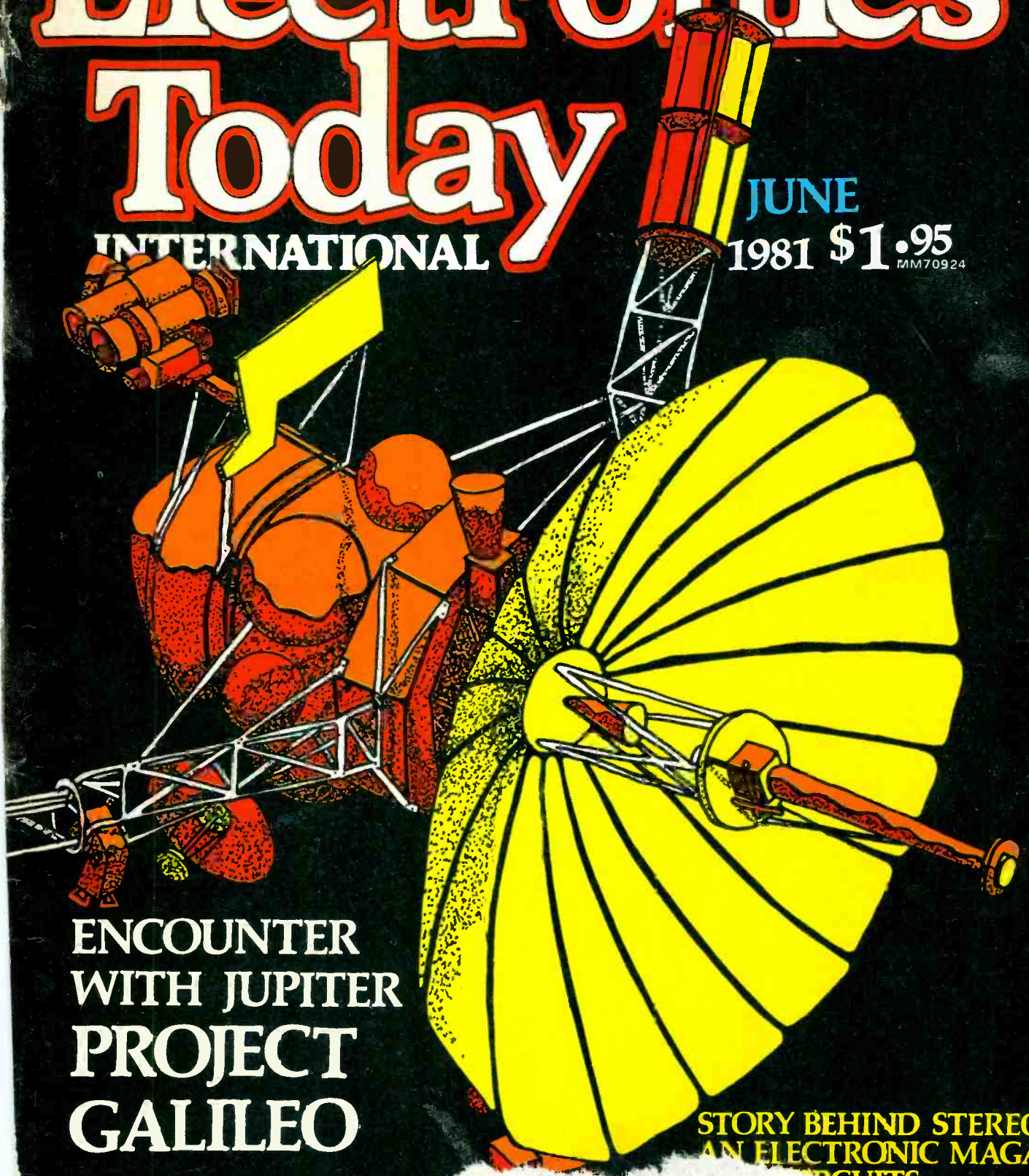
Electronics Today

INTERNATIONAL

JUNE 1981 $1.95

MM70924



ENCOUNTER WITH JUPITER

PROJECT GALILEO

STORY BEHIND STEREO

AN ELECTRONIC MAGAZINE

RCUITS

SSETTE INTERFACE

DOUBLE DICE

LE SPEEDOMETER

06

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arkon electronics ltd

COLOUR MODULATOR Kit #1 $24.95
This video modulator has been designed to complement the small home computer. It allows the standard colour television to be used as a high quality colour video monitor. Uses state of the art integrated circuit technology. Direct coupling is employed to provide white level compensation in the vestigal sideband output. The gain device of the LM1889's croma oscillator is used to buffer, level shift, and invert the incoming composite colour input. The signal then passes to the RF modulator where a channel 7 carrier is provided. Requires 12 volt DC for operation.

VIDEO TO RF MODULATOR Kit #2 $8.95
Converts a video signal to a RF signal. The RF output terminals connect to the antenna of your TV. Connecting in the video and supplying 5 to 10 volts DC is all that is needed. You turn your channel selector to 4, 5 or 6 (whichever is not used in your area) and tune the adjusting coil for a suitable display.

POWER SUPPLY Kit #3 $16.95
This kit has been designed to satisfy the need for an economical power supply. Provides 5 volt DC at lamp for TTL projects plus a separate floating power supply that is variable from 5 to 35 volt DC at 1/2 amp for CMOS and other uses.

MAD BLASTER Kit #4 $4.95
The MB-1 produces a load "ear shattering" and attention getting siren like sound. This kit can supply to 4 watts of obnoxious audio into an 8 ohms speaker. Requires +5-15 volts DC for operation.

COLOUR ORGAN Kit #5 $14.95
Good for home colour organ to light up your sound system. Three channel, four level controls. Up to 500 watts per channel (more with heatsinking).

SIREN KIT Kit #6 $3.95
The siren kit will duplicate the sound of a police siren at a low volume (200 MW) or at a high volume (5 watts) depending upon construction. Closing of the pushbutton will produce the upward wail typical of a police siren, opening will cause the tone to fall downward. Requires 3-12 volts DC.

LM380 AMP-SUPER SNOOP Kit #7 $6.95
Many applications for this kit, intercom, mini pa system, telephone amplifier, room bug amplifier and more. Uses ceramic or crystal mike for input with 8ohms output. Requires 9 DC volts for operation.

CRYSTAL TIME BASE KIT Kit #8 $6.95
The crystal time base kit provides a highly accurate source of 60 HZ which is useful for operating digital clocks when there is no cource of 60HZ power available.

ELECTRONIC UNIVERSAL TIMER KIT Kit #9 $5.95
The universal timer kit provides the basic parts required to provide a source of precision timing and pulse generation. The U.T. makes use of the versatile 555 timer IC which is capable of both astable and monostable operation.

TONE DECODER KIT Kit #10 $6.95
Can be used as a touch-tone decoder. Its frequency range is 400HZ to over 5KHZ. Bandwidth 2% to greater than 15% of center frequency. Output sink current 100ma. Requires +8-15 volts DC. Audio input level should be 50-100m volts. Useful for touch-tone burst detection, or as a stable tone encoder.

CODE OSCILLATOR/TONE GENERATOR Kit #11 $2.95
Can be used as a code oscillator (1KHZ), burglar alarm, light operated oscillator, light operated burglar alarm, variable frequency audio oscillator and much much more. Runs on +3-12 volts.

LED BLINKER Kit #12 $2.95
Great attention getter with many applications. Alternates flashing of two LED's. Flashing rate is determined by two capacitors which can be changed to increase or decrease the rate of flashing. Runs off voltages up to 20 volts.

BI-POLAR LED BLINKY KIT Kit #13 $3.95
Another great attention getter. Same as #12, however, it uses 1 LED. The LED changes from red to green. Requires 3-9 volts DC.

FM WIRELESS MIKE KIT Kit #14 $3.95
The FM-1 is a small circuit used to transmit onto the FM band. Requires crystal or dynamic mike and 3-9 volts DC. Transmits 300 feet.

FM WIRELESS MIKE KIT (WITH PRE-AMP) Kit #15 $5.95
Same as #14, however, it has a sensitive mike pre-amp.

DECISION MAKER Kit #16 $5.95
A random flashing of two LED's. Red for no, green for yes. Requires 9 volts DC.

MAGNETIC PRE-AMP (ASSEMBLED) Kit #17 $9.95
This magnetic pre-amp provides the required pre-amplification and R1AA equalization for a magnetic cartridge. Runs on 18 to 24 volts.

ARKON LOGIC PROBE LOGIC 1 Kit #18 $24.95
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LED POWER METER Kit #19 $24.95
Uses the popular LM3915 display driver. Features switch selectable peak or average peak power level indication. The front end utilizes precision half wave rectification. LED displays included 30 db (−24 db to +3 db) dynamic range.

LED VU/POWER METER Kit #20 $29.95
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NSM 3916 — 23 db (−20 db to +3 db VU)

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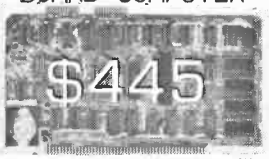

Z80A-CPU RUNS AT 4 MHz; 8K EPROM AND 1K RAM; SERIAL AND PARALLEL I/O PORTS; 4-CHANNEL COUNTER/TIMER USING Z80-CTC; PROGRAMMABLE BAUD RATE GENERATOR; NO FRONT PANEL REQUIRED FOR OPERATION.

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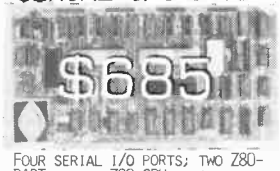

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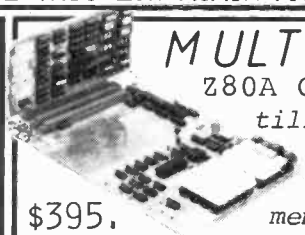

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Toronto, Ontario, M4H 1B1
Telephone (416) 423-3262

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INTERNATIONAL EDITIONS
Electronics Today International,
145 Charing Cross Road,
London WC2H 0EE, UK

Electronics Today International,
Ryrie House, 15 Boundary Street,
Rushcutters Bay, Sydney, Australia

Elrad
Kommanditgesellschaft, Bissendorfer
Strasse 8, 3000 Hannover 61, Germany

Electronica Top Internationaal
Postbus 93, Bilthoven, Holland

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

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

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Second Class Mail Registration No.3955.
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Electronics Today INTERNATIONAL

Features

Project Galileo **35**
Project Galileo is an interplanetary probe that will go to Jupiter to make people out there feel like they're being watched. Steve Rimmer investigates the launch at T minus three years (and counting)

Story Behind Stereo **42**
You probably think stereo was invented to help dispose of a manufacturer's over-production of speakers. It could very well be. Ian Sinclair explains.

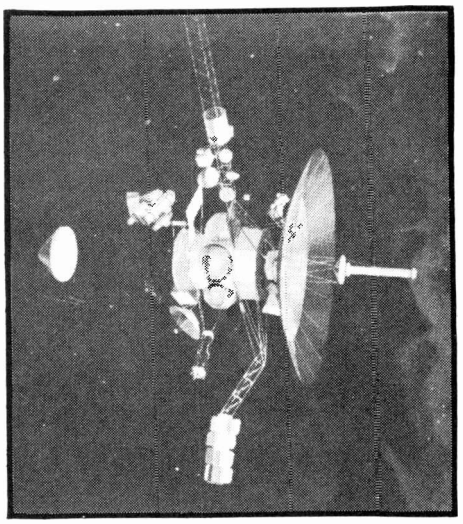
Solder **15**
Solder can be used for purposes other than bending it into little wire animals while on the phone. K.T. Wilson suggests a few.

Computerese **24**
Computerese is more colourful than Eight is Enough on Acid, and easily as interesting as The Love Boat getting torpedoed. It's a whole computer magazine on your tube. . .via Telidon. Shane Dunne views the phosphor splendor.

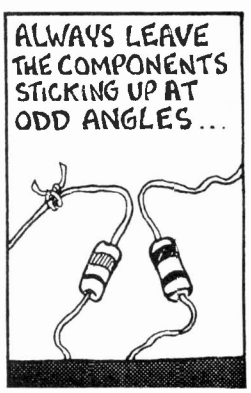
Projects

1537A VCA **54**
This new chip will do truly astounding things as a voltage controlled attenuator. Stick Pierre Trudeau into it and it'll turn him down to Rene Levesque. Keith Brindley mans the pot.

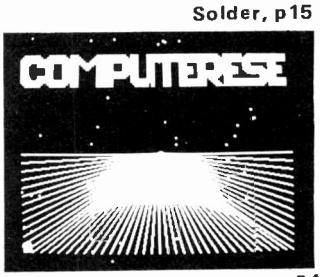
High Speed Cassette Interface **11**
Ever listened to computer data at 4800 baud? Ever try writing it down at that speed? Hard, isn't it? This little wonder saves you from blistering your thumb and forefinger.



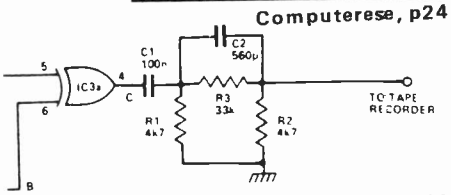
Project Galileo, p35



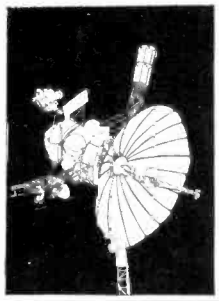
Solder, p15



Computerese, p24



Cassette Interface, p11



Cover: If you find this device in your back yard you are (a) quite loaded, (b) the recipient of a huge mis-calculation or (c) living on Jupiter. This is Galileo, mankind's first ambassador to the house of Jove. (cover by Sarah Jane Newman)

ISSN 0703-8984

Double Dice 19
If you roll regular dice enough times they'll go round, and become useless. ETI has found a solution to this vexing problem. . .electronic dice. Battery powered, of course.

Bicycle Speedometer 29
Ride off into the sunset at a speed of your choosing with this project. One thing, though. . .you've got to do it on a two wheeler. The circuit doesn't seem to work on horses.

Bike Speedometer, p29

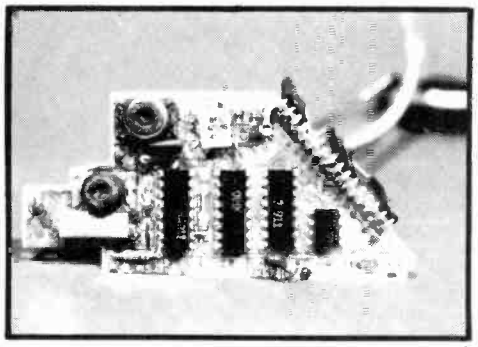
Columns

What's New 49
Steve Rimmer

Fun of Electronics 61
Paul Geiger

Audio Today 68
Wally Parsons

Tech Tips 72



What's New, p49

News & Info

News 7
Book Service 26
ETI Order Form 27
ETI Binders 27
Arr Billy 27
Special Publications 48

Sinclair's Latest, p52

ADVERTISERS' INDEX

Active Component Sales Corp . . 80
Allan Crawford Associates Ltd . . 8
Arkon Electronics 2
Audiovision 73
Avalon Audio 77
BCS Electronics 74
Ceres 73
Challenge Software 46,77
Classified 71
Cyprus Products 34
Dominion Radio and Electronics 6,7
Duncan Instruments Ltd. 48
Dynamic Sound and Components 40,41
Electronic Packaging Systems 74
Electronics 2001 46
Exceltronix 3
Heath Company 39
Kyll Electronics 39
Len Finkler Limited 79
McGraw Hill 33
Metermaster 47
Nu West Video Systems Ltd. . . . 76
Orion Electronic Supplies 78
R-A-E Industrial Electronics Ltd. 76
H. Rogers Electronic Instruments 75
Tuner Service Co. of Calgary . . . 73
Videoland 74

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Binders made especially for ETI are available for $6.75 including postage and handling. Ontario residents please add sales tax.

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ETI is available for resale by component stores. We can offer a good discount when the minimum order of 15 copies is placed. Readers having trouble in obtaining the magazine could ask their local electronics store to stock the magazine.

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

PCB Suppliers
ETI Magazine does NOT supply PCBs or kits but we do issue manufacturing permits for companies to manufacture boards and kits to our designs. Contact the following companies when ordering boards.
Please note we do not keep track of what is available from who so please don't contact us for information on PCBs and kits. Similarly do not ask PCB suppliers for help with projects.

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A-1 Electronics, 5062 Dundas Street W., Islington, Ont., M9A 1B9.
Beyer & Markin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3M 1H1.
Spectrum Electronics, Box 4166, Stn 'D', Hamilton, Ontario L8V 4L5.

535 Yonge Street,
Toronto, Ont. M4Y 1Y5
Phone (416) 922-1818
No collect calls please

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RESISTORS

Values from 1 ohm to 10 meg. 1/4 or 1/2 watt. Still Only 3½¢ each.

CAPACITORS NISSEI POLYESTER FILM

Price	uF	Price	uF	Price	uF
.0010 .20	.012	.20	.0027	.20	.027
.0012 .20	.015	.20	.0033	.20	.033
.0015 .20	.047	.30	.0039	.20	.039
.0018 .20	.056	.30	.0047	.20	.12
.0022 .20	.068	.30	.0056	.20	.15
.0068 .20	.082	.30	.018	.25	.18
.0082 .20	.10	.30	.022	.25	.22
.010 .20					

CAPACITORS

AXIAL LEAD

uF	WV(SV) 16 (20)	WV(SV) 25 (32)	WV(SV) 50 (63)
1			.25
2.2			.25
3.3			.25
4.7			.25
10	.25	.25	.30
22	.30	.30	.35
33	.30	.35	.35
47	.35	.35	.35
100	.35	.40	.50
220	.35	.40	.55
330	.40	.50	.65
470	.45	.55	.75
1000	.60	.70	1.00
2200	.75	1.05	
3300	1.05	1.35	
4700	1.65	1.95	

TANTALUMS

DIPPED SOLID TANTALUM
Capacitance Tolerance +/-20%

uF	WV(SV) 16 (20)	WV(SV) 25 (32)	WV(SV) 35 (46)
0.22			
0.33			
0.47			.35
0.68			.35
1.0			.35
1.5			.35
2.2			.35
3.3			.35
4.7	.35		.35
8.8	.35		.35
10	.45	.50	.55
15	.50	.55	.85
22	.55	.65	1.35
33	.65	1.20	2.25
47	1.95	2.75	
66	2.75		
100	3.50		

RADIAL LEAD

uF	WV(SV) 16 (20)	WV(SV) 25 (32)	WV(SV) 50 (63)
1			.25
2.2			.25
3.3			.25
4.7		.25	.25
10	.25	.25	.25
22	.25	.25	.25
33	.25	.25	.30
47	.25	.30	.35
100	.30	.30	.35
220	.30	.35	.45
330	.35	.40	.60
470	.40	.50	.85
1000	.60	.75	
2200	1.00		

POWER SUPPLY

POWER SUPPLY

1400	16	.65	6800 Com	25	6.95
1600	16	.65	15000 RPE	10	4.50
2200	16	.75	12000 COM	40	6.95
2500	10	.65	14000 COM	40	7.50
1000 Can	16	1.50	15000 RPE	10	4.50
4700 Elec	40	1.75	15000 Can	16	4.90
4700 COM	100	8.95	15000 CAN	25	5.50
6800 RPE	25	6.95	15000 Com	50	11.95
			44000 Com	35	14.95
			80000 Com	20	14.95

PC BOARD SPECIALS

Epoxy Base PC

6"x6½" ..... 25¢ ea.
13"x4" ..... 35¢ ea.
13"x6" ..... 50¢ ea.

ETCHANT

16 oz .....$ 2.25
32 oz .....$ 4.25
140 oz $14.95

ZENERS

TYPE #	VOLTAGE	WATTAGE			
BZX61-C75	3.3V	1W	IN758A	10	1W
IN4623	4.3	1W	IN759A	12V	1W
IN751A	5.1	1W	IN964B	13	.5
IN4733A	5.1	1W	3E21605	14	1W
IN4734	5.6	1W	IN966	16	1W
14-515-04	6.2	1W	BZX61-C18	18	1W
114574	6.2	.5	HZ20C	20	1W
IN753A	6.2	1W	BZX61-C20	20	1W
IN754A	6.8	1W	GE5028	20	.1W
IN752A	5.6	1W	14-515-31	22	.5
17-515-35	6.8	1W	IN4751A	30	1W
HZ7B	7	1W	BZX61-C30	30	1W
IN755A	7.5	1W	BZX79C36	36	½W
IN74738A	7.5	1W	BZX61-C56	56	1W
IN757A	9.1	½W	IN5045	56	5W
IN4739A	9.1	.5	BZX61-C68	68	1W
BZX61-C9V1	9.1	1W	IN4764A	100	1W
IN757A	9.1	1W	1N5593B	183	1W

49¢ EA

PART No.	REPLACE	DLR. PRICE					
2N2906 -	ECG - 159	1.79	AD161 -	ECG - 155	4.95	2SC940 -	ECG - 283	11.95
BF-245 -	ECG - 133,	1.99	2SC1025-	ECG - 175	2.95	2SC939 -	ECG - 163A	12.95
2N3391 -	ECG - 199	1.15	2SC1304-	ECG - 124	2.59	BF245A -	ECG - 133	2.25
BF-199 -	ECG - 161	1.59	2SC1104-	ECG - 124	2.59	2SC945 -	ECG - 199	.89
T1S 92 -	ECG - 128	2.40	2SD24Y -	ECG - 124	2.59	2SC1685-	ECG - 199	.89
E0136 -	ECG - 185	2.99	AD162 -	ECG - 131	3.99	2SC454 -	ECG - 289	1.59
E0135 -	ECG - 184	2.79	AD139 -	ECG - 104	1.89	2SC839 -	ECG - 123A	1.59
2SC1505-	ECG - 198	2.95	2SC1160-	ECG - 175	3.50	2N6358 -	ECG - 191	4.25
2SC1520-	ECG - 198	3.00	2N3614 -	ECG - 171	3.95	2SC458 -	ECG - 289	1.49
2SC1507-	ECG - 198	2.95	2SC1106-	ECG - 162	9.95	2SB77 -	ECG - 102A	1.99
2SC1446-	ECG - 198	2.95	BD182 -	ECG - 130	4.79	2N1613 -	ECG - 128	1.99
MJE2370-	ECG - 242	3.59	BU205 -	ECG - 165	9.95	AC-187 -	ECG - 103A	2.30
			BU108 -	ECG - 165	9.95			

POTENTIONMETERS

A huge selection available. Slider controls from 99¢ to $2.95; Single pots 49¢ (with switch 59¢) Dual pots 69¢ (with switch 79¢) See out catalogue for full range and other types.

MINIMUM ORDER

$10.00. All merchandise subject to prior sale. Prices subject to change without notice.

SHIPPING.

Add 5% extra to cover shipping, excess refunded. Orders over $75 shipped pre-paid. Ontario residents add 7% P.S.T.

7400	.43	7423	.55	7472	.55	74123	1.10
7401	.45	7425	.65	7473	.70	74125	.98
7402	.45	7426	.65	7474	.70	74141	1.15
7403	.40	7427	.55	7475	.98	74150	2.50
7405	.75	7430	.45	7476	.70	74151	.98
7406	.85	7440	.45	7485	1.40	74154	2.50
7407	.95	7441	1.35	7486	.60	74160	1.75
7408	.75	7442	1.35	7490	1.15	74164	1.25
7409	.45	7446	1.45	7491	1.15	74177	1.45
7410	.39	7447	1.65	7492	.85	74190	1.65
7411	.55	7448	1.75	7493	.85	74191	1.60
7412	.55	7454	.65	74121	.65	74192	1.55
7413	.85	7460	.40	74122	.90	74193	2.95
7420	.45						

4000 SERIES

4000	.50	4015	1.50	4026	2.35	4044	1.05
4001	.45	4016	.50	4027	.85	4045	1.78
4002	.45	4017	1.50	4028	1.50	4047	1.09
4006	1.25	4018	.75	4029	1.25	4049	.45
4007	.20	4019	1.65	4030	.60	4050	1.50
4008	1.15	4020	1.25	4033	1.95	4069	.45
4010	.75	4021	1.95	4040	1.29	4510	1.95
4011	.65	4024	1.25	4041	2.05	4511	1.95
4013	.65	4025	.40	4043	1.30	4516	1.35
4014	.90						

MICRO PROCESSOR

LS SERIES	PRICE				
74LS00	.85	74LS32	.80	74LS109	.80	8080	8.95
74LS04	.60	74LS33	.60	74LS125	1.00	8212	3.00
74LS08	.65	74LS38	.80	74LS132	1.40	8216	3.50
74LS10	1.50	74LS74	.70	74LS151	1.60	8224	8.95
74LS11	.75	74LS75	1.10	74LS155	1.10	8228	6.25
74LS20	.70	74LS86	.70	74LS247	1.18	8255	8.95
74LS30	.65	74LS90	.95	Z80	14.95	4116	7.95

Edu Kit's

LOGIC TRAINER.....$74.95
MODEL DLT01
A new development package for a BASIC DIGITAL LOGIC COURSE. Four gates and a counter. Circuit is included along with an in-depth manual. Protoboard included.

STEREO PHONO PREAMP KIT.....$11.25
MODEL EK80SP001
Anyone with a ceramic input receiver can enjoy the quality of a magnetic cartridge with this simple but very effective Stereo Phono Preamp.
Specification: Standard RIAA, Frequency Response: 20Hz to 2KHz + 1.5dB, Input Sensitivity: 5mv input for 500mv output. Maximum Ouput: 700mv rms. Input Overload: 100mv rms. S/N Ratio: Greater than 60dB.

16 CHANNEL MULTI-MODE LED CHASER KIT.....$32.95
MODEL EK80LCM16
We're proud to add this to our line. It's similar to our 15 channel LED chaser but with many extra features. There are over 60 selectable modes. A few: Up, Down, Skip, Pulse, Scramble, Single Pulse. Multi Pulse and many more. An optional 120 vac board is avaliable. (Extra)

STROBE LITE KIT.....$21.95
MODEL EK80SL001
Fantastic for special effects. Variable speed Xenon flash gives you a "STILL MOTION" effect. A real attention getter.

CRYSTAL RADIO KIT....$8.95
MODEL EK80CR001
A self powered radio which uses a resonant circuit and detector for AM radio reception. An ideal project for the beginners.

1.5 to 24v POWER SUPPLY KIT.....$24.95
MODEL EK80PS024
A variable Power Supply suitable for many digital and linear applications. Delivers an output current of 100ma. from 1.5v to 15v and 500ma. from 16v to 24v.

0.28 VOLT POWER SUPPLY KIT.....$39.95
MODEL EK80PS028
A true 0 to 28 volts capable of delivering 1 amp continuous. Full wave rectification, filtering and capacitance multiplication provides a clean dc source for sensitive audio and digital work. An ideal supply for the experimenter.

STEREO AUDIO MIXER KIT.....$49.95
MODEL EK80AM001
Inputs 2 phono, 1 aux. Master control. Expandable. Frequency response 20Hz–20kHz; 5v output, 0.01% distortion.

16 CHANNEL LED CHASER KIT.....$22.95
MODEL EK80LC016
A very familiar sight seen at discos, department stores, and on neon signs. 16 LED's flash in sequence up-down or alternate. Adaptable to 120 vac. (Extra)

POWER SUPPORT 120 ...$24.95
MODEL EK80PLC120
A 120 volt power board which allows you to connect regular lamps to our LED Chaser Kits. 8 channels are supplied per board with 150 watts per channel. They can be easily interfaced for 16 channels.

5 WATT IC AUDIO AMPLIFIER KIT $19.95
MODEL EK80A00S
A general purpose 5 watt amplifier with Thermal Overload and Short Circuit Protection. Because of its low operating voltage and high

DOMINION RADIO: The Home of Radio and Electronics Supply

Circle No. 12 on Reader Service Card.

RADIO

TRANSFORMERS

8801S $8.95
Primary 110V. Secondaries 700V @ 150mA, 250V @ 50mA, 13.5V @ 1.5A (Specifically designed for the 7984 transmitting compactron tube.)

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Primary 110V. Secondaries 28V @ 2A, 6V @ 500mA

24-10182-1 . . . . . $14.95
Primary 110V. Secondaries 56V (CT) @ 8A, 2V @ 2A, 6.3V @ 4A

24-10182-2 . . . . . $14.95
Primary 110V. Secondaries 58V (CT) @ 10A, 24V @ 2A, 6.3 @ 4A

321 TK. $3.95
Primary 1 120V: Secondaries 10V (CT) 500mA, 14V @ 500mA
Primary 2 120V: Secondaries 20V (CT) 500mA, 28V @ 500mA

PHILIPS

PHILIPS Electron Devices Division

DeForest *Quality Loudspeakers*

Tweeters — Dome

		Regular Prices
AD00400T8/4	18MM	15.40
AD00800T8/4	18MM	14.25
AD00900T8/4	18MM	15.00
AD140T8/4	Polycarbonate	15.40
AD141T8/4	Textile	15.40
AD01600T8/4/15	Exposed Textile	19.25
AD01605T8/4/15	Square Exposed	19.40
AD01627T8/4/15*	Polycarbonate	17.40
AD01637T8/4/15*	Textile	17.30
AD01630T8/4/15	Textile	18.00
AD01631T8	Textile Square	21.20
AD01632T8	Paper	18.00
AD01633T8/4/15	Paper Square	21.00
AD01635T8/15	Diamond Cut Plt.	48.00

Tweeters — Dome — Ferro Fluid

AD01404T8/4	Available	17.30
AD01624T8/4	Early	18.00
AD01634T8/4	81	18.00

Tweeters — Cone

AD2273T8	2" Cone	5.45
AD2296T8	2" Cone	8.40

Squawkers (Mid Range) Dome

AD0211SQ8/4*	5" Textile	39.90
AD02110SQ8/4		37.75
AD02150SQ8/4		44.25
AD02160SQ8/4		46.50
AD02161SQ8/4	Deluxe Version	52.15

Squawkers — (Mid Range) Cone

AD5060SQ8/4*	5" Cone	28.00
AD5061SQ8/4	5" Cone	20.00
AD5062SQ8/4	5" Cone	26.65

Woofers

AD4060W8/4	4" 30W	22.25
AD5060W8/4	5" 10W	20.55
AD70650W8	7"	31.20
AD70652W8/4	7"	28.50
AD08120W8	8"	6.62
AD80100W8/W8W	8" 40W	43.00
AD80601W8	8" 30W	25.95
AD80651W8/4	8" 50W	32.40
AD80652W8/4	8" 50W	30.00
AD80671W8/4	8" 50W	37.50
AD80672W8/4	8" 50W	36.00
AD1065W8*	30 W 10"	56.25
AD10100W8/4*	40 W 10"	75.00
AD10240W8/W8W	70 W 10"	67.50
AD10650W8	30 W 10"	54.00
AD12200W8	80 W 12"	78.00
AD12240W8/W8W	70 W 12"	69.00
AD12250W8	100W 12"	85.50
AD12600W8	40 W 12"	46.80
AD12650W8	60 W 12"	52.00
AD15240W8/W8W	80 W 15"	69.75

Combi Plates (Squawker & Tweeter on Aluminum Plate)

		Regular Prices
AD21160ST8	Diamond Cut	85.00
AD21161ST8	Flat Back	85.00

Full Range

AD5081M8	10 W 5"	20.75
AD7062M8	30 W 7"	26.25
9710MC	20 W 8"	48.00
AD12100M8	25 W 12"	80.00

Passive Radiators ("Drone Cones")

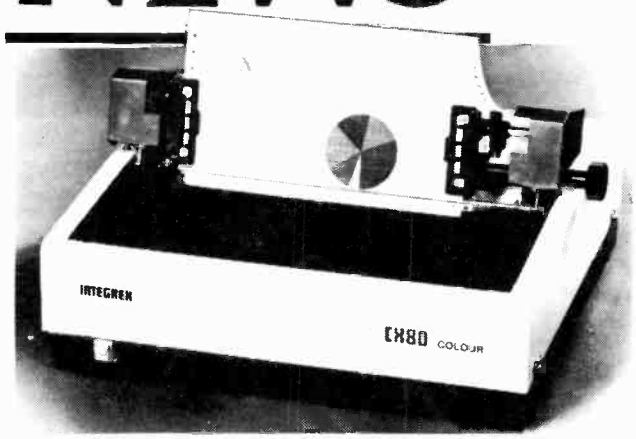
AD8000	Rubber Surround	14.25
AD8001	Rubber Surround	12.00
AD8002	Foam Surround	14.25
AD1000	Rubber Surround	34.50
AD10000/W	Foam Surround	15.00
AD12000	Foam Surround	18.75
AD1201	Rubber Surround	35.90

Cross-Overs

ADF1500/8/4	2 way	9.75
ADF1600/8/4	2 way	9.15
ADF2000/8	2 way	9.15
ADF2400/8	2 way	7.50
ADF3000/8/4	2 way	8.85
AD3WXSP	3 way hi-Power	37.50
ADF6/5SP	3 way hi-Power	32.00
ADF7/3SP	3 way hi-Power	41.10
ADF500/4500/8	3 way	17.40
ADF700/2600/8/4	3 way	22.50
ADF700/3000/8/4	3 way	22.50
AD1SUBW	Sub Woofer	37.50

535 Yonge St., Toronto, Ont. M4Y 1Y5

NEWS



Low Cost Matrix Printer

A new colour matrix printer, which requires no special absorbency paper has been developed by a British company.

The Integrex CX 80 can print text, graphs, histograms, colour VDU dumps and so on in up to seven different colours. Claimed to be a highly cost effective solution for colour printout, there is no restriction on the mixing of characters, dot addressed areas and colour changes on the same line. Colours are selected by 1 or 7 colour control codes. The printer decides which stripes from the tricolour striped ribbon are selected to produce the required colours, thus greatly simplifying host programme requirements. Special paper is not required for this printer, unlike the high absorbency paper required for ink jet types Normal plain white edge perforated paper is used, width 4" - 10".

The CX 80 is fully dot addressable in all 7 colours; the Character ROM contains 96 ASCII and 64 graphics characters. The 7 wire head produces a character format 5 × 7 plus graphics format 6 × 7. Print width is 80 columns of 0.1" wide characters. Resolution is 60 dots/inch. Print speed is 125 char/sec in a primary colour. There are also 15 user programmable characters. All characters may be printed in double length and/or reverse. Buffer length is two lines. Paper movement is programmable, with form feed and perforation skip up to 42.5" and line feed in 3 modes; 6 lines/inch, 8 lines/inch and microstep from 0.007" to 1.77".

The printer is compatible with most processors. The standard interface is Centronics, with RS232/V24 and IEEE488 as options. For more information contact Integrex Inc., 233 North Juniper Street, Philadelphia, Pennsylvania, 19107 U.S.A.

Satellite Mail

Postmaster General Andre Ouellet announced that Montreal, Ottawa, Halifax, Winnipeg, Calgary and Edmonton have officially joined the Intelpost link operating between Toronto, and cities in England, Europe and the United States.

A joint venture between Canada Post, CNCP Telecommunications and Teleglobe Canada, Intelpost is a high-speed facsimile service which allows Canadians to send clear copies of documents across Canada and overseas.

Located at main postal facilities, Intelpost uses CNCP's microwave network and Teleglobe Canada's international satellite facilities to transmit letters, charts, and other documents in seconds. Messages sent by Intelpost cost $4.00 a page in Canada and $5.00 a page internationally and can be picked up in 30 minutes.

Introduced in June 1980, between London, England, and Toronto, Intelpost was the first international electronic mail service of its kind. Washington, New York, Berne, Switzerland, and Amsterdam, the Netherlands, have since joined the system.

Introducing JET STOCK

● NEXT DAY SHIPMENT

● OVERNIGHT DELIVERY ACROSS CANADA

Introducing "Jet Stock", a high priority service from ACA Electronic Centres that doesn't cost you anything extra. With "Jet Stock" you get next day shipment of all orders and prepaid delivery across Canada, all at ACA's highly competitive prices.

This exciting new service is yours automatically, when you order products designated as "Jet Stock" inventory, including the following popular equipment:

- ***Fluke hand-held digital multimeters***
- ***Fluke bench digital multimeters***
- ***Fluke current, HV, RF, and temperature probes***
- ***Fluke multifunction counters***
- ***Anatek laboratory power supplies***
- ***Gould 15 and 25 MHz dual-trace scopes***
- ***Wavetek waveform and function generators***
- ***Shimpo digital tachometers***

Accessories and other products are also included. Additional items will be added as market demand and inventory quantities permit.

ON-LINE COMPUTER

This new service has been made possible through an on-line computer system which links all seven ACA offices and which automatically processes all documentation, right down to shipping instructions and inventory replacement orders.

NEXT-DAY SHIPMENT

ACA's extensive inventory program and accelerated shipping procedures ensure that your order is on its way to you not later than the next day after receipt of order.

DOOR-TO-DOOR DELIVERY

Highly efficient door-to-door delivery service now permits overnight delivery to most centres across Canada. Next day shipment followed by overnight door-to-door delivery gets your order to you faster than ever before.

COMPETITIVE PRICES

Automated order processing has permitted us to dramatically improve our service to you while maintaining our highly competitive prices. Now, we even ship prepaid at no extra cost to you.

HOW TO ORDER JET STOCK

Just place "Jet Stock" items on a separate order from other ACA products. That's all. We'll look after the rest.

To find out which products are "Jet Stock" call your local ACA office. And remember, the sooner we receive your order the faster you'll receive delivery.

aca JET-STOCK

Allan Crawford Associates Ltd.

Toronto: 6503 Northam Drive, Mississauga, Ontario L4V 1J2 Telephone: (416) 678-1500
Montreal: 7018 Côte de Liesse, St. Laurent, P.Q. H4T 1E7 Telephone: (514) 731-8564
Ottawa: 881 Lady Ellen Place, Ottawa, Ontario K1Z 5L3 Telephone (613) 722-7682
Halifax: 192 Joseph Zatzman Drive, Dartmouth, Nova Scotia B3B 1N4
In area codes 902 and 506 phone toll free: 1-800-267-6131
In area code 709 phone toll free: Zenith 01720
Vancouver: 3795 William Street, Burnaby, B.C. V5C 3H3 Telephone: (604) 294-1326
Calgary: 1935-30th Ave. N.E., Calgary, Alberta T2E 5Z5 Telephone: (403) 230-1341
Edmonton: 15043A – 118th Avenue, Edmonton, Alberta T5V 1H9 Telephone (403) 451-4893
In area code 403 phone toll free: 1-800-332-1092

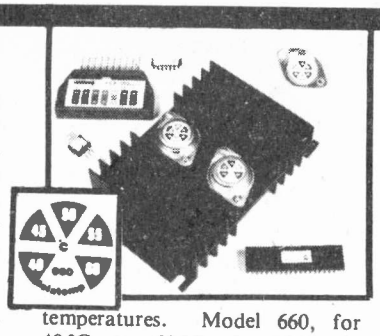
Circle No. 30 on Reader Service Card.

