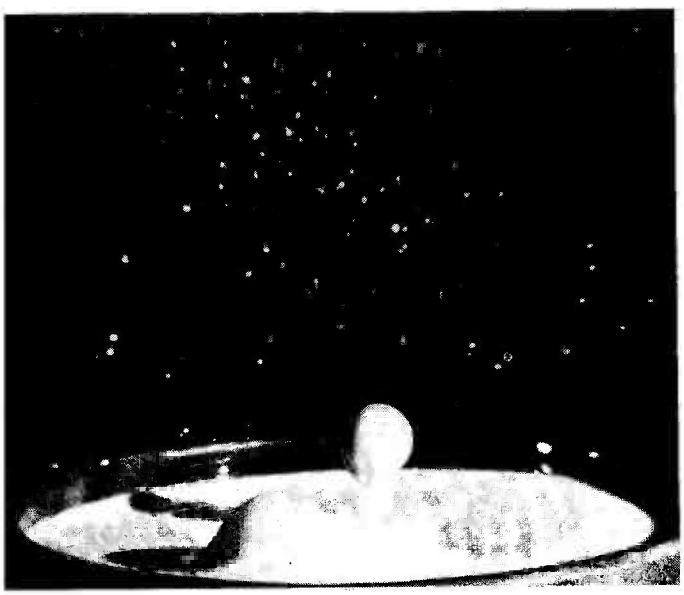
Transistor Q1 is normally held on by the current through RV2, and its collector is high, reverse biasing diode D1.

When an audio signal from the microphone produces at pin 3 a level exceeding that set on pin 2 by RV1, the IC will rapidly change state and its output will go high.

The front edge of this transition turns off Q1 via C3. The collector of Q1 will fall, D1 becomes forward biased and pulls down pin 2 to about one volt – the IC output is maintained in its high state

After a time – determined by the time constant of C3 and RV2 – Q1 turns on again allowing the IC to revert to its normal low output.

The output signal from Q1 is differentiated by C4 and the negative pulses (which occur first) are clipped off by diode D2. The positive pulse which occurs at the end of the delay period, triggers the SCR and fires the flash.



Slave-flash unit

ET PROJECT 515

This simple slave flash unit uses only five basic components.

PHOTOGRAPHS taken with a single photographic flash are often harsh, with unnaturally sharp shadows.

This problem may be overcome by using a slave flash – triggered by the light from the main flash – for filling in and/or background illumination. The unit described in this project is very simple and easy to build, and will provide vastly improved results for a very moderate outlay.

Figure 1 shows the circuit of the slave unit. Any phototransistor may be used for Q1. We used a BPX25 – this is an npn device. If a pnp phototransistor is chosen (such as an OCP71), the device must be assembled into the circuit with the emitter and collector reversed, rather than as shown in Figs. 1 and 2.

The unit is powered by a small nine volt battery (such as Eveready type 216).

CONSTRUCTION

Our prototype was made on a small piece of Veroboard – the component overlay for this is shown in Fig. 2. Note that one track of the Veroboard must be cut beneath C1. If a battery switch is required it should be connected in series with the nine-volt battery; otherwise the battery can simply be unplugged when the unit is not in use.

The containers of the unit may be any small metal or plastic box large enough to hold the components. We found that a plastic SCOTCH sticky tape dispenser was ideal. If a transparent box is used, the phototransistor may be mounted directly onto the Veroboard, if not it must be mounted externally.

OPERATION

Usually there is no need to locate the slave flash close to the master unit. The lights of the main flash unit is nearly always sufficient to trigger the slave flash anywhere inside a room. If the unit is used externally it may be necessary to orientate the slave flash so that the phototransistor is looking into the light from the main unit.

Before an exposure is made, the master flash unit should be set off once or twice to ensure that enough light is reaching the slave flash to ensure reliable triggering.

Make sure that all flash units are fully charged before taking photographs.

Calculate the F stop required for the main flash and stop down the camera accordingly. The slave flash must now be positioned such that an adequate exposure will be given to the background with the previously determined camera stop.

If the slave is used as fill, some adjustment to the exposure may be necessary and this is best found by trial and error. ●

HOW IT WORKS

Normally the phototransistor Q1 has high resistance – the actual value depending upon the level of ambient light. When the sudden light from the main flash illuminates Q1, its resistance suddenly falls and the resultant positive going pulse is impressed – via C1 – onto the gate of the SCR. The SCR immediately triggers thus setting off the flash.

PARTS LIST ET1 515

R1	–	resistor 10k ½ watt 5%	
R2	–	resistor 33k ½ watt 5%	
C1	–	capacitor 0.1μF 100 volt polyester	
SCR1	–	thyrister type C106D1	
Q1	–	phototransistor – any type	
		typical	BPX25 NPN
			OCP71 PNP
			MEL12 NPN

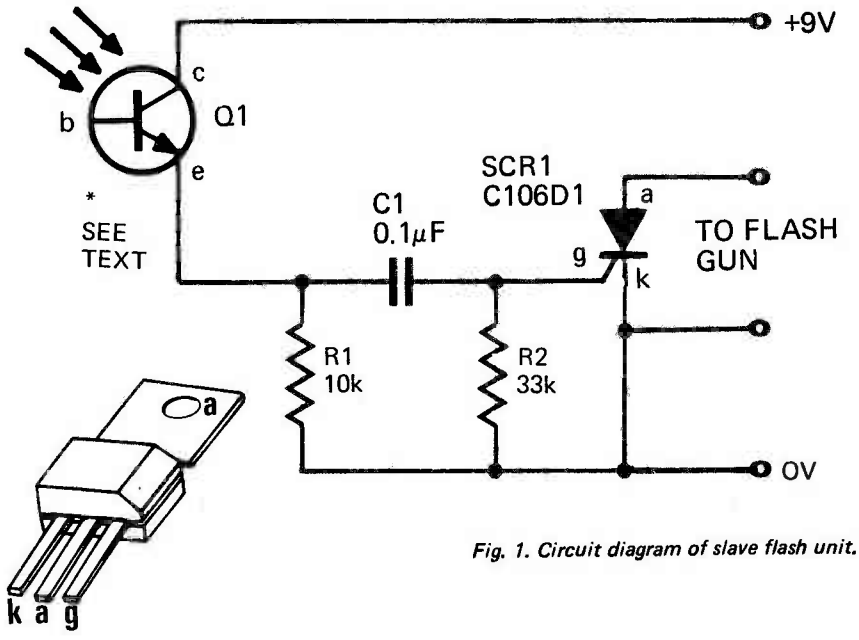


Fig. 1. Circuit diagram of slave flash unit.

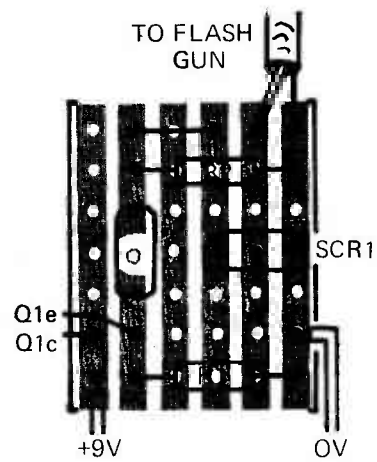


Fig. 2. How the components are located on the Veroboard; note that a break is made in one track of the Veroboard underneath C1.

NATION WIDE SERVICE + ATTRACTIVE DISCOUNTS

Everything brand new and to spec.
No surplus, 'seconds' or clearance lines

ELECTROVALUE

Electronic Component Specialists

Minitron DIGITAL INDICATOR TYPE 3015F

Seven segment indicator compatible with standard logic modules and power supplies. Figs 0-9 from combinations of well illuminated filament segments to give character height of 9mm plus decimal point. Power requirement 8mA from 5v d.c. per segment. A limited number of alphabetical symbols also available. In 16 lead dil case **£2.00**

Suitable BCD decoder driver type FLL121T **£1.45** Dil Socket; 16 lead **30p.**

Alternative type No. 3015G showing + or — and fig. 1 and decimal point **£2.00**

RIVLIN PRECISION RESISTORS 0.1 - 0.01% TOLERANCE

Prices and details on request.

Example—values under 100K £1—2.

RESISTORS—10%, 5%, 2%

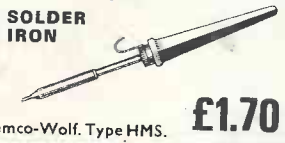
Code	Power	Tolerance	Range	Values available	1 to 9	10 to 99 (see note below)	100 up
C	1/20W	5%	82Ω–220KΩ	E12	9	8·	7
C	1/8W	5%	4·7Ω–470KΩ	E24	1	0·8	0·7
C	1/4W	10%	4·7Ω–10MΩ	E12	1	0·8	0·7
C	1/2W	5%	4·7Ω–10MΩ	E24	1·2	1	0·9
C	1W	10%	4·7Ω–10MΩ	E12	2·5	2	1·8
MO	1/2W	2%	10Ω–1MΩ	E24	4	3·5	3
WW	1W	10% ± 1/20Ω	0·22Ω–3·9Ω	E12	7	7	6
WW	3W	5%	12Ω–10KΩ	E12	7	7	6
WW	7W	5%	12Ω–10KΩ	E12	9	9	8

Codes: C = carbon film, high stability, low noise.
MO = metal oxide, Electrosil TRS, ultra low noise.
WW = wire wound, Plessey.

Values:
E12 denotes series: 10, 12, 15, 18, 22, 27, 33, 39, 47, 56, 68, 82 and their decades.
E24 denotes series: as E12 plus 11, 13, 16, 20, 24, 30, 36, 43, 51, 62, 75, 91 and their decades.

Prices are in pence each for quantities of the same ohmic value and power rating. NOT mixed values. (Ignore fractions on total value of resistor order.)

SOLDERSTAT SOLDER IRON



Type HMS, 16 or 24 watt, AC mains. We are appointed distributors for the whole range of these fine irons by Elremco-Wolf. Type HMS. **£1.70**

MISCELLANEOUS ITEMS FROM OUR CATALOGUE

30W BAILEY AMP. PARTS
Transistors and PCB for one channel .. .. **£6·46**
Rs and Cs for one channel **£1·95**
Power Supply Kit (Unreg.)

MAIN LINE AMP. KITS IS
70 watt power amp module kit .. **£12·60 nett**
Power supply kit .. **£6·00 nett**
Matching pre-amp kit .. .. **£3·30 nett**
(Above prices for mono.)
Stereo Kit. 2 power amps, pre-amp kit, power supply and matched controls for building into your own cabinet **£38·40 nett**

LIGHT DEPENDENT RESISTORS
Cadmium Sulphide type TPMD (equiv. ORP.12), **40p.**

ENAMELLED COPPER WIRE
Even No. SWG only: 2 oz. reels: 16-22 SWG **25p**; 24-30 SWG **30p**; 32, 34 SWG **33p**; 36-40 SWG **35p**. 4 oz. reels: 16-22 SWG only **41p.**

S-DeC £1·44. Four pack £5·10. DeCSTOR pack £2·88. T-Dec, may be temperature-cycled (208 points), £2·88. μDecA, £3·18. μDecB, £5·94. Also l.c. carriers.

THERMISTORS
VA1039, VA1040, VA1055, VA1066, VA1077, CZ-6, K151-1K, VA1100, **15p.** R24, R53, **£1·35.**

HANDBOOK OF TRANSISTOR EQUIVALENTS 40p
HANDBOOK OF TESTED TRANSISTOR CIRCUITS (H. Ness) 40p
RADIO & ELECTRONICS. Colour-codes and data wall chart **15p**
(Add 3p for each of above if bought separately.)

INSULATED SCREW TERMINALS in range of seven colours, each **12p**
Matching plugs 2mm each **5p**
4mm each **7p**

Plugs, sockets, hardware, Veroboard, edge connectors, switches, etc., in stock at keen prices.

CAPACITORS

SIEMENS 5% POLYCARBONATES

250V up to 0·1mF: 100V 0·1mF and above 0·01, 0·012, 0·015, 0·018, 0·022, 0·027 .. .. **5p**
0·033, 0·039, 0·045, 0·056, 0·068, 0·082, 0·1, 0·12, 0·15, 0·18, 0·22 .. .. .. **6p**
0·27, **7p**; 0·33, 0·39, **9p**; 0·47, **10p**; 0·56, **13p**; 0·68, **15p.**

MULLARD polyester C280 series

250V 20%: 0·01, 0·022, 0·033, 0·047 **3p each**; 0·068, 0·1, **4p each**; 0·15, **4p**; 0·22, **5p.** 10%: 0·33, **7p**; 0·47, **8p**; 0·68, **11p**; 1μF, **14p**; 1·5μF, **21p**; 2·2μF, **24p.**

MULLARD SUB-MIN ELECTROLYTICS C426 range, axial lead .. .. .. 6p each

Values (μF/V): 0·64/64; 1/40; 1·6/25; 2·5/16; 2·5/64; 4/10; 4/40; 5/64; 6·4/6·4; 6·4/25; 8/4; 8/40; 10/2·5; 10/16; 10/64; 12·5/25; 16/10; 16/40; 20/16; 20/64; 25/6·4; 25/25; 32/4; 32/10; 32/40; 32/64; 40/16; 40/2·5; 50/6·4; 50/25; 50/40; 64/4; 64/10; 80/2·5; 80/16; 80/25; 100/6·4; 125/4; 125/10; 125/16; 160/2·5; 200/6·4; 200/10; 250/4; 320/2·5; 320/6·4; 400/4; 500/2·5.

LARGE CAPACITORS

High ripple current types: 1000/25, **28p**; 1000/50, **41p**; 1000/100, **82p**; 2000/25, **37p**; 2000/50, **57p**; 2000/100, **£1·44**; 2500/64, **77p**; 2500/70, **98p**; 5000/25, **62p**; 5000/50, **£1·10**; 5000/100, **£2·91.**

SIEMENS POT CORES

In a range of types having air gaps from 1·0 mm. to zero at prices from **19p** for cores and **14p** for adjusting screw. Full details, see our catalogue.

CARBON TRACK POTENTIOMETERS, long spindles. Double wipers

SINGLE GANG linear 100Ω to 2·2MΩ, **12p**; Single gang log, 4·7KΩ to 2·2MΩ, **12p**; **Dual gang** linear 4·7kΩ to 2·2MΩ, **42p**; Dual gang log, 4·7KΩ to 2·2MΩ, **42p**; Log/antilog, 10K, 47K, 1MΩ only **42p**; Dual antilog, 10K only, **42p.** Any type with 2A D.P. mains switch, **12p** extra.
Only decades of 10, 22 & 47 available in ranges quoted.

DUAL CONCENTRIC in any combination of above values, **60p**; with switch, **72p.**

CARBON SKELETON PRE-SETS

Small high quality, type PR, linear only: 100Ω, 220Ω, 470Ω, 1K, 2K2, 4K7, 10K, 22K, 47K, 100K, 220K, 470K, 1M, 2M2, 5M, 10MΩ. Vertical or horizontal mounting, **5p each.**

ZENER DIODES 5% full range E24 values:

400mW: 2·7V to 36V, **15p each**; 1W: 6·8V. to 82V, **27p each**; 1·5W: 4·7V to 75V, **60p each.**
Clip to increase 1·5W rating to 3 watts (type 266F), **4p.**

10W/15Ω BAXANDALL SPEAKER

As originally designed by P. J. Baxandall and described in Wireless World. 10 watt/15 ohm loudspeaker with equaliser network speaker unit and specially designed cabinet in kit form. Size when built, approx. 18" × 12" × 10". Price, inc. carriage paid in U.K. **£13·90**

COMPONENT DISCOUNTS

Not allowed on nett price items

10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
Prices subject to alteration without prior notice.

APPOINTED DISTRIBUTORS FOR SIEMENS FINE PRODUCTS

TTL INTEGRATED CIRCUITS, CAPACITORS, THYRISTORS, RECTIFIERS, POT CORES, ETC.

SPECIAL TRANSISTOR OFFER SIEMENS 2N3055 POWER TYPE

with free insulating set. Tested and to spec. Special price, only **50p.**

THE ELECTROVALUE CATALOGUE

1972 Edition (No. 6)—our biggest yet—over 80 pages packed with bargains, information, diagrams, etc. Well printed and illustrated Post free. **10p**

COMPONENT DISCOUNTS

Not allowed on nett price items

10% on orders for components for £5 or more.
15% on orders for components for £15 or more.
Prices subject to alteration without prior notice.

POSTAGE AND PACKING

FREE on orders over £2. Please add 10p if orders under £2. Overseas orders welcome; carriage and insurance charged at cost.
U.S.A. CUSTOMERS are recommended to contact ELECTROVALUE AMERICA, P.O. Box 27, Swarthmore PA 19081.

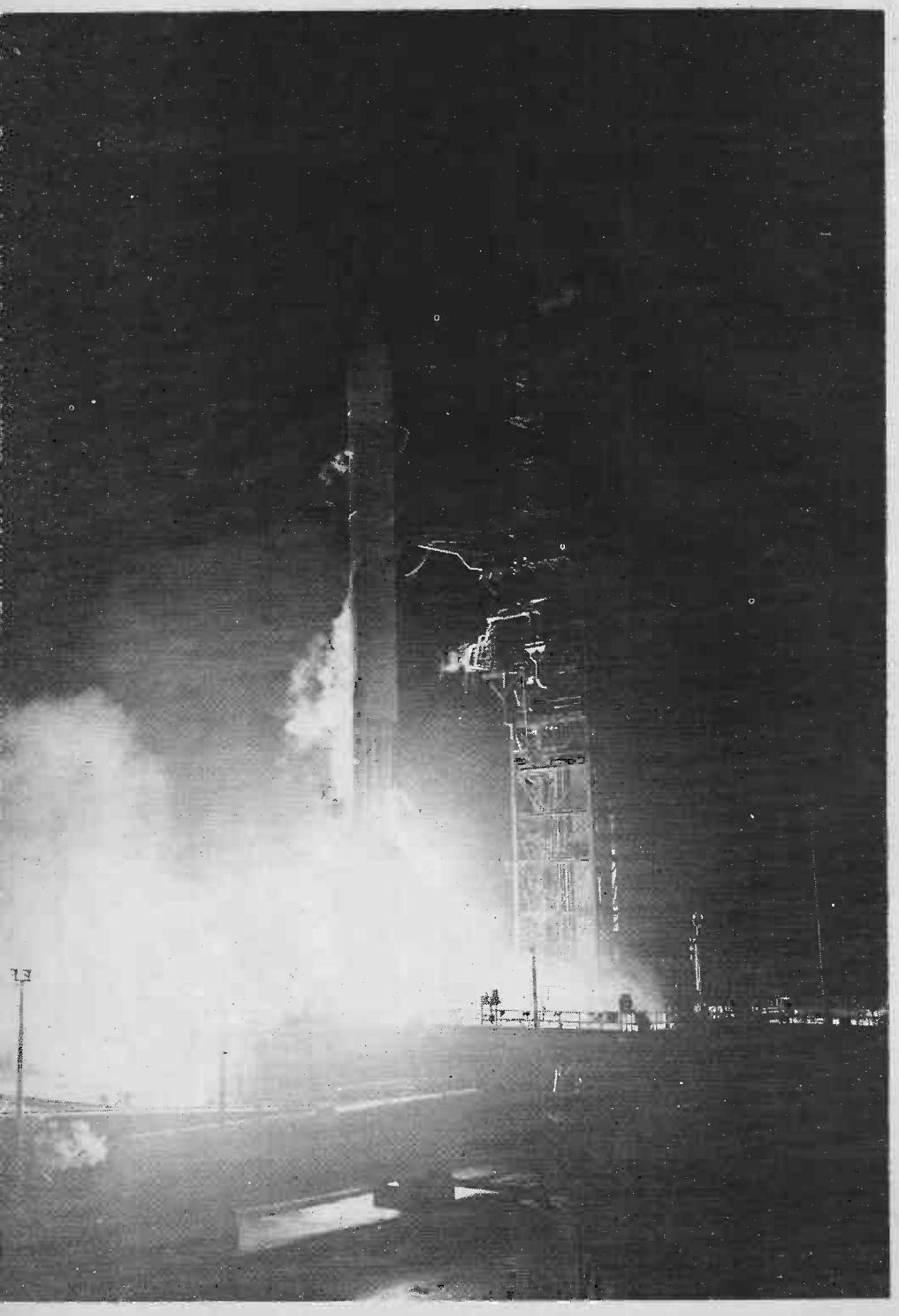
SEMI-CONDUCTORS

Brand new, guaranteed to spec. No seconds or surplus.

1B40K10	175p	2N2925	22p	2N5163	25p	AD142	50p	BC149	10p	BF167	18p	NKT212	25p
1N914	5p	2N3926	11p	2N5172	18p	AD149	58p	BC153	19p	BF173	19p	NKT213	25p
1N316	10p	2N3053	27p	2N5192	125p	AD150	50p	BC154	20p	BF177	25p	NKT214	23p
1N1763A	24p	2N3054	60p	2N5195	147p	AD161	33p	BC157	12p	BFI78	31p	NKT217	50p
1N3754	90p	2N3055	60p	2N5457	49p	AD162	36p	BC158	11p	BF194	14p	NKT261	21p
1N5399	21p	2N3325	53p	2N5459	49p	*AD161/162	60p	BC159	12p	BF195	15p	NKT271	18p
1N5402	28p	2N3405	60p	40250	71p	AF114	24p	BC167	11p	BF244	30p	NKT274	18p
1N5407	45p	2N3663	52p	40251	89p	AF115	24p	BC168	10p	BF254	14p	NKT275	23p
1844	9p	2N3702	13p	40361	55p	AF116	22p	BC169	11p	BF255	15p	NKT403	65p
18940	5p	2N3703	13p	40362	68p	AF117	22p	BC177	14p	BFX18	90p	NKT404	61p
2N696	17p	2N3704	13p	40406	75p	AF118	82p	BC178	13p	BFX29	31p	NKT405	79p
2N697	18p	2N3705	13p	40408	70p	AF124	24p	BC179	14p	BFX84	25p	NKT603F	30p
2N706	12p	2N3706	13p	40412	67p	AF125	24p	BC182L	11p	BFX85	32p	NKT613F	30p
2N930	21p	2N3707	13p	40430	140p	AF126	22p	BC183B	10p	BFX87	29p	NKT674F	24p
2N1131	29p	2N3708	10p	40432	185p	AF127	22p	BC184L	11p	BFX88	26p	NKT677F	22p
2N1132	29p	2N3709	11p	40512	195p	AF139	33p	BC186	42p	BFX50	23p	NKT713	30p
2N1302	19p	2N3710	13p	40602	52p	AF239	36p	BC212L	16p	BFY51	20p	NKT773	25p
2N1303	19p	2N3711	13p	40669	140p	AL102	77p	BC213L	16p	BFY52	23p	OA47	8p
2N1304	28p	2N3731	120p	AC107	48p	ASY26	27p	BC214L	16p	BFY90	104p	OA90	6p
2N1305	28p	2N3794	15p	AC126	20p	ASY27	36p	BC257	9p	BSX20	16p	OA91	5p
2N1306	33p	2N3819	23p	AC127	20p	ASY28	27p	BC258	8p	BY164	45p	OA95	6p
2N1307	33p	2N3820	53p	AC128	20p	ASY29	36p	BC259	9p	BY238	18p	OA200	9p
2N1308	36p	2N3904	35p	AC141H	34p	AU111	97p	BC267	17p	BYX38-300	38p	OA202	10p
2N1309	36p	2N3906	35p	AC141HK	37p	B30C250	24p	BC268	18p	BYX38-300R	38p	OC19	50p
2N1596	102p	2N4036	55p	AC142H	25p	B30C550/300	34p	BC269	17p	C407	17p	OC25	42p
2N1598	122p	2N4058	13p	AC142HK	29p	B1912	66p	BC300	49p	C762	19p	OC28	70p
2N1613	23p	2N4059	10p	AC153K	22p	B5041	72p	BC301	37p	C1412	102p	OC29	78p
2N1711	28p	2N4060	11p	AC176	16p	BA102	25p	BC303	60p	E2512	164p	OC35	60p
2N1893	54p	2N4061	11p	AC176K	17p	BA130	22p	BCY30	60p	EA403	10p	OC36	65p
2N2147	95p	2N4062	12p	AC187K	17p	BA145	27p	BCY33	78p	EB383	10p	OC41	42p
2N2218	34p	2N4124	18p	AC188K	23p	BA155	15p	BCY70	18p	EC401	18d	OC42	46p
2N2218A	44p	2N4126	27p	*AC187K/188K		BA156	13p	BCY71	33p	EC402	17p	OC44	42p
2N2219	38p	2N4284	24p		40p	BAX13	13p	BCY72	15p	ER900	54p	OC45	38p
2N2219A	53p	2N4286	15p	ACY17	31p	BB103/B	16p	BD121	105p	MC140	25p	OC70	21p
2N2270	62p	2N4289	15p	ACY18	19p	BB103/G	16p	BD123	105p	MJ481	120p	OC71	38p
2N2369A	19p	2N4291	15p	ACY19	23p	BC107	12p	BD124	100p	MJ491	135p	OC72	38p
2N2483	35p	2N4292	15p	ACY20	20p	BC108	11p	BD130	50p	MJ371	108p	OC75	40p
2N2484	42p	2N4410	24p	ACY21	21p	BC109	12p	BD131	79p	MJE521	92p	OC81	25p
2N2646	47p	2N4443	111p	ACY22	21p	BC122	21p	BD132	86p	MJE2955	165p	OC81D	25p
2N2904	38p	2N4906	305p	ACY39	63p	BC125	15p	BD135	38p	MJE3055	82p	OC83	25p
2N2904A	42p	2N4915	215p	ACY40	17p	BC126	22p	BD136	44p	MPF102	37p	OC84	25p
2N2905	44p	2N4991	62p	ACY41	18p	BC140	30p	BD141	227p	MPS6531	35p	P346A	26p
2N2905A	47p	2N5062	61p	ACY44	31p	BC147	10p	BDY20	92p	MPS6534	30p	S2CN1	10p
2N2924	20p	2N5088	38p	AD140	63p	BC148	9p	BF115	23p	NKT211	25p	* Matched pair	

ELECTROVALUE DEPT. ETD.1, 28 ST. JUDES ROAD, ENGLEFIELD GREEN, EGHAM, SURREY, TW20 0HB
Hours: 9-5.30, 1.0 p.m. Saturdays. ***Phone: Egham 5533 and 4757 (STD 0784-3) Telex 264475***

SPACE SPECTACULAR



The US National Aeronautics and Space Administration are seriously investigating the possibility of landing men on Mars — in 1985.

