

CANADA'S NEW ELECTRONICS MAGAZINE

# electronics today

JULY 1977

incorporating

electronic  
workshop

\$1<sup>25</sup>

## MASTERMIND

BUILD YOUR OWN ELECTRONIC VERSION



### PROJECTS:

- TEST GEAR
- DIGITAL VOLTMETER
- AUDIO
- THE OVERLED
- MOTOR CYCLE
- INDICATOR CANCELLER

**SPECIAL!**

**C.B. SUPPLEMENT**

TECHNIQUES AND TECHNOLOGY

# HIGHEST QUALITY — LOWEST PRICES !



**ONE  
YEAR  
UNCONDITIONAL  
GUARANTEE**

**CELEBRATING OUR  
19th YEAR  
SERVICING THE  
ELECTRONICS  
INDUSTRY**

This is a partial list. Write for full tube listing catalogue

TYPE	EACH	TYPE	EACH	TYPE	EACH	TYPE	EACH
1B3GT	1.90	6BK4C	4.05	6HS8	2.55	10GF7A	2.95
1K3	2.05	6BL8	1.55	6HZ6	1.35	10GK6	1.65
1S2A	1.50	6BM8	1.60			10GN8	2.05
1X2B	1.25			6JC6A	1.50	10JY8	5.10
		6BN6	2.80	6JD6	2.00	10KR8	2.80
2AV2	1.60	6BQ5	1.25	6JF6	4.70		
2GK5	1.30	6BQ7A	1.85			11HM7	3.85
3A3A	2.80	6BU8A	2.40	6JS6C	4.10	11MS8	2.60
3AT2	2.25			6JT8	4.50		
		6BZ6	1.15	6JU6	4.75	12AT7	1.15
3AW2	2.70	6C4	1.95	6JU8A	1.75	12AU7A	1.30
3BW2	2.70	6CA7	3.20	6JW8	1.60	12AV6	1.15
3BZ6	1.40	6CB6A	1.05	6JZ8	2.80	12AX4GTB	2.00
3CB6	1.20			6KA8	2.00	12AX7A	1.20
		6CG3	2.10	6KD6	4.85		
3CU3A	2.90	6CG7	1.45	6KE8	2.10	12BA6	1.35
3DB3	2.70	6CG8A	1.40			12BE6	1.60
3DC3	2.95	6CL8A	1.85	6KG6	5.80	12BY7A	1.60
3DF3	2.95	6CM7	2.00	6KT8	2.55	12C5	1.75
3DJ3	3.15			6KZ8	1.45		
		6CS6	2.00	6L6GC	3.60	12DQ6B	2.95
3GK5	1.45	6CW4	7.05	6LB6	4.10	12DW4A	2.05
3HA5	1.65			6LD6	7.50	12GN7	2.30
3HQ5	2.10	6DJ8	2.25	6LE8	5.00		
4AU6	2.25	6DQ6B	3.30			14GW8	2.00
				6LF6	5.60	15DQ8	1.65
4BZ6	1.25	6DT5	2.45	6LF8	2.00		
4DT6A	1.20	6DT6A	1.90	6LJ8	2.00	17AY3A	2.15
4EH7	2.10	6DW4B	1.70	6LN8	1.50	17BE3	1.90
4EJ7	2.00	6DX8	1.70	6LO6	4.45	17BF11	3.10
		6EA8	1.45	6LT8	2.70		
4HA5	1.45	6EC4	3.40	6LU8	3.90	17DQ6B	4.25
5AQ5	1.45	6EH7	1.40	6LX8	1.75	17JN6	3.35
		6EJ7	1.40			17JZ8	2.40
5CG8	2.35			6SN7GTB	2.25	17KW6	8.95
5GH8A	1.30	6EM7	2.75			17KV6A	3.95
5GJ7	2.00	6ES8	2.45	6U8A	1.70		
5GS7	1.80	6EW6	1.25	6U10	2.65	18GV8	2.15
5GX7	2.25	6FM7	3.15	6V6GT	3.20	19CG3	2.05
				6W6GT	2.75	21GY5	3.45
5LJ8	2.65	6GB5	3.10	6X9	3.45	21JZ6	3.25
5U4GB	2.45	6GE5	3.85				
5U8	2.95	6GF7A	2.40	6Z10	4.00	23Z9	3.45
		6GH8A	1.55	8AW8A	1.80	24LQ6	4.10
6AF9	4.10	6GJ7	2.20	8B8	3.05		
6AJ8	1.75	6GK5	1.80	8B10	2.75	27GB5	3.45
6AL3	1.60	6GK6	2.40	8BM11	6.35		
6AL5	1.50	6GM6	1.45				
				8CG7	1.60	30AE3	1.65
6AQ5A	1.40			8DX8	3.40	30KD6	7.15
6AQ8	1.40	6GU7	1.25	8GJ7	2.05	31JS6C	4.35
6AU6A	1.25	6GV8	2.45	8JV8	2.05	33GY7A	3.30
6AV6	1.50	6GW8	2.40	8LT8	2.10		
		6GX7	2.20			35W4	1.35
6AW8	1.70	6GY5	4.45	8U9	3.30	38HE7	4.80
6AX3	2.30	6GY6	1.20	8X9	3.80	38HK7	4.70
6AX4GTB	1.95	6HA5	2.15	9A08	1.60	40KD6	4.80
6AY3B	2.25			9GV8	4.20	40KG6	5.50
6BA6	1.20	6HE5	3.65	9JW8	1.45	42EC4	2.95
6BA11	3.65	6HQ5	1.55	10DE7	1.75	50C5A	1.80
6BE6	1.70	6HS5	7.40				

**FULL FUNCTION  
CALCULATOR  
for only \$1.99  
(including case)**

With special orders of \$100. or more

**FULL FUNCTION  
CALCULATOR**

- \* 8 Digit Display
- \* Includes % Key
- \* Add on and Discount Features
- \* 2 Input Registers
- \* Constant Repeat Calculation

**PLUS MANY MORE  
FEATURES**

**LIMIT 4 TO A CUSTOMER**

**TERMS & CONDITIONS:** ABBEY pays full shipping charges anywhere in Canada on all prepaid orders over \$25.00. C.O.D. orders, send 25% deposits, balance C.O.D. All orders shipped same day. Minimum order 10 tubes.



**abbey** ELECTRONICS LIMITED  
306 Rexdale Boulevard, Rexdale, Ont. M9W 1R8 745-9555

# GAMASONIC CANADA LTD./LTÉE

## OUR PRODUCTS



### SELFIX

- ELECTRONIC PARTS
  - HiFi ACCESSORIES
- HEADPHONES
  - MICROPHONES
- 8 TRACK TAPES
  - CABLES



### SANYO

- AUTOMOTIVE SOUND EQUIPMENT
  - TRANSCEIVERS
- CB MOBILES—BASE
  - VTR-CCTV EQUIPMENT
- CAMERAS—MONITORS
  - VIDEO RECORDERS

### Rembrandt

- TELEVISION ANTENNAS

### Goodmans

- RAW SPEAKERS

### NEC

- VTR EQUIPMENT



### SANYO

- VTR CAMERAS—MONITORS
  - VIDEO RECORDERS



Gamasonic Canada Ltd./Ltée,  
5780 Royalmount Avenue,  
Montreal, Quebec H4P 1K5  
Tel: (514) 735-2721

- HALIFAX
- TORONTO
- WINNIPEG
- EDMONTON
- VANCOUVER

ANOTHER FIRST BY

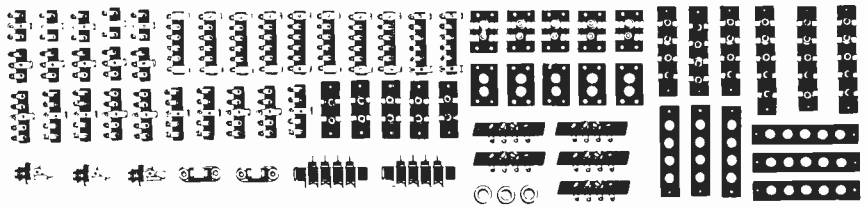


**MAGNUM** electronics, inc.

**QUALITY ELECTRONICS PARTS KITS**

**KIT NO. 1 — 72 PIECES-ELECTRONIC HARDWARE**

- \$9.97**
- 10 pc 3 Terminal Strip/10 pc 5 Terminal Strip
  - 10 pc 6 Terminal Strip/5 pc 4 Screw Terminals
  - 10 pc 2 R C A Phono Jacks/5 pc 2 Phono Insulators
  - 3 pc 4 R C A Phono Jacks/3 pc 4 Phono Insulator
  - 3 pc 5 Phono R C A Jacks/5 pc 5 Phono Insulator
  - 3 pc Stereo Phone Jack/3 pc Deluxe Nuts for Phone Jack
  - 2 pc AC Chassis Receptacle/ 2 pc Heavy Duty 4 Screw Terminal



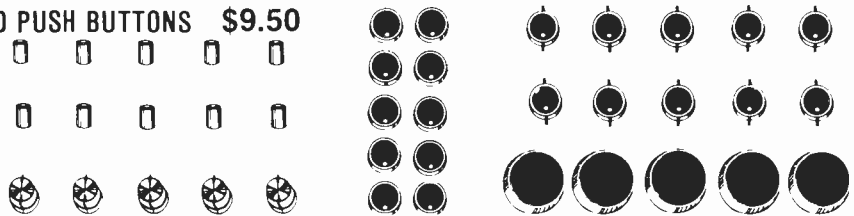
DRESS UP YOUR EQUIPMENT

**KIT NO. 2 — 40 PC. TUNING KNOBS AND PUSH BUTTONS**

**\$9.50**

Tuning Knobs and Push Buttons

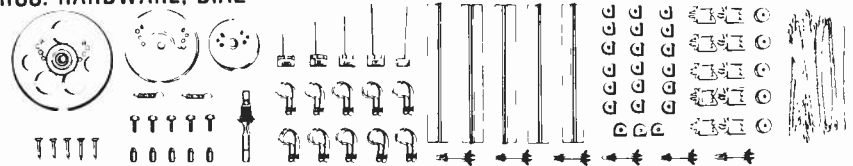
Quant.	Shaft	Knob Dia.	Colour & Style
5	Flat 1/4" Dia	1 3/4"	Black with spun aluminum
5	Flat	7/8"	Black with spun aluminum
10	Flat	5/8"	Black spun aluminum with wings
5	Flat 187"	7/8"	Black spun aluminum with wings
5	Flat 1/4 Dia 3.3 mm x	5/8"	Black grooved aluminum
10	3.3 mm square	10mm	Spun aluminum push button



**KIT NO. 3 — APPROX. 100 PIECES OF MISC. HARDWARE, DIAL PARTS AND WIRE DRESSING**

**\$6.59**

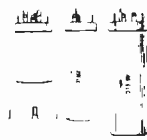
- 2 Dial Springs 3 Dial Wheels 5 Dial Pulleys 5 Pulley Shoulder Rivets 1 Drive Shaft with Washer and Nut, 5 Dial Pointers 20 P.C Board Mounting Insulators 10 Nylon 1/2" Dia Cable Clamps, 6 Wire Saddles 6 Snap in Type Nylon P.C Board Spacers 5 Metal Spacers drilled and tapped 6 32 5 6 32 Screws for Spacers 5 P.C Board Guides, 20 Wire Wrap Ties



**KIT NO. 4 — 4 PIECES ELECTROLYTIC CONDENSER AND CIRCUIT BREAKER**

**\$6.95**

- 1 pc 4000 Mfd 60 Volt 3 Amp
- 1 pc 2500 Mfd 40 Volt 2 Amp
- 1 pc 1000 Mfd 50 Volt
- 1 pc Circuit Breaker 1 6 Amp

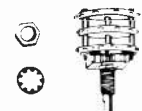


AN UNBELIEVABLE BARGAIN VALUE \$9.50

**KIT NO. 5 — 3 PIECES**

**\$1.69**

- 1 Rotary Switch Ceramic Plate 4 Pole 6 Position with Ball Detent
- 1 3/8" Nut 1 Lock Washer



QUALITY CONTROLS PREVIOUSLY UNAVAILABLE

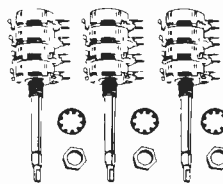
**KIT NO. 6 — 9 PIECES**

**\$8.49**

- 3 4 Section Precision Controls, 3 3/8" Nuts 3 Washers

- Specifications:
- 1. 25 K Volume with Tap
  - 2. 250 K Linear
  - 3. 500 K Linear

The rear and front elements are in pairs on shafts of .187" Dia rear and .265" Dia Front The Two Shafts are clutched for Paired or Independent Operation

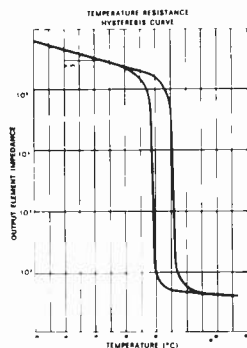
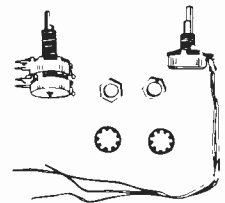


PROFESSIONAL QUALITY

**KIT NO. 7 — 6 PIECES**

**\$3.95**

- 1 Tandem Precision Balanced Volume Control 25 K with Tap
- 1 50 K Linear Balance Control with Centre Detent
- 2 3/8" Nuts 2 3/8" Washers



1001 USES FOR THIS ONE **KIT NO. 8 — 2 PIECES**

2 pc. - Thermal Sensors

**\$1.98**

Specifications:

- Case T05
- Resistance at 25°C Min. 100K Ohm.
- Resistance at 57°C Max. 100 Ohm.
- Element Current 10 MA.
- See Graph



PLEASE USE ORDER CARD



**MAGNUM** electronics, inc.

P.O. Box 492 Station C Toronto, Ontario M6J 3P6

Minimum order \$5  
Add \$1 for shipping and handling if  
total less than \$20.

CUSTOM DESIGNERS, MANUFACTURERS AND DISTRIBUTORS OF ELECTRONIC EQUIPMENT

# electronics today

international

## Features

A GENERATION AWAY 2 .....	10
<i>Evolution or revolution</i>	
I <sup>2</sup> L EXPLAINED .....	17
<i>The new technology</i>	
C.B. SUPPLEMENT .....	27
<i>Techniques and technology</i>	
INTRODUCTION TO COMPUTERS 2 .....	40
<i>What's involved and how it's evolved</i>	

## Projects

MASTERMIND .....	21
<i>Codebreaking electronic game</i>	
DIGITAL VOLTMETER .....	45
<i>High quality test gear</i>	
SHORT CIRCUITS	
THE OVERLED .....	53
TURN INDICATOR CANCELLER .....	55

## Information

NEWS DIGEST .....	6
CIRCUITS BOOK NO.1 .....	15
SUBSCRIPTIONS TO E.T.I. ....	26
PUBLICATIONS FROM E.T.I. ....	36
AUGUST ISSUE PREVIEW .....	39
DATA SHEET .....	50
TECH TIPS .....	57
FEEDBACK .....	60
ADVERTISERS INDEX .....	63

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

Copyright: All material is subject to world-wide Copyright protection. All reasonable care is taken to ensure the accuracy of the information.

Vol. 1 No. 6

JULY 1977

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

Editor MIKE KENWARD

Assistant Editor GRAHAM WIDEMAN

Circulation Dept. SENG HARRISON

Marketing Manager and Advertising  
PETER PRIEST

Advertising Representative JIM O'BRIEN

Eastern Canada Advertisement  
Representatives  
JEAN SEGUIN & ASSOCIATES INC.  
601 Cote Vertu, St. Laurent, Quebec M4L 1X8  
Telephone (514) 748-5561

Editorial Director TOM GRAHAM

Published by: Electronics Today  
International (Canada) Ltd.

Printed by: Heritage Press, Mississauga,  
Ontario

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

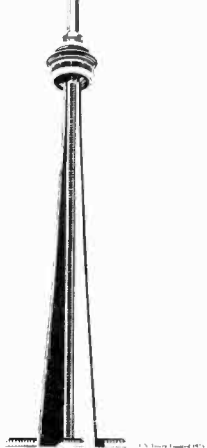
BRITAIN:  
Electronics Today International  
25-27 Oxford St., London W1R 1RF  
Editor: Halvor Moorshead

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

HOLLAND:  
Electronica Top Internationaal,  
Postbus 260, Emmen, Holland  
Editor: Denis Loos

FRANCE:  
Electroniques Pour Vous International  
42 rue Jacob, Paris  
Editor: Denis Jacob

# VA3RRL



TORONTO, ONTARIO, CANADA  
JUNE 3, 4, 5, 1977

## ARRL NATIONAL CONVENTION

BRASS AND BRASSPOUNDERS gathered in the Sheraton Centre Hotel for the June 3,4,5 American Radio Relay League National Convention, ending Amateur Radio Week in Toronto. Sunny skies and warm weather greeted over 3000 Hams (X) YLs and friends from Canada, the U.S., and elsewhere. The Convention was hosted by the Scarborough A.R.C., Gord Steane — VE3BMG — as General Chairman of the Convention Committee, with Henry Dannals — W2TUK — ARRL President, and other ARRL headquarters staff also in attendance.

Occupying much of the hotel's second floor, the extensive array of exhibits were on display with something for everybody. For those looking into the past, the Antique Wireless Association were showing off their collection of (to the eyes of today) amusing old time equipment.

Those looking into the future (and their bank books!) were perusing with longing eyes the new communications produces from a variety of manufacturers. The latest engineering advances were there, all dressed up in seductive cabinetry — black panels and digital displays in several colours. (Ham equipment is getting so good looking these days you could probably sell it to a hi-fi buff!)

For those just looking there were exhibits by the ARRL, CRRL CARF (Canadian Amateur Radio Federation), CLARA (Canadian Ladies' Amateur Radio Association), the U.S. F.C.C., and our own D.O.C.. And of course, microprocessors and systems, starting to take their place in the shack, were also on display.

Meanwhile, throughout the weekend, a series of seminars and discussions put participants in the picture regarding such topics as: basic ICs, propagation, antennae, repeaters, microprocessors, ATV, and so forth on the technical side: NTS forum, Ham radio public relations, Amateur Radio Emergency Service, in the public service area, and talks on QRP and DXing. A selection of films on Amateur radio were shown and also a general interest presentation on the world's tallest freestanding pile of concrete, the CN Tower.

'Operation in a Liquid Environment' and other topics were covered at the evening "Eyeballs" and Saturday banquet.

Naturally, an international Ham convention would not be complete without at least one station, at this one there were eight base stations in operation on the Friday, and no doubt more by the end of the weekend. At the fourth floor "Talk-In" station, three 2m rigs operating through repeaters in Toronto and Hamilton were used to encourage local Hams to drop in to the convention. A fourth set handled traffic in the hotel, as many of the visitors had brought their 2m hand-talkies.

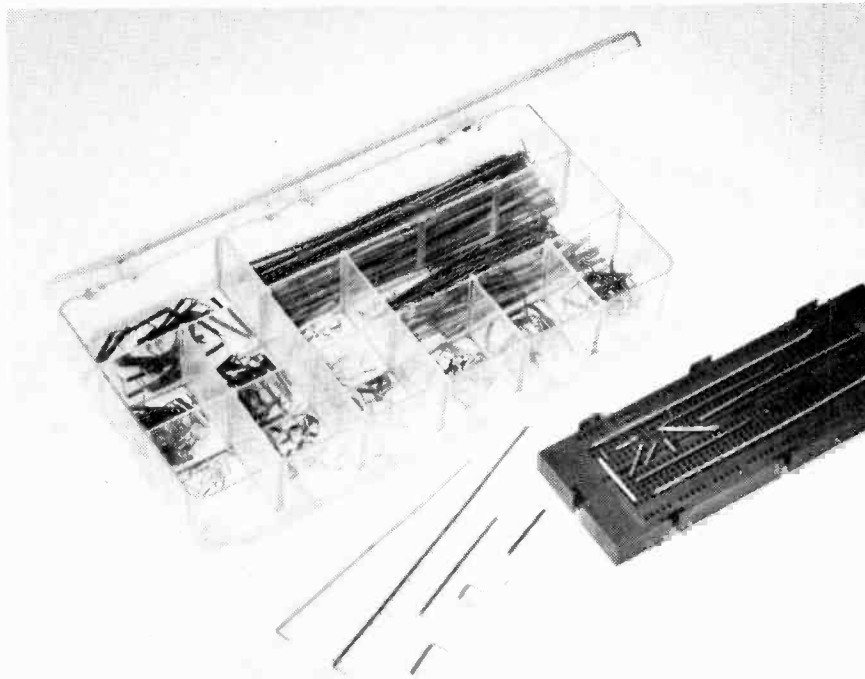
*Spec checking and knob twiddling were part of the action at the many manufacturer's booths.*



*Three "window plane arrays" worked through repeaters VE3RPT, VE3TOR and VE3DRW at the Talk In station. In the background are Toronto's old City Hall, and the arches and fountains in front of the new City Hall.*

At the top of the hotel, floor 42, the Westside Radio Club, and the 10-10 Club each were operating into antennae on the roof covering bands from 10 to 75m. All the official stations were using the special conference call sign, VA3RRL (and more than one operator was heard swallowing an 'E!') with QSL as pictured here.

All in all — a "fine business".



### STRIPPED AND BENT

Having recently reported on the Hammond breadboard we now have details of a jumper wire kit designed for use with plug in breadboards. Each kit contains 350 wires in 14 different lengths from 0.1 inch to 5 inches long. Each wire is stripped and bent at both ends

and each length has a different colour for easy identification.

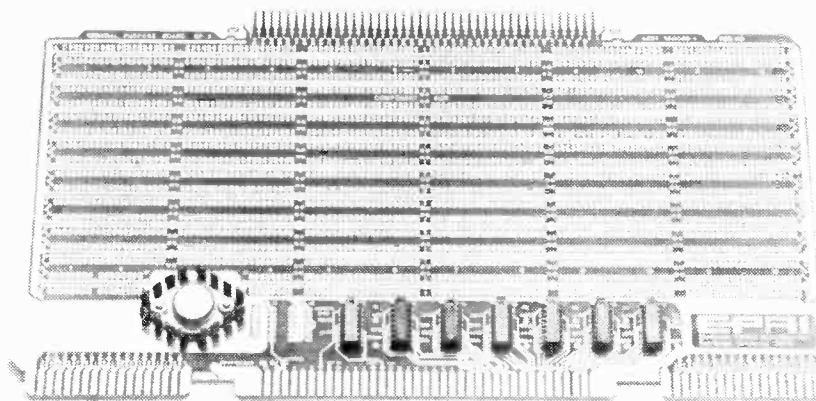
Of course you could make your own but stripping and bending 700 times is enough to wear anyone out — and you get a plastic box with divisions from Hammond anyway. *Hammond Manufacturing Company Ltd., 394 Edinburgh Road North, Guelph, Ontario N1H 1E5.*

### HOLY!

3,000 holes, to be exact, available on one board used for prototyping Micro 68 microprocessor systems.

The 8 x 14.8 inches (20.32cm x 37.59cm) GP-2 board is exorcisor bus compatible and has complete bus buffering already established on-board with 8833 driver/receivers.

The GP-2 board contains Vcc and ground busing 3000 holes worth of blank dip patterns for thirty-five 24, 40 or 42 pin dip packages, or 107 14 or 16 pin dip packages. Price is U.S. \$170.00 and they are available from, *Electronic Products Associates, Inc., 1157 Vega St., San Diego, Cal. 92110.*



### HAMS

A new information booklet entitled *Talk to the World* has recently been published by the Radio Society of Ontario. The booklet, which provides basic information for anyone who may be interested in becoming a licenced amateur is designed to be used by amateur radio clubs across the country.

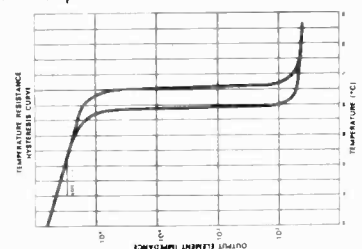
Clubs or groups wishing to make use of this booklet, may obtain copies, in reasonable quantities, from the Radio Society of Ontario, at no cost, other than a nominal charge to cover out-of-pocket handling and mailing expenses. Send a stamped, self-addressed envelope to *RSO, Box 334, Station "U", Toronto, Ontario M8Z 5P7*, for a sample copy, and details of how to place your club order.

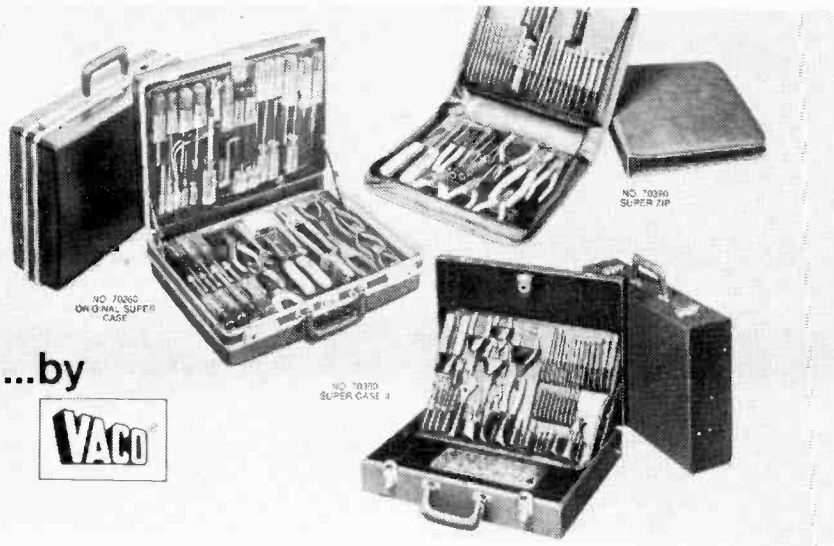
### AEROSOL PULSATOR

A new device which produces "vibrational solvent impacts" when connected to an aerosol cleaner has recently been introduced by Chemtronics Inc. The device called Vibra-Jet works on the ventri effect which produces a pulsating effect in the spray. Vibra-Jet is supplied with a flexible hose and 12 inch probe for cleaning in difficult places, and is intended primarily for use with electronic cleaners and degreasers. Available from *Paco Electronics Ltd., 45 Stinson Street, Montreal, Quebec H4N 2E1.*

### MOXIE

A T53-75 thermal sensor called a MOXIE is now available at a special price from *Magnum Electronics Inc., P.O. Box 492 Station C, Toronto, Ontario M6J 3P6* (see their ad for details) in fact you can get two for just \$1.98. What do they do — just change resistance with temperature. Nothing unusual in that but they do it quickly at about 80 degrees C. The graph below shows the change and should provide some ideas for their use in such places as protecting power amplifier output stages, as a simple fire alarm or reliable thermal cut-out for any equipment. They're not big either, in fact an ordinary T05 can with a metal mounting tab on the top.





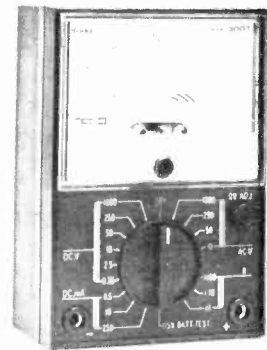
...by



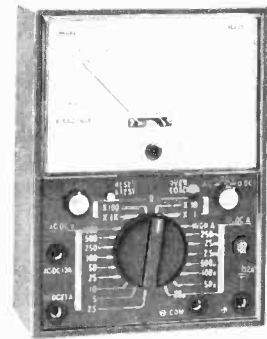
## A CASE OF TOOLS

If you need to get about with a good set of tools then a look at three tool cases from Vaco may be worthwhile. In addition to their original Super Case, Vaco now have a Super Case II and a Super Zip. The II contains 45 tools while the

Zip has 36 tools. Full details of all the tools will take more room than we have but we're sure Vaco will be happy to supply their catalogue SD 210 which gives full details. Write Vaco Products Company, 150 North Dearborns St., Chicago, Illinois 60610.



The 3001 — cheapest of the range —



and the 3011 — most expensive — meters

## 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.



## MORE METERS

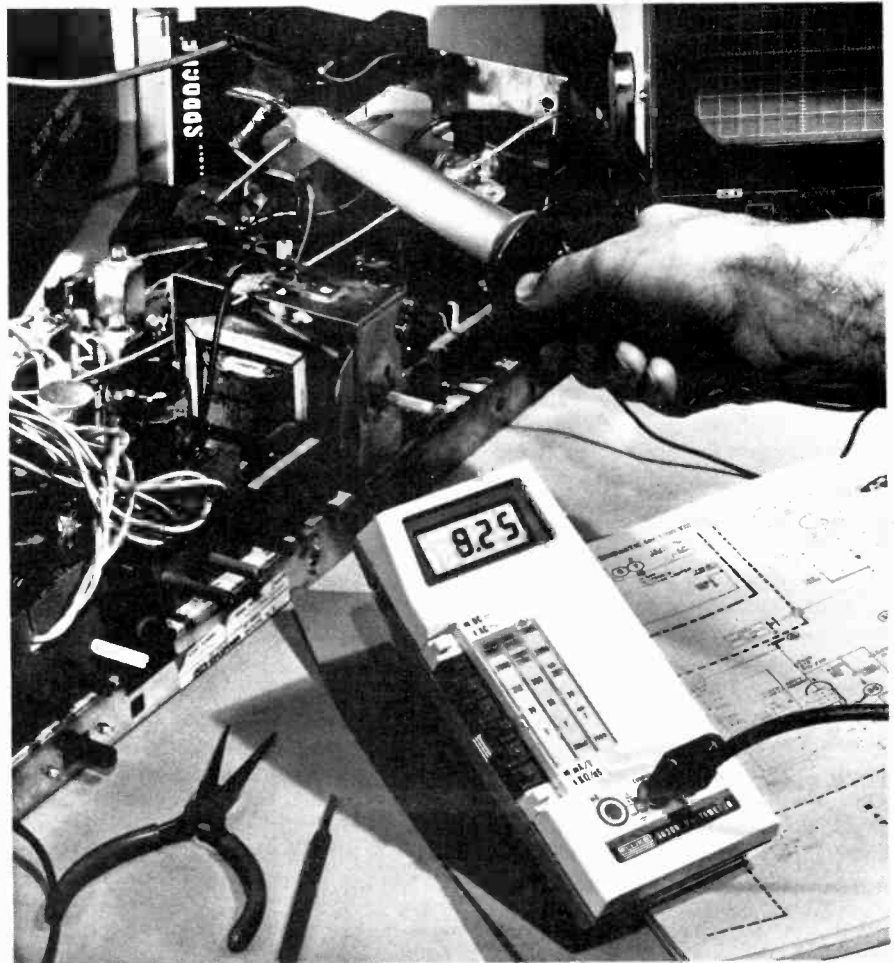
Arriving just to late for our multimeter guide last month we now bring you brief details of the Hioki Electric 3000 series of multimeters.

There are 6 meters in the range the simplest with 6 DC voltage ranges from 0.25V to 1000V at 3 per cent  $2k\Omega/V$ . Three DC current ranges from 0.5 to 250mA at 3 per cent. Four AC voltage ranges from 10V to 1000V at 3 per cent,  $2k\Omega/V$  and three resistance ranges, again with 3 per cent accuracy.

The top of the range has 9 AC and 9 DC voltage ranges from 2.5 to 1000V at 2 and 3 per cent respectively,  $40k\Omega/V$  and  $10k\Omega/V$  respectively. Nine DC and AC current ranges from 25 $\mu$ A to 10A at 2 per cent and 3 per cent respectively. Plus four resistance ranges at 3 per cent accuracy.

All six meters are circuit protected, all except the cheapest have mirrored scales with a single switch for all ranges. There should be something there for just about everyone! Available from *W. Miller Marketing Ltd., 55 East 5th Avenue, Vancouver, B.C. V5T 1G7.*

# How do you really use a multimeter?



Usually at your bench, in the shop, shared with others. And, if it's a Fluke multimeter, you use it with confidence.

Now you can carry that same bench precision on the job. Introducing the new Fluke 8020A DMM for only \$184.\*

This rugged beauty packs more field-valuable features than any other DMM available, at any price. And that means field versatility when you need it most.

The 8020A has six resistance ranges, including a 20 megohm range for those special high-resistance TV components. Plus, you can measure focus dividers, pcb and capacitor leakage clear up to 10,000 megohms with the new conductance function. And conductance allows you to measure transistor beta—unique

with the 8020A.

Ever damaged your meter in the fly-back circuit? Rest easy. The 8020A is MOV-protected to 6000V against hidden spikes and transients.

Your 8020A comes with a full-year warranty, with worldwide service back-up. Regardless of what happens to it, we'll fix it inexpensively and quickly, making the 8020A a truly cost-effective investment.

To get your hands on one, call the ACA office nearest you: Toronto 416/678-1500; Halifax 902/469-7865; Ottawa 613/829-9651; Montreal 514/670-1212; Calgary 403/276-9658; Vancouver 604/980-4831.

\* Canadian price, duty paid, taxes extra

## TOP QUALITY ETI CIRCUIT BOARDS

BOARD	PROJECT	PRICE EA.
122	LOGIC TESTER	6.50
444S*	5W STEREO AMPLIFIER	6.00
445	GEN. PURPOSE PREAMP	2.00
447	AUDIO PHASER	5.50
448	DISCO MIXER MAIN BD.	6.50
448A	HEADPHONE AMPLIFIER	2.00
449	BALANCED MIC PREAMP	2.50
449A	VU CIRCUIT	3.50
480	50/100W AMPLIFIER	6.00
480PS	PWR SUPPLY FOR 480	5.00
576*	REACTION TESTER	5.85

ASTERISKED ITEMS IN STOCK. ALLOW 2 TO 5 WEEKS FOR DELIVERY ON OTHERS. MOST PARTS FOR ABOVE PROJECTS ARE IN STOCK.

### - STOPWATCH KIT -

One of the marvels of the LSI age. Kit includes IC, crystal, small parts to convert a low cost calculator into a 6 digit, battery operated timer stopwatch. Display can be held for timing laps or multiple finish events while clock continues counting elapsed time. Operates in Split/Taylor modes. Counts to 59 min 59 sec 99 hundredths.

STOPWATCH KIT, less calc. & bty. .... \$38.95

Boards postpaid in Canada. IC's, etc. add 50c to total for P&P. Ont. residents add 7% provincial sales tax. No COD's

WRITE FOR LATEST CATALOGUE

**CAN ELECTRONICS**  
**MOS** BOX 1690,  
PETERBOROUGH,  
ONT. K9J 7S4

**FLUKE**

Exclusive Canadian Representative

Allan Crawford Associates Ltd.



**Command Performance: Demand the Fluke 8020A.**

# a generation away

by Peter Sydenham

PART 2

MAJOR CHANGES THAT COME about in our lifestyle and attitudes are usually the result of basic needs being recognised by some agency that has the resources to bring such changes about. We begin to use new products of technology when both the need emerges and the technological availability to fulfil it is available. Progress can come from either direction: either as technology developed to meet a big enough need or a need being exploited because a new technology has become available. In both instances our society has generally, in the past, helped this process where economic or political gains are to be had. Not all developments are as good as they are promoted to be and many excellent concepts fail to catch on because the cost expended cannot be regained. In too many instances the quality of the promotion given to a new device or technique is the key to its acceptance. In numerous instances the inherent quality of the product is not a factor in people's minds when selection — the act of helping the idea gain a hold — is made. Communication and its off-shoot, entertainment, are

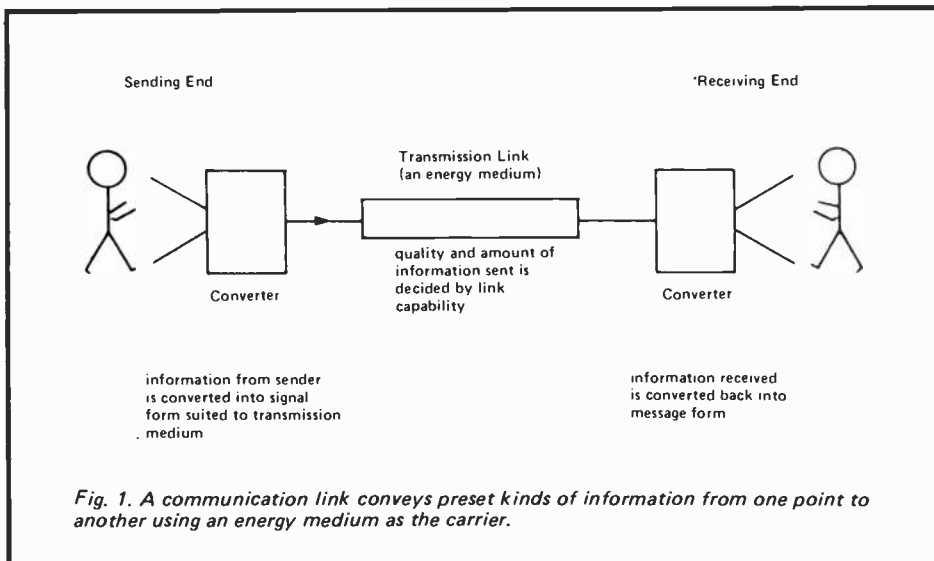
aspects of life which are very susceptible to over-promotional effort (what Dorothy Parker once described as worship of the fecund rate). In order to extrapolate and, perhaps, predict some breakthroughs in communication method in the future century we can and should look at ideas from the two progress motivations above — what we need and what we could be given.

### The Role of Communication

Communication is needed to enable information to be imparted from one person to another person (Fig. 1). It is the act of passing information from point to point. An energy medium is always needed for information to pass. Some messages mean more than others, even though they may have the same number of words — a phenomenon not definable in scientific terms. We do have a good idea, however, of the carrying capacity, of a given communication channel. To do this we ignore the *meaning* of messages and concentrate on their 'bit' content. On this basis — the Shannon concept —

it is easy to see that facts containing many 'bits' of information will need a communication method having the required 'bit'-carrying capacity — this turns out to be the available frequency bandwidth in electronic communication techniques. Increasing the bandwidth usually means an increase in cost, so many potential communication needs are limited by economic reasons, not technological ability to provide bandwidth. As an example, for cost reasons, we make do with telex and telegram messages written in stilted format doing without the facial and tonal expression of face-to-face communication. A better alternative would be to use a video-link (such as may one day be in widespread use) instead of the teleprinter, though such a thing requires around 10 000 times more bandwidth. Figure 2 shows a unit that has been on trial since 1971.

The pattern of current civilisation requires people to interact as a living system of coordination, cooperation and coexistence. This means people need to communicate with each other. Usually the closer that a man-made



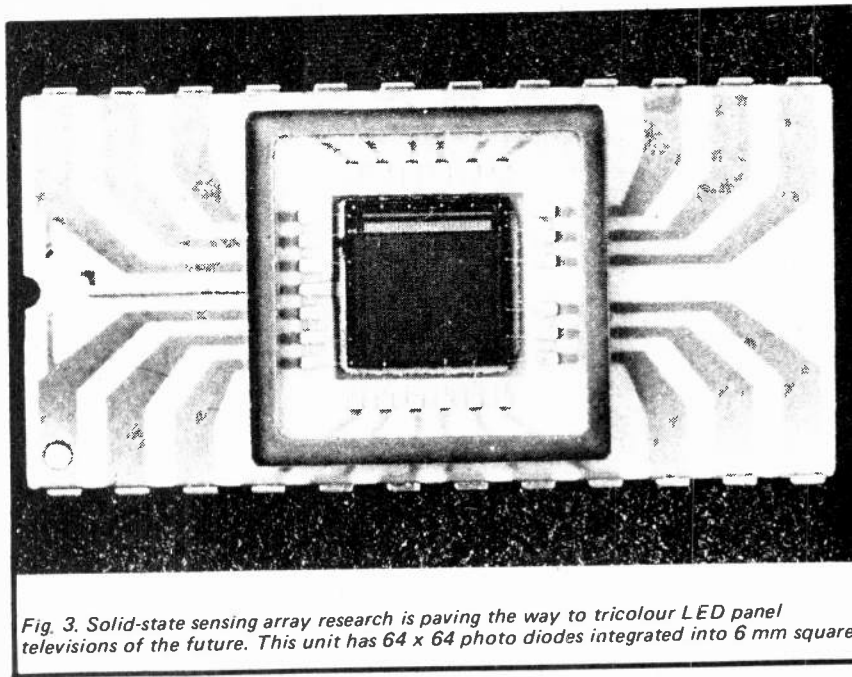


Fig. 3. Solid-state sensing array research is paving the way to tricolour LED panel televisions of the future. This unit has 64 x 64 photo diodes integrated into 6 mm square.

communication link can approach the real face-to-face case the better. Our awareness is enhanced as the simulation provided by the communication link is made more and more a true image of real contact.