LCD Component Temperature Indicator

Telatemp Corporation, a leading maker of products for surface thermometry, has introduced the industry's first LCD reversible stick-on temperature indicators. The indicators are ideal for monitoring electronic component and PC board temperatures.

Unlike the industry-standard Telatemp Temperature Recorder which permanently records a temperature attained, the new reversible Telatemp LCD Contact Thermomenters allow continuous monitoring of changes in surface temperature.

Two models have been designed specifically to monitor component



temperatures. Model 660, for 40°C to 60°C, is 5/8" in diameter and is ideal for use with TO-3 and TO-66 metal cans. Model 880, for 45°C to 60°C, can be placed on DIP packages. Other LCD Contact Thermometers include the Model 770-1 (0 to 30°C and 32°F to 86°F) and Model 770-2 (30°C to 60°C and 86°F to 140°F).

Each LCD Contact Thermometer contains up to seven display windows. Each window has a different rated value in 5°C increments from 0°C to 60°C. At ±1°C, the windows are green. The windows turn blue when temperatures rise above the rated value or brown when temperatures fall below the rating.

An introdutory Component Temperature Indicating/Recording Kit consisting of three reversible models and three permanent recorders (value: $15.90) is offered to readers of ETI for just $10.00. Order LCD Kit No. 2. $10.00 U.S. payment must accompany order.

Kit includes 1. each, reversible models 770-2, 660 and 880; 1 each non-reversible models DIP-410 (for DIP packs), Model 505 (for TO-5 size cans) and Model 550 (for TO-3 size cans).

For more information write Teletemp. Corporation, P.O. Box 5160, Fullerton, California 92635.

ACA INTRODUCES NEXT DAY SHIPMENT

"Jet Stock", a new concept in order processing, has been introduced by Allan Crawford Associates Ltd., providing next day shipment of orders and prepaid overnight delivery to major centres across Canada, all at no extra charge

According to Al Martin, National Sales Manager for the Test & Measurement Division of Allan Crawford Associates Ltd., the new service has been made possible by the company's on-line computer system and the high volume of business.

All seven ACA offices across Canada are linked by the on-line computer system. Orders placed through any ACA office for designated "Jet Stock" products will now be shipped not later than the next day. Overnight delivery service is then provided to all major Canadian Centres.

Products presently designated as "Jet Stock" include many models of hand-held and bench digital multimeters, multi-function generators, and tachometers. Additional products will be added regularly as demand and inventory availability permit.

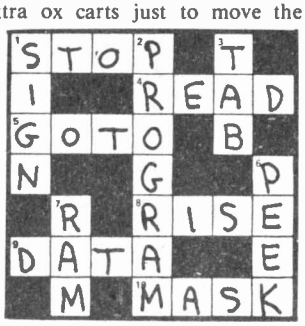
To obtain this service, however, it is important that non-Jet Stock items must not appear on the same order with designated "Jet Stock" products. Customers can quickly determine which products are designated as "Jet Stock" by contacting the nearest ACA office in Toronto, Halifax, Montreal, Ottawa, Calgary, Edmonton or Vancouver.

Making Telidon Cheaply

Starside Softworks of Toronto has announced a data capture and transfer package for the Apple II computer. This set of programs is for the creation of Telidon pages suitable for use in conjunction with Telidon systems. The package does not provide any high level graphic commands although it is possible to generate PDI commands. An improved version is in the works. Starside Softworks sees this package eing used by schools, businesses and individuals who wish to generate pages, but don't have access to costly IP terminals. For more information on Apple/Telidon Ver 1.0 write to Starside Softworks, 1179A King Street W., Suite 215, Toronto, Ontario, or telephone (416) 532-0230.

Winner

Yes, we seem, to have come up with a winner in our computer contest. It wasn't easy by any means. First off, you don't suppose it's a great laugh having to wade through over nine hundred million entries, do you? No sir. We've had to hire four extra ox carts just to move the



things around the office. And then, sadly enough, there were the bribes. One poor desperate lad sent in $11.31 in Canadian Tire money, and a three page disertation on how a microprocessor system would save his mother, who was at that moment afflicted with terminal varicose veins. However, we did eventually select one worthy soul, by throwing all the entries into a cement mixer to tumble them around, and drawing one out. Sadly, no entries can be returned, as one of our former employees carelessly forgot to take the cement out of the truck prior to the draw.

The lucky dude is one *Vladimir Glavac,* of Longueuil, Quebec. His entry, with the cement chipped off, is shown below...this is the right answer, by the way. He receives a complete 6800 microprocessor training course, along with a 6800 microprocessor and assorted on board paaraphenalia to train with, all generously donated by Heath. Congratulations from everyone at ETI, and the guy who owns the cement truck.

New Zentronics'

Zentronics, a devision Westburne Industrial Enterprises Ltd., plans to open a stocking branch in Dartmouth, N.S. The new branch will be opened in mid April & situated at 30 Simmonds Drive, Unit B, Dartmouth, N.S., B3B 1R3, telephone (902) 463-8411. The branch supervisor wil be Roy Sutton and inside man is Bob Blackwood.

Multiflex Z80 Review

One point arising from last month's article. The purchaser of the Multiflex Z80A will get an automatic three month subscription to the newsletter. Not one year as stated in the article.

Looking Back SI Units, December 1980

It has been pointed out to us that the definition of the metre given in the article is quite incorrect. Our reader A.T. Williamson says;

'Not so. They actually decided to use one ten millionth of the quadrant of the earth's circumference represented by the meridian . . . which passes through Paris. To their credit . . . (they achieved an error of) less than 0.023%. . .'

The original article, of course, was completely incorrect on this point. Our apologies to prospective metre stick manufacturers, Ian Sinclair has been sent off to reform school.

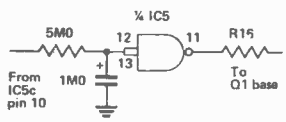
Guitar Preamp, May 1981

First off, C4 and C7 on the schematic are incorrectly labelled, their values are 22u. The Parts List is correct. Also, the track cutting diagram is incorrect. Insert a break at point J8 (this should improve the action of the bass control for those who have built the unit).

Ultrasonic Alarm, February 1981

Jan Vincent of Toronto suggests this modification for the unused Schmitt trigger of IC5. Essentially the circuit introduces a time delay to allow you to dash in and shut the unit off before it sounds. The values shown will give a delay of about 20 seconds.

One snag though. The signal from this gate will be inverted, so you'll have to do some tricks with PNP transistors or the relay contacts.



ETI SPECIALS

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Contains 25 of the best projects from recent issues including the High Performance Series 4000 Amplifier (including Preamps and Power Supply), Rumble Filter, Dynamic Noise Filter, Logic Probe, Cable Tester, Function Generator, Rain Alarm, Digital Tacho, Two Octave Organ, Light Chaser, Shutter Speed Timer, Ni-Cad Charger and more. First published January 1981.

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A collection of major articles on various aspects of circuit design including CMOS, Audio Amplifiers, Power Supplies, SCR's, Op-Amps, Using the 3080 and Temperature Control. A large number of useful circuits are given but the emphasis is on guidance and how to tackle the design for yourself.

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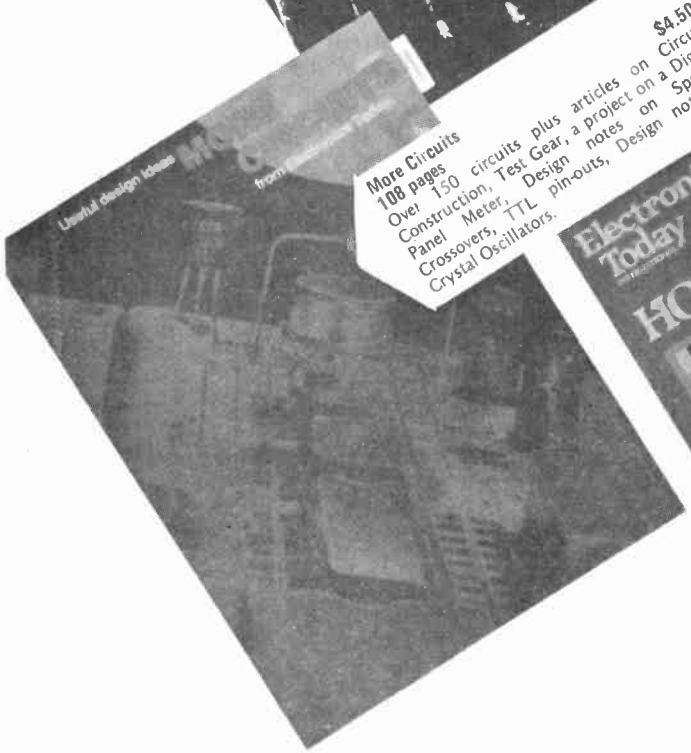

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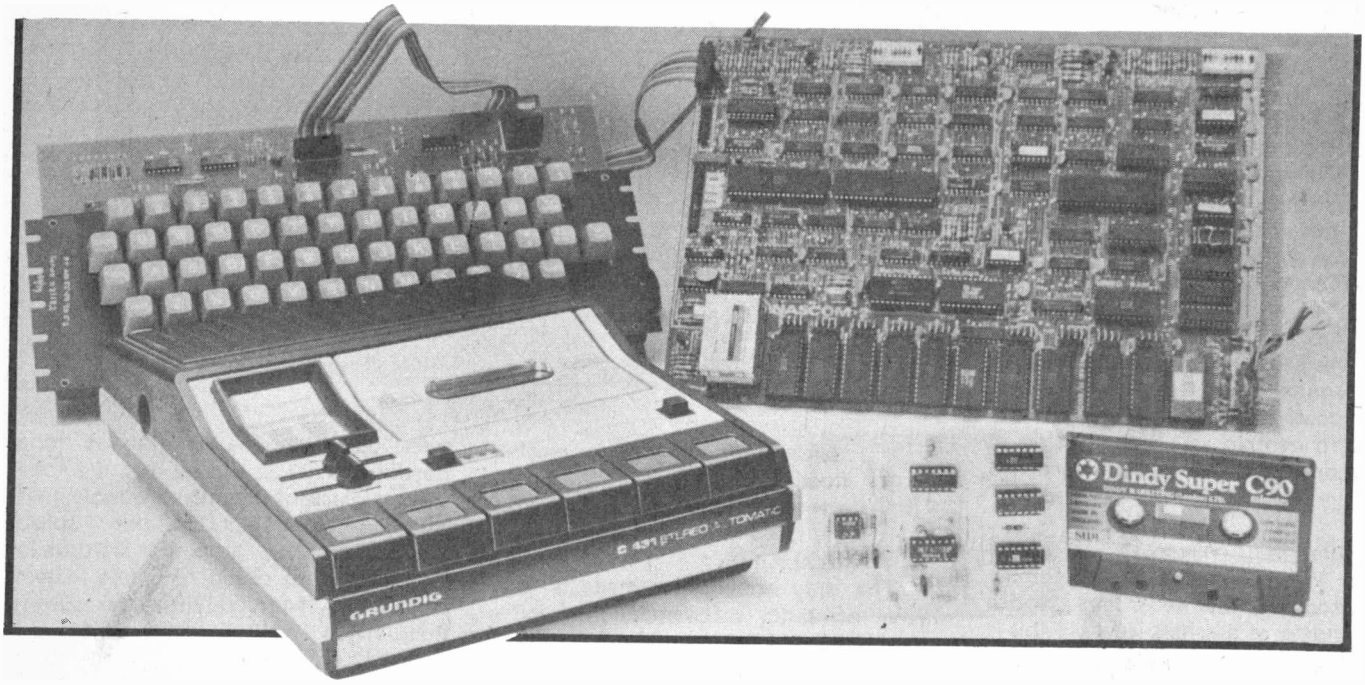
HIGH SPEED CASSETTE INTERFACE



Use ETI's supersonic interface to store and retrieve digital data on cassettes at an incredible 4800 bits per second. Design by Hugh Koanantakool.

MODERATE-SPEED cassette systems running at speeds up to 1200 baud have been with us for some time, but unfortunately the standard setters seem to prefer a slower 300-baud Kansas City standard. 300-baud can be too slow if you have a lot of data to manipulate and is suitable only for software distribution. That is, once the original chunk of a software package has been implemented in a system, the user or owner could then make a copy of that piece of software for his (or her) normal use. This working copy should be running at the highest data-transfer rate that the owner can afford. In case of a failure in the fast working copy, the user can always fall back on the original master copy running at the slow rate. This design enables you to store and retrieve digital data using an unmodified cassette recorder at 4800 bits per second. The prototype proved to be as reliable as any 300-1200 baud systems.

Dropout

One reason for cassette load/save failures is tape dropout – momentary loss of playback signal due to the absence of, or damage to, the ferromagnetic coating somewhere on an imperfect tape; or due to bad contact between the tape and the tape head. In audio cassettes, the tape runs at 1.875 inches a second. Thus, for a 300-baud KC (Kansas City) tape, a bit of data occupies approximately 0.00625 inches – how tiny! Any dropouts which are larger than that size will cause one or more bits of errors. The only practical solution is to use high quality cassettes which are certified or known to be originally free from dropouts. This applies to both 300-baud and the fast 4800-baud systems. From experience most tapes which are error-free at 300 baud can cope well at 4800 baud, but in the latter case, cassettes having good high-frequency specifications are preferred.

How Good?

This design aims to surpass all existing cassette interfaces in both speed and reliability, given that it should require no more hardware than other systems to build one. It should run well with an average tape recorder and cassette tapes which can cope with the KC standard or CUTS 1200-baud standard. There will be no timing adjustments. The system can be implemented on any existing serial, asynchronous communication channel and thus can be readily added to most home computers. If it becomes impossible to run the system at 4800 baud due to any reasons including those in my list of observations then you might have to slow down the data rate to, say, 2400 baud.

To do so you only have to slow down your UART (Universal Asynchronous Receiver and Transmitter) clock frequency. There is nothing else to adjust, thanks to the all-digital timing.

Phase Encoding

There is nothing new or magic about the phase encoding format for data storage on magnetic tapes. Figure 1 illustrates how it works. A logic one is represented by the 5 V level and the zero by 0 V (Fig. 1b). Most tape recorders cannot record and playback slowly varying

signals or DC. Therefore, a long series of ones or zeros will just come out the same if we attempt to connect the data signal (also called NRZ or Non-Return to Zero) directly to the recorder. This is because the data signal in NRZ format contains important information which is extended down to the very low-frequencies, beyond the frequency range of tape recorders.

Figure 1a shows a carrier wave oscillating at, in this case, 4800 Hz. The carrier is modulated by the data signal of Fig. 1b by the following rules:

(a) The data signal is assumed to be synchronised to the carrier. This means their transitions (edges) are perfectly in alignment.

(b) The carrier wave is inverted if data is a one and nomal ie non-inverted if data is a zero. The resulting modulated carrier is shown in Fig. 1c.

The phase encoded signal in Fig. 1c is known to contain very little energy at low frequencies and can be recorded and played back with little distortion.

Demodulation

Figure 1d shows the typical replay signal from the tape recording. Notice the rounding of all sharp edges – this is due to the high-frequency cut-off of the tape recorder. Also the high-frequency components of the signal will suffer from more attenuation than the low frequency components. By using some form of equalisation circuit, we can easily improve the signal into that shown in Fig. 1e, which is now good enough for a slicer circuit to decide whether it is high or low. The sliced signal in Fig. 1f is very similar to that of Fig. 1c but it may or may not be inverted by the playback amplifier inside your recorder; pulse transitions may not be so precisely timed as in Fig. 1c due to tape-speed fluctuations and it is more or less independent of the playback volume control setting. We then feed the signal of Fig. 1f to a digital circuit (a demodulator), which recovers the data signal (Fig. 1b) from the sliced signal (Fig. 1f) and presents it to the UART receiver section.

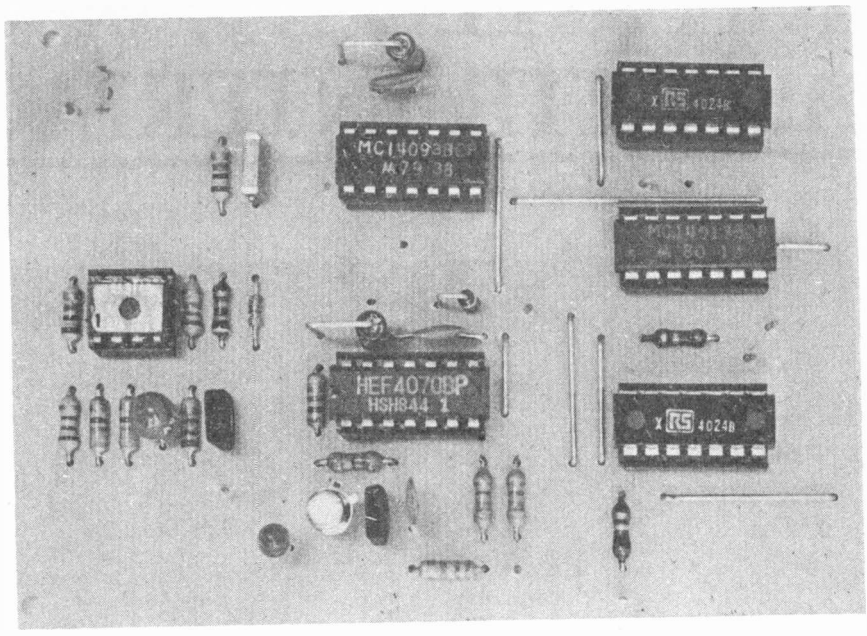
Implementation

You will probably need a "double standard" approach at least in the beginning so that tapes can be converted from the original slow rate to 4800 baud. The interface circuitry can be connected to your computer system using five wires:

– two power lines (common ground and the 5 V supply),

– two serial data lines (one for transmit (dump), one for receive (load),

one clock line running at 16x the baud-rate, i.e. 76,800 Hz at 4800 baud.



The only assumption made is that your computer software could handle the UART at 4800 baud. Some systems may not cope with a fast transfer rate. The serial I/O by program control instead of using a dedicated UART could be too slow, or maybe the VDU or TTY is not fast enough to dump some characters, eg file names, in real-time. However, if you are using a memory-mapped VDU (PET, Superboard II, etc) or your system monitor buffers the load time messages in RAM, there is no problem, since no major hardware modifications are to be made and no software or data format to be changed. The fast system has been in use since March 1979, accumulating the bit error rate to better than 1 in 10. The tape conversion process is fairly straightforward; switch your system to the original interface, load the original tape to computer, switch to 4800 baud and record the same software onto a new cassette.

Also, before you erase the old tapes, it may be a good idea to run both systems in tandem until you are sure you can trust the faster system.

Postscript

After experimenting with various kinds of tape recorders it is sad to say that some cassette recorders just cannot cope with the 4800-baud system. These recorders don't work with 300-1200 baud systems anyway, (or work with persistent troubles) and they can't even play back a continuous tone steadily! That is, if you record a tone and playback, it sounds so wobbly that anyone can detect its poor speed regulation. These properties are usually associated with cheap recorders. Users must avoid recorders with peak speed-fluctuations well over ± 20%, our required tolerance. Poor speed-regulation of a new recorder is associated with the lack of motor-regulator circuit, but it can also happen to a more costly recorder if the pinch-roller has been deformed, eg by leaving the machine off in the play position for a long time.

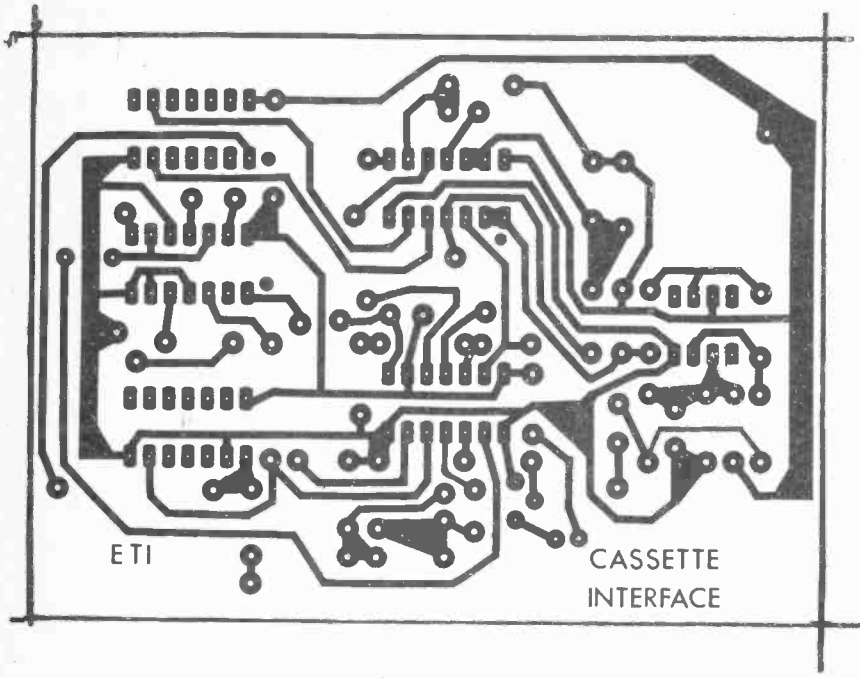
To sum up, the 4800-baud system may not work with all recorders due to the following reasons, in order of seriousness:

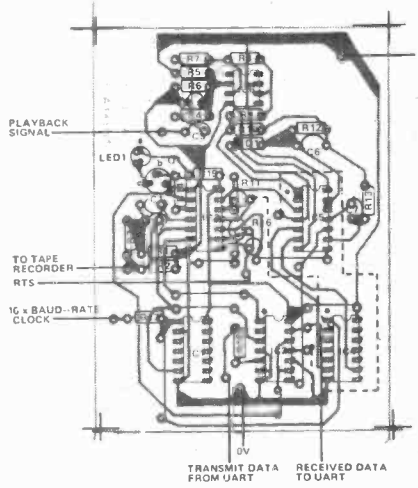
(a) recorder transport mechanics – you need a recorder that can at least reproduce clean steady tone,

(b) tape quality: use tapes which are better than just a "low-noise one, eg "Super Dynamic", "High Frequency", etc,

(c) recorder bandwidth – you tend to get more bandwidth from a radio-cassette than a hand-held recorder.

If your system has an RTS line and you are using it to control the cassette's motor, then you may also use it to control the received data line of this interface as well. When there is no input signal from the recorder, the idling sequence at point L (Fig. 2) is 1010101, which is a series of the valid ASCII 'U' characters causing over-run error in the UART. This error is normally reset by the tape loader routine before the data transfer takes place. A normal way





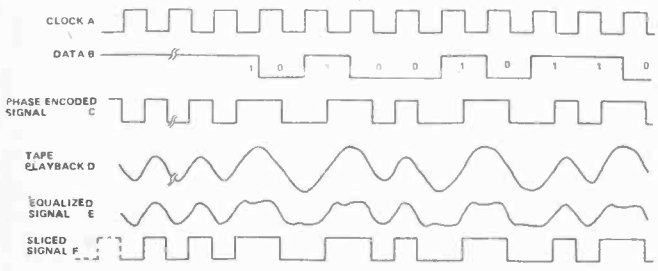


Fig. 1 Timing diagram. The signal output is attentuated to about 100 mV (RMS), suitable for the mic input of most cassette recorders. A high pass filter is included to pre-compensate any loss in high frequency in the cassette. You may not need pre-emphasis capacitor C2 if you use a hi-fi deck.

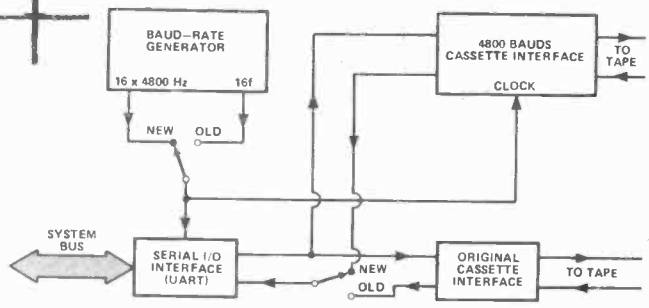
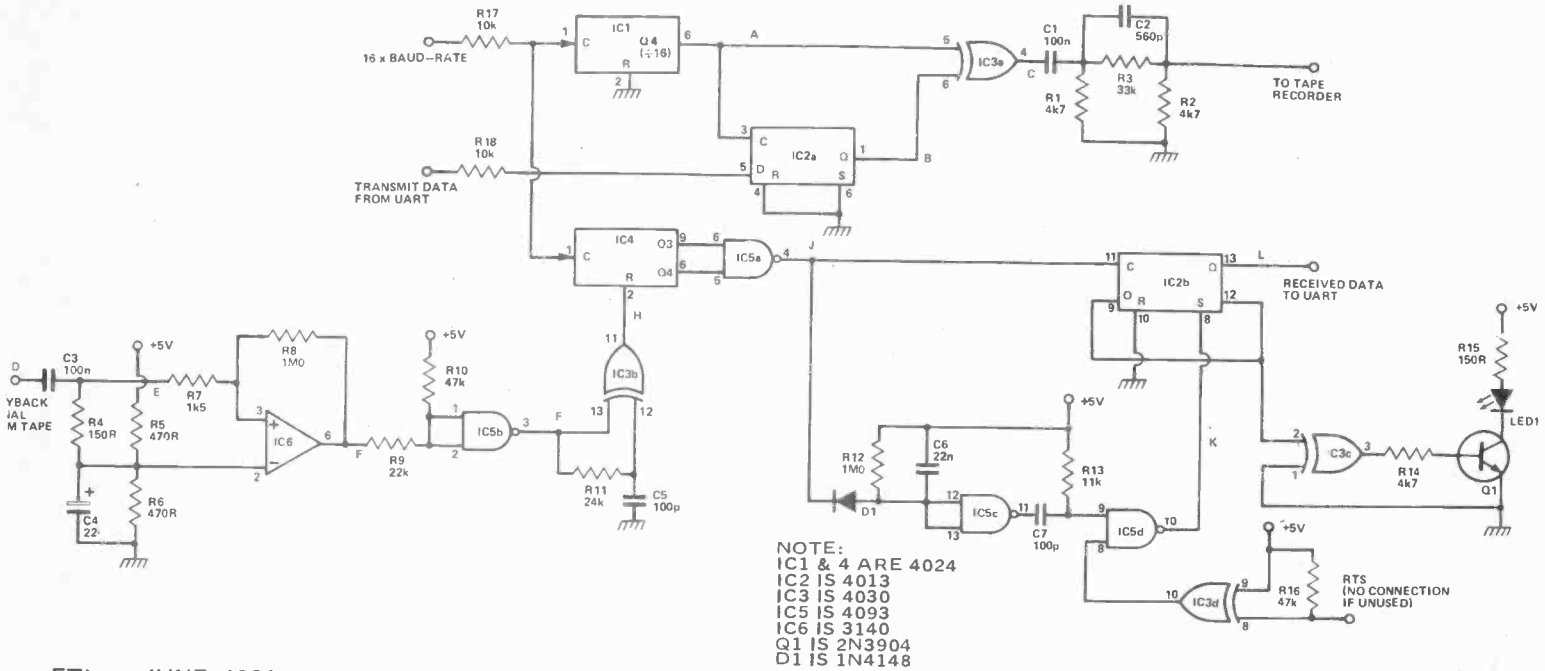


Fig. 3 Adding the fast cassette interface to your system.

Fig. 2 Circuit diagram. You may need a Request to Send (RTS) control. When the RTS output of the UART is active, the computer is ready to accept serial data from cassette interface or modem. When RTS is not used and there is no connection to IC3d pin 8, some series resistance is needed to prevent damage to the IC.



HOW IT WORKS

The upper part of Fig. 2 is the phase encoder. IC1 divides the UART clock signal by 16 to 1x baud-rate. The UART data signal is then brought to synchronism to our local clock (carrier) by means of a D-type flip-flop (IC2a). This synchronisation circuit makes sure that data transitions at IC2a always take place at the rising edge of the local clock (at A). However, if the computer data and the local clock happen to be in sync already, (a random choice of 1/16), this D-type flip-flop might be in trouble. In reality, this "perfect" chance of trouble never occurs, since the UART's internal + 16 clock divider circuit works much faster than IC1, even though both are triggered by the same falling edges of the 16x clock. Thus it is sure to achieve perfect synchronisation.

The lower part of Fig. 2 shows the receiver/demodulator section of the system. First the signal from the recorder's earphone plug is fed to IC6 via C3. The values of C3 and R4 are such that any drop in level of the high frequency signal from an average cassette recorder is equalised. IC6 then slices through the average level of the equalised signal (Fig. 1e). IC6 is wired as a Schmitt trigger circuit in order to suppress the background noise during playback. The output of IC6 is further buffered by IC5b. R9 and R10 make sure that the op-amp signal is well within the input range of the CMOS gate, IC5b.

The sliced tape signal is then passed through IC3b, which is configured as a one-shot triggered by both positive and negative-going transients. Its function is to generate a short pulse at point H whenever there is a level of transition at pin 10 of IC5b. The timing diagram is continued in Fig. 4 for the sake of explanation of the demodulation process. Pulses at H should be made as narrow as possible: anything shorter than 10 uS will be suitable. The pulse duration at H is proportional to the product of R11 and C5. The narrow H pulses reset the binary counter IC4, which is again clocked at 16x baud-rate. The counter outputs Q3 and Q4 are NANDed so as to enable us to detect whether its count reaches 12 or more (1100 to 1111 in binary notation). In other words, as long as the H pulses are no more than 0.75T apart, where T is the duration of one bit, the output of IC5a at J will always be a one. This is because the counter is always reset to zero before it counts to 12. At 4800 baud, T is 208 uS. Theoretically the H pulses are either 0.5T or 1T apart, corresponding to 8 and 16 counts respectively. Thus, discriminating the spacing interval by the threshold of 12 counts seems to be most logical, allowing some ± 20% tape speed fluctuation. In the other case, if the H pulses are more than 0.75T apart, we will get a negative-going pulse at point J. If there are no pulses at H at all, as in the absence of the playback signal from the tape, the signal at J will be pulsed regularly at the baud-rate frequency with the mark-space ratio of 12:4.

From the timing diagrams (Figs. 1 and 4), we may conclude that a "change" of the carrier phase corresponds to a change in the original data stream. This change in turn corresponds to the larger separation between successive H pulses, equal to 1T. Subsequently, long separation of H pulses is detected as a J pulse. We can, therefore, recover the original data signal from the J pulses by using IC2b, connected as a toggle flip-flop. It inverts its state upon receiving a J pulse. All seems to go well but we might still run into trouble if we happen to start IC2b wrongly and get all the datat bits inverted, yet still obeying the change conditions discussed. Care must, therefore, be taken to ensure that the logic state of IC2b is always properly defined before data transfer can take place.

Fotunately, the asynchronous serial data transmission convention is such that on a UART getting ready to transmit, it always sends a series of marks (logic one). This means that we always have a steady tone recorded prior to the actual data signal. Therefore, we can preset IC2b to logic one before any transfer process commences. This function is carried out by means of IC5c and d. If the carrier is detected continuously for longer than 20 mS, the circuit will assume that this is a series of marks or logic one. It then resets IC2b accordingly. All subsequent data bits will then be demodulated with the correct polarity.

PARTS LIST

RESISTORS ¼w, 5%

R1,2,14	4k7
R3	33k
R4,15	150R
R5,6	470R
R7	1k5
R8,12	1M0
R9	22k
R10,16	47k
R11	24k
R13	11k
R17,18	10k

CAPACITORS

C1,3	100n ceramic
C2	560p ceramic
C4	22u 25V tantalum
C5,7	100p ceramic
C6	22n polycarbonate

SEMICONDUCTORS

IC1,4	4024B
IC2	4013B
IC3	4030B
IC5	4093B
IC6	3140
Q1	2N3904
D1	1N4148
LED1	TIL209

of tape loading is to type into the computer, specifying a tape load command, start playing the cassette recorder until you hear the header tone (continuous 4800 Hz) then type RETURN to start loading. The presence of the continuous tone is also indicated by the LED going off temporarily. However, if you happen to get a monitor which does not reset the UART then you need to get rid of the 1010101 pattern by means of the RTS line. With RTS line low (no request for data transfer) the LED is also off and the data output line is kept high and no longer causes overrun errors.●

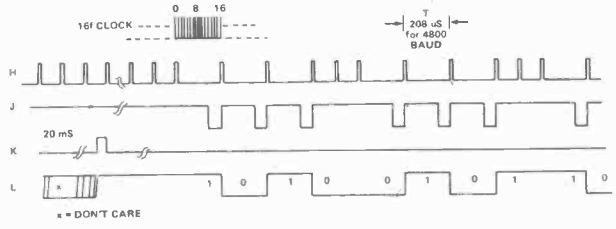


Fig. 4 Timing diagram.

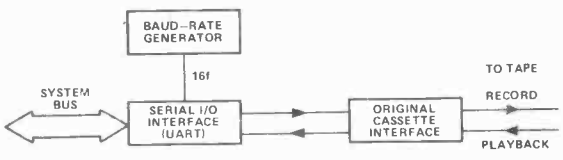
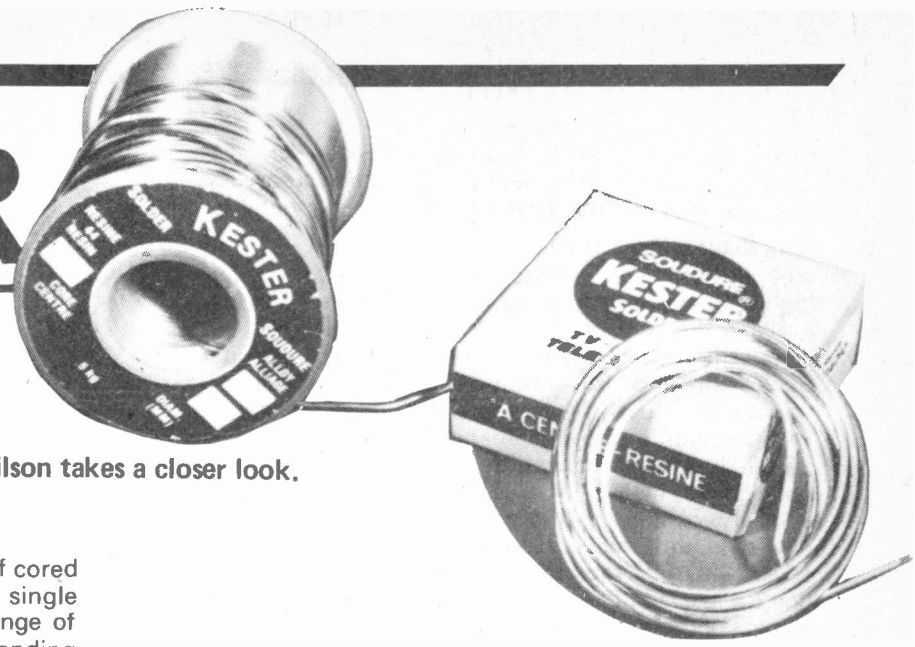


Fig. 5 Component overlay.

PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in Table of Contents. If you still have problems, please address your letters to 'ETI Query' care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.

SOLDER



Solder is solder is solder. . . .or is it? K.T. Wilson takes a closer look.

SIMPLE ENOUGH, isn't it? You just buy a reel of cored solder and that's it. Or is it? In fact there is no single material called solder, and there's a very wide range of behaviour that you can expect from solder, depending on their composition. Add to that dozens of materials that can be used for a flux core, and it doesn't look so simple.

Basically, solder is a mixture of lead and tin. Pure lead melts at about 327 C, tin at 232 C, but mixtures of tin and lead melt at temperatures which depend on the composition. Fig. 1 is a diagram which shows the melting points of various alloys — the important solders are the alloys which contain up to 60% tin. This type of diagram shows an important point — that there are mixtures of tin and lead which have melting points lower than either tin or lead. This lowest melting point is for a 63% tin mixture, called the eutectic — a name given to any mixture of materials whose melting point is the minimum.

The graph of Fig. 1 shows only melting points — but there's more to it than that. Pure materials, such as pure tin or lead, have sharp melting points — meaning that they go from liquid to solid for only a tiny fraction of a degree change in temperature. The eutectic mixture (63% tin) does this also, but all other mixtures of tin and lead which contain more than about 15% tin have a 'pasty' stage (Fig. 2), neither liquid nor solid. This pasty stage is important in soldering, because slight vibration during the setting of solder can cause fractures if there is no pasty range of temperatures. Fig. 2 shows the temperature range of the pasty stages for the various mixtures — not that these are always completely solid at 183 C, so that this is the final setting temperature of any tin/lead solder.

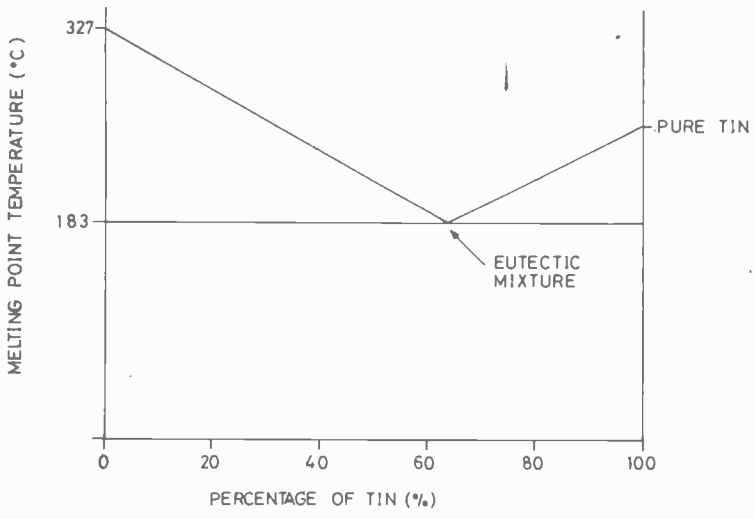


Fig. 1. Graph of melting point plotted against compositon for tin/lead mixtures.

Solder On

The reason for the popularity of the 60/40 alloy (60% tin) is fairly clear. It has a low melting point and a small pasty range; a good combination of qualities for hand-soldering. The low melting point lets us use low-power irons, and also avoids damage caused by the quick burn-off of flux which would occur at higher temperatures. The small pasty range (flux 180 C to 188 C) means that the alloy will set fairly quickly — blow on it once or twice and it's then strong enough to forget about. There are some merits which do not appear in the graph, though. One is that the 60/40 mix is one of the strongest, another is that it is the best electrical conductor of all the tin/lead alloys (about 11.5% of the conductivity of pure copper).

The 60/40 alloy, along with the 50/50, 45/55 and 40/60 alloys are the solders most commonly used for soldering small electrical equipment. Solders with lower tin contents are used for purposes where higher running temperatures are encountered, such as in lamp bases, electric motors, dynamos and fuses.