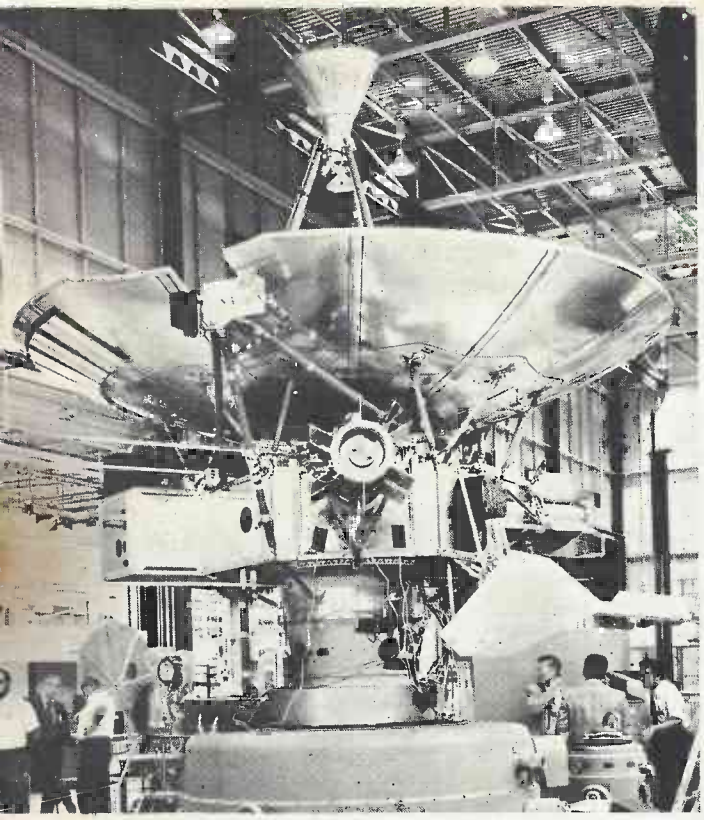
This report — based on a NASA Technical Paper — outlines the proposed mission.

In all likelihood the next body in our solar system to be visited by man will be the planet Mars, for possibly the most intriguing question faced by man today is the prospect of life on other planets, and although recent data from Mariners VI and VII discourage such prospects on Mars, they do not rule them out. Therefore, the search for life has been given the highest priority, followed by the desire to learn more about the origin and evolution of the solar system.

PROPOSED MISSION

Two planetary space vehicles, of essentially the same design, will depart Earth in the Spring of 1985 on a heliocentric transfer to Mars. Each space vehicle will have two principal components: a planetary mission module (PMM) and a Mars excursion module (MEM). After a Venus swingby the space vehicles will arrive at Mars where, after a brief orbital period, one MEM from each space vehicle will descend to the surface. The planetary mission module will remain in orbit. After a 40 to 60-day surface stay-time, the ascent stage of the MEM will rendezvous with the planetary mission module for a direct heliocentric transfer to earth. The approximate dates for the proposed 1986 mission are as follows:

Launch from Earth .. March 26, 1985
Arrive Venus .....Sept. 12, 1985; 170 days
Arrive Mars .....March 11, 1986; 350 days
(About 60 days at Mars, 40 days on surface)
Leave Mars ..... May 10, 1986; 410 days



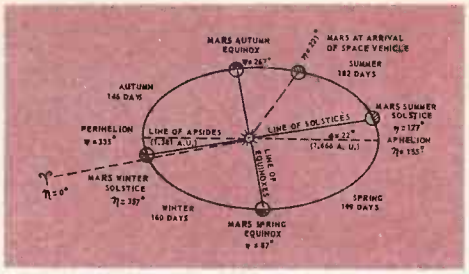


Figure 1. Position of Mars in orbit on arrival.

Preceding the proposed manned Mars space flight are a number of unmanned journeys to the outer solar system.

Here a test model of a Pioneer spacecraft is seen mounted on a shaker table to check its ability to withstand in-flight vibration.

Pioneer F is the first spacecraft designed to travel into the outer solar system and operate effectively there, possibly for as long as seven years. It will travel a distance of one and a half thousand million miles from the Sun, and explore a curving strip of space 620 million miles long extending from the Earth's orbit to Jupiter.

The spacecraft's primary objective will be to take the first close-up look at Jupiter. It will return data on about 20 aspects of the planet, its moons and environment.

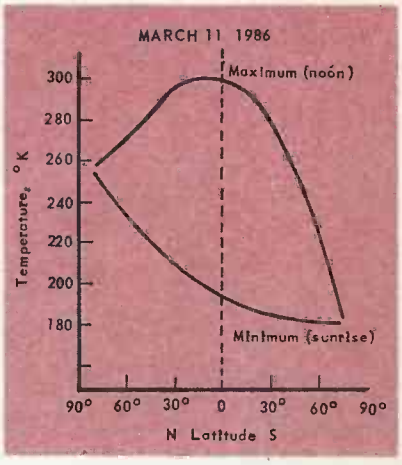


Figure 2. Martian temperature variations with latitude at time of landing.

Arrive Earth ..... Oct. 7, 1986; 560 days.

Some of the important physical features existing at Mars on arrival are illustrated in Figures 1, 2, and 3. Figure 1 presents the locations of Mars in its orbit, Figure 2, the temperature as a function of latitude, and Figure 3, the extent of the polar caps and wave of darkening.

In accomplishing the experimental objectives, the inherent and unique abilities of man will bring a dimension to scientific investigations heretofore absent in the study of any planet other than Earth. Man is the only reliable instrument available that can rapidly adjust observations over the many orders of magnitude resolution needed for some scientific investigations. His judgment is unsurpassed in selecting locations for instruments and for gathering samples and examining complex situations. His ability to interpret experimental results and, if necessary, redirect the investigations will be very valuable. He can manipulate and repair the instruments. His faculty for appraising and correlating interdependent measurements (some occurring simultaneously) of many physical properties and for improvising when unexpected situations occur cannot be overemphasized.

Estimates of the instrumentation state-of-the-art in the early 1980's can be made by extrapolating the advances that have occurred during the last 10 to 15 years. Using these estimates as a guide it is envisioned that most of the measurement results will be transmitted in near real-time to earth.

Earlier space missions will test for the presence of life, and if these tests are positive, scientists will attempt to measure and characterize this life. If any indications of life are found, the question of compatibility or possible pathogenesis and back contamination must be resolved.

Therefore, an additional precursory experiment that may be beneficial, and even necessary, to the manned mission is a lander system which contains numerous earth-type life samples, even possibly including human tissue cultures, that could be exposed to the Martian bio-environment and the results monitored. Because of the highly specific nature of pathogens, a positive result may be a necessary but not sufficient guarantee that man (or any earth organisms) will be safe, but at least such an experiment would be a partial answer.

Some biologists believe that it is necessary to firmly establish before a manned mission whether life exists on Mars and if so, whether it is pathogenic to Earth life. If this is to be done, the number and type of unmanned probes needed, e.g., Viking, and Soft Landers with remote-controlled roving vehicles and with soil samples return capability, may be greater than is currently planned.

THE ORBITAL MISSION

Soon after arrival at Mars a landing module (MEM) will separate from the space vehicle and descend to the surface, leaving in orbit the part designated as the planetary mission module.

The orbital part of the mission will consist of experiments done on the planetary mission module and experiments done on an unmanned spacecraft. The unmanned spacecraft mode is needed because of the orbital characteristics required for in-situ atmospheric measurements in the transition zone. This zone, located at about 80 to 120 km in the Earth's atmosphere and probably below 100 km in the Martian atmosphere, divides the uniformly chemically mixed region and the diffusely separated region. A 100-km altitude would be unacceptable for periapsis of the planetary mission module because of orbital lifetime, aerodynamic heating, and other engineering considerations.

One unmanned spacecraft will be launched from each space vehicle (before MEM descent) and placed into

turn to page 74

Part 1

psi in the sky

TRANSDUCERS IN MEASUREMENT AND CONTROL

A series of articles by Peter Sydenham M.E., Ph.D., M. Inst. MC.

A TRANSDUCER, is a device that converts (transduces) one physical variable into another. Transducers are not restricted to electrical signal conversion techniques, but in the main these predominate as electrical methods are universal, and provide a common interconnecting method for an engineering system or a scientific experiment.

This series will describe the proven practical methods (and this includes economic sense, as cost is important) now used to produce, in the main, electrical signals from the original physical effect to be measured.

Transducers provide convenient signals for measuring a process, for automatically recording these measurements when needed and, finally, for providing a signal that can be used to control. It is not possible to control without measuring and so the fundamental basis of automation is the transducer. The transducer is also able to provide gain by amplifying weak original signals before they are used. Application factors of a million are commonplace.

Often, more than one basic transducer principle is used to produce the required output. Units are cascaded. Consider the fuel gauge of a motor car, shown diagrammatically in Fig. 1. The first stage is known as the primary or input transducer, following are the secondary or intermediate stages and, finally, there is an output transducer.

In the fuel tank a float transduces the fuel level to an equivalent rotary motion. This drives a rotary potentiometer which provides a voltage proportional to the angle of rotation. Sometimes there is a calibration or adjustment stage in the chain. At the dashboard the voltage is turned back to a rotary displacement in the fuel gauge meter movement. The advantage of the electrical signal is that it avoids the need for a complicated mechanical linkage between the fuel level and the gauge. In a control application an electrical measurement output signal also enables in-line correction, compensation and computation to be made before the signal is used. Recording is also made most easily with electrical plotters.

In principle, a transducer is a simple device. In practice, however, simple schemes invariably suffer from defects that limit the ability of the device to provide repeatible and accurate values.

They may suffer from wear as time proceeds: environmental factors such as temperature, pressure, humidity and shock for instance, may be a significant problem. Consequently, at first sight, the developed transducer system usually appears quite complicated. But if treated systematically, it can be broken up into separate sub-systems that perform distinctly different tasks, each being joined to produce a satisfactorily reliable and accurate device.

A list of all the different transducers yet devised would be never ending, for the basic physical effects that could be used is beyond complete classification. Each may be used for many different purposes. For example, a light spot moving across a photo-cell can be used to measure position, alternatively, the movement might be used to change the sound level of a radio receiver by varying the voltage applied to the receiver output stage.

Nevertheless some transducers have emerged that are well developed for specific tasks. Thus a brief list can be made of primary devices, and those quantities measureable by the use of intermediate stages.

Linear Movement: From this are also derived thickness, velocity, acceleration, force, wear, vibration, hardness, stress, strain, pressure, gravity, magnetic field, level and position, by the use of secondary devices.

Angular Movement: Angular vibration, tilt, torque, position are obtained with angular transducers.

Temperature: Flow, turbulence, heat conductivity, remote sensing and displacement can be obtained by use of this basic measurement.

Illumination: Length, force, strain, torque, frequency, and light distribution have been measured using illumination.

Time: Speed, counting, frequency and position rely on time measurement.

Force: Weight, density, stress, torque and viscosity use force indirectly.

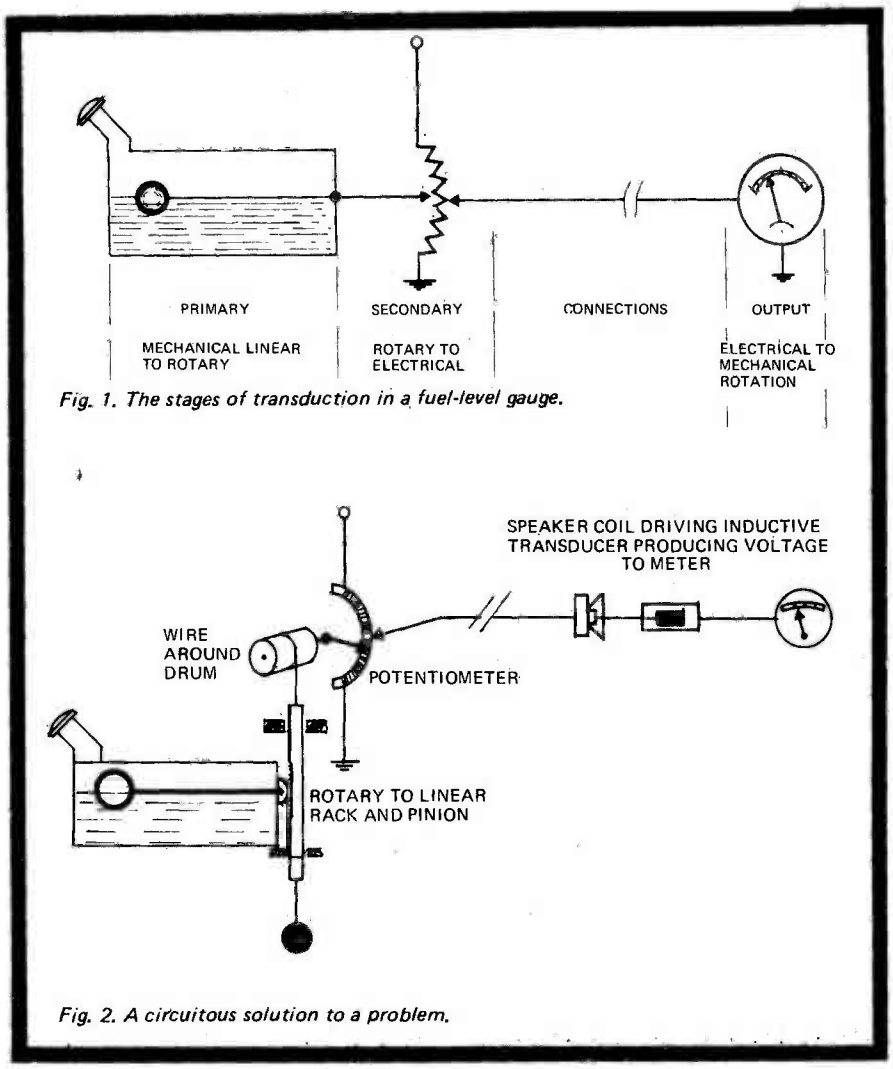


Fig. 1. The stages of transduction in a fuel-level gauge.

Fig. 2. A circuitous solution to a problem.

It is many years since James Watt thought of using the speed indicator of an early steam engine automatically to control its speed, and so producing what was probably the world's first industrial feedback control system.

In that case, a centrifugal governor was used to change the difficult-to-detect shaft speed into an equivalent mechanical displacement. It was, in fact, what is now called a transducer.

Since the time of the industrial revolution, machines and processes have developed at an ever quickening rate and the need to convert difficult-to-use effects into alternative physical forms has grown rapidly.

Late in the 19th. century, electricity became available to industry and science. Then the electronic discipline emerged. Electronic techniques, allied with those of mechanical, optical, thermal and acoustic origin — the list is never-ending — enabled a vast array of transducers to be developed to fulfil the needs of sophisticated measurement and control.

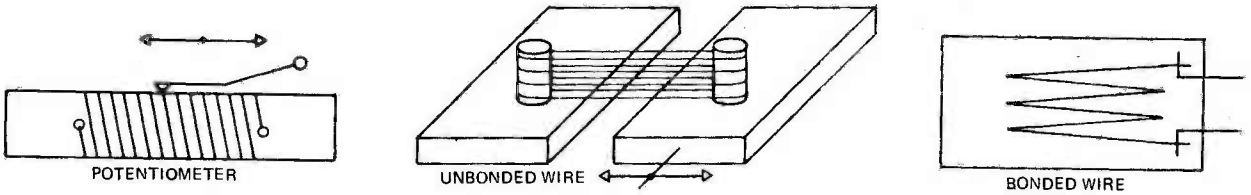


Fig. 3. Resistive displacement principles

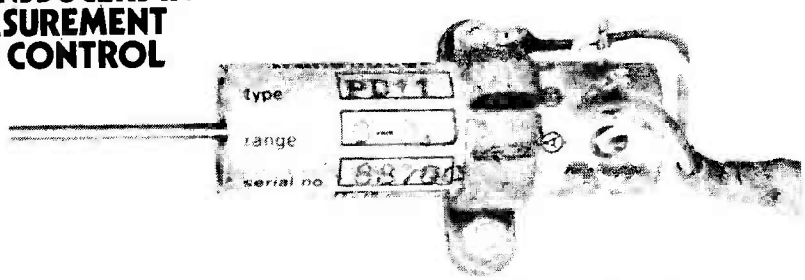


Fig. 4. A linear wire wound displacement transducer having 25μm resolution.

This list is not complete but it does illustrate the variety of possibilities open to the designer. A problem can be solved by circuitous means (Figure 2 is a fuel gauge arrangement with redundant use of transducers) but economic and reliability factors decide which way is acceptable in reality.

Transducers may provide the transduction in one of two basic ways. It may, firstly, control the available source of energy as a tap lets water through or a variable resistance controls the current flow from the power source in a circuit. Secondly, the transducer may actually convert the original energy form into another more appropriate form. An example is the use of a photo-voltaic cell in which light radiation energy generates electrical energy. Transducers may also provide mechanical energy from the available electrical source as happens in the moving coil loudspeaker.

An interesting fact is that the dynamic and static behaviour of mechanical, acoustic and electrical systems are each described by similar mathematical equations. This analogy, as it is called, enables the behaviour of large machines to be simulated by inexpensive electrical networks. For example, the internal-combustion engine can be simply represented by a resistor and a capacitor at speeds above idling. So for research purposes, once the value of R and C are determined, it is possible to study the performance of that engine in a computer.

Some transducer applications need only a slow speed static response but often the need is for rapid conversion. The frequency response is, therefore, of interest. Mechanical systems are generally incapable of the same high speeds obtainable in electrical devices. For this reason there is a trend toward total electronic technique if possible. This is not always a prudent way to solve the problem as many mechanical devices have been extensively developed to provide reliabilities of years (or millions of operations). A simple example is the choice made when several independent circuits have to be switched together. A bank of reed-relays is inexpensive, simple to design and capable of excessive overloads. A solid-state equivalent circuit is more expensive to develop and more prone to overloads. Each case should be considered on its merits.

Several terms, commonly used in measurement are often misunderstood and misused. The first is the **repeatability** of measurement. If repeated measurements are made of a static process by an instrument with sufficient sensitivity there will be a **scatter** of the values around some mean value. This scatter represents the uncertainty of the measuring process used. The most commonly used method of expressing this scatter is by what is known as the standard deviation (σ). This is found by a simple statistical mathematical formula. The important thing to realise is that there is a 68% chance of the true value lying between plus and minus 1 σ. For example, if a voltage is measured 100 times and its mean value found to be 100V with a standard deviation of 2 volts this means that 68 times it will lie between 98 and 102 volts and 32 times it will be outside these limits. In practice, one-σ limits are not tight enough. For $\pm 2\sigma$ limits it is 95 times out of 100 and for $\pm 3\sigma$ limits 99.7 out of 100 times within. Repeatability is the first requirement of a transducer for without it accuracy has no meaning. (The standard deviation of any transducer or precision measuring instrument is almost always quoted by the manufacturer.)

The **resolution** of a measuring instrument is the smallest quantity that it can detect. But to have extreme resolution does not imply that it will repeat each time nor be accurate. A screw-thread micrometer could have a drum of enormous diameter enabling extremely small distances to be gauged, but the screw friction and error would produce scatter and inaccuracy.

Precision is the term used to describe how well the instrument measures and gives a reliable value. The smallness of the standard deviation, therefore, is a measure of precision.

Accuracy is the most difficult factor to obtain. An instrument may be precise, always giving the same value, but to be accurate, that value must be true to the established standards. For example, a voltmeter may indicate

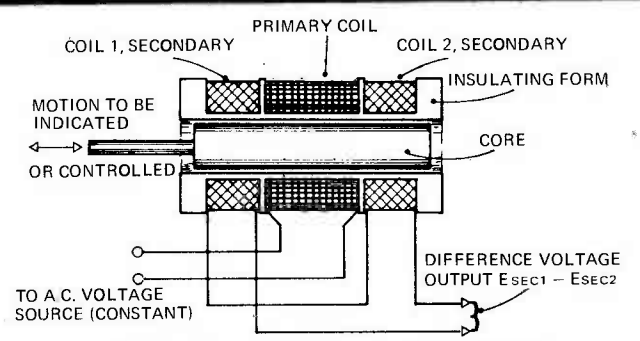


Fig. 5a. Linear variable differential transformer.

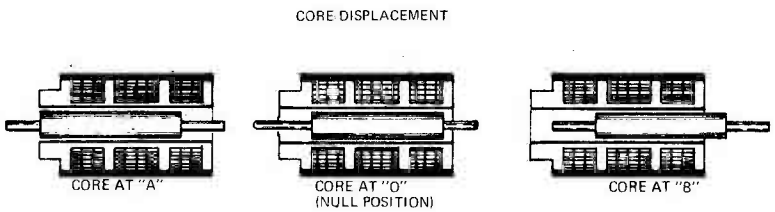


Fig. 5b. This shows the core of the l.v.d.t. in three different positions.

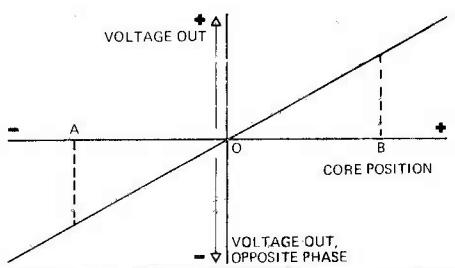


Fig. 5c. Output voltage of l.v.d.t. with core in positions shown in Fig. 5b. above.

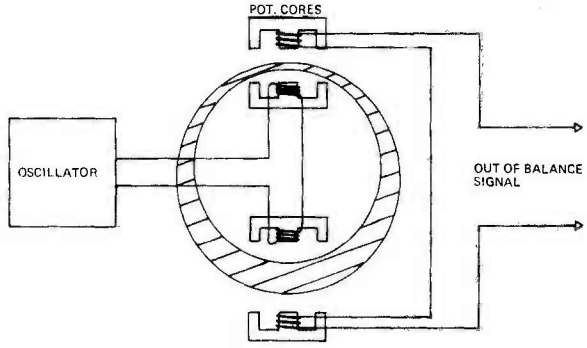
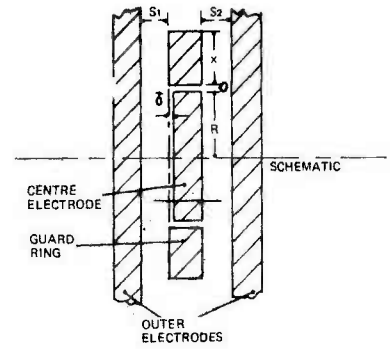
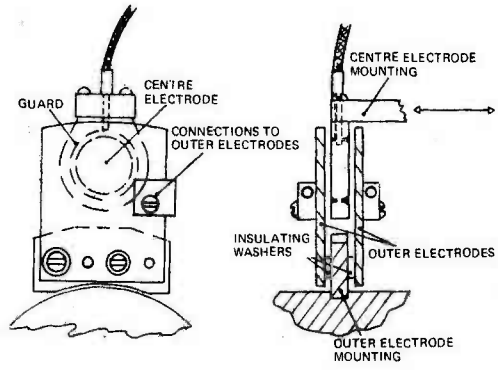


Fig. 6. A differential arrangement using two variable reluctance transducers for monitoring tube eccentricity.





Differential parallel plate capacitance transducer developed at the National Standards Laboratory, Sydney.

10.1 volts repeatedly but if the pointer is bent or the multiplier resistor incorrect, the actual voltage may be only 9.5. There is no way of establishing accuracy without resorting to another measurement device. Often, accuracy is added to a precision instrument by resorting to calibration. In transducer application, this must usually be automatic, or built in to the device, as a human link is undesirable.

So much for a general basis of transducer technology. The series now continues by discussing various measurements in turn. We start with the methods used to transduce displacements.

This initial article deals with small displacement transducers ranging in capability from a few millimetres down to hundredths of the diameter of atoms. These devices are particularly useful in obtaining derived quantities as well as direct measurements (as will be seen later). The second article in the series discusses the industrial displacement range, that is, from millimetres to several metres, and then the surveying range from hundreds of metres to the size of the Earth and larger.

MICRODISPLACEMENT TRANSDUCERS

Displacement is measured directly with resistive, inductive and capactive methods and, indirectly, by optical means.

Resistive: The simplest way to transduce movement into electrical signals is mechanically to vary the properties of a resistance. This can be realised by direct mechanical movement of the tapping point, as in a potentiometer, or by straining the resistance element, as in a strain gauge, (Fig. 3).

Potentiometers, whether linear or rotary, consist of a resistance track upon which slides a contact wiper. The earliest precision potentiometers used fine resistance-wire wound around a toroidal former. As the wiper moved over the turns, the output changed abruptly and this limited the resolution. A modern type linear potentiometer is shown in Fig. 4, infinite resolution has been obtained by using a continuous slider running longitudinally along the wire (it may also be obtained by the use of composite-material track). Repeatibility is limited by the precision of the wiper contact position and slight variations in electrical contact. Due to relatively poor repeatibility and reliability, and because of the high operating force, it is unusual for a resistance potentiometer of this type to be used for applications where high resolution is required.

An unusual type of resistance potentiometer is that whereby a tightly coiled tension spring is stretched to open the coils and increase the resistance. The required displacement-output signal characteristic is determined by the method of hard-coiling the spring.

The sensitivity of resistive methods is limited by the allowable self-heating of the element, for temperature changes alter the resistance value.

Strain gauges are resistances that are strained bodily so as to alter their physical cross-section and length. Resistive types are made as wire, or stamped foils of thickness around 20μm, and are arranged to obtain multiple elongations connected in series. Adhesives are used to attach the gauge to the member to be measured. This ensures faithful movement with the parent. Typical resistance values range from 10 to 10,000 ohms. Self heating and temperature effects limit the sensitivity of these devices but absence of mechanical moving contacts enables resolutions of better than 1 microstrain to be obtained.

The ratio of strain to proportionate resistance change is termed the gauge factor. This is usually quoted by the manufacturer. For linear resistance gauges it is close to 2.0. Calibration is necessary for precision work.

Wheatstone bridges, of simple and advanced form, are used to measure the resistance changes of both potentiometers and strain gauges. To compensate for temperature, a dummy resistance is used in one arm of the bridge.

The main advantage of resistive strain gauges is their extremely small size, ranging from 2mm upwards. Frequency response exceeds 50MHz for special, surface deposited types.

Solid-state strain gauges are also available. If a semiconductor element such as silicon is strained, it also shows a change in resistance. Their gauge factor is not constant but depends upon instantaneous strain magnitude and temperature. Gauge factors of 100 are typical.

The main disadvantage of resistive strain gauges is their fragility, and this requires them to be mounted on a more substantial element. For fixed applications, it is practicable to mount the gauge between the two moving members in what is known as an unbonded arrangement.

Strain gauges are used extensively in civil and mechanical engineering testing. Gauges are glued to the structure in many places. A data-logger reads each in turn recording the strain at that time. This data is then processed to produce the required information.

Inductive: Electromagnetic and electrostatic fields can be utilised for

displacement sensing, each having practical advantages. Alternating current excitation can be employed and dissipative circuit elements are kept to a minimum (factors which enhance sensitivity and reduce drift). Inductive methods use, in the main, either the linear variable differential transformer (l.d.v.t.) principle, or operate on a reluctance variation concept.

The l.v.d.t. consists of a spatially centre-tapped solenoid in which moves a magnetically-hard steel core, (Fig. 5). The coil is energised either by a separate primary coil or by direct connection across the winding. As the core moves relative to the winding the flux-linkages cutting each half of the winding vary, resulting in amplitude unbalance between the halves. The degree of unbalance is linearly related to the core's displacement from the coil centre.