Distances, cost and time often make direct communication unrealistic, so technology is brought to bear to reduce the inconveniences. Communication is needed to make commercial and political decisions, to fulfil social needs, to provide education and to entertain. In each of these the hardware forms are similar — it is the use to which they are put that may influence improvement.

The telephone grew from commercial needs for faster and more informative communication than was offered by

telegraphy (which, in itself, was a vast improvement over hand-carried letters) but by contrast television grew because of its consumer market in the entertainment and news media fields. A few video-links have been established but the great operating cost limits them at present more to mass-audience needs, such as inter-city television interviews, than to telephone replacement.

### Expected Hardware of the Future

The area where greatest development in communications will be seen must be in the forms and use of the domestic television receiver. The receiver itself is sufficiently inexpensive for the majority of people in the developed countries to expect to own a set. We would, there-

fore, expect little more development on the receiver itself from the point of view of need-induced research.

Styling and operation changes will be prevalent in keeping with promotionally-induced change brought about by manufacturers who must keep seeking markets. Future receivers will most surely incorporate solid-state screens comprising millions of light emitting diodes giving the three primary colours. These screens will be flat and of insignificant thickness — they will be suitable for wall mounting like a picture. The receiving and processing circuits will be integrated onto the same panel. The concept of a television set as a piece of furniture will vanish. This development is currently at the very small monochrome (black and white system) stage — see Fig. 3 — with cameras, rather than displays, being the point of emphasis. The size will gradually increase to acceptable proportions after or during which colour solid-state systems will emerge. The cost of the technology, not its capability, limits this approach at present. IBM have made a 1 m x 1 m area of light sensitive diodes that has close to the current television resolution.

At present, however, the cathode-ray tube method is the only economic technique for generating the picture in a television set.

Because visual experience is in three dimensions, not two, development will not rest with the current 2-D systems. A 3-D cathode ray oscilloscope trace representation was demonstrated back in the 60's using a rotating phosphored disc as shown in Fig. 4. Holography using coherent light enables 3-D images to be generated in colour as well as in the usual red experienced when

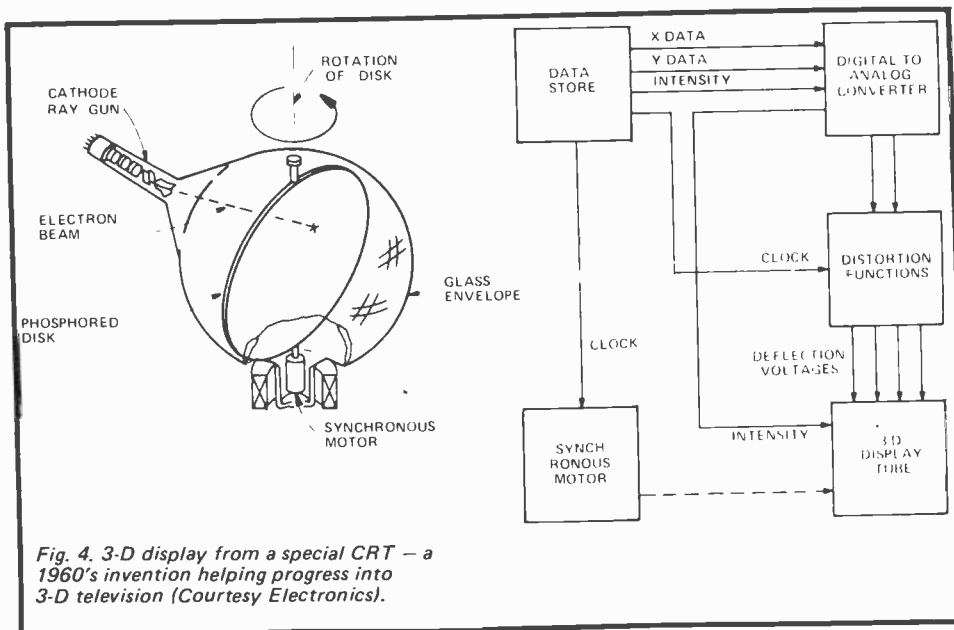


Fig. 4. 3-D display from a special CRT — a 1960's invention helping progress into 3-D television (Courtesy Electronics).

CEEFAX 101 Thu 17 Apr 16 06/30  
BBC CEEFAX INDEX - p101

NEWS		INFORMATION	
Headlines	102	Demonstration	110
Home	103	Index repeat	111
Foreign	104	Exchange rates	112
Sport	105	Consumer news	113
Travel	106	Education	114
Charity	107	Weather	115
FT INDEX	108	TV programmes	117
Business	109	Radio	118
NEWS FLIGHT	150	Pools News	119
		Farm prices	120
		FARM NEWS	121
		Test card "A"	122
		Test card "B"	123
		BBC NEWS	124
		Test designs	125-30
		Pages are regularly	
		updated between 8am and 6pm at present	

A full CEEFAX magazine will be 100 PAGES on each channel

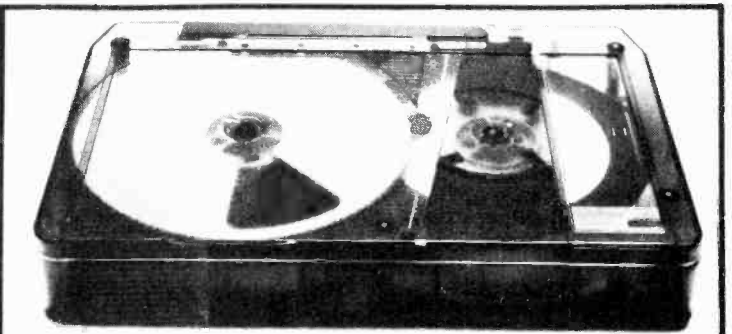


Fig. 6. This Sony cassette gives one hour of colour television with sound-tracks using a domestic television receiver to display the output of a special replay tape deck.

Fig. 5. Index page of earlier CEEFAX page system now available on domestic television in the U.K.

using the helium-neon laser source. Barriers to the introduction of 3-D television are both cost and the lack of a suitable technique. We have no obviously acceptable systems in existence at present. We can expect the usual period of multiple source development which will generate many alternatives in the outset before one or two methods settle-out to become the norm.

Returning to more obvious extras for use with the domestic television set we will very soon see widespread use of the currently developed systems which transmit information over a spare part of the television channel. In the British CEEFAX and ORACLE systems the date is stored until a complete single frame of written or pictorial information is ready to show. These are now combined as TELETEXT. Television networks in Britain have systems now well past the prototype test-state. Any television set owner (who can build or purchase a decoder unit) in Britain can today obtain up to several hundred full 'page' items on the screen. Items such as the weather forecast, share prices, programmes, time and programme reviews are listed. Figure 5 gives just one

of the selection. It is not hard to see that this offering logically extends to giving access to an enormous amount of information.

The TV monitor of the future will also become the domestic equivalent of the micro-film/micro-fiche reader now rapidly replacing the book in libraries and storehouses. Recorded video-tapes can be quite cheap to replay on special purpose replay-only units. Such units have been available for about five years now and it will not be long before the cost will be such that we will be buying video as well as audio cassettes in the music shop. Video discs are also close to being marketed in large volume. Figure 7 shows one market contender for the consumer market - prototype development having been reported three years ago.

One day in the future we will be visited by salesmen selling encyclopaedias in video cassette form instead of as bulky books. The publishers will also be able to offer an exchange service - old cassettes can have their facts updated at minimal expense.

Perhaps, too, the monitor will become the terminal for optimal video-links added to the telephone. For this to

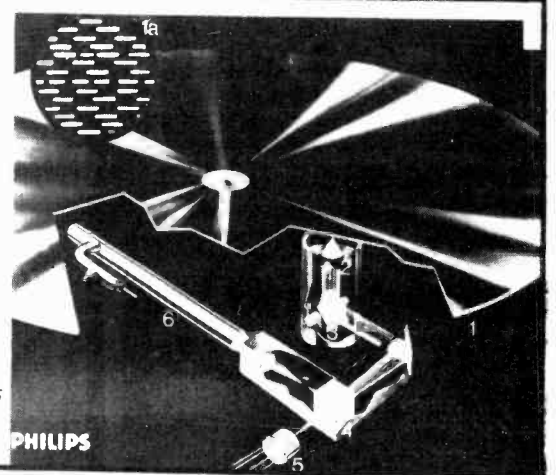
occur we would need low-cost very-wide bandwidth telephone channels. Current open wire and cable telephone systems have inadequate bandwidth handling capabilities on a single line so the change to video phones would need an entirely new concept of transmission or a complete replacement of the telephone cable network including the switching and processing plant installed within the telephone system. The bigger the capital invested the longer it can take to change to new technology. The bi-motional mechanical selector switches (see Fig. 8) used in telephone exchanges were first patented by Strowger in 1891. Some are still in use today.

A spread of the current cable TV systems might duplicate all local telephone cables with adequate video-bandwidth networks. This would set the scene for a gradual change to video-phones. There will still, however, remain the immense task of providing national and international bandwidth capability that is 10 000 times its current provision for not much more in cost to the user.

Laser beams sent along fibre-optic paths



Fig. 7. Video record playing equipment is already developed. Records provide 10-45 minutes of colour television.



the smaller clientele to satisfy and persuade.

### New Forms of Transmission Medium may Emerge

It is instructive to go back in history and try to imagine the attitudes of 18th century people to the likelihood of a communication form other than by message or word of mouth. To people of that era, sending messages over electro-magnetic (EM) waves would have been fantasy indeed. They knew and had some understanding of acoustic waves but knew nothing of radio waves. In the 19th century Maxwell predicted from his mathematical understanding of magnetic fields and their observed local-field behaviour, that it was possible to radiate a field away from a source — the energy literally escapes from the generator. It took about thirty years for this idea to be verified (by Hertz) by a crude experiment (see Fig. 9) and out of this was born radio. Once the concept of the electromagnetic spectrum was realised, EM frequencies other than in the radio region were exploited for communication purposes. Even today we have not completely filled in our use of all EM radiation wavelengths.

Field theory is a generalised theory that handles any kind of effect that can be experienced in space — magnetic, electric, gravity and force fields are examples. The operative word is 'experienced'. Until Hertz demonstrated radio waves no one had experienced them and, therefore, they did not exist as a tool of technology. Perhaps, today there are similarly other methods of radiation, so small in magnitude and so alien to any detectors we possess at present that we do not know of their existence. There is much evidence to suggest this is the case. Theory predicts the existence of gravity waves which are force fields propagated from exploding galaxies. On a closer basis we know that a mass exerts a force on another mass by gravitational attraction (but why is an unknown of science). The force falls off as the square of the

distance between the masses. In theory a small mass (the transmitter) vibrating rapidly causes a minute varying attractive force on another mass (the receiver). These forces can be calculated and the sums show that they are exceedingly small if the masses are of reasonably small size. To date many scientific research projects have tried to detect macro gravity — wave effects from the galaxies but now it appears that the current mechanical detectors being used are clouded by their own internal Brownian motion, which appears as a noise source. A new detection principle is needed — a second Hertz type historical event will occur one day when, and if, the generation and detection of gravity waves is demonstrated providing practical experience of the effect.

Moving on to less theoretically based fields there are the photographs made of energy fields of objects. These are unexplained but it is fact that photographs taken in a special way reveal an 'aura' surrounding the object. Lack of understanding of such phenomena is not an adequate basis for saying they are necessarily fakes.

Extra sensory perception (ESP) also may be part of potential future communication. Perhaps it, too, makes use of an energy field we do not yet recognise. It is sobering to remember we only understand experiences that our physiological senses and brain allow us to observe.

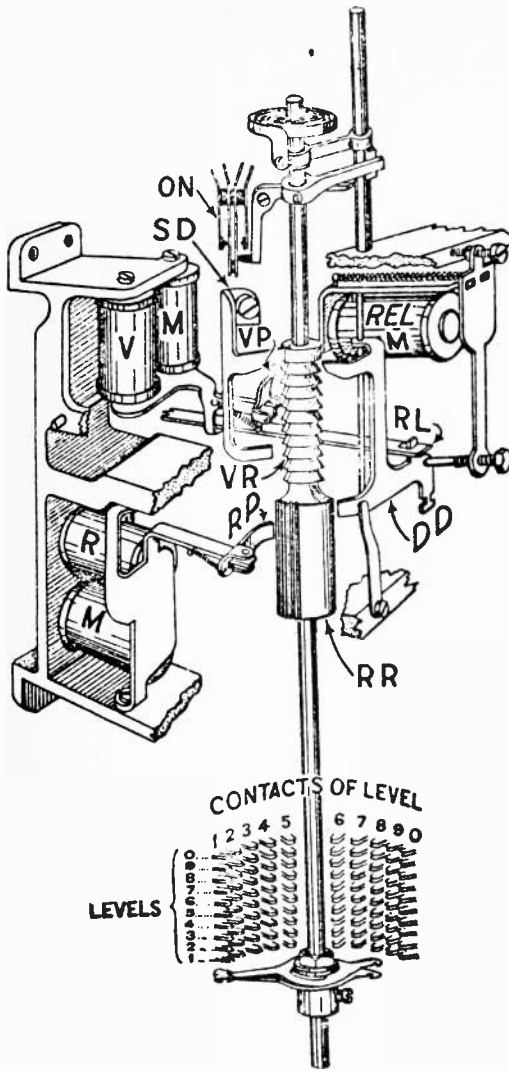
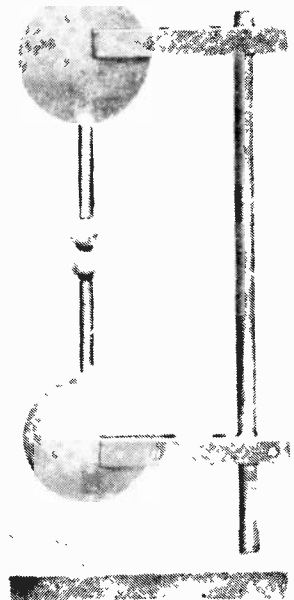


Fig. 8. Strowger bi-motional selector switches were first patented in 1891. Today many telephone exchanges still use them because it is uneconomic to change to new technology.

are often reported to be the answer to bandwidth needs: considerable research and development is being performed today on these technologies. If and when their price falls enough to be competitive with other wide-band systems the first places of application will most likely be in heavy-traffic telephone and video links between cities. Domestic application, on the other hand, (in the form of cable TV) is an area where developers will be able to influence change more rapidly due to

Fig. 9. Hertz oscillator (upper) and resonator (lower) of 1894. Until Hertz proved radio waves could be generated, transmitted and detected, communication by EM waves was fantasy even though they existed.



ESP, mental-telepathy, clairvoyance, precognition and parapsychology contribute physical experiences such as levitation, materialization, automatic writing, spirit photographs, psychokinesis, apparitions, poltergeists, miracles and voice recording. These are observed (perhaps apparently observed?) facts. It is quite in order to expect them to have a rational basis, one which we cannot understand as yet. It must be remembered that fantasy is only fact

associated with certain physiological actions of the body. Progress of understanding these rhythms is positive but slow. No doubt at some time in the future brain rhythms will be used to produce extensive communication as a direct thought process between people and machines — see Fig. 10. If we could hook up to another person by a wirelink it would be clearly feasible to do so without wires using wireless techniques of today. Typewriters that

plistic data about the person's functions. Perhaps allied research will reveal the existence of radiated energy waves which are allied to the brain rhythms.

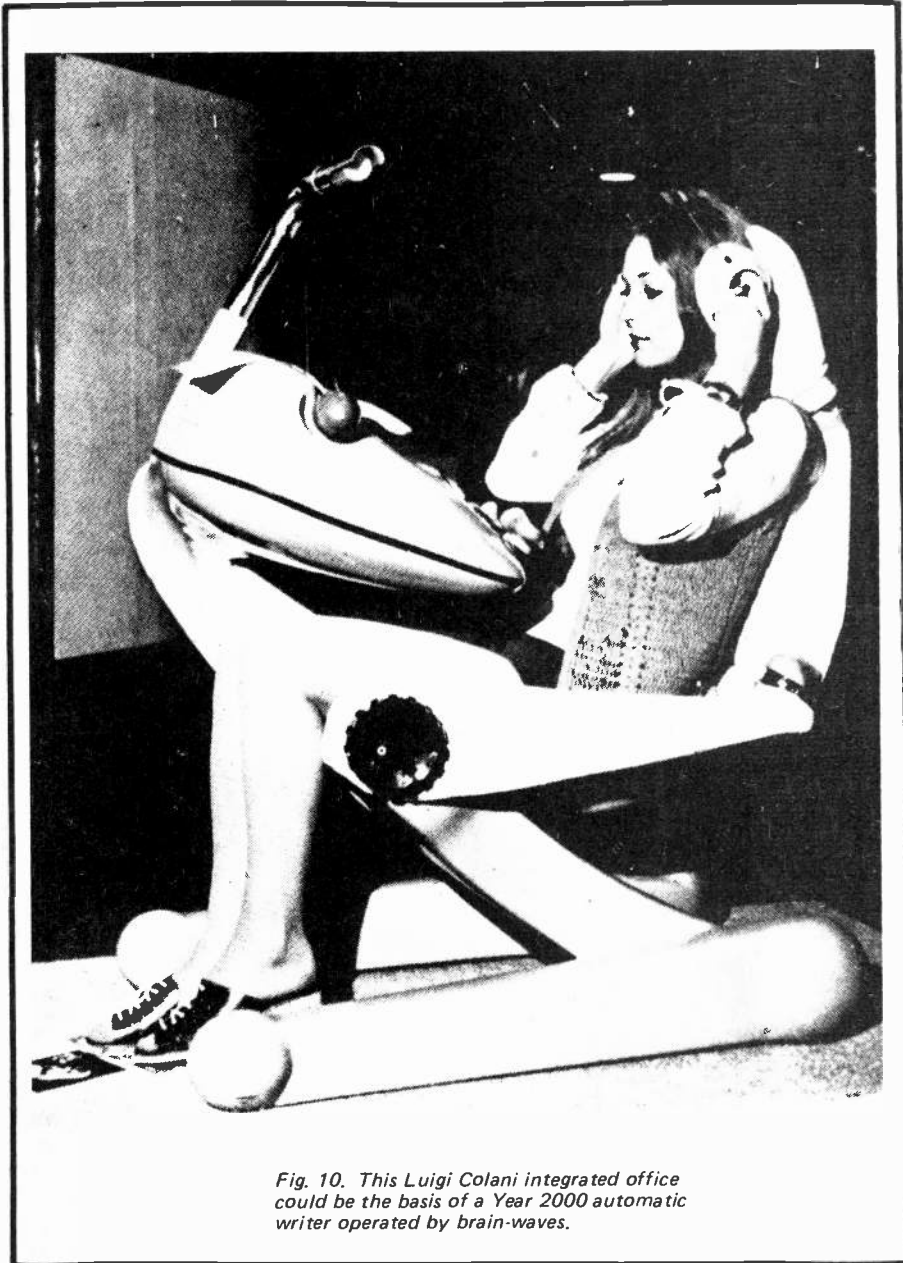
Assuming another form of energy field were discovered we could surmise that it might have direct person-to-person communication ability over global ranges rather than over the several metres experienced by our acoustic talking and hearing communication system. If this were so then the bandwidth problem of current systems might not be the limitation of the future. We would then have a breakthrough discovery that would completely change our attitude to what is feasible. Attitudes to community participational behaviour would be completely upset by such a finding.

For example, consider the experiences arranged in a theatrical show. Instead of having to relay the performance over cable or EM systems we might be able to 'attend' from remote distances. The whole concept of theatre would change. For this to be an adequate experience the "distance attendance" form of participation must fully simulate actual participation in the audience. Such a capability would obviate a vast amount of travel necessity and vastly reduce the need for transport mechanisms.

The live theatre is one form of entertainment that has changed little since its inception — at least until recent times. Lighting has improved beyond the lime-light of the last century to computer-controlled electric lighting of today. Electronic amplification of players' voices is still often avoided but electronic effects are used extensively in musical productions.

Current moves in the industry are to automate set changing. At the command of a mini-computer the several tonne sets will soon trundle out from the wings to their correct positions on stage without the aid of any stagehands. Will the players one day become automatons controlled by computer also?

We have seen in this and the previous part that electronic facility is a major influence on change. The mass-production of integrated circuits by photo replication methods enables many identical parts to be made most cheaply. Cheap data processing will continuously influence the kinds of ideas that are exploited and promoted in the future. One interesting question to ask, however, is whether electronics is the only discipline for powerful information handling. In the 1940s mechanical elements were thought to be the answer; today it is electronics. Could tomorrow see a change to electro-chemical or some other system of signalling not yet known?



*Fig. 10. This Luigi Colani integrated office could be the basis of a Year 2000 automatic writer operated by brain-waves.*

unexplained. There is no reason to think all knowledge is known at this point in time.

The brain produces electrical signals — one kind is known as alpha rhythms. These can be recorded and a little is known that enables the signals to be

write directly from thought waves will emerge to speed up the tedious task of transducing thought into clearly printed text. Here the hold-up is a scientific knowledge barrier for we cannot adequately decode the rhythms to obtain any more than the most sim-

# Number One ETI CIRCUITS

The first in a new series  
of 'ideas books' for the experimenter

## Contents

### ALARMS

Basic Alarm  
Photo Intruder Alarm  
Intruder Alarm  
Photo Electric Relay  
Low Temperature/Lights out  
Temperature Sensor  
Coolant level  
Water Level  
Electronic Lock  
Car Battery Watchdog  
Simple Car Alarm  
Simple Lock

### AMPLIFIERS & PREAMPLIFIERS

High Input Impedance  
High Impedance Buffer  
Low Output Impedance  
High Input Impedance  
Low Frequency Extender  
Virtual Earth Preamp  
IC Tape Head Preamp  
Simple Stereo Tape Player  
2.5 Watt  
20 Watt Slave  
10 Watt  
Loudspeaker Microphone  
Voltage Controlled Amp  
Wide Band Amplifier  
Video Power Amp  
Broadband Amp

### SIGNAL PROCESSORS

Fuzz Box  
Guitar Fuzz  
Fuzz Box  
Waa Waa  
Disco Autofade  
Simple Autofade  
Information Transfer  
Optical Pulse Conditioner  
TV Sound Pickoff  
Cracklefree Potentiometer  
Voltage to Frequency  
Sine to Square Wave  
Precision AC to DC  
Voltage Processor  
Universal Meter  
Double Precision  
Fast Half Wave  
Simple Chopper  
Noise Rejecting SCR Trigger  
Phase Shifter

### SIGNAL GENERATORS

Simple  
Variable Duty cycle  
Fast Edge  
FET  
Improved Multivibrator  
Variable Duty cycle  
Stable R.C.  
Cheap (CMOS)  
Simple TTL XTAL  
Uncritical XTAL  
Pulse  
Zero Crossing  
Simple Pulse  
Needle Pulse  
Stable Linear Sawtooth  
Zener  
Noise  
Pink

Simple Relaxation  
Triangle with independent slope  
Exponential  
Widerange Multivibrator  
Multiple Waveform  
Linear Sweep  
Step Frequency  
Beeper  
7400 Siren  
Simple Siren  
Ship Siren  
Two Tone  
Toy Siren  
Kojak, Startrek, Z Cars  
Sound Effects  
Sound Effects

### FILTERS

Bandpass  
Low & High Pass  
Rejection Notch  
Bandpass  
Cartridge EQ & Rumble  
Hum Stopper  
Tape Hiss Reduction  
Simple Crossover

### DIGITAL

Thermometer  
Heads or Tails  
Binary Calculator  
Voltmeter  
Seven Segment to Decimal  
Die  
Random Binary  
CMOS Die  
Multiplexer Hints  
Learning Memory  
CMOS Clock

### POWER SUPPLIES

Constant  
Temperature Stable  
Constant  
Voltage Controlled  
Precision Voltage Divider  
Dual Polarity  
Simple Balanced  
Voltage Divider  
Low Regulated  
Short Circuit Protected  
Simple TTL Supply  
ZN414 Supply  
Stable Reference  
Transformerless inverter  
DC to DC AC  
Voltage Multiplier  
Automobile Converter  
Shaver Adaptor  
DC-DC  
High Voltage From Battery  
Variable +ve or -ve output  
Simple  
12V from Battery Charger  
Bucket Regulator  
Adjusting Zener Voltage  
Variable Zener  
Zener Boosting of Regulators  
High Power  
Electronic Fuse  
Better Fuse  
Regulator & Fuse  
Fast Acting  
SCR Crowbar  
Voltage Polarity  
NI CAD Discharge  
Current Limiting

### TEST

Diode Checker  
GO/NO GO Diode Tester  
Zener Check  
GO/NO GO Transistor Tester  
Quick JFET Test  
Current Gain Tester  
Basic Transistor Tester  
Simple Transistor/SCR  
SCR Tester  
Crystal Check  
Good/Bad Battery Tester  
Battery Tester  
Op-Amp Tester  
Op-Amp Checker  
Cheap Logic Probe  
Audible TTL Probe  
Audible Slow Pulses  
Logic Probe  
Logic Analyser  
I and O Display Probe  
Simple High Impedance  
Voltmeter  
Audio/RF Tracer  
Thermocouple Thermometer  
Metering Stabilised supplies  
Simple Frequency Meter

### TIMERS & DELAYS

Low Standby Drain  
741 Timer  
Self Triggering Timer  
Pulse Timer  
Pulse Delay  
Voltage Controlled Monostable  
Sequential Relays  
Door Chime Delay

### SWITCHING

Touch Triggered Bistable  
Touch Sensitive Switch  
Electronic Switch  
Sound Operated 2 Way  
SPST Switch Flip Flop  
Two Signals on one Wire

### INDICATORS

Line-o-Light  
3 Step Level  
Light Level  
Bargraph Display  
Fuse Failure  
Blown Fuse  
Back Up Lamp  
DC Lamp Failure  
FM Tuner Station  
Current Flow  
Disco Cue

### FLASHERS

Dancing Lights  
Low Frequency Strobe

Flasher  
Ultra Simple

### POWER CONTROL

LDR Mains Control  
Floodlamp Control  
Zero Crossing Sync  
Train Controller  
Low Differential Thermostat  
Simple Temperature Control  
Full Wave SCR Control

### AUTOMOBILE

Brake Lamp Failure  
Courtesy Light Delay  
Simple Hazard Light  
Light Extender & Reminder  
Four Way Flasher  
Headlamp Dipper  
Wiper Delay  
Suppressed Zero Voltmeter  
Rev Counter/Tachometer  
Auxiliary Battery

### DETECTORS & COMPARATORS

Peak Detect & Hold  
Window Detector  
Peak Program  
Positive Peak  
Reaction Comparator

### RADIO FREQUENCY

Crystal Marker  
100 kHz Marker  
RF Voltmeter  
RF Detector  
LED RF Indicator  
RF Amplifier Protection  
FET-Radio  
Op-Amp Radio

### MISCELLANEA

Phase Locked Loop  
Touch Doorbell  
Phase Lock Control  
Audio Mixer  
Virtual Earth Mixer  
Pop Eliminator  
Loudspeaker Protection  
Digital Capacitance Probe  
Digital Tape Recorder Adaptor  
Breakdown Diode Substitution  
Dual Function Charger  
Dual Mode Amp

Capacitor Substitution  
Electronic Capacitor  
Speeding Up Darlington's  
Shutter Saver  
Thyristor Sensitivity  
Sound Operated Flash  
Strength Tester  
Logic Noise Immunity

### TIPS

Identifying 74 Series  
Supply Pins  
Soldering IC's  
Tinning With Solder Wick  
PCB Stencils  
Front Panel Finish  
DIL Drilling  
Fluorescent Starting  
Avoiding Insulated Heat Sinks  
TTL Mains Interface  
Boost Your Mains  
High Resistance on Low Meters  
High Voltage Electrolytics  
Transistor Identification  
Template & Heat Sink for  
Power Transistors  
Transistor Socket  
Solder Flow Problems  
Odd Resistor Values  
Resistors in parallel  
CMOS DIL Handling  
Identifying Surplus ICS  
Extending Battery Life  
Battery Snaps  
Power Supply or Battery  
Battery Checking  
Muck Remover  
Transformers in reverse  
Loudspeaker Checking  
Improving UJT Linearity  
Signal Tracer  
Crystal Earpieces  
Cheap Varicaps  
Zener Lifts Capacitor Rating

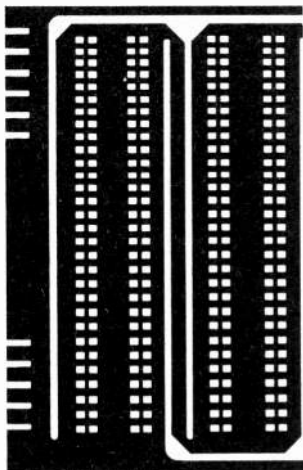
### DATA

741 Op-Amp Data  
BC 107-109 Data  
BC 177-179 Data  
CMOS & TTL Data  
2N3055 Data  
MJ2955 Data  
Bipolar Data Tables  
Bipolar FETs Rectifiers  
Diodes Pinouts Zener Misc

**SEND \$5.00 TODAY**  
To: ETI Circuits, ETI Magazine  
Unit 6, 25 Overlea Boulevard  
Toronto, Ont. M4H 1B1

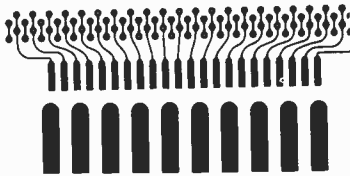


Printed Circuit Board materials for the Hobbyist and Technician.



PRINTED CIRCUIT KIT FOR STUDENT - EXPERIMENTAL - HOBBYIST ALL THE MATERIAL NECESSARY TO MAKE YOUR OWN PRINTED CIRCUIT BOARDS

MAKE YOUR OWN PRINTED CIRCUIT BOARDS

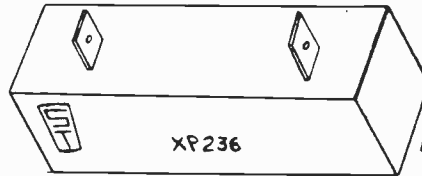


INJECTORALL - from Fingers to Doughnuts a very complete line of quality circuit board materials.

**omnitronix Ltd.**

2056 SOUTH SERVICE RD. TRANS CANADA HWY. - DORVAL, QUE. H9P 2N4 - PHONE: (514) 683-6993

# TOP QUALITY PARTS



**SILICON RECTIFIER**  
5KV 2AMPS  
\$1.50 each  
4 for \$5.00

**Tellon Wire**

MS35471 #10 awg, stranded, silver plated, double glass braid, 600 V, 200 deg. C. 10-100 ft, 12¢/ft.

Duncan 10 turn precn pot, 5W, 200K, +3% tol, .05% linearity. \$3.50 each.

Precision & std resistors, dipped micas, mylars, switches, transistors transformers, circuit boards, knobs, hardware, sockets....many more. U.S. & CANADA ONLY.

**FREE CATALOG**

**BRAND X ELECTRONICS**

Rt. 3, Box 223

ONTARIO, OREGON 97914 U.S.A.

## CHANGE OF ADDRESS

ATTACH OLD MAILING LABEL HERE

PRINT NEW ADDRESS AND ATTACH HERE.

If you have a subscription to ETI this coupon can be used to notify us of any change of address (If you have no subscription see page 15).

To be sure you get your copies allow six weeks for the change to become effective.

Send the coupon to ETI Magazine, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.

## KIT BONANZA

DOMINION RADIO & ELECTRONICS COMPANY

535 Yonge Street, Toronto 5, Ontario, Telephone 922-1818

COAST TO COAST MAIL ORDER

<p>100 <b>ASSORTED RESISTORS</b></p> <p> FOR THE HOBBYIST</p> <p><b>99¢</b></p>	<p>50 <b>ELECTROLYTIC CAPACITORS</b></p> <p>assorted 10 uf to 150 uf</p> <p>AXIAL LEAD</p> <p><b>\$3<sup>95</sup></b></p>
<p>50 <b>FILM CAPACITORS</b></p> <p>assorted values NON POLAR</p> <p><b>\$1<sup>95</sup></b></p>	<p>100 <b>TRANSISTOR SOCKETS</b></p> <p>ASSORTED</p> <p><b>\$1<sup>95</sup></b></p>
<p>100 <b>ASSORTED TRANSISTORS</b></p> <p></p> <p><b>\$4<sup>95</sup></b></p>	<p>25 <b>INTEGRATED CIRCUITS</b></p> <p>ASSORTED</p> <p></p> <p><b>\$2<sup>95</sup></b></p>
<p>4 rolls <b>30ft VINYL TAPE</b></p> <p>ASSORTED COLOURS</p> <p><b>99¢</b></p>	<p><b>SPECIAL!</b></p> <p>2N3704 TRANSISTORS</p> <p>20 NPN </p> <p><b>\$1<sup>95</sup></b></p>



# I<sup>2</sup>L EXPLAINED

I<sup>2</sup>L is being used for mass production of LSI ICs, but little has been said about the theory behind this new technology.

In this article Brian Dance explains how it works...

A FEW YEARS AGO THERE WAS one principal technique used in the manufacture of logic circuits, namely TTL or Transistor-Transistor Logic. Devices using this technology have the advantage of being able to switch very quickly, but they are not suitable for applications like electronic watches where the logic circuits must consume very little power and occupy the minimum possible area on the silicon chip.

The development of the Complementary Metal Oxide Semiconductor technology known as CMOS (or COS/MOS) by RCA about 1970 provided devices which have an extremely high component packing density on the silicon chip and which operate at a very low quiescent current. The complementary MOS field effect transistors used in CMOS devices take appreciable current only for the time taken to switch logic states. Silicon-on-sapphire is a variation of the basic CMOS technology which offers relatively high speeds of operation, but at the present time such devices are expensive to manufacture.

## I<sup>2</sup>L

Integrated injection logic or I<sup>2</sup>L now provides serious competition to CMOS circuits where minimum current and high component packing density is required. Devices using I<sup>2</sup>L circuitry can be produced very economically and the speed of operation rivals that of TTL. This new technology is being used by some of the major semiconductor manufacturers for products ranging from microprocessors to quartz-controlled electronic watch devices. All I<sup>2</sup>L devices are large scale integration LSI products — they contain a very large number of components on a single silicon chip.

I<sup>2</sup>L was developed quite separately (in Europe) by Philips and IBM around 1972. It employs bipolar devices (that is, devices like conventional transistors rather than FETs) in circuits which have been derived from the early DCTL (Direct Coupled Transistor Logic). It is only quite recently that developments in the I<sup>2</sup>L production processes have made this circuit technique economically attractive.

A DCTL circuit is shown in Fig. 1. Three transistors are shown in each of

the three NOR gates with the output of Gate 1 feeding one of the inputs of both gates 2 and 3. Other connections, which are not shown, are made to the other inputs of the gates. Circuits of this type were used in simple SSI (small scale integration) devices, but suffered from the disadvantage that the current was unequally divided among the transistors in any one gate owing to minor differences in their base-emitter voltages. In addition, the load resistor had to be separated from the transistors and this used up a considerable area of the chip.

Note that in the circuit of Fig. 1 there are direct connections between corresponding regions of the transistors: all of the emitters are joined together, whilst the two bases which are driven from the collectors of gate 1 are common. The current to these bases passes through the load resistor of the gate 1 circuit. In an I<sup>2</sup>L circuit, these common electrodes share the same area on the chip.

A cross section through an I<sup>2</sup>L gate is shown in Fig. 2 and the circuit is shown in Fig. 3. A single pnp transistor is employed as a current source to

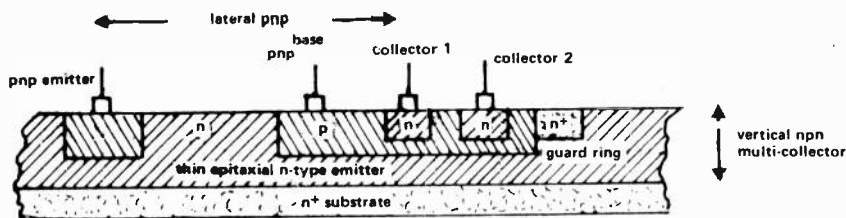


Fig. 2. Cross section through an I<sup>2</sup>L gate.

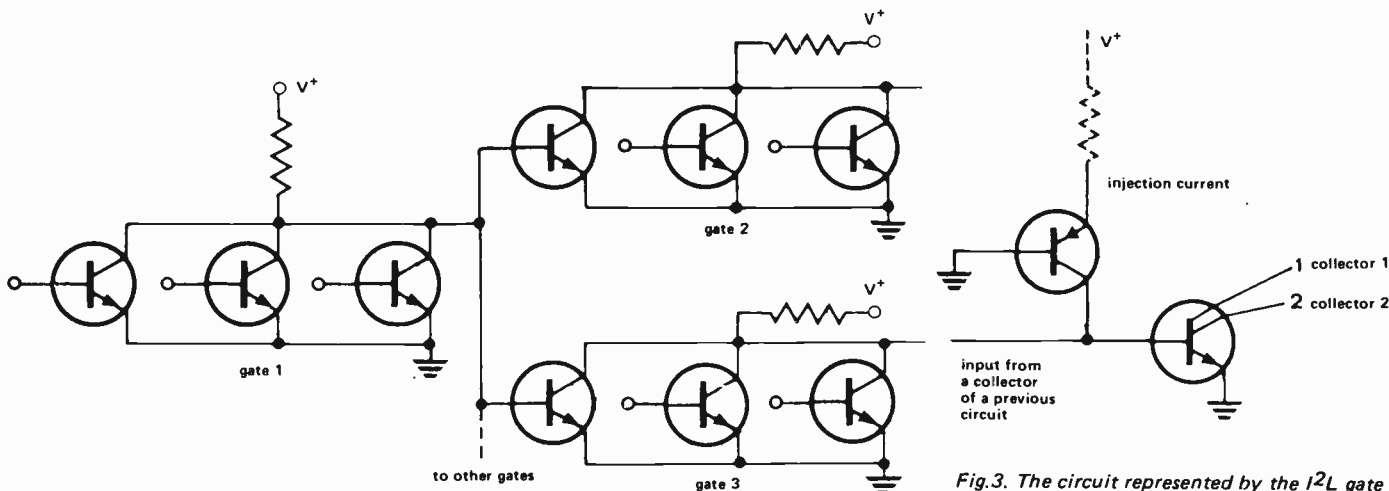


Fig. 1. A Direct Coupled Transistor Logic circuit (DCTL).

Fig. 3. The circuit represented by the I<sup>2</sup>L gate shown above in Fig. 2.

supply current to many transistor bases without the use of a load resistor. The whole of the emitter region is a common one beneath the surface structure on the chip. This eliminates the need for surface metallisation for each separate ground connection. In addition, the area required per transistor is greatly reduced. IBM initially used the name Merged Transistor Logic (MTL) instead of  $I^2L$ .

It should be noted that the pnp transistor is formed laterally along the surface of the silicon chip. The other component is a multi-collector npn transistor characteristic of  $I^2L$  devices. However, this npn transistor is formed vertically in the silicon. The n-type epitaxial layer acts as the grounded emitter of the npn transistor and also as the grounded base of the lateral pnp device. The p-type base of the multi-collector transistor also serves as the collector of the pnp device. Thus the two devices do not exist as separate structures.

### Injection

The pnp transistor 'injects' current into the base of the multi-collector transistor — hence the name Integrated Injection Logic. Current from a current source (not shown in Fig. 3) passes to the emitter of the pnp transistor and hence to the collector. Switching of the logic state occurs when this current is switched to or from the base of the multi-collector transistor.

If the input at the base of the multi-collector transistor is low (less than about +0.7 V), this potential will be inadequate to overcome the natural forward junction potential of the npn base-emitter junction and the npn device will be non-conducting. The injected current will flow out of the input connection to the collector of the previous circuit (not shown in Fig. 3). The multi-collector transistor outputs will therefore rise to the 'high' logic level, this voltage being determined by the collector circuitry.