The lead/tin alloy isn't the only type of solder mixture, though, particularly for the industrial user. A straight lead/tin mixture dissolves copper, and copper is the material that we use for the business end of the soldering iron. The result is that bits of irons wear away very rapidly as the copper of the 'iron' bit dissolves, and the tracks of PCB's can also be dissolved in the same way, causing thinning of the copper layer. This problem is serious for large-scale production soldering work in particular, and can be overcome by making solder which already has a content of about 1.5% of copper. This is about as much copper as a tin-lead solder would normally dissolve, so that the inclusion of copper into the solder virtually puts an end to the dissolving of copper by the alloy from the bit or the PCB. Copper-alloy solder, invented by Multicore (a British firm), and sold under the

trade name of SAVBIT is used extensively for large-scale work, and is sufficiently well proven to be approved for soldering work on military equipment.

Gold Solders Never Die

Not all soldering makes use of 60/40 alloys. For high-temperature soldering, alloys with only 5% tin are available (melting at 301 C); at the other end of the composition scale there is non-toxic solder which has 96.3% tin and the remainder silver. Such lead-free solder can be used when soldering has to be in contact with foodstuffs (as in tin-cans for example, or water pipes). Just for a bit of variety, there is also a low melting point solder, melting at 145 C, which contains 50% tin and 18% cadmium. This is of particular use in soldering onto gold, and the very low soldering temperature is an advantage for IC internal soldering. Another low melting point alloy is 62% tin, 2% silver, 36% lead, which solders particularly well to silver-coated sufaces. It finds particular use in soldering ceramics to metals. Table 1 shows some alloy compositions.

The metal, of course, is only half of the solder process. When we solder metals together, the temperature that has to be used is high enough to enable the oxygen in the air to attack the metals and the solder as well. In addition, we want the solder to spread over the surface of the metals. Now the spreading of a liquid over a solid is greatly affected by the presence of other materials — for example, water will not spread on glass if there is a trace of silicone grease on the glass. Liquid solder is equally fussy, and traces of dirt on metal surfaces will simply prevent solder from spreading.

A flux is a material which is used to avoid both of these problems. A good flux should help to clean up the metal surfaces (though it can't be expected to perform miracles) and should form a protective coating around the solder and the metals being joined so as to avoid oxidation.

For non-electrical soldering, acid fluxes can be used. These materials are acid enough to dissolve away impurities; the sort of work that is soldered in this way is usually 'pickled' in acid anyway, so that the acidity of the flux is unimportant. For electrical work, however, strongly acid flux of this type has to be avoided like the plague. It's not very often that we can boil our printed circuit boards in water for several hours to get rid of acid, and if we don't remove it then the life of the conductors will be pretty short.

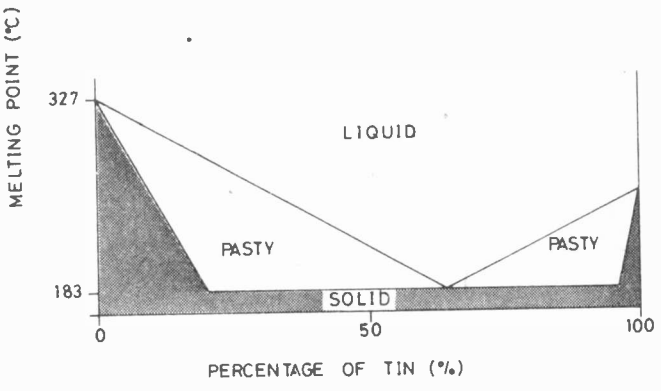


Fig. 2. The pasty part of the temperature/composition graph.

Solder Glue

Electrical fluxes are therefore based on resin, the gummy material which is extracted from wood. Molten resin flows evenly over metals, giving protection for the joint for some time. Any resin which remains on a joint is hard and non-corrosive; a useful protective coating in fact.

Unfortunately, resin by itself does not dissolve a film of oxide from a metal surface, so that it doesn't have the cleaning effect of an acid flux. Fortunately, we can make use here of the fact that soldering is a high temperature operation. Some chemicals, such as the range of salts called halides, will dissociate when heated, meaning that they will release acid vapours which will be neutralised again when the material cools. Chemicals such as tin or lead chlorides can be used for the purpose. The addition of such materials, called activators, to a resin has a very noticeable effect on the fluxing ability of the resin. The release of chlorine from a chloride, for example, cleans metal oxides very effectively, but has less adverse effects than acid on the life of the joint because the chlorine is reabsorbed wherever the material cools. Less strongly active materials can be used when there is any risk of contaminating the area around the joint. In general, fluxes for electronics use have a fairly low halide content. A few types of halid-free fluxes have also been developed, and are used for such applications as circuits which are to be encapsulated. For circuits which must have very long corrosion-free life in hot climates, pure resin-flux is available.

In the early days of soldering, the flux was always applied separately from the solder. Since Multicore pioneered the idea of flux-cored solders, the separate-flux system has died out almost completely. Though several manufacturers now make flux-cored solders, Multicore are still unique in offering five cores (Fig. 3), ensuring quick and even dispersion of the flux. In case you were in any doubt, by the way, resin cored solder is made from a thick rod of solder cast with five holes running through it. These holes are filled with flux, and the whole thing is drawn out into the fine solder which we use.

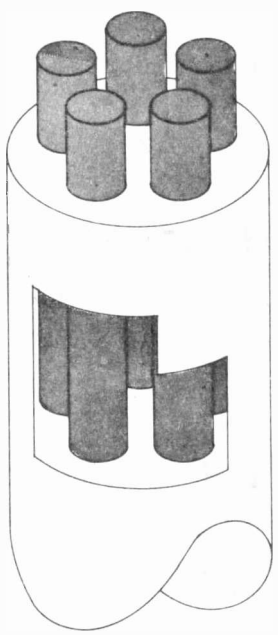


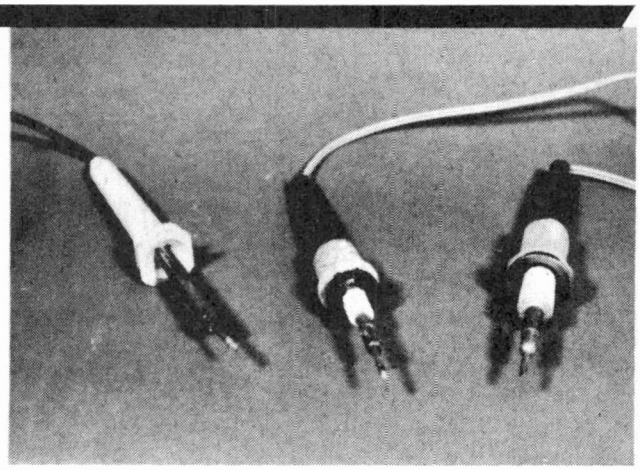
Fig. 3. Cross-section of 5-core solder.

Keep It Clean

And after all that, let's hope we are soldering correctly. Boards such as Veroboard which have copper tracks should be scrubbed clean — don't let the flux have to do all the job of cleaning the board. Similarly, tarnished leadout wires of components should be cleaned by pulling them through loops of emery-paper. For really good joints, it pays to use leads and tracks that are tinned in advance.

Make sure the iron is hot enough. Some irons always seem to run a bit cool and if a very small bit is used, the heat sinking action of a circuit board can be enough to keep the bit too cool to melt the solder properly. A very hot iron, on the other hand, will cause oxidation and burning if it's left on too long. The power output of soldering irons for electronics use is so low that a simple thyristor controller can cope, and excellent heat regulation can be obtained if an auto-transformer is also used (Fig. 4). Incidentally, a lot of awkward problems can be overcome by using ready-formed solder shapes, such as rings and spheres, or by the use of solder and flux mixed in the form of a cream or paint.

May the flux be with you!



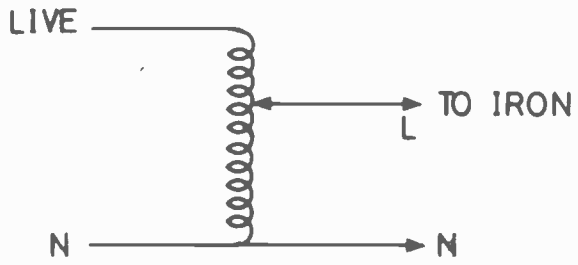


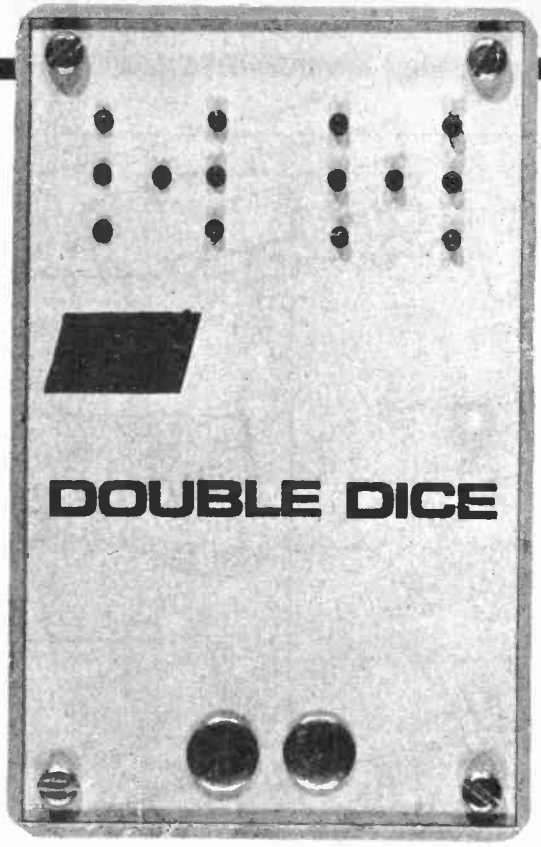
Fig. 4 Using an autotransformer, such as a variac, to control iron temperature.

ALLOY	GRADE	Melting Temp. Solidus °C	Melting Temp. Liquidus °C	USES
2/2/96 Sn/Sb/Pb	DOUBLE TWO	305	315	High temperature High creep strength
5/93.5/1.5 Sn/Pb/Ag	HMP	296	301	High melting point
95/5 Sn/Sb	95A	236	243	High melting point Lead free
Pure Tin Sn	PT	232	232	Lead free
15/85 Sn/Pb	W	225	290	Lamps
96/4 Sn/Ag	96S	221	221	Stainless steel Bright, strong, non-toxic
20/80 Sn/Pb	V	183	275	Lamps
30/70 Sn/Pb	J	183	255	Lamps, motors
31.2/67/1.8 Sn/Pb/Sb	L	185	243	Radiators, general purpose Non-electrical
40/60 Sn/Pb	G	183	234	General purpose
45/55 Sn/Pb	R	183	224	General purpose
50/48.5/1.5 Sn/Pb/Cu	SAVBIT 1	183	215	Saves copper erosion
50/49.7/0.3 Sn/Pb/Sb	Sn 50	183	212	General purpose
50/50 Sn/Pb	F	183	212	General purpose
60/39.7/0.3 Sn/Pb/Sb	Sn 60	183	188	Electrical
60/40 Sn/Pb	KP	183	188	Electrical
63/36.7/0.3 Sn/Pb/Sb	Sn 63	183	183	Electrical
62/35.7/2/0.3 Sn/Pb/Sb/Ag	Sn 62	179	179	Silver-plated surfaces
62/36/2 Sn/Pb/Ag	LMP	179	179	Silver-plated surfaces
18/180.1/1.9 Sn/Pb/Ag	ALU-SOL 45	178	270	Aluminium
50/32/18 Sn/Pb/Cd	TLC	145	145	Low melting point, soldering on gold
70/30 Sn/Zn*	—	196	307	Spray wire for metal film capacitors
80/20 Sn/Zn*	—	196	268	
30/70 Sn/Cd*	TC 30	176	240	Low thermal EMF solder

* These alloys are only available as solid wire. For those purposes where solid wire is still used on automatic appliances precision made solid wire can be made in any alloy to special order.

ETI's HELPFUL HINTS PRESENTS...
THE PROF IN HOW NOT TO SOLDER OR THE RETURN OF THE BLOB!
SIZZLE
FIRST OF ALL WE'LL DEAL WITH 'TINNING THE BIT', THIS IS OBVIOUSLY A COMPLICATED JOB BUT...
SOOP
...IT WARMS UP YOUR SOUP WONDERFULLY!
OBVIOUSLY YOU'LL BE WORKING WITH A LOT OF P.C.B.s...
ALWAYS LEAVE THE COMPONENTS STICKING UP AT ODD ANGLES...
...SO THEY CAN ACCIDENTALLY FLOP TOGETHER...
... WITH THE MOST INTERESTING RESULTS!!
GETTING A STRONG JOINT IS EASY~
A NICE BIG BLOB OF SOLDER WILL JOIN EVERYTHING!
ALWAYS FLICK THE SOLDER OFF THE BIT...
DANGER HIGH VOLTAGE
IT GIVES YOU THAT RAKISH DEVIL-MAY-CARE LOOK!
BUT AS A LAST RESORT~ READ THE ARTICLE ON SOLDERING IN THE NEXT ISSUE...
HARP LESSONS
IT COULD SAVE YOU A LOT OF AGGRAVATION!
FLETCH

DOUBLE DICE



Chance your luck with ETI's latest game of fortune – for those readers who can't find the energy to shake'em – here's a pair you only have to touch

SUMMER approaches, when more games are played than at any other. A large percentage of these games need some system whereby a random number between 1 and 12 can be quickly and easily generated – the usual way of doing this is with a pair of dice. A good electronic dice project hasn't materialised in any of the electronic magazines recently and so we thought that the time was right for ETI to produce a dice to beat all dice. Although quite ingenious in operation, the ETI Double Dice is simplicity itself to build – apart from the display there are only 18 other components, and all parts mount on a small PCB.

The display is formed from individual LEDs, seven in each die, grouped together into the well-known dice formation. Five ICs perform all logic, control, counting and driving functions of the circuit and both die displays are completely random and non-synchronised.

The device is touch-controlled: simply placing a finger over the two contacts starts operation of the dice. The LEDs light up and are seen to flash at a fast rate (showing that the 1 to 6 sequence is in operation.) Upon removing the finger, the LEDs stop flashing and hold the last number displayed.

After a short time, all the LEDs extinguish, showing that the dice is ready for its next "roll". The display period is defined, mainly, by the value of capacitor C1, and using the value shown a period of about 5 seconds is obtained. Increasing its value lengthens illumination time and vice versa.

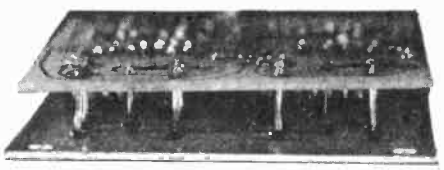
LEDs need a fair amount of current to give a reasonable illumination and if they remained on at all times, battery life would be severely limited. The self-cancelling function reduces the average current consumption of the circuit and therefore prolongs battery life.

Construction

Start construction by inserting the six links into the PCB as shown in the overlay diagram. It is helpful to use a pair of long-nosed pliers to bend the link wires before insertion. Resistors, capacitors and IC sockets, if used, should be put in now, but leave the ICs till last.

Next, insert LEDs 1 to 14 into the board in the double dice formation. Mount them about 10 to 15 mm above the PCB so that they stand above the maximum height of the other components. Connect the switch, battery and touch contacts (two wires will do for test purposes), plug in the five ICs, switch on and test the project.

Housing the PCB in a case should not be a problem. Suggestions are: either mount your board on the underside of the case lid, drilling holes for the LEDs to mount into, or make a panel out of coloured transparent plastic (or similar) through which the LEDs will be visible.



Side view of the Double Dice showing the position of the LEDs

You can make your touch contacts out of virtually any small pieces of electrical conductor. We chose to use the heads of metal drawing pins inserted through the case lid. Soldered connections can be made underneath the lid to the board. If you do the same, remember that a metallic lid conducts and the contacts will have to be insulated from it.

PARTS LIST

RESISTORS (All ¼W, 5%)

R1	4M7
R2	220k
R3	10M
R4,8	2k7
R5,9	1k0
R6,10	680R
R7	270k

CAPACITORS

C1	1u0 polycarbonate
C2,3	100n polyester

SEMICONDUCTORS

IC1	4001 quad, 2-input NOR
IC2,4	4025 triple, 3-input NOR
IC3,5	4522 programmable BCD counter
LED1-14	miniature red LEDs

MISCELLANEOUS

single-pole, single-throw toggle switch
battery clip
case to suit
touch contacts

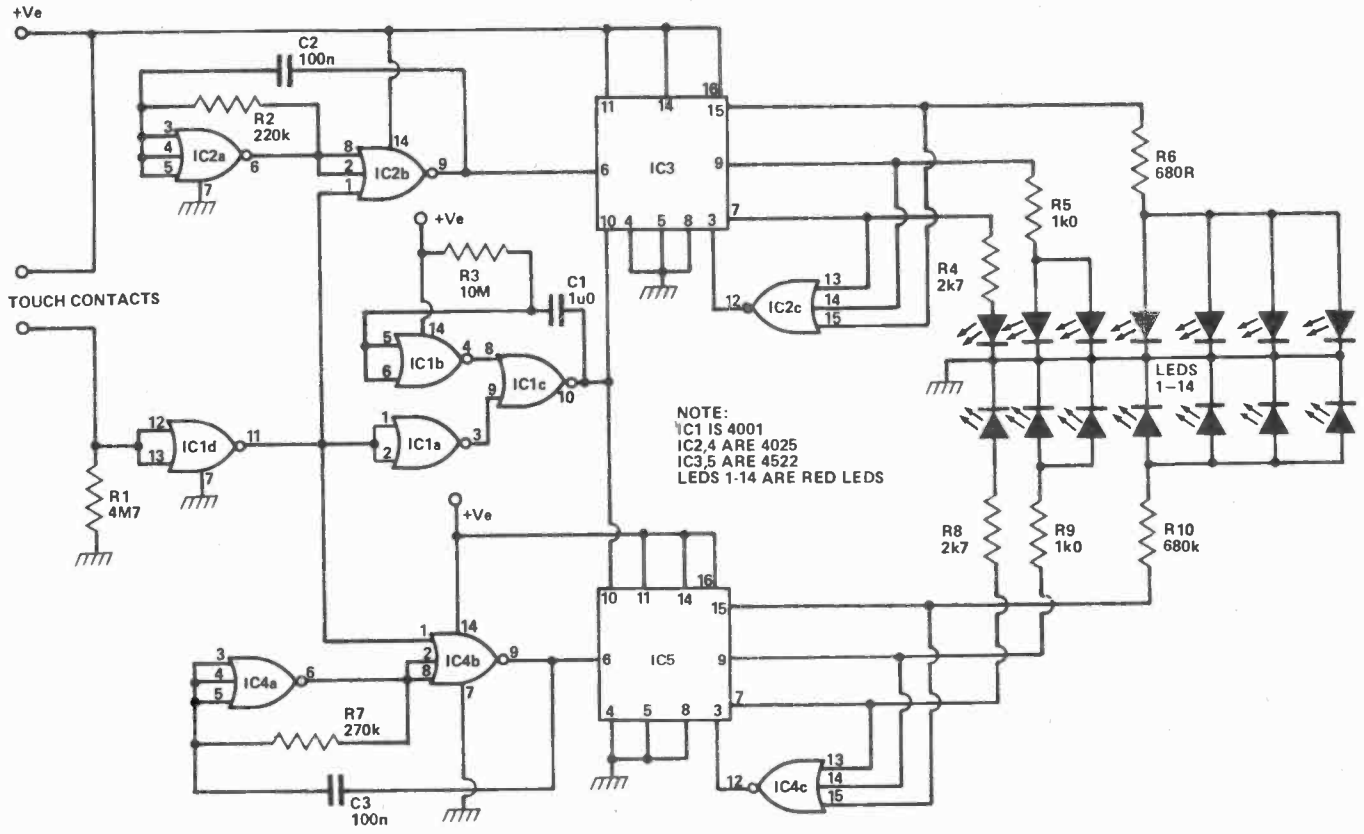


Figure 1. Circuit diagram of the Double Dice

Continued on page 70

PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in the Table Of Contents. If you still have problems, please address your letters to 'ETI Query', care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.

HOW IT WORKS

The circuit of theDouble Dice can be seen in Fig. 1. By cross-referring to it, the operation of the dice may be more easily understood. Most of the circuit is duplicated for each dice (IC2,3 and common components) – the action of the other dice is identical (using IC4 and 5 instead).

A	B	C	NUMBER DISPLAYED
OFF	OFF	ON	1
OFF	ON	OFF	2
OFF	ON	ON	3
ON	OFF	OFF	4
ON	OFF	ON	5
ON	ON	OFF	6

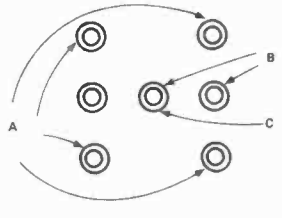


Figure 3.

The LEDs are formed on the PCB to a standard dice configuration as in Fig. 3. In this diagram the individual points have been grouped together into three categories A, B and C. By looking at the numbers on a dice in turn, a table can be drawn up, as in Fig. 3. to show that all LEDs in any one category must be either on or off at the same time. Therefore, we can consider the groups as single logical levels in a set code. It just happens that the set code is required is part of the binary code, of which the part of interest is shown in Fig. 4 against the corresponding denary, or ordinary number value.

ICs which count in binary are readily available and the 4522 (IC3) does just that.

DENARY NUMBER	BINARY NUMBER		
0	0	0	0
1	0	0	1
2	0	1	0
3	0	1	1
4	1	0	0
5	1	0	1
6	1	1	0
7	1	1	1

THE PART OF THE BINARY CODE WHICH IS OF INTEREST

Figure 4.

It is a *down* counter, meaning that it starts its cycle at binary 15 and counts down to 0. On the next count after 0 it would (normally) reset to 15 and start the cycle over again. However, we have taken advantage of the fact that the 4522 is a programmable counter which can, on a commmand pulse, be programmed or set to a particular number in its cycle. In our circuit this number is 6 (represented by the logic levels at pins 14, 11 and 5, that is 1, 1, 0). The command pulse is obtained from the output of IC2c, which is at logic 1 only when its three inputs are 0. These inputs are in parallel with the LED drive outputs of IC3 so that as the number 0 is displayed by the LEDs the counter automatically jumps to the number 6. The interval between the count to 0 and the display of 6 is so small that to the human eye it appears that the counter progresses naturally from 1 to 6.

IC2a and b form a simple astable multivibrator which produces a square wave of about 100 Hz and which clocks the counter whenever pin 1 of IC2 is at logic 0.

The part of the circuit which is common to both sides is that of IC1. Pins 12 and 13 of this IC are held normally low by R1, a very high resistance. The output of IC1d is therefore normally high (the gate is acting as an inverter). If a finger is placed on the touch contacts, skin resistance takes the input to this gate high, and the output, pin 11, goes low. This pin is connected to pin 1 of the astable which as detailed above, clocks the counter.

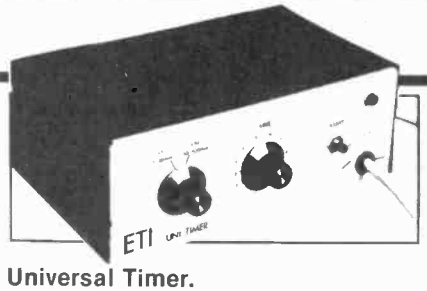
As well as enabling the astable, pin 11 is connected to the input of a monostable multivibrator with an 'on' period of about 5 seconds so that as a finger is put on the touch contacts the monostable enters its 'on' state. The output of the monostable is connected to pin 10 of the counter so that during the 'on' state the LED display is allowed to function. At the end of the 5 second on-period the monostable switches off and the display is disabled (the LEDs are held off) thus saving unnecessary battery drain.

Electronics Today INTERNATIONAL

NEXT MONTH

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

JULY



Engineer's Stethoscope.
How you'll get your car to breath deeply and cough is your hassle. However, if you get it together, here's the box to let you hear what's going on within the works.

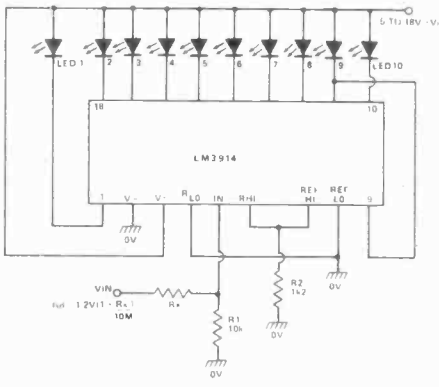
Bargraph Car Voltmeter.
Is your battery charged? Over charged? Undercharged? Dead? Stolen by Bedouins and spirited off to the Morovian Desert? This project will indicate the state of your electrical system.

IC Master.
$100.00 worth of IC data sheets may sound like what's behind door number four, but this book is probably the best one shot designer's reference going. In thirty days its secrets will be revealed.

Project Fault Finding
Yes, it is a drag to build a 128 megabit computer only to find it can't add. It could be that you've used an incompetent processor, or there could be . . a fault. This article will help you locate hassles in your circuits.

Universal Timer.
Just the thing for timing universes that don't last more than a half hour.

AutoSound Survey.
It's hard to understand people who have 125 watt stereos in their MGBs. Possibly pointing the speakers rearward gives them better mileage. Next month, Wally Parsons reviews the E.P.A. rating of the available equipment.



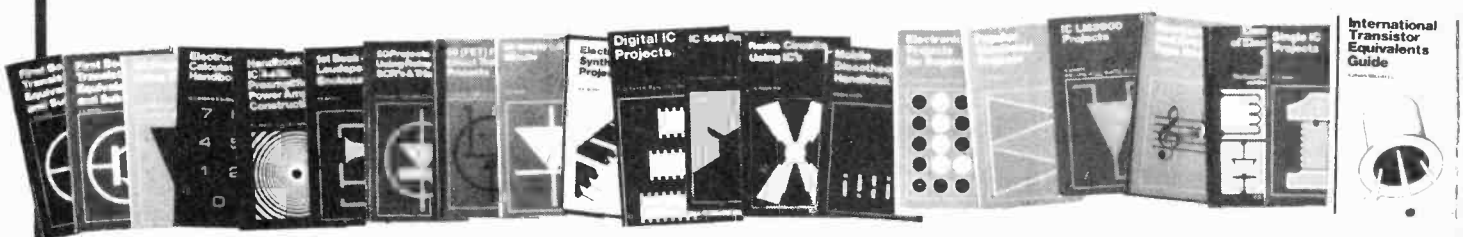
LM3914 Circuits.
LM3914 Bar Graph chips are shiny black with silver legs and transistors inside. This will be useful to know if one accosts you in the park. If this does, in fact, transpire, stall it 'till next month when we tell you what to do with it.

Michael Faraday.
Far from being, as some might suspect, the lead guitarist for the Sesmic Toenail Clipper Band, Michael Faraday was one of the founding fathers of Modern Electronics. Good to know the industry isn't illegitimate. His life and times, next issue.

Current Affairs.
At the moment, the only current affair that comes to mind is between the office gruel bucket carrier and the lady who maintains our dungeon. Therefore, this article will have to deal with electrons and holes and suchlike theory.

How To Solder.
This month we had a look at the magic wire. Next time around, we'll show you how to use it. The month after that we plan to aquire a philosopher's stone and outline how to transmute it into gold. If we figure it out that issue may be in some demand. . .subscribe now.

BABANI BOOKS FROM ETI



BP1: First Book of Transistor Equivalents & Substitutes $2.80

More than 25,000 transistors with alternatives and equivalents make up this most complete guide. Covers transistors made in Great Britain, USA, Japan, Germany, France, Europe, Hong Kong, and includes types produced by more than 120 different manufacturers.

BP14: Second Book of Transistor Equivalents & Substitutes $4.80

This handbook contains entirely new material, written in the same style as the "First Book of Transistor Equivalents & Substitutes". The two complement each other and make available some of the most complete and extensive information in this field.

BP24: Projects Using IC741 $4.25

The popularity of this inexpensive integrated cicuit has made this book highly successful. Translated from the original German with copious notes, data and circuitry, a "must" for everyone, whatever their interest in electronics.

BP33: Electronic Calculator Users Handbook $4.25

An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples.

BP35: Handbook of IC Audio Pre-amplifier & Power Amplifier Construction $5.50

This book is divided into three parts: Part I, Understanding Audio ICs; Part II, Pre-amplifiers, Mixers and tone Controls; Part III, Power Amplifiers and Supplies. Includes practical constructional details of pure IC and Hybrid IC and Transistor designs from about 250mW to 100W output. An ideal book for both beginner and advanced enthusiasts alike.

No.205: First Book of HI-FI Loudspeaker Enclosures $3.55

The only book giving all data for building every type of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams are provided showing all dimensions necessary.

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

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

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

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

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

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

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

BP81: Electronic Synthesiser Projects $7.30

One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effcts generator.

Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

The book does just that and is divided into the following chapter headings, 1: — Analogue Delay Line;2: — Single Chip Synthesiser; 3: — Programmable Sequencer; 4: — Voltage controlled Oscillator; 5: — Envelope Shaper with voltage controlled amplifier; 6: — Putting it all together.

BP84: Digital IC Projects $8.11

Contained in this book are a number of simple and also more advanced projects, for the home constructor, based on digital integrated circuits.

To assist the newcomer to the hobby, the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects have been designed to be built and tested section by section so as to help avoid or easily correct any faults that might occur.

Highly recommended to both the beginner and more advanced enthusiast alike.

BP44: IC 555 Projects $7.55

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

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

BP46: Radio Circuits Using ICs $5.90

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

BP47: Mobile Discotheque Handbook $5.90

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco gear". The approach adopted is to assume the reader has no knowledge and starts with the fundamentals. The explanations given are simplified enough for almost anyone to understand.

BP48: Electronic Projects For Beginners $5.90

The newcomer to electronics, will find a wide range of easily made projects and a considerable number of actual component and wiring layouts. Many projects are constructed so as to eliminate the need for soldering. The book is divided into four sections: "No Soldering" Projects, Miscellaneous Devices, Radio and Audio Frequency Projects and Power Supplies.

BP49: Popular Electronic Projects $6.25

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

BP50: IC LM3900 Projects $5.90

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

BP51: Electronic Music and Creative Tape Recording $5.50

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

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

BP62: BOOK 1. The Simple Electronic Circuit & Components $8.95
BP63: BOOK 2. Alternating Current Theory $8.95
BP64: BOOK 3. Semiconductor Technology $8.95
BP77: BOOK 4. Microprocessing Systems & Circuits $12.30

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

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

The course concentrates on the understanding of the important concepts central to electronics. Each book is a complete treatise of a particular branch of the subject and, therefore, can beused on its own. However, later books assume a working knowledge of the subjects covered in earlier books.

BOOK 1: This book contains fundamental theory necessary to a develop a full understanding of the simple electronic circuit and its main components.

BOOK 2: This book continues with a lternating current theory.

BOOK 3: Folows on semiconductor technology, leading up to transistors and integrated circuits.

BOOK 4: A complete description of the internal workings of microprocessors.

BP65: Single IC Projects $6.55

All the projects contained in this book are simple to construct and are based on a single IC. A strip board layout is provided for each project, together with any special constructional points and setting up information, making this book suitable for beginners as well as more advanced constructors.

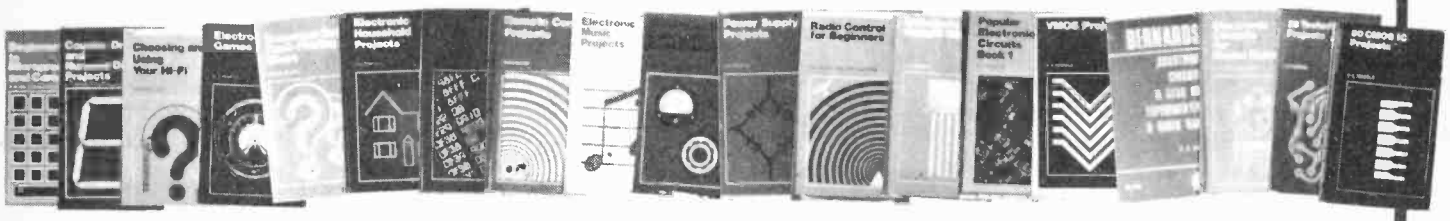
BP85: International Transistor Equivalents Guide $12.25

This book is designed to help the user find possible substitutes for a popular user-orientated selection of modern transistors and includes devices produced by over 100 manufacturers.

Wherever possible the equivalents are subdivided into European, American and Japanese types. Also shown are the material type, polarity, manufacturer and an indication of the use or application of the device.

These books are specially imported from England by us. All prices include handling and postage. To order, use the order form in this publication or write to:

ETI Magazine, Unit 6, 25 Overlea Boulevard, Toronto, Ontario, M4H 1B1.



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

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

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

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

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

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

BP69: Electronic Games **$7.55**

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

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

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

BP71: Electronic Household Projects **$7.70**

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

BP72: A Microprocessor Primer **$7.70**

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

BP73: Remote Control Projects **$8.58**

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

BP74: Electronic Music Projects **$7.70**

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

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

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

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

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

An ideal book for both beginner and advanced enthusiast alike.

BP76: Power Supply Projects **$7.30**

Power supplies are an essential part of any electronic project.

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

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

BP78: Practical Computer Experiments **$7.30**

This book aims to fill in the background to microprocessors by describing typical computer circuits in discrete logic and it is hoped that this will form a useful introduction to devices such as adders, memories, etc. as well as a general source book of logic circuits.

An essential edition to the library of any computer and electronic enthusiast.

BP79: Radio Control For Beginners **$7.30**

The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

Details are then given of actual solid state transmitting equipment that the reader can build. Plain and loaded aerials are then discussed and so is the field-strength meter to help with proper setting up.

The radio receiving equipment is then dealt with, this includes a simple receiver and a crystal controlled superhet. The book ends with electro-mechanical means of obtaining movement of the controls of the model.

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

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

BP80: Popular Electronic Circuits-BOOK 1 **$8.25**

Another book by the very popular author, R.A. Penfold, who has designed and developed a large number of circuits which are accompanied by a short text giving a brief introduction, circuit description and any special notes on construction and setting up that may be necessary.

The circuits are grouped under the folowing headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Projects, and Miscellaneous Circuits.

An extremely useful book for all electronic hobbyists, offering remarkable value for the number of designs it contains.

BP83: VMOS Projects **$8.20**

Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitation. With the advent of field effect devices it seemed that it would only be a matter of time before improved power transistors became available, this has happened and a number of different power FETs are now available to the hobbyist.

This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits.

A number of varied and interesting projects are covered under the main heading of: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

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

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

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

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

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

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

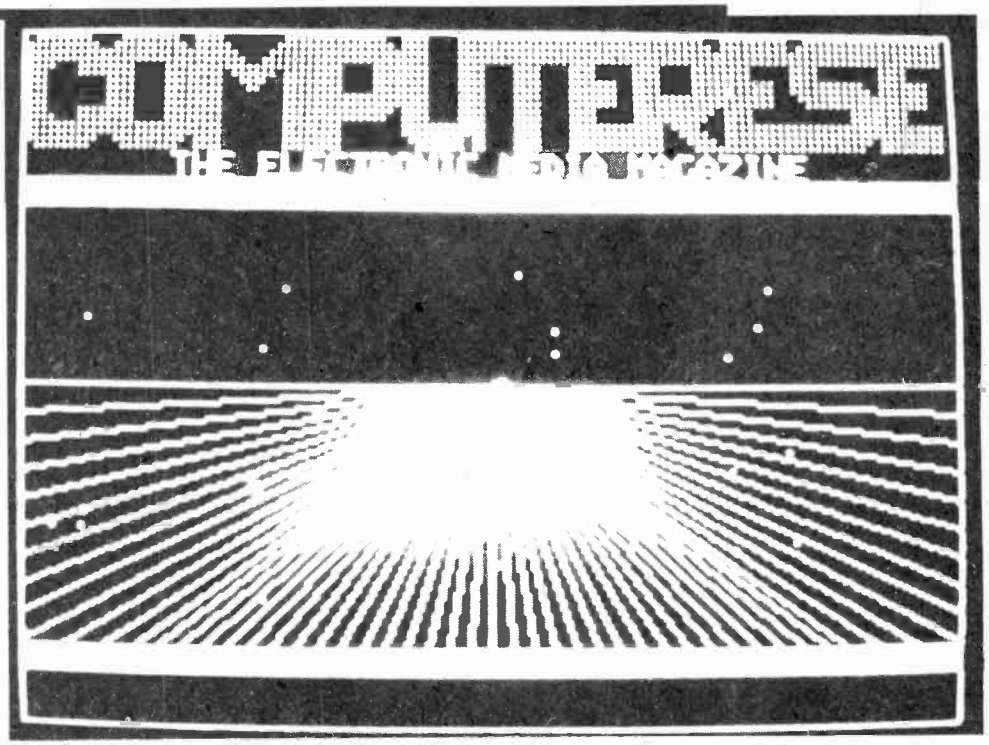
No.224: 50 CMOS IC Projects **$4.25**

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

Babani Books are now available from Arkon, CESCO, Dominion Radio and General Electronics.

COMPUTERESE

Just as moveable type made the scribe and the minstrel obsolete, electronic magazined such as Computerese may put printers out of business. Shane Dunne reports.



A star speckled void fills the television screen. Glowing letters appear across the top. A small dot appears at right and moves towards the centre of the screen. Abruptly it chirps and settles on a field of converging red lines. This is Computerese, The Electronic Media Magazine.

RIGHT NOW, people in Toronto and Montreal are reading the first issues of a very interesting new magazine. Not an ink-and-paper magazine like the one you have in front of you now, but one of Canada's first *Electronic* magazines. It's called Computerese, and it represents the beginning of the biggest revolution in the communications industry since the invention of the printing press.

Videotex, Telidon, and Vista

These three names represent the driving forces behind this revolution. Videotex is a generic term referring to various digital transmission, storage and retrieval systems that allow users to access large amounts of visual information, typically using television receivers connected to some sort of intelligent terminals. Telidon refers more spacifically to a standard for videotex transmission developed by the Canadian Department of Communications (See September, 1980 ETI). Bell Canada has just launched Project Vista, a major field trial of Telidon technology, involving the placement of about 500 receiver terminals in homes, stores and public facilities. These terminals will have access to a central data base whose content is supplied by various private and commercial operators. The first people to see Computerese will be those who participate in the Vista trial in Toronto and Montreal, but there will be other field trials across Canada and Computerese will be part of them if its founder, Bill Perry, has his way.

The Message is The Medium

Perry intends to make Computerese a progress journal for users of videotex technology, emphasizing the human side of the coming information revolution. "It is our intention", says Perry, "to address the basic issues surrounding videotex and related new technologies (video-disks, fibre-optic transmission, and microprocessors) and discuss their meaning in personal terms."

What are these "basic issues"? Roughly, they fall into three major categories; legal (or political), technical, and sociological. The legal/political issues primarily involve the difficulty of keeping the new "electronic highways" (information networks) free from excessive restriction and out of the hands of commercial monopolies. New developments and the possible merging of personal computing with videotex are examples of the technical issues. The sodiological issues are the human factors. How will ordinary people be affected by the information revolution?

