CANADA'S OWN ELECTRONICS MAGAZINE

electronics today

FEBRUARY 1978

incorporating electronic workshop

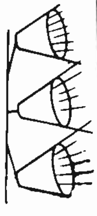
$1.25

PROJECTS

Digital Panel Meter
Freezer Alarm
Tachomonitor
CB Power Supply

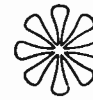
PET
Computer
Review

COLOR ORGAN KIT



PSYCHEDELIC LIGHT CENTER

SEE THE BEAT IN COLOR



3 CHANNEL **$19.95**

5 CHANNEL **29.95**

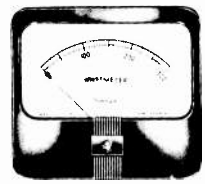
Creates beautiful psychodelic lighting effects from any sound source. Easily connects to your stereo system, musical instrumests amplifier, PA system, etc. divides the sound into three separate channels, low, med. and high frequency. You plug three lights or three sets of lights into the back of the controller (not to exceed 500 watts per channel). Each set of lights can be individually controlled.

Receiving Tubes

SPECIAL OFFER!

.99	1.29		1.49	
2D21	0Z4	6EA8	1R5	6GX7
3AU6	1BC2	6EH7	1S4	6HA5
3BC5	1S2A	6EJ7	1T4	6HB7
3CS6	1S5	6EM5	1U4	6HD7
3CK6	3GK5	6GH8	2AF4	6HQ5
3DT6	4CS6	6GK6	3AF4	6HS8
4BZ6	4DK6	6HZ6	3AT2	6HZ6
4CB6	4EH7	6J4	3BU8	6JC6
4DT6	4EJ7	6JW8	3HA5	6JD6
6AK6	4HM6	6KZ8	3HQ5	6JU8
6AS5	4HS8	6T8	4BU8	6JV8

Panel Meters



4½" scale

A.C. VOLTMETER 0 - 234 v.A.C.

A.C. MILLIAMMETER _ TWO SCALES
LOW 0 - 27.5 ma.
HIGH 0 - 242 ma.

$6.95

5 for $30.00

Special Computer Grade Capacitors

SPRAGUE, MALLORY SANGAMO and G.E.
GUARANTEED FOR ONE FULL YEAR

YOUR CHOICE

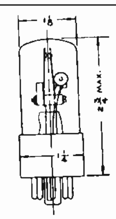
1.95 YOUR CHOICE

Plastic Cased

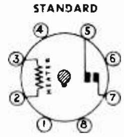
1½" dia. x 4½"	
2,500mfd.	45 v.
5,500	19 v.
7,000	13 v.
7,750	10 v.
8,000	15 v.
10,000	10 v.
11,000	10 v.
3" dia. x 4½"	
74,000mfd.	10 v.

2" dia. x 4½"	
250 mfd.	350 v.
500	200 v.
1,500	100 v.
1,500	150 v.
2,000	50 v.
2,000	100 v.
3,500	75 v.
3,750	75 v.
5,000	55 v.
11,000 mfd	19 v.
14,000	13 v.
15,000	10 v.
15,500	10 v.
19,000	8 v.
25,000	6 v.
36,000	4 v.

Thermal Delay Relays



Standard Octal Base



STANDARD

Bottom View Schematic Diagram

VOLTS	CONTACTS	DELAY
6.3 v.	N.O.	5 sec.
115 v.	N.O.	10 sec.
115 v.	N.O.	15 sec.
115 v.	N.O.	20 sec.
115 v.	N.O.	30 sec.
115 v.	N.O.	60 sec.
115 v.	N.O.	90 sec.

2.95 EACH

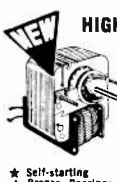
YOUR CHOICE
10 for $20.00

7.5 R.P.M. MOTOR

$6.49

★ Enclosed Gear Train
★ ¼" Diameter Shaft
★ Clockwise Rotation
★ Self-Starting
★ Size: 5½"x2¾"x2¾"
110-120 V. A.C. 60 cps. Shpg. wt. 3 lbs.

NEW HIGH TORQUE SHADED POLE MOTOR

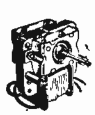


$3.95

★ Self-starting
★ Bronze Bearings
★ Heavy Duty 1⅛" Core
★ ⅜" Dia. Spline Shaft
Size: 2⅞" x 2½" x 2". 110-120 V. AC, 60 Hz. Shpg. wt. 2 lbs.

AC MOTOR

115 v. AC 60 cyc.
1¼" shaft
3/16" dia.
3"x2½"x1½"



$2.95

with MOUNTING BRKTS.

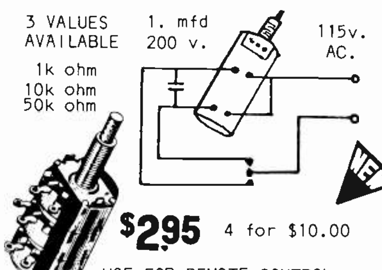
Motorized Controls

115 v. AC REVERSIBLE DIRECTION

3 VALUES AVAILABLE
1k ohm
10k ohm
50k ohm

1. mfd 200 v.

115v. AC.

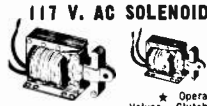


NEW

$2.95 4 for $10.00

USE FOR REMOTE CONTROL

117 V. AC SOLENOIDS



★ Operates Valves., Clutches, Switches, Etc.

LARGE: 2¼" x 1⅞" x 2⅜" Stroke: to 1"
$2.95 ea. 3/$8.00

SMALL: 1⅝" x 1¼" x 2⅛" Stroke: to ¾"
$1.95 ea 3/$5.00

FM Variable Capacitor

Capacitor range 6.6-23 mmfd.

79c

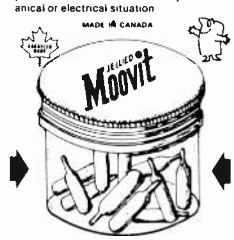
4 for $3.00

"MOOVIT"

THE SUPER LUBRICANT

for tuners — switches — changers removes rust — inhibits corrosion permanent lubrication for every mechanical or electrical situation

MADE IN CANADA



CJM CAPSULED LENLINE JELLIED MOOVIT 20 INDIVIDUAL APPLICATIONS OF MOOVIT IN FIRE ENGINE RED CAPSULES, IN A RE-USABLE ROUND PLASTIC BOTTLE NET PRICE PER PLASTIC JAR ~~$2.99~~

SPECIAL **1.75**

THIS IS PROBABLY THE BEST CLEANER LUBRICANT PRESERVATIVE AVAILABLE, FOR THE ELECTRONIC TECHNICIAN, THE MECHANIC OR THE TINKERER

Miniature Lamps

FLASHLIGHT BULBS

PR-2 2.4v.
PR-3 3.6v.
PR-13 4.75v.

10 for 65¢
100 for $4.50

PRE-FOCUSED BULBS

112 1.2v.
222 2.2v.

10 for 65¢
100 for $4.50

BAYONET BASE BULBS

G590 14 v. .06 A.

12 for $1.00
100 for $7.00

SCREW BASE BULBS

248 2.5 v.

12 for $1.00
100 for $7.00

FUSETRON FUSES,

LIMITED QUANTITY Stock Up NOW...

DUAL-ELEMENT SLOW BLOWING TYPE

¼" x 1¼"
* 1½ amp.
* 10 amp

12c

100 for $10.00

GLOBE ELECTRONICS

CORP. LTD.

DISTRIBUTORS OF ELECTRONIC EQUIPMENT AND PARTS

1925 AVENUE ROAD – TORONTO, ONT. M5M 4A1

783-1801 783-1832

VOL. 2 NO. 2
FEBRUARY 1978

Editor
STEVE BRAIDWOOD BSc

Assistant Editor
GRAHAM WIDEMAN BASc

Accounts Department
SENGA HARRISON

Subscriptions Department
BEBE LALL

Marketing Manager and Advertising
PETER E. PRIEST

Advertising Services
SHARON WILSON

Layout and Assembly
GAIL ARMBRUST

Advertising Representatives
JIM O'BRIEN, ALAN FLANCMAN.

Eastern Canada JEAN SEGUIN & ASSOCIATES INC., 601 Cote Vertu, St. Laurent, Quebec H4L 1X8. Telephone (514) 748-6561.

Editorial Director TOM GRAHAM.

Published by Electronics Today International (Canada) Ltd.

EDITORIAL AND ADVERTISING OFFICES
Unit 6, 25 Overlea Boulevard, Toronto, Ontario, M4H 1B1
Telephone (416) 423-3262

Printed by Livingstone Printing Ltd.

News Stand Distribution Gordon & Gotch, Toronto.

Subscription Rates $12.00 per year, $20.00 for two years. Send to Subscription Dept., ETI Magazine, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

INTERNATIONAL EDITIONS
Electronics Today International
25-27 Oxford St., London W1R 1RF, UK.
Editor Halvor Moorshead.

Electronics Today International,
Ryrie House, 15 Boundary St.,
Rushcutters Bay, Sydney, Australia.
Editor Collyn Rivers.

Electronica Top Internationaal,
Postbus 260, Emmen, Holland.
Editor Denis Loos.

Elrad,
Kommanditgesellschaft, Bissendorfer Strasse 8, 3000 Hannover 61, Germany.
Editor Udo Wittig.

electronics today international

CANADA'S OWN ELECTRONICS MAGAZINE

PROJECTS

FEATURES

NEWS & INFORMATION

Cover: **Computer graphics, cover photo, and PET review by Graham Wideman.** **Turn to page 10 for full story.**

Second Class Mail registration number 3955. Return postage guaranteed. Post Office returns to Unit 6, 25 Overlea Boulevard, Toronto, Ontario, M4H 1B1.

NEWS DIGEST

Interfacing Calculator

A new computing data acquisition device that combines an HP programmable calculator with interfacing technology has been introduced by Hewlett-Packard

The HP 97S I/O calculator, based on the HP97 programmable printing calculator, uses BCD interfacing to gather data from a wide range of instruments. The HPS then manipulates the data according to user-designed programs and produces a printed hard-copy report. With the HP97S, the user can take an instrument measurement and compare it to a standard or calibrate in data, do computation on each individual reading, or take multiple measurements and conduct computation and statistical analysis.

The list of products that can be used with the HP97S, includes electronic balances, photometers, densitometers, thermal conductivity measurement devices, strain gauge systems, colorimeters, devices that measure ion activity, titrators and pH meters, coordinate measuring equipment and physical parameter measuring equipment.

The logic is TTL compatible and may be configured with either positive or negative trueness. The ten BCD input lines allow entry of numeric data, sign information, the exponent, and the decimal point. Four output lines aid in the instrument control. These output lines may be set and cleared under software control. (For example, when connected to a peripheral device they might open or close a relay, provide pulses for a stepper motor, signal that an event has taken place or perhaps change ranges on a measurement instrument.)

The basic system costs $1744 in Canada (duty and taxes extra). OEM discounts are available. Delivery is 12 weeks.

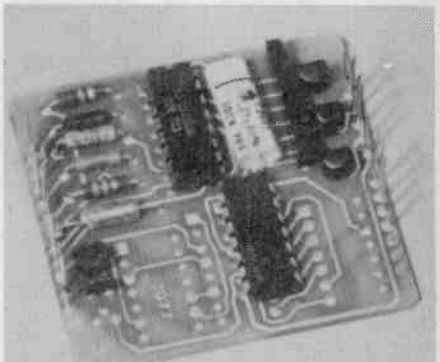
DPM Module

A 2" x 2" x 0.4" module that offers all of the electronics necessary to construct a 3-digit digital panel meter with the designer's choice of external displays is now available from the Instruments and Systems Group of Analog Devices.

Requiring only a +5 V supply, the units accept input voltage between -99 mV and +999 mV with automatic polarity indication. Two different output versions are available. The multiplexed seven-segment version can drive a 3-digit LED display directly; the only additional part necessary is a gain pot. The BCD output version allows the user to add decoder/driver circuits as required to drive a variety of displays such as LED, LCD, and gas-discharge. Microprocessor interfacing is also simplified with the BCD output; application details are provided in the data sheet.

US prices for the AD2023 with 7-segment output is $28 in 100s, $39 1-9; the AD2023B for BCD output is $27 in 100s, $37 1-9.

The Canadian agents are Tracan Electronics, Downsview, Ontario.



Pocket Digital Thermometer

A new Pocket Size Digital Thermometer has been introduced by PID Instruments. The Temp-Master 10C will read temperatures from -55 to +999°C and the 10F will read within the same range in °F.

Input is from an ISA type K (chromel-alumel) thermocouple sensor. This instrument comes with a metal lined leather case for $275.00 (which includes a ⅛" stainless steel immersion type thermocouple).

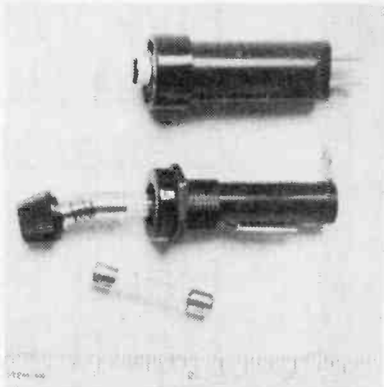
For more information contact PID Instruments division of R H Nicols Co Ltd, 214 Dolomite Drive, Downsview, Ontario M3J 2P8.

Motorola's LM148

Motorola is now a source for the LM148/248/348 series of quad operational amplifiers. The four independent op-amps feature 741-like true differential inputs, internal compensation, and low supply current (0.6 mA per amplifier). Available from stock, the 100-up pricing is LM348J (0 to +70°C, ceramic) $1.15 each, and LM348N (0 to +70°C, plastic) $.87 each.

Circuit Protector for $1.00 Plus a Blown Fuse

Heinemann Electric Co., Trenton, New Jersey, has announced a program whereby it will send a sample of its new 'Re-Cirk-It' circuit protector for a dollar and a blown fuse.



The Re-Cirk-It protects like a fuse but is resettable. It installs in the same panel space as a conventional ⅝" diameter fuseholder, and it trips instantaneously on short circuits and with delay on sustained overloads. It can only be electrically tripped, and it can't be turned off or held against a fault.

The use of a circuit protector helps equipment manufacturers and users by eliminating nuisance service calls due to blown fuses. For the equipment user, it ends the bother of finding a fresh fuse and the danger that the wrong size replacement will be used.

The protector is available in a wide range of current ratings from 0.25 through 10 A. It is UL-recognized and CSA-approved as a component protector.

To participate in the special offer (which runs through December 1978) a blown fuse and $1.00 should be sent to Heinemann Special Re-Cirk-It Offer, PO BOX CN01908, Trenton, N.J. 08603. For further information about the Re-Cirk-It protector, request Bulletin KD-4001 from Heinemann Electric Co, Magnetic Drive, Trenton, NJ 08650.

Delta Design Appoints National Electrolab

Delta Design, Inc of San Diego, California, has appointed National Electrolab Ltd as their exclusive representative for Western Canada. National Electrolab also provides complete repair and calibration services.

Delta Design Inc is a manufacturer of environmental temperature chambers, semiconductor handling equipment, and burn-in systems. National Electrolab are at 1536 Columbia St, North Vancouver, BC, V7J 1A4 (phone (604) 985-0511).

IC Temperature Sensor

An integrated circuit temperature sensor capable of 1°C absolute accuracy over a -55 to +150°C range has been introduced by Analog Devices Semiconductor. The company claims that the device represents the first application of thin film resistor technology and laser trimming to an IC temperature sensor.

The AD590 is a two-terminal device that produces an output current proportional to absolute temperature when driven by a DC supply voltage between 4 and 30 V. The device is laser trimmed at the wafer stage to produce an output of 298.2 uA at 25°C; the output changes 1 uA/°C from that point.

Power requirements for the new devices measure only 1.5 mW with a 5 volt supply at 25°C, which means that sensor self-heating effects are kept to an absolute minimum. This low power consumption, combined with the device's high level output and small two-terminal package, make the AD590 ideal for remote probe applications and as a replacement for thermocouple probes.

Three models of the AD590 are available. The high-precision "L" version is guaranteed to a calibration accuracy of +1°C linearity over the range of -55 to +150°C; the "K" version offers 2°C calibration accuracy with +1°C linearity; and the "J" version offers 5°C calibration accuracy and a +2°C linearity.

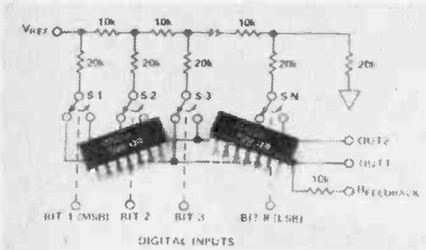
Initial versions of the device will be offered in a TO52 metal can or in chip form; miniature ceramic packages will be offered at a later date. US pricing of the three versions of the AD590 in the TO52 can is $1.95 in 100-piece orders for the "J" version; $3.95 for the "K"; and $7.95 for the high precision "L". All are available to MIL-STD-883A Class B.

Canadian Agents are Tracan Electronics Corporation, 558 Champagne Drive, Downsview, Ontario M3J 2T9, (Tel: 416-638-0052).

8-Bit Monolithic CMOS DAC

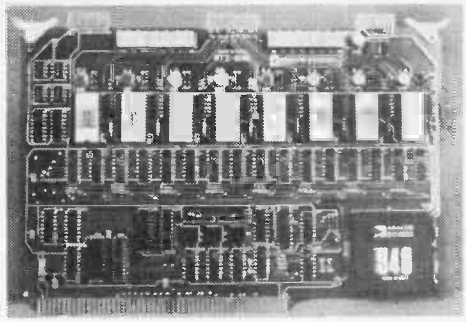
8-bit multiplying CMOS digital/analog converter has been introduced by Analog Devices BV. This is also the company's first device to be designed at its recently established integrated circuit operation in Limerick, Ireland.

The new AD7523 uses thin-film-on-CMOS technology to provide 8-bit resolution, 10-bit accuracy and very low power dissipation.



The ICs are housed in a 16-pin plastic DIP and are priced at $2.00, $5.00 and $7.50 for the AD7523JN, KN, and LN (with linearities of +½LSB, +¼ LSB and +½ LSB).

The Canadian agents are Tracan Electronics, Downsview, Ontario.



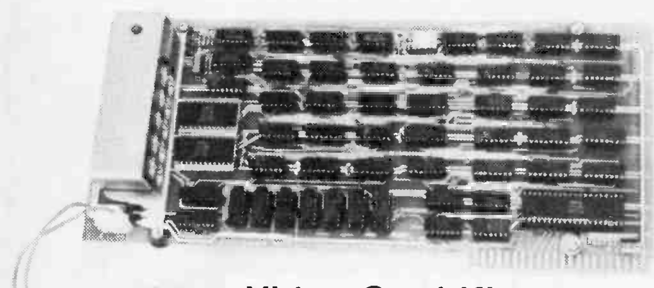
TM-990/100M- Compatible Analog I/O Boards

The first family of analog input/output subsystems compatible with Texas Instrument's TM-990/100M 16-bit microcomputer has been introduced by the Instruments and Systems Group of Analog Devices.

The family of six devices is functionally, electrically, and mechanically compatible with the TM-990/100M and allows users of the TI series to interface that device to analog

Each of the subsystems can be addressed as a memory-mapped I/O interface device, offers convenient address and feature selection with wire-wrap jumpers and is available with an optional dc-dc converter which allows the board to operate off the +5 V logic supply.

The RTI-1242 and RTI-1243 will be available in the USA at $395 and $675. The RTI-1240 and RTI-1241 models will be priced from $445. Canadian agents are Tracan Electronics, Downsview, Ontario.



Video Card Kit

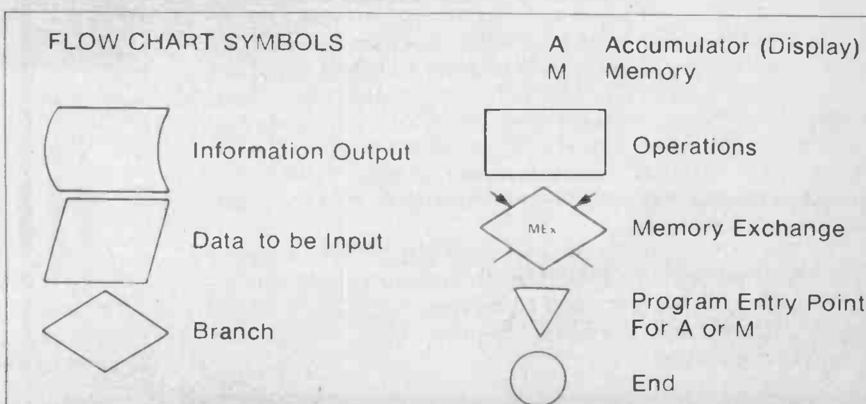
Cybernex inform us of their new TH6416 video terminal card kit. This 5" by 12" logic card generates 16 lines of 64 characters from a parallel input from a keyboard or microcomputer; or from serial data, via its on-card UART. Eight baud rates from 110 to 9600 are selectable at the edge connector.

The TH6416 displays 64 character USASCII and with the lower case option it displays 128 character USASCII and has transparency mode. The 75 ohm video output is formatted for a normal TV set or overscanned monitor. Composite and non-composite video with H and V drive are available on the board. The optional on-card power supply powers the TH6416 and has 200 mA in reserve to supply to a keyboard requiring 5 volts.

The TH6416 sells in Canada for $184.00 plus $15.00 for the lower case option and $16.00 for the power supply option. For more information contact Cybernex, 3221 Council Ring Road, Mississauga, Ontario, Canada L5L 1L5. Dealer inquiries are invited.

SOFT SPOT

Another new feature hits the ETI planning sheet! Softspot is ETI's software department, where we will publish readers' programs. Our limits are pretty wide: any programs using some form of conditional branching that can be entered in any common programmable calculator. And so that readers with other calculators can adapt the program for their machines we ask you to draw a flow-chart of your program. And any additional explanation about executing the program would be helpful. So if you have devised a game or other interesting program that's not been published elsewhere please send it to ETI Softspot, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.



IC Test System

A new combination of a micro-programmed integrated circuit device tester, desktop computer and printer has been announced by Hewlett-Packard. It gives the user the ability to write or modify IC test programs for his special needs in addition to performing a wide range of functional and parametric tests.

With this new HP 5046A system, the user is able to write one-of-a-kind programs, change test parameters quickly, create special component evaluation programs or modify existing test programs. In-house programming capability not only saves time but allows the user to keep proprietary information confidential.

The system includes an HP 5045A digital IC tester, an HP 9825A desktop computer, and an HP 9866B printer and appropriate software. Full hardware and software manuals are provided which include startup and operating procedures and self-instruction on the system software.

Programs can be written for, and tests performed on, logic families such as ECL. TTL (including low power TTL and other subfamilies), CMOS, RTL, HTL and DTL. A built-in thermal printer provides a permanent record of IC failure information.

Tests can be run manually on the 5045A IC tester alone. However, the tester is also designed for high-volume testing using automatic IC handlers. Over 800 standard (catalog) test programs are already available.

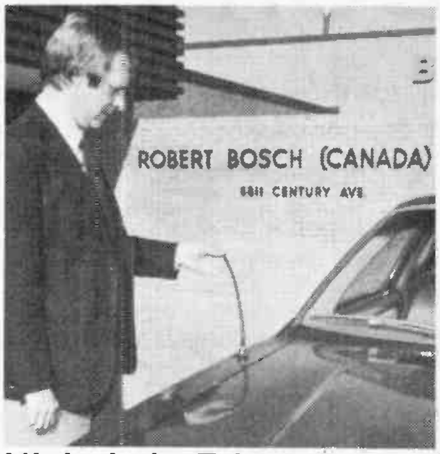
The Canadian price of the Hewlett-Packard Model 5046A Digital IC Test System is $30,200. Delivery is ten weeks. (duty & taxes extra where applicable.)

Bendy FM Antenna

A new Bosch car antenna, designed to improve fringe FM reception, is being introduced to the Canadian market by the Blaupunkt car radio division of Robert Bosch (Canada) Limited.

Approximately 40 cm (or 16 inches) long, the new antenna has a high degree of flexibility — as demonstrated in the photo — making it particularly safe in automatic car washes.

The antenna features low loss leads and separate preamplifiers for AM and FM. It must be installed with a dashboard switch (not included), so that the preamp section can be switched off to reduce overloading and cross modulation in strong signal areas.



Nichols in Edmonton

R H Nichols has opened a new sales office and service centre at 100-11 80th Avenue, Edmonton, Alberta. P6E 1T4 (phone 403-432-7746).

CORRECTIONS AND NOTES

Equaliser — Oct. 77 Issue: The circuit diagram as published does not agree with the pcb overlay. In most respects this is simply a case of different sections of the quad op-amps being used, which of course are interchangeable. However, some pins were incorrectly numbered. Below we give the changes to make the circuit diagram match the pcb which is correct. On IC 2, change pin 1 to 5, 2 to 6, 4 to 3, 3 to 4, and 5 to 2 and 6 to 1. On IC 3change pin 1 to 2, and 2 to 1.

50D50 Amplifier Dec. 77 Issue The text refers to a 65V power transformer, while the Parts List and circuit diagram correctly show a 50V one. Seems like an extra factor of root 2 slipped into the calculations!!

Digital Thermometer Nov. 77 Issue: In addition to those notes given last month, some readers have informed us of problems with Radio Shack 3911 sensors. It appears that the packaging is incorrectly printed, showing the pinouts for the metal can version rather than the Mini-DIP one. Our pin numbers are correct.

Inside The Commodore PET

We don't feel that "Personal Electronic Transactor" completely describes it, but we liked what we found in this machine. Review by Graham Wideman and Mark Czerwinski

LOOK WHAT HAPPENS when an aggressive, popular-market calculator company joins forces with a low profile, high technology microprocessor manufacturer! Commodore and their mpu wing, MOS Technology have come up with a product which while technologically unsurprising is revolutionary from a packaging and marketing point of view. Never before has a company tried to convince the public that a computer is an acceptable, fun, useful, perhaps even an essential thing to have around the house.

In the past it's happened with radios, TV s, automobiles, calculators, digital watches. We really are now seeing the introduction of the personal computer to widespread use.

We were dying to get some hands on experience, and managed to borrow one of the few (one or two) PETs that Commodore had in Canada. Here's the story, with some surprises!

IT'S COMING, IT'S ALMOST HERE . . .

No doubt many of our readers will have heard so much about this machine that they feel it's a little late to do a review and call it news. Certainly literature, advance press releases, tantalizing hints and the like have been with us for over six months, but the real machine is still only almost just arrived. A few words with MOS Technology in Pennsylvania put us in the picture.

By early December about 500 to 600 PETS had rolled off the assembly line, being produced at a rate of about 30 per day. These were almost all being shipped in the States and without complete manuals. A temporary manual was being issued, which contained little more than a description of BASIC, and a few elementary explanations for how to operate the machine. There was no sign of a complete manual in mid-December, nor much hope of its appearance within the near future.

As for sales of the PET in Canada, no one seems to know very much. The price fluctuates (mostly upwards) from week to week, and availability??? The price started at $695 and $895 (Canadian) for 4k and 8k models with delivery in January. At the time of writing (mid-December) the price is up to $850 and $1,100 for those same machines, and no CSA approval has been granted, which means no deliveries to consumers. A couple of machines have appeared in very eager stores, but these outlets can still only accept orders.

In view of the low speed of production, and the incredible demand we expect will have developed for this equipment, it is likely that the US demand will exhaust most of the supply and Canadians will have a long wait. March is our optimistic guess for first delivery, but then it's just a guess.

THE MACHINE ITSELF

The actual, non-imaginary, not-just-promised hardware we borrowed is pictured on the cover. We have several assurances that what's in that one is what you'll get if you order one. It does

Fig. 1. An "old" (and not very good) Commodore press release photo. Note rounded case.

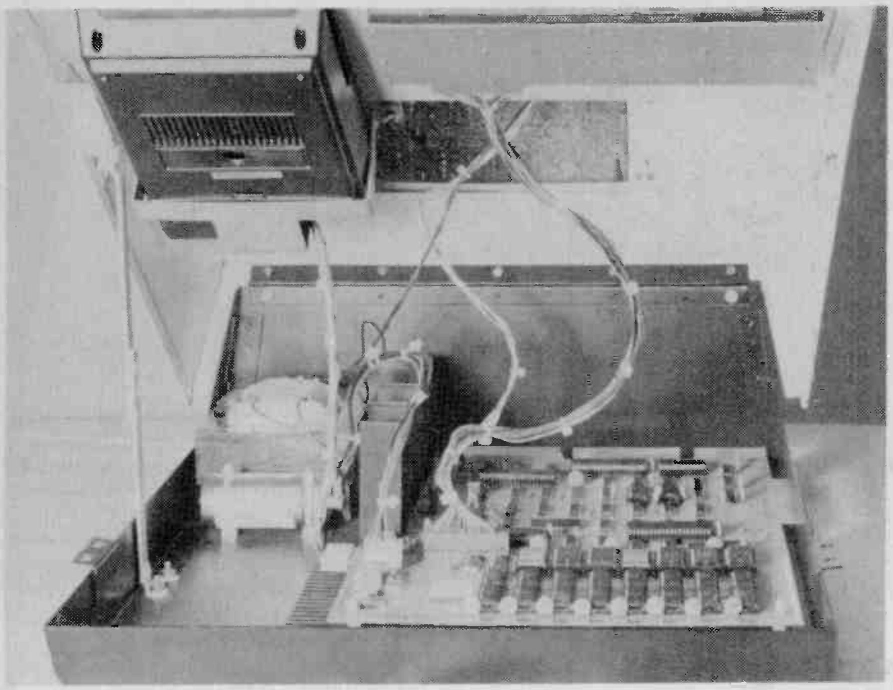


Fig. 2. Our first sight of the insides. It's a real pleasure to open it up and discover a "prop" already in place to hold up the top. Notice neat cabling and connecting plugs, making for cheap efficient assembly and service.

however look significantly different from that pictured in Fig. 1., chiefly in case styling, recessing of the keyboard, and cassette deck. In addition the keyboard in Fig. 1. has completely different graphics symbols. In any case (?), it appears that our model is closer to a production machine, or may even be one, having regard to the fact that dates inside indicate it was built in early October, and the main pcb is numbered 0109. The cassette worried us a little though (see below).

So what do you get? Basically, what you see, and a few other features. Inside is a microprocessor system, and it's hooked up to an alpha-graphics keyboard, numeric-and-more graphics keyboard, CRT display, and cassette recorder. The microprocessor system uses the (big surprise) MOS Technology 6502 mpu, with 14k of ROM containing everything to operate the hardware, and purportedly a very fast interpreter for BASIC. As stated above 4k or 8k of RAM is provided for user program and data storage.

HOW DID WE LIKE IT

There is no doubt that this package of micro-pieces is well thought out, and designed with the idea that the user needs to know very little about computers to get "into" the PET. Remember the increased popularity of tape recording when cassettes came out? Make it simpler to use, easier for the human being. Same philosophy at work here, and that is what will sell it. Needless to say in spite of the fact we had very little documentation, we were highly impressed.

First of all there is no wiring up to do. When you plug in and switch on the PET, after only a couple of seconds it's ready for action. No BASIC to load from tape, it's already in there. This is one great headache reliever if the program you've written bombs out and writes all over memory in selected vital (of course) locations. No waiting for a 20 minute BASIC reload. 14k of built-in software is worth ten times its weight in silicon.

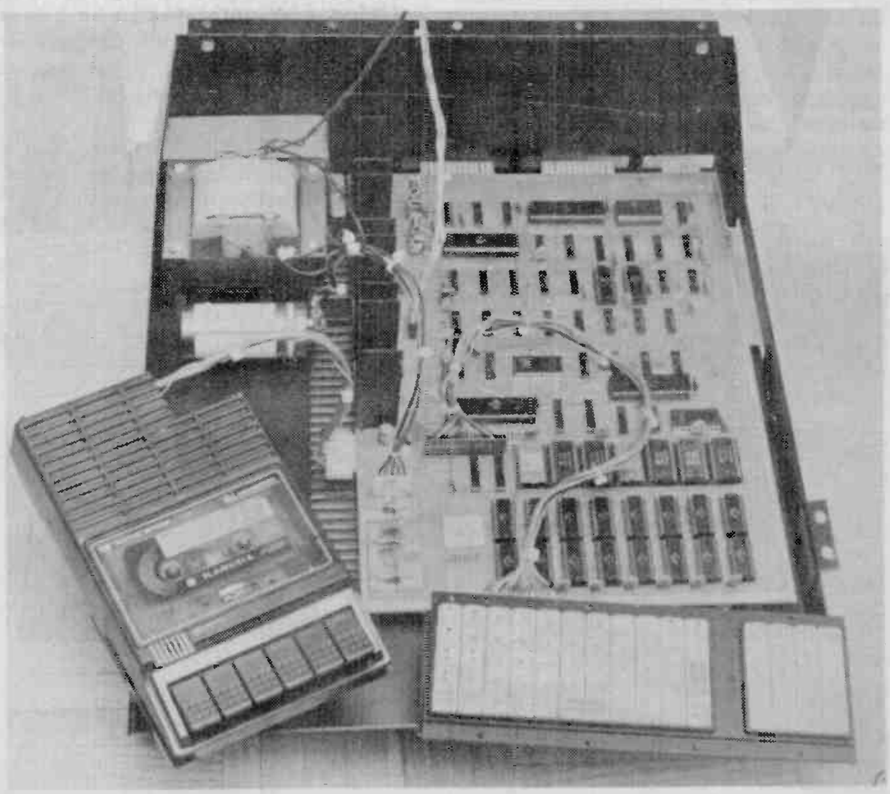
So after "power up" you can start programming, (more about that under SOFTWARE) or load from a cassette the software you want. Presumably in the future, tapes for various useful software packages will be widely available, so you will infrequently *need* to write your own, but it's lots of fun so you'll actually want to.

TAPED

Upon entering the LOAD instruction, the machine tells you to stick the tape in and press the "PLAY" button. Here's where a compromise has been made. Although the PET can switch the transport motor on and off, it tells you to do the muscle work. Commodore have saved money by using a standard (cheap) cassette recorder, which is sensible for the consumer market they are aiming at. In fact, as you can see in Fig. 3., our cassette was so standard it had a grille for "condenser mike", and the corner had been somewhat roughly cut off for the wires to enter its body.

The cassette feature worked quite well, although a couple of demonstration tapes did not load properly (we suspect over-worn tapes due to heavy

Fig. 3. Here we've detached some of the parts from their mountings so we didn't have to draw a block diagram. Video monitor board is above.



use). One feature we would have liked, (which could not have been included without a large extra cost) would be a fast forward search. Without it the machine took a long time to find a program if the tape was started at the beginning and the program happened to be near the end. For this reason it seems most economical (time wise) to only use C30 cassettes (these are thicker and stronger anyway) and then record only one or two programs near the start of each side, unless programs are recorded in some long sequence in which they are to be used, or for storage of little used data etc.

KEY FEATURES

Another cost saver is the keyboard, being of calculator type construction and feel. An idea of its size and action may be gathered from Fig. 5. All our reviewers disliked the feel (no feedback, you have to look at the screen to see your entry) particularly since we had a lot of problems with a reluctant "N". On the other hand these reviewers were all used to sitting down at expensive IBM terminals for days (and nights) on end, so perhaps the comments are unfair.

The keyboard arrangement has all the rows of keys lined up instead of offset as in a normal keyboard, which would appear to be a big disadvantage to experienced typists. However, one is unlikely to enter vast quantities of text, and this turned out to be less annoying than anticipated.

To solve all these problems, it would be a simple matter to replace the main keyboard with a "proper" one. Since there are no electronics inside, it would simply be a question of configuring the switches the same way. How long will it be until some one comes out with a PET soup-up kit, come on, we've started counting . . . !