If the input voltage now becomes 'high' (that is, over +0.75 V), the npn transistor will be biased to saturation and the output of the collector will be 'low'. This low value can be about 0.02 V. Thus the change of the logic level is represented by a voltage swing of around 0.7 V.

### Power Supply

The positive power supply line of  $I^2L$  circuits is connected only to the emitters of the pnp injection transistors. The base of these transistors is earthed, so the  $I^2L$  circuit as viewed from the power supply line is effectively just a forward-biased silicon diode. The total power supply current is therefore the sum of the currents fed to the injection transistor emitters.

The voltage levels in  $I^2L$  circuits can be very low; indeed, such circuits can operate from a supply of 0.85 V upwards. The supply current per gate can be very low (about 1 nA), but the injected current can be increased in value up to about 1 mA to permit switching of the circuit at a much higher speed.

Although the  $I^2L$  circuits can operate at such low voltages, the input and output circuits normally included in the same package require a higher supply voltage and their requirements normally determine the operating voltage of the whole device. A series voltage-dropping resistor is used in the power supply line of some  $I^2L$  devices, whilst other devices incorporate a voltage regulator on the chip to eliminate the need for an external resistor.

The use of an internal regulator circuit also enables various injector current levels to be obtained at different points in the circuit so that each part can operate at the minimum power level for the switching speed required by that particular part. For example, the fast frequency dividing circuits of a quartz controlled watch can operate at a high injection current for

a satisfactory performance at 32 kHz, whereas the following frequency dividing circuits operating at a low frequency can use lower injection current levels. The increased cost of fabricating such circuits may be well worth while when current consumption must be minimised.

In many applications a single dry cell can be an ideal power source for  $I^2L$  circuitry.

A guard ring of n+ material (shown in Fig. 2) is required in  $I^2L$  devices to reduce cross-talk between adjacent gates. However, this ring can touch the base of the npn device and it occupies little surface area.

### Gates

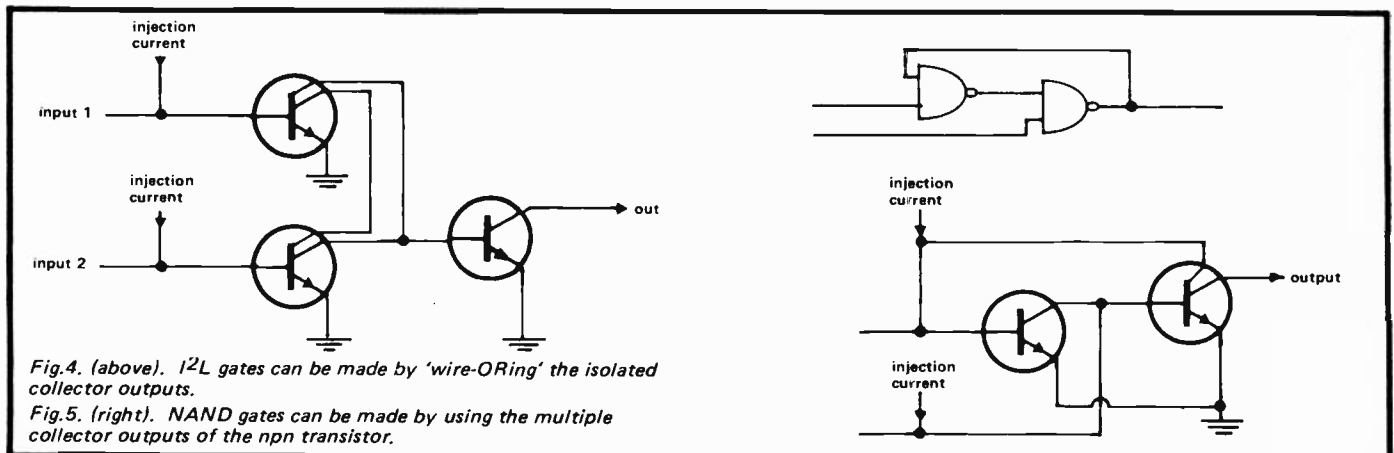
$I^2L$  gates can be made by "wire-ORing" the isolated collector outputs as shown in Fig. 4. Similarly NAND gates can be made by using the multiple collector outputs of the npn transistor connected as shown in Fig. 5.

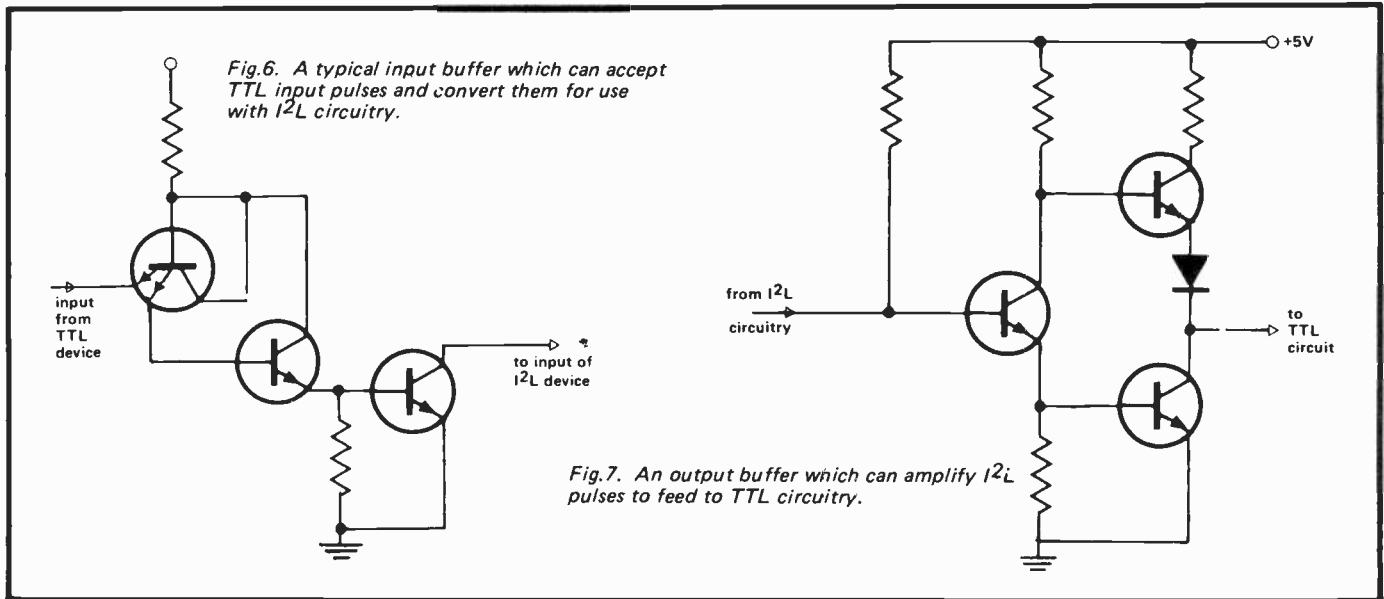
### Input/Output Circuits

$I^2L$  is almost always used in conjunction with other circuitry. The voltage change when an  $I^2L$  circuit switches is only about 0.7 V at current levels which may be very low. If the inputs and outputs of the  $I^2L$  circuits were brought out directly to external connecting pins, any small stray noise pulses or interference picked up by the circuit would be likely to trigger the  $I^2L$  circuitry, owing to its great sensitivity to low amplitude pulses.

Buffer interfacing circuits are therefore used between the input and output connections of a device and the  $I^2L$  circuitry itself. A typical input buffer which can accept TTL input pulses and convert them into pulses suitable for the operation of an  $I^2L$  circuit is shown in Fig. 6. The input buffer circuit used with some of the older logic systems can be even simpler.

An output buffer circuit which can amplify the low voltage pulses from the





output of an I<sup>2</sup>L circuit and provide enough current and voltage to drive a TTL input is shown in Fig. 7.

### Technology Comparison

An I<sup>2</sup>L gate can be made with what is effectively a single component on a chip area about one tenth of that required for a normal three-component CMOS gate. In addition, I<sup>2</sup>L is one of the most economical technologies used in device fabrication, since the number of masking and diffusion operations on the silicon slices are less than in most comparable techniques.

One of the advantages of I<sup>2</sup>L technology is that it is so very similar

to that of other standard linear and Schottky TTL manufacturing processes that it is easy to fabricate other types of component on the same chip. For example, light emitting diode driver circuits can be built on the same chip as I<sup>2</sup>L circuitry; this enables a single chip to be used to drive the display of a watch or a calculator as well as to carry out the required logic operations. Operational amplifiers, oscillators, voltage regulators, etc. can be fabricated on chips containing I<sup>2</sup>L circuitry.

The CMOS process is essentially suitable only for the production of purely digital devices, although simple devices such as transistors and diodes

can be fabricated on the chip. In contrast, Schottky TTL devices can be combined with I<sup>2</sup>L circuits on a single chip to produce products which are faster and which have higher component densities than can be achieved in other ways. The Texas Instruments SN74S201 and SN74S301 256 bit random access memories are examples of such products.

The power consumption of I<sup>2</sup>L circuits increases linearly with the speed of operation required and in practice you can use the minimum injection current required for maximum speed at which the circuits will ever operate. CMOS circuits consume very little power in the quiescent state, but

### Discovery of I<sup>2</sup>L

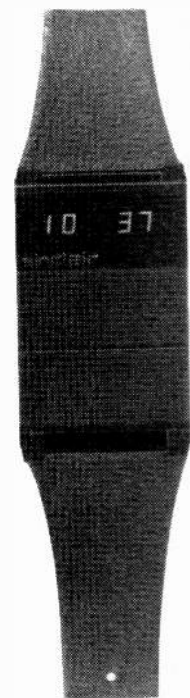
The discovery of I<sup>2</sup>L is quite a story in itself. Horst H. Berger and Siegfried K. Wiedmann of the IBM Boeblingen Laboratory in Germany reported on their MTL (or I<sup>2</sup>L) circuitry at the International Solid State Conference in Philadelphia in February 1972. However, the next paper at the Conference was by Cornelius M. Hart and Arie Slob of Philips Research Laboratories of Eindhoven, in which they disclosed details of their I<sup>2</sup>L circuits.

The IBM workers produced their circuit designs after a long, but rational, effort. On the other hand, the Philips workers evolved their basic ideas within a few days in what was essentially a flash of inspiration. Within three months the Philips Laboratories were producing large scale I<sup>2</sup>L chips.

Hart and Slob saw I<sup>2</sup>L from the physicist's point of view in which minority carriers from a p region

were injected into an npn device in order to solve the problem of the high current and large limiting resistors required with conventional bipolar logic. On the other hand, Berger and Wiedmann saw their circuits from the point of view of a circuit designer in which the individual devices on a chip were merged together.

The Philips organisation produced a pocket calculator using I<sup>2</sup>L technology as early as 1971. It contained over 1000 gates in an area of 4x4mm. Even in the first I<sup>2</sup>L chips, the elimination of the physically large resistors and the thermal dissipation in these resistors showed the main advantages of I<sup>2</sup>L technology. Each logical operation required about one picojoule of energy; this may be compared with the estimated value of 0.2 picojoule required to operate the logic cells (the "neurons") of a human brain.



The Sinclair Black Watch was one of the first commercial applications using I<sup>2</sup>L.

## I<sup>3</sup>L

The symbol I<sup>3</sup>L is a trade mark used by the Fairchild Company for their Isoplanar Integrated Injection Logic technology. It is employed in such products as the Fairchild 9408 microprogram sequencer which controls the order in which micro-instructions are fetched from a

control memory having up to 1024 words; it is fully compatible with TTL devices.

### Applications

I<sup>3</sup>L devices are used in such applications as electronic games, frequency synthesisers, micropro-

cessors, high speed calculators, computer interfaces, counters, timers, telephone switching, tone generators, electronic organs, remote control systems for TV sets, analogue to digital converters, digital voltmeters, vehicle anti-skidding, fuel injection control etc.

the power required increases with the switching speed. Thus no circuit adjustments or settings need be made if minimum power consumption is important and the maximum operating speed is always available. In other words, CMOS circuits always consume minimum power at low operating speeds, but have a high speed capability "on demand" whereas I<sup>2</sup>L circuits must be adjusted for low power or high speed or some intermediate value of power consumption and speed.

I<sup>2</sup>L is faster than CMOS, whilst Schottky-clamped I<sup>2</sup>L is even faster still. The silicon-on-sapphire version of CMOS is another way of obtaining faster logic devices, but emitter coupled logic (ECL) offers the highest speed at the expense of ease of use.

The susceptibility of I<sup>2</sup>L devices to noise pulses has already been mentioned. CMOS devices require input pulses with an amplitude of about half the supply voltage used and are therefore very resistant to spurious operation by stray noise pulses. It is difficult to see how future I<sup>2</sup>L can be fabricated without input and output buffer circuitry because of the noise problem.

A comparison between the various logic systems is given in Table 1.

### Applications

I<sup>2</sup>L is employed in a wide range of applications which require large scale integration. It is unsuitable for making devices with only a few gates, so it

seems most unlikely that simple I<sup>2</sup>L logic devices will become available (like those one meets using CMOS and TTL technologies).

I<sup>2</sup>L devices are expected to have a wide range of applications in the computer field. Although most of the larger semiconductor manufacturers are considering whether to become involved in I<sup>2</sup>L device manufacture, a few (such as Texas Instruments) are already producing devices in quantity. The SBPO400, for example, is Texas' 4-bit parallel binary processor element in I<sup>2</sup>L. I<sup>2</sup>L computer and microprocessor devices satisfy fairly high speed requirements, but they meet competition from fast versions of CMOS and silicon-on-sapphire devices.

I<sup>2</sup>L technology is likely to be used in many consumer applications where its relatively low price is a vital factor. ITT are already producing their ITT 7170 device in England for the Sinclair "Black Watch" which is a very economical product. The 7170 chip incorporates over 2000 transistors on a piece of silicon only 3mm by 3mm in area. It is used in the first watch to incorporate all of the circuitry on a single chip, since I<sup>2</sup>L can offer the high drive current for the LED display (whereas CMOS devices must be used with separate display-driver devices). The frequency of the quartz-controlled oscillator used in this watch is 32.678 kHz. Current consumption without the display is 159  $\mu$ A. The display operates on demand and naturally

requires a greatly increased current from the batteries to produce the emitted light.

The Exar Company of California also produce a watch using I<sup>2</sup>L logic.

### Cameras

Another consumer field in which I<sup>2</sup>L seems destined to play an important part is in the electronic control of camera shutter speeds. Conventional electronic shutter devices consume a current from the battery in the camera whenever they are switched on, but I<sup>2</sup>L devices can be operated on the current from a photocell. Unfortunately a battery is required in such cameras to actually operate the shutter magnets, but the time for which the battery current is required is very small and hence new cameras employing I<sup>2</sup>L devices will have a much longer battery life than other types.

One camera circuit is made by Micro Components Corporation in Cranston, Rhode Island, USA. The I<sup>2</sup>L circuit operates as a light to frequency converter to produce an output of 100 Hz to 1 MHz, linearly related to the intensity of the incident light. This signal drives a ring oscillator made from I<sup>2</sup>L transistors which determines the shutter speed. The whole device is mounted in a clear plastic package consuming some tens of nA. The Matsushita Company of Japan are also working in this field using I<sup>2</sup>L.

Another consumer example of the use of I<sup>2</sup>L, is the Motorola three-chip logic synthesiser for digital tuning of car radios. The devices can scan the band and make the tuning lock the required frequency.

### Conclusion

In the end the challenge any new technology must meet if it is to be successful is either (i) it must perform tasks which competitive techniques cannot accomplish or (ii) it must perform a task more economically than other technologies. I<sup>2</sup>L can't do much that can't be done in other ways. However, in certain applications, it can be very cost effective. This criterion will determine in which applications it will be employed in the future. ●

Table 1. A Comparison of TTL, CMOS and I<sup>2</sup>L

Type of logic	Packing density (Gates/mm <sup>2</sup> )	Typical Quiescent dissipation per gate	Typical Dissipation per gate at 1 MHz	Logic voltage swing
I <sup>2</sup> L	140 to 220	5 nW	100 $\mu$ W	0.7 V
CMOS	70 - 80	5 nW	150 $\mu$ W	Varies with supply voltage
TTL	20	10 mW	10 mW	3.5 V

an electronic game to develop clear thinking

# ETI MASTERMIND

DIGITAL ELECTRONICS is a natural for game circuits. Things that go 'high' in the night and will keep scores accurately (when told to), conjure up visions of nice neat Veroboxes lined with LEDs and seven-segment displays all flashing away in time to a maniac beat.

In practice such pyrotechnic exuberance is rarely achieved, and the vaulted scheme reaches completion as yet another digital dice, or in the event of a unprecedented brainstorm, a clock.

Well, although we must admit to a minimum of pyrotechnics, we can *truthfully* claim to have gone berserk with the T.T.L! This project should, however, provide a nice 'middle-class' undertaking for those wishing to move from Reaction Testers to MPU's.

## Getting stars for dots

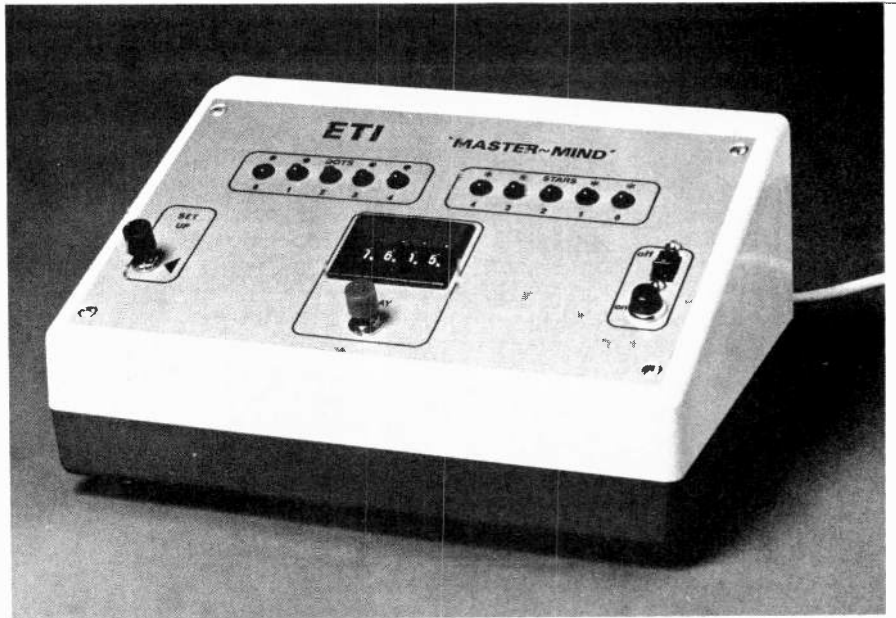
The game is based on the old 'star and dot' game where one player sets up a number code consisting of three to six digits (depending on how clever his opponent is — or thinks he is!) and another attempts to 'break' the code. Stars are awarded for correct digit, correct position, and dots for correct digit, wrong position.

For example if the code was 1234, and the guess 0247, one star is awarded for the '2' and one dot for the '4'. The game has recently been marketed under the name 'Mastermind', using colours for numbers.

Our version uses logic to replace one of the protagonists, such that the game becomes playable in solo fashion. When the 'set up' button is operated, the circuit generates its own random 4-digit number and stores this. The player then has to 'guess' using the four BCD switches and the 'play' button.

Once this is pressed, a comparison is run, and the machine will award the appropriate stars and dots on the bars of LED's. These *do not* correspond in position to the BCD switches, so that all you know is how many you got right, and not where the correct numbers lie.

## FROM A CIRCUIT DESIGN BY GILES GUMMER



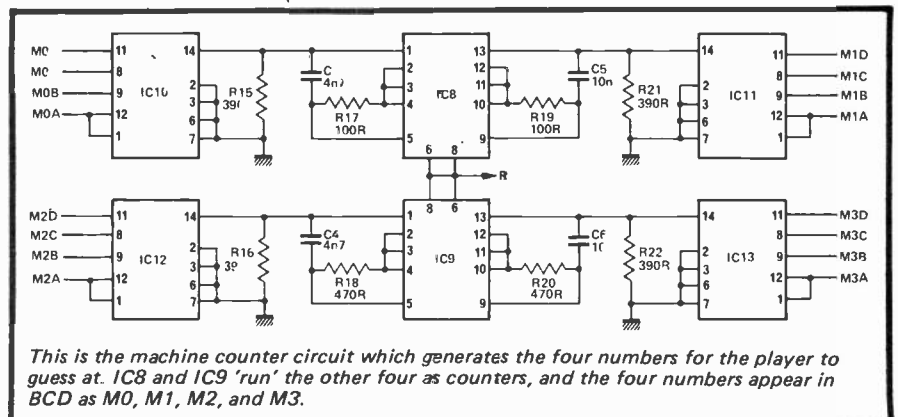
## Conditional discharge

One proviso — repeated digits are not allowed in either your guesses or the machines code. The circuit won't cheat you — it checks its own number on generation, and will re-run the counters if a repeat occurs. This means there will be  $10 \times 9 \times 8 \times 7$  (5040) possibilities for the answer. We consider this sufficient for all except the bionic brained!

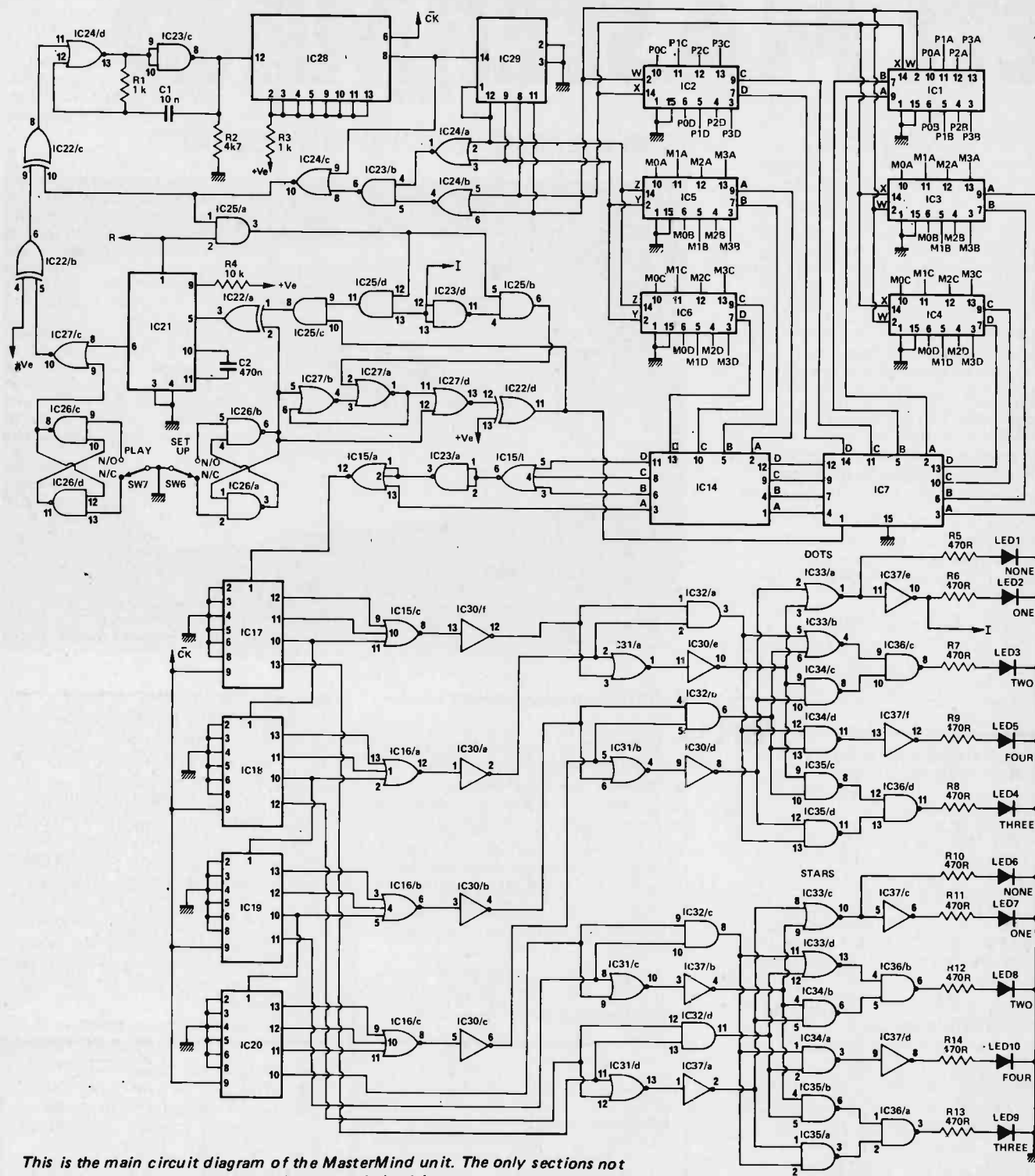
Keep a note of past attempts and what score you obtained for it if you like, but its more fun just

playing without notes — time yourself and see how the time you take goes down the more you play. As a competition between two people, it is the fastest time which will be an obvious decider rather than number of attempts.

Having said that, it would require very little extra circuitry to add a counter and LED display to the play button, so that every time it was pushed, the display advanced by one. A limit could be set, and the game played much the same way as the commercial version.



# ETI MASTERMIND



This is the main circuit diagram of the MasterMind unit. The only sections not shown here are the counters and the BCD switch wiring

## Building up to it

Although this is a very complex project, actual construction is not *that* bad. Having paused a second there to allow those who fainted at the audacity of that remark to recover, let us continue

unabashed, to point out that most of the potential problems are side-stepped by use of the PCB's.

If you are the proud owner of a wiring pen however, this is the perfect chance to put those pretty little reels to work. Make up a list of point-to-point connections from

the circuit diagram before you start (and CHECK it) and work your way down the list. Use IC holders.

This method produces excellent, neat results, but requires amounts of patience guaranteed to enhance the soul — or so they tell us.

# How it works

The control logic has to provide a single cycle of WXYZCk whenever a play push-button is pressed, must run the machine's counters, stop them, run a self-comparing play sequence, and repeat the process if the number generated is illegal.

The two control pushbuttons — play and set-up — are each bounce-protected by a pair of cross-coupled NAND gates — IC26. A test sequence is run, either by pushing play or by triggering the monostable IC21, through the OR gate formed by IC27c and IC22b. The five bit counter that cycles WXYZCk (IC28 and IC29) is run by a gated astable built around IC24d and IC23c. The gating input comes from IC22c and the astable runs when the gate line goes low. Exclusive OR (XOR) gates are used to drive both the astable (IC22c) and the monostable (IC22a). These gates provide four distinct phases of operation per cycle, and allow for slow fingerwork from the player. The five bit counter has a five input NOR gate, formed from IC23b and IC24a, b and c, attached to its output lines, which goes high when the counter is in its rest state (00000).

Normally the test input of IC22 is low and the other input high. Thus its output will be high and the astable disabled. When play is pressed, its output falls and the astable runs. The counter counts once, the five input NOR gate goes low, the inputs of IC22c differ again, and the counter stops. Releasing play lowers the second input, and the astable runs the counter once more until the NOR gate detects the end of the cycle, and stops it.

Since the shift register is clocked by a falling pulse, the Q output of IC28 (Ck) is used, though the NOR gate is fed with Q.

Pressing set-up does two things. Firstly, it sets the anti-race latch formed by IC22d and IC27a, b and d, which raises P/M to order the 'self-comparison' test from the multiplexers. Secondly, it triggers the monostable IC21. This causes its Q output to go low, which enables the four astables running the machine's number counters (via line R). Simultaneously its Q output rises and, as described above, the five bit counter counts to 00001, and stops. (This means that the first test comparison is run on the machine's old number, but this information is not in fact used.) When the monostable falls, the machine's counters stop and the rest of the test sequence is run on the number they have settled into. The display logic includes circuits to detect illegal numbers which are signalled on Line I. At the end of the test cycle, IC25a turns on IC25d if the number is declared illegal, and IC25b if not — IC23d is an inverter. IC25b resets the latch and ends the set-up sequence. IC25d re-triggers the monostable if the latch is set (IC25c) and if the set-up button has been released (IC22a — which operates similarly to IC22c).

The four machine counters (ICs 10, 11, 12 and 13) are each run by one of the four gated astables formed by NOR gates in ICs 8 and 9. These astables run at different speeds and provide an unguessable, if not truly random, four digit number after a run pulse on Line R. The data from these counters, as well as that from the player's BCD switches, is passed to the multiplexers, ICs 1 to 6. These are dual four-to-one multiplexers, type 74153, wired so that each multiplexer (two to a package) chooses the same bit from one of our digits, e.g. for the four player digits, bit B is multiplexed in the lower half of ICI. ICs 1

and 2 form multiplexer 2 (Mpx 2) and present at their four outputs the bits of the digit selected by W and X, their control inputs. Mpx 3 (ICs 3 and 4) does the same for the machine's number, and Mpx 4 (IC7, a 74157 quad two-to-one multiplexer) presents either the selected machine digit or the selected player digit to one side of the comparator circuit. P/M is the control line; raising it selects the machine digit, required for a 'self-comparison' test.

The other side of the comparator circuit is permanently connected to Mpx 1 (ICs 5 and 6) which selects a machine digit according to the state of the control lines Y and Z. In the comparator circuit equivalent bits are compared in an XOR gate (all four in IC14). All four bits must be identical if the digits are equal, so all four XOR gates must be low. IC15a and b, and IC23a, form a four input NOR gate that sums the outputs and goes high for identical digits.

Information from this gate is passed to the serial input of the shift register (ICs 17 to 20). These four ICs, type 7495, are cascaded to form a 16 bit, serial in/parallel out register. Data is clocked in once the state of the multiplexer outputs has had time to settle — on the rising edge of Ck, i.e. the falling edge of Ck.

The sixteen parallel outputs of the register provide Star information directly the cycle has ended, but as each digit has a choice of three from which it can 'earn' a Dot, four three input OR gates are required to sum this redundant information. These are formed from IC15a, b and c, IC16c and IC30a, b, c and f.

An illegal number generates at least one Dot when compared with itself. Thus the I Line is driven from the same source as the 'ONE' Dot LED.

## Parts List

### RESISTORS — all ¼W 5%

R1,3,23-38	1k
R2	4k7
R4	10k
R5-14,18,20	470R
R15,16,21,22	390R
R17,19	100R

### CAPACITORS

C1,5,6	10n polyester
C2	470n polyester
C3,4	4n7 polyester
C7-14,17	100n polyester
C15	2,200u 16V (or 2 x 1000u 16V)
C16	220n polyester

### SEMICONDUCTORS

IC1-6	74153
IC7	74157
IC8,9,24,27,31,33	7402
IC10-13	7490
IC14,22	7486
IC15,16	7427
IC17-20	7495
IC21	74121
IC23,26,34-36	7400
IC25,32	7408
IC28	7472
IC29	7493
IC30,37	7404
LED1,6	.2" type green
LED2-5,7-10	.2" type red
REG1	5V 1.2A (min.) TO3 cased regular i.e. 7805 k.c.
BR1	200V 1.6A bridge rectifier

### SWITCHES

#### SW1-SW4

miniature BCD switches. Interswitch: 4 x MB731 switches, one pair end-plates MBW, 2 x M2X40 tie rods, 4 x M2 nuts. (Many makes of thumbwheel switch are available, new and surplus, they simply need to have positions 0-9, with BCD type contact arrangement.)

#### SW5

On-off rocker 120V

1A type

#### SW6,7

S.P.D.T. momentary action

### TRANSFORMER

T1 120V/8.5V 1A (Hammond 166 J8)

### CASE

Vero type 65 - 2523E sloping front.

### MISCELLANEOUS

Neon indicator, ribbon cable, pcb mounting pillars, nuts, bolts, etc. line cord, aluminum for heatsink, T03 insulating kit, feet for case.

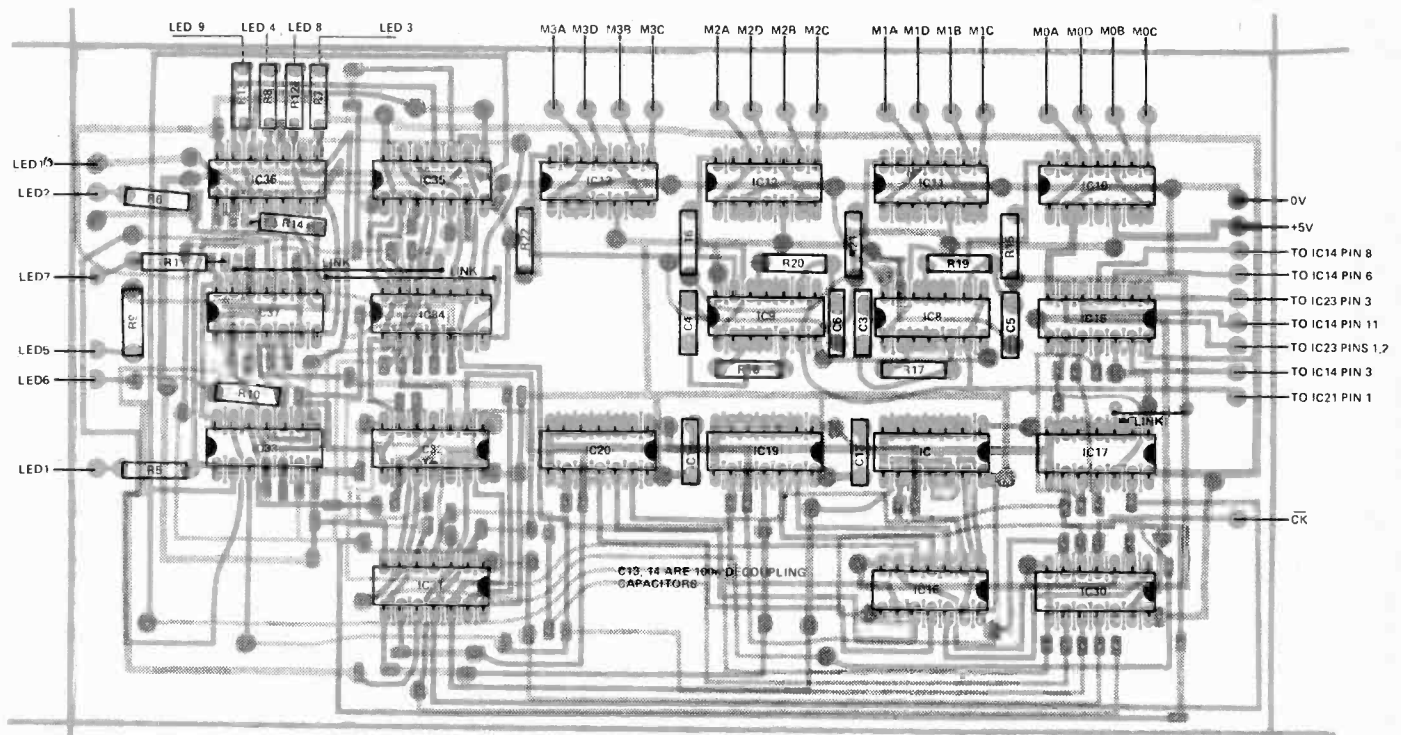
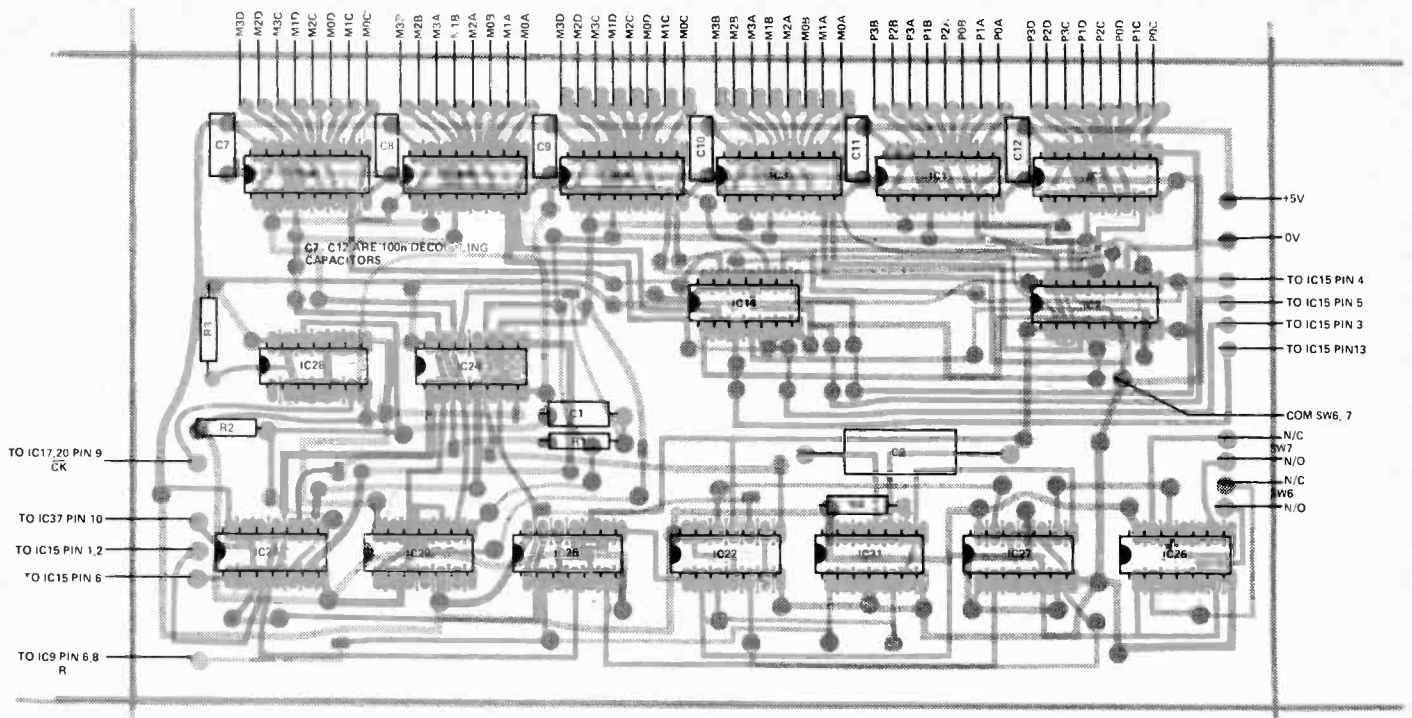
The circuit boards for this project are available from Dominion Radio — see page 62 for their address.

Full size foil patterns of the two main boards for home etchers are available direct from us for \$1.00 (to cover postage etc.) — see page 5 for the address for these.

Meanwhile back at the PCB there are a large number of through hole connections to make. With a logic circuit of this complexity it is unfortunately unavoidable. Through-plating the holes pushes the price too high to reach. So the first step is to wire up all the through board links, solder top and bottom, and check each one with an ohm-meter. IC sockets (or solder-con pins) *must* be used for all ICs; we spent hours unsoldering, when troubleshooting a faulty chip on the first prototype!

Another important point is that ¼ W 5% resistors *must* be used, especially on the back of the BCD switches, otherwise the front panel will not fit properly, fouling the PCBs inside.

Decoupling capacitors should be mounted on the boards where indicated, and if soldered both sides will act as through-links quite happily. The biggest hurdle to construction will be the interwiring. With all the data passing around the various circuit blocks, there is no way we could make this any simpler. Ribbon cable is expensive, but will more than save its cost in avoided headaches.



Component overlays of the main circuit boards. Any holes without component leads are through-board links. Solder these both sides, and check for continuity. Because of the size of these double-sided boards, we have not given the foil patterns, as usually we do.

Since there are so many connections to make, keep a record (written, preferably emblazoned on marble with holy fire), of which colour goes where, and which is what in each ribbon cable. Don't try and build the project in an evening. The small hours are no time to be checking a 20-way ribbon cable connection, and "midnight-oil" light will confuse the colours anyway. Take your time!