One method of sensing the unbalance is to connect the sensing coils in opposition and measure the output voltage. It is necessary, however, in this simple method, to determine the phase relationship between the excitation and output in order to decide the sign of the displacement. A superior technique uses a phase-sensitive detector, the output then being a bi-polar dc voltage which is linear with displacement.

Linear variable differential transformers are used extensively in industry in weighing machines, pressure transducers and load cells; and in science in earth strain-meters, tilt meters and seismometers. A major manufacturer offers over 2000 different models. In these applications resolution required is rarely less than 5μm.

The principle is also used in some industrial dimensional metrology gauging heads where 100nm is the best resolution needed.

The core and winding are mounted to avoid mechanical contact, but perpendicular movement to the core's axis is not possible. Axial core travel can be over very large distances and the zero position can be set electronically at any point along the length of the winding. Humidity, even liquids, do not affect the operation. Magnetic shielding is used to isolate the winding from external fields.

The other main inductance technique employed is known as the reluctance transducer. If the air-gap of a magnetic circuit is varied, the magnetic circuit reluctance changes. As the majority of the circuit reluctance is produced across the air-gap the response is reasonably linear. In practice the iron circuit can be made from a pot-core as shown in the tube gauge (Fig. 6). This contains the sensing coil and a freely

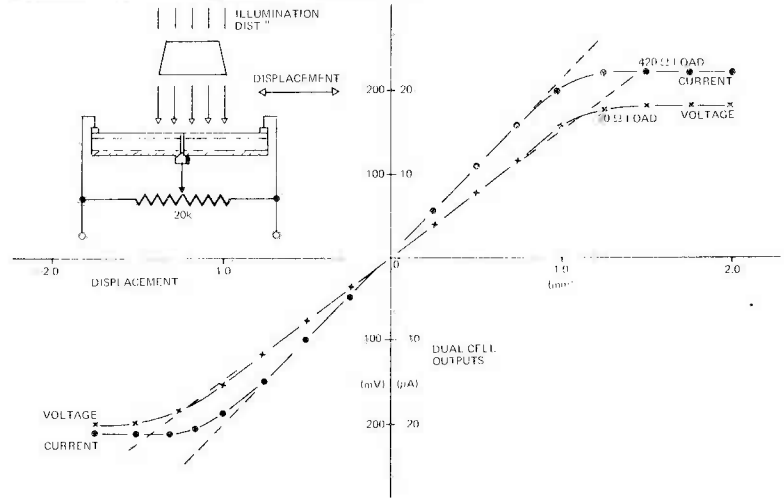


Fig. 8. Dual cell position-sensitive optical transducer.

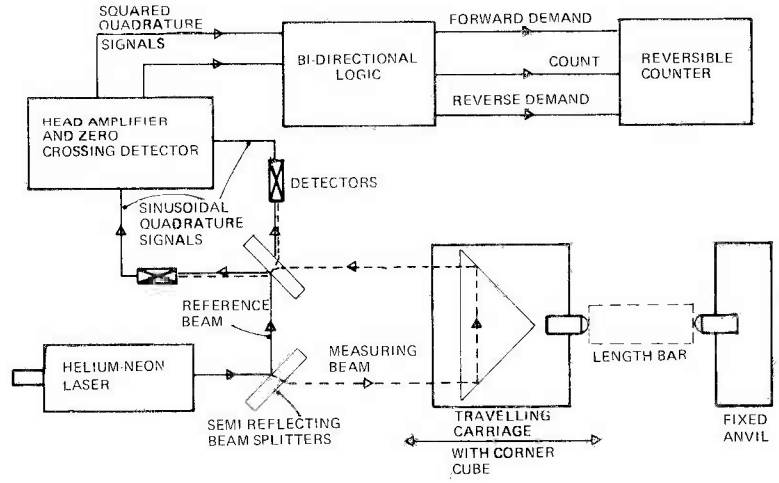


Fig. 9. One form of industrial laser length measuring interferometer.

moving limb which completes the circuit. The device is directly energised and may be sensed by similar methods to l.d.v.t.'s. A differential arrangement is often used to balance the effects of temperature and stray fields.

Reluctance transducers have been employed for measuring tube eccentricity, as shown for measuring dynamic lubricant film thicknesses, and in pressure gauges. Current research on a borehole tilt meter at the Australian National University uses a reluctance technique to sense the pendulum movements. Sensitivities of these small range inductive methods can be as high as 200mV/μm. Frequency response is limited by the excitation frequency used (10-10kHz) and mechanical factors.

Capacitive: The most favoured extreme precision sensing method is known as capacitance micrometry. In its simplest form it consists of measuring the capacitance changes resulting as the separation between two plates of a capacitor is varied. As capacitance is inversely proportional to gap distance, the displacement/output characteristic is a non-linear hyperbolic. A guardring is used to control fringing of the electrostatic field existing between the plates and to reduce the effect of lead strays which shunt the small variable-capacitance limiting the attainable sensitivity. Linearization has been achieved in one manufactured gauge by placing the sensing capacitance in the feedback of an operational amplifier.

The magnitude of the sensing capacitance is only a few picofarads. Reactive bridges can sense to 10^{5} pF, or a little better, using tap changing inductive transformers. As the capacitance value is proportional to plate area and inversely to separation,

TRANSDUCERS IN MEASUREMENT AND CONTROL

Fig. 10. Testing the corrosion thickness of a pipe with an ultrasonic gauge.

highest sensitivities result for largest plate sizes and smallest gaps.

Practical considerations of plate flatness and degree of parallelity limit the gap size to around 100nm or more. Plate diameters in use range from millimetres to centimetres. In most applications the sensitivity of the method to stray capacitance is reduced by using a differential capacitance mechanical layout. A central plate moves between two fixed sensing electrodes, the plate being earthed. Any temperature effects and air dielectric changes occur equally in each arm of the arrangement. If sensed by a bridge circuit, these effects are largely cancelled. A unit developed at the National Standards Laboratory in Sydney is shown in Figure 7.

Capacitance gauges have been used in geophysical instruments such as gravimeters, tilt meters and strain meters. They are also used in industrial gauging and machine tool control.

Optical: Mechanical displacements of interest can be converted into movements of a light beam which can then be sensed with a position-sensitive optical detector. Rotations can be magnified using an optical-lever if space permits.

In simple arrangement, the radiation beam is either split into halves, each half feeding a separate photocell or alternatively, the beam may impinge directly onto a photo-device with position-sensitive characteristics. In each case a differential bridge arrangement is usually incorporated giving zero output if the beam is truly centred. This null position can be conveniently displaced by electrical means.

In brief, static arrangements use position-sensitive photo cells or passive optico-mechanical arrangements (beam splitting mirrors, prisms) and dynamic methods use optico-mechanical devices (rotating prisms and wedges, vibrating apertures) or electrodynamic devices (image dissector tubes, magneto-optical and wavefront shearing).

Numerous possibilities exist, but for simplicity and cheapness, solid-state position-sensitive photo-cells will usually be the first choice considered. The simplest method uses two (or four for 2 axis measurement) silicon solar cells, about 10mm square, which are mounted adjacent to each other. This is illustrated in Figure 8. A rectangular light spot is traversed across the junction. If central, each produces an equal signal which cancel if they are differentially-connected; this is the null position. Displacement from the null gives a proportional output until the spot moves entirely onto a single cell where a saturated displacement characteristic occurs.

In 1957 a lateral-effect position-sensitive photocell was reported in which the output is logarithmically related to the spot displacement as it moves between two ohmic contacts made on the junction surface. Extensive research was concentrated on these cells for tracking of military targets such as the plume of a missile.

A third form of position sensitive cell uses the light-spot as a contact 'wiper'. Its effectivity shorts a low-impedance, via a photo conductive strip, to a position along a high-impedance potentiometer track.

In most of these optical position-sensing methods it is paramount that the beam intensity remains constant as output away from the null (at the null point intensity is less important) is proportional to the luminous flux falling on the cells. This in turn, is decided by the total beam flux and its distribution.

Another way to detect position is to have an array of photo-diodes, interrogating them to find the position of a spot or a pattern illuminating them. Arrays containing 2500 diodes have been made.

These optical methods can detect movements perpendicular to the beam's axis. Interferometry can detect movements along the axis to extreme precision.

If a coherent radiation source is split into two paths, each being optically mixed upon return from reflectors, the position of the interference fringes resulting is a direct measure of length differences between the two arms. If one arm is fixed as a reference length, displacements in the other arm can be measured by monitoring the fringe movements. A unit developed in Britain is shown in Figure 9. Suitable radiation wavelengths range from millimetres to micrometres, so in most cases the monitoring task involves whole fringe counting and then fringe width subdivision or interpolation. The shortest practical wavelength is around 500nM, which in the simplest interferometer accounts for 250nm displacement of the measuring arm.

One well-used method of interpolation is to produce two signals from the fringes which are 90° spatially separated. Digital operation on these dc coupled signals will yield a divide by 4 factor. This technique was developed simultaneously in 1953 for interpolation in an interferometer and in Moire grating use for industrial control by Ferranti. A number of totally electric methods have been devised to obtain improved resolution from dc quadrature-phase signals. These include mechanically activated sine and cosine potentiometers driven to balance, use of resistance networks to produce a set of different phase triangular signals which can be divided by trigger levels and super-position of the signals on to an ac carrier which then enable phase-sensitive detection to be used. At the best, however, only 1% precision can be retained.

Another way to interpolate the fringes is to drive the return mirror so as to maintain the fringe in a constant position. This method has been used in the University of Cambridge laser earth strain meter. In all cases of fringe monitoring, however, it is possible for optical and electronic noise to displace the fringe too rapidly for the system to record, thus losing or gaining an integral number of error counts.

Laser interferometers are used in industry for the exacting calibration of jig boring mills and the like. With the industrial units, the effects of the air (that is the change in temperature, humidity and pressure) limit the precision to around 1 part in a million. This is improved by feeding back data on the conditions using appropriate transducers. In some applications, notably earth strain interferometers, the complete system is contained in an evacuated tube to avoid these errors. In such cases, precision of around 1 part in 10,000 million are realised if the wavelength of the laser is stabilised.

Concluded overleaf

TRANSDUCERS IN MEASUREMENT AND CONTROL

Miscellaneous:

The above are the most popular methods for sensing small displacements. There are many other ways to solve the problem and each has its particular attributes which make them suited to special applications. Here are just a few.

Radiation Gauging – Here a source of short wavelength radiation (α,β and γ) is located on one side of the (thin) material to be measured. The degree of absorption, measured by a radiation counting detector on the other side, is a measure of thickness. A number of variations exist on this, for example, shuttered absorbers are used to measure axial displacement in turbines and one-side gauges have application in continuous thin plastic-film measurement. The measurement precision depends upon radiation count integration so accuracy is increased by averaging the count over a longer period.

Ultrasonic Gauging – If the velocity of propagation is known, the transit time of an acoustic wave within a material is a measure of thickness. Sound waves travel at about 300m/sec in air, 1500 m/sec in water and 5000m/sec in metals. This principle has been used for small distance gauging. The slower velocity of acoustic waves, compared with electro-magnetic radiation, enables finer resolution to be obtained for a given technological limit on transit time measurement. An extensive study of an ultrasonic micrometer has been made at the Atomic Energy Research Establishment in Britain where they have developed units that resolve to 2μm. Ultrasonics have been successfully employed for engineering component thickness measurement, corrosion thickness measurement in pipes, (see Fig. 10), and for medical applications in which foreign objects are located, growths discovered and probes guided.

Laser Beam Diffraction – Coherent radiation diffracts around a small object to produce an interference pattern beyond it. This has been used to gauge wire size diameters down to 10 m. The position of the chosen diffraction fringe, (best produced by a laser source) can be monitored by a position sensitive photocell to enhance the resolution. This method is capable of size measurement at very high speed.

Sub-millimetre Waves – In many applications of interferometry the wavelength of the source is too short compared with the surface finish to be gauged against, and a mirror must be added. The National Physical Laboratory in England have developed an interferometer using submillimetre waves of wavelength 50-1000μm. Their device has been called the Teramet. It can measure to normal tight engineering tolerances (2μm) but needs no specially-provided reflector as in laser interferometry.

Other lesser known techniques include vibrating-wire strain gauges in which the tension of a continuously vibrated wire is varied. (The resonance frequency is then a measure of length change causing the tension change); piezo-electric crystals in which a force (accompanied by very small proportionate compression or extension) produces an electric charge flow which can be calibrated as displacement; pressure sensitive paints and semiconductors that exhibit resistance changes as they are deformed mechanically; and the use of a television pick up tube (usually the vidicon) to produce serial electrical signals of an optical shape enabling amplification to be achieved and an electrical output to be obtained.

In the next article we shall deal with methods for converting lengths from several millimetres to celestial distances into electrical signals for use in applications ranging from control in the workshop to guidance in space. ●

THREE IN HAND

Keithley's new digital multimeter has the readout in unit with the probe.

In practically every branch of electronics or electrical engineering, there is a need to make quick, accurate measurements of voltage, resistance and current.

But as circuit assemblies become ever smaller, the need to locate a test probe onto a component, (or a thin track on a printed circuit board) whilst one looks at a meter some distance away – becomes increasingly tedious.

Keithley's new digital multimeter – designated type 167 Digital Multimeter – has resolved this problem by building a solid-state readout right into the unit's hand-held probe.

The unit measures dc voltage from 1mV to 1000V and ac voltage from 1mV to 500 volts. As an ohmeter the unit measures 1 ohm to 20 Megohms. Current measurements can be made with optional shunts.

To obtain a three digit readout small enough to be built into a hand-held probe, a custom designed, solid-state, gallium arsenide phosphide display module 0.4" x 0.2" x 0.75" long was fabricated. Apart from three full, seven segment digits it contains decimal points, overrange "1", minus sign, and function indicators.

Multiplexing the display has reduced the number of wires in the cable between the probe and battery pack. To display all the digital information would normally require 23 lines for the three digits plus over-range "1", with an additional four lines for decimal point, one line for polarity, four lines for function, and one common return line, making a total of 33. Multiplexing reduces the number of lines required to 12.

The multiplexing drives eight lines, containing the data for a single 7-segment digit, plus the decimal point associated with that digit. The overrange "1" in the display as well as the minus sign and four function indicators form another "7-segment" digit – although the digit is dismembered. The cathode for this dismembered digit, as well as those for the other three whole digits, is also controlled by the multiplexing circuitry. Thus, the cathode lines determine which digit will display the information contained on the data lines at any given instant.

The 167 has automatic ranging and polarity sensing. The ranging circuit is located on the LSI module (along with the digital circuitry) except for five discrete diodes which decode the ranging signals from the module. The use of FET type range switches simplified the circuitry since the gates of the FET's can be turned on directly by low-level signals from the LSI module.

An absolute-value amplifier on the input determines polarity and also reduces the number of components in the A-D converter. The absolute-value amplifier is an arrangement of op-amps that provides a positive voltage output – no matter what the polarity of the input. Polarity sensing is obtained by monitoring direction of conduction in one of the op-amp feedback loops. The amplifier also rectifies incoming ac signals to provide the 167 with its ac ranges.

Since the A-D converter only has to handle a single polarity, the number of components and the converter's complexity are reduced. The A-D converter consists of only one LSI module and two IC's and thus contributes to long battery life.

BATTERY OPERATION

By incorporating a highly efficient power regulator, the total power dissipated by the unit was kept small enough for battery operation to be used. Additionally, the unique power regulator of the unit required no warmup – merely turn-on. Thus, a "Push-to-Read" switch could be built into the probe and a user could obtain a meaningful measurement from a cold start in less than two seconds (that includes turn-on, ranging time, and settling time to rated accuracy on the final range).

The power from the batteries is transformed to +12, –5 volts by a highly efficient switching regulator.

The output of the regulator is monitored to assure that sufficient energy to run the unit is available. When it is not – either because the batteries are too weak or the supply somehow gets shorted out – the regulator (and thus the instrument) turns off. Thus, excessive discharge of batteries is prevented. This extends the life of rechargeable batteries and prevents potentially destructive battery leakage.

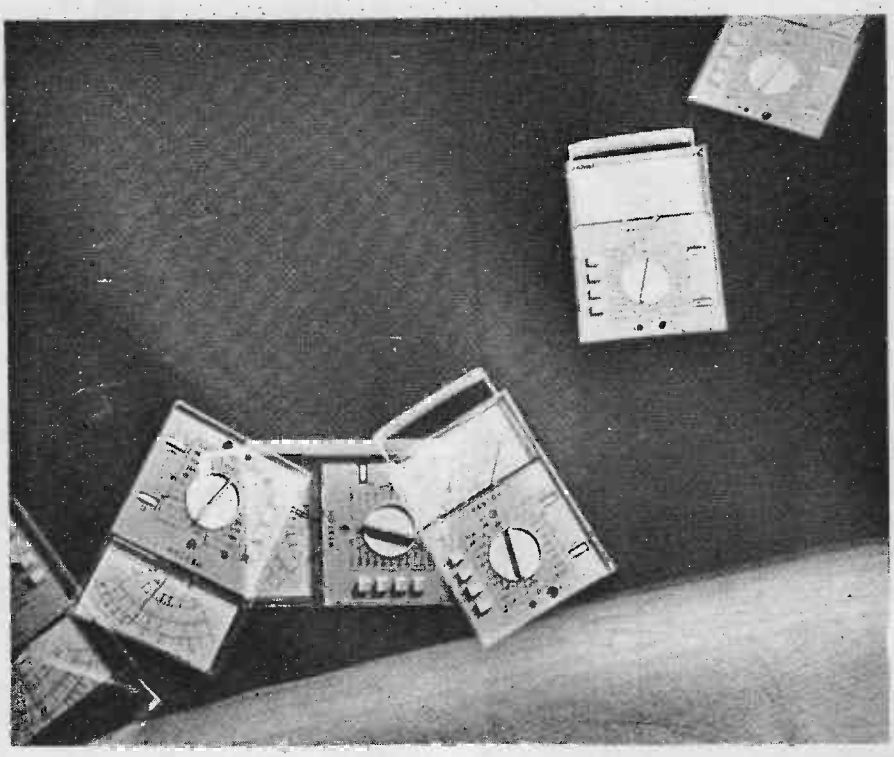
LARGE SCALE INTEGRATION

Large scale integration is employed to minimize the number of discrete components and their required connections. A single LSI chip contains the digital section of the A-D converter, BCD counters, latches for the display, multiplexing circuitry, BCD to 7-segment converter, range counter, function decoder, overrange circuitry and timing circuitry. This one package contains the complete digital section of the instrument and replaces 55 TTL packages of MSI and SSI complexity.

The number of discrete components was minimized by use of thick film resistor networks which had the added advantage of providing excellent stability over wide temperature ranges. ●

DROP-PROOF MULTIMETER

Schlumberger claim their 660 Series VOM to be drop-proof — we took them at their word — here's how it performed.



The firm of Weston Instruments Inc. are well known in the electrical and electronics industries as manufacturers of precision instrumentation. Weston were one of the pioneers of the basic D'Arsonval moving coil meter movement and over the years have continually improved the design. One of their most recent developments is the drop-proof taut-band meter movement used in the Schlumberger Model 666 V.O.M.

The Schlumberger 660 series meters are available in five basic versions, all housed in the same drop-proof, blue-grey, polycarbonate case. This case has a raised front panel edge to protect the meter face and front panel controls. The snap-on range plate is reverse engraved in black with a light grey background. The range switch push buttons and calibration potentiometer knobs are made from white plastic. These harmonise well with the blue-grey housing, and light grey range plate.

THE 660 SERIES METERS

The 660 series meters have a broad range of sensitivities and optional features. The first of these, the model 660 has

MEASURED PERFORMANCE OF SCHLUMBERGER MODEL 666 V.O.M. METER SERIAL NO 83804

D.C. CURRENT

Selected Range	Input Current	Meter Reading
30 mA	29.9 mA	30 mA
	9.99 mA	10 mA
10 mA	9.95 mA	10 mA
1 mA	1.00 mA	1 mA
	0.900 mA	0.9 mA
	0.800 mA	0.8 mA
	0.710 mA	0.7 mA
	0.610 mA	0.6 mA
	0.500 mA	0.5 mA
	0.410 mA	0.4 mA
	0.300 mA	0.3 mA
	0.210 mA	0.2 mA
	0.104 mA	0.1 mA
100μA	100.4 μA	100μA
10μA	10.1 μA	10μA
1μA	1.00 μA	1μA

A.C. CURRENT
Linear From 50Hz to 20,000 Hz ± 1%

Selected Range	Input Current	Meter Reading
30 mA	30.0 mA	30 mA
10 mA	9.97 mA	10 mA
1 mA	1.01 mA	1 mA
100 μA	101 μA	100 μA
10 μA	10.1 μA	10 μA
1 μA	1.00 μA	1 μA

A.C. VOLTAGE at 100 Hz

Selected Range	Input Voltage	Meter Reading
1000 V	1000 V	1000 V
300 V	300 V	300 V
100 V	100 V	100 V
30 V	30.0 V	30 V
10 V	10.0 V	10 V
3 V	3.00 V	3 V
1 V	1.01 V	1 V
0.3 V	0.300 V	0.3 V
0.1 V	0.100 V	0.1 V

"Consider that men will do the same things nevertheless, even though thou shouldst burst"

– Marcus Aurelius Antoninus.

electronics TODAY INTERNATIONAL

product test

the following ranges:–
DC volts – 5 mV to 5000 V
AC volts – .05 V to 5000 V
DC amps – 1μA to 10A
Ohms – $\frac{1}{2}\Omega$ to 20 M Ω
dB scales – -10dB to +56dB

The required range is selected by a large centrally located white knob and by use of the correct probe socket (total of seven). The instrument has a claimed accuracy of 2% on dc and 3% on ac ranges and is basically a passive multimeter.

The Model 662 V.O.M. features the same ranges and accuracy as the 660 but is also fully protected by a resettable relay type of overload circuit.

The models 661 and 663 are higher accuracy versions of the 660 and 662 (respectively). They have the same basic ranges with accuracies of 1% on dc and 2% on ac.

The only noticeable external difference between the 661 and 663 is the mirrored strip on the 663 meter scale.

The Model 666 reviewed in this article is completely different from those mentioned above in that it is an active, solid state multimeter specifically designed for the electronics industry.

THE MODEL 666

The Model 666 has four clearly labelled push buttons located on the lefthand side of the front panel. These provide the following meter mode selections:–

The top button labelled "AC" is for ac voltage, ac current and decibel measurements (reference 1dBm or 1 milliwatt into 600 ohms).

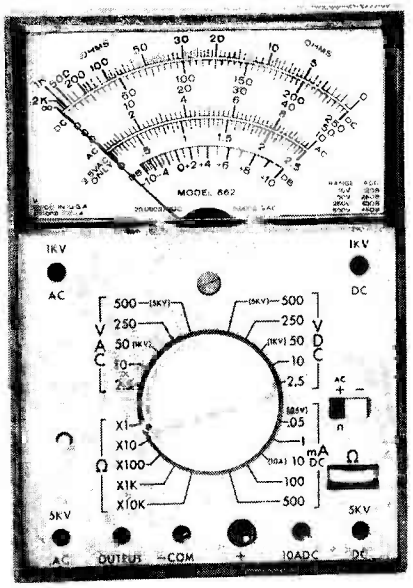
A second button labelled "ΩLV" programmes the instrument for resistance measurement by the application of a very low voltage (85 millivolts open circuit). This facility is invaluable for checking resistors in semiconductor circuitry, and for the measurement of low wattage, low value resistors.

The third button is labelled "DC – Ω" and is used for reversed dc measurements, or resistance measurements with the test voltage polarity reversed.

The last button is labelled "DC + Ω" and is used for conventional polarity dc measurements, or resistance measurements with the test voltage conforming to the test probe polarity.

A large range selector knob is located in the centre of the snap-on range plate. The "off" position is in the twelve o'clock position. The selectable ranges are shown in Table 1.

The "zero" and "infinity" set potentiometer thumbwheels are located at the righthand side of the range knob and provide smooth and adequate control within the normal range of battery operating voltage.



Another in the Schlumberger 660 range, this 662 VOM features passive circuitry. It has the same 'droppable' characteristic of all the 660 range of instruments.

METER SCALES

The meter dial, which is approximately 4" x 2", has five graduated scales. The top scale, for resistance measurements, is graduated from 0 to 1k.

The next scale is for both voltage and current measurements and is graduated from zero to 1 for use on ranges that have full scale readings that are multiples of ten.

The third scale is for both voltage and current measurements and is graduated from zero to 3 for use on ranges which have full scale readings that are multiples of three. The second last scale is graduated from —20 to +2dB.

The bottom scale, which is for null

D.C. VOLTAGE

Selected Range	Input Voltage	Meter Reading
1000 V	1001 V	1000 V
300 V	300.1 V	300 V
100 V	100.1 V	100 V
30 V	30.02 V	30 V
10 V	10.07 V	10 V
3 V	3.02 V	3 V
1 V	1.01 V	1 V
0.3 V	0.300 V	0.3 V
0.1 V	0.100 V	0.1 V

dB SCALE

Selected Range	Attenuator Step	Meter Reading
0 dB	0 dB	0 dB
	-1	-1.0
	-2	-2.1
	-3	-3.1
	-4	-4.4
	-5	-5.2
	-6	-6.2
	-7	-7.3
	-8	-8.3

Selected Range	Attenuator Step	Meter Reading
0 dB	-9	-9.4
	-10	-10.5
	-12	-12.5
	-14	-15
	-16	-17
	-18	-19
	-20	-21

The -10 dB, +10 dB and +30 dB scales are accurate throughout the entire scale.
The -20 dB, +20 dB and +40 dB scales have the same reading errors as the 0 dB scale shown previously.

OHMS

Selected Range	Source Resistance	Meter Reading
X 1 L.V.	300.0	400
	99.98	50
	3.000	2.95
	0.9998	1.00
X 10 L.V.	9998	10,000
	3000	4000

Selected Range	Source Resistance	Meter Reading
X 10 L.V.	1000	1000
	300.0	300
	99.98	99
	30.00	29.5
	9.998	9.8
X 100	9998	10,000
	3000.5	3050
	1000	1050
	300.0	300
	99.98	100
X 1000	9998	10,050
	3000.5	3000
	1000	1000
X 10k	9998	10,000
	989,700	1×10^6
X 100k	989,700	1×10^6
X 1M	989,700	1×10^6

DROP-PROOF MULTIMETER

detection is centrally located and approximately ½" long. The centre stroke is marked "O". Left and right extremities are marked minus and plus respectively. This scale may be used on the 0.1, 1.0, 10, 100 and 1000 volts dc ranges allowing null balancing to within 2% on these ranges. A scale to the right of this null scale indicates the acceptable battery voltage when the battery test position is selected.

CONSTRUCTION

The probe sockets are located at the bottom of the range plate and accept standard banana plugs. A 2 amp 240V fuse, which protects the input, is changed by removing the socket with a $\frac{3}{16}$" Allen key (or the rear battery cover retaining screw). A retractable plastic carrying handle is fitted to the top of the meter. The back cover is retained at the top end by two lugs and at the bottom end by a screw which also doubles as an Allen key for removal of the front fuse. Removal of this cover reveals the five batteries and the three printed circuit boards.

