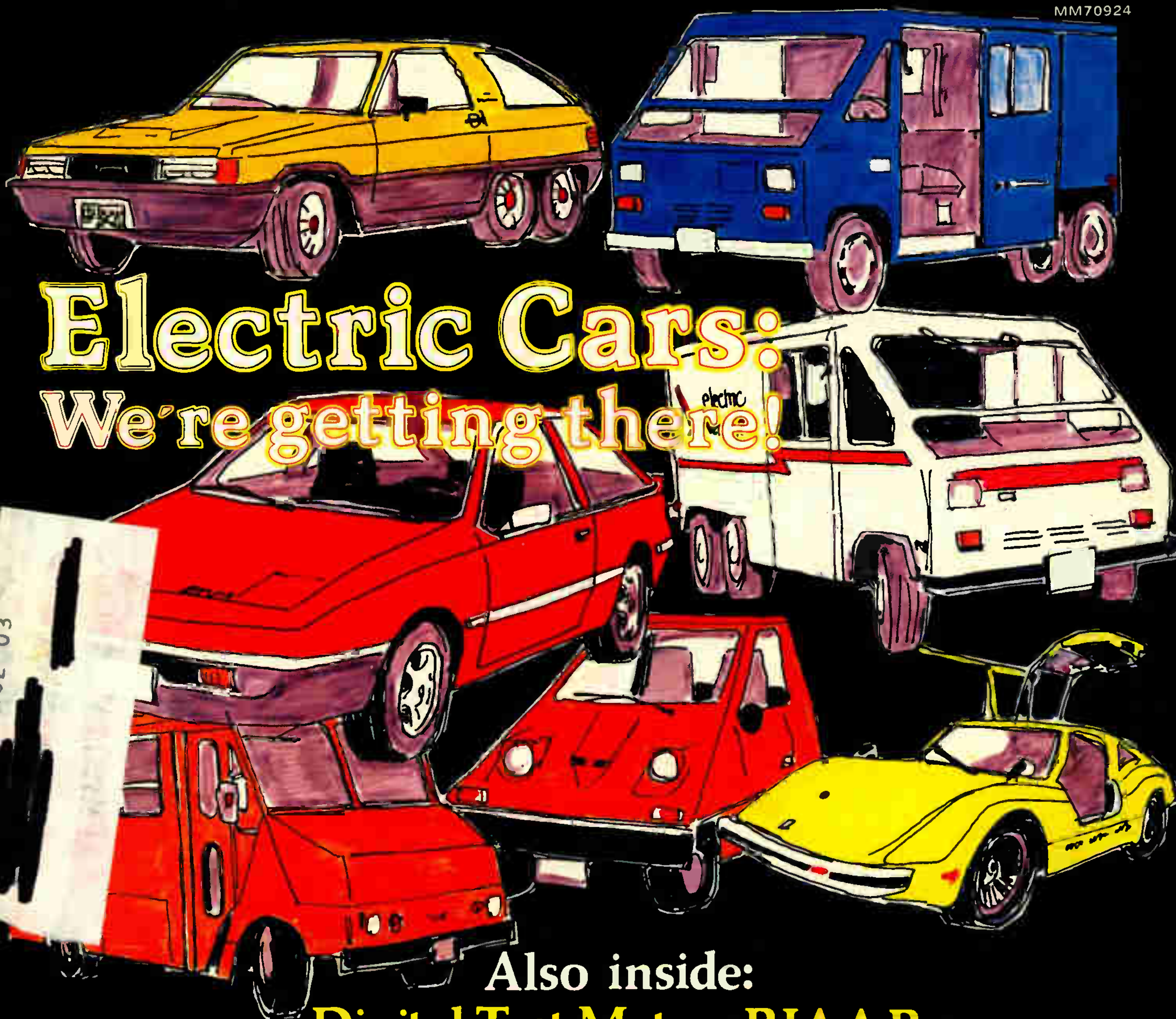
Electronics Today

INTERNATIONAL DECEMBER 1980 $1.75

MM70924

WIN A Z-80 COMPUTER SYSTEM
from Exceltronix



Electric Cars: We're getting there!

[redacted] 0482 03

Also inside:

Digital Test Meter ■ RIAA Preamp
Ten Useful Transistor Circuits ■ S.I. Units
Transducers in Audio ■ Survival!
Floppy Disk Principles

0 57438 70924 12

arkon electronics ltd

QUALITY DESIGN BEGINS WITH QUALITY PARTS

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ARKON KEYBOARD KIT

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CPM computer on a single S-100 card. Add memory for a complete system.
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Exceltronix Components & Computing Inc.

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- *Programs 74S-188, 287, 288, 387, 470, 471, 472, 473, 473, 474 and 475 PROMs*

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$450 *assembled & tested*

SEE PAGE 8 IN OCTOBER ETI, OR CONTACT US FOR COMPLETE INFORMATION

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- *Similar to professional units costing $2500 or more*
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The first single-board complete microcomputer
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SPECIAL INTRODUCTORY PRICE $389
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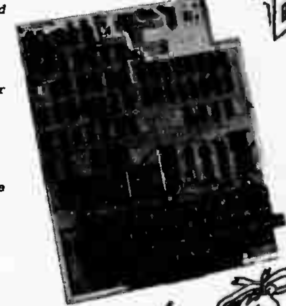

CHALLENGER 1P SERIES
- *similar to Superboard but with custom case and power supply*

$489 WITH 4K RAM; $540 WITH 4K

OHIO SCIENTIFIC C1P-MF
- *mini-floppy based version of C1P, fully expandable with 8K BASIC-in-ROM, 20K RAM and OS-65D software package*

$1789 COMPLETE

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8:	*American Siren*	$ 3.95
14:	*Windshield Wiper Controller*	$ 4.50
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16:	*Programmable Chaser Expander*	$16.95
17:	*Opto-Isolated Triac board*	$23.95
18:	*"Lightning Bolt"*	$59.95
19:	*Dot/Bar LED Wattmeter*	$22.95
23:	*Automatic Morse Code Generator*	$69.95
26:	*Car Headlight Shutoff Delay*	$ 7.50

Come in or check our catalogue for full details

OUR COMPETITIVE POLICY:

TELL US IF YOU KNOW OF ANY BETTER PRICES THAN OURS, AND WE'LL TRY TO BEAT THEM. WE ARE ALSO OFFERING BIG DISCOUNTS TO QUANTITY BUYERS.

Come in or write for our catalog.

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Canadian computer systems

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48K Dynamic RAM board	*$842*
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A/D board	*$267*
Color Video Graphics board	*$459*
Alphanumeric display unit	*$267*
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TRS-80 Converter	*$217*

COMPONENT SPECIALS

This is just a sneak preview. Come on in or check our new catalog to see the whole lot.

TTL *most types in stock*

74LS00	.29	74LS90	.57	74LS240	1.53
74LS04	.37	74LS93	.49	74LS241	1.48
74LS08	.43	74LS123	1.09	74LS244	1.76
74LS10	.29	74LS124	1.29	74LS245	3.58
74LS20	.35	74LS136	.85	74LS251	1.89
74LS30	.24	74LS138	.90	74LS253	.77
74LS32	.55	74LS161	1.16	74LS257	1.22
74LS47	.90	74LS163	1.27	74LS374	1.89
74LS48	.90	74LS174	.64	74LS375	1.29
74LS74	.73	74LS175	.68	74LS377	1.87
74LS75	.64	74LS193	1.16	74LS640	3.40
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CD4001	.38	CD4024	.62	CD4511	.90
CD4007	.51	CD4027	.57	CD4512	1.00
CD4009	.64	CD4049	.57	CD4514	2.54
CD4010	.64	CD4050	.51	CD4518	1.76
CD4011	.38	CD4051	1.00	CD4522	1.16
CD4013	.51	CD4052	1.42	CD4528	1.09
CD4016	.51	CD4066	1.00	CD4532	1.42
CD4017	.85	CD4075	.38	CD4543	2.24
CD4018	.74	CD4081	.34	CD4584	.62
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Z80-CPU	12.80	8216	3.75	6802	14.95
Z80A-CPU	14.40	8224	4.45	6810	4.85
Z80-PIO	7.95	8226	3.80	6820	4.25
Z80A-PIO	10.25	8228	6.45	6821	4.85
8080A	6.95	8251	8.50	6850	4.99
8085	14.95	8255	8.50	6502	12.85
8212	3.55	6800	8.40	6522	4.25

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2716	*(2Kx8, 450ns, 3-supply)*	$18.50
2516	*(2Kx8, 450ns, single +5v)*	$16.00
2532	*(4Kx8, 450ns)*	$48.00

(GOOD NEWS: Now you can program your own 2708, 2716 or 2516 EPROM's right here in our store for FREE if the EPROM's are bought from us, or for $2.00 per PROM if bought elsewhere .) Note: The PROM Burner you will be using is one of the many features of MULTIFLEX's Z-80A Computer KIT. Please write for more info.

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Send a certified cheque or money order (not cash). Minimum order is $5 plus $1 handling charge. Ontario residents must add 7% P.S.T. Master Charge and Chargex accepted: Send account no., signature and card expiry date.

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We couldn't possibly fit all the equipment into this space, but here's a few samples.

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CDC 4096 8" floppy drive	*Shugart SA800 8" drive*
Single or Double sided	*Single sided*
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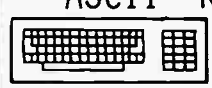
IBM 3740 compatible	*IBM 3740 compatible*
Soft Sectored $649	*Hard Sectored* $749

ASCII KEYBOARDS



$119.80

S-100 BACKPLANES

$75 *with frame* $65 *without*

S-100 CONNECTORS $5.00

IC SOCKETS: A PENNY A PIN

Merry Christmas!!

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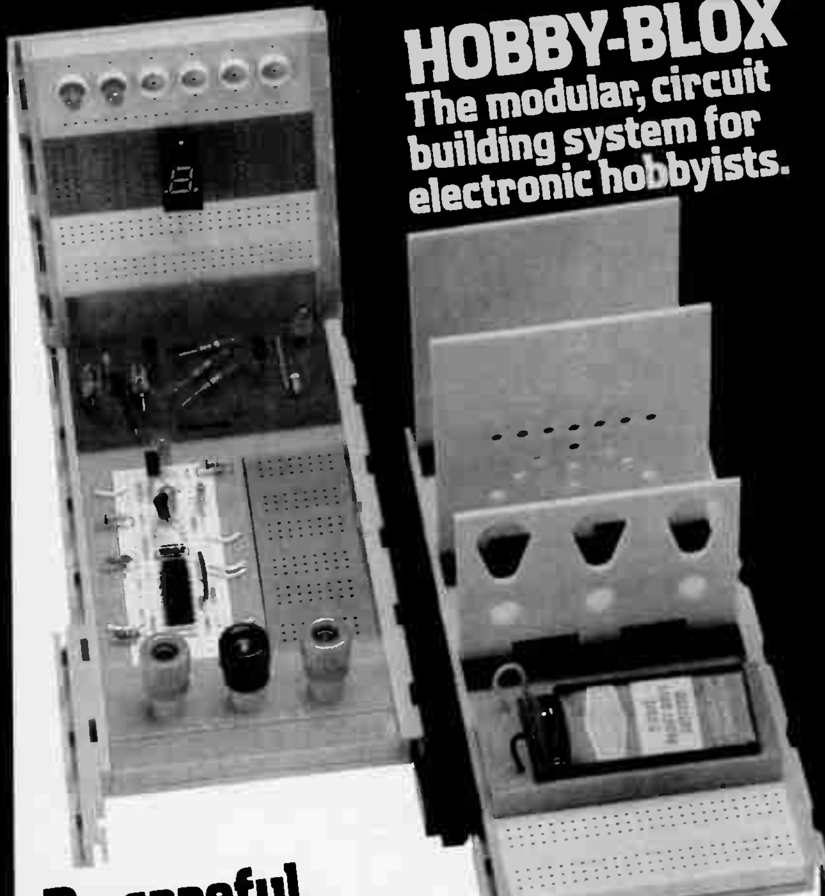
Circle No. 44 on Reader Service Card.

HOBBY-BLOX™

The modular, circuit building system for electronic hobbyists.



Be careful. Your hobby is about to become an obsession.

The 14 modular units in the solderless, Hobby-Blox™ system are color-coded and cross-indexed. Projects go faster, easier.

For the beginner, there are two starter packs. One for integrated circuits, one for discrete components. Each has its own 10 project booklet.

Once you get into Hobby-Blox, look out. You're going to get hooked.

For a free catalog, contact your local HOBBY-BLOX dealer listed below:

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Free "Project of the Month" to Hobby-Blox purchasers!

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1980 Printed circuit boards from ETI magazine:

Jan. '80	Guit. Eff. Unit $2.80 ETI 472 $4.85 (Stereo Amp. PSU) ETI 148 $1.45 (Logic Probe)
Feb. '80	ETI 473 $9.95 (Moving Coil Preamp.) ETI 254 $1.80 ETI 577 $5.90 (Power Supply)
Mar. '80	ETI 320 $.75 (Bat. Cond. Ind.) Wire Tracer $1.30
Apr. '80	Electromyogram $13.65 — ETI 730 $5.00 — ETI 731 $5.00 (Radio Teletype) Warning Systems Mon. $6.15 Complex Sound Gen. $20.15 Complex Sound Gen. $20.15
May '80	Click Elim. $18.70 Moisture Det. $1.80 Fuel Mon. $3.70
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Oct '80	ETI 561 Metal Detector Baby Alarm $5.50 ETI 152 $2.65
Nov' 80	ETI 452 $15.70 (Guitar practice AMP) Infra red remote control $13.55 (Set of pcbs)
Dec'80	Digital Test Meter $16.65 Survival Game $3.30 RIAA Preamp $1.20

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HAPPY HOLIDAYS

Circle No. 11 on Reader Service Card.

NEWS

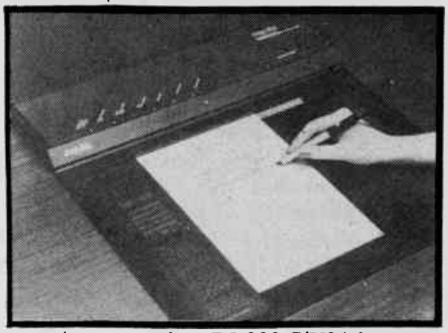
Write On

A multifunction input device, developed by a British company, is equipped with both a handprint recognition mode and a sketch and drawing mode which give it a wide range of applications in industry, commerce and government.

The Image Data Tablet is shaped like a desk blotter, only 4mm thick. It will accept 8" X 11" size paper placed horizontally or vertically. It is possible to enter handprinted alphanumeric characters and a wide range of special characters either on an unformatted sheet of paper, and existing form or a specially formatted document.

Designs or drawings can be made by tracing with a specially designed pen on paper, and the results are displayed on a screen and stored off or on-line to a mainframe computer. It is also possible to express a mathematical problem on a document on the tablet, and, as the equals sign is written, the solution to the problem is displayed on the screen and can be written on the document. The device will also accept input through a tele type compatible touch table.

Characters entered on the tablet are converted to ASCII code for transmission to a



host computer via a RS-232-C/V24 interface at rates up to 9600 baud.

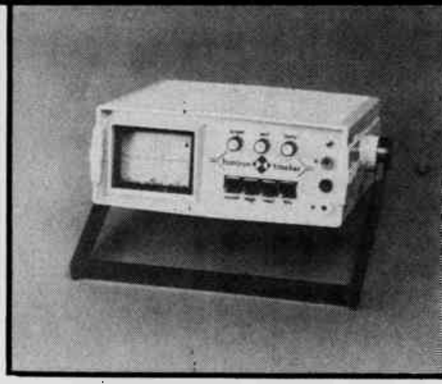
The manufacturer? Image Data Products Ltd., 1–4 Portland Square, Bristol, BS2 8RR England.

Keeping Track

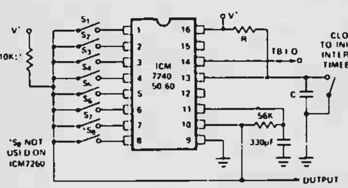
A new version of the Huntron Tracker is now available from Cyprus Products Inc. The model HTR 1005B1S is designed for trouble-shooting solid state components and circuits with no circuit power applied.

The dual channel input feature, selectable by a front panel control, provides automatic, timed A-B input switching as well as fixed A or B channel operation. A graticule face-plate provides a reference standard for visual comparison of the devices under test. These features allow rapid testing of analog or digital devices either in or out of circuit.

The "Compar-A-Trace" model can cut equipment down time by speeding up fault diagnosis. An illustrated brochure is available



which describes the instrument and applications. Write to Cyprus Products Inc., 7117 Tisdall Street, Vancouver, B.C. V6P 3N2 or phone (604) 327-8814.



Programmable Timers

A new family of CMOS programmable timers and counters for precision micropower timing, delay intervals, or sequencing has been introduced by Intersil, Inc. The ICM7240/50/60 series of RC oscillators/timers/counters have selectable output counts from 1 RC to 255 RC (ICM7240), 1 RC to 99 RC (ICM-7250) or 1 RC to 59 RC (ICM7260).

Applications for the ICM7240 family include programmable timing, long time delay generation, cascadable and programmable counting, low-frequency oscillators and sequence timing. The new circuits are packaged as 16-pin DIP devices, and prices start at $2.25US in 100-unit quantities. Availability is from stock.

For more information, contact Lenbrook Industries Ltd., 1145 Bellamy Road, Scarborough, Ontario M1H 1H5 or phone (416) 438-4610.

New Omnitronix Warehouse

Omnitronix Limited has opened a branch warehouse facility in the Toronto area to better serve its customer base in the Ontario marketplace. Direct your inquiries to Morriss Gordon, 6295 Shawson Drive, Unit 7, Mississauga, Ontario L5T 1H4 or phone (416) 678-7170, Tlx: 06968653. (Omnitronix Limited represents Injectorall, Jersey Specialty, Leader Instruments, Oaktron, Telematic, UniSound, UniVolt, Waldom, and Winegard.)

A Really Big EPROM

Intel will be offering a 64-kilobit erasable programmable read-only memory (EPROM) that conforms to the new industry standard for high-density byte-wide memories. It was introduced by Intel Corporation. The Intel 2764 has a rated worst-case access time of 250 nanoseconds, which makes it the fastest 64K EPROM available today.

The 2764 is a completely static device (no clocks are required) with two-line control and low power dissipation. In active mode, the 2764 draws 150 milliamperes from a single 5-volt supply. When not enabled, the chip automatically goes into standby mode so that current consumption drops to 35mA and the eight output lines go into a high-impedance state.

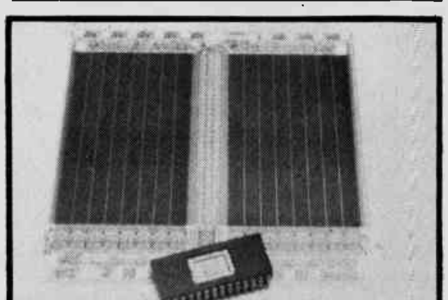
Right now, the 2764 is listed as $163.US for 100 piece quantities. Only samples are available, volume shipments are expected to start in early 1981.

A DPM Alternative

User's of Intersil's 7106/7107 DPM ICs now have a new source. Teledyne Semiconductor now second sources these popular ICs. The 7107 is designed to be used with LED displays whereas counterpart, the 7106, will drive most LCD display devices. Both devices are pin for pin compatible with the original Intersil devices.

An evaluation kit is available for either of two ICs. Each kit consists of one IC (7106 or 7107), a pcb, suitable LCD or LED display, passive components and a six-page application note.

The 7106 Kit is listed as selling for $33.90 US and the 7107, $27.90US. For more information, write to Vitel Electronics, 3860 Cote Vertu, Suite 203, StLaurent, PQ H4R 2B7 or phone (514) 331-7393.



Electronics Today International
Editorial and Advertising Offices
Unit 6, 25 Overlea Boulevard,
Toronto, Ontario, M4H 1B1
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INTERNATIONAL EDITIONS
Electronics Today International,
145 Charing Cross Road,
London WC2H 0EE, UK
Electronics Today International,
Ryrie House, 15 Boundary St.,
Rushcutters Bay, Sydney, Australia
Elrad
Kommanditgesellschaft, Bissendorfer
Strasse 8, 3000 Hannover 61, Germany
Electronica Top Internationaal
Postbus 93 Bilthoven, Holland

ETI Magazine is published by:
Electronics Today International (Canada) Ltd
Printed by:
RBW Inc., Owen Sound, Ontario.
Newsstand Distribution:
Master Media, Oakville, Ontario.

SUBSCRIPTIONS
$16.95 (one year), $29.95 (two years). For US add $3/yr., other countries $5/yr. Please specify if subscription is new or renewal.

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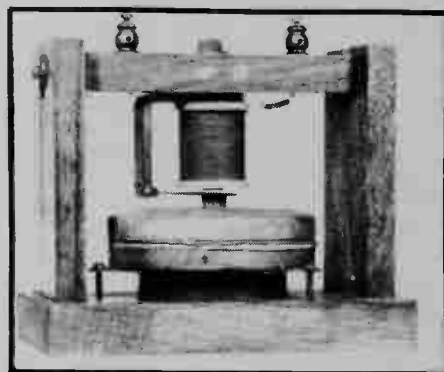
DECEMBER 1980 Vol.4 No.12

FEATURES

Digital Test Meter, p.11



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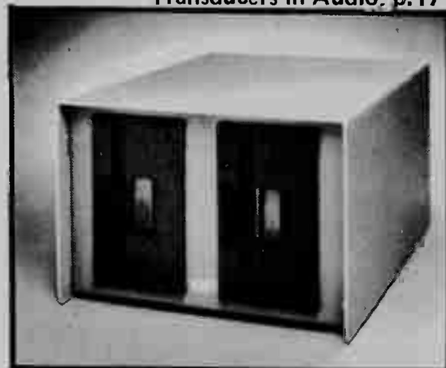

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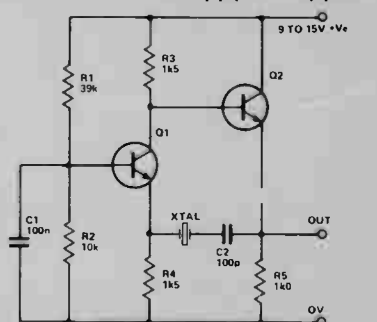

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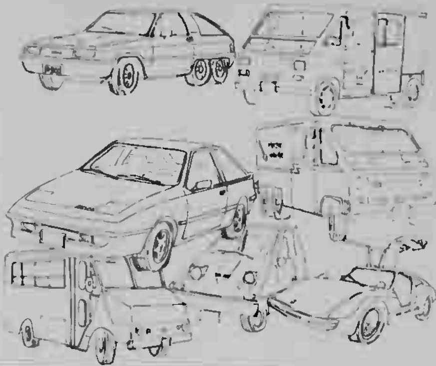


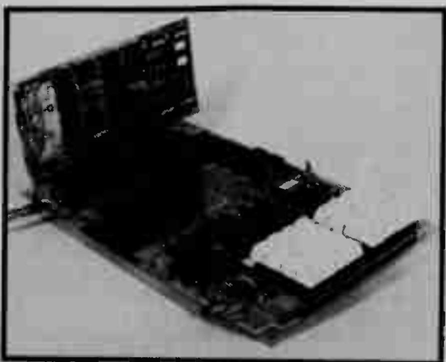
Cover: Sketches of just a few of the electric vehicles which have been developed. Most of these are experimental but considerable advances have been made. See page 31.

ISSN 0703-8984

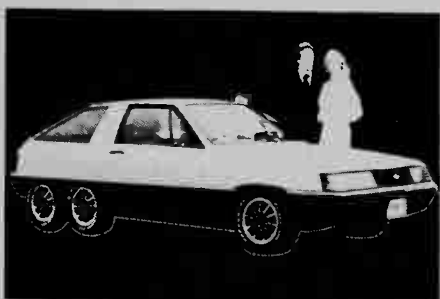
PROJECTS

COLUMNS

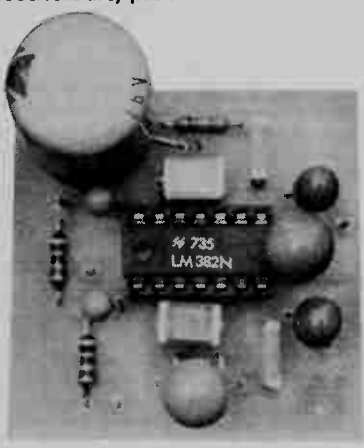
NEWS / INFO



Win a Computer, p.30



Electric Cars, p.31



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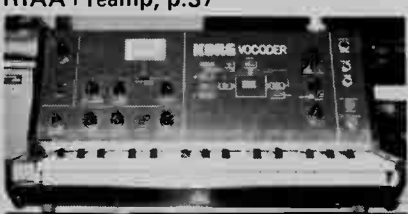

What's New, p.45

ADVERTISERS' INDEX

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Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

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COMPONENT NOTATION AND UNITS
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier, thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100n, 5600pF is 5n6. Other examples are 5.6pF=5p6, 0.5pF=0p5.
Resistors are treated similarly: 1.8M ohms is 1M8, 56k ohms is the same, 4.7k ohms is 4k7, 100 ohms is 100R and 5.6 ohms is 5R6.

PCB SUPPLIERS
The magazine does not supply PCBs but these are available from the following companies. Not all companies supply all boards. Contact these companies direct for ordering information.
B&R Electronics, P.O. Box 6326F, Hamilton, Ontario, L9C 6L9
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Danocinths Inc. P.O. Box 261, Westland, MI 48185, USA.
Exceltronix Inc., 319 College St., Toronto, Ontario, M5T 1S2
Arkon Electronics Ltd., 409 Queen St. W., Toronto, Ontario, M5V 2A5.
A-1 Electronics, 5062 Dundas St. West, Islington, Ontario M9A 1B9. (416) 231-4331.

Cat News

The long awaited Exceltronix catalogue is finally out. The catalogue is unusual in that you get a DuoTang binder loaded with inserts. As new products become available, Exceltronix will send out updates, suitably punched for easy insertion. The catalogue is available free by writing to Exceltronix, 319 College Street, Toronto, Ontario M5T 1S2 or phone (416) 921-5295.

File Under 'F'

Designed to fit into a standard filing system, the Finkler File, is a complete set of product data and catalogues of 18 companies involved in electronic and electrical equipment industry, represented in Canada by Len Finkler Limited.

For further information contact: Len Finkler Ltd., 25 Toro Road, Downsview, Ontario M3J 2B4.

Flat LEDs

To permit light-emitting diodes to be arranged in particularly tight rows, Siemens is now supplying flat types, which with parallel side faces exhibit a rectangular radiation cross section with the dimensions 2.5 X 5.1mm. Large illuminated scales can thus be implemented with high "packing density".

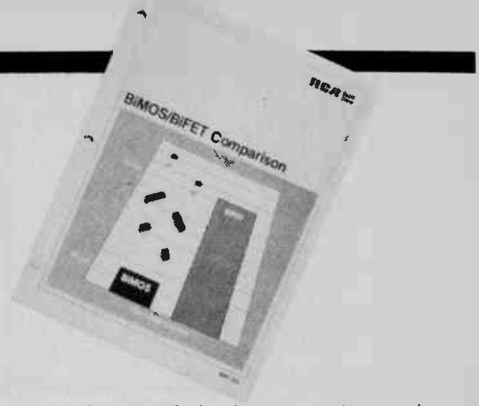
The flat LEDs with diffuse plastic cases are available as standard red (LD 80), TSN (transparent substrate, nitrogen-doped) red (LD 82), TSN yellow (LD 86) and GaP green (LD 87) diodes. The light intensities are in three groups, ranging from less than/equal to 0.6 millicandela to 3.2 millicandela, each measured at a forward current of 20mA. The diodes can be loaded with up to 100mA (LD 80) or 60mA, the permissible power dissipation is 20mW in all cases.

For more information contact: Siemens Electric Ltd., P.O. Box 7300, Pointe Claire Quebec H9R 4RG or phone (514) 695-7300.

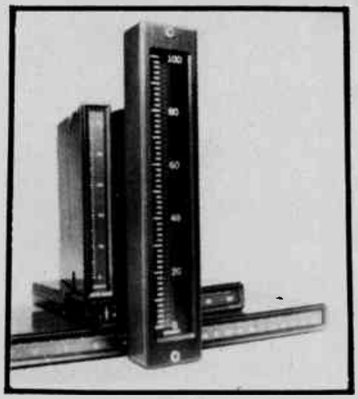
Op Amp Technologies

A 16-page brochure, "BiMOS/BiFET Comparison, " comparing performance characteristics for operational amplifiers involving bipolar-MOS (BiMOS) and bipolar-field effect-transistor (BiFET) technologies is available from RCA Solid State Division.

The booklet uses the industry-standard 741 op amp as a base reference for comparisons and stresses such parameter improvements as input offset current, input bias current, input offset voltage, slew rate, bandwidth, input impedance, output swing capability, zero standby current consumption, and supply voltage range.



Copies of the brochure, "BiMOS/BiFET Comparison," BBC-320, may be obtained by writing to RCA Solid State Division, Box 3200, Somerville, NJ 08876.



New 5" Analogue DPM

Metermaster announces a new 5" solid state analog panel meter, Model AMP 500. The panel meter has a 50-segment LED bar-graph display with a full scale response of 2.5 msec. Accuracy is ±2% of F.S. It's 100 kohm input impedance is well in excess of most needle type meters. The AMP 500 will accept AC or DC voltages and current, and 7-bit binary inputs.

Options include differential input, "high input impedance", single and dual alarm set points along with special ranges and scales.

For more information contact Metermaster, 214 Dolomite Drive, Downsview, Ontario M3J 2P8 or phone (416) 661-3190.

Update On Surveillance Video

Readers interested in Steve Rimmer's video surveillance column for October 1980 might want to check out this item. A 20-page booklet entitled "Management Guide to Closed Circuit Television Security Systems" is now available from ADT Canada.

Written by Allan E. Schwartz, ADT National Marketing Manager, Closed Circuit Television Systems in the United States, the publication is an easy-to-read review of the basics of closed circuit television systems as they are applied to controlling losses.

Single copies of "Management Guide to Closed Circuit Television Security Systems" are available without charge from Robert J. Wood, Manager, Marketing and Sales, ADT Security Systems, 4881 Yonge St., Suite 700, Willowdale, Ontario M2M 5X3.

Looking Back

Electronic Thermometer
Designer Circuits, September 1980

As indicated last month, a pin number fell off the schematic during production. The right hand leg of C2 goes to pin 8 of IC1.

Also the pinouts given for the 7805 regulator are incorrect. Referring to the base diagram (not the schematic), pin 1 is ground, pin 2 is the input and pin 3 is the output.

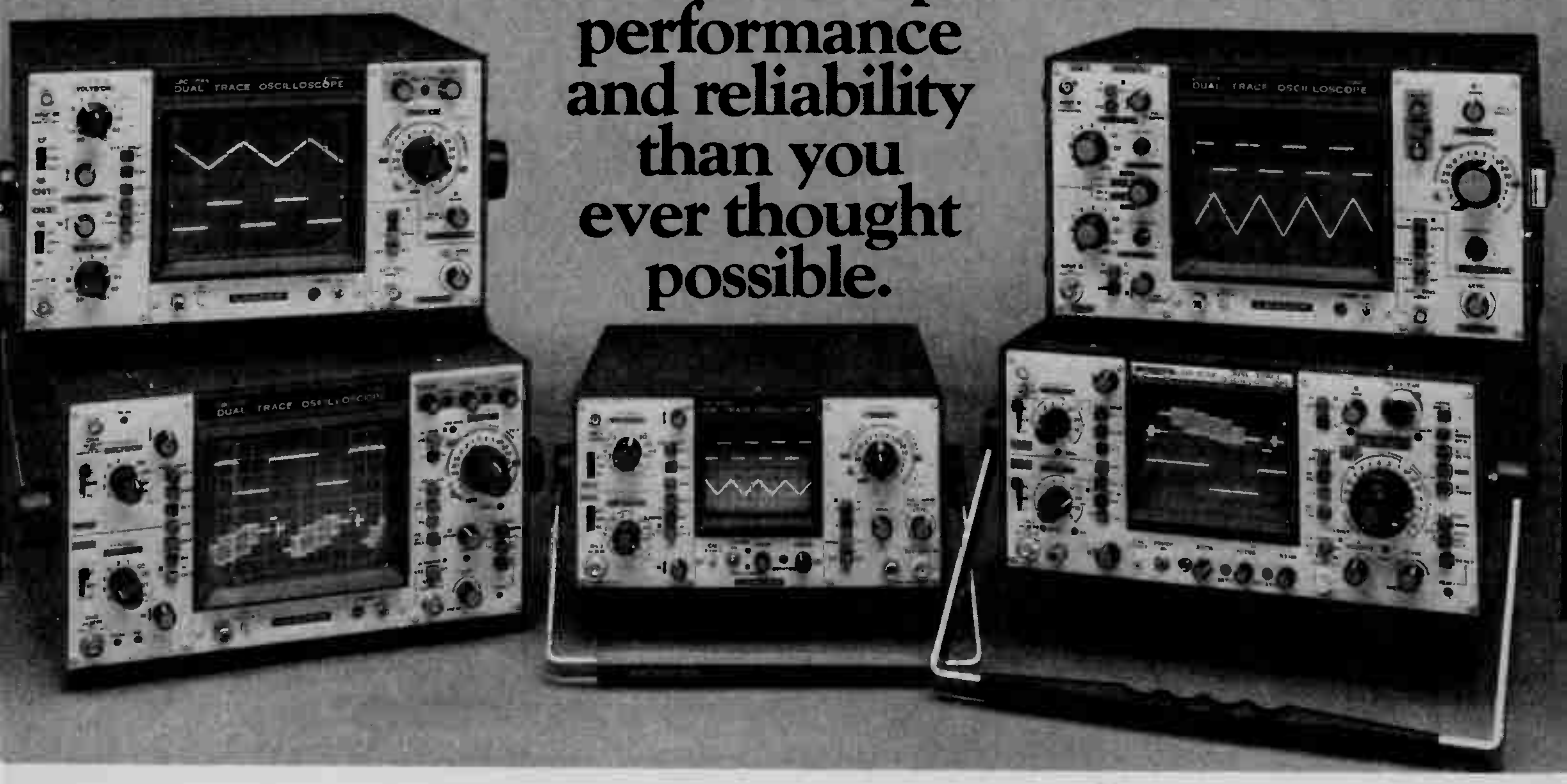
While on the subject of regulators, the 7805 is really too large for this application, a 78L05 would work just as well. Any 4-6V supply will work, but it must be well regulated. Any inaccuracies in regulation will contribute to inaccuracies in the final temperature measurements.

The Last Word

People who are aware of what happens within the industry, also know of the fantastic shortages that can occur. In California the situation is so bad that now some companies have turned to theft (the break and enter variety) and even armed robbery to get the parts they need. In one case over $100,000 worth of TI, Fairchild, National and Motorola components were taken at gunpoint from General Transistor Supply, Inc. The thieves apparently were working from a shopping list.

The theft is one of a rash of similar happenings in California's Silicon Valley. Most distributors are protected against burglary by suitable alarms, but it now appears that armed security guards will be needed, just as in jewelry stores and banks. ●

10 to 30 MHz oscilloscopes with more performance and reliability than you ever thought possible.



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30 MHz delayed sweep – NEW

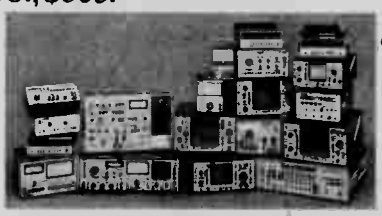
LBO-515B is a compact, precision oscilloscope at a moderate price. Using a PDA 4-inch CRT with parallax-free internal graticule, it features 5 mV sensitivity and delayed sweep for viewing and measuring complex waveforms. Also has 120 ns signal delay, trigger hold-off and x-y operation at full sensitivity.

30 MHz with signal delay – $1585.

LBO-520 combines a 11.7 ns rise time with 5 mV sensitivity and 120 ns signal delay lines. Has single shot triggering, X10 sweep magnifier and bright, sharp PDA CRT. Triggers to 50 MHz.

20 MHz dual and single trace – $1100., $865.

LBO-508A and LBO-507A give you versatility at low cost. Rise time is 17.5 ns with 1 MΩ (35 pFd) input impedance. Automatic or external triggering, X5 sweep magnifier, 10 mV/cm sensitivity and add/ subtract modes.



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LBO-514 has both vertical and horizontal X5 magnifiers. Sensitivity is from 1 mV/cm to 10 V/cm. Sweep speeds from 0.2 s/cm to 0.1 µs/cm. Auto or normal triggering. Z-axis modulation. (Single trace version, LBO-513, $775.)

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20 MHz battery/ac portable – $1350.

LBO-308S provides lab performance and high reliability in field service applications. Sensitivity is 2 mV with a complete set of triggering controls and 18 sweep ranges to 0.1 µs/div. with X5 magnifier. Compact, lightweight with 3-inch rectangular, internal graticule CRT. (Optional 2 hour internal battery pack is recharged during ac operation.)

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"The RCA CTC 108 and CTC 109 chassis have earned the highest possible serviceability rating category... Excellent... by incorporating serviceability features required in the ISCET Serviceability Rating Form.

"RCA's many years of cooperation with ISCET's Serviceability Committee has helped produce excellent results."