As regards a PSU, batteries will most definitely *not* do this time — current consumption is not far short of an amp most of the time,

### Conclusions?

Well it could have been simpler, but it could have been worse! If we'd used static logic, there would have been approx 70 chips, and about 2.5A (yes Amps) drawn from the supply. As it is the project is a

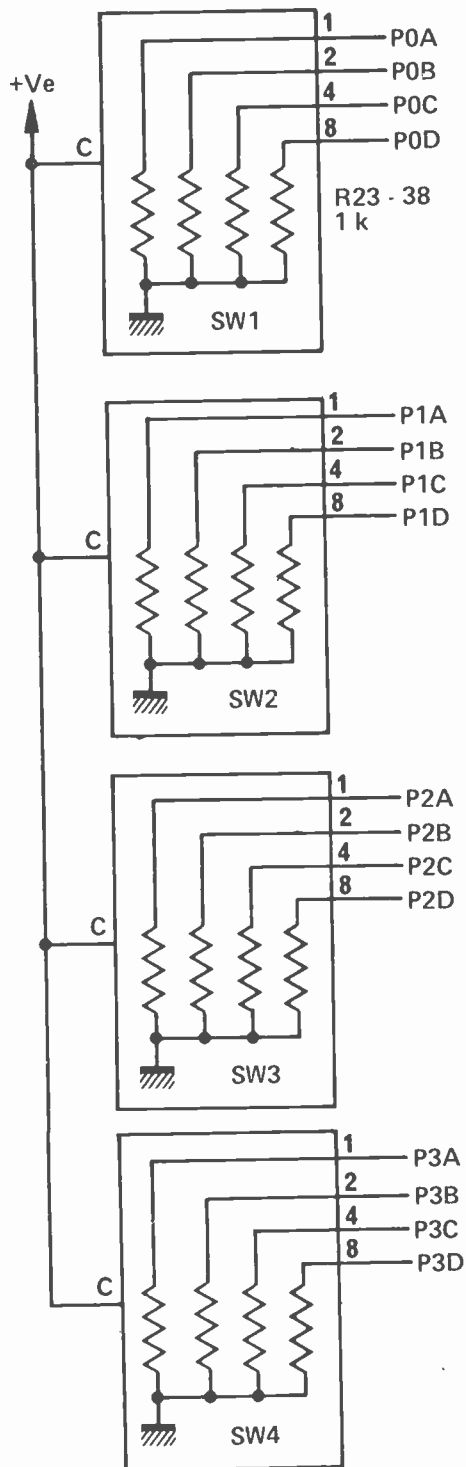
good exercise in logic design, and following through the circuit in conjunction with the 'How It Works' should pay dividends in return for time expended.

Once built of course it is a compulsive game to play (if there is no ETI next month you'll know why!) and should prove a nice alternative to "As The World Turns" now and then!

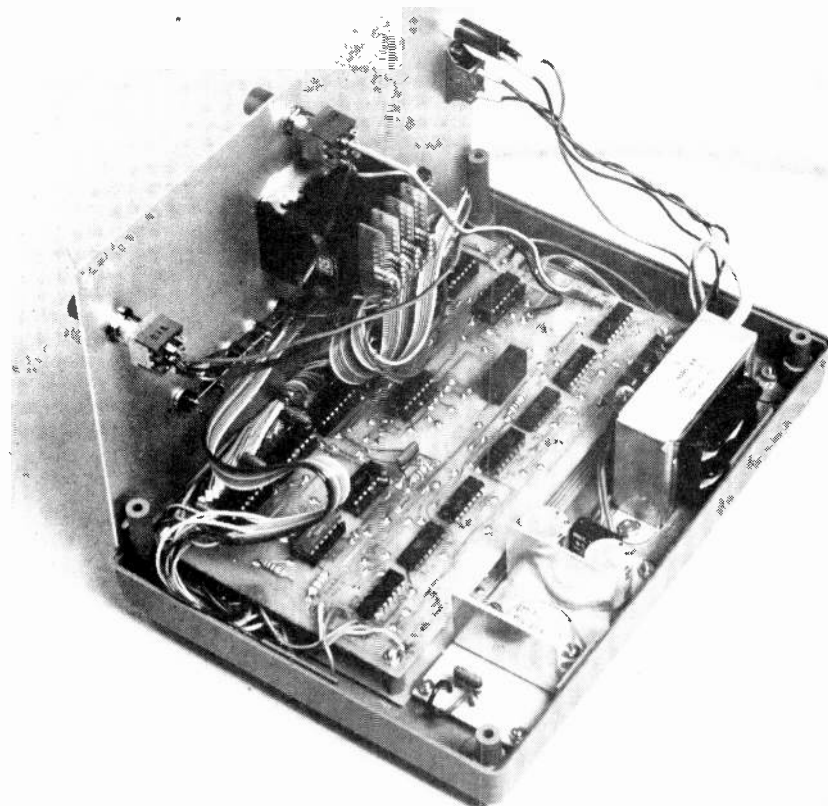
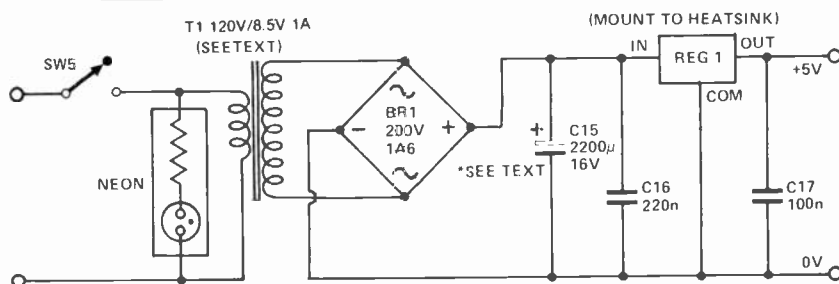
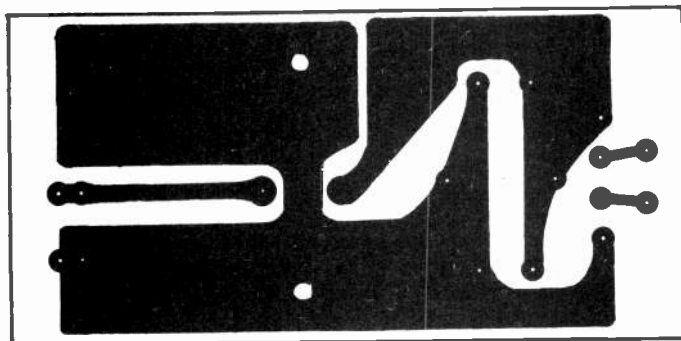
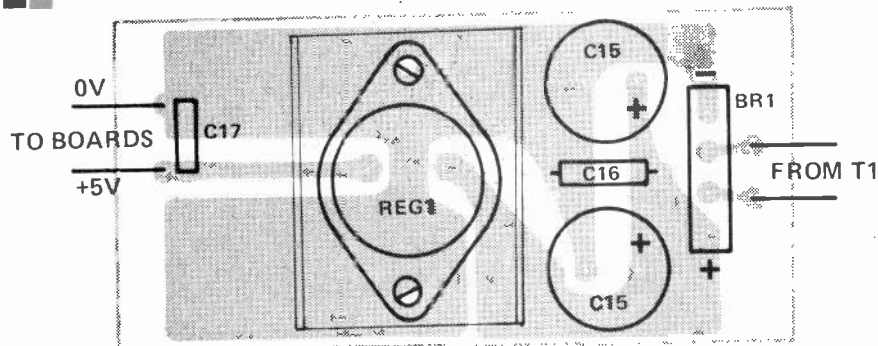


# ETI MASTERMIND

Power supply details. below the foil pattern for the PCB is the circuit diagram of the supply. Reg.1 will get very warm in operation, and if it is a problem, or you run the thing continually for hours and hours, some ventilation holes will be needed in the case—say beneath the heatsink and in the rear of the box will do. Heatsinking is necessary in this case, so PLEASE don't leave it off!



Wiring for the BCD switches. The lettering refers to the contacts on the switches. These are best wired before mounting the switches on the front panel.





**You buy'a  
dis magazin  
we give'a  
you dees  
books!**

**You no  
buy'a dis  
magazin,  
maybe  
you'a no  
see  
Electronics  
Tomorrow  
huh!**

**Take out a subscription now  
and we will send you either:**

- or Electronics It's Easy Volumes 1 and 2**
- or ETI Top Projects Nos. 3 and 4**
- or ETI Circuits No. 1**

**FREE!**

The offer is for a limited period only — after that the guy above comes calling with his friends! So tick which you require on the back of the card or coupon below and send off your

money to us. Subscriptions will start with the next available issue but please allow six weeks for postage and processing.

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 \_\_\_\_\_

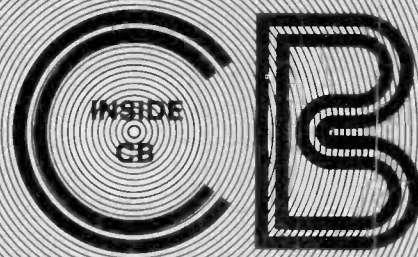
Cheque enclosed. DO NOT send cash.

Bill Mastercharge. A/C No. \_\_\_\_\_ Signature \_\_\_\_\_

Bill Chargex. A/C No. \_\_\_\_\_ Expiry Date \_\_\_\_\_

Electronics It's Easy 1 and 2  
 or Top Projects 3 and 4  
 or Circuits No. 1

# TECHNIQUES AND TECHNOLOGY



## SUPPLEMENT

### TRANSCEIVER DESIGN

**THE MODERN C.B. set** requires the circuitry to be housed in a small space, to be reliable and to have a high degree of stability. The latter requirement has always demanded the use of crystal controlled oscillators. Until a few years ago most C.B. sets were a.m. with single conversion receivers and thus required 23 crystals in the receiver section and a further 23 in the transmitter. This not only introduced the possibility of crystal breakdown but also increased the cost and size.

#### **CRYSTAL SYNTHESIS**

To reduce these problems manufacturers introduced the crystal synthesizer, this reduces the number of crystals to 14 by heterodyning. In this system there are basically two sets of four different "low frequency" crystals the outputs of which are mixed with six "high frequency" crystals to obtain the required frequencies for receive and transmit. Fig. 1, shows a block diagram of a single conversion system and Fig.2 that of a dual conversion system.

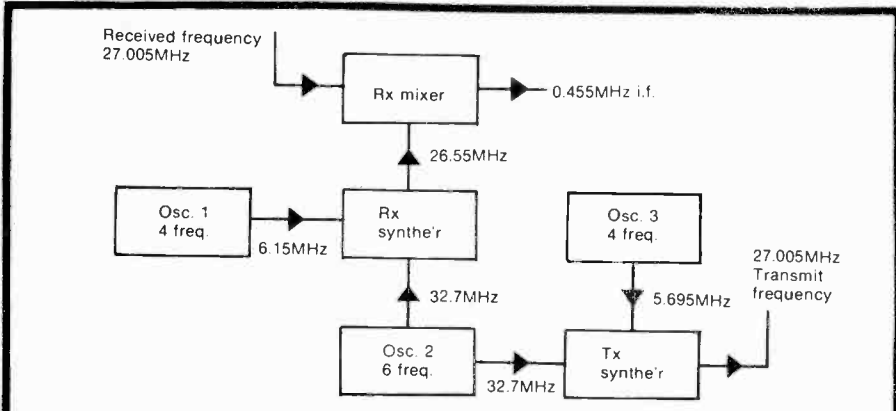


Fig. 1 Crystal synthesis on an a.m. single conversion transceiver.

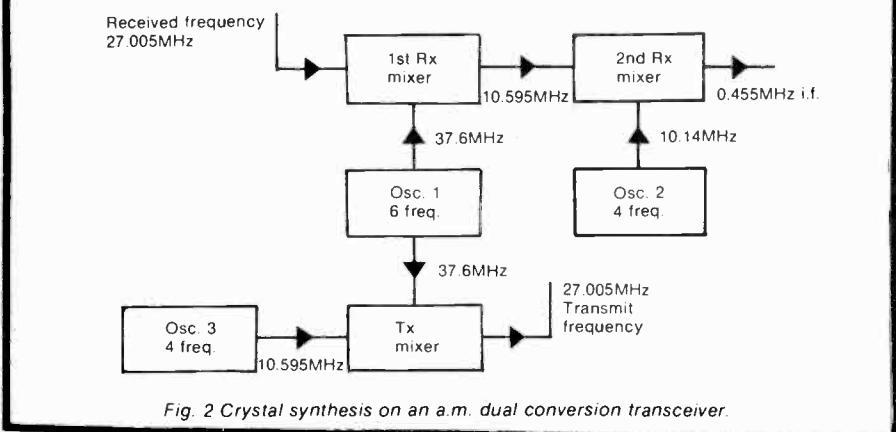


Fig. 2 Crystal synthesis on an a.m. dual conversion transceiver.

Frequencies shown are for a 27.005MHz transmit/receive frequency. The first i.f. of the dual conversion system is at approximately 10.6MHz.

Having covered the basic a.m. systems which are obviously extravagant on crystals we must now look at s.s.b. (single side band) equipment. The main advantage of s.s.b. is that it is much more efficient than a.m. because only part of the complete signal is transmitted. Instead of transmitting a signal consisting of two sidebands and the carrier wave, only one sideband is transmitted. The second sideband carries the same information as the first and thus one is redundant. However, a frequency equivalent to that of the carrier is required by the receiver before the signal can be detected.

The receiver is equipped with a beat frequency oscillator designed to produce the carrier frequency and this is then mixed with the incoming sideband signal usually after the first stage. The b.f.o. also provides one of the frequencies for transmit mixing.

It is also desirable for the s.s.b. set to be able to receive a.m. and for this dual conversion to the normal 0.455MHz i.f. is used. A basic diagram

of such a system using a similar synthesizer to that previously described is shown in Fig.3. Once again it is obvious that with the type of synthesizer described the sets are extravagant on crystals. For this reason, and because stability can be maintained, modern sets now employ digital synthesis.

### PLL SYNTHESIZER

Digital synthesis is achieved by using a phase locked loop (PLL)

synthesizer. The basic synthesizer employs a reference oscillator which feeds a phase comparator, also fed with an input from a divider (Fig.4). The phase comparator produces an output voltage that is proportional to the difference between its input frequencies. The output of the comparator is then smoothed to d.c. by a low pass filter. The resultant voltage is used to control a v.c.o. (voltage controlled oscillator), which provides the output frequency.

The v.c.o. output is also fed, via a Schmitt trigger which converts it to a square wave, to a digital divider which can be switched to change the division. As previously mentioned the divider output is one of the inputs to the comparator and the loop is thus completed.

### ACTUAL SYSTEM

Having examined the basic system it is perhaps a good idea to see how an actual unit functions and the frequencies involved, we will also go on to see how the remainder of the set differs from earlier models. We have used the Motorola 40 channel range as an example.

The Motorola synthesizer employs a voltage controlled oscillator, a reference frequency oscillator, an offset oscillator, a TTL programmable divider, and a CMOS divider, (Fig.5). The CMOS divider plays the minor role of reducing a 2.56MHz signal from the reference oscillator to a 10kHz reference frequency, so it will not enter the discussion again.

The v.c.o. frequency is fed back to a mixer transistor to be mixed with the offset oscillator frequency (29.030MHz in the receive mode, 29.485MHz in the transmit mode) to produce a difference frequency. The

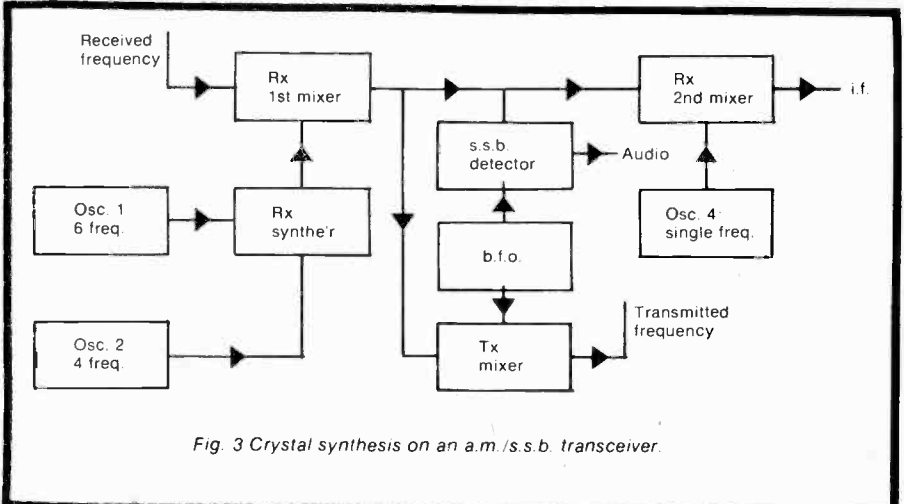


Fig. 3 Crystal synthesis on an a.m./s.s.b. transceiver.

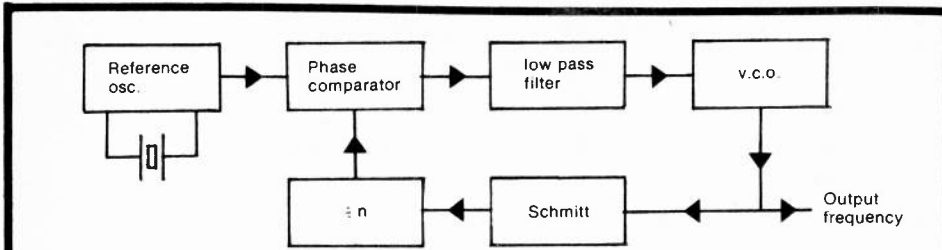


Fig. 4 Basic phase locked loop synthesiser arrangement.

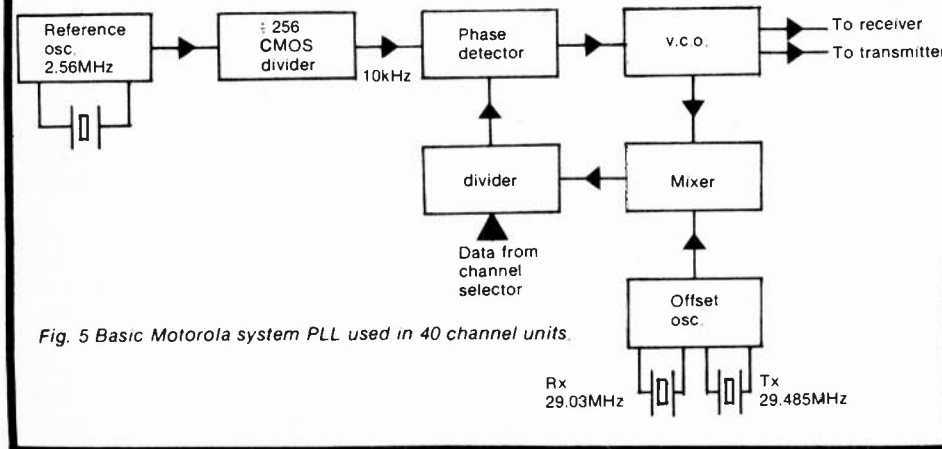


Fig. 5 Basic Motorola system PLL used in 40 channel units.

may occur otherwise. The synthesizer eliminates all but three crystals, drastically reducing the chances of crystal failure (one of the more common ailments of CB transceivers) and allowing a more compact circuit. The synthesizer allows much of its more important circuiting to be incorporated into integrated circuits.

The transmitter itself is a four stage a.c. coupled power amplifier transformer modulated at the last two stages. It incorporates a three stage harmonic rejection filter that holds those nasty TVI frequencies down more than 65dB. The output stage is self-protecting against high VSWR, due to an internal loading device that compensates for any loss of antenna match.

## RECEIVER

The receiver section of the set is loaded with the latest "goodies". Dual gated MOS front end and FET mixer for higher sensitivity. Ceramic i.f. filter for good selectivity and an i.f. section built totally of integrated circuits. Integrated circuit a.g.c. amplifier. The receiver incorporates a noise-blanking circuit called the "extender", after the fact that it effectively "extends" the range of reception.

The extender circuit operates on the principle that atmospheric noise occurs simultaneously across the frequency spectrum. Noise is sampled at the antenna by a separate r.f. amplifier tuned to 24MHz. The noise carrier is detected and the resulting noise pulses are sent to a pulse amplifier for shaping and amplification. From there they go to the actual blanking stage.

The blanking stage consists of two transformers coupled face-to-face after the mixing stage. A network of switching diodes is shunted across the junction of the two transformers. Normally, the transformers merely pass the signal from the mixer straight through to the i.f. stages. However, when a blanking pulse occurs the diodes are forward-biased and effectively short the mixer output for the time the noise pulse lasts, usually about 2µs. Thus noise pulses are "erased" with no discernible loss of reception quality.

An IC compressor circuit limits modulation to 100 per cent at microphone inputs up to 40dB over the microphone sensitivity. It also limits audio output at the speaker to 3W.

difference frequency, which will, of course, depend on the channel selected, is coupled to the programmable divider, which divides this frequency by an amount programmed into it by the channel selector to obtain the 10kHz reference.

The phase detector compares this signal to the reference frequency (10kHz), and if there is a difference, a correcting signal is sent to the v.c.o. to bring it to the correct frequency. That correction has been made, is registered back to the phase detector through the loop, and the PLL is said to be in the locked state.

## OPERATION

The best way to illustrate the operation of the synthesizer is to use an example: You're skulking around down at the bottom of the band, on, say, channel 10, when a breaker comes on and asks you to pick a channel further up. You decide to go all the way and soon find yourself transmitting up on channel 40.

On channel 10, your transmission frequency was 27.075MHz, which was being provided by the v.c.o. This was mixed with the offset oscillator frequency, which was 29.485MHz during transmission, to produce a difference frequency of 2.410MHz. With the channel selector set at 10, the TTL programmable divider is

dividing by 241, yielding 10kHz. As there is no difference between this and the reference frequency, the phase detector is emitting no error correction voltage.

Now you spin up to channel 40 (27.405MHz). The programmable divider is now dividing by 208. Thus 2.410MHz (the channel 10 frequency still being produced by the v.c.o) is scaled down to 11.59kHz. The phase detector detects this deviation from the 10kHz reference and sends out a positive correction voltage, causing it to oscillate at the higher frequency. The difference frequency now falls to 2.08MHz, the divider scales it down to 10kHz, and the PLL synthesizer has locked onto the new frequency.

The receiver injection frequency is provided by another crystal in the offset frequency oscillator which oscillates 455kHz (the receiver i.f. frequency) below the transmission offset frequency. This causes the v.c.o. to provide an injection signal 455kHz away from the frequency being received, thus setting the i.f. frequency.

## ADVANTAGES

This circuit has many advantages over the old one-crystal-per-channel and heterodyne synthesizers. The PLL synthesizer is a self-correcting device that cancels any "drift" that



The microphone design is unique in that Motorola have built preamp into the microphone casing without necessitating a battery. This eliminates the noise pick-up problems inherent in some preamp-less microphone designs, because of the high signal level output. The battery is eliminated by putting the amplifier transistor load inside the CB unit, thus allowing one line to be used for both powering the microphone and feeding audio to the set.

The power supply of the set splits the 13.8V supplied at the power jack into six different supplies for different

sections of the set. Two of them are transistor-regulated, one is diode-regulated. Another two are transistor switched for keying of the transmitter and receiving sections separately. The set is Zener protected against over-voltage and reverse polarity protected as well. All other switching at various parts of the circuit is accomplished by diode switching. This eliminates noisy and unreliable relay contacts and cuts current drain.

## DEVELOPMENTS

It can be seen from the general trends that as circuitry develops and

digital techniques are introduced CB units lend themselves more and more to large scale integration and we will soon be seeing the introduction of such systems.

At the present time Motorola and others are producing integrated circuits that contain the complete frequency synthesizer, less the crystal, and are compatible with digital display devices.

## ACKNOWLEDGEMENT

We would like to acknowledge the assistance of Gerry Blaney of Motorola in compiling this article.

# WATTS IN AN ANTENNA

## THE ELEMENTS

PERHAPS THE MOST widely misunderstood part of a CB station is the antenna system. Mystery and wonder surround this item, and consequently also the most dubious of advertising claims, not to mention what one hears from some instant experts on the subject. We hope in this article to clear up some of the confusion.

The first thing to remember is that an antenna is nothing more nor less than a device for converting energy from its electrical form at the transmitter, to electro-magnetic form propagated through "space". (This is analogous to the job a loudspeaker does in converting electrical energy to mechanical — sound — energy). We are going to discuss antennae chiefly from a transmitting point of view, but it all applies to receiving as well, though in reverse.

## MAKING WAVES

Let us consider the properties of interest in the two forms of energy we are looking at — namely frequency (f), wavelength ( $\lambda$ ) and velocity (v). An idea of "waves" may be imagined by the analogy of a stone dropped in a pond with waves of water travelling outward from it. The wavelength is that distance from peak to peak, or trough to trough. Frequency is the number of waves passing a certain fixed point per unit of time. Velocity is the rate at which a certain point (a peak say) on a particular wave moves. Finally, if we multiply the wavelength by the frequency (number of waves

per second) we arrive at the "length per second" which of course is the velocity. Thus  $v = \lambda \times f$ .

Relating this to the electrical energy in the transmission line from transmitter to antenna, if we could take voltage measurements along the line at one instant in time, and then plotted them, we would observe a sinusoidal waveform, just as would be revealed by a stop-action photo of the pond.

While voltage measurements along a wire are one dimensional, and in a unit (volts) which is familiar to most of us, the corresponding concept of the electro-magnetic field in space is more difficult. Here it is the electric or magnetic field intensity that is analogous to the waves in the pond radiating outward.

As for the three characteristics previously mentioned, the following apply. The frequencies of the CB channels are contained in a narrow band at about 27 MHz (27 million cycles per second). The wavelength cannot be calculated until the velocity is known. In free space, which is approximately the same as our atmosphere, the velocity of electro-magnetic radiation is 300 million meters per second, resulting in  $\lambda = 11.1\text{m}$  (437 inches). Velocity is lower in a co-axial cable, about 66% for solid dielectric and 78% in foam filled cable. This results in wavelengths 7.33 m (289 inches) and 8.67 m (341 inches) respectively. Finally, a generally accepted value for a typical antenna element is 95%, resulting in  $\lambda = 10.55\text{ m}$  (416 inches). These

percentages are commonly referred to as velocity factors.

The lengths calculated above are important in considering the elements and transmission lines for antennae.

## POLARIZATION

Radio waves are polarized, most usually horizontally or vertically. Without detailed reference to what the individual electric and magnetic fields are doing, suffice it to say that the characteristics of the signal are not the same in all directions perpendicular to its direction of travel. CB signals are generally transmitted and received with vertical antennae, be they whips or vertical dipoles and yagis, while TV reception is usually via a horizontal antenna.

## GAIN

In connection with the performance of antennae, a diagram of the radiation pattern is used, which represents the relative power at various locations. This is done by drawing contours of equal power, or field strength, in much the same way as a contour map shows elevations. Some times a three dimensional sketch is made, but more often a two dimensional sketch is drawn covering either the vertical or horizontal distributions (see Fig. 1).

Now we can discuss gain. The first point to realize is that an antenna has no power supply hence no more power can come out of it than goes in through the transmission line. Hence the term "gain" is to a certain extent a

misnomer. What we are really interested in is how the power is distributed, and that it is radiated usefully. Thus gain is actually the apparent increase in power at some location due to power being concentrated in that direction, and not in some other direction. This is similar to focusing the sun with a magnifying glass. No power is provided by the glass, what happens is that radiation (sunlight) originally falling on say a three inch circle, is concentrated into a small spot, while the rest of the area under the glass is in shadow.

Gain is usually expressed in terms of decibels (dB), a logarithmic scale which gives the ratio between two quantities, in this case the signal at a certain location from the antenna in question, compared to that from a reference antenna. A theoretical reference is the "isotropic" antenna which radiates equally in all directions, in other words a spherical

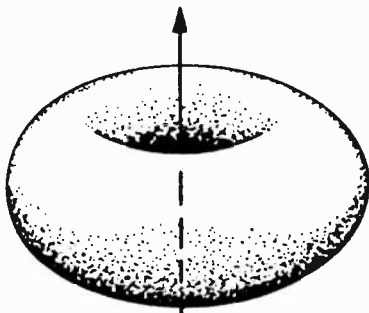


Fig. 1 (a). How an omnidirectional antenna radiates and receives signals. The doughnut shape represents the directions and signal strength in which the antenna best radiates or receives; strongest in all directions at right angles to the antenna, weakest from directions straight up or down.

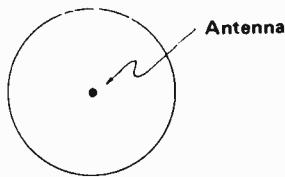


Fig. 1 (b). Looking down on top of the antenna, it is seen that it radiates equally in all directions in the plane of this page.

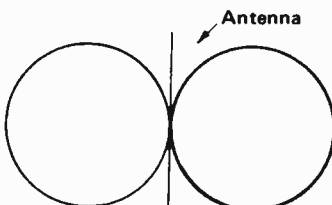


Fig. 1 (c). Looking at the antenna from the side, from any direction, the radiation is best straight out of the antenna, decreasing in directions up or down from this.

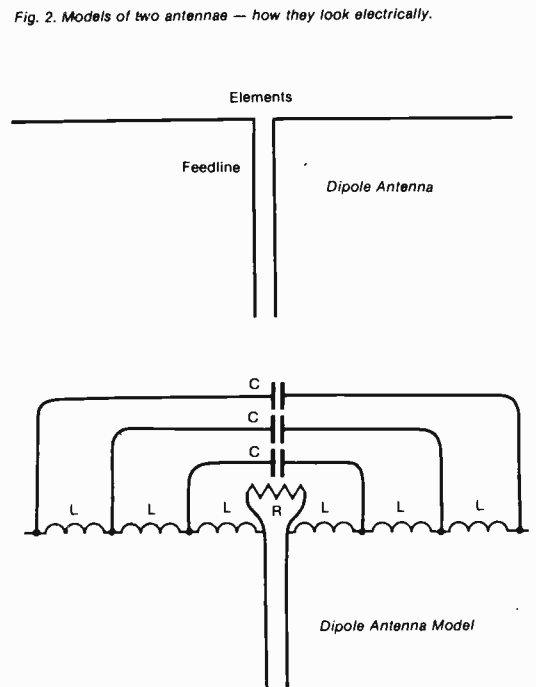
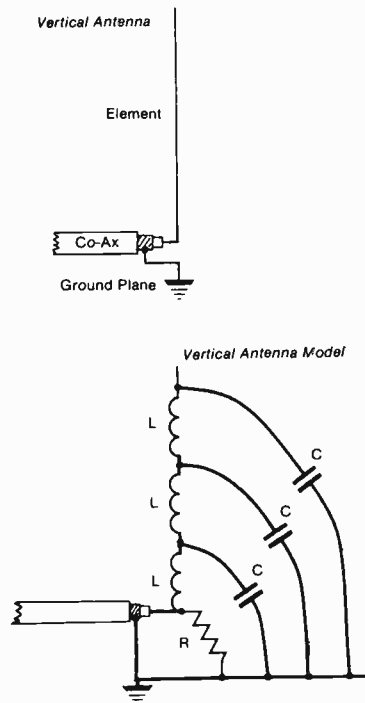


Fig. 2. Models of two antennae — how they look electrically.

radiation pattern. However, no such antenna can be built, so a practical reference is that of a simple dipole.

In the decibel scale, 3dB represents a doubling (or halving) of power, 6dB — four times and so on. Practically, 3dB is a barely audible increase in power.

## THE ANTENNA AS A LOAD

An important factor that we need to know about an antenna, is how it should be designed to best provide an efficient conversion of power from electrical to electro-magnetic form.

### RESISTANCE

The only way power can get out of an antenna is through heat or electro-magnetic radiation, hence anything which reduces the heat loss component is helpful. Heat can be dissipated from the electrical resistance of the antenna elements, with power  $P=I^2R$ . However, in the 27 MHz region we are looking at, this resistance is reasonably low. With higher frequencies and power ranges other factors come into play. It would be desirable to provide the antenna current with thicker elements or conductors to reduce the resistance,

yet this is partially negated by the tendency for high frequency currents to flow only in the outer part of a conductor. For this reason it makes little difference whether solid or tubular elements of the same diameter are used.

The next task is to make the antenna look as much like a resistive load as possible, at the operating frequency. Not resistance measurable with an ohmmeter (we just covered that) but simply that the characteristics are such that the current and voltage are in phase at the input terminals. This can be understood with reference to Fig. 2. The antenna looks like a complex assortment of capacitance, inductance and resistance distributed along the antenna elements.

If the antenna is too capacitive the current lags behind the voltage, if too inductive the reverse. The reason to avoid these situations is that we want to maximize power output, and since power is the product of current and voltage it can be maximized by having current and voltage occur together. In other words, current and voltage should be in phase, which is the same as calling the antenna resistive. Thus it is desired to have the capacitance and inductance balance each other, and be left with resistance only. This of course explains the



assorted antenna tuning devices intended to compensate for particular conditions by adding capacitance or inductance as needed.

But where does the resistance come from? This is just as fictional as the rest of the model. It is basically what the electrical to electromagnetic conversion process looks like after the inductive and capacitive components have been cancelled!

## BALANCED OR UNBALANCED

The aforementioned dipole is an example of a balanced load, which is to say that both input terminals are "live", but are fed with voltages of opposite polarity. It is physically and electrically symmetrical. This arrangement is similar to the two phase AC line supplied to most houses.

On the other hand the vertical antenna is an example of a single phase load.

It should be noted in connection with this topic that the outputs from most CB transceivers are single phase — suited to driving a vertical antenna. Co-ax cable is also suited to single sided transmission, in as much as the outer conductor is intended to be grounded. Even if co-ax were used for a two phase application, it is obvious that characteristics such as the inductance and capacitance of each conductor would not be matched or balanced. So — all you people driving a dipole type antenna from a co-ax directly — you are not getting the best from your rig. It does work, but there is a little gadget designed for the job, called a bal-un, basically an RF transformer which matches the unbalanced (single phase) line to the balanced load.

However, considering that most CB dipoles are mounted vertically they are not symmetrical with respect to the ground anyhow, but at least ensure that is the lower element that is connected to the shield.

## TRANSMISSION LINES

Having discussed the objective of trying to make the antenna look resistive, we must consider how the power gets to the antenna from the transmitter, and what happens in between.

The chief problem here is that of impedance mismatch causing reflections.

## IMPEDANCE EXPLAINED

Let's get impedance straightened out. To work backwards, most of us are familiar with the components resistors, capacitors, and inductors. Each has a specific characteristic of operation, namely the relationship between voltage applied and current flow through it. In the resistor this relationship is fairly simple — current proportional to voltage, as stated by Ohm's law  $I=V/R$ . This characteristic is known as "resistance".

In a capacitor the relationship is more complicated, current is proportional to the rate of change of voltage, while in an inductor the voltage is proportional to the rate of change of current. These two characteristics are described as "reactance", capacitive and inductive respectively. The family name for resistance, and reactance, or combinations thereof, is impedance.

All of the above are measured in ohms, although complex numbers must be used for reactive components. So basically, impedance is a name for a voltage — current relationship.

It should be noted that the impedance of co-ax or other transmission line is NOT say 50 ohms per foot, or meter or whatever, it is simply a characteristic of that cable (hopefully designed in!) that it works "best" with a voltage to current ratio as given by the impedance figure. What it means is that (at least theoretically) looking at a load, a

transmitter could not tell the difference between say a 50 ohm resistor, or any length of 50 ohm co-ax with a 50 ohm resistor attached to the end of it. (In practice there would be some loss in a length of co-ax, to be discussed.)

## REFLECTIONS

Power flowing one way in a transmission line will ultimately reach the interface at the antenna and if the impedance of the antenna does not match that of the line, part of that power will be reflected back toward the transmitter. This is similar to what happens with "silverized" sunglasses and one way mirrors. Here the signal is light. When the light meets the air to glass interface, there is a large mismatch between the two media. A large amount of light is reflected, while only a small amount is allowed to pass through.

Back to the CB situation, there is not usually a problem at the transmitter to co-ax junction as most sets are designed for 50 ohm cable. (Make sure it is 50 ohms though, there are many different types, cable TV typically uses 75 ohm for example.)

At the antenna, even supposing it is entirely resistive, it may not look like the desired resistance to match the line, so some reflection will occur back towards the transmitter, and consequently not out of the antenna.

Now the reflected power is in the same wire as the forward power, and

Fig. 3. Observing voltages in co-ax feedline — typical scope traces.

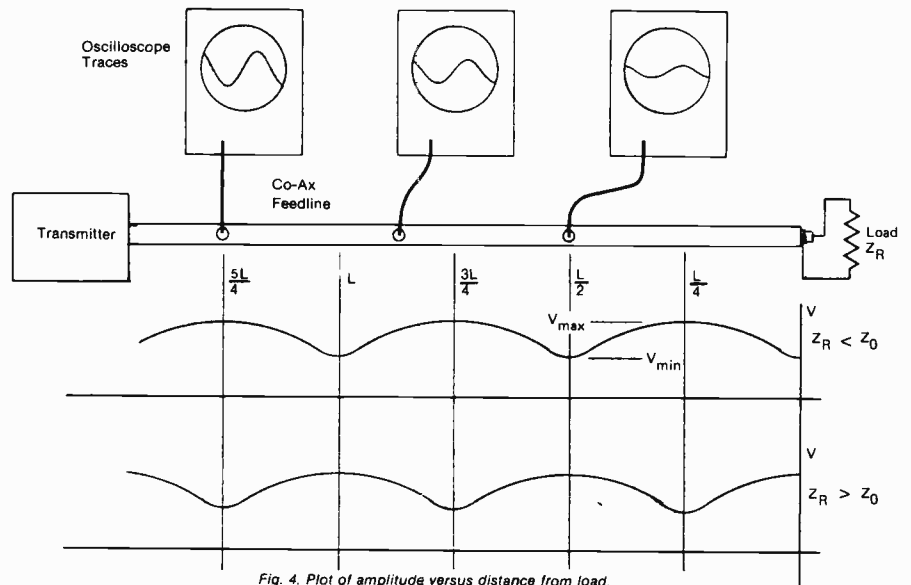


Fig. 4. Plot of amplitude versus distance from load.



at any point at any instant the two voltages or current add or subtract. Hold onto your seatbelts, here comes SWR!

### STANDING WAVE RATIO

Suppose you had a 27MHz response 'scope, and your transmission line had convenient access holes all the way along it so you could stick a probe onto the line at any point to observe the waveform. If the load at the antenna end was exactly 50 ohms, then only the forward signal would be observed, and at every point the same size of wave would be seen on the 'scope.

Now if a different load is attached we start to get reflected signal back along the line. The interaction between forward and reflected

signals will result in sine wave signals of different amplitudes at different positions on the line (Fig. 3). This is a result of the phase relationships between forward and reflected signals. If the amplitudes are now plotted versus distance along the line the graph of Fig. 4 results. This amplitude graph is stationary with respect to time, i.e. it doesn't change, hence the term "standing waves". Finally "standing wave ratio" is defined to be the ratio between maximum and minimum points on this graph. Note that with no reflection the graph would be flat, maximum and minimum would be equal, so the ratio would be 1:1 as expected. High SWR means high peaks (larger than the rig is capable of putting out itself) with the

possibility of damaging the output stage.

A further note of interest on SWR is that the SWR which should result from a mismatched resistive load is as follows:

$$SWR = Z_L / Z_0 \text{ or } Z_0 / Z_L$$

(put the larger quantity on the bottom)

where  $Z_L$  is the resistance of the load, and  $Z_0$  is the characteristic impedance of the line.

This brings up a method of calibrating an SWR meter. With a 50 ohm resistor (greater than 5 watts!) soldered on the end of the co-ax the meter should indicate 1:1. With a 100 ohm, 2:1 and so forth. Don't exceed 2:1 by too much or you may need a new transmitter.

# PRACTICAL ANTENNA SYSTEMS

**WE WILL CONSIDER** the most popular antennae — namely monopole or vertical antennae, and dipole based systems, along with other practical considerations.