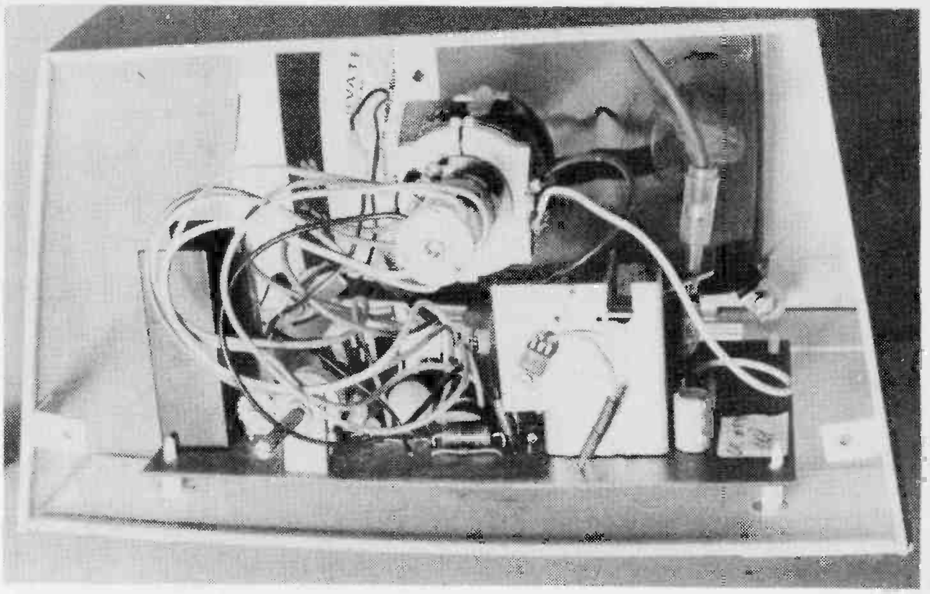


Fig. 4. Peeking in the back of the video monitor reveals a fairly standard set of works.

A CRT-ICAL LOOK

The video monitor appears to be quite standard, Fig. 4 is a view in the back. The 9 inch CRT provided us with high resolution for the 25 lines of 40 characters. A brightness control is located at the rear.

ELECTRONICS

For the electronics enthusiasts (well, you're reading this magazine, aren't you?) we've got Fig. 6. Most of the important features are shown on this photo, from which a basic idea of the system configuration can be gleaned. All the big chips are plugged into sockets, something nice to see, especially for ROMs. (When's APL coming???)

Commodore appears to be producing mostly, if not exclusively 8k models at the moment, but the hefty ($250) price difference between 4k and 8k models means that it could be significantly cheaper to buy a 4k model and plug your own 4k worth of RAM into the sockets, or holes, left vacant. No doubt 4k buyers will be offered the option of having an extra 4k installed later, and they may as well save by doing it themselves. In addition, a planned option is a 24k memory unit with its own power supply, to connect onto the expansion connectors. Commodore literature says this unit "cannot be described as static or dynamic but somewhere between the two". This we take to mean dynamic memory chips with additional hardware to handle the refresh independently from the PET. This would allow simple interface, servicing, and great savings in the power supply using low power cheap dynamic RAMs. The 6502, like 6800 does not use the entire clock cycle, thus allowing (through suitable synchronizing circuitry) memory refresh to occur in the unused part of the cycle. Clever and cheap; economy attainable in such a large memory unit.

The keyboard is accessed via a 16 line Peripheral Interface Adapter (6520 like a 6820 for Motorola fans) which we expect uses 8 outputs and 8 inputs for decoding 64 keys, and then also a couple of the PIA "handshaking" lines for the rest of the work. In other words most of the keyboard decoding is done by software.

The cassette recorder as previously mentioned is a customised standard one, with a new pcb inside full of electronics suitable for data recording.

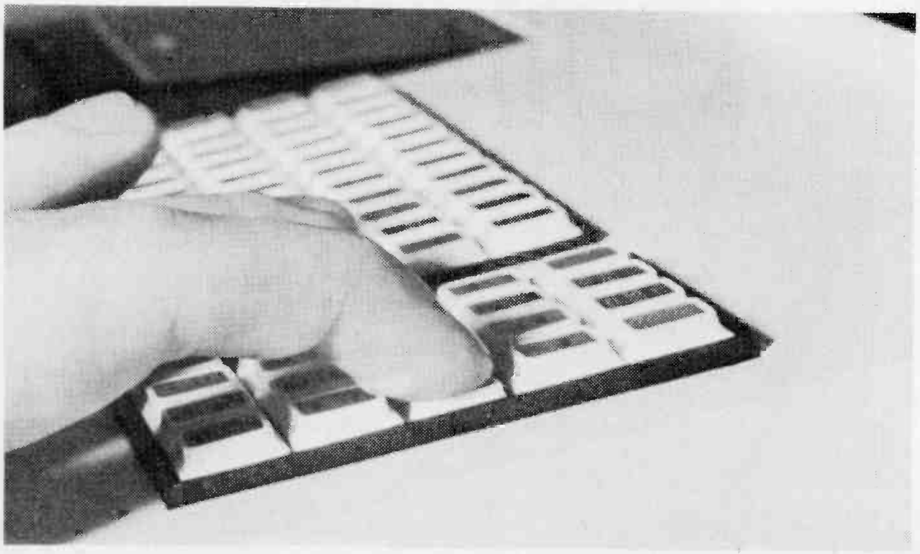


Fig. 5. We call this one "Finger on the key of ". Portrays finger pushing down key all the way to illustrate keyboard action.

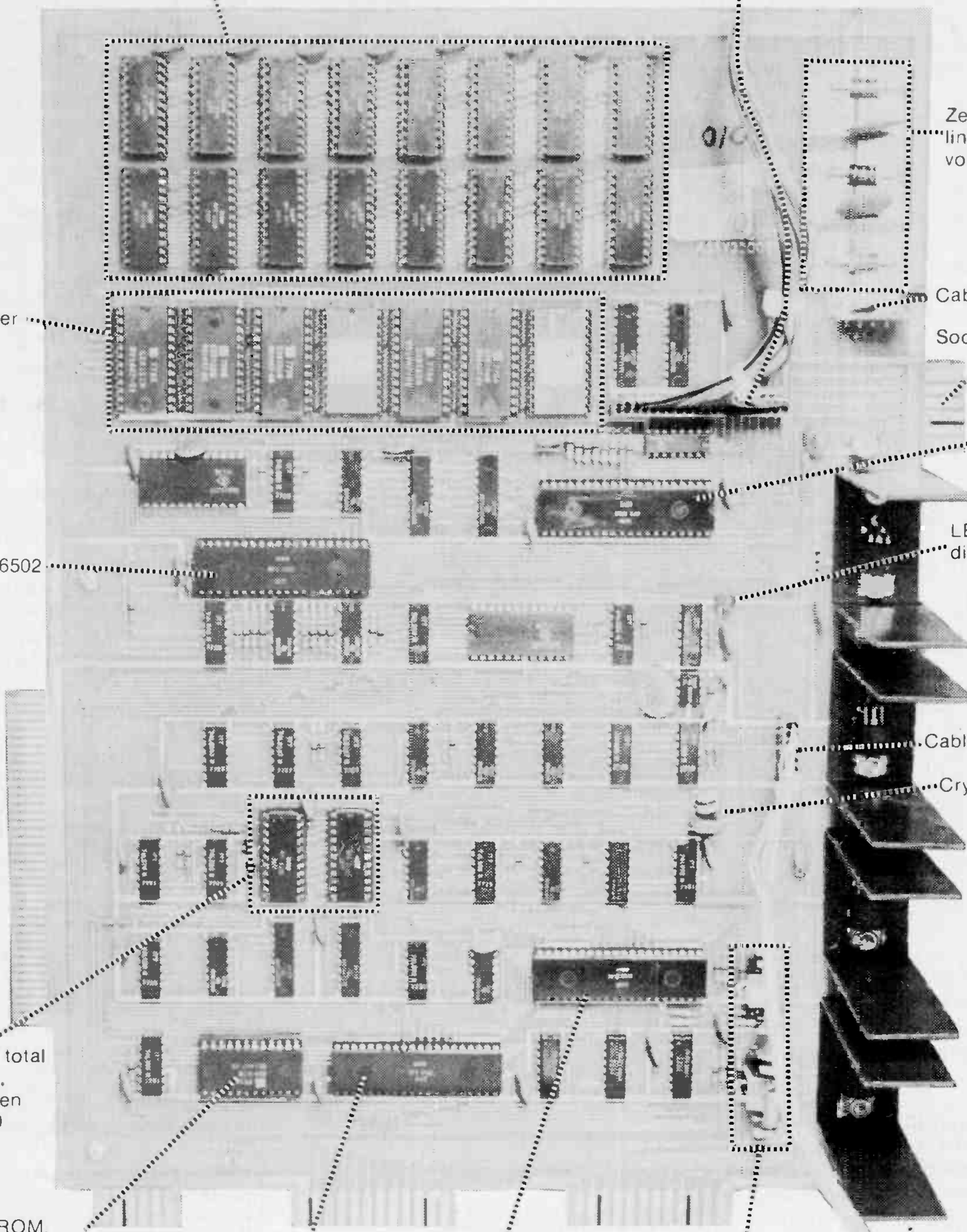


Fig. 6. This is the main PET board, containing all the electronics except for video monitor and cassette circuitry. Note well thought out layout, and edge letters/numbers for easy location of areas on the board.

In fact two cassette interfaces are included (second cassette recorder available for about $100.00 sometime) with input, output, and motor on/off lines. This uses six lines of the 16 on the second 6520 PIA (we assume) leaving 10 lines, 8 for parallel I/O, and 2 serial, at TTL levels. Both cassettes record at 1000 baud, but using built in software any program is recorded twice in series for reliability, cutting the effective rate to 500 baud. Thus an 8k program takes about 2½ minutes to load.

In addition, the PET is probably the first popular micro-computer to use the IEEE 488 bus for instrumentation communications, making it compatible with many existing and future digital instruments, printers etc. Commodore themselves plan to hang on this a printer ($1,000.00?), floppy disc (mini $1,000.00, "full size" $2,000.00??) and telephone interface ($?) available when we don't know, but with a standard bus you can be sure there will be a swarm of cheap add-ons from other sources in the not too far future, just like when the S100 bus caught on.

A final note of the hardware. Unlike some of the early hobby computer equipment the inside of this machine looks like it's built for business, and for the manufacturer to stay in business. Constructed with quality electronics, and chassis and pcb arrangement for easy assembly and service.

SOFTWARE

As stated before, one of the beauties of the PET is its built in ROM — full of software. The 14k includes 8 k BASIC, 4k Operating System, 1k Machine Language and 1k Diagnostic routine, according to Commodore's literature.

First there's 8k of "extended" BASIC. The correct term is "BASIC interpreter". In simple terms an interpreter is a machine language program which takes your BASIC program as data, "translates" it to machine language subroutines and then executes it. This process actually occurs in a line-by-line translate-execute manner. The term "extended" refers to the fact that many statements are included that are omitted in some versions of BASIC. Using BASIC means that programming can be conducted in a civilized manner, using statements that are almost readable in English, with base ten numbers. The machine does the work of converting to machine language and 8 bit binary arithmetic. As encouragement to skeptics we've included a description of the language and how (easy it is) to use it.

Commodore claim that their BASIC is significantly faster than anybody else's which we cannot attest to, but for general use the PET performed admirably as compared to the reasonably typical IBM 360 and 370 interactive, multi-user systems that the reviewers were familiar with. (But we do like APL!)

The cassette I/O, keyboard, video, and other functions are handled by the 8k operating system.

Lacking documentation, we can only guess at the other two ROM items. The diagnostic routine we assume verifies the operation of the hardware, and uses the LED as an indicator for this task.

The 1k machine language we guess refers to an assembly language ("machine language" is what the mpu uses, "assembler" is one step higher, using mnemonics for each instruction, and is generally more readable and useable). There is also a mention of next year's "assembler device", to be plugged into the expansion port for "machine language" (?) programming. The advantage of machine or assembler language programming is increased efficiency of programs over those "interpreted" from BASIC. This could be critical in case of a routine which runs several thousand times in a loop, or for a frequently used function.

BASIC BASIC (INTERACTIVE)

One can think of the PET as operating in one of two modes: "calculator mode" in which the operator asks the machine to execute and give the results of one statement; and "programmed mode" in which the programmer enters a series of statements, then has the machine execute the entire set at one go. The second mode requires a little more structure for "administrative" purposes.

A list of the available statements and commands with comments may be found to the right for reference.

CALCULATOR MODE

Known by this name because it is the process of getting a quick answer from a small formula, (similar to calculators), or telling the machine to do one thing.
Example: PRINT 3+4
The machine works out 3+4 and "prints" the result on the screen.
Another example: LOAD FRED
This causes the machine to obtain a program called "FRED" from the cassette, including giving you instructions about what buttons to push on the recorder.

PROGRAM MODE

Problem: Figure out the sum of the integers zero to ten.

Program:
```
10 J% = 0
20 FOR I% = 1 TO 10
30 J% = J% + I%
40 NEXT
50 PRINT J%
60 END
```

The numbers down the side are line numbers which can be any integers, and they keep the lines in order. We have chosen multiples of ten as it makes for easy editing at a later date by inserting line numbers in between if necessary. The variables are J% and I%. The % signs identify them as integers.

The FOR — NEXT pair signify a "loop" to be executed many times. The first time I% has the value 1, the second time 2, and so on up to 10.

On each iteration the value of I% is added to the accumulated total J%. After the 10th interation the program continues to line 50, prints the answer, then stops at 60. A simple task, a simple

BASIC

Commodore claims that their full floating point BASIC is the fastest yet implemented on a microcomputer. Here are the statements and features included.

Standard Dartmouth BASIC Statements: LET, READ, PRINT, DATA, IF, THEN, FOR, NEXT, DIM, END, GOTO

Extended BASIC Statements: RESTORE, REM, GET, GOSUB, DEF, RETURN, STOP, STEP, INPUT, FN, ON . . . GOTO, ON . . . GOSUB

Scientific Functions: SGN, INT, ABS, SQR, RND, SIN, COS, TAN, ATN, LOG, EXP, PI

Logical Operators: AND, OR, NOT

Operation Commands: RUN, NEW, CLR, LIST, CONT, FRE

Formatting Functions: TAB, POS, SPC

Machine Level Statements: PEEK, POKE; Allow the user to examine and store at specific memory locations. USR, SYS; Link BASIC to machine language subroutines with parameter passing or developmental subsystems. WAIT; Monitors status of a memory location such as an I/O port until specified bits are set.

String Functions: LEFT$, RIGHT$, MID$: Returns substrings (of specified length and position) of string acted upon. CHR$, ASC: CHR$ returns a character, given a numeric code. ASC returns a numeric code corresponding to a character. LEN: Returns the length of a string. VAL, STR$: Convert decimal values to numeric strings and vice-versa.

Extended I/O Statements: OPEN, CLOSE: Control association of a logical file number to a physical device and, optionally, a file name on the device. SAVE, LOAD, VERIFY: Store and retrieve a program, with optional file name, on a physical device. Load allows for program overlay, VERIFY compares contents of memory to stored program. PRINT#, INPUT#, GET#: Allow communication with logical device numbers other than keyboard or screen. GET# inputs one character. CMD: Permits communication with multiple devices simultaneously.

Variables
TYPES: Real, Integer (%), String ($)
NAMES: Variable names are uniquely given as a letter or a letter followed by a letter or digit.

Special Variables
TI, TI$: Time of day. ST: Status word for I/O operations.

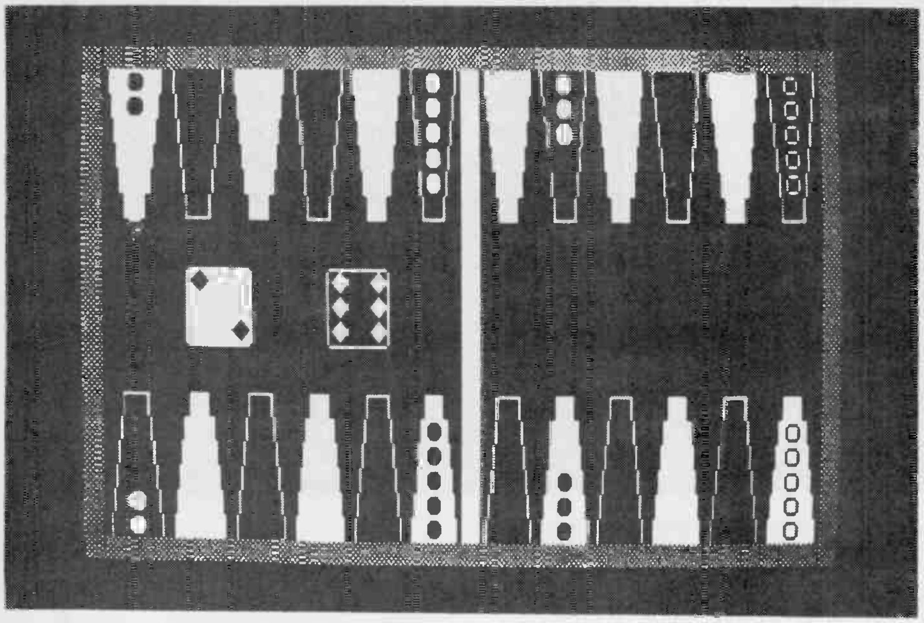


Fig. 8. The PET's impressive array of graphic symbols makes game playing or creating quite a pleasure.

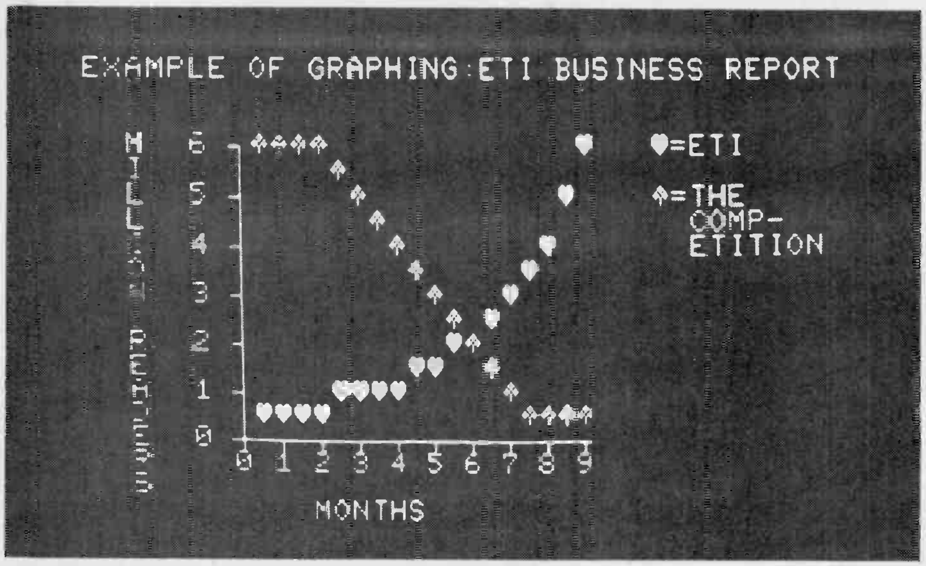
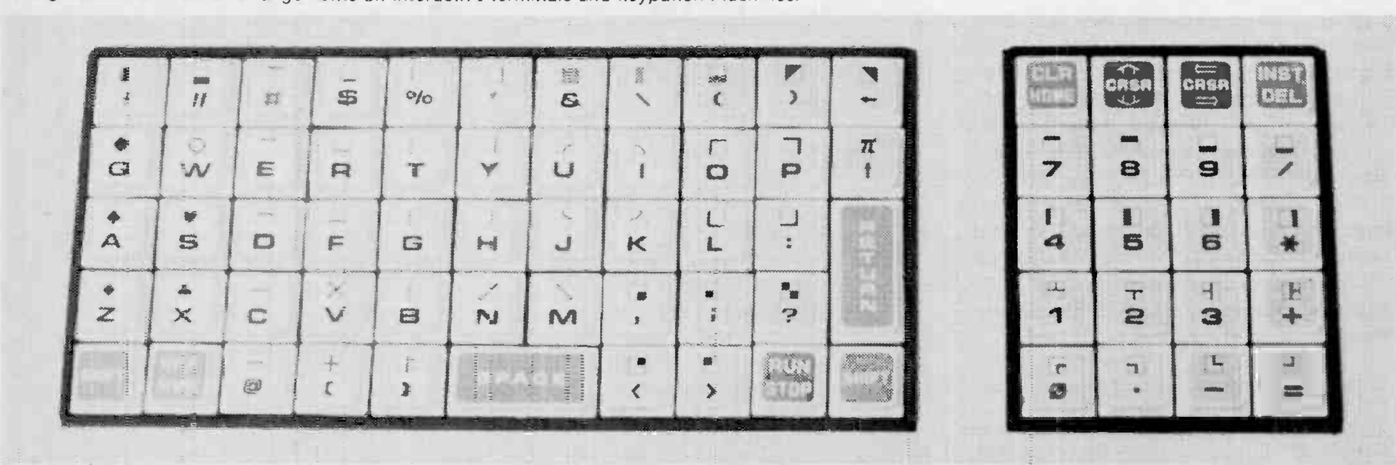


Fig. 9. We were even more impressed when we saw the machine produce this graph!

Fig. 7. The two PET keyboards. We found it quite handy to have a separate numeric pad having hassled with other arrangements on interactive terminals and keypunch machines.



program. With the program stored in the machine, the operator keys in "RUN" and the answer appears. How boring. But it does illustrate the ease of programming.

Of much more interest to people are fun programs like games, and business software which helps you make (more) money. These can also be simple, or of complexity running to many hundred statements. These programs not only do simple calculations, but manipulate character data, set up filing systems on tape, draw fancy graphics on the screen and other entertaining activities. And you can exercise your imagination writing your own programs. A computer can be a very creativity promoting toy, requiring very little activation energy (other than original outlay) to get you involved, alot more healthy than a TV set, that's certain!

GRAPHICS

We suspect some pretty creative, intelligent people sat down and worked out the graphics character set on this machine. Figure 7 shows the keyboard and all the characters you can key in.

The display system is based upon 8×8 dot units, which may contain 5×7 dot upper case letters, or assorted symbols which are so designed to provide very versatile diagram and graphing capabilities. Because the 8×8 blocks fit together both horizontally and vertically, it means that adjacent lines of text look a little crammed together, but this can be avoided by judicious line spacing if necessary.

Commodore PET

The "cursor" is a flashing "element" or character that can be moved about the screen, and it normally indicates the next space to be typed in. After typing in that space the cursor moves to the next adjacent spot and so forth. "RETURN" causes the cursor to move to the first position on the next line, just as a carriage return does on a typewriter. Additional cursor control is provided to move it quickly up, down or sideways. The cursor is useful also for editing and correcting programs already written on screen, with the facility for inserting and deleting characters. When the cursor attempts to move below the bottom of the "page", the screen "scrolls up". That is to say each line moves up one, with the top line disappearing.

In addition to the normal characters, each may be "reversed", that is appear as black on white, which can be used to advantage on some occasions.

Finally, here's our big surprise! If you've been counting keyboard characters, there are alot less than the 256 possible with the character generator shown in Fig. 6. Quite by accident we found a whole set of lower case letters! Very interesting. We're not quite sure what does it but check the pictures for yourself. That still doesn't add up to 256 characters, so there may be yet more we don't know about. In fact our Fig. 1 photo, upon close scrutiny of the keyboard shows another set of graphic symbols including assorted Greek letters, could they be inside as well? We don't know, but it all depends on what's in the character generator. We wonder if Commodore has lower case letters planned as a future "add-on option?" For that matter you could always burn your own PROM . . .

WHAT MORE CAN WE SAY?

It looks like computers are starting their march into the homes of the masses, which sounds very science-fiction and scary to some. We hope that the familiarity with computers this may bring to the man/woman/child in the street will reverse the widespread fear of THE COMPUTER as an enemy. Perhaps man will once again feel master over objects. There was after all a time when the automobile was regarded as an evil fire breathing monster, until everybody got one.

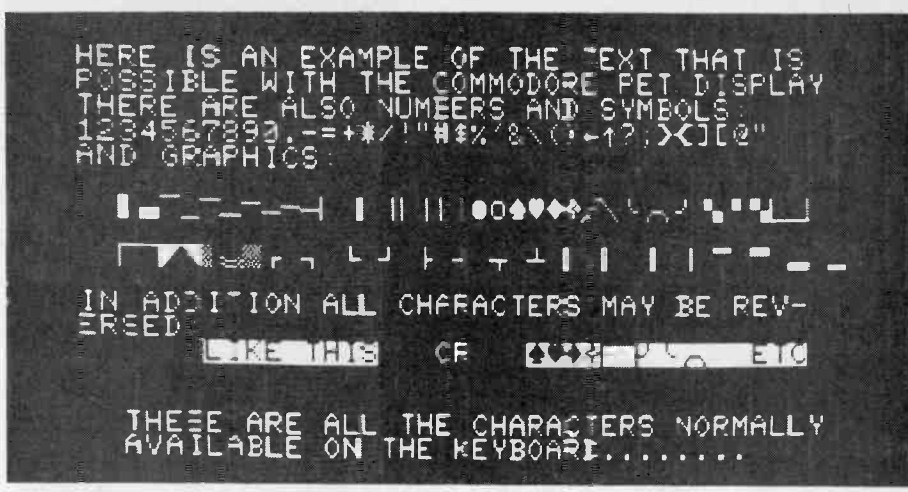
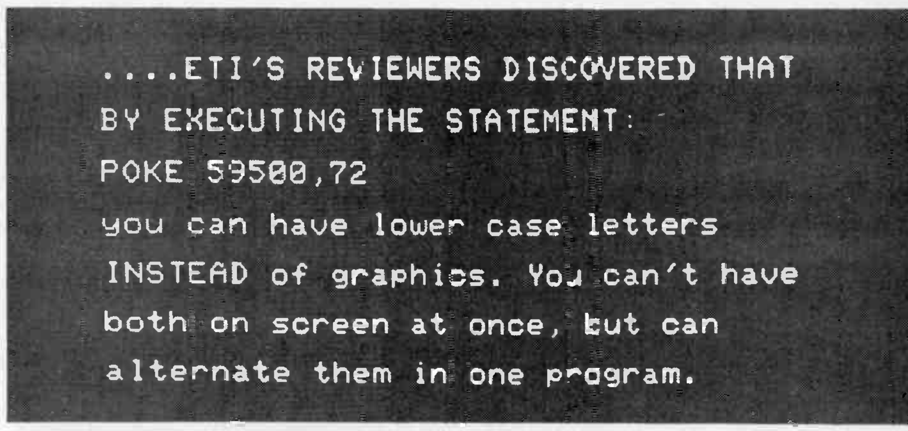


Fig. 10. Text can look a little cramped as the lines of capital letters are quite close. It's designed that way so that the graphic symbols will join together.

Fig. 11. OK, we'll have to admit it was luck, but there they are, lower case letters and how to get them. Go and impress your local PET dealers. Don't forget to tell them where you read it . . .



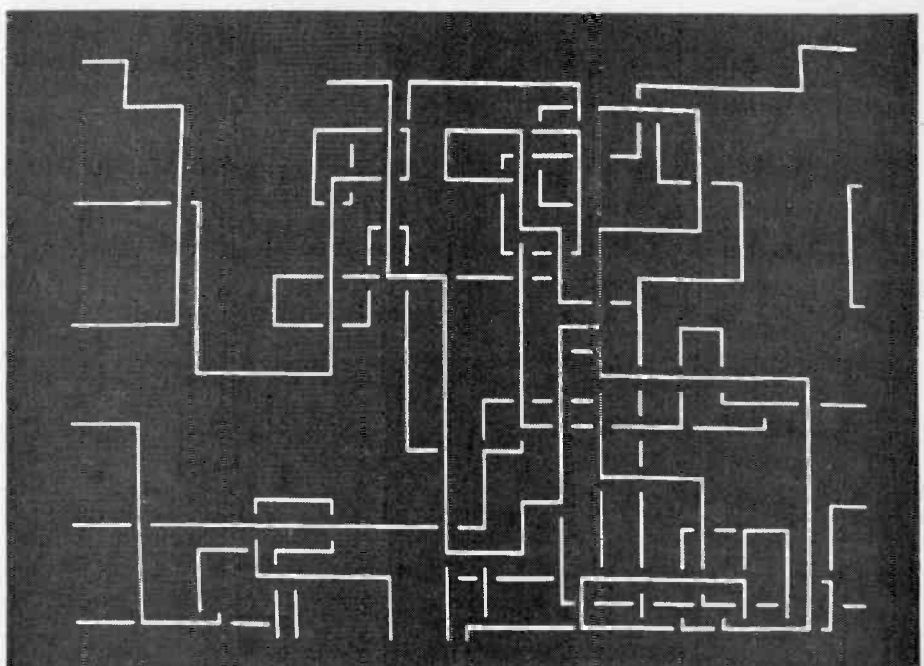


Fig. 12. No kidding, we really turned our machine into a labour saving device, designing our pcb layouts for us!!! Any errors in future . . . "Well, it was the computer's fault".

Electrets in Audio

Electrostatic headphones have long been acknowledged as the ultimate in sound transducers, but are restricted in usage by needing a high voltage supply to operate. Recently electret headphones have appeared, and are claimed to give a similar performance with no drawbacks. Cartridges and microphones too have begun to see the advantages of this new technology. But what exactly are electrets? Ian Sinclair explains the principle and its applications.

SEASONED CONSTRUCTORS are fairly used to the problem of a noisy transformer or choke. In some cases the noise is caused by laminations which are not sufficiently tightly clamped together, and so vibrate at line frequency. Transformers which work at higher frequencies may cause sound to be emitted because of magnetostriction, meaning that the cores change in size as they magnetise. In our experience, capacitors do not cause such problems and yet some recent research work ties up capacitance with microphonics, loudspeakers and even a new method of measuring temperatures.

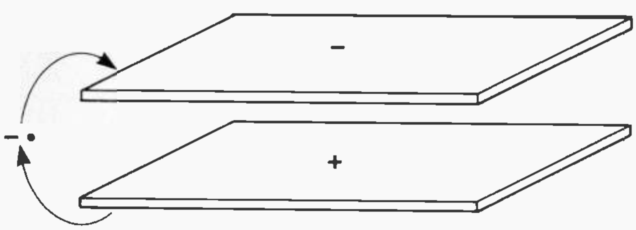
PUTTING IT ABOUT, AND CHARGING

In its simplest form, a capacitor consists of two parallel metal plates insulated from each other by air or some other non-conducting material between the plates. If we bring an electric charge, meaning a few electrons, from one of the plates and put it on the other, so charging the capacitor, this causes a voltage to appear between the plates.

It is the ratio of the amount of charge to the value of voltage which is the quantity which we call capacitance. The relationship can be described more formally as Q=CV, where C is the capacitance in farads, Q is charge in coulombs, and V is the voltage in volts (see Fig. 1). When a capacitor has charged, the charge will stay where it is unless there is some conduction between the plates of the capacitor which will allow the electrons to travel back to where they started. While the capacitor is charged, there will be energy stored in the form of electric field between the plates.

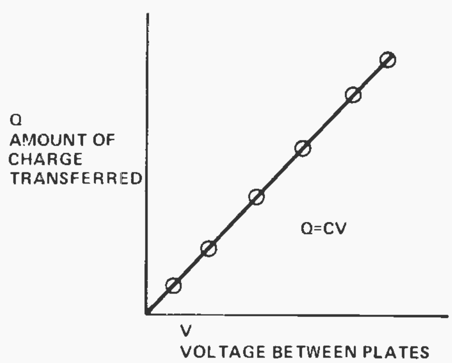
For any simple capacitor of this type, the value of capacitance is proportional to the area of the plates and inversely proportional to the distance between them; mathematically this is

$$C=\frac{\epsilon_0 A}{d} \quad \text{(see Fig. 2).}$$

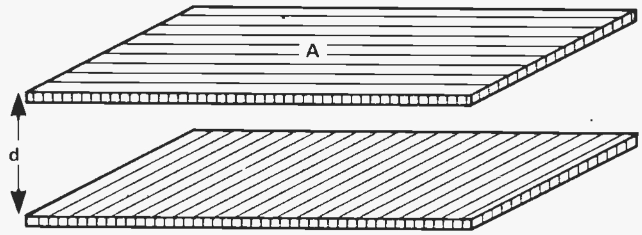


QUANTITY	SYMBOL	UNITS
CHARGE	Q	COULOMBS
VOLTAGE	V	VOLTS
CAPACITANCE	C	FARADS

Fig. 1. The parallel-plate capacitor. (a) Charging consists of shifting electrons from one plate to the other. (b) A graph of charge transferred plotted against voltage is a straight line and its slope is the value of capacitance.



Electrets in Audio

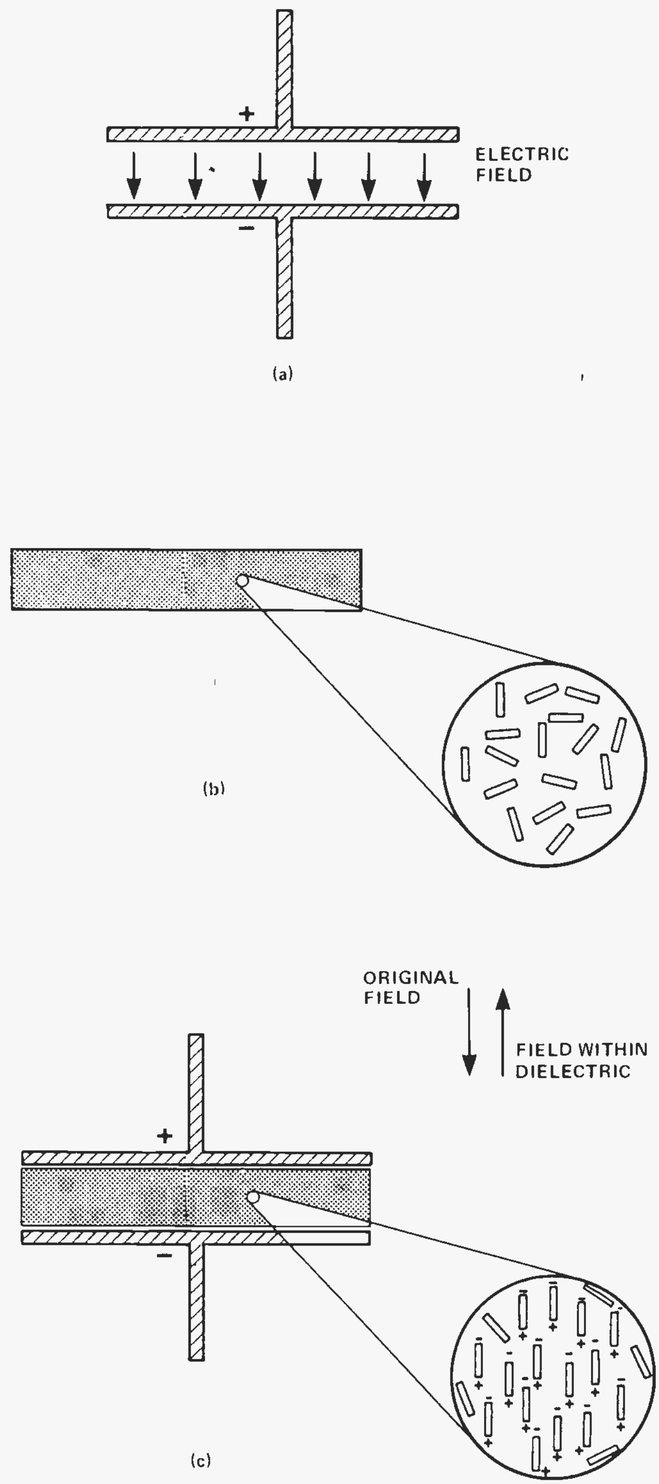


$$C=\frac{\epsilon_0 A}{d}$$

QUANTITY	SYMBOL	UNITS
CAPACITANCE	C	FARADS
AREA	A	METRES^2
SEPARATION	d	METRES
PERMITTIVITY OF FREE.SPACE	ϵ_0	FARADS/METRE

Fig. 2. Capacitance values. The value of capacitance of a parallel-plate capacitor is decided by the area of the plates and the spacing (when no dielectric is used). Tubular capacitors are simply parallel plate types, with a thin film dielectric, which are rolled up with another layer of insulation.

Fig. 3. Dielectrics. (a) The electric field between the plates of a capacitor. (b) Representing a dielectric; the molecules are randomly arranged. (c) In a polarised dielectric, the direction of the field inside the dielectric opposes the field (of the capacitor plates) which has created it.