—Dean R. Mock, Chairman, NESDA/ ISCET Serviceability Committee

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All subassemblies plug into chassis. No tools are needed to remove chassis (main circuit board). Just remove the cabinet back, unplug subassemblies and the chassis is ready for removal.

Roadmapping on both sides of the board. Although the XL-100 chassis use single-sided circuit boards, double road-mapping means you can easily trace circuits from either side.

Circuits and voltages directly identified. Major circuit areas as well as power supply source and key pulse voltages are labeled by name on the board. So you can find them fast.

That all means that when you do have to repair our new XL-100 chassis, in most cases you can fix them quickly and easily.

And you won't have to waste your valuable time trying to find out where to go to fix what you already know is wrong.

Because to us that's what really counts. Making your job easier and your customers happier.

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Circle No. 2 on Reader Service Card.

DIGITAL TEST METER

This unique and modestly priced piece of test gear uses the very latest 3½ digit LCD DVM module and acts as a combined 25-range digital multimeter and a 5-range digital frequency meter. It's another 'first' from ETI.

TWO OF THE most useful pieces of modern electronic test gear are the Digital Multimeter (DMM) and the Digital Frequency Meter DFM. These instruments are highly accurate, rugged and can be used in an attitude (vertical, horizontal, upside down, etc). Trouble is, they tend to be a bit expensive; a decent pair of such instruments can cost about $400.00.

We have overcome the price by producing a unique 30-range digital instrument that acts as a combined 25-range DMM and 5-range DFM. We've decided to call this new instrument a Digital Test Meter, or DTM. Our DTM is designed around the very latest 3½ digit liquid crystal digital voltmeter module (thereby simplifying construction), is powered from two 6V battery supplies and typically gives several months of operation from a single battery set.

The AV (alternating voltage) ranges of the DTM are frequency compensated; they are typical responses that are flat within 1% or 40Hz or to within 1dB to 120kHz.

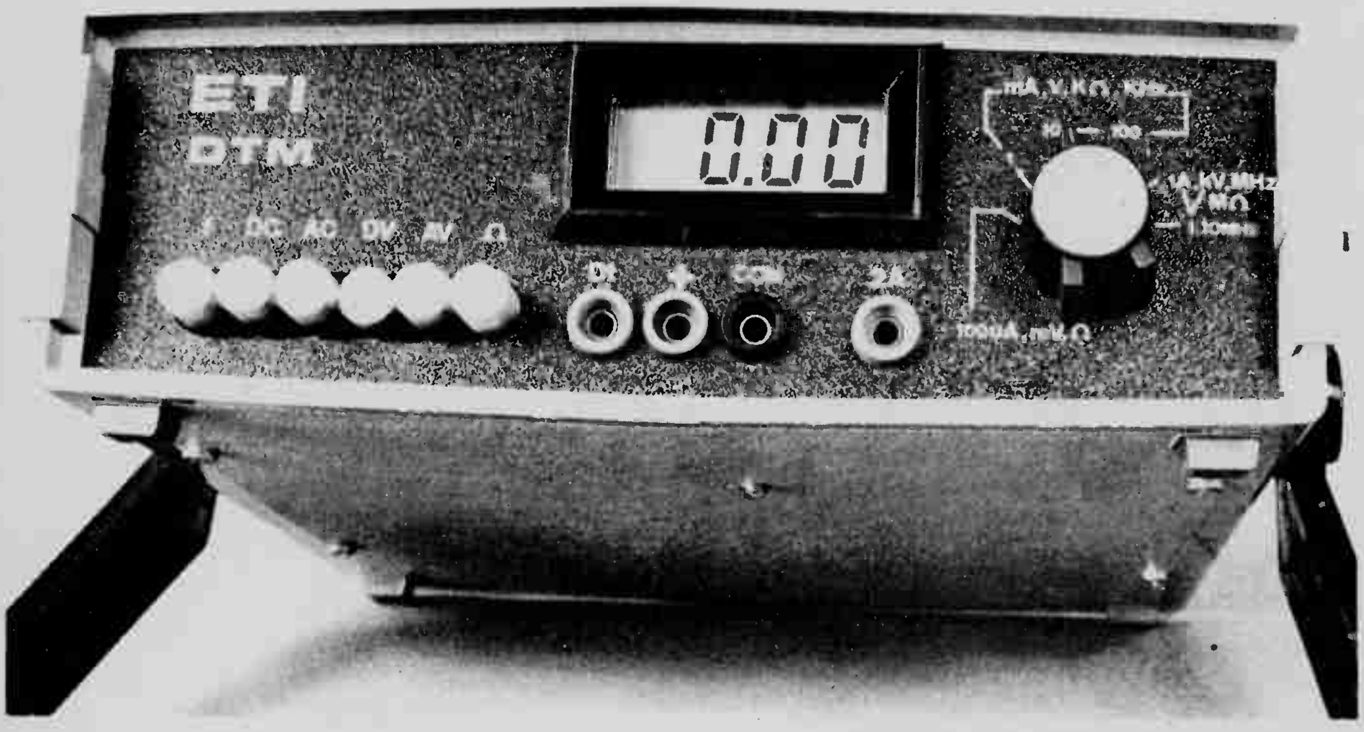
The resistance indicating section of the DTM uses a ratiometric measurement technique and a test voltage of about 300mV maximum, thereby enabling in-circuit resistance measurements (such as a resistor in parallel with a semiconductor junction) to be made without forward biasing in-circuit junctions. The DTM is provided with an independent facility (via a specific test terminal) for testing semiconductor junctions.

The frequency meter section of the unit can be used to measure frequencies in the range 10Hz to 1.999MHz. The input impedance of the section is roughly 200k and signal levels in the approximate range 10mV to 100V can be accepted.

The DTM is provided with a built-in precision 1V22 DC reference, which can be used for basic calibration of the DC and DV ranges. Resistance calibration is automatically established by built-in standard resistors. The instrument must be compared with external standards to calibrate the basic AC, AV and frequency ranges.

Accuracy

The basic 3½ digit DVM module used in the DTM is intended to read 100mV full scale, with 100% over-range capability



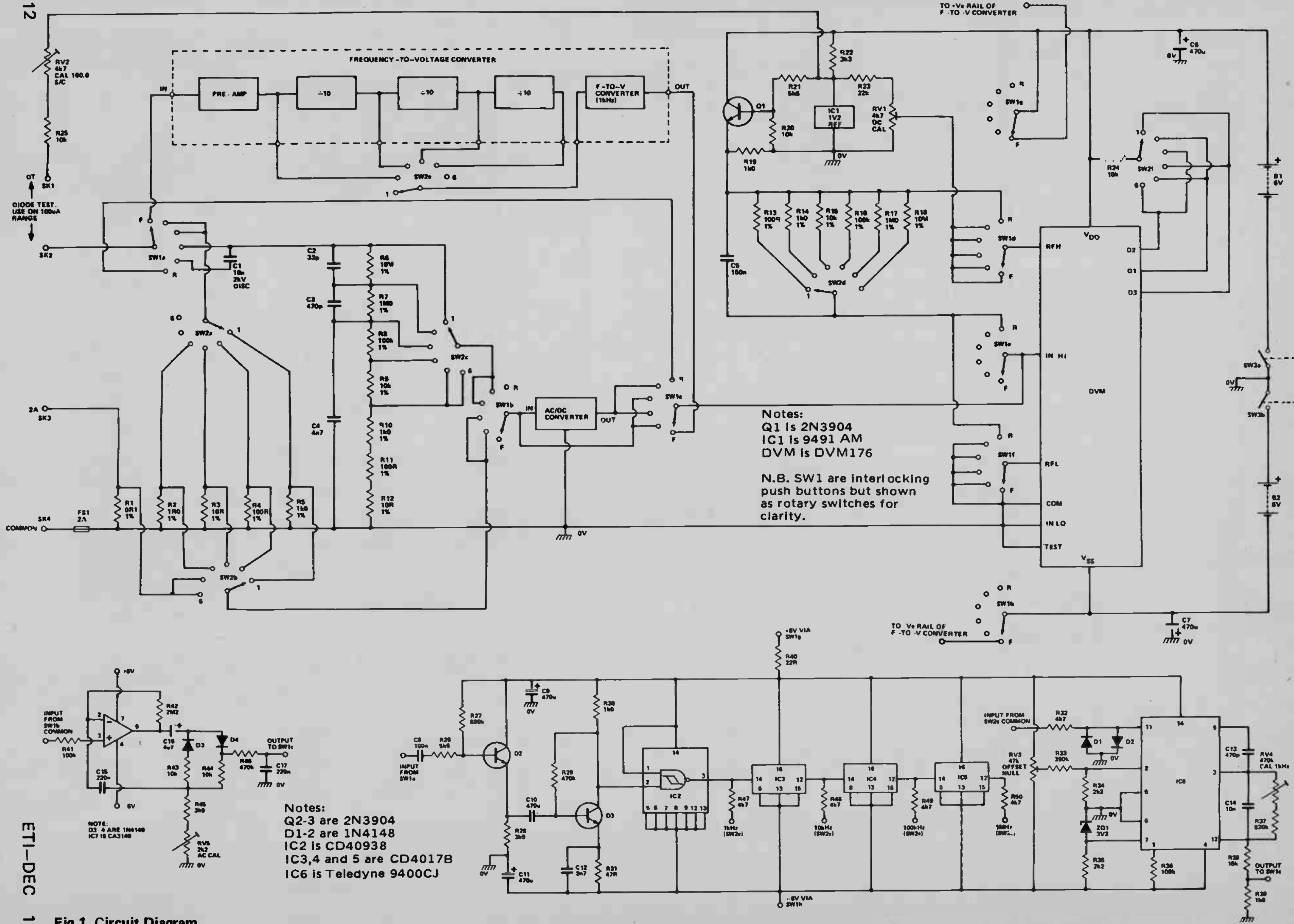


Fig.1. Circuit Diagram.

HOW IT WORKS

The heart of the DTM is a DVM 176M Rev C 3½ digit liquid crystal DVM module. This module has a built-in voltage reference and is intended to be powered from a single 9V battery. The complete module (including the readout) typically draws only 1mA of current and is intended to read 100mV DC full scale with 100% over-range capability (giving a maximum reading of 199.9mV).

In our particular application we need, for various reasons, to power the module from a split 12V (6-0-6) battery supply, which makes it necessary to ignore the module's built-in voltage reference, and supply it with a reference voltage from an external source. IC1 and the RV1-R23 divider are used for this purpose.

In the completed DTM, voltage ranging is obtained by feeding inputs to the DVM module via the R6-R12 potential divider network. AC voltage ranging is obtained by feeding inputs to the DVM module via the same potential divider (which is frequency compensated via C2-C3 and C4) and via a precision AC/DC converter (designed around IC7).

Current ranging is obtained by feeding the test current through the appropriate one of the R1 to R5 ranging resistors and monitoring the voltages that they generate. In the DC mode, the generated voltages are fed directly to the input of the DVM module. In the AC mode, they are fed to the module via the AC/DC converter.

Frequency indication is obtained by feeding input signals to the DVM module via a precision frequency-to-voltage converter. The f-to-v converter has a basic range of 10Hz to 1,999kHz and frequency ranging is achieved by feeding input signals to the converter via switch-selected decade divider networks.

Resistance measurements are made by disconnecting the external reference from the DVM module and connecting the test resistor in series with the appropriate one of the R13 to R18 ranging resistors and powering the combination with a few hundred millivolts DC (via the IC1-Q1 network). The voltage of the ranging resistor is monitored at the reference-input terminals of the DVM module and the voltage of the unknown resistor is monitored at the module's signal input terminals. The DVM module compares the ratios of the two voltages (and thus the ratios of the resistors) and gives a readout that is interpreted directly in terms of resistance.

This 'ratiometric' system of resistance measurement has two distinct advantages. First, maximum test voltage of only a few hundred millivolts are applied to the unknown resistor, thereby enabling in-circuit resistance measurements to be made without causing semiconductor junctions to become forward biased. Second, the accuracy of measurement is independent of the energising voltage and is determined solely by the accuracy of the ranging resistors, thus eliminating calibration problems. Our circuit measures resistances of 0R1 to 19.99M in six ranges.

In the DTM, multi-pole switch SW1 is used to select the mode of operation and SW2 is used for range selection. SW2f sets the decimal point of the display to a position appropriate for the selected range.

The DTM has a facility for testing semiconductor junctions. To use this facility, the unit is switched to the 100uA range in the DC mode and the test device is connected between the DT+ and + terminals of the instrument. The DT + terminal is energised from the built-in 1V2 source via RV2 and R25 and the resulting device current is read out by the DVM module. Open circuit devices give a reading of zero. Short circuit devices give a reading of 100.0. Good silicon junctions give a forward reading of roughly 60.0.

The AC/DC converter section of the instrument is designed around IC7, which is connected as a precision rectifier. The gain of the circuit can be pre-set, for calibration purposes, via RV5. The output of the converter is integrated by the R46, C17 network and by an additional network that is incorporated in the DVM module.

Frequency to voltage conversion input test signals are fed to high-impedance (roughly 200k) input buffer Q2 via safety resistor R26 and are then amplified by Q3 and converted to square waves at the input frequency via IC2. The resulting square waves are then divided down by decade dividers IC3 to IC5.

The heart of the converter is IC6 which, quite simply, is a dedicated precision frequency-to-voltage converter chip, in which the input signal is fed to pin 11 via R32 and a proportional analogue voltage appears at the junction of R38-R39. In our applications, the IC is configured to cover the basic range of 10Hz to 1.999kHz. Frequency calibration can be set via RV4 and offset nulling (zero output for zero input) can be achieved via RV3.

Frequency ranging of the complete converter circuit is obtained by feeding the input of IC6 from an appropriate point in the IC2-IC5 network via SW2e. Thus, on the 1kHz range IC6 is fed directly from the output of IC2; on the 1MHz range, IC6 is fed from the output of IC5.

PARTS LIST

Resistors
¼W 5% unless specified

R1	0R1 ½W 1%
R2	1R0 ½W 1%
R3, 12	10R ½W 1%
R4, 11, 13	100R ½W 1%
R5, 10, 14	1k0 ½W 1%
R6, 18	10M ½W 1%
R7, 17	1M0 ½W 1%
R8, 16	100k ½W 1%
R9, 15	10k ½W 1%
R19, 30, 39	1k0
R20, 24, 25, 43, 44	10k
R21, 26	5k6
R22	3k3
R23	22k
R27	680k
R28, 45	3k9
R29, 46	470k
R31	47R
R32, 47, 48, 49, 50	4k7
R33	390k
R34, 35	2k2
R36, 41	100k
R37	820k
R38	15k
R40	22R
R42	2M2

Potentiometers

RV 1,2	4k7 miniature horizontal preset
RV3	47k miniature horizontal preset
RV4	470k miniature horizontal preset
RV5	2k2 miniature horizontal preset

Capacitors

C1	10n 2kV ceramic disc.
C2	33p silver mica
C3	470p silver mica
C4	4n7 silver mica
C5	150n polycarbonate
C6, 7, 9, 11	470u 16v electrolytic, PCB type.
C8	100n polycarbonate
C10	470n polycarbonate
C12	2n7 ceramic
C13	470p ceramic
C14	10n polycarbonate
C15, 17	220n polycarbonate
C16	4u7 electrolytic, PCB type

Semiconductors

DVM	176M Rev. C.
IC1	Teledyne 9491AM
IC2	4093B
IC3, 4, 5	4017B
IC6	Teledyne 9400CJ
IC7	CA3140
Q1, 2, 3	2N3904
D1-4	IN4148

Miscellaneous

SW1a, 8 pole change over interlocking push button
SW1b, c, d, e, 6 pole change over interlocking push button
SW1a-f, 2 pole 6 way wafers (3 off) rotary switch
SW3, DPDT miniature toggle
SK1-4, banana sockets
2, 4 section battery holders for AA cells
1, 1¼" fuse & holder chassis fixing or similar
1 winged knob
Case Hammond 9H CM BG

(giving a maximum reading of 199.9mV). The basic module is capable of reading with an accuracy that is within 0.1% (one digit, or 100uV) of full scale, once it has been initially calibrated against a suitable reference standard.

In practice, all other ranges of the DTM are obtained by feeding inputs to the DBM module via resistive potential dividers, current ranging resistors and resistance standards.

In our prototype DTM we've used 1% resistors in all pertinent positions, thus giving the completed instrument an overall accuracy of 1% which we consider to be adequate for most practical purposes. If you want higher accuracy, you'll have to locate a source of supply of ultra-precision resistors.

Construction of the unit presents a bit of a challenge due to the complexity of the interwiring. Construction needs to be tackled in a methodical manner, with the unit being given a functional check at the end of each building stage. The following building sequence is recommended.

DV Ranges & AV Ranges

Gather all hardware together (switches, battery pack, sockets, fuse holder and the DVM module and bezel) and secure them in their final positions in the instrument case. On our prototype, we've used a bank of push-button switches for SW1 (mode selection) and a rotary switch for SW2 (range selection). On/off switch SW3 is mounted on the rear of the instrument. SW1 is mounted on a small PCB and fixed, via self-tapping screws and a 1/8 inch spacers into studs moulded into the base of the case.

Make up PCB A as shown in the overlay, taking special care over the construction. Note that 1% resistors are used in the range-determining positions. Fit Veropins or flea clips in all appropriate positions on the board, to facilitate wiring interconnections. Make up the power supply (+6V, 0V and −6V) connections to the board via SW3.

Make up the following interconnections to the DVM module, noting that the module is a MOS device and can be damaged by static charges; Vss to −6V and VDD to +6V on PCB A. Connect COM, IN LO and TEST together and connect to the 0V power supply line. Connect the 0V line to the instrument's common input terminal via FS1. Connect RFL to the common terminal of SW1f. Connect RFH to the common terminal of SW1d. Connect IN HI to the common terminals of SW1c and SW1e.

Refer to the main circuit diagram and make the following connections. Wire up SW1d and make the connection to RV1 slider on PCB A. Wire up SW1f and make the connection to COM terminal on the DVM module. Trace the DV (direct voltage) path through the circuit and make the appropriate connections as follows. From SK2 to SW1a common; from SW1aDV to R6 and from the R6-R12 chain to the 1 to 6 pins of SK2c; from SW2c common to SW1b DV/AV; from SW1b common to SW1c DV and AC; from SW1c common to SW1e common and to the IN HI terminal of the DVM module.

With all the above connections made, double check the wiring and then switch the unit on. Short the instrument's input terminals and check that the DTM reads 000 on all ranges in the DV mode. Switch to the 1V range, connect the unit's input terminal (SK2) to SK1 and trim RV1 to obtain a reading of 1V22 (1220). The unit is now approximately calibrated (within 5%) on all DV ranges. Remove the connection from SK1 and check that the unit is functional on all DV ranges.

If you have access to a precision DV source or to an accurate DMM, you can precisely calibrate the DTM by switching it to the 100mV DV range, connecting a known input test voltage (100-199mV) and adjusting RV1 for a correct reading.

SW2 RANGES	SW1 'MODE' SETTINGS					
	f	DC	AC	DV	AV	R
1	–	100uA	100uA	100mV	100mV	100R
2	1kHz	1mA	1mA	1V	1V	1k0
3	10kHz	10mA	10mA	10V	10V	10k
4	100kHz	100mA	100mA	100V	100V	100k
5	1MHz	1A	1A	1kV	1kV	1M0
6	–	1A	1A	1kV	1kV	10M

Table 1. SW2 range details for the six meter functions.

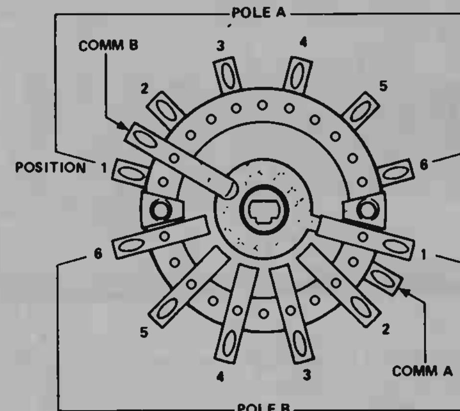


Fig. 2. The wiring of SW2 (above) can become a veritable jungle if you're not careful. Lock yourself away from all distractions for half an hour and work round each pole in turn.

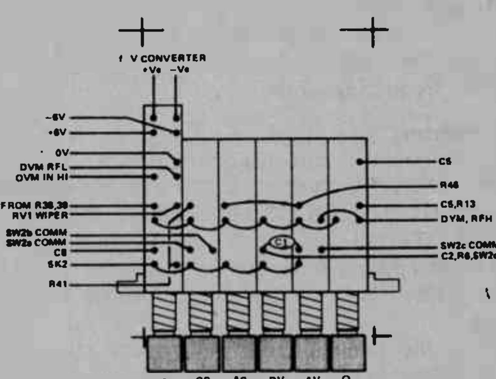


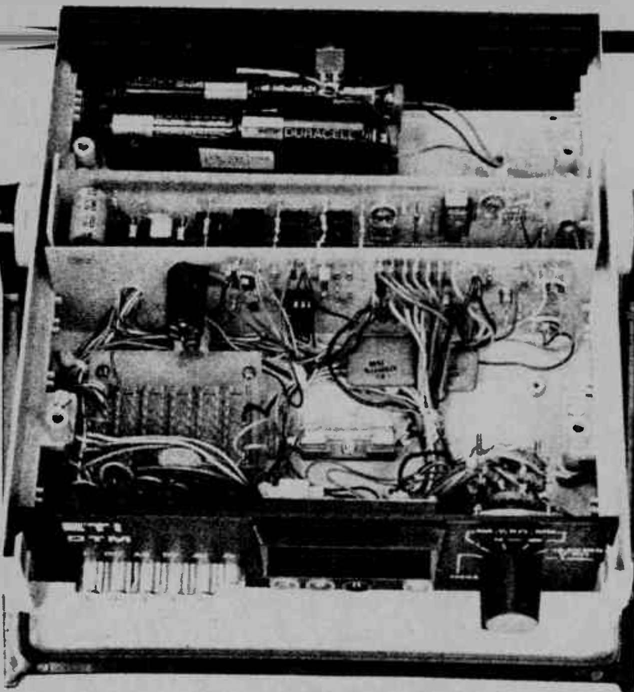
Fig. 3. The mode switch assembly fits on its own PCB (above).

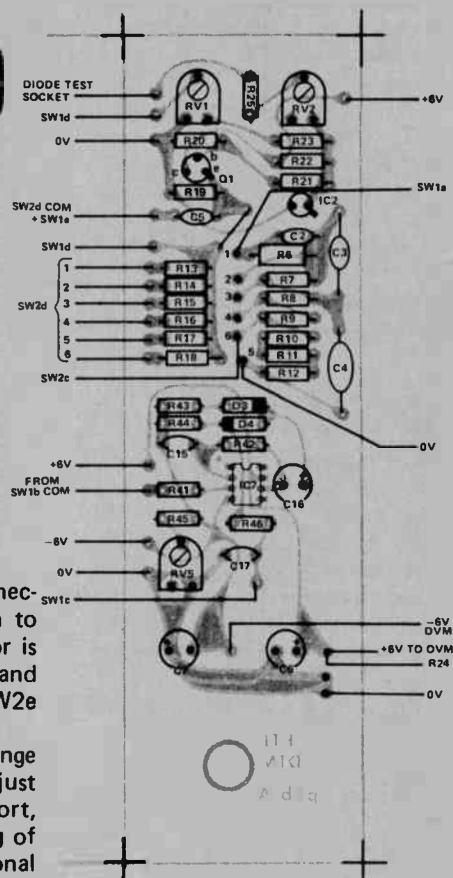
Note that, due to the low-voltage ratiometric resistance measuring technique used in this instrument, the readout tends to jitter somewhat when used to test resistors with values in excess of 200k or so. This tendency can be minimised by keeping test leads as short as possible, to avoid hum pickup.

Make the connection from R25 (on PCB A) to Diode Test Socket SK1. Short SK1 to SK2 and adjust RV2 for a reading of 100.0 on the 100 uA DC range. Remove the short and check that a reading of 0.00 is obtained. Connect a silicon diode between the two sockets and check that a reading of about 60.0 is obtained in the forward direction and 00.0 in the reverse.

Frequency Ranges

Construct the frequency-to-voltage converter circuit on PCB B and make its supply connections via SW1g (+6V) and SW1h





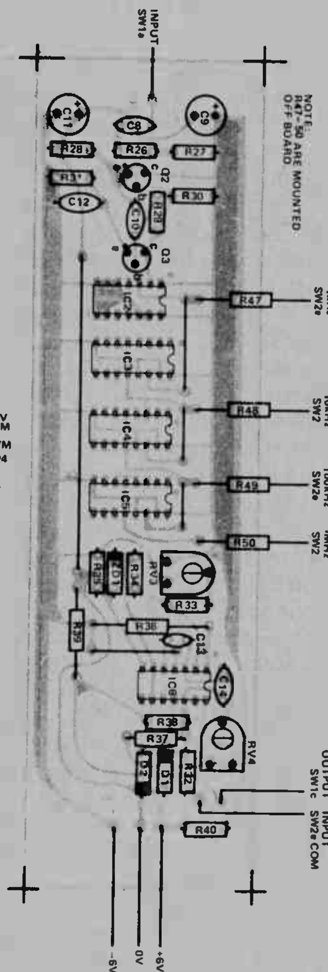


Fig.4. Component overlays of the two Digital Test Meter boards. Frequency ranging (top board) is achieved by feeding IC6 from an appropriate point in the IC2-5 chain.

Resistance measurements are made by using one of the resistance ranging resistors R13-18 (bottom board). IC7 is the heart of the AC/DC converter.

(−6V) and the supply common line. Make the input connection to the PCB from SW1a and the output connection to SW1c. Wire up SW2e as shown, noting that a 4k7 resistor is connected directly to each of the 1kHz, 10kHz, 100kHz and 1MHz output pins of PCB B, with the connections to SW2e made via these resistors.

When construction is complete, switch to the 1kHz range in the 'f' mode, short the unit's input terminals and adjust RV3 for zero reading on the meter. Remove the input short, connect a 1kHz input signal and adjust RV4 for a reading of 1.00 on the meter. Finally, check that the DTM is functional on all other frequency ranges.

Decimal Pointing

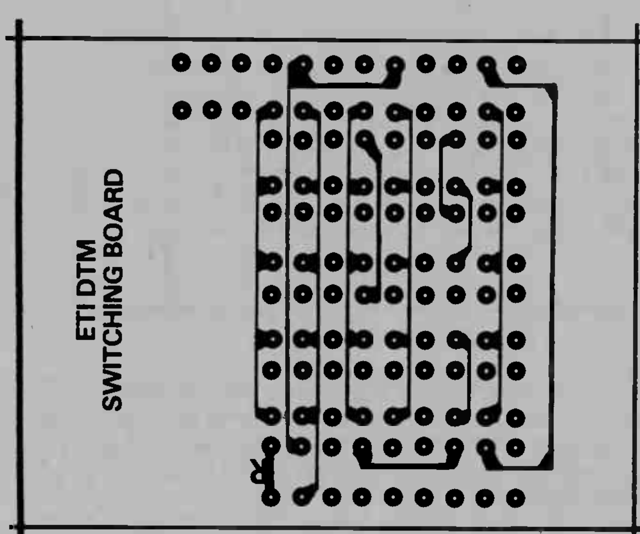
Refer to the main circuit diagram and make the connections from +6V to SW2f common via R24 and from the SW2f range pins to the D1, D2 and D3 terminals on the DVM module. Switch the DTM on, on the DV ranges, and check that the decimal point appears in sensible positions on each range (eg. 100 mV reads 100.0 on the 100mV range or 100 on the 1V range).

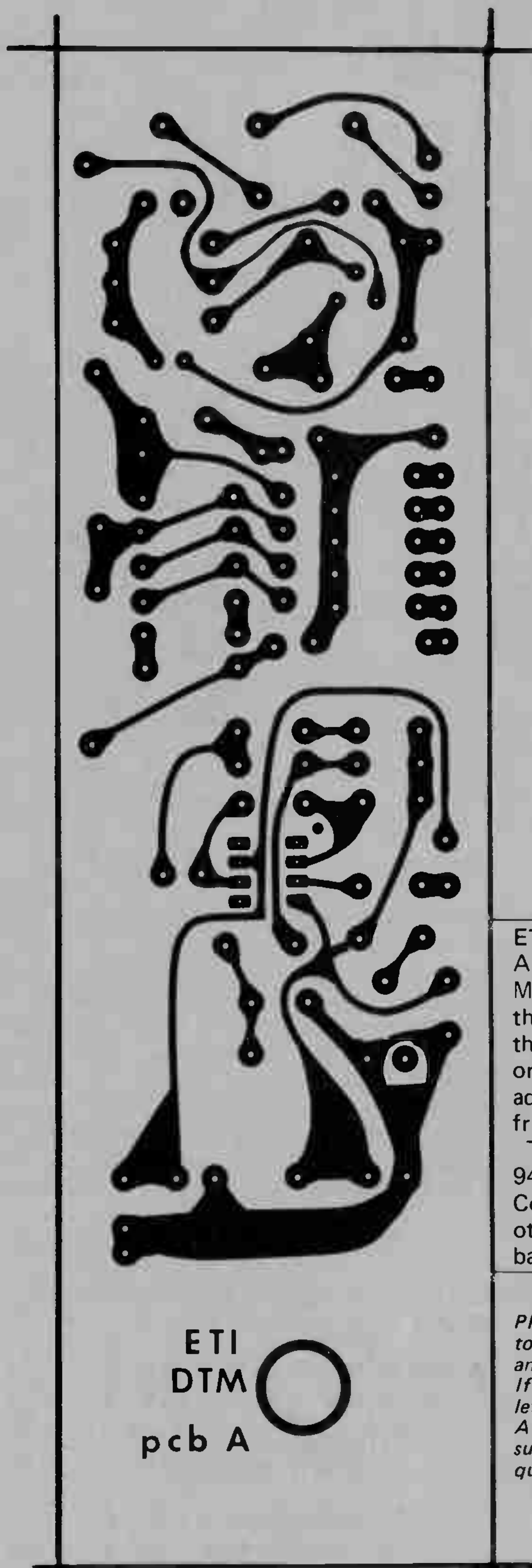
Refer to the main circuit diagram and trace the AV (alternating voltage) path, making additional connnections as appropriate, as follows. From SK2 to the top of R6 via SW1a and C1; from SW1b common to R41 of the AC/DC converter on PCB A and to the DV and DC pins of SW1c; from R46 of the converter on PCBA and to the DV and DC pins of SW1c common to IN HI on the DVM module.

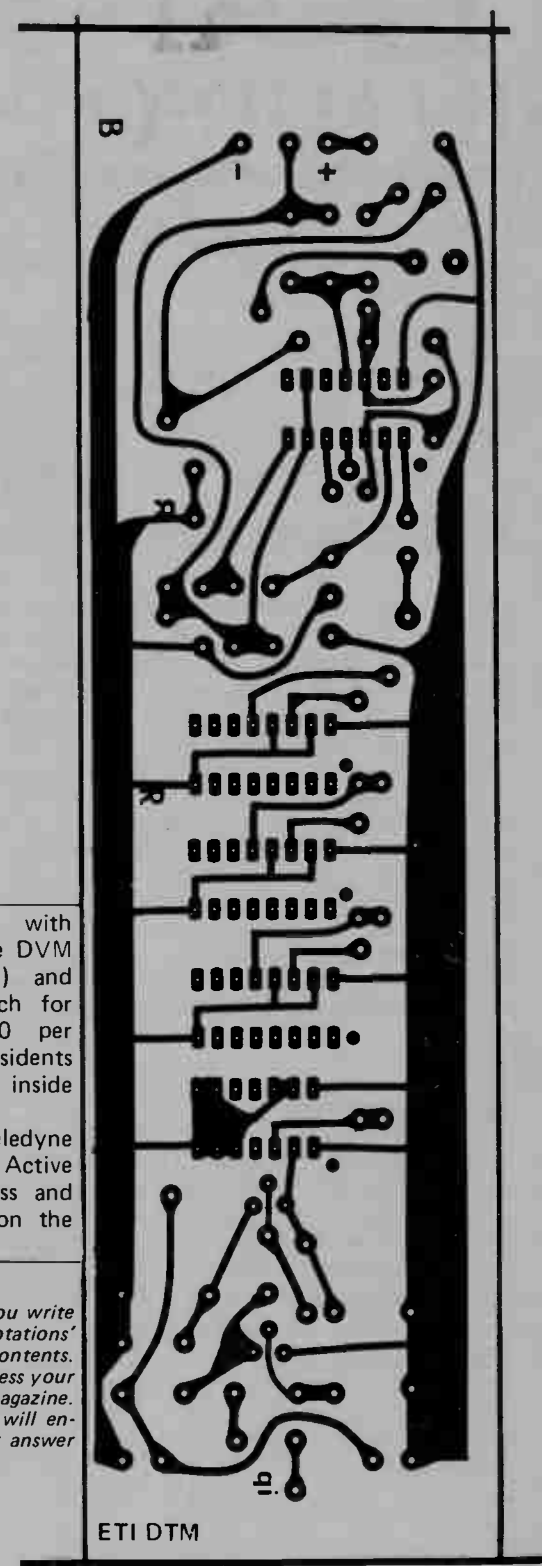
When the above connections are complete, set the unit to the 100mV AV range, connect a 1kHz sine wave of known amplitude (100-199mV) to the input of the DTM and adjust RV5 for a correct reading. Switch the unit to the 1V range, increase the input signal to a sensible value and check the frequency response of the instrument. The response should be virtually flat from 20Hz to 40Hz; if necessary, the value of C2 can be padded up slightly to obtain the required response. Check that the unit is functional on all other AV ranges.

DC Ranges & AC Ranges

Refer to the main circuit diagram, trace the DC (direct current) circuit path (via R1-R5), add all appropriate switching connections and then give the unit a functional check on all DC ranges.







Left: Foil pattern for PCB board B, from the ETI Digital Test Meter project.
Note that this project comprises a total of three boards.

Right: The second of the DTM boards.

ETI has made arrangements with Arkon Electronics to supply the DVM Module 176M Rev.C ($64.95) and the specified push-button switch for this project ($6.95). Add $2.00 per order for shipping; Ontario residents add 7% PST. See Arkon ad on inside front cover for ordering details.

The Teledyne 9491AM and Teledyne 9400CJ are available from Active Component Sales Corp. Address and other details are in their ad on the back cover of this issue.

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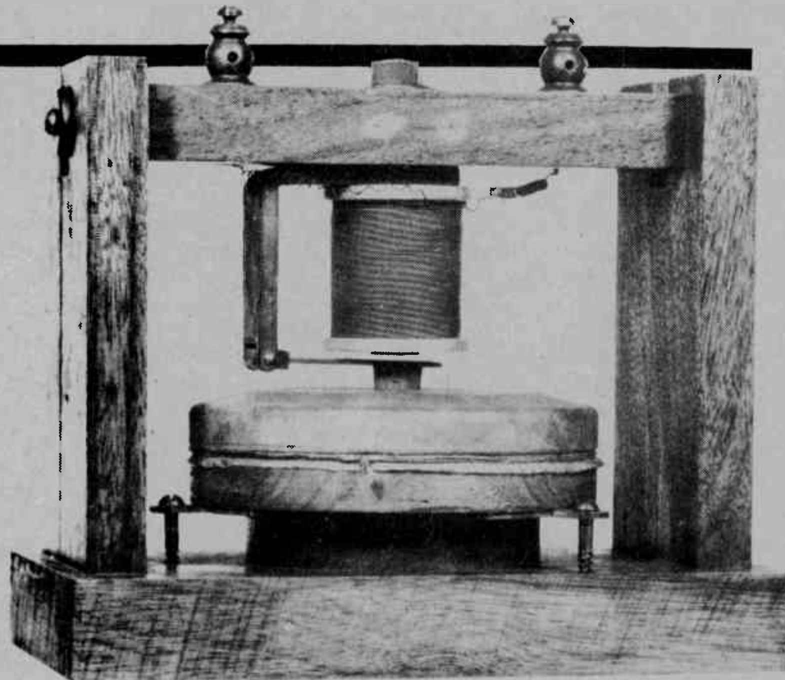
Refer to the main circuit diagram, trace the AC (alternating current) circuit path, add any appropriate switching connections and give the unit a functional check on all AC ranges.

Resistance Ranges

Refer to the main diagram again, trace the resistance measuring circuit (via R13-R18 and SW2d, SW1d-SW1e-SW1f and from the IN HI pin of the DVM module to SK2 via SW1c and SW1a) and make all appropriate connections. Give the unit a functional check on all ranges by connecting appropriate test resistors to the DTM test terminals. ●

TRANSDUCERS IN AUDIO

Transducers — the things which convert electronic signals into other forms — are at their subtlest when that other form is sound.



Bell's original transducer!

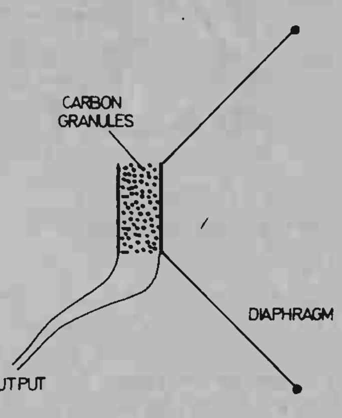
"MR WATSON, COME HERE, I want you . . ." No, not a line from an Arthur Conan Doyle novel, but the world's first telephone message sent by Alexander Graham Bell to his assistant Thomas Watson.