The circuit basically consists of a dual FET source follower input stage driving an IC operational amplifier. The major advantage of the dual FET input stage is the constant input impedance of 10 megohms irrespective of range selected.

When the source impedance of a measured voltage approaches the input impedance of a meter, serious measurement errors are introduced (equal impedances give 50% error). The constant 10 megohm input impedance of the 666 therefore allows much more accurate measurements to be made on its low ranges than is possible with a passive multimeter. This high input impedance is maintained on the ac ranges thus making the meter superior in this respect to the average VTVM.

Four "AA" size cells provide power for the FET and operational amplifier stages and a further size "D" cell is used as a current source for resistance measurements. The condition of the "AA" cells is monitored by switching to the battery check position.

No hook-up wire is used for connection within the meter. This unusual, but very practical feature ensures utmost reliability. The instrument is built onto three printed circuit boards. The push button switches are mounted directly onto a sub-board into which two other larger pc boards plug. Two sections of the five wafer function switch are mounted on the 'inner' of these two boards, and the remaining three sections on the 'outer'. All other connections, battery, meter and input terminals are all made directly to the boards. All board-mounted preset potentiometers are accessible by removing the "snap-on" range plate allowing adjustments to be made with the meter fully assembled.

Another worthwhile feature is the rubber covered test leads. These are superior to the normal PVC covered leads which are readily affected by heat.

Table 1

SCALE	READING	
BATTERY CHECK	full scale	
	full scale	
	full scale	ac or dc
	full scale	
	full scale	
	full scale	
	10 ohms centre scale	
	100 ohms centre scale	
	1000 ohms centre scale	high or low
	10 k ohms centre scale	voltage source
	100 k ohms centre scale	
	1 M ohms centre scale	
	10 M ohms centre scale	
	or	20dB
	or	10dB
	or	0dB
	or	10dB
	or	20dB
	or	30dB
	or	40dB
	or	50dB
	or	60dB

DROPPABLE METER

During the laboratory measurements we took Schlumberger at their word and dropped the unit several times from a height of five feet onto a carpeted floor and then once onto a concrete floor. After these drops there was no measurably change in sensitivity, but the case had a slightly deformed corner where it hit the concrete. The meter remained well within the manufacturer's tolerances on all ranges and scale calibration was maintained.

The only slight disadvantage we found with the meter was the constant 100 millivolt loss on the current measuring ranges. This could cause measuring errors on the 1 μ A range in some circuits.

The meter supplied was complete with a 27 page instruction book covering:

i) general description

ii) specifications

iii) operating instructions

iv) theory of operation

v) maintenance.

The section on "Theory of Operation" has schematic illustrations of each basic mode of meter operation, together with a basic circuit description. The maintenance section contains printed circuit board layouts, component values and part numbers, and gives comprehensive wiring diagrams.

The Schlumberger Model 666 Electronic V.O.M. is an accurate instrument that may be used for either laboratory or field measurements. It offers wide measurement capability and is surprisingly free of vices.

It is a very predictable instrument, offering an almost purely resistive load up to quite high frequencies on ac ranges.

The ability to withstand the shock of being dropped from a height of five feet onto concrete without mechanical damage or change in calibration makes this fairly expensive instrument well worth considering in view of its durability and reliability.

Being a transistorised voltmeter it will, no doubt, find increasing use in service organisations in preference to the traditional VTVM.

The provision of voltage and current ranges down to 100mV and 1μA respectively, is an improvement over existing multimeters. This is particularly true of ac measurements which previously could only be performed at these levels by using specialised laboratory equipment.

Currently Schlumberger have no plans to market the Model 666 in the UK, although others in the range are available.

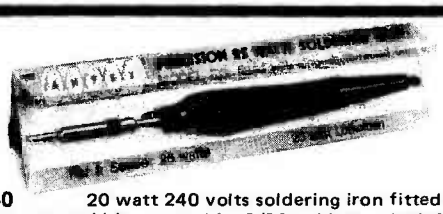
CN.240/2 Miniature soldering iron 15 watt 240 volts, fitted with nickel plated 3/32" bit and packed in transparent display box. Also available for 220 volts. **Price £1.70**

CN.240 Miniature soldering iron 15 watt 240 volts, fitted with iron coated 3/32" bit. Up to 18 interchangeable spare bits obtainable. This iron can also be supplied for 220, 110, 50 or 24 volts. **Price £1.70**

G.240 Miniature soldering iron 18 watt 240 volts extensively used by H.M. Forces. Suitable for high speed soldering and fitted with iron coated 3/32" bit. Also available for 220 volts. Spare bits 1/8", 3/16" and ¼" are obtainable. **Price £1.83.**

CCN.240 New model 15 watt 240 volts miniature soldering iron with ceramic shaft to ensure perfect insulation (4,000 v A.C.). Will solder live transistors in perfect safety: fitted with 3/32" iron coated bit. Spare bits 1/8" 3/16" and ¼" available. Can also be supplied for 220 volts. **Price £1.80**

CCN.240/7 The same soldering iron fitted with our new 7-star high efficiency bit for very high speed soldering The triple-coated bits are iron, nickel and chromium plated. **Price £1.95**



E.240 20 watt 240 volts soldering iron fitted with ¼" iron coated bit. Spare bits 3/32", 1/8" and 3/16" available. Can also be supplied for 220 and 110 volts. **Price £1.80.**

ES.240 25 watt 240 volts soldering iron fitted with 1/8" iron coated bit. Spare bits 3/32", 3/16" and ¼" available. Can also be supplied for 220 and 110 volts. **Price £1.83**

SK. 2 SOLDERING KIT

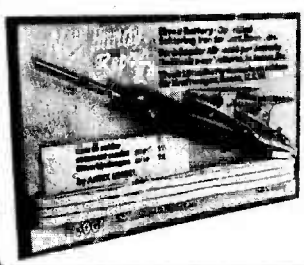
This kit contains a 15 watt 240 volts soldering iron fitted with a 3/16" bit, nickel plated spare bits of 5/32" and 3/32", a reel of solder, Heat Sink, 1 amp fuse and booklet "How to Solder".

Price £2.40.

SK.1 SOLDERING KIT

The kit contains a 15 watt 240 volts soldering iron fitted with a 3/16" bit, nickel plated spare bits of 5/32" and 3/32", a reel of solder, heat sink, cleaning pad, stand and booklet "How to Solder". Also available for 220 volts.

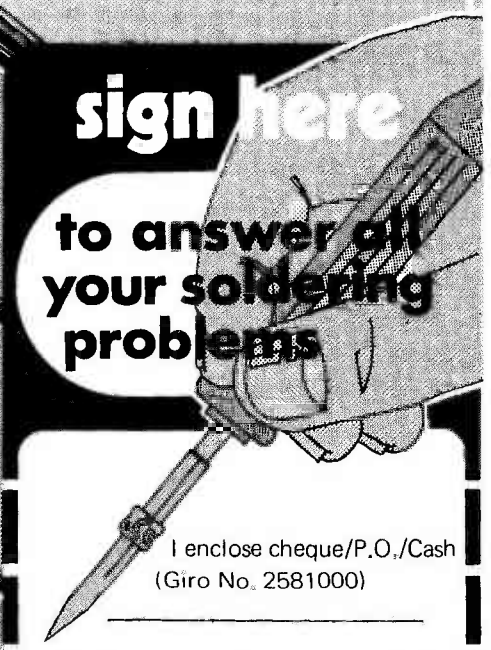
Price £2.75



MES. 12

A battery operated 12 volts 25 watt soldering iron complete with 15' lead, two crocodile clips for connection to car battery and a booklet "How to Solder" packed in a strong plastic wallet.

Price £1.95.



I enclose cheque/P.O./Cash (Giro No. 2581000)

Name _____

Address _____

ET5

☐ Please send the Antex colour catalogue.

Please send the following:

_____

_____

_____

A N T E X

from electrical, radio or car accessory shops or from **Antex Ltd., Freepost** (no stamp required) **Plymouth PL1 1BR** Telephone 0752 67377/8

PRACTICAL GUIDE TO TRIACS

Part 2 - Phase control

Last month we showed how Triacs are used as switches and the various ways they can be triggered. The second article of this three-part series describes how they are used to control the amount of power applied to electrical loads.

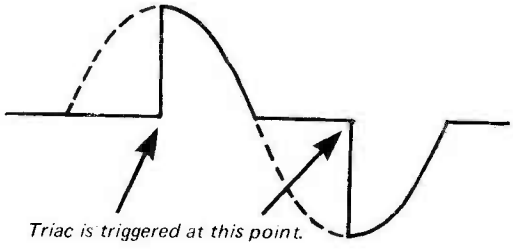


Fig. 16
Drawing shows Triac triggered at half-way point.

TRIACS not only switch power on and off and thus replace mechanical contactors — they can also control the *amount* of power applied to a load.

There are two quite different ways of using Triacs for this purpose — 'phase control' and 'zero voltage switching'.

Phase control is the method used to control light dimmers, electric motors, and for voltage and current regulators.

Heating loads can also be controlled in this way — but, for reasons outlined later in this article, zero voltage switching is a better technique.

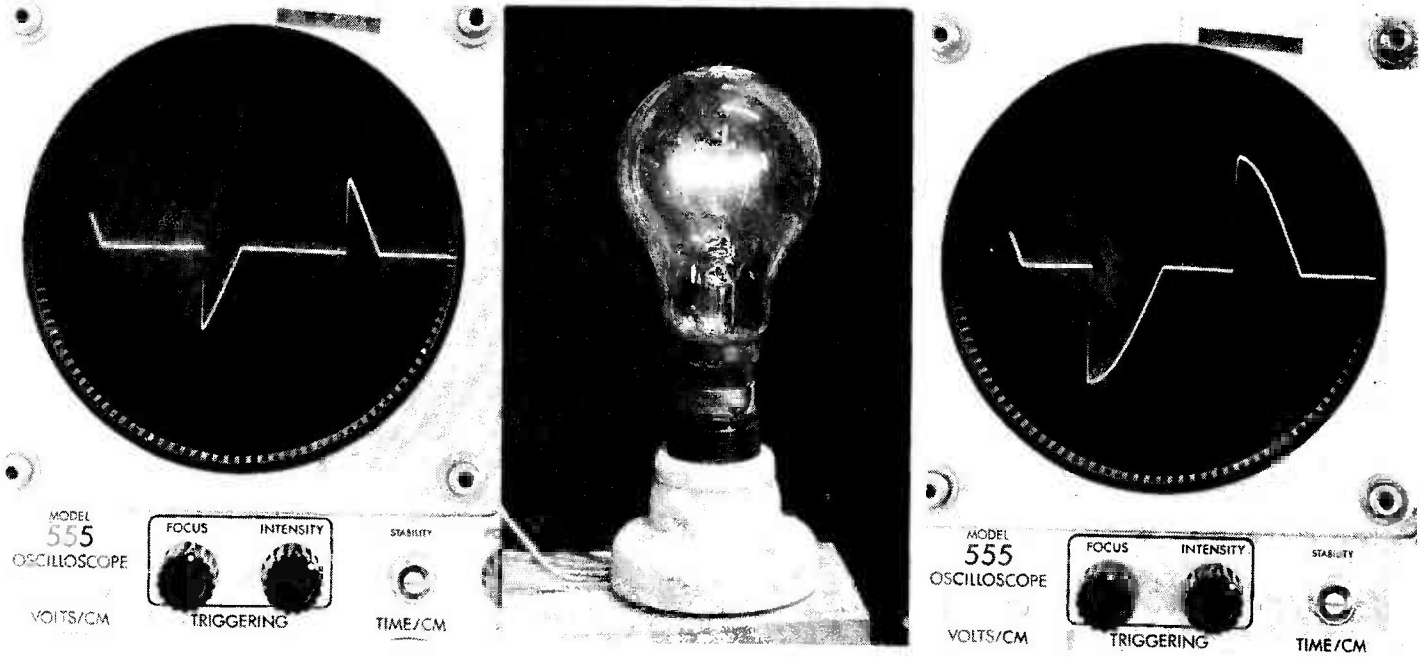
HOW PHASE CONTROL WORKS

A Triac can be triggered into conduction during any part of a half-cycle of applied voltage, and will *remain conducting* until the end of that half-cycle.

Thus, if a triggering signal is applied at the beginning of each half-cycle, the Triac will in effect conduct as if it were a switch that had been turned on. But if the triggering signal is applied halfway along the waveform, the Triac will conduct only for the remaining period of that half-cycle; and as the Triac conducts for only half the time it reduces the power applied to the load by roughly the same amount (Fig. 16).

Thus the power input to the load can be set at any level simply by

Fig. 17
Actual waveforms of a domestic light dimmer showing triggering at ¼, ½ & ¾ points. Note corresponding changes in lamp brightness.



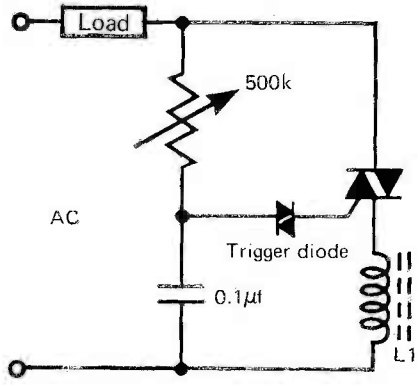


Fig. 18
Basic phase control circuit.

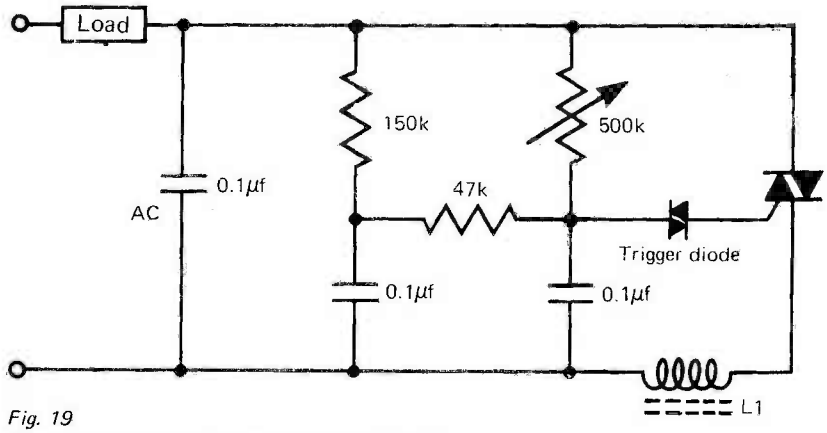


Fig. 19
Simple versatile phase control circuit is suitable for domestic light dimming and other resistive loads.

controlling the point at which the triggering signal is applied. Oscilloscope pictures (Figs. 17a, b, c) show the 50Hz waveform triggered at three different points. Notice the corresponding change in brilliance of the lamp used as a load.

LIGHT DIMMERS

The circuit of a commercially produced light dimmer is shown in Fig. 18.

During each half-cycle the 0.1 μf capacitor charges up (via the control potentiometer) until it reaches 30-32 volts. At this voltage the trigger diode conducts and the voltage across the capacitor 'gates' the Triac into conduction. (A neon lamp is sometimes used instead of a trigger diode).

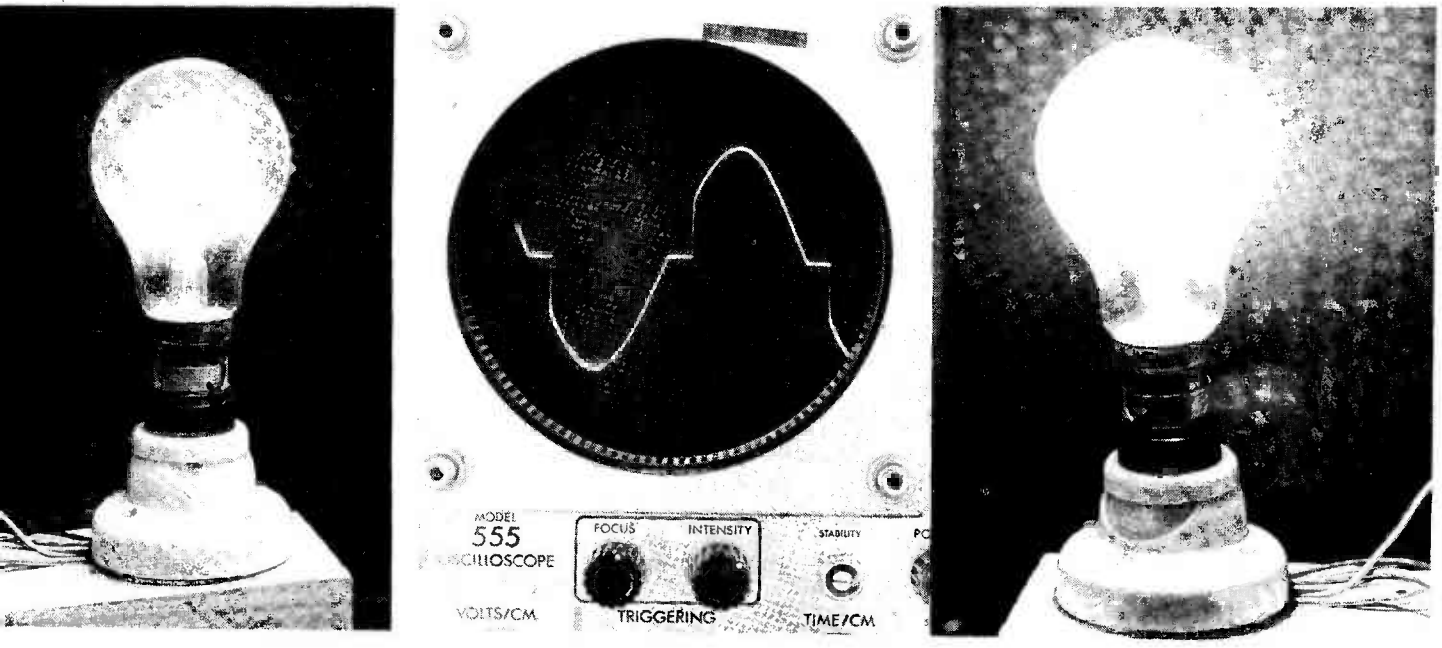
The time required for the 0.1μf capacitor to charge to the diode triggering voltage is determined by the resistance of the control potentiometer. When this is reduced to zero, the capacitor will charge to the trigger voltage instantaneously and the Triac will be gated into conduction for practically the complete half-cycle. At maximum potentiometer resistance the capacitor may not reach the diode triggering voltage until the end of the half-cycle, and the Triac will conduct for only a very short time.

The circuit shown in Fig. 18 is very simple and cheap to make but has one major limitation – namely, that power cannot be controlled smoothly from zero to maximum. As the potentiometer control is advanced, the load current will jump quite suddenly from zero to some intermediate value from which it can only then be controlled smoothly in either direction.

If the power supply is momentarily interrupted while the lights are dimmed below this 'jump' (hysteresis) level, the lights will remain off when power is subsequently restored.

REDUCING HYSTERESIS

The hysteresis effect is considerably reduced in the circuit shown in Fig. 19. This circuit is ideal for use as a domestic light dimmer. All components can be mounted behind a wall switch plate – and if the load



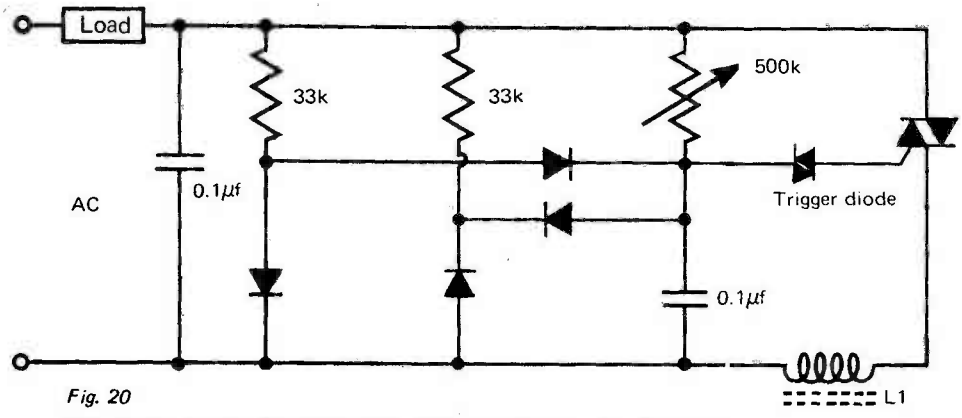


Fig. 20
Suitable for theatrical light dimming, this circuit has very low hysterisis.

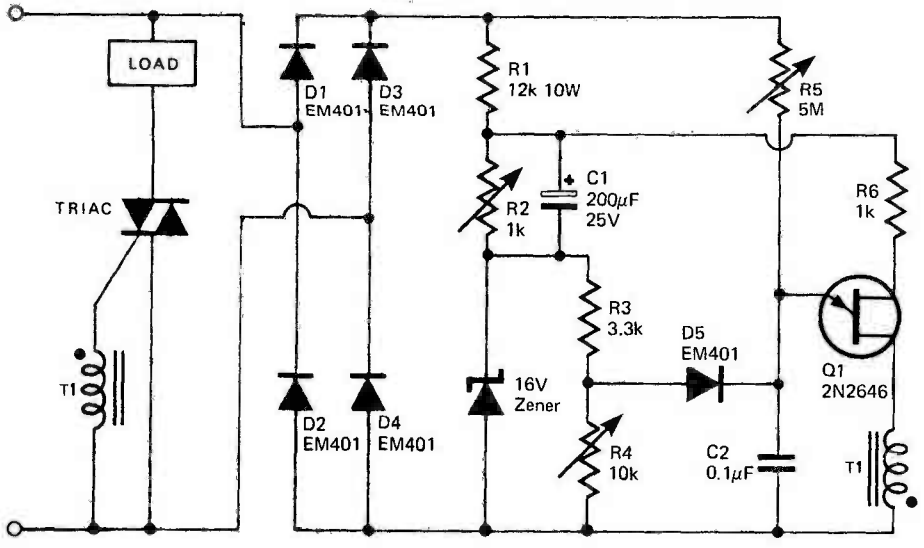


Fig. 21
Zener stabilised circuit maintains constant pre-set output despite changes in line voltage.

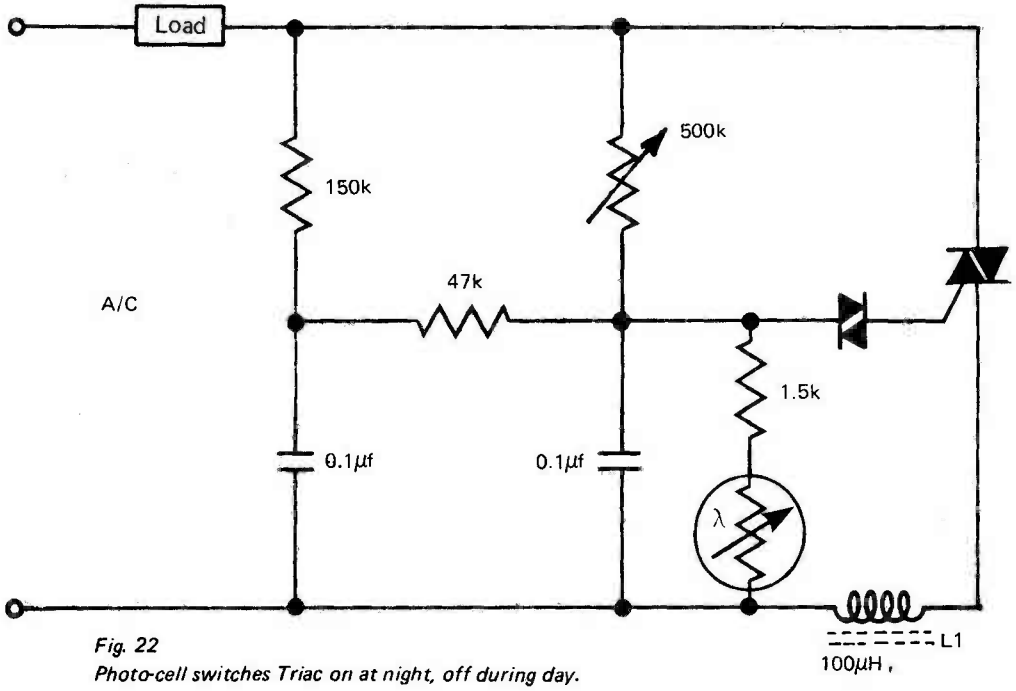


Fig. 22
Photo-cell switches Triac on at night, off during day.

does not exceed 200 watts, the Triac will not require a heat sink.

Almost total freedom from hysteresis is required for theatrical light dimmers. This can be achieved by using the circuit shown in Fig. 20.

WHAT SIZE TRIAC?

Incandescent lamps draw a very heavy current during the time taken for the filament to reach operating temperatures. This on-rush current may exceed the working current by 10 to 12 times. Fortunately domestic light bulbs reach working temperature within a cycle or two, and the short-term overload is absorbed by the Triac.

This does not apply to theatrical lighting equipment, where the larger wattage bulbs take longer to reach working temperature. For this type of use the Triac must be rated to carry at least five times the normal maximum load.

VOLTAGE FLUCTUATIONS

All the control circuits shown so far are voltage dependent – that is, the output voltage changes if the input voltage changes.

This voltage dependence can be overcome by using a circuit in which a Zener diode plus a dc error signal compensates for changes in line voltage.

This arrangement will hold the rms output voltage within 5% for a 50% change in line voltage. It is often used in photographic and other applications where a constant light level is required.

FLUORESCENT LAMPS

With all the phase control circuits shown so far, incandescent filament lamps can be controlled with no further modifications to the house lighting system. Fluorescent lamps can also be dimmed by this type of control unit – and the technique will be fully described in a future issue.

Quartz iodine and similar lamps using a regenerative halogen cycle should not be dimmed for any length of time. If the envelope temperature of the lamp drops below 250°C, the regenerating halogen cycle ceases. Tungsten from the filament will be deposited on the wall of the lamp, reducing filament life and decreasing the light transmission of the glass.

A modification which can be used with any of the circuits discussed so far is shown in Fig. 22. This arrangement turns lights on as darkness falls and turns them off again at daybreak. The photo cell must see ambient light and be shielded from the controlled light.

MOTOR SPEED CONTROL

Triac phase-control can be used to vary the speed of electric motors.

The universal type of series-wound motor may be controlled by circuits similar to those used for light dimming – except that, to ensure reliable commutation, a capacitor and series resistance must be connected in parallel across the Triac (Fig. 23). With this arrangement the speed of the motor will vary with changes in load and supply voltage, but for non-critical applications (such as fan speed control), where the load is constant at any given speed, the circuit may well be adequate.

Motor speed which, once pre-set, is maintained despite load changes is a useful characteristic for power tools, laboratory stirrers, watchmakers' lathes potters' wheels, etc. To obtain this 'load sensing' characteristic, an SCR is commonly used in a half-wave configuration (Fig. 24). The circuit works quite well over a limited range of speed but is prone to low-speed 'cogging' and the half-wave operating principle precludes controlled operation much beyond half speed.

A load sensing phase-control circuit in which a Triac provides full zero to maxiumum control is shown in Fig. 25.