PERMITTIVITY CONSTANTLY

The constant here (pronounced epsilon nought) is called the permittivity of free space, and applies when the capacitor plates have air (strictly, a vacuum) between them; if any other material is used, then a numerical multiplier, called the relative permittivity, of this constant will also appear, making the formula:

$$C=\frac{\epsilon_0\epsilon_r A}{d}.$$

In each of these formulae, A represents the area of overlap of the plates in square metres, and d is the spacing between the plates in metres. The effect of the relative permittivity is to increase considerably the capacitance between two plates which were formerly air-spaced.

INSULATION ON A PLATE

The reason for this behaviour of insulating materials is that the electric field between the plates of the capacitor acts on the atoms of the dielectric, that is the insulator which is placed between the plates, so that there is a force trying to separate the electrons from the remainder of each atom in a direction which is towards the positive plate of the capacitor. These electrons cannot shift very far; if they could, the material would not be an insulator but a conductor. The result of this slight shift is to "polarise" each atom or molecule, meaning that one end of the molecule is slightly negative and the other end slightly positive, and the amount of this polarisation which takes place depends very much on how the atoms of the material are constructed.

Polarisation causes another electric field to appear, this time inside the material and in the opposite direction to the field between the plates. Because these two fields

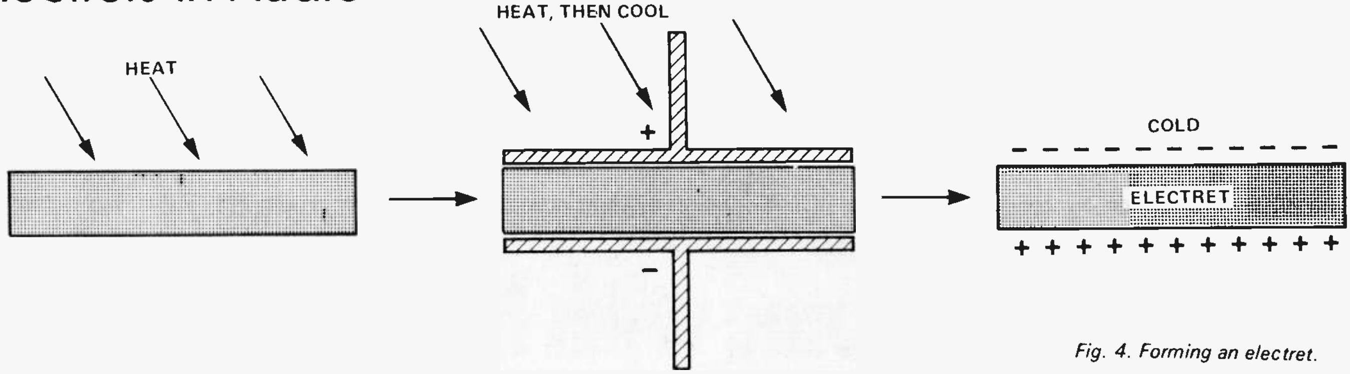


Fig. 4. Forming an electret.

are in opposite directions, their effect subtracts, and the total electric field between the plates is less than it would be if the dielectric were not present. Because the field is less, so is the voltage and so the capacitance is *greater*.

BEING SENSITIVE TO SIZE

The use of dielectrics in this way makes it possible for us to manufacture capacitors of comparatively large values in a reasonably small size, , but can cause problems, one of which is voltage sensitivity.

We may find, for example, that the amount of the shift between the atom and the electrons of the dielectric varies with the voltage we apply to the plates of the capacitor, in which case the amount of polarisation will change as the voltage is changed. A capacitor like this will be voltage-sensitive, and its capacitance will change as the applied voltage changes. If such a capacitor, typically the high-K ceramic type, is used as a by-pass, this variation of capacitance is of no great consequence, but it makes such capacitances useless for tuning resonant circuits. (The experienced constructor will know that certain types of capacitors are specified for various purposes.)

CAUSING A SPARK

Most observable effects work in *both* directions, and dielectrics are no exception. In this case, the opposite of the normal action of the dielectric occurs in piezo-electric crystals, where we apply a force which shifts atoms slightly out of place relative to their electrons, and causes a voltage to develop across the crystal of the material. This voltage can be detected by connecting to metal plates formed on opposite sides of the crystal. In this case it is the force which causes the field, and the field which then causes the voltage.

In many types of piezoelectric crystals, the voltages which are generated can be quite high, high enough to cause a spark, which is why piezoelectric crystals can be used as igniters for gas fires.

Another variation on this effect, of course, is the familiar piezoelectric crystal pickup cartridge, where a much smaller force is applied from the stylus through the cantilever, and the voltage between the plates is the signal output.

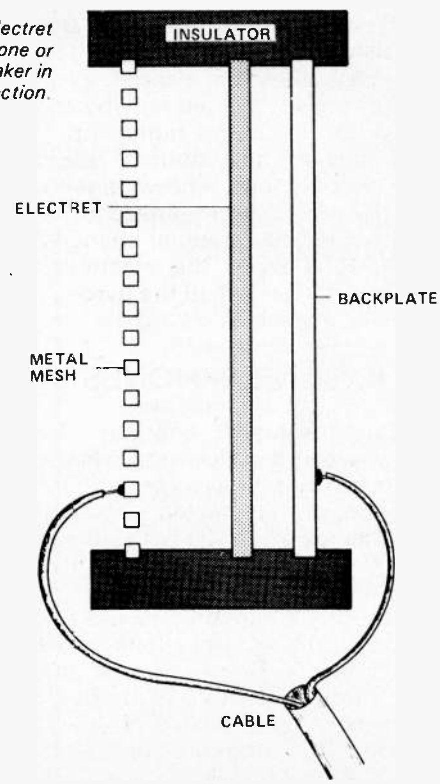
Piezoelectric effects, however, last only as long as the normal structure of the material has been distorted, and they disappear as soon as normal conditions are resumed. *Electrets* are materials which have a structure which has been changed permanently, and which therefore have permanent amounts of charge displaced. Such materials have been known for sixty years or so, and the name comes from the resemblance to the magnet.

DUSTY PICK UPS?

A slab of electret material will pick up the dust or powder of most materials, insulating or conducting, and so is rather useful in dust-collecting devices, and if we use an electret as a dielectric in a capacitor then there will be a permanent DC voltage between the plates of the capacitor, though we will not be able to draw any measurable current if the plates are connected together.

Now there are many materials which have molecules with a natural and permanent polarisation, water is one of them, yet these are not electrets. The reason is that in such materials these permanent polarisations are not

Fig. 5. An electret microphone or loudspeaker in cross-section.



held in one particular direction, so that the electric fields which are caused by each molecule simply cancel each other out, with no overall effect. What makes a material an electret is the combination of a polarised molecule with a fairly low melting point and a very high resistivity, so that the material can be heated, the molecules brought into line by an external field, and the material allowed to solidify again so that the molecules are permanently "frozen" into position again. The high resistivity then ensures that there is no movement of charge which could reverse the process.

GETTING INTO HOT PLASTIC!

Many modern plastics materials are ideal electrets, some even have their charges established during the manufacturing process simply because of the electric fields which exist while the material is cooling. In most cases, however, the plastic has to be made into an electret by the combination of heating, applying an intense field, and cooling while the field is applied.

Such plastics sheets will "stick" tightly to each other and to other plastics, will pick up dust, and show all the other behaviour which is normal to electrets. (It may well be that some of the problems we experience with modern vinyl phonograph records are due to partial electret formation during pressing.)

As far as the applications of electrets to electronics is concerned, these arise because an electret is sensitive to anything which disturbs the arrangement of its molecules. A capacitor containing an electret as dielectric, for example, should be sensitive to vibration, i.e. microphonic. The opposite effect should also be true; if we apply AC between the plates of an electret capacitor we should be able to cause vibration of the electret material (if it is free to move) the capacitor would then act as a loudspeaker.

As well as these AC effects, there is also a DC effect. Any electret capacitor will have a steady voltage between its plates which is caused by the field which permanently exists across the electret.

This voltage can be detected only by an electrostatic voltmeter or by a very high input resistance electrometer, because the internal resistance of the capacitor is extremely high. The voltage, however, will change as the temperature difference between the surfaces of the dielectric material changes, and this is particularly obvious when the electret is struck by radiant heat; the effect is called the pyroelectric effect.

HOT AIR AND TELEPHONES

A pyroelectric detector consists of an electret sandwiched between a solid metal plate and a metal gauze, or between two transparent conducting plates, with an electrometer connected between the plates. Changes in air temperature will not cause any change in the voltage reading if they affect both sides of the electret. If we shine radiated heat on to one side of the electret a difference in temperature will exist across the electret, causing a difference in voltage. The sensitivity is quite remarkable. Placing your hand at a distance of about 1 metre from this pyroelectric detector radiates enough energy to cause a reading of about 1V.

With some DC amplification, a temperature difference of a millionth of a degree caused by radiated heat can be detected, so that the pyroelectric effect has immense possibilities for measurements. Even without amplification, detectors using pyroelectric effect have applications in burglar alarms, fire alarms, detecting hot spots in machinery, even possibly for replacing fuses.

It was recently announced that some phone companies intend to replace the old carbon microphone in telephones by an electret type, and presumably the earpiece can be replaced similarly. Some electret pickup cartridges have now appeared, but we are still waiting for a range of electret loudspeakers which would need no polarising voltages and hence no AC supply.

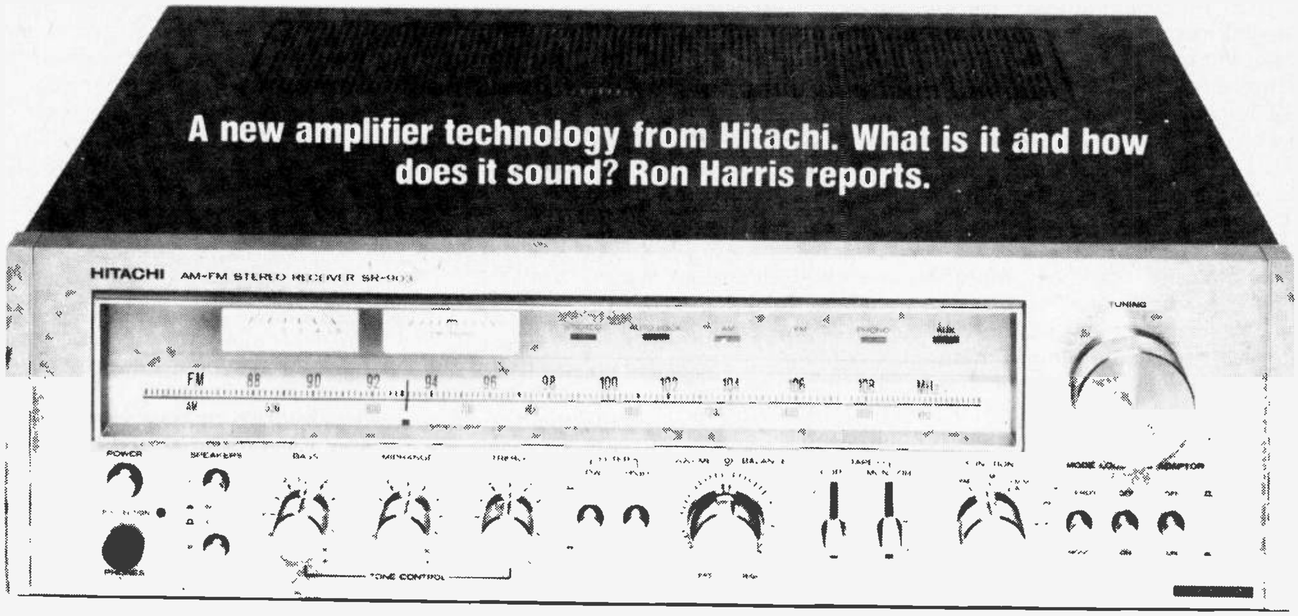
STOCK QUESTION

This is one of the fields of modern materials research in which it is possible for almost anyone to get into the act. So many modern plastics form electrets easily that it is not impossible to manufacture them for yourself, though the effort would hardly be worthwhile on a one-off basis. Ready made electret materials are by no means easy to obtain, though there is always a possibility of manufacturers of plastics sheeting for electronics use, or capacitor manufacturers, having small quantities in stock. (Perhaps one of our enterprising surplus dealers might be able to obtain some of this material.)

Finally, suppose one were able to manufacture capacitors with a permanent voltage across them, how much would this save us on high value bias resistors for FETs?

Class G

A new amplifier technology from Hitachi. What is it and how does it sound? Ron Harris reports.



HITACHI NOW HAVE three units in the hi-fi market employing this new amplifier configuration, which they have entitled Dynaharmony. Basically, class G is an improvement on the older class B circuit, specially designed to eliminate 'clipping'.

Since clipping is a form of distortion which occurs when an amplifier runs out of watts, to avoid it means providing more power when a peak occurs on the signal. There are two ways of doing this. One is to use an amplifier of far greater power than is needed normally, so that in the 5% of the time when the peak power capacity is necessary it is there to be called upon.

Hitachi are now proposing the second solution, that of adding a second amplifier in the same case, so configured to operate only on the peaks, and hence to avoid the main circuit clipping off the waveform.

When we first heard details of the scheme, we wondered whether the switching in and out of circuit of this second amplifier would cause any audible degration of the sound, and so politely requested Hitachi to lend us an SR903 which is their 75 + 75 W Dynaharmony receiver. This unit is capable of supplying some 160 W of good clean power when it matters most, and sounded superb — but more of that later, let's look at the circuit in more detail first.

OUTPUT ON A G-STRING

Figure 1 shows the version of the class G output stage employed in the SR903 receiver. Q2, Q6 and Q3, Q7 constitute the normal 75 W RMS amplification stage. When the input voltage is lower than V1, Q5 and Q8 are cut off, and the load current is supplied by Q2 and Q6, and by Q3 and Q7 on the -ve half cycle.

Once the input exceeds V1 ie. 31.5 V Q1 and Q5 are switched in on the +ve half cycle and Q4 and Q8 come in on a —ve half cycle. As this occurs V1 is shut off, and V2 (67 volts) is now employed to handle the signal.

REALISING POTENTIAL

In effect we now have a much higher power amplifier operating than previously. Once the incoming signal no longer requires this, and the potential at Q5 emitter drops to 31.5 V, V2 is shut off and V1 once more supplies the output current.

For music operation, the amplifier operates with V1 90% of the time, thus keeping power dissipation low. This enables the unit as a whole to be presented smaller and lighter as a result. (Mind you, hauling the SR903 around nearly ruined a few lives here — that thing is HEAVY.)

Very fast diodes are employed for D1 and D2 so that the changeover is as rapid as possible. Residual spikes caused by the switch can be designed out, say Hitachi, and so do not appear on the output signal at all. We could detect none, certainly.

Class G efficiency is close to 80% for most of the time, which compares very favourably with the 65% *peak* efficiency of class B. This comes about because in the former circuit each transistor in the output stage is working

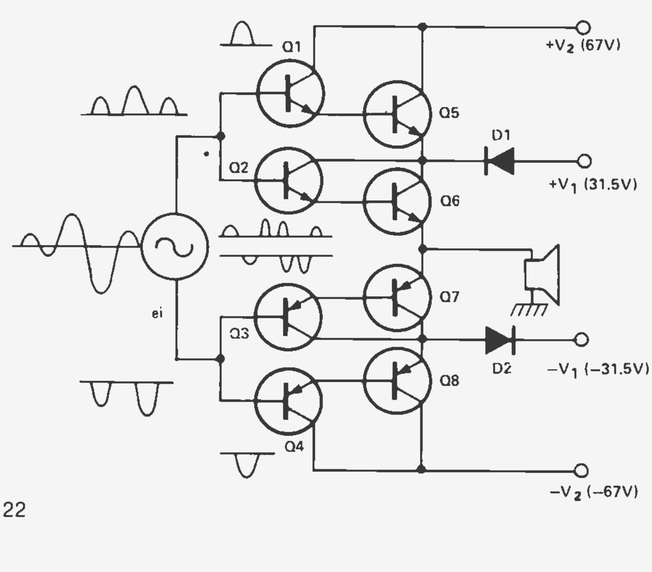


Figure 1. The output stage of the SR903 receiver, showing how the two power supplies are connected to the transistors. Input signal ei is shown going into the bases of Q1, 2 and Q3, 4. Other waveforms are then given, showing how the circuit handles each half cycle.

close to its optimum efficiency point *all* of the time, while in class B this only occurs close to rated output power.

A SOUND CHOICE

In order to see where all this ingenious engineering has put the final sound quality, we put SR903 through its paces in a domestic situation. Laboratory measurements were not taken, as we were entirely concerned with how the unit *sounded*, not how many zeroes are packed in between the decimal point and the distortion figures.

We believe that the most important specification for any piece of hi-fi is its sound. Specifications are a useful, nay vital, guide in choosing a piece of hi-fi, and can indicate whether or not X lies within the band you intend to select from. And that's all!

Make up a shortlist from paper performances by all means, but do your choosing by earhole alone! Whatever the equipment, cartridge, turntable, amplifier, tuner, tape deck – what it will do to the sound of your system is what matters, not the fact that its output power is 5.031 W higher than your old one.

ALL IN CONTROL

Anyway sermon over, back to the SR903. This is a receiver of 75 W RMS nominal power, and with a good quality tuner to boot. The multiplicity of facilities provided can be read off Figure 3, suffice to say here they are more than enough for any domestic set-up.

The tuning action is smooth and totally free of backlash, and the meter ballistics good. The Auto-Lock facility works well too, and is controlled by touching the tuning knob. All that is required is that you tune roughly into the station, and let go the control. The circuit then locks on to the correct frequency by itself. Neat and effective.

Volume and tone controls are both 'click action' with positive indents at

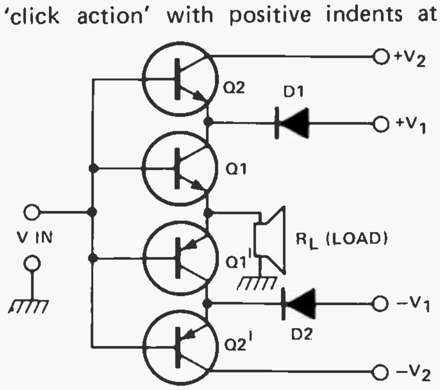


Figure 2. Simplified version of the output stage which more clearly shows the operation of class G. Q2 and Q2' switch on when the input V1N demands a higher level than +V1, and switch off again as the level passes V1 going down.

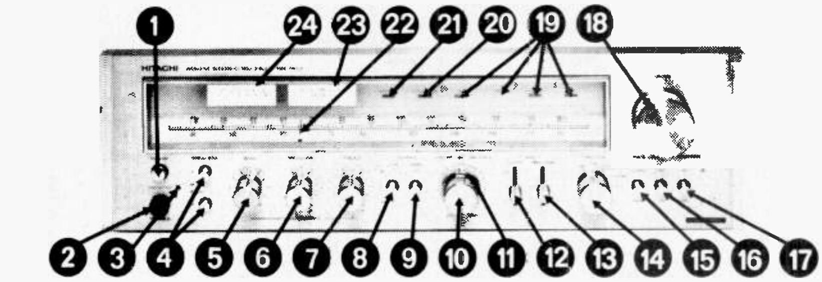


Figure 3. Frontpanel layout of the SR 903 receiver. To explain the numbers: 1. Power on / off switch. 2. Headphone output (¼" jack socket). 3. Protection indicator lights up when the protection circuit is operating, ie first few seconds after switch on, and whenever an illegal condition exists at the output. 4. Speaker controls (both pairs) 5, 6, 7 tone controls 8, 9 Filters. 10. Step attenuation volume control. 11. Concentrically mounted balance control. 12. Tape copy switch. 13. Tape monitor switch. Overrides function control (14) whenever put into either position 1 or 2. 15. Mode control. 16. Loudness switch. 17. Adaptor control. Can be used to add Dolby, or even a third tape deck.

the graduations. They are beautiful to use, and are of very high quality indeed, as are all aspects of the controls. Everything about it has been carefully thought out, and the finish is immaculate. Personally pushbuttons are not my favourite type of switch at all, but if you must have them, Hitachi's are nicer than most peoples, showing no tendancy to be 'sloppy' or 'touchy' in use.

A CASE, A TAILOR AND A LEAP

Even though the case is large by any standards, an amplifier capable of these sort of powers would normally be larger and heavier and riddled with heatsinks. Maybe Dynaharmony did save us a few trusses (trussi?) after all.

In use the first thing to prove itself was the midrange tone control, allowing more exact response tailoring to the room being 'bombarded'. The balance control however is far too sudden in operation. One touch either way, and the sound leaps sideways at incredible velocity! All the action seems restricted to about 1/8th rotation either side of the centre. How about it Hitachi?

Musically the amplifier section of the SR903 is very good indeed, being quite neutral in tone with good transient behaviour and a solid, tight bass.

MUSIC TO BE EVICTED BY

Comparing the 903 to another reputable 70 W amplifier really began to show the advantages of class G. Long after clipping became painfully evident from the other, the Hitachi soared gracefully on unperturbed by the demands made of it.

The loudspeakers used, Celestion Ditton 66s, were very efficient and the levels reached were quite horrendous at times! On heavy rock or full blown orchestral splendour the 903 would undoubtedly lose any similarly specified amplifier for sheer power of delivery. Its sound is clear and open, and has great 'bite' without ever becoming hard. At very high levels, however, a slight thickening could be detected in the upper midrange – but this is a very slight effect indeed, and it took a great deal of A–B comparison to uncover it at all.

TUNING UP AND IN

Onto the tuner. Reference here was drawn with respect to a Pioneer TX9500 FM/AM tuner which is ETI's standard quality reference. This was wired into the AUX input on the 903, so that straight A–B work could be carried out.

The first difference to become apparent is that the Hitachi is not as sensitive, and even in full limiting the noise level slightly higher. Both parameters though are perfectly acceptable and astounding in a receiver of this price. Sound quality is high overall, but a bit hard in nature and prone to slight sibilance. Again though it compares more than favourably with the opposition around in its own price range.

Sensitivity and selectivity were good enough to allow usage for good stereo reception in fringe areas, and over a period of time listening remained a pleasure.

G, WOT CLASS!

Overall the 903 is an excellent product, and quite amazing value at its price. Think of it as a 160 W + 160 W receiver, with a good FM/AM department, and you can see that the 903 is cheap!

Class G amplification too comes out of this very well, a good example of a sound piece of technical innovation having played an important part in improving the sound subjectively.

It gave the 903 a sense of ease when handling peak signals, and allowed it to cruise happily at sustained levels it had no right to in the first place!

5 ETI Publications

Circuits No. 1 $5.00

A brand new concept from the house of ETI. More than 100 pages packed with a wide range of experimenters circuits. Based on the 'Tech Tips' section carried in the overseas editions of ETI, Circuits 1 is the first of a series of specials — produced for the enthusiasts who know what they want, but not where to get it! Circuits 1 will also act as a catalyst for further development of ideas, ideal for the experimenter. The collection of more than 200 circuits is complemented by a comprehensive index, making searches for a particular circuit quick and simple. Also, similar circuits can be compared easily, due to the logical layout and grouping used throughout. Last and by no means least, Circuits 1 has no distracting advertisements in the main section!

Top Projects No. 3 $2.50

Now available in Canada, this book contains 27 projects reprinted from the UK edition of ETI. Includes WaaWaa, Hifi Amp, Car Alarm, Audio Millivoltmeter, Pushbutton Dimmer, Expander-Compressor, Dual Tracking Power Supply, Photo Timer, Car Amp, Touch Switch, Exposure Meter, etc.

Top Projects No. 4 $2.50

Twenty-eight projects from the UK edition of ETI. Includes Twenty-Five Watt Hifi Amp, FM Tuner, Line Amp, Dual Beam Scope Adapter, Impedance Meter, DVM, Ignition Timing Light, Colour Organ, Radar Intruder Alarm, Electronic Ignition, Fluorescent Light Dimmer, Drill Speed Controller, etc.

Electronics — it's easy Volume 1 $3.50*

The best introductory series to electronics ever published in a magazine. Volume three completing the series, will be available in a few months. Volume One introduces electronics to the beginner by going through the systems approach, basic concepts, meters and measurements, frequency and wavelengths, electronics and communication, capacitance and inductance, capacitive and inductive reactance, resistance, capacitance and inductance in combination, detection and amplification, elements of transistor amplifiers, emitter followers and DC amplifiers, and basic operational amplifiers.

Electronics — it's easy Volume 2 $3.50*

Volume Two introduces the sources of power, simple power supplies, how regulated power supplies work, general purpose supplies, generating signal waveforms, generating non-sinusoidal waveforms, all about electronic filters, more about filters, introducing digital systems, the algebra of logic, integrated circuit forms of logic functions, digital sub-systems, counters and shift registers.

$6.00 For Both*

These publications are at present only available from ETI

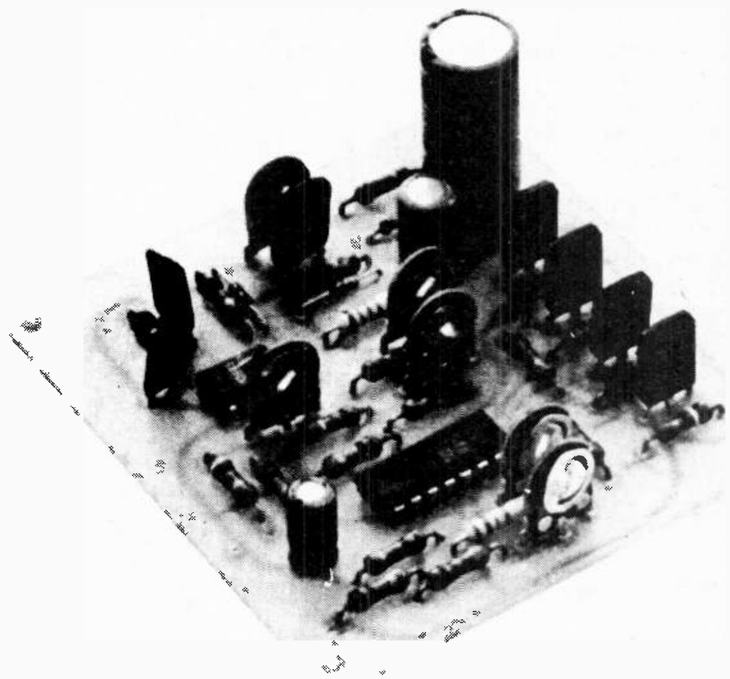
Send your order, with payment (not cash), to

ETI PUBLICATIONS
Electronics Today International
Unit Six
25 Overlea Boulevard
Toronto, Ontario
M4H 1B1

Please specify which publications you require, and print your name and address clearly.

Rev. Monitor-Counter

This design uses light bulbs to indicate the upper and lower limits of ideal rev ranges. Details are also given of an optional analogue tacho which can easily be added.



WE HAVE HAD many requests to publish the design of a digital tachometer for use in cars. However, a couple of factors make this less than a practical proposition.

The most important drawback is difficulty of reading the digital display. Many cars can rev out over a 5000 rpm range in less than two seconds; even with 100 rpm resolution this would have the second digit changing every 0.04 seconds.

Additionally, the simplest design principle — counting the number of pulses from the distributor over a period of time — would not offer acceptable resolution for a reasonable sampling rate. On a four-cylinder car, a two-digit readout, i.e. 100 rpm resolution, calls for a sampling time of 0.3 sec, while 3 sec is needed for a three-digit readout.

Analogue meters are easier to read but may be a little sluggish with cars which can rev out quickly in first gear. We therefore decided to design an analogue tacho and add three indicator lamps to give an instant indication or warning of engine speed. One of these is on below a set rpm indicating that the motor is below the ideal minimum, a second which is on between certain limits indicating the working range of the engine and the third comes on above a set rpm indicating too high an engine speed. All the limits are adjustable and by overlapping the limits five bands of engine speed can be indicated.

Where the vehicle is already fitted with a tacho, or one is not wanted, the lights can be used by themselves. This reduces the cost considerably, while the lights still give an indication of engine speeds and when to change gear.

CONSTRUCTION

The electronics can be assembled on the printed circuit board with the aid of the overlay in Fig 3. Due to the number of components, the use of the printed circuit board is recommended. The value of R4 should be selected from Table 1.

The mechanical arrangment for the lights and meter we have left to the constructor as variations in style required make it difficult to give any details.

ADJUSTMENT

The potentiometer RV1 should be adjusted to give stable readings over the entire rpm range. Calibration of the meter is done by RV2 and this should be done against a known instrument. The lights are adjusted by RV3, RV6, RV4 and RV5 (from the lowest to the highest limit) to whatever levels are required.

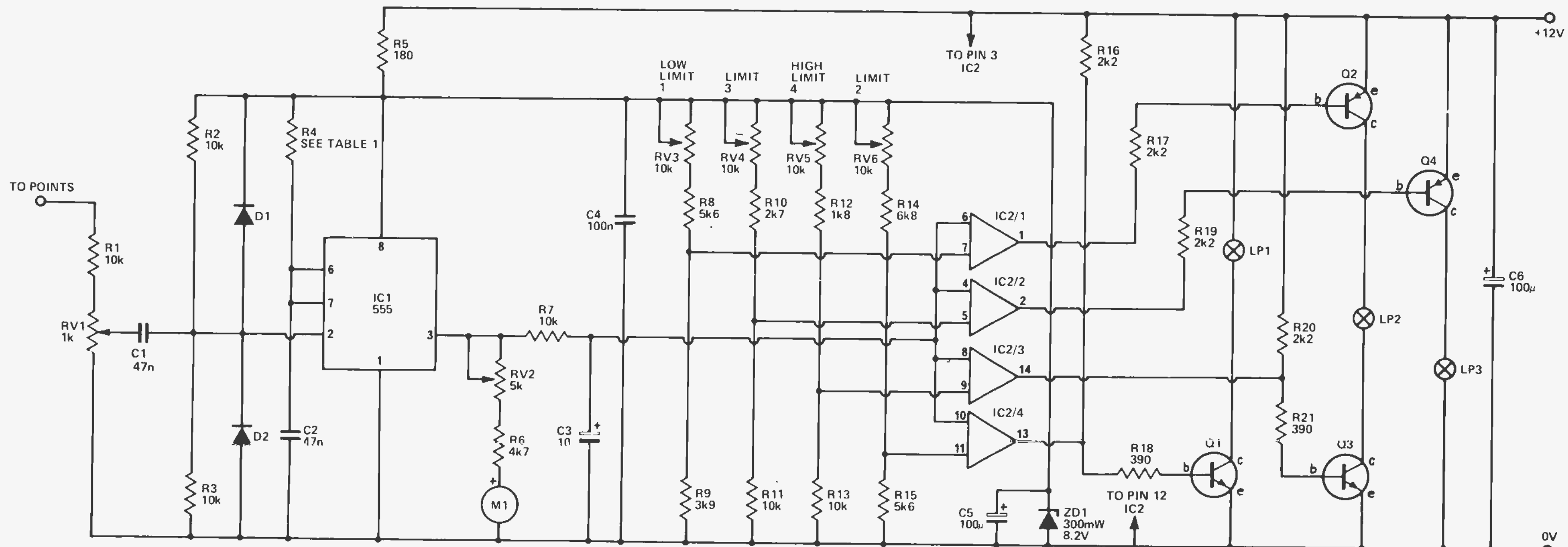


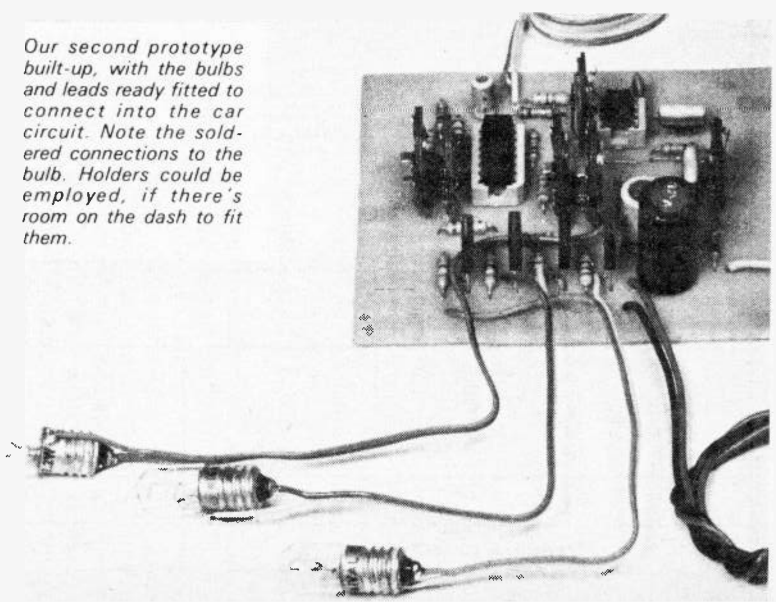
Fig. 1. Circuit diagram of the rev. monitor - counter.

HOW IT WORKS

The pulses from the distributor points are used to trigger a 555 timer IC1. This is connected as a monostable where the pulse width is 1.1 x R4 x C2 seconds. Pin 2 is normally at about 4 volts and the input pulse causes this to drop to less than the 2.7 V trigger point. The supply voltage for this IC is regulated to 8.2 V by ZD1. The output of this IC is a positive pulse on pin 3 and this is used to drive the meter to give a readout of rpm.

The output is also filtered by R7 and C3 to give an output voltage which is proportional to rpm. IC2 is a quad comparator which compares this voltage with four preset levels. If the input voltage is lower than the set level the output of the comparator will be high. The output of the LM339 is an open collector transistor and can only sink current and therefore appears as an open circuit when high.

Our second prototype built-up, with the bulbs and leads ready fitted to connect into the car circuit. Note the soldered connections to the bulb. Holders could be employed, if there's room on the dash to fit them.



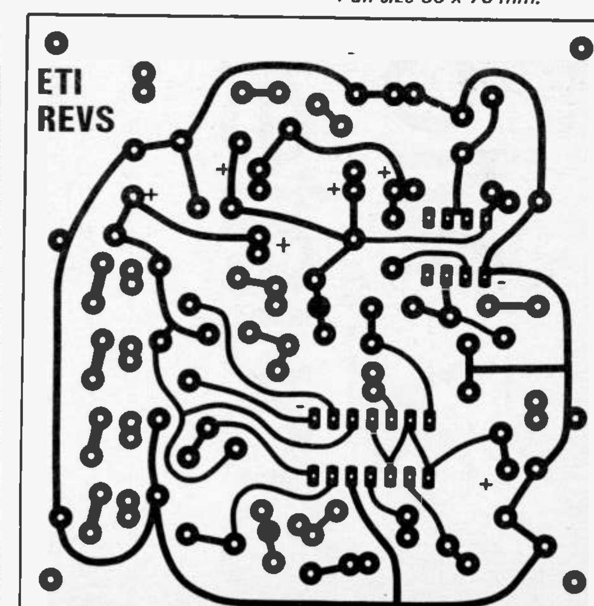


Fig. 2. Printed circuit layout. Full size 80 x 75 mm.

The outputs of IC2 control the transistors Q1 to Q4 which handle the current required by the lamps. If the rpm is below the lower limit Q1 and Q3 will be on lighting LP1 but as Q2 is off LP2 will be off. Above the first limit Q2 will be turned on and so LP2. Above the next limit Q1 and LP1 will turn off, above the next Q4 and LP3 will turn on, and finally when the upper limit is reached Q3 will turn off LP2 leaving only LP3 on.