## VERTICALS

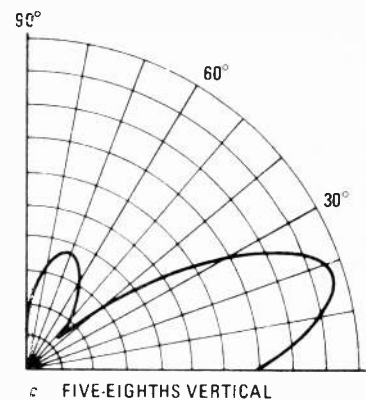
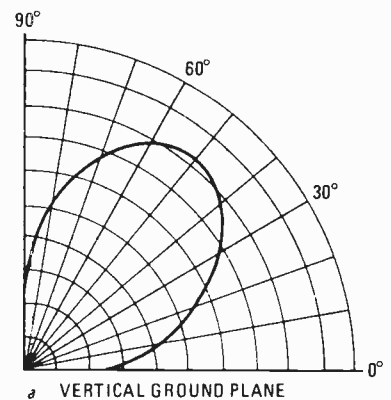
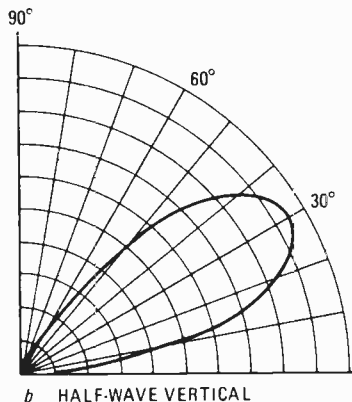
Here we find an assortment of antennae of various lengths and styles, all quite similar however in design. Referring back to the theoretical discussion, the idea is to make the antenna look resistive, and matched to the transmission line. In the case of a vertical, the two "elements" of interest are the vertical piece, and the other half of the circuit, the ground plane.

The most popular vertical antennae lengths are the quarter wave, chiefly for mobile applications, and half and  $\frac{5}{8}$  wavelength verticals which are for base stations, unless you drive a ship. The main advantage of the longer ones is that as the antenna is lengthened, but kept matched, the radiation pattern becomes lower to the ground where it is more useful. The increase in gain gives the half wave about 2 dB advantage over the quarter wave antenna.

The other half of the circuit — the ground of the system may be provided by actually sitting the

antenna on the ground — which is good if it is moist and conductive — not often the case. If not, a system of "radials", conductors spreading outward from under the base of the antenna, may be laid out on or in the ground surrounding the antenna, as an aid to conduction.

Unfortunately, the ground in most places is fairly low (slightly below foot level!) and the antenna at this



*Comparison of vertical plane radiation patterns of the three types of base station antenna. The 5/8-Wave antenna provides highest gain through its narrower pattern and lower radiation angle.*



height is surrounded by objects restricting its range. The solution to this is to mount the antenna on a rooftop or tower, in which case a substitute ground is needed. This is provided by a set of radials, similar to those mentioned before, usually a quarter wavelength. This length is used as it is resonant and looks like a low impedance at the connection point in the middle at the base of the antenna. For most uniform radiation pattern, an infinite number of radials should be used, however as this can be expensive 3 or 4 will often suffice.

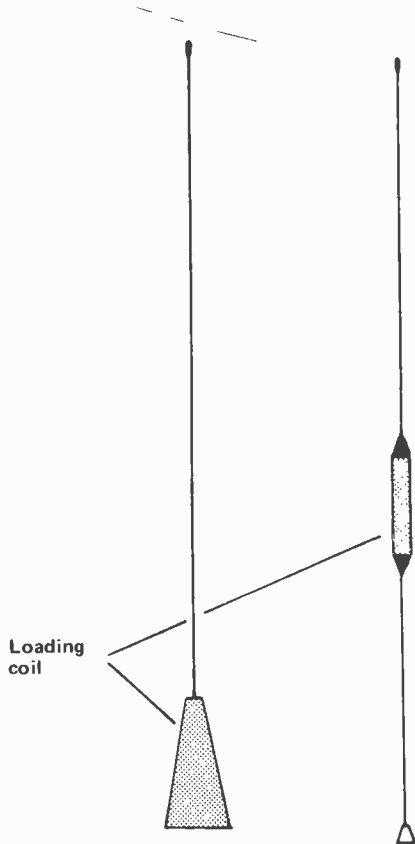
In the case of mobile applications where it's tough enough to fit in a quarter wave upwards, let alone outwards in both directions, the metal car body must serve as the ground plane. And remember this ground plane isn't even connected to the real ground as a base installation would be. Radiation from a vertical is in a circular pattern, but from a mobile antenna the pattern is uneven, as shown, best in the direction of best ground.

Assorted tuning and loading devices are seen in commercial

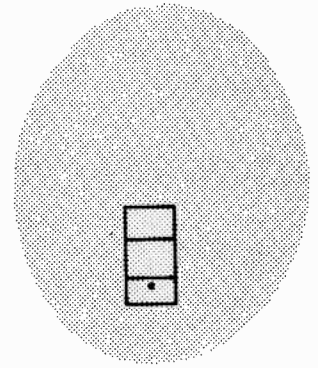
verticals to make the antenna as close to a 50 ohm load as feasible. For a base antenna, the designer's job is reasonably straight forward, since the expected antenna conditions cover only a small range of variations. However, the environment of the mobile antenna is quite widely variable. The mounting position can be one of several, effectiveness of the ground is different from car to car, and thus the antenna impedance may fall anywhere in a wide range. It will even change with the location of the car itself. Thus, a mobile antenna that works well is one that happens to match well the vehicle it is used with, and the available adjustment correctly made.

The most popular matching device is the loading coil, an extra inductance inserted in the antenna used to cancel an excess of capacitance. The coil is generally positioned at the base or in the centre of the antenna, leading to the terms "base" and "center" loaded. The center loading arrangement is electrically slightly superior, but mechanically requires more support.

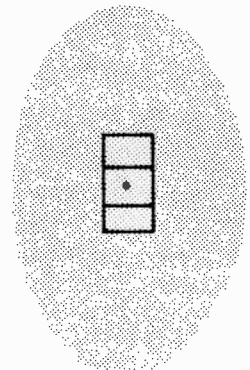
Finally, we find that two or more verticals are used together in a phased array to achieve various results. The principle is that signals from the two antennae will interact, cancelling in some directions, but reinforcing in others. This provides gain and more selective reception in these directions. Examples are shown in Fig. 5.



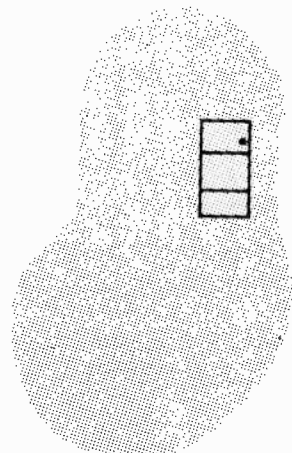
Typical examples of bottom loader, and center loaded whip antennae. The loading coil is placed in the antenna element to physically shorten the antenna while maintaining its electrical length.



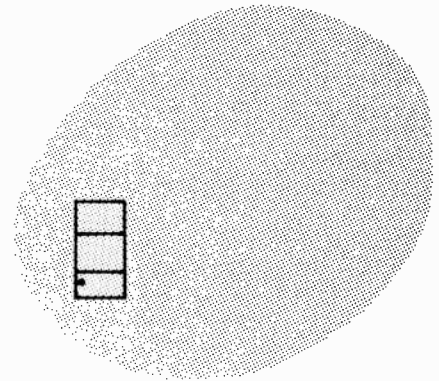
A trunk mounted antenna positioned on the centre-line of the vehicle produces a radiation pattern that favours the forward direction. Good signals are obtained off to both sides.



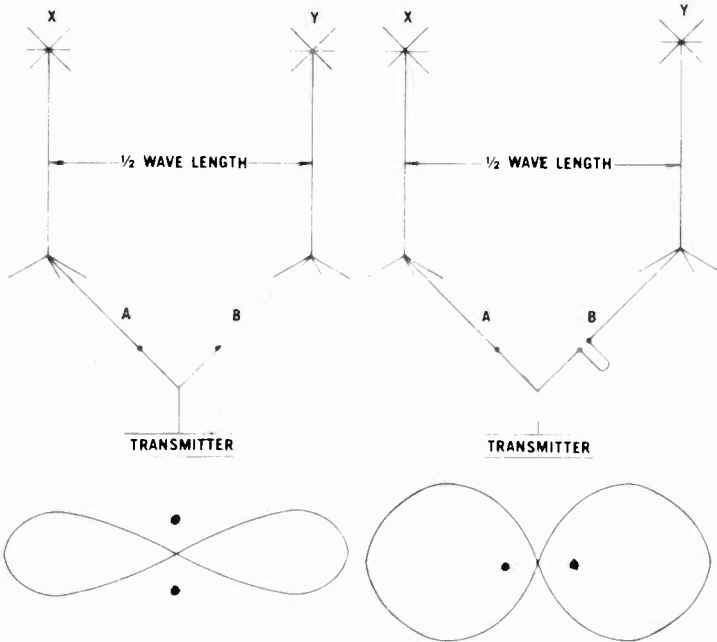
Mounting the antenna in the centre of your car roof produces about the best radiation pattern — but, overhead clearance is a problem. Good transmission front and rear is obtained with some reduction off to the sides.



An antenna mounted on the forward cowl puts most signal across your left shoulder but has advantages in convenience apart from allowing larger whips to be used.



A trunk mounted antenna positioned to one side angles the radiation pattern diagonally across the car in the forward direction.



When feedline "A" is the same length as feedline "B" the currents arrive at the base of each antenna at the same time, giving the "inphase" broadside pattern.

When feedline "A" is  $\frac{1}{2}$  wave length shorter than feedline "B" the current arrives at antenna "X"  $\frac{1}{2}$  wave length sooner ( $180^\circ$ ) than at antenna "Y" giving the "out of phase" end fire pattern.

## ELECTRICAL SPECIFICATIONS

	Broadside	End Fire	Two Phased Verticals
Pattern Width, half power points	60	80°	120°
Gain over single vertical.....	3.86 DB	2.3 DB	4.5 DB
Side Attenuation.....	30 DB	20 DB	20 DB.
Impedance.....	52 OHMS	52 OHMS	52 OHMS
Directional characteristics.....	Bi-directional	Bi-directional	uni-directional
Rear Attenuation.....			30 DB

Fig. 5. Typical "Co-phase" antenna combinations. BI-DIRECTIONAL ARRAY

The most effective spacing for a bi-directional array is  $\frac{1}{2}$  wave length. When two verticals are excited "in phase" the radiation is broadside to the plane of the verticals, offering substantial gain and bi-directional characteristics. Side nulls offer excellent signal cancellation to the undesired direction.

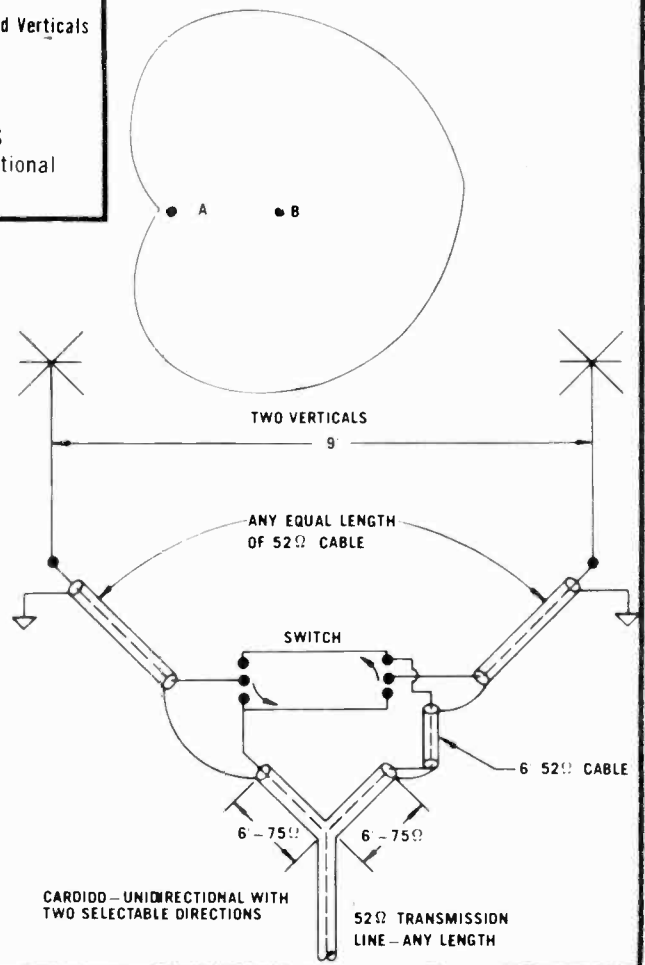
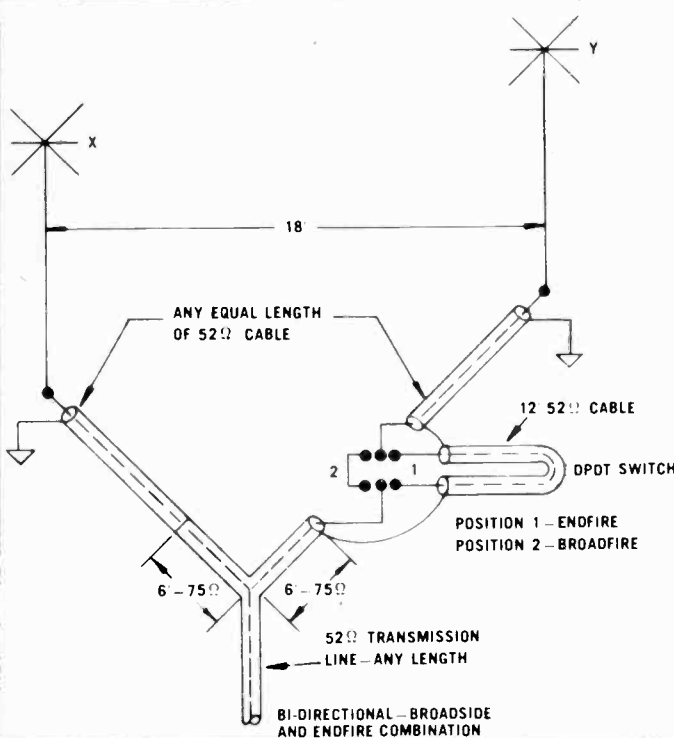
When excited "out of phase," these same verticals can be made to give an "end fire" or bi-directional pattern in the opposite direction through the plane of the verticals. This then nulls out signals in the opposite directions. More gain is exhibited by the "broadside" pattern over the "end fire" arrangement, but the "end fire" arrangement offers a wider frontal pattern.

Both arrangements offer an excellent advantage over a single vertical since either phasing combination exhibits noticeable signal gain with side attenuation of undesired signals. This added gain and low angle vertical directivity is the secret of success from the phased vertical array.

## CARDIOD ARRAY

When two or three identical verticals are excited directly and fed  $90^\circ$  out of phase with a spacing of  $\frac{1}{4}$  wave length, a cardioid pattern may be switched in either direction. By inserting a  $\frac{1}{4}$  wave length delay line the antenna will "fire" or be directive to that particular element.

The beam pattern for two  $\frac{1}{4}$  wave length verticals will be approximately  $120^\circ$ . An arrangement of three switchable verticals gives a  $60^\circ$  pattern in six selectable directions.



CARDIOD - UNIDIRECTIONAL WITH TWO SELECTABLE DIRECTIONS

# PUBLICATIONS FROM ETI



## CIRCUITS No. 1:

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. 4:

A collection of 28 constructional projects reprinted from ETI. This is the fourth in a series published by the British edition (Nos. 1, 2, and 3 are not available). Projects are complete and include: Sweet Sixteen Stereo Amp, Waa-Waa, Audio Level Meter, Expander/Compressor, Car Anti-Theft Alarm, Headlight Reminder, Dual-Tracking Power Supply, Audio Millivoltmeter, Thermocouple Meter, Intruder Alarm, Touch Switch, Push-Button Dimmer, Exposure Meter, Photo Timer, Electronic Dice, High Power Beacon, Temperature Controller, Electronic One-Armed Bandit plus many more.



**\$5.00 FOR CIRCUITS No. 1**

**\$2.50 FOR TOP PROJECTS No. 4**



## ELECTRONICS — IT'S EASY:

Volumes 1 and two of the best introductory series to electronics ever published in a magazine. Volume three, completing the series, will be available in a few months.

Electronics - It's Easy! takes a fresh look at electronics: it avoids the usual introductions to the subject which mostly seem designed to frighten you away before you reach page 10!

Volume one leads the raw beginner from a gentle introduction, explaining circuits in 'black-box' form up to the use of operational amplifiers.

Volume two deals with more advanced techniques, and deals with digital and logic circuits.

These books have sold extremely well in Australia and in Britain. In Holland they form the basis for a correspondence course.

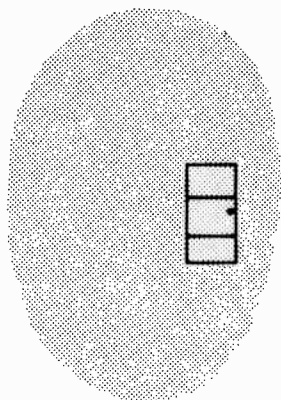
**\$6.00 FOR BOTH,  
\$3.50 INDIVIDUALLY**

THESE PUBLICATIONS ARE AT PRESENT ONLY AVAILABLE FROM ETI

Send your orders, 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.



Gutter mounting places the antenna high up but distorts the radiation pattern. Good transmission and reception front and rear is still obtained with good signals across opposite side of vehicle, somewhat reduced on same side as antenna.

It is worth discussing how to match the two antennae to the line. To do this we make use of the impedance transformation properties of certain lengths of co-ax cable. The quarter wavelength (about 6 feet of ordinary co-ax) is of particular interest. A resistor ( $R_L$ ) connected at one end of a quarter wavelength of co-ax, of characteristic impedance  $Z_0$ , will look like a resistance at the other end of

$$R_X = Z_0^2/R_L$$

(Note that this is only valid over a small frequency range where the length is close to the quarter wavelength).

If we happen to have 50 ohm antennae, and choose 75 ohm cable for the matching job, the "end" result will be 112 ohms. Connecting the two leads in parallel, and the result is 56 ohms, a close match.

If a phased array is used for a mobile station its directional characteristics should be taken into account. Don't turn any corners while on the air!

## DIPOLLES

The basic dipole is a two element antenna which works best with balanced operation independent of ground, as shown back in Fig. 2. However the antenna is frequently driven straight from co-ax without a balun, and is positioned vertically to match polarization with verticals. In the vertical position the radiation pattern is circular.

To add directivity and gain extra elements may be added — this combination referred to as a beam or Yagi. The extra elements are not connected electrically to the main or

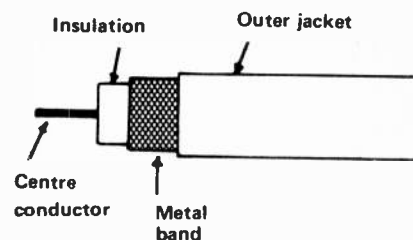
"driven" element. They operate by picking up the signal and reradiating it. By judicious adjustment of the length and spacing, the reradiation occurs in, or out of phase with the main signal.

The element behind the driven element is known as a "reflector", and is cut slightly longer. Reradiation from this one cancels out backward radiation, but reinforces forward radiation. Similarly the elements in front are called "directors", cut progressively shorter, and again reinforce forward radiation.

The more elements, the more directive the antenna — more gain and more selective reception in the direction the antenna is aimed.

## CO-AX CABLE

The main choice facing the CBER in the selection of co-ax is between the two common 50-53 ohm cables, RG8/U and the smaller RG58/U. Typical losses for the two cables are 1dB and 3dB per 100 feet respectively, so it is a good rule of thumb to use RG8/U for runs over 50 feet.



Coaxial cable. The most common feedline. The two common types are RG58 (6 mm dia) and RG8 (13 mm dia).

**TABLE 1**

It is almost impossible to have a perfectly matched antenna system and a standing wave ratio of 1:1 is virtually impossible. Anyone who claims an SWR of 1:1 for his antenna is either Superman or a liar. And we all know Superman only exists in comics! Here's what happens to your transmitter power for various standing wave ratios — plus comments.

SWR	PERCENTAGE POWER INTO ANTENNA	COMMENTS
1:1	100%	Perfection! But, remember above.
1.05:1	99.93%	Occasionally achieved. Don't bother to attempt any improvement.
1.1:1	99.78%	Some well-tuned mobile antennas and often base station antennas achieve this
1.2:1	99%	Lots of well-tuned and properly installed antennas make this. If you get it — be happy!
1.5:1	96%	This sort of SWR is pretty common — and really quite satisfactory. If you get it — great!
2:1	88%	Encountered more often than you think. No cause for alarm. Get it down a bit — for your transmitter's peace of mind.
2.5:1	82%	Losing 18% of your power is like spilt milk, not worth crying over. But, reduce it if possible for reasons given above.
3:1	75%	Your transmitter is likely to get a little unhappy at this.

A handy use of co-ax is the shorted quarter wave "stub" as a lightning protector. As mentioned previously, the quarter wave section acts as an impedance transformer. Plugging zero ohms (a short circuit) into the equation, we come up with the perhaps surprising result that this looks like an infinite impedance at the operating frequency. If one of these stubs is then attached at the antenna as shown in Fig. 6 it will act as a short circuit to ground at all frequencies except those close to 27MHz. Thus static build-up, or inadvertent electrical connection to the antenna will not be allowed to damage the rig. Do not however attempt to transmit with this set-up and the antenna removed.

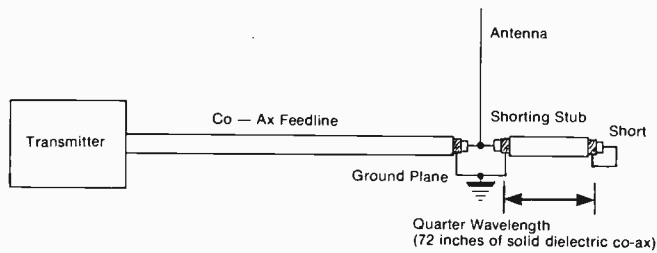


Fig. 6. Use of shorting stub for transmitter protection.

## CONCLUSIONS

That about covers the basics of the antenna field, it's more than just any old stick with a wire attached! But when you know how they work there is not alot to them, and they are in one of the few areas where CBers can brew up their own and do some experimentation. For more practical and theoretical information on antenna design and construction, the reader might be interested in the excellent publications of the ARRL, specifically the Radio Amateur's Handbook, and the ARRL Antenna Book.

## ACKNOWLEDGEMENT

We would like to acknowledge the assistance of John Magnusson of Hy-Gain in compiling this article.

# CB INSTALLATION

By Brian Hind, VE3DAH

A great deal has been published about making CB useful to the owner. Most articles extoll the virtues of specific products and fail to aid the reader in maximizing the performance of HIS equipment. The following is applicable to virtually all equipment.

Without question a well-planned, professional installation, whether mobile or fixed station, has the greatest influence upon performance. An adage says, "When all else fails — read the directions"! Failure to comply with the manufacturer's instructions for assembly of antennae, connectors, etc., has been the cause of much equipment owners' dissatisfaction.

When assembling station gear, make available a clear area. If possible, have someone else double check your measurements, soldering, etc. Make antennae measurements at least twice. Coating the hardware with silicone seal ensures that they can be disassembled when, and if, necessary. Fill the antenna socket with silicone lube, tighten the connector finger-tight, and then lock it with plumber's pliers. Wipe the connector with a dry rag to remove any lube or dirt and then wrap it with black plastic tape and coat the tape with silicone seal. If this seems like a lot of trouble, consider having to take the antenna down a second time to reinstall it!

Co-axial cable and connectors are among the most common and maligned materials in a CB station. RG8/U should be used for runs over 50'. The choice of a solid dielectric or foam cable is up to the user. If a 90° bend must be made in the cable it should conform to the rule of making

the radius of the bend no less than 10 cable diameters. When a PL259 connector is installed and the braid soldered as it should be, the dielectric tends to melt locally and enhances the possibility of a short. PL259 connectors are a technician's nightmare. Unless you are 100% sure you know how to properly install one, read and follow the instructions. Full directions may be found in the Radio Amateur's Handbook.

The location of the transceiver in a fixed installation is usually a matter of convenience. Try to make any bends in the feedline (co-axial cable) as gentle as possible. Cables should be routed to provide the shortest practical path. Entrance can be made to the house by drilling a window frame, etc., or by drilling a hole through the wall with a masonry drill. Wall tubes that fit the hole are available and provide both a cable conduit and a finished appearance to the entry.

Some differences of opinion exist concerning station grounds. If the ground lead can be connected to water pipes or a ground rod (actually at ground potential) through a conductor less than 9' long, then do it. Ground straps of 9' or greater length have considerable reactance at 27 MHz. and may actually radiate the signal they are designed to suppress! The mobile environment is radically different from its fixed counterpart and is subject to considerations of a varied nature. Safety is foremost, and the location of the CB unit will reflect this concern. Very few of the new cars have metal instrument boards and so, the so-called "hump mount" that attaches to the floor over the transmission hump is

gaining popularity. Regardless of position, the bracket must be solidly affixed to some metal surface. ¼ x 20 lag screws with hex heads for hump mounts and appropriately sized machine screws with nuts and lockwashers for underdash or roof-mounts will usually suffice. Many units require a tail bracket fashioned from flat steel strap to prevent motion in the fore and aft direction. Vibration is second only to heat in shortening the life of a radio; so, a sturdy mount is essential.

Mobile antennae are expected to work regardless of their placement on the vehicle. A hole drilled in the centre of the roof and the antenna mount and antenna installed thereon is a proven best performer. The popularity of the trunk-grip type mount indicates that the majority are unable or unwilling to drill a hole. With the increasing use of plastics and other synthetics in today's cars it is extremely common to find a trunk grip mount exhibiting a high VSWR (more than 2:1). This is caused by the trunk lid forming one plate, and the car body the other plate of a capacitor, the dielectric of which is the plastic, sound deadner, weather seal, paint, rust, or what-have-you on, and around the trunk lid and hinges. A pair of heavy bonding straps between the trunk lid and the sheet metal body — as short as possible — will usually correct this problem. In any case, this procedure should be carried out before mounting the antenna. Trunk mirror mounts are subject to the same problem and the cure here is to bond the doors to the cab and the mirror frames to the door. A DC ohmmeter check is practically useless in these cases.

# electronics today

international

WHAT TO LOOK FOR IN THE AUGUST ISSUE:

## SKEET

SHOOT IT OUT WITH OUR ELECTRONIC GAME!

If you don't own a gun and don't want to — even if you do and do, this is the game for you. In fact it's just right for everyone from 5 to 105. Slip it in your pocket and amuse yourself wherever you are. We show you how to build it next month.

## SOLDERING

You all use it and you're all good at it — but are you really? Many people treat soldering simply as a means of sticking bits together and then wonder why their unit won't work, packs up quickly or falls apart. Next month we look at the tools for the job and, hopefully, show you how you should be doing it. Of course you are doing it properly anyway, so you won't read it will you — or should you?

## BASS ENHANCER

If you own a pair of bookshelf speakers or need to get some but are put off by the lack of the very low frequencies, we can help. Our Bass Enhancer has been designed specially to uplift the low frequencies that tend to drop off in the smaller speaker designs. If you are interested in this project you might as well start building the Overled in this issue, as it forms part of the complete design.

## THE TUBE SOUND

Not one but two articles on "The Tube Sound" or why hi-fi buffs and/or musicians prefer the "old sound". A technical article that looks at the measured differences, shows graphs and figures and draws various conclusions. And a "seat of the pants" approach from two professional sound engineers. Their theories and conclusions will not draw agreement from everyone, but they are based on their experiences.

*Draw your own conclusions the debate will continue for a while yet.*

## DIGITAL FREQUENCY METER

As an adjunct to our D.V.M. published in this issue we present a matching D.F.M. Make sure your workshop/bench is really well equipped with this test gear dynamic duo.

The D.F.M. has five ranges and will read from about 1Hz up to 9.9 MHz. However, with our p.c. board design, construction is simplified.

The articles described here are in an advanced state of preparation, but circumstances may necessitate changes in the issue that appears.







mechanical sensing up to 600 characters per second or more with high-performance optical equipment.

A considerable amount of electronic logic and drive circuitry is needed to operate a punch unit. Figure 3 is the block diagram of a reader using brushes to sense the presence of holes. Input commands to the punch would emanate from the control unit of the EDP system.

### MAGNETIC TAPE INPUT/OUTPUT UNITS

Cards and paper tape store information about commands to the EDP system (the programme) and hold the numerical data to be manipulated. They are, therefore, a form of permanent data storage. They suffice (in the form described above) as a data store when the data quantity is not great. A recent trend, which has speeded up data transfer and reduced the bulk needed to store the programme and data, makes use of magnetic tape in cassette form. The compact unit shown in Fig.4 can transfer data at 6000 bits per second at a density of 30 bits per millimetre of tape. (Total capacity on a cassette — five million bits). These can also be used as additional memory in the system.

### PRINTERS

Teletype units are able to provide hard copy printout but due to the slow printout resulting from letter by letter operation they are not used as the main alpha-numeric output of an extensive EDP system. They can print-out at only 10 characters per second or so.

The line printer was evolved to speed up this form of output. It prints all the characters of a complete line simultaneously. Line lengths are typically 132 characters and the faster models can print lines at rates exceeding 1000 lines per minute. (For which an outlay of \$50,000 is required!)

Printing mechanism vary considerably, ranging from development of the fundamental typewriter method, to

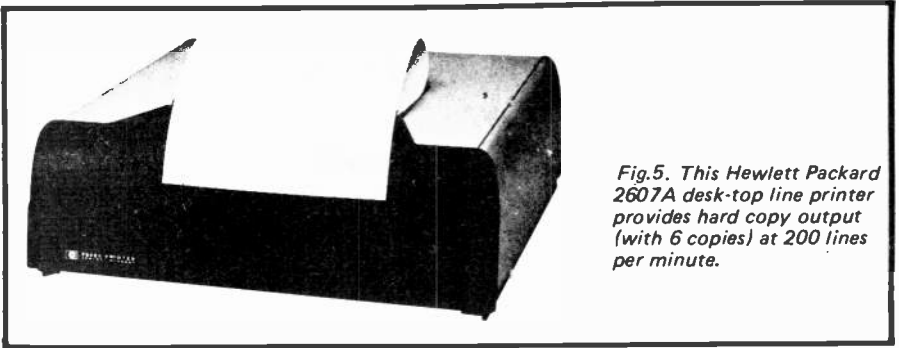


Fig.5. This Hewlett Packard 2607A desk-top line printer provides hard copy output (with 6 copies) at 200 lines per minute.

devices that print each character from a 5 x 7 matrix of dots. Line printers were originally bulky units. Today desktop, typewriter size units, are in common use (Fig.5)

Printers can be programmed via the EDP system to provide any format required — periodic reports, invoices, records, data lists, software record. A crude form of graphical display can also be produced using the position in a line as one ordinate and the lines as the other.

When computers are used for automatic pagination the printer can be one that produces print-type direct.

### GRAPHIC DISPLAY — PLOTTERS

Many computational tasks ideally require a graphical display of output information, not a long list of numbers. Plotters may be of x-y type or y-t type.

The x-y type of plotter is arranged so that the graph paper is held stationary and the pen is capable of being driven both vertically (y axis) and horizontally (x axis).

The y-t plotter has a roll of graph paper which is driven at a constant (and usually adjustable) speed; the pen can be driven in one axis only (y axis). Hence the y-t plotter basically plots a single variable against time. Plotters

made specifically for computer operation will be provided with the interface facility that enables direct connection to the EDP system. (Normal plotters require an extensive amount of extra equipment to make them compatible).

Computer controlled plotting of x-y format has the ability to be scaled on demand and to generate alpha-numeric legends on the plot. It is an easy matter to replicate the plot — the programme is run again.

Plotters may be of the analogue drive kind (a later part discusses plotters in detail) but due to the nature of digital processing the result may still have a quantized appearance if the resolution is not sufficiently small. Alternatively the axes may be driven with stepping motors — such machines are called incremental plotters.

Flat-bed style of x-y plotters are available which can handle paper of all sizes — from a few centimetres square to size of a wall. A medium-size computer controlled flat-bed plotter is shown in Fig.6

Line drawing rates are limited by inherent electro-mechanical response to around 0.4 m/s in small plotters. The very large machines, when under tight control, are usually capable of around 0.1 m/s translation rates when working

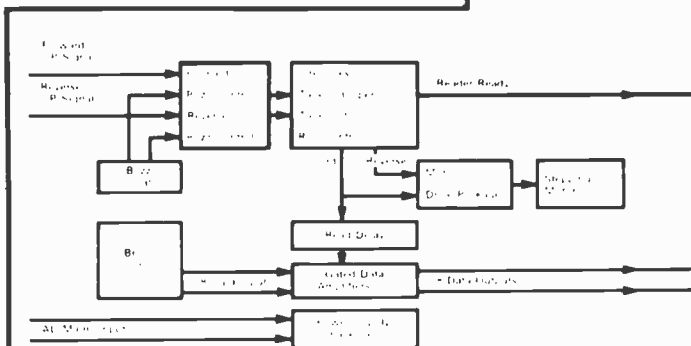
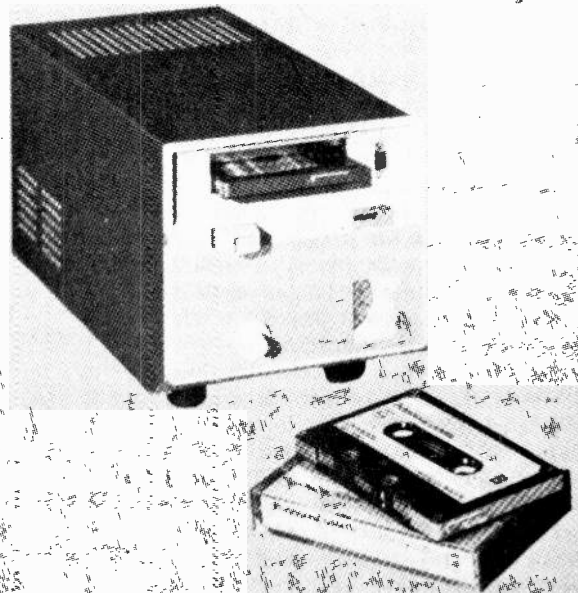


Fig.3 Block diagram of early model Data Dynamics low-speed tape reader (30 c.p.s.).

Fig.4 Cassette form of magnetic tape is finding greater application as a standard EDP and computing calculator peripheral.



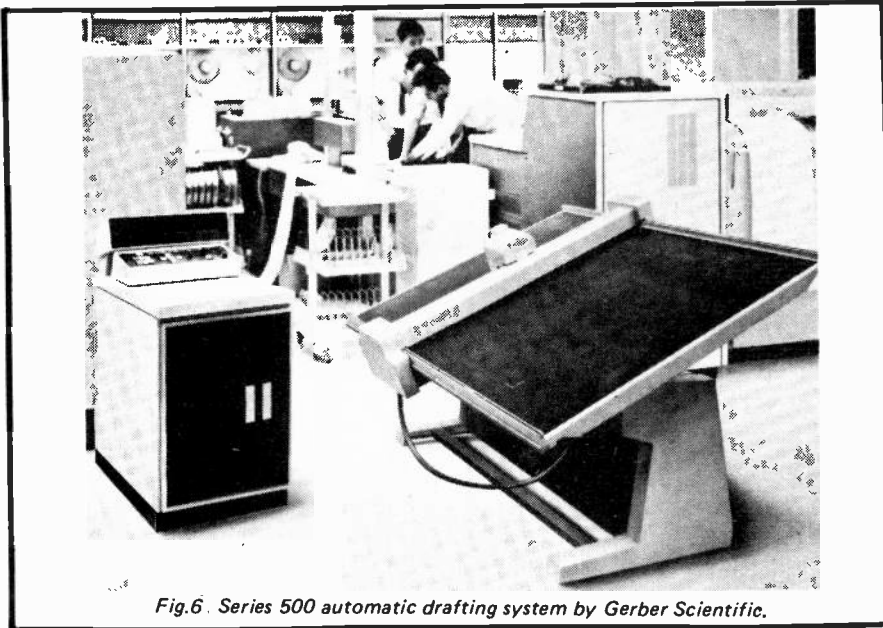


Fig.6 Series 500 automatic drafting system by Gerber Scientific.

to precisions of 25  $\mu$ m.

Some y-t plotters incorporate bi-directional drive for the t axis (the paper drive) enabling very long lengths of paper to be driven back and forth along the roll in order to produce an x-y form of plot from a y-t format machine.

## GRAPHIC DISPLAY – VISUAL MONITORS

Many applications require rapid call-up of data that is presented in a way that can be easily read by the operator. It may be quite unimportant to receive it as hardcopy. The cathode ray tube (television) type of display was an obvious choice. Such displays are known as visual display units, VDU for short.

Originally, visual display units were very limited because of the need for a considerable amount of storage with which to generate written and graphical display forms. However solid-state mass data storage is now relatively inexpensive and VDUs in one form or another are now standard peripherals.

The simplest use of VDUs is to display alpha-numeric information – a section of the software programme, a readout of process plant variables, airline arrivals and departures. This is achieved using digital control and data storage to cause the beam of the CRT to deflect, blanking appropriately, to form the appearance of a static written page.

When the operator becomes involved with the data on the screen and is given the ability to manipulate it toward a desired task the terminal is said to be an interactive graphic terminal. An early example of this is given in Fig.7 which depicts a system whereby air traffic controllers are trained using display terminals.

Once it had been realised how the

VDU could be used to produce line drawings designers sought ways to 'draw' on the screen. The result was the 'light-pen'. The operator holds a special stylus on the screen of the CRT. Closed loop controls cause the spot to lock onto movements of the stylus. If the trace path is to be retained, the x, y and intensity coordinates values are fed into the digital memory. Once a line is drawn it can be retained and regenerated in this way. Other operations enable the operator to automatically erase sections of line, straighten lines and smooth curves by computer processing. The complete drawing can then be permanently recorded as hard copy on a plotter or as a data set. Interactive methods have saved an enormous amount of time in tasks such as deciding the extremes of an automobile wheel movement during the many combinations of springing and steering

positions within the wheel arch.

Today's graphic terminals are extremely versatile. Completely self-contained units which incorporate a built-in processor are in common use. A recent release is shown in Fig.8

Improvements in the storage-tubes used to hold the displays of a CRT system have been coupled with the power of modern computing to provide display terminals that have half-tone photographic quality presentation. Figure 9 shows the quality (after our recopying) obtainable. The images shown are entirely reconstructed on the VDU from digital, not analogue data. Colour displays are also coming into use adding yet more dimensions to the interaction available to the operator.

A recent project of the Australian National University gives some idea of the use of the interactive VDU. In the Department of Engineering Physics a team of research workers have developed a colour display terminal that can call-up the data recorded by the ERTS satellite. The computing system has in its memory file copies of the original ERTS data. Using the graphic terminal the operator can select which form of photograph – IR, false colour, etc., to study. He can then rapidly zoom into a particular area using a joystick control expanding the spatial scale as the search becomes concentrated. Other control includes enabling the colours to be digitized into level zones and to be complimented.

## INSTRUMENTATION INTERFACES

When the digital computer has to manipulate measurement and control data from analogue processes, the system must be provided with the appropriate A to D and D to A converters, and the multiplexing arrangement which forms the data logger.

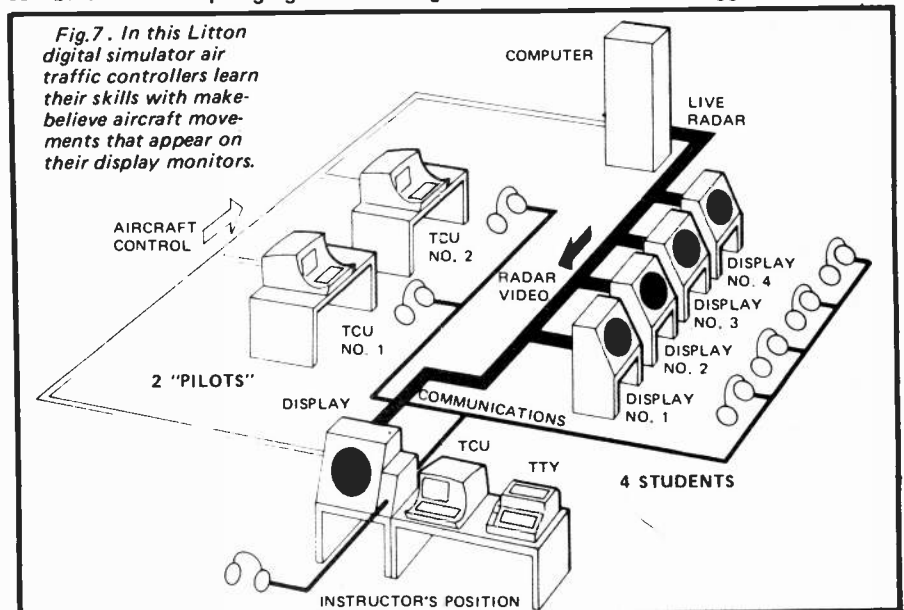


Fig.7. In this Litton digital simulator air traffic controllers learn their skills with make-believe aircraft movements that appear on their display monitors.