Bell had invented the telephone, or, to be more precise had developed the first practical audio transducers. The telephone consists basically of a microphone, earpiece and some connecting wire between them. Electric wire was not a new invention — the important developments were the transducers at its ends, which converted the sound into an electrical signal and back to sound again. The development of 'microphones' was hampered in Bell's day as any form of electrical amplifier could not yet be constructed. This meant that the technology was limited to producing microphones with a sufficiently large enough output to drive an earpiece directly.

Advances in technology since Bell's day (the invention of amplifying devices like the tube and transistor) mean that today we have a wide variety of audio transducer operating on a variety of different principles.

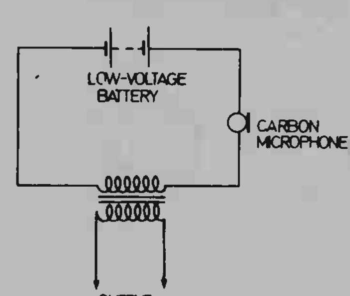
Sound Developments

Taking transducers which convert sound into electrical energy first (although in some case devices can be used as either microphone or loudspeaker units), these can be divided into two main groups. These groups are: devices which respond to sound by changing one of their electrical properties and devices which directly produce an electrical signal as an output. The carbon microphone is one of the first group. It is found universally in telephone hand-sets, although it was not the type used by Bell in his first system.



A carbon microphone

The carbon microphone consists of a diaphram, two electrodes and packed carbon granules. Normally the resistance between the electrodes through the carbon is a constant value of a few hundred ohms. When the diaphragm vibrates with incident sound, the spacing between the carbon granules changes. As they are forced closer together the resistance decreases and as they space out more the resistance increases. The resistance of the microphone thus changes with incident sound.



Circuit for using a carbon mike.

To make the microphone work usefully, the varying resistance must be converted to a varying electrical signal. This can be done quite simply by putting the microphone in series with a low voltage DC power source (could be a battery) and a transformer. As the resistance of the microphone varies, so too (from ohm's law) will the current through it. The current through the primary winding will also vary, and a similar changing signal will be induced in the secondary.

This type of microphone does not provide a high quality signal — it is really only suitable for speech, and is also not particularly sensitive — you have to talk quite near to it. Despite these two drawbacks, the carbon microphone is ideal for use in telephones, although there is some talk of it being replaced by electret microphones.

Condensation

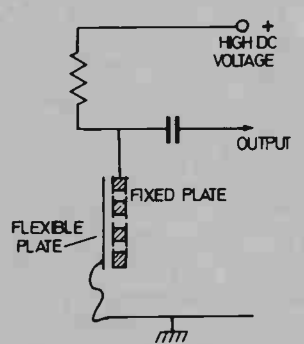
The other important type of microphone which fits into the same category as the carbon microphone is the capacitor (or condenser) microphone. These devices can be again divided into two groups.

As its name may suggest, the capacitor mike provides an output in the form of a varying capacitance.

Essentially the device consists of two parallel metal plates separated by a small air gap. One of these plates is rigid but perforated, the other is thin and flexible. The thin plate is able to vibrate in sympathy with incident sound. As it does so, the distance between it and the other plate varies. The two separated plates are essentially the basis of a capacitor. The capacitance being given by the formula

$$C = \frac{EA}{d}$$

where C is the capacitance, E a constant, the permittivity of air, A the area of the plates and d the distance between them. As the distance (d) between the plates varies, it follows that so too will the capacitance.

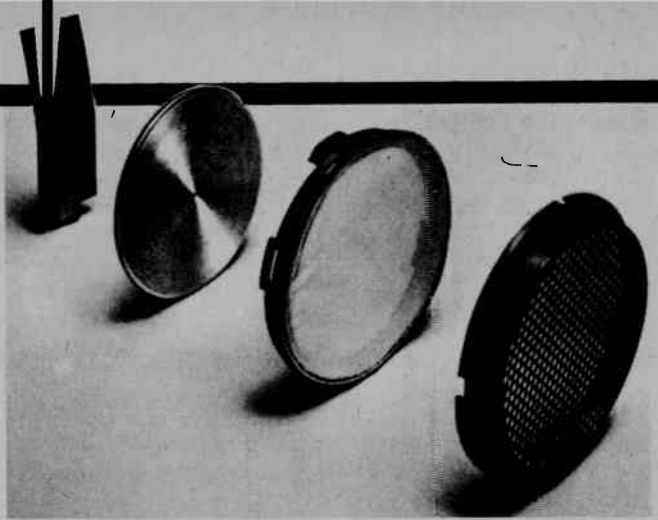


Circuit for using a condenser microphone.

Changing this varying capacitance into an electrical signal is quite a problem as the capacitance of the plates can be as low as 30p (3×10^{-8} farads) and the maximum change only about 3p. Producing the varying voltage is done by applying a high voltage to the plates through a large value resistor. This voltage can be anything from 60 volts upwards, depending on the model of microphone.

When the capacitance changes with sound striking the plates, the charge on the plates will remain constant but the voltage between will vary (this follows from the formula $Q=CV$, Q, the charge on the plates is constant, so as the capacitance, C, changes the voltage, V, will vary inversely). This varying voltage forms the output.

The output from the actual microphone capsule is of a very high impedance and if it were connected directly to a cable, the signal would be severely deteriorated over even a few feet. It is thus necessary to have a small preamplifier very close to the capsule. This is usually in the body of the microphone, normally only a couple of centimetres away from the capsule. The preamp has a very high input impedance, a value of 200M (200 million ohms) being a typical figure.

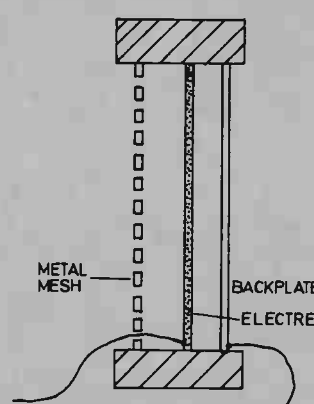


Not all transducers are used in audio work. The condenser unit is used in Polaroid's Sonar One Step cameras.

Capacitor microphones are very high quality, very fragile, and very expensive. They are also very flexible. By having two flexible plates, one either side of the rigid plate, and by altering the polarising voltage to the plates, the characteristics of the microphone can easily be changed.

Electrets

A variation on the capacitor microphone is available which does not need the high voltage polarising supply. Electret microphones are manufactured with a slab of electret material between the two capacitor plates. Electrets are specially manufactured substances which carry a permanent charge. This permanent charge removes the need for the high voltage supply, but a low voltage supply is still required to power the preamplifier. This is usually obtained from a battery housed in the microphone body.



Section through an electret microphone.

Electret microphones are much cheaper than the normal capacitor types. The quality of the microphone is not quite as good, but at about 1 / 10 of the price, this is really only of concern to a professional user.

Many portable cassette recorders have electret microphones built in.

Crystal Clear

Crystal microphones work on the piezo-electric effect. When crystals of some chemical salts are physically distorted, a voltage appears across two of its faces. The crystal microphone uses this principle — a diaphragm is linked to the crystal. When sound waves make the diaphragm vibrate the crystal is distorted and metal contacts are used to make connection to the crystal faces.

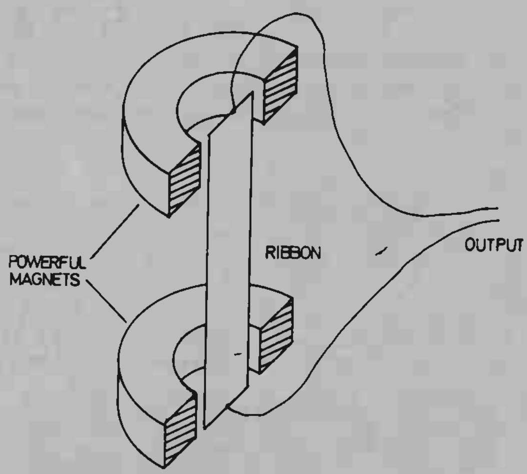
Crystal mikes are very poor quality but do provide a high output.

Toiling Coils

If a wire is moved at right angles to a magnetic field, then a current will be induced in the wire perpendicular to both the magnetic field and the movement.

This principle is also used in some types of microphone. In its simplest form, a ribbon is suspended between the poles of powerful magnets. Leads are connected to the top and bottom of the ribbon.

When sound strikes the ribbon, it will vibrate to and fro between the poles of the magnet and a current will flow along it and through the connected wires.



Section through a ribbon mike

The signal generated by the ribbon is very small. Any length of wire to which it is connected would have a resistance large enough reduce the signal quite considerably. For this reason a transformer is always mounted inside the microphone. The transformer increases the impedance and voltage of the ribbon's output so that any connecting wire has less attenuating effect. For obvious reasons this type of microphone is called a ribbon mike.

The actual ribbon is very fragile and has to be well screened from winds (or heavy breaths) making it unsuitable for outdoor use. If a coil of wire were used instead of a ribbon (in a different mechanical assembly) the output would be much higher. This is done in the common 'dynamic' microphone. A diaphram is attached to a coil which vibrates in the magnetic field. The mechanical construction of this type of microphone is much more rugged as there is no longer a thin vulnerable ribbon.

However, the mass of the diaphram and coil is much higher than that of just the ribbon. At high frequencies this extra mass makes it harder for the sound to vibrate it and there is less output.

Thus, by making the device more rugged other problems are encountered. The poorer high frequency response could be overcome by making the coil and diaphragm smaller and lighter. This would unfortunately affect the low frequency response.

A solution offered by some microphone manufacturers is to build two microphones into one body. One has a large diaphram, and the other a much smaller one. These two-way microphones however, are much more expensive.

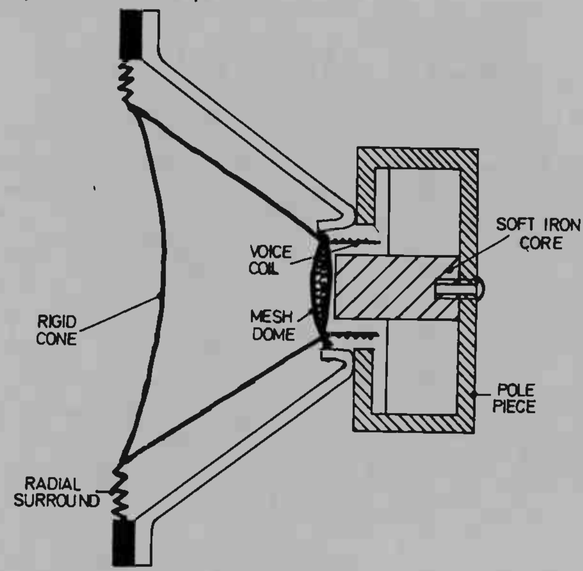
The first microphone used by Bell was one of the magnetic induction type and not the carbon type by the way. The output from it was very low, and as amplifiers did not yet exist, the sound reproduced at the receiving end very faint.

Mister Speaker

It would be logical to assume that if microphones produce an electrical signal when excited by sound they should produce sound when an electrical signal is applied.

The theory behind this does in fact support this assumption to all the microphones mentioned except the carbon microphone.

In practice however, the requirements of an electric to sound transducer are such that mechanical design of loudspeaker and earphones is different.



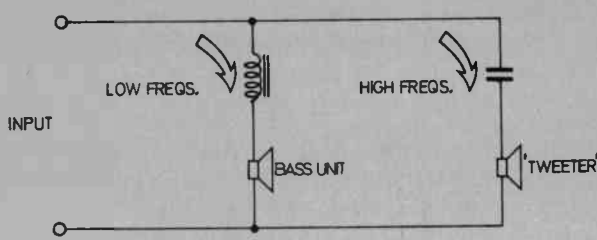
Cutaway of a moving coil loudspeaker

The moving coil loudspeaker consists of a paper cone attached to a fine coil of wire, which is suspended in a strong magnetic field. The edge of the cone is attached to the metal frame of the speaker so that it is free to move. When an electric signal is applied to the coil (called the voice coil) a magnetic field is set up around the coil. This interacts with the magnetic field caused by the large magnet and the coil is moved. The coil and thus the cone move in sympathy with the signal in the voice coil.

As with microphones (only more so), large loudspeakers with big cones are only capable of effectively reproducing sound in the lower end of the sound spectrum. For this reason, all high fidelity loudspeakers contain two or more 'drive' units. Each unit will be of a different size and designed to handle a particular range of audio frequencies.

An electronic circuit within the loudspeaker cabinet, called a crossover unit, routes the incoming signal so that the high frequency sounds are handled by the smaller unit ('tweeter') and the lower frequencies by the 'woofer'.

The crossover unit in its simplest form consists of a

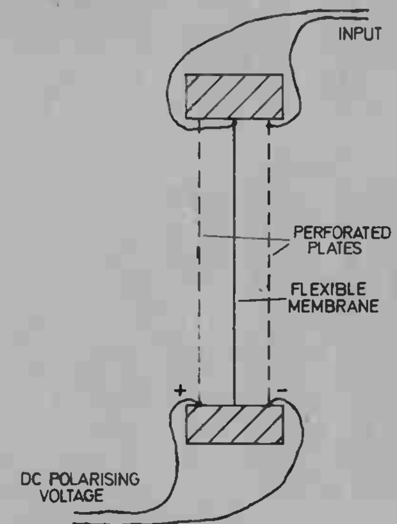


A simple crossover

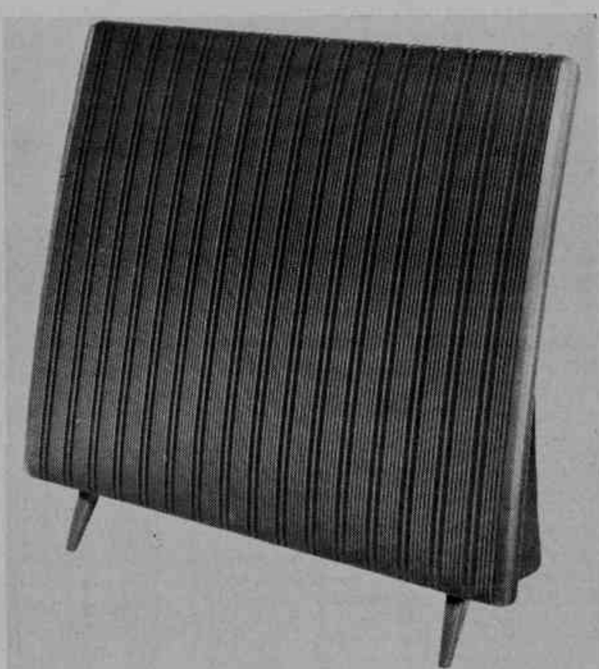
capacitor and an inductor. The AC impedance of the capacitor decreases as the applied signal's frequency increases. The reverse is true with the inductor.

Dual-Purpose Transducers

In some applications it is very convenient to use the same transducer as both a microphone and loudspeaker. An example of this is in simple intercoms. Here, a small transducer is used as a loudspeaker when listening to messages, but doubles as a microphone when messages are being sent.



Cross-section through an electrostatic loudspeaker.



A commercial electrostatic loudspeaker.

Electrostatic Speakers

Just as there are capacitor microphones, we also have 'capacitor' or electrostatic loudspeakers. Electrostatic loudspeakers provide a very high quality sound at a very high quality price.

The cross section drawing of an electrostatic loudspeaker shows three plates. The outer two plates have charges applied to them by a high DC voltage (the polarising voltage). The audio signal (which is stepped up in voltage) is applied to the centre plate.

The charge on this plate will be changing with the audio signal. When there is a positive charge on the centre plate it will be attracted to the rigid negative plate, and repelled from the positively charged plate. The centre plate will vibrate, producing a sound output for the electrical input. A company in England (Quad) has been producing electrostatic speakers based on this principle for the last 20 years. ●

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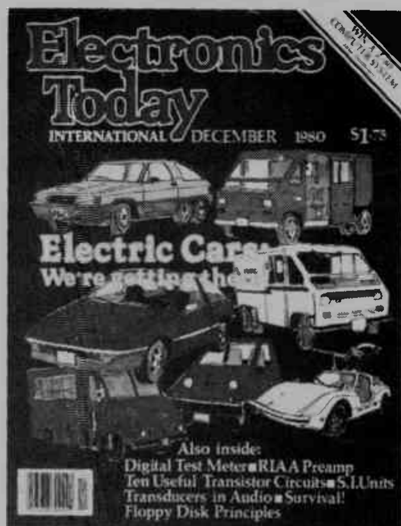

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TIPS

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Soldering IC s
Tinning With Solder Wick
PCB Stencils
Front Panel Finish
DIL Drilling
Fluorescent Starting
Avoiding Insulated Heat Sinks
TTL Mains Interface
Boost Your Mains
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Battery Snaps
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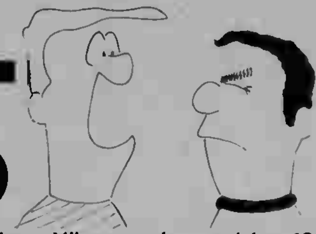
FLOPPY DISKS



Hey, Y'know what weighs 100 tons, lives in the ocean, and stores 200 megabytes of data? . . . . Moby Disc.

ETI's own John Van Lierde takes a look at this data storage system.

FOR THE average person, buying a computer is much like buying a camera or a car. One makes the initial financial plunge and is satiated for a while. This is shortlived, and the owner eventually starts looking around for accessories.

Unlike cameras or cars, most computer accessories (in the form of software) are fairly inexpensive. These take the form of 'certified' audio cassettes that are, hopefully, compatible with the system in use. Unfortunately cassettes are not the ultimate means of program storage. This dilema brings us to the topic of this article, floppy disks.

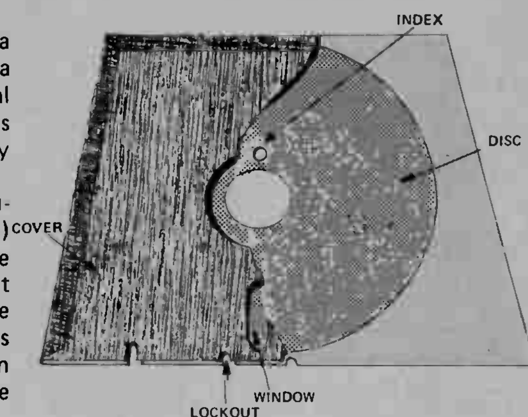


Fig.1. Inside a Diskette.

Storage For the Masses

Both floppy disks and cassette tape are methods of mass storage. One employs mass storage for a number of reasons. Mass storage is *non-volatile,* that is to say, the data stored is not lost when power is removed. This is useful for when you've spent four hours developing a program and don't want to leave it in the computer's *volatile* (an apt term) memory. Nasty things like brown outs and the maid unplugging your PET so she can dust under it will ruin the fruits of your labour.

Additionally the RAM available to a user is not terribly large, typically 4—8K. This is inconvenient if a user wishes to work on several programs at once, or, has several K of names and addresses to store.

Additionally, Floppies and cassettes are highly portable and easily stored. Even if you could unplug your PET without wiping its memory, it would still be a nuisance hauling it across town so a friend could copy a program.

A Look At Cassettes

To the early computer experimenter, the audio cassette was a natural for mass storage. Cassettes and the hardware (cassette recorders) were widely available, proven and inexpensive.

The cassette method of storage became popular and today virtually all home computers available have built-in cassette interfaces. Indeed, even the early Commodore PETs (the ones with the hideous keyboards) were equipped with built-in cassette recorders.

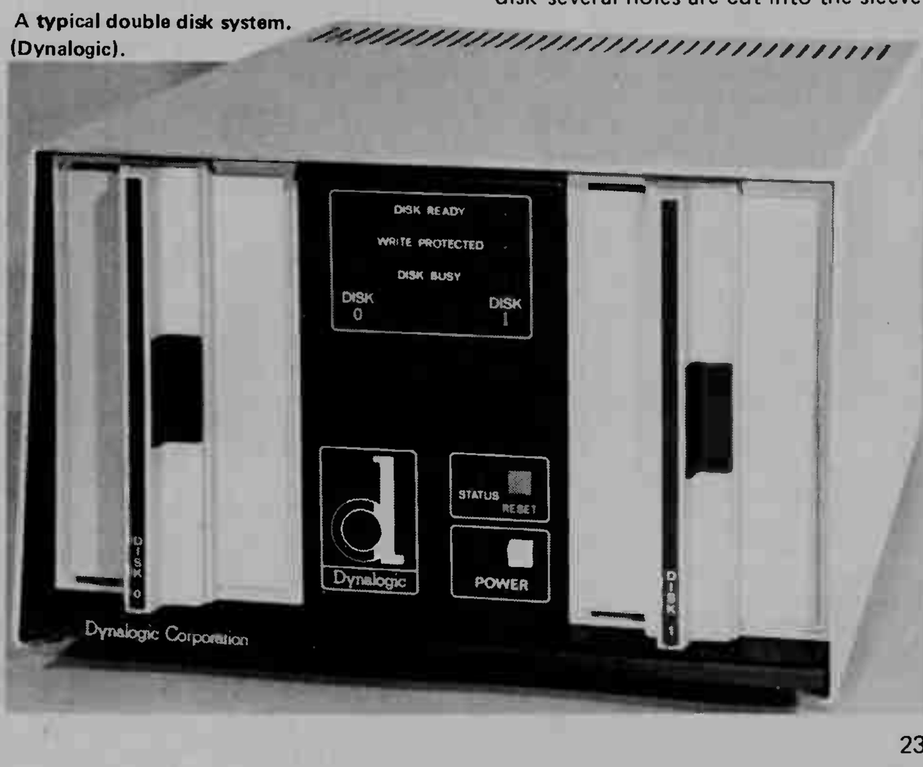
The disadvantage of tape storage is that, unlike a computers RAM or A disk, the data on a cassette is not addressable.

In order to find a particular program or block of data, it is necessary to search through the entire cassette. If the data you want is at the tail end of a C-90, you might as well take your dog for a walk. Even then, loading and dumping a full 8K will take close to five minutes at 300 Baud.

You can get around this by only putting one program on a side, but this is highly wasteful.

Another possibility is to speed up the rate of data transfer. Speeds of up to 4800 Baud are possible with high quality equipment. While this would reduce search time, it is really only a lateral sort of solution.

A typical double disk system. (Dynalogic).



Additionally, most cassette transports do not provide some electrical means of control. All cassette functions must be initiated by the human digit. For this reason there are not many cassette file systems available.

A New Shape

The idea of storing data on a magnetic medium is a sound one, the only problem being the actual accessability of that data. This problem can be solved by changing the medium from a strip to a surface. An 8-inch diameter surface (ie. disk) is much more easily searched than 130m of cassette tape.

The construction of a floppy disk is depicted in Fig. 1. The disk itself is an 8-inch Mylar disk, flexible and covered with magnetic oxide. Both the disk and its magnetic covering are thicker than their cassette counterparts. This in itself, results in greater reliability and greater freedom from dropouts etc.

The disk has two holes cut into it. A large one is cut into the centre for the drive mechanism to spin the disk. A smaller one is punched several centimeters from the centre to serve as an index.

The disk is kept in a cardboard or plastic sleeve which is permanently sealed to prevent removal. To access the disk several holes are cut into the sleeve.

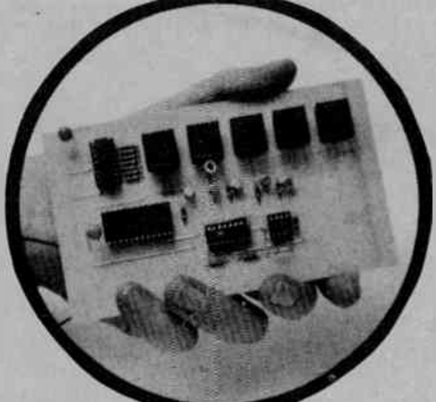
Electronics Today INTERNATIONAL

NEXT MONTH

At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.

JANUARY

DIGITAL FREQUENCY METER



A really neat, single board project which covers 20Hz to 2MHz in four ranges using just 4 ICs and 8 transistors.

THE EDISON EFFECT

Many famous discoveries were made by accident: this includes the Edison Effect. What makes this unusual is that this genius discovered the diode in 1880 but (unusually for him) failed to appreciate its significance: it had to be invented much later all over again by Fleming.

ELECTRONIC IGNITION

Now, more than ever, you want to get the best from your gas dollar. Many, if not most, of the 1981 cars use electronic ignition to peak the performance. Next month we give full constructional details on how to build your own.

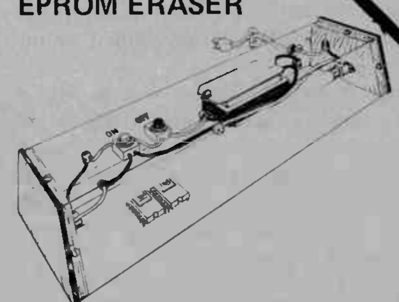
DIRECTORY OF ELECTRONIC PARTS RETAILERS

ETI has been scouring Canada for electronics parts retailers — and there are a lot more than we ever believed possible. Next month we present a 'yellow pages' listing all those we were able to contact.

POWER TO THE PEOPLE

Practically all electronic equipment needs some form of power: this may be from the line or from a battery. We take a look at the merits and practicalities of each. In addition we've investigated the new batteries; are they really better value considering their high cost? we'll tell you next month.

EPROM ERASER



Commercial EPROM erasers start at well over $100 but you can build your own very easily for about a third of that. Our author considered a number of alternatives before settling on the final design.

STUDIO TECHNIQUES

What goes on inside a recording studio? We hear about multi-tracking, reverberation, vocoders and so on frequently enough but how do they all fit together? Steve Rimmer reports.

ALARM CIRCUITS

Our circuits feature next month covers the area of security alarms. The circuits and their operation are described by Ray Marston.

Save up to 28% on the newsstand price by subcribing to ETI — see page 21.

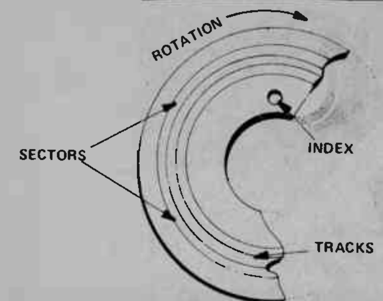


Fig.2. An expanded view of a disk's surface.

The largest of these is the one in the centre. There's an oval-like hole to allow the read/write heads to sweep across the surface of the disk. A small hole is also cut to allow access to the index hole.

When a disk is inserted into a drive mechanism, it is immediately engaged and spins at 360 rpm. A small LED/photocell combination sends out pulses to the disk controller corresponding to the passage of the index hole passing between them.

The read/write head (or heads if we're talking about a double sided system) are kept in direct contact with the disk's surface. Unlike cassettes, the method of recording is digital, with several tens of thousands of flux changes per second.

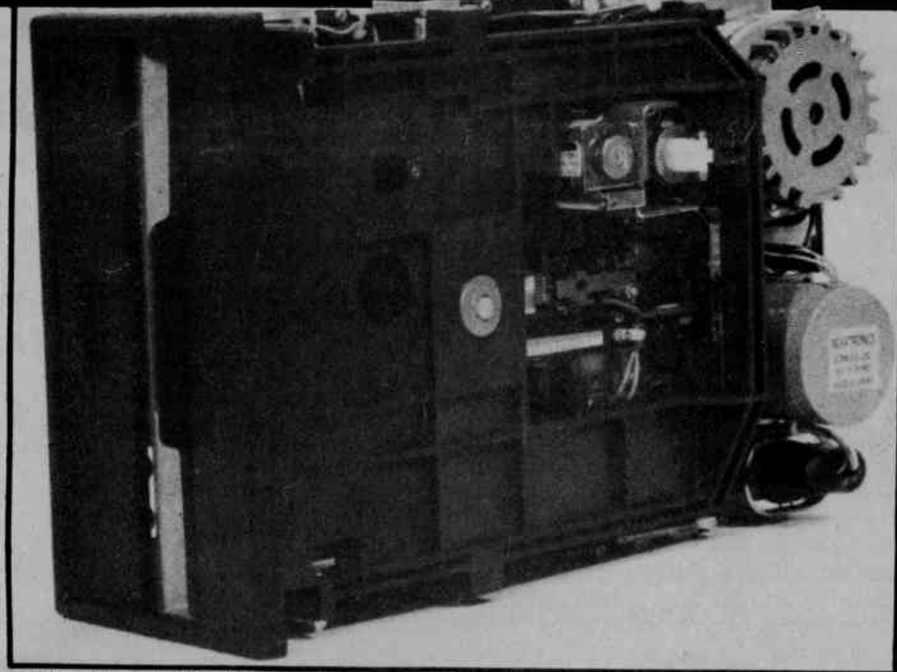
There are several methods of moving the heads across the disk, such as lead screws, pulley, bands and spiral wheels. These are driven by stepper motors. The drive has no means of knowing where the heads are, instead they are moved to the innermost track and the controller counts the number of steps outward.

Capacity and Formatting

Most eight-inch disks follow the IBM 3740 method of formatting which holds close to 380,000 bytes of *unformatted* data. There are other systems. For instance many manufacturers supply 5¼-inch disks that can hold 90K or even 315K, however we'll confine our discussion to the IBM system.

Note that the 380,000 byte figure quoted earlier is *unformatted* capacity. Some space on the disk must be reserved for housekeeping, so the actual *formatted* capacity is more like 256,256 bytes.

The data is stored on the disk in 77 tracks of 26 sectors (Fig.2). Each sector contains 128 bytes of data. Additionally space is devoted to preamble, addressing, cyclical redundancy character or CRC (which is merely the sum of the data in that sector) and a postamble. These, however are essentially transparent to the user. It isn't necessary for the sectors to be numbered in order, the controller always has a starting point on the disk in the form of the index hole. This is known as *soft sectoring*. Another method, known as *hard sectoring*, has several holes punched into the disk, one for each sector.



Inside a Typical disk drive. Note the two motors at the back. The top one drives the disk, the other one moves the head. (Control Data/Exceltronix)

The Controller

The disk drive is a stupid beast. All it does is spin the disk, read and write. The actual thinking is done by the floppy disk controller.

A simplified floppy disk system is shown in Fig.3. Physically the controller is usually a card that plugs into the micro's backplane. The CPU treats the controller like a memory location. A request for data takes the form of asking the controller to retrieve a specific block of data. The controller accepts the required sector and track addresses and stores them in its internal registers. It then searches and waits for the appropriate sector to come up. When the data appears, the controller generates an interrupt to the CPU and dumps the data into memory via DMA. The process is virtually instantaneous and is, for all intents and purposes, user transparent.

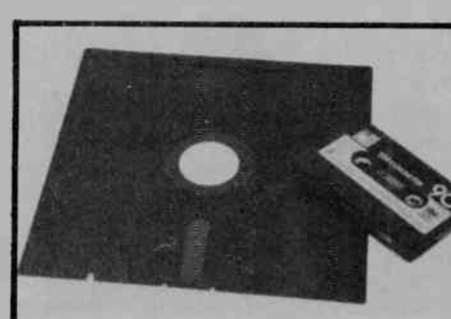
(right) A comparison of a compact cassette and 8" floppy. The large notch on the left of the diskette can be used to prevent overwriting by placing a piece of tape over it.

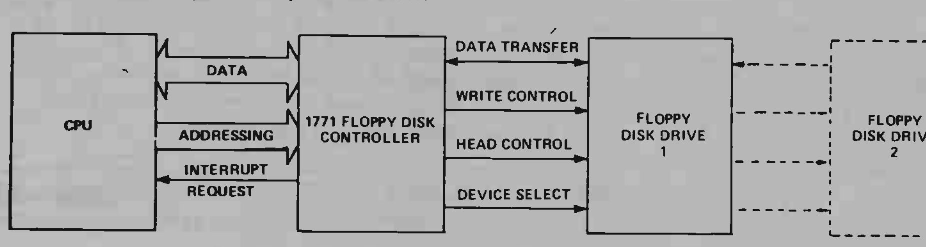
Fig 3 (below) A basic floppy disk system. The 1771 is relatively common controller IC manufactured by National, Rockwell etc.

Using It

It would be possible for users to specify the individual tracks and sectors and so store and retrieve data. This, however, is a highly unnecessary drudgery. What the average user sees is the *Disk Operating System* (DOS). A basic DOS system gives a user the capability to name erase, edit retrieve any number of files. A list of files is kept on the disk itself. When the user wants a file, the listing is downloaded, and the DOS system can then retrieve the appropriate sectors.

The most commonly used operating system is CP/M. CP/M can be used alone or it can be incorporated within larger programs, such as text editors, assemblers, compilers, etc.





Continued on page 54.

10 TRANSISTOR CIRCUIT

Ray Marston presents ten simple transistor projects to help while away your evenings.

REGULAR READERS of ETI will no doubt have noticed (and possibly regretted) the almost total absence of simple transistor circuits from the 'projects' sections of the magazine. The truth is, of course, that one- and two-transistor circuits are usually regarded as a bit 'old hat' these days, when inexpensive ICs such as the 741 Op-Amp and the 555 timer can so easily outstrip them in most applications in terms of performance sophistication and cost effectiveness.

Still, one of the greatest pleasures of hobby electronics comes from actually 'working' with circuits and thereby 'learning things'. In these terms, transistor circuits can be as much fun as any other type, so, with these points in mind, we devote this month's feature to describe ten simple little transistor circuits that you can fiddle with when you have a few spare evenings.

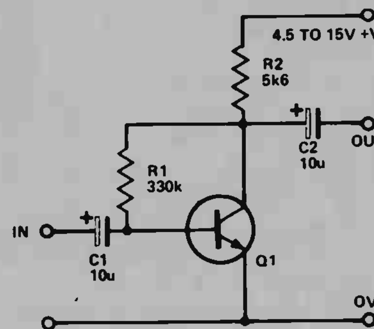


Fig.1. Simple Pre-Amplifier circuit gives a voltage gain of about 50 and has a frequency response extending from 25 Hz to 120 kHz. Q1 is 2N3904.

Linear Amplifier Circuits

Our first circuit (Fig 1) is a simple common-emitter pre-amplifier that you can use for boosting weak audio input signals to a more useful level. For a simple demonstration of its effectiveness, feed its input from the output socket of a radio and then alternately connect a crystal earpiece between the circuit's input and output. The circuit gives a voltage gain of about 50, so you'll notice a great difference between the input and output signal levels.

The Fig 2 circuit is a simple emitter follower stage. The main purpose of this circuit is to convert the signal from a high-impedance source (such as a crystal pick-up) into a low-impedance output. The circuit gives unity voltage gain. This particular design has an input impedance of about 180k.

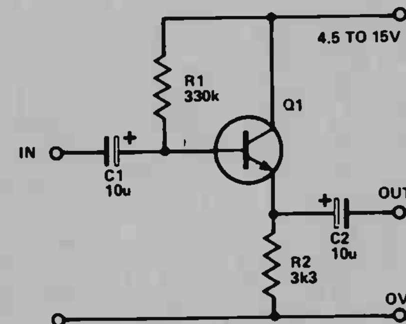


Fig.2. This simple Emitter-Follower circuit gives unity voltage gain but has an input impedance of about 180k. Q1 is 2N3904.

The Fig.3 circuit is a 'souped-up' emitter follower. It uses two transistors and lots of feedback (via C2) to boost the input impedance to about 4M0. The two transistors are wired as a 'Super-Alpha' pair and act like a single transistor with a current gain equal to the product of the two individual gains, about 10 000 in this case.

Fig 4 shows another application of the 'Super-Alpha' principle, in which Q1-Q2 can be regarded as a single transistor with a gain of about 10 000. In this case the 'transistor' is used in the common emitter mode and uses relay RLA as a collector load. If we assume that the relay turns on at about 100 mA, you'll see that this current can be obtained with a Q1 base current of only 10 uA (= 100 mA/10 000). This current can in turn be obtained via the positive supply line by wiring a resistor of 1M0 or so across the probes.

In practice, the relay will turn on at less than 100 mA and the Super-Alpha gain of Q1-Q2 will probably be

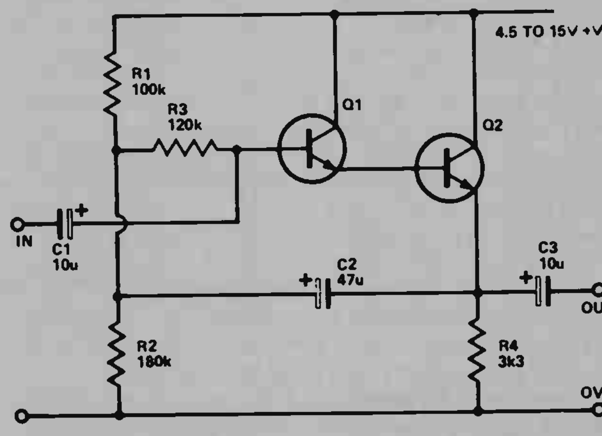


Fig.3. This 'Bootstrapped' Emitter Follower has an input impedance of about 4M0 and can be used to convert a High-Impedance Pick Up to the low-impedance signal. Q1,Q2, are 2N3904.

greater than 10 000, so you'll find that the relay will turn on if any resistance less than a couple of megohms is placed across the probes. Water, steam and skin resistance have resistances below this value, so this simple little circuit can be used as a water, steam or touch-operated relay switch.