Electronic Publishing

Computerese is an electronic magazine, quite unlike any other magazine that has ever existed before. Electronic Publishing, the profitable dissemination of information by electronic means, is a new field which may generate revenues in the billions in the next decade. It will also profoundly affect the publishing industry as we know it today, to the extent of forcing small publishers out of business. The "big guys" have already recognized the dangers and such giants as Time-Life Books, Southam Press and Torstar (the Toronto Star) have already purchased Telidon technology to get a head start in te Electronic Publishing race.

The Electronic Magazine has a number of advantages over the ink-and-paper type. Most important is the availability of user statistics, details on how many people have read each part and what opinions they have about it. In the Vista trial, information providers such as Bill Perry will receive regular reports on such matters, allowing them to tailor their information packages to their audience's desires. It is expected that future commercial Telidon systems will retain this facility because it will attract both users and information providers.

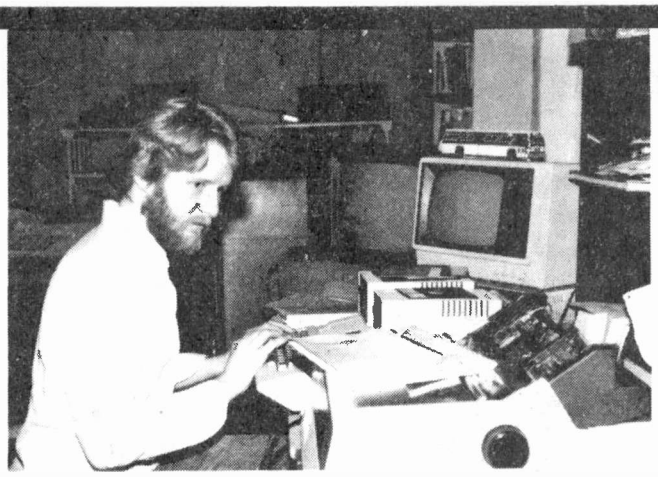
The Electronic Magazine can also be re-edited again and again. Instead of issuing a whole new information package every month, the producer can revise and/or condense what is already in the system and add a little more each month, each week, even each hour. This is where the term "electronic magazine" becomes inadequate, because the Electronic Magazine combines the best features of a book, a magazine, a newspaper, and a cable-TV news channel.

Finally, once videotex technology becomes firmly established, the Electronic

Magazine will have a tremendous economic advantage over its paper counterparts, because many of the steps involved in conventional publishing will be eliminated. For example, this article was written first by hand, then typed into a computer word-processing system, stored on a floppy disk, printed out and delivered to ETI. There it was edited and retyped on a type composer (a sophisticated electronic typewriter capable of producing text in aligned columns, in any of several character styles). The columns of type were then cut up and, together with photographs and titles, pasted down on a layout sheet. All the layout sheets (one per page) were delivered to the printer, who made a film negative of each one, from which printing plates were produced. Finally, after printing, folding, cutting and stapling, this issue of ETI along with thousands of others was dispatched to a distributor who sent the magazines to stores across Canada. If all this wasn't enough, you had to physically go out and buy the issue before you could see this article (unless you have a subscription).

If ETI were an Electronic Magazine using a computer data base, things would be a lot quicker. I could have sent in my floppy disk (or transmitted the manuscript over the phone lines in seconds) and within a few hours it could be edited and combined with digitized illustrations, and put on the data base. You could then turn on your TV set and Telidon adapter, punch a few buttons and read the article, all without leaving your favourite chair.

The Electronic Magazine producer can get his final product on the market much faster than the conventional publisher can, without paying for paper, printing, or most photographic processes. Back issues can be stored on magnetic tape or disk and reproduced flawlessly on request.



Bill Perry, originator of Computerese, creating videotex pages on an Apple II.

Home-Grown

These advantages will make electronic publishing a very profitable enterprise, very soon. And it won't be just the "big guys" who will see the profits. The initial investment required to start a magazine will be so low that individual entrepeneurs will have excellent chances of success. There may well be a revival of "cottage industry" in Canada.

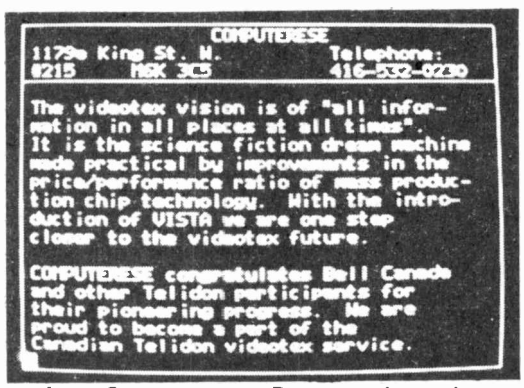
Bill Perry has seen this coming for a long time, and intends to devote a large portion of Computerese to discussing the various forms of cottage industries that videotex technology will make possible. These will include artistic endeavours using Telidon's high-resolution colour graphics capabilities, computer software exchanges and other types of clubs, as well as many types of electronic publishing. If it becomes possible to interface home computers to videotex systems in a two-way fashion, as Perry would very much like to see, any microcomputer owner could start his or her own videotex data base and make money providing information to customers who could call up the data base directly.

The Medium Was The Message

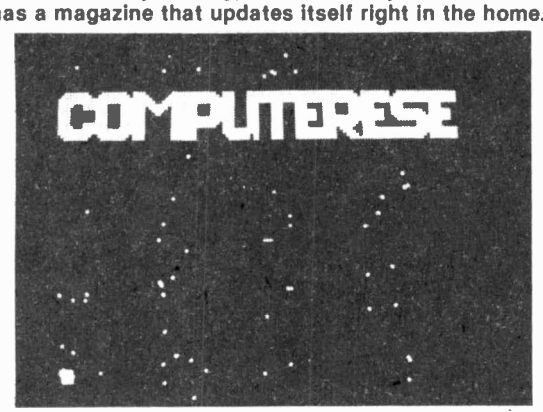
This is the promise of the information revolution. Individuals can profit by selling information itself, their own thoughts and ideas, and devise new handicrafts requiring only ideas as raw materials and their own brains as equipment.

When the late Marshall McLuhan studied the mass-communication systems of the sixties and seventies (mostly television), he predicted the evolution of a "Global Village" consisting of millions of eyes glued to millions of TV sets. This has occurred to some extent in North America, which is essentially a "Global Village" whose fads and fashions emanate largely from California, where most major TV shows are produced. But McLuhan had no way of knowing that mass-oriented, broadcast television was only the first phase of a much larger information revolution. In the light of Videotex and related new technologies, scholars are replacing McLuhan's "Global Village" by the concept of many "Electronic Cottages" linked by a world-wide "Electronic Highway".

Broadcast television, the boob tube, the idiot box, whatever you wish to call it, has accomplished the difficult task of placing high-resolution colour video display devices in the majority of North American homes. In Canada the "Electronic Highway" networks are largely in place, thanks to cable TV, a good telephone system, and Anik satellites. And now that we have developed the world's most advanced videotex system, we may well lead the rest of the world into the information age. ●



Two pages from Computerese. Pages such as these can be altered on a monthly, weekly, or even a daily basis. In effect, the user has a magazine that updates itself right in the home.



Tab books from ETI

Master Handbook Of 1001 Practical Circuits
TAB No.800 **$18.30**
Master Handbook of 1001 More Practical Circuits
TAB No. 804 **$18.35**

Here are IC and transistor circuits for practically anything and everything — with ALL the data needed to put them to work. The ideal schematic source-book for all active technicians, engineers, experimenters, amateurs — for anyone who must occasionally or regularly construct or adapt electronic circuits for any purpose whatsoever. You'll find any circuit you're ever likely to need in the pages of this rich volume. The schematics are classified according to general application, and the Sections themselves appear in alphabetical order.

99 Test Equipment Projects You Can Build
TAB No. 805 **$11.75**

Here's the A to Z guide you need to build all sorts of electronic test equipment — from a simple signal tracer to a sophisticated modularized 50 MHz counter — and virtually everything in between! Here are voltmeters and ammeters, capacitance meters, resistance and impedance measurers, testers for solid-state components, digital volt-veters, calibrators and frequency standards, signal generators, frequency counters, oscilloscopes, and a variety of RF test equipment. The variety is incredible and almost endless . . . virtually every test instrument you could possibly want to build for yourself.

The Power Supply Handbook
TAB No. 806 **$11.75**

A complete one stop reference for the Hobbbyist and engineer. Contains high and low voltage supplies as well as mobile and fixed units. Everything you need to keep your project perking with the right volts and amps.

Build Your Own Working Robot
TAB No. 841 **$8.55**

Here are complete instructions — plans, schematics, logic circuits, and wiring diagrams — for building Buster. Not a project for novices. Buster is a sophisticated experiment in cybernetics. You build him in phases, and watch his personality develop as you add progressively more advanced circuitry to his mainframe. The first of this three-phase robot, Buster I, is "leash-led" and dependent on his master for decision-making; you create the "animal" and give him wheels, steering capability, and the capacity to "understand" your basic commands, Phase II makes Buster more independent. Now he has a basic brain he can use to decide when he's in need of a battery charge, or trapped into a physically binding situation he can't get out of.

A Beginner's Guide To Computers & Microprocessors — With Projects
TAB No. 1015 **$9.70**

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

How To Design, Build & Test Complete Speaker Systems
TAB No. 1064 **$11.85**

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

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

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

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

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

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

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

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

Whether you want a robot for a experimenting, for a security application or to perform some task suitable for "smart" machine, all the ideas you need are packed into this book.

The Active Filter Handbook
TAB No. 1133 **$9.75**

A designer's and users' guide to the theory and applications of active filter circuits.

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

Electronic Music Synthesizers
TAB No. 1167 **$8.40**

If you're fascinated by the musical possibilies of elec-tronic music synthesizers, this book provides all the information you need to choose, use, adapt, or even build a synthesizer. It's filled with data on synthesizers in general. . .and on individual models, candidly explaining the advantages and disadvantages of each one. Such musical workhorses as the Moog (Minimoog and Polymoog), ARP 2600, Oddessy, PAIA, Oberheim, RMI and EML synkey synthesizers are presented in full detail. Also included is a Chapter on accessories and on the various components that can, with the help of this book, produce almost any sound you hear . . . or can imagine!

But that isn't all — once yo've learned what makes a synthesizer work and how to produce all kinds of music and sound effects, Horn includes a full section on how to build your own. Ther's even a list of universal patch diagrams to assist you in your tinkering and experimenting. If you'd like a book that gives you solid, practical help in choosing and using — or building — a synthesizer, this informative manual is your best choice.

Towers International Op Amp Linear IC Selector
TAB No. 1216 **$11.40**

If you deal with op amps (and linear-ICs with op amp characteristics) in any way, here's a wealth of practical information that will help you solve selection, design, and replacement problems. This international guide includes basic specifications for over 5,000 op amps and linear ICs, and contains data on ratings, characteristics, case details, terminal identifications, applications use, manufacturers, and substitution equivalents. Here you'll readily find data on a specific op amp when you know only the type number. Plus, you'll be able to locate the manufacturer of the device. And, particularly important with obsolete units, you'll find guidance on a readily available substitute.

A series of Appendices includes a glossary of op amp terms, tabulation codes for manufacturers, manufacturer house numbers, tabulation codes for applications, case outline and leadout diagrams, and codes for leadout connections. If you want the latest, most complete details on op amp-linear-IC's available today, you'll find it in this book.

How To Build Your Own Self-Programming Robot
TAB No. 1241 **$11.75**

This is a straightforward how-to book about machine intelligence — a practical guide that shows you how to build a robot capable of learning how to adapt to changing circumstances in its environment. The unique little creature described in this book, named Rodney, can pick up signals and stimuli from his environment and develop perceptions just like humans and higher animals do. Yet Rodney is fully trainable, and his "personality" can be altered and molded by human intervention. All in all, Rodney is in a class by himself, and is a most remarkable and fascinating machine — he can program himself to deal with the problems of the moment and devise theories for dealing with similar problems in the future. Yes, Rodney is self-programming, and as a result no two Rodneys behave exactly the same way. In fact, if you wipe out his self-generated memory, he'll develop another one that's somehow different from the first.

To get yours, fill in the form in this issue or write to ETI Magazine, Unit 6, 25 Overlea Blvd., Toronto, Ontario M4H 1B1. Please allow six weeks for delivery. Due to sometimes uncertain supplies, some books may not be in stock, please indicate whether you wish your order held or if you wish your money refunded.

Arrr, Billy... Have Ye Ever Been Te Sea?

No, I suppose not. . . well, better off fer ya, I suppose. Nothin' out there but salt 'n' spray, pirates 'n' ol' Davy Jones's locker. Naw, Ye wouldn't a' liked it one bit. Ye'd get cold, 'n' wet, Ye're not even dressed fer the sea, Billy, me Boy. . . If'n ye wants te be livin' the life o' a pirate, ye gots to get yerself some cloths, Lad. Like an ETI T-shirt, fer example. Ay, that's what all the swashbucklers 're wearin these days. Nice sky blue, so's 'is Majesty's Gunners can't sees yer against the sky. Made of fine polyester so's it'll dry real quick if'n ye gets dunked in the icy North Atlantic. Gets yerself a T-shirt , Billy in small, medium or large Send.$5.50 each plus PST in Ontario. to:

ETI T-shirts
Unit 6, 25 Overlea Blvd.
Toronto, Ontario. M4H 1B1
(Yes Captain Highliner)

NEW!

The skies may darken, the rain may fall, the winds blow, typhoons and monsoons typh and mons respectively. Hurricanes may muss your hair and torrential apocalyptic downpours thunder from the firmanent for forty days and forty nights. . BUT YOU WILL BE WARM AND DRY IN YOUR ETI HAT!!!

When it's sunny again your hat serves a second, equally useful function as a magazine binder. The new combination ETI hat/ETI binder costs no more than the old ETI Binder only used to. Just $6.75 plus 7% political contribution for ontario residents.

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Unit 6, 25 Overlea Blvd
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M4H 1B1

(Made in Canada of 100% stuff)

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1980	January	February	March	April	May	June	July	August	October	November	
1981	January	February	March	April	May						

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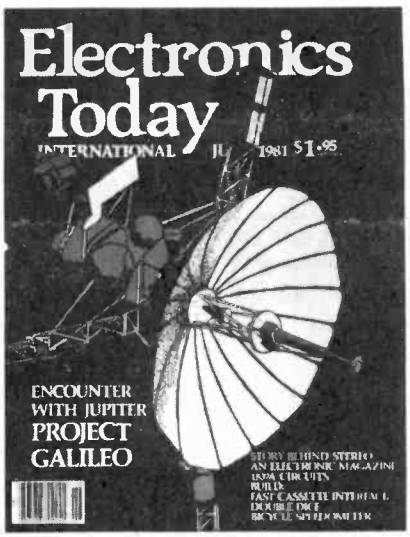

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GUD STUF!

BICYCLE SPEEDOMETER

0 – 99 MPH in sixty minutes – that's how long it will take you to build this all electronic solid-state speedometer

WITH FUEL getting more expensive, the world's oil supply running out and gas disappearing in a puff of smoke, it can't be long now before pedalpower makes a comeback. We can see it now; CB freaks with cycle mounted rigs and six-foot whips on the back. Of course there will be lots of research into optimum wheel size, cruising speed etc. That's where this dandy little project will come to your aid. Featuring a two-digit readout, bright red LED display with 1 MPH resolution updated every few seconds, it can be built in a trice (ideal if your bike has three wheels) and powered from a single 9 V battery.

Swift And Silent

There have been many bike speedometer designs published over the years but never before has so much been brought to so many with so little. Yes, only Electronics Today can do this for you! No, seriously, before this gets totally over done, we'll explain. Only three ICs are required plus the two displays and a handful of passive conponents. The whole thing is very easy to put together so you can assemble it whichever way you like best. The speedometer works by detecting each revolution of the bike's wheel using magnetically-sensitive reed switches with one or more bar magnets mounted on the wheel. The faster you go, the more pulses are counted and the speed displayed increases. The display blanks out while the counters are advancing to avoid a distracting flicker and the count period is set up by adjustment of a single resistor when the speedometer is mounted on your bike. Okay, so it doesn't tell your weight, but it won't burn a hole in your pocket either!

Construction/Setting Up

Nothing to cause any problems here. As usual we'd recommend you use sockets for the ICs. If you use our PCB design you should have success first time though the circuit is simple enough to

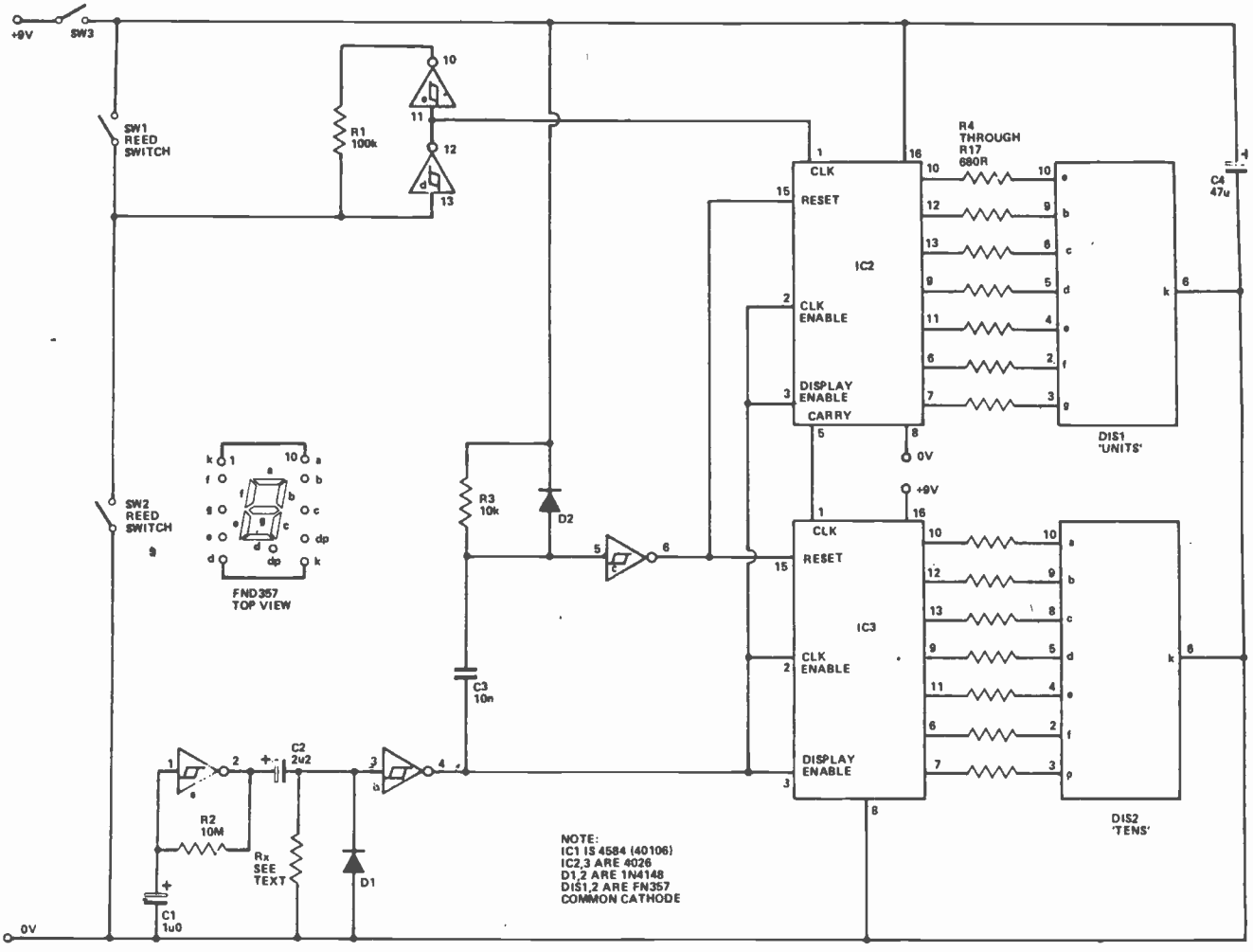


Figure 1. Circuit diagram of the Bicycle Speedometer

be put together on Veroboard or whatever comes to hand . . . except for the original breadboard which went out of fashion when ICs arrived. (You try knocking nails into a piece of wood the size of a postage stamp . . . and anyway, you would look silly with a breadboard between the handlebars!)

Reed switches come with two main switch actions, either single-pole, double-throw or single-pole, double-throw (changeover). You can use two of the former or simply one of the latter (with its centre contact connected to the common point on the circuit board for the two switches (see **Fig. 2**).

Reed switches are usually supplied as glass tubes with the switch contacts brought out to tags at either end. For better protection against the elements a single pole double throw reed switch is ideal. You can however, do as we did, and get by with two single throw units.

The relationship between wheel diameter, gate period and number of

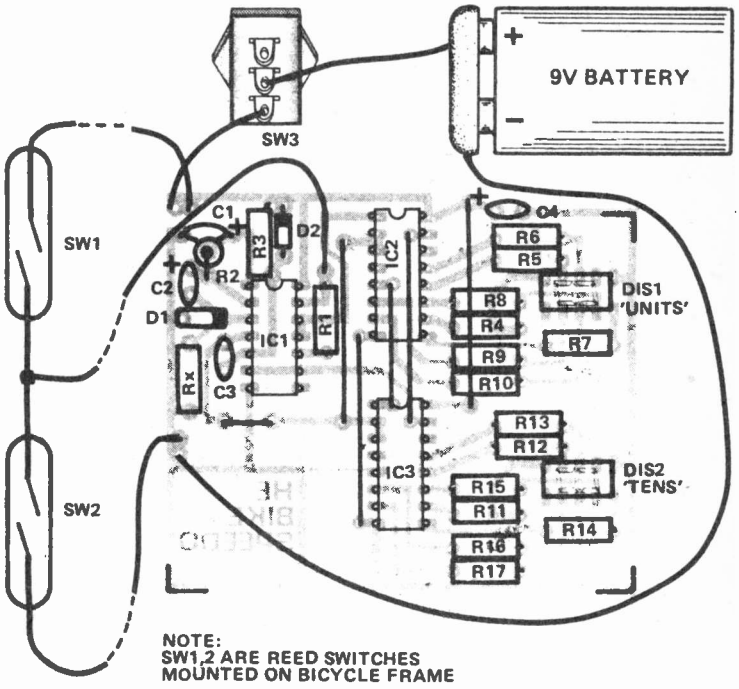
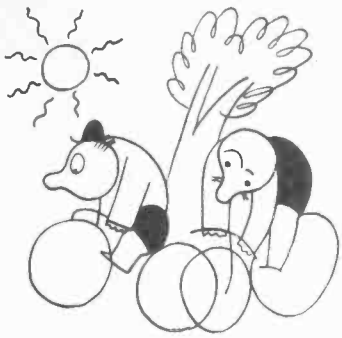
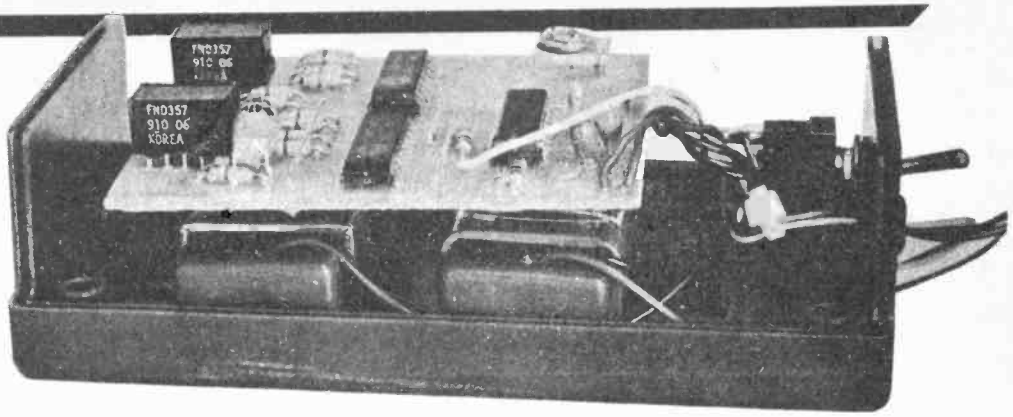


Figure 2. Overlay and connection details. Remember that SW1 and SW2, the reed switches, can be combined as one changeover type reed switch





Side view of speedometer, showing the two batteries mounted under the PCB

magnets required is not a simple one. Toy bikes and bikes with 'baby' wheels will get away with one or two magnets. To obtain a reasonable gate period with larger wheels you'll need to use more magnets. In practice, fix between five and 10 small magnets (the type usually supplied with reed switches) around the rim of the wheel (the more the merrier). To stop them falling off it's best to glue them in place or secure them with pads of double-sided tape. Once fixed, a dab of paint or varnish will prevent them from getting rusty.

Connect a 1M0 potentiometer or preset at the Rx position, get on your bike and adjust the pot until you get the right speed reading. Now, measure its value and make it up from fixed value resistors or just fasten the pot or preset onto the board – there's plenty of room.

If you use separate reed switches, make sure that both are never on at once or the battery will be short – circuited through them. To safeguard against this you can connect 10k resistors in series with the wires from the battery.

Ideally you'll need a box with a clear lid so you can see the display without having to cut holes in the box, which would let in water. It's best to mount the box centrally on the bars so that, if the bike takes a tumble no damage will be done. Lacquer the back of the board so that if any condensation appears in the box no shorts will result. The circuit takes about 40 mA of current when running so two batteries in parallel are advisable and there's just enough room under the PCB to put them.

Alternatively, you might like to make a proper facia panel to hold a whole set of instruments (oil pressure, ammeter, etc!?) Watch this space!

PARTS LIST

RESISTORS

R1	100k
R2	10M
R3	10k
R4-R17	680R

POTENTIOMETER

Rx	1M0 linear potentiometer

CAPACITORS

C1	1u0, 16 V tantalum
C2	2u2, 16 V tantalum
C3	10n ceramic
C4	47u, 16 V tantalum

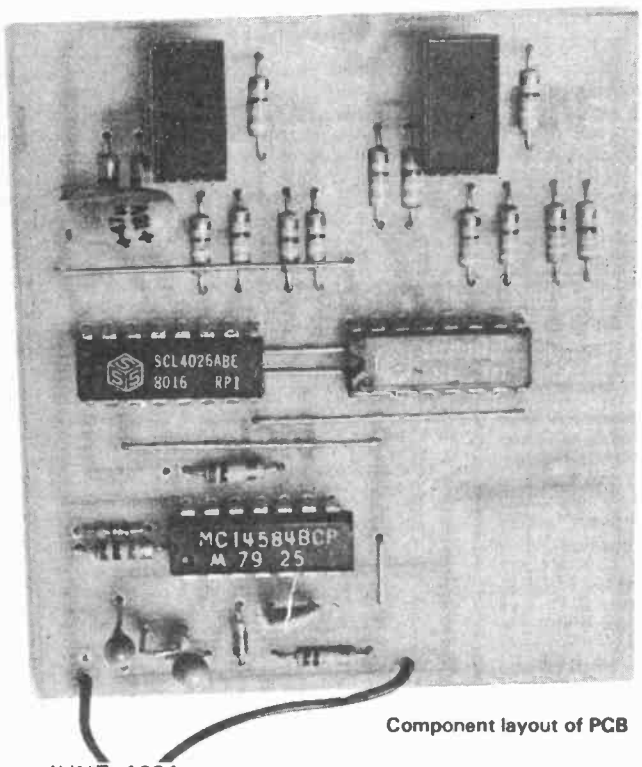
SEMICONDUCTORS

IC1	4584 or 40106 hex inverting, Schmitt trigger
IC2,3	4026
D1,2	1N4148 diode
DIS1,2	FND357, common cathode, 7-segment displays

MISCELLANEOUS

SW1,2	reed switch inserts
SW3	single-pole, double-throw toggle switch

Magnets
Battery and clip
Case to suit



Component layout of PCB

HOW IT WORKS

A low-frequency astable oscillator provides the master clock for the circuit. IC1a, R2, C1 take care of this. Pulses are then differentiated and squared up by IC1b and IC1c to provide clock enable and reset signals. Figure 3 shows this in detail.

Integrated circuits IC2 and IC3 form a two-digit counter and display driver, which needs only correct timing and clock pulses to operate both 7- segment displays. While IC1b's output is low the counters are enabled and clock pulses from IC1d cause the counters to advance. When IC1b goes high the counters are disabled and the count is displayed on the 7-segment displays. The combination of IC1d and IC1e forms a simple but effective debouncing circuit. Some form of signal conditioning circuit like this is nearly always required when mechanical switches are interfaced to digital counters. Resistors R4 through R17 limit the current in the displays and C4 provides overall decoupling.

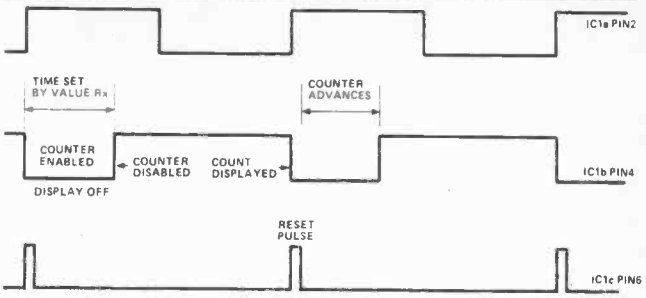
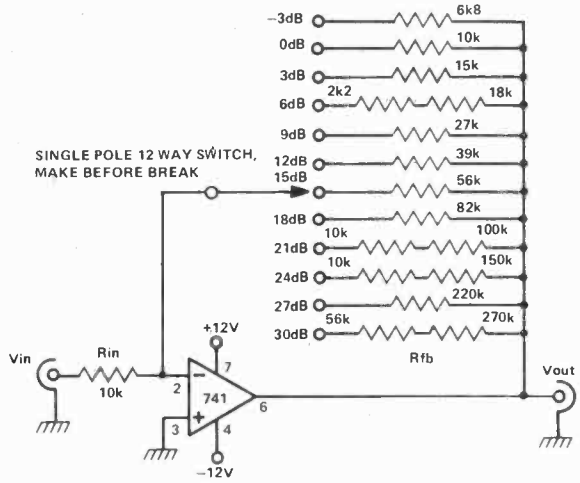


Figure 3. Waveforms within the circuit, not to scale

PROBLEMS? NEED PCBs? Before you write to us, please refer to 'Component Notations' and 'PCB Suppliers' in Table of Contents. If you still have problems, please address your letters to 'ETI Query' care of this magazine. A stamped, self addressed envelope will ensure fastest reply. Sorry, we cannot answer queries by telephone.

Designer Circuits

DB STEPPED GAIN CONTROL



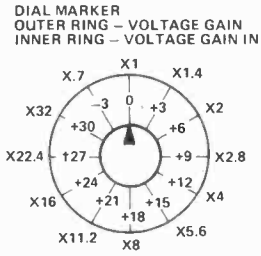
VOLTAGE GAIN = Rfb/Rin
NOTE: AMPLIFIER INVERTS SIGNAL

A handy little piece of test equipment is a preamplifier with stepped gain control selected by a rotary switch. The circuit here uses a single IC, a 741, 14 resistors and a single-pole, 12-way rotary switch.

The voltage gain of an op-amp (and that is what the 741 is) is determined by the ratio of R_{FB}/R_{in}; thus by having R_{fb} switched, the voltage gain can be varied.

The input impedance of the preamplifier is set by R_{in} to 10k. Having the gain set in decibel (dB) intervals is most useful in audio applications because our hearing, like dBs, is logarithmic. The gain in dB is defined as being equal to $20\times\log_{10}$ (Voltage Gain) which equals $20\times\log_{10}(R_{FB}/R_{in})$. Therefore a voltage gain of 1 is $20\times\log_{10}1=0$dB but a voltage gain of 2 is $20\times\log_{10}2=6$dB.

Although this may at first seem like a complex approach, the decibel is an easy to use method for describing gain and attenuation since all you have to do is add and subtract them. For instance, say a



signal passes through four devices with gains of 9dB, 15dB, −3dB and −3dB, the overall signal gain is 9+15−3−3 which is 18dB (this is a voltage gain of times 8). Note that negative dB means attenuation (reduction in strength). Now consider the same situation without using dB; a signal passes through four devices with gains of 2.8, 5.6, 0.7 and 0.7. The overall signal path is $2.8\times5.6\times0.7\times0.7$ which comes to the same result but a lot more difficult to calculate than adding and subtracting.

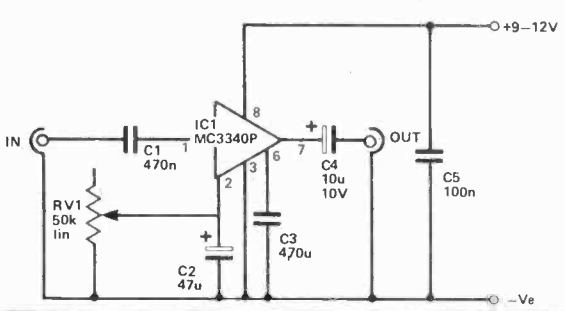
REMOTE AND TOUCH VOLUME CONTROLS

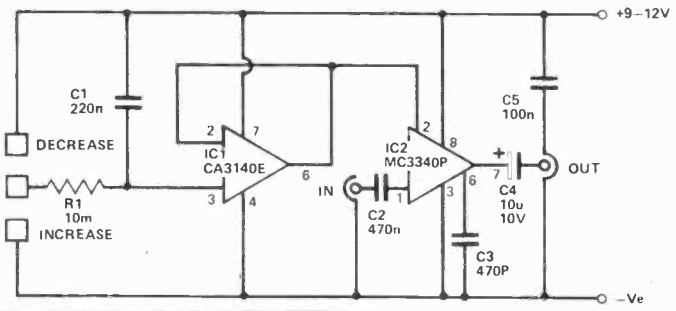
An electronic attenuator such as the MC3340P IC can be used as the basis of a remote volume control, as shown in the first circuit. RV1 controls the voltage gain of the MC3340P, which varies from typically 13 dB at minimum resistance to about −80 dB at maximum resistance. Since only a DC level is controlled by RV1, any AC pick-up in the connecting cable can be filtered out, which is the purpose of C2. The cable only needs to have two conductors, it can be many metres long, and does not have to be a screened type. C1 and C4 are merely input and output DC blocking capacitors respectively. C3 rolls off the RF response of the circuit so as to aid stability and prevent RF breakthrough.

The MC3340P can be used as the basis of a novel touch operated volume control, as shown in the second circuit. This has the advantage over a conventional volume control of having no moving parts to wear out. The device is controlled by a voltage rather than a resistance and gives the same attenuation range as the previous circuit.

The control voltage is obtained from a charged capacitor (C1) via an op amp unity gain buffer stage utilizing IC1. IC1 has a PMOS input stage which produces a typical input resistance of 1.5 million Meg ohms. This ensures the charge on C1 is not significantly affected by the amplifier of attenuator circuit, so that once set it remains virtually unaltered for a long period of time.

The charge voltage on C1 is set by the operator who, by touching the lower two contacts, can charge C1 via R1 and his or her skin resistance. This decreases the control voltage fed to IC2, and increases the volume. Touching the upper two contacts causes C1 to gradually discharge; increasing the control voltage and decreasing the volume. When the unit is switched off, C1 gradually discharges. At switch on it is necessary to bring the volume up to the required level, rather like using an ordinary combined on/off switch and volume control. Both circuits will handle input levels of up to 500 mV RMS, with a THD figure of only about 0.6% at high volume settings, rising to about 2% or so at low settings.





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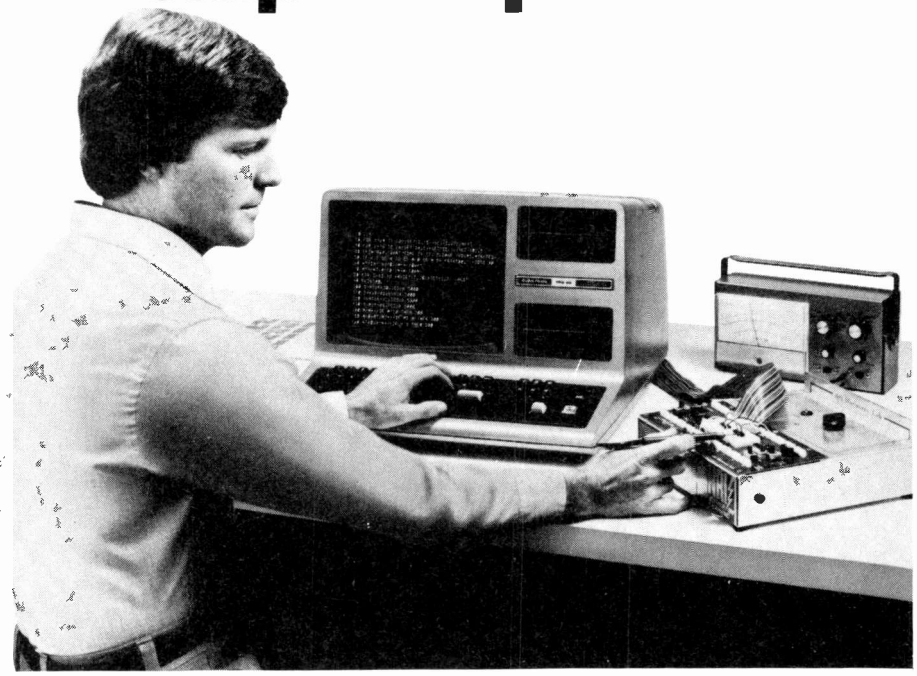

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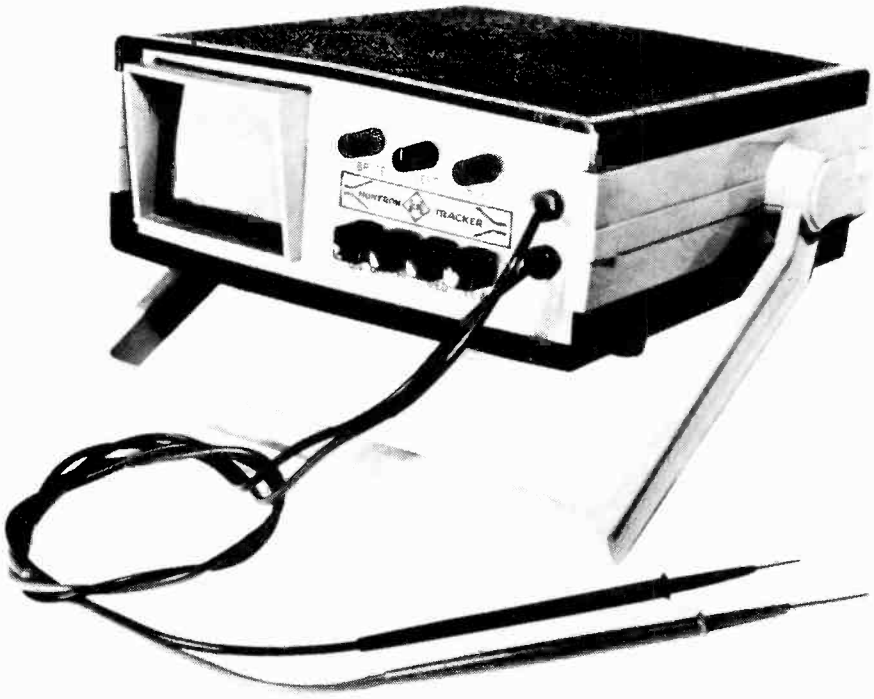

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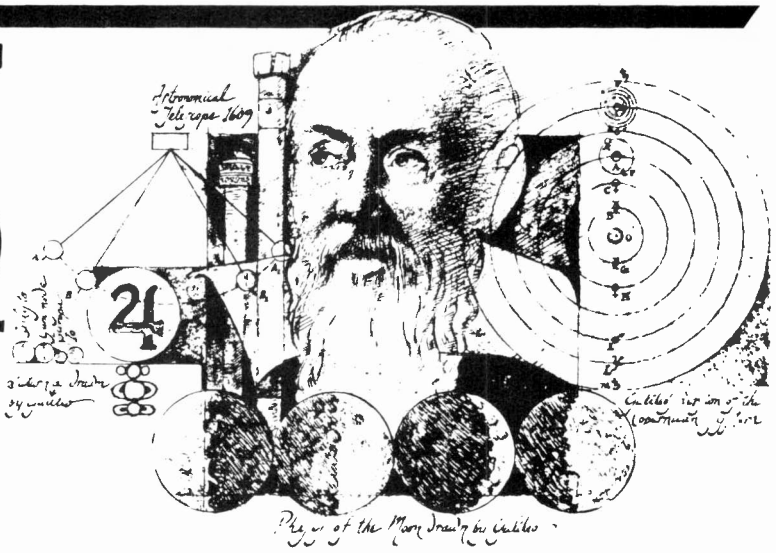
PROJECT GALILEO



Sailing, sailing, over the bounding vaccuum. Reef the mains'l, lads. Avast ye swabs, we's bound for Jupiter. Cap'n Steve Rimmer shivers the the interplanetary timbers.