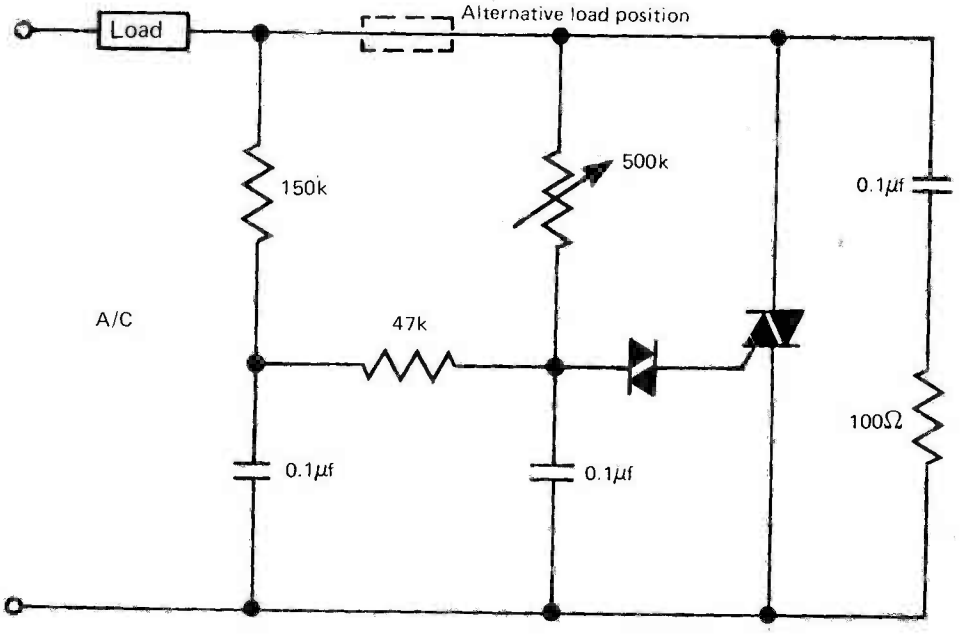


Fig. 23
Phase-control circuit for inductive loads, it may be necessary to connect the load in alternative position shown to obtain adequate control.

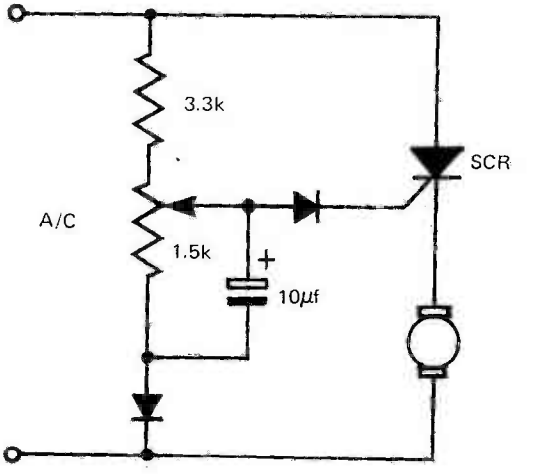


Fig. 24.
Half-wave SCR circuit provides feedback speed control.

INDUCTION MOTORS

Induction motors can also be Triac controlled – but some problems may be encountered, especially with split-phase or capacitor start motors.

In general, induction motors can be controlled between full and half speed, providing they are not run at full load. A reasonably reliable guide is motor operating temperature. This must not exceed the manufacturer's rating at any speed.

Once again, the modified light dimmer circuit shown in Fig. 23 can be used, but the load should be connected in the alternative position shown in dotted lines.

VARYING TRANSFORMER VOLTAGE

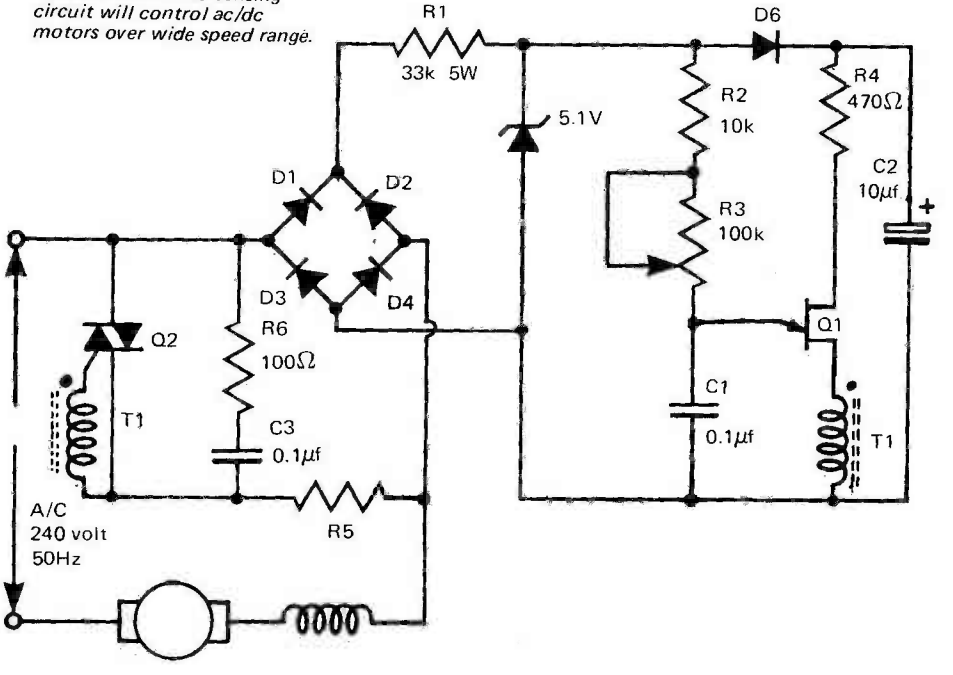
The circuit arrangement described above can also be used to vary the voltage in the primary winding of a transformer and thus obtain an adjustable secondary output.

This arrangement was used in a range of microscope lamp controllers designed by the writer some years ago. An adjustable zero-set was obtained by replacing the 47K resistor by a 100k potentiometer.

HEATING LOADS

Any of the Triac phase-control circuits shown so far can be used to control heating loads, although the

Fig. 25
This full-wave load sensing circuit will control ac/dc motors over wide speed range.



temperature of the controlled load will vary with changes in line voltage and ambient temperature.

A circuit which compensates for these changes is shown in Fig. 26. Theoretically this circuit can maintain temperature to within 1% of the set point despite line voltage changes of ±10%. Actual performance depends upon the design and construction of the system in which the controller is used.

This circuit provides proportional control – that is, full power is applied to the heating elements while the load is warming up, until, at some intermediate state, the power is reduced by an amount proportional to the difference between the actual load temperature and the required load temperature. The proportional band is adjustable by a 'gain' control.

The circuit is simple yet effective, but it has one major failing which restricts its use to all but light loads. This is radio interference.

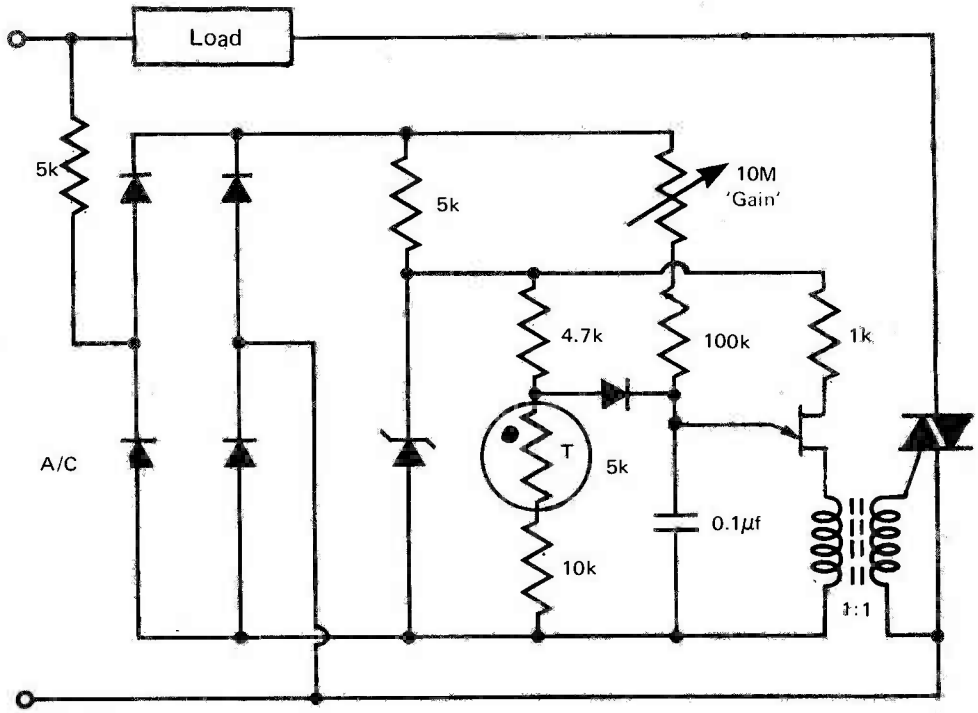


Fig. 26
This circuit provides proportional control of heating loads.

RADIO INTERFERENCE

All phase control systems generate large amounts of radio interference, primarily at low and medium frequencies. It seriously affects the long and medium wave reception of radio transmissions and will also be picked up by audio equipment, when it is heard as a raucous buzz. This rfi can also interfere with laboratory apparatus, especially pH meters, and has been known to cause erratic operation of digital computers and other equipment.

The radiated energy can be reduced by including an rf choke in series with the power line (shown as L1 in circuits accompanying this article). A suitable choke can be made by winding 40 to 50 turns of enamelled copper wire around a piece of ferrite aerial rod. This will provide an inductance of approx. 100 μH. For greater suppression it will be necessary to increase the inductance to as much as 5 μH, and this neccessitates a full-size choke.

The limitation of this type of circuit is that the rf choke has to carry the full load current, and once this exceeds a kilowatt or two, the physical size of the choke becomes excessive. The larger the load, the more difficult and expensive it becomes to filter out the rf components. (The problem is not as acute for inductive loads such as electric motors, where the load itself attenuates the rfi).

Phase control also introduces another problem – namely the load power factor. This is adversely affected and is something that power supply authorities regard with less than equanimity.

ZERO VOLTAGE SWITCHING

Virtually total freedom from rfi can be achieved by a Triac control system known as zero voltage switching.

This system differs from phase control in that line voltage is switched 'on' as well as 'off' only at the zero crossing points of the sinusoidal waveform. The power applied to the load is controlled by varying the ratio of time that power is applied, to the time that power is switched off. For example, if only a small amount of power is required, the Triac is caused to pass just a few complete half-cycles, then remain switched off for a further 30 or 40 complete half-cycles before repeating the sequence. (Fig. 27).

It will be apparent that the zero voltage switching system can only be used to control loads that have considerable inertia, such as heating elements which by their nature will average out the bursts of energy. Zero voltage switching cannot be used for controlling lighting or motor speed.

Load power factor is not affected in any way by zero voltage switching.

Until recently the drawback to zero voltage switching was that the technique required a large number of components.

Fortunately the functions necessary for zero voltage switching have been made available in an integrated circuit – and, by using this specialized ic, zero voltage switching circuits can be built that are outwardly no more complex than their phase control equivalents.

A full description of zero voltage switching techniques will form Part III of this article, to be published next month. ●

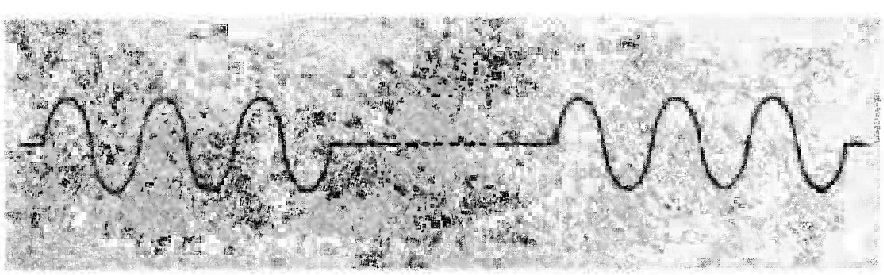
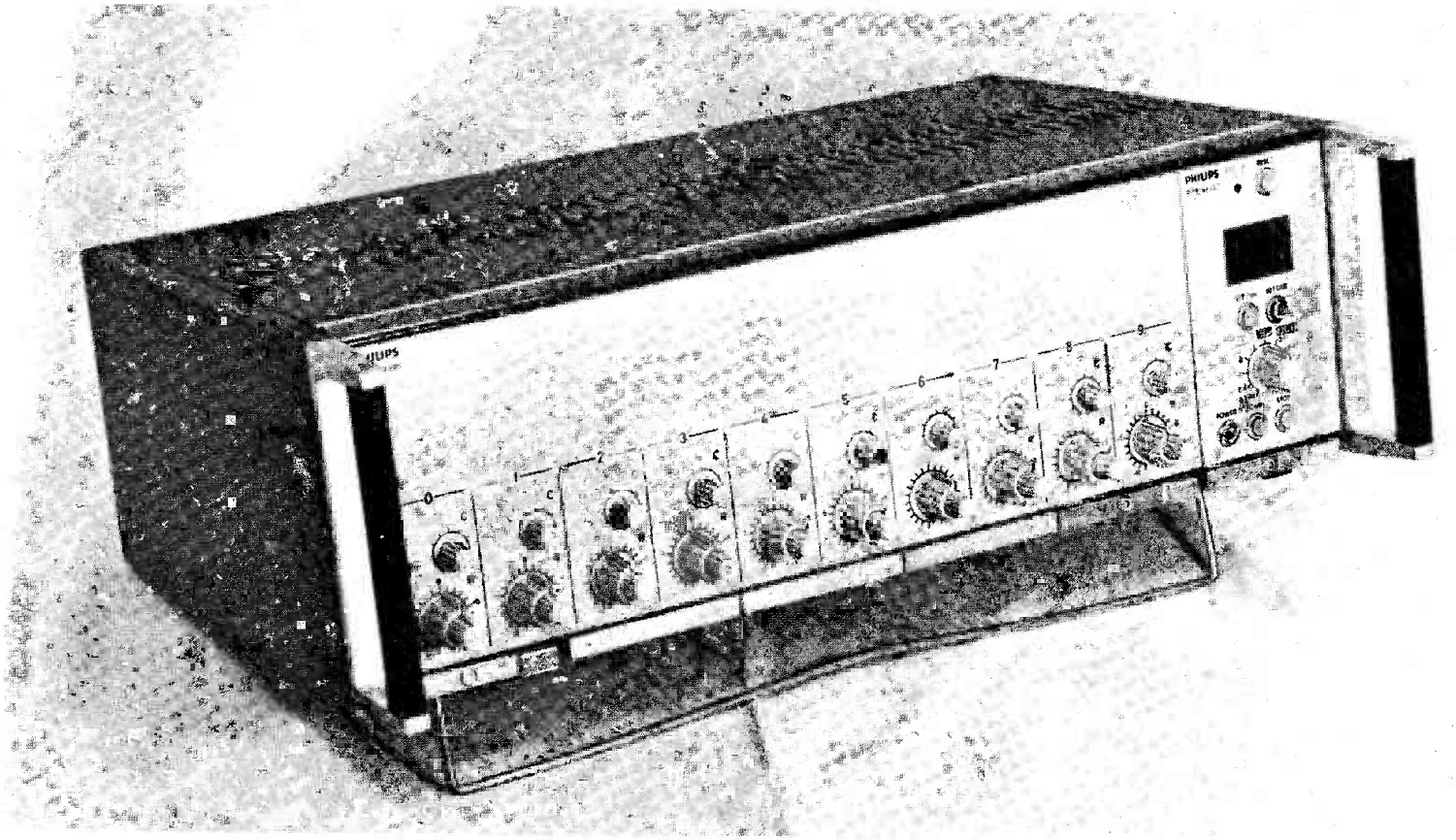


Fig. 27
Zero voltage switching waveform – power is controlled by varying the ratio of complete half-cycles 'on' to complete half-cycles 'off'.

NEW SCANNING SYSTEM

Multi-channel scanner uses pre-heated strain gauges to ensure drift-free measurements



A COMPACT multi-channel bridge-balancing and scanning system in which preheating of strain gauges prior to measurement ensures drift-free operation and permits high-speed scanning, has just been introduced by Philips. The system can be used accurately to balance and continuously scan up to 100 individual strain-gauge or transducer-bridge networks.

The system is intended for use with strain gauges, transducers employing such elements, and inductive transducers, and can be employed in test and monitoring systems measuring such parameters as stress/strain, pressure, acceleration, differential pressure, torque, displacement and temperature. It is intended to be used in conjuction with measuring bridges such as Philips PR 9307 or PR 9308 and a recorder or oscilloscope, and provides a very effective means of monitoring physical parameters that vary at medium and low frequencies.

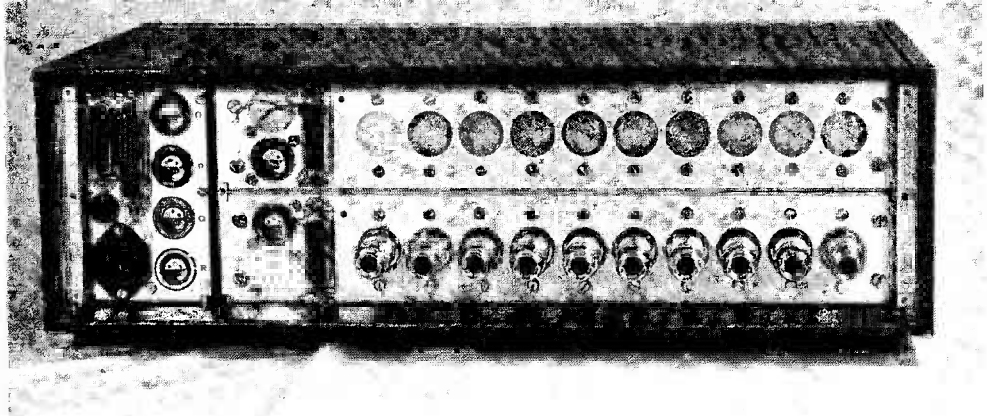
BALANCING TO WITHIN 0.05 u STRAIN

The PT 2266 system comprises two basic units: one 10 or 20-channel bridge-balancing and switching unit and a control unit. The bridge-balancing unit permits each bridge network to be accurately balanced to within 0.05 u strain through combined use of a 23-position resistor network and a 10-turn potentiometer, and allows strain-gauge imbalances of up to ± 2.5% to be corrected. During actual measurements, all the strain gauges except the one being measured are pre-heated to eliminate drift problems. When the scan switches to a new channel, then the pre-heating is switched from this channel.

The above system can be used with strain gauges connected in quarter, half and full-bridge circuits employing 2, 3, 4, 5 and 6-wire conductor systems. With all these circuits a special relay-contact configuration can be used to eliminate any instability in contact resistance. The system can also be used with strain-gauge type transducers, inductive transducers and thermo-couples. With all the above connections plug-in circuit boards within the unit provide the additional bridge components necessary for each measurement-point network.

Scanning of the 10 or 20 channels is carried out via the control unit. This permits the following scanning modes:

1. Manually-controlled scan
2. Automatically-controlled scan



3. Automatically-controlled scan for one cycle
4. Scan controlled by external pulses

In the continuous-scanning mode one of four speeds between 0.5 and 10 channels/s can be selected. The slowest of these speeds is used mainly for balancing purposes and for measurements with low-speed recorders. If the scan is controlled by an external pulse generator, then it is possible to have a variable scan speed.

When more than 20 channels are needed in the test or monitoring system, additional 10 or 20-channel units can be added, up to a total of 100. In such cases it is necessary to use a group divider unit that switches the control unit's connections from one 10 or 20-channel balance unit to the next as the scan proceeds. A digital display on the control unit indicates the particular channel being scanned at any given time.

ZERO AND SENSITIVITY CHECK AS OPTIONS

As well as its standard features, two options will shortly be provided. The first of these permits the measuring bridge or channel's sensitivity to be measured against a calibrated signal whose amplitude can be adjusted. The second allows the K-factor of each channel to be adjusted with the range 2.2 to 1.8 thereby permitting its sensitivity to be adjusted. Other K-factor ranges can be provided for measurements with inductive pick-ups.

The complete PT 2266 system makes extensive use of high reliability relays and printed-circuit techniques, and alos employs high-quality Lemo plugs to minimize contact-resistance variations which are critical in circuits where signal levels are in the microvolt region. The system's compact dimensions make it suitable for mounting either in 19-in rack or test-bench housings. Normally, one control unit and a 20-channel balance unit can be accommodated in one 19-in rack drawer and additional units can be added in adjacent drawers. A complete 100-channel system can also be accommodated in a standard 15 x 5¼ in bench housing. ●

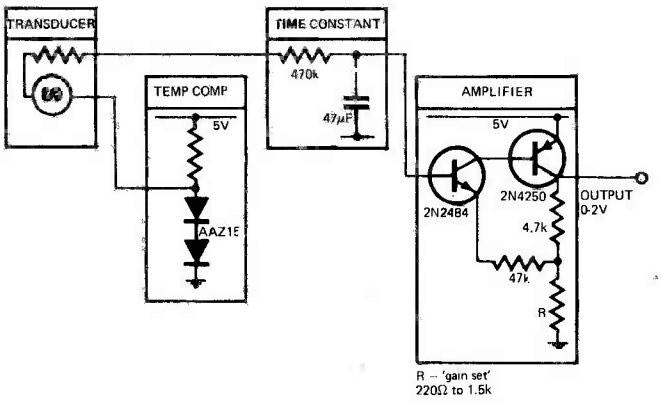


Fig. 16. Meteorology electronics.

temperature change +20°C to −75°C, the impact strength at −40°C may be only 12 percent of that at +20°C; this emphasises the mechanical design criteria of avoiding sudden loads – achieved in the auroral camera by geneva drive to the film.

Mylar base magnetic tape is adequately flexible at −80°C and at slow tape speeds significant mechanical stress is avoided. The permeability of ferrite falls with temperature decrease; at −100°C a value about 50 percent of that at +20°C is typical.

Accurate timing is fundamental in geophysical research for the inter-relation of data. For the work covered by the present observatory an absolute accuracy around 10 seconds is required throughout the year; long-term stability is thus the major criterion.

The observatory uses a stable quartz crystal reference divided to provide time pulses and BCD time data in the range one second to 999 days.

CHRONOMETER

For chronometer accuracy of ten seconds per year, a long-term stability of 3×10^{-7} is required. Assuming stable operating conditions and linear aging, the reference crystal must have an average weekly rate within 1×10^{-8}, Modern frequency standards, based on ovened AT-cut crystals, readily meet this requirement but with power consumption of typically 15 watts. For low-power operation the oven must be either eliminated, or drastically reduced in power.

Over the past decade, Antarctic Division station chronometers have used DT crystals as the frequency reference. After an initial ageing period, these crystals have maintained a stability around 1×10^{-7} per month, using simple ovens. More recent work with high stability proportional ovens has shown frequency stability approaching the present requirement of 3×10^{-8} per month. Crystal ageing may be related to manufacturing procedures, current techniques appearing to ensure a low ageing rate after an initial operating period of about two months.

The temperature for zero coefficient of DT crystals may be controlled in manufacture to within 10°C over a wide range. By choosing this temperature to be 20–30°C above the mean annual temperature for the site, the oven power is minimized for the temperature expected in the shelter.

Due to difficulties with the GT crystal, the ovened DT was chosen. The Colpitts derived oscillator (Figure 11) and the temperature controller are mounted in the oven.

CRYSTAL OVEN

The circuit of the oven temperature controller is shown in Figure 12. The oven temperature is sensed by a thermistor. Over a one-month test period, the temperature was maintained within 0.02°C for an ambient temperature range of ±15°C and supply variations of five to ten volts.

FREQUENCY DIVISION

The Antarctic Division's experience has shown that binary ripple counters are superior in conditions of low temperature, variable supply voltage and noise. At clock rates of less than 10kHz the principal load of a binary counter is its static power consumption. As frequency rises the circuit dynamic impedance must fall to cater for the increased switching speeds, with consequent rise in power consumed. A typical power frequency profile, comparing 10 kHz power consumption with that at 10 kHz and 1 mHz, shows a respective power increase of three and 100 times, thus power is conserved by limiting the reference frequency. From consideration of stability and power, a fair compromise in the present application is 100 kHz.

The basic binary circuit (Figure 13) consumes about 0.1 milliwatts and operates at temperatures from +40°C to −100°C with supply voltage in the range three to 10 volts.

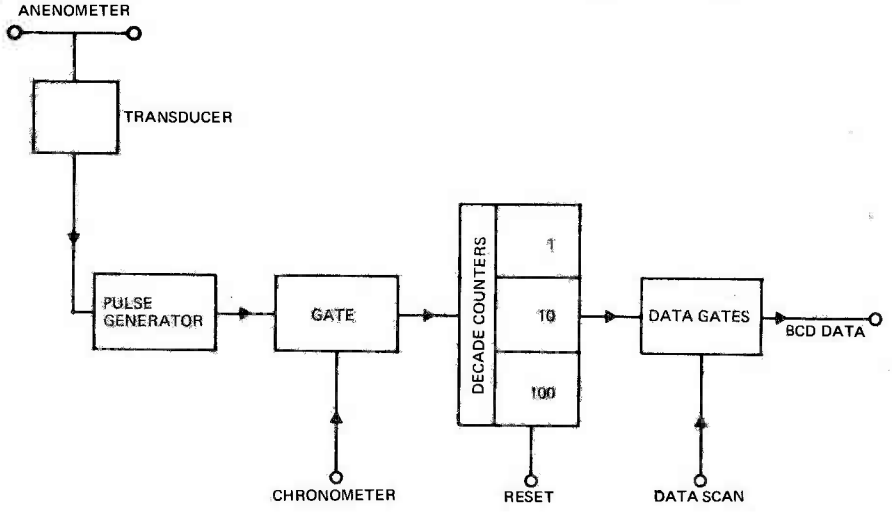
The complete chronometer is illustrated in Figure 14.

THE INSTRUMENTATION

The riometer is a device that measures the relative opacity of the ionosphere due to changes in the electron density.

Basically, it is a 30 MHz radio receiver coupled to an antenna that looks vertically. The riometer compares incoming cosmic noise passing through the atmosphere, with a noise source reference. It uses synchronous detection and a

Fig. 18. Anemometer electronics.



servo-controlled system to balance the two noise signals. A block schematic drawing of the riometer is shown in Figure 15.