Oscillator Circuits

Oscillator circuits often make amusing and/or useful projects. One of the simplest oscillators is the 2-transistor astable multivibrator or square wave generator, an example of which is shown in Fig 5. Here, the two transistors are cross-coupled via R-C networks (C1-R4 and C2-R3) in such a way that the transistors alternately switch on and off in opposition to one another. If the R-C networks have equal values, as in Fig 5, symmetrical but anti-phase signals are produced at the collectors of Q1 and Q2, with one transistor turning on when the other is off, and vice versa.

In the Fig 5 circuit LEDs are wired in series with the transistor collectors and flash on and off in opposition to one another at a rate of about 1 flash per second. The flash rate can be changed by altering the values of either C1/C2 or R3/R4. This simple 'flasher' circuit provides about 10 seconds of interest to the casual onlooker but hours of pleasure to the avid electronics experimenter.

A simple variation of the astable circuit is shown in Fig 6. Here, a non-symmetrical waveform is generated and is fed to a speaker and limiting resistor in the collector of Q1. The unit can be used either as a 'sound generator' or as a 'morse code practice oscillator'. The tone frequency can be changed by altering the C1 and/or C2 values.

Fig 7 is a simple crystal oscillator circuit which can be used to calibrate the dial of a radio or the timebase of a scope. If, for example, you use a 100 kHz crystal, the circuit will give 10 uS markers on a 'scope waveform or 100 kHz harmonic calibration points (100, 200, 300 kHz, etc) on a radio dial. To calibrate a 'scope you need to feed the circuit's output directly to the 'scope's 'Y' terminals. To calibrate a radio, no physical contact is required and it is sufficient to simply place the oscillator close to the radio antenna.

The Fig 7 crystal oscillator circuit will only work well with good quality crystals. The 2-transistor Fig 8 circuit, on the other hand, will work with just about any 50 kHz to 10 MHz series-resonant crystal that shows the slightest signs of life. Q1 is wired as a common base amplifier and Q2 is an emitter follower and the circuit acts as a strong oscillator that generates a large-amplitude output. An excellent circuit.

DC-to-DC Converter

The Fig 9 circuit is a simple design that converts an innocent 9 volt battery supply into a shocking 300 volts DC output. What you do with such an output in the privacy of your own home is your own affair: the mind boggles. The circuit is, however, an absolute MUST for the experimenter.

Circuit operation is quite elementary. Q1 is configured as an L-C oscillator, with the primary of any low-power 6 V-0-6 V line transformer acting as it's 'L' load. This voltage is stepped up to about 350 volts peak at T1 secondary and is half-wave rectified by D1 and used to charge C3. With no permanent load on C3, the capacitor can deliver a healthy but non-lethal 'belt'. With a permanent load on the output, the output falls to about 300 volts at a load current of a few milliamps. A neon 'power' indicator can be wired across C3 to indicate the presence of the high ouput voltage.

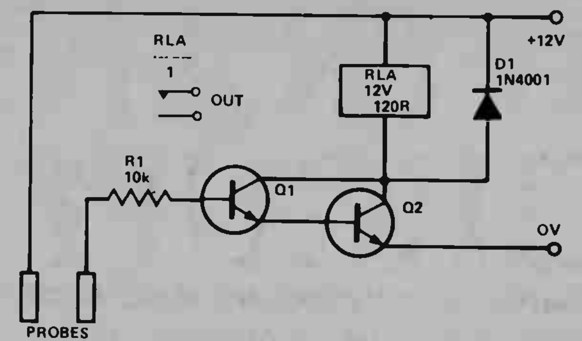


Fig.4. Touch, water or steam operated relay turns on when a resistance less than a couple of Megohms is placed across the probes. Q1 & Q2 are 2N3904.

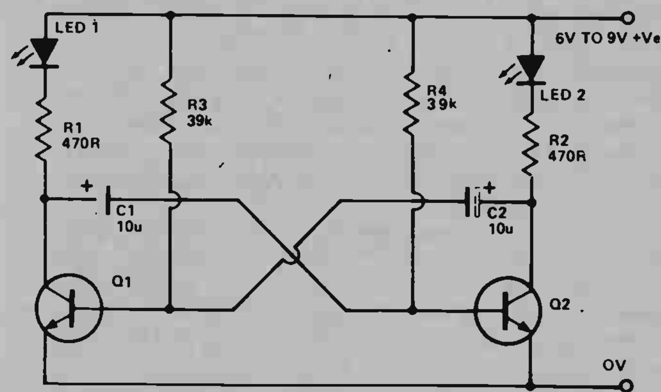


Fig.5. This LED flasher operates at about 1 flash/second. The rate can be increased by reducing the C1/C2 values or vice-versa. Q1 & Q2 are 2N3904.

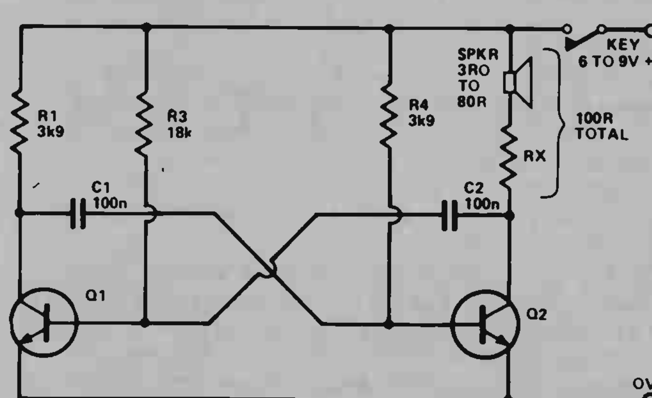


Fig.6. This morse-code oscillator is a simple modification of the Fig.5 circuit. Q1 & Q2 are 2N3904.

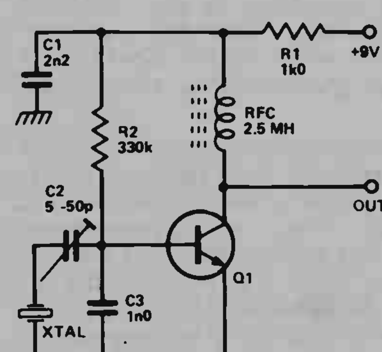


Fig.7. This simple crystal-controlled oscillator can be used with any good 100 kHz to 5 MHz crystal. C2 can be used to set the crystal against a standard. Q1 is (you guessed it) 2N3904.

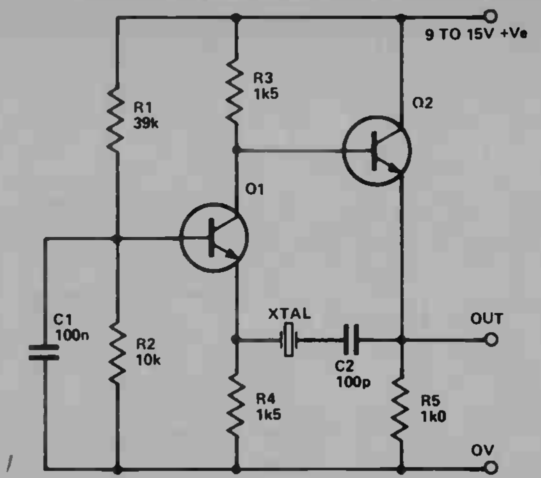


Fig.8. This wide-range oscillator can be used with virtually any 50 kHz to 10 MHz crystal. Q1 & Q2 are 2N3904.

A Lie Detector

Our final circuit (the lie detector of Fig 10) is most emphatically an 'experimenters' circuit. Here, the 'victim' is connected, via a pair of substantial metal probes, into a Wheatstone bridge circuit formed by R1-RV1-Q1 and R3-R4. The meter, which should be a centre-zero type, is used as a bridge-balance detector. In use, the victim makes firm contact with the probes and, once he or she has attained a relaxed state (in which the skin resistance attains a stable value), RV1 is adjusted to obtain a null on the meter. The victim is then cross-questioned.

The theory of operation is that the victim's skin resistance will change and the bridge will go out of balance if he or she lies or shows signs of emotional upset (embarrassment, etc) when being questioned. Some people claim wonderful results from this circuit.

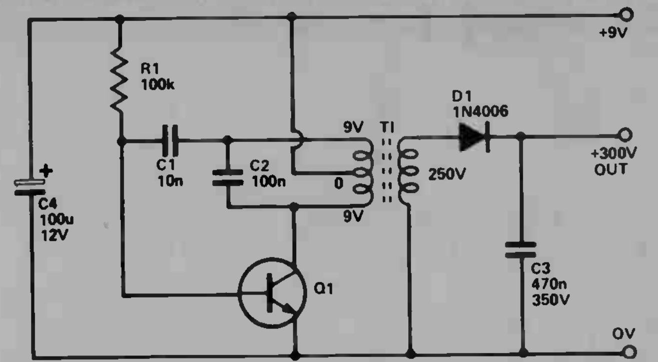


Fig.9. This simple 9 V to 300 V 'converter uses a 9 V-0 V-9 V line transformer in the oscillator/Inverter mode. Output current is limited to a few mA. Q1 is 2N3904.

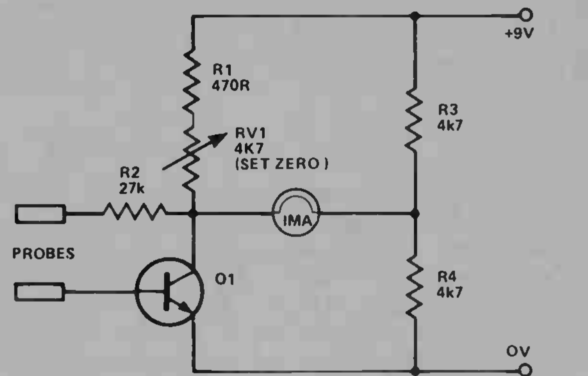
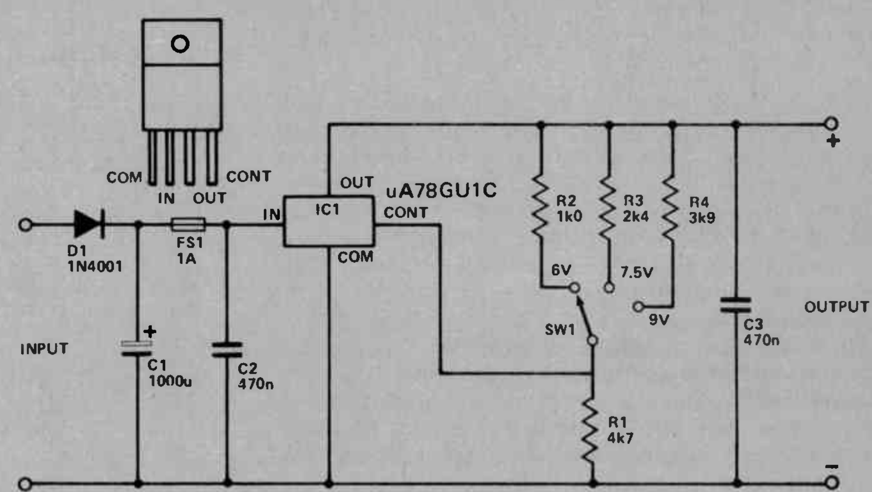


Fig.10. A simple 'Lie Detector'. The two probes are held in both hands and RV1 is then adjusted for a meter 'null'. Any change in the skin resistance (due to embarassment, etc) causes the meter reading to change. Q1 is 2N3904.

Personally, I find that it gives not the slightest flutter when I lie but goes absolutely berserk when I think about "thingy' (you know). Maybe you'll find the same.

Designer Circuits

CAR CASSETTE POWER SUPPLY



When using a portable cassette recorder in a car or boat it is far cheaper to run the unit from the vehicle's battery than from internal batteries. Many recorders have a socket for an external power source, and it is not usually too difficult to adapt recorders not having this facility to operate from such a source. This circuit will give an output of 6, 7.5, or 9 V from a nominal 12 V input with a maximum output current of 1 A. It can therefore be used to match most recorders to a 12 V supply.

The circuit uses a four terminal monolithic voltage regulator (ICl) to give the voltage stepdown and provide a well stabilised output. The input to the regulator is obtained via D1 which blocks the supply if it is connected with the wrong polarity, and fuse FS1. The input will probably contain a certain amount of noise which is smoothed by C1. C2 and C3 are decoupling capacitors which aid the stability of the circuit, and should be connected as close to IC1 as possible.

The output voltage of IC1 is set by a potential divider connected across the output and feeding into IC1's CONT (control) terminal. A negative feedback action stabilises the voltage at the CONT terminal at 5 V, and the output at a level equal to 5 V plus the potential dropped by the potential divider. The value of R1 sets the potential divider current at just over 1 mA, giving a drop of about 1 V across R2, 2.5 V across R3, and 4 V across R4. SW1 can thus be used to select output voltages of 6 V, 7.5 V, and 9 V by switching the appropriate resistor into circuit. If only a single output voltage is required, SW1 is omitted and the appropriate resistor is connected directly between IC1's CONT terminal and the output.

IC1 must be mounted on a heatsink, and this can be the case of the units if a metal type is used. The heat-tap of the device connects internally to the COM terminal, and so the tab must be insulated from the case in the usual manner if the latter is earthed and the unit is installed in a positive earth vehicle. The uA78GU1C has thermal overload protection circuitry and foldback output current limiting incorporated in its design.

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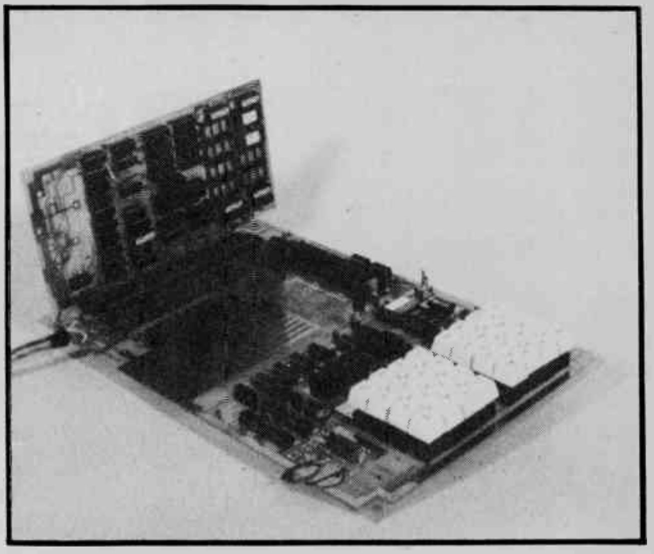
ETI-Exceltronix Contest
WIN A MULTIFLEX Z80A COMPUTER OR A LOGIC STATE ANALYZER
total value $925!

After the tremendous response to our May Win-A-Computer contest, we just couldn't resist throwing another. The result? Exceltronix Components and Computing Inc. and Electronics Today proudly present Win-A-Computer II.

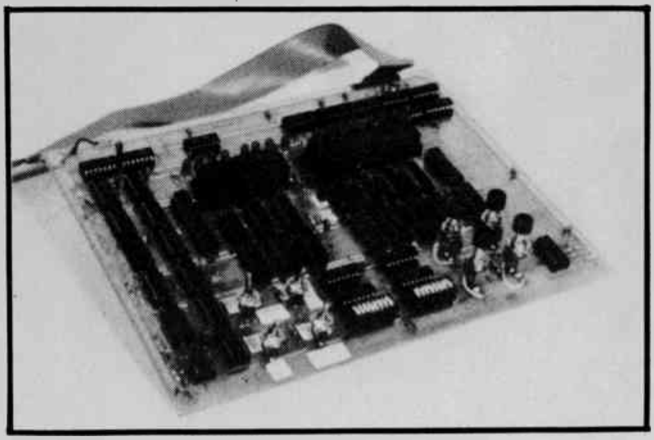
This time we're not just giving away a Z80 Computer, but a Logic State Analyzer as well. Both units are manufactured by Multiflex Inventions and Technology Inc., an Exceltronix affiliate dedicated to high performance equipment at the lowest possible cost. These are not kits, but rather are fully wired and ready to go.

The Multiflex Z80A Computer System (advertised in October 1980 ETI) consists of a separate CPU and motherboard. The CPU board comes with 1K RAM (with provisions for another 3K), 3K ROMed monitor, provision for 8K or 16K EPROM. The system is based on the Z80A CPU, which can operate at clock speeds of up to 4MHz. The motherboard supports four S-100 cards and features a wire wrap area, on board PIA, on board 2708/2716 EPROM programmer, on board cassette interface, provisions for an RS-232 interface with selectable Baud rate, and more.

Second prize is the new Multiflex Logic State Analyzer, the ultimate diagnostic tool for the computer experimenter. The Logic State Analyzer allows you to monitor any 16 points within a digital system. The analyzer can be triggered by a particular bit pattern or word and will then record the next 1023 patterns for subsequent examination. It can also be triggered by any combination of MRD, MWD, DMA, interrupts or any other control signals. The unit features 16 display LEDS, 4 hex digit displays, forward and back stepping, switch selectable logic polarity and clocking edge, and will operate to 5MHz. Priced at $475, it is comparable to other units costing as much as $10 000. The Multiflex LSA is the only way to properly 'feel the pulse' of your computer system!

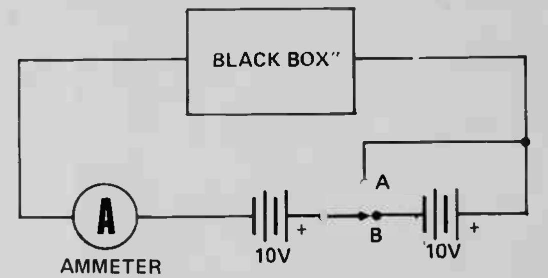


The Multiflex Z80A Computer, worth $450.



The Multiflex Logic State Analyzer, worth $475.

How do you enter? Examine the problem below and enter your solution in the entry form provided. Mail the form in and watch News Digest in future issues for contest results.



THE BOX shown in the schematic is a "two terminal passive network", meaning that the circuit inside contains no transistors, diodes, relays, or anything else with a non-linear transfer characteristic. The meter is indicating some value of current, which is greater than zero and less than infinity. As the switch is moved back and forth between positions A and B, this value of current remains the same. Note that in position B, 20 volts is applied across the box – twice the amount in position A. Bearing in mind that $I = \frac{E}{R}$, how would you construct a circuit within the box that would allow this effect to be observed?

HOW TO ENTER

When you have determined what you think the circuit is, enter your answer, along with your name and address and phone number in the appropriate spaces on this form. Mail the entry form to:

WIN A COMPUTER II
c/o Electronics Today International
25 Overlea Blvd., Unit 6
Toronto, Ontario M4H 1B1

The first two correct answers drawn, win.

Readers not wishing to cut up their magazines may submit their entry on a photostat or handdrawn facsimile of this form. Only one entry per person, multiple entries will be disqualified.

This contest is open to residents of North America with the exception of ETI staff members and their families, their printers and distributors and employees of Exceltronix Components and Computing, Inc.

All entries become the property of Exceltronix.

Contest closes January 16th, 1981.

Editor's decision is final.

THE BLACK BOX CONTAINS ....
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You can draw your circuit here but make sure you list the components in the space above.

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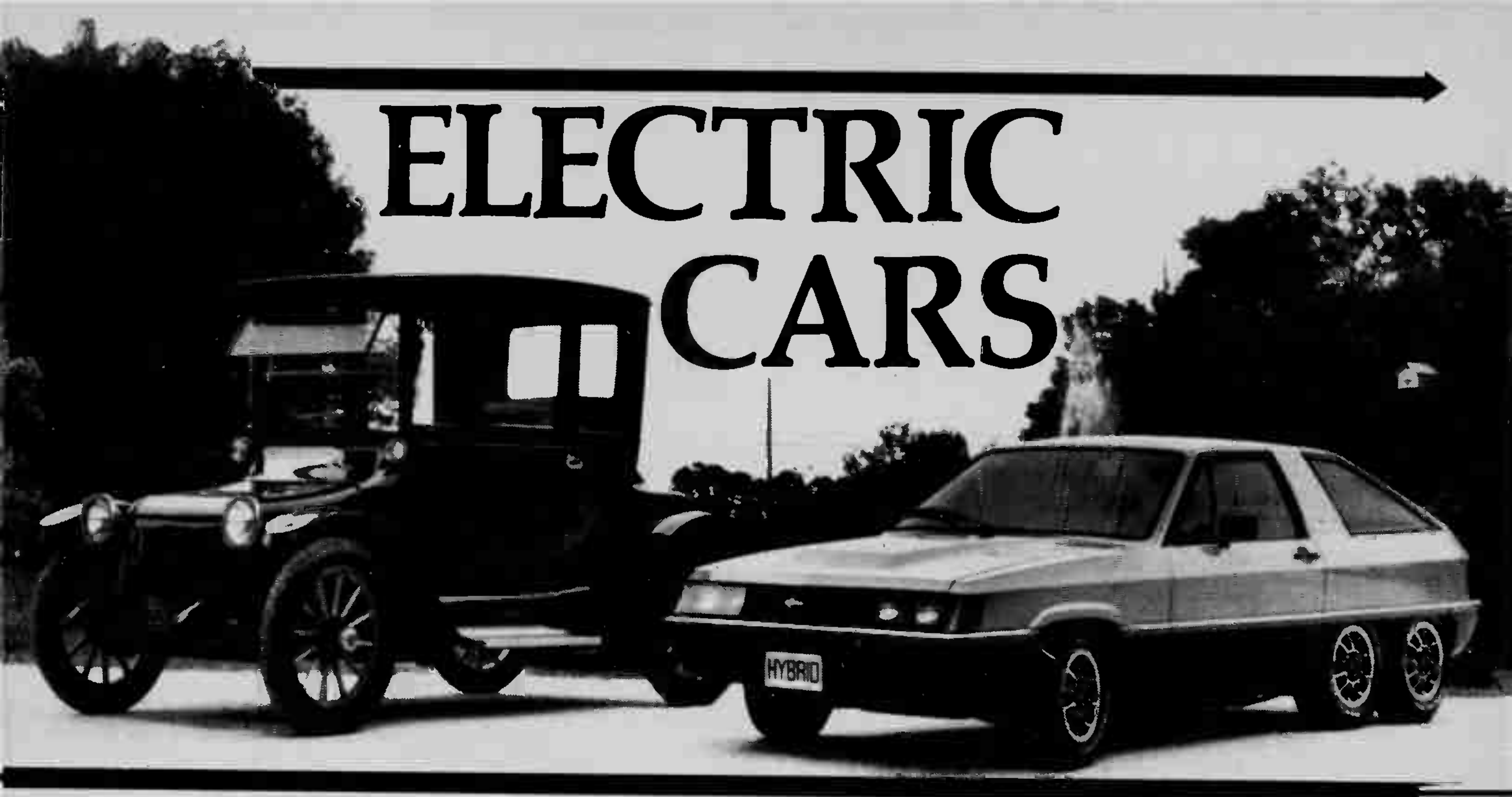
ELECTRIC CARS



Electric cars aren't new but although they now seem very attractive with the shortage and price of gasoline, a lot of problems remain, principly in the area of batteries. Wally Parsons has been looking at the latest developments.

IT MAY COME as a great surprise to many people, but the electric car actually predates the gasoline powered machine, as far as general public usage is concerned. Anyone who has ever attended an antique auto show has probably seen a Baker Electric or perhaps the Detroit electric car, both of which look a little like modified Hansom cabs with nowhere to plug in the horse! These were indeed true horseless carriages.

The first known American electric car was designed by Philip Pratt, had three wheels, room for the driver and battery pack. It was first demonstrated in Boston in 1888. Although it never really caught the public's imagination, it was said to have been very popular with the ladies because of its "clean odourless operation". It had no clutch to bother with, no crank to turn as the early gasoline engines had, and no boiler to explode, as did some of the steam engines around at the time.

Although it was criticized for its lack of speed and hill-climbing ability, the first known speeding ticket was handed out in New York City in 1899 to Jacob German who was driving at the then-reckless speed of 12 mph — in an electric car. Range was only about 20 miles with the batteries then available, about the same as was later achieved with the first pneumatic tires between flats.

The eclipse of the electric car was brought about by two factors: the introduction of the electric starter in 1911 solved one major safety problem with gasoline engines; and a major Texas oil strike in 1901 made petroleum available cheaply at less than a nickel a barrel.

Well, the universe continues to unfold as the world turns, and in the fullness of time we have reached the point where petroleum is even more expensive than in 1900, and supplies are also diminishing.

In the meantime, the electrical and electronic industries have continued minding their own business and improving batteries and electric motors, so that a great many people are now seriously looking at the electric car in a new light.

Battery Limitations

Great! So why aren't the dealer showrooms bulging at the seams with electric cars?

It must be admitted that there are some problems; some technical, some political and commercial but there are also solutions.

To obtain an immediate grasp of the problems, open your Canadian Tire catalogue to the battery section. You will notice that automotive batteries are no longer rated in Ampere Hours, but rather by minimum reserve time at 26° C and minimum cranking Amperes at −17°C. These are, respectively, the total time which the battery from full charge, can sustain a drain of 25A, and the amount of current which can be drawn for 30 seconds before discharging.

Notice that the biggest truck battery shown provides for minimum cranking Amps of 800A and minimum reserve of 420 minutes. In other words, it's good for about 10 Horsepower for 30 seconds.

Not very impressive, to say the least.

Even with considerable weight reductions, electric vehicles (or EV's) use motors rated at around 10HP. If this is needed to run at 50 mph then we're using power at the rate of 15 kWh. That means a *lot* of batteries and an enormous amount of weight.

Indeed, this has been the biggest problem. The best of the lead-acid batteries has a weight/power ratio of about 20Wh/kg, less than a third of minimum requirements. This ratio is important, because the batteries must supply power to move not only the weight of the vehicle and passengers, but the weight of the batteries themselves. As an example, with advanced battery sytems, a battery weight of 800 lbs is not at all unusual. Compare this with Chrysler's new 2.2 Litre 4 cylinder engine at 203 lbs, and you get some perspective on the problem.

Refuelling Time

Anyone who's been stranded with a dead battery knows that it takes considerably longer to recharge it than it takes to fill up an empty gas tank. 30 minutes is about the shortest possible time without running the risk of the battery exploding — very many charge cycles like that and you won't have a battery at all.

The voltage generally used is in the order of 100V, this can be achieved by connecting several batteries in series. To get 20HP you need about 150A, so we are looking at series/parallel or parallel/series combinations of high efficiency batteries. These batteries are available, although not yet at you local Canadian Tire, and it's possible to get about a 40 to 50 mile range with up to 20 such batteries, depending on the car.

Obvoiusly, such a range is inadequate for anything but short urban runs, and fortunately, the majority of motor trips fit this pattern. Moreover, most such trips are made up of shorter trips of only a few miles each, with stopovers of 30 minutes or more. Several people involved with electromobiles have discovered a practice which electronics enthusiasts have regarded as routine for years: when the thing's not in use, plug it into the wall and charge up the batteries, don't wait until they've discharged.A rather obvious idea, perhaps, but this is where the political/commercial problems come in. When did you last drop a dime into a parking meter and plug your block heater into a convenient outlet mounted on it? How many public or employee parking lots provide for such facilities, except perhaps in the coldest parts of Canada? And who would incur the expense of installing such outlets when there are so few users on the road.

As an example of circular thinking, how many more such vehicles would be bought if such outlets were available? Dr Victor Wouk, a long time pioneer in EVs, has estimated that the cost of installing 10 million outlets would be less than the cost of constructing one synfuel plant to convert coal to gasoline at a rate of 20 thousand barrels a day, enough at best to fuel 100,000 vehicles.

Obviously this vicious circle must be broken so that people will buy the vehicles in sufficient quantity to justify someone putting in outlets to make more vehicles attractive.

Since range and refuelling time are the problem here, how about combining battery electric power for use most of the time, with a gasoline engine to handle heavy load conditions such as acceleration, highway speeds and long runs, all of which tax conventional battery systems heavily.

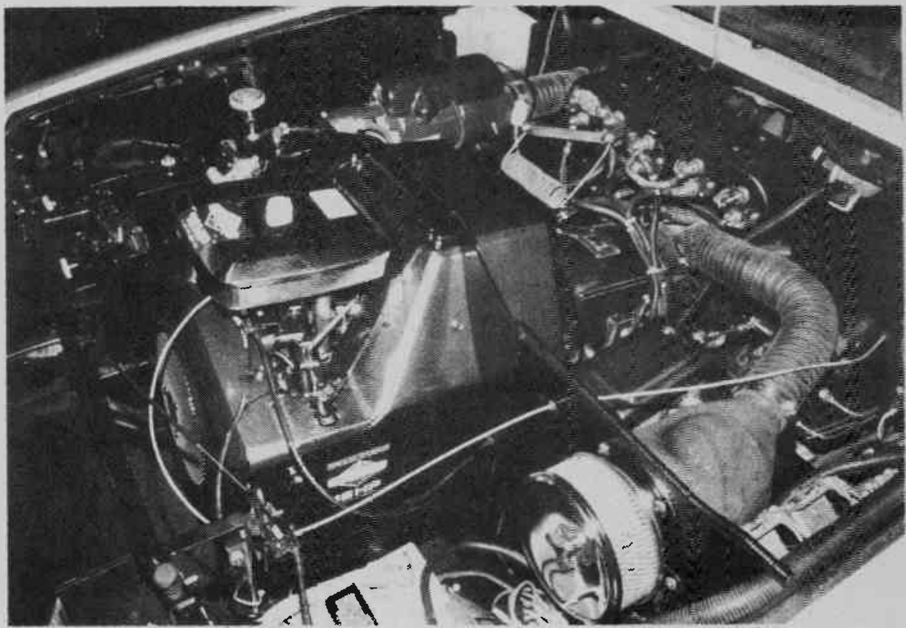
Hybridology

Such an approach has been tried with some success and such a vehicle is called, appropriately enough, a hybrid. With this technique the drive wheels are connected to an electric motor which is battery powered. It is also connected, via a transmission, to a gasoline engine.

In what is referred to as a series configuration, the vehicle is driven by an electric motor powered by a battery, which is also connected to an electric generator driven by a gasoline engine. Although at first glance this would seem a logical and elegant approach, the inefficiencies involved in the multiple energy conversions have resulted in disappointing performance. The electronic speed controls which cut in the gasoline engine at high peak loads must themselves handle extremely high currents, so designing a reliable system has proven difficult. DC motors also are quite inefficient except over a narrow speed range.

A parallel system may use one of two configurations. The simplest uses a dynamotor driven by a battery. Such a motor, when driven by an external mechanical force becomes a generator and will recharge the battery. Such a

ETI's Editor Halvor Moorshead sits at the wheel of an electric van made by Marathon Electric Vehicles of Montreal. A number of these have already been delivered, mainly for experimental purposes. Illustrations of the control console and the on-board computer are shown elsewhere.



Under the hood of the very attractive Briggs and Stratton Hybrid. There are no plans to manufacture this prototype but it does overcome one of the main problems in electric vehicles of power when you need it and a back-up power system should you run out of charge.

One of the few electric cars that is available right now, the Bradley GTE Electric made in Plymouth Maine. The price is about $17,000 and so far about 50 have been delivered.

force could be dynamic braking, such as allowing the vehicle to slow down by removing power to the motor, using the car's inertia to turn the motor. This is similar to the engine compression braking experienced with gasoline engines.

Another source of generator force could be gasoline engine, clutch coupled to the dynamotor's shaft. When power demands indicate, the gasoline engine is fired up and drives the shaft and the dynamotor rotor together, supplying power to the wheels.

Another parallel system literally parallels a gasoline engine via a transmission, and an electric motor via a fixed gear to a drive shaft, to accomplish the same end.

An example of the first type of parallel system is an experimental vehicle built by Briggs & Stratton. It uses an 18 Hp Briggs & Stratton engine, 8 Hp Baldor electric motor and 12 Globe Union batteries. Cruising range is over 200 miles at about 60 mph, and gets over 40 mpg on alcohol fuel. It's fast enough for Indy 500 winner Johnny Rutherford to have set a hybrid speed record with it, averaging 71.009 mph for 20 miles at Long Pond, Pennsylvania. The extra set of wheels at the rear is used to take the batteries' weight and functions as a captive trailer. Thus straight-ahead stability is maintained while cornering is not sacrificed.

Having seen it in the flesh, as it were, about the only thing I can find wrong with it is that there are no plans to produce it commercially.

Another series system is that used by Marathon Electric Vehicles, of Montreal. It too uses the common centreline which also appears in the Briggs & Stratton, in a body formed of aluminum urethane sandwich material developed specifically for electric vehicle use.

Back To All Electrics

This is all very well, you might say, but isn't there something Rube Goldberg-ish about such an arrangement, which might appeal more to a mouse named Mickey.

No more so than carrying an outboard motor on a sailboat for use when there's no wind. No more so than the practice in hospitals of installing generators as back-up in the event of power failure.

But an all-battery system would certainly be more elegant, and logical. The problem has been batteries and recharge facilities.

So let's look at some batteries other than the familiar lead-acid.

Zinc-Chloride

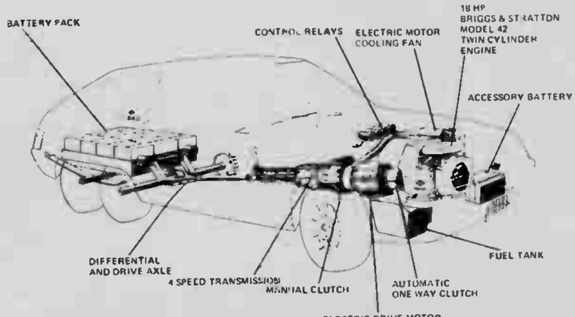
The best known of the exotic battery systems, it was recently announced by Gulf + Western (yes, indeed, the same conglomerate whose logo appears under Paramount Pictures). Unlike other developers, G + W plans to manufacture and market their own voltmobile fitted with their own power plant.

The G + W system is quite literally a system; this is no rectangular block which you drop in place. Rather than having closed individual cells, it pumps an electrolyte over graphite plates. Chlorine is mixed with water then chilled to a slushy consistency. Ordinarily, chlorine is a poisonous gas, and this method is used to contain it. G + W claim that a 1200 pound installation is equivalent to 4000 lb of lead-acid, for a 45 kWh capacity.

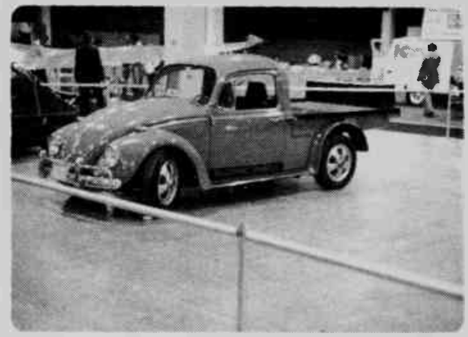
During the charge cycle, zinc-chloride dissolved in water is circulated by a

You need a lot of batteries to drive an electric vehicle at the moment; this shows the array under the hood of the Bradley.

The simple control panel of the Marathon.



The guts of the Briggs and Stratton Hybrid. A low power gasoline engine (18 HP) is connected in series with an electric motor. The reason for the double rear wheels is to provide an independent suspension for the battery pack at the rear. This prototype has been built on a chassis made by Marathon in Montreal.



An impressive range of electric vehicles were shown at the recent Energy Lifestyle Show held in Toronto. The vehicles shown above were on display in addition to the Briggs and Stratton Hybrid and the Bradley GTE Electric. On the left is shown an experimental vehicle for the Canadian Armed Forces; another experimental vehicle from Varta is shown together with a modified Volkswagen.

pump over the electrodes. DC applied to the electrodes results in zinc collecting on the negative electrode, while chlorine collects at the positive, to be dissolved in the water and carried away.

The electrolyte passes from the plates and is chilled to a chlorine hydrate slush which is retained in a holding tank. Excess solution is returned to the plates and the process continues until the holding tank is full.

During discharge the hydrate is carried to the positive plates, allowing withdrawal of current. This causes the zinc metal to react forming zinc-chloride ions. Circulation of the zinc-chloride rich solution, which has now warmed up in the process causes further decomposition of the hydrate.

The chiller unit is powered up at the same time charging current is supplied to the battery. Charging takes from six to eight hours for a fully discharged battery, but of course, partial charging is possible.

Overcharging or overdischarging will not harm the cells, and the system is designed to discharge itself every 1500 miles to clean the graphite cells.

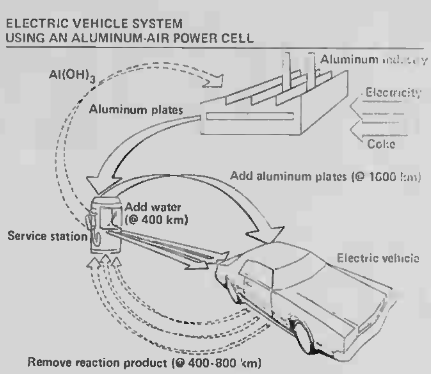
The range of such a vehicle can be competitive with gasoline engines, but there is still the problem of recharge time, if partial charging facilities are unavailable.

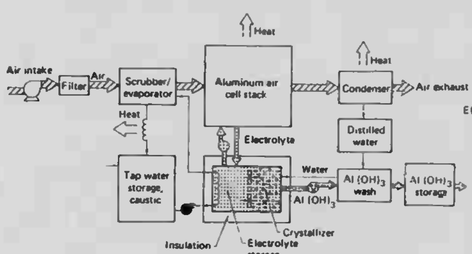
Now, if only we could get a power source which could be recharged as conveniently and as quickly as filling a gas tank.