What Goes Up. . .

GALILEI GALILEO was a fairly together head. For example, he is credited with inventing the telescope, by which all astronomy and peeping Tom-ing is made possible. This, in fact, is not altogether accurate. Actually, he had the good sense to realize that inventions are much easier to invent when somebody else does all the hard work. Clever man, he borrowed the design from somebody else.

Galileo was not thought too kindly of in his day . . . he had the poor foresight to come up against the major nasties of the period; de church. For one thing, he maintained that the sun, not the Earth, was the center of the solar system, and that most of the ideas held in this area at the time were dead wrong. The church had a point; there's nothing like getting a whole truckload of textbooks printed up just to have someone come along and try to get you to trash them. Eventually they made a deal with him. For his part, he'd change his views and for their part they wouldn't lay a heavy medieval torture chamber trip on him. Being a reasonable man, and not terribly into pain, he aquiesced. Of late, the church has come 'round to Galileo's way of thinking . . . the moral majority will soon see to changing that.

A while ago, NASA came up with a really freaky idea, this being to send a little whizzbang out to check out what was going on under the cloud cover of Jupiter. They decided to name it after old Galilei, essentially for two reasons. First of all, he discovered four moons of that planet, giving him some stake in the affair. Secondly, and perhaps, most important, the thing was not destined to come off quite as planned. Of course, NASA didn't know that at first, but, then, neither did Galileo. He lived a long time before Murphy.

The Craft

The initial concept for Project Galileo was to have this rather odd looking space craft which would go sailing out into space early last year, and hit the suburbs of Jupiter in 1985. The timing of all this was to be fairly acute, because right around now, as it happens, all the planets are rather nicely lined up, meaning that an outward bound probe can use the gravitational fields of the innermost ones to sling it along. This means that the little fellow would get where it's going a whole lot faster, and with the expending of much less fuel. Things won't be so propitous for quite a number of years to come, so there has been quite the push on to get some hardware out there while things are still cool. The two Voyagers were a part of this effort, each producing some fairly mind bending stuff from the outer solar system. Galileo was due to leave for Jupiter and all points East just before the window began to close.

Initially, the probe was to be a single unit, which would separate into two sections upon reaching its destination. The larger of the two was to be the Orbiter, which would hang around above the planet to gather and relay data. The smaller was the probe proper, which was to go sailing into the atmosphere bristling with instruments, in order to send back data and give anyone living down there an acute sense of paranoia.

To put it simply, though, things have not gone off quite as planned. The initial concept was for the whole works to be put into Earth orbit by one of the early space shuttle missions, from whence it would go dancing lightly off toward the stars. Well, as you may have noticed, there haven't been many shuttles going up of late, which could very well have put a damper on things. This, however, isn't a wholly relevant problem, as the probe wouldn't have been ready to go on schedule, even if the launch vehicle had.

There have been quite a number of hardware hassles with the actual probe, many stemming from disagreements over what exactly the thing should be designed to do and withstand when it hits Jupiter. No small problem, this, as nobody really has any clear idea of what the neighbourhood's really like . . . except that I certainly wouldn't want to live there. In order to have a better chance at getting good data out of the shot, the system has been becoming increasingly complex. This, in turn, has made it heavier.

At the same time as the probe has been developing obesity problems, the lads working on the drive mechanism to kick it out to the far fringes haven't been asleep at the switch. In fact, their end of things has been gaining a bit on the initial specs too. By the time everything was considered relatively space worthy, the whole works was just too huge to be managed by the shuttle. Even after some trimming, getting the thing into space would have meant modifying the lifters considerably, stripping the beast to the bones, and burning everything at somewhat more than one hundred percent capacity . . . not too well received, considering that, by the time the Galileo mission rolled around, the shuttle was set to have had but two previous flights on its log.

The ideal window for the mission, sometime in 1982, is now considered to be pretty well un-attainable, and things have been largely retrenched to shoot for early 1984. This is still not a bad bit of timing. Mars will still be in position to assist with the trajectory of the orbiter to a large degree, though, of course not so much as it would have been were the whole works to have sailed as originally planned. However,

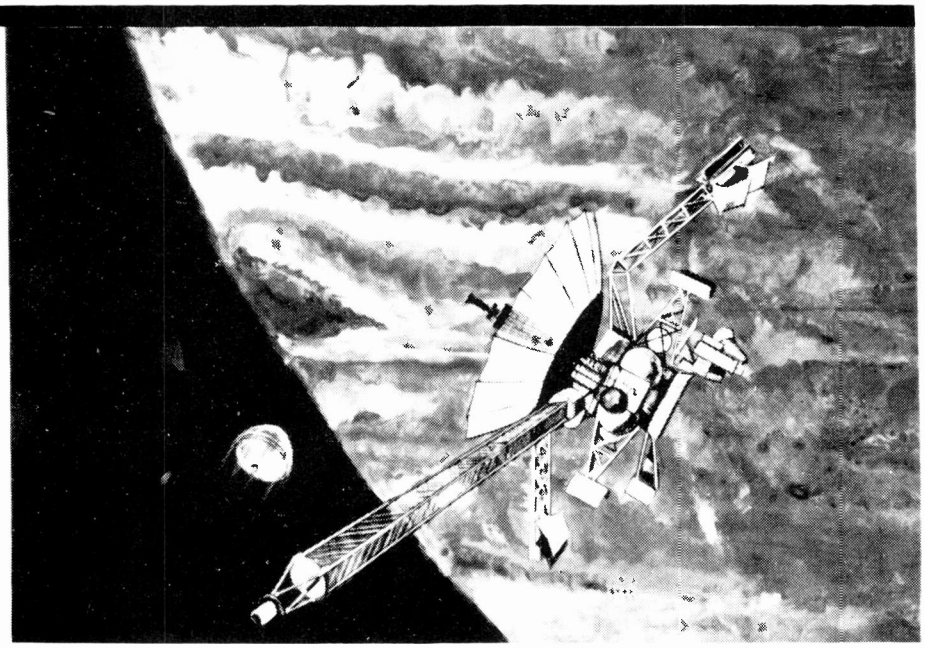
because of this weakened assist, it has been decided to be good and proper that the probe be fitted with an extra booster to be jetisoned after leaving the Martian influence.

Junk men are going to really have wonderful things to say about NASA, in a hundred years.

The new plan also calls for a split mission, in which the probe and the orbiter travel in separate accomodations. In fact, they take wholly different routes. The probe won't be swinging by Mars at all, but will go more or less directly to Jupiter under its own steam. This will result in its taking considerably longer to arrive; three and a half years, as opposed to two and a half for the orbiter.

Here in we get into another of these cause and effect hassles. If the probe is to go solo, it will be wanting a space craft of its own for the trip, so as not to upset the Union of Interplanetary Probes, Satelites and Infernal Galactic Whizzbangs. At the moment, this is being designed and built by Hughes Aircraft Company for forty million dollars. If that doesn't keep the nasty union happy, it deserves to sulk.

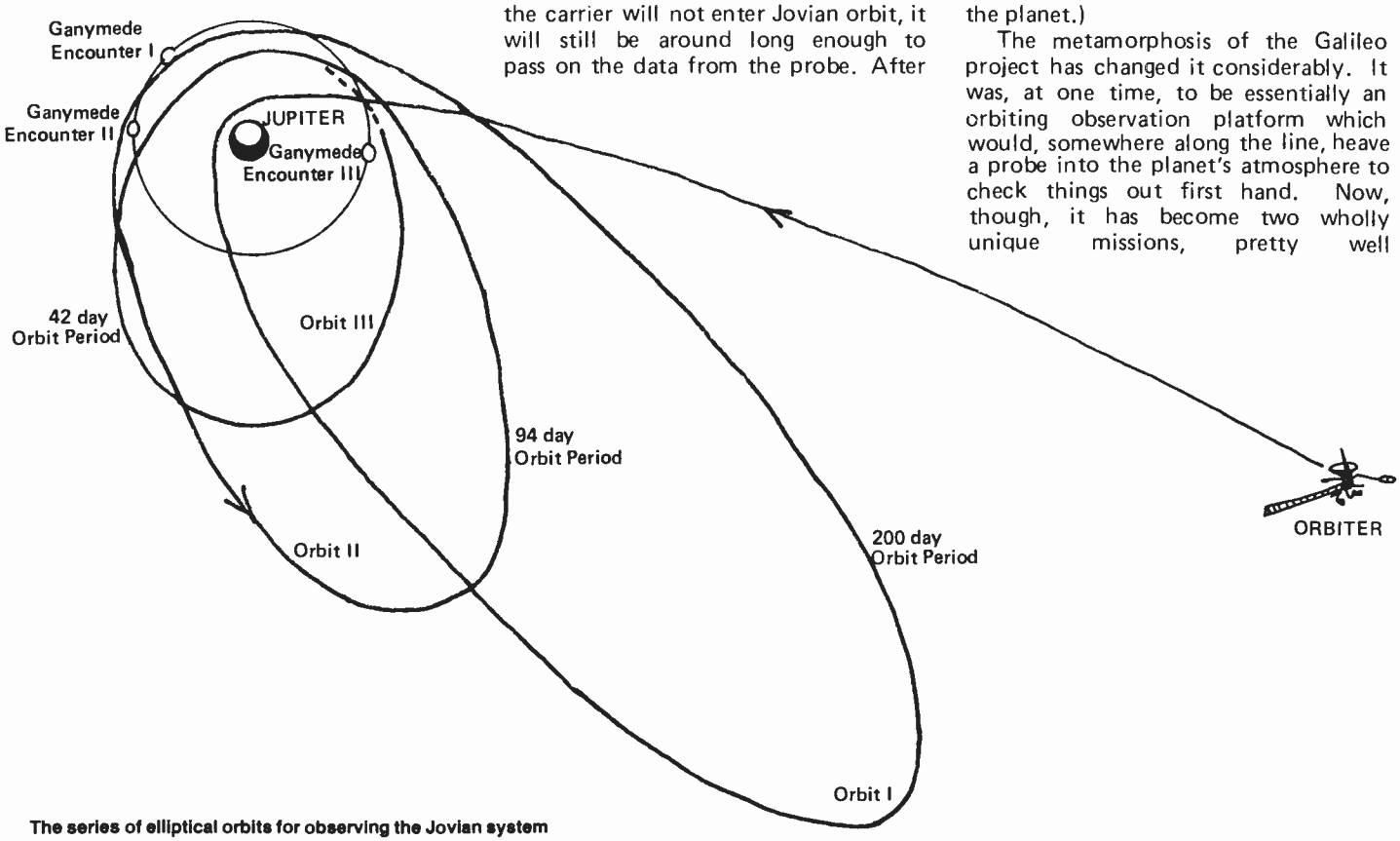
Now then, we also come up with another problem, namely, that the orbiter, which was originally supposed to relay the data from the probe to Earth (that's us, the good guys) won't be in the right location to do so, given this new trajectory. Therefore, it has been relieved of this function, along with the necessery transponders, dishes and other spindlies that went with the job, in favour of the hardware that will carry the probe. This is possible because the actual descent time of the probe will be quite short. Even though the carrier will not enter Jovian orbit, it will still be around long enough to pass on the data from the probe. After that, well, it's pink slip time, boys. Little fellow's off to the far flung reaches of space.



Galileo high above the Northern hemisphere of Jupiter.

(Somewhere, out in space, there are some little green men watching all this. The first thing they'll get from us will be a TV transmission of Felix the cat, followed shortly there after by a novel variety of what could very easily be abandoned Volkswagons. Beam me up, Scotty. There's no intelligent life on the planet.)

The metamorphosis of the Galileo project has changed it considerably. It was, at one time, to be essentially an orbiting observation platform which would, somewhere along the line, heave a probe into the planet's atmosphere to check things out first hand. Now, though, it has become two wholly unique missions, pretty well



The series of elliptical orbits for observing the Jovian system

independent of each other. It may very well crawl back into the cocoon for a third time before launch day . . . er, days.

The Works

The hardware of the mission will, naturally, be of a slightly changed configuration. It was originally to be a one piece affair that gradually came undone as things progressed, splitting into the orbiter and the probe. Now, however, it will consist of no less than three seperate bits, these being the orbiter, the probe, and the newly developed probe carrier. This last is still partially a figment of someone's imagination at Hughes, so very little is to be said of it.

The probe itself will remain largely unchanged from its inital design concept, at least in its major details. It is comprised of two concentric pieces, the deceleration module and the descent module. The deceleration module is basically the heat shield and its associated workings, which is to keep the innards from getting crisped as the probe hits the Jovian atmosphere. Once there is sufficient atmosphere around the probe, the deceleration module will deploy a parachute, which will slow down the fall considerably. Even with this, though, the heat shield wants to be fairly beefy . . . in fact, nearly half the weight of the probe is tied up in this one component. It is, naturally, fairly conservatively designed, as the Universal Interplanetary Probe Designer's Cookbook doesn't list very much data about what's going on beneath the Jovian smog.

By the time the probe gets down into the atmosphere, and wants to start doing its thing, it will no longer be travelling fast enough to have to be concerned about getting fried, so the heat shield will be jettisoned, and mankind will have boldly littered where no man has littered before.

The descent module looks like half a grapefruit that has begun to sprout. It carries all the instrumentation to make the most of the rather short time it will have in the cloud cover before getting squashed. Unlike the orbiter, which is nuclear powered, the probe will get juiced by a lithium battery pack. Not exactly your typical D cells, these. It will switch itself on about five hours prior to the big leap, checking out lightning and radio emissions from Jupiter. The transmitter will be activated when the heat shield is shrugged off, at which point any data stored in the probe's memory will be fired along. After this, the descent module will just transmit like mad until the warranty runs out.

This happens concurrently with system failure.

What will eventually snuff the probe, somewhere along its descent, is the combined heat and pressure down there. A lot of thought has been given to keeping things happening for as long as possible under these most unpleasant of conditions. The pressure is the worst problem. If the case of the probe were to be built to withstand it, it would be the heaviest part of the whole venture several times over. What's to happen instead is to build the thing to purposely leak, and equalize itself. This, in turn, raises the problem of what the atmospheric gasses are going to do once they get inside the probe, and start wandering the circuits. This, however, is considered to be a much more manageable hassle than the prospect of having the little beasty turn into a pancake.

Orbiter

Meanwhile, up in space, there flies Orbiter. No longer having anything much to do with the probe's descent, it will shoot itself into an elliptical orbit around the planet, partially assisted by the gravity of Io, one of the moons. By the time all the manoeuvring has been completed, the craft will be in a position to pass as close as 900,000 kilometres from the Jovian atmosphere. From this point on, the orbit will modify itself periodically each time the Orbiter hits the gravitational field of Ganymede, providing at least eleven close passes to the planet, and at least as many to the outer Galilean satellites. It will be possible, during the closest passes, to resolve details less than half the length of a football field across.

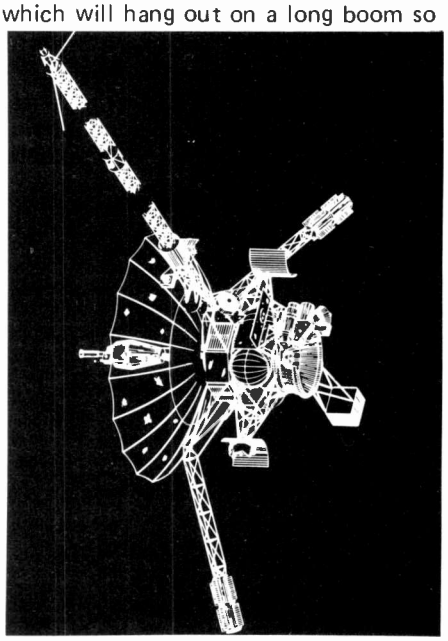
The design life of the orbiter is to be about twenty months . . . it may very well exceed this by a considerable margin. Because the sunlight out around Jupiter isn't terribly intense (definitely not the ideal vacation spot if you're after a tan), solar powered energy sources wouldn't be all that cool. Thus, the juice will be provided by other, more atomic means. Two power cells will sit just behind the main dish.

Now, as to what gets powered . . . there are more high technology electric nit-pickers bristling off this thing than a Lincoln from Texas. First off, we find a TV camera, to shoot back some more of those trendy images we've all gotten used to seeing in Time Magazine. Unlike the previous planetary probes, which used vidicon tubes, the Galileo camera will be all solid state . . . CCD image sensor, you know, which is said to actually exceed the resolution of a tube, as well as having a broader spectral response.

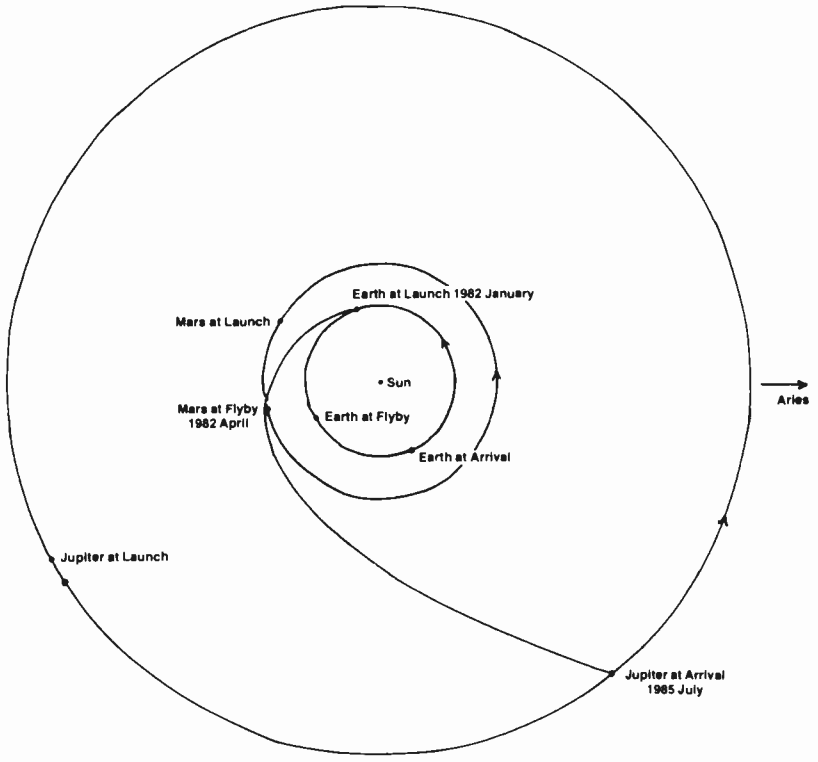
Next to the camera there sits an infra-red mapping spectrometer . . . you can't get one of these on a Lincoln, even as an option. This is actually a camera, of sorts, too, but it churns out plots of the infra-red scene down below. Because infra-red radiation can pass through dense cloud cover without being diffused or diffracted, this little box will permit scientists to check out the lower reaches of the planet. An ultra-violet spectrometer will cover the upper cloud masses, as well as providing for the surfaces of the Jovian satellites, which don't have atmospheres . . . or much happening in the infra-red spectrum, for that matter.

The last instrument in this particular package is the photopolarimeter/radiometer. The big brown book of Fun with Science out in the front office doesn't list what this is, so I'll just have to give you what NASA gave us. By some devious means it detects the temperature of things very remote to itself, such as the planet's atmosphere and the surfaces of the moons. By doing this, it can, among other things, check out a lot of data about the planet's cloud cover, by correlating this information with the results of other experiments.

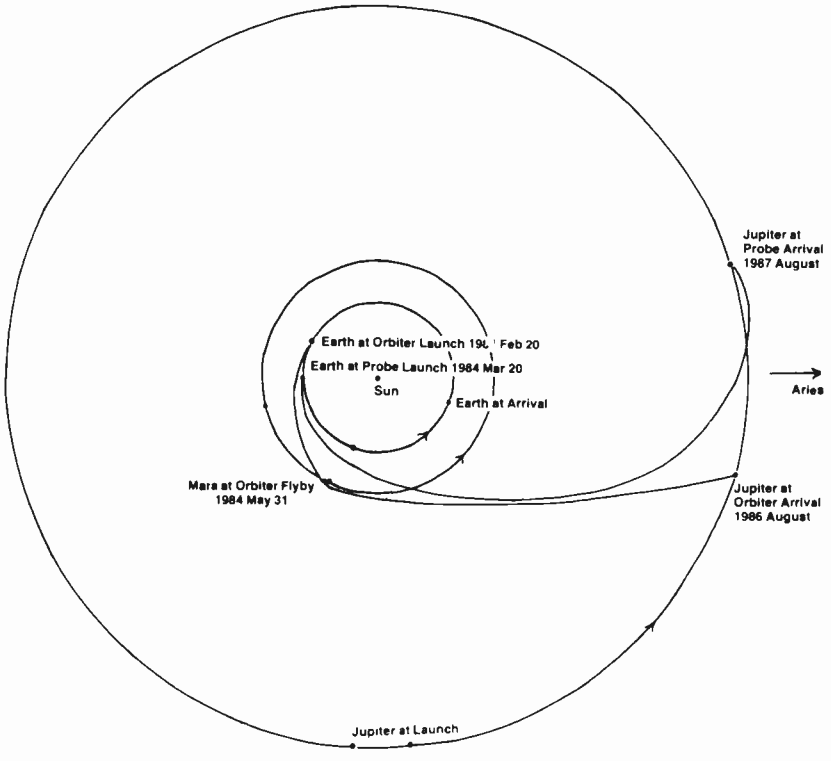
The back end of the orbiter will be permitted to spin. It will carry a number of instruments, including any or all, probably all, of the following. There's the ever popular magnetometer, which will hang out on a long boom so



Galileo in its present location: on the drawing board.



TRAJECTORY OF CANCELLED 1982 GALILEO MISSION



TRAJECTORY OF PLANNED 1984 GALILEO MISSION

that the electrical currents and magnetic fields kicking around the craft won't upset its delicate temperament. It will check out variations in the magnetic fields of the various heavenly bodies in question. No, taking one down to the bar next Friday won't help you in the least.

Plasma collectors will pick up data on low energy particles and ionized gasses out in the fringes. There's a particle detector for high energy ones. Jupiter has a series of radiation belts, particles trapped in its magnetic fields, just like the Van Allen belts of Earth. They probably also have Northern lights out there, although I don't know of anyone who's come back talking about them.

Stuck out with these instruments will also be some apparatus for radio propagation experiments, and celestial mechanics plotters to map anomalities in the gravitational field of the planet and its moons. This would, in turn detect either large concentrations of mass or buried Martian space craft. We don't actualy hold out much hope for the Martian space craft.

The Future

Pretty wild right? I'll bet you're all fired up, right about now, to trek right out, build yourself a space ship, and go explore the outer worlds. Hey, no sweat. Next Month in ETI we'll be beginning a new series on the construction of interplanetary probes and shuttles for the novice builder. Included will be such topics as fashionable Gloria Van der Pickup designer space suits, how to home brew a nuclear power cell, 64 LM741 circuits for use in deep space, and a furlable parabolic dish antenna you can build out of metallized mosquito netting and an umbrella. We'll also have a special bit on how to survive on the Jovian satellites by farming the ammonia fields. Hopefully, there'll be a great new mail order offer, too, for a rub down transfer of a man and a woman without any cloths on, and a bunch of scientific looking diagrams to put on the outside of your craft, in case you miscalculate and it takes off for Alpha Centauri.

Maybe we can even get an interview with old Galilei himself. He's probably hanging out around Jupiter these days, watching the fun . . . and thinking about taking up skeet shooting. ●

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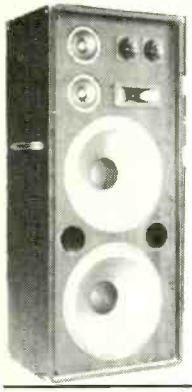

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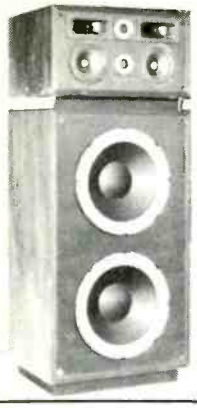

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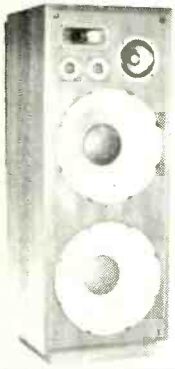

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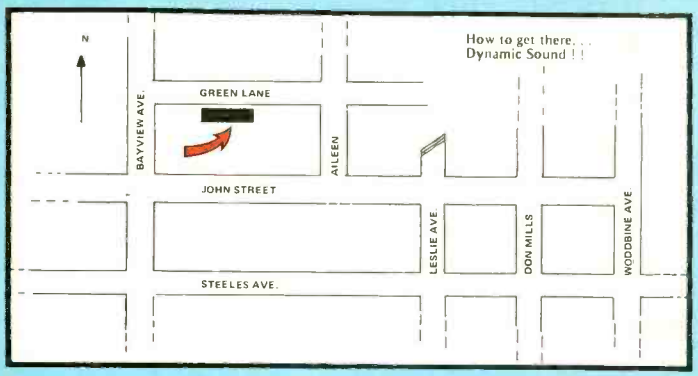

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Linear Taper.
10K, 25K, 50K, 100K, 250K, 500K, 1M. single $2.25 ea.
10K, 50K, 100K, 500K, 1M. dual $4.35 ea.

60mm Slide Potentiometers, approx. 2 3/8 inches long. Smooth gliding and quiet slide pots.
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10K, 25K, 50K, 100K, 250K, 500K, 1M. $2.78 ea.

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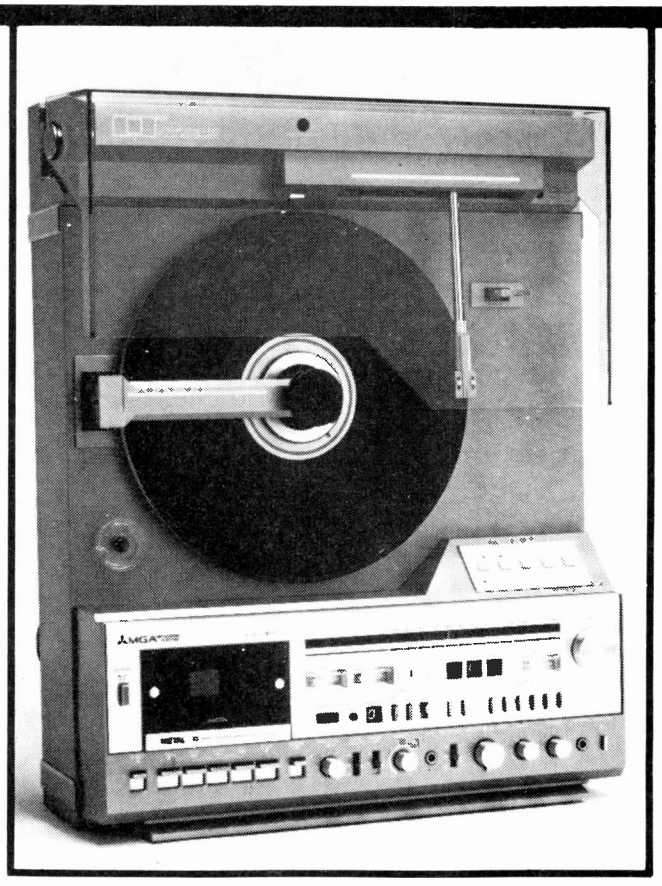
STORY BEHIND STEREO



We have become complacent over the past few years. Technological developments come so quickly that we rarely pause to consider how they were developed. Ian Sinclair looks into the (surprisingly) long history of stereo and where future research may lead.

NOW THAT we have the technical ability to process almost anything with electronics, it's interesting to note how many ideas which have been around for a long time are now being used at last. Stereo sound was one of the first of these ideas to be picked up, particularly when transistors became cheap enough to allow two amplifiers to be built for a price which previously bought only one. In this article, we'll try to trace the shaky beginnings of today's stereo.

Musicians have, of course, played with different arrangements of choirs and orchestras for centuries, and in many cathedrals, carefully chosen seating arrangements for the choristers were found by trial and error to give much clearer sound over a large space. By contrast, many composers preferred to write for small groups of players, deliberately avoiding the large spread of sound of the full orchestra.

The effect of the arrangement and spacing of sound sources which was well known to musicians was not lost on the physicists either, though it took some time before their knowledge of sound waves was sufficient to match up to the needs of analysing something so complex. Much of our knowledge of sound waves was laid down by the great physicist Helmholtz, and carried on by Lord Rayleigh of Terling, Essex. Rayleigh's Theory of Sound, published in 1896, is still the sourcebook for anyone investigating sound waves, and his work is the real starting point of the stereo systems which were developed after that time.

Rayleigh conducted a large number of experiments to find what factors determined how the human hearing system could 'localise' sound; that is, discover where the source of a sound appeared to be. One of his classic experiments involved fitting a listener with a pair of tubes, one to each ear, and sounding identical tuning forks at the end of each tube. He used this scheme for tuning forks with a wide variety of pitches, and found that the listener, who was blindfolded, imagined that the sound was directly in front of him when the higher-frequency tuning forks were used. This illusion did not persist when low frequencies were used, and could be restored only when a single fork was used and its sound taken through tubes of equal lengths to both ears.

Phased Forks

Rayleigh's conclusions were that the information on sound direction which we obtain arises in different ways at different frequencies. At low frequencies, it is phase differences between waves which carry the sensations of direction. Since he could not ensure that two tuning forks stayed in phase, the listener was unable to locate the source of low notes from two separate forks. At high frequencies, phase differences seemed less important, and the most important factor was the intensity of the sound; the direction of the sound always seemed to be towards the louder sound.

Rayleigh's experiments and theory weren't at all ahead of technology. Some fourteen years *earlier,* a telephone engineer in Paris had patented a system for enabling latecomers to a theatre to hear a realistic performance. His ideas was to use two microphones, one on each side of the stage. Each listener had also two earphones, left and right, so that the effect was that of headphone stereo. Since no amplification was needed, the system was quite practicable, and was, in fact, exhibited in action in 1881.

The lack of amplification in all early sound systems forced inventors to concentrate on headphone systems. Now, though headphones produce interesting effects, there is a vast difference between the sound heard on headphones, with its artificial separation, and the sound you hear live, or through loudspeakers. A good description of the difference is that headphone sound always makes your ears feel fifty feet apart, and this must be caused by the complete separation of signals which doesn't happen under normal listening conditions.

Early attempts at providing some form of loudspeaker stereo had to use the horn gramophone, and some of these were actually made.

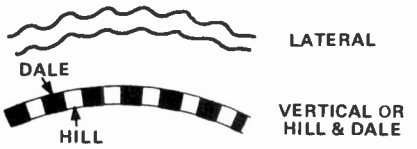


Fig. 1. In the early years of this century, both lateral (side-to-side) and vertical (hill-and dale) recordings could be bought. No one seems to have seen that both types of cut could be made on a single track.

Two Channel Radio

World War I turned inventor's minds to less harmless pastimes, and at the end of the conflict, the new possibilities which were opened up by radio broadcasting began to excite considerable interest. One scheme which was tried in 1925 was the separate broadcasting of two channels on different wavelengths. The medium-wave bands were not so crowded then as they are now – you didn't get the call-sign of Radio Bohemia continually coming over the station you wanted in those days!

In Berlin, stereo experiments were carried out using 430 and 505 metre transmitters, and at New Haven, Connecticut, station WPAJ won a place in history as a stereo transmitter using 270 metres and 227 metres. Details of the

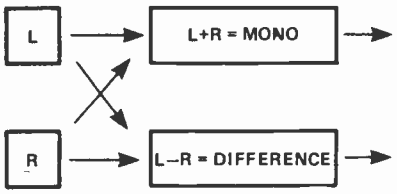


Fig.2. Blumlein's sum-and-difference methods. The important point is that the sum signal is the normal mono signal, and the differences signal is at a much lower amplitude.

Berlin system are lost, but the New Haven system is quite well documented. At the studio, the microphones were seven inches apart, a distance which had been picked by trial and error.

Station WPAJ had to bow to its listeners, though. Most listeners, still using headphones, didn't like the effect, which in any case was available only to listeners with two receivers. For the less well off, the reception of only one of two stereo channels was not a particularly good deal, and the scheme was abandoned.

For The Record

Curiously enough, disc stereo was not in such an advanced state. It's curious because all the information that was needed was already present. The early cylinder recordings had used what was known as 'hill and dale' recording (**Fig. 1**) – the sound waves were recorded as a pattern of vertical bumps on the cylinder. Emil Berliner's flat discs of 1888 used lateral recording, the familiar groove which waves from side to side. It must surely have occurred to many inventors that it should be possible to record one programme on a vertical recording and another on a lateral recording in the same groove – and yet there's no trace of it.

Stereo as we know it has its roots in the work of one man – Alan Blumlein of EMI. Blumlein was probably the ultimate virtuoso of electronics; his patents cover all aspects ranging from stereo sound through most of television to radar. What he might have eventually accomplished is something we can only guess at, because he was killed in an air crash, during radar tests, in the early days of World War II.

His work at EMI started in 1929, and by 1931 he had taken out the patent which forms the foundations for most of today's stereo systems. This patent outlines all the requirements that we use today, and suggests in particular, the use of sum and difference rather than straightforward L and R sound channels. The important point about a sum-and-difference system (**Fig. 2**) is that the sum signal is a normal mono signal, which can be used by mono equipment, and the difference signal is of comparatively small amplitude, easier to transmit. The sum-and-difference system has survived in FM stereo, though it was not used for either tape or disc stereo systems after World War II. The principles were revived, however, for most of the so-called 'quad' systems.

By 1932, Blumlein had turned his attention to the problem of coding two separate signals onto discs. The obvious method, stemming from gramophone history was to use both lateral and hill and dale recording on the same groove. This isn't entirely satisfactory, because one of the reasons for abandoning hill and dale recording was that the pickup could not follow the dales at high frequencies; it simply slipped from one hill to the next. Blumlein suggested that the two walls of the disc, set at 90° to each other (and at 45° to the vertical) could be separately modulated, and this is the scheme which was eventually used.

Degrees Of Stereo

Now, earnest students of physics will have realised what the significance of 90° is in all this, but everyone else deserves some sort of explanation. Without going into a lot of detail, any motion in a straight line can be imagined as being caused by two movements at right angles to each other.

For example, if you pull on the two strings illustrated in **Fig. 4**, then the block moves in the straight line which is shown. These two motions at right angles to each other are quite independent – changing one does not affect the other. Translating this into something closer to our applications now, imagine a device which consists of a miniature railway track with a plunger touching

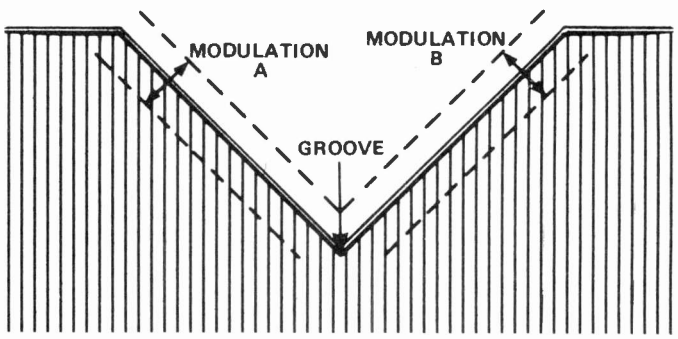


Fig. 3. Groove cross-sections – the walls are at 90° to each other, 45° to the horizontal. Each wall is separately recorded on by a hill-and-dale method.

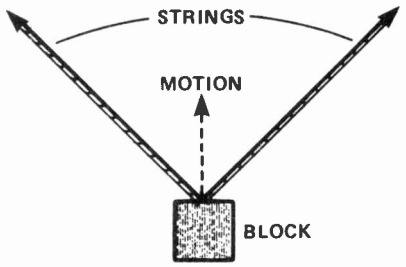


Fig. 4. How forces at 90° to each other can produce movement at 45° to each force.

the surface of a plate between the rails (**Fig. 5**). If the plate is shaped like a wave, the plunger will be forced to move up and down as the 'truck' is moved along. The up-and-down movement, however, does not cause the truck to move from side to side. Similarly, if the plate is flat, but the 'railway track' is a set of Z bends, the truck and the plunger with it will zig-zag without causing the plunger to move up or down. The two separate motions do not interfere with each other, provided that their directions are always at 90° to each other. We can now imagine that both sets of motions exist, with a wave shaped plate and Z-bends in the track, causing the directions simultaneously – this is as close as we can come to showing what takes place on a stereo recording. Imagine now that the whole caboodle is tilted through 45° – and you're there!

Fantasy Sounds

By the early thirties, all of the methods for obtaining and transmitting stereo had been worked out. The sum-and-difference coding for radio had been contributed by Blumlein, the 45°/45° disc was his work as well, and the third system, separate channels on tape was still waiting for further development of tape recorders.