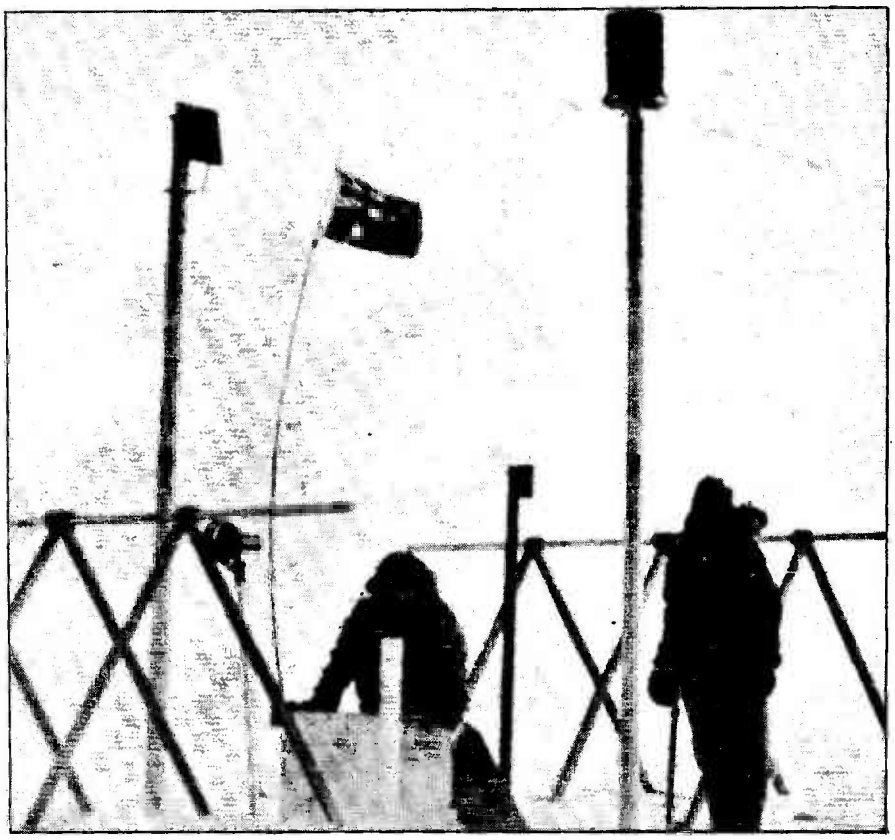
Existing riometers suffer from a number of disadvantages as fas as their application to low power, low temperature, unattended operation is concerned.

The riometer designed and constructed for the Antarctic Division's unmanned observatory overcomes these problems. Many new techniques have been incorporated.

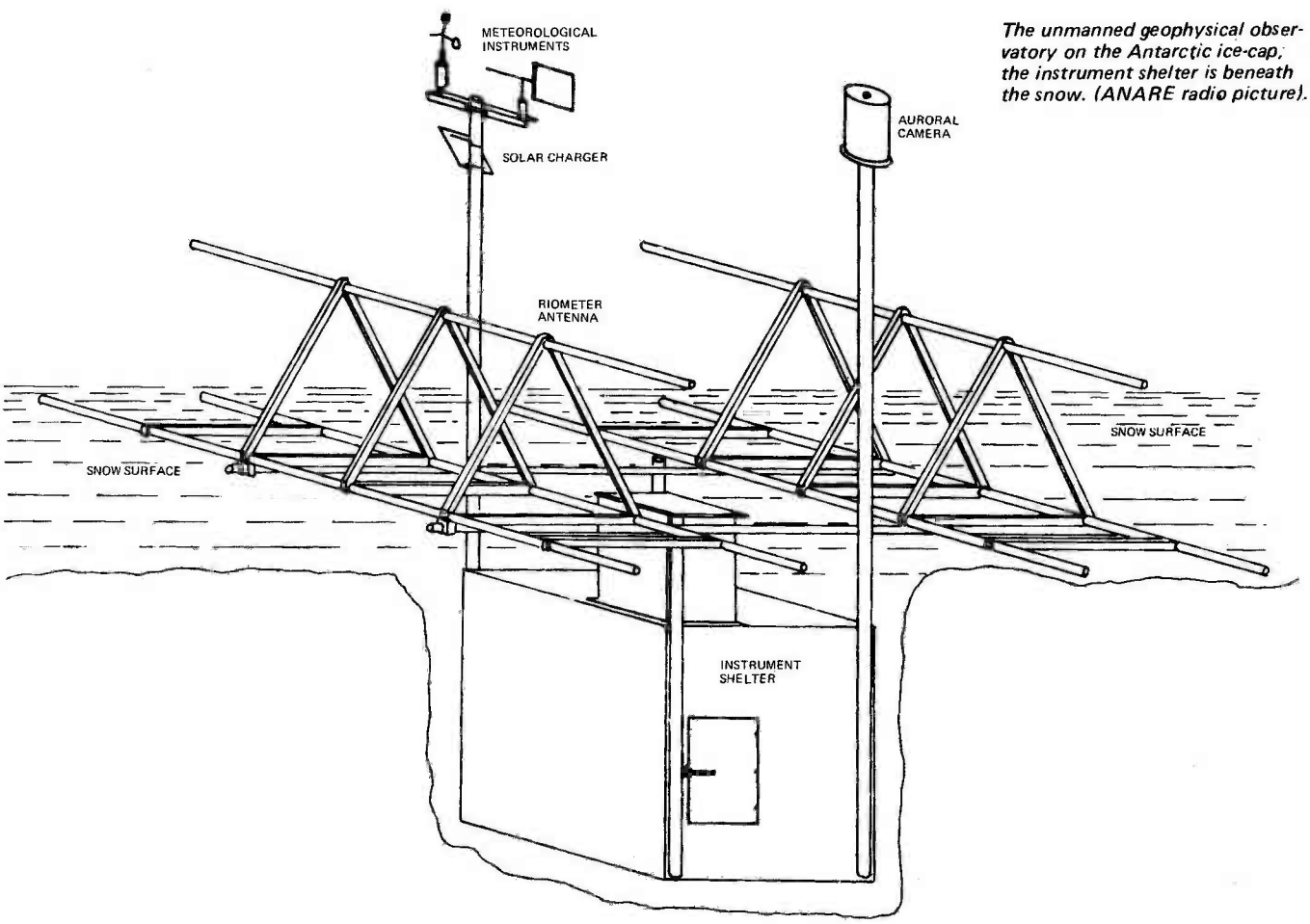
The power consumption of the unit is only 100 milliwatts, and this is a significant advance on the ten to twenty watts consumption of most other units.

Another new technique is the use of the shot-noise of a transistor (operated well above its corner frequency) as a noise generator. This has resulted in noise variations as low as one percent for 50°C changes in ambient temperatures.

The input noise figure of the riometer receiver is a mere 5dB and it will operate satisfactorily at temperatures as low as −70°C.



The unmanned geophysical observatory on the Antarctic ice-cap, the instrument shelter is beneath the snow. (ANARE radio picture).



ELECTRONICS IN THE ANTARCTIC

MICROPULSATIONS MAGNETOMETER

The strength of the earth's magnetic field is influenced, to some extent, by the charged particles trapped by the solar wind in the magnetosphere. The effect of these particles is to cause very small, generally rapid fluctuations, called micro-pulsations, having periods from 0.5 second to several hundred seconds; these micro-pulsations are of interest to physicists.

These micro-pulsations are measured by utilising the change in voltage induced in a coil by the changing flux of the earth's magnetic field; the amplitude of the induced voltage is proportional to the rate of change of magnetic flux.

As with riometers, instruments currently available were not suitable for the rigours of unattended Antarctic operation and once again the Department designed and constructed their own instruments. High performance operational amplifiers using integrated circuit techniques have been used, and the resultant units are capable of detecting pulsations in the order of 0.1 gamma (10^{-6} gauss).

The output of the magnetometer is recorded on a four-track analogue tape recorder operating at 2¼ in. per hour. For later analysis the ¼ in. tape is played back at increased speed and the output analysed by a conventional audio spectrum analyser.

Power consumption of the instrument, including the tape recorder, is approximately 100 milliwatts, and the instrument will operate down to -70^{o}C.

METEOROLOGY

Micrometerology of most Antarctic inland areas is relatively unknown. Consequently, data, even though at low resolution, are valuable.

Wind speed and direction, barometric pressure and air temperature are averaged over 20 seconds and recorded hourly by the digital logger; this time-integration limits the effect of transient variations from the mean value. The equipment is powered for about 5 minutes each hour and consumes an average 50 milliwatts.

Transducers

For wind direction, barometric pressure and temperature, resistive elements provide a variable voltage from a stable reference supply; circuits to provide damping and amplification are shown in Figure 16. An optical wind speed transducer provides a pulse output. All transducers must be ruggedly constructed and have a well proven performance under Antarctic conditions.

Electronics Today International would like to thank the Antarctic Division of the Australian Dept. of Supply for their assistance in the preparation of this article.

Wind Speed

The anemometer generates one pulse per revolution; at wind speed of ten metres second^{-1} the pulse rate is about 300 per minute and is linear within one percent over the range 0.25 to 60 metres second^{-1}. The pulse is generated by chopping light from a light-emitting diode directed onto an integrated photo sensor, thus providing BCD data for the digital logger (Figure 18).

(i) Air Temperature

For small temperature sensors, aspiration is not absolutely necessary for satisfactory measurement, but a free flow of air is required through the radiation shield.

(ii) Barometric pressure and wind direction

Both barometric pressure and wind direction are sensed by resistive elements in the transducer unit. The barometric pressure aneroid element provides resolution around one millibar. The transducers are supplied with stable 450mV.

INSTRUMENT SHELTER

The extremes of surface temperature may be avoided by sub-surface installations. Above-surface installation is attractive for ease of placement and retrieval of the observatory, however, the very considerable thermal inertial provided by even moderate snow cover is important for a non-thermally controlled shelter. The philosophy of the installation is to remove from the surface environment all but those instruments and structures necessary for data collection and power generation.

The shelter is a 2.2 metre cubic non-ferrous structure of aluminium section sheeted with plywood and insulated with rockwool. It is buried so that the roof is one metre beneath the snow surface. Temperature variations inside this structure will be within $\pm 12^{o}$C of the mean annual temperature for the site; thus, for the worst case of a mean temperatures of -58^{o}C, the lowest instrumentation temperature is about -70^{o}C inside the shelter and possibly -100^{o}C for the above-surface equipment.

As the shelter is a magnetic observatory with sensors mounted in close proximity, there is no significant volume of ferrous material in its structure, fittings or instrumentation.

The structure also functions as a container for transport of the equipment to the site, a shelter for on-site work, a darkroom for film handling and a foundation for the above-surface structure.

CONCLUSION

A prototype automatic geophysical station for unmanned operation in Antarctica has been designed to function at unusually low power consumption and temperature; the environment has been used to advantage for solar and wind generation of power, increased circuit reliability and to avoid the extremes of surface temperature.

Some of the techniques used should find wider application in geophysical instruments. In particular, application of solid-state devices to the riometer noise source and magnetic micropulsations amplifier meet real needs.

New technology, no doubt, will simplify the circuitry and improve reliability. An inexpensive and efficient low temperature power source is still needed. At this stage the isotope power source seems the only suitable source for use below 75^{o}S latitude. Satellite links would upgrade the usefulness of these unmanned observatories. ●

SPACE SPECTACULAR

Continued from page 51

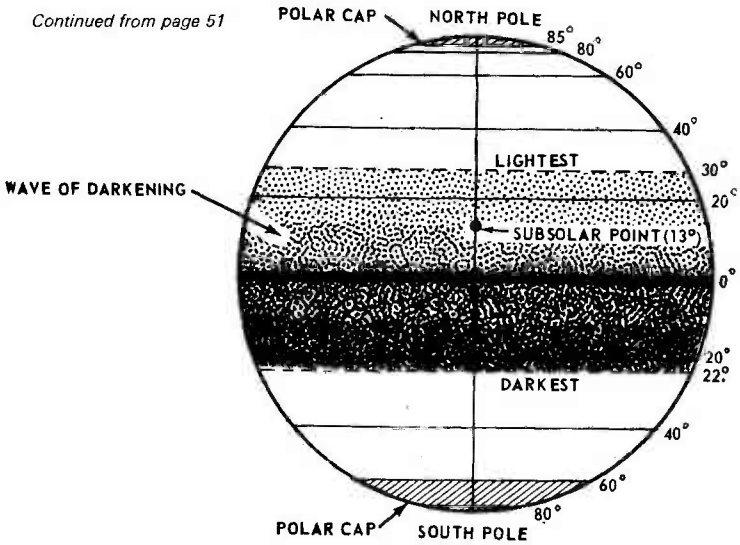


Figure 3. Physical conditions on Mars at time of landing.

an elliptical orbit around Mars with a periapsis and apoapsis of approximately 100 km and 1000 km, respectively. The first orbiter will be deployed soon after the space vehicle orbit is determined. After observation of orbital parameters, the scientist will select and optimize the orbital parameters for the second orbiter.

Although the principal activities on the planetary mission module during the initial orbital phase will be related to preparations for the manned descent, several experiments, in addition to those on the unmanned orbiter, will be accomplished to support the final site selection. Among these will be the topographic and thermal mapping experiments. The scientists will study the most interesting areas determined from precursor data, compare and evaluate the most recent information (in particular noting significant changes from the precursor data), and choose the site with the greatest potential for manned exploration and scientific return.

A very significant experiment to be done from Mars orbit will be the observation of the two Martian moons (Phobos and Deimos). These moons will appear to observers on Mars as smaller objects in the sky than the Earth's moon appears to observers on Earth. Only if the spacecraft approaches within about 1800 km of Phobos (or about 900 km of Deimos) will they appear as large as the earth's moon. However, high-resolution observations can be made with the reflecting telescope if the proper orbit can be achieved. In any case, the observation of the Martian moons by scientists in the planetary mission module will be a major activity.

THE SPACE VEHICLES

The convoy mode (spaceships separated) is recommended over the single mode (spaceships coupled) during the voyage to and from Mars. The convoy mode will enable cooperative experiments between the two spaceships, such as investigation of low-frequency RF transmission through the solar plasma. Also, it may be possible to compute the solar wind velocity by recording the time needed for particles to travel the distance separating the spaceships. Tracking of orbiters about Venus can be done from two points rather than one if the two spaceships are separated. In Martian orbit the separated spaceships can reduce the problem of continuous communication by serving as relay links.

At the Venusian encounter each spaceship will launch an orbiter which will provide information about density, temperature, composition, magnetic fields, charged particles, and electron density. The orbiters will be placed into elliptical orbits with a periapsis of approximately 150 km and an apoapsis of approximately 5000 km. The orbiters will have inclinations differing by about 90 deg. From each orbiter an entry-probe will be launched. Each entry-probe will divide into two probes — an atmospheric drifter and a soft-lander. These will make vertical soundings to measure the atmospheric temperature, pressure, and composition; additionally, the soft-lander will carry a TV camera. The drifter may search for biological activity at an altitude of approximately 25 km.

Each space vehicle will have accommodations for an astronomical observatory, which will house a 25 to 40-cm-size telescope. During the transit part of the mission, opportunities for viewing celestial bodies, including the earth, will exist. In transit and while at Mars opportunities, unavailable from Earth, may occur for the observation of stellar occultations by the outer planets.

On arrival at Mars each space vehicle will launch one unmanned orbiter and several relay satellites. The orbiters will pass through the upper Martian atmosphere and make measurements of the physical properties. This is not possible from the planetary mission module because of its orbit. The orbiters will be placed in equatorial and polar orbits and will have a periapsis and apoapsis of about 100 km and 1000 km respectively.

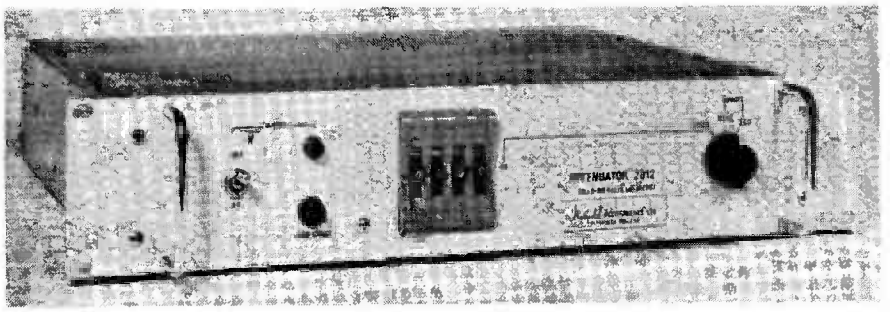
The relay satellites will provide real-time communication links between the MEM, mission module, remote stations, and other components. A module using a laser system to obtain high data-rate transmission will be separated from each mission module (just before return to Earth) and will serve as a continuous communication link between Mars and Earth. This orbiter will continue to relay data from automated surface measurements to earth after completion of the mission.

The landings should be made at different sites, permitting the investigation of different locations. For this mission two sites have been selected. One is located at about 50 deg. south latitude so as to be on the edge of the polar cap, permitting investigations of this interesting feature. The other site should be at or near the equator, perhaps in the Tithonius Lasus area which is located at 5 deg. south latitude. This area becomes darker earlier than other areas in the region. The equatorial region probably has a greater chance of harboring life because of the higher temperatures, 298°K maximum at the equator).

A manned Martian rover similar in design to the lunar rover will be necessary to fully explore the immediate surface area. It should be able to carry two scientists over a traverse distance of approximately 30 km. The vehicle should also be designed to carry heavy equipment to the remote stations and possibly to pull an automated drill to the drilling sites.

The MEM should be designed to provide adequate transportation to the Martian surface for the scientific instruments and associated laboratory equipment, the drill, and the rover. The five scientists will use the MEM for transportation to the surface, as crew quarters, and as a base of operation. ●

EQUIPMENT NEWS



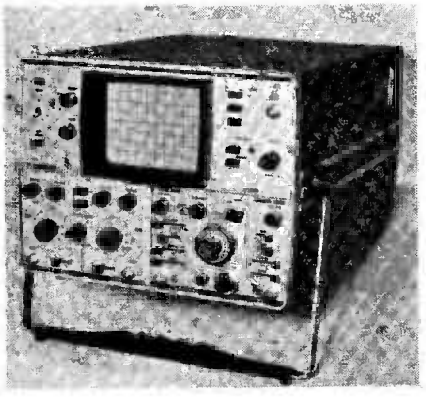
PROGRAMMABLE ATTENUATOR UNITS

The Hatfield 2010 series provides a range of rack mounting Radio Frequency Attenuators designed primarily for use in Automatic/Computer-controlled test systems. The range provides units with attenuation values of up to 119·9dB in 0·1dB steps at either 50 or 75 Ω characteristic impedance. The attenuators have been developed from the basic K series of remote controlled Attenuator units which have been marketed successfully for several years.

This latest design, in addition to 4-line compatible BCD programming provides one out of ten line code control permitting the unit to be remotely programmed by one single pole rotary switch per decade, and local programming from thumb wheel switches on the front panel of the instrument.

Further details from Hatfield Instruments Limited, Burrington Way, Plymouth, Devon PL5 3LZ.

NEW MODEL 3100 OSCILLOSCOPE FROM COSSOR



The new Model 3100 oscilloscope, manufactured by Cossor Electronics Limited, of Harlow, Essex, is a versatile instrument offering the user a basic 5mV/cm sensitivity and a 35 MHz bandwidth.

The "Y" input and "X" timebase amplifiers are contained in separate plug-in units and additional plug-ins available will be a dual channel "Y" amplifier unit and a dual timebase unit with delayed sweep. This configuration caters for the majority of applications but in addition a differential low-level input amplifier and a low-cost single timebase plug-in unit will be made available.

Other features include a variable hold-off delay for digital applications and the ability to maintain stable triggering when adjusting the vertical position. The display is 10 × 8 cm and the oscilloscope may be rack mounted.

Further details from Cossor Electronics Limited, Sales Division – Instruments, The Pinnacles, Elizabeth Way, Harlow, Essex.

VIDEO TAPE RECORDER

A production model of the Ampex VPR-7903 closed circuit television video tape recorder is now available with the new time base corrector accessory Model TBC-793.

The colour version of the TBC-793 is claimed to enable the VPR-7903 to produce colour pictures stable enough to meet all government and industry standards. Tapes recorded on a VPR-7903, when played back using the time base corrector, are claimed to give pictures virtually as sharp and clear as the original camera signal. This greatly enhances the VPR-7903's capability as an editing machine and as a storage device for mixing recorded material with live camera pictures.

The VPR-7903, introduced in Europe last year, is a professional tele-production colour recorder designed for closed circuit television production, editing and duplication.

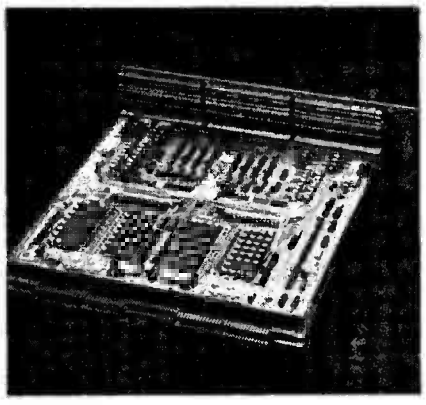
The basic TBC-793 consists of a time base corrector and processing amplifier which correct errors introduced into a tape recording by the electro-mechanical portions of the recorder. It stabilises the horizontal picture into which jitter has been introduced. It is claimed to reduce the output jitter to ±30 nanoseconds in monochrome and ±2·5 nanoseconds in colour, from the ±250 nanosecond output stability of the VPR-7903 without the TBC-793.

The TBC-793 also can contain a direct PAL colour module which corrects colour phase errors to assure accurate colour playback. A SECAM version of the TBC-793 will also be available.

An optional colour dropout compensator can be fitted which senses drop-outs and replaces them with video and chroma information from the previous line.

The TBC-793 also incorporates first automatic velocity compensation. The velocity compensator eliminates line-by-line colour errors caused by minute mechanical disturbances occurring within each line. It results in greatly improved colour playback when tapes recorded on one machine are played back on other machines. Also, it assures the user of high quality in making multiple generation colour tape copies.

Further details from Ampex Great Britain Ltd, Acre Road, Reading, Berkshire.



COMPUTER AUTOMATION'S NAKED MINICOMPUTERS

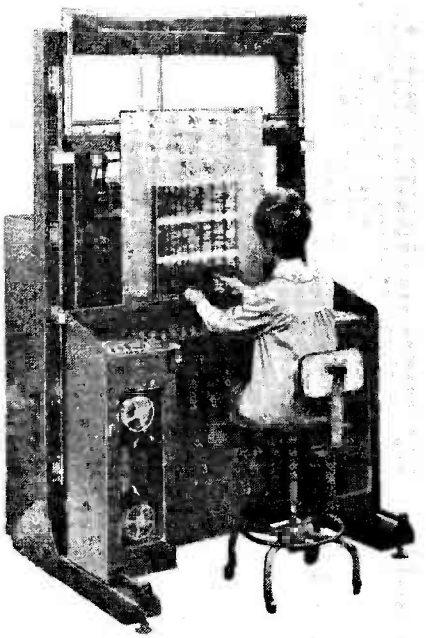
The age of the minicomputer as an off-the-shelf component has now arrived, and Computer Automation have already produced two such OEM machines – the 16-bit Naked Mini 16 and its 8-bit cousin the Naked Mini 8. Both of these are suitable for general-purpose applications and offer as standard especially powerful instruction

sets, 1·6 μsec full cycle times, up to 32 K words of random access core memory, a hardware multiply/divide facility, and software selection of byte or word-mode processing.

The dressed versions of the Naked Minis are the stand-alone Alpha 16 and Alpha 8 minicomputers, which include power supply control panel and chassis.

One of Computer Automation's minicomputers is at the heart of their "Capable" logic tester. This system enables unskilled operators to test logic cards, lsi and msi circuits, ROM's, ic components and cable assemblies automatically at rates exceeding 100,000 tests per second on up to 319 pins in any digital or analogue circuit.

Further details from CAI Limited, 95a High St, Rickmansworth, Herts.



SYNERGISTIC FORM UK COMPANY

Synergistic Products Inc, the Santa Ana, California manufacturers and distributors of N/C Wire Wrap, DIP Insertion and PCB Drilling Systems have formed an associate UK Company, Cavitron (Europe) Ltd. Mike Kennedy, formerly Equipment Division Manager of K & N Electronics Ltd, has been appointed Managing Director.

The Company has been formed to market Synergistic products in the UK, and to provide a contract numerically-controlled wire wrapping service. It will also be responsible for the installation (including operator training), and after-sales servicing of Synergistic equipment throughout Europe.

Cavitron plans to operate from the SE of England from April of this year. It will provide a fast and quality-guaranteed N/C wire wrapping service for panels with a wiring area up to 36×18 ins. in both standard and mini-wrap, using a Synergistic N/C Model 3182 wire terminating system. Full punched tape preparation facilities, supported by the Synergistic Santa Ana plant where necessary, will be available. Both production and prototype quantities will be undertaken, with charges on a sliding scale relative to the number of wires per contract.

Running parallel to this, and using a "Multimatic" manually operated machine, the Company will also offer a printed circuit board drilling service for boards up to 26×14 ins. (drilling area 24×12 ins.) with drill sizes from No. 80 to $\frac{1}{8}$ inch diameter at speeds from 15,000 to 54,000 rpm.

Synergistic equipment available from Cavitron will include: (*a*) Semi-automatic numerically controlled wire terminating systems, for example, Gardner Denver wire wrap and AMP Termi-Point and taper pin insertion, among others, capable of wiring areas up to 120×30 ins. on horizontal table systems, and 24×36 ins. on vertical table systems. A full range of machines and N/C units will, it is claimed, meet all customer requirements. (*b*) Manually and numerically controlled printed circuit board drilling machines including four station systems capable of drilling 4×$\frac{1}{2}$ inch stacks at one time. The manual system utilises either stylus/template or optical determination of hole position. The N/C version has many options including "on" and "off" line punched paper tape preparation. (*c*) "Dual-in-line" integrated circuit insertion systems, both manual and N/C and fitted with an entirely new method of component handling. These are capable of inserting 14 and 16 lead devices, selected from a 20 or 50 "stick carrier" magazine with 680 or 1700 device loading capacity, into board insertion areas up to 18×18 ins. (*d*) Full "Fortran IV" software programmes for punched paper tape preparation to drive the above systems.

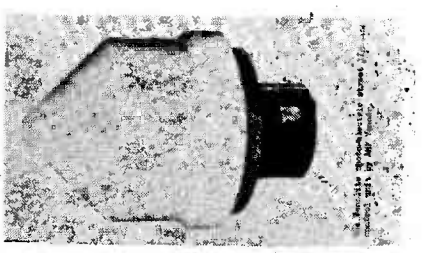
Further details from Cavitron (Europe) Ltd, 37 Thame Road, Haddenham, Nr Aylesbury, Bucks. Tel: Haddenham 649.

DANA 8000B H/S COUNTERS

Dana Electronics' new 8000B series of high-speed digital counters is based on their well-known 7900 and 8000 series. Five models are available, three of them spanning up to 150 MHz on direct count. For measurements up to 500 MHz a prescaler incorporating a fast-acting wideband agc is claimed to give constant performance even with signal fluctuations between 50 mV and 1000 mV, and full accuracy is said to be maintained up to 99% amplitude modulation on the rf signal. All models in the range have an 8-digit display, analogue voltage output of trigger level settings, and a reference oscillator with $\pm 1 \times 10^{-8}$ per day ageing rate. The result is meaningful frequency measurements up to rf with an accuracy, it is claimed, of one part in 10^8

Available options to extend the capabilities of the 8000B counter range include a TTL-compatible systems interface, consisting of BCD output and remote programming, a $\pm 3 \times 10^{-9}$ ageing rate reference oscillator, and a 9-digit display.