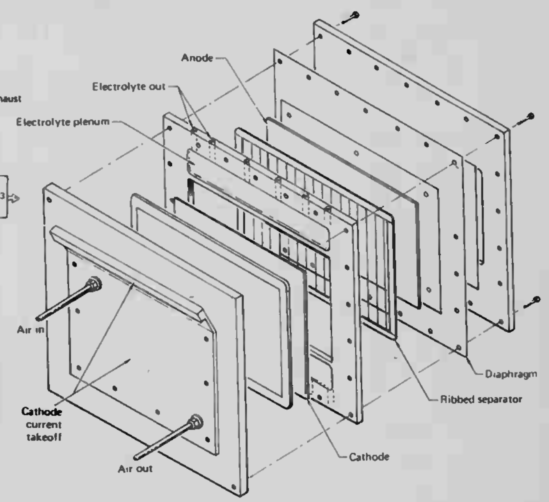
Aluminum-Air

So far this is only in the experimental stage, but offers more promise than other types. While the energy/weight ratio for lead-acid is only about 20W/kg, and zinc-chloride about 84W/kg, Aluminum-air offers densities as high as 300W/kg, according to researchers at the Lawrence Livermore Laboratory in California. *Continued on page 36*

One of six vans purchased by Ontario Hydro from Marathon for evaluation purposes.







The Aluminum-Air Battery developed at the Lawrence Livermore Laboratory in California shows some promise. It is a primary cell but has fifteen times the charge capacity per kilogram than lead-acid types. A cut-away and block diagram of it are shown. Although it is a primary cell, the hydrargillite produced can be recycled by the aluminum industry. This could present certain advantages; instead of recharging you would simply have to replace the water and anode plates which could be as fast as a fill-up.

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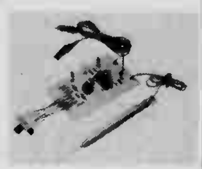

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Continued from page 34.

In addition, the battery is recharged by replacing the anode plates every 1600-3600kM, and water ever 400kM. That's better range than the average gas tank, and the anode replacement is a quick in/out procedure.

Basically, power is generated by the reaction of aluminum with water and air in an electrolyte of sodium hydroxide. The product of the reaction is a polymorph crystal of aluminum trihydroxide called "hydrargillite". Obviously, aluminum and water are used up, so to recharge, the water is replaced, and the hydrargillite is replaced with metallic aluminum. This is not a reversible process, and in a sense the battery is a primary one.

A secondary side benefit of the process is that the hydrargillite is used as a feedstock of the aluminum industry. Therefore, it is not a waste product, but is recycled.

Although these seem the most promising battery technologies around, there is some competition, such as a Lithium-Molybdenum disulphide system under development at the University of British Columbia, a Nickel-iron system which offers long life but is quite expensive, and Nickel-zinc which potentially could deliver high peak currents, the lack of which has resulted in poor accelleration characteristics.

Motors

Most drive systems use a DC electric motor coupled to the drive wheels in a manner not a lot different from that used with gasoline engines.

DC motors, as mentioned before, offer efficiency over a limited range, but can deliver high torque at low speeds. Total weight to HP ratio is a limiting factor, as is the mass of the rotor itself.

One US designer has two electric motors under development, one an electronically commutated DC motor which has operated at 24000 rpm, with a mass of 1.3 kg/kw. Another has a disc-type rotor using a samarium-cobalt magnet, for a mass of 0.7 kg/kW.

General Electric and Westinghouse are also working on disc rotors. GE uses electronic commutation and multiple manganese-aluminum magnets.

Then there's the unusual motor first used over ten years ago in military vehicles in which the motor and the wheel are integral: something like a direct drive turntable. Actually, the idea goes back to the early part of the century and was supported by no less eminent a figure than Ferdinand Porsch.

The big car makers are probably doing more in the field of electric vehicles than they care to divulge — it's a competitive business after all. This experimental version was made by Chrysler Corporation for the US Department of Energy, it has a range of 75 to 100 miles under ideal load conditions. GM have commited themselves to an electric car for introduction in 1985.

With range limited by battery capacity, it is important to make the best use of what you have got. This shows the computer on the Marathon.

Inside the Bradley it looks very like a conventional sports car.

This offers an easy route to four-wheel drive, but does present problems with unsprung weight to give suspension designers headaches.

While not exactly a motor, the flywheel has been used sort of as a load-leveling device, reducing variations in battery load variations from cruising to acceleration, much as a capacitor in an electrical circuit levels the instantaneous drain on the power supply. Most batteries deliver a lower watt/hour rate at higher discharge rates than at low rates. In one design, the flywheel is set in motion, up 25000 rpm. On the road, it's momentum is tapped to generate electricity for the motor. When braking to a stop, the car's momentum generates electricity to respin the flywheel. Meanwhile, the battery puts out a steady current to help run the car's motor.

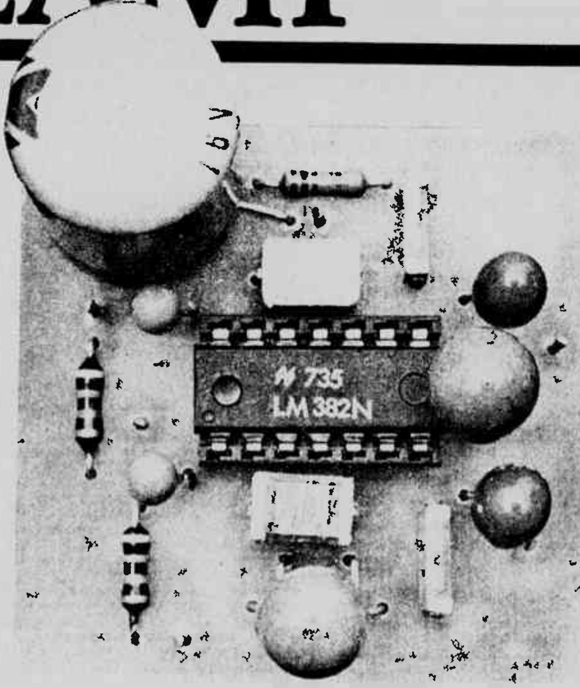
The electric car can be efficient, non-polluting, very driveable, and quiet as a Rolls-Royce. More important they are not necessarily dependent on non-renewable resources.

Once we've converted our electrical generating systems to nuclear, they can break the umbillical cord to OPEC which is rapidly strangling the Western world.

Saving a civilization is a pretty worthy achievement. ●

RIAA PREAMP

Fit a magnetic cartridge to your system with our economical preamp design.



CERAMIC OR CRYSTAL cartridges have found wide application in lo to mid-fi stereo systems. Manufacturers like them because they are cheap. As they have a high output level (100mV – 2V) no preamp is required, enabling a simple and economical system to be readily assembled. Of course, the disadvantage is that the quality of reproduction reflects the cost.

The next step up the hi-fi ladder is the use of a magnetic cartridge. However, you cannot simply plug one in. Magnetic cartridges have a comparatively low output level and their playback response coupled with all the jiggery-pokery that goes into the manufacture of a record results in a very squeaky sound.

Stylish Motion

Ceramic and magnetic cartridges are distinguished by their different responses to the movement of the stylus as it follows the fluctuations of the groove. A ceramic transducer produces an output proportional to the deflection amplitude of the stylus, whereas the output of a magnetic cartridge reflects the rate of change (velocity) of the stylus. Recordings could be made in either a constant velocity or constant amplitude (against frequency) mode. Each has its advantages. In fact a combination of the two is used in an attempt to get the best of both worlds and a standard was set out by the Record Industry Association of America (RIAA – get it?).

Ideal Response

Our graph shows the RIAA playback equalisation curves with the ideal response shown dotted, and what you actually get indicated with a solid line. With a 0dB reference at 1kHz, it can be seen that the response ranges over nearly +20dB between 20Hz and 20kHz, a scale of 100 to 1. The high gain at low frequencies means that care must be taken to avoid line hum pickup and screened connecting cables are essential.

Two Into One

The preamp and equalisation are neatly combined in one circuit. Our design utilises a single chip from National which features dual amplifiers with an internal resistor matrix. Use of the internal resistors enables an RIAA response to be achieved with just a few components. The unit exhibits a gain of 46dB (200) at the 0dB reference frequency of 1kHz and may be powered from any 10-14V supply. Current consumption is around 16mA maximum.

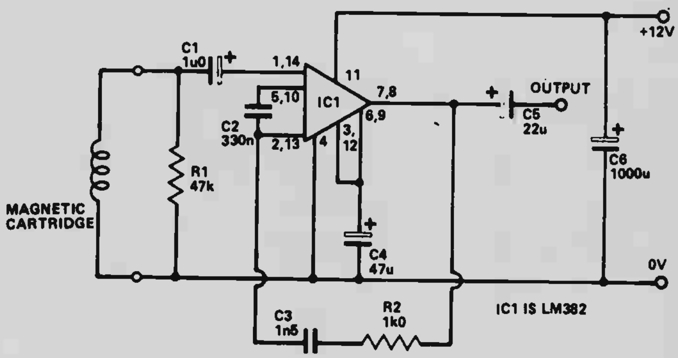


Fig. 1. Circuit diagram

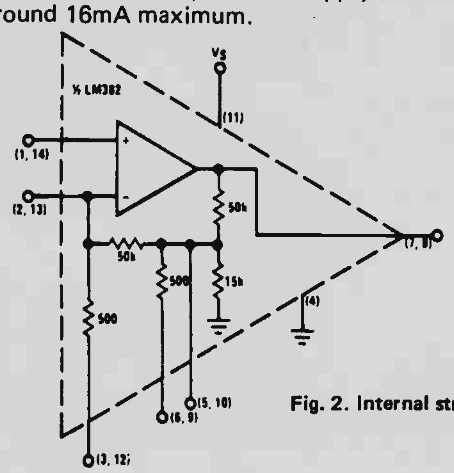


Fig. 2. Internal structure of the LM382.

HOW IT WORKS

The desired RIAA frequency response is achieved through the use of a resistor-capacitor network in the feedback loop of an op-amp. Use of an internal resistor matrix in the LM382 chip enables a very simple practical circuit to be used. The circuit is absolutely conventional. A 12V supply was chosen as the LM382 is characterised for operation in automobiles and its output is biased to 6V.

The circuit offers a gain of 46dB(200x) at the RIAA 0dB reference frequency of 1kHz. As the output of a typical magnetic cartridge is in the range 2-7mV, this should result in a preamp output of around 1V, an ideal level for the 'line' input of most amps. A 47k resistor at the input provides the standard cartridge load and a single 1,000uF capacitor is used for overall supply decoupling.

Note that the integrated circuit pins are identified for the left and right channels with pairs of numbers on the circuit diagram. Also that all components except IC1 and C6 are duplicated on the component overlay.

Construction

Use of a printed circuit board is recommended for this project. If you use another method of construction, ensure that connecting leads are kept short and locate the decoupling capacitor close to the supply pins of the integrated circuit. The unit may be assembled into a metal case for good shielding. Once assembled, just connect your cartridge to the inputs and connect the outputs to your amp, either directly to the 'line' input or via the passive tone controls if you have them. Then put on your favourite disc, relax and enjoy it. ●

PARTS LIST

Resistors all ¼W 5%	
R1	47k
R2	1k0
Capacitors	
C1	1u0 tantalum
C2	330n polyester
C3	1n5 polyester
C4	47u tantalum
C5	22n tantalum
C6	1000u electrolytic
Semiconductor	
IC1	LM382

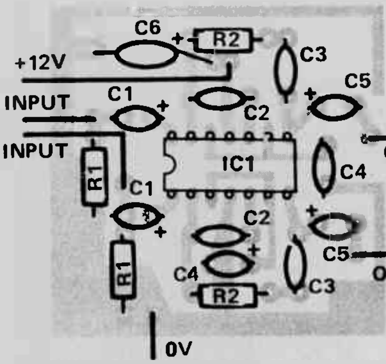
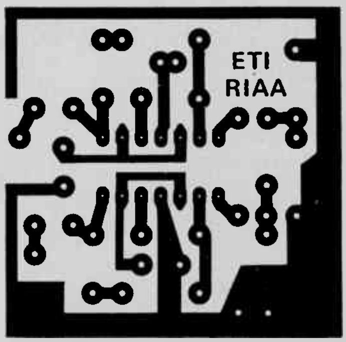


Fig. 3. Component overlay.



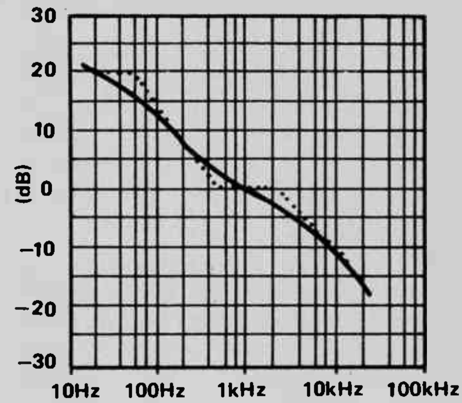


Fig. 4. RIAA playback equalisation curve.

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VIP-590 .... $94.75

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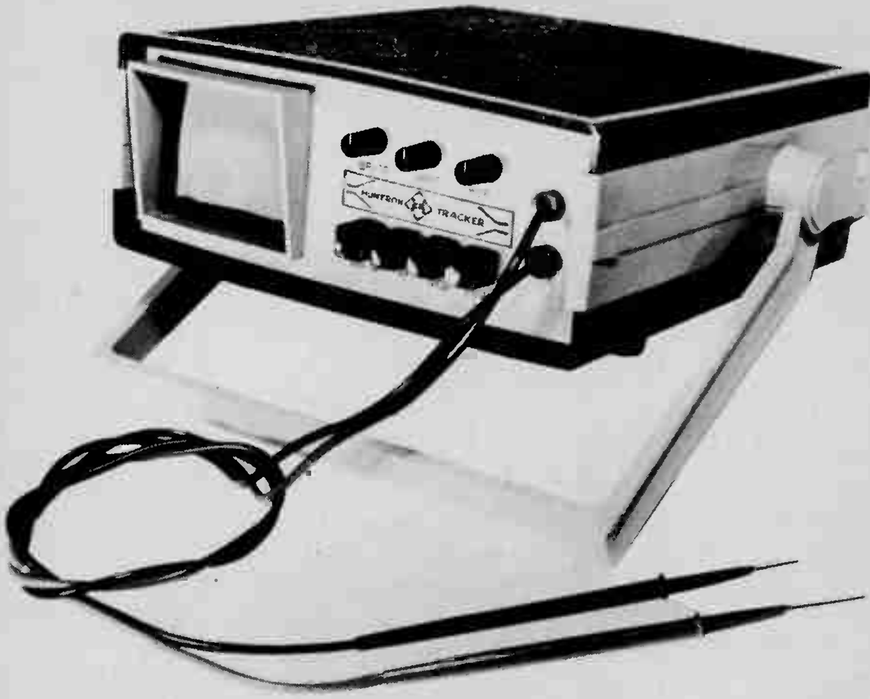

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SURVIVAL GAME

A highly addictive but infuriating game. Escape from the tyranical machine if you can. Naturally, the game has sound effects, LED readouts and a skill level control.

SURVIVAL IS A small hand-held game in which the contestant pits his wits against those of the machine. The machine is a tyrannical device, dedicated to enslaving you by repeatedly making threatening gestures towards you (indicated by a brief flash of a LED as the threat is unleashed). When a threat is made you can either submit, by doing nothing, or you can defy the tyrant by pressing a JUMP button and trying to escape up a flight of steps (indicated by a vertical column of ten LEDs).

To escape, you must press the JUMP button only when the threat LED is on. Each time you make a successful jump, you move a discrete amount towards the top of the steps and eventual escape (indicated by a pulsed WIN sound as the top of the column illuminates). If you make a single wrong move while on the steps, however, the tyrant will instantly strike you (indicated by a 'bleep' sound) and send you tumbling back down to the bottom of the steps. Alternatively, if you submit to the threats (by doing nothing) the tyrant will slowly lure you down from your perilous perch.

An Evening's Work

The machine makes a threatening move once every second or so, but the actual threat lasts for only a fraction of this time. The game is provided with a SKILL level control, which enables the threat duration (and thus the escape time) to be varied from over 200mS to less than 50mS. At the lowest skill level, it is possible to escape from the tyrant in only four to five successful moves. At the top of the skill level, between thirty and forty successful moves are needed to ensure escape. The escape 'steps' are exponentially weighed, so that climbing becomes progressively more difficult with each move.

The SURVIVAL game is designed around three ICs and three transistors, is reasonably inexpensive to build and is powered from a single 9V battery. The project can be built in one or two evenings.

Construction

Construction of this project should present few problems if the overlay is followed with care. Note that IC3 is a CMOS device and should be mounted in a suitable socket.

When construction of the PCB is complete you can either make temporary connections to the eleven LEDs and the transducer etc and give the unit a functional check, or you can dive in and fit the whole shebang in a suitable box and give the unit a functional check afterwards. If you decide on the latter approach, note that the unit typically consumes some 30—40mA and should ideally be powered from a 416 or larger battery, but that our own prototype is in fact powered (or under-powered!) from a 216.

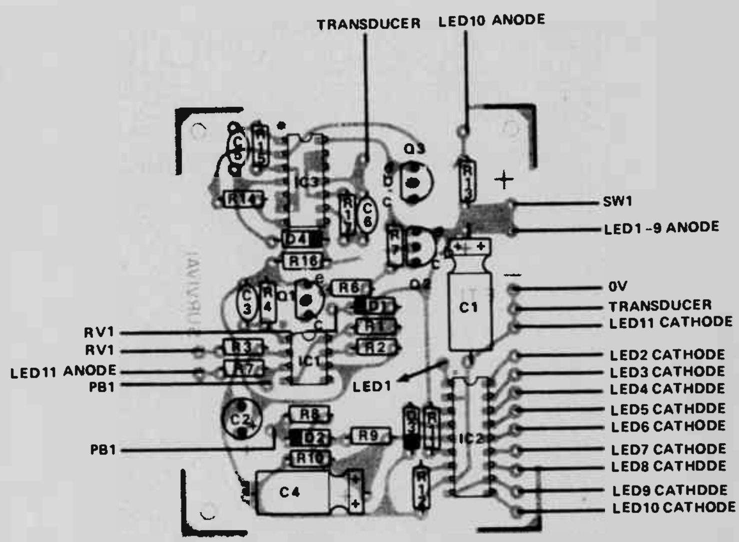

Fig.2. Component overlay. Lots o' LED leads to lace up — there's nothing to it.

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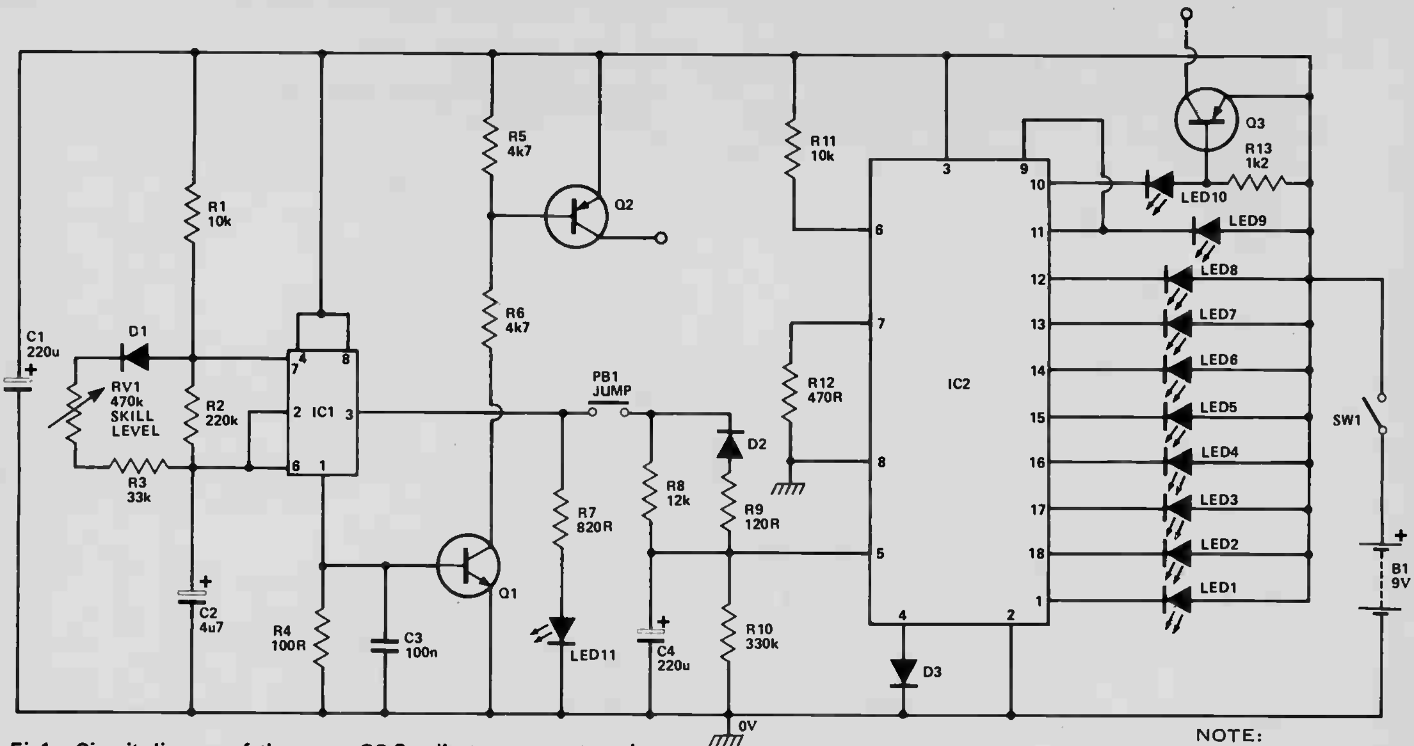


Fig1a. Circuit diagram of the game. Q2,3 collectors connect to the sound effects part of the circuit (Fig.1b.) Press PB1 every time LED 11 flashes on to ascend the ladder of LEDs 1-10.

NOTE:
D1—4 are 1N4148
Q1 is 2N3904
Q2 & Q3 are 2N3906
IC1 is 555
IC2 is LM3914
IC3 is CD4011B

PARTS LIST

Resistors
all ¼W 5%

R1, 11, 14, 16	10k
R2	220k
R3	33k
R4	100R
R5, 6	4k7
R7	820R
R8	12k
R9	120R
R10	330k
R12	470R
R13	1k2
R15	1M0
R17	68k

Potentiometer

RV1	470k

Capacitors

C1, 4	220u electrolytic axial
C2	4u7 electrolytic
C3, 5	100n polycarbonate
C6	10n polycarbonate

Semiconductors

IC1	NE555
IC2	LM3914
IC3	4011B
Q1	2N3904
Q2, 3	2N3906
D1-D4	1N4148
LED 1-10	TIL 220 or square LEDs
LED 11	TIL 220 standard red 0.2"

Miscellaneous
PB1 momentary push button
SW1 SPST miniature toggle
B1 9V (No. 416)
Tx transducer Projects Unlimited No. AT32
Ceramic resonator
Case

HOW IT WORKS

The basic operating principle of the game is quite simple. IC1 is a low frequency (less than 1Hz) astable; its output switches alternately between the low (zero) and high (+9V) states, driving LED11 on whenever the output is high. The idea of the game is to close PB1 whenever LED 11 is on, thereby causing C4 to slowly charge up via R8, but to ensure that PB1 is open whenever LED 11 is off, thereby preventing C4 from rapidly discharging via R9 and D2. The voltage of C4 is monitored by a LED voltmeter (IC2 and ten LEDs) and the game is won when C4 charges to roughly half supply voltage (LED 10 on). IC3 is used as a sound effects generator and produces a brief tone whenever C4 goes into the discharge mode or a pulsed tone when the game is won.

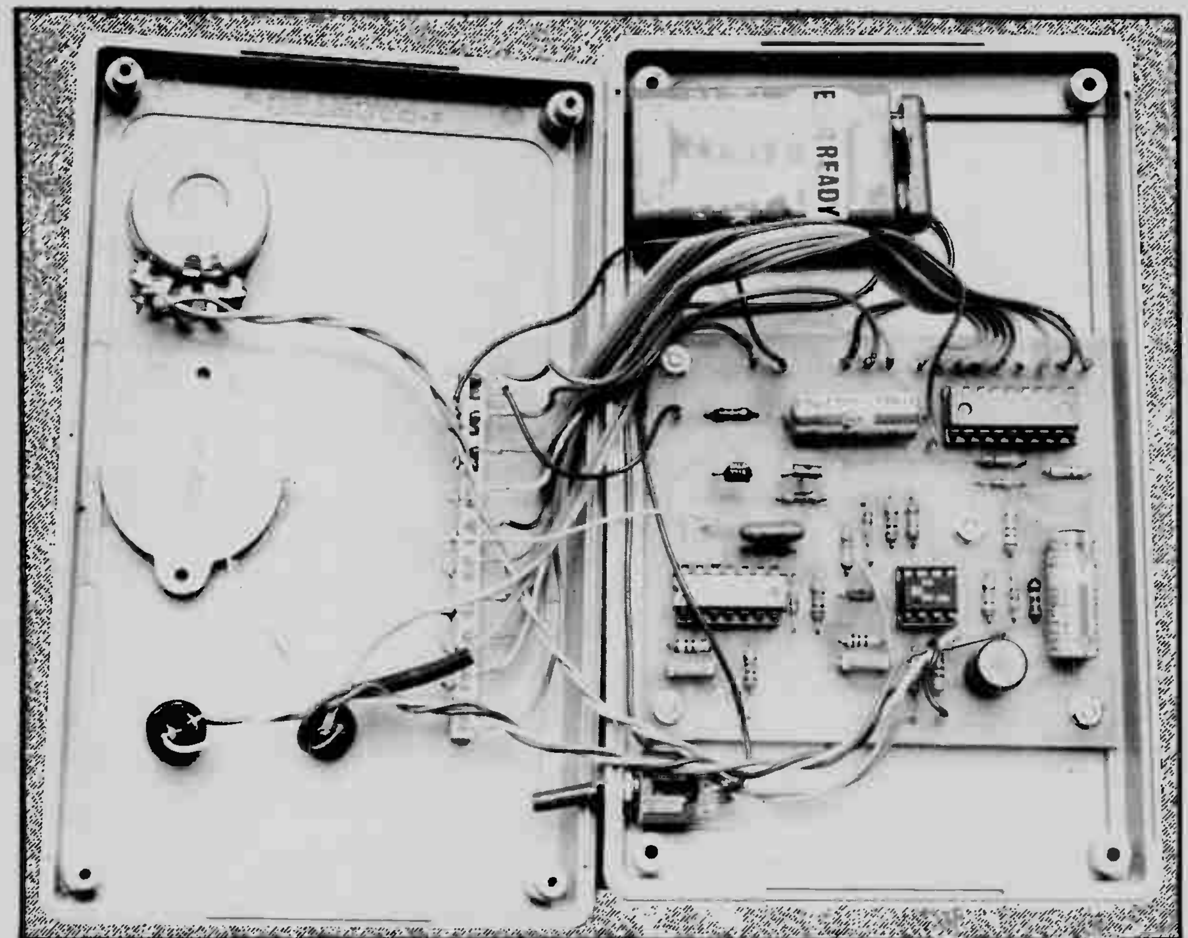
The operation of the IC1 astable is slightly unusual. Here, C2 alternately charges (LED 11 on) via R1-D1-RV1-R3 in parallel with R2 and discharges (LED11 off) via R2 only, thereby producing a non-symmetrical output waveform in which LED 11 is on for a shorter period than it is off. The on/off ratio is variable via RV1, which thus acts as a Skill Level control.

The pin 1 ('ground') terminal of IC1 is taken to the 0V line via the base-emitter junction of Q1, shunted by R4 and C3. Whenever C4 is inadvertently discharged by closing PB1 at the wrong time, the capacitor discharges through this junction and turns Q1 on, thereby causing Q2 to turn on and activate the IC3c-IC3d half of the sound effects generator circuit.

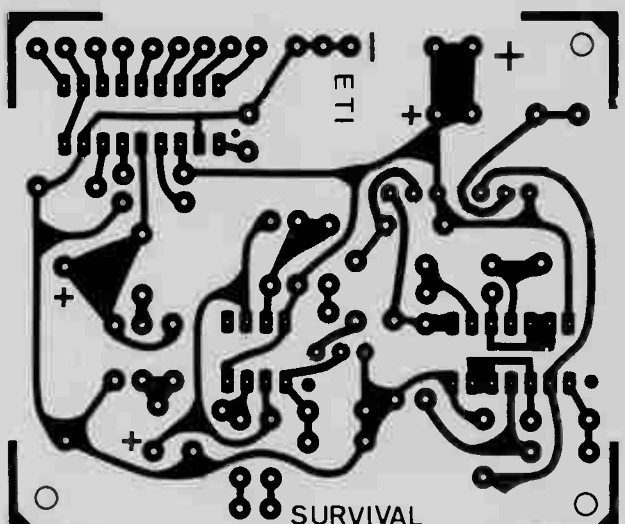
Capacitor C4 charges slowly in the exponential mode via R8 when PB1 is correctly closed and discharges rapidly via R9 and D2 when PB2 is incorrectly closed. The capacitor discharges very slowly via R10 when PB1 is open. The C4 voltage is monitored by LED voltmeter IC2, which drives a line of ten LEDs in the 'dot' mode. The voltmeter is programmed (via R11) to read full scale and is offset by approximately 600mV via D3. The base-emitter junction of Q3 is wired in series with LED 10, causing Q3 to turn on and activate the IC3a-IC3b half of the sound effects generator when LED 10 turns on (game won).

The sound effects generator is made up of two gated astable multivibrators. IC3c-IC3d act as a fast (1kHz or so) astable which directly drives a piezo transducer or sounder and is gated on via Q2 collector when ever PB1 is incorrectly closed. IC3a-IC3b act as a slow (a few Hertz) astable which is activated via Q3 collector when LED 10 turns on and pulses the fast astable on and off to produce a distinctive pulsed-tone GAME WON sound.

The entire circuit is powered from a 9V battery. The circuit typically consumes some 30-40mA, so this battery needs to be a 416 or larger size.



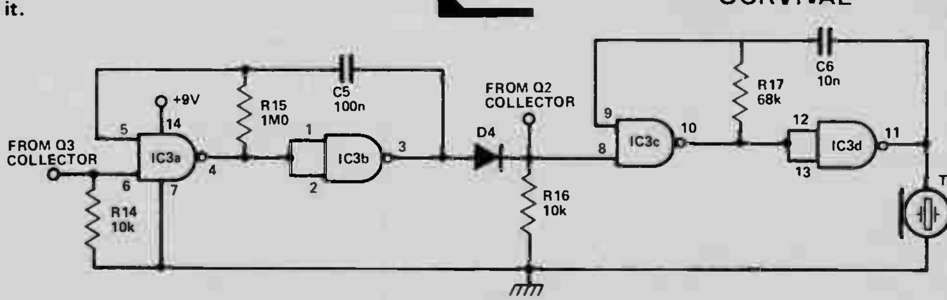
Construction of the Survival game is relatively straightforward – PCB in one half of the case, LEDs and controls in the other



It is advisable, before completing the interwiring, to functionally check the performance of each of the eleven LEDs used in the unit.

When construction is complete, switch the game on and check that LED 11 flashes briefly once every second or so and that the flash duration can be varied by RV1. You can check the action of C4 and the ten-LED read-out circuit by temporarily shorting the top of R8 to the positive supply line, in which case the LEDs in the column should sequentially illuminate and the WIN alarm (a pulsed tone) should sound when the upper LED (LED 10) turns on. Finally, remove the temporary short and press PB1 when LED 11 is off, checking that the column of LEDs turn off and a brief tone is generated. Your game is then complete and ready for use. ●

Fig.1b. The sound effects generator consists of two gated astable multivibrators. The game just isn't complete without it.



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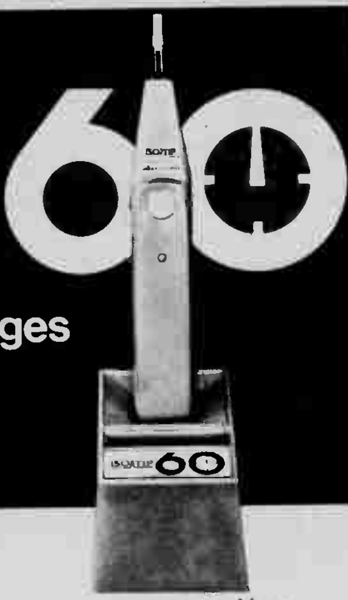

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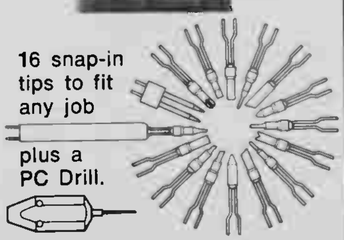

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WHAT'S NEW

By Steve Rimmer

The Korg VC10 Vocoder.

This month we take a look at vocoders, what they are, how they work and at some of the exceptional design problems they present.

DANGEROUS AS HE is with anything louder than a broken tin whistle, I was beginning to wonder who had let ol' Max into the studio to play with the percussives. He'd been doing kettle drums and timpanies for the last hour or so, with just a sprinkling of vibes, in a kind of jazz-rock-washing machine fusion that was reminiscent of an Aborigine funeral dirge played backwards at half speed on a defective tape recorder. The dog, whom he'd dressed in a "Stoned Again" T-shirt, and fitted with one of my Indian elephant bells (this last outweighing the poor mutt by a pound or two) had tunneled its way into a pile of instrument covers, hoping perhaps for the descent of the calm of blessed deafness. By the sound of things, the architect of this accoustic Dali production had felt it some time before. Like Tommy, he now played by sense of smell. One of the cats had stopped toying with its ball of yarn, and in the dim glow of the candelabra on top of one of the amps, appeared to be weaving it into a hangman's knot. Cats, by and large, are cowards. If you'd played Max backwards at sixteen r.p.m., he'd have said "Paul is dead, Paul is dead . . . he couldn't stand the noise."

"Had a few too many o' Josi's mushroom muffins again, didn't ya?" I asked the bearded Quasimoto, clad only in his ritual filthy cutoffs and a cloud of strawberry incense.

"Quiet, I'm creating," he intoned. I couldn't have said what he was creating right then, but, if it had lived, it might have spawned a whole new generation of Japanese horror films.

"This place'll never be quiet again," I observed. The echoes wouldn't be dying out for weeks. "Could you cool it a bit, Maxwell, old thing? Some of the furniture's comin' apart."

"Can't stop now man, " he cried, placing a pipe in his mouth with grim determination. He looked like some bovine sea captain right then, a crusty old mariner doing hash. "I'm lookin' for the sound."

"You won't be able to hear it when you find it, man."

"That doesn't matter – it's for art."

"Whoever Art is, I hope he'll eventually appreciate the suffering that transpired in his interest. "Hey, listen, man," I said at last, "What you need is a thing, you know."

Max punctuated the genesis of an idea with a final belt of a kettle drum mallet on the high hat, and then, mercifully fell silent for a moment.

"A thing? Like, ya, man, a thing – you got a thing?"

"Hey, man," I replied, hoping that, his inertia lost, the drugs would take effect and he'd pass out, "When've I ever been without a thing, y'know?"

"Ya, a thing," he mused. He stroked his beard, perhaps scratching a few small trolls living therein.

"A thing, man," I was wondering how quick I could become a hypnotist.

Thus it was that I turned Max onto the first black box with knobs that came into sight, which turned out to be a Korg Vocoder that Rod had scarfed up a few weeks before. I told him that, because of the transconductance of the filter channels, it could only be used with headphones, and he believed it.

There has been relative silence since, and, I must say, I've gotten quite a bit of playing done. The creative potential of a vocoder has, thus, been unveiled to me, and the unheard of musical heights it has allowed me to explore defy description.

I think it safe to say that, without this marvelous machine, there are many sounds I might never have heard again. Certainly, anything below 95 decibels would surely have been lost for good.

If Bach Had Had One

One can but imagine what might have happened had Johann Bach had a Vocoder. Consider the limitless possibilities, the boundless horizons of musical development were such a mind to be given an instrument of these potentials. He probably would have placed his immortal hands upon it and cried, "Ya, it ist chust vat I need to keep der vind from blowing avay der cheet musick."

Even Bach had his limitations.

These days, of course, we realize that there are all sorts of things one can keep from blowing away by placing a vocoder on top of them, sheet music being but one. The instrument has countless other potentials as well; a doorstop, a dog dish raiser for tall, lazy dogs, an egg cracker, the list is endless. And, as an added feature, the thing can also be used to process sound and make music! Yes. Isn't that amazing?

A vocoder is, in effect, a speech synthesizer, and, in fact, the first efforts which eventually culminated in the musical vocoders of our day were in this direction. About two hundred years ago, the earliest attempts at fabricating the human voice with non-human bits and pieces were undertaken by a fellow named Von Kempelen. Realizing that there was a scarcity of vacuum tubes and other electronic parts at the time (it would be well over a century before anyone would even get around to inventing the things) he constructed his apparatus out of mechanical devices. The first vocoder then, was accoustic, just like the predecessors of most contemporary electronic instruments. Being slightly ahead of his time, Von Kempelen never taped his talking machine (the wire recorder too, was rare due largely to its non-existence) so all we have are his notes, which testify that, amidst a certain amount of lo-fi wheezing and hissing, it could produce human sounding speech. The last thing it is known to have uttered is "Help! There's a leak in my number three bellowsssss!"