There, for some reason, it rested. It was as if people couldn't take any more novelties, or perhaps that everyone sensed a coming war. Whatever happened, stereo sound didn't change, at least as far as the home user was concerned. Where it all started to happen was where there was money to play with, in the film world. The historic date was 1935, when the Bell Telephone Laboratories demonstrated before the Society of Motion Picture Engineers (SMPTE now, the T standing for Television) a stereo sound system for films, using twin tracks of the conventional type. It made some impression, but only on a few dedicated engineers. The big break-through came only in 1941 when Walt Disney Studios made Fantasia, a film of such remarkable originality that it still goes the rounds today. The theme of Fantasia is the fitting of cartoons to music, and Disney's engineers, who had heard the demonstrations in 1935, were convinced that a very large step forward in cinema sound was desirable. They certainly achieved it, after umpteen experiments and as many as ten full scale attempts, they ended up with an eight channel recording system. Their idea, later expressed in an article, was that if this improvement in sound was to catch the attention of the public it must be a dramatic improvement – there was no point in spending a million dollars in making something just slightly better. It's a principle that a lot of inventors ought to remember!

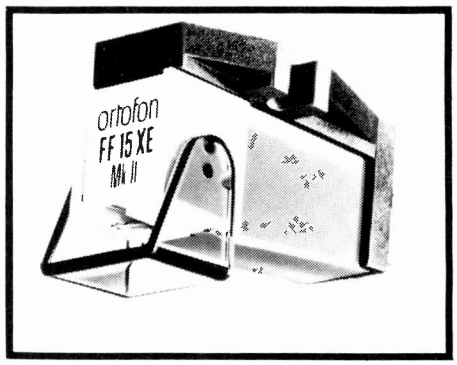
Fantasia certainly made its mark in the USA. No cinema carried the equipment necessary to reproduce the sound tracks, so the Disney Studios devised travelling sound systems, which had to be carted to each cinema and set up where a copy of the film was playing.

Coils And Cutters

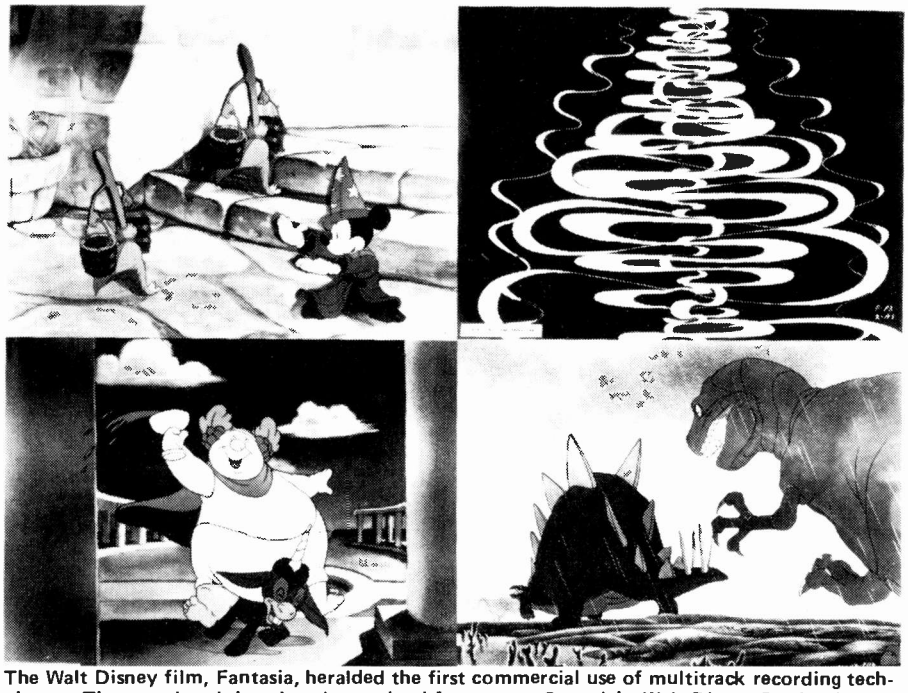
By the mid '50s everyone was waiting for stereo to happen, and there were countless proposals, ranging from the well-researched to the simply silly, lined up. As usual someone had to break the ice and take the first step into the water. The someone in this case was that champion of all the innovating companies in electronics, RCA. At that time, virtually all the disc cutting heads were made by one company, Westrex, a branch of Westinghouse. In 1957 RCA instructed Westrex to make them a 45°/45° stereo cutting head – with the option that if they didn't, RCA would start manufacturing the heads themselves. It was an offer Westrex couldn't refuse, because several other companies were already in the business of developing such cutters, notably Telefunken in Germany, Decca in Britain and Orotofon in Denmark. Westrex went ahead to develop a type of cutting head which, with later refinements, is still in use today.

The Westrex head uses two separate moving coil assemblies. The moving-coil principle is an old and well known one in the history of disc cutting and reproduction, and is illustrated in **Fig. 6.** A coil is driven with signals, and its magnetic field, which increases and decreases in step with the signal current, causes variable forces on an iron core. If the coil is suspended on springs, it will move in sympathy with the variations in magnetism, so producing a mechanical movement which keeps in step with the waveform of the signal. This is the motion which is used to operate the cutting stylus, and the Westrex arrangement consisted of two moving coil drives (or motors, as they are called) set at 90° **(Fig. 6).**

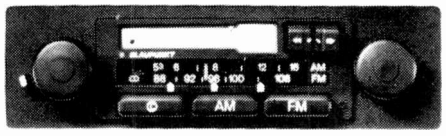
Once the Westrex stereo cutter went into production, the manufacturing of stereo discs became possible. By that time, the microgroove long-play disc had been developed also, and the modern stereo disc became a reality.



A modern phono cartridge.



The Walt Disney film, Fantasia, heralded the first commercial use of multitrack recording techniques. The soundtrack has since be remixed for stereo. Copyright Walt Disney Productions.



Modern tape decks for home use boast features undreamed of 20 years ago. The compact cassette took stereo to the streets

Through The Air

Stereo radio, as we've seen earlier, actually started much earlier than stereo discs, though the systems which used separate channels broadcast on separate wavelengths were not compatible. Compatibility is always a problem which tends to prevent new systems from being developed for any established process. The argument is that the customer already has equipment which mustn't be made out of date. The fact that advertising is continually trying to tell the same customer that his equipment *is* out of date is conveniently ignored. The compatibility problem has affected two systems in particular – stereo radio and colour TV. The argument in each case was that the existing owner of radio or TV should continue to be able to receive the same transmissions.

As it happened, the first FM transmitter had been built by the beginning of World War II, by Edwin Armstrong, inventor of frequency modulation, and in the post-war years, FM transmitters multiplied rapidly in the USA. The users of FM tended to be listeners who were interested in higher quality reproduction of music, so the FM transmitters were seen as the natural medium for stero transmissions. The bandwidth of an FM broadcast is much greater than that of medium wave, however, and this, along with the compatibility problem, ruled out the use of transmitting each channel on a separate frequency.

Transmission Systems

Once again, the field was open to inventors to devise methods of modulating the two channels onto one single carrier in such a way that an existing one million radios would continue to receive an acceptable signal, but a specially adapted stereo radio would be able to separate the two channels. A large number of proposals were put forward mostly hinging on the use of a subcarrier. A subcarrier is a sinewave which can be modulated by a signal, and which is then, in turn, modulated on to a main carrier along with other signals. This time, the systems had to pass the scrutiny of the Federal Communications Commission, the body which controls broadcasting technical standards, and it showed! The FCC had previously insisted (1953) that any colour system should be compatible, and it certainly wasn't going to make its rules any easier for half-baked schemes to provide FM stereo.

The system which was eventually chosen was the Zenith Radio-General-Electric joint submission. This is the stereo system which, unlike the NTSC colour system, is used world-wide with only minor modifications, and a brief reminder of its principles might be useful.

The Zenith GE system **(Fig.7)** relies on Blumlein's principle of sum and difference signals, L + R and L – R. The sum signal, L + R is frequency modulated onto the main carrier in the usual way, so that the user of mono equipment has the same signal input to his receiver as he had before. The carrier is also modulated with two other signals. One of them starts as a subcarrier at 38 kHz, which is amplitude modulated by the difference signal, L – R. The subcarrier is then removed, leaving only the modulated sidebands, mainly low amplitude, to be modulated onto the main carrier. The third signal which is modulated onto the main carrier is a low amplitude sinewave at 19 kHz, which is obtained to the transmitter by dividing down the 38 kHz subcarrier frequency.

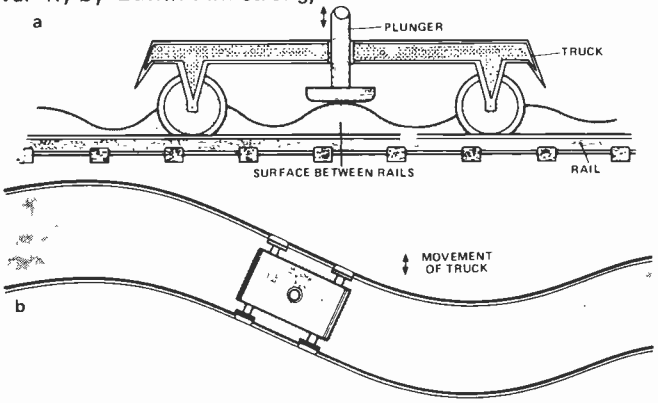


Fig. 5. Independent movements which do not affect each other. The vertical motion in (a) is quite separate form the horizontal motion of (b), but the two are combined, the plunger will have both types of motion simultaneously.

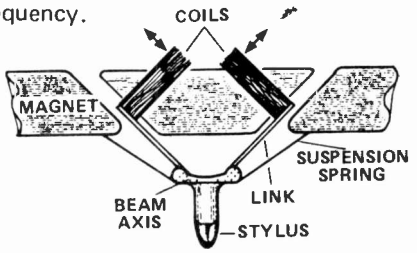


Fig. 6. Front view (simplified) of a classic type of stereo cutter. The two coils are driven in directions at 90° to each other, so producing a 90° cut by the stylus.

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At the receiver, these signals can be separated without much difficulty **(Fig. 8)**. A mono receiver detects only the sum signal, with its normal de-emphasis circuits (low pass filter) removing the 19 kHz sinewave (the 'pilot tone') and the sidebands of the sub-carrier. A stereo receiver uses no filtering immediately after the demodulator, so that the pilot tone can be detected, amplified and frequency doubled to 38 kHz again. This newly regenerated carrier frequency can now be used to demodulate the subcarrier sidebands (a method called synchronous demodulation is used) to recover the L – R signals. The L + R and L – R signals can be combined to provide the L and R signals which are the stereo channel signals.

On Tape

Tape recorders? Oddly enough, though stereo on tape was used comparatively early by the manufacturers of discs, stereo tape for the home user came a lot later. The use of tape was only ever a minority interest in any case, apart from the brief craze for tape-recording in the early sixties, until tape became capable of providing better quality sound at reasonable prices. Though stereo tape recorders eventually became available, with such excellent machines as the Revox providing considerable competition to the best of discs, tape stereo still remained a minority pursuit. Things stayed this way until the cassette developed four channels and efforts were made to sort out the miserably poor signal-to-noise ratio.

Because commercially-made stereo cassettes could be bought, unlike stereo tapes, stereo on cassette flourished despite its technical shortcomings. Rapid development ensured that whatever stereo equipment you bought one year would be out of date by the next year, so keeping manufacturers keenly interested in research. In some cases, the research simply resulted in more shiny cases with less insde them, but some very important advances were made in tape material, in circuit techniques (such as Dolby and dbx), and in convenience (such as being able to set up the recorder easily for different types of tape). Because cassette stereo was the most recently developed stereo system, it's still developing, trying to reach nearer perfection before the next big breakthrough.

The next one? There are digital tapes, laser-read discs, and presumably, laser-read tapes all being developed, all with the promise of high packing density (lots of music in a small space) and very low noise levels. That doesn't mean that manufacturers have learned from early mistakes — there are as many systems competing now as ever were, some with such obvious flaws that it's difficult to imagine they were being seriously put forward except as a way of keeping a place in line. All we can do is wait and hear! ●

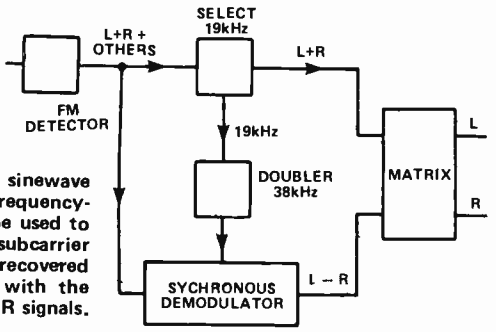

Fig. 8. At the receiver, the 19kHz sinewave is selected by filtering, and then frequency-doubled to 38kHz so that it can be used to demodualte the sidebands of the subcarrier signal. Once the L-R signal has been recovered in this way, it can be combined with the L + R signal to form separate L and R signals.

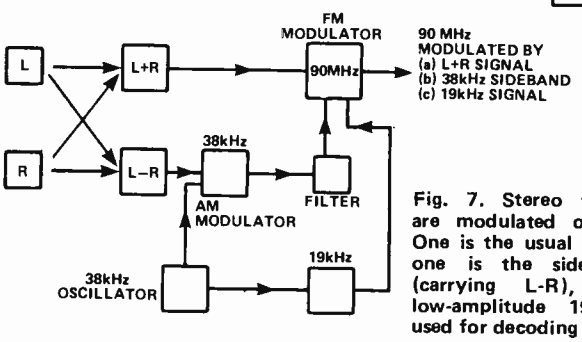

Fig. 7. Stereo transmission. three signals are modulated on the main VHF carrier. One is the usual (mono) L + R audio signal, one is the sidebands of the subcarrier (carrying L-R), and the third is a low-amplitude 19kHz sinewave which is used for decoding at the receiver.

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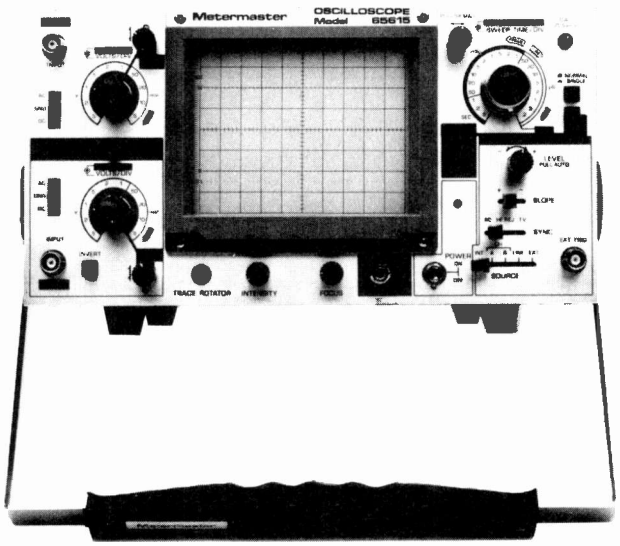

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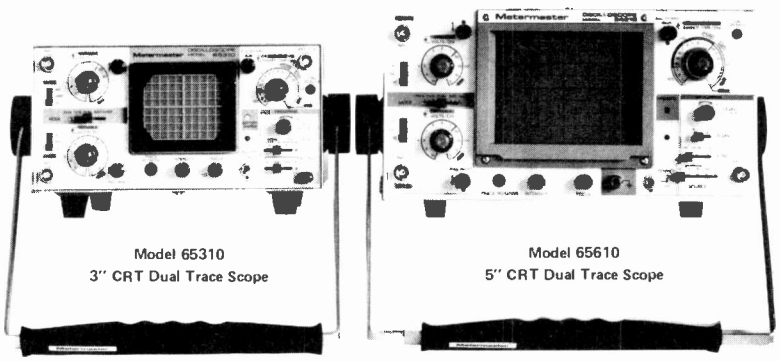

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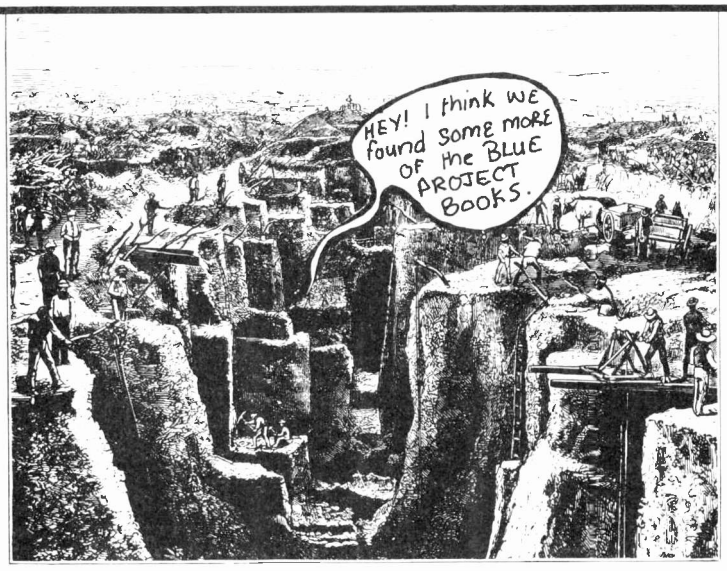

When the announcement of this discovery was made, John got real excited, jumped up and down and accidently fell into the magazine storage pit. Bit of a drag, but you can understand how he felt. ETI's Hobby Project Book has 25 first rate projects, including an LED Tachometer, A Graphic Equalizer and a Linear Scale Ohm-Meter. If you send us $3.95, we'll send you one . . . better hurry, though. Our chaps been down there a while, and he must be getting hungry by now.

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WHAT'S NEW

By Steve Rimmer

Ever wondered how those self focusing cameras work? Well you're going to find out anyway. Steve Rimmer plumbs the depths.

THERE'S NOTHING more frightening than coming home from a long day, hard at work doing nothing, yes, slaving over a hot electric guitar. . . well, I didn't know it was hot when I bought it. . . only to find an addition to ones decore. I mean, like, I was very thoughtful in laying out the place, y' know. I have four old style plastic milk crates holding up the TV, and two more, matched ugly green ones, dig it, for the stereo. The couch is truly priceless...I came upon it in a quaint little out of the way little boutique called Harry's Emporium of Swill and Vileness, where the owner personally offered me the piece right then and there if I could have it off the premises by noon. The lighting is diffused into a gentle, incandescent glow by an Allen's Apple Juice can with welding torch holes in it. The walls are accented by several original works of art, absolutely none of which are on black velvet, plus two excellent reproductions, one of which illustrates the Grateful Dead in concert, and the other being a blow up of a Springsteen cover. There are also several custom made ragged holes where assorted glass vessels once intended for the containment of fermented drink have impacted with the gyprock? It's the sort of dwelling one could expect to find in Dive Beautiful or Better Hovels and Gutters. . . at least it was. However, just the other day I repaired to my lushly appointed retreat only to find. . . Max.

Yes, Max, whose name is mumbled through a mouthful of frozen fish and peanut butter, whose eye invokes the curse of the mystic glue sniffing worm pickers of Scarberia, whose aroma has put my cat into a coma. . . Max was there, sitting in front of my tube watching a videotape of the All Night Show munching raw hamburger and salt. 'Air conditioner's busted over at m' flop, man. Stickier'n candy bar in yer jeans.'

'Is that the one you tried to make into an energy efficient still?' I ask, naive.

'Hell, ya. . . was doin' jus' marvy, man. Just tight, right, an' then. . . boom.' He gestures to simulate a mushroom cloud. I think he's on a mushroom cloud. 'Service man said he doesn't work on slag.'

'That's 'cause you had a penny in the fuse box, man...'

'Wha...oh, no, man, that melted ages back. I eventually just said ace it, like, an' I stuck a big hunk o' wire 'cross the thing. Fixed it good.'

'You lookin' at a prolonged occupancy here, Maxwell, old thing?' Now this is probably the dumbest question of the afternoon.

'Well, y'know, gotta have a conditioner, man. That solar heating thing I put in is nice, but you can't shut those suckers off.'

'If I give y' something to play with will you go over and bother Josie for a while?' This has been known to work.

Well, it took a while to find something that would amuse Max. Actually, I didn't have any of what he really wanted, but that was okay, because if he got caught with any again he'd be drinking from a tin cup for some time to come. What I eventually laid on him was a rather neat little troll I had been given to review. He kind of got off on it...he kind of got off on it so much that he didn't really want to give it back. I eventually had to get Josie to threaten to hit him with the dreaded Curse of Sobriety if he didn't cough it up.

This, of course, was to no good end. He's back living in front of my set, rolling ginseng joints. This month we're going to get into the Polaroid Ultrasonic Ranging System Designer's Kit...and you'd better read every word of it. I would not be pleased to think that Max has infested my digs for nothing.

Fig. 1. This is my foot.

My Foot.

My foot is exactly 1.8 feet away from my face with my knee somewhat bent, while propping my leg up on an Arborite pedestal table. . . a very useful bit of data, actually, considering the absoluteness of relative space, and all that stuff. Now, you may be wondering how I came to know this. Did I, for instance, consult an oracle, or was it one of these

string and yardstick deals, successive approximations and similar,unscientific voodoo. None of this, no, I determined the precise linear co-ordinate using purely electronic means. You see, unbeknownst to all but an elite inner circle comprised of myself and the cleaning lady who steals oranges out of my desk, I have a Polaroid Ultrasonic Ranging System Designer's Kit. . . de-de-de-de-da-deee. (That was a fanfare. It's very hard to do a fanfare on an electric typewriter.)

This is, in spread out form, Polaroid's fiendishly sophisticated Ultrasonic Ranging System, initially developed for use on their automatic focussing instant cameras. It is, in operation, deceptively simple. To range an object, one simply switches on the power and aims the box at the rangee, reading the distance off the LED display in feet and tenths of feet. If the interval can be kept between 0.9 and 35 feet, the system expresses beneficient karma, and is astoundingly accurate.

The purpose of the kit is to serve as a demonstration of the performance of the system, and to give the great itching hoards of the orb a chance to fiddle with the actual transducer. It is, in fact, the transducer that Polaroid's trying to get everyone shook up about. . . methinks the R&D budget for this one was a bit steep, and they want some of it back. The idea seems to be to get some designs happening around this device.

In any case, let the inspired take note that the hairy minions of Dr. Land are only offering the transducer for sale, outside the confines of the designer's kit. . . the circuit boards aren't available in mass quantities.

My Foot In The Works.

Lookit me, ma. I'm a transducer. Check out what I'm up to now.

The operation of the transducer in the Polaroid system is quite interesting. The principal of sonar ranging is, of course, quite simple. There is a transducer of some sort, essentially a speaker at first, which emits a pulse of sound, or, rather, ultra-sound, I guess. . . energy at some frequency slightly above the range of human hearing. Now, as we all know, or, at least, should, sound takes a finite time to travel from point A to point B, and, in fact, it's pretty slack about it. Sound, furthermore, has the useful property of being easily reflected, to some degree, from

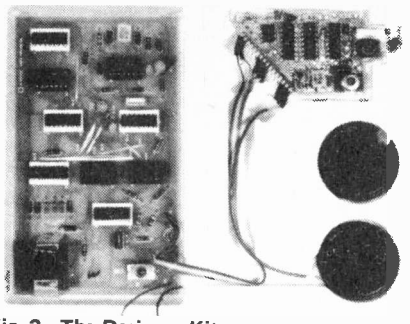


Fig. 2. The Designer Kit.

most surfaces. Thus it is that our burst of ultrasonic energy shot out from the aforementioned hypothetical transducer will go screaming out. Until it intercepts some solid object, at which point it will rebound away, and some portion of it will motor its way back toward the original source. Having done so, what we need is a second transducer, or, alternately, to have our original transducer serve a dual function. For if there was a microphone at the point from which the sound was initially radiated, it could pick up the returning pulse. If this pulse were to be stuck up alongside the original, outward bound pulse, there would be a period of time between the two corresponding to twice the distance between the transducer and the object, at the speed of sound. Blows the consciousness into the fourth dimension, I know.

Now, there are lots of things one can do with these pulses, but most of them get into some sort of gating arrangement. What goes down in the Polaroid kit is probably the simplest to understand. What we're into here is a clock, which is running at a fixed speed, such that one pulse will give a reading of one tenth of a foot when gated into a counter. Thus, when the first pulse, the driving tone, comes through, this clock is gated on, and the counter starts wildly racking up the digits. When the return pulse hits land, it switches off the counter, and the resulting three digits are dumped to the LEDs. If the clock period was accurate, we would now have a digital readout of the distance between the transducer and the object. In the time it took you to read this, the reading would have been updated about fifty times. Yes, Max, this is one of those things that's a lot easier to do than to explain.

What limits the effectiveness of sonar ranging is very much what does in human hearing, roughly the same sort of mechanism. Ambient noise will bother the system, as the transducer, when acting as a receiver, may not be able to differentiate between a lot of white noise, a portion of which will have its distribution at the same frequency as the sonar pulse, and the returning pulse itself. As the distance gets greater, naturally, the pulse gets weaker, so this problem is aggrevated the further off the subject is. Obviously, for any given ambient noise scene, there will be a distance beyond which things get universally uncool. However, even before this point is reached, the system may get quite erratic.

The second hassle involves standing waves, and other oddities of pitch versus space. Without getting into all the math involved, which I flunked miserably anyway, if one has any internal space, such as the distance between the ranger and the rangee (no remarks about Silver and Tonto, s.v.p.), one has a tuned cavity of some sort. If one places a point source of sound in this thing, given the right pitch, there will come a point where in any given area in the cavity is in a node, a region of high intensity sonic energy, or an anti-node, a region where all the phase thingys conspire to cancel out. Tough luck if your transducer happens to be sitting in an anti-node with respect to the object to be ranged.

Lastly, and, admittedly, not too important, is the hassle of having multiple return echos. Naturally, the sonar pulse will not lance out of the transducer like Jim Kirk's phaser beam, but will emerge in a roughly conical sort of pattern. Part will be reflected by the object of the ranging, and part by the rusted 1958 Edsel coupe sitting upside down on top of a Volkswagen somewhat behind and to the right. There is also a herd of crazed Albanian killer llamas thundering across the tundra, which will no doubt cause reflections of their own. It is therefore necessery to distinguish the first, and meaningful echo from all the rest of the grass, and deal with it alone. (After that, the system should illuminate a LED to indicate that the operator is about to be pummeled into the sands of time by all those llamas, and might well initiate a consideration process dealing with the beating of a hasty retreat.)

Now, as far as the demo kit is concerned, most of these little inconveniences aren't too planet shaking, but, as you may recall, digging deep into your phyche, we

noted that the system is, in fact, lifted lifted from those little Polaroid cameras, and great woe would be betided if the ranging thing started going squirrelly with ten dollar film packs. Thus, quite a lot of really genuine cleverness has gone into the engineering of the system, which we'll now have a peer at, for those bent on devising applications for the transducer. It should be kept in mind that no matter how slimy one may feel about lifting circuit designs, these ones do work.

Working With My Foot.

The transmitted pulse is actually not a single burst of ultrasonic tone, but rather, a careful blending of four carefully aged and mellowed frequencies; eight cycles at 60 kHz, eight at 57 kHz, sixteen cycles at 53 kHz and twenty four cycles at 50 kHz. The whole works plays for one millisecond. This gets around the phase cancellation hassles at any specific frequency.

The receiver also has a neat trick. Its bandwidth is self adjusting. After the outgoing pulse lets loose, a counter starts to increment, generating a sixteen level stair step waveform, which controls the Q of the receiver's bandpass filter. The longer it takes for the pulse to come back, the narrower the filter becomes. Its centre frequency is at 50 kHz when its at its sharpest. Now, what this means is that it is better able to pull a weakened returning signal out of the grass, essentially by cutting out increasingly more of the grass. It also reduces the effectiveness of the multiple frequency phase cancellation fixer at greater distances, but one would suppose that this becomes less of a problem as the light years increase.

There are two grades of transducers available, which are, in probability, two sorts through the output of the assembly line. The better of the two is Instrument grade. There're also Commercial grade beasties available, which are somewhat cheaper, but with looser specs. Concerning playing with them, the good stuff only costs about seven bucks each, which isn't too heavy. As far as what their capabilities are, the instrument grade transducers are used in the design kit, so one can be sure they're good for a range of at least .9 to 35 feet.

Your average transducer is .328 inches thick, and 1.690 inches in diameter, or about the size of the lid of a baby food jar. The housing is all

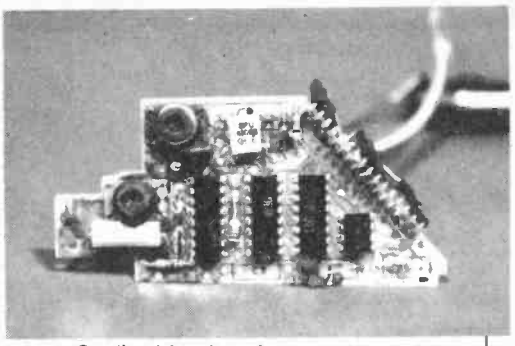


Fig. 3. The driver board.

natural plastic, garenteed not to rust, dissolve or reform into a Barbie doll. Its weight is not given in the back of the manual, so I won't include it here. I suppose it's fairly irrelevant anyway.

The transducer is a bit demanding in terms of its desires for voltages of one sort or another. First off, it likes a 150 volt DC bias across its terminals, and a drive signal of at least 150 volts AC. Neither of these involve any real amount of current, though, so little ginchy power inverters and backwards matching transformers are perfectly suitable for juicing it. It exhibits a 400 to 500 picofarad capacitance across its terminals when biased to 150 volts. Under these circumstances, it exhibits a transmitting sensitivity of at least 110 db, and a receiving sensitivity of at least -42 db. It will operate over a range of 32 to 140 degrees, and 5 to 95 percent humidity. Its typical dispersal pattern gives it a pattern that is about 50 db down 30 degrees off axis.

Groovy numbers, man. (Can you smoke it?)

Footing The Bill.

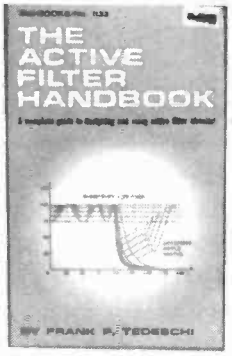
The applications for the transducer are limited only by your imagination and the bounds of reasonable intelligence. Yes, I suppose it would make a nice ultra-tweeter, but do you really need one? However, there are all sorts of fairly practical uses for it that come to mind, such as an ultrasonic measuring tape, a parking aid, automatic garage door opener, ultrasonic remote control system...I don't see why it couldn't be used as a doppler intruder alarm thing, too.

And that, yes, that would be a very practical application. Because it could drive a relay. And the relay could drive a solenoid. And the solenoid could be inside me fridge. Yes, lads, and whenever Max came in to satiate an attack of the raving munchies, the solenoid would lock the fridge, and he wouldn't get in. My food would be. . . no no no, never mind.

Forget it. He'd eat the cat.

Stay tuned.

AUDIOPHILES! SYNTH NUTS!



No electronic enthusiast should be without one! The Active Filter Handbook discusses all types of filters. The author starts with two fundamental filter types, Butterworth and Chebyshev, and explains all definitions, concepts and fundamentals. Unlike others, this book does not ignore mathematics, but rather shows the derivation of all design equation.

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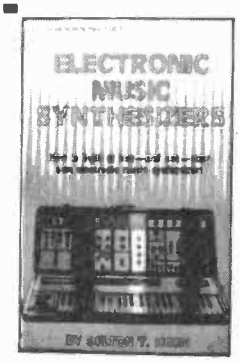

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SINCLAIR'S LATEST

Having broken cost barriers with his ZX80 computer, Clive Sinclair now refines and expands his system. John Van Lierde reports.

SOME MONTHS ago(February, 1981 to be precise) I looked at the Sinclair ZX80. The ZX80, I felt, represented a significant step in low cost ready-to-run computers.

The machine I reviewed at the time suffered from some limitations. The major one, its integer only BASIC, severely restricted the number of interested users. Its inability to communicate in ASCII prevented users from adding such desireable peripherals as printers and real keyboards. Lastly, its 1K memory, while suitable for general work, did not allow the programmer to utilize any number of dimensioned or string variables.

Since then, Sinclair has introduced a number of products that make his computers more attractive to potential computer buyers.

New! Improved!

First off is a new version of the miniscule machine dubbed, appropriately, the ZX81. Like its predescessor, the ZX81 embodies many unique features, both hardware and software. The first surprise is the price, almost 40 percent off the that of the ZX80! How is this done? Is it slave labour? Stolen chips? Hamsters on treadmills? No, it's high tech. Essentially, the secret lies in the replacement of some 18 ICs with a single uncommitted logic array. This done, the entire machine has been reduced to keyboard, RF modulator, and four (count 'em) ICs. These are: the CPU, ROM and RAM and the logic array. Not bad!

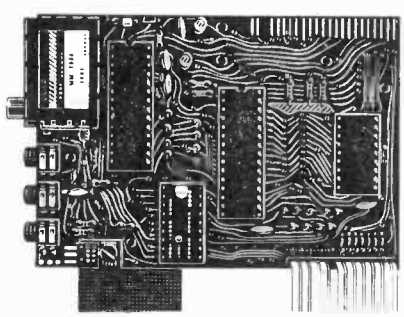
The Sinclair ZX81 computer. Note that some keys have three or four functions. Additionally, integral functions such as PEEK and POKE have been brought down to the keyboard.

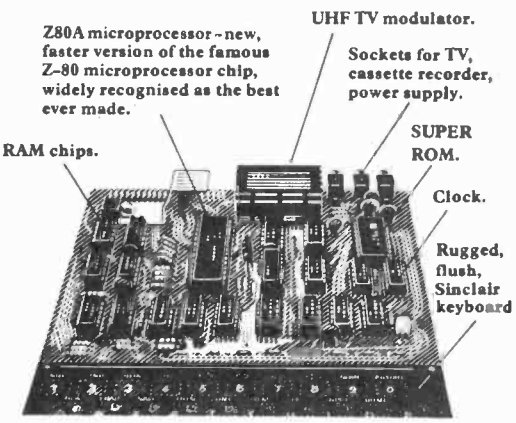
The ZX81 embodies all the standard ZX80 features and then some. Aside from 'one touch' command entry, Sinclair's unique error checking facility and others, the machine now boasts such capabilities as: floating point arithmetic; a full complement of mathematical and scientific functions accurate to eight decimal places; multidimensional strings and arrays; graph drawing and animated display capability. In operation it is similar to the ZX80. Four sockets make the necessary connections to power, cassette input and output, and television. Power it up and it's ready.

The machine comes with the standard 1K of RAM. Needless to say, this is unsuitable for any heavy duty work, and so Sinclair offers a 16K RAM pack to alleviate this heretofore painful space restriction. There are even hints of a disk system somewhere in the future.

Sinclair has also come to terms with the need for hard copy and will be introducing a printer soon. Details are sketchy, but it seems it that can duplicate the contents of the video display, characters *and* graphics. This would mean a 32 character line. Judging from the picture and the description, the proposed printer is of the thermal or static discharge type.

The ZX81 board (left) and the ZX80 board (right), notice the difference in parts count.



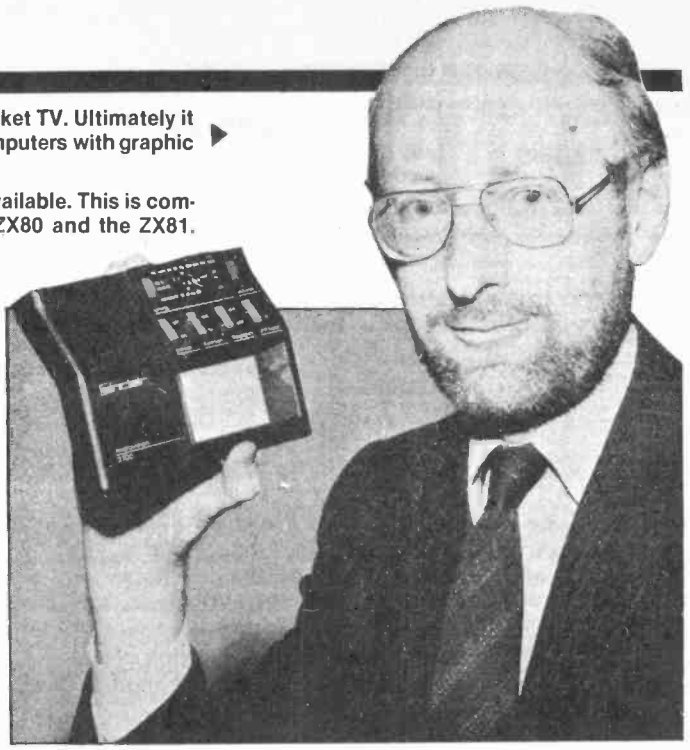


Old Machines Don't Die

But what about ZX80 owners? Sinclair hasn't forgotten them. An 8K ROM is available as a replacement for the original 4K part. Just plug it in. All the ZX81 features are now enabled with the exception of animated graphics. Additionally the aforementioned 16K RAM will also work in the ZX80.

Already the ZX80 has generated considerable interest and there is a growing add-on peripheral market. We have been told that there are such extras available as a keyboard beeper (which is probably quite useful), a $99(US) printer, and an add-on *real* keyboard for about $100US.

A 16K RAM module is available. This is compatible with both the ZX80 and the ZX81.



Clive Sinclair with is pocket TV. Ultimately it may lead to 'pocket' computers with graphic capabilities.

A preview of the ZX printer. Designed exclusively for use with the ZX81, it will also work on ZX80s equipped with the 8K ROM.

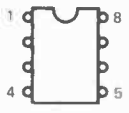
Flat, The Shape Of the Future?

Finally, Clive Sinclair recently announced the developement of a flat video picture tube. Initially, it will be produced as a pocket television, but word has it that the flat screen TV will be worked into the ZX computer system. This would result in a small, portable and very powerful system.

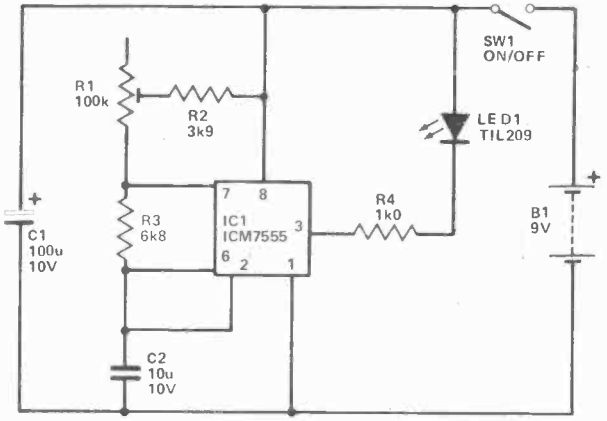
Having seen what has been promised, it would appear that ZX computer system is maturing to a level of power and capability at a price that should make it attractive to a large number of people. It's certainly worth a second look. ●

Designer Circuits

SIMPLE PHOTOGRAPHIC TIMER



ICM7555 TOP VIEW



Although this timing device may seem to be rather unsophisticated, it is a handy little gadget for timing darkroom exposures, or time exposures, or time exposures made on a camera with the shutter set to the "B" position. The unit simply flashes a LED indicator briefly at 1 second intervals. If, for example, one wishes to make a ten second time exposure, then the shutter is opened during any convenient flash produced by the unit, and then closed after a further ten flashes have been produced. Adequate accuracy for normal requirements can be obtained in this way.