Further details from Dana Electronics Limited, Bilton Way, Dallow Road, Luton, Beds.



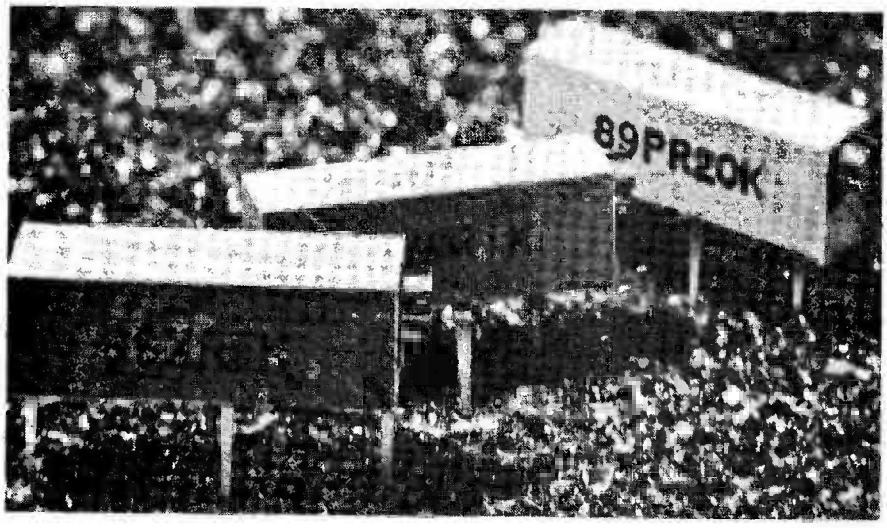
PHOTOELECTRIC LIGHTING CONTROLLER

The Ven-O-Lite, being introduced by AMF-Venner, is a new type of photoelectric lighting controller for automatic switching of street lighting, etc, at a selected ambient light level.

This unit employs a cadium-sulphide light-sensing element in a precise electronic control circuit. It is claimed to offer a much closer degree of setting accuracy than the conventional thermal-relay types of controller, and a high standard of reliability that is intrinsic to the solid-state circuits used.

Further details from Venner – AMF International Limited, Kingston By-Pass, New Malden, Surrey.

COMPONENT NEWS



NEW TRIMMING POTENTIOMETERS FROM BECKMAN

Helipot Series 89 trimming potentiometers introduced by Beckman Instruments Ltd., Glenrothes, Fife are economical, high quality cermet units specifically designed for a wide range of computer, instrumentation, and industrial applications.

These new "low profile" units stand just 0.250 inches high, allowing closer stacking of p–c boards.

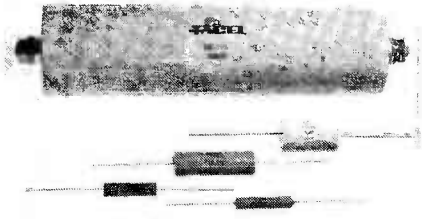
Setting ability of the 15-turn units is claimed to be within $\pm 0.05\%$ of full scale when used as a voltage divider, with substantially improved stability and performance when used in rheostat applications.

Another feature of the Series 89 is a stable, trouble-free life expectancy. Stability is claimed to typically improve with time over the expected life span of more than 5 years continuous duty at rated power. Standard off-the-shelf tempcos are ± 100 ppm from 100 ohms through 2 megohms.

The trimmers are available in three popular pin spacings of 0.200", 0.100" and RJ12Y 0.100".

Further details from: Beckman Instruments Ltd, Glenrothes, Fife, Scotland.

HIGH VOLTAGE POLYCARBONATE CAPACITORS



A new range of high voltage Polycarbonate Capacitors – the PTA range – has been announced by Athena Semiconductor Marketing of Egham, Surrey.

The PTA Capacitors – manufactured by Facel – are all claimed to meet the standards laid down in the IEC specifications for Capacitors, and their DC working voltages cover the full spectrum from 1500V to 100,000V, which, it is said, makes them one of the very few high voltage ranges now still available in the UK. They are tubular, protected in resinated glass wool tubes and sealed with thermo-setting epoxy resin. The working temperature range is claimed to be —55°C to +130°C, and the temperature coefficient $-60 \times 10^{-6} \pm 40 \times 10^{-6}$. Voltages are 1500V; 2500V; 3500V; 5000V; 10,000V; 16,000V; 22,000V; 25,000V; 50,000V and 100,000V; and capacitance covers 470pF to 1.5 F.

The IEC tests – which parallel the requirements of BS9000 for capacitors – showed that their electrical characteristics were unchanged after 10 days' continuous working with a thermal cycle from —55°C to +100°C once every 12 hours.

The new PTA range of Capacitors is available for delivery from stock. A comprehensive catalogue giving performance characteristics and listing the available types is also available.

Further details from: Athena Semiconductor Marketing Co Ltd, 140 High Street, Egham, Surrey.

TRI-STATE QUAD 2-INPUT MULTIPLEXER

A high-speed TRI-STATE quad 2-input multiplexer, the DM7123/DM8123, has been announced by National Semiconductor (UK) Ltd.

It is claimed to be fully compatible with standard TTL and, except for the TRI-STATE operation, has the same functions as standard TTL multiplexers such as the SN54157/SN74157 and 9322. Pinouts are the same.

The DM7123/DM8123 contains four 2-input multiplexers with common input-select and common output-disable circuitry. It multiplexes two groups of 4 bits each to four parallel outputs. A disable puts the outputs into a high-impedence third state.

The DM7123 operates at —55°C to +125°C and the DM8123 at 0°C to 70°C.

Further details from: National Semiconductor (UI2) Limited, The Precinct, Broxbourne, Hertfordshire.

RECORDINGS... CLASSICAL

REVIEWERS: John Clare, John Araneta

MUSSORGSKY-RIMSKY KORSAKOV Boris Godunov Soloists, Vienna Boys Choir, Sofia Radio Choir, Vienna State Opera Chorus, Vienna Philharmonic, Herbert von Karajan (cond.) DECCA SET 514-7.

My initial reaction on receiving this set was one of irritation at yet another Rimsky-Korsakov version of Boris Godunov. This was no doubt heightened when upon opening the libretto I found a photograph of Rimsky. In actual fact, this set is perhaps the most honest I have come across with regard to the textual problem of Boris. On the rather dazzling box, we find both Mussorgsky *and* Rimsky-Korsakov. The credits in the libretto explicitly state this is the Rimsky version and Act 4 (1) edited by Ippolitov-Ivanov. The notes on the production do not lamely defend the use of the Rimsky edition with the usual fiddle: ie. it is more brilliant, Rimsky was after all more expert, etc. The notes state that Karajan studied both original and Shostakovich versions before deciding on the Rimsky, especially since the singers objected to relearning their parts, an understandable problem since relearning the original manuscript is nothing short of learning another opera. Rimsky almost transforms Boris into one of the many fantasy operas he wrote – little starkness but always polish couched in splendid if at times banal orchestration, the sharpness gone. There can be no doubt about Rimsky's expertise; he did invest just about every scene with great, if obvious splendour and colour. But the original has its own dark, often crude splendour. As Stravinsky put it, where, for instance, "Mussorgsky accompanied Pimen, as he wrote, by a single bassoon," Rimsky, "to make certain everyone saw the point, added other instruments, with the result that an original idea is reduced to commonplace."

I must admit to having played this set six times now and after the fifth time I was still wondering what could possibly be wrong either with me or this production. At this point I decided to go back to the Cluytens-directed set on ANGEL and could after that better understand why I could never play through that set as well. Trying the Bolshoi recording on MELODIYA merely served to confirm my suspicions. The Bolshoi performance, generally wretchedly sung and conducted, and featuring a not particularly profound Boris in Ivan Petrov, nevertheless excites me enough to play through it, precisely because it is crude, it is more idomatic, and is done with almost patriotic fervour. Both ANGEL and the present DECCA sets are hardly crude, and especially in the case of the latter I felt at times as if I were appreciating Rimsky's editing for the first time all too clearly. But going back a sixth time to this recording I felt I could well admit its undoubted qualities. Let me say that this Boris is in a technical sense the best available. As far as sound goes, everything is excellently managed. Trust DECCA to bring in really impressive bells for the Coronation Scene and for once they do not seem to come from a completely separate track. Sound and separation are always clear no matter what forces are involved and just about down to the last orchestral detail. As for the performance, it is, I feel, the best played and conducted Boris, and certainly the most finely sung. I am still surprised to find, even the bit roles well sung, which is not unremarkable in the history of performances of this opera. If only there had been more snap, and drive to this performance, I would have no hesitations whatsoever about recommending this set in lieu of any recording of the original Boris. If there is any one act in this performance that I thoroughly enjoyed and played through, it is, strangely enough, the Polish Third Act. The Polish Scene has always been for me that portion of Boris I would willingly omit, and I have never heard any performance, be it in the original manuscript or Rimsky versions, that could make me want to come back to it. But even at this writing, the music of the Polish Scene in this performance always comes to mind as the outstanding moment of this set. Karajan evidently enjoys this moment and plays it for all it is worth. It is hard to forget the way Karajan brings out the rhythms of the Polonaise, and the cries of "Vivat!" from the guests shortly before the concluding duet is simply thrilling. But Karajan's singers are also no less remarkable. Galina Vishnevskaya (Princess Marina) may no longer sound as vocally secure as she used to but she is the Princess Marina. She is never just temperamentally crude or vain as Irina Archipova is in the MELODIYA nor just well sung as Evelyn Lear is on the ANGEL. There is always dignity, reserve, and yet fire to her performance. For once too, Rangoni is not the tiresome dullard one expects from portrayals of this role. Zoltan Kelemen coaxes, insinuates, never just threatens. One is quite prepared to believe Rangoni is a Jesuit. Ludovico Spiess (Grigori, later Prince Dimitri) has an almost Italianate break in his voice, but this I feel only helps to portray a not particularly subtle and romantic Pretender. The choruses in this act are very well differentiated and sing well.

The Vienna Philharmonic here plays with the appropriate grace and refinement. Unfortunately, I feel, as I have said, that Karajan lets too much refinement take over the Russian scenes so that while one is always aware that first rate forces are at hand, power is often sadly lacking. The all-important choruses are hardly differentiated between peasants, monks, urchins, boyars, and in any case, they are all too well-mannered. To take certain scenes: the Prologue, for one, lacks that feeling of restlessness that Mussorgsky has evoked so well from Russia's "Time of Troubles". The urchins in the St. Basic Cathedral Scene (Act IV, 1) are pleasant sounding enough to make it hard to believe even a simpleton could be perturbed. Incidentally, tame sounding as this scene is, surely Karajan could have gotten Shuisky to sound a bit more outraged when the simpleton confronts the Tsar with Dimitri's murder. It hardly matters that simpleton and Shuisky are sung by the same person (Aleksei Maslennikov). The editors could have also helped by reducing the pause before Shuisky's words of outrage. The final Revolutionary Scene, which Karajan wisely includes, is, once again, well sung but hardly a revolution. Listen to the incredibly revolutionary sounding MELODIYA performance, and this scene becomes not just an epilogue, as in Karajan's performance, but the true finale of the opera, an enigmatically moving ending with its strange unresolved chords. But I must again emphasize the fact that Varlaam, Missail, Shuisky, everyone sings well. But where is the evil, or coarseness? Which brings me finally to Nicolai Ghiaurov's Boris. If there is a more beautifully sung Boris to be heard I have not found it. Ghiaurov only mars his otherwise musical performance by shouts in the Clock Scene. Still, I felt Ghiaurov sounds too youthful for Boris, not Batyushka enough. His death scene is nevertheless natural and moving. Bearing in mind, therefore, the reservations I have stated above, I would still finally recommend this set very highly. This recording is the only complete recording to be had; all other available sets have seen fit to omit various numbers and scenes. – **J.A.A.**

RECORDINGS... JAZZ

REVIEWER: John Clare.

CHARLIE MINGUS. Blues And Roots Atlantic Stereo SD-1305. Wednesday Night Prayer Meeting. Cryin' Blues, Moanin', Tensions, My Jelly Roll Soul, E's Flat Ah's Flat Too. Jackie McLean and John Handy altos, Booker Ervin, tenor; Pepper Adams, baritone; Jimmy Knepper and Willie Dennis, trombones; Horace Parlan or Mal Waldron, piano; Dannie Richmond, drums.

This is an extremely important reissue, particularly for those who have just started to collect jazz: this is what it's all about! Although all of these pieces are based on modified blues forms, there is not one which does not sound entirely contemporary. That is because the very best of contemporary jazz – Shepp, Cecil Taylor, Joseph Jarman – belongs to the same tradition of emotional, high energy, inventive music as Johnny Dodds, Red Allen, Coleman Hawkins, Roy Eldridge, Bird and Diz, James Moody, Mingus, Ellington, Monk and so on. Though I've often defended the validity of the best West Coast jazz, of the equally four-square but honest and invigorating Chicago jazz, of beautiful melodic players like Paul Desmond, Bobby Hackett and Jimmy Hamilton – these forms, these players are to me but minor planets lit by the fiery core of great wild innovators, some of whom I've listed above.

This music must seem to the newcomer as loose and sprawling as a Faulkner novel, but it is unified by the same underlying strength of form, the same pervading richness of tone. Tough, jabbing solos emerge from turbulent ensembles, which themselves sound as though they were improvised on the spot. Mingus urges his men on with hoarse cries which become part of the music. In solo and support his bass, with its agility, clubbing percussiveness and odd short resonance creates an unmatched sense of urgency.

Wednesday Night Prayer Meeting sounds as the title would indicate like a wild church service in Harlem with the congregation spontaneously erupting in shouts of jubilation. Note the powerful solos of Willie Dennis and Booker Ervin over frantic triple metre. But all this excitement is channeled through compositions and arrangements of great ingenuity. Fine use has been made of the reeds and trombone instrumentation. If one can describe sound in visual terms, I would say that the predominant tones are sepia, yellow, cocoa and mohogany.

This record was made originally in both stereo and mono. The stereo gives the music an appropriate spread, but my old mono copy sounds a little clearer. –J.C.

ARCHIE SHEPP. Pitchin' Can. America, Stereo 30 AM 6106. Uhuru, Pitchin' Can. Bobby Frew, piano; Bob Reid, bass; Clifford Thornton, valve trombone; Mohamed Ali, drums; Al Shorter, flugel horn; Lester Bowie, trumpet; plus various percussionists. Personnel on Pitchin' Can includes Leroy Jenkins, viola; Sonny Murray, drums; Julio Finn, harmonica; Chicago Beau, vocal.

The title track takes up about a third of this recording. Uhuru occupies the rest of the playing time, and though it is basically just another Archie Shepp bash it is essential listening if you want to have a comprehensive picture of what Shepp does. This, like almost every other Shepp recording, is markedly different to every other Shepp recording. It's not that Shepp's own playing changes radically from session to session (though his soprano is quite different to his tenor), but that he creates new musical settings almost every time he records.

Sometimes he carefully organises a new musical environment, writing some passages, having other passages improvised by unusual combinations of instruments; sometimes he just gathers a new set of musicians together and they all have a long jam, which seems to be what he has done here.

Newcomers will find Uhuru one of Shepp's more difficult things to get into. The percussion section plays rhythmically throughout. It sounds rather like furniture falling over at high speed. The piano can be heard chiming, and splintering like chips of ice, almost without let. If you concentrate on this it becomes rather hypnotic, sometimes filling your head with leafcutter ants, suggesting at whiles a mad proliferation of architectural fragments up through the floor, as though a bewildering city were being constantly rebuilt. On its own it is on the level of mere psychedelic effect, but it is meant to serve, and it does serve as a mosaic backdrop for the soloists.

Shepp, on tenor, is by far the strongest. Clifford Thornton is the least interesting. Bowie is not at his best, but he is always good to hear. There are some dull spots, and it all goes on a little too long, but there is a lot of exciting stuff. Take note of Shepp's African influenced singing near the end of side one. His voice is just as rich and compelling as his saxophone, and I think that he does this sort of thing much better than Leon Thomas.

Pitchin' Can is totally different – an open, rolling riff in waltz time, repeated over and over and broken by a really fine Shepp solo on soprano. This sounds like something recorded at the same time as the Black Gypsy session. The first time I heard this I thought that the riff was repeated for longer than it was worth, but after a couple of hearings it got into my system, and I felt that it could go on forever. This is music which anyone can enjoy.

I thought that the soloists apart from Shepp could have been further forward on Uhuru, but Pitchin' Can is quite well recorded. Nothing you could quarrel with on a budget price recording such as this. – J.C.

GEORGE WEIN. George Wein's Newport All Stars. Atlantic Stereo SD 1533. Blue Boy, These Foolish Things, In a Little Spanish Town, Am I Blue, Ja Da, Topsy, My Melancholy Baby, Sunny, Nobody Knows You When You're Down And Out, Exactly Like You. Red Norvo, Tal Farlow, Barney Kessel, Ruby Braff, George Wein, Larry Ridley, Don Lamond.

There's not a great deal that I can say about this, beyond the fact that it's a pleasant, rather homely session by a group not exactly exploding with talent. Tal Farlow seems to me to be the most interesting of them, but he's not given enough space to do much. In any case, it would be hard to sound all that great over the rhythm section, which is – I hate to say it, it's a bit corny.

Many respected musicians I know are enthusiastic about Ruby Braff. I have never heard him play an original, nor even a particularly authoritative phrase, but perhaps they like him because he is several trumpeters in one. There's a lot of Buck Clayton in his playing on Spanish Town and the beginning of a Dizzy Gillespie phrase (Diz usually repeats it several times and then flies off at an alarming tangent; Ruby comes out of it in very pedestrian fashion), while Roy Eldridge creeps into the introduction to Melancholy Baby.

Miles Davis recently championed George Wein's piano playing, but there's nothing here to convince me that he wasn't joking. He's obviously listened to Ray Charles's organ work, but he plays it in a pretty four square fashion.

I was happy to hear the fellows having such a good time, but I can't see myself listening to it much in the near future. – J.C.

RECORDINGS... POP TRENDS

REVIEWER:
Michael Delaney, John Clare.

EVOLUTION – The Best Of Iron Butterfly – Iron Butterfly. Kinney. Stereo SD.33-369. Iron Butterfly Theme – Possession – Unconscious Power – Flowers & Beads – Termination – In-A-Gadda-Da-Wida – Soul Experience – Stone Deliver – Belda Beast – Easy Rider – Slower Than Guns.

Iron Butterfly had the barest necessities. They were one of the few successful exponents of West Coast psychedelia. The concept was totally amorphous – Californian rock vintage 1967 post Byrds. Los Angeles still reigned supreme and nobody knew what was happening least of all the groups involved. It didn't matter in any case. This was something new. There really was a high degree of method in the musical madness that ensued despite the stylistic mayhem. The general approach was restricted to voltage and feedback with lots of sinister lyrics – very flash. Atmosphere was almost always foreboding. Iron Butterfly was much more a catalyst than an innovator as they were remote – vaguely talented. It was a mood thing that crept up on you when you were most vulnerable. The band worked extra hard on image and soon became the highlight of drug culture cool. The hypsters pulled out all the stops. "In-A-Gadda-Da-Vida" remains their one noteworthy achievement as it sold well in excess of three million copies. This one track captures complete the stone terrific attitude adopted by mid-sixties' American rock. Iron Butterfly never had the time to find out what'd hit them. "In-A-Gadda-Da-Vida" sealed their fate as it was eventually to become the major reason behind the not so recent split. It was one of the only tracks that didn't come across as either affected or pretentious. "Evolution – The Best Of Iron Butterfly" presents an insight into a band unable to move with the times. "Slower Than Guns" and "Stone Believer" – two fine cuts from the "Metamorphosis" album – are the only songs that can boast definite impact. "Flowers & Beads" is simply trite. It's an uninspired attempt at the full love scene – weekend hippie muzak. "Unconscious Power" must have the worst set of seemingly portentous lyrics yet recorded. Iron Butterfly offer nothing that hasn't been done better by someone else. The group was loaded with latent potential – each melody is distinct; the instrumentation above average. It just fails to lead anywhere. The album doesn't really serve much of a purpose as most of their fans have moved to other things. Production is discerning. – M.D.

JADE WARRIOR: Vertigo Stereo 6360033. The Traveller, A Prenormal Day at Brighton, Masai Morning, Windweaver, Dragonfly Day, Petunia, Telephone Girl, Psychiatric Sergeant, Slow Riad, Sundial Song.

This group has imagination, ability and some lovely sounds at its disposal. As with Pink Floyd (whom they resemble in only a few places) one wonders what they could produce with more extensive musical knowledge. Perhaps that would spoil it altogether, but I feel that they would avoid some of the cliches which seem to check them here and there in full flight.

The Oriental effects on a Prenormal Day at Brighton disappointingly resolve themselves into a sort of tin pan alley Japanese motif. You know the sort of thing "Sayonara, pretty orange blossom" or however it goes. Still, the track is genuinely exotic and pleasing. If they really knew something about Eastern music – who knows what they might have done.

The Traveller begins with brooding flamenco chords on the guitar and then moves into an ethereal feeling, with superficial resemblances to Debussy. This is interesting. One could launch into a discussion of the range of expressive possibilities of the Phrygian cadence which occurs in Spanish music, in Bach and in the modal forms of Debussy etc. That feeling of something left unsaid, umemphatic resolution, mystery. It can release a continuous unwinding passion, or a play of sensuous atmospherics, or a feeling of religious awe. Jade Warrior have created a very enjoyable atmospheric piece.

One thing which makes the group sound distinctive is the absence of a conventional drum kit. Even the heavy rock riffs they use from time to time are backed by congas and maraccas. Thus the usual rock drum cliches are avoided. Flute and congas are used effectively, and when the electric guitar suddenly cuts loose with heavy fuzz tone and that tearing, unravelling sound they get, the effect is truly electrifying.

The lyrics of Masai Morning and Psychiatric Sergeant are well worth listening for. Elsewhere hoary old poetic cliches obscure some good ideas. The vocalist is disturbingly like Cliff Richard at times.

Sound is clear and very vivid, with a bit of unwanted distortion in three or four places. A very interesting and often pleasing album. I wonder about their next one, because I have the feeling they do not know enough to do much more. Now somebody is going to tell me they've all studied music for about ten years! –J.C.

"SIGNS" MGM Stereo. FXLP. 2315.060

Five Man Electrical Band adheres to convention. They're strictly entertainers. They try to cultivate as broad a market as possible without debasing the current Top 40 status. The group is commercial – immediate melody backed by competent performance. Their appeal is that enjoyed by the average stateside chart outfit. Recognition is transitory. This Canadian team suffers from a somewhat nondescript character. They lack definition. Five Man Electrical Band tends to over-react. There seems to be very little sense of dynamic contrast outside the occasional rhythm interplay.

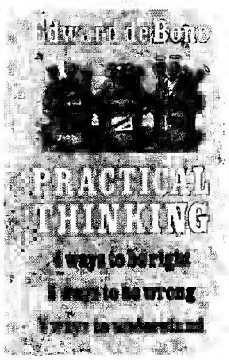
The influences range between country-blues and funky gospel. They play amorphous rock'n'roll centred on staccato guitar riffs and heaving keyboard. "Signs", "Swamp Woman" and "Butterfly" promise a technical standard that is otherwise unattained. "Safe & Sound" is reminiscent of a poor man's Three Dog Night. The remainder of the material draws varying degrees of comparison with either Creedence Clearwater Revival or The Band.

This group requires a pronounced direction. They have a sensitivity and flow that is wasted due to the lack of positive goals. Five Man Electrical Band can be quite compelling once they realize the effect of relative approach. Each member is an accomplished musician and vocalist. Les Emmerson – leader & chief songscribe – possesses a natural skill with arrangement and presentation that could well prove to be the one major strength behind continued disc success. The over-all sound is clever. The band manages to avoid most of the old cliches that haunt all forms of semi-religious rock. They have developed an articulate nucleus that needs to be expanded.

Emmerson has a way with time changes that rarely fails to intensify both mood and excitement. He uses the guitar/keyboard section in a series of fat, chunky bursts to illustrate the various themes. He's quite an ingenious guy. Production could be better. Separation is poor. – M.D.

BOOK REVIEWS

REVIEWERS: Brian Chapman, Jan Vernon.



PRACTICAL THINKING
By Edward de Bono.

Published 1971 by Jonothan Cape Ltd, London. Hard covers, 198 pages.

de Bono has a basic contention that our traditional approach to thinking is not the best way. The traditionalist's argument is that if each small step is correct then the ultimate conclusion must be correct, but de Bono says it may be essential to be *wrong* in thinking at some stage to enable one to move far from the old pattern and restructure it. The 'intermediate impossible' is his name for an idea which is wrong in itself but nevertheless serves as a useful stepping-stone to an idea which is perfectly valid.

In this book, his examples of the ways in which people think, come from an experiment which he performed many times with a wide variety of subjects. "Imagine," he says "a tall black cylinder standing on a white table in front of you. No one is near the table and there is nothing on the table except the cylinder which stands stark and alone. Suddenly without warning, the cylinder falls over with a crash. Why? Given ten minutes, de Bono's subjects are asked to give an explanation. de Bono then analyses and grades their ideas as different levels of understanding, from simple descriptions, "It fell", to porridge words, "The cylinder had a mechanism to make it fall over" (words like "mechanism" and "device" are porridge words – no real form, shape or definite meaning in this context), to full details "concealed clockwork mouse with suction pad feet climbs up tube which becomes top-heavy and falls over. Clockwork mechanism is silent".

Throughout the book, de Bono uses the answers given by people in the experiment as examples for the points he is making in each chapter. He discusses the levels of understanding we use when we think, the basic thinking processes, (how we move from one idea to another or connect up separate ideas,) how we decide an idea is the right answer and the types of mistakes which people make in thinking their way to a conclusion.

Everyday thinking, he says is often different from the thinking of a scientist. Though it may appear that a deeper level of understanding is better, in our routine life when we must reach a level of understanding before we act, the lesser levels are often sufficient – knowing that a car works by switching on the ignition is a deep enough level of understanding for most people to be able to drive one. and the engineer who sneers at this ignorance probably does not know all there is to know about the physical chemistry of exploding petrol, the surface physics of lubricants or the metallurgy of gear wheels, yet he is still able to perform his job competently.

In describing different types of thinking, de Bono also defends each type. "Everyone is always right" and "no one is ever right" are his basic rules of everyday thinking. He does quite convincingly explain what he means by these apparently contradictory rules.