TABLE 1

Value of R4	Number of cylinders		
Max. RPM	4	6	8
5000	100k	68k	47k
6000	82k	56k	39k
7000	68k	56k	39k
8000	68k	39k	33k

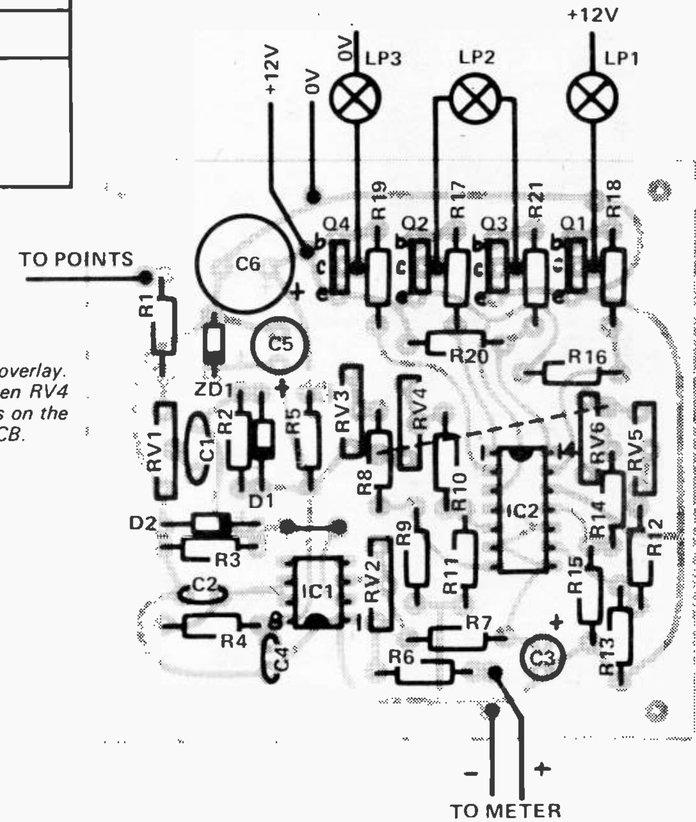


Fig. 3. Component overlay. Note the link between RV4 and RV6. This link is on the copper side of the PCB.

PARTS LIST

RESISTORS all ½W 5%

R1-3,7,11,13	10k
R4	See table 1
R5	180R
R6	4k7*
R8,15	5k6
R9	3k9
R10	2k7
R12	1k8
R14	6k8
R16,17,19,20	2k2
R18,21	390R

CAPACITORS

C1,2	47n polyester
C3	10u 16V electrolytic
C4	100n disc ceramic
C5	100u 16V electrolytic
C6	100u 25V electrolytic

POTENTIOMETERS

RV1	1k Vertical trim type
RV2	5k Vertical trim type*
RV3-RV6	10k Vertical trim type

SEMICONDUCTORS

IC1	555
IC2	LM339 see 'Buy-lines'
Q1,3	TIP 29C
Q2,4	TIP 30C
D1,2	1N914
ZD1	8V2 400mW

MISCELLANEOUS

PCB as pattern, LP1-3 12V lamps (2W2 Max) 1mA FSD Meter*, flexible wire, case to suit.
*Delete if tacho is not needed.

CLUBS

ETI likes clubs. Electronics clubs, computer clubs, radio clubs, audio clubs, etc.

Tell your club's Public Relations Officer (and if you haven't got one stand for the position yourself at your next meeting) that we want to hear from him (or her).

We, first of all, want to know that your club exists. So we can tell our readers.

Secondly we want to hear your plans — what's coming up and on what dates. Also funny stories about what you have done.

And if you want any help — a place to meet, unwanted equipment, etc. — we'd be happy to spread the word.

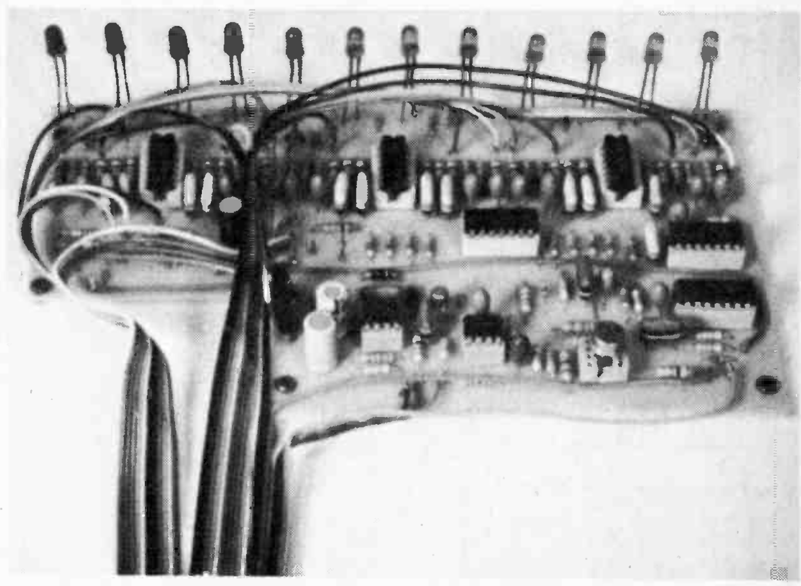
Write to Club Call, ETI Magazine, Unit Six, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

electronics today international

Coming up in March's ETI . . .

House Alarm

Protect your possessions with this sophisticated project. CMOS technology monitors your home as you leave, when you are away and when you return. The basic system has seven perimeter sensors and four internal ones, but these are all expandable — see the full project next month.



Hammer Throw

Press the play button and the hammer spins, first slowly then faster and faster. But don't let the speed build up too much or you will not be able to release the hammer at the correct place.

The straight line of LEDs shows you how far you throw the hammer; the faster the hammer at the time of release the further it travels.

Free Message Service

Do you know how, for the cost of a local phone call, you can send a message by radio to anyone in North America? Read more about this alternative communications network in ETI.

Equalization

Graphic equalisers, parameters equalisers, disc, tape, etc. . . . It is a wide subject but Wally Parsons manages to give you all the basic concepts in this informative article.

CANADA'S OWN ELECTRONICS MAGAZINE

Digital Panel Meter

This simple, economical yet highly accurate voltmeter uses a large liquid crystal display for easy reading and low power consumption. It can be the basis of many projects as well as being a useful meter in its own right.

WE INITIALLY purchased a number of Intersil evaluation kits for our own use but soon realised that while they were very good electronically, the physical layout wasn't too hot. We therefore redesigned the PC board, reducing the size dramatically, adding the decimal point drive circuitry and some dropping resistors and zener diodes to allow the board to run from a dual power supply of +/– 5V or more (e.g. with op-amps).

This resulted in a very useful device which we decided to run as a project. It is basically a panel meter suitable for DC voltage and current (with a shunt) and could be used in a variety of projects.

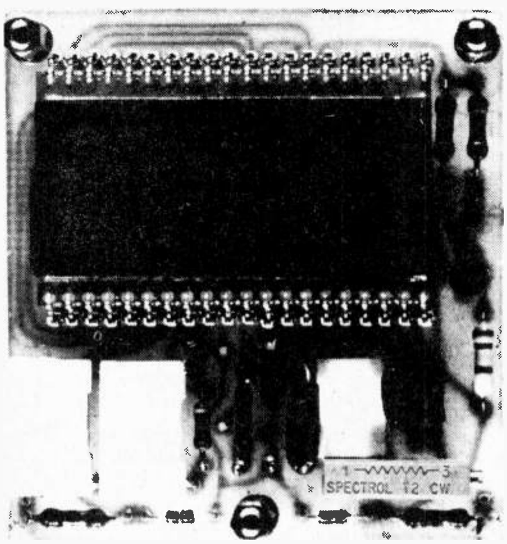
CONSTRUCTION

To save on real estate, the main IC is mounted under the display. We used the Molex connectors supplied with the evaluation kit for the display and soldered the IC directly into the board. If you want to mount the IC in a socket a low profile type should be used, with a high one for the display. As a socket is not available for the display a standard 40 pin one can be cut up to fit.

However before fitting either the display sockets or the IC, fit all the other components first. The over lay in fig. 3. shows the positioning of the components. Most of the components come with the evaluation kit. The large capacitors are laid on their side to minimise height.

When fitting the IC solder pins 1 and 26 first (the power supply pins) so that the protection diodes on the inputs can operate, thus preventing damage by static electricity. It is necessary that a small tipped iron and fine solder be used to prevent bridging tracks. The Molex sockets can now be fitted in two strips of 20 with the top connecting pieces being broken off using long nosed pliers after they are soldered in.

As there are no polarity marks on the display it is necessary to hold it at an angle to the light and look for the outline of the digits. The full format of the display is shown in fig. 2. In this unit the arrow, semicolon and the vertical part of the + sign are not used.



SPECIFICATIONS

Full scale reading	200mV
Resolution	100μV
Accuracy	$<$1 digit
Display	3½ digit LCD
Input impedance	$>10^{12}$ ohms
Input bias current	≈2 pA
Polarity	automatic
Conversion method	dual slope
Reference	internal ± 100ppm
Power supply	±5V to ± 15V dc 1mA @ ±5V

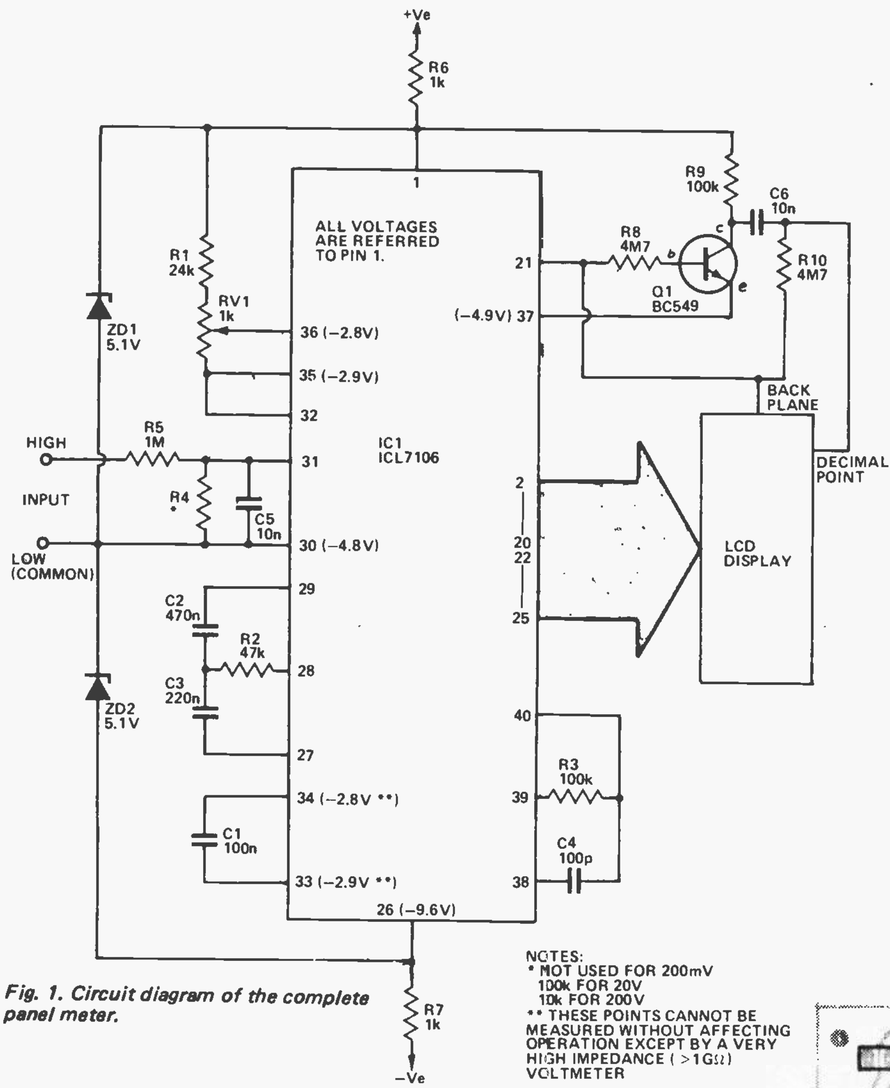


Fig. 1. Circuit diagram of the complete panel meter.

NOTES:
* NOT USED FOR 200mV
100k FOR 20V
10k FOR 200V
** THESE POINTS CANNOT BE MEASURED WITHOUT AFFECTING OPERATION EXCEPT BY A VERY HIGH IMPEDANCE (>1GΩ) VOLTMETER

HOW IT WORKS

Not much can be said on how this project works as everything is done by one IC and if anything goes wrong it is usually the IC. We have included some waveform diagrams and voltages for reference purposes. The conversion works on the dual-slope integration technique, which is the most reliable of the simple methods available. A capacitor is charged up at a rate proportional to the input voltage for a predetermined time (in this case 1000 clock pulses), then it is discharged at a constant rate until it reaches the starting point again. The time taken to do this (i.e. the number of clock pulses) is proportional to the input voltage.

It is a true dual polarity system where the integration direction depends on the polarity of the input voltage. Provided AC ripple on the input averages to zero over 1000 clock pulses it will be rejected, hence where 60Hz AC is to be rejected a 48 kHz clock should be used, giving 83 ms sample time (5 cycles of 60 Hz). The clock can be adjusted by varying R3 if desired. R3 if desired.

For further details of the IC see the data sheet in this issue.

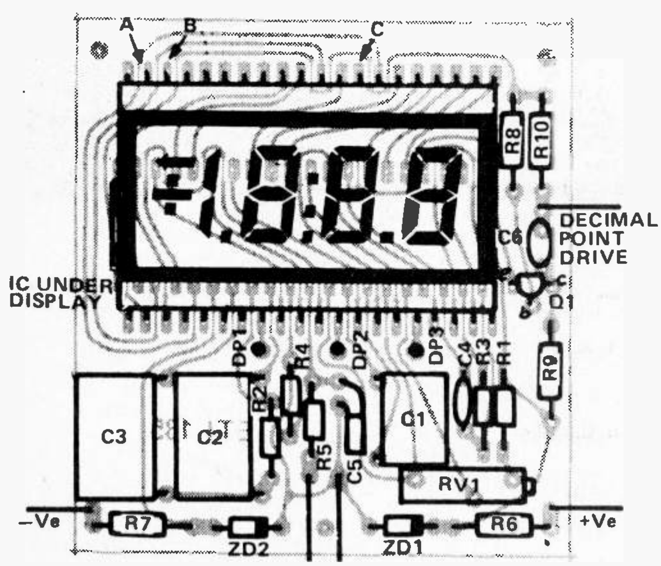


Fig. 2. Component overlay with the display in place. Points marked A, B and C are the unused display segments — the vertical part of the + sign, the arrow and the semicolon respectively.

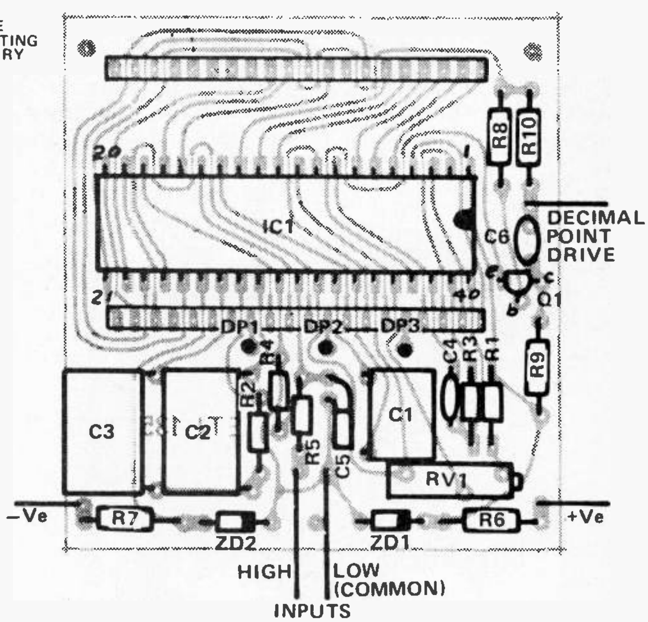


Fig. 3. The component overlay without the display showing the positioning of the integrated circuit.

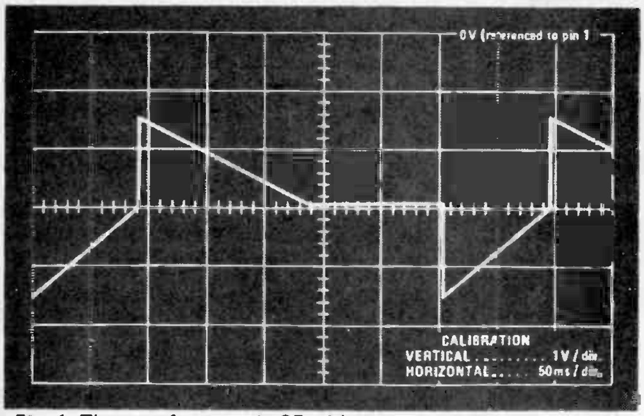


Fig. 4. The waveform at pin 27 with a negative input voltage of about 170mV.

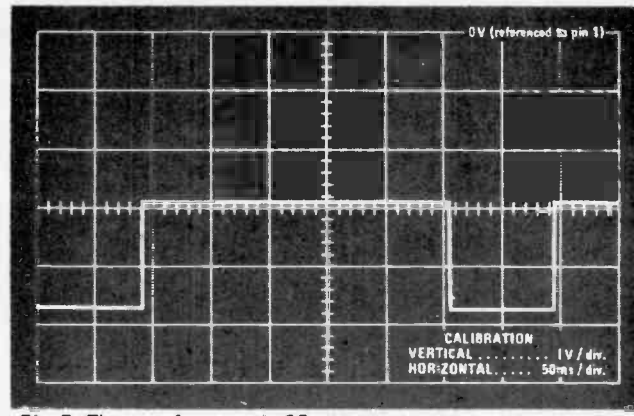


Fig. 7. The waveform at pin 28.

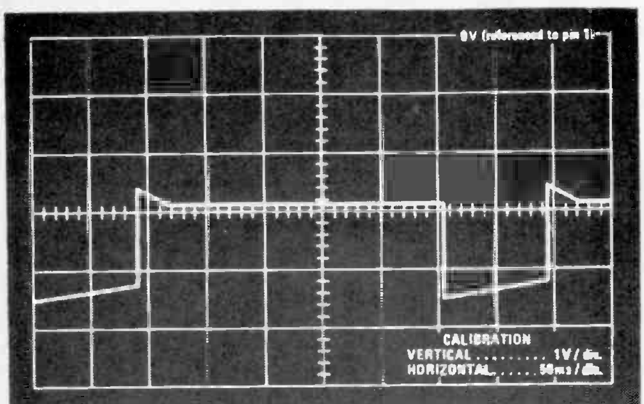


Fig. 5. The waveform at pin 27 with a negative input voltage of about 30mV. Compare this with Fig. 4.

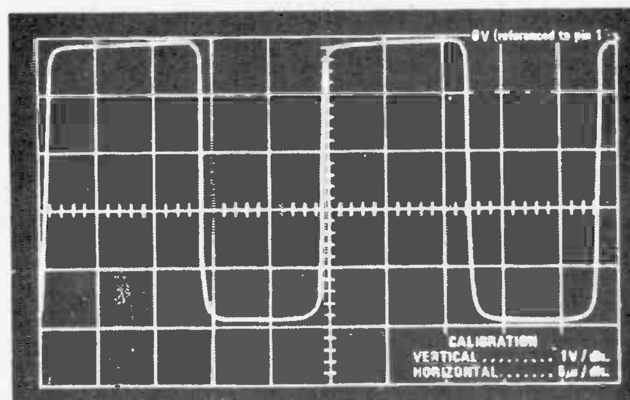


Fig. 8. The output of the master oscillator on pin 38.

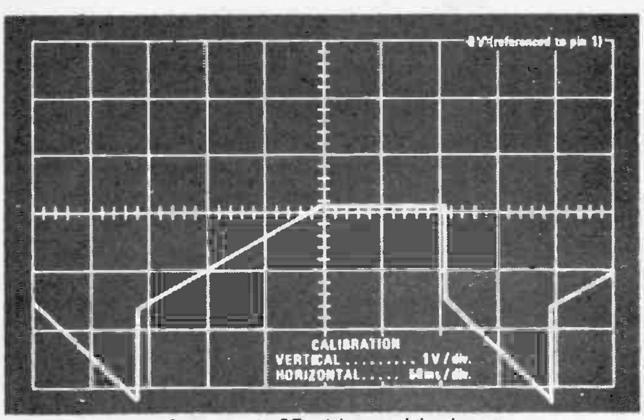


Fig. 6. The waveform at pin 27 with a positive input voltage of about 170mV.

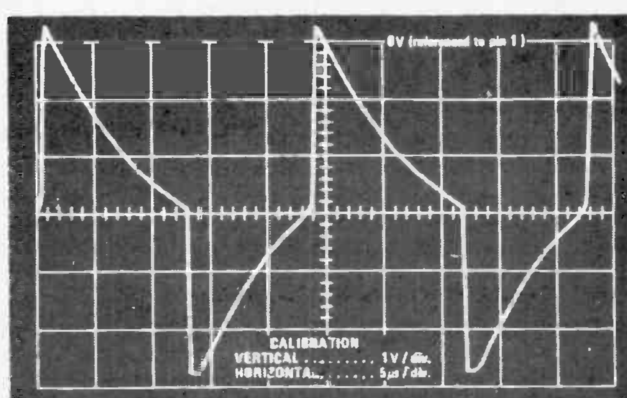


Fig. 9. The input of the oscillator — pin 40.

The Intersil evaluation kit containing most of the parts for this project is available from Zentronics Ltd. 99 Norfinch Dr., Downsview, Ontario, also in Montreal and Ottawa. The part number is 7106 EV/KIT, and it costs around $42. The 7106 itself, (and 7107 LED version) costs around $15.

PARTS LIST

RESISTORS all ¼ or ½ W, 5%
R1* 24k
R2* 47k
R3* 100k
R4 . . . . see circuit diagram
R5* 1M
R6 . . . . 1k
R7 . . . . 1k
R8 . . . . 4M7
R9 . . . . 100k
R10 . . . . . . 4M7

POTENTIOMETERS
RV1* . . . . . . 1k 10 turn trim

SEMICONDUCTORS
IC1* ICL7106
Q1 . . . . 2N3904
ZD1,2 . . . . . 5.1V 300mW

MISCELLANEOUS
PC board
LCD display
* Socket for LCD display

* These components are supplied with the Intersil ICL7106EV evaluation kit.

ETI DATA SHEET

INTERSIL ICL7106/7107 Digital Panel Meter IC

These chips provide all the works for 3½ digit LED or LCD panel meters using low power CMOS

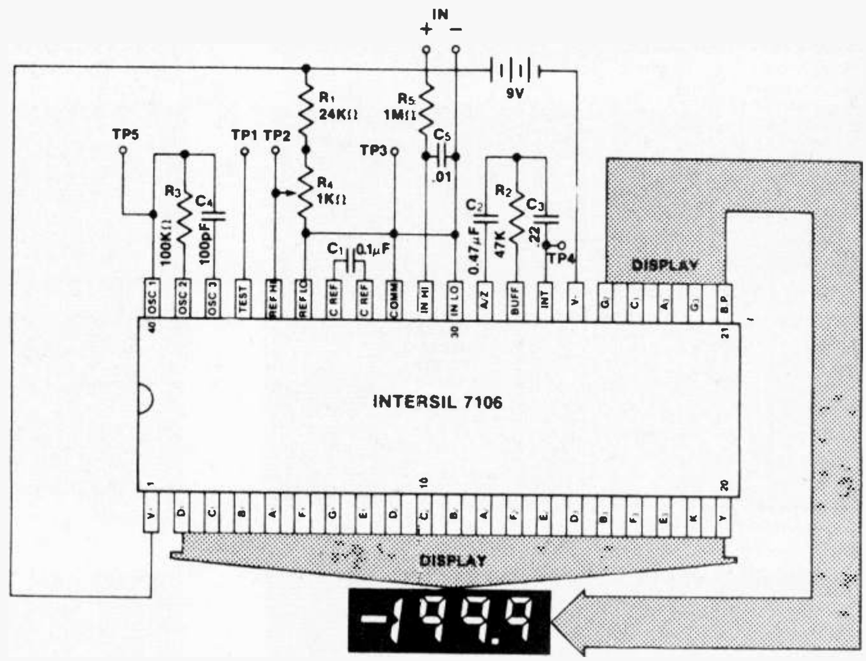


Fig. 3. LCD Digital Panel Meter Using ICL7106.

THE ICL7106 and 7107 are high performance, low power, CMOS 3½ digit A/D converters that contain all the necessary active devices on a single monolithic IC. Each has parallel seven-segment outputs which are ideal for use in a digital panel meter. The ICL7106 will directly drive a liquid crystal display including the backplane drive. The ICL7107 will directly drive instrument size LEDs without buffering. With seven passive components, display and power supply, the system forms a complete digital voltmeter with automatic zero connection and polarity (see figs. 3 and 4).

Both ICs use the time-proven dual slope integration technique with all its advantages, i.e. non-critical components, high noise rejection, non-critical clock frequency and almost perfect differential linearity. Both the ICL7106 and 7107 can be used not only with its internal reference, but true ratiometric reading applications may also be accomplished over a full scale input range of 199.9 mV to 1.999 V.

The accuracy of conversion is guaranteed to plus or minus 1 count over the entire plus or minus 2000 counts and the auto-zero facility provides a guaranteed zero reading for 0 volts input. However, the chip does provide a true polarity output at low voltages for null detection. Both chips have an on-board clock and reference circuitry, as well as overrange detection.

DISPLAYS AND DPs

The additional components required to build a DPM are a display (either LCD or LED), 4 resistors, 4 capacitors, and an input filter if required. Liquid crystal displays become polarised and damaged if a DC voltage is continuously applied to them, so they must be driven with an AC signal. To turn on a segment, a waveform 180 degrees out of phase with the backplane drive (but of equal amplitude) is applied to that segment. The 7106 generates the segment drive waveform for all digits internally, but does not generate segment drive for the

Fig. 1. Pin Configuration.

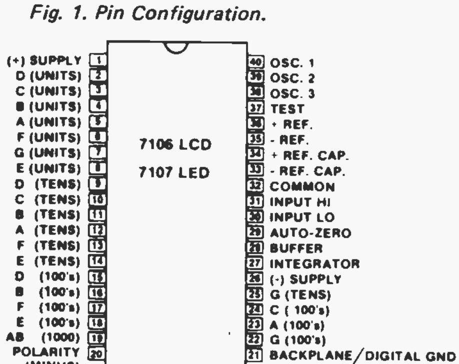
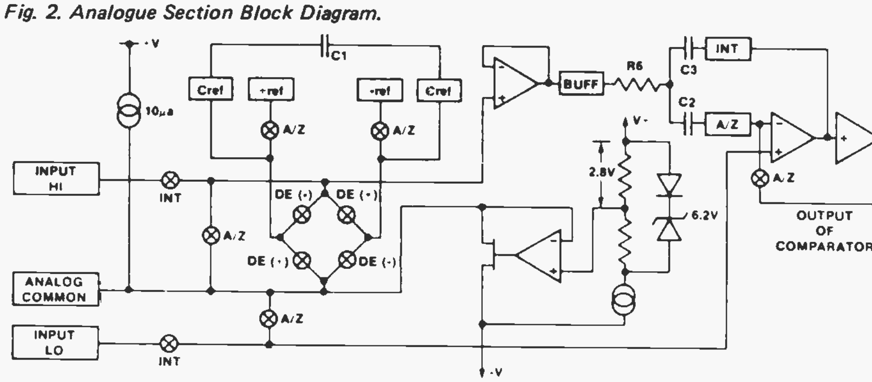


Fig. 2. Analogue Section Block Diagram.



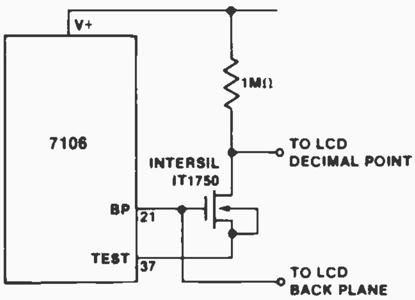


Fig. 5. Simple Inverter for fixed decimal point.

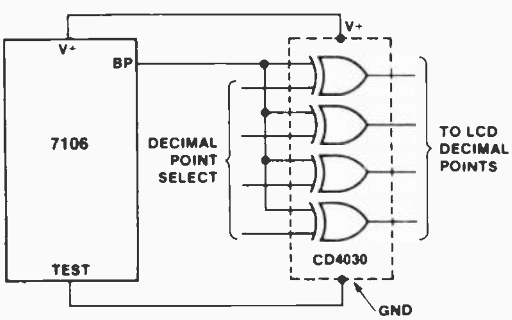


Fig. 6. Exclusive-OR gate for DP drive.

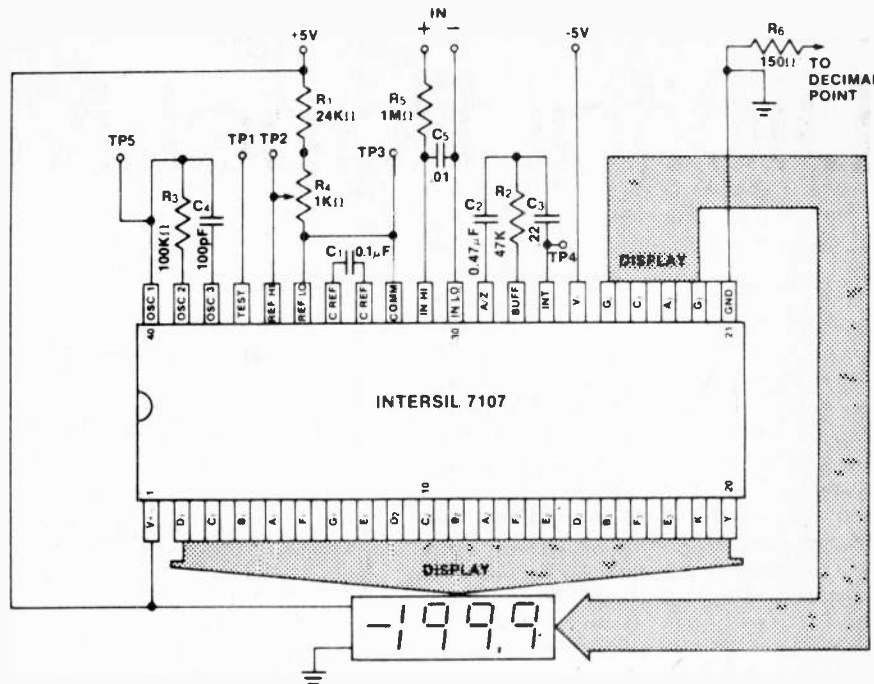


Fig. 4. LED Digital Panel Meter Using ICL7107.

decimal point. This must be done using an inverter or exclusive-OR logic (see figs. 5 and 6). For use with LED displays the 7107 pull-down FETs will sink about 8 mA per segment, which produces a bright display suitable for almost any indoor application. A fixed decimal point can be turned on by tying the appropriate cathode to ground through a 150 ohm resistor.

CAPACITORS

The integration capacitor should be a low dielectric-loss type, such as a polypropylene. Mylar capacitors are suitable for the reference and auto-zero capacitors.

THE CLOCK

The chip carries the active parts of an RC oscillator which runs at about 48 kHz and is divided by 4 for use as the system clock. The integration period (1000 clock pulses) is therefore 83.3 ms. Each conversion requires 4000 clock pulses, i.e. 3 readings per second. This is optimum for rejecting 60 Hz line frequency, 1000 clock pulses being 5 cycles.

THE REFERENCE

For 200.0 mV full scale, the voltage applied between REF Hi and REF Lo should be set at 100.0 mV. For 2.000 V full scale, this should be 1.000 V. The reference inputs are floating, and the only restriction on the applied voltage

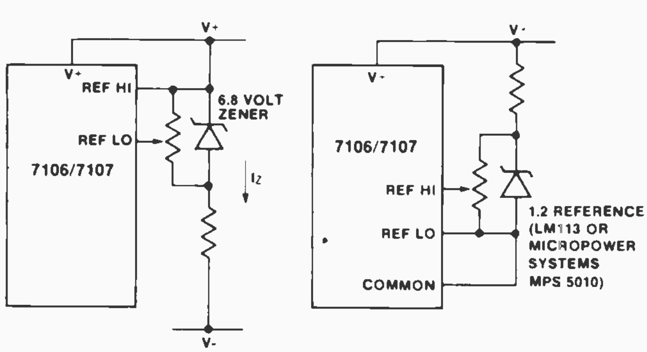


Fig. 7. Using an external reference.

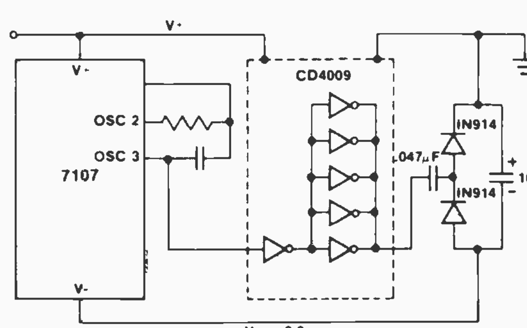


Fig. 8. Generating a negative supply from +5 V.

ETI DATA SHEET

is that it should lie in the range V– to V+.

For many applications, the internal reference of 2.8 V between V+ and COMMON is adequate, but power dissipation in the 7107 LED version can wreck this. However, an external reference can be added as shown in fig. 7.

POWER SUPPLIES

The 7106 will run from a single 5 to 12 V supply. If INPUT Lo is shorted to COMMON, this will cause V+ to sit 2.8 V positive with respect to INPUT Lo, and V– at 6.2 V negative with respect to INPUT Lo.

The 7107 requires dual supplies, +4.5 to +6 V and –3 to –6 V at 1 mA. A negative supply may be derived from +5 V using the circuit given in fig.8.

FURTHER INFORMATION

Evaluation kits for the 7106 and 7107 are supplied with a data sheet and application note. In addition, Intersil produce three other Application Bulletins: A016 'Selecting A/D Converters', A017, 'The Integrating A/D Converter', and A018 'Do's and Dont's of Applying A/D Converters'.

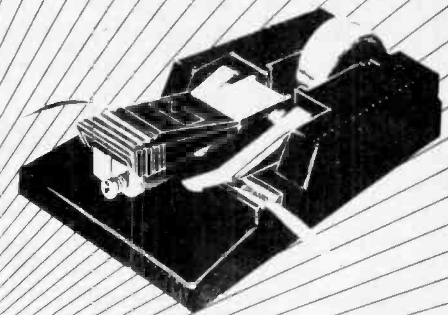
Electrical Specifications: ICL7106/7107

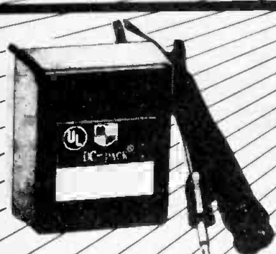
Full Scale Voltage Rating	∓200 mV (5.0 V min V+ to V–) ∓2.0 V (6.0 V min V+ to V–)
Full Scale Digital Range	∓2000 counts
Accuracy with external reference 10° to 50° C	<½ count
Noise referred to input	15 µV typical
Input circuit	Differential
Input Bias Current	2 pA
Input Impedance	>1 TΩ
Reference (Internal)	2.8 V, referenced to V+ Temperature Coefficient 100 ppm typical
Conversion Characteristic	Dual Slope with Auto-zero Integrating Time = 1000 counts Reference Time = 0 – 2000 counts Auto-zero time = 1000 + 2000 – Ref. Time

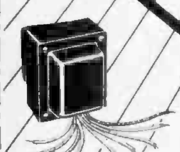
Recommended External Components:

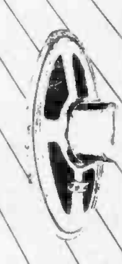
	200 mV full scale	2 V full scale
Integrating Cap (C3)	0.22 µF	0.22 µF
AZ Cap (C2)	0.47 µF	0.047 µF
Ref. Cap (C1)	0.1 µF	0.1 µF
Clock Cap (C4)	100 pF	100 pF
Integrator Resistor (R6)	47 kΩ	470 kΩ
Clock Resistor (R3)	100 kΩ	100 kΩ

Clock Frequency	48 kHz, internally divided by 4
Power Requirements	LCD: 1 mA at 4.5 – 6 V LED: 1 mA at 4.5 – 6 V, plus LED current
Read Rate	Accurate from .1 to 15 readings per second





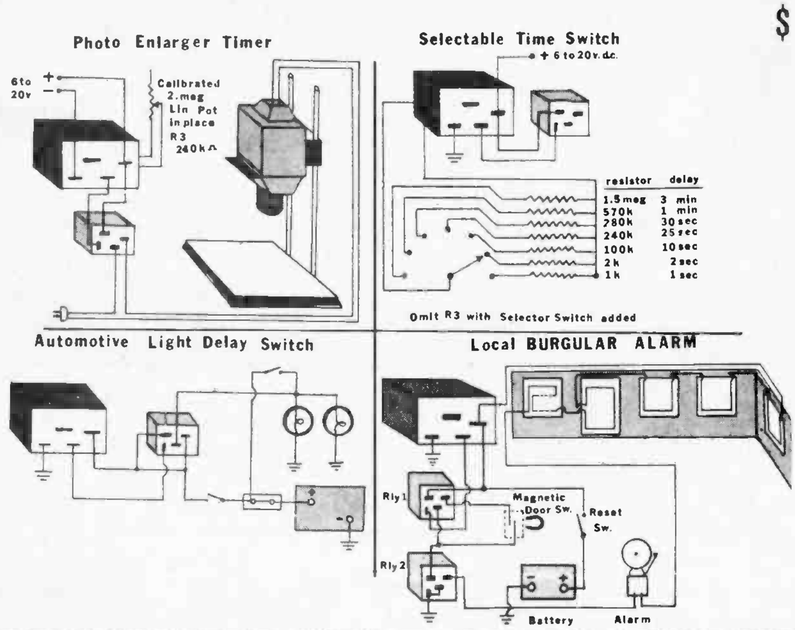




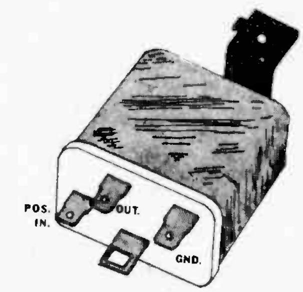
FOR THE HOBBYIST

SOLID STATE TIMERS

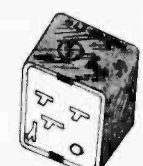
APPLICATIONS



$ 3.95 pr.