The circuit is based on the CMOS version of the well known 555 timer device. The CMOS version has the advantage of having a current consumption which is only about one hundredth of that taken by the conventional version, and this is obviously beneficial in a battery powered piece of equipment such as this one. The average current consumption of the unit is actually less than 1mA., giving an extremely long battery life.

The CMOS version of the 555 operates in the same basic manner as the ordinary version, with timing capacitor C2 first charging up to ⅔ V+ by way of the timing resistors — R1 — R2 — R3. The device is then triggered into the discharge mode, resulting in C2 being discharged through R4 to a potential of ⅓ V+ whereupon the circuit reverts to its original state with C2 charging up once again. Contuous oscillation thus results. The frequency of operation is adjusted to 1 HZ by adjusting R1, and in practice this is adjusted by trial and error to obtain (say) 60 flashes in a one minute period. Longer calibration periods can be used if better accuracy is required.

The output of IC1 assumes the high state while C2 is charging, and the low state while it is discharging. As C2 charges via R1, R2 and R3, but only discharges through R4, the discharge time is therefore much shorter than the charge time. By connecting LED indicator D1 and its current limiting resistor R4 between the output of the IC1 and the positive supply the required brief flashes are thus obtained.

THE 1537 VCA

Our Stereo Image Coordinator made use of a useful device. The 1537A offers some very impressive specs. Keith Brindley explains.

THERE IS always a great deal of excitement generated in electronics on the arrival or introduction of a new circuit, concept or chip, particularly if the system is potentially a field leader. The 1537A chip is just that! The specifications which the device can offer in situ are well above those of any similar preceding systems. Table 1 gives a listing of specifications, which can be obtained in the correct applications.

Parameter	Specification
Bandwidth	DC-200kHz
T.H.D., 20Hz-20kHz	0.004%
I.M.D. (SMPTE TEST)	0.03%
Noise	-90dBv, ± 1dB (worst case, unity gain)
Overshoot and Ringing	None
Slew Rate	> 10v/usec, symmetrical & constant
Input Impedance	20KΩ
Maximum Input Level	+20dBv
Gain	0dB (Unity)
Maximum Attenuation	>94dB
Control Voltage	0 to +10V
DC shift vs. Attenuation	≤ 5mV
Power Requirements	Regulated ± 15V at +25, -33mA

Table 1. The maximum possible specifications available from a 1537A system.

With harmonic distortion of 0.004% and a signal/noise ratio of over 90 dB the system is of course well suited to studio applications, although use in this environment is by no means its only area of involvement. The IC itself seems at first glance, somewhat highly priced at around $22, but nevertheless, it requires few extra components to produce a VCA system of the superb quality (suggested in the specifications of Table 1) and overall represents good value for money to the amatuer and professional engineer alike.

Amplifier Or Attenuator

The term VCA is normally used as an abbreviation of the phrase Voltage Controlled Amplifier, but in its simpler modes the 1537A is, strictly speaking, a voltage controlled attenuator ie with a maximum gain of unity. The inventors do, however, stress that connection of the 1537A into the feedback loop of an amplifier (such as an op amp) produces a voltage controlled amplifier. The applications section of this article show how this can be achieved.

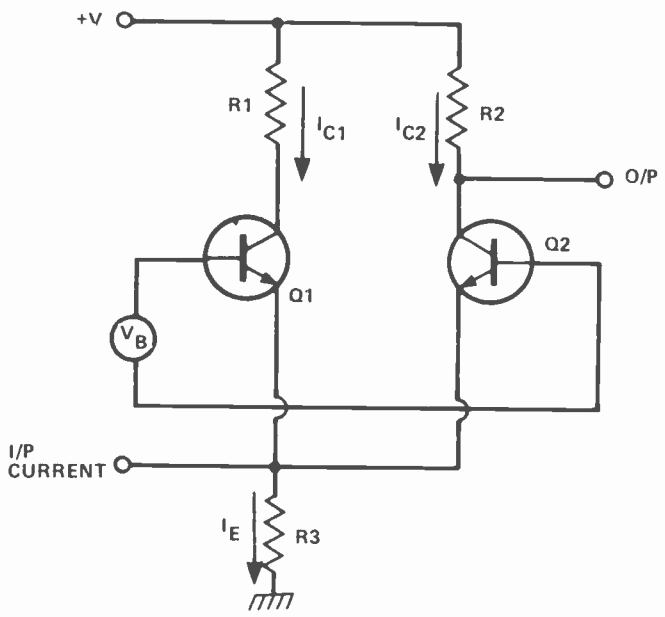
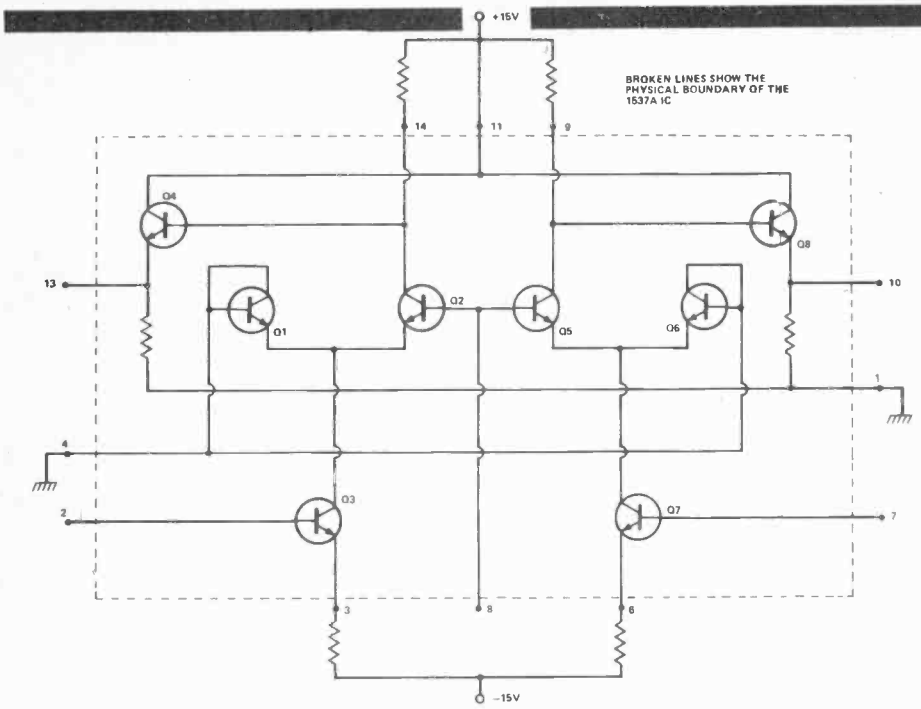


Fig. 1. A differential pair of transistors — the basis of a VCA.

The operation of the 1537A VCA depends upon the gain control function of a differential pair of transistors as in Fig. 1. The transistors in Fig. 1 are connected at their emitters. The current through R3 (I_E) is, therefore, approximately equal to the sum of their two collector currents I_{C1} and I_{C2} through R1 and R2 respectively. The relative bias voltage, V_B, between the two bases determines the relative collector currents. If we now apply an input signal current to the joined emitters we obtain output signal currents through R1 and R2, the sizes of which are determined by the bias voltages. In other words, by altering this bias voltage we alter the size of the output signals.

Figure 2 shows a simplified internal circuit of the 1537A chip giving pin numbers and external load and emitter resistors necessary for operation. There are two basic gain control circuits within the chip, similar to that in Fig. 1 (built around Q1, 2 and Q5,6) except for three main differences:
— the diode connection of the transistor pair not used for signal output ie Q1 and Q6, which reduces the distortion due to transistor gain differences.
— the addition of buffers around Q4 and Q8 to reduce loading of the output collectors of the gain transistors, in turn allowing idealised characteristics over the full gain range.
— the use of transistors Q3 and Q7 as voltage to current converters enabling the input to be applied as a voltage rather than as a current.



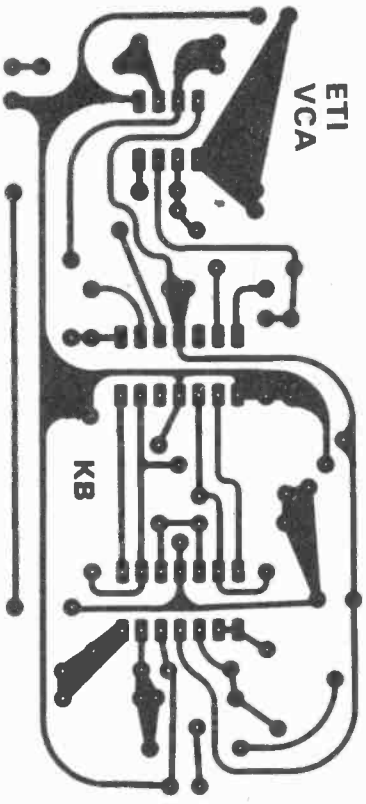


Fig. 2. A much simplified internal circuit of the 1537A IC, showing external load and emitter resistors.

There is, however, a much more subtle difference, on top of this and that is the use of large geometry transistors. The effect of larger geometry transistors can improve second order intermodulation by as much as ten times for a tenfold increase in transistor size. Noise can also be reduced by about 10 dB for a similar increase in geometry.

This leads us now to the simplest mode of operation of the 1537A using each gain control circuit individually, although the control voltage affects the gain of each circuit simultaneously (Fig. 3).

The ratio of R9 and R10 is calculated to allow a control voltage range of 10 volts (ie 0 to minus 10 V), altering the gain of the system from 0 dB to about —90 dB. The input impedance of the circuit to applied signal is low and ideally buffers should be placed before this circuit. Although this circuit does not give studio quality specifications it will, however, still produce results in the "high fidelity" range, providing impedance matches are considered.

Figure 4 shows a circuit application which gives a higher impedance input. Also included is an inverting stage in the control voltage link which allows a voltage of 0 to + 10 volts to be used for controlling attenuation.

Although any operational amplifier could be used for ICs 1, 2 and 3 in the previous circuit, it should be fairly apparent that the noise, distortion and bandwidth specs of the circuit are limited to those of the op amps used.

Either of the two circuits of Figs. 1 and 2 can be adopted as the voltage controlled gain heart of a stereo system. Their outputs are about 10 dB down on the inputs so necessary amplification should be given before or after the attenuator.

Coming Up To Scratch

Now, three more developments to the circuitry can be undertaken to improve the specifications to those of Table 1. Figure 5 shows the circuit of the ideal system capable of these high specs.

Firstly, actively linearised voltage to current sources (op amp 3 and 4 in Fig 5) improve distortion figures when using a wide range of input signal voltages.

Secondly, parallelling of the two individual gain control circuits (ie the same input signal is fed to both devices at their inputs and mixed at their outputs) gives a 3 dB improvement in S/N ratio.

Finally, a technique is utilised which is complementary to the previous development of parallel devices, whereby the same input is applied to both gain control devices but 180 degrees out of phase. The two outputs are combined in a differential amplifier to give a single ended output. The differential amp is formed around op amp 6. This technique has the effect of reducing DC shift caused by bias and control voltages and with careful adjustment of RV1, the minimal DC shift now left at the output can be reduced even

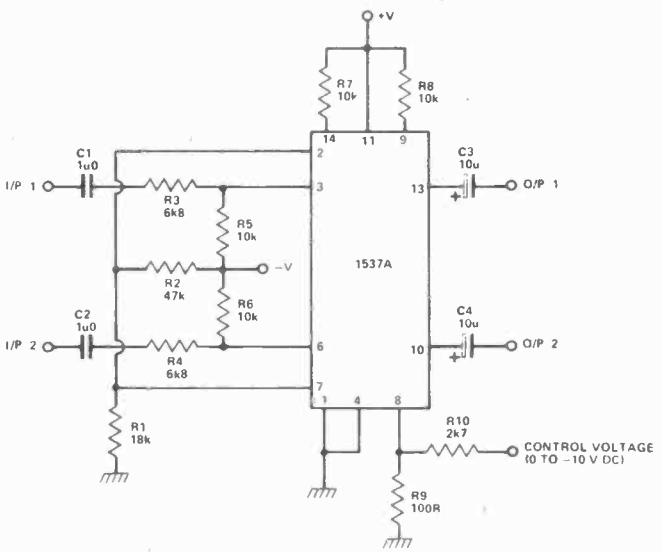
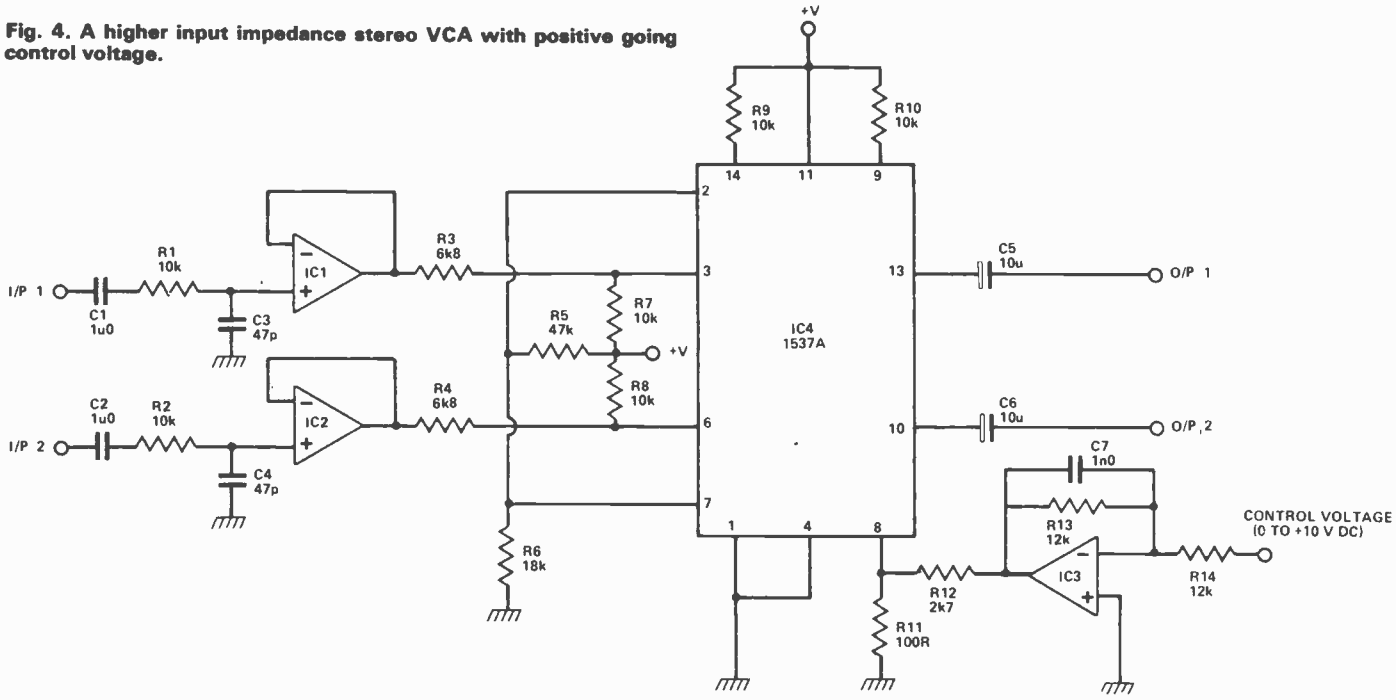


Fig. 3. The simplest mode of operation of the 1537A — a low input impedance stereo VCA with a negative going control voltage.

Fig. 4. A higher input impedance stereo VCA with positive going control voltage.



further to near (if not actually) zero. The prototype circuit shown, upon testing, actually gave no DC shift at all (or at least none measureable on our test equipment).

The complete circuit can be used as an exceptionally high quality VCA whose signal input can be anything from a few millivolts through to about 20 volts pk to pk without distortion. The lack of DC blocking capacitors at the input and output means that the system can be used to control a DC voltage applied to the input. AC signals up to well over 200 kHz are easily catered for, due to the system's wide bandwidth.

The overlay in figure 6 shows the component layout on printed circuit board of the circuit. As far as we know this article is the first of its kind to present a circuit in a form where "experimenters" can benefit easily and directly from the written text while simultaneously using the device in a tried and tested form.

Construction

If the circuit board layout is followed then there should be no problems. IC holders are advisable though by no means necessary. RV1 should be a good quality type (cermet), to assist in setting up the output offset shift to zero, cheaper quality presets can sometimes be tricky to adjust in low voltage DC applications of this nature. Op amps 1 to 4 in the circuit are combined in IC1 and can be of a wide range of types from a quad 741 type (3403) upwards. Obviously, if you wish to obtain the best specs the quality of the op amps are critical. LF 347 or TL 074 will give the best results.

Similarly op amps 5 and 6 are included in IC3 and LF 353 or TL 072 are of optimal quality.

Setting Up

The system should work without any adjustment for an AC signal and varying the control voltage from 0 to 10 volts should give total control over the output amplitude. Some setting up will be required if the input is to be DC, though. This is best achieved by earthing the input. Measure the output voltage using a high impedance voltmeter (it should only be the order of a few millivolts). Adjust RV1 until a complete sweep of control voltage ie from 0 to 10 volts produces only minimal change in DC output voltage. The circuit is now completely set up to accept an input signal in the frequency range DC to 200 kHz. At minimum attentuation the system operates as a unity-gain wide range, high quality buffer, with a reasonably high input impedance and low output impedance. Variation of the DC control voltage over the range 0 to 10 volts will produce over 90 dB of attenuation of the output signal.

If an overall gain is required in the circuit, resistors R18 and R20 can be changed as in Table 2.

GAIN	R18 & R20
0dB	10k
6dB	22k
10dB	33k
15dB	56k

Table 2. The values of R18 and R20 to give the required overall gain in the VCA system of Fig. 5.

The control voltage range of 10 volts can be altered as required simply by changing the ratio of resistors R13 and R14 to suit.

To our knowledge, there is no officially recognised standard symbol for a VCA and rather than redraw the whole circuit of figure 5 upon every reference to the circuit we thought it better to invent a symbol for the purposes of this article. A horizontal trapezoid shape appeared to be the ideal symbol, as shown in Fig. 7. It symbolizes the system as a modular buffer amplifier, whose output (symbolized by the top line), decreases as the control voltage (the bottom line). increases. We shall use the modular sumbol of a VCA whenever reference is made to the circuit of Fig. 5, although any VCA module of another design should function in the applications which we give.

Fig. 5. Full specification mono VCA (showing component numbers and values of a practical circuit).

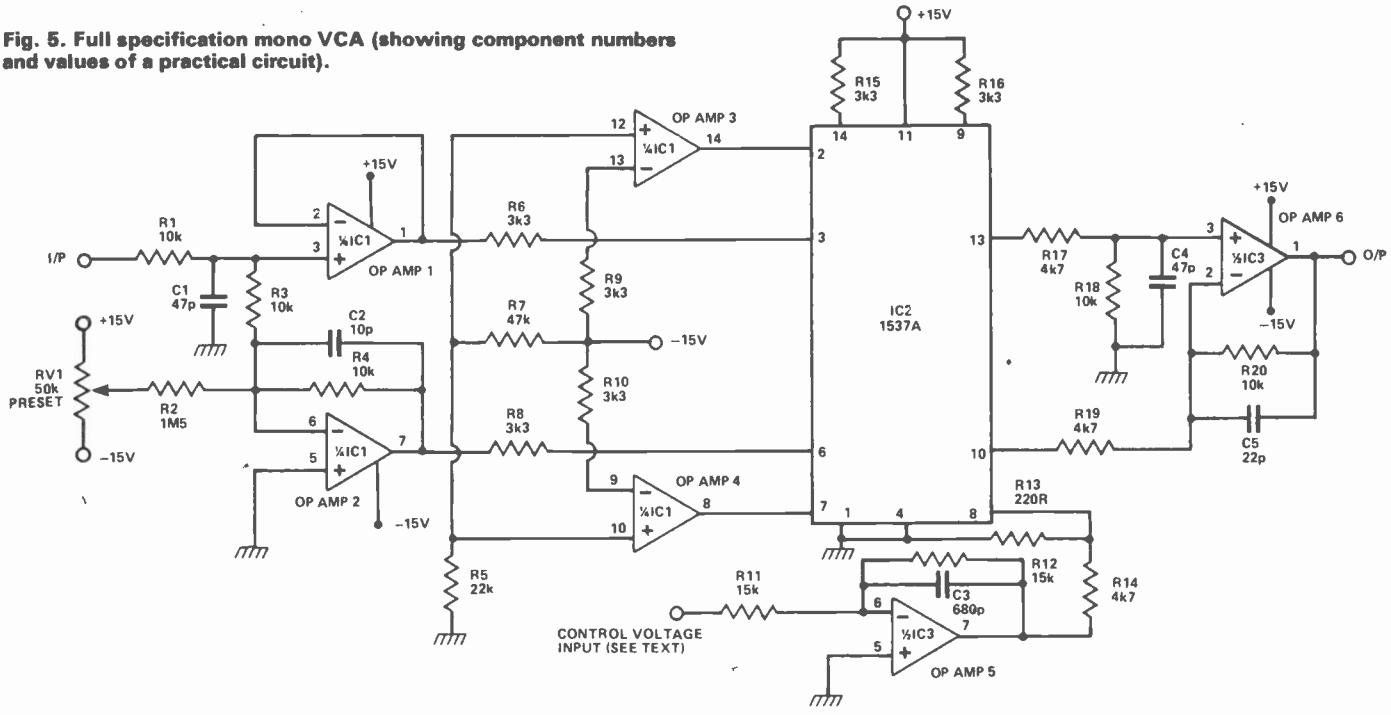
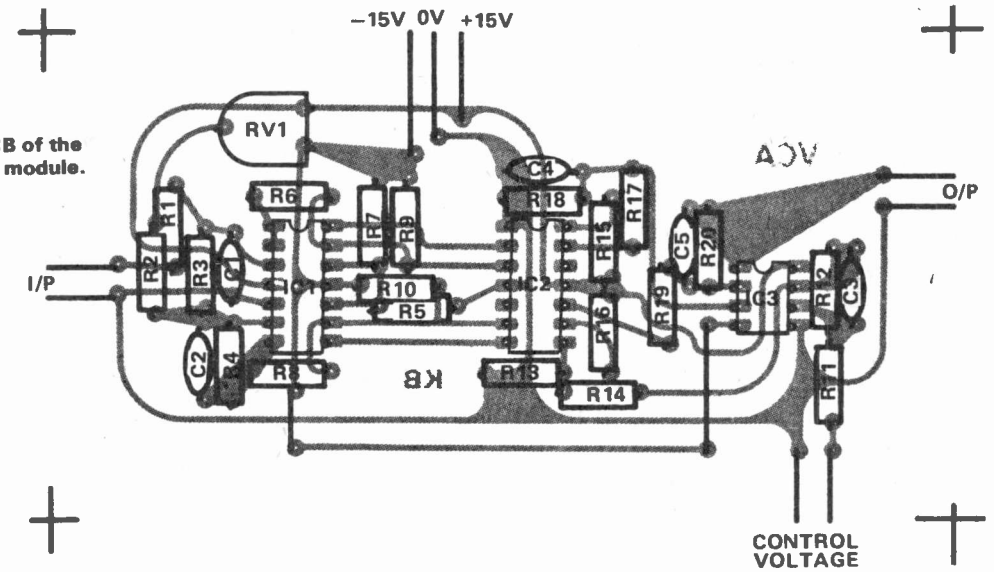


Fig. 6. Overlay of PCB of the 1537A VCA module.



Use of the 1537A system module as a DC controlled analogue gate can produce many effects. Amplitude modulation of the signal occurs and the usual associated effects are observed. For instance, in Fig. 8 we can see a simple but high quality tremelo unit. Transistors Q1 and Q2 are connected as a phase shift oscillator and buffer, with speed and depth controls whose varying DC output is connected directly to the control port of the 1537A module. The frequency range of the oscillator is approximately 2 to 5 Hz. Altering the values of all three capacitors will change the main frequency, though that stated will give the best results.

The control voltage in the last application was varied as a sine wave of course, but there is no reason why other waveforms eg square, could not be used for control purposes. Figure 9 shows a 555 operating in the astable

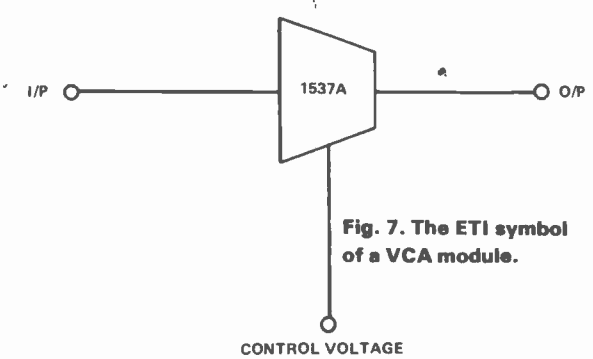


Fig. 7. The ETI symbol of a VCA module.

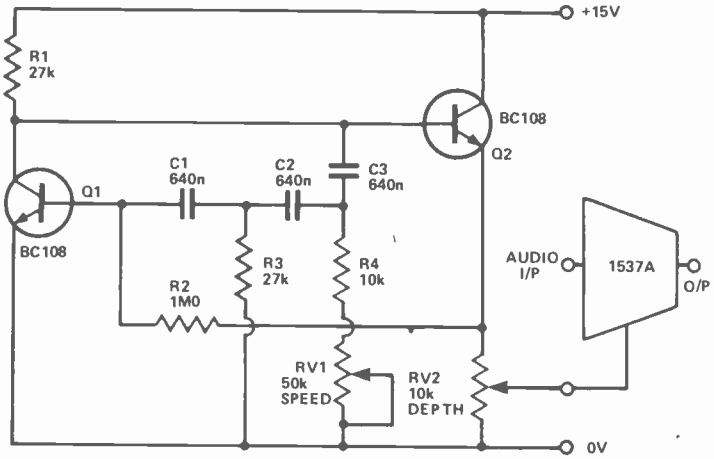


Fig. 8. A simple tremolo circuit.

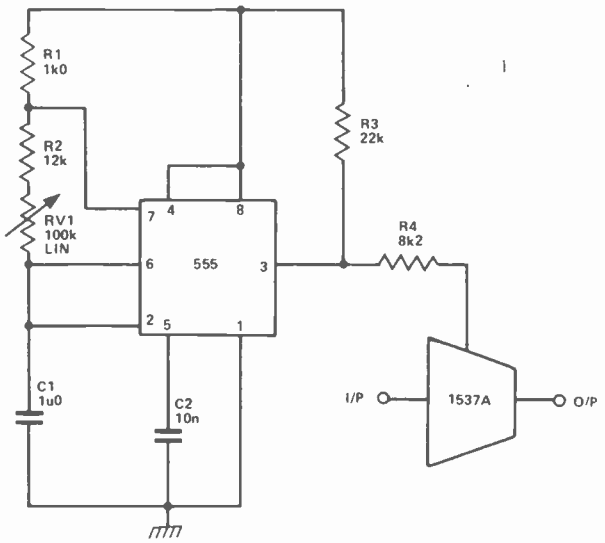


Fig. 9. Ring modulator.

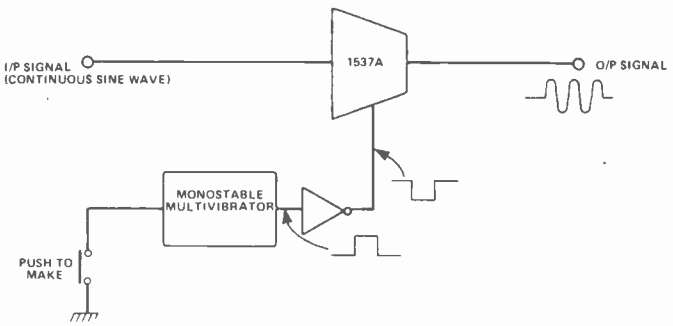


Fig. 10. A simple system enabling the construction of a tone burst generator.

mode with a frequency range of approximately 5-50 Hz. The output signal will be modulated with the square wave and the overall product is a computerized type sound if a vocal signal is applied to the 1537A module.

This square wave control can be taken one stage further if the control voltage is the output from a monostable as in Fig. 10. A tone burst generator can be very easily constructed with this mode of operation. In a tone burst generator, a rectangular envelope 50-500 uS long is formed around a single sine wave frequency of normally 1 kHz. Tone burst generators are useful for testing the transient response of speakers, A push to make switch is used to provide the trigger to fire the multivibrator, producing the correct length pulse which in turn is inverted to form the control voltage pulse, applied to the control port of the 1537A.

The previous applications have all used automatic waveform control of the applied signal to produce the required attenuation characteristics, but this is not a necessary trait. The control voltage can be simply tapped off a variable resistor having the maximum control voltage range (ie 10 volts) across it. In this way, altering the position of the wiper alters the attenuation of the applied signal. The pot acts quite simply as a volume or level control. Ordinary non-DC volume controls can suffer from pick-up problems because the signal itself is being rotated through the pot. As only DC is applied to the pot in this application no pick-up can occur and the control can be remotely mounted from the module with no screened cable being necessary. Figure 11 shows such a volume control.

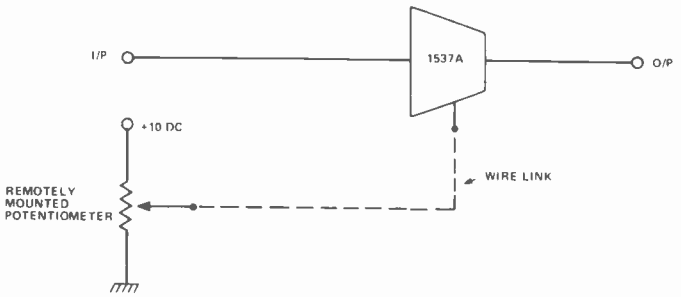


Fig. 11. Remotely (wire-linked) controlled volume control.

This remote control facility can be utilised in an audio mixer which includes remote faders for each channel. Figure 12 shows the general idea of such a circuit, An op amp is used as a summing amplifier into which the output of each channel's VCA is fed and mixed. The mix is relative to the control voltage applied from the remote faders to each VCA. The circuit allows for up to N inputs, where N to practical limits will probably be a maximum of about 12, but with careful layout techniques, there is no reason why this cannot be increased further.

Figure 13, shows an interesting outline to enable digital control of the VCA, say from a computer link. In order that the computer can operate in real-time, ie control of the VCA is not just its only job, it is necessary for the interface to provide a latch for the digital word. The output of this latch is changed to a linear DC voltage by the D/A (digital to analogue) convertor whose output is taken to the control port of the VCA.

The digital latch, once set by a strobe pulse, provides the facility that after the volume required has been found, the computer is free to perform other tasks, When the volume is to be altered, the latch is reset to the new digital input.

The last six applications of the 1537A VCA system have simply shown methods of providing a control voltage (automatically, manually or digitally) to control the module in its function as an analogue gate. The following section begins with the assumption that the control voltage is already present, perhaps by one of the previous methods.

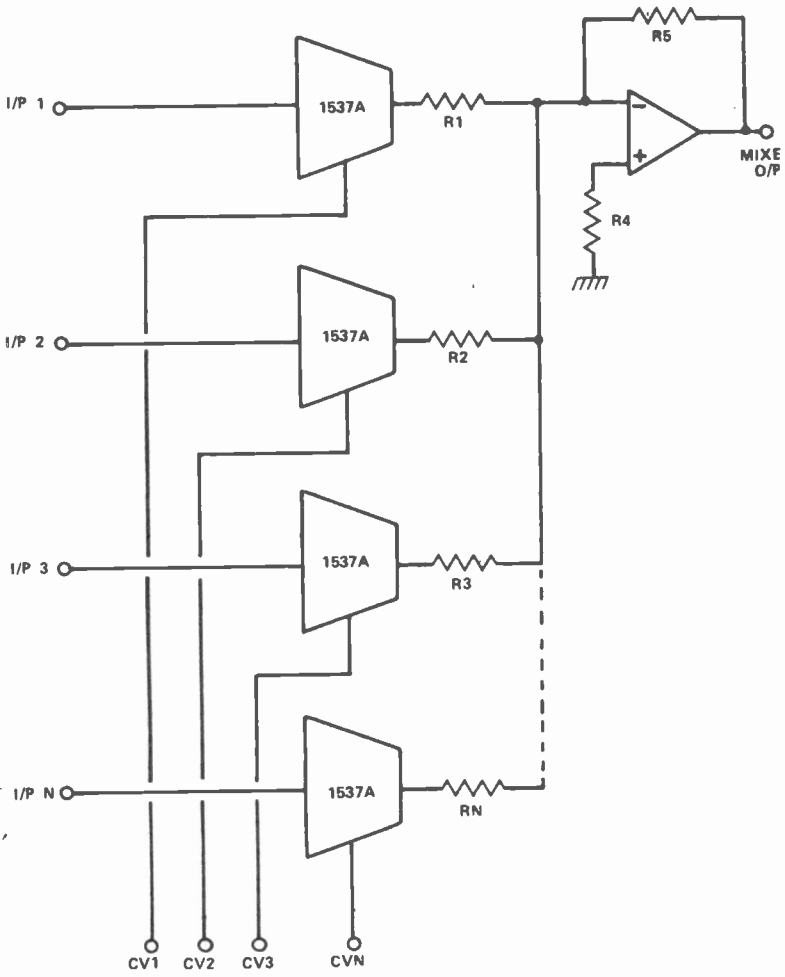


Fig. 12. High quality, remote fader controlled mixer.

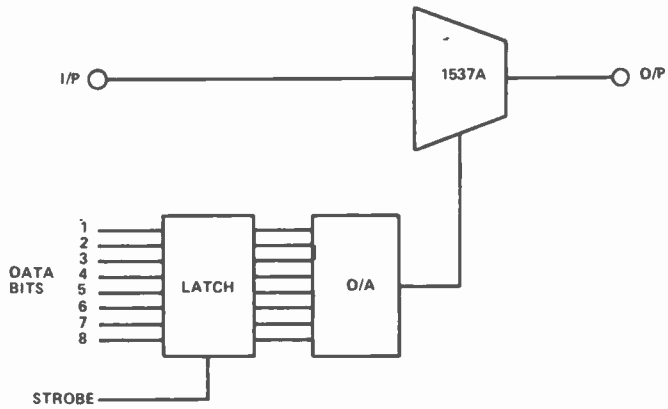


Fig. 13. Main components of a digitally controlled attenuator.

PARTS LIST

RESISTORS ALL ¼W, 5%

R1,3,4,18 20	10K
R2	1M5
R5	22k
R6,8,9,10 15,16	3k3
R7	47k
R11,12	15k
R13	220R
R14,17,19	4k7

PRESET

RV1	50k min horiz cermet

CAPACITORS

C1,4	47p polystyrene
C2	10p polystyrene
C3	680p polystyrene
C5	22p polystyrene

SEMICONDUCTORS

IC1	TL074, LF347 etc.
IC2	1537A
IC3	TL072, LF353 etc.

MISCELLANEOUS

IC Holders
PCB

Applications

Consequently the next few circuits show the system in a much more versatile role — not just as an analogue gate, but one in where the system itself becomes part of a larger system. Figures 14 and 15 give details of circuit in which the 1537A module is used in the feedback loop of conventional operational amplifiers to allow voltage controlled amplifiers to be constructed. The resistance values used give gains of approximately 1 to 100 over the VCA control voltage range and an inverting VCAmp and a non-inverting VCAmp can be easily built as shown.

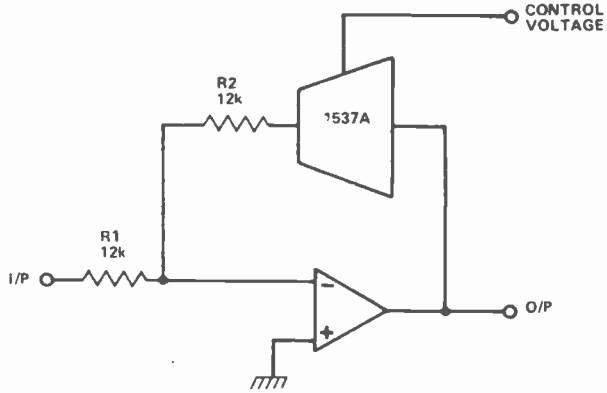


Fig. 14. A non-inverting controlled attenuator.

BUYLINES

The Aphex 1537A is available only from Octopus Audio, Suite 315, 69 Sherbourne St, Toronto, Ontario M5A 3X7. Cost is $22.00 each postpaid (Ontario residents add 7% P.S.T.).

Note the Motorola MC1537 and its second source variants will not work. The Motorola device is a dual 709 op amp.

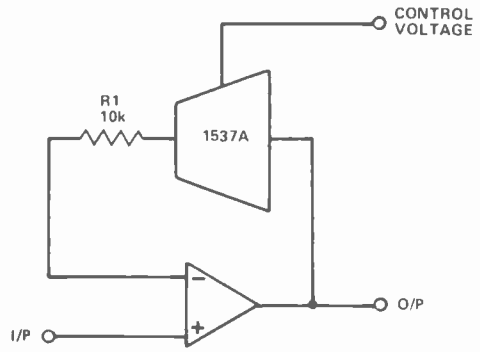


Fig. 15. An inverting voltage controlled amplifier.

A voltage controlled resistor is shown in the application of figure 16. The apparent resistance, R1, is given approximately by the formula

$$\frac{R1}{1 - A}$$

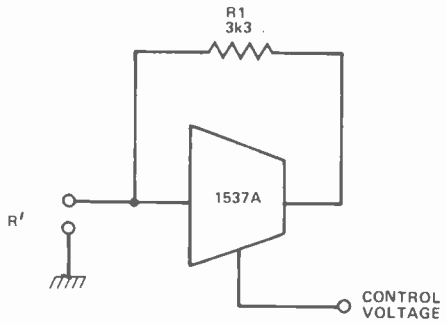


Fig. 16. A voltage controlled variable resistor.

where A is the gain of the VCA module (remembering that it has a maximum gain of unity). The value of R1 shown gives an apparent voltage controlled resistance of 7 k to 100 k over the ten volt control voltage range.

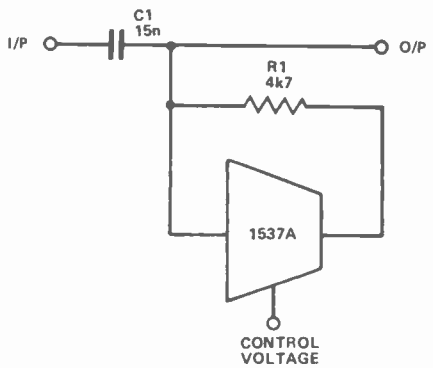


Fig. 17. A voltage controlled High Pass Filter.

The effect of a VCR (voltage controlled resistor) is used in the final two applications as the control element in filter circuits. Figure 17 shows a simple voltage controlled high pass filter. The component values shown filter out all frequencies below the variable limit of 1-2 kHz. Adjustment of the control voltage alters the lower cutoff point.