He is firmly against arrogance and dogmatism and people who feel they are so right they must impose their ideas on others. If one accepts that no one is ever right in an absolute sense then one is more willing to look around for better ideas and to look at the ideas of others. "I would go so far", he says "to suggest that a person who was incapable of arrogance would be incapable of stupidity"

His last chapter (Think-2) gives his suggestion for a different sort of thinking – which seems more a method of communicating one's own ideas to others. He says that if one assumes one is talking about the same thing as someone else, one moves steadily from idea to idea trying to convince the other person of the validity of the argument (and wondering why the other person remains unconvinced). Instead he says, each person should carefully map out the landscape of their own starting place. Thinking then becomes a matter of discovering where there is overlap and where there is distance. An attempt may then be made to set up new areas that are otherwise separate. One tries to find out where people are, instead of trying to convince them of where they should be. In the case of a father who has discovered that his daughter is smoking pot and wants to discuss this with her, daughter's ideas could be – only smokes it occasionally, does not want to appear square and old-fashioned, better than alcohol (no hang-over or sickness); while father's ideas could be, pot leads to other dangerous drugs like heroin and methedrine, failure as a parent, beginning of a downward trend from which there is no escape – etc. It is obvious then, says de Bono, that the starting places are so totally different that the two are really talking about different things. Each has a different point of view, different pictures.

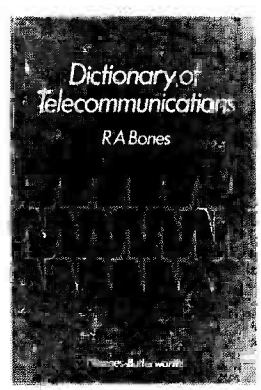
In ordinary thinking one tries to reach a conclusion by making strenuous efforts to deny the right to exist of any picture that is judged to be 'wrong'. In Think-2 one accepts the existence of different pictures and then tries to develop new bridging ideas whereby one can move from one picture to a different one.

Practical thinking is de Bono's seventh book. All cover various aspects of thinking – the author is an internationally recognized authority on the subject and has lectured to a wide variety of groups throughout the world.

The book is well set out and clearly written. Each chapter is followed by a summary of the main points. The author uses amusing examples to illustrate his points but his intentions are obviously serious. He is not joking when he quotes de Bono's 1st and 2nd Laws.

Our present ways of thinking are not as productive as they might be, and the author's intention appears to be to convert readers to his suggested method. The suggestion that it is possible to change ones own thinking is interesting. For a time after reading this book one has a tendency metaphorically to stand back and watch oneself think. This may or may not be permanent. –J.V.

DICTIONARY OF TELE-COMMUNICATIONS
By R.A. Bones.



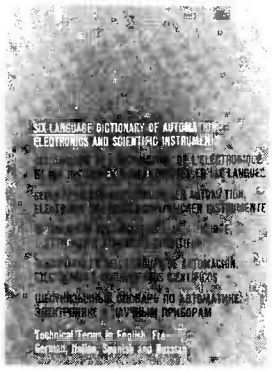
Published 1970 by Newnes Butterworths Ltd, of London. Hard covers 200 pages 7" x 5".

This work is a companion volume to the "Dictionary of Electronics" reviewed last month. As the name implies, the coverage of this volume is more specialised, dealing specifically with terminology commonly encountered in the field of telecommunications.

Coverage is excellent, I tried many terms of recent origin. Only on one occasion did I fail to find a reference. I did feel however, that some of the references were too brief, to the point where it would be necessary already to know the answer in order to understand the explanation.

Nevertheless this dictionary must prove to be quite valuable to technicians and others employed in the field. – B.C.

BOOKS



SIX LANGUAGE DICTIONARY OF AUTOMATION, ELECTRONICS AND SCIENTIFIC INSTRUMENTS

Compiled by A. F. Dorian and published by Butterworths, London, 1962. Hard covers, 732 pages, 10″×8″. U.K. price £6.50.

Have you ever seen an interesting circuit in a foreign journal and been frustrated by not understanding the language.

Here is the answer, a cross-referenced dictionary of electronic and scientific terms in six languages. The languages are English, French, German, Italian, Spanish and Russian.

Although this book will by no means make you an expert linguist, it will enable you to get the gist of technical descriptions. This, of course, is all that is required by those who are proficient in their own field.

Structure of the dictionary is as follows: In the main body of the dictionary each English word or phrase is given a line number and the other five language equivalents are listed across the double page spread.

At the rear of the book, five separate listings are provided, one for each language. The procedure is to find the phrase in this alphabetical listing and hence a line number for the main cross referenced listing. It is thus quite easy, for example, to obtain the Spanish equivalent of a Russian phrase.

One criticism is that one needs to know the Russian alphabet to readily find a Russian phrase. The inclusion of a Russian alphabet at the beginning of the appropriate reference section would be of assistance.

Nevertheless, a very valuable book for those whose business it is to know what others are doing. – B.C.

110 SEMICONDUCTOR PROJECTS FOR THE HOME CONSTRUCTOR By R.M. Marston.

Published 1969 by Butterworths, London. Hard covers, 125 pages, 8½″×5½″. U.K. price £1.80 (limp edition £1.20).

One would expect this book to contain the usual gambit of 'one transistor' radios, audio oscillators and amplifiers, etc, found in other books with similar titles. To some extent this is true, but this one is decidedly a cut above average.

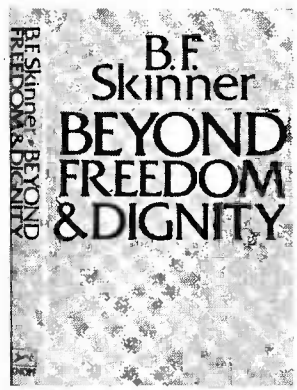
R.M. Marston is a wellknown freelance author who writes under several pen-names for most of the better known electronic journals. In fact, as is stated on the dust cover, R.M. Marston is probably five of the ten best known authors in the UK today!

Due to unfamiliarity with the various semiconductor devices, that have appeared so rapidly over the last few years, many hobbyists confine their activities to building pre-designed projects. Although this is interesting, how much more satisfying and rewarding it is to be able to design your own special gadgets.

The present volume tries (quite successfully) to achieve this aim by introducing new devices by experiment. A good sound explanation of device operation is given, unclouded by unnecessary mathematics, followed by projects which are designed to illustrate device application.

These projects are designed using commonly available components. In fact, there are 65 projects based on only two silicon transistor, one field effect transistor and one unijunctior transistor. In addition there are 15 SCR projects and 30 linear IC projects. All IC projects are again based on the one IC, the μL 914.

Excellent value as programmed instruction material and as a source book for useful circuitry. – B.C. ●



BEYOND FREEDOM AND DIGNITY, B.F. Skinner, published by Alfred A. Knopf, New York, 1971. Hard cover 232 pages.

To solve the problems that face us in the world today we need to make vast changes in human behaviour, and to do this we need a *technology* of behaviour.

This is the opinion of Burrhus Frederic Skinner, Professor of Psychology at Harvard University, who states his views in his new book 'Beyond Freedom and Dignity'.

Considered the most influential of living American psychologists, Skinner is a leader in 'behaviouralistic' psychology. The Skinner method of controlling behaviour is known as operant conditioning; 'contingencies of reinforcement' are set up, being circumstances under which a particular bit of desired behaviour is 'reinforced' (rewarded) to make sure it will be repeated. (In a typical laboratory experiment a hungry rat is placed in a box equipped with a lever. While moving around the box the rat eventually touches the lever and a pellet of food is automatically ejected into the box. Soon the rat learns to press the lever whenever he wants food).

Skinner's book will probably outrage people who feel that he is planning to treat society like a laboratory experiment, but Skinner's purpose in his work is not to show that behaviour *can* be controlled in this manner. He is saying that our behaviour actually *does* come about through the rewards we have received for previous behaviour; therefore it is time we thought about the situation and planned our culture accordingly.

At present, human behaviour is commonly attributed to indwelling states of mind, agents and feelings. Skinner rejects these traditional explanations of behaviour in favour of explanations to be sought in an individual's genetic endowment and personal history.

Scientific analysis of behaviour, says Skinner, shows that we react in a given way because similar actions in our past have had particular consequence – we are not free to choose a path in life – our behaviour is a result of genetic endowment and environmental influence. But our present society assumes a person is free to choose right from wrong and condemns a person who chooses the wrong path. Skinner says we should accept the fact that we are controlled by our environment; stop trying to persuade people to be better but concentrate on the design of better environments: better people will then follow.

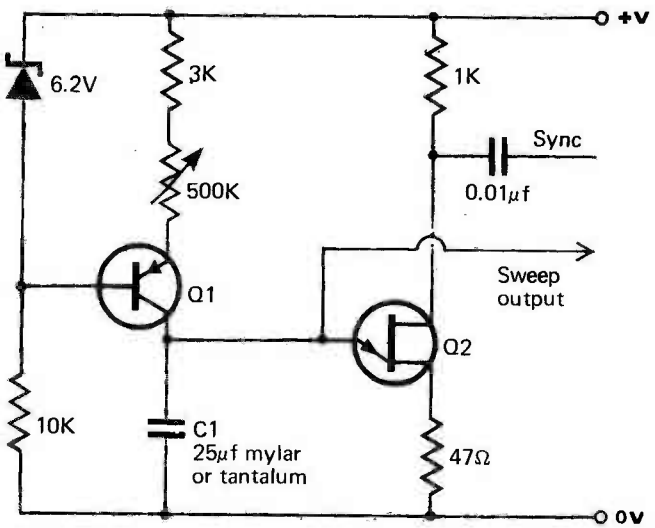
But, Skinner says, we must plan our culture carefully for behaviour is shaped and maintained by its consequences. We must consider the behaviour we want in our society and learn how to obtain this behaviour.

The use of science in designing a culture is commonly opposed. People fear they will be controlled, that there will be uniformity or regimentation. But if we are designing a culture then it is up to us to design it well so that we have the interchange between control and counter-control which is essential to the evolution of a culture.

A scientific view of man offers exciting possibilities, says Skinner, we have not yet seen what man can make of man. – J.V.

TECH-TIPS

LINEAR SWEEP GENERATOR

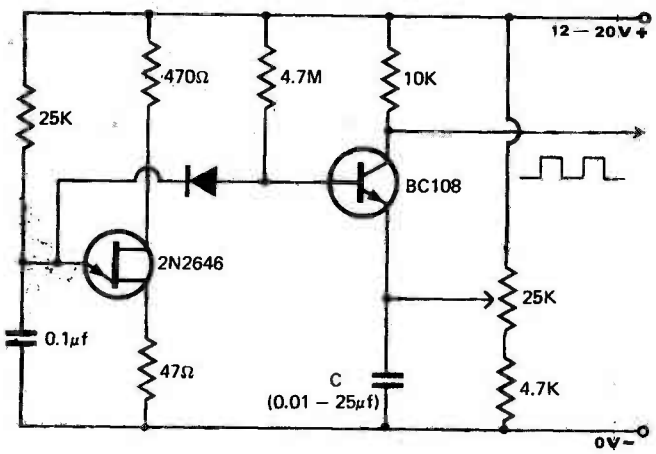


This circuit provides a linear time-base with a sweep time adjustable from a few milliseconds to over one minute.

The constant-current effect of emitter follower Q1 causes C1 to be charged at a constant rate.

The increasing voltage across C1 will be essentially linear (displacement error is less than 1%). The sweep is terminated when the increasing capacitor voltage reaches the peak valley point of unijunction Q2, when capacitor C1 will discharge through the current limiting resistor R1.

VARIABLE DUTY SQUAREWAVE GENERATOR



A variable duty cycle squarewave can be obtained from this unijunction circuit. The light loading imposed on the emitter timing circuit preserves frequency stability.

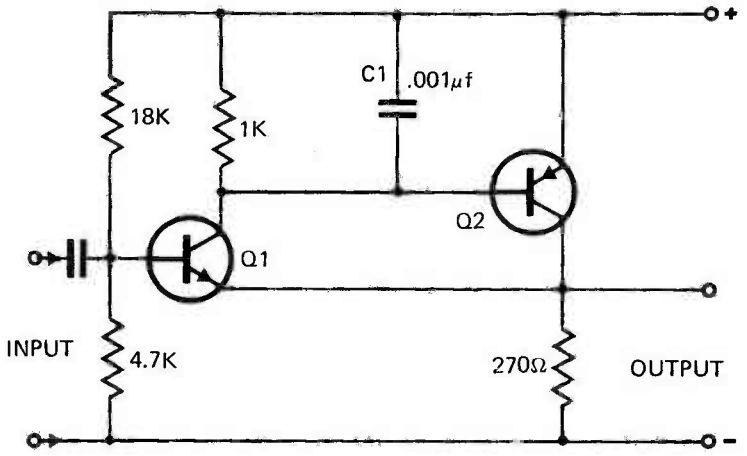
Faster rise and fall times can be attained by including bypass capacitor C. The value of this capacitor should be chosen to suit the pulse shape required.

CAREER OPPORTUNITIES

EMPLOYERS—Seeking Staff? Electronics Today International is read by the very people you seek.
Managers, Engineers, Technicians, Draughtsmen, Salesmen, etc. ▪ You already have a good job but seek a better one. Here they are.

TECH-TIPS

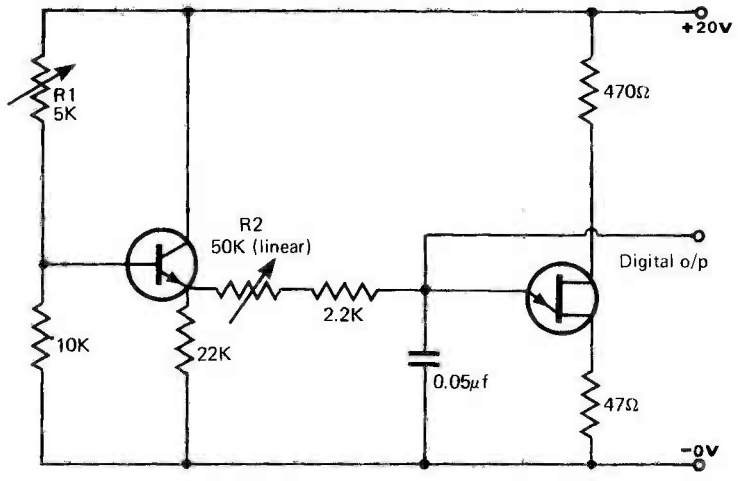
VERY LOW OUTPUT–IMPEDANCE



Output impedances as low as 0.05 ohm can be obtained by using this configuration.

Transistor Q1 is an ordinary emitter follower, assisted by Q2. Main load current is supplied by the collector of Q2. Transistor Q1 senses the difference between input and output voltage and regulates Q2 accordingly. C1 prevents oscillation.

SHAFT–POSITION DIGITAL TRANSDUCER



R2 is a low friction potentiometer used as angular position indicator.

A shaft angular-position to digital output transducer is shown in this circuit.

Rotating the angular position potentiometer R2 will provide a digital output varying from approximately 200 Hz to 2000 Hz.

The 5k trim potentiometer R1 provides a rate adjustment of a further 50%. This trim adjustment is independant of the main timing potentiometer.

READER INFORMATION SERVICE

For further information on Suppliers listed below, complete the coupon/s stating information required, including company and position held (if relevant). Cut out the coupon and post to:

ELECTRONICS TODAY INTERNATIONAL, 107 Fleet St., London, EC4.

ADVERTISERS Page No.

EDITORIAL

Four reply coupons are provided here for your convenience. Please list only ONE supplier and ONE product on each coupon. If you require information on more than four individual products, make as many copies of the coupons as you like (preferably typed) – again using one coupon form for each product.

Send to ELECTRONICS TODAY INTERNATIONAL, 107 Fleet St., London, EC4.

ADVERTISER ....
PRODUCT ....
NAME ....
ADDRESS ....
....
....
COMPANY ....
POSITION ....

5:72

Send to ELECTRONICS TODAY INTERNATIONAL, 107 Fleet St., London, EC4.

ADVERTISER ....
PRODUCT ....
NAME ....
ADDRESS ....
....
....
COMPANY ....
POSITION ....

5:72

Send to ELECTRONICS TODAY INTERNATIONAL, 107 Fleet St., London, EC4.

ADVERTISER ....
PRODUCT ....
NAME ....
ADDRESS ....
....
....
COMPANY ....
POSITION ....

5:72

Send to ELECTRONICS TODAY INTERNATIONAL, 107 Fleet St., London, EC4.

ADVERTISER ....
PRODUCT ....
NAME ....
ADDRESS ....
....
....
COMPANY ....
POSITION ....

5:72

NEWSAGENT: .....

Please deliver ELECTRONICS TODAY INTERNATIONAL for 12 months, starting with the.....issue:

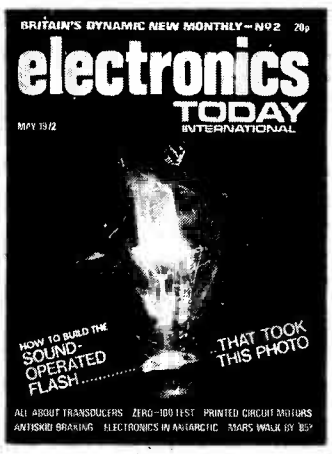
NAME .....

ADDRESS .....

.....

GIVE THIS COUPON TO YOUR LOCAL NEWSAGENT

USE THIS COUPON



costs no more delivered to your door...

...by your local newsagent

For only £2.40 a year (12 issues at 20p each) you ensure that every copy of ELECTRONICS TODAY INTERNATIONAL will arrive on your doorstep as soon as it is published — and that you'll never miss out on it if an issue happens to sell out.

electronics TODAY INTERNATIONAL

Alabaster Passmore & Sons Ltd

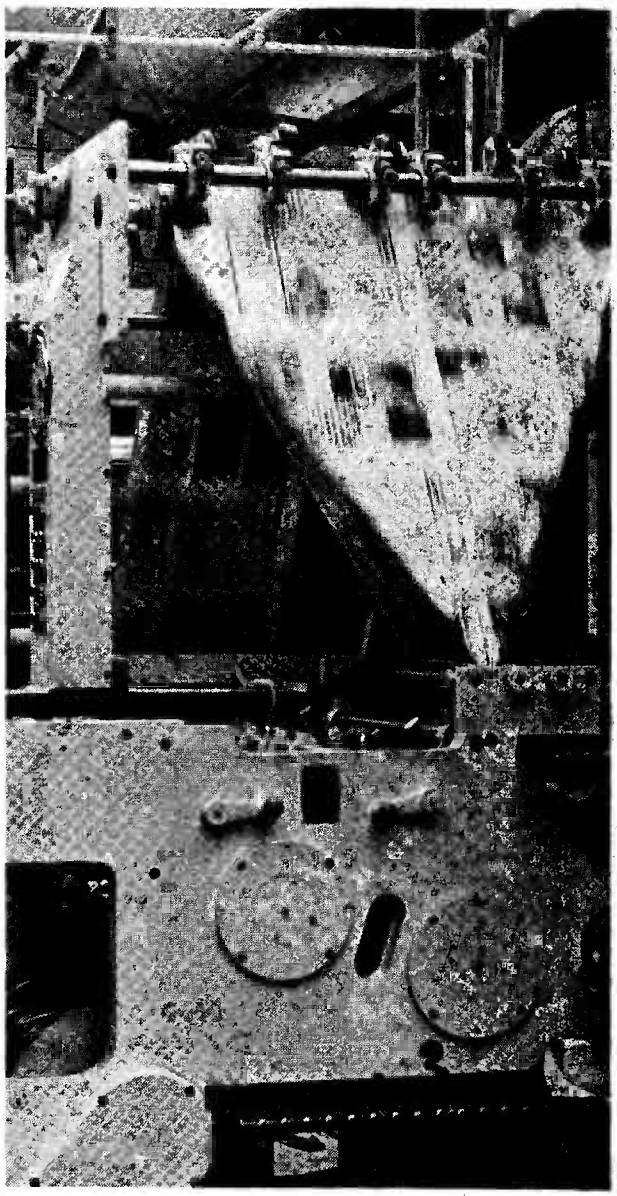
33 Chancery Lane, London WC2A 1ES

Telephone 01-405 3251

and

Tovil Printing Works, Maidstone

Telephone Maidstone 55361



Printers of

ELECTRONICS TODAY INTERNATIONAL

on their 1972 Albert Web Offset press

Colour work on one of their

Roland 4-colour presses

In just 2 minutes, find out how you can qualify for promotion or a better job in Engineering . . .

That's how long it will take you to fill in the coupon below. Mail it to B.I.E.T. and we'll send you full details and a free book. B.I.E.T. has successfully trained *thousands* of men at home—equipped them for higher pay and better, more interesting jobs. We can do as much for YOU. A low-cost B.I.E.T. Home Study Course gets results fast—makes learning easier and something you look forward to. If you'd like to know how just a few hours a week of your spare time, doing something constructive and enjoyable, could put you out in front, post the coupon today. No obligation.

THEY DID IT— SO COULD YOU

"My income has almost trebled . . . my life is fuller and happier." – Case History G/321.

"In addition to having my salary doubled, my future is assured." – Case History H/493.

"Completing your Course meant going from a job I detested to a job I love." – Case History B/461.

FIND OUT FOR YOURSELF

These letters—and there are many more on file at Aldermaston Court—speak of the rewards that come to the man who has given himself the specialised know-how employers seek. There's no surer way of getting ahead or of opening up new opportunities for yourself. It will cost you a stamp to find out how we can help *you*.

WHICH SUBJECT WOULD INTEREST *YOU?*

Mechanical
A.M.S.E. (Mech.)
Inst. of Engineers
Mechanical Eng.
Maintenance Eng.
Welding
General Diesel Eng.
Sheet Metal Work
Eng. Inspection
Eng. Metallurgy
C. & G. Eng. Crafts
C. & G. Fabrication

Draughtsmanship
A.M.I.E.D.
Gen. Draughtmanship
Die & Press Tools
Elec. Draughtsmanship
Jig & Tool Design
Design of Elec. Machines
Technical Drawing
Building

Electrical & Electronic
A.M.S.E. (Elec.)
C. & G. Elec. Eng.
General Elec. Eng.
Installations & Wiring
Electrical Maths.
Electrical Science
Computer Electronics
Electronic Eng.

Radio & Telecomms.
C. & G. Telecomms.
C. & G. Radio Servicing
Radio Amateur's Exam.
Radio Operators' Cert.
Radio & TV Engineering
Radio Servicing
Practical Television
TV Servicing
Colour TV
Practical Radio & Electronics (with kit)

Auto & Aero
A.M.I.M.I.
MAA/IMI Diploma
C. & G. Auto Eng.
General Auto Eng.
Motor Mechanics
A.R.B. Certs.
Gen. Aero Eng.

Management & Production
Computer Programming
Inst. of Marketing
A.C.W.A.
Works Management
Work Study
Production Eng.
Storekeeping
Estimating
Personnel Management
Quality Control
Electronic Data Processing
Numerical Control
Planning Engineering
Materials Handling
Operational Research
Metrication

Constructional
A.M.S.E. (Civ.)
C. & G. Structural
Road Engineering
Civil Engineering
Building
Air Conditioning
Heating & Ventilating
Carpentry & Joinery
Clerk of Works
Building Drawing
Surveying
Painting and Decorating
Architecture
Builder's Quantities

General
C.E.I.
Petroleum Tech.
Practical Maths.
Refrigerator Servicing
Rubber Technology
Sales Engineer
Timber Trade
Farm Science
Agricultural Eng.
General Plastics

General Certificate of Education
Choose from 58 'O' and 'A' Level subjects including:
English
Chemistry
General Science
Geology
Physics
Mathematics
Technical Drawing
French
German
Russian
Spanish
Biology
B.I.E.T. and its associated schools have recorded well over 10,000 G.C.E. successes at 'O' and 'A' level.
WE COVER A WIDE RANGE OF TECHNICAL AND PROFESSIONAL EXAMINATIONS.

Over 3,000 of our Students have obtained City & Guilds Certificates. Thousands of other exam successes.

Free!

Why not do the thing that really interest you? Without losing a day's pay, *you* could quietly turn yourself into something of an expert. Complete the coupon (or write if you prefer not to cut the page). We'll send you full details and a FREE illustrated book. No obligation and nobody will call on you . . . but it could be the best thing you ever did.

BRITISH INSTITUTE OF ENGINEERING TECHNOLOGY

Dept. B28, Aldermaston Court, Reading RG7 4PF.

Accredited by the Council for the Accreditation of Correspondence Colleges.

POST THIS COUPON TODAY

CARPE DIEM BIET

Write if you prefer not to cut this page.

To: B.I.E.T., Dept. B28, Aldermaston Court, Reading RG7 4PF
Please send me book and details of your Courses in

.....

Name .....
BLOCK CAPITALS PLEASE
Address .....

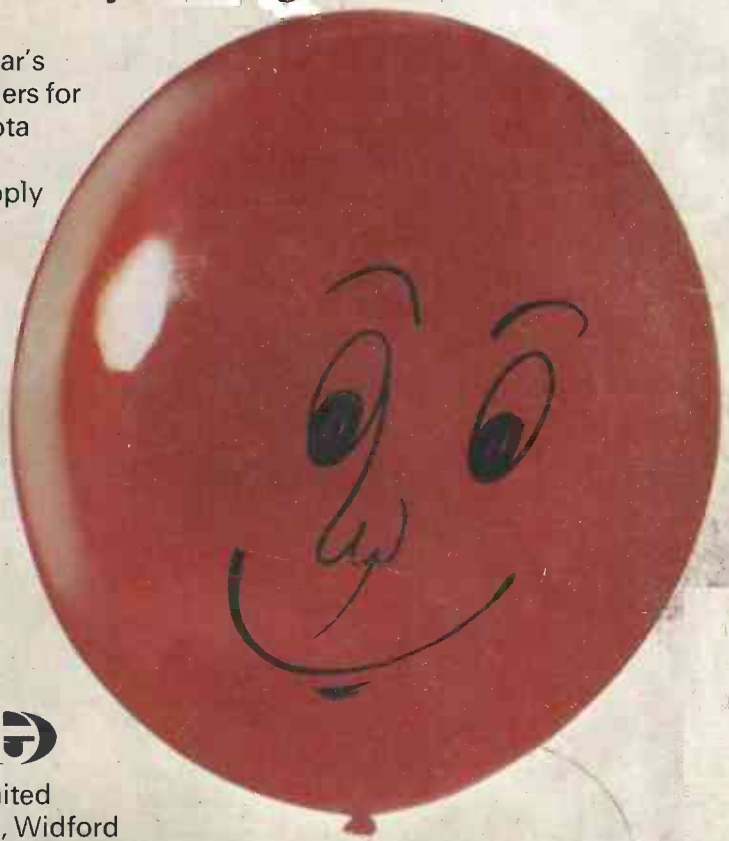
.....

Subject of Interest..... Age .....

B.I.E.T.-IN ASSOCIATION WITH THE SCHOOL OF CAREERS-ALDERMASTON COURT, BERKSHIRE

Now available in quantity – the big hit of the Radio Show

On the very first day of last year's Radio Show, you gave us orders for Mr Teleton's whole 1971 quota of Super Twelve Portable Colour Sets. Now, at last, supply is beginning to catch up with demand. And with the lowest RRP (£180) in the business, demand for the Super Twelve is going to grow and grow. So ask Teleton today to help you put some of these great shadow-mask colour portables (with built-in loop aerial) on your shelves soon. They won't stay there long.



Teleton

Teleton Electro (UK) Co. Limited
Teleton House, Robjohns Rd, Widford
Chelmsford CM1 3DW Tel : 0245 62442.
Showrooms and distribution centres throughout the country.

Mr Teleton looks even better in colour