With the coming of the dawn of electronics, the vocoder was investigated anew by the one agency that could view it with the proper clarity; the phone company thought it might be a way to make some money. At this point, the notion of what constituted a vocoder was becoming a bit clearer. One of its components consisted of a vocal spectrum analzer, or "encoder". This section took the vagaries of human speech and chopped it up into a finite number of packets of voltage, each one representing a small slice of spectrum. It was found that if a sufficient number of these slices were to be taken, the voltages could be utilized to reconstruct the encoded speech. This may seem like the most complicated way ever of sending sound between two points but, in fact, it did look to have a few useful applications. The aggregate spectrum occupied by all the derived control voltages was much smaller than the bandwidth of the speech that had originally provided them. Thus, in theory, Ma Bell could run a greater number of channels over the same lines, and this made her very happy.

We may all take heart in knowing that this nefarious scheme of these dark and inhuman powers, involving the overthrow of several natural, physical laws, never saw much success. Much of its original magic was lost when some beady eyed gnome from accounting started comparing the cost of the vocoders with the expense of just stringing some more wire. A futher dampening of enthusiasm was felt when the crude mathematics of the day pointed out that telephone switching stations equipped with vocoders of the required stability and resolution would be bigger than the towns they served. No one had predicted that "vocoder" would become a household word, and they were right, every one of them. The same was also successfully not said about such words as "electro-mesoscopic analysis", "dioxyribose neucleic acid" and "zort". How many times have you been at the dinner table talking about "zort"? See.

The research that Bell labs put into the vocoder, at our expense, was not however, entirely wasted. It eventually became a musical instrument, to be used by such bands as The Beatles and the Electric Light Orchestra. ELO, as you may remember, sang those immortal lines "Ma Ma Ma Bell, I Will Get You," So I suppose that justice has been wrought.

If The Beatles Had Not

The transition of the vocoder from a speech encoder to a sound processor probably deserves some explaining. At least, I hope so, or else this next bit is to be quite wasted.

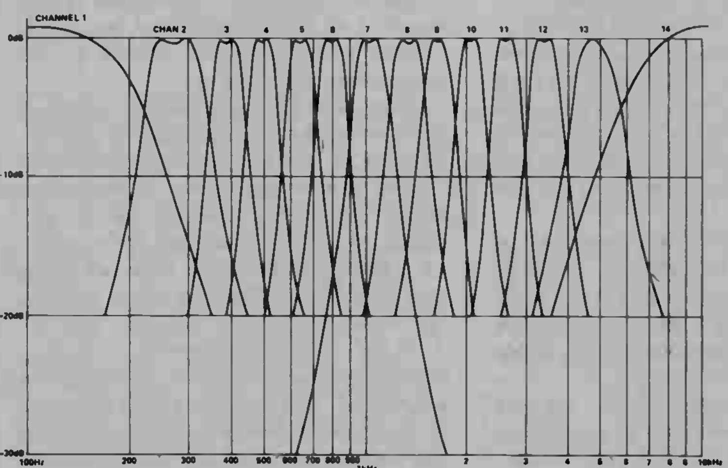
The speech analyser part of the vocoder, of which we have spoken moments ago, can be looked upon as a bank of notch filters, to start with. Suppose we had quite a number of these, each tuned just a tad higher than the one before it. Yes, I know, the signal coming out would be exactly what went into the things, as, collectively, they'd pass the whole spectrum. However, instead of just mixing the output lines all together again, we're going to lay envelope followers on each. Now we'll have a number of frequency independent signals – control voltages – each one representing the instantaneous signal level in a given section of the spectrum of interest. You may think the sound has been processed into unintelligibility here, but wait, it gets stranger.

In order to reconstruct the speech, what we'd do would be to set up a pack of oscillators, whose frequencies corresponded to those of the original notch filter bank, and run them into voltage controlled amplifiers, the control voltages of which would be those derived from the followers following the filters. The result, with the output of all the amplifiers combined, would be speech – sort of.

This brings us to an important tenet of vocoderism – or vocoderization, or whatever. As you can probably see, this principal would work perfectly if there was a filter and corresponding amplifier for absolutely every frequency involved. With one hertz resolution, a nice ten kilohertz bandwidth, 10^3 channels would be needed. Aside from being as big as a house, this sort of system would like about twenty amps of power and produce some 35 dbm of combined random noise. Even Dolby can't fix that.

Thus, any practical vocoder is a trade-off between resolution and complexity, and, as such, is imperfect in its reproduction. By cutting down on the number of channels, usually to something less than fifty, we, in effect, are substituting one frequency for several.

At this point, all we've succeeded in accomplishing with the vocoder is getting out an unfaithful reproduction of what we put in. With vocoders starting at about a grand, one might question the usefulness of this. Therefore, let's push on. Suppose the oscillators in the reproduction section were to be removed. In their place, we'll put a



Typical analysis of filter frequency response for vocoder.

second bank of filters, identical to those in the encoder, into which can be fed a second signal. We have, at this point, turned the beast into a signal processor; and at last rendered it useless to the phone company. Success.

If voice is fed into the input of the analyser, or encoder, and another signal, say an oscillator, were to find its way into the reproducer, the result would be that the oscillator would be given the amplitude characteristics of the speech, while keeping the frequency characteristics of a tone. If the vocoder were to have sufficient resolution, it would be quite possible to make out what the oscillator was talking about, which is actually more than what you can do with most people.

Replace the oscillator with a real instrument, such as a quitar, and some of the potentials of the vocoder will begin to become apparent. The guitar can actually follow the dynamics of accompanying vocals. Alternately, the dynamic characteristics of the instruments can be controlled through a specially assigned mike. With a vocoder having individually assignable filters, such that, for example, the five hundred hertz encoder channel need not, necessarily, be patched into the corresponding five hundred hertz reproducer channel, but, rather, could be sent to control any other channel, the potential for scrambling up the spectrum is truly wonderful. For example, if the relationship of encoder to reproducer spectrum is inverted, such that the lowest channel of one is patched to the highest of the other, and so on, the treble of the guitar would be modulated with the dynamic of the bass range of the voice. This would also be true at the other end of the spectrum. However, having the voice's treble chopping up the bass of the guitar would result in a great deal of harmonic generation, in addition to the two initial signals, resulting in a controllable "richness" in the low end of the spectrum. Obviously, one can fool around with patches like this for weeks.

And If You Had One

Okay, so you gets yerself a raft o' filters, like, an' some amps, handful o' diodes in there, somewheres, stick 'em all in a box, put in a pilot light, and, crazy, you gots yerself a vocoder. What's the expensive part?

The high cost of vocoders belies the fact that our simple "on paper" model is a bit too ideal to work. There are a number of practical considerations that must be taken in before you can actually get sound out of one of these things, and quite a number more if that sound is to be presided over by a really high degree of control.

First of all, the notch filters in the encoder are quite high brow and finicky, and demand the utmost attention if they are not to throw a fit. There are two rather conflicting requirements of this section. The first is that the adjacent filters really be adjacent, that is, that the descending edge of the response curve of one be right up against the ascending edge of the next, such that there aren't gaps in the spectrum. One can see the difficulty, after all, if the note which one is singing happens to be located in a gap, with the result that no control voltage is produced from it. The other hassle, in all this closeness and friendly cameradery, is that the response curves must overlap as little as possible, lest the information from one channel also be found in the next, leading to a blurring of the frequency spectrum at the output.

This all would suggest that nasty, sharp filters are called for; in fact, few applications will be found in which sharper ones are dictated. Most vocoders have a minimum of 48dB per octave response filters, which are quite brutal.

A filter of these proportions needs no small amount of designing. With a usual response of 6dB per octave per stage, the thing will require a good eight stages. This is, then, eight little filters which must all be tuned to the same frequency. They must all be very stable and all must be virtuously decoupled from the supply rails, lest there be the least scrap of feedback, and they go jolly into oscillations. In designing a commercial instrument, this means either three battalions of trimpots, or many precision parts. The first is a drag due to size, the complications of initial setup, and mechanical instability over time, and the second is expensive, plus posing supply problems. Right off the bat, a twenty channel vocoder has one hundred and sixty op amps in its encoder filter section. Even the sockets for these little bugs would cost a fortune.

In fact, it is also usually necessary to add a buffer to each channel, in order to trim out any gain irregularities from channel to channel, and to keep the overall response reasonably flat. More chips.

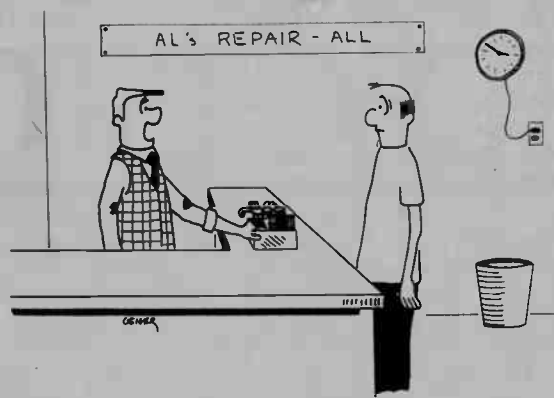
Once the encoder filters are all accounted for — well, we've got to go and repeat them in the reproducer. Same filters, same specs, but a further problem. Since the actual carrier signal, the one which will be heard at the output of the vocoder, must pass through these filters, noise is an important concern. With eight filter chips and a buffer, very low noise op amps must be used. Fortunately, the filters restrict their own internal noise to their own limited bandwidth, so the aggregate noise at the output is, in a broadband sense, of only nine chips, not one hundred and eighty; which would sound like a day at the beach during typhoon season.

The filters in the encoder, as we've said, are followed by envelope followers. This would certainly make sense, I suppose — envelope followers would, by rights, be designed to follow something, and, with the post office the way it is, actual envelopes would certainly be the last thing I'd pick. These followers can be thought of simply as a diode and a capacitor to ground; although, of course, nothing is that simple, and the follower circuit alone usually employs four or five op amps per channel. The time constant of the capacitor is quite critical. If it is too slow for a given application, the intelligibility of the voice will be filtered down to a small ripple. If it's too fast, the whole voice signal will go through, resulting in general hash at the output. As you may have guessed by now, there is no real optimum point, and most vocoders are designed so as to be able to permit shifting the time constant of the follower. Since the capacitor effect is, in fact, taken care of by a low pass filter, this means having the filters all adjustable. Since putting a pot, or rather a ganged pot, on each channel's filter is a bit impractical, even if only from the point of view of the poor sod who has to set each one up to play the vocoder, this entails that the filters all be voltage controlled from a master pot. These are usually 12 to 24 dB Butterworth low pass affairs, and, again, the problems of tuning and component tolerances rise to haunt us.

The last difficult point, (short of figuring out how one is actually going to pay for all this), is in the voltage controlled amplifiers found in the reproducer channels. Usually when one thinks of VCA's, one goes scuttling off to a synthesizer, where they are an established fact of existence, and copies down the circuit. Invariably, this uses a chip called an *operational transconductance amplifier*, or, to its friends, a CA3080. This is an op amp whose gain is reasonably linearly controllable by the current being spewn into its control input. However, it has two serious drawbacks when removed to the more critical milieu of the vocoder, where in it is sitting side by side with nineteen

Continued on page 70.

That's the 'memory refresh' input. Every 2 weeks I have to pour 5 pints of beer into it.

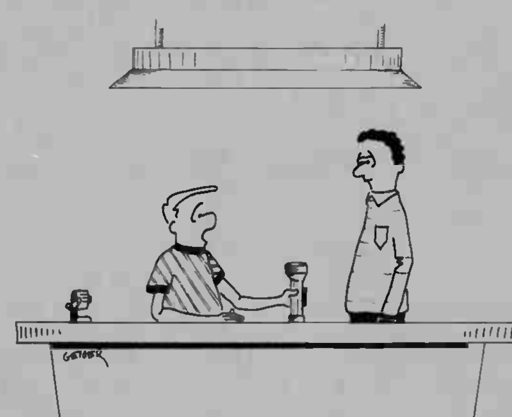


We found the trouble; there was too much grid leak because you forgot to shut off the center tap.

Great news, sir! We've just finished tests that show conclusively that our video pong games don't leave a permanent image on TV screens.

Here comes that current pulse I always get when I switch on my amplifier.

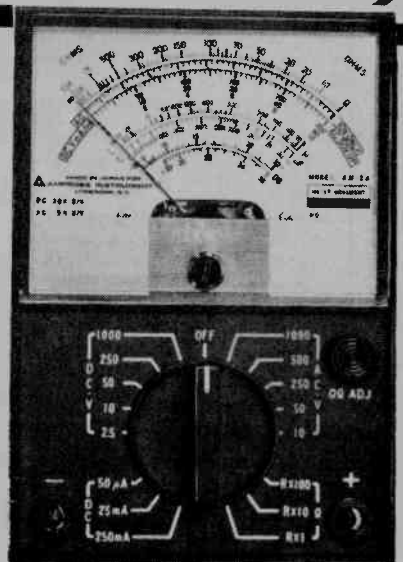
It's our new dessert-maker. Its 'A LA MODE' mode is especially popular with people who like pie and ice cream.



Here's another invention of mine that never really caught on: a solar powered flashlight—it only works in very brightly lit areas.

INTO ELECTRONICS (PART 3)

This month we take a break from hard theory and look at measuring instruments, block diagrams and electronic construction.



A relatively simple multimeter costing approximately $48.00. This model has a sensitivity of 20k/V and is ideal for hobbyist applications.

Measuring Instruments

THE MULTIMETER is the most commonly used measuring instrument for electronics work. It consists of a meter dial with switching arranged so that several ranges of voltage, DC or AC (RMS), DC current and resistance can be measured. The resistance range is used mainly for checking that a circuit is continuous (continuity checking), and for measuring the values of resistors, but the voltage scales are the most widely used scales, particularly DC voltage ranges.

To make a reading of voltage at a point in the circuit, the negative socket of the meter is connected to the negative supply lead, and the positive socket of the meter to the point whose voltage is to be measured. What we are reading in this way is the voltage between the point and supply negative. The meter is then set to a suitable voltage range, greater than the supply voltage, and the circuit switched on. The reading is then taken, making sure that the correct scale on the dial is being used. If the meter reading is too near zero to be read with any accuracy, a lower voltage range can be switched in. Never start with a low voltage range, and never leave the meter switched to a current range. The meter operates by passing some current from the circuit through a coil of fine wire (the moving coil), and too great a current can overheat and damage the coil. Connecting the meter to a high voltage when it is switched to a low voltage range, or connecting to almost any voltage when it is switched to a current range will cause too much current to flow. The safest setting, if no OFF position is provided, is the highest voltage range.

DC voltage readings can be taken quickly, and can be a useful guide to the 'health' of a circuit, since many circuit diagrams show the normal voltages that can be expected at several points in the circuit. The readings can sometimes be misleading, however. The meter takes some current from the circuit, and the current has to pass through the resistance of the circuit, so that extra current flows. By Ohm's law, there must be greater voltage drops across the resistors, so that the voltages are not the same as they were before the meter was connected. This is not a fault of the meter — it reads as accurately as it can the voltage that is present when it is connected, but it cannot read what the voltage *was* when it was not connected.

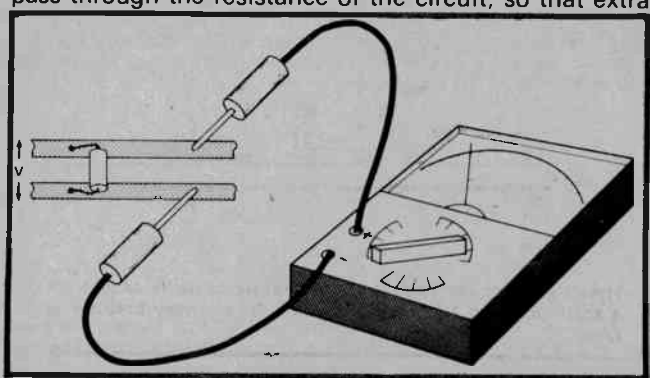


Fig.1 A voltage measurement. The leads of the voltmeter are connected between the points where voltage is to be measured.

The cure for this is to be certain that the resistance of the meter is much higher (ten times at least) than the resistance in the circuit connected across the meter. The resistance of the meter is found by multiplying the range value by the figure of ohms-per-volt for the meter. For example, using a 10 k/V meter on the 10 V range, the meter resistance is 10 × 10 = 100 k, and the voltage readings will be unreliable when we are taking readings in circuits where resistances of 10 k or more are used. One solution to this problem is to take current measurements in circuits that cause difficulty, but this involves breaking the circuit and connecting the multimeter leads, with the multimeter set to a current range, in the gap in the circuit. The most satisfactory solution is to use a multimeter of at least 20 k/V and to avoid readings at awkward parts of the circuit.

The Oscilloscope

The scope is the most useful single electronic measuring instrument, since it can be used to measure voltage (AC or DC), the time of one cycle of a wave, and also to show the shape of a waveform. In its normal use, the oscilloscope negative lead is connected to the supply negative ('earth' or 'ground') of the circuit being tested, and the oscilloscope + or 'signal' lead is connected to the point in the circuit where we want to take measurements. With the scope switched on, a horizontal line of light appears on the screen. The line is caused by a spot of light moving at a steady speed from left to right, retracing rapidly, then repeating the trace. We can

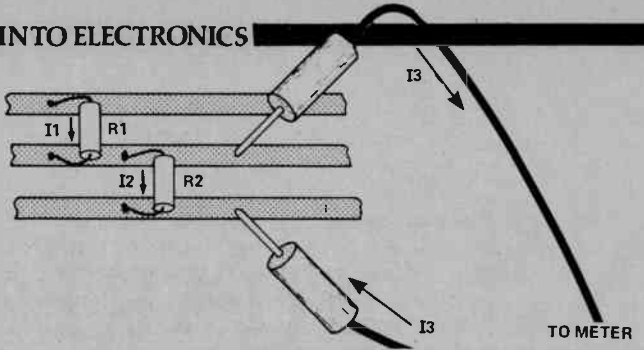


Fig.2. Errors caused by a voltmeter. The current flowing through R1 must split, some going through R2, some through the meter. More current is being drawn through R1 now than when the meter was not present.

adjust the speed at which the spot sweeps across the screen. The speed can be varied from very slow, perhaps 0.1 seconds for 1 cm, to very fast, 1uS or less for 1 cm. This is called 'timebase' control.

A signal voltage applied at the input will cause the spot of light to be deflected vertically, up and down. If we set the timebase switch to OFF, or to its slowest position, we can see the effect of the vertical deflection by itself. The amount of vertical deflection is a measure of the amplitude, in volts peak-to-peak, of the wave. The calibration in volts/cm is shown on the input sensitivity switch. To find the peak-to-peak amplitude of a waveform, we measure the vertical distance in centimetres from peak to peak on the screen, then multiply this reading by the setting in V/cm on the Y-sensitivity switch. For example, if the waveform measures 4 cm vertically, and the setting of the switch is 0V5 V/cm, then the peak-to-peak voltage of the wave is $4 \times 0.5 =$ 2V0.

With a waveform input, starting the timebase will cause the spot of light (the trace) to draw a graph of waveform voltage plotted against time. The shape on the screen is the waveshape, and we can measure its amplitude. The time of one wave can be measured by noting the distance in centimetres, horizontally, from one peak to the next, and then multiplying by the setting of the TIME/CM switch. For example, if the distance horizontally between peaks is 5 cm, and the TIME/CM switch setting is 5uS/cm, the time between peaks is 5 $\times$ 10uS which is 25uS. The frequency of the wave is 1/time, which is $1/25\times10^{-6} = 10^{-6}/25 = 4000$ Hz or 4 kHz.

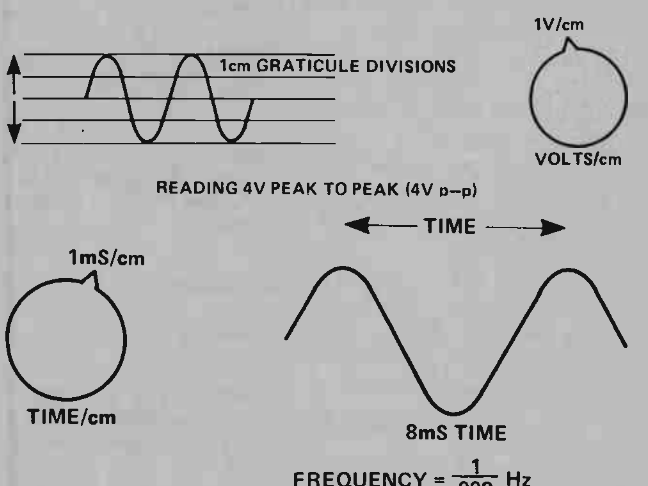


Fig.4. Measuring the voltage and frequency of waveforms using the oscilloscope.

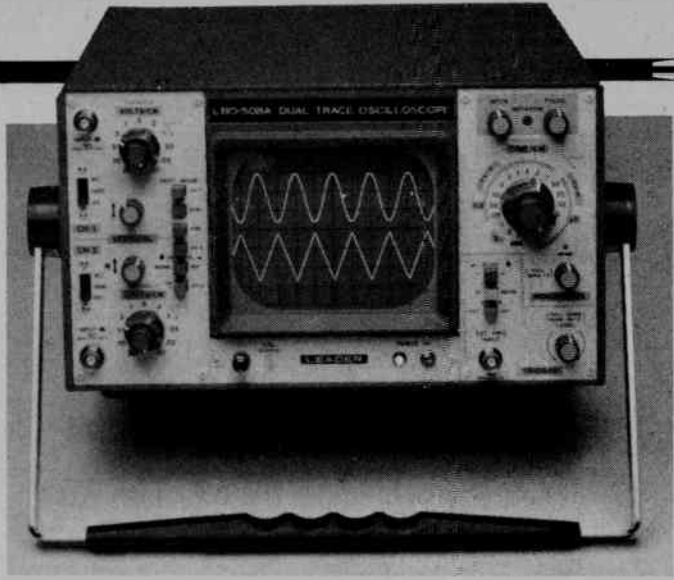


Fig.3. The front panel of an oscilloscope. (Leader).

This is, of course, only a skeleton outline of the use of a scope, so that the reader can understand how we know the shapes of the waves we use in electronics, and how we measure such quantities as wave voltage and frequency.

Block Diagrams

A block diagram of an electronic system shows us what is done to a signal, without any detail of how it is done. A block diagram of a car would show an outline of an engine, a gearbox, a clutch and the final drive, but without any details of what happens inside these components. Block diagrams are useful because they show us what to look for in a detailed circuit.

For example, Fig.5 shows a block diagram of a simple record player. The cartridge is the transducer that converts the squiggles on the disc into electrical waves. These are then amplified, the amount of amplification is controlled, and the amplified signal used to drive another transducer, the loudspeaker.

Taking another example, Fig.6 shows an alarm which sounds when a light beam hits a photocell. The light falling on the cell causes a signal which is amplified and used to switch on an audio generator, which in turn causes a sound from a loudspeaker. The actual circuit for this would take much longer to understand. Block diagrams are particularly useful for very complex electronic systems such as TV, radar or computers.

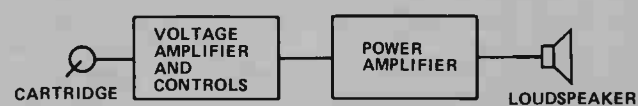


Fig.5. Block diagram of a record player. The cartridge converts vibration of the stylus into an electrical signal, which is amplified and used to drive the loudspeaker.

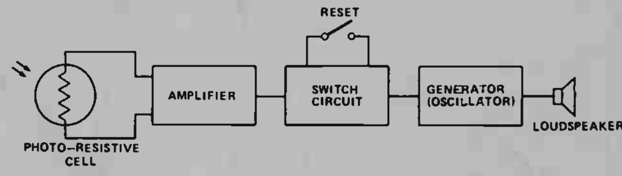


Fig.6. Block diagram of a light-operated alarm. Light falling on the photocell causes a signal which is amplified and operates the electronic switch. This in turn switches on the oscillator, and so sounds an alarm from the loudspeaker. The alarm sounds until reset by a switch.

Circuit Diagrams and Symbols

If we are to be able to build electronics circuits (and that's what we're here for), we need to be able to read and understand circuit diagrams. Why not use photographs and sketches of a finished circuit? Well, it's much more difficult, to start with. Photographs and drawings are useful only if your components look identical to the ones in the photo, and if you want to copy exactly the layout in the photo. If you can read circuit diagrams, you can use any shape of components, and make your circuits as you want them. It's like the difference between-building from a kit and rolling your own.

Circuit diagrams use symbols for each component, and some of the most common symbols are shown in Table 1. Notice the way arrows are used. For components like resistors, capacitors and inductors, arrows are used to mean a variable quantity (a variable resistor or potentiometer, variable capacitors, variable inductors) which can be adjusted. A different symbol is used for preset values that are set to some value and then left alone. An arrowhead used with components such as diodes and transistors shows the normal (+ to —) direction of current flow.

A circuit diagram shows what components are connected together, *not* how they are arranged. A circuit may show a line, representing a connection, joining a battery + pole to one end of a resistor. In the practical layout of the circuit, these components might be near each other or several centimetres apart, but they must be joined by wires or metal strips. The great advantage of a circuit diagram is that it shows the action of each component in a circuit, no matter where it happens to be placed physically. Trying to figure out the action of a circuit by looking at its arrangement on a board is nobody's idea of good clean fun!

In many circuit diagrams the symbol for an earth or ground connection is shown and this sometimes puzzles beginners. It's a hangover from the old days of telegraphs. At first, the electric telegraph used two lines connecting transmitter and receiver. The pioneers then found that they could use one wire line, with the return current flowing through the earth itself, and to do this, the return was taken to a large metal plate buried in the ground. From then on, its been earth in the U.K. and ground in the U.S.A. and ever shall be.

Nowadays, line operated circuits use a ground or connection for safety, so that any line voltage fault will cause a large current through the ground connection (rather than through you) so blowing the fuses.

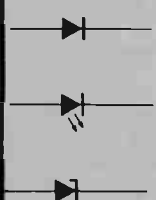
In battery powered equipment, the earth or ground connection may simply be to any metalwork, such as a case. This ensures that the case is at the same voltage as the signal zero voltage line, usually battery negative. The purpose of this is to make sure that the metalwork does not cause interference by radiating signals into or out of the circuit. For many circuits a ground connection is not needed at all, but the ground symbol is sometimes still used on circuit diagrams to show which line of connections is at zero signal voltage.

Practical Circuit Construction

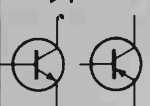
Laying out a circuit from a circuit diagram is one of the most satisfying parts of electronics, and yet is seldom taught. In the old days of tubes, laying out a circuit used to be a metal bashing exercise which had the constructor pretty cheesed off with the circuit before any wires had been soldered, but modern components and circuit boards have made the whole process so much easier.

Start by looking at the circuit and finding the circuit junctions. A circuit junction is where wires from various

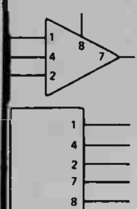
TABLE 1



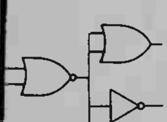
Three types of diode. The first is just a diode, the second is a light emitting diode (which glows when current passes through it). The third is a zener diode, used for creating fixed voltages.



Two types of transistor. The first is NPN, the second PNP.

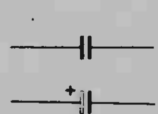


Integrated circuits. The box can be of almost any shape, although the top one is usually used to indicate some form of amplifier. The numbers refer to the pin numbers on the IC package.

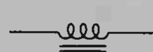


Logic gates. Logic ICs usually contain several of these each, and so they are suffixed IC1a, IC14b, et cetera.

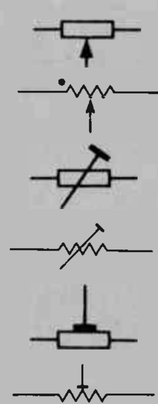
A resistor.



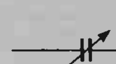
Two types of capacitor. The lower one is of the "electrolytic" or "tantalum" type and can only be used one way round.



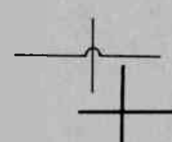
A coil. The lines indicate what it was wound on. Two coils which share the same lines represent a transformer.



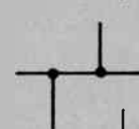
Various forms of variable resistor. The top one is panel mounting, the dot representing the right-hand side when viewed from the front. The other two are pre-set resistors which are used for setting up only. The middle one has its sliding contact connected to one end of the resistive "track."



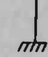
A variable capacitor.



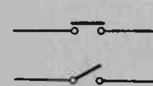
Two wires crossing on a diagram without touching.



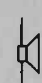
Two wires in contact with a common line.



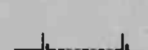
ground symbol. Usually means battery negative terminal or chassis.



Two different types of switch. The upper one is only closed while it is held closed.



A loudspeaker.



A battery. The short terminal is negative (easy to remember: it looks like a "—").

A "jack" socket and a "phono" socket.

components are all joined together. For example, Fig.7 shows a piece of circuit with five junction points. At 1 the battery connects to R1. At junction 2 the input signal (from a socket) connects to C1. At 3, components C1, R1, R2, R3 are all connected together and at 4 the output socket joins to R3 and C2. 5 is the junction at which battery negative connects to C2 and R2. Each of the components in this circuit has two leads, and these two leads must be taken to different junctions. Later we shall be using components with three leads (such as transistors) but the same rules apply, the three different leads on each component must go to three different junctions.

Why should we disfigure our circuit diagrams with these pencilled loops? Well, the reason is that it makes circuit construction simple, electronics by numbers! Practically all circuits nowadays are built on insulating boards which have copper strips laid on them. Each of these copper strips can be used as a junction, with the wire leads of components soldered to the strips. Some types of boards use perforated copper strips, with component lead-out wires fed from the plain side through the holes to the copper side and soldered. Another type of board uses plain undrilled, ready-soldered strips, and the component lead-out wires are soldered directly in place. Whatever type is used one strip represents one circuit junction (the strip can of course be broken to form two or more).

Using our example again we take a circuit board, and make strips with numbers, 1,2,3,4,5. All we need to do now is to connect the leads of each component across the strips shown in the circuit diagram. For example, R1 is connected between strip 1 and strip 3, R2 is connected between strip 3 and strip 5, C2 is connected between strip 4 and strip 5 and so on. One type of board even has the strips already numbered for you! Couldn't be easier! The only thing to watch is that if you use the drilled type of copper strip board, you must have the strips numbered on *each* side. The reason is that a line of holes looks pretty much the same as any other line of holes, and it's easy to mistake one for another if they are unmarked. The undrilled type of board is already numbered and needs no other preparation.

Mastered soldering? Make sure the bit of the iron (electric 25W or less) is clean, then switch on and allow it to warm up. Place the component so that its lead is at the correct part of the track of the board. Hold the iron so that its tip touches both track and component leadout wire. Now touch this hot zone with the end of a piece of resin-cored solder and watch the solder run around the wire and onto the track. When it's smooth and before it stops smoking, take the iron away. Let it all cool before disturbing it. That's all! **Do** clean the wire and the track, keep the iron hot and clean. **Don't** snatch the iron away before the solder has flowed freely or keep it on so long that the board starts to burn.

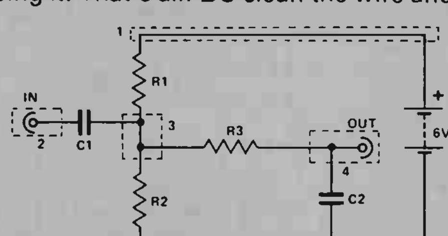


Fig.7. Circuit junctions. Marking out a simple circuit diagram so that it can be easily built on strip-board.

TABLE 2

RESISTIVITY AT 20°C

The resistivity figure for a material is a way of comparing the resistance, R, of samples of standard size. For a wire which is s metres long and A m² cross-section, the resistivity is $\frac{RA}{s}$, units ohm-metres. The resistivity figures for some materials of interest are shown below.

Material	Resistivity in ohm-metres
Aluminum	2.7×10^{-8}
Copper	1.7×10^{-8}
Iron	10.5×10^{-8}
Constantan	45×10^{-8}

(Constantan is an alloy of copper, nickel and managanese used to make wire-wound resistors).

Germanium	about 10^{-1}
Silicon	about 10^{4}
Diamond	10^{13}
Perspex	10^{19}
Quartz (silicon oxide)	10^{20}

Conductors

Once upon a time, folks, life looked simple. We had conductors, which conducted electric current and insulators which didn't. Then we discovered *why* some materials conduct and others don't, and it's not so simple as we once thought. As usual it all boils down to these electrons. The best conductors, metals, have their atoms arranged so that some electrons are loose, about one electron for each atom. These loose electrons can travel through the material, so that the metal is a conductor. We once thought that this was the only way that electricity was conducted through a solid material, but it's not.

Around the turn of the century, a physicist called Hall, who had set up an experiment to test the sign of charge of the current carriers in metals, found that positive charged particles seemed to carry current also. We now know that these positive particles exist only in materials that form crystals and that they are really gaps in the regular arrangement of electrons. These gaps can move and behave like positively charged particles. We call them holes. What convinces us that they are not truly particles is that they cannot be removed from the material as electrons can. Inside a metal, though, the hole is as 'real' as the electron.

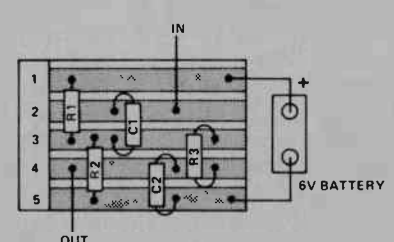


Fig.8. Piece of strip-board with the circuit of Fig.7. assembled.

Semiconductors

Between the good conductors, like metals, and the insulators like so many non-metals, there are some curious materials called semiconductors. The difference between semiconductors and other materials is not so much their resistivity (Table 2) but the way in which the value of resistivity can be altered. Take a piece of metal wire, measure its resistance at room temperature, then heat the wire. What happens? The resistance increases by only a few percent. Try the same measurement with an insulator, and the resistance is too high to measure, both times. Now use a chunk of a pure semiconductor material. Whatever value of resistance it had at room temperature, it's a darn sight less when you heat it, not just a few percent but a really big change. A typical result might be a change from 4k to 200R for a temperature rise of 50°C.

That's a very obvious difference, and the other difference is even more important. Compare two bits of wire, one pure copper, the other copper with about 1% zinc. The resistivity values are pretty much the same,

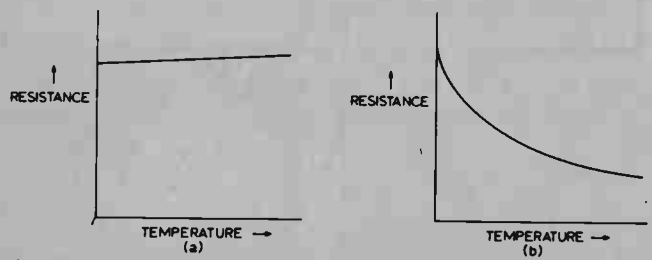


Fig.9. Resistance/temperature graphs (a) for a metal, (b) for a pure semiconductor.

because the impurity (zinc) has as much effect as you would expect from the quantity — 1%. Try mixing two insulators and you still can't measure any resistance charge.

Semiconductors behave quite differently. Almost immeasurably small amounts of impurity will cause the resistance of a sample of a semiconductor to drop enormously. The amounts of impurity needed are not 1%, or 0.1% but something like one millionth of one percent to make a huge change in the resistance. Difference No. 2, and more to come.

Pure semiconductors, like germanium and silicon, are more like insulators than conductors. Adding other elements to the semiconductors will make them into conductors and we can even choose how they conduct. Elements such as phosphorus make semiconductors conduct mainly by **electron** movement. Elements such as indium make semiconductors conduct mainly by **hole** movement. The addition of impurity is called **doping** and is rather a delicate operation, because we don't exactly operate with bucket loads! Nevertheless, we can now make semiconductors which have whatever resistivity values we want (within reason). What's more important we can make them **N-type** (most of the carriers electrons) or **P-type** (most of the carriers holes) by doping with the appropriate materials. Incidentally because these doped materials have a good supply of electrons or holes, heating them makes little more difference to their resistance value than it does for a metal.

Up the Junction:

We wouldn't think much of the show so far but for one discovery — one of the discoveries that's changing life

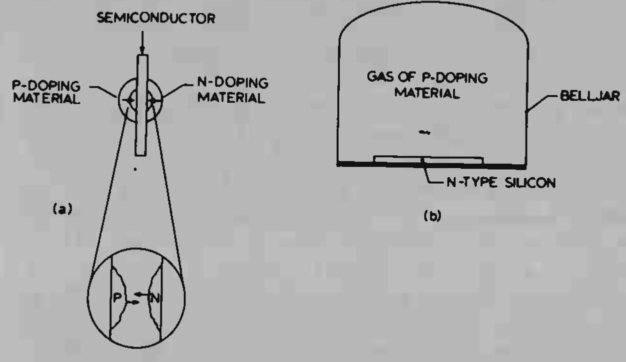


Fig.10. Creating a junction (a) Diffusing solid material into both sides of the thin crystal, the old-fashioned method. (b) Modern method of diffusing the impurity atoms into oppositely doped material from a hot gas atmosphere.

around us right now. Take one tiny crystal of silicon or germanium and slice a wafer from it. Now dope it on one side with indium (making P type) and on the other side with phosphorous (making N type). Heat it up in a vacuum, so that the atoms of the doping materials can spread into the semiconductor and at some stage in the procedure, P and the N bits will meet each other. Logically enough, this meeting place is called a junction. We don't make junctions this way now, but the junction of P and N is the big step forward, because of its behaviour in a circuit.