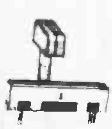
25 Second Turn On SOLID STATE AUTO TIMER



Normally Closed SPST Relay

CONTROLS

Slide



$1.29

MODEL		TRAVEL
JJ-10006	10K	30mm
JJ-10006B	100K	30mm
JJ-10006C	500K	30mm
JJ-10006D	1 MEG	30mm

$1.59

MODEL		TRAVEL
JJ-10007	10K	45mm
JJ-10007A	50K	45mm
JJ-10007B	100K	45mm
JJ-10007C	500K	45mm
JJ-10007D	1 MEG	45mm

Available in log taper only

Knob included

PIHER

Available in
10 K ohms
50 K ohms
100 K ohms
log or linear taper

Matching Knob

SLIDER CONTROLS

60mm Travel

$2.49

49¢

49¢ *Rotary* 69¢

SINGLES	DUALS
100	1 meg - 500K
220	200K -dual
470	10K - 5K
500	200K - 500
750	10K - 500
1K	500 - 5K
2K	100 - 25K
2.5K	50K - 100
5K	100 - 20K
10K	50K - 150
20K	20K - 200K
50K	500 - 10K
100K	5K dual
200K	
750K	
1meg	
2.5meg	

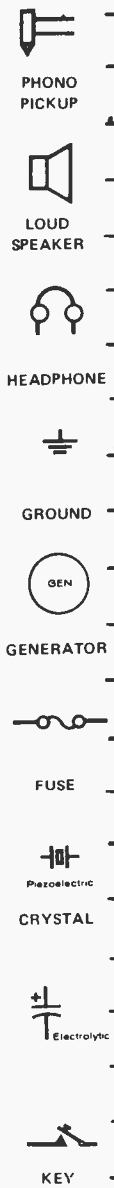
DOMINION RADIO & ELECTRONICS COMPANY

THE HOME OF RADIO & ELECTRONIC SUPPLIES

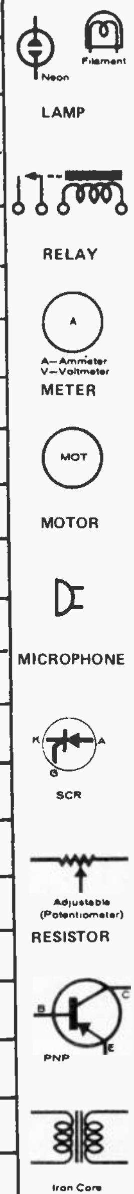
ELECTRONIC PROJECTS

Jana

HOBBYIST and SCHOOL LEARNING BY DOING and LOTS OF FUN



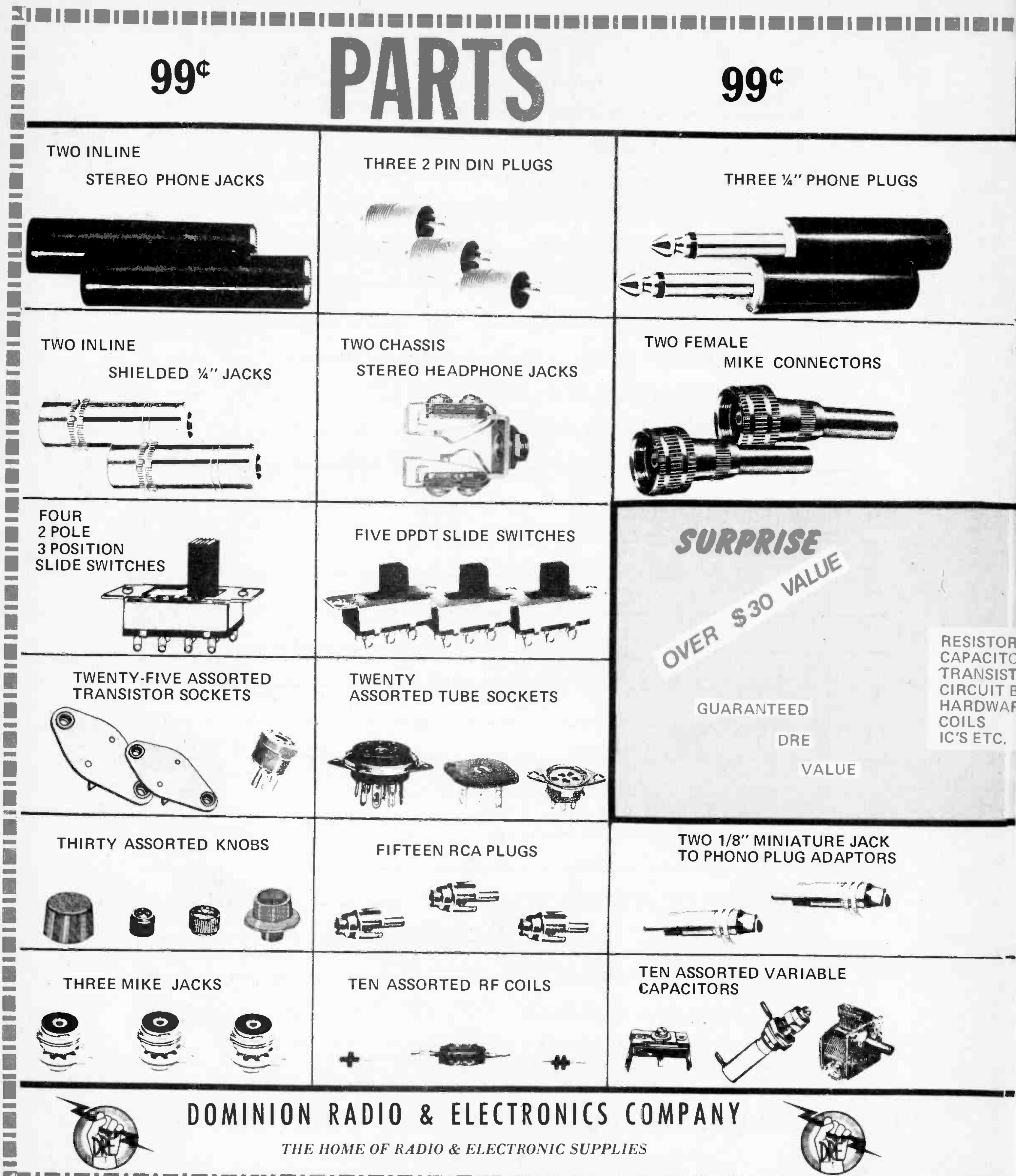
1.	**AUTOMATIC HEADLIGHT REMINDER** Novel circuit to remind you to turn your headlights off if they are left on when the ignition is off.	$ 4.25
2.	**BATTERY OPERATED FLORESCENT LIGHT KIT** Useful circuit that can be built into small (20 W max) fluorescent fixture in mobile vans & campers for 12 VDC	$14.25
3.	**BUG SHOO** Produces a sound to keep annoying bugs away.	$ 5.25
4.	**CODE OSCILLATOR** Practice up your "Morse Code" with this simple project.	$ 5.55
5.	**CRYSTAL RADIO** Crystal radio receiver picks up local AM radio stations.	$ 4.95
7.	**CURIOSITY BOX II** Great for parties — a novelty electronic item.	$ 7.25
8.	**DALLY LIGHTER** Time delay circuit for turning a light circuit off after a predetermined length of time.	$ 5.75
9.	**DECISION MAKER** Novelty item — great for the junior electronic enthusiast.	$ 4.25
10	**FISH CALLER** A real fisherman's lure — not guaranteed to catch the big one but only to make it more interesting.	$ 4.25
11.	**HI POWER 12 V DC FLASHER** Electronic signal flasher circuit for warning lights, etc.	$ 7.25
12.	**PHOTO ELECTRIC NIGHT LIGHT** Night watchman — turns lights on at dusk and off at dawn.	$ 5.50
13.	**6V POWER SUPPLY** Regulated & filtered 6V DC power supply 1/2 amp.	$ 9.95
14.	**9V POWER SUPPLY** Regulated & filtered 9V DC power supply 1/2 amp.	$ 9.95
15.	**0-24 V POWER SUPPLY** Variable regulated & filtered power supply @ 1 amp.	$18.69
16.	**SINGLE CHANNEL COLOR ORGAN** Dancing lights are possible by connecting this to your HiFi and adding a light bulb.	$ 5.75
17.	**ELECTRONIC SIREN** Police siren simulator.	$ 4.59
18.	**SHIMMER STROBE LIGHT** Shimmer light is great for special lighting effects.	$ 6.25
19.	**TONE GENERATOR** Audio tone generator produces different tones by "waving your hand".	$ 5.59
20.	**5 TRANSISTOR 1 WATT AMPLIFIER** HiFi quality amplifier — great for many uses.	$ 7.25
21.	**TUBE CONTINUITY CHECKER** Tube filiament tester for 7, 8 and 9 pin tubes.	$ 3.69
22.	**XENON STROBE** Super strobe effects are possible with this Xenon strobe.	$10.95
23.	**LJ 12016A COLOR ORGAN** 3 Channel color organ complete with PC board & instructions. 300W per channel.	$19.95
24.	**LOUDMOUTH SIREN** Various siren like tones are produced with an ear shattering noise level *NEW*	$11.25
25.	**ROULETTE WHEEL** Great party item — duplicates the real Vegas game, electronically. *NEW*	$ 9.95



Jana projects have been developed and refined over the past few years with the help and assistance of teachers in the school system. Many of our projects are part of the electronics teaching programs in many provinces. Each of the projects illustrate a principle of electronics. These principles may be covered in depth or they may be just accepted as is.

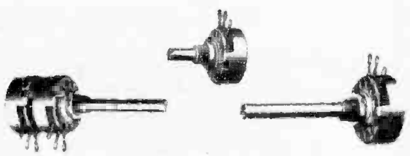
DOMINION RADIO & ELECTRONICS COMPANY

THE HOME OF RADIO & ELECTRONIC SUPPLIES

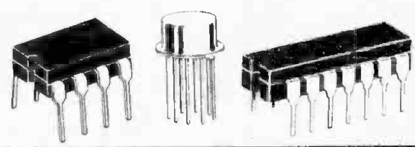

99¢
PARTS
99¢
TWO INLINE
STEREO PHONE JACKS
THREE 2 PIN DIN PLUGS
THREE ¼" PHONE PLUGS
TWO INLINE
SHIELDED ¼" JACKS
TWO CHASSIS
STEREO HEADPHONE JACKS
TWO FEMALE
MIKE CONNECTORS
FOUR
2 POLE
3 POSITION
SLIDE SWITCHES
FIVE DPDT SLIDE SWITCHES
SURPRISE
OVER $30 VALUE
GUARANTEED
DRE
VALUE
RESISTOR
CAPACITO
TRANSIST
CIRCUIT B
HARDWAF
COILS
IC'S ETC.
TWENTY-FIVE ASSORTED
TRANSISTOR SOCKETS
TWENTY
ASSORTED TUBE SOCKETS
THIRTY ASSORTED KNOBS
FIFTEEN RCA PLUGS
TWO 1/8" MINIATURE JACK
TO PHONO PLUG ADAPTORS
THREE MIKE JACKS
TEN ASSORTED RF COILS
TEN ASSORTED VARIABLE
CAPACITORS
DOMINION RADIO & ELECTRONICS COMPANY
THE HOME OF RADIO & ELECTRONIC SUPPLIES

BARGAINS 99¢

FIVE ASSORTED VOLUME CONTROLS

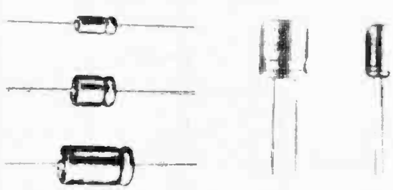


TEN ASSORTED INTEGRATED CIRCUITS



2 – 300 WATT BULBS (Standard base)
or
2 – 500 WATT BULBS (Standard base)
or
2 – 1000 WATT BULBS (Mogul base)

TWENTY ASSORTED ELECTROLYTICS



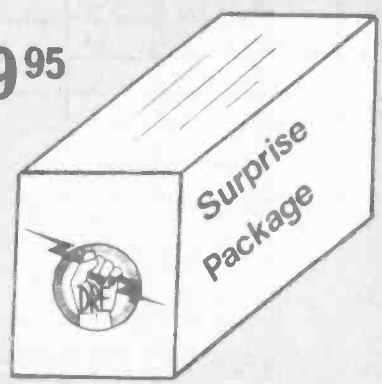
FIFTEEN ASSORTED MINIATURE BULBS

ONE POUND ASSORTED HARDWARE

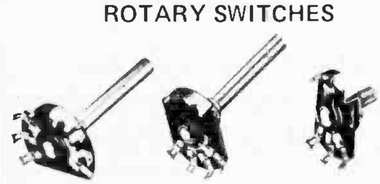
PACKAGE

$9.95

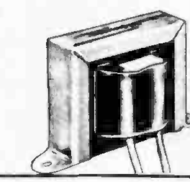
S
RS
ORS
OARDS
E



EIGHT ASSORTED ROTARY SWITCHES



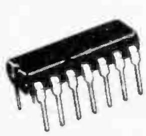
THREE ASSORTED FILTER CHOKES



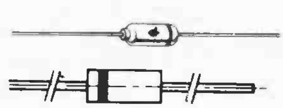
TWENTY ASSORTED SEMICONDUCTORS

TWO NE 555 TIMERS

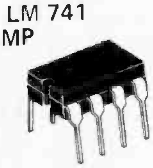
FOUR SN7402 IC'S



TEN ZENER DIODES



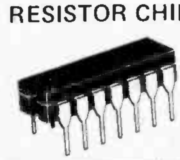
TWO LM 741 OP AMP



ONE HUNDRED ASSORTED RESISTORS

THIRTY ASSORTED SPADE LUGS

TEN RESISTOR CHIPS



DOMINION RADIO & ELECTRONICS COMPANY

THE HOME OF RADIO & ELECTRONIC SUPPLIES

ELNA

ELECTROLYTIC AND TANTALUM CAPACITORS

AXIAL LEAD

uf c \ wv (sv)	16. (20)	25 (32)	50 (63)	80 (100)
1			.15	
2.2			.15	
3.3			.15	
4.7			.15	
10	.15	.15	.20	.25
22	.20	.20	.25	.30
33	.20	.25	.25	.30
47	.25	.25	.30	.35
100	.25	.30	.40	.50
220	.30	.35	.50	.60
330	.35	.45	.60	
470	.40	.50	.70	.90
1000	.50	.60	.90	1.10
2200	.65	.90		
3300	.90	1.20		
4700	1.20	1.50		

RADIAL LEAD

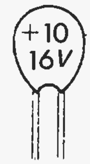
uf c \ wv (sv)	16 (20)	25 (32)	50 (63)	80 (100)
1			.10	
2.2			.10	
3.3			.15	
4.7		.10	.15	
10	.15	.15	.15	.20
22	.15	.15	.20	.20
33	.15	.20	.20	.25
47	.20	.20	.25	.30
100	.20	.20	.30	.35
220	.20	.25	.40	.50
330	.25	.30	.50	
470	.30	.35	.70	
1000	.45	.60		
2200	.60			

POWER SUPPLY TYPE

uf c \ wv (sv)	16 (20)	25 (32)	50 (63)	100 (125)
2200		1.80	2.50	4.00
3300	1.80	2.20	3.00	5.50
4700	2.00	2.50	3.50	6.00
6800	2.50	3.00	4.50	8.50
10000	3.00	3.50	6.00	
15000	3.50	4.50	8.50	
22000	4.50	5.50		
33000	5.50			
47000	6.50			

PRICE INCLUDES MOUNTING CLAMPS

Note: WV – Rated Voltage (V)
SV – Surge Voltage (V)
C – Rated Capacitance (uf)



DIPPED SOLID TANTALUM

Capacitance Tolerance −20 +20%

DC Leakage Current (uA) 0.02 or 1.0

uf c \ wv (sv)	16 (20)	25 (32)	35 (46)
0.22			.25
0.33			.25
0.47			.25
0.68			
1.0			.25
1.5			.25
2.2			.25
3.3			.25
4.7	.25		.30
6.8	.25		.30
10	.30	.35	.30
15	.30	.35	.50
22	.30	.50	.70
33	.50	.70	1.10
47	.70	1.10	1.50
68	1.10	1.50	
100	1.50	1.90	

ATTENTION !

SAVE MONEY ON VOLUME BUYS

RADIAL & AXIAL LEAD ELECTROLYTIC CAPACITORS

100 of each value – LESS 10 %
1000 mixed values – LESS 15 %
1000 of each value – LESS 20 %

POWER SUPPLY CAPACITORS

25 of each value – LESS 10 %
100 mixed values – LESS 15 %
100 of each value – LESS 20 %

TANTALUM CAPACITORS

50 of each value – LESS 10 %
100 mixed values – LESS 15 %
100 of each value – LESS 20 %

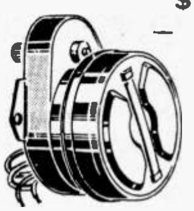
ALL ABOVE ARE PER UNIT PRICES

DOMINION RADIO & ELECTRONICS COMPANY

TIMING MOTORS

2 RPM

#M10 $1.29



- ★ 5" Leads
- ★ Dustproof Gear Housing
- ★ Self Starting
- ★ Sizes: 2½" x 1¼" x 2"
- ★ All Operate on 117 V. AC.

FAST ACTING

FUSES

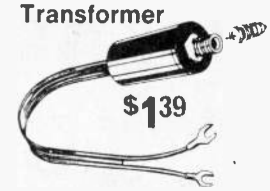
SPECIAL

½ AMP	3 AMP
1 AMP	4 AMP
2 AMP	5 AMP

89¢ PACK OF 5

250 Volt or Less
1/4 x 1 1/4 inch.Glass Tube.Formerly 3AG

75-300 OHM Matching Transformer

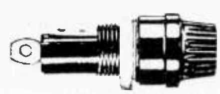


$1.39

N-9065. CATV MATCHING TRANSFORMER. Now you can match the impedance of any CATV co-axial line to the impedance of your TV or FM receiver. Converts 75 ohms CATV output to 300 ohms FM/TV input. Hardware and F-59 connector included.
N-9066. Same as above but with slimline ½" casing.

HOOK UP WIRE

65¢ 100'



69¢

Panel Mount Fuse Holder
Bayonet type Knob - ½" (12.7 mm) panel hole. Accommodates all ¼" (6.3 mm) x 1¼" (31.7 mm) Fuses.

19¢

N-F59.

N-F59. MALE CONNECTOR. For use with RG-59/U cable. Fits F-61, F-61A, F-81 and F-81B Connectors. Ferrule supplied.

DOMINION RADIO & ELECTRONICS CO.

THE HOME OF SURPLUS RADIO & ELECTRONIC SUPPLIES
535 YONGE STREET
TORONTO 5, ONT.

SHIP TO ______

STREET OR R.R. NO. ______

TOWN ______ PROV. ______

PLEASE PRINT YOUR NAME AND ADDRESS CLEARLY.

FOR OFFICE USE ONLY
(DO NOT FILL IN)

SHIPPED VIA ______
AMT. ______
REFUND ______
OWING ______
B # ______
______
DATE ______

FILL IN AMOUNT ENCLOSED

MONEY ORDER $ ______	CHEQUE $ ______
CASH $ ______	C. O. D. ☐

IMPORTANT – Please use a separate sheet for all correspondence to speed your order and assure prompt reply to your letter.

IF YOU MOVED, PLEASE ADVISE NEW ADDRESS.

PLEASE NOTE:
MINIMUM ORDER
SHIPPED $5.00

master charge
THE INTERBANK CARD

MASTERCHARGE NO. ______

SIGNATURE ______

DO NOT USE	QUANTITY DESIRED	STOCK NUMBER	DESCRIPTION (Show Manufacturer's Name Whenever Possible)	PRICE: Each, Foot, Set, Pair, Roll, Pkg., Etc.	TOTAL PRICE DOLLARS	CENTS

SPEED DELIVERY — CERTIFY YOUR CHEQUE IN ADVANCE

TOTAL ______

ALL GOODS ARE FOB TORONTO

Ontario Residents ONLY ADD 7% SALES TAX ______

POSTAGE AND INSURANCE ______

AMOUNT ENCLOSED ______

POSTAGE AND HANDLING CHARGES:
Consult with your local postmaster for prevailing postage rates. If you are unable to ascertaint what the charges will be, please include about 10% extra to cover postage and handling. We will refund any overpayment.

LIMITED OFFER! CHOOSE YOUR PROJECTS BOOK

FREE WHEN YOU TAKE A SUBSCRIPTION TO ETI

OFFER CLOSES MAR. 31st 1978

These two projects books are worth five dollars — see the ad on page 24 for more details

Use this coupon if somebody's already used the card

To:

ELECTRONICS TODAY INTERNATIONAL, Unit 6, 25 Overlea Blvd., Toronto, Ont. M4H 1B1

☐ Send me ETI for one year (12 issues) for $12.00 ☐ Send me ETI for two years (24 issues) for $20.00

For U.S. add $3.00 per year for postage, outside North America add $5.00 per year.

PLEASE PRINT CLEARLY

NAME ______________________

ADDRESS ______________________

TOWN/CITY ____________ PROVINCE/STATE ____________

CODE ____________ DATE ____________

☐ Cheque enclosed. DO NOT send cash. ☐ Projects 3 ☐ Projects 4

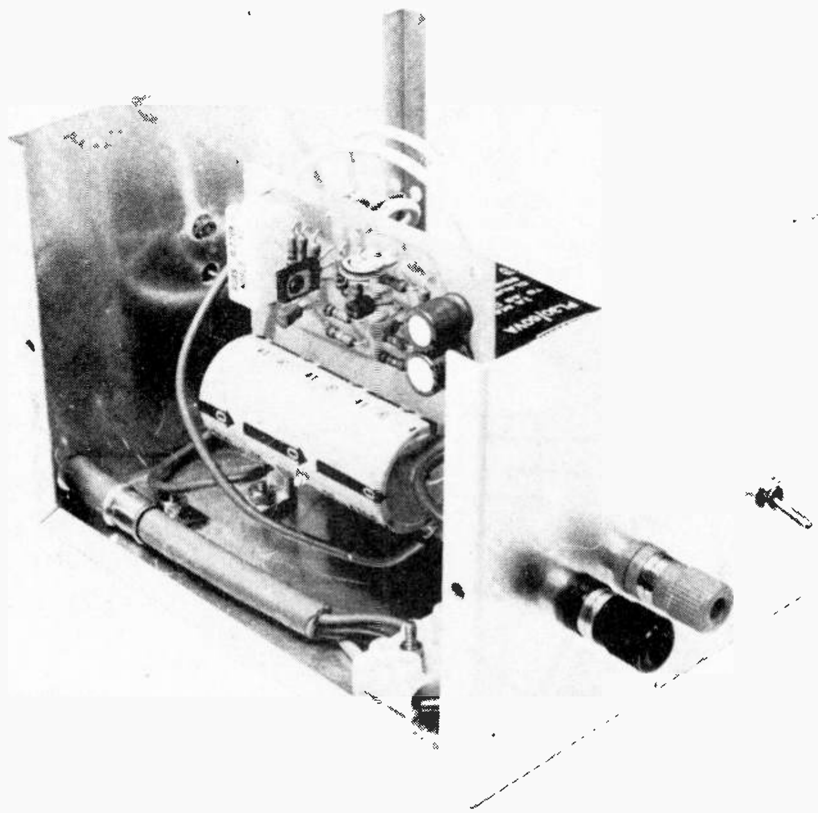
☐ Bill Mastercharge. A/C No. ____________ Signature ____________

☐ Bill Chargex. A/C No. ____________ Expiry Date ____________

2/78

CB Power Supply

Here's the answer if you want to run the mobile rig off the line as a base station



WITH THE EXPLOSION in the popularity of CB radio there is a growing demand for a power supply designed to operate mobile transceivers as a base station. In the mobile situation these operate off a 12V battery but while a battery can be used for the base station the problem of keeping it charged is a nuisance. Some people have tried simply a transformer, rectifier and filter capacitor but have run into problems with hum.

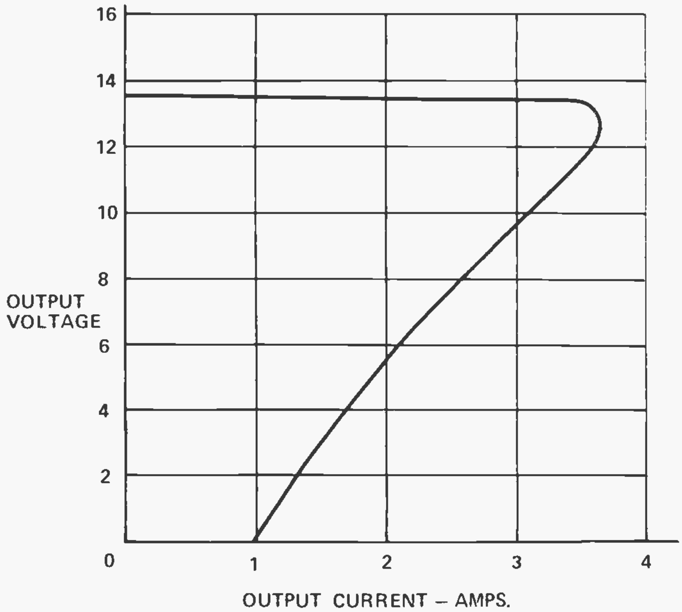
This power supply has been designed to operate the base station and can supply up to 2.5A at 13.5V of well regulated and filtered power. While it has been designed for CB use it is a good general purpose fixed voltage regulator. By changing a few components voltages from 5 to 50 volts at up to 3 amps can be achieved. Current protection is of the foldback type which gives less current into a short circuit than at the nominal output voltage so giving more protection to the output transistor without affecting normal operation.

DESIGN FEATURES

While we could have designed this supply using a special voltage regulator IC such as the 723, we decided to use transistors as it allows a wider range of input — output voltages and from an educational point of view it is more worthwhile. By changing the value of R11 the output voltage can be altered provided the input voltage is suitable. We chose foldback current protection as it minimises the power dissipated if the output is shorted, reducing the need for a large heatsink.

SPECIFICATIONS

Nominal output voltage	13.5 volts
Adjustment range	12V – 14.5V
Nominal output current	0 – 2.5 amps
Load regulation 0 – 2.5 A	150mV
Ripple @ 2 A	0.8mV
Short circuit current	1A



Graph showing relationship between output voltage and current. Note that the current into a short circuit is less than that available at 13 V.

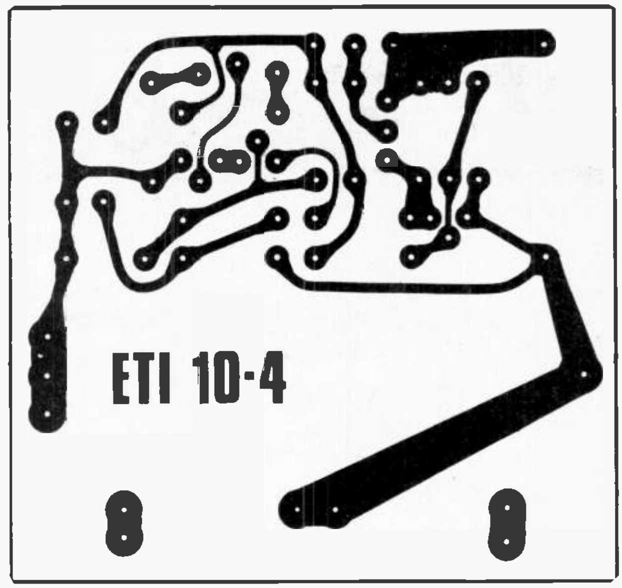


Fig. 2. Printed circuit layout. Full size 80 x 75 mm.

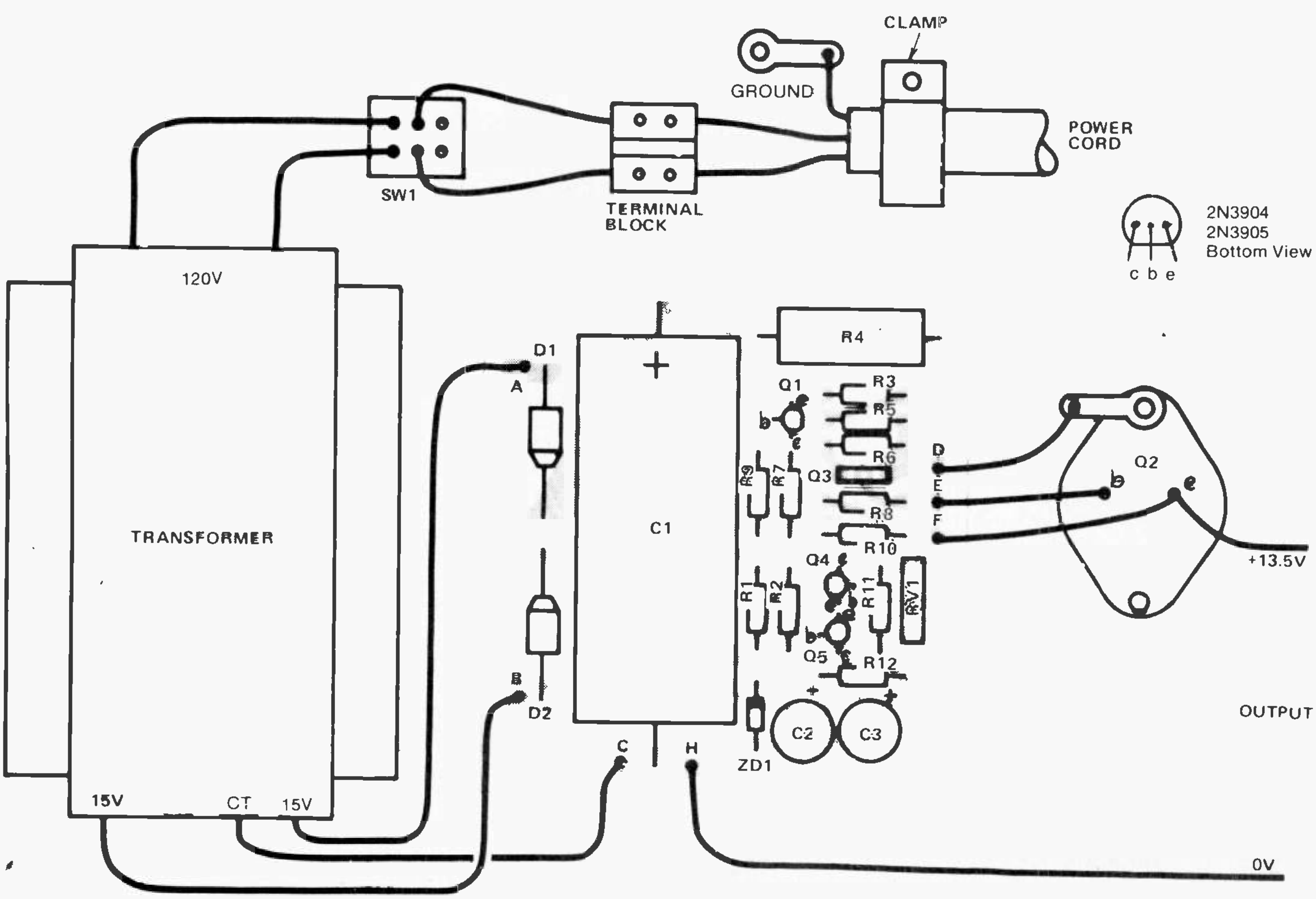


Fig. 3. Component overlay and wiring diagram.

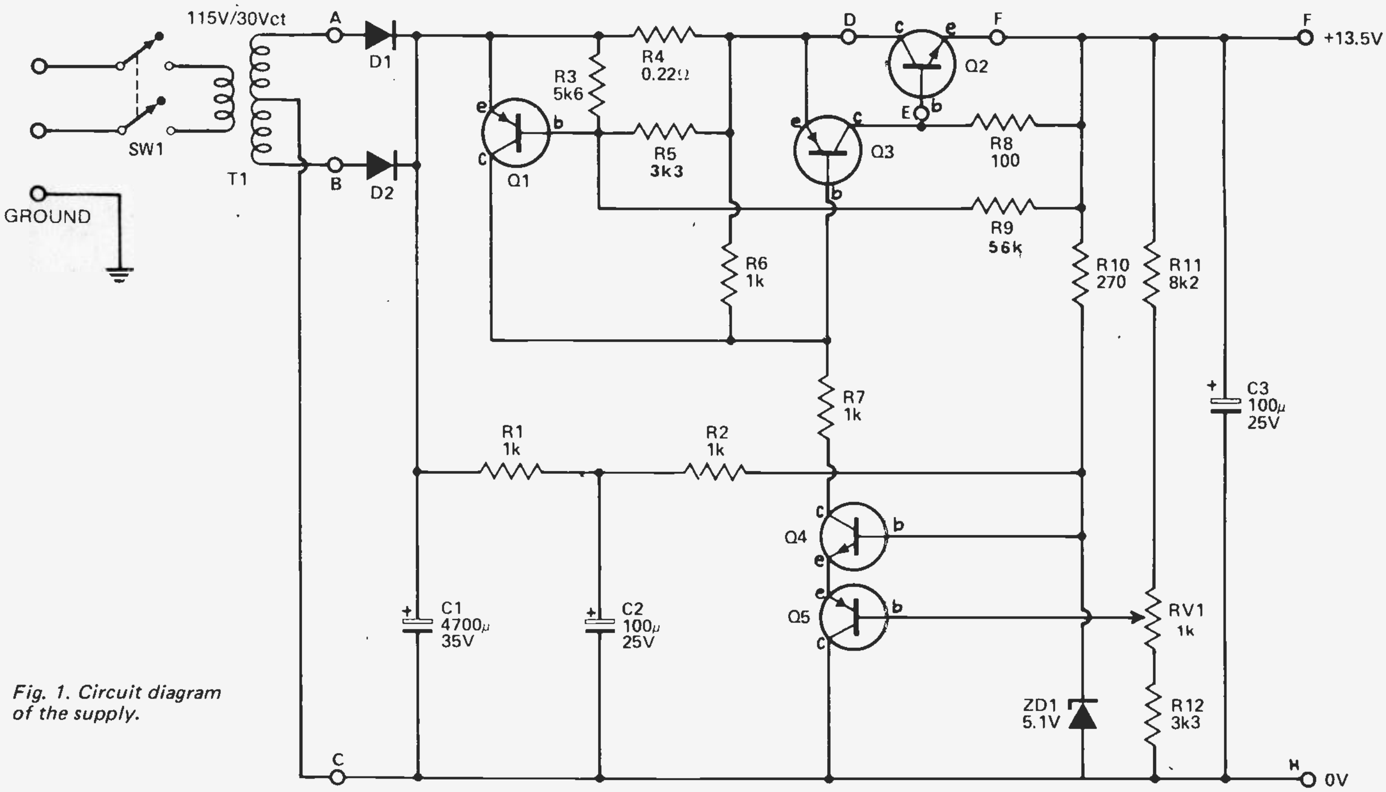


Fig. 1. Circuit diagram of the supply.

HOW IT WORKS

As high regulation is not required for CB use or most applications, we deliberately chose not to use a high gain circuit with its stability problems. The regulator is of the series pass type with Q3 dissipating the excess power. The gain of this transistor is increased by Q2 and the Q2/3 pair appears as a high gain (> 1000) PNP transistor.

The voltage reference in the supply is a 5.1 V zener diode and the majority of the current needed for this comes from the regulated output. To enable the unit to start R1 and R2 supply some current from the unregulated supply and C2 provides additional filtering to help eliminate 120 Hz ripple from the reference voltage. The output voltage is divided by R11, 12 and RV1 and then compared to the reference voltage by Q4 and Q5 which act as a comparator. There is a 1.2V difference between these two voltages due to the base emitter junctions of the two transistors. The comparator then controls the output stage Q2 and Q3 maintaining the output voltage within limits.

Overload protection is given by Q1 which measures the voltage across R4 (current) and the voltage across the transistor and if the sum exceeds a set level Q1 will bypass some of the current from the base of Q2 so limiting the output current. This technique allows high output currents at normal output voltages but reduces the current, and power dissipation, if the unit is shorted.

CONSTRUCTION

The layout of the circuit is not critical and any construction method can be used. We have given a printed circuit board layout which will make it easier especially if you are not experienced in electronics. When assembling note that all the components except the resistors are polarised and that the orientation of the small transistors should be checked carefully.

We used a simple folded aluminium box to house the supply as anything more fancy was a lot more expensive. The transistor Q3 should be mounted on a heatsink preferably on the outside of the box. The wiring diagram is given in Fig. 3.

Peanuts By Charles Schulz

PARTS LIST

RESISTORS all W 5%

R1,2	1k
R3	5k6
R4	0.22 ohm 5W
R5	3k3
R6,7	1k
R8	100
R9	56k
R10	270
R11	8k2
R12	3k3

POTENTIOMETERS

RV1	1k trim

CAPACITORS

C1	4700µ 35V
C2,3	100µ 25V

SEMICONDUCTORS

Q1	2N3905
Q2	2N3055
Q3	2N3905
Q4	2N3904
Q5	2N3905
D1,2	1N5404
ZD1	5.1V 300mW

MISCELLANEOUS

Transformer 115V/30Vct @ 2A
PC board
Heatsink
Case, line cord and plug

NOTES FOR READERS OF "TOP PROJECTS" AND "CIRCUITS"

For readers of our special publications "Top Projects" and "Circuits" we present here some useful conversions. We will in future be including this information with the books.

DIODES

OA91 Germanium	1N34
OA95 Germanium	1N38
OA200 Silicon	1N4148
BA100 Silicon	1N4148

GERMANIUM TRANSISTORS

AC127	2N2430
AC128	2N2706
AC132	2N2706
AC176	2N2430
AC187	2N2430
AC188	2N2706
ACY22	2N1188
AD161	2N4077
AD162	2N2835
OC72	2N2706

SILICON TRANSISTORS

BC107	2N3904
BC108	2N3904
BC109	MPS6514; MPS6515
BC109C	TIS97; MPSA18
BC148	2N3904
BC153	2N3904
BC158	2N3905
BC169C	MPSA18*
BC177	2N3905
BC178	2N3905
BC179	2N3905
BC182L	2N3904*
BC184	MPS6515*
BC209	MPS6515
BC212	2N3905
BC214	MPS6523
BC258	2N3905
BC327	2N5819
BC328	2N5819
BC337	2N5818; 2N2222A
BC441	TIP31A*
BC461	TIP32A*
BC548	2N3904
BC549	MPS6515
BC558	2N3905
BCX 31	2N5858
BCX 35	2N5857
BCY54	2N3905
BCY71	2N3905
BD135	TIP29A
BD136	TIP30A
BD137	TIP29B
BD138	TIP30B
BD139	TIP29C
BD140	TIP30C
BD266	TIP145
BD267	TIP140
BDY20	2N3055
BF224	2N3904*
BFR40	TIP31A
BFR80	TIP32A
BFX30	2N2905A
BFX84	2N2297
BFX85	2N4001
BFX88	2N2905A
BFY50	2N2297; 2N2222A
BFY51	2N2297; 2N2222A
BSS15	2N5320
ZTX300	2N2222A
ZTX500	2N2907A

*These transistors may have different lead configurations. Check carefully before use.

ORP12: This light dependent resistor has a dark resistance of 10M, which decreases to 300R in bright sunlight.

PP3 battery: This is our 9V "transistor" battery.

Project

Freezer Alarm

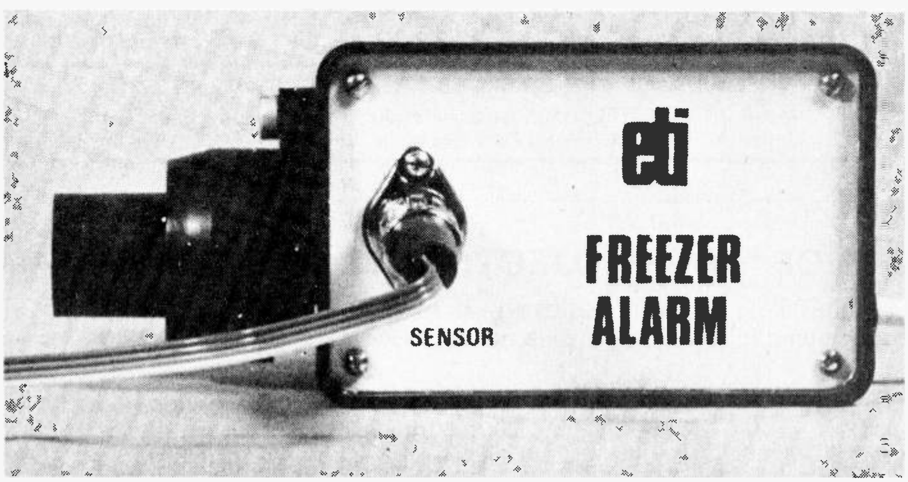
An economical ETI Project Team design that provides warning of freezer failure.

THE INCREASE IN popularity of the domestic home freezer over the past few years can be attributed to a number of factors.

One of the major attractions of the freezer is that by buying in bulk, most goods can be purchased at prices that are significantly less than those obtained by purchasing the items one off from the supermarket shelf.

Large savings can also be made if seasonal produce is bought in quantity while cheap, then frozen to provide an all year round supply of those transient fruits of nature.

Yet another reason for the appeal of the home freezer is that it is far more convenient and economical, both in terms of time and (expensive) energy, than making continual trips to the local shops.



The completed Freezer Alarm showing how we mounted the audio warning device on our prototype.

KEEPING YOUR COOL

All the above advantages would, however, be negated if the freezer were to fail. It is often the case that the contents of a freezer are worth more than the thing itself, some hundreds of dollars, and failure would prove very costly.

The design presented here will provide warning of any such failure, allowing prompt action to be taken in order to prevent disaster.

A warning of this sort is particularly valuable in the case of a freezer as, unlike a fridge, many people pay only occasional visits to their freezer and failure is likely to go unnoticed until its too late to take action.

FROZEN DESIGN

We opted to use the LM3911 temperature controller chip, rather than the more conventional diode or thermistor, as the temperature sensing element.

At first sight this may seem an unnecessary expense, the LM3911 costing somewhat more than the 10¢

HOW IT WORKS

IC1, an LM3911, forms the temperature sensitive element of the freezer alarm. The device, described in detail in a data sheet published in October's ETI, produces a voltage output that is related to the temperature at which the sensor is held.

This output voltage is given by the formula:

$$V_{OUT} = 10(T + 273)\ mV$$

where T is the sensor's temperature in degrees centigrade.

In this application we do not require the linear output of the chip when used in its standard configuration, preferring an output that is either "on" or "off".

To achieve this two state output, and to provide a positive switching action, we have introduced hysteresis.

Hysteresis is a desirable feature in many switching circuits and means, in this case, that the voltage level at which the output stage changes state, to activate the warning device, is higher than the level at which it reverts to its quiescent state.

The hysteresis is provided by applying positive feedback from the collector of Q1 to the feedback input of IC1 via R5. This feedback input is also connected to the slider of RV1. This preset potentiometer, together with R2 and R3, provides the means by which the unit is calibrated.

In operation, with the sensor maintained at the working temperature of the freezer, RV1 will be adjusted so that the voltage output of the LM3911 is just above the OV7 or so volts required to turn Q1 on.

If now the sensor chip's temperature is allowed to rise, the voltage at Q1's base will fall with respect to the O V rail.

(The chip's output is usually taken between the output and the positive rail – this explains the absence of a minus sign in the above formula.)

This voltage is applied to Q1's base and, as it falls, the voltage at Q1's collector which until now has been low, will begin to rise.

The increasing positive voltage at Q1's collector is fed back via R5 to the LM3911 and this will cause the output to fall still further – positive feedback. This gives the required on/off switching action.

Once triggered, the feedback via R5 will have the effect of keeping the device in this state until the sensor's temperature falls to well below the original triggering level.

R1 is a current limit resistor required by the LM3911.

Q2 is a straightforward transistor switch that energises the warning device when Q1's collector goes high.

The power supply is provided by T1, the encapsulated bridge (BR1) and C1 which provides some smoothing.

or so charged for a 1N914. Upon looking at the situation, however, the LM3911 does however, have a number of advantages. These include not having to bother with stabilised supply rails (the LM3911 has its own internal regulator), and not having to use op-amps with their split supply rails and temperature drift problems.

When these considerations are borne in mind, the temperature controller chip is an attractive choice in this type of circuit — we would not have used it otherwise.

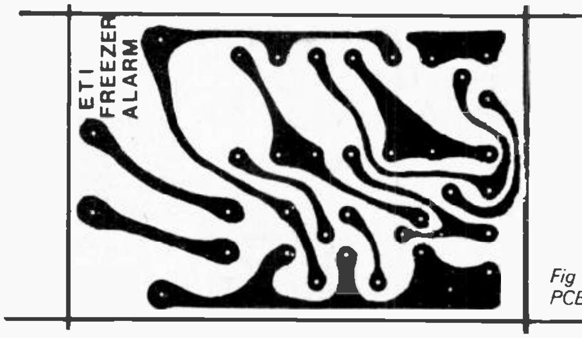


Fig 1. The full size (60 x 40mm) PCB foil pattern is shown left.

BUY LINES

No special components are used in this project. The LM3911 is obtainable from Radio Shack or National distributors.

PARTS LIST

RESISTORS all ¼W 5%

R1	3k3
R2	33k
R3	47k
R4	22k
R5	1M
R6	2k2
R7	1k

CAPACITOR

C1	1000u 25V electrolytic

POTENTIOMETER

RV1	22k Vertical trim type

SEMICONDUCTORS

IC1	LM3911
Q1	2N3904
Q2	2N2222A
BR1	0.9A 100V

TRANSFORMER

T1	120V —9 V 50mA

TRANSDUCER

Audible Warning Device, Sonalert or similar

MISCELLANEOUS

Box to suit, 5 pin DIN plug and socket, cable and plug, thin wire for sensor.

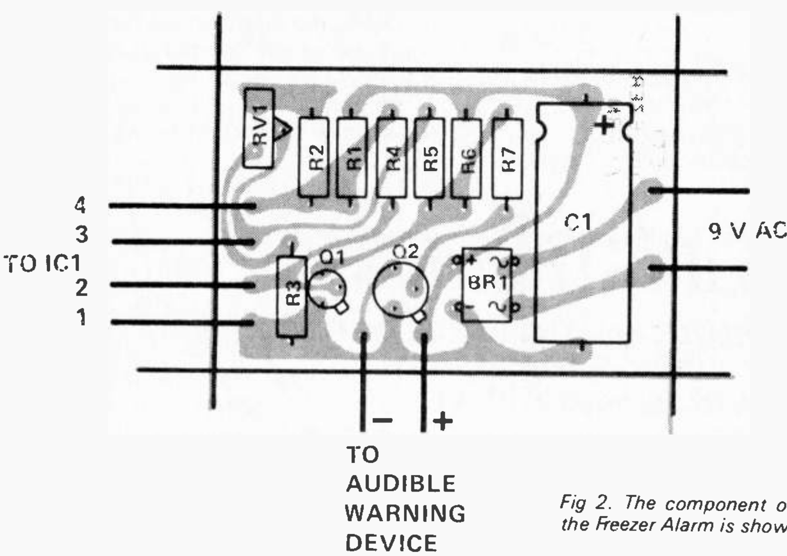
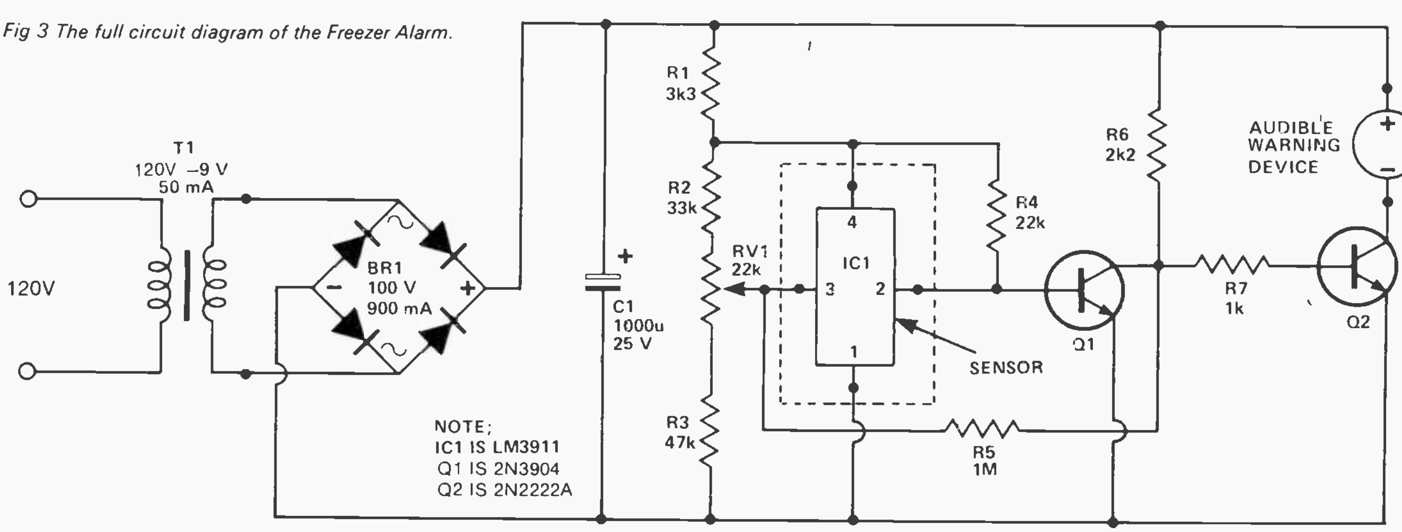


Fig 2. The component overlay for the Freezer Alarm is shown above.

Fig 3 The full circuit diagram of the Freezer Alarm.



ALARMING REACTION

We also decided to use an audio warning device, as the method of indicating failure of the freezer.

This little fellow emits a piercing tone which should not fail to alert you, your neighbour, your neighbour's neighbour . . . . .

Just hope it does not go off in the small hours.

CONSTRUCTION

Construction of the alarm is unlikely to pose any problems. The majority of components are mounted on the PCB and this should be assembled according to our overlay.

We used a fairly small box for our alarm and this resulted in a nice compact layout that can be seen in the photographs of the finished unit.

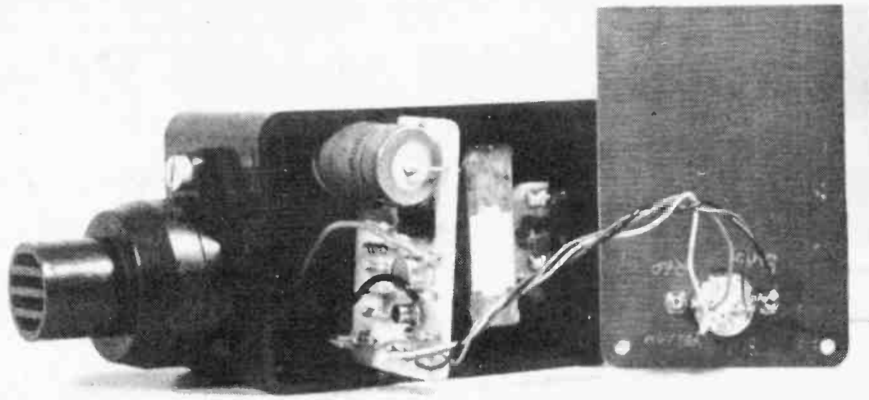
The warning indicator was mounted on the outside of our box but could easily be installed at a location remote to the main circuitry if the freezer is tucked well out of the way.

The alarm is provided with an adjustment to allow the point at which the alarm triggers to be set at any temperature within the range likely to be found in a freezer.

To set up the unit, place the sensor in the freezer and leave it for a few minutes.

Apply power, and adjust RV1 until the alarm triggers. A setting just before this point should prove suitable.

If the alarm triggers spuriously, the control is probably set at too sensitive a level. ''Backing off'' the control should put matters right.



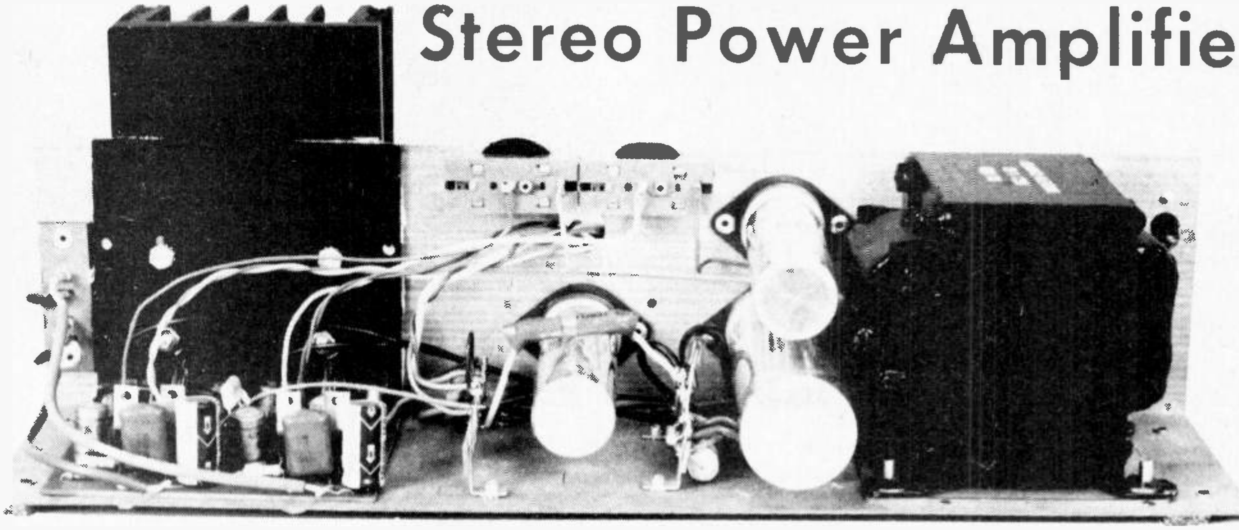
An internal view of our prototype showing the compact layout achieved.

FROZEN ASSETS

Insuring the contents of your freezer must be a good idea, but as with all insurance, is a rather negative approach designed to soften the blow when something nasty happens. Installing the alarm should enable you to take positive action to prevent the untoward occurring.

A final thought — a defrosted freezer, full of food, is not a pretty sight.

NEW from MAGNUM ETI's 50D50 Stereo Power Amplifier



Specifications: Line input 120 Volt A.C. 60 Hz; Power Output 50 Watt R.M.S. per Channel at 8.0 ohms; Distortion Harm. @ 1Khz 0.15% at Rated Output; Distortion I.M. @ 1 Khz 0.2% at Rated Output; Power Band with Rated Output at 18 Hz to 30 KHz ± 3 dB; Input Sensitivity 0.7 Volt; Input Impedance 15K.

THE QUALITY STEREO POWER AMPLIFIER FOR THE HOME OR PROFESSIONAL ENTERTAINER

PARTS LIST FOR 50/50 WATT AMP. LIT #PA50-1 $49.50

All Resistors are ½ Watt 5% unless noted.
2 x R1 - 150 K
2 x R2 - 82 K
2 x R3 - 39 K
2 x R4 - 1K8
2 x R5 - 270 R
2 x R6 - 820 R
2 x R7 - 1K Trimpot
2 x R8 - 2K2
2 x R9 - 180 R
2 x R10 - 8K2
2 x R11 - 180 R
2 x R12 - .5R-5 Watt
2 x R13 - .5R-5 Watt
2 x R14 - 3K9

Capacitors
2 x C1 - 470n Polyester
2 x C2 - 100 u 63 Volt Electrolytic
2 x C3 - 100 u 63 Volt Electrolytic
2 x C4 - In Ceramic
2 x C5 - In Ceramic
2 x C6 - 2500 u 60 Volt 2 Amp Ripple
1 x C7 - 100 n Polyester
2 x C8 - 100 p Ceramic

Transistors
2 x Q1 - 1RK5 (TCS 100)
2 x Q2 - 4RK4 (TCS 101)
2 x Q3 - 2N5525
2 x Q4 - Tip 141
2 x Q5 - Tip 146

Misc:
4 x Jumper .500 Spacing
1 x Heat Sink Mounting Plate
1 x Heat Sink Mounting Angle
2 x Hex Head 6/32 Screws
2 x Hex Nuts
1 x PC Board #PA-50X-O
1 x Diagram #PA-50X-02

Kit PA50-1 $49.50

Kit PA50-3 $78.50

Both Kits $128.00

PA50-6 Both kits totally pre-assembled only $195.00

PARTS LIST FOR POWER SUPPLY, CHASSIS AND HEAT SINK FOR 50/50 WATT AMP. KIT #PA50-3 $78.50

Chassis #50X-16GA
Transformer #XF50 (65VDC at 2.5 Amp.)
Heat Sink #5K
Electrolytic #40ELC (4000MFd80V)
Bridge Rectifier #MDA 3502 (35 Amp 200 Volt)
Reset Breaker 3 Amp.
Reset Breaker 3 Amp.
Fuse 3 Amp Fast Blow
Terminal 6G4AG
Terminal 8G6AG
4 Screw Speaker Terminal
2 Phono Input Socket
Line Cord
Line Capacitor 10n/300 V A.C
19 pc #22 Wire Cut to Size
2 pc Shielded Input Leads
10 pc Pop Rivets
4 pc #8/32 ½" Screw
4 pc #8 Nuts
4 pc. #8 Lockwasher
6 pc. #6 Screws
2 pc #6 Screws 6/32 x 1"
2 pc. #6 Nuts
18 pc #6 Lockwashers
2 pc Felt Washer
2 pc 10 n/500V Capacitor (A.C. Bridge Rectifier to Ground)
1 pc 100 R 1/2 Watt R15)
1 pc LED — Red
1 pc Hyco
4 pc Cork Feet
3 pc #20 Wire Cut to Size
2 pc (n Ceramic Capacitors C Input to Ground)

ETI PCBs for recent and current projects including:

"3 Channel Tone Control"	$4.20
"Digital Thermometer"	$7.15
"Watchdog" (Both boards)	$8.40
"Spirit Level"	$4.90
"Egg Timer"	$4.15
"Compander"	$9.95
"Equalizer" (one ch)	$9.15
Power supply	$4.20

All boards pre-drilled and guaranteed. Most boards supplied in G10. No C.O.D.'s, Ontario Res. add 7% P.S.T. - Prices are postpaid.

Reception Problems? Try our 85FM power antenna for improved home F.M. reception. For the car, the Mobile Power Sleuth will bring in those distant AM and FM stations.

Great variety of manufacturer's 1st line electronic and hardware parts at below wholesale prices.

Send for your FREE Magnum Catalogue

magnum
ELECTRONICS INC.

72 Stafford Street, Toronto Ontario M6J 2R8 (416) 364-8754

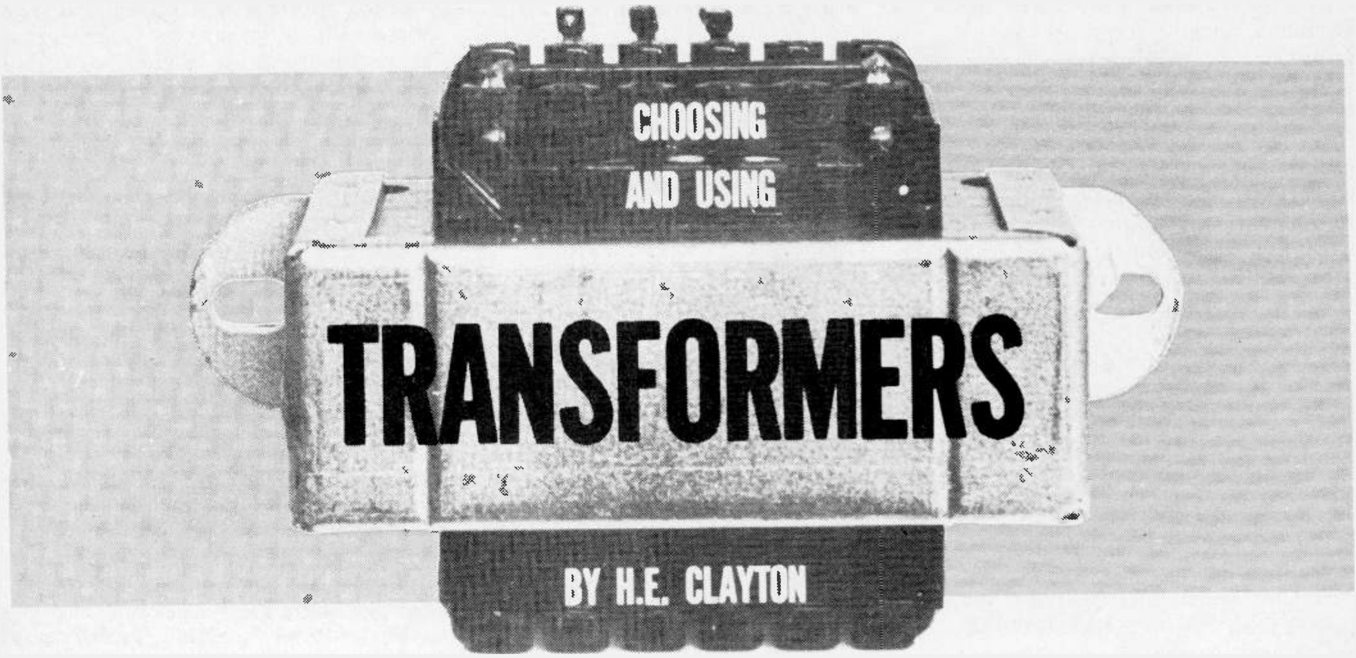
MAGNUM electronics 72/74 Stafford Street - Toronto

Please send me

..... Kit(s)	PA50-1	@49.50	$________
..... Kit(s)	P50-3	@78.50	$________
..... Both Kit(s)		@128.00	$________
..... PA50-6 Pre-Assembled		@195.00	$________
..... PCB's..................			$________
....			$________
....			$________
		TOTAL	$________

Ontario residents add 7% PST.
Cheque or Money Orders only. - No C.O.D.'s

A power transformer is often the single most expensive item in a project — H.E. Clayton of Reading Windings takes a close look at this often neglected item.



CHOOSING AND USING TRANSFORMERS

BY H.E. CLAYTON

TRANSFORMERS ARE USED to increase or decrease either an AC voltage or an AC current level.

All transformers change both AC current and voltage levels simultaneously, but no transformer significantly changes power levels, as the input power equals the output power plus losses which are in general, negligible. Transformers can also be used to transform impedance from one level (in the primary circuit) to another level in the secondary circuit, the impedance transfer ratio being the square of the transformer turns ratio.

It is often possible to use transformers in the opposite mode to that for which they were designed e.g. by feeding into the secondary of a step down transformer and using it to step up in voltage. This will, however, usually give an output voltage below the rated value because the turns ratio is normally made less than the rated transformation ratio to compensate for voltage drops in the windings.

Power transformers can usually be operated at frequencies higher than that for which they were designed, e.g. a 50Hz transformer can be used at 60Hz, but not vice versa.

WHAT WE WANT IS . . .

Before deciding on a transformer for a particular application, it is helpful to list one's requirements and to have some idea of what options there are it is hoped that the following outline will help.

RMS input voltages and supply frequency: In addition to the nominal input voltage the maximum value to which this can rise should also be considered. Most transformers will operate satisfactorily at about 6% overvoltage for short periods of time but if it expected to exceed this figure it is advisable to increase the rated input voltage. Primary windings can be tapped to cater for several voltages but this adds considerably to the cost of the transformer and may detract from performance. Twin series — parallel windings on the other hand, although adding a little to the cost, do not substantially interfere with efficiency as all of the winding is in use for both series and parallel connections. They are however limited to dual input voltage applications where one voltage is twice the other e.g. 240/120V.

Output Currents and Voltages: Unless otherwise agreed, the nominal or rated output voltage is that at full load output current based on resistive load. Again, several voltages can be provided by tapping and, unlike the primary taps, several secondary tappings can be used simultaneously to supply a number of loads. If, however, there is a significant difference between the load currents at different tappings, it may be preferable to have separate windings.

NB: The information above is the minimum which must be decided by the user, all the following requirements may remain unspecified unless circumstances demand otherwise, always remembering that special features can add considerably to a transformer's cost.

Regulation (usually Maximum Value): The regulation is defined as the difference between a secondary terminal voltage on open circuit and the secondary terminal voltage at rated full load current.

Maximum permissible Temperature rise: This is often decided by the manufacturer rather than the user as it may depend on the materials used. Higher standard temperature rises are associated with lower ambient temperatures.

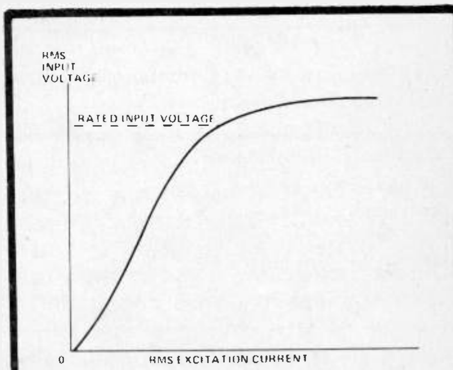


Fig. 1 Plot of excitation currents vs. RMS input voltage for typical transformer. The transformer should not be operated for long periods above the 'knee' of this curve.

Input Current (or Excitation or Magnetising Current): The no load input characteristic is shaped as in Fig. 1 and care should be taken not to use the transformer for long periods with voltages much higher than the "knee" of the curve.

Electrical requirements: Limitations to distortion of secondary waveform, any special phasing requirements etc.

Insulation requirements: The basic standard requirement is for a 2kV RMS test between the input and output windings and between any winding and the core if accessible.

Impregnation etc: Transformers without hygroscopic materials (those that absorb moisture) are often varnish dipped while those using absorbent materials such as paper are varnish impregnated. Both of these processes are effective for minimising lamination vibration and sealing against ingress of moisture.

Dimensions: Any limiting dimensions and/or fixing centres.

Construction: Some of the common alternatives are described below.

WHAT CORE

Interleaved laminations are widely used for small power transformers, the most common shape being the no-waste 'E' and 'I' in which the 'I's are cut from the 'E's (see Fig. 2) and the coils assembled over the centre limb (shell type construction). These are available in .50mm and .355mm thickness in various grades of hot rolled silicon iron and in 0.355 mm grain-orientated silicon iron.

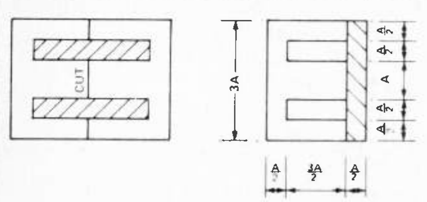


Fig. 2. No-waste E and I construction of transformer laminations

Toroids and 'C' cores are made of 0.355 and 0.10 mm thickness, the thicker material being used in the 50-60Hz devices. Toroids have a highly efficient magnetic circuit and by virtue of their circular shape, low leakage flux. They are sometimes chosen because they can be used to make a "low profile" i.e. low height transformer.

Because the cost of toroidal transformers can be three times that of an E and I laminated transformer, a compromise between the two which is sometimes used for low profile units uses U and I laminations with the coils on the long limbs of the 'U'. (Core type construction).

WINDING THINGS UP

Moulded bobbins are widely used for smaller transformers. They have the advantage that they can be wound on high speed machines. Insulation thickness between windings and core and between windings can be assured. The winding space factor (ratio of area occupied by active copper and total winding area) is high and terminal tags can be mounted on the bobbin cheeks. Certain bobbins may be fitted with shrouds encasing the windings and giving good mechanical and electrical protection.

ENDING IT ALL

The cheapest terminations are solder tags on the bobbin cheeks. For applications where solder connections are not convenient terminal blocks can be mounted on the transformer. For larger transformers terminal panels with turret lugs or bolted connections are used.

MOUNTING UP

Mounting brackets are available for the range of standard no-waste E and I laminations. They take the form of 'U' clamps with two hole fixing which are crimpled on to the smaller sizes (up to about 50VA) and flanged and frames secured to the larger transformers with core bolts and providing four fixing slots on each of their four sides (universal mounting). At the small end of the range (up to about 5VA) pin terminations can be used for PCB mounting.

ELECTRICAL PERFORMANCE

In its simplest form a transformer consists of an input and output winding magnetically coupled with an iron core. The windings represent an impedance in series with the load and the core can be considered to be an impedance shunting the load. The winding impedances cause voltage drops proportional to the load current and a watts (copper) loss proportional to the square of the load current. The core impedance does not directly produce a voltage drop but is associated with an energy (iron) loss approximately proportional to the square of the volts per turn for a fixed supply frequency. The total losses (copper and iron) determine the operating temperature rise of the transformer which is usually the most important factor limiting the use of the transformer.

WATTS A VA

Although the transformer total losses depend on both voltage and current, they are independent of the phase factor. For this reason transformers are rated in maximum VA and not in watts although with resistive loads VA = watts.

Transformer windings also have "self inductance" which can be thought of as a reactance in series with the winding resistance and the load and is usually referred to as the "leakage reactance". This does not usually effect the performance of small power transformers (below about 100 VA size) particularly when used with resistive loads.

PHYSICAL PERFORMANCE

As transformers increase in VA rating and physical size, the working flux density and the winding current density are reduced, but even over a relatively large range of sizes, the variation is small enough to assume that they are constant.

With this premise, it is interesting to consider the effect on various parameters of change in physical size for the same overall shape.

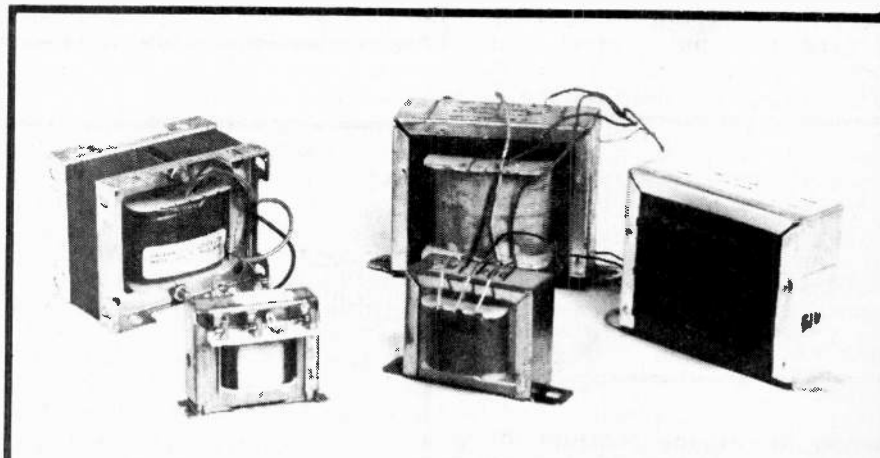


Fig 3 A collection of some of the more common transformer types. Some of the wide variety of constructions and terminations available can be seen in this photograph.

TRANSFORMERS

We can show that

1) The regulation of small transformers with resistive loads decreases in inverse ratio to the increase in any linear dimension and
2) The reactive voltage drop increases while the resistive drop decreases linearly with dimensions.

Figure 4 shows the relationship between transformer VA rating, volume (or weight) and regulation. The volume here is the length × width × height, not the displacement. This is based on mains transformers using E and I no waste laminations and operating at 60 Hz. It is often possible to increase the output current of a power transformer beyond the rated value if one can accept a temperature rise higher than the designed value. Overloading the transformer in this way will, however, cause the output voltage to fall because of the increased voltage drops in the windings.

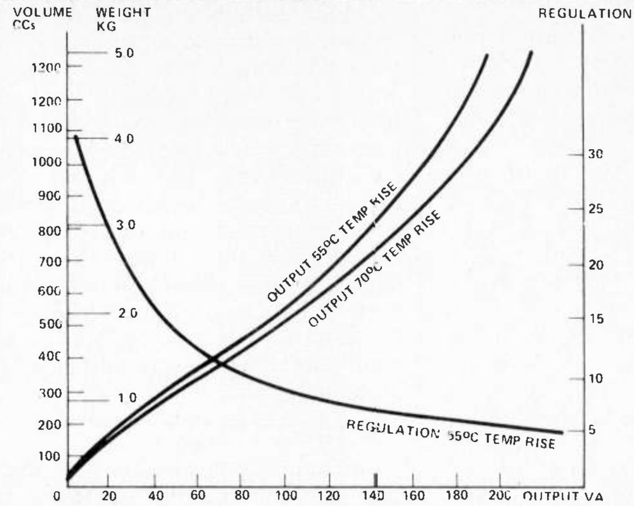


Fig. 4. Graph showing relationship between transformer VA rating and both volume (or weight) and regulation. These curves are based on E and I no-waste laminations operating at 60Hz.

TRYING TIME

The following tests can be used to establish basic transformer characteristics.

Turns Ratio: Apply a known voltage, less than the rated value, to the primary winding and measure the secondary voltage. Care should be taken, especially with transformers below about 20VA rating, that the instrument used does not impose a significant load on the transformer.

Excitation Characteristic Connect as in Fig. 5 and apply the rated input voltage to primary terminals and measure input current and voltage.

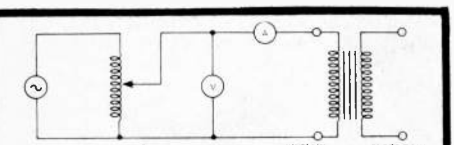


Fig. 5. Connections for the excitation or open-circuit test. The rated input voltage is applied to the primary and the excitation current is shown by A.

Winding Resistance Measure the primary and secondary DC winding resistances with a multimeter or Wheatstone bridge.

Phasing. Where windings can be interconnected e.g. with series/parallel designs, it is important to establish the relative polarity of terminations. This can be done by connecting the windings concerned in series, applying an alternating voltage to one and measuring the overall voltage (Fig. 6). If this measured voltage is greater than the applied voltage, then the windings are in phase. Conversely, if the measured voltage represents the difference of the two winding voltages the connection is in anti-phase.

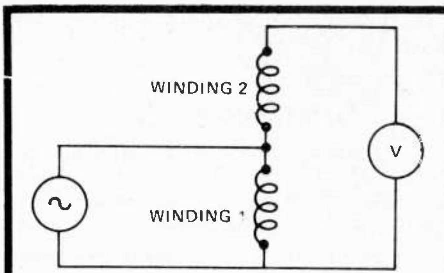


Fig. 6. Connections for the relative polarity test

IT TAKES ALL SORTS

Transformers Feeding Rectifiers. A common application for small transformers is to supply full wave rectifier circuits including capacitor input filters. The most common are the bridge amd bi-phase circuits shown in Fig. 7.

For the same power rating, the transformer for the bi-phase circuit will be larger than that for the bridge circuit because its secondary produces twice the voltage and carries current during each half cycle only. Ideally the secondary winding for the bi phase transformer occupies $\sqrt{2}$ times the space of the primary winding. Although transformer cost is higher, rectifier costs are lower for the bi-phase circuit.

The relationship between the average DC voltage and the RMS secondary voltage is complex and is dependent on the smoothing capacitance, the supply frequency, the transformer series impedance and the load impedance. Curves illustrating this and other relevant relationships are published by rectifier manufacturers but neglect the effect of

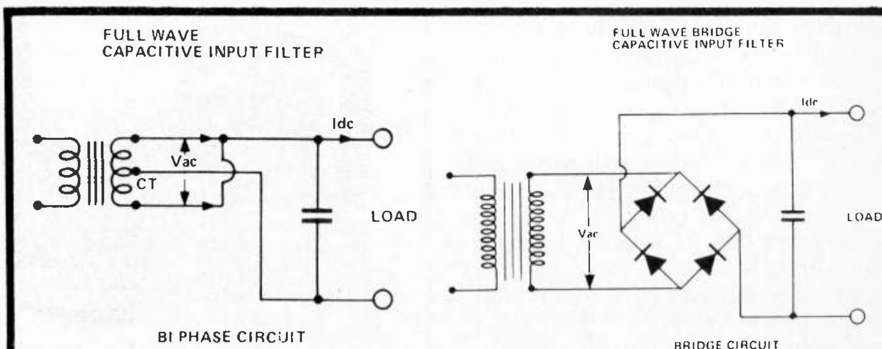


Fig. 7 Two of the most common rectifier circuits for use with capacitive input filters

transformer leakage reactance which may be significant on some larger transformers. Because the waveform of the transformer current is very 'peaky' the effective reactive volt drop is greater than may be expected by considering RMS values.

Autotransformers have a single tapped winding to provide both input and output circuits. With transformation ratios near unity, autotransformers can be much smaller than similarly rated double-wound transformers.

A disadvantage of autotransformers is that there is a direct electrical connection between primary and secondary circuits so that both circuits share a common relationship to ground.

Isolating Transformers usually have a 1:1 transformation ratio and are provided specifically to electrically isolate the secondary circuit from any earth connection in the primary circuit e.g. 'line' circuits.

Inverter Transformers (.e.g for switched mode power supplies). These usually operate in the kilohertz range of frequencies and are supplied with square wave-form voltage.

High Impedance Transformers are used for a variety of purposes a few of which are mentioned below.

Short-Circuit Proof transformers are designed to continue in operation without damage when the secondary terminals are short-circuited. Small

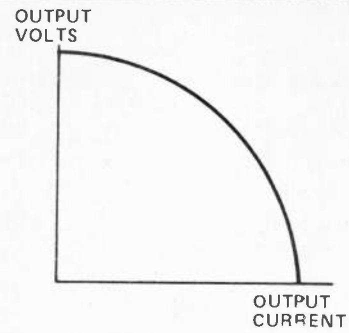


Fig. 8. Relationship between output current and output volts of high reactance transformer with resistive load.

transformers (below about 5VA size) are sometimes made with sufficiently high winding resistances to restrict the short circuit current but with larger transformers an adjacent winding structure is used with an intermediate magnetic shunt. This gives an output characteristic as shown in figure 8 when used with resistive loads.

High Frequency Transformers. The foregoing is concerned with transformers operating only at a constant supply frequency and with sinusoidal waveforms. Transformers used in communication circuits are required to handle a wide range of frequencies and waveforms, although any repetitive waveform can be expressed as a series of sine wave components. Such transformers are often used in an *impedance matching* role. It is well known that to transfer the maximum amount of energy into a load from a voltage source the load impedance should equal the source impedance.

SHIELDING

Stray magnetic fields produced by power transformers can cause hum in high gain amplifiers in the same locality. Shielding around the power transformer is not normal because a large percentage of the stray flux, which is emitted in all directions, would strike the shield at right angles and pass through it rather than be diverted. On the other hand input (e.g. microphone) transformers are often enclosed in a screen of magnetic material to reduce pick-up.

PRODUCTION METHODS

Coil winding techniques and machinery have improved immensely in recent years. Unfortunately it is not always possible to make the best use of these improvements which are mainly geared to high volume production of standard products. Although some degree of standardization in small transformers has been achieved equipment designers still expect transformers to be tailor-made, often in small quantities, to their particular electrical and dimensional requirements.

Summarizing, before seeking a special transformer, consider first if readily available standard transformers can be used. It is generally cheaper to use a standard transformer and make circuit modifications to accommodate it, than to use a custom one. However companies such as Hammond Mfg. give surprisingly reasonable prices on non-standard models in quantities of just two or three. ●

DIODES/ZENERS

1N914	100v	10mA	.05
1N4005	600v	1A	.08
1N4007	1000v	1A	.15
1N4148	75v	10mA	.05
1N753A	6.2v	z	.25
1N758A	10v	z	.25
1N759A	12v	z	.25
1N4733	5.1v	z	.25
1N5243	13v	z	.25
1N5244B	14v	z	.25
1N5245B	15v	z	.25

SOCKETS/BRIDGES

8-pin	pcb	.25	ww	.45
14-pin	pcb	.25	ww	.40
16-pin	pcb	.25	ww	.40
18-pin	pcb	.25	ww	.75
22-pin	pcb	.45	ww	1.25
24-pin	pcb	.35	ww	1.10
28-pin	pcb	.35	ww	1.45
40-pin	pcb	.50	ww	1.25

Molex pins	.01	To-3 Sockets	.45
2 Amp Bridge		100-prv	1.20
25 Amp Bridge		200-prv	1.95

TRANSISTORS, LEDS, etc.

2N2222	NPN	(Plastic .10)	.15
2N2907	PNP		.15
2N3906	PNP		.10
2N3054	NPN		.35
2N3055	NPN	15A 60v	.50
T1P125	PNP	Darlington	.35
LED Green, Red, Clear			.15
D.L.747	7 seg 5/8" high com-anode		1.95
XAN72	7 seg com-anode		1.50
FND 359	Red 7 seg com-cathode		1.25

C MOS

4000	.15
4001	.20
4002	.20
4004	3.95
4006	1.20
4007	.35
4008	.95
4009	.30
4010	.45
4011	.20
4012	.20
4013	.40
4014	1.10
4015	.95
4016	.35
4017	1.10
4018	1.10
4019	.60
4020	.85
4021	1.35
4022	.95
4023	.25
4024	.75
4025	.35
4026	1.95
4027	.50
4028	.95
4030	.35
4033	1.50
4034	2.45
4035	1.25
4040	1.35
4041	.69
4042	.95
4043	.95
4044	.95
4046	1.75
4049	.70
4050	.50
4066	.95
4069	.40
4071	.35
4081	.70
4082	.45

– T T L –

7400	.15
7401	.15
7402	.20
7403	.20
7404	.15
7405	.25
7406	.35
7407	.55
7408	.25
7409	.15
7410	.10
7411	.25
7412	.30
7413	.45
7414	1.10
7416	.25
7417	.40
7420	.15
7426	.30
7427	.45
7430	.15
7432	.30
7437	.35
7438	.35
7440	.25
7441	1.15
7442	.45
7443	.85
7444	.45
7445	.65
7446	.95
7447	.95
7448	.70
7450	.25
7451	.25
7453	.20
7454	.25
7460	.40
7470	.45
7472	.40

7473	.25
7474	.35
7475	.35
7476	.30
7480	.55
7481	.75
7483	.95
7485	.95
7486	.30
7489	1.35
7490	.55
7491	.95
7492	.95
7493	.40
7494	1.25
7495	.60
7496	.80
74100	1.85
74107	.35
74121	.35
74122	.55
74123	.55
74125	.45
74126	.35
74132	1.35
74141	1.00
74150	.85
74151	.75
74153	.95
74154	1.05
74156	.95
74157	.65
74161	.85
74163	.95
74164	.60
74165	1.50
74166	1.35
74175	.80

74176	1.25
74180	.85
74181	2.25
74182	.95
74190	1.75
74191	1.35
74192	1.65
74193	.85
74194	1.25
74195	.95
74196	1.25
74197	1.25
74198	2.35
74221	1.00
74367	.85
75108A	.35
75110	.35
75491	.50
75492	.50
74H00	.25
74H01	.25
74H04	.25
74H05	.25
74H08	.35
74H10	.35
74H11	.25
74H15	.30
74H20	.30
74H21	.25
74H22	.40
74H30	.25
74H40	.25
74H50	.25
74H51	.25
74H52	.15
74H53J	.25
74H55	.25

74H72	.55
74H101	.75
74H103	.75
74H106	.95
74L00	.35
74L02	.35
74L03	.30
74L04	.35
74L10	.35
74L20	.35
74L30	.45
74L47	1.95
74L51	.45
74L55	.65
74L72	.45
74L73	.40
74L74	.45
74L75	.55
74L93	.55
74L123	.55
74S00	.55
74S02	.55
74S03	.30
74S04	.35
74S05	.35
74S08	.35
74S10	.35
74S11	.35
74S20	.35
74S40	.25
74S50	.25
74S51	.45
74S64	.25
74S74	.40
74S112	.90
74S114	1.30

74S133	.45
74S140	.75
74S151	.35
74S153	.35
74S157	.80
74S158	.35
74S194	1.05
74S257 (8123)	.25
74LS00	.35
74LS01	.35
74LS02	.35
74LS04	.35
74LS05	.45
74LS08	.35
74LS09	.35
74LS10	.35
74LS11	.35
74LS20	.35
74LS21	.25
74LS22	.25
74LS32	.40
74LS37	.35
74LS40	.45
74LS42	1.10
74LS51	.50
74LS74	.65
74LS86	.65
74LS90	.95
74LS93	.95
74LS107	.85
74LS123	1.00
74LS151	.95
74LS153	1.20
74LS157	.85
74LS164	1.90
74LS367	.85
74LS368	.85

LINEARS, REGULATORS, etc.

8266	.35
MCT2	.95
8038	3.95
LM201	.75
LM301	.25
LM308 (Mini)	.75
LM309H	.65
LM309K (340K-5)	.85
LM310	1.15
LM311D (Mini)	.75
LM318 (Mini)	.65

LM320K5 (7905)	1.65
LM320K12	1.65
LM320T5	1.65
LM320T12	1.65
LM320T15	1.65
LM339	.95
7805 (340T5)	.95
LM340T12	1.00
LM340T15	1.00
LM340T18	1.00

LM340T24	.95
LM340K12	2.15
LM340K15	1.25
LM340K18	1.25
LM340K24	.95
LM373	2.95
LM380	.95
LM709 (8,14 PIN)	.25
LM711	.45

LM723	.50
LM725	1.75
LM739	1.50
LM741 (8-14)	.25
LM747	1.10
LM1307	1.25
LM1458	.95
LM3900	.50
LM75451	.65
NE555	.50
NE556	.95
NE565	.95
NE566	1.75
NE567	1.35

9000 SERIES

9301	.85
9309	.35
9322	.85
95H03	.55
9601	.75
9602	.50

MEMORY CLOCKS

74S188 (8223)	3.00
1702A	6.95
MM5314	3.00
MM5316	3.50
2102-1	1.75
2102L-1	1.95
TR 1602B/ TMS 6011	6.95
8080AD	15.00
8T13	1.50
8T23	1.50
8T24	2.00
2107B-4	4.95

INTEGRATED CIRCUITS UNLIMITED

7889 Clairemont Mesa Blvd., San Diego, CA 92111 U.S.A.

No Minimum

All prices in U.S. dollars. Please add postage to cover method of shipping. Orders over $100 (U.S.) will be shipped air no charge. Payment should be submitted with order in U.S. dollars. All IC's Prime/Guaranteed. All orders shipped same day received.

Phone (714) 278-4394 BARCLAYCARD/VISA/ACCESS/AMERICAN EXPRESS

SPECIAL DISCOUNTS

Total Order	Deduct
$35 - $99	5%
$100 - $300	10%
$301 - $1000	15%
$1000 - Up	20%

BITS, BYTES and BAUDS

by Bill Johnson VE3APZ

This month's subject is memory of all shapes and sizes employed in various computer systems.

AT THIS POINT in our series, we have seen how a computer works, how it addresses memory, and how it can send data to and receive data from a peripheral. The program (or set of instructions for the computer to follow) must reside in the memory that is readily available to the computer so that it has access to all it needs, simply by sending an address on the address lines and receiving instructions on the data lines. If the computer in our example were to be doing a constant, repetitive, function such as controlling the traffic lights at an intersection, then it would only ever need to run one program. This program would be permanently burned into a ROM (Read-only-memory). This is the simplest form of a computer system, and its description ends here.

Of more interest to us is the general purpose computer, such as may be found in an office, for example. This type of computer may have more than a hundred different programs for various day-to-day jobs, as well as dozens more that are executed only once a week, once a month, or less often. These programs are not all needed at the same time, and so need not all be stored in the **main memory**. Main memory is very expensive (see Fig. 1) when compared to **offline memory**, such as paper tape, cassettes, and discs, and so shrewd system designers store as many programs offline as possible to reduce main memory needs.

ONLINE-OFFLINE STORAGE

To get a better idea of the difference between **online** and **offline** storage, let's compare our computer to a theatre. The actors who are currently performing occupy the stage, which is a very elaborate platform, designed to be in full view of the audience, and having lots of expensive accessories, such as lights, microphones, scenery, etc, to make it a very effective place for the actors to work. When the actors are not acting, they leave the stage and wait in the wings. The wings on the stage are very crowded places where space is at a premium, and so you will only find them there immediately before and after their performance on the stage. Beyond the wings you will find all sorts of space reserved for dressing rooms, etc, where actors can go to relax. They know that when they are in these rooms, they will get plenty of notice before they are needed on the stage.

In a computer, the stage is the main memory, which is sometimes referred to as **executable** memory, because programs must be in this type of memory to be executed. It is very expensive, like the stage, because it is very fast, and programs are only put here when they are needed.

The wings of the stage represent any form of fast-access device, such as a floppy disc, where data can be stored and retrieved very quickly. Data and sub-programs that are used constantly by a main program in memory are stored on such a device, because during the course of a program's execution they may be brought into memory and taken out again as required by the program.

The dressing rooms of our computer are devices such as a cassette system where we can store programs until their turn comes to go into the main memory. Changing of main programs happens relatively infrequently, and lots of notice can be given, so the delays in getting programs into memory aren't very serious.

Now that we have decided that it's smart to store programs and data offline when not using them, let's look into the multitude of devices that can be used for storage.

OLD FAITHFUL – THE PAPER TAPE

For the small system owner just building his system, an obvious starting point is a teletype machine (TTY). TTYs sometimes have a punch and reader added, capable of storing and retrieving data by punching them on paper tape. For computer purposes, an 8 level machine is needed, such as the Teletype Corporation model ASR33 or ASR35. (ASR stands for Automatic Send-Receive, meaning that it is a basic unit with a reader-punch added, as opposed to a KSR

TYPE	DEVICE COST $	MEDIA COST $	STORAGE CAPABILITY K Bytes	COST/ BIT ¢	TIME TO FIND DATA	TRANSFER RATE ONCE FOUND
PAPER TAPE	1000	10¢/K	N/A	.01	UP TO 1 HOUR	110 Bps
AUDIO CASSETTE	50	2.00	80	.3	1-2 mins	300 Bps
FLOPPY DISC	4000	10.00	250	.03	500 ms	250 KBps
RAM			65K	1-2	450 ns	2 MBps

Fig. 1. — Cost of various types of memory and their speed

which simply means Keyboard Send-Receive — i.e. no punch/reader).

In order to store all programs in a manner that can be readily reloaded into the computer, a standard must be established to define what each item on the tape means. Each part of memory, as it is dumped onto punched tape, can be considered as a **block**. These blocks of memory can be any convenient length, and are stored as individual **records** on the tape. Every byte of data, when sent to the teletype machine, will cause the eight hole-punches to pierce the paper or not, depending on whether the corresponding bit is a 1 (hole) or a 0 (no hole). The paper moves forward after one byte, or **frame** has been punched, and at the same time the teletype machine is receiving the next character for punching. In this way, the result of sending a complete block of memory, one byte at a time, will be a long tape with holes corresponding to the bits stored in memory as ones.

HOLES ARE NOT ENOUGH

However, just to store the contents of memory onto paper tape does not constitute a complete record. Generally-accepted practice dictates that prior to starting a dump of some memory, the computer shall send the following to the teletype: (see Fig. 2)

a) A **leader** consisting of several frames (usually ten or more) of blank tape. This gives the user space to write on the tape describing the program, and also provides an alert to the reader (when the program is loaded into the computer again) that a new block follows.

b) One or two frames with a code that indicates that a new record is about to start, and sometimes, optionally, the type of record (data or program).

c) Two frames which specify the address where this program starts in memory.

d) Two frames that specify the address to which control should be given at the completion of loading if this is a self-starting program.

e) One or two frames which specify the length of this block of data, so that the loader knows when to expect the end of the data.

f) A variable number of frames containing the actual data taken from memory, beginning at the address specified in part (c).

g) A special frame or frames that contain a **checksum**, compiled from a process which is affected by every byte of data on the tape. This byte is calculated and stored as the computer is dumping the program. When the computer reads in the program again, it makes the same calculation as it made before when it dumped the data, except that this time it is basing the calculation on the data received from the tape. After the computer has made this calculation on all information read in, it then compares the answer it now gets to the answer that is stored as the last frame(s) on the tape. If the two answers disagree, then the operator is warned that an error occurred during the reading of the last block, and that he should retry that block.

h) Several **rubouts**, or all-holes-punched frames to indicate an end-of-block.

A long program would be broken down into many smaller blocks, so that if an error occurs during a single block, the block itself would be retried by the operator until it is received correctly, instead of having to wait until the entire program has read in before reloading it all.

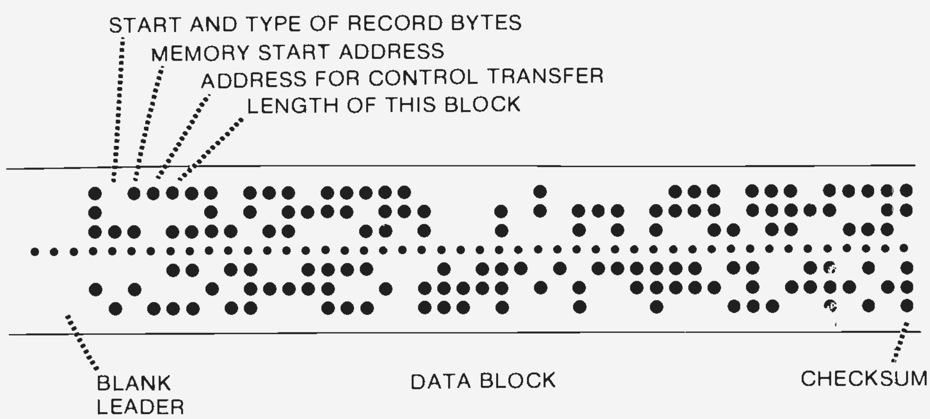


Fig. 2. — Data and preamble/postamble layout on paper tape.

The above program tape description does not necessarily represent an actual format used by any particular manufacturer, but rather a general idea of how most of them operate.

This method is similar to the main form of program loading in the early days of small minicomputer and microcomputer systems. It is largely obsolete now in the minicomputer field, except for small, dedicated systems such as industrial controllers whose program is changed very rarely. It is still used, however, as a last-ditch method of getting diagnostic programs into a computer system when a field engineer cannot get a major system device, such as a disc, to load programs. For this reason, most minicomputer manufacturers still ship diagnostics on paper tape with their products.

BUT EVERYBODY HAS A CASSETTE

A natural development from paper tape was the cassette, although this method has failed to fulfil the expectations of commercial users, since cassette transports designed for home entertainment use are not accurate enough for high-speed data use, and the development of purely digital systems was largely overshadowed by IBM's introduction of the floppy disc. A cassette can be viewed in exactly the same manner as paper tape, including the way that blocks are formatted as described above. The only difference is that instead of parallel holes being used to represent the ones and zeroes, tones are used in pure serial fashion on the cassette, i.e. one after the other. The simplest method of recording data on a cassette would be to send the data to an asynchronous line, just as if it were going to be punched on a teletype machine, but replacing the teletype machine with a modem and recording the tones from the modem on tape. This method is rarely used, more modern and efficient methods such as CUTS and Kansas City standards having been developed by computer hobbyists for better reliability.

One major disadvantage of both the paper tape and cassette systems is that they are both **sequential access** systems. This means that if you store fifty programs, and later want to retrieve the fiftieth one, you have to read through the preceeding forty-nine programs until you get to the one you want. With paper tape, this headache is almost eliminated by putting every program on a separate piece of paper tape, but this has the disadvantage of requiring operator intervention to find the correct tape and load it into the reader. Cassette systems can sometimes have a better approach to this problem. This type of system can turn off the tones completely for a distance between the data blocks, so that there is a quiet spot on the tape. The program puts a program name or identifier at the beginning of every block. (see Fig. 3) When the cassette controller is instructed to find a particular block number or program name, it reads the first few frames of a block, checks to see if the identifier matches that which it is looking for, and if so, reads the whole block. If it does not match, it then fast-forwards the tape until another silent gap is detected, at which time the controller slows down the tape to read the first few frames, and so on until the whole program is loaded.

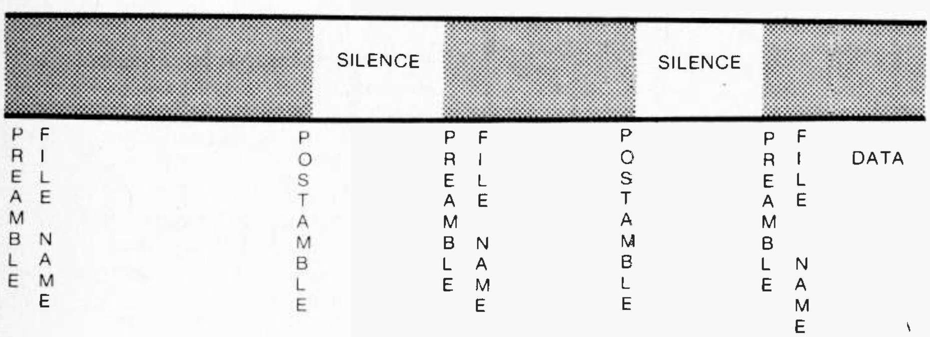


Fig. 3. — Data files on a cassette.

ENTER THE FLOPPY DISC

When IBM introduced the floppy disc, it was designed to be a quick, reliable method of reloading the microprogram of their big mainframes, quickly and effectively after a power failure or other cause of loss of control memory. As a result of the availability of the floppy disc it is not worth the trouble and expense for anyone to develop a general-purpose, commercial-grade cassette system, since cassettes are inherently unsuited for data purposes and a floppy disc system is only marginally more expensive. Also, the floppy disc wins hands down over all sequential-access devices, because it is a **random-access** device.

Random access simply means that any part of a file can be accessed without having to read all data before it.

The floppy disc is made up of a flexible, circular piece of mylar, about the size of a 45 rpm gramophone record. (see Fig. 4) One side of the "diskette" is covered with metal oxide, just as is one side of a cassette tape. On this surface, all data are recorded, in the following manner:

As the diskette spins around at 360 rpm, the head can move in and out along a line joining the centre of the hub of the diskette and a fixed point on the perimeter of the diskette. The actual diskette is enclosed in an envelope to protect it, and a slot is cut in the envelope along the line of travel of the magnetic recording head, on the side of the diskette containing the oxide. The inside of this envelope contains a felt-like material that cleans the diskette and traps any foreign particles as the diskette spins.

The head can be moved in and out over the surface of the diskette in increments of 1/48 inch. Every 1/48 inch is defined as being a track, starting at a predetermined distance in from the edge of the diskette. Each track forms a circle, centred on the centre of the disc. Thus all data are written on the 77 concentric tracks.

At a specified spot on the mylar, a hole is punched so that light can pass through it. This point is defined as being the start point of all the tracks. As the disc spins past this point, no matter which track the head is over, it will be at the beginning of that track.

Each track is further divided into 26 sectors. In some diskettes, a hole is punched in the mylar to signal the beginning of each sector. These are known as hard-sectored diskettes, since the hardware (photocell) actually gives a signal to the interface to tell it when a new sector is starting. The IBM 3740 standard diskette is a so-called **soft-sectored** diskette, since the start position of each sector is determined by a calculation based on the time interval after the main index hole has passed.

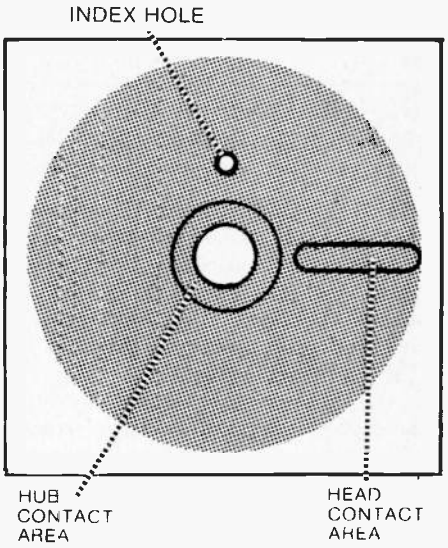


Fig. 4. — IBM 3740 Diskette.

At the beginning of each sector are written a series of identifying marks telling the controller the track and sector it has found. It compares these when it has read them with where it has calculated the head to be and sees if there has been an error. Also found at this point at the beginning of each sector is a series of check marks specially encoded to test that the head is decoding the magnetic flux changes properly. Following the above (called **preamble**) there are 128 bytes of data, followed by some more checking marks called **postamble**.

Thus the floppy disc controller can randomly retrieve any 128 byte record from the 2002 such blocks on the diskette. All the user has to do is specify the track and sector number where he stored the data, and he can retrieve it years later.

In most actual operating systems, the track and sector numbers are not used by the system user, but files are referenced by a name that is given to them at creation. At the beginning of the diskette there is a cross-reference file which contains the file names and their corresponding track and sector numbers. This file is known as the directory, and is manipulated by the programs of the manufacturer-supplied operating system software to store and later retrieve all files required by the user.

Sinclair Cambridge Programmable

Don't be fooled by the tiny size — this is really a programmable calculator, and a useful one at that! — **Les Bell reports.**

MOST OF OUR READERS are involved with circuit design or other vaguely mathematical problems from time to time. In fact some may actually use Bessel functions, Chebyshev polynomials and other frightening beasts from the mathematical night.

A common requirement is to solve a problem repetitively; for example, a filter design may have to be optimised and values recalculated – a long and tedious job. This is where the programmable pocket calculator comes into its own – you can load in the keystroke sequence required to do the job and then run that program as often as you want.

The problem is that programmable pocket calculators are expensive; true, they're getting cheaper, but not fast enough for most of us. But at last, the programmable is down in price to the stage where even schoolkids can afford to use one. One company behind this move is Sinclair Radionics.

PROGRAMMABLE

Sinclair have been producing the Cambridge range of pocket calculators for a good few years now and the design has stood the test of time pretty well. There have been a few minor changes, both internal and external, since the original models, but none so big as with the introduction of the Cambridge Programmable.

Sinclair have had an earlier attempt at a programmable calculator as an extension of their Oxford series, but the machine was not very successful from the design point of view – it abused Reverse Polish Notation (no stack!) and could best be described as quirky in its operation. Fortunately, Sinclair have sorted out the good points from the bad and used the best ideas in producing the Cambridge version.

The Cambridge format is tiny – only 110 x 50 x 17 mm with 19 keys, and this makes for a very busy keyboard indeed. All the numeral keys have three functions, i.e. digit entry, and up-shift and down-shift functions. Because there is little space between the keys, the legends are a little cramped and confusing, but with practice you soon get to know your way around.

NEAT TRICK

Very neat trick No. 1: when in the program-entry mode all the numeral keys are automatically interpreted as upshifted functions, unless preceded

This is the animal slightly larger than life; you can see how crowded the keyboard is.

by a 'hash' symbol. This saves a fair number of keystrokes, but if you're not used to it, you forget that symbol and your program goes berserk. Back to square one, and more practice.

Apart from the mere ability to parrot-fashion execute sequences of keystrokes, an important facility offered by many programmables is that of decision-taking. This enables the calculator to act differently on different input values, or more importantly, to loop around, performing an iterative calculation until an accurate enough result has been achieved. A good example of the need for decision-making capabilities occurs in games such as 'Lunar Lander', where the calculator has to decide whether you're at a height of less than zero feet, in which case you've landed, and the calculator now works out your terminal velocity.

The Cambridge Programmable does have rudimentary conditional branching, in the form of a 'go if neg' instruction, which jumps to a specified line number if the result is negative, or continues otherwise.

The calculator is a little bit awkward to use at first, for a variety of reasons: just to get into the program mode you have to press seven keys, and every time you reset it to step 0 to run a program, it displays the first step.

HANDY WRINKLE

Rather than reset the machine to the beginning of your program by hand, insert the sequence 'downshift/goto/0/0' at the end (if you have room) and when the machine halts at the end of the program, pressing 'RUN' will automatically reset the machine to step 0. Clever stuff, eh?

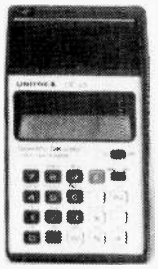
There is a wide variety of scientific functions on the C.P. including all the trig functions, which operate in radians. In addition, there are all the standard technical functions, (except log and antilog to base ten), and degree/radian conversions. On top of all that there are the usual exponent entry, sign change, memory functions, etc., and also the program control and editing keys. This makes for a crowded keyboard, but after a little practice, this is no problem.

Cont'd on p. 64

CALCULATOR BARGAINS

We are able to offer you a selection of quality scientific calculators at clearance prices. This most unusual offer is available on a first come, first served basis. If you ever thought of owning a powerful calculator, but didn't want to invest a small fortune, this is your opportunity. Calculator prices now are on the increase and you will probably never see such low prices again. So don't delay — as we have limited quantities of these models.

BARGAIN #1: UNITREX UC-55

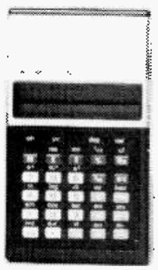


Full function scientific has most popular scientific functions including: sin, cos, tan and their inverses; log, antilog, squares and square root, reciprocal, all basic functions and more. Full 4-key memory, 8-digit LED, display with scientific notation. Works off 9V battery or A/C adapter (not included).

REG. TO $20.00

Clearance $9.95

BARGAIN #2: MICROLITH

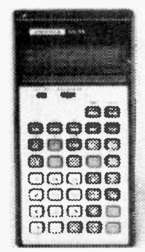


Advanced scientific with large green display and click-stop keys. Has all popular trigonometric and logarithmic functions and their inverses. Powers roots, squares; 4-levels of parenthesis, 8-key memory function, radian to degr. conversions plus all basic functions and more. Operates from 9V battery or A/C adapter (not included).

REG. TO $30.00

Clearance $12.95

BARGAIN #3: UNITREX UC-75



Deluxe advanced scientific with all functions listed in bargain #2 plus polar to rect. conversion and simplified single function keyboard, of most functions. Will satisfy the most discriminating buyer.

REG. TO $40.00

Clearance $16.95

BARGAIN #4: UNITREX S874LR

Rechargeable full scientific with all popular scientific functions listed in bargain #3, plus factorial key and simplified single function keyboard. Has 10-digit LED display with scientific notation. Includes rechargeable batteries and charger.

REG. TO $50.00

Clearance $22.95

MARKETRON CALCULATOR STORE

1240 BAY STR.-MALL (AT CUMBERLAND)
TORONTO, ONT. - PHONE 416/923 1917
STORE HOURS 10-6 THURS & FRI til 8 p.m.

All clearance calculators carry a 30 day replacement warranty against manufacturer's defects. Simply return via registered mail.

A/C adapter for items 1, 2, 3. $4.95

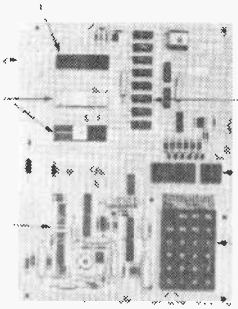
NEW IN CANADA

Latest technology in calculators. New from Commodore. Liquid crystal display scientific provides 1500 hours operation on standard batteries. Has all popular trig and log functions, plus powers, roots, squares. Statistical mean and standard deviation sum of X and X2. Full memory all basic functions. 10-digit LC display with scientific notation. Includes batteries and carrying case.

Ultra Slim only ¼" thick.

Now only $ 39.95

LOW COST MICRO-COMPUTER



Commodore Kim I: plays games. Capable of controlling inventories or home appliances; yet affordable to the hobbyist, teacher or student. It's educational and a lot of fun.