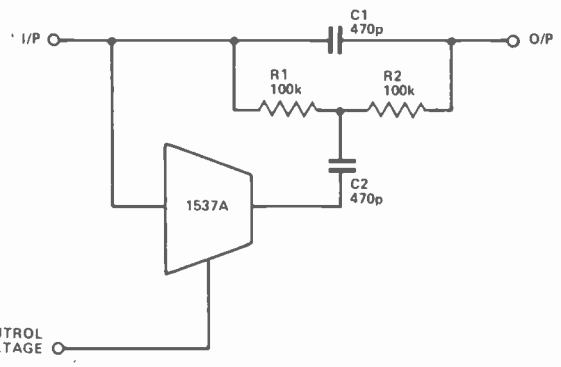
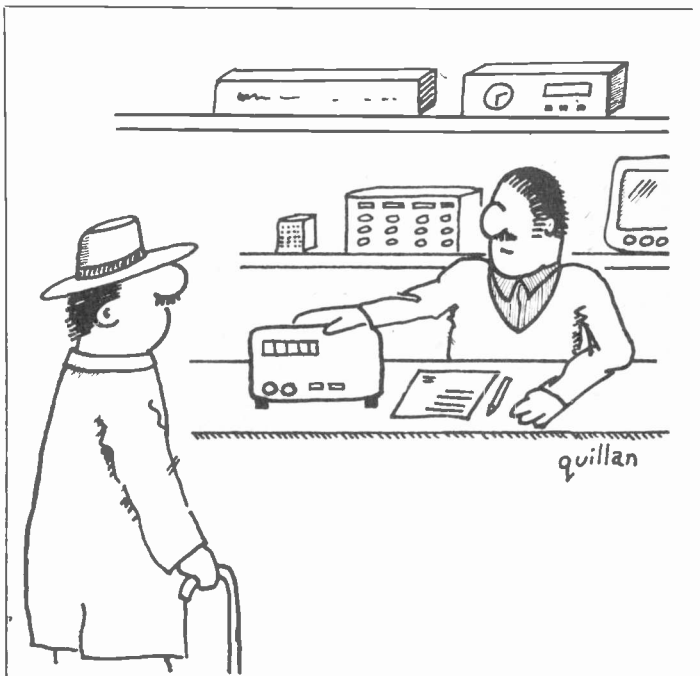


Fig. 18. A voltage controlled Band Reject (Notch) Filter.

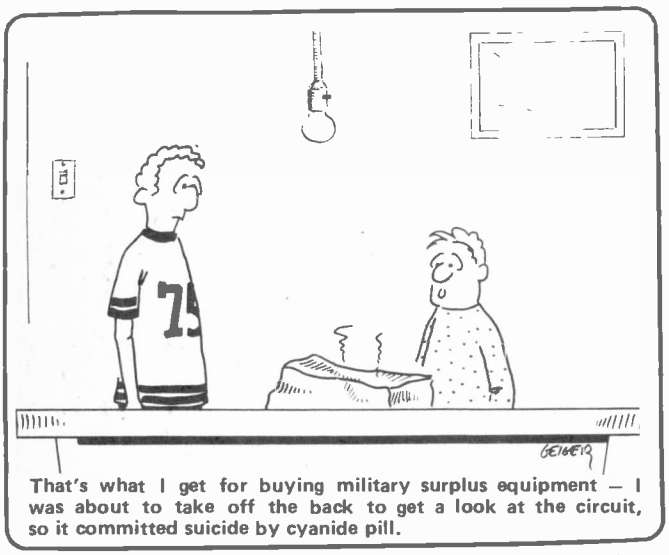
Figure 18 consists of the circuit of a voltage controlled band reject or notch filter whose depth of notch is adjusted by the control voltage. The component values shown set the frequency at about 300 Hz and depth of notch is variable from 0 dB to about —15 dB.

Conclusions

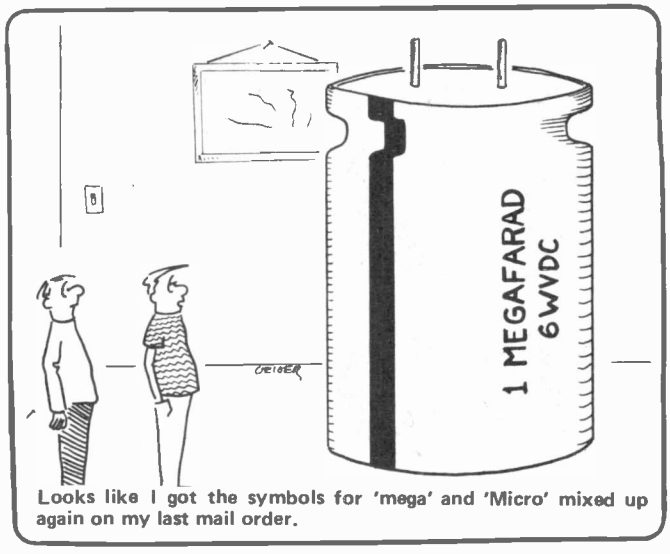
The applications given in this article show the 1537A chip to be a very versatile device. It is remarkably easy to work with, a fact which is borne out by the quality (in technical terms) of the circuitry in the breadboarded fashion of our experimental design work, let alone in the modular fashion allowed by the use of our PCB layout.



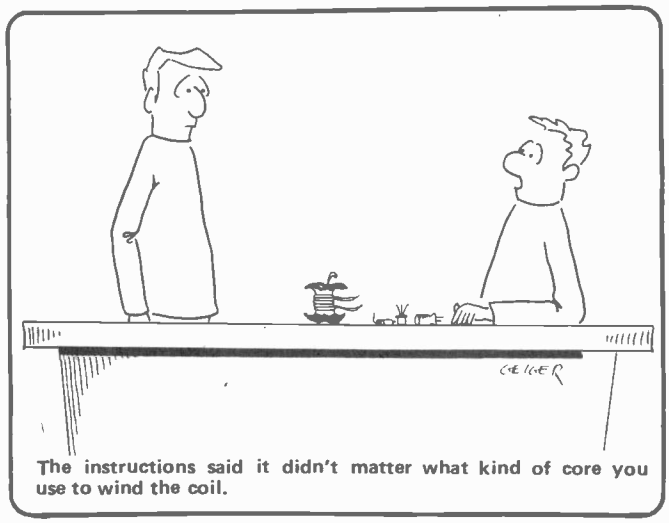
THIS IS A VERY GOOD LOGIC STATE ANALYSER AND IT ALSO SOLVES CROSSWORD PUZZLES.



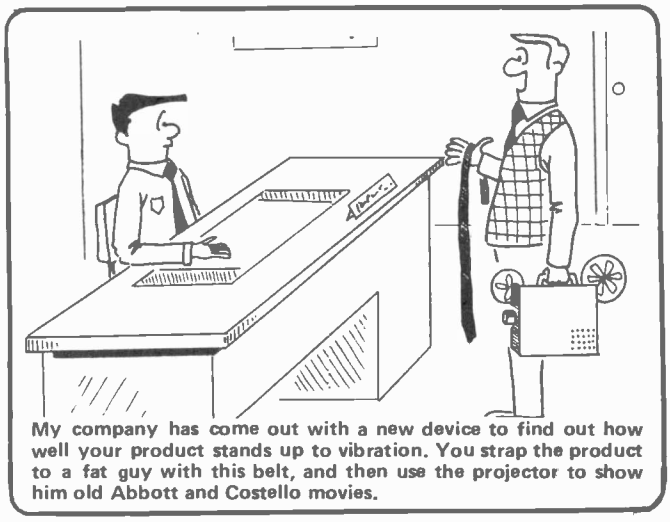
That's what I get for buying military surplus equipment – I was about to take off the back to get a look at the circuit, so it committed suicide by cyanide pill.



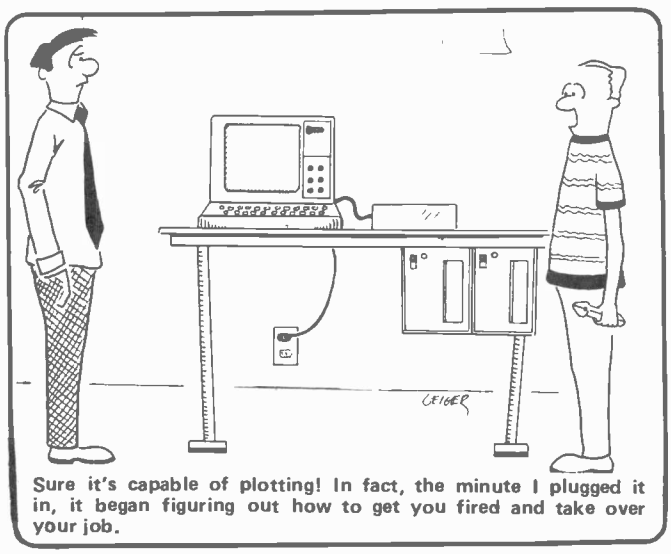
Looks like I got the symbols for 'mega' and 'Micro' mixed up again on my last mail order.



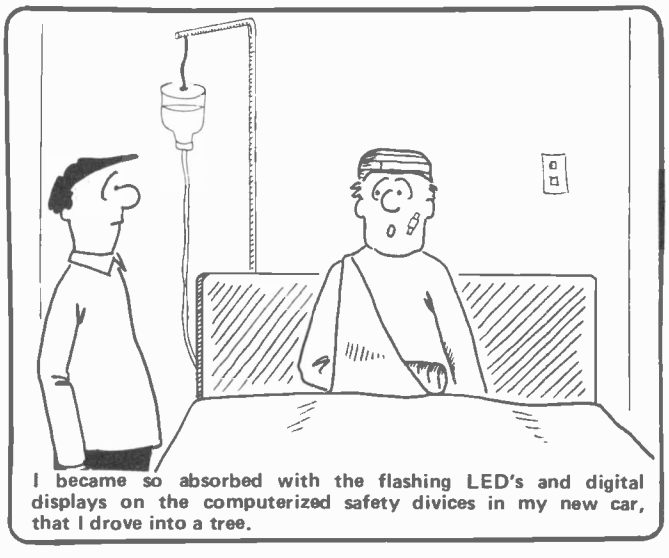
The instructions said it didn't matter what kind of core you use to wind the coil.



My company has come out with a new device to find out how well your product stands up to vibration. You strap the product to a fat guy with this belt, and then use the projector to show him old Abbott and Costello movies.

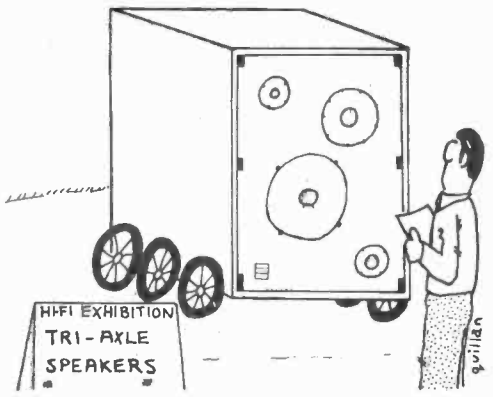


Sure it's capable of plotting! In fact, the minute I plugged it in, it began figuring out how to get you fired and take over your job.



I became so absorbed with the flashing LED's and digital displays on the computerized safety divices in my new car, that I drove into a tree.

SPEAKER DESIGN PROPOSAL



An ingenious method of increasing both efficiency and bass linearity from H.Lipschutz.

IN EFFORTS to improve speaker systems a great deal of energy devoted to increasing driver efficiency. Described herein is a speaker design (patent applied for) that promises reduced size and increases efficiency at least ten fold. But before talking about the solution, let's first consider the problem. This is that at low frequencies the travel required of the diaphragm has to be much further than at higher frequencies. This can easily be seen when looking at a gramophone record groove, where the bass frequency dominates the groove spacing, and can easily be recognized. Now a cone in free air, when driven with a bass note, would automatically take up the distance required. When the speaker is mounted in a sealed enclosure however, the air behind the cone gets compressed every time the cone moves inwards.

Efficiently Up!

The enclosed air resists that movement and tries to return the cone to centre. Reducing the size of the box has the same effect as changing a gas engine into a very high compression diesel, i.e. a much bigger starter motor is now required to turn the engine over. Similarly, with the speaker, we need 12 dB more power per octave from the amplifier, — not for playing louder, but only for compressing and rarefying the enclosed air, and heating it up.

Obviously it is a great waste of good amplifier sound to use it for just that. By raising the acoustical efficiency of the speaker, it is possible to manage with normal amplifier power used with conventional bass speakers, and still reduce the size of the box. However, the difference of 12 dB/oct is still there, and I can porduce all the enclosed air, however,

Fig. 1. The first version of the speaker design with a common magnet but which uses individual Air Flux Gaps. The letters mark the the beginning and end of the windings. Audio is present on coil AF and coils DC carry the centering current. The numers stand for: (1) Speaker chassis: (2) Diaphragm: (3) Roll surround: (4) Suspension of spider: (5) Magnet: (6) a Voice Coil air gap: (6b) Balancing coil air gap: (7) Coil Former: (8) Voice coil: (9) Balancing coils.

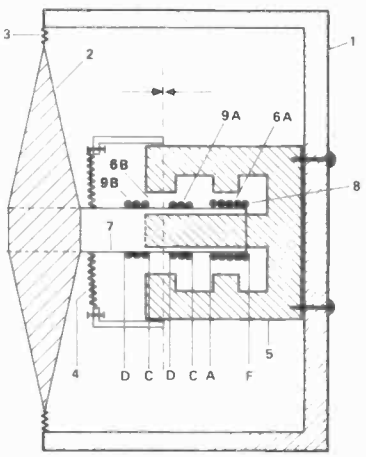


Fig 2. A version of the design which uses an indepdent flux balancing system. Key:— (10) Coil former: (11) Diaphragm: (12) Voice coil magnet: (13) Voice coil: (14) Balance coil magnets: (15) Chasis: (16) Spider frame: (17) Balancing coils: (18) Air gap.

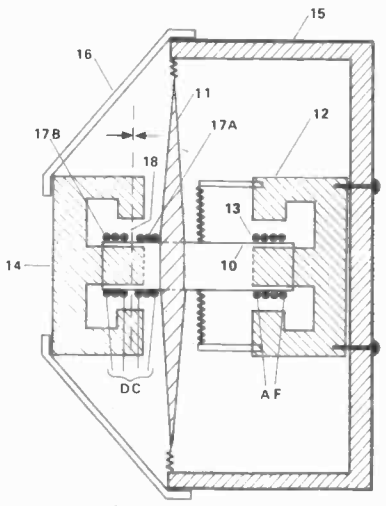
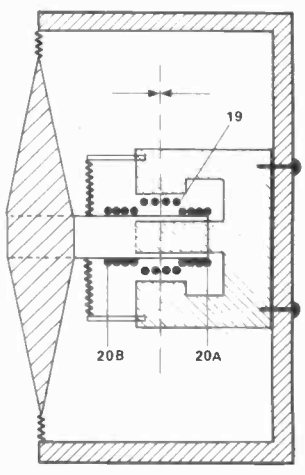


Fig 3. Here the balancing coils and the audio carrying voice coils share a common air gap and magnet system. The dotted line represents the point about which the centering force acts. (19) Voice coil (20) Balancing coils.



the same bass level could be produced with 3W!

For every position of the cone there is a corresponding compression or rarefaction of the enclosed air, which acts as a restoring or excess centering force. The force needed to overcome this is the same for every cycle, and is therefore predictable. It can therefore be overcome by a force acting in the opposite direction, and by so ballancing it cancels

Thus, all that is necessary is to add two more coils, i.e. one to each end of the voice coil, and connect these two 'balancing coils' to a DC supply. When the cone now is moved off-centre by the voice coil, the balancing coil at one end moves closer towards and into the magnetic flux gap, which then produces a force pulling it further, and assisting the voice coil to overcome the excess centering force of the enclosed air. Naturally the balancing coils have to be wound with suitable shape, and the DC supply has to be adjusted so that the force produced is just enough to overcome the resistance of the enclosed air to the movement of the cone. If too much DC is applied, then the cone would tend to be unstable and possibly move on its own, and with not enough DC we would be back to square one, and most of the work would have to be done by the voice coil, i.e. the amplifier, and bass would be lost unless especially boosted.

By adjustment of the DC supply therefore, the balancing forces can be adjusted to compensate for just the right proportion of work to be done, and thereby relieve the amplifier of this pump load represented by the enclosed air. Furthermore, by the simple expedient of limiting the length of the balancing coils, their effectiveness is limited to normal excursions of the cone, thereby preventing excessive swing.

Brake to Stop

Practically every modern car has servo-assisted brakes, and this is taken for granted. I therefore see no reason why not to apply the same sort of solution to bass speaker work load. There is no difficulty in supplying DC, which, for car speakers, can be taken from the car battery without trouble, and from rectified lines for home equipment. The alternative the conventional approach of the big box, with walls that are difficult to prevent from vibrating and thereby colouring the sound, and paying for the woodwork and room space required. But in the mobile field, there really is no choice.

There remains the last area of improvement, – quality of reproduction. That too can be improved, with designs which retain small size and high efficiency.

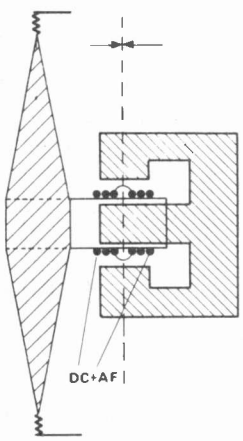
However, even in the version just described there is an improvement in quality too, due to the fact that when a proportion of the centering force is cancelled, any non-linearity of the suspension is cancelled as well, resulting in a lowering of distortion.

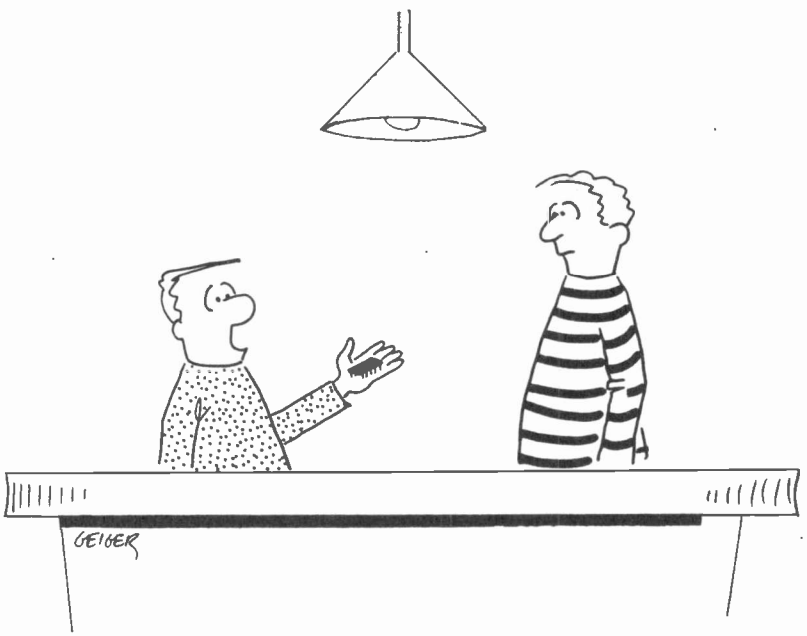
In Summary

A transducer with electro-magnetically extended bass response, with a vibratory diaphragm, incorporating adjustable means to oppose the centering force exerted upon the said diaphragm by the enclosed air of the transducer's sealed enclosure, said means comprising a magnet assembly defining a gap across which a magnetic flux extends to form a magnetic field, two coils secured to said diaphragm and movable axially in said gap, said coils' operative length limited to the designed travel distance of said diaphragm, and a DC supply for said coils, adjustable for balancing the air stiffness of differently sized enclosures, and lowering of 'main system resonance' to that exhibited by conventional, normally much larger enclosures.

Howzat?●

Fig 4. A much simplified and improved version with utilising virtually a standard loudspeaker chassis, but where the coil is much much longer and carries both DC and AF signals.





It's a custom IC. If you look close enough, you can see the tiny little chrome exhaust pipes.

INTO ELECTRONICS (PART 9)

Having expounded upon the subject of gates, Ian Sinclair now strings them together.

GATES are designed to give a signal out for a definite combination of signals in. Railway signalling, for example, has for years depended on mechanical gating systems, so that signals cannot be set to accept a train until the points have been correctly set. Electronic gates are smaller and faster to operate, so that we can make gating actions which are much more complicated, all from the set of gates we know, the AND, OR, NAND, NOR and NOT.

Just for starters, look at the set of gates in Fig. 1. This shows four inputs, all to NAND gates, with the outputs of the NAND gates feeding into a NOR gate. What is the truth table for this lot? A drop of Boolean Algebra can solve this fairly quickly, but it's the hard slog for us. Four inputs means sixteen possible combinations (2^4) of inputs, all different, so we start by writing them all down. It's easier if we're fairly methodical about it, so we write columns for the numbers in order, and in the column write the binary numbers in sequence up to 1111. A quick count should now show that we have 16 lines of figures, and provided that we have kept to the binary sequence, we should then have every possible combination of ones and zeros, Now draw two more columns for the outputs of the NAND gates, and label them (X and Y) and one final column for the output Q of the NOR gate. The table is now ready to complete, the worst part is over.

Starting with the NAND gate whose output is X, ignore inputs C and D and concentrate on inputs A and B. X will be at zero only when A = 1 *and* B = 1. For all other inputs, X = 1, so that we can complete the X column fairly quickly. Now ignore A and B and fill in the columns for C and D, with their output, Y. Once again, because the gate is a NAND type, Y is zero only when C and D are both 1; all other values of Y are 1, and can be marked in.

Now for the last column. The action of the NOR gate is that the output is low if either input is high, and will be 1 only when both inputs are low. There's only one line in which X = Y = 0, and that's the last line. For this logic circuit, then Q = 1 for A = B = C = D = 1, so that the circuit is a 4-input AND gate. Simple, really!

The point of all this is that with the basic gates we can make a circuit with any sort of truth table we want, so that the output will be 1 for whatever set of inputs we like to specify.

A	B	C	D	X	Y	Q
0	0	0	0	1	1	0
0	0	0	1	1	1	0
0	0	1	0	1	1	0
0	0	1	1	1	0	0
0	1	0	0	1	1	0
0	1	0	1	1	1	0
0	1	1	0	1	1	0
0	1	1	1	1	0	0
1	0	0	0	1	1	0
1	0	0	1	1	1	0
1	0	1	0	1	1	0
1	0	1	1	1	0	0
1	1	0	0	0	1	0
1	1	0	1	0	1	0
1	1	1	0	0	1	0
1	1	1	1	0	0	1

Fig. 2 Finding the truth table from the gate circuit.

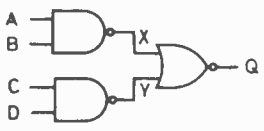
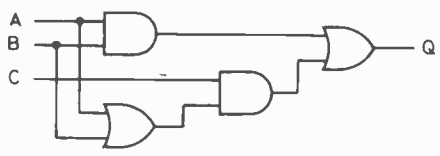


Fig. 1 A gate circuit made from standard components.

De-Luxe, Piping Hot Logic

Suppose, for example, we have a central heating system that is controlled by logic gates. The system has a boiler



A	B	C	Q
0	0	0	0
0	0	1	0
0	1	0	0
0	1	1	1
1	0	0	0
1	0	1	1
1	1	0	1
1	1	1	1

Fig. 3 A 2-out-of-3 gate truth table, and one suitable circuit.

which can be switched on by a relay which clicks over when the gate that operates it goes to logic 1. The hot water from the boiler will heat the radiators in the house only when it is pumped through the pipes, and the pump is switched by another relay similarly arranged so that it can be operated by the output of a logic gate. How about inputs? Well, we could imagine that this is a de-luxe system and that we have detectors for outside air temperature, inside air temperature in all rooms, water temperature, and also, of course, a time switch. What sort of system could we design?

To start with, the time switch could operate a bistable that switched AND gates. That way we could have the heating pump operated by one set of gates during the day and another set during the night — a bit of an improvement on the usual single thermostat. Then we could make good use of the temperature detectors in the rooms — we could, for example arrange the gating so that we had a 1 output if two out of three selected rooms were at a lower temperature than the set amount. The truth table for such a 2 out of 3 arrangement is shown in Fig. 3. The gate arrangement shown alongside should produce this truth table – check it out for yourself.

Of course we could arrange that the rooms we chose for the night temperature measurements were not the same rooms as we used for the daytime measurement, and we would also want to ensure that the water was not pumped around when the air temperature inside was high enough. Another thermostat senses the temperature of the water in the hot-water cylinder, and the boiler fires if the pump is working OR if the cylinder temperature is low. Complicated? Not really, and to do the same actions by any other methods would be a nightmare — which is why so many houses waste heat needlessly.

Practice Makes Perfect

Logic circuits can be built with separate transistors (these are called discrete circuits) but it's much simpler to make use of the ready-made ICs which are cheap and easily obtainable. The best types for experimental work are the ones referred to as TTL (Transistor-Transistor Logic). A typical circuit for a TTL gate (it's a 2-input NAND gate) is shown in Fig. 4. The gate consists of four transistors, a diode, and four resistors, and four gates like this can be packed onto one tiny silicon chip with plenty of room left. The IC coded SN7400N contains just this package of four NAND gates.

The action is something like this. The transistor Q1 at the input is made with two separate emitters, taken to different connections, A and B. We can make more emitters, so a seven-input is obtainable. The base of Q1 is connected to the supply voltage through R_1, so that if either emitter of Q1 is grounded, the transistor can conduct between collector and emitter. The collector, though, is connected directly to the base of Q2, so that when A or B is ground and Q1 conducts, this has the effect of connecting the base of Q2 to earth, switching Q2 off. O.K. so far? If A or B is low, Q2 is off; if both A and B are high, Q2 is switched on.

When Q2 is off, its collector voltage is high, so that Q3 is switched on. The emitter voltage of Q2 is low, so that Q4 is off. The output is high, connected to +5 V through Q3. When Q2 is on, its collector voltage is low and its emitter voltage is high, so that Q3 is off and Q4 is on. Perhaps you'd like to make up a truth table for each part of the circuit just to convince yourself.

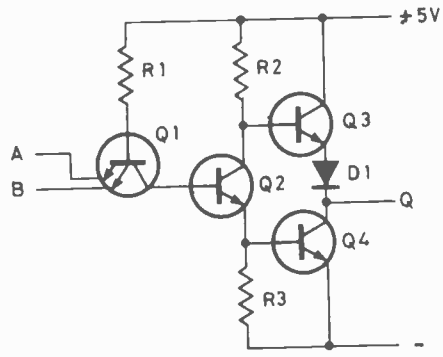


Fig. 4 A TTL NAND-gate circuit.

Now this type of circuit may look rather odd compared to most of the transitor circuits you've built or seen, but there are good reasons. One is that these circuits are easy to make in IC form, another is that they switch over very quickly — on an average it takes one of these gates only 13 ns to switch over — that's just the time it takes a beam of light to travel the length of a fairly large room. It's these types of fast-switching circuits that are used in most computers at the moment, although pocket calculators and micro-computers use a different (MOS) type of circuit which is not so fast-switching.

The Riot Act

The way these circuits are designed, though, means that we have to use them correctly, so here are the rules.

Rule 1. The supply voltage has to be 5 V. You can get away with 4.5 V, but you can't get away with 6 V The supply should preferably be a stabilised 5 V power supply. Reason? The inputs are always to the emitters of transistors with the bases connected to supply voltage. If you use a 6 V supply, far too much base current will pass when an emitter grounded. Remember that the base current is limited only by R1 in Fig. 4.

Rule 2. Inputs of gates have to be supplied either from the outputs of other gates or from some switching arrangement that will connect them either to earth through a large value resistor (anything over 1k), then it behaves just as if it had been left unconnected or connected to +5 V. The reason is that the input circuit is like that of an emitter follower output, and the emitter tries to follow the base. Inputs from switches, relay contacts, or transistor collectors are useable.

Rule 3. The output of a gate will switch anything from 5 to 10 inputs of other gates. This is called the fan-out of the gate, so that the gate with a fan-out of 10 will drive ten more gate inputs. If you want to use the output of a gate, to drive a relay, a power transistor should be used so that the power transistor operates the relay, and the gate operates the transistor. The reason this time is that the tiny transistors inside the IC cannot be expected to handle a large amount of power.

For Beginners

At this stage of the game it would be good to get some actual hands on experience. There are many excellent books and circuit articles on the topic. Three Babani books: No 224, 50 CMOS IC Projects; BP78, Practical Computer Experiments; and BP84, Digital IC Projects. These are available from ETI. Two excellent references are Don Lancaster's TTL and CMOS Cookbooks, published by Sams books and available from many retailers (but not ETI).

The TTL circuits which are so useful for learning about digital logic are not ideal for all applications. For one thing, they need a well-stabilised 5 V supply, and 5 V is an awkward figure for the experimenter who has to rely on batteries. Another snag is that TTL circuits take quite a lot of current. The big plus factor for the TTL circuits from our point of view is that they are easy to handle, readily available, and not easily damaged.

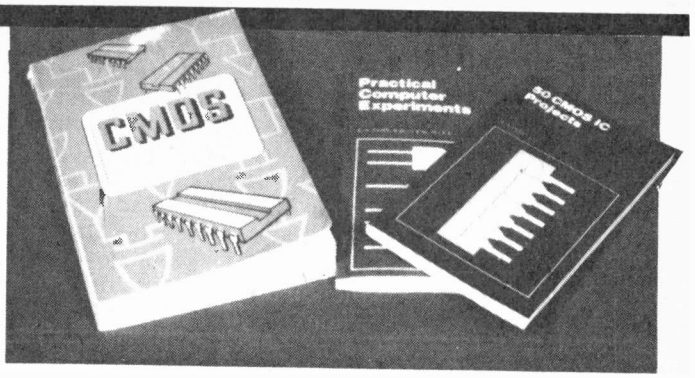
Logical FET-Tish

There's another family of logic ICs, though, called variously CMOS, Cos-Mos, MaCMoS, and so on. Unlike TTL circuits which use ordinary (bipolar) transistors in integrated form, CMOS ICs use MOSFETS (Metal-Oxide-Silicon FETs) in integrated form. These FET circuits can be used to make up the usual range of gates and bistables that we expect to use, and in addition a few circuits (such as transmission gates) that are not possible with TTL circuits.

What makes these CMOS circuits attractive, though, is that they can be operated on voltages ranging from about 4 V up to 12 V, so that the popular 9 V battery can be used as a power supply for most CMOS circuits. In addition, the use of FETs means that the input resistances are very high, and CMOS circuits can be operated with very low currents. A CMOS output can drive a large number of inputs, because practically no current is needed. This also is a bonus point for battery operation, because it means that CMOS circuits take very little battery current and batteries have a long life unless the circuit includes components (like LED displays) which have a greater appetite for current. Incidentally, the name CMOS comes from Complementary MOS, because the FETs that are used are of two types, P-channel and N-channel, corresponding to PNP and NPN bipolar transistors respectively.

With so much going for them, why don't we use CMOS for all our digital work? Well, we do use them a lot, and you'll see them used in ETI projects, they're also used in all pocket calculators and in digital watches, but they are not the ideal type of ICs for learning about digital circuits. The reason is the very high input resistance. As we mentioned earlier, any electronic component which has a high input resistance is easily damaged by the electrostatic voltages which exist on your hands, on insulating materials, and on any isolated prices of metal — any metal that is not connected to earth by a resistance of less than a few megohms. The result is that if we pick up a CMOS IC and touch the pins — it might die. No the best introduction to digital logic circuits, is it?

We get around the problem in two ways. One is that the circuits have built-in diodes which help to short-circuit excessive voltages. The other is the fact that damage can occur only when one lead is at a very different voltage from another. Now when the IC is connected into its circuit, all of the pins will be connected through resistors either to ground or to supply voltage, and the voltage between two pins can't be more than the battery voltage, which is safe enough. Our main problem, then, is just to get the darn thing into circuit in one piece. CMOS ICs come packed with their pins embedded in plastic foam. It's not any old foam, but a



Books are a great way to go further in digital electronic. Here are a few.

conducting material that makes sure that all the pins are shorted together, keeping them all at the same voltage. Keep the ICs in this and they're safe, come sparks or lightning.

Do Not Touch!

Now for the awkward bit — how do we put them into the circuit. Well, we build all the rest of the circuit first, checking to make sure that each pin of the IC will be connected to a part of the circuit which has components connected, or is grounded. The CMOS IC goes in last, and there two ways of dealing with this. One way is to solder IC holders into the circuit instead of soldering in the ICs directly. We then hold the ICs by the ends of the case, fingers away from the pins, whip off the plastic foam, and plug in the ICs, making sure that we've got them the right way round. Unless we are particularly unlucky we should be able to do this without touching any of the pins. The other method is direct soldering. The negative line on the board is connected to ground through a flexible wire fitted with aligator clips. The ICs are fitted, one at a time into their places, and the pins are soldered in one at a time using a grounded soldering iron. The ground pin of the IC is soldered in first, then the + supply pin, then all the others. This is no more trouble once you have had a bit of experience, but the less experienced constructor is advised to use holders at first — apart from anything else, it's a darn sight easier to remove ICs.

Glow-Worm's Benefit

One little item we haven't touched on yet, how do we know when a gate or bistable output is high? Voltmeters being the price they are, we need some sort of display. For transistor circuits, as good a method as any is a 6 V 60 mA cycle dynamo rear light bulb. If we use 6 V supplies fpr our transistor circuits, then a 6 V bulb in series with a transistor collector will indicate when the collector voltage is low (bulb on), Fig. 5a. The trouble with this is that 60 mA is rather a lot of current to have to pass just to indicate whether a transistor is on or off, and it's certainly too much to load onto our TTL ICs.

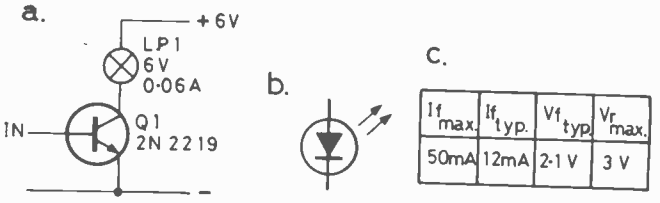


Fig. 5 Displaying a binary digit. (a) transistor-and-lamp, (b) LED symbol, (c) LED typical characteristics. This LED has a forward voltage drop of 2.1 V at 12 mA. Note the low peak reverse voltage of only 3 V. LEDs must always be protected from reverse voltage.

For most display purposes, then, we make use of LEDs. The name is short for Light-Emitting Diode, and that's just what they are diodes that emit light when current passes through them. These aren't silicon or germanium diodes, but they are P-N junctions made using compound materials such as Gallium Arsenide or Indium Phosphide. It just happens that crystals of these materials are transparent, so that any light generated happens to be visible to the eye.

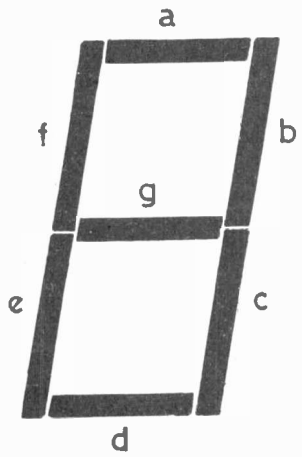


Fig. 6 The seven-segment display.

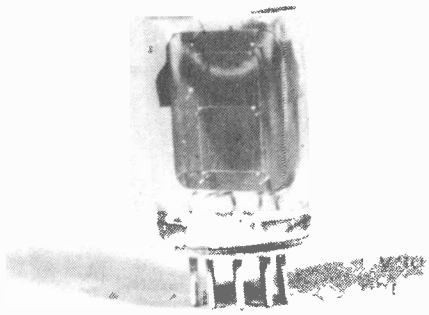
Until Death Us Do Part

electron and a hole find each other and live happily ever after. In normal diodes or transistors we try to avoid recombination like the plague, because it removes electrons and holes from circulation. When recombination takes place, energy is released, the same amount of energy as was needed to separate the electron from the hole in the first place. As it happens, the amount of energy that is released is just the right amount to create a light ray; the colour of the light depends on the amount of energy.

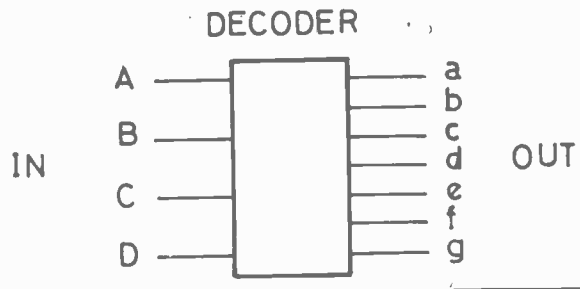
LEDs behave otherwise like any other semiconductor diodes, but they need a higher voltage between anode and cathode to conduct, about 2 V for some types. The symbol is shown in Fig. 5,6 along with typical data.

The LED principle is also used in making seven-segment displays (Fig. 6) which, as the name suggests, have seven bar-shaped strips of LED. These can be used to display all the numbers 0 to 9, and also a few letters, and are used to show the outputs of bistable counters. Wait, though, bistables count in scale of two, and these displays are decimal – something wrong here? There would be, but as it happens there's an IC which acts as a binary to seven-segment converter – put in a binary number and out come the voltages which light up the correct strips of the display to show the decimal number. The truth table, shown in Fig. 7, looks a bit fearsome, but it's all done with the usual set of NAND'NOR and NOT gates.

Right now, another type of display is becoming available, though still a bit pricey. This is the LCD display. LCD means Liquid Crystal Display, and the liquid crystals are curious substances (related to amino-



A seven segment incandescent display. Seven segment displays come in all types, fluorescent, LED, LCD, plasma as well as incandescent.



A	B	C	D	a	b	c	d	e	f	g
0	0	0	0	1	1	1	1	1	1	0
0	0	0	1	0	1	1	0	0	0	0
0	0	1	0	1	1	0	1	1	0	1
0	0	1	1	1	1	1	1	0	0	1
0	1	0	0	0	1	1	0	0	1	1
0	1	0	1	1	0	1	1	0	1	1
0	1	1	0	0	0	1	1	1	1	1
0	1	1	1	1	1	1	0	0	0	0
1	0	0	0	1	1	1	1	1	1	1
1	0	0	1	1	1	1	1	0	1	1

Fig. 7 Binary-to-seven segment decoder truth table. The number 1 under a segment letter (a to g) indicates that segment is lit. Note that a four-input binary number can have values up to 15 (1111) but only a count of 9 is displayed by this decoder. Hexadecimal decoders display letters to indicate the numbers 10, 11, 12, 13, 14 and 15.

acids, if chemistry grabs you) which can be turned from opaque to transparent by applying a small electric field. These displays can be made into the seven-segment pattern, and have the great advantage that they need very little current. Unfortunately, they need a high-frequency AC supply, and the life is limited because the liquid crystal material is broken down by sunlight. Watch displays have a ultra-violet filter to extend the life of the liquid crystals, but