Try to imagine a junction. Fig 3 is a diagram that helps, showing + and — signs to show which sign of carriers can move. If this junction is made part of a circuit with one wire connected to the P type side of the crystal

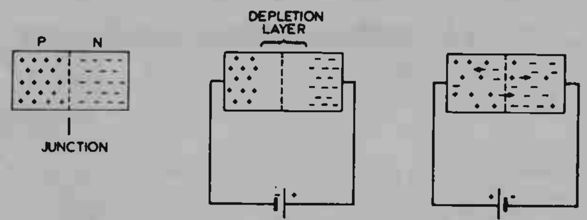


Fig.11. Junction action. (a) Diagram showing the signs of the mobile charges (b) Action under reverse bias, carriers are drawn away from the junction. (c) With forward bias carriers cross the junction, so that the junction conducts.

and another wire connected to the N-type side, the action of the junction will depend on which way round the circuit is connected. With the N-type side connected to battery + and the P-type side to battery —, no current flows. Why not?

Good old-fashioned 18th century electrostatics, that's why. The battery +ve attracts the loose electrons of the N-type material away from the junction, and the battery —ve attracts the loose holes of the P-type material away from the junction. Nothing moves right round the circuit, so no current flows. the junction is depleted — drained of electrons and holes, just a chunk of non-conducting material. This connection is called the **reverse bias connection.**

Diodes

Now, think of the battery connected the other way round. This time it's a very different story. The battery +ve pulls loose electrons across the junction from the N-type side. The battery —ve pulls loose holes across the junction from the P-type side. Everything is moving, it's all happening, current is flowing; the bias now is **forward.** The whole arrangement of P and N materials meeting at a junction is called a **semiconductor diode.**

The P-type part of the diode is called the **anode**, and the N-type is called the **cathode**. The diode is forward biased when the anode is more positive than the cathode. A germanium diode will just start to conduct when the voltage between anode and cathode is about 0.15 V, a silicon diode will just start to conduct when the voltage between anode and cathode is about 0.55 V.

When the bias is in the reverse direction, there are so few electrons and holes (called the minority carriers) left in the junction that the diode is almost an insulator. A reverse current of only a few nanoamps ($1\,nA = 10^{-9}A$) is typical.

We use diodes, as described above, in great quantities; in power supplies, in radio reception, in computing. Details later, folks, but most of the uses for diodes stem from one thing, the current flows one way only. The symbol for a diode shows this direction of current by an arrowhead, using the usual convention of current flowing from battery positive to negative.

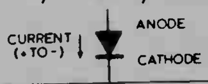
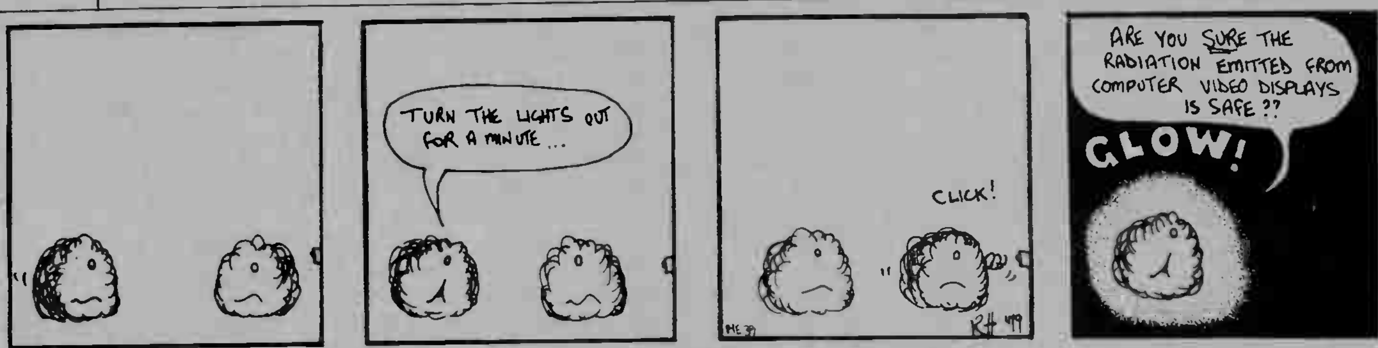


Fig.12. Diode symbol and terminal names.

Zener Diodes

One exception is the **zener diode,** though. This type of diode (different symbol, too) is always used reverse-biased, but conducting. Reason is that a junction that's heavily doped on each side will break down and start to conduct if enough voltage is put across it on the reverse direction. How much voltage? Well, that's what is so useful. Suitable design and doping will give a range of breakdown voltage from around 3 V to around 200 V. What's more, the voltage is pretty well fixed in any given diode. Whether you pass 1mA or 100mA through the zener diode (reverse direction) the voltage across the diode is the amount written on it — the **zener voltage**. We use them for voltage stabilisation — obtaining a voltage which remains steady despite large changes in current or supply voltage. ●



FLOPPY DISKS

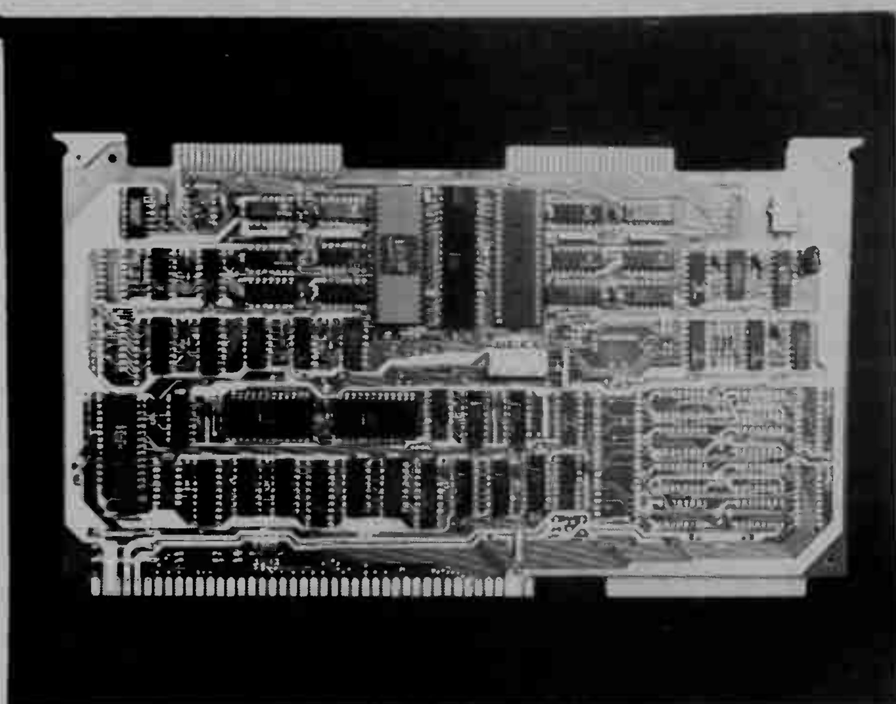
Continued from page 24.

Odds 'n Ends

There are many advanced techniques for storing data on a floppy disk. There are two goals to be achieved, decreasing access time and increasing capacity. The former is achieved by more sophistacated formatting techniques, the latter is solved by more sophisticated recording techniques. Interested readers might want to check out 'The Fitful Journey To Double Density' by David Jenkins, which appeared in the February 1980 issue of *Microcomputing*.

Despite their many advantages, in some ways floppies are no more reliable than cassettes. It's still possible for a drive to mangle a disk. Accumulations of dust within the sleeve can also lead to its early demise. This is why drives are often sold in pairs. Aside from increasing a system's capacity, it makes it possible to copy one disk onto another. In this way important data can be protected.

While the initial cost of a floppy disk system is high, the cost of a diskette is comparable to cassettes (typically $8.) and certainly cost effective when you consider the volume of data it will store. ●



A Typical disk Controller for OEM use. (Intel).

Many manufacturers supply software on disk. (Intel).

To get yours, fill in the order form in this issue or write to ETI Magazine, Unit 6, 25 Overlea Boulevard, Toronto, Ont. M4H 1B1.

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57 Practical Programs & Games In Basic
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Game programs include blackjack, one-arm bandit, craps, and two space war games. Math and accounting programs include compounding, straight line depreciation, statistical permutations, instant derivatives, and solutions for integrals — even a whole section of geometric solutions for modern-day Euclids. For history buffs, there is a Day-of-the-Week program for any date back through 1753.

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A Beginner's Guide To Computers & Microprocessors — with projects
TAB No. 1015 — $9.70

Here's a plain-English introduction to the fascinating world of the microcomputer — its capabilities, parts, functions, and programming . . . and how you can have one in your own home. Numerous projects, using actual computer parts, demonstrate the operation of a computer and lead to the assembly of a working minicomputer capable of performing many useful functions around the home and office.

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If you've always wanted to build your own speaker system, here's a book crammed with everything you need to know to do it right . . . the first time! It contains a variety of ready-to-build speaker system projects, from simple speaker-in-a-box setups to complex multi-driver systems, plus all the information even a beginner needs to design and build his or her own.

This clear guide shows you exactly how a speaker works, how its power and resonance are attained, and how speakers may differ from one another. It's as thorough a book as you'll find on the complete subject of speakers, speaker systems, and enclosures.

Digital Interfacing With An Analog World
TAB No. 1070 — $12.35

Are you looking for ways to really put your microcomputer to work? This book tells you how to go about it — how to convert energy produced by pressure, force, position, temperature, etc. into an electrical voltage or current that your microcomputer can deal with. It's for the user who views the microcomputer as a bit of hardware to be applied, and who views software as either a simple set of instructions to make the machine go or, more importantly, as a valid substitute for hardware. It presents information, in handbook style, for users of microcomputers who want to design a device or system with a microcomputer at its heart.

Very simply, this book is for the microprocessor/computer user who wants to use the machine to measure certain conditions, or to control external devices.

The Complete Handbook Of Robotics
TAB No. 1071 — $10.90

Create your own robot? All the information you need to build a walking, talking friend and companion or a helpful servant appears in this book!

Your robot can take on many forms and operate in any way you choose. Every possible option is covered in minute detail — including light, sound, heat, and proximity sensors, minicomputer "brains" and more.

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Illustrated Dictonary Of Microcomputer Terminology
TAB No. 1088 — $11.85

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For anyone interested in electronics, this handy one-stop guide to modern filter technology will prove invaluable. It introduces filters and their purpose, compares different filters, and covers LC passive filter operation, op amps, Butterworth filters, Chebyshev filters, low-pass filters, high-pass filters, etc. This all-inclusive manual offers coverage of electronic math and basic electronic theory also. Cannot be beat for a complete and practical discussion and examination of filter techniques.

Antenna Data Reference Manual
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The Giant Handbook Of Computer Projects
TAB No. 1169 — $13.75

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An Introduction to Personal & Business Computing
SYBEX C200 — $10.75

This is a basic introductory text on microcomputers. Its main goal is to answer the question "What do I need for . . . ?" in specific detail. No previous technical background is assumed. The author addresses progressively all the essential topics of interest to the microcomputer user (as opposed to the designer). How a system works. Which modules are required for which function. How much memory is needed. Which peripheral should be used. The cost. The software. Differences between existing microcomputers. Is a mini-BASIC sufficient? The real cost of a business system. Its limitations. Can you really manage a mailing list on a floppy disk? Packages and other programs. The traps for the hobbyist. Application techniques. New systems and facilities.

The book is designed to educate the reader in all the aspects of a system, from the selection of the microcomputer to the required peripherals. No computer background is required.

Programming the 6502
SYBEX C202 — $18.75

An educational text designed to teach you programming from the ground up. Already one of the most successful programming books ever published, it has been revised and expanded at both the low end and high end of the spectrum. The range of programming concepts and techniques presented is such that it addresses the needs of virtually every programmer interested in using the 6502 microprocessor, from beginner to expert.

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Truly the "input output" book for the 6502, it includes more than 50 exercises designed for testing yourself at every step.

6502 Games Book
SYBEX G402 — $18.75

This book is designed as an educational text on advanced programming techniques. It presents a comprehensive set of algorithms and programming techniques for common computer games. All the programs are developed for the 6502 at the assembly language level.

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S.I.UNITS

We've had a number of letters recently asking about the use of SI units. We tend to use them more these days so it's as well to find out a little more about them. This article by Ian Sinclair will help you do just that.

WITHIN THE LAST TEN YEARS a major revolution in scientific measuring units has taken place, with hardly a ripple noticeable to the general public. The big change is to the use of a system of units which replaces many of the old measuring systems of the past incorporates new discoveries, deletes old mistakes and generally makes life simpler in all branches of science—including electronics. The new system is called the Systeme Internationale', SI for short. How did it come about?

Think for a moment what measuring anything, from the length of granny's clothes line to the resistance of a length of wire, means. When you measure anything you compare it with a standard, called a unit, and find how many units you have. This way, granny's clothes line gets compared to the standard metre, and the resistance of the length of wire gets compared to the standard ohm, so that you end up with a length in metres and a resistance in ohms. Not much to it, really, is there?

The trouble with measurement, though, is that we didn't start with a set of units for measuring everything. There wasn't much call for measuring voltage or current or resistance before electricity was discovered, so nobody ever thought of measuring units for these things. What has happened is that we've invented measuring units as the need arose, as new items needed to be measured. This business of making up new units as we went along, mainly over the last three hundred years or so, has served us well, but by the turn of this century had left a bit of a mess as far as measurement was concerned.

Why so? Well, it's all because measuring units affect each other, so that when you choose a couple of units, you automatically make others. If a whole set of units is designed at one time, they can be made to fit each other properly—but that didn't happen in the early days. The SI system is just such an attempt to design one complete set of units for measurement.

New Units for Old

Let's go back to basics to see why our measuring systems got into such a mess. A good illustration is the old Imperial units, inch, foot and yard. These are measurements of length—which are always the first measurements any civilisation has to find units for. Reason is, of course, that builders want to be able to make measurements of length. Ancient civilisations ran through a number of units like the cubit which are practially forgotten now because they were never standardised—there never was a metal bar which everybody agreed was one cubit long. The real history of measurement has to start with units which are the same everywhere—and that's surprisingly difficult. The Imperial yard, for example, is the length of an arm span. To be more precise, it's the arm span of Henry VIII from breast bone to one finger tip. He needed the other arm for the wife, so the yard is shorter than it might have been. The foot is, so to speak, a well-trodden unit; and the inch was invented by King David I of Scotland.

In the first attempt at using an **average**, he decreed that the inch should be distance across the thumb, measuring the thumb widths of a small man, a medium man, and a large man. Quite democratic, when you think about it, but not really much more scientific. These measurements are all very well for rough work, but there's no reason why 36 Scotsmen's thumbs should equal half-a-King Henry, is there? Relationships like 12 inches to the foot and 36 inches to the yard only work if the units are fixed so as to **be** that way, and that took a long time.

$$\text{FORCE} = \frac{q1 \times q2}{d2}$$

Fig.1. Colomb's law of 1784. For the first time, this established the relationship between the size of electric charges and the forces of attraction and repulsion between them.

Bakers Dozen

By the middle of the eighteenth century, each country had its own sets of weights and measures, sometimes differing from one end of a country to the other. Phrases like 'a baker's dozen' remind us how imprecise these measures were. A baker's dozen was thirteen loaves, the number he had to supply to be sure that the weight of bread was at least the amount specified for twelve.

All this lack of precision was, of course, a handicap to science, and yet in a curious way, a help. It was a handicap in the sense that the results of work in one part of the world might not apply in another place, because it was so difficult to ensure that the same weights and measures were used. It helped, surprisingly, because news of any discovery prompted dozens of other reservers to try out the same methods. In this way, each discovery was carefully checked, and, more important, relationships were formed which did not depend on what units of measurement were used. Just to take one example (though from the 19th century, rather than the 18th) Ohm's Law will always be V = RI no matter what units we choose for V and I, as long as the units of R are units of $\frac{V}{I}$. Even if all the units are chosen separately, the only effect on the law is to put a constant into it, like V = 1528RI—but it's still recognisably Ohm's Law.

That last point is important. The laws of Physics, which includes electrical and electronic laws, don't change according to what units of measurement we use. Life becomes much simpler, though, if all formulae are direct, with no number constants. In other words, it's easier to remember V = RI than V = 1528RI. When measuring units are just added, one by one, as they are needed, we can never achieve this simplicity. In fact, we could reasonably argue that it's impossible because we would have to know of everything that could be measured—and we have a bit of historical evidence for this view coming up.

PRACTICAL UNIT	EQUIVALENT IN ESU	EQUIVALENT IN EMU
Volt	1/300 ESU	10,000,000 EMU
Ampere	3×10^9 ESU	1/10 EMU
Coulomb	3×10^9 ESU	1/10 EMU
Henry	$\frac{1}{9 \times 10^{11}}$ ESU	10^9 EMU
Farad	9×10^{11} ESU	10^{-9} EMU

RELATIONSHIPS

Current: $\frac{\text{EMU}}{\text{ESU}}$ = speed of light

Inductance: $\frac{\text{ESU}}{\text{EMU}}$ = speed of light

Capitance: $\frac{\text{EMU}}{\text{ESU}}$ = speed of light

Fig.2 Some examples of the three sets of units which were all in use until recently.

French Rulers

The French revolution started in 1789. We tend to remember it now as an example of the general rule that revolutions benefit very few and leave most people worse off, but the periods of dictatorship which followed the execution of the King and Queen did start off something of benefit to the rest of us. Dictators always seem to be obsessed by order—in more recent times both Hitler and Mussolini were fanatical about building new motorways and about railways running to time. The aftermath of the French Revolution was an obsession with standardised weights and measures, culminating in what we know as the metric system.

The metric system was the first attempt to invent a **system** of weights and measures, the units are related to each other, and not just chosen at random. That way, with a bit of luck, your equations contain no awkward numbers. We often speak of the yard, foot measurement as the 'Imperial system' but in fact it's not a system at all, just a random set of units with no attempt to relate one to another.

Let's illustrate this a bit more clearly. The designers of the metric system decided to create units which would be constant, so that they could be re-checked at any time, unlike the arm-span of a dead King. For the standard of length, always the first and most important unit, they decided to use one ten-millionth of the diameter of the earth. Now this was a bit useless, really, because the diameter of the earth had only been measure approximately, and it's not constant—its a bit more round the equator than it is round the poles. At times of revolution, through, people tend to do rather silly things, and no-one working on the committee which made the decision wanted to stick his neck out—literally! As it happened, they were about 27% out, but this has never been important because they had standard metres made in the form of metal bars with scratches to show the distance of one metre. The present standard metre is the distance between two scratch marks on a platinum bar kept in a case at a constant temperature in the French Standards Laboratory, at Sevres.

COULOMB'S LAW IN SI

$$F = \frac{q_1 q_2}{4\pi\epsilon_0 r^2}$$

F—	**Force** in Newtons	
q_1, q_2—	**charge** in coulombs	
ϵ_0—	**permittivity** of free space in farads/metre	
r—	**distance** between q_1, and q_2 in metres	

Fig.3. Colomb's law in SI units. The quantity E_0 is called the permittivity of free space, units Farads per metre. The idea behind this quantity is that even a vacuum allows radio waves to pass, behaving like a transmission line with capacitance and inductance per metre.

Relationships

They may have let their revolutionary enthusiasm overcome common sense (it often does) in that case, but the committee made sound decisions all the rest of the way. They realised, for a start, that there were only a very few units which had to be standardised—the ones we call fundamental units. At that time, the fundamental units were those of length, mass and time. The need for units of electric current, light flux, temperature, and chemical equivalence hadn't hit them yet—that's the danger in trying to set up a system of units before you know of every quantity that can be measured. At the end of the 18th century the notion that light was measurable would have seemed, shall we say, a bit too revolutionary.

With the metre established, they then decided that all larger or smaller units should be powers of ten, such as 10, 100, 0.1, 0.01 and so on. After a few tries at making a decimal scale of time, they decided to retain seconds, minutes and hours, but they were more successful with the third fundamental unit of mass, the gram. Now mass isn't an easy quantity to explain to anyone who hasn't been taught what Physics is about. Mass is a measure of quantity of material, not its size (that's volume) nor its weight (that's the force of gravity on it). Masses are compared on a balance, and any sort of standard can be used. The metric committee hit on the bright idea of taking as their standard of mass a cubic centimetre of pure water at 4°C—a standard which anyone in the world could duplicate.

Having settled the three fundamental units, all other units are derived from them, whatever they happen to be called, by combining the fundamental units in the right ways. The volume of anything, for example, is found by multiplying three lengths together, so that the units of volume are units of length multiplied together three times. That makes the volume units cubic centimetres or cm^3. Similarly, speed is measured in centimetres per second (cms), acceleration in centimetres per (second)^2 or cms^2, force in dynes. Dynes? No, its not a new fundamental unit. From Newton's Laws of 1666, we know that Force = Mass × Acceleration, so that the unit of force was a unit of mass multiplied by a unit of acceleration, grams × cms² — it's too much of a mouthful, so that the word dyne was used.

Political Considerations

This was the first real system of scientific measurement, and it went hand-in-hand with a complete set of weights and measures for everyday use. The scientific measures were called the CGS system (meaning centimetre-gram-second), and they lasted until just a few years ago, when they were superceded at last by SI. What went wrong, and why did it take so long to sort it all out?

The answer is the same old problem—you can't really design a sensible system of units until you know everything you might have to measure. The members of the revolutionary committee thought they had it all licked, but they had, unfortunately, executed a few people who might have been able to tell them more about it all. The situation is pretty familiar, after all, our own parliament often makes decisions which affect the electronics industry, and yet these decisions are made by lawyers, teachers and good 'Party men' with little or no knowledge of electronics. They don't nowadays execute people who know better, just ignore them.

What the revolutionary committee could not have known was that current electricity, static electricity and magnetism were all part of the same thing. Nor, of course, could they have known that light was an electromagnetic wave, and that there was an absolute zero of temperature, colder than any temperature they could imagine. All these things were to come later, along with Joule's discovery that heat was just one other form of what we now call energy. These, however, were the things that with 50 years were to make the CGS system start to look rather foolish. Let's look at the electrical problems, since they affect electronics more than some of the others.

Coulombs Calculations

At the end of the 18th century, electrostatics was fairly well understood, measurements of magnetism well established, and current electricity just a curiosity. Ohm was still a young man and Faraday had not started his remarkable career. As far as the CGS committee was concerned, static electricity, current electricity and magnetism were three separate, unrelated branches of electricity, which could use units derived from the CGS fundamental units.

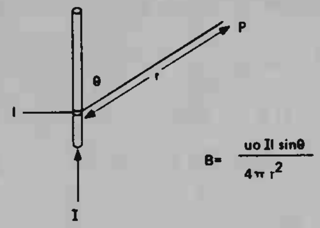
For example, Coulomb had discovered in 1784 that the amount of force between two electrical charges, Q1 and Q2, obeyed the equation of Fig. 1. Now since the CGS system has units for force and for distance, this fixed the units of electrical charge as cm $\times\sqrt{\text{dynes}}$ written as cm.dyn½). Around the same time, measurements on long magnets showed that an almost identical law held for the magnetic 'poles'. Once again, the CGS system appeared able to cope.

Things started to go wrong when current electricity started to be more than a laboratory curiosity. By the early 19th century, researchers began to be quite certain of something they had suspected for a long time: that electrostatics, magnetism and current electricity were part of the same thing. By this time, 'practical' units, the familiar volt and ampere were in use for making measurements on electrical circuits. The discovery of a few more relationships then wrecked the structure of the CGS system.

Charged Subject

One discovery was that which we call electric current is the movement of electric charge, so that the units of current should be units of charge per second. The other vital discovery was that magnetism and electric current are related, so that electric current can be measured in terms of the units used to measure the strength of a magnet.

By now there were three sets of units for electrical measurements. For electrostatics, we used electrostatic units, ESU, and for magnetism the electromagnetic



B IS THE MAGNETIC STRENGTH AT POINT P
uo IS THE PERMEABILITY OF FREE SPACE, HENRIES/METRE
l IS THE LENGTH OF A SHORT PIECE OF WIRE
θ IS THE ANGLE BETWEEN THE WIRE AND A LINE DRAWN TO POINT P
I IS THE CURRENT IN AMPS
r IS THE DISTANCE FROM THE WIRE TO P

Fig.4. The Biot-Savart law of magnetism. This law shows how much magnetic flux density, B is caused by each bit of wire carrying current. The quantity u_0 is called permeability of free space. Once again, if space is thought of as a transmission line, permeability measures the inductance per metre.

units, EMU. For electrical circuits, however, we used the practical units, Ampere and Volt, joined now by Ohms, Henries and Farads. All three sets of units were needed and used, and anyone seriously working in electricity had to learn all three and also the conversions between them. For example, an electrostatic volt was 300 practical volts, and a practical volt was 100 million electromagnetic volts. Just to make things more embarrassing, the ratio between ESU and EMU was always related to the speed of light (Fig. 2).

Things were equally chaotic elsewhere, with one unit of energy (the Calorie) being used for heat, one in mechanics (the ERG) and another in electricity (the Joule). That sort of thing had been forgivable once, when heat, mechanics and electricity were thought of as completely un-related, but the work of Joule (1840 on) had shown that all forms of energy were equivalent, so that only one unit was needed. By the 1880's the need for a system of measurement was becoming rather pressing, but how could it be done?

Rationalisation

The answer was brilliantly provided by Georgi in 1904. He proposed that the whole system could be reversed without making really drastic changes if only two of the original fundamental units were changed, and a few more added. The changes were to the metre and kilogram instead of the centimetre and gram, keeping the second, and adding the ampere as a basic electrical unit. The system became known as the MKS or MKSA system (metre, kilogram, second, ampere), and gradually established itself until it was being almost exclusively used by electrical engineers. This took time, though, and the MKSA system was not being taught to engineers until the 1950's. Nobody really wanted to upset the established system, despite the fact that even college students were having to learn three different sets of

Continued on page 68.

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A collection of the most popular types of circuits and projects which will provide a number of designs to interest the electronics constructor. The projects selected cover a very wide range. The four basic types covered are: Radio Projects, Audio Projects, Household Projects and Test Equipment.

BP50: IC LM3900 Projects **$5.90**

The purpose of this book is to introduce the LM3900, one of the most versatile, freely obtainable and inexpensive devices available to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses.

Simple basic working circuits are used to introduce this IC. The reader should set up each of these for himself. Familiarity with these simple circuits is essential in order to understand many more complicated circuits and advanced uses.

BP51: Electronic Music and Creative Tape Recording **$5.50**

This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

For the constructor, several ideas are given to enable him to build up a small studio including a mixer and various sound effects units. All the circuits shown in full have been built by the author. Most of the projects can be built by the beginner.

BP69: Electronic Games **$7.55**

The author has designed and developed a number of interesting electronic game projects using modern integrated circuits. The book is divided into two sections, one dealing with simple games and the latter dealing with more complex circuits. Ideal for both beginner and enthusiast.

BP70: Transistor Radio Fault-Finding Chart **$2.40**

Author Mr. Chas. Miller has drawn on extensive experience in repairing transistor radios to design this book. The reader should be able to trace most of the common faults quickly using the concise chart.

BP71: Electronic Household Projects **$7.70**

Some of the most useful and popular electronic construction projects are those that can be used in or around the home. These circuits range from such things as 2 Tone Door Buzzer and Intercom through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP72: A Microprocessor Primer **$7.70**

A newcomer tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer that is easy to learn and understand. Such ideas as Relative Addressing, Index Registers, etc. will be developed and will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

BP 73: Remote Control Projects **$8.58**

This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control and many of the designs are suitable for adaptation to the control of other circuits published elsewhere. Full explanations have been given so that the reader can fully understand how the circuits work and see how to modify them. Not only are Radio control systems considered but also Infra-red, Visible light and Ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP74: Electronic Music Projects **$7.70**

Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category, ranging in complexity from a simple guitar effects unit to a sophisticated organ or synthesiser.

The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser Units, Tremelo Generator etc.

BP75: Electronic Test Equipment Construction **$7.30**

This book covers in detail the construction of a wide range of test equipment for both the hobbyist and radio amateurs. Included are projects ranging from a FET Amplified Voltmeter and Resistance Bridge to a Field Strength Meter and Heterodyne Frequency Meter.

Not only can the home constructor enjoy building the equipment but the finished project can also be usefully utilised in the furtherance of his hobby.

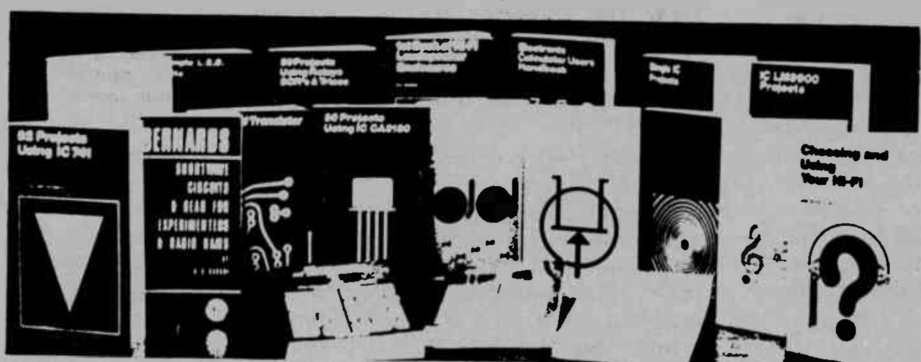
An ideal book for both beginner and advanced enthusiast alike.

BP76: Power Supply Projects **$7.30**

Power supplies are an essential part of any electronic project.

The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised types, the latter being primarily intended for use as bench supplies for the electronic workshop. The designs are all low voltage types for use with semiconductor circuits.

There are other types of power supplies and a number are dealt with in the final chapter, including a cassette supply, Nicad battery charger, voltage step up circuit and a simple inverter.



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BP37: 50 Projects Using Relays, SCR's & Triacs **$5.50**

Relays, silicon controlled rectifiers (SCR's) and bi directional triodes (TRIACs) have a wide range of application in electronics today. These may extend over the whole field of motor control; dimming and heating control, delayed, timing and light sensitive circuits and include warning devices, various novelties, light modulators, priority indicators, excess voltage breakers, etc.

The enthusiast should be able to construct the tried and practical working circuits in this book with a minimum of difficulty. There is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP39: 50 (FET) Field Effect Transistor Projects **$5.50**

The projects described in this book include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home. This book contains something of particular interest for every class of enthusiast – short wave listener, radio amateur, experimenter or audio devotee.

BP42: 50 Simple L.E.D. Circuits **$3.55**

50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most expensive and freely available components – the Light Emitting Diode (L.E.D.). Also includes circuits for the 707 Common Anode Display. A useful book for the library of both beginner and more advanced enthusiast alike.

BP44: IC 555 Projects **$7.55**

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. It is manufactured by almost every semiconductor manufacturer and is inexpensive and very easily obtainable.

Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP46: Radio Circuits Using ICs **$5.90**

This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. Chapters on amplitude modulated (a.m.) receivers and frequency modulation (f.m.) receivers. Discussion on the subjects of stereo decoder circuits, the devices available at present for quadrophonic circuits and the convenience and versatility of voltage regulator devices. An extremely valuable addition to the library of all electronics enthusiasts.

BP62: BOOK 1. The Simple Electronic Circuit & Components **$8.95**
BP63: BOOK 2. Alternating Current Theory **$8.95**
BP64: BOOK 3. Semiconductor Technology **$8.95**

Simply stated the aim of these books is to provide an inexpensive introduction to modern electronics. The reader will start on the right road by thoroughly understanding the fundamental principles involved.

Although written especially for readers with no more than ordinary mathematical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

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BOOK 1: This book contains fundamental theory necessary to a develop a full understanding of the simple electronic circuit and its main components.
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All the projects contained in this book are simple to construct and are based on a single IC. A strip board layout is provided for each project, together with any special constructional points and setting up information, making this book suitable for beginners as well as more advanced constructors.

BP66: Beginners Guide To Microprocessors & Computing **$7.55**

This book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming. The only prior knowledge which has been assumed is very basic arithmetic and an understanding of indicies. A helpful Glossary is included. A most useful book for students of electronics, technicians, engineers and hobbyists.

BP67: Counter Driver & Numeral Display Projects **$7.55**

The author discusses and features many applications and projects using various types of numeral displays, popular counter and driver IC's, etc.

BP68: Choosing & Using Your HI-FI **$7.25**

The reader is provided with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of stereo equipment currently on the market. This should aid him in understanding the technical specifications of the equipment he is interested in buying. Full of helpful advice on how to use your stereo system properly so as to realise its potential to the fullest and also on buying your equipment. A Glossary of terms is included.

NO.213: Electronic Circuits For Model Railways **$4.50**

The reader is given constructional details of how to build a simple model train controller, controller with simulated inertia and a high power controller. A signal system and lighting for model trains is discussed as is the suppression of RF interference from model railways. The construction of an electronic steam whistle and a model train chuffer is also covered.

NO.215: Shortwave Circuits & Gear For Experimenters & Radio Hams **$3.70**

Covers constructional details of a number of projects for the shortwave enthusiast and radio "Ham". Included are: an add in crystal filter, adding an "S" meter in your receiver, crystal locked H.F. Receiver, AM tuner using phase locked loop, converter for 2MHz to 6MHz, 40 to 800MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

NO.221: Tested Transistor Projects **$5.50**

Author Mr. Richard Torrens has used his experience as an electronics development engineer to design, develop, build and test the many useful and interesting circuits in this book. Contains new and innovative circuits as well as some which may bear resemblance to familiar designs.

NO. 223: 50 Projects Using IC CA3130 **$5.50**

In this book, the author has designed and developed a number of interesting and useful projects using the CA3130, one of the more advanced operational amplifiers that is available to the home constructor. Five general categories are covered: Audio Projects, R.F. Projects, Test Equipment, Household Projects and Miscellaneous Projects.

NO.224: 50 CMOS IC Projects **$4.25**

CMOS IC's are suitable for an extraordinary wide range of applications and are now also some of the most inexpensive and easily available types of ICs. The author has designed and developed a number of interesting and useful projects. The four general categories discussed in the book are: Multivibrators, Amplifiers and Oscillators, Trigger Devices and Special Devices.

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Audio Today

Wally Parsons reviews the various proposed AM Stereo systems.

THE FIRST attempts to broadcast stereophonic sound occurred in the 1950's and used the simple expedient of transmitting one channel on AM with the other on FM. Since the modern stereo disc was not available, programme material was limited to prerecorded stereo tapes and live or taped performances.

At that time AM-FM simulcasting was the rule, so once the problems of production were solved, this was fairly easy to do. However, only extensive operations such as the CBC had the material to do much along these lines, and, of course, many AM operators did not have FM licences, so only a handful of broadcasters were able to participate in these experiments.

From the listeners' standpoint these experiments were pretty much a bust. In the first place, separate AM and FM systems were required and even the rare person with stereo facilities needed an extra tuner since it was very rare to find a single unit with independently tuneable AM and FM sections. But of even greater importance, it was not possible to receive the entire programme on AM only or FM only: not a very satisfactory arrangement, even if we ignore the differences in fidelity between channels. But it does illustrate some of the considerations over and above the purely technical which must be satisfied for a stereo system to be acceptable.

First of all, it must do what it is supposed to do, to an acceptable standard.

It would be economic suicide for any broadcaster to adopt a system such that his station could not be received on existing sets.[1] It would be political suicide to legislate the adoption of such a system. Therefore, it must be compatible with existing receivers at least to the extent that a stereo trans mission can be received in mono with no significant loss of quality.

Of equal importance, a receiver equipped to receive a stereo signal must also be able to receive the signal of a mono station with no loss of quality.

It must not cause interference with other stations nor should it be unduly sensitive to interference signals.

Finally, conversion of transmitting facilities should not be unreasonably expensive and the technology should allow the manufacturing of receivers covering a wide price range, including low price portables.

When FM stereo was approved, some performance compromises were accepted, primarily restriction of frequency response and reduced signal/noise ratio, but since AM is rather retricted in these areas already, it would be nice if no compromises had to be made.

The Competing Systems

Of the five systems accepted for evaluation, two of them were actually discrete systems, that is, each channel was transmitted separately and intact, while the other three were matrix systems, in which both channels were combined into L+R and L−R for transmission, then recombined after reception to produce separate left and right channels.

The simplest was the COMM Associates, in which the left and right channels modulated a carrier just below and one just above, respectively, the main carrier. The upper and lower sidebands, respectively, are filtered out, resulting in two single sideband transmission with suppressed carrier.

Reception could be via two receivers, tuned respectively to each of the sidebands, or a single wideband receiver which would separate the two sets of sidebands internally. Advantages claimed were good fidelity and low noise.

Certainly it would be possible to receive such a signal in mono with one standard receiver, but the demands on the IF characteristic are not likely to be met by many AM receivers and tuner sections currently in use. Thus the compatibility requirement is not really fulfilled.

The MOTOROLA system was a little more elegant in that it used two carriers operating at the same frequency but separated by 90 degrees in phase. Although Motorola claimed to have eliminated distortion on mono reception due to interaction between modulation components, maintaining the precise phase relationship would be quite a task for stations which use phased arrays for pattern control.