1. 6530 chips, 2048 ROM bytes 128 RAM bytes, 30 I/O pins 2 timers.
2. expansion option
3. 6502 microprocessor
4. 1024 bytes RAM
5. display
6. keyboard
7. TTY interface

OPTIONS
first book of Kim $9.00
power supply $45.00 additional

Now only $275.00

price includes 3 manuals

YOU MAY PURCHASE AT OUR STORE OR BY MAIL ORDER

Send: Cheque ☐ Money Order ☐ Chargex ☐ Master Charge ☐ American Express

Card number ____________

Signature ____________ Expiry Date ____________

To: **MARKETRON CORP. LTD.**
1240 BAY STREET — MALL
TORONTO, ONTARIO M5R 2A7
PHONE: 416-923-1917

Ordering QUANTITY	PRODUCT	PRICE	TOTAL
______	UNITREX UC-55	9.95	______
______	MICROLITH	12.95	______
______	UNITREX UC-75	16.95	______
______	UNITREX S874LR	22.95	______
______	ADAPTER FOR 1, 2, 3	4.95	______
______	COMMODORE LC43SR	39.95	______
______	KIM I COMPUTER	275.00	______
______	FIRST BOOK OF KIM	9.00	______
______	KIM POWER SUPPLY	45.00	______
		Total	______
		Ont. Resident add 7% tax	______
		Delivery charge	3.50
		Total enclosed	______

Name ____________
Street ____________
Town ____________
Province ____________ Postal Code ____________

they're here!

the new HEATHKIT low-cost personal computing systems

The new VALUE-STANDARD in personal computing systems! Heathkit computers give you the power and performance to go wherever your imagination and programming prowess take you. They're designed to get you up and running fast, interface with I/O devices easily and quickly, accept additional memory and I/O devices, store and retrieve data with speed and accuracy, respond to your requests with lightning speed. They offer complete mass storage capabilities, power and reliability for any programming application, and they're priced low enough to give you real VALUE for your computer dollar! We've told you they're the ones you've been waiting for — here's why!

These Heathkit computer products are "total system" designs with powerful system software already included in the purchase price. They're the ones you need to get up and running fast. And they're backed by superior documentation including easy-to-follow step-by-step assembly and operations manuals, and service support from the Heath Company, the world's largest and most experienced manufacturer of electronic kits.

NEW H8 8-Bit Digital Computer. This 8-bit computer based on the famous 8080A microprocessor features a Heathkit exclusive "intelligent" front panel with octal data entry and control, 9-digit readout, a built-in bootstrap for one-button program loading, and a heavy-duty power supply with power enough for plenty of memory and interface expansion capability. It's easier and faster to use than other personal computers and it's priced low enough for any budget.

NEW H11 16-bit Digital Computer. The most sophisticated and versatile personal computer available today — brought to you by Heath Company and Digital Equipment Corporation, the world leader in minicomputer systems. Powerful features include DEC's 16-bit LSI-11 CPU, 4096 x 16 read/write MOS memory expandable to 20K (32K potential), priority interrupt, DMA operation and more. PDP-11 systems software for fast and efficient operation is included!

NEW H9 Video Terminal. A full ASCII terminal featuring a bright 12" CRT, long and short-form display, full 80-character lines, all standard serial interfacing, plus a fully wired and tested control board. Has autoscrolling, full-page or line-erase modes, a transmit page function and a plot mode for simple curves and graphs.

NEW H10 Paper Tape Reader/Punch. Complete mass storage peripheral uses low-cost paper tape. Features solid-state reader with stepper motor drive, totally independent punch and reader and a copy mode for fast, easy tape duplication. Reads up to 50 characters per second, punches up to 10 characters per second.

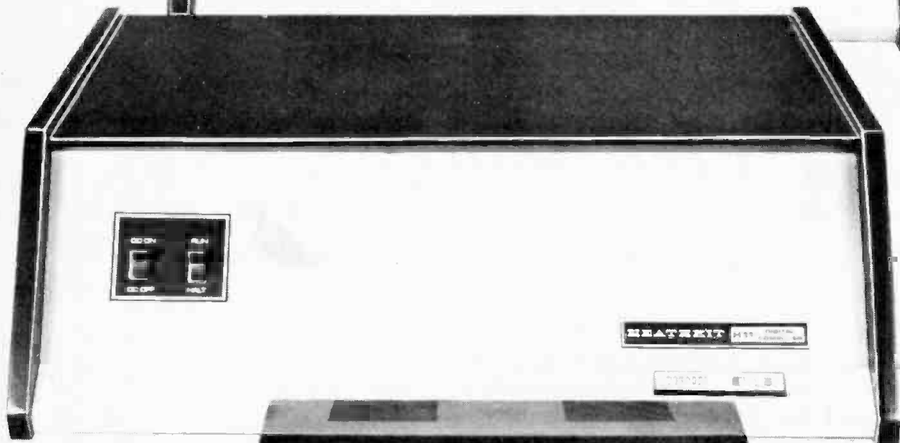
Other Heathkit computer products include a cassette recorder/player and tape for mass storage, **LA36 DEC Writer II keyboard printer terminal,** serial and parallel interfaces, software, memory expansion and I/O cards, and a complete library of the latest computer books. The Heath User's Group (HUG) provides a newsletter, software library and lots more to help you get the greatest potential from your Heathkit computer products. We've got everything you need to make Heath your personal computing headquarters, send for your FREE catalog today!

H8

8-Bit Computer

$499^{95}

Also Available: the famous LA36 DEC Writer II Keyboard Printer Terminal only $2195 (Assembled)!



H11

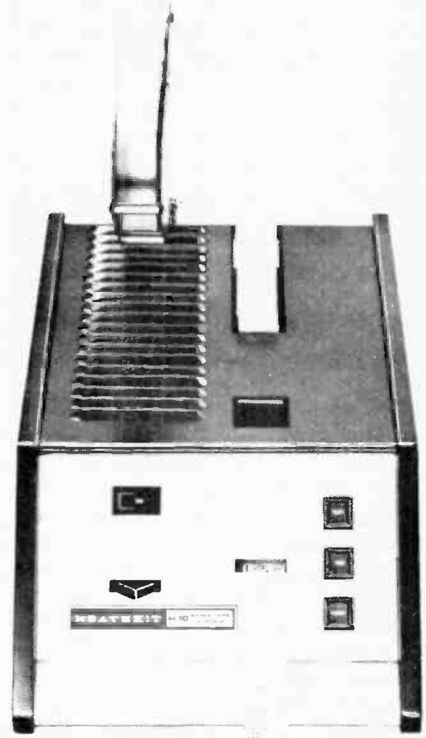
16-Bit Computer

$2195^{00}

H9

Video Terminal

$899^{95}



H10

Paper Tape Reader/Punch

$499^{95}

FREE!

HEATHKIT CATALOG

Read all about our exciting computer systems and nearly 400 other fun-to-build, money-saving electronic products in kit form.

Prices are mail-order FOB, Mississauga Ontario
Prices and specifications subject to change without notice.
Heath Company, EU0278 Mississauga, Ontario.

HEATH
Schlumberger

Heath Company. Dept. EU0278
Mississauga. Ont. L4X 2R7

Please send me my FREE Heathkit Catalog.
I am not on your mailing list.

Name ____________________

Address ____________________

City ____________________ Prov. ________

CP-126 Code ________

The major failing with this calculator is, we feel, the lack of accuracy on the log and trig functions. While these are probably good enough for everyday use, there is considerably more importance attached to accuracy in a programmable calculator. The reason for this is simple: if one is using an iterative technique to, for example, find a root of an equation, then the calculator is going round a loop, using the result of the last run through the loop as the input for the next. It is possible to go round a loop of this nature hundreds, or even thousands, of times.

Now, if the loop includes a log or trig function, the first time round the loop an error will be introduced into the calculation, which may not be very large; but the second time round the loop the error is compounded, the third time it is still greater, and so the error is multiplied through the calculation, possibly reaching the same order of magnitude as the correct result.

We found that the e^x (or exp) function was a bit hairy; for example, exp (1) gave a result of 2.7179766, as opposed to the correct answer of the transcendental number e, which equals 2.718281828.... This is an error of 0.012% (!). The trig functions had lower errors — compare these results with the correct answers in brackets: sin $\pi/2$ = 0.9998814 (1), cos $\pi/2$ = 0.0154012 (0), tan $\pi/2$ = 64.95699 (infinity), sin π =0.0814007 (0), cos π = 0.9966814 (−1), tan π = 0.0816717 (0). In each of these cases the error symbol lit on the display. For mid-range values: sin $\pi/3$ = 0.8658722 (0.8660254034), cos $\pi/3$ =0.5002651 (0.5), tan $\pi/3$ = 1.730829 (1.732050806).

These results are not stunningly accurate. The accuracy is adequate for most everyday applications, but has to be watched in iterative programs. Who needs 12-digit accuracy anyway — there is virtually nothing in the universe that can be measured that closely, so that five or six digits suffice for most calculations. We shall qualify our comments later when discussing the innards of the machine.

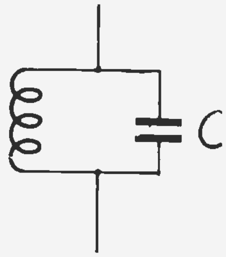
Other minor moans: the 'power bulge' in the back of the machine is not very elegant, and there is no y^x function. Both of these are only minor quibbles.

INNARDS

Very neat trick No. 2: when you open up the back of the calculator you will be pleasantly surprised to discover that there is nothing inside to go wrong (well almost). There is one calculator chip, one digit driver chip, a capacitor, and a display and keyboard. The keyboard is Sinclair's standard design, the digit driver is National Semiconductor's standard design, the capacitor is ITT's, and the display, although made by National, is not standard, and is presumably specially made for Sinclair.

But the calculator chip is the real belle of the ball. It is National's MM5799 Controller Oriented Processor (COPS), a MOS/LSI device which can scan up to 56 keyboard switches, can output BCD or 7-segment data, and has serial I/O ports for expansion to external memory and peripherals such as printers. On the chip are 384 bits (96 digits) of RAM, and 1536 bytes of ROM, an ALU (Arithmetic and Logic Unit), and an on-chip clock plus lots of other bits of logic. The ROM is mask-programmed, which is an expensive operation and only economical for quantities in the tens of thousands, so don't go out and try to buy one! This device is really an 8-bit microcomputer organised to do BCD arithmetic.

RESONANT FREQUENCY OF A PARALLEL TUNED CIRCUIT



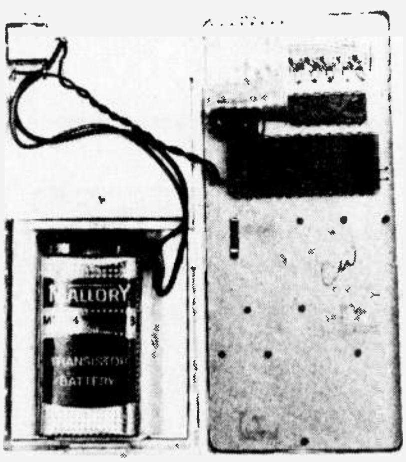
Solves $f = \frac{1}{2\pi\sqrt{LC}}$

Execution sequence:

C/x/L/RUN/(f_0)

(Note: pre-execution calculate LC; then press RUN)

=	−	00
$\sqrt{x}$	1	01
×	.	02
#	3	03
3	3	04
.	A	05
1	1	06
4	4	07
1	1	08
5	5	09
9	9	10
2	2	11
7	7	12
×	.	13
#	3	14
2	2	15
=	−	16
÷	G	17
=	−	18
stop	0	19
▼	A	20
go to	2	21
0	0	22
0	0	23



Despite being made in England, it doesn't work by springs and gears.

And here we discover why the Sinclair is not too hot in the accuracy dept. With only 1.5 Kbytes available for their calculator microcode, just getting in a reasonable number of scientific functions would be very tricky, and making it programmable would be very tricky indeed. Now, for a calculator application, the COPS processor seems to have rather more RAM than is required for the amount of ROM; and so we suspect that Sinclair's designers found themselves stuck with a tricky decision. They could either provide a comprehensive and accurate straight scientific, which would fully utilise the ROM but leave a lot of spare RAM, or they could omit some of the functions and/or compromise on the accuracy, thereby releasing some ROM to implement programmability — the program could then be stored in the 40-odd spare nybbles of RAM.

Well, they went for the programmable; I would have, too. The loss of accuracy is easily tolerable in exchange for programmability. The problem with iterative loops is not a serious one — perhaps one of our readers who has time to spare may like to do a study of this, as we just haven't had the time. Iteration is a useful technique for solving equations of the form $x = f(x)$, e.g. $x = 1/x + 4$, but this is only one application for programmable calculators, and most will not be troubled by accuracy considerations.

Now that Sinclair's engineers are fully aquainted with the COPS processor, it is quite probable that they will produce other calculators using it — a financial machine is particularly appealing, since another standard COPS chip provides a complete interface to a Seiko printer.

PROGRAM LIBRARY

Here is very neat trick No. 3: due to the fact that the calculator is algebraic, strange and very non-obvious keystroke sequences can be used to perform useful functions — the most obvious one is that pressing x twice performs squaring. These tricks considerably expand the power of the calculator, but unfortunately they are not explained in the manual (which we reckon gives you all the information you need, but only just).

The main source of information is Sinclair's Program Library. Seeing that a major attraction of the machine would be a large amount of readily-available software for people who do not wish to write their own programs, they have compiled a collection of 294 programs relevant to a wide variety of disciplines. Their application programmer obviously understands the machine fully and uses every trick in the book to maximise the power of his programs. The 4-volume Program Library is worth every penny, even if you never use half the programs, but also for what you can learn from it.

Σ

Or, summing up (sorry, I couldn't resist it!). The Sinclair Cambridge Programmable is an enthusiast's machine. Experimenting with it will pay off handsomely, especially if you take the time to work through some of the programs in the Library and figure out just what the calculator is doing. If you're not very enthusiastic about calculators, and don't really need a programmable, forget about this one, you'll get fed up with the fiddliness of the key sequences, and probably give up.

Although we have been pretty critical, we reckon we have covered just about all the failings of this calculator, and if these are all there are, then it stands head and shoulders above similarly priced calculators. It offers superb value for money, virtually unlimited capability, and a lot of fun. We confidently predict that it will be popular with our readers, so if you write any interesting programs let us know about them and we'll pass them on. Beginning with our March issue we will be publishing interesting software in our SOFTSPOT department. We will welcome programs for this or other programmable calculators — see the announcement elsewhere in this issue.

tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

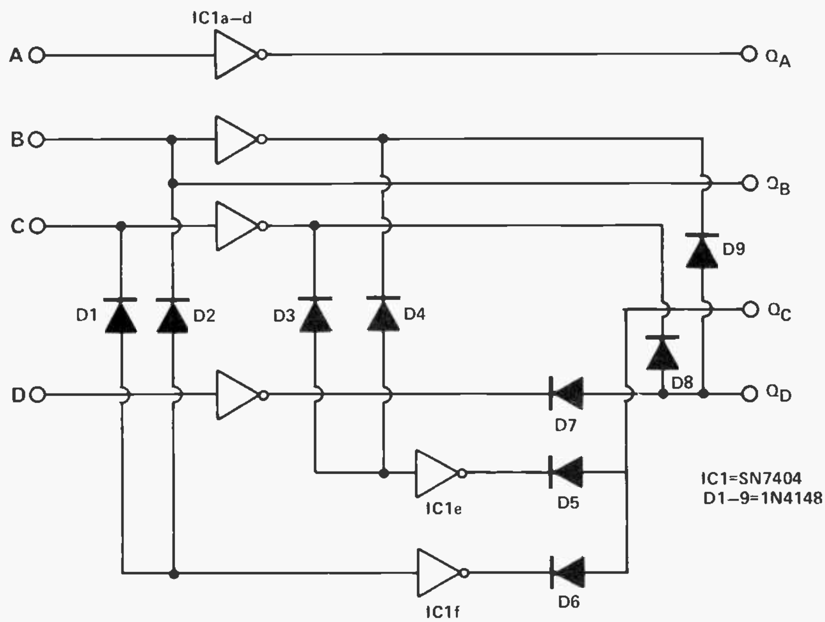
CHEAPO DOWN COUNTER

AF Bush

This circuit, when presented with a 4 bit binary number in the range 0000–1001 will present the nines complement of that number at the output.

Connecting the circuit between a 7490 and a 7447, will, instead of the usual up count, provide a display which counts down from nine.

This provides a useful alternative to the 74192 when only a down count is required.



BCD COUNT	INPUTS				OUTPUTS				COMPLEMENT
	D	C	B	A	Q_D	Q_C	Q_B	Q_A	
0	0	0	0	0	1	0	0	1	9
1	0	0	0	1	1	0	0	0	8
2	0	0	1	0	0	1	1	1	7
3	0	0	1	1	0	1	1	0	6
4	0	1	0	0	0	1	0	1	5
5	0	1	0	1	0	1	0	0	4
6	0	1	1	0	0	0	1	1	3
7	0	1	1	1	0	0	1	0	2
8	1	0	0	0	0	0	0	1	1
9	1	0	0	1	0	0	0	0	0

$Q_A=\overline{A}$
$Q_B=B$
$Q_C=(\overline{B\cdot C})\cdot(\overline{\bar{B}\cdot\bar{C}})$
$Q_D=\bar{B}\cdot\bar{C}\cdot\bar{D}$

NPN-PNP INDICATOR

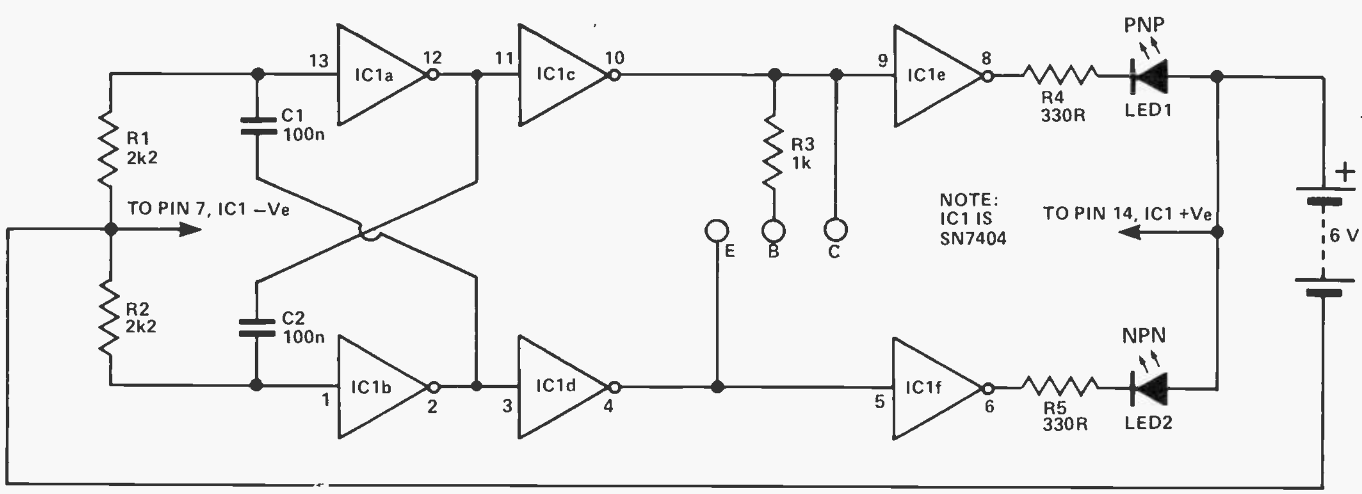
F Read

The first 2 inverters IC1a and IC1b form a multivibrator running at approximately 2 kHz. The next two inverters buffer the multivibrator outputs, which then go to the collector and emitter of the transistor under test.

The signal applied to the base of the transistor is always in phase with the collector so the transistor, whether PNP or NPN, will always be turned fully on every half cycle.

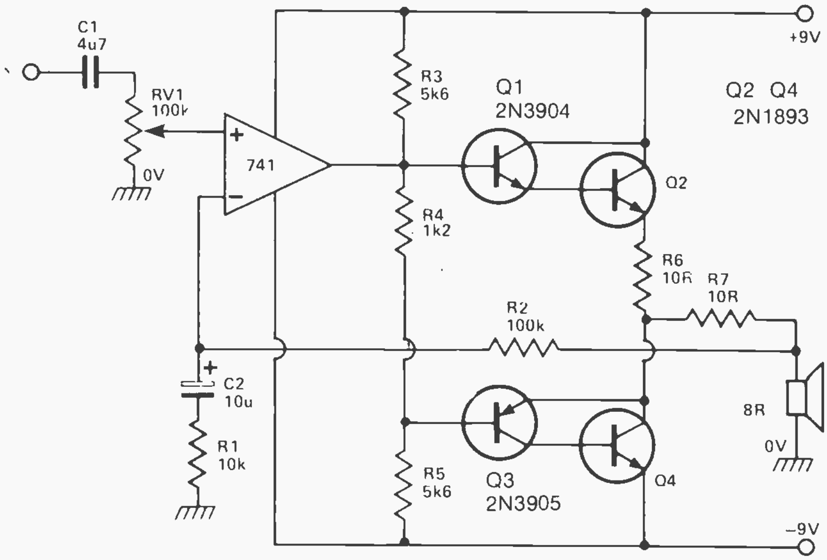
When an NPN transistor is being tested the collector will always be near OV and when a PNP transistor is being tested the emitter will always be near OV. The last two inverters detect which terminal is held at OV and drive the appropriate LED via the current limiting resistors R4 and R5.

The six inverters needed are all contained in a single IC package - the SN7404.



tech-tips

ONE CHANNEL ONLY SHOWN



Headphone Amplifier

J. Macaulay

The circuit will deliver full 'orchestral' levels to four pairs of stereo headphones connected in parallel across the output.

Input signals are coupled to the non inverting input of a 741 op amp via the volume control RV1.

This IC is used to drive a quasi-complementary output stage consisting of Q1-4.

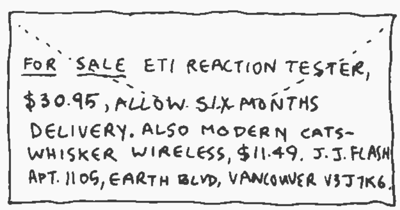
Quiescent current in the output transistors is provided by the voltage drop across R7 and local feedback provided by R6 in Q2's emitter circuit.

R6 is included to render the whole amplifier short circuit proof (to protect Q2 and Q4). Overall feedback is applied from the load end of R7 so this component has negligible effect on the damping factor of the amplifier.

With the components shown the frequency response is —3dB at 4Hz and 100KHz, distortion below 0.1% at 1KHz (50mW out, 8Ω load), and sensitivity 60mV.

ETI MARKET PLACE

We will allow you up to twenty-five words to advertise items you want to buy or sell, or to publicise meetings of clubs, etc. Advertising will be accepted at our discretion — we will not accept commercial or any form of company advertising. Please type, or clearly print, your message on the back of a sealed empty envelope — as shown below. Our tentative plan is to run ads up to two consecutive issues as space permits. For more insertions mail in again.



When this issue went to press readers' advertising had just started to come in. Here are the first items . . .

THE FIRST ADS

WANTED: PLANS FOR A TRANSISTORIZED HI-SENSITIVITY AMP. NAME YOUR PRICE. ALSO WANT CIRCUIT FOR UNIJUNCTION TRANSISTOR ELECTRONIC ORGAN. WILL BE WILLING TO EXCHANGE CIRCUIT DESIGNS INSTEAD OF MONEY. ANYBODY INTERESTED? PLEASE SEND CORRESPONDENCE TO: STEPHEN KAWAMOTO, BOX 165, ALDERGROVE, B.C. V0X 1A0

FOR SALE: TRANSISTORIZED MULTI-METER WITH FIVE POPULAR SCALES. ALSO 5" OSCILLOSCOPE — NEVER BEEN USED. DETAILS/OFFERS — OTTO A WEINKAUF, BOX 400, MACKLIN, SASK. S0L 2C0.

FOR SALE: CPU 8080A, NEW AND UNUSED, $10.00 @ COMPLETE WITH SPECS AND TROUBLESHOOTING CHARTS. M. JESSOME, P.O. BOX 78, DARTMOUTH, NOVA SCOTIA B2Y 3Y2

JE DEMANDE LIVRES ET PERIODIQUES ELECTRONIQUE DE TOUTES SORTES. WANTED: ELECTRONIC BOOKS AND MAGAZINES OF ALL SORTS. J.C. LACHAPELLE, 3924 MENTANA, MONTREAL H2L 3R8.

FOR SALE BEARCAT 101 SCANNING MONITOR RECEIVER. COVERS 3 VHF AND UHF BANDS. REQUIRES NO CRYSTALS. $250. WRITE G. PERRY, 121 PRESLEY AVE., SCARBOROUGH ONT M1L 3P9. PHONE 416-599-4127.

DANGER
LASER
ON
NOTICES
LABORATORY
Cisco.

Try Our new ADK40 for intimate locations

Want power?

The kind of power that only our new compact Philips DeForest ADK 40 can give you. The clear highs...definitive mid-range...lowest octaves... at a price to fit your budget. Our ADK 40 competes in tonal quality with many of the costlier high power three-way high fidelity speaker systems.

The tweeter is the latest development of the extremely sensitive Philips dome tweeter. It has one of the widest dispersion patterns and lowest distortion characteristics. Magnet is 10 oz., among the largest size used for tweeters. Level control (located on the back panel) gives up to 10 dB attenuation of the upper frequencies. Tweeter never shuts off, even in the minimum position of level control. At maximum, sparkle of the high end is rarely matched.

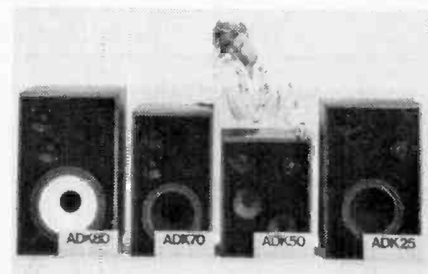
ADK 40 shown without removable grille

7″ woofer has 16 oz. magnet. An 8″ passive radiator is used to lift the lower bass. In effect, it acts as a motional port to give you the "North American Sound".

Crossover network has two close tolerance copper-wound inductors. Woofer coil is air-cored for very low losses. Tweeter crossover capacitor is ± 10 percent polyester film component that will never drift in value or dry up as is possible with electrolytic capacitors.

Our new ADK 40 looks good too. Finished in matched oiled American walnut veneer, the solid ¾″ top, front, back, bottom and sides are structurally solid. The grille frame is removable, and enclosure front in its smooth matte black finish is esthetically pleasing.

Settle in and enjoy the intimate Philips DeForest ADK 40. Size: 25″ H., 11½″ W., 9″ D., only $150.00 (suggested retail price).



Other Philips DeForest state-of-the-art speakers

Look into the Philips DeForest ADK 40 today. Ask your dealer about preassembled kits. For the location of your nearest dealer, look in the Yellow Pages under "stereophonic", or get in touch with us: Gayle Quintilian, Philips Electronics Ltd., Electron Devices Division, 601 Milner Ave., Scarborough, Ont. M1B 1M8.

DeForest
Quality Loudspeakers

PHILIPS Electron Devices Division **PHILIPS**

Classified Advertising Rates

Minimum charge $27.00 per insertion
Minimum size One inch depth by one column wide (2⅛").
Allow 36 letters and/or spaces per line.
Bold face Heading and Signature $3.00 extra.
Otherwise only **FIRST** word and **NAME** set in bold caps.

Nine lines of this size of type to one inch depth.

Nine lines of this size of type to one inch depth, including Heading and Signature and white space if used.

Advance payment required except for classified ads placed by recognized advertising agencies. P.O. Box not accepted unless advertisers provides permanent address and phone number. 10% discount on consecutive insertions without copy change. Copy must be received 8 weeks preceeding month of issue.

Semi-Display Advertising Rate

Camera ready copy must be supplied or work will be billed back to client. 10% discount on repeat insertions without change. Payment in advance, except for recognized agencies. Deadline 8 weeks preceeding month of issue.

0.7" Led Clock Module
4 Digits Alarm Clock
$13.50 EACH
LT701E, 60Hz 12 hr. display
LT701G, 60 Hz 24 hr. display


Power Supply 12V AC
Ideal for panel clock, desk clock, or auto clock kit
COMPANY NAME AND ADDRESS HERE

One size only
One column, 2" wide by 1" inch depth
Cost $40.00 per insertion

Send copy and cheque or money order to
ETI Magazine; Classified Advertising Dept.,
25 Overlea Blvd, Unit 6,
TORONTO, Ontario, M4H 1B1

HAYDEN

have a complete line of educational and "do-it-yourself" books covering every aspect of electronics from the beginner/hobbyist level right on up to the Electronic Technician who wants to be kept up to date on the latest advances in electronics servicing. The following is but a brief sampling of the total line.

For the Electronician

COLOR TELEVISION — Principles and Servicing by Howard & Marvin Bierman — A practical guide to understanding color television receivers. Discusses tube circuits, transistor circuits and ICs, with special sections on test equipment and trouble-shooting. #5929-9 .... **$7.15**

SIMPLIFIED TRANSISTOR THEORY by Training Systems Inc. and Stanley L. Levine — Planned for those who have little or no previous knowledge of transistors, this book presents the basic theory of transistor operation by the use of detailed programmed instruction. #0705-1 .... **$7.15**

For the Hobbyists

50 IC PROJECTS YOU CAN BUILD by Ronald M. Benrey — The project selection ranges from a simple IC crystal set to an automotive tachometer and TV commercial killer. Comes complete with parts list and instructions. #0723X **$6.55**

103 SIMPLE TRANSISTOR PROJECTS by Tom Kneitel — For the beginner and advanced experimenter, this book contains a number of projects from an audio amplifier to a geiger counter. Many hours of fun for everyone. An ideal gift! #0313-7 .... **$5.95**

Other exciting "how to" books for everyone . . .

25 SOLID STATE PROJECTS by Rudolph F. Graf and George J. Whalen — Projects include an intercom, electronic timer, two metal detectors and much, much more with detailed information on circuit theory, construction, trouble shooting and use. #0134-7 .... **$5.95**

John F. Rider #0146-0 $5.10

All books are paper back and you can order them directly, adding 50¢ to all prices for handling and mailing. Allow 4 to 6 weeks delivery.

HOW TO BUILD A LOW COST LASER by Ronald M. Benrey — This book is structured to present the basic theory, experimental techniques and provides practical information. Written especially for the hobbyist, this book shows how to actually build a low cost gas laser. #5934-5 .... **$5.95**

REPAIRING TRANSISTOR RADIOS — 2nd Edition, revised, by Sol Libes. Information on the operation and servicing of transistorized equipment including portable AM receivers. Provides up to date coverage on hybrid and all transistor auto radios, PA and hi-fi amplifiers. FM and multiband receivers. #5057-7 .... **$7.15**

HOW TO MAKE ELECTRONIC TESTS WITHOUT SPECIALIZED EQUIPMENT by Rufus P. Turner — Designed to aid the reader in finding ways of making tests for voltage, current, etc. Describes a number of tests that can be made without specialized instruments. #5868-3 .... **$5.95**

ATTENTION
Dealers and Distributors!

Walgram Publishing Limited have been appointed National Canadian Distributors for the complete Hayden line of technical books including Rider, Aherns and Sparton. Inquire on your official stationary if you wish to stock these or any of the total line of electronics and communications books at regular discount prices. Write for complete listing.

WALGRAM PUBLISHING LIMITED
2175 Sheppard Ave. East, Suite 106
Willowdale, Ont. M2J 1W8 (416) 496-1203

To **WALGRAM PUBLISHING LIMITED,**
Box 569, Don Mills,Ont. M3C 2T6

Please rush the following book(s) # (s)__________

I have included a cheque or money order for the full amount plus 50¢ each for handling and mailing.

Note: on orders of 3 or more, only 35¢ each book.

NAME______________________

ADDRESS______________________

City/Town______________________

Prov. ______________**Postal Code**__________

INFORMATION

COMPONENT NOTATIONS AND UNITS

We normally specify components using the recently agreed International Standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be used by everyone 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: 1.8Mohms is 1M8, 56kohms is 56k, 4.7kohms is 4k7, 100ohms is 100R, 5.6ohms is 5R6.

BACK NUMBERS

Previous issues of ETI-Canada are available direct from our office for $2.00 each. Please specify issue by the month, not by the features you require.

EDITORIAL QUERIES

Written queries can only be answered when accompanied by a self-addressed, stamped envelope, and the reply can take up to three weeks. These must relate to recent articles and not involve ETI staff in any research. Mark your letter ETI Query.

NON-FUNCTIONING PROJECTS

We cannot solve the problems faced by individual readers building our projects unless they are concerning interpretation of our articles. When we know of any error we shall print a correction as soon as possible at the end of News Digest. Any useful addenda to a project will be similarly dealt with. We cannot advise readers on modifications to our projects.

COMPONENT STORES

ETI is available for resale by component stores. We can offer a good discount and quite a big bonus, the chances are customers buying the magazine will come back to you to buy their components.

PRICES

All prices quoted in the editorial of ETI are in Canadian dollars, except where stated. Advertisers in U.S. may give U.S. dollar prices. Where we only know an overseas price, e.g. in U.K. pounds, we convert approximately to Canadian dollars, erring on the conservative side, where possible.

COMPONENT SUPPLY

We do not supply components for our projects and are unable to supply advanced information on components used in any projects. However to enable readers to obtain printed circuit boards without undue delay we will be supplying retailers and manufacturers with certain p.c. board designs. Any company interested in receiving such designs should write to us on their headed note paper requesting details.

CLASSIFIED

5 Major Types That Handle Practically All Your Capacitor Requirements

ORANGE DROP® DIPPED TUBULAR FILM CAPACITORS

Double-dipped in bright orange epoxy resin to beat heat and humidity.

Won't leak or drip.

Crimped radial leads for correct spacing when mounted on printed wiring boards.

Marked with black stripe to indicate outside foil.

Capacitance values from .001 to .5 μF.

Voltage ratings from 200 to 2,000 WVDC.

TWIST-LOK® CAN-TYPE ELECTROLYTIC CAPACITORS

Lock in place with twist of tabs.

Sealed aluminum cases for long life.

Withstand high surge voltages, high ripple currents, high temperatures.

Single, dual, triple, and quadruple section units.

Capacitance values from 2 to 5000 μF.

Voltage ratings from 6 to 600 WVDC.

ATOM® TUBULAR ELECTROLYTIC CAPACITORS

Dependable metal case construction with plastic insulating sleeve.

Withstand high temperatures, high ripple currents, high surge voltages.

Low leakage currents.

Long shelf life.

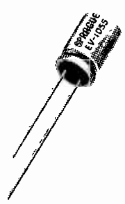
Designed for operation at temperatures to 85° C.

Single, dual, triple, quadruple and quintuple units.

Capacitance values from 1 to 50,000 μF.

Voltage ratings from 1 to 600 WVDC.

VERTI-LYTIC® SINGLE-ENDED ELECTROLYTIC CAPACITORS



For vertical installation on high-density printed wiring boards.

Used for coupling, decoupling, bypass, filtering.

Excellent capacitance stability.

Low leakage current, low ESR.

Metal-encased, with plastic insulating sleeve.

Capacitance values from .47 to 3300 μF.

Voltage ratings from 6.3 to 63 WVDC.

CERA-MITE® DISC CERAMIC CAPACITORS

Fit easily into tight spaces, even across subminiature tube sockets.

Low self-inductance of silvered flat-plate design yields very high by-pass efficiency.

Designed for 85° C operation.

General application, High-K, frequency-stable, temperature-stable, temperature-compensating types available.

Capacitance values from 1.0 pF to .022 μF.

Voltage ratings from 250 to 7500 WVDC.

For complete listings of more than 5600 replacement components get Catalog CC-621 from your Sprague distributor, or write or call:

JOHN R. TILTON, LTD.

1900A Eglinton Ave. East
Scarborough, Ontario M1L 2M1
Tel. (416) 757-4171

P.O. Box 117
Dollard Des Ormeaux, Que. H9G 2H5
Tel. (514) 747-4266

SMITH-PATTERSON & ASSOCIATES

1120 Hamilton St.
Vancouver, B.C. R3E 2T1
Tel. (604) 681-0743

30 Midland St.
Winnipeg, Manitoba R3E 2Y6
Tel. (204) 774-1855

5S-7101R1

YOUR NUMBER 1 SOURCE FOR ELECTRONIC COMPONENTS

SPRAGUE®
THE MARK OF RELIABILITY