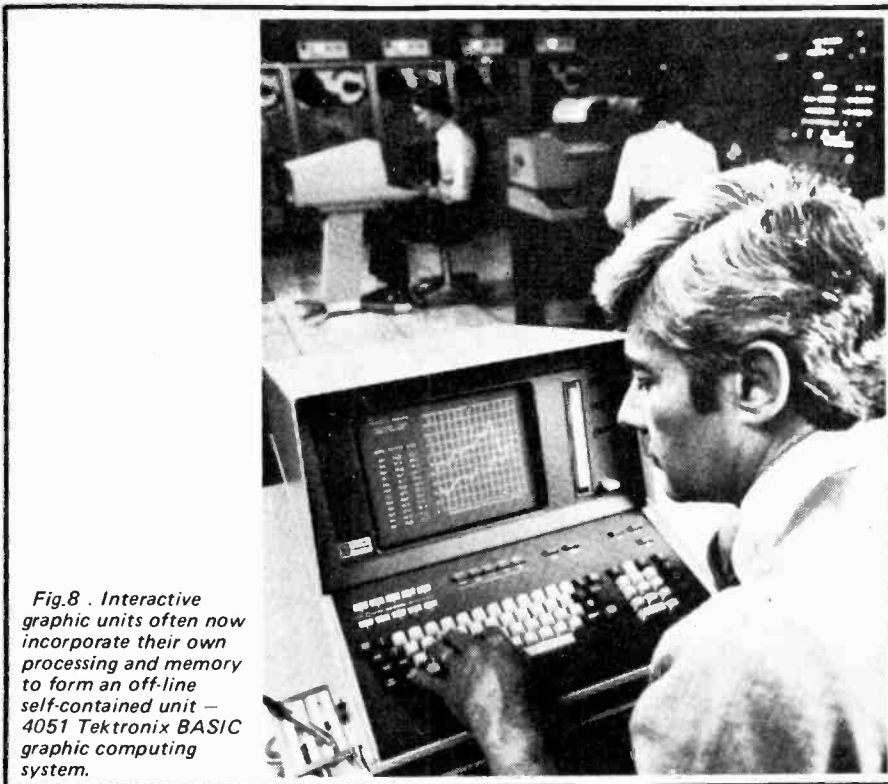


Fig.8 . Interactive graphic units often now incorporate their own processing and memory to form an off-line self-contained unit — 4051 Tektronix BASIC graphic computing system.

### MODEMS AND OTHER LINKS

When computer data has to be transmitted over considerable distances it becomes expedient to use telephone lines or microwave links. Units interfacing computers over telephone lines have become known as MODEMS (a word built by combining Modulator and Demodulator).

### MISCELLANEOUS PERIPHERALS

New methods for communicating with the power of an EDP system continue to be devised in an endeavour to overcome the interface difficulty humans have with electronic machines. We are still a long way from the stage where we need only casually to talk to the machine. Steps are, however, in progress

toward this aim with research into spoken word and written word recognition. Neural research into brain waves may one day be coupled with electronic hardware to provide direct thought links.

Work at Warwick University has resulted in computer - controlled production of braille maps for the blind. Automatic mapping and language translation are other areas where positive progress is being made into very complex human communication processes.

### STORAGE

Inside a CPU and external to it will be found a memory of some kind. This is used to store the vast quantities of coded data needed to perform the various tasks.

Memory within the CPU is characterised by the need for high speed access to any data bit needed. The requirement on capacity is less stringent. Memory external to the CPU will, by the necessity of machine organisation, be a little slower to access but it will usually need much greater storage capacity.

### CPU MEMORY

Core - storage is needed in the CPU to hold important programme instructions and to act as a temporary home for data generated in the course of a manipulation.

There are many options open to the designer but the storage method that has emerged as the optimum for CPU storage is magnetic core storage — known simply as the core store. (This situation will, however, soon change, the preference going to solid-state methods). Magnetic core storage makes use of the fact that magnetically hard materials, such as ferrite, will swing remanent magnetism polarity from one state to the other with the passage of a quite widely tolerated current through a wire passed through the core — see Fig.10a To make a practical core store it is necessary that any chosen core can be switched on demand. If a second wire is passed through the loop this can be used to prevent or enhance the magnetic switching action by the passage of the current.

A core store comprises a plane of ferrites arranged in a grid as shown in Fig. 10b Two half-current units appearing in the same direction in a core will switch that core but no other. Thus two lines will select a unique core in the plane as the place to store or readout one bit.

To read out the values it is necessary to interrogate the selected core using input signals in the write wires that will, if switching takes place, induce currents in an additional readout wire. As this process can destroy the data on the core

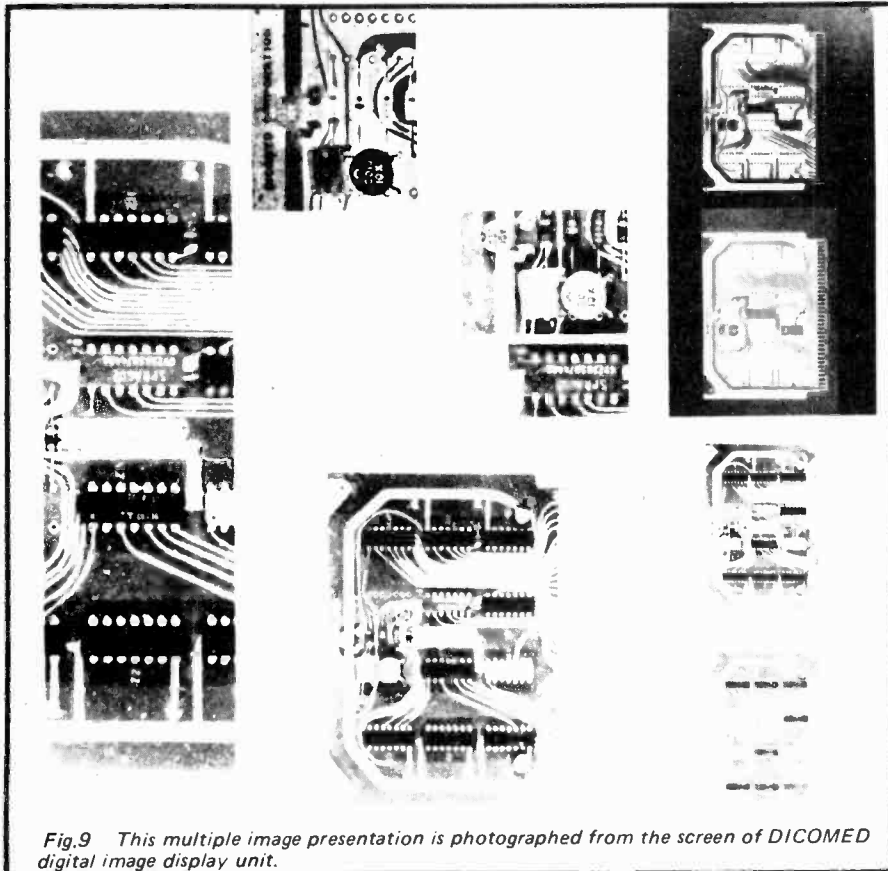


Fig.9 This multiple image presentation is photographed from the screen of DICOMED digital image display unit.

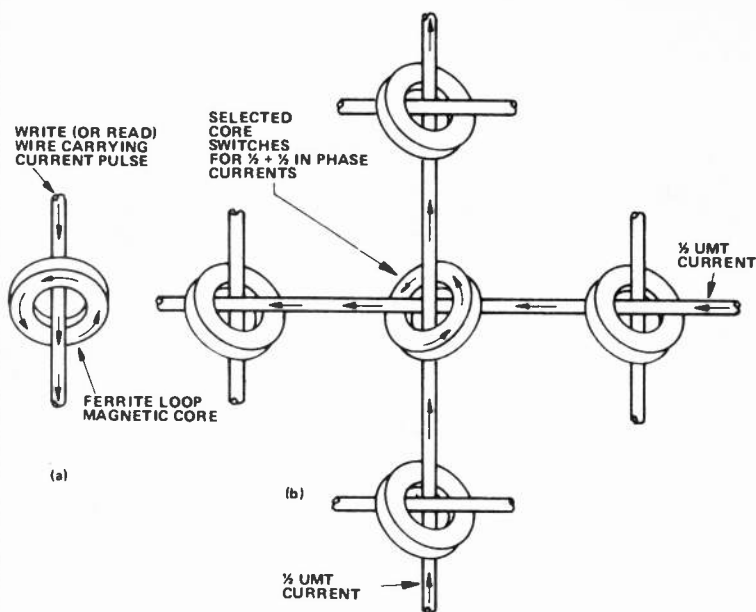


Fig. 10. (a) When a large enough write current passes in one direction through the ferrite core the core becomes magnetised in one polarity. It thus records a bit.  
 Fig. 10 (b) A second wire is added to act as an inhibitor or enhance line.  
 Fig. 10 (c) Finishing touches being added to a Philips 3-D core store. (20 planes of 64 x 64 cores, one X wire, one Y wire, read and inhibit wires).

a test means may be provided to rewrite it again ready for reuse. Figure 10c shows a stacked core-plane. Ferrite cores are typically 0.1 mm overall. Planes are either stacked one on the other or mounted flat on a printed circuit board to provide a memory unit. The capacity of core storage varies from thousands to millions of bits. Core-store is more usually quoted in word capacity, words being of 32-60 bit length. The terminology is to refer to capacity as, for example, 32 K of 16 bit words.

Core storage can be cycled in 100 ns (typically) with some systems taking only 10 ns. The disadvantages of core are the relatively high cost resulting from the labour intensive production method and the comparatively large space needed.

### DELAY LINES

Another reasonably fast storage system makes use of the delay-line concept. It is the property of materials, such as mercury, to pass only waves of acoustic energy at a given rate of propagation. Early computers used mercury delay lines in which the acoustic equivalent of a binary word was sent down a tube of mercury to emerge at a later time at the other end. Whilst in transit the word was in storage. The method (if used at all in a computer today) would now be implemented using solid wires or clocked-on registers. It has the severe shortcomings of low storage capacity.

### SOLID-STATE

Although core storage still forms part of many computer installations the current

trend is clearly toward the use of a solid state circuitry which stores bits in register style flip-flop systems. Read only memories (ROM), content addressable memories (CAM), random access memories (RAM), and Programmable ROM devices (PROM) are available as IC chips with typical arrays downward from 512 eight bit words – that is 4096 bits on a

single IC chip. Figure 11 shows just one of a huge range of alternatives – 1024-bit read-only memory. Memories such as this exhibit a typical delay from address to output of 36 ns. Chips such as these are also available ready mounted as memory cards with as much as 65 536, 16-bit word capacity. ●

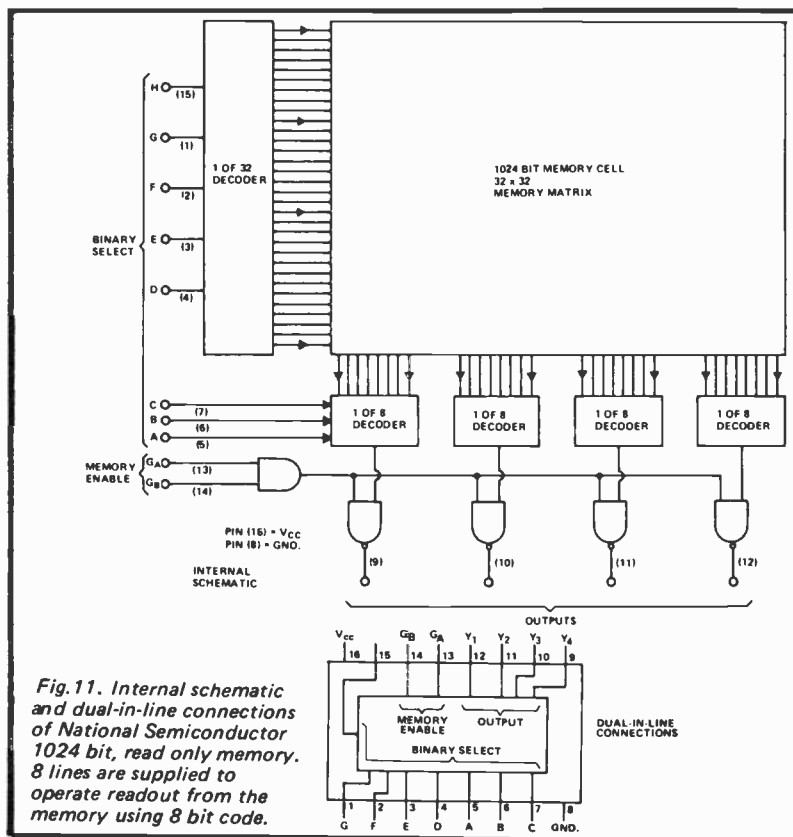


Fig. 11. Internal schematic and dual-in-line connections of National Semiconductor 1024 bit, read only memory. 8 lines are supplied to operate readout from the memory using 8 bit code.

# DIGITAL VOLT/METER

EVERY NOW AND THEN AN IC drops into the public eye, which, on removal, proves to be a new-quick-answer to an old problem. Such a useful mote is the ZNA 116E from Ferranti. This is a DVM chip, which simplifies the construction of a 3½ digit instrument to a nicely ridiculous extent.

Armed with this device we set about the production of this project. In its present form it is an extremely accurate (< 0.1% error) with a 5V stabilised supply. It is possible that we shall, in the future, extend the instrument to have multimeter capability, and with this in mind we leave space within our recommended case to accommodate this modification.

## CONSTRUCTION COMMENCED

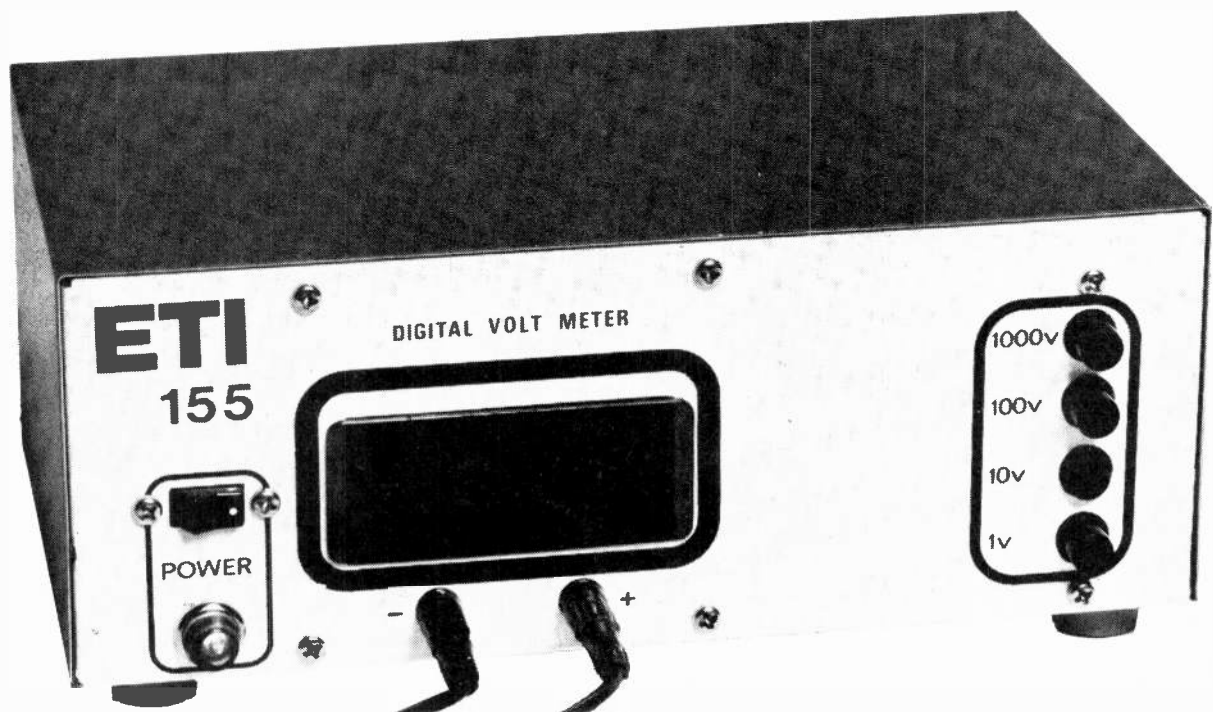
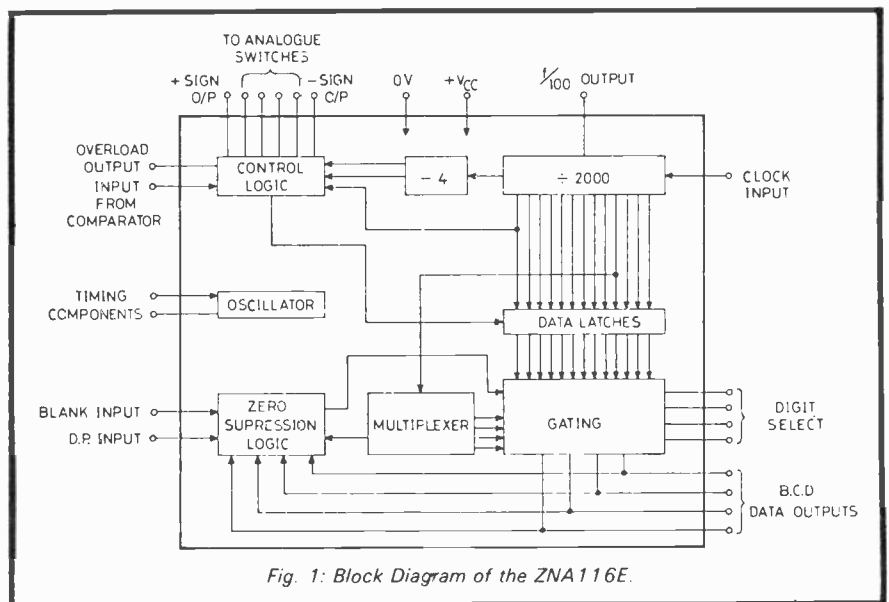
Although the circuit diagrams depict a complex device, construction is really very simple. The first thing to do is build the power supply as shown in fig. 9. Assemble the components onto the board as per fig 8. The regulator is mounted onto the rear of the case — no insulator is required, but be careful that the legs do not contact the case. Check the output of this — it should lie

between 4.7V and 5.2V. Don't proceed if it doesn't! Wire up the mains switch and neon.

Once the supply is operational and mounted in the case, assemble the main PCB's. Follow the overlays given in figs 4, 5, and 7 — watch the orientation of the components. Fit link leads to the digital board, and mount this into the box such that the

display locates behind the plastic panel you fitted there when you did the metal-work. (You did leave a hole for the displays — didn't you? . . . Oh.)

Next connect up the links to the analogue board and fit this into the case. Keep all inter board wiring as short as possible — and definitely less than six inches. The last block to



## Parts List

### Resistors

R1 16k\*  
 R2, 33 68k\*  
 R3-9 150R  
 R10, 11, 12 1k5  
 R13, 18, 19, 20/3k3  
 R14 33k  
 R15, 26 15k  
 R16, 17 680R  
 R21 100R  
 R22, 23 100k  
 R24, 25, 31, 34\* 10k  
 R27 27k  
 R28 1M\*  
 R29, 30, 36 51k\*  
 R32 470R  
 R35 560R  
 R37 240k\*  
 R38 180R  
 R39 180k\*  
 R40 2M\*  
 R41, 42 10M\*  
 R43 22k\*  
 (All Resistors 5% Ex \* = 2% type.)

### Potentiometers

RV1 100k Bourns 3009P  
 RV2, 3 5k Bourns 3009P  
 RV4, 5, 6 4k7 Min Hor. Trim.

### Capacitors

C1 2n2  
 C2, 4 33n  
 C3, 5 68µ 10v electrolytic  
 C6, 10, 11, 12 100n  
 C7 2µ, 2  
 C8 10n  
 C9 470p  
 C13 2,200µ 16v electrolytic  
 C14, 15 220n

### Semiconductors

IC1 ZNA 116E  
 IC2 7447A (TTL)  
 IC3, 4 ZN 424E  
 TR 1 - 4 2N4403  
 TR 5 - 11, 13-16 2N3903  
 TR 12 2N3905  
 D 1,2 ZN423 Reference IC  
 D3 IN914  
 BR 1 200V 2A Bridge Rectifier  
 REG 1 5V 1A Regulator - T03 case LM309K  
 Display 1 DL 701  
 Displays 2, 3, 4, DL 707L

The following are available from  
 Ferranti Electric  
 East Bethpage Rd.,  
 Plainview, N.Y. 11803  
 U.S.A.

ZNA 116E	US \$10.50
ZN423E	2.55
Postage & Handling	.50

### Switches

The switches used in the prototype are available through W.A. Components Ltd., 65 Granby St., Toronto, Ontario M5B 1H8. The ordering codes are: 338-636 (4 off — signal switches); 338-563 (1 pack - buttons); 338-254 (1 off — mounting bracket).

A four pushbutton assembly which has a similar electrical specification but differs physically is available from Dominion Radio & Electronics Co., 535 Yonge St., Toronto 5, Ontario. Use of this switch will require p.c. board redesign or hand wiring, but the unit price is lower than the imported version used on the prototype.

\* Price from Dominion is \$1.39

### Transformer

T1 120V - 8.5V IA  
 Hammond 166J8

### Miscellaneous

Boards, case, fuse holder, fuse, neon indicator, 2mm red and black sockets, PCB supports, 3 wire line cord, red plexiglass, nuts and bolts etc.

be positioned will be the switching bank and input attenuators. Wire this to the other boards once in place.

Before connecting *anything* to the PSU check over the boards again. Note the 'overload' diode D3, is mounted on the foil side of the digital PCB. Check the number of links. There are five on the analogue board, and twelve on the digital.

## CALIBRATING AND ATTENUATING

Unfortunately, there is no simpler way of calibrating such an instrument other than by applying known voltages. First one to try is zero volts. Set the range switch to the "one volt" position, short the input, and set RV1 until the polarity indicator just flickers from plus to minus.

Connect your known voltage, preferably positive, (can be measured with another meter known to be accurate) to the DVM and adjust RV3 until the instrument reads correctly. Reverse the terminals and set RV2 accordingly. This achieves the basic accuracy.

Each range of the attenuator is independent of the others, so each can be set individually.

Calibration is now complete.

## USING THE METER

When the input voltage exceeds the maximum reading the display will flash and no further measurements can be taken — switch up a range. Decimal point is automatical-

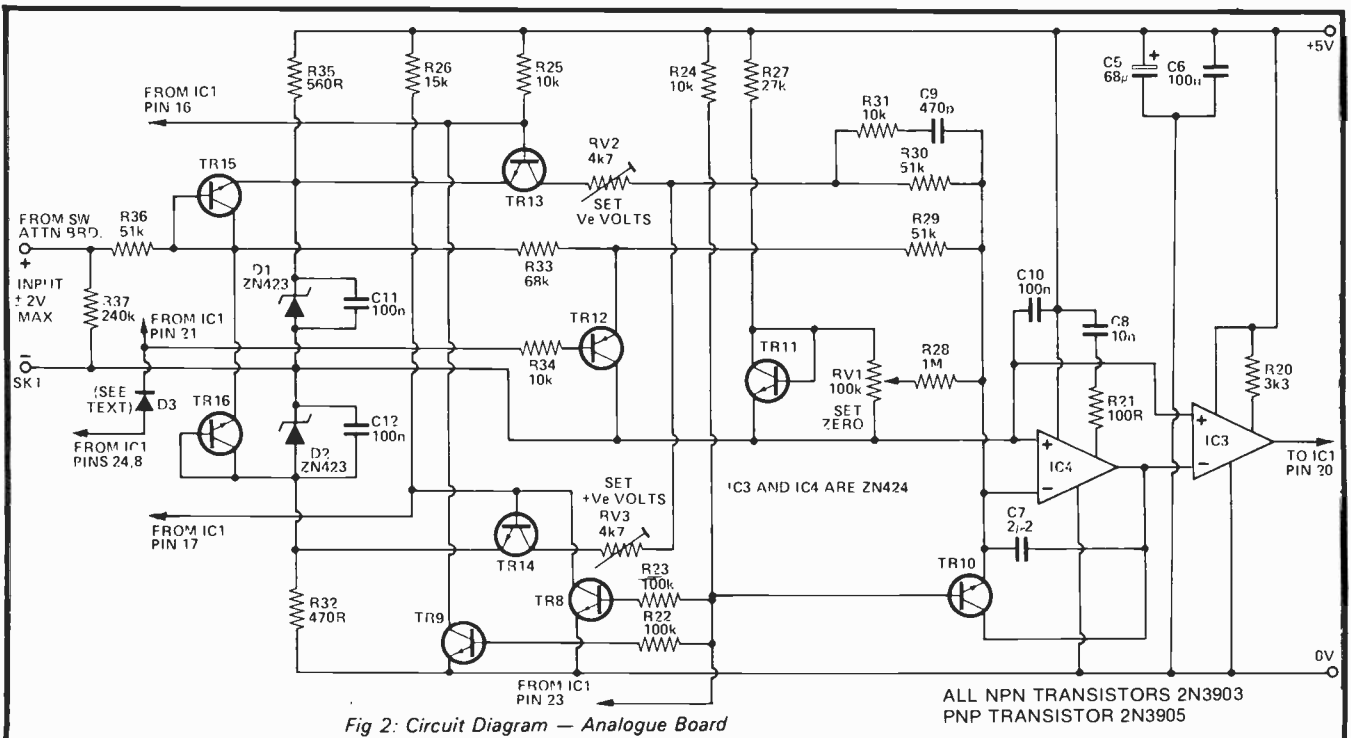


Fig 7: Overlay — Input Switching Board

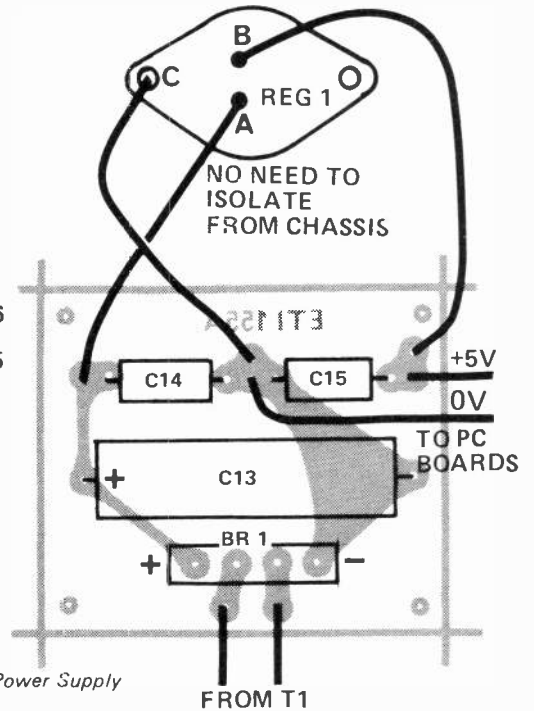
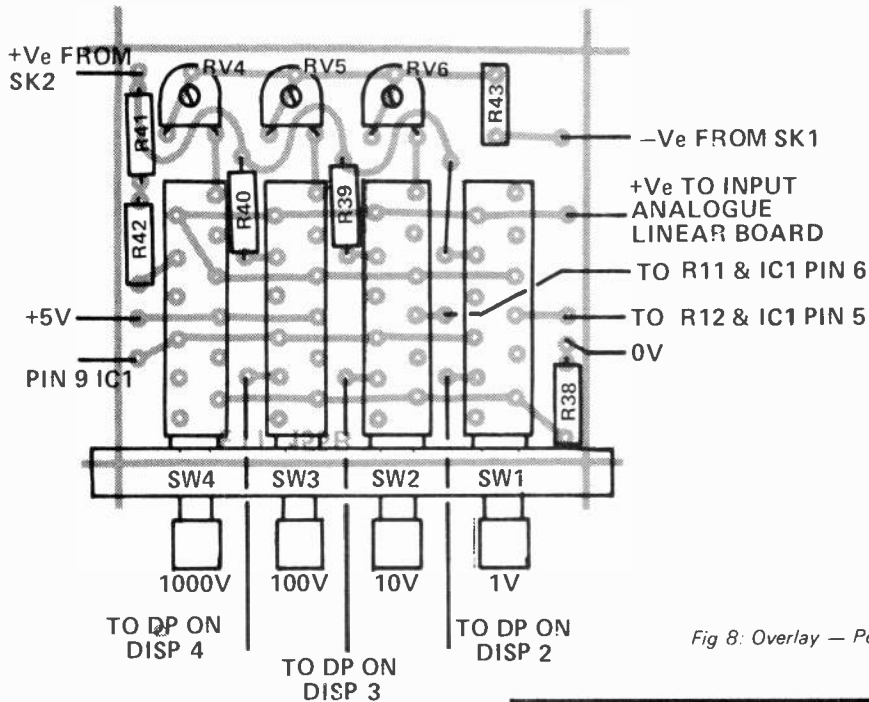


Fig 8: Overlay — Power Supply

ly set. Input impedance of the meter varies from 100kΩ on the 1V range to 20MΩ on the 1000V range. Maximum reading is ± 1999. If the accuracy of your setting-up is good — so is the DVM's! Insulting though it sounds, as the constructor YOU are the weakest link in the chain!

An internal view of the DVM unit. The display board is shown fixed in place upright against the front panel. Note the three holes in the back panel to adjust the three multi-turn presets on the analogue board. The voltage regulator need not be insulated from the back panel — but ensure the 'legs' do not short to the case.

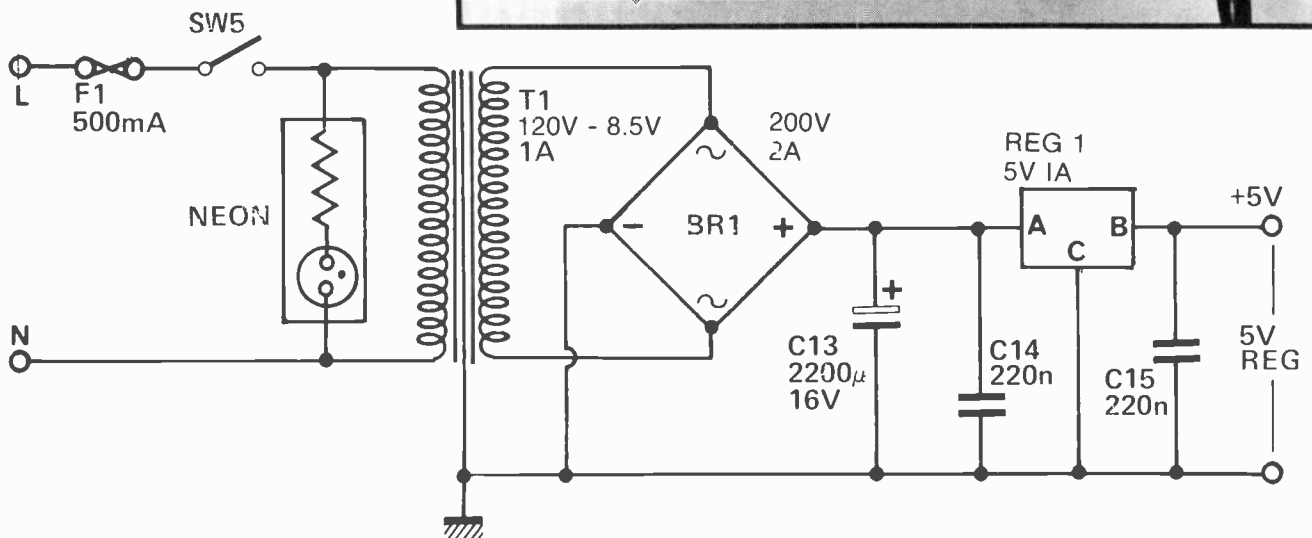
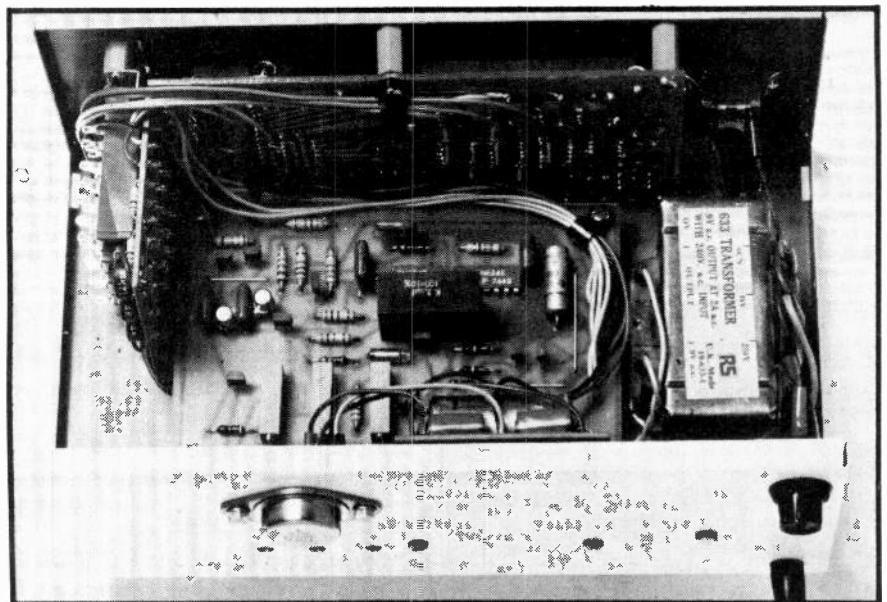


Fig 9 Circuit Diagram — Power Supply

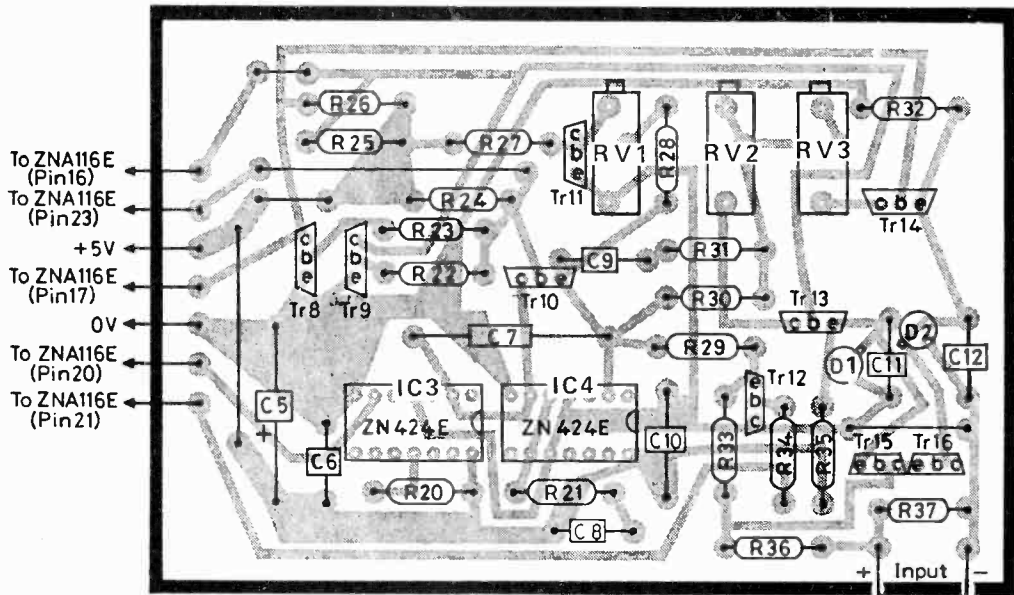
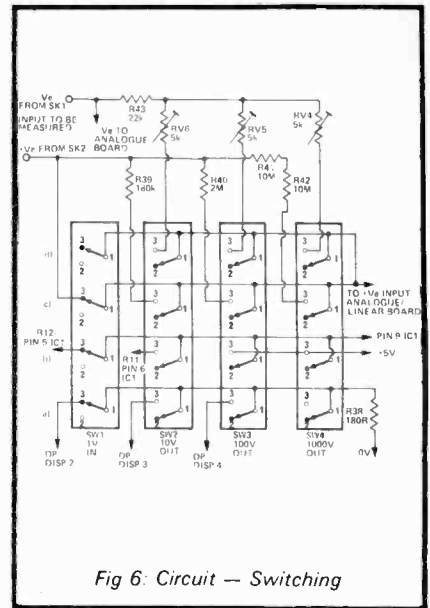
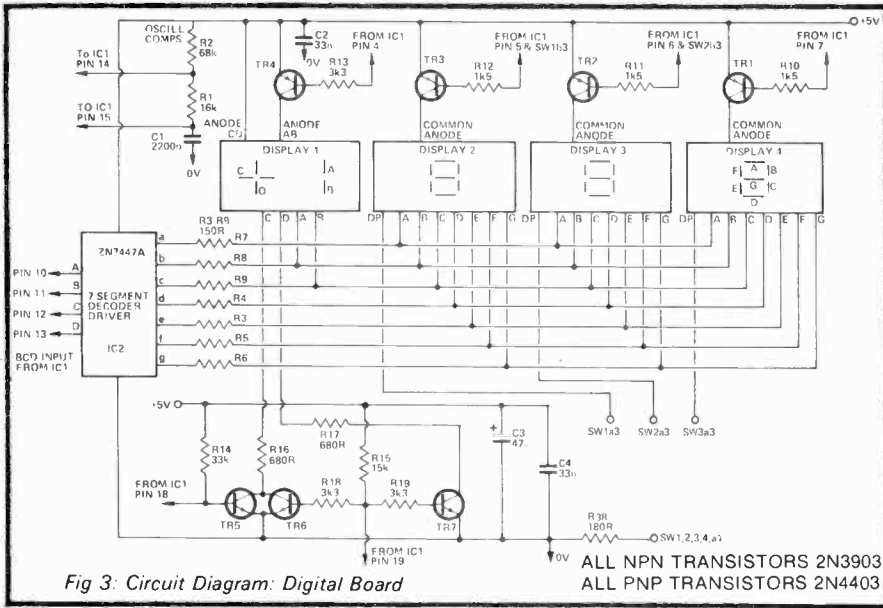
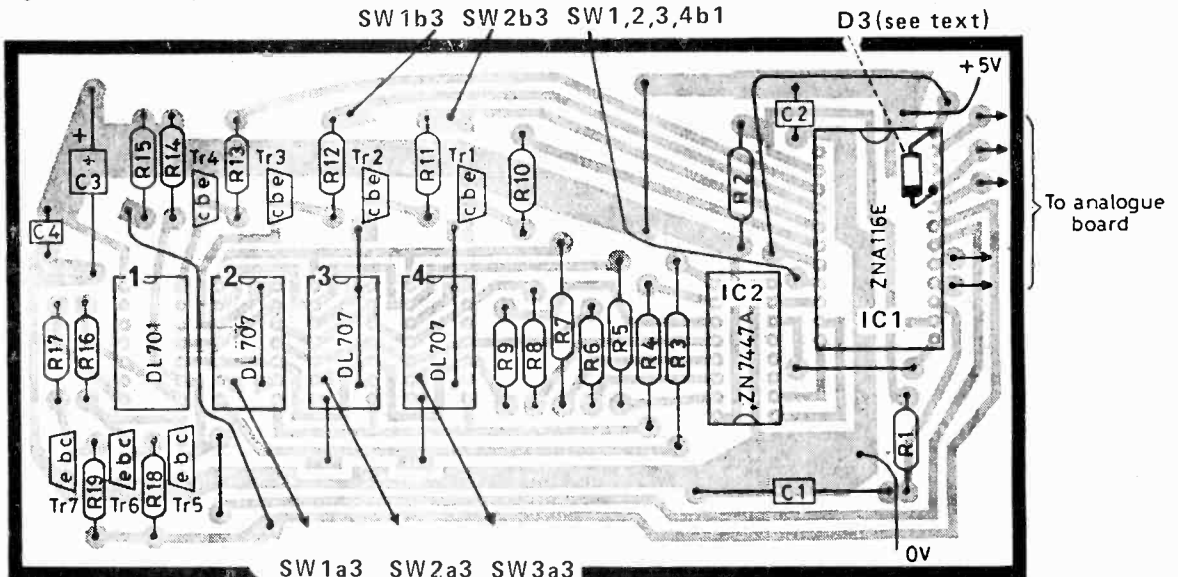


Fig 5: Overlay - Digital Board





# How it works

The method of A→D conversion used in the system is dual slope integration. Referring to the drawing below this operates thus:

At time  $T_1$ , S4 S3 and S4 are open, and S1 closes to apply the input voltage to the integrator. The integrator capacitor C will charge up linearly until time  $T_2$  (4000 clock pulses later). The voltage at the integrator is proportional to  $V_{in}$ .

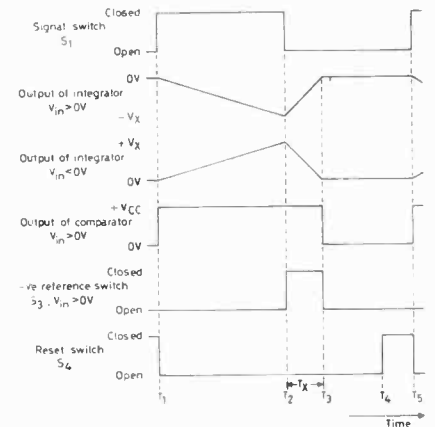
After time  $T_2$ , S1 opens and either S2 or S3 closes, applying a reference voltage (of opposite polarity to  $V_{in}$ ) to the integrator. C now discharges at a constant rate, and at time  $T_3$  the output of the integrator is again

zero. This is detected by the comparator, and the ref. is switched off, and the number of clock pulses corresponding to  $T_x$  transferred to latches. This number is directly proportional to  $V_x$ , hence to  $V_{in}$ . If  $T_x$  is greater than 2000 clock pulses, an overload condition exists, and the display is flashed.

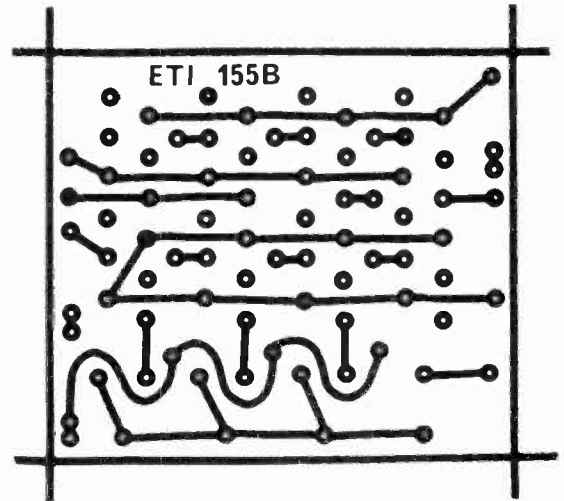
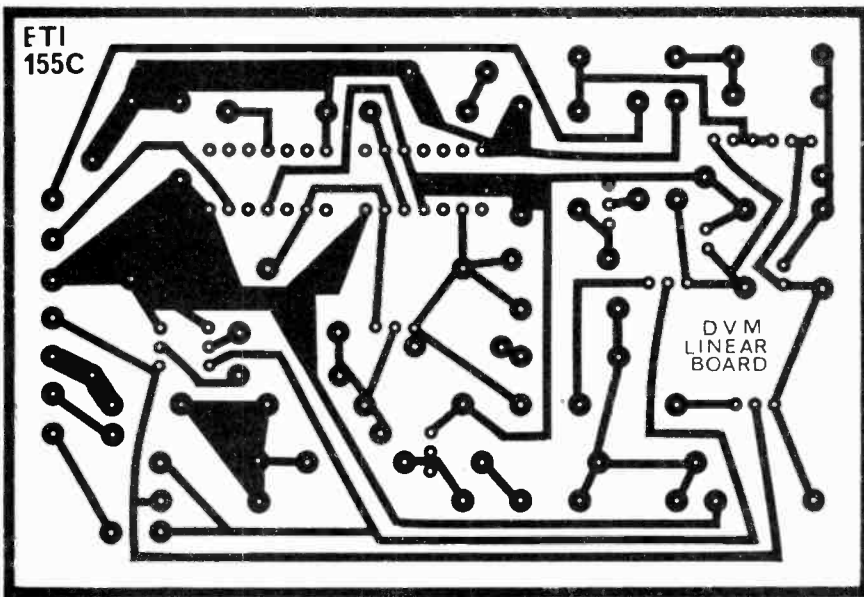
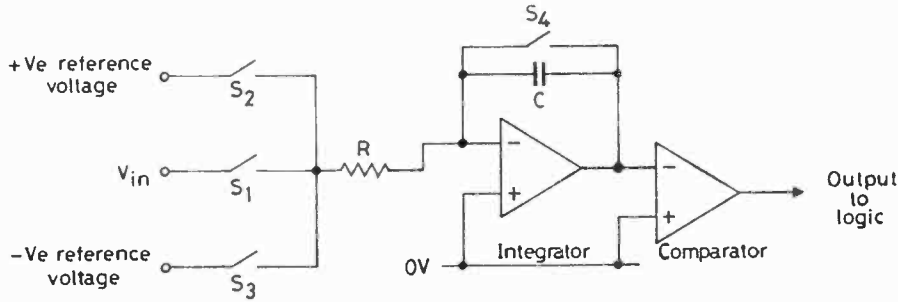
S1 is made to be closed for a time which is an exact multiple of 20msec. the period of the mains, and hence any ripple superimposed on  $V_{in}$  will be integrated to zero. Very convenient.

Using the dual slope technique means that neither the capacitor C nor the oscillator (clock) has to possess high stability.

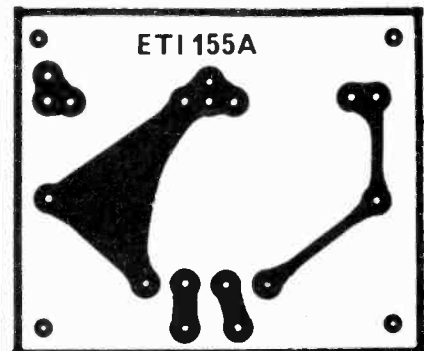
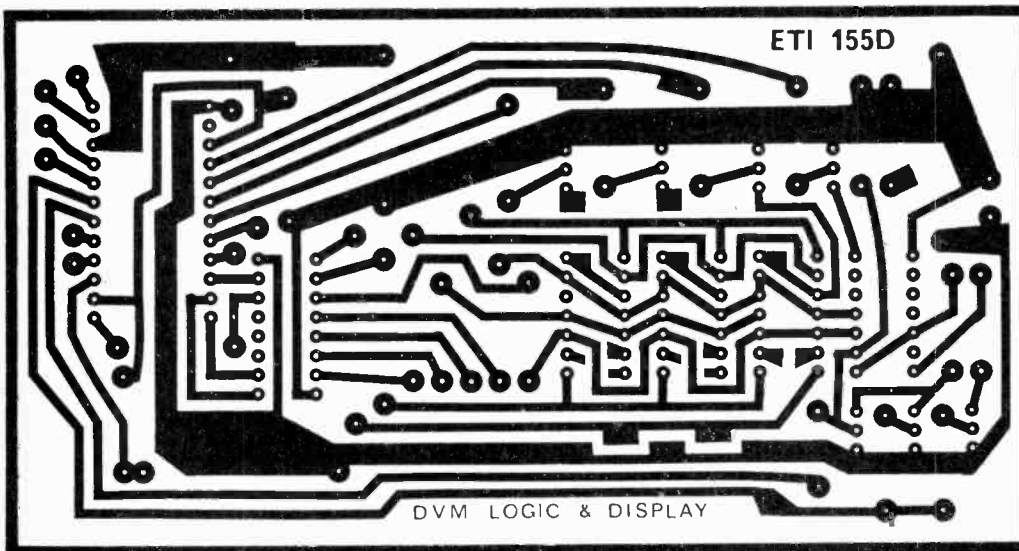
Referring our discussion to this circuit, IC4 forms the integrator, IC3 the comparator, IC1, the ZNA 116E is the control logic which



performs the transfer and timing for the system. A block diagram of this chip is given in fig. 1.



Our thanks to Ferranti who designed boards 155C and 155D for this project



# ETI DATA SHEET

## ICL 8038 WAVEFORM GENERATOR / V.C.O.

INTERSIL

The 8038 has been around for about 5 years — which is a long time in electronics. In fact it has reached the position of becoming an 'Industry Standard' on a par with the 741. An inherently versatile device it has its drawbacks like most chips — but overall has a lot going for it, Intersil even produced a very honest application bulletin (A013) called 'Everything you always wanted to know about the 8038', which explained how to get the best out of this device and admitted its defects — an uncommon event with most manufacturers! Some of the data from A013 has been included in this data sheet, and the latest information sheet (strangely referenceless, but brown in colour!)

### Description

The 8038 Waveform Generator is a monolithic integrated circuit, capable of producing sine, square, triangular, sawtooth and pulse waveforms of high accuracy. The frequency (or repetition rate) can be selected externally over a range of less than 1/1000 Hz to more than 1 MHz and is highly stable over a wide temperature and supply voltage range. Frequency modulation and sweeping can be accomplished with an external voltage and the frequency can be programmed digitally through the use of either resistors or capacitors. The Waveform Generator utilizes advanced monolithic technology, such as thin film resistors and Schottky-barrier diodes.

### Theory of operation

A block-diagram of the waveform generator is shown in Figure 1. An external capacitor C is charged and discharged by two current sources. Current source #2 is switched on and off by a flip-flop, while current source #1 is on continuously. Assuming that the flip-flop is in a state such that current source #2 is off, then the capacitor is charged with a current I. Thus the voltage across the capacitor rises linearly with time. When this voltage reaches the level of comparator #1 (set at 2/3 of the supply voltage), the flip-flop is triggered, changes states, and releases current source #2. This current source normally carries a current 2I, thus the capacitor is discharged with a net-current I and the voltage across it drops linearly with time. When it has reached the level of comparator #2 (set at 1/3 of the supply voltage), the flip-flop is triggered into its original state and the cycle starts anew.

Four waveforms are readily obtainable from this basic generator circuit. With the current sources set at I and 2I respectively, the charge and discharge times are equal.

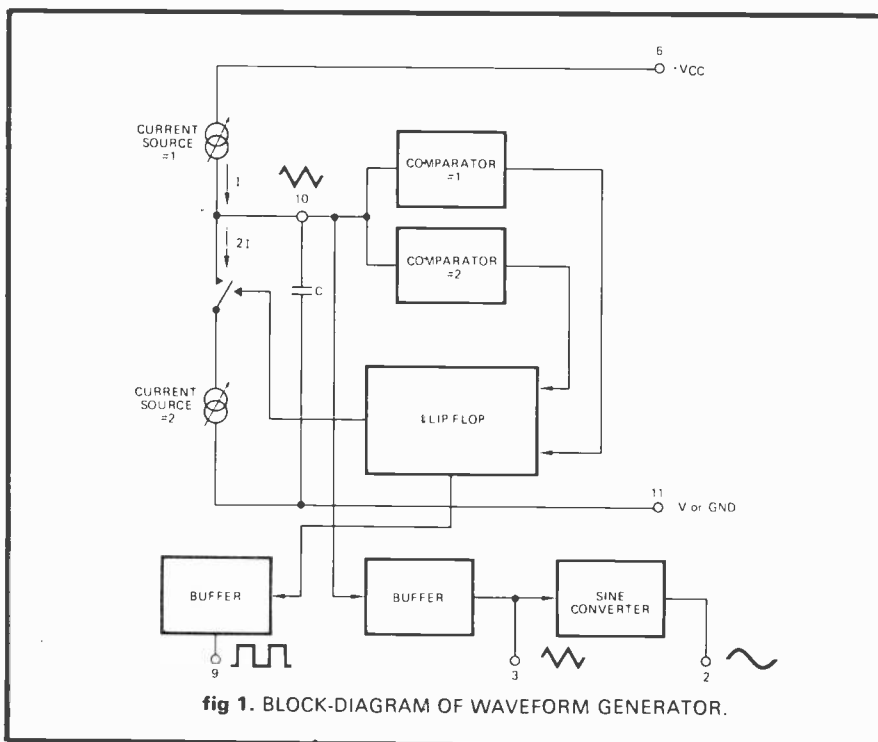
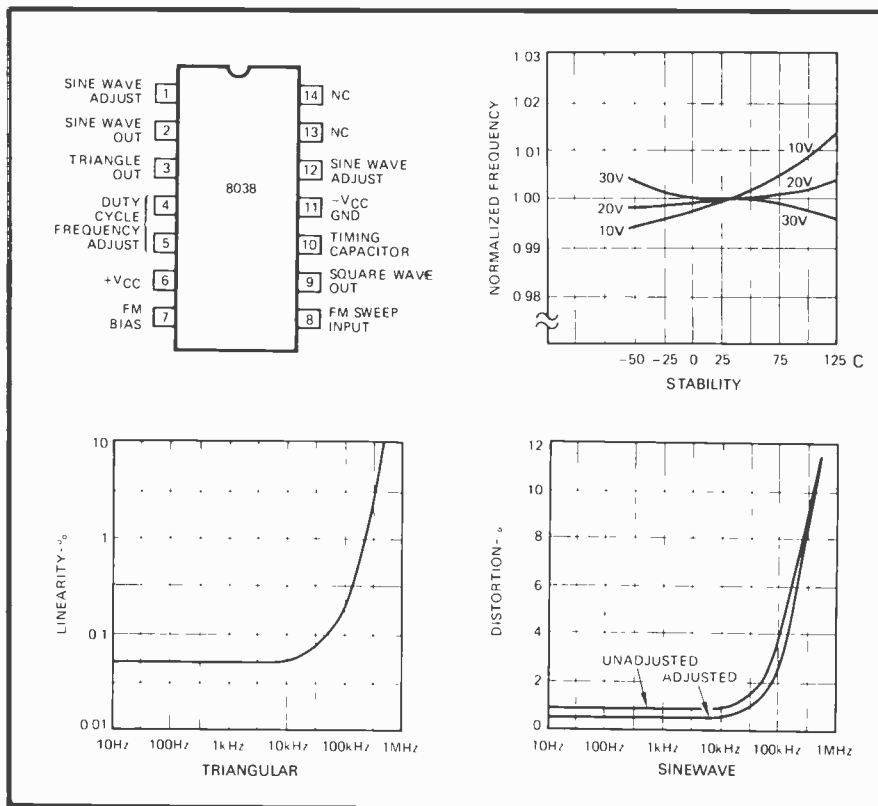


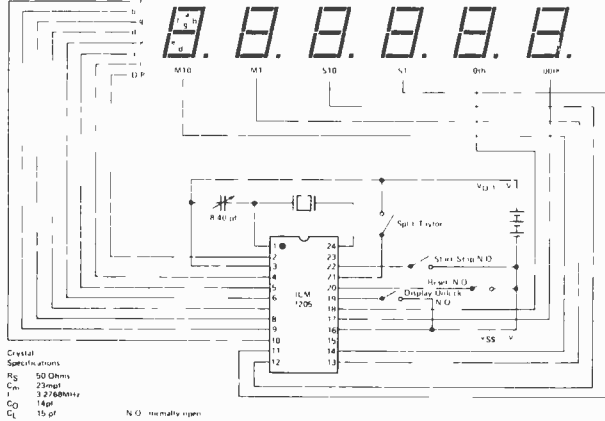
fig 1. BLOCK-DIAGRAM OF WAVEFORM GENERATOR.

The Intersil ICM 7205 is a relatively new device, main points of interest are: on chip display drivers, fully protected against static - no special handling precautions required, average current of only 10 mA when in operation (including display!)

The ICM 7205 is a fully integrated CMOS six digit stopwatch circuit. The circuit interfaces directly with a six digit/seven segment common cathode LED display. The low battery indicator can be connected to the decimal point anode or to a separate LED lamp. The only components required for a complete stopwatch besides the display are: three SPST switches, a 3.2768 MHz crystal, a trimming capacitor, three AA batteries, and an on-off switch. For a two function stopwatch one additional switch would be required.

The circuit divides the oscillator frequency by  $2^{15}$  to obtain 100 Hz which is fed to the fractional seconds, seconds and minutes counters. An intermediate frequency is used to obtain the 1/6 duty cycle 1.07 kHz multiplex waveforms. The blanking logic provides leading zero blanking for seconds and minutes independently of the clock. The ICM7205 is packaged in a 24 lead plastic DIP.

Stopwatch Circuit



Switch Characteristics

The ICM7205 is designed for use with SPST switches throughout. On the display unlock and reset inputs the characteristics of the switches are unimportant, since the circuit responds to a logic level held for any length of time, however short. Switch bounce on these inputs does not need to be specified. The Start/Stop input, however, responds to an edge and it requires a switch with less than 15 ms of switch bounce. The bounce protection circuitry has been specifically designed to let the circuit respond to the first edge of the signal, so as to preserve the full accuracy of the system.

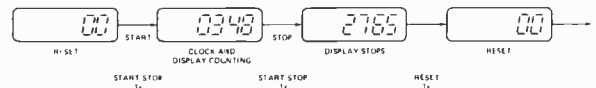
Low Battery Indicator

The on-chip low battery indicator is intended for use with a small LED lamp or with the decimal points on a standard LED display. The output is the drain of a P-channel transistor of approximately half the size of one of the segment drivers. The LBI circuitry is designed always to provide a voltage difference between the LBI trigger voltage and the minimum operating voltage, i.e. the lower the LBI trigger voltage the lower the the minimum operating voltage. In this way a stopwatch using three AA batteries will provide at least 15 minutes of accurate timekeeping after the LBI comes on.

Functional Operation

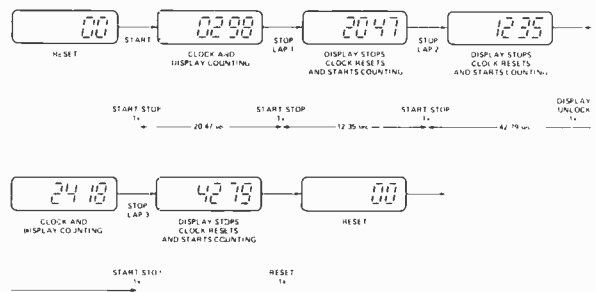
Turning on the stopwatch will bring up the reset state where the fractional seconds are on displaying 00 and the other digits are blanked. This display always indicates that the stopwatch is ready to go.

Start/Stop



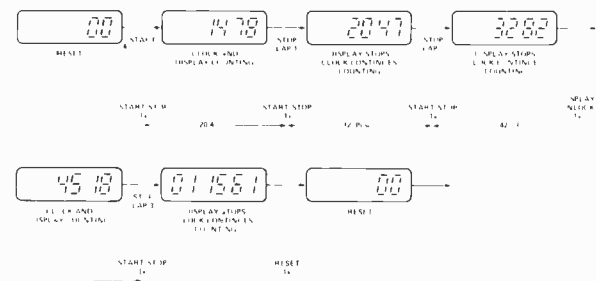
The Start/Stop modes can be used for a single event timing with the Split/Taylor input in either state. The illustration indicates the operations and the results. To time another event the reset switch must be used prior to the start of the event. Seconds will be displayed after one second, minutes after one minute. The range of the stopwatch is 59 minutes 59.99 seconds. If an event exceeds one hour, the number of hours must be remembered by the user. Leading zeros are not blanked after one hour.

Taylor



When the Split/Taylor input is left open circuit or is connected to Vss, the stopwatch can be used in the Taylor or sequential mode. As depicted graphically above, each split time is measured from zero in the Taylor mode, i.e. after stopping the watch, the counters reset to zero momentarily and start counting the next interval. The time elapsed since the last activation of Start/Stop. The display is stationary after the first interval unless the display unlock is used to show the running clock. Reset can be used at any time.

Split



When the Split/Taylor input is connected to VDD the stopwatch is in the Split mode. The Split mode differs from the Taylor in that the lap times are cumulative in the Split mode. The counters do not reset or stop after the first start until reset is activated. Any time displayed is the cumulative time elapsed since the first start after reset. Display unlock can be used to let the display 'catch up' with the clock. Reset can be used at any time.

Points to Note!

Absolute maximum supply voltage is 5V5. Never short outputs to earth or low impedance power supply as this will destroy the device.

Thus a triangle waveform is created across the capacitor and the flip-flop produces a square-wave. Both waveforms are fed to buffer stages and are available at pins 3 and 9.

The levels of the current sources can, however, be selected over a wide range with two external resistors. Therefore, with the two currents set at values different from 1 and 21, an asymmetrical sawtooth appears at terminal 3 and pulses with a duty cycle from less than 1% to greater than 99% are available at terminal 9.

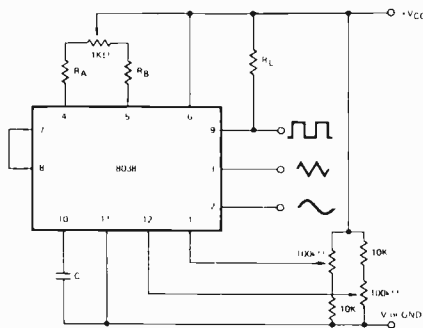
The sine-wave is created by feeding the triangle-wave into a non-linear network (sine-converter). This network provides a decreasing shunt-impedance as the potential of the triangle moves toward the two extremes.

## Power Supply

The waveform generator can be operated either from a single power supply (10 to 30 Volts) or a dual power supply ( $\pm 5$  to  $\pm 15$  Volts). With a single power supply the average levels of the triangle and sine-wave are at exactly one-half of the supply voltage, while the square wave alternates between +V and ground. A split power supply has the advantage that all waveforms move symmetrically about ground.

Also notice that the square wave output is not committed. The load resistor can be connected to a different power supply, as long as the applied voltage remains within the breakdown capability of the waveform generator (30 V). In this way, for example, the square-wave output can be made TTL compatible (load resistor connected to +5 Volts) while the waveform generator itself is powered from a much higher voltage.

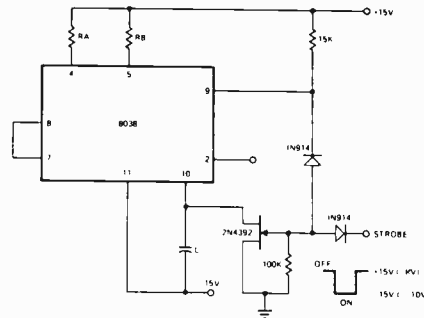
## Purity



The symmetry of all waveforms can be adjusted with the external timing resistors. To minimize sine-wave distortion the resistors between pins 11 and 12 are best made variable ones. With this arrangement distortion of less than 1% is achievable. To reduce this even further, two potentiometers can be connected as shown. This configuration allows a reduction of sinewave distortion close to 0.5%.

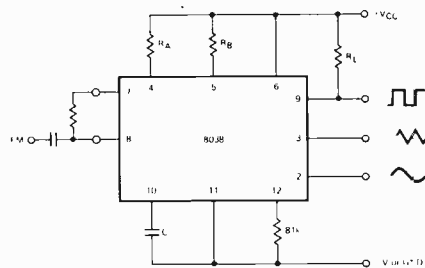
Both the sine-wave and triangular outputs, are only useful up to about 20kHz if a reasonably pure signal is required. A perusal of the graphs will show why.

## Strobe



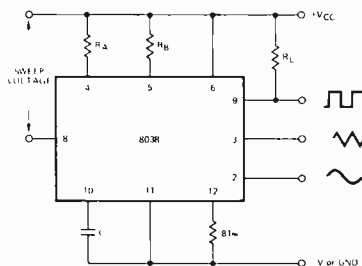
With a dual supply voltage (e.g.,  $\pm 15$ V) the external capacitor (pin 10) can be shorted to ground so that the sine wave and triangle wave always begin at a zero crossing point. Random switching has a 50/50 chance of starting on a positive or negative slope. A simple AND gate using pin 9 will allow the strobe to act only on one slope or the other.

Using only a single supply, the capacitor (pin 10) can be switched either to V+ or ground to force the comparator to set in either the charge or discharge mode. The disadvantage of this technique is that the beginning cycle of the next burst will be 30% longer than the normal cycle.



The frequency of the waveform generator is a direct function of the DC voltage at terminal 8 (measured from +VCC). Thus by altering this voltage, frequency modulation is achieved.

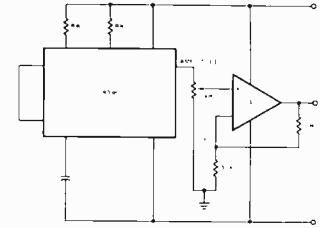
For small deviations (i.e.  $\pm 10\%$ ) the modulating signal can be applied directly to pin 8, merely providing dc decoupling with a capacitor. An external resistor between pins 7 and 8 is not necessary, but it can be used to increase input impedance. Without it (i.e. terminals 7 and 8 connected together), the input impedance is 8k, with it, this impedance increases to  $(R + 8k)$ .



For larger FM deviations or for frequency sweeping, the modulating signal is applied between the positive supply voltage and pin 8. In this way the entire bias for the current sources is created by the modulating signal and a very large (e.g. 1000:1) sweep range is created ( $f = 0$  at  $V_{\text{sweep}} = 0$ ). Care must be taken, however, to regulate the supply voltage; in this configuration the charge

current is no longer a function of the supply voltage (yet the trigger thresholds still are) and thus the frequency becomes dependent on the supply voltage. The potential on pin 8 may be swept from  $V_{CC}$  to about  $2/3 V_{CC}$ .

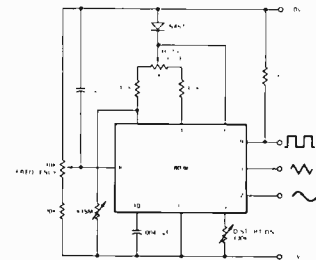
## Buffering



The sine wave output has a relatively high output impedance (1K Typ). The circuit provides buffering, gain and amplitude adjustment. A simple op amp follower could also be used.

If the available outputs are all fed through a buffer, extra resistors can be inserted in series with the signal before a switch. Values of 47k (square wave), 15k (triangular) and 10k (sine wave) will ensure equal amplitude signals.

## Audio Oscillator



To obtain a 1000:1 Sweep Range on the 8038 the voltage across external resistors RA and RB must decrease to nearly zero. This requires that the highest voltage on control Pin 8 exceed the voltage at the top of RA and RB by a few hundred millivolts.

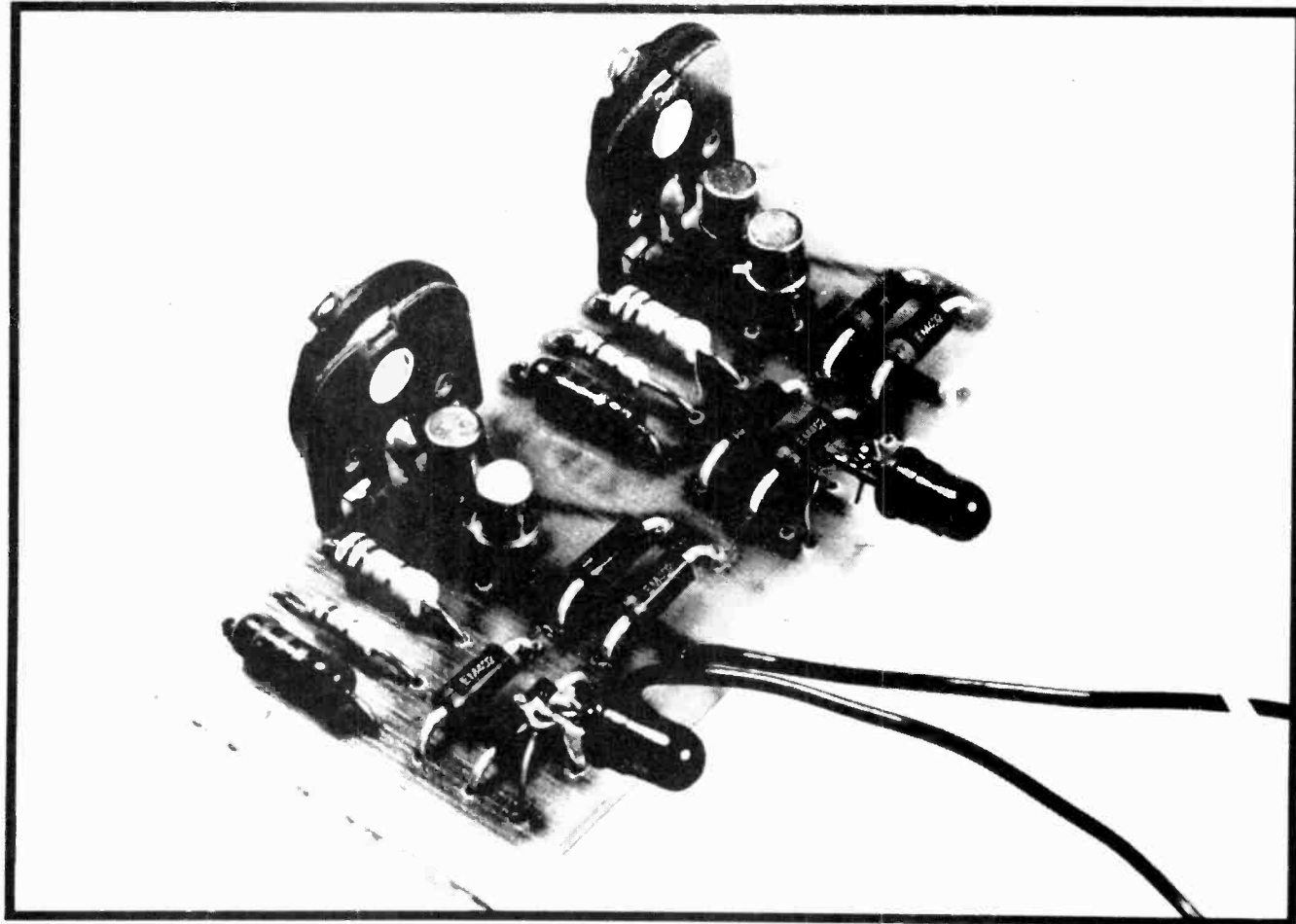
The Circuit achieves this by using a diode to lower the effective supply voltage on the 8038. The large resistor on pin 5 helps reduce duty cycle variations with sweep. The range of this circuit is 20Hz to 20 kHz, output buffer can be added to make a general purpose bench unit.

## Points to Note!

The 8038 runs hot to touch, this is normal, and is due to the resistive nature of the sinewave shaping network.

The optimum supply voltage, for minimum temperature drift is 20V, this can be seen in the stability graph.

# SHORT CIRCUITS



## THE OVERLED

Is your power amplifier clipping? This simple monitor lets you know.

TABLE 1

RMS watts per channel	SPEAKER IMPEDANCE					
	4Ω		8Ω		16Ω	
	R1	R3	R1	R3	R1	R3
5	68	5.6k	82	8.2k	120	12k
10	82	8.2k	120	10k	180	18k
15	100	10k	150	15k	220	22k
20	120	12k	180	18k	240	24k
25	150	15k	220	22k	270	27k
35	180	18k	240	24k	330	33k
50	220	22k	270	27k	390	39k
75	240	24k	330	33k	470	47k
100	270	27k	390	39k	560	56k

MANY people are aware of distortion when they turn up the volume control on their hi-fi equipment — but are usually unaware of the cause.

Nine times out of ten this distortion is caused by 'clipping'. That is, the amplifier does not have enough reserve power to handle the peak music transients at the required volume.

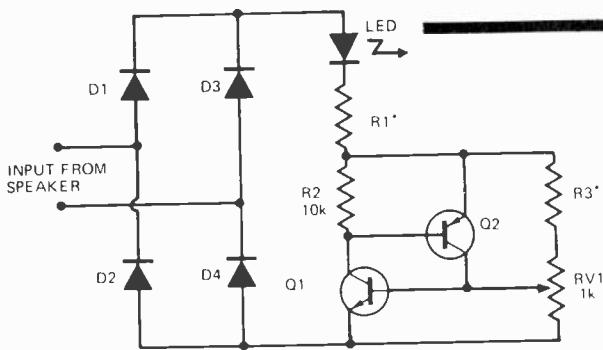
During such peaks, the amplifier is driven into an overload condition and as a result the music peaks are 'clipped'. This results in harsh sounding reproduction.

This simple device, which may be built into your existing amplifier, or separately located, flashes a warning light if the power level at which clipping occurs is exceeded.

The unit will also provide the monitoring section of the Bass Enhancer to be described next month — see preview of the August issue.

Two completely independent circuits are provided so that each channel of a stereo system may be monitored separately.

# Short Circuits



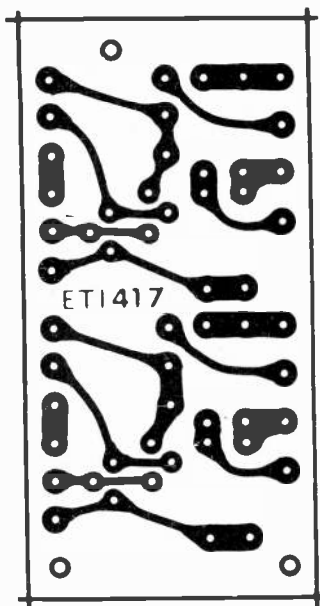
\*SEE TABLE 1 FOR VALUES  
ONE CHANNEL ONLY SHOWN  
*Fig. 1. Circuit diagram of overload detector. One channel only shown.*

## How it works

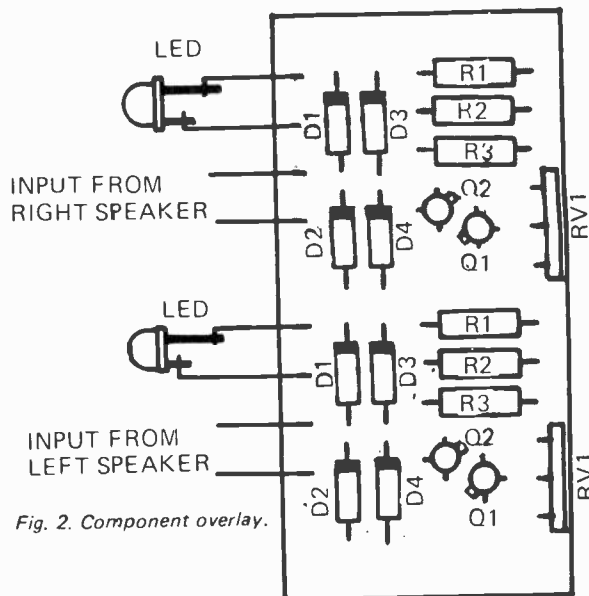
The output of each power-amplifier channel is monitored at the speaker terminals. The output is bridge rectified by D1-D4 so that both positive and negative transients may be detected.

Transistors Q1 and Q2 (together) are equivalent to a sensitive gate SCR (silicon controlled rectifier). If the voltage at the base of Q2 is more than about 0.6 volts above its emitter, Q1 and Q2 will each turn hard on and latch on, until the current through them drops to zero.

When transistors Q1 and Q2 are on, the current flowing through them also flows through the LED causing it to illuminate. Resistor R1 limits the peak current through the LED to about 100 mA. The range of calibration potentiometer RV1 is set by resistor R3. The values of R1 and R3 are provided in Table I for various amplifier power ratings and speaker impedances. These values are not critical. If your amplifier has a power rating other than that specified, the nearest values will do.



*Fig. 3. Printed circuit board (full size).*



*Fig. 2. Component overlay.*

## Parts List

One set is required for each channel  
**RESISTORS** all  $\frac{1}{2}W \pm 5\%$

R1 see Table 1  
R2 10k

R3 see Table 1

### SEMICONDUCTORS

Q1 2N 2222  
Q2 2N 3965  
D1 to D4 1N4001 (4off)

LED TIL209 light emitting diode

### POTENTIOMETER

RV1 1k skeleton preset

### MISCELLANEOUS

Printed circuit board, case if required, connecting wire etc.

## CONSTRUCTION

Mount all components on to the printed circuit board in accordance with the component overlay. Make sure that all diodes are correctly orientated, in particular the LED's. The LED's will not be damaged by reverse polarity but will not operate in that mode.

Whether the unit is mounted inside the amplifier or external to it in a small box will be a matter for the individual constructor. The printed circuit board may be mounted in any suitable position within the amplifier and leads extended to front-panel mounted LEDs if required.

Polarity of the leads to the amplifier output terminals is immaterial but make sure that the leads of separate channels are not mixed. This is best avoided by twisting each pair of leads to each channel.

## CALIBRATION

There are several ways of calibrating the unit.

By far the best way is to connect an audio oscillator to the input of the amplifier (both channels driven at the same time), then, with the amplifier volume control at a low setting, adjust the oscillator to provide a 1 kHz sine-wave.

Set both trim potentiometers (RV1) so that their wipers are nearest R3.

Now increase the amplifier volume until clipping occurs. This is very easily identified as a sudden harshness of tone. Do not leave the volume control at this setting for more than a second or two, as apart from the pounding you are giving to your ears, some amplifiers will not tolerate a sine-wave input at clipping level for extended periods without damage.

Once the clipping point has been established, turn the volume down again, and then quickly turn up to the clipping point momentarily, meanwhile adjusting the trimming potentiometers RV1 until a point is reached where the light emitting diodes just come on.

Repeat the procedure a few times — finally arriving at a setting at which the LED's come on just before the clipping point.

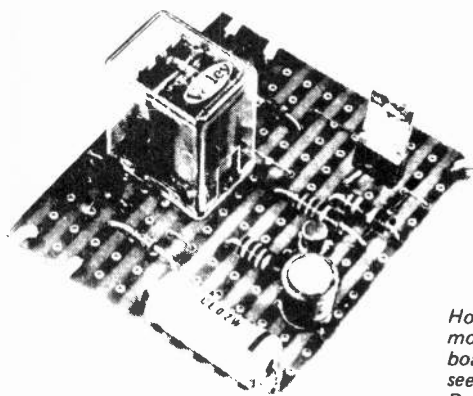
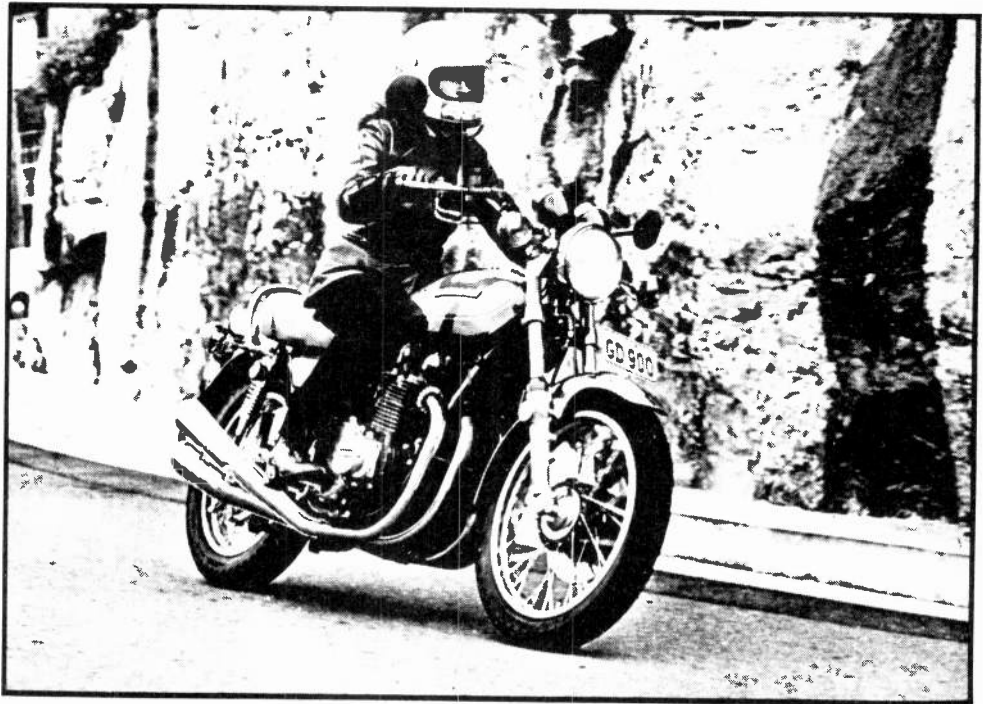
If you do not have access to an oscillator, the device can be set by playing a test record that contains a sine-wave tone — or failing this — by playing a record of a solo instrument such as a flute. A recording of the human voice is also very effective. In such cases the same calibration procedure described above should be followed.

# TURN INDICATOR CANCELLER

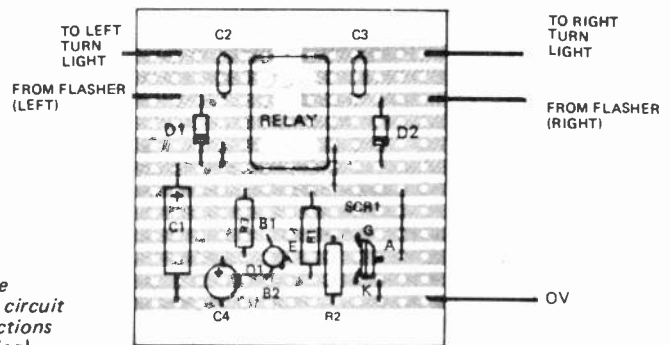
Simple electronic unit cancels turn indicators after 30 seconds.

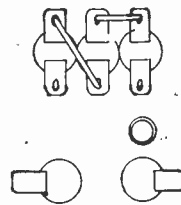
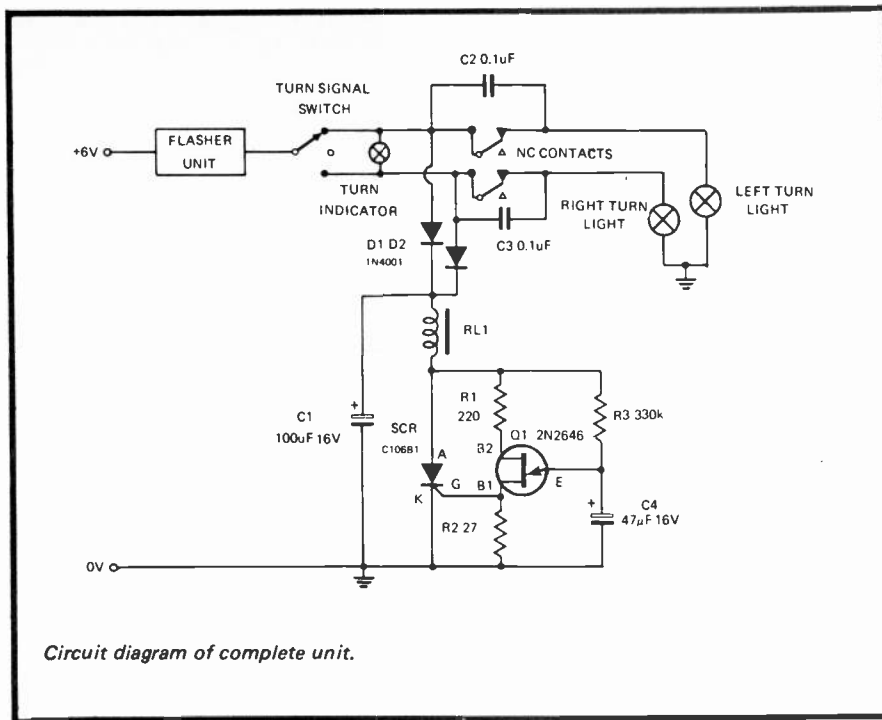
FOR MANY YEARS now all automobiles have had turn signals that automatically cancel themselves after the turn has been executed. However, only relatively recently have any sort of turn signals been mandatory on new motorcycles, and these have almost all been completely manual.

Driving or riding such vehicles, failure to remember to cancel the indicator causes traffic nuisance and hold-ups and, in extreme cases, may even render you legally culpable (in the eyes of some magistrates) for any ensuing accident.

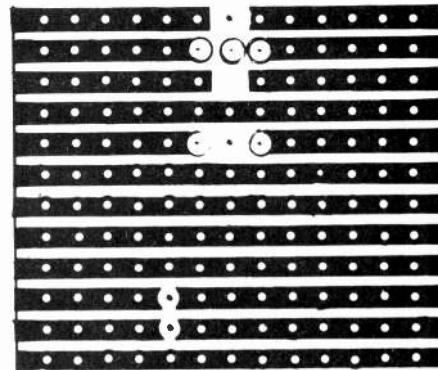


*How the components are mounted on the printed circuit board. (For relay connections see accompanying drawing). Refer also to photograph left.*





Relay connections. Holes should be drilled through the veroboard large enough to accommodate the twin tags. The tags are then bent over and soldered as shown.



Use a sharp drill to break the tracks on the veroboard as shown. Several holes must be enlarged to enable the relay tags to pass through.

Automatic cancellation of the indicator in an automobile is done by the steering. On a bike much of the steering is done by leaning the machine into the turn, hence the same system can not be used so effectively. The unit described is an economical means of ensuring that turn indicators are switched off automatically 30 seconds after a turn signal has been initiated. However, being essentially a 'delay-off' circuit operating on 6 or 12 volt pulses, it may also find other uses such as immobilisation of electrical circuits after an alarm has been initiated etc.

## CONSTRUCTION

There are only 12 components all told, therefore there should be no problems with construction providing

the wiring diagram and overlay are studied carefully.

Most motor cycles have six volt power, either from a battery, or mag-dynamo and in this case a relay with 52 ohm coil should be used. Where a 12 volt system is used, the relay should have a 185 ohm coil.

Locating the unit will be a matter of choice, and will depend on the particular machine — for this reason we have not provided case details. The unit should be mounted as close to the turn signal switch as possible so that long leads are not necessary.

To wire the unit into the turn indicator circuit, locate the two wires coming from the flasher, cut both and connect them as shown on our overlay diagram. There is no need to identify left and right, so long as each wire is cut and then terminated with both sections on one side of the matrix board as shown. ●

## PARTS LIST

SCR	—	silicon controlled rectifier C106B1
Q1	—	unijunction transistor 2N2646
D1, D2	—	silicon diode 1N4001
R1	—	resistor 220 ohm, 1/2 watt, 10%
R2	—	resistor, 27 ohm, 1/2 watt, 10%
R3	—	resistor, 330k, 1/2 watt, 10%
C1	—	electrolytic capacitor, 100uF, 16V
C2, C3	—	polyester capacitor, 0.1uF, 100V
C4	—	electrolytic capacitor, 47uF, 16V, upright
Relay	—	miniature relay. For 6V vehicles (52 ohm coil), 12V vehicles 185 ohm coil — see text
Veroboard	—	2 3/4 inches wide, 3 inches long, 0.2 inch spacing
Sundries	—	hookup wire, solder etc.

## HOW IT WORKS

When either blinker is switched on, pulses from the flasher unit charge C1 and C4 via either D1 or D2, and in the case of C4, also via the relay winding and R3. When the charge on C4 is sufficient to trigger UJT Q1, a pulse occurs across R2. This in turn gates the SCR on allowing C1 to discharge via the relay and the SCR. The C1 discharge current through the relay winding actuates the relay and the normally closed contacts are opened, breaking the current path to the light concerned.

This removes the major load on the flasher unit, which then stays on. Providing the indicator switch is left on, the SCR will continue conducting via the relay winding, thus the contacts remain open. Since the timing circuit is directly across the SCR, it is reset immediately the SCR turns on which ensures that the next timing period will be the same as the first. Switching the indicator switch to the off position, removes power from the relay and it then drops out.

The blinker on-time is determined by the C4/R3 time constant. In this case about 30 seconds. Increasing the value of either component lengthens the 'on' time, and vice versa. The capacitors across the relay contacts are included to protect the contacts from arcing.



# 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.

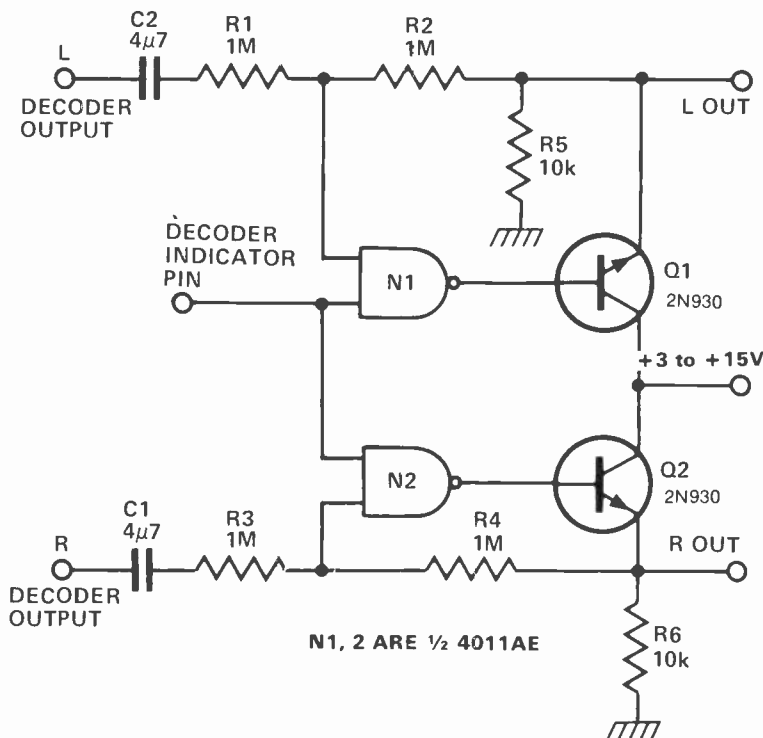
## SIMPLE STEREO SWITCH

A device to switch the audio from a stereo tuner only when a stereo signal is being received.

Two CMOS NAND gates and two transistors are employed. One of the inputs from each gate is connected together and to the indicator output of the decoder IC.

The other gate inputs are connected to the emitter's of Q1 and Q2 respectively, by means of the feedback resistors R2 and R4. On reception of a stereo signal the indicator output of the decoder goes high and the feedback resistors bias the gates into the linear region passing the signal. On reception of a mono signal or interstation noise, no signals pass through the gates, the circuit providing a 'mute' function.

N.B. Some CMOS will not function in the linear mode. All unused inputs should be connected to ground.

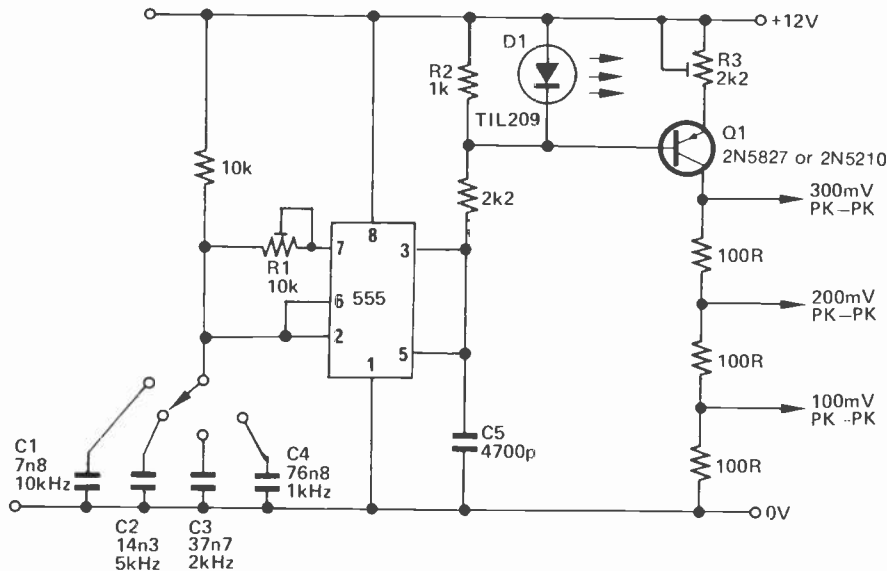


## VOLTAGE AND FREQUENCY CALIBRATOR

This circuit provides simultaneous voltage and frequency calibrations by generation of a precision squarewave.

The 555 timer IC is used in a slightly unusual configuration, having the advantage that an exact 50:50 mark/space ratio may be attained by trimming R1. The frequency of oscillation may be set between 10 kHz and 1 kHz by switching timing capacitors C1-4. C5 decouples the internal reference potential-divider of the 555 from supply-transients.

The squarewave output from pin 3 of the IC, while stable in frequency, is not stable in peak-to-peak voltage as this depends on the supply voltage. This is used to switch on and off a temperature-compensated constant-current source Q1. R2 ensures that the current-source turns off completely when pin 3 goes high. The current-source output, trimmed by R3 to be exactly 1 mA, drives a resistor ladder network so that a series of precise squarewave voltages are generated. The advantage of current drive rather



than voltage drive for this sort of network is that calibration is much easier. A simple ladder network is shown by way of example, and more complex ones may simply be constructed to give a wider variety of output voltages.

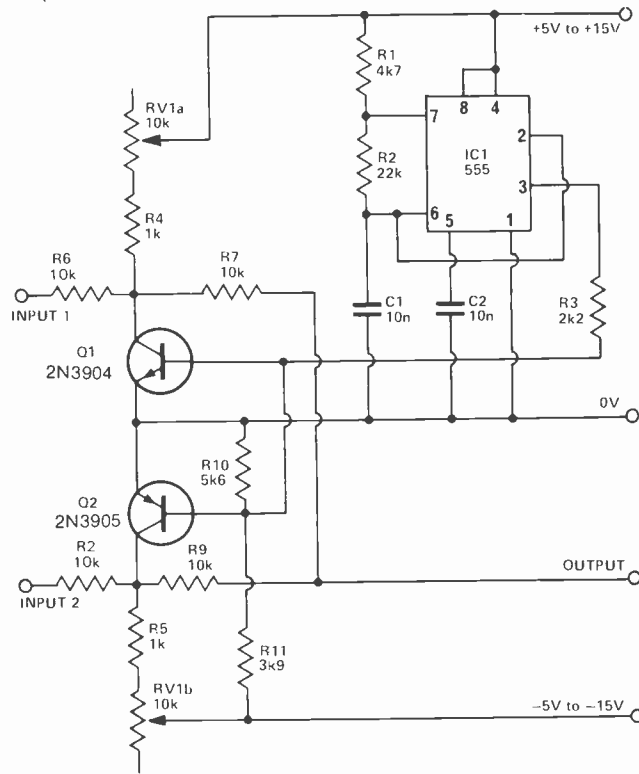
The non-standard component values used were obtained by paralleling standard values. For the timing capacitors several in parallel had to be used, and only the resultant value is shown on the diagram.

## BEAM SPLITTER FOR OSCILLOSCOPE

The basis of the beam splitter is a 555 timer connected as an astable multivibrator, components R1, R2 and C1 being selected to give approximately equal high/low pulses of about 3 kHz.

Resistor R3 couples the output of the oscillator to the npn/pnp pair Q1 and Q2. When the output of the oscillator is low, resistors R10 and R11 allow Q2 to be on so that any signal applied to input 2 is effectively short-circuited via resistor R8 to the common line of the power supply. At the same time, the npn transistor Q1 is off, so that any signal at input 1, plus a positive voltage provided by RV1a and R4, appears at the output via R7.

Conversely, when the output of the oscillator is high, Q1 is biased on whilst Q2 is off. A signal at input 2 plus a negative voltage via RV1b and R5 appears at the output via R9. Thus signals at the two inputs are alternately displayed on the oscilloscope with a clear separation between them. The separation is controlled by the tandem potentiometer RV1a/b which also varies the amplitude of the traces.



## A SIMPLE V.C.O.

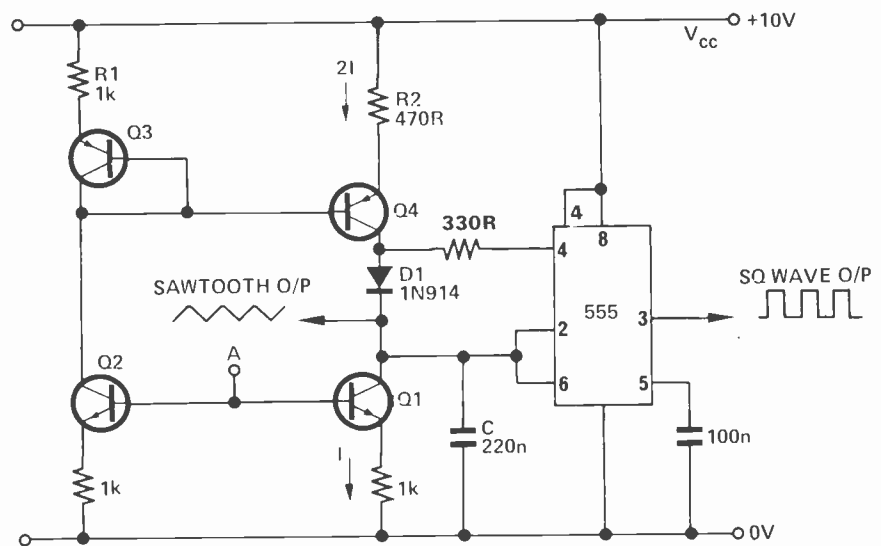
This circuit generates sawtooth and triangle waveforms at a frequency set by an external control voltage.

Current source Q1 draws a current  $I$  from timing capacitor C. Simultaneously current source Q2 draws the same current from current mirror Q3, Q4; this is set up (by R1 and R2) to deliver (from the collector of Q4) twice the current leaving Q2.

Hence C receives a current  $2I$  from the top rail, at the same time delivering  $I$  to the bottom rail, the net effect being that the capacitor is charged by a constant current  $I$ , its voltage rising linearly until the 555's upper trigger point (at  $2/3V_{cc}$ ) is reached.

The output (pin 3) then goes low, as does the open-collector discharge output at pin 7. The latter shunts the output of the current mirror to earth, D1 becoming reverse-biased and isolating C.

Now only current source Q1 is connected to the timing capacitor which is now linearly discharged by current  $I$ . In this way C is alternately charged and discharged. When the voltage on C falls to the 555's lower trigger point at  $1/3V_{cc}$ , the output and discharge pins go high, and the



cycle recommences; the repetition frequency is determined by the magnitude of  $I$ , which is set by the voltage applied at the input point A.

With the component values shown, the frequency range is from approx.

2.5 kHz to less than 10 Hz, as the control voltage varies from +10 V to zero; the frequency is directly proportional to the control voltage. Other ranges may be obtained by altering the value of C.

# CLASSIFIED

**J & J ELECTRONICS LTD.,**  
P.O. Box 1437 E.  
Winnipeg, Manitoba R3C 2Z4

Semiconductor Specialists  
Do you get our bargain flyers? Send \$1.00 to receive the current literature and specials and to be placed on the mailing list for the future publications.

**FREE! New 64 page electronics parts and surplus catalog jam packed with exciting items and hard to find bargains for hobbyist, industry and schools.**

Thousands of super buys in; Electronic parts, motors, hardware, microphones, semis, fans, assemblies, timers, knobs, connectors, CB accessories, speakers, transformers, telephones, leds, ICs, optics, wire alarm parts, meters, amplifiers, kits, photocells, TV parts, audio accessories, computer parts, power supplies, bulbs, transmitters, fuses, switches, tape, heaters, crystals, etc. etc. Over 100 top name stereo brands discounted. Amazing values for everyone. We are big buyers of factory clearouts, distress merchandise and government surplus. Largest inventory of surplus in Canada

**ETCO ELECTRONICS, Dept.**  
ETI, 183G Hymus Blvd., Pointe Claire, Quebec. H9R 1E9

## SUPREME ELECTRONICS

Our new catalogue will be available September 1/77. Reserve your copy now by sending \$1.00 (redeemable) to our new address: **P.O. Box 58276**, Postal Station L, **VANCOUVER, B.C. V6P 6E3**

## AMPLIFIER KITS, ELECTRONIC PARTS

best quality and cheapest

50W/50W RMS stereo kits ... \$155.00  
125W RMS pow. amp. module \$95.00  
40W RMS pow. amp. module \$40.00  
2N3055/MJ2955 2MHz 200W \$3.50/pr.  
MJ802/MJ4502 5MHz 200W \$8.50/pr.  
7400, 7402, 7404 ..... \$0.21  
LM-741 \$0.30, LM-1310 \$1.50,  
LM-555 \$0.55, Resistor \$0.50 each;  
capacitor \$0.10 each, Free catalog:

**COMPUTRONICS**  
**P.O. BOX 531, STA "H"**  
**MONTREAL, P.Q.**

# VIBRA-JET®

URNS TUN-O-WASH INTO A



patent pending

## PULSATING...VIBRATING... "CLEANING MACHINE"

You have never seen anything like Vibra-Jet, our new patent pending aerosol pulsating device. Just plug it into a can of Tun-O-Wash and you get strong vibrational solvent impacts that instantly penetrate heavy grease, gunk and baked-on contaminants. Vibra-Jet action even washes away dirt on horizontal surfaces . . . makes Tun-O-Wash more effective, leaving tuner parts and controls "vibrantly clean."

Vibra-Jet is made of strong durable polyurethane construction. Works in all positions and comes complete with 26 in. hose and 12 in. probe for hard-to-reach parts.

**FREE! FREE! FREE!**

FOR A LIMITED TIME ONLY, Vibra-Jet will be offered free with the purchase of 2 cans of Tun-O-Wash.

Pick up our "Cleaning Machine" . . . it will be the best time saving investment you've ever made.

Available at participating distributors.

The Sound choice from...

**PACO®**  
PACO ELECTRONICS LTD.



45 stinson st eet montreal, quebec h4n 2e1  
tel. (514) 748-6787

Our business is improving yours!



## YOU CAN'T TELL THE COVER BY THE COVER!

Dear Sir: I've been racking my brains for the last couple of days but I still can't figure out the significance of the cover picture of the June issue of *Electronics Today*.

Is it appropriate for a trade magazine? If so, please explain.

L.P. Oraziotti, Chairman  
Mechanical/Electrical Technology  
The Sault College of Applied Arts  
and Technology, Sault Ste. Marie.

*First of all we must make the point that we are not a trade magazine, although we no doubt appeal to many in the trade. The cover picture applies to the "Learn to relax" associated with the G.S.R. Monitor — so for any others that are getting tensed up over it — there's the answer.*

## ANY MORE?

Dear Sir: Perhaps you could add a page of *Tech Ideas* for which the readers could be given free subscriptions to E.T.I.

Mr. H. Dyrda  
Victoria, B.C.

*We believe our Tech Tips fills the bill and payment for each one should cover a subscription.*

## MAIL ORDERING

Dear Sir: In going through your list of catalogues I find you have neglected Cam Gard which is very informative except they do not have prices. This was advertised last year in Tom Graham's "Workshop" and sells for \$5.00 which is refundable on the first order. The catalogue is over 900 pages and they have offices and outlets from Halifax to

## YOUNG AND IMPRESSIONABLE

Dear Sir: Because you're so young and impressionable, as your editorial suggested I'm going to use this opportunity to criticize, and perhaps mould you into the kind of magazine I would like to see. It's almost like taking advantage of you isn't it?

1. Both the longer feature type of construction article and the short quickies are great. I'm a hobbyist and I find both types of articles useful in designing new circuits for problems I encounter.

2. However, telling me that I should use an Arama AT-49 doesn't help very much unless I happen to have a catalogue or spec. sheet. Odds are that I have an equivalent in my parts box but unless I know the specs. on the components, I'll never know. If you can please publish the component specs. with the manufacturer's house number.

3. Please start an index! I get so frustrated in trying to remember where I saw a specific circuit. A detailed index, even an annual type, listing every circuit, even the tiny ones, would be an incredible help.

4. Your article describing the "V.C.T." was great "new technology" articles are stimulating and informative.

5. Even your advertising can be of some

value. I would like to be made aware of Canadian parts suppliers, especially domestic equivalents of Poly Paks and other such surplus dealers. Delays of 4 weeks and duties and taxes of 27 per cent on imported components are two drawbacks of ordering from U.S. companies, although in most cases, prices are still better than anything available domestically.

6. So your Canadian! You can't depend on flag covers for customers, nor does a Canadian post mark make a good magazine. If you put out a good magazine, I'll buy it. Incidentally though, it is nice to see "US \$3.00 extra" on your form, that is one small irritation I have with U.S. publishers and their mailing policies.

7. Someday, perhaps when enough IC's fall together before my very eyes and I create the world's most complicated flashing I.e.d. circuit, I will send it to you. Until then, good luck.

G. Stasyne  
Springstein, Manitoba,

*Thanks! We will be publishing a yearly index and have noted your other requests. All constructive criticism like this is welcome — we produce this magazine for you, the reader, so it's nice to hear your views, good or bad!*

**AKTRON'S**

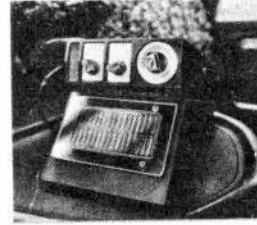
New CB  
Sound Saddle  
let's you hear  
What you've  
been missing

Oaktron Industries puts your CB radio in the SB Sound Saddle to give you reception you never before thought possible. The specially made, built-in 3" x 5" voice communication speaker virtually eliminates unwanted high and low frequency interference — then directs the sound to you, not to the floor.

Oaktron's CB Sound Saddle is fully adjustable to almost any transmission hump. Even

if it is not permanently attached, it's designed to ride out any kind of trip with ease, yet is fully portable if you want to remove entire unit.

CB Sound Saddle includes all hardware needed, takes 4-6 minutes for custom assembly. No tools needed. Your choice of grilles; Black Enamel, Walnut Woodgrain or Chrome Plated. All American made for dependability's sake.



Meet a whole  
new concept  
in CB sound  
and convenience.

1. Powerful 3" x 5" voice communication speaker aims clear, crisp sound directly at you.
2. Puts your CB radio controls within easy reach.
3. Custom-fits completely secure on most any transmission hump.
4. Permanent or portable installation.

**omnitronix ltd.**

2056 SOUTH SERVICE RD. TRANS CANADA HWY. - DORVAL, QUE. H9P 2N4 - PHONE: (514) 683-6993

Vancouver. I believe that they are a division of Neonex.

There has been quite an argument re: buying in kit form. Living in a small community I have to order by mail. This makes me favour the kits:

1. The items are complete in one package.
2. The guarantee is with one company
3. One order
4. One remittance
5. One delivery charge
6. In the case of importation — one customs clearance.

I have bought many kits from the U.S.A. and have no disappointments. Kits have come from PAIA, Southwest Tech., and Bill Godbout and have had no trouble with customs or shipping. In addition to those suppliers I have purchased from Gladstone in Toronto, Radio Shack in Barrie, J & J and Cam Gard in Winnipeg, ETCO and Coronet in Montreal, Dartec in Dartmouth and Vargard in Edmonton. Our success has been in finding out whether or not these people appreciate mail orders and then sticking with them. There are many outfits who do not appreciate mail order business and steer clear of them.

I have been rambling but I hope some of the information is interesting.

Jim Henry  
Marathon, Ontario

## JAM PACKED!

Dear Sir: First yours is about the only magazine that I have seen in Canada that has all that good information in; it is the only electronics magazine that I have seen that carries most all of the ads from Canada. And finally it's the best magazine that I have found so jam packed full of good information, how do you get it all in

that small magazine?

I have bought this magazine now for over a year. It sure is nice to see it in Canadian voltages and terms, keep up the good work. I hope that you will be as good as this from here on

F. Spencer  
A C N.T. Worker in P.Q.

*So do we — if not better!*



"IF YOU CAN'T SEE IT  
— IT'S GONE!"

**WHY**  
TAKE CHANCES

?

TAKE OUT A  
SUBSCRIPTION

GRAPHIC EQUALISER, 25W + 25W  
HI-FI AMP, LOUDNESS CONTROL,  
SIMPLE STEREO, BASS BOOSTER,  
STEREO FM TUNER, LINE AMP,  
GUITAR ATTACK CONTROL,  
DUAL HEADPHONES

**ETI TOP PROJECTS**  
No. 3 electronics £1  
today international

ADAPTOR, AF METER,  
DIGITAL DISPLAY, IMPEDANCE  
METER, TTL SUPERTESTER, DIGITAL  
VOLTMETER, CAR ALARM, TACHO  
TIMING LIGHT, COLOUR ORGAN,  
RADAR INTRUDER ALARM, BIKE  
SPEED, ELECTRONIC IGNITION,  
AUTO-LUME, FLUORESCENT LIGHT  
DIMMER, COMBINATION LOCK,  
DRILL SPEED CONTROLLER, LIGHT

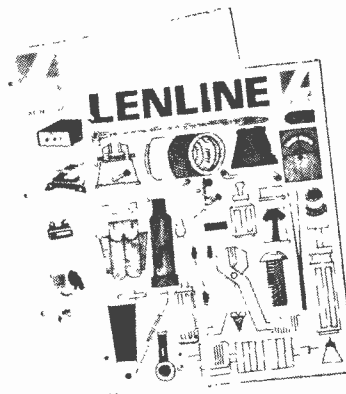
## NOW AVAILABLE IN CANADA! ETI TOP PROJECTS No. 3

The third in our popular series of reprints of the most popular projects in ETI. Includes projects for the audiophile, motorist, for the home, test gear and many more. Full constructional details of each project are given — 27 in all, including a stereo tuner, 25W per channel amplifier and a graphic equalizer; put those together and you have a superb hi-fi system.

Top Projects 3 costs only \$2.50 — please order from

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

## GET YOUR FREE CATALOGUES... NOW!



Here are two fully illustrated, specialized complete-line catalogues for the C.B. and electronics enthusiast.

**Lenline Cat. #1:** with 35 pages, it provides a broad range of quality electronic tools, accessories and hardware. Choose from adaptors and heat guns to screws, testers and wrenches.

**C.B. Accessories Cat. #2:** with 27 pages, it offers a complete range of dependable C.B. accessories. These include antenna mounts, boosters, coax connectors, noise suppressors, speakers just to name a few.

All merchandise is available at authorized distributors, located across Canada.

Mail the order coupon today and get your free catalogues now!



**len finkler ltd.**

25 Toro Rd., Downsview, Ont.,  
M3J 2A6 416-630-9103  
Telex 065-24010

Mail to: len finkler ltd.

25 Toro Rd., Downsview, Ont. M3J 2A6

Please send me the free catalogue(s) I have indicated:

Lenline Cat #1:

C.B. Accessories Cat #2:

Send to: Name: \_\_\_\_\_

Address: \_\_\_\_\_

City: \_\_\_\_\_

Postal Code: \_\_\_\_\_

Prov: \_\_\_\_\_

# LEADER TEST INSTRUMENTS

WHATEVER YOUR NEED, LEADER HAS THE RANGE OF GOOD FUNCTIONAL INSTRUMENTS TO MEET ALL YOUR SPECS... AT REASONABLE PRICES.



"PUT US TO THE TEST."

**omnitronix Ltd.**



2056 SOUTH SERVICE RD.  
TRANS CANADA HWY  
DORVAL, QUE. H9P 2N4  
PHONE: (514) 683-6993

WRITE FOR YOUR COPY OF OUR DETAILED CATALOG. YOU OWE IT TO YOURSELF TO COMPARE.

## COMPUTER GRADES & ELECTROLYTICS

FOR POWER SUPPLIES AND AUDIO APPLICATIONS



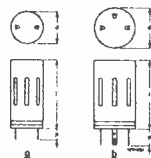
### SUMMER SPECIALS

500 mfd	75 volts	\$1.75
4700 mfd	40 volts	\$5.20
15000 mfd	25 volts	\$6.90
22000 mfd	10 volts	\$6.90
22000 mfd	25 volts	\$7.95
33000 mfd	40 volts	\$8.95
47000 mfd	10 volts	\$7.50

TYPE NO.	WORKING VOLTAGE (V)	CAPACITANCE (μF)	CAN SIZE	PRICE
431CR A10000	6.3	10000	6	3.50
431CR A15000		15000	8 <sub>a</sub>	4.10
431CR A22000		22000	9 <sub>a</sub>	5.20
431CR A33000		33000	9	6.00
431CR A47000		47000	10	6.90
431CR E3300	16	3300	5	2.70
431CR E4700		4700	6	3.50
431CR E6800		6800	8 <sub>a</sub>	3.70
431CR E10000		10000	8	4.20
431CR E10000/9A		10000	9 <sub>a</sub>	5.20
431CR E15000		15000	9	6.20
431CR E22000		22000	10	6.90
431CR F2200	25	2200	5	2.70
431CR F3300		3300	6	3.50
431CR F4700		4700	8 <sub>a</sub>	3.70
431CR F6800		6800	8	4.20
431CR F6800/9A		6800	9 <sub>a</sub>	5.20
431CR F10000		10000	9	6.20
431CR F15000		15000	10	6.90
431CR G1000		40	1000	5
431CR G2200	2200		6	3.50
431CR G3300	3300		8 <sub>a</sub>	3.70
431CR G4700	4700		8	4.20
431CR G4700/9A	4700		9 <sub>a</sub>	5.20
431CR G6800	6800		9	6.20
421CR G10000	10000		10	6.90
431CR H680	680		5	2.70
431CR H1000	1000	6	3.50	
431CR H1500	1500	8 <sub>a</sub>	3.70	
431CR H2200	2200	8	4.20	
431CR H2200/9A	2200	9 <sub>a</sub>	5.20	
431CR H3300	3300	9	6.20	
431CR H4700	4700	10	6.90	

CAN SIZE	FIG	DIMENSIONS (mm) & (ins)*					
		d		l		p	
		mm	ins	mm	ins	mm	ins
5	a	21	0.84	50	2.0	12	0.47
6	a	25	1.0	50	2.0	12	0.47
8 <sub>d</sub>	a	30	1.2	50	2.0	12	0.47
8	a	30	1.2	80	3.2	12	0.47
9 <sub>a</sub>	b	35	1.4	50	2.0	12	0.47
9	b	35	1.4	80	3.2	12	0.47
10	b	40	1.6	80	3.2	12	0.47

Fig a & b



## DOMINION RADIO & ELECTRONICS COMPANY

THE HOME OF RADIO & ELECTRONIC SUPPLIES

535 YONGE STREET TORONTO 5, ONTARIO

TELEPHONE 922-1818

## AD INDEX

Abbey Electronics	2
Allan Crawford Associates Ltd./Ltee.	9
Brand X	16
Canmos Electronics	9
Cesco Electronics Ltd.	63
Classified advertisements	59
Dominion Radio and Electronics	16, 62
Gamasonic Canada Ltd./Ltee.	3
Len Finkler Ltd	61
Magnum Electronics Inc.	4
Omnitronix Ltd.	16, 60, 62
P.T.S. Electronics Canada Ltd./Ltee.	O.B.C.
Paco Electronics Ltd.	59

## AUTHORS

OK, all you budding authors, we know you're out there. ETI, as you may have noticed is the only Canadian magazine for the electronics hobbyist and enthusiast. Now, we like to think of you all frantically rushing about buying components for, and building, our projects. But we know you won't all do that — it would be very boring if you did, because some of you are doing your own things, designing your own projects, and sometimes, getting them to work.

So, if you've built something interesting, and it works, perhaps you would like to see it as an ETI project. We even pay you for the privilege of seeing your pride and joy in print. Or, perhaps you haven't built anything you feel worthy of the accolade, but you could write an interesting feature article.

Either way we'd like to hear from you.

### Classified Advertising Rates

Minimum charge \$27.00 per insertion  
 Minimum size One inch depth by one column wide (2 1/8").  
 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 advertiser provides permanent address and phone number. 10% discount on consecutive insertions without copy change. Copy must be received 8 weeks preceding 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 preceding month of issue.

#### 0.7" Led Clock Module



#### 4 Digits Alarm Clock

LT701E, 60Hz  
12 hr. display  
EACH LT701G, 60 Hz  
24 hr. display

Power Supply 12V AC  
Ideal for panel clock, desk clock, or auto clock kit

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

COMPANY NAME AND ADDRESS HERE

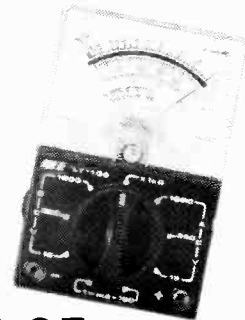
Send copy and cheque or money order to  
 ETI Magazine; Classified Advertising Dept.,  
 25 Overlea Blvd, Unit 6,  
 TORONTO, Ontario, M4H 1B1

# CESCO

## A WORLD OF ELECTRONICS

### 1000 OHM/VOLT MULTITESTER

Compact pocket-size multitester with 1000 ohm/volt. Mirror scale. Measures AC & DC volts to 1000 volts; DC current to 150 ma; Resistance to 150 ohms; Decibels — 10 to + 22 db. Uses one 'AA' size battery. Battery and test probes included.



Model LT106 Only **\$9.95**

Complete range of multitesters up to 100,000 ohms/volt available. Write for information.

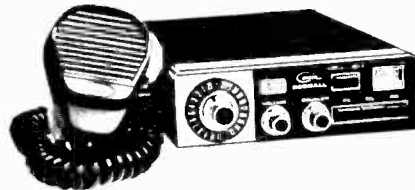
### INTEGRATED CIRCUITS



CESCO has one of the largest stocks of Integrated Circuits in Canada, off-the-shelf at competitive prices. Only top brand name manufacturers such as Texas Instruments, Motorola, R C A, Signetics, Monsanto, AMI, stocked.

Write for your requirements and our best prices. Drop into any of our branches or write for complete information.

### CB MOBILE UNIT



Compact heavy duty 23 channel mobile. Features full 3 watt audio speaker. Positive/negative ground. Can take overvoltage up to 16 VDC. Push-button controls include local/distance noise limiter, noise blanker and PA/CB. Illuminated channel selector.

Model REDBALL Only **\$229.95**

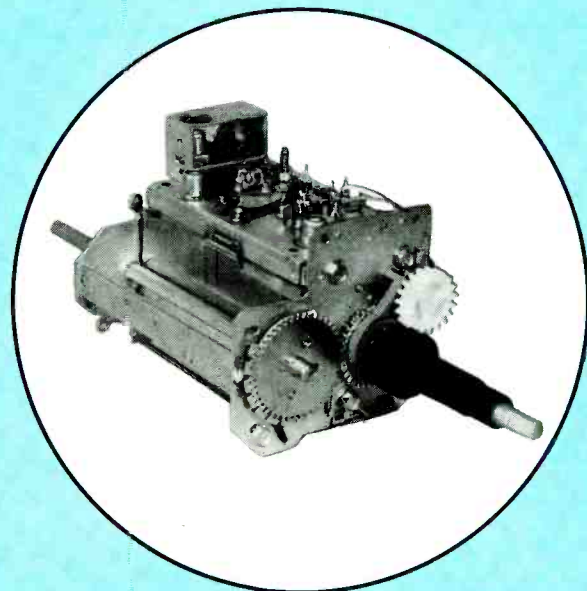
COMPLETE RANGE OF CB UNITS  
 IN STOCK

# CESCO

electronics ltd.

MONTREAL 4050 JEAN TALON ST. W. (514) 735-5511  
 QUEBEC 98 ST. VALLIER O. (418) 524-4641  
 OTTAWA 1300 CARLING AVE. (613) 729-5118  
 TORONTO 24 MARTIN ROSS AVE. (416) 661-0220

# 4 reasons pts canada offers the best in tuner repair service



## *Same Day Service*

Eight hour service means that tuners are repaired and ready to go the same day we receive them.

## *Original Parts*

Only original parts are used on all tuner repairs.

## *One Year Warranty*

Workmanship and parts are warranted one year from the date of repair.

## *Versatility*

We repair them all—Color Black & White, Tube, Electronic/Varactor or Transistor. . . Any Make, Any Model, including foreign makes.

VHF or UHF...\$13.95      UV-COMB. \$21.95  
(Major Parts and Shipping Extra...Dealer Net)

**PTS ELECTRONICS CANADA LTD.**  
PRECISION TUNER SERVICE

8400 St. Lawrence Blvd., Room 205  
Montreal, Quebec H2P 2M4  
514-381-5838

Ask about our Tuner Replacement Guide and Parts Catalog. PTS Canada also has a complete line of tuner testing instruments, fully assembled or in kit form.