BELAR Laboratories proposed a system which was essentially a complement of the present FM stereo system. That is, the sum signal *amplitude* modulates the main carrier, while the difference signal *frequency* modulates a sub-carrier which in turn amplitude modulates the main carrier. Trouble with this approach is that with the limited channel bandwidth available it would not be possible to use a subcarrier frequency high enough to avoid beating with the higher audio frequencies.

KAHN COMMUNICATIONS' proposed system virtually combines the Magnavox system (coming up next) with the COMM Associates, by amplitude modulating the carrier with the sum signal, after phase modulating it with the difference signal. Additional circuitry produces a carrier with the left channel on one side-band and the right channel on the other. The signal can be received in a similar manner as in the COMM system, or with a single receiver with phase detection to separate the matrixed signals.

Although field tests yielded excellent results, in the real world one could expect the same disadvantages as with COMM, and a very complicated system as well.

The MAGNAVOX system which was finally approved seems to combine the best features of the other two matrix systems while avoiding the worst objections. Moreover, it is completely compatible with mono reception to such an extent that even the poorest sample in use at present will receive the sum, or mono, signal just as well as it receives present mono transmissions, and indeed, on such a receiver the listener is not likely to be able to distinguish one kind of transmission from another.

In the final system the sum signal amplitude modulates the station's carrier, while the difference signal phase modulates the same carrier. But before any of this occurs, a 5Hz pilot tone frequency modulates the carrier to provide a stereo indicator signal at the receiver.

The AM/PM signal is generated in three steps. First a 3.69MHz oscillator is frequency modulated with the pilot tone. Next, a phase modulator adds the difference audio signal as phase deviation to the output of a tunable (4MHz to 6MHz) frequency synthesizer. The two modulated signals are heterodyned down to the desired broadcast frequency and fed to the transmitter's RF input.

A suitable receiver system uses a single IF system and a standard envelope detector for the Amplitude Modulated signal, that is the sum signal. This particular signal path is identical in a mono or stereo receiver.

The Phase Modulation is recovered by sampling the IF output, limiting it, and detecting it with a phase locked loop. One of the advantages of this approach lies in the ready availability of IC devices to perform this function, which reduces lead time in getting receivers on the market.

The pilot tone is regenerated by recovering the audio tone present between the main VCO and the loop filter, as a by-product of the phase detection process. It is then fed through a second PLL to drive an indicator. It should be noted that this pilot tone is not an integral part of the difference signal transmission and is not required for decoding. Thus, a simple low-cost bare bones stereo receiver could dispense with it with no problems.

The recovered sum and difference signals are then combined in a standard matrix to produce Left and Right channels.

Prospects

Before everyone goes rushing off in all directions attempting to buy AM Stereo tuners and turn out converters, buying up all the Phase Locked Loop IC's in sight, remember that it will take a little time before the system becomes a widespread reality.

First, CRTC approval is required, and although this is likely to be automatic, we must remember that the CRTC is a bureaucracy with all that implies.

Then the station operators will have the job of modifying their transmitters, debugging the system, providing proof of performance, and getting CRTC approval. This is not an expensive conversion, but some stations which use complex antenna phasing arrays for pat-

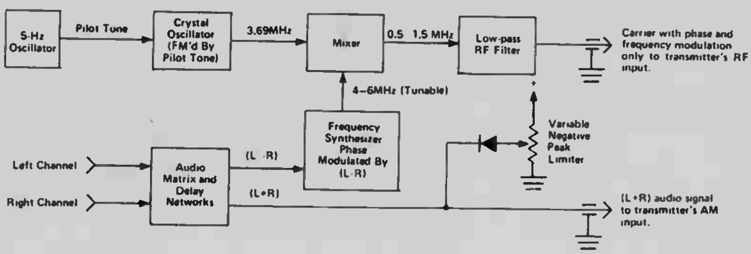

Fig.1. Functional representation of the transmitter encoding section.

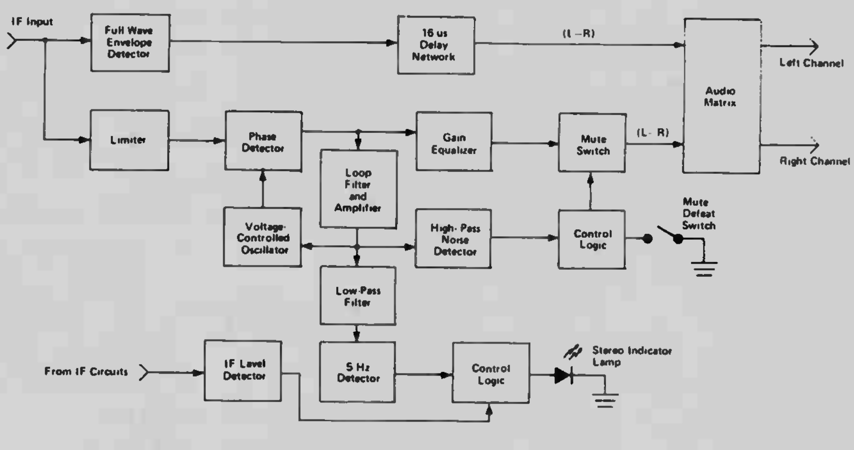

Fig.2. The AM stereo receiver as described in the Magnavox system.

tern control may find it more complicated than others. To compound their difficulties, some stations find it necessary to use rather questionable signal processing practices in order to get maximum penetration. They may find it necessary to revert to more acceptable practices ensuring a good quality signal, and find some other way to make themselves heard over their neighbours on the band.

Those stations in major centres who also have FM outlets, as well as the small town operators who use both media, generally have stereo studio facilities so it won't be difficult to provide stereo programming, but some AM only operations which have already been operating on shoestrings may not be so equipped, so it will cost more and take more time for conversion. But it will come. Stereo will increase the stations' audience delivery, and the size of audience delivered has a direct bearing on advertising rates.

Probably the first stations to convert will be CBC outlets, where all the production facilities are already in stereo, and some of the major stations who already have a large investment in hardware and probably have FM facilities. These are usually Class I or Class II stations operating on fairly clear channels.

Educated estimates seem to be in the order of about two years before the first stereo AM transmissions appear.

Don't expect much in the way of stereo converters, though, such as appeared with FM stereo. Decoding with this system requires a far superior IF bandpass characteristic than is common with most tuners and receivers in current use. On the plus side, though, it will mean better AM tuner sections, and finally manufacturers may start to brag about their AM specifications.

Kudos to Magnavox. I don't know whether the motive was magnanimity or just plain good business sense, but Magnavox has made it known that they will waive royalties on any of their patents used in transmitting stereo via this system, and will limit royalties to a matter of pennies to receiver manufacturers. This is good thinking, since it encourages rapid introduction of the system, which is to Magnovox' advantage. A similar approach was taken by Philips with regard to the Compact Cassette system now in use and we all know how well that worked out.

And in case anyone doesn't know, Magnavox is owned by Philips. •

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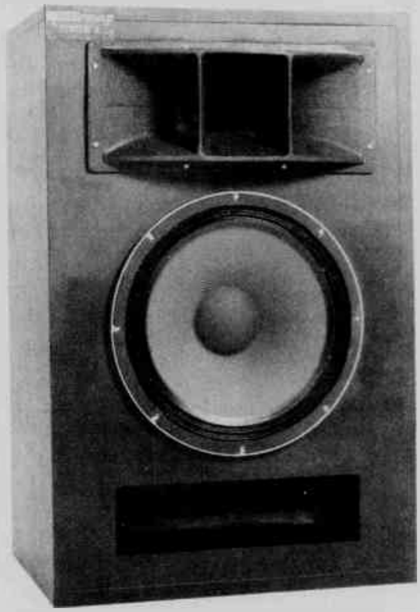

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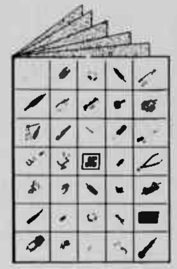

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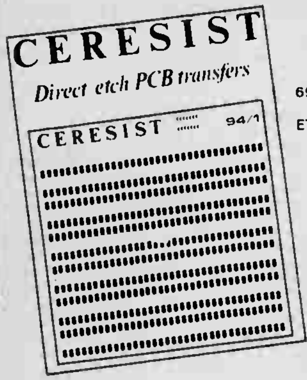

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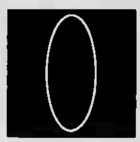
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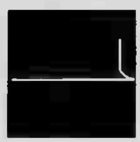
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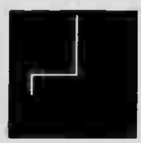
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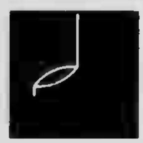
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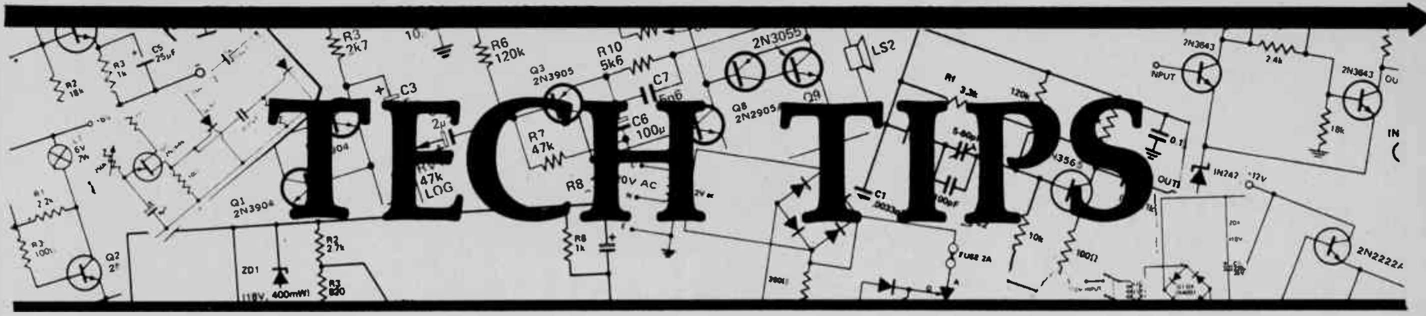
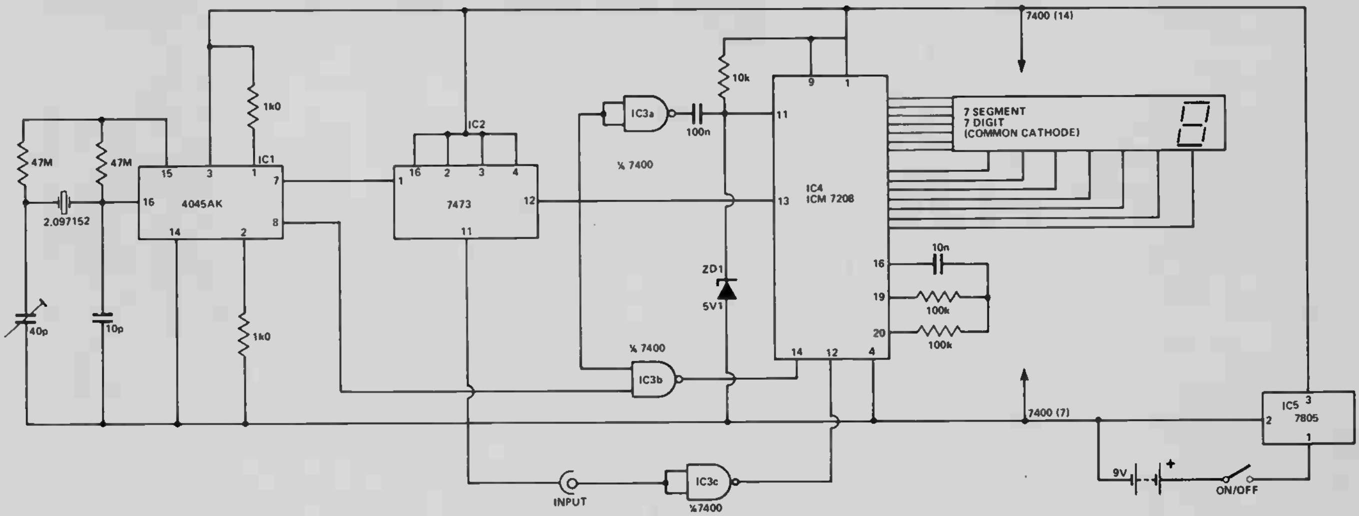
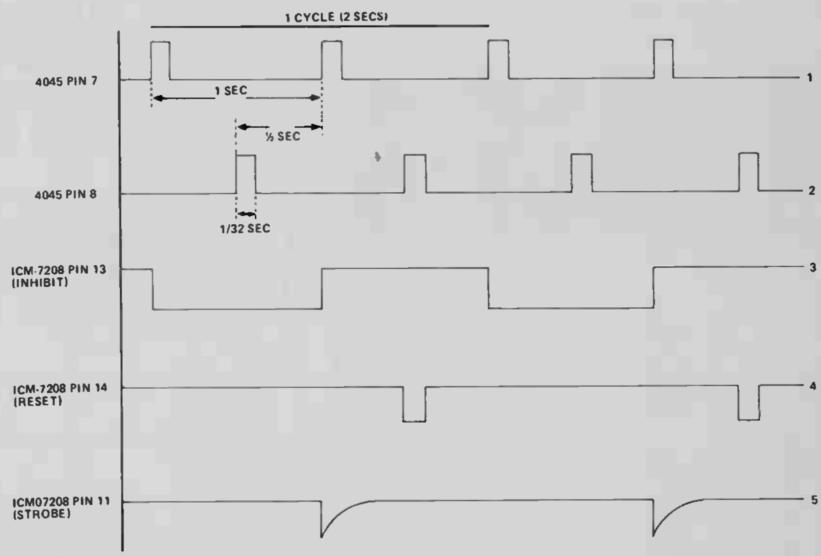


TECH TIPS





A Pocket Digital Frequency Meter
S. J. Barlow

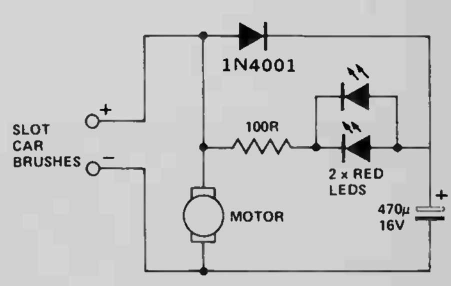
The circuit uses only five ICs and 13 passive components. It is designed to fit into the casing of a pocket calculator and makes use of the calculator's seven segment display.

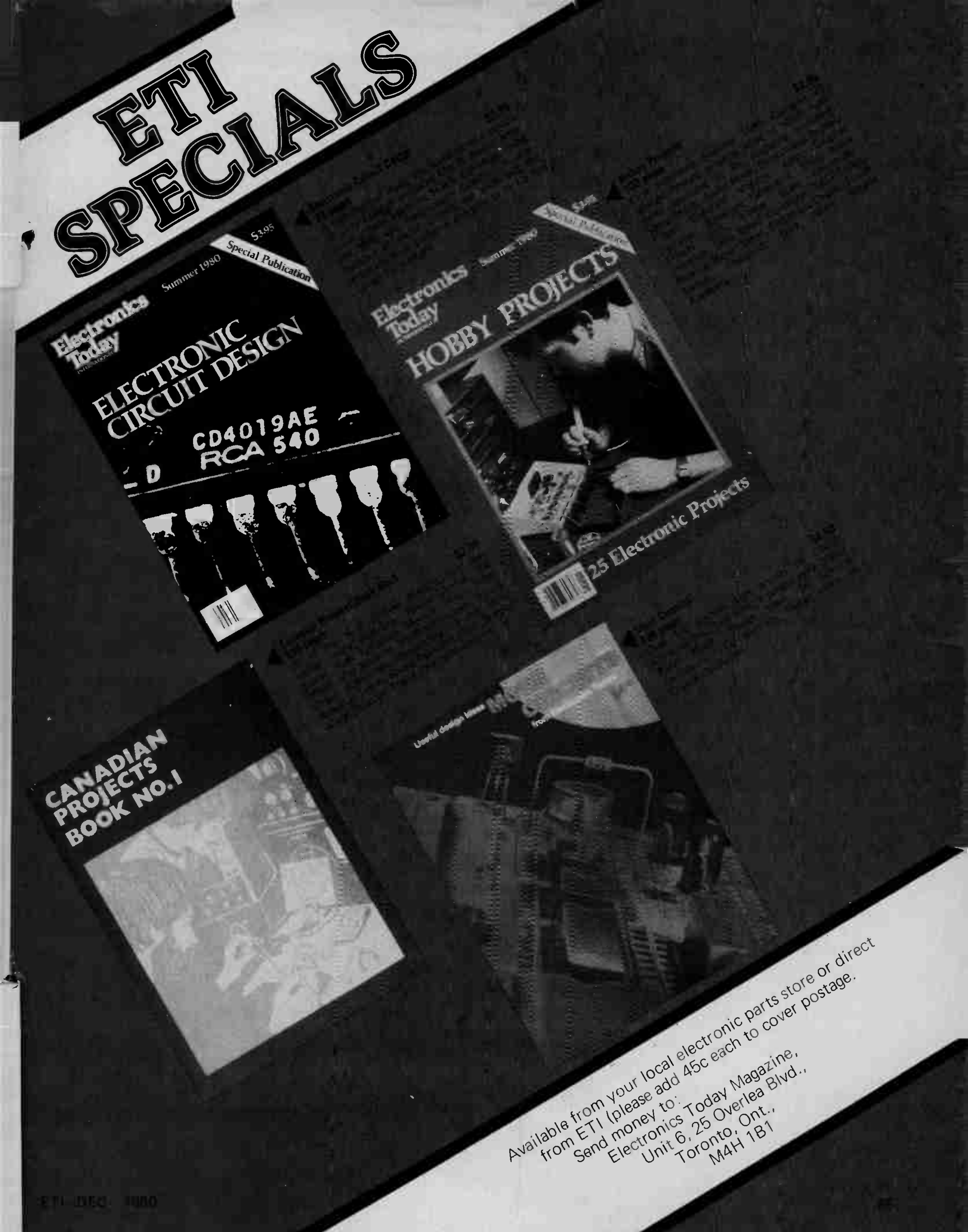
It has a single range measuring up to 10 MHz. The display is updated with a new reading every seconds. The preceding frequency count is held in the display during this period, thus avoiding a flashing display during the sampling interval.

The 7805 provides the 5V supply for the logic. The 4045 and the crystal form an oscillator and 21 stage binary counter producing 1/32 second pulses at 1 sec intervals as shown in waveforms 1 and 2. The 7473 flip-flop produces the one second gating pulse (waveform 3). Waveforms 2 and 3 are NANDed into pin 14 of the ICM 7208s counter chip to produce the RESET signal. Waveform 3 is also inverted before driving a differentiator with a 5V1 zener diode providing a clamp and discharge path. The differentiated waveform (5) gates the new frequency reading into the display.

Slot Car Brake Lights
P. Ruse

Add some realism to your slot cars by building this little circuit into them. When the voltage on the track reduces, the LEDs light up. Neat and simple. Unfortunately, this circuit is not applicable to model railways as trains don't have brake lights.

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Regulator Problems
P. Dennis

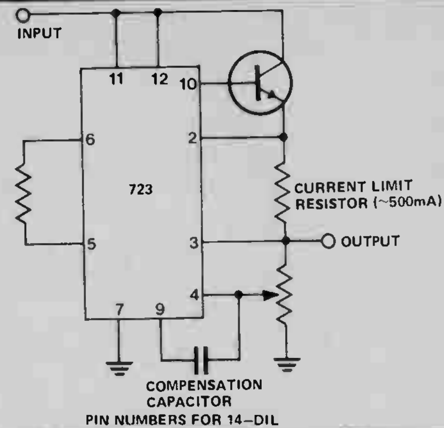
Some comments on the use of the 723 regulator IC.

Firstly, the shown circuit configuration, designed to supply about 500mA, will oscillate at times, even with a 220p compensation capacitor. The solution to this one is to use a transistor with lower gain. As long as the f_t stays the same, then the 3dB corner frequency will go up by the same amount that the beta goes down.

Usually the lower gain presents no problem to the 723, although it does represent a high load.

Secondly, if for any reason the wiper of the output voltage preset pot goes to ground, the IC may be damaged as the amplifier differential voltage (5V max.) may be exceeded. This usually occurs with multi-turn pots where the wiper position cannot be seen. It can easily be avoided by pre-setting the wiper to the output end of the track before switch-on.

Thirdly, when operating the 723 without an output transistor (in which case it can supply up to 150mA), remember that it may heat up, causing the reference voltage to drift.



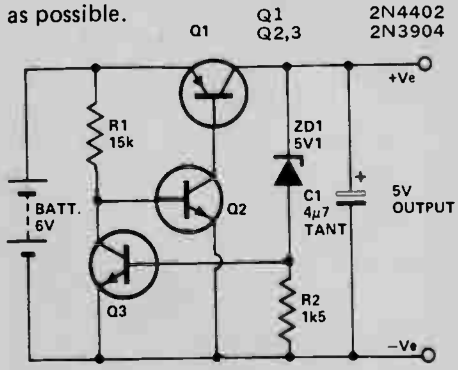
Tech-Tips is an ideas forum and is not aimed at the beginner; we regret that we cannot answer queries on these items. We do not build up these circuits prior to publication.

ETI is happy to consider circuits or ideas submitted by readers; all items used will be paid for. Drawings should be as clear as possible and the text should be preferrably typed. Anything submitted should not be subject to copyright. Items for consideration should be sent to the Editor.

Stabiliser For Battery Supplies
F. Gillespie

The accompanying circuit is useful when voltage sensitive devices (such as TTL ICs) must be battery operated. It uses very little power from a good battery voltage. ZD1 should be selected to obtain approximately the desired output voltage; for fine trimming, R2 may be selected between 470 ohms and 3k3. With the components shown, the output voltage varies less than 2% for battery voltages from 5V to 8V and output currents from zero to 200mA. For higher currents, R1 may need to be decreased.

Always use a power transistor for Q2, or it will overheat when the battery is nearly flat. Both Q1 and Q2 should have a current gain of at least 40, while the gain of Q3 should be as high as possible.



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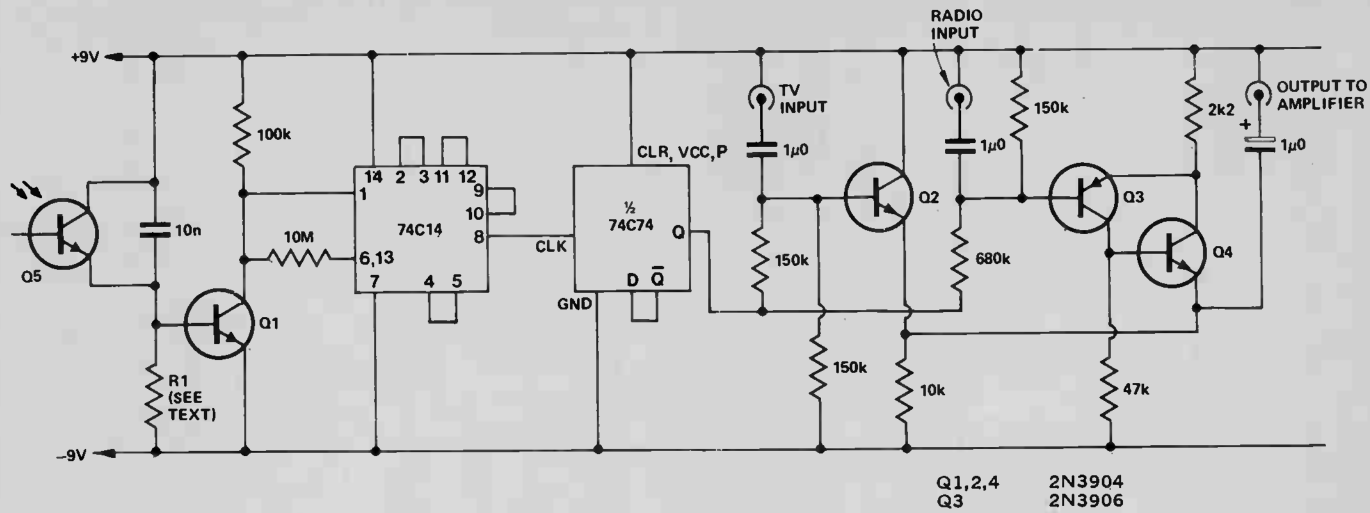

TV Ad Blanker

Graham Taylor

If you dislike having to watch TV ads, then this idea may be to your liking.

Basically, it's a light-controlled AB switch. When the photo-transistor receives a pulse of light —from a flashlight held by the person watching the TV — it toggles the bistable IC2 and changes the state of its Q output.

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The use of this device has another, hidden advantage. Listening to the TV with the radio sound playing instead sometimes produces hilarious combinations.

S.I. UNITS

Continued from page 58.

electrical units. Eventually, the lunacy of it all had some effect and an international committee which had been considering a change of units came down at last in favour of the MKSA system.

That, in essence, is what we have now, re-named SI. The basic units are the metre, kilogram, second and ampere, along with the candela for light, the Kelvin for temperature and the mole for chemical quantity. At long last, there's only one set of quantities for electrical units and for energy (though they weakened a bit on light energy). Most equations are straightforward, with no conversions to remember, at the expense of a few new names to remember, like Newtons of force, Teslas of magnetism and Pascals of pressure. Nothing changes the law of physics, though, and the old business of the speed of light still appears. Coulomb's law of electric charge appears with a new constant Eo. (Fig. 3), and the Biot-Savart law of magnetism with another new constant µ (Fig. 4). The quantity $\frac{1}{\sqrt{E_o \mu_o}}$ is C, the speed of light, reminding us constantly that what we call radio waves are just one form of the family of electromagnetic waves of which light is another equally distinguished member.

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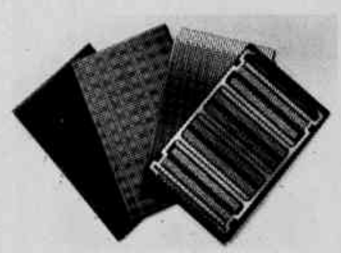

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WHAT'S NEW

Continued from page 47.

others just like itself. The first is that it's noisy, and the second is that a fairly large percentage of 3080's leak to some degree.

The result of all this bad karma is that even with silence prevailing, the vocoder will be putting out quite a bit of signal; hiss and some snippets of carrier that are sneaking through. On inexpensive instruments, a circuit to shut down the output during silent bits partially solves this hassle, but it's a sneaky way out, and has its drawbacks. Usually, the answer is to go to better types of VCAs; but to really get up into the realm where the results are suitable for framing, or, more to the point, pressing on wax, fairly drastic and expensive circuitry must be brought in. One recent approach involved an A/D converter and a digital step attenuator for each channel, which might serve to illustrate the lengths to which one must go.

And in conclusion, once all problems have been surmounted and wrestled into the ground — (boy, is that Freudian) well, we are still not out of the artificial forest yet. It turns out that human voice consists not only of modulated tones, but also of sibilance and percussives, or modulated noise. This is only found in certain sounds, mostly used to swear with ("p" and "f" are two examples), but is essential, none the less, if complete speech vocoderization is desired. Thus, a circuit must also be included to detect these sounds in the voice as it exists upon entering the encoder, and when they are unmasked, fire the correct amount of broadband noise into the input of the reproducer. Considerations of space and sanity prevail upon me to leave this one to the imagination.

This feeling, by the way, is shared by several of the vocoder manufacturers, who leave these things off all but the most expensive instruments.

Snuffing It

And now, the story closes, and I shall be away. To sleep, perchance to dream, or perchance, to hallucinate, for I think there was something in the muffins I had awhile back that Betty Crocker didn't call for in the recipe. Next month, the Martians may land, and declare the planet closed until further notice. If this should happen, I'll be mailing in my column from beside a gently tossing canal. Of course, they may be carnivorous. One never knows with Martians.

We'll soon see. Stay tuned. ●

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Z80A-CPU	4.0 MHz	12.94	Z80A-SIO/0	4.0 MHz	36.21
Z80-PIO	2.5 MHz	8.65	Z80-SIO/1	2.5 MHz	31.14
Z80A-PIO	4.0 MHz	10.01	Z80A-SIO/1	4.0 MHz	36.21
Z80-CTC	2.5 MHz	8.65	Z80-SIO/2	2.5 MHz	31.14
Z80A-CTC	4.0 MHz	10.01	Z80A-SIO/2	4.0 MHz	36.21

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Part No.	Price	Part No.	Price	Part No.	Price	Part No.	Price
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8212	3.58	8253	14.24	6810	4.88	6505 CPU	12.94
8214	5.14	8255	9.04	6821	4.88	6520	9.04
8216	3.84	8257	14.24	6850	5.14	6522	12.94
8224	4.49	8259	16.84	6852	4.88	6532	18.14
8226	3.84					6551	18.14

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MOS Static RAM's

Part No.		Price
2102-25	1K (1K x 1) 250NS 16 PIN	1.76
P2111-35	1K (256 x 4) 350NS 18 PIN	5.14
P2112-35	1K (256 x 4) 350NS 18 PIN	4.49
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40 Khz Single 5V Supply

1K CMOS RAM

5101	1K (256 x 4) 450NS 22 PIN Low Power	6.44

4K CMOS RAM

P6504	4K (4K x 1) 550NS 18 PIN 110MW	12.84
P6514	4K (1K x 4) 450NS 18 PIN 110MW	12.84

SHIFT REGISTERS

3341APC FIFO 1 MHz	7.15

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74S00N	.73	74S37N	2.15	74S134N	1.11	74S168N	7.35	74S241N	7.54	74S373N	5.14
74S02N	.85	74S38N	2.15	74S135N	2.57	74S169N	7.35	74S244N	7.54	74S374N	5.14
74S03N	.85	74S40N	.70	74S138N	1.53	74S174N	1.68	74S251N	2.43	74S412N	3.87
74S04N	1.11	74S51N	.85	74S139N	1.53	74S175N	1.68	74S253N	12.29	74S470N	10.34
74S05N	1.11	74S74N	1.09	74S140N	2.13	74S181N	6.31	74S257N	2.59	74S471N	15.44
74S08N	1.11	74S85N	2.93	74S151N	1.55	74S182N	3.59	74S258N	2.59	74S472N	22.04
74S09N	1.11	74S86N	2.15	74S153N	1.55	74S189N	20.61	74S260N	4.60	74S474N	38.94
74S10N	1.11	74S112N	2.15	74S157N	2.98	74S194N	5.93	74S274N	38.35	74S476N	19.31
74S11N	1.11	74S114N	2.15	74S158N	3.71	74S195N	2.57	74S275N	38.35	74S478N	32.44
74S20N	1.11	74S124N	3.45	74S161N	5.14	74S201N	18.14	74S280N	3.73		
74S30N	.85	74S132N	2.00	74S162N	5.79	74S225N	18.14	74S283N	6.44		
74S32N	1.89	74S133N	2.57	74S163N	5.14	74S240N	9.95	74S299N	10.21		

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LM304CH	1.16	LM339N	.70	LM747CN-14	.77
LM307N-8	.38	LM348N-14	1.28	LM748CN-8	.51
LM308N-8	1.16	LM358N-8	1.03	LM1458N-8	.55
LM308CH	1.24	LM555N-8	.42	LM1488N-14	.90
LM309K	1.68	LM556N-14	.64	LM1489N-14	.90
LM310HC	1.94	LM723CH	1.16	LM3046N-14	1.29
LM311N-8	.77	LM723CN-14	.64	LM3302N-14	.72
LM317T (TO-220)	1.94	LM725CN-8	2.28	LM3403N-14	1.16
		LM733CN-14	2.07	LM3900N	.64
LM318N-8	1.89	LM739CN-14	1.68	LM4136N-14	1.29
LM318CH	2.28	LM741CH	.85	ULN2003AN	1.16

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16 PIN	.20	28 PIN	.42
18 PIN	.27	40 PIN	.61
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TIC126B	1.42	SCR 12 amp 200V TO-220
TIC216B	1.29	Triac 6 amp 200V TO-220
TIC226D	1.24	Triac 8 amp 400V TO-220
TIC236D	1.89	Triac 12 amp 400V TO-220
TIC246D	1.89	Triac 16 amp 400V TO-220

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TL064CN	3.58	Quad low power
TL071CP	.77	Low noise
TL072CP	1.55	Dual low noise
TL074CN	3.06	Quad low noise
TL081CP	.64	J-FET input
TL082CP	1.29	Dual J-FET input
TL084CN	2.54	Quad J-FET input

CMOS

CD4000BE	.36	CD4025BE	.40	CD4066BE	1.18	CD4516BE	1.33
CD4001BE	.36	CD4026BE	2.68	CD4068BE	.40	CD4519BE	.70
CD4002BE	.31	CD4027BE	.66	CD4069BE	.36	CD4520BE	.96
CD4006BE	1.18	CD4028BE	.81	CD4070BE	.56	CD4522BE	1.26
CD4007BE	.59	CD4029BE	1.26	CD4072BE	.31	CD4526BE	1.48
CD4008BE	1.11	CD4030BE	.62	CD4073BE	.43	CD4527BE	2.17
CD4009BE	.73	CD4033BE	2.68	CD4075BE	.38	CD4528BE	1.18
CD4010BE	.73	CD4034BE	3.74	CD4076BE	1.11	CD4531BE	1.18
CD4011BE	.36	CD4035BE	1.33	CD4078BE	.43	CD4532BE	1.47
CD4012BE	.31	CD4040BE	1.18	CD4081BE	.36	CD4539BE	1.18
CD4013BE	.51	CD4041BE	2.33	CD4082BE	.31	CD4543BE	2.57
CD4014BE	.96	CD4042BE	.88	CD4085BE	.81	CD4553BE	4.32
CD4015BE	.88	CD4043BE	1.33	CD4086BE	1.03	CD4555BE	.88
CD4016BE	.51	CD4044BE	1.03	CD4093BE	1.03	CD4556BE	.88
CD4017BE	.96	CD4046BE	1.18	CD4099BE	2.57	CD4581BE	2.59
CD4018BE	.81	CD4047BE	1.18	CD4104BE	2.59	CD4582BE	1.31
CD4019BE	.96	CD4049BE	.59	CD4508BE	2.31	CD4584BE	.72
CD4020BE	1.18	CD4050BE	.57	CD4510BE	1.03	CD4585BE	1.18
CD4021BE	.96	CD4051BE	1.11	CD4511BE	.96	CD4702BE	12.94
CD4022BE	1.78	CD4052BE	1.47	CD4512BE	1.18		
CD4023BE	.36	CD4053BE	1.47	CD4514BE	2.61		
CD4024BE	.72	CD4060BE	2.17	CD4515BE	2.61		

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LED212	T-1 3 mm Yellow	.18
LED220	T-1¾ 5 mm Red	.14
LED222	T-1¾ 5 mm Green	.31
LED224	T-1¾ 5 mm Yellow	.21

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74S188/MB7056	5.14	256 bit, 16 PIN
93427/MB7052	5.14	1K, 16 PIN
93417/MB7057	5.14	1K, 16 PIN
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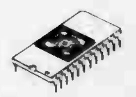

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74LS01N	.27	74LS21N	.33	74LS73N	.49	74LS96N	.88	74LS139N	.90	74LS163N	1.11
74LS02N	.36	74LS26N	.51	74LS74N	.90	74LS107N	.55	74LS145N	1.63	74LS164N	.83
74LS03N	.30	74LS27N	.42	74LS75N	.55	74LS109N	.68	74LS147N	3.19	74LS165N	1.65
74LS04N	.36	74LS30N	.25	74LS76N	.68	74LS112N	.55	74LS148N	1.87	74LS166N	2.43
74LS05N	.36	74LS32N	.51	74LS78N	.47	74LS122N	.70	74LS151N	.59	74LS170N	3.58
74LS08N	.36	74LS37N	.47	74LS83N	1.14	74LS123N	1.03	74LS153N	.55	74LS173N	.96
74LS09N	.47	74LS38N	.47	74LS85N	1.56	74LS124N	1.29	74LS155N	1.13	74LS174N	.57
74LS10N	.33	74LS42N	.59	74LS86N	.68	74LS125N	1.29	74LS156N	1.89	74LS175N	.57
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74LS194N	1.16	74LS249N	1.29	74LS290N	1.09	74LS365N	1.11	74LS447N	.46		
74LS195N	.88	74LS251N	2.93	74LS293N	.49	74LS366N	1.11	74LS490N	2.54		
74LS196N	1.46	74LS253N	.77	74LS298N	1.55	74LS367N	1.11	74LS630N	110.50		
74LS197N	1.29	74LS257N	1.16	74LS299N	3.58	74LS368N	1.11	74LS631N	110.50		
74LS221N	1.14	74LS258N	.88	74LS320N	3.84	74LS373N	1.92	74LS669N	1.16		
74LS240N	1.29	74LS259N	6.05	74LS321N	5.02	74LS374N	1.92	74LS670N	3.45		
74LS241N	1.29	74LS260N	1.29	74LS322N	6.44	74LS375N	3.84				
74LS242N	1.29	74LS266N	.70	74LS323N	6.44	74LS377N	1.87				
74LS243N	1.29	74LS273N	1.81	74LS324N	1.55	74LS378N	1.55				
74LS244N	1.29	74LS275N	6.44	74LS348N	3.19	74LS379N	2.54				
74LS245N	3.58	74LS279N	.88	74LS352N	1.65	74LS390N	2.57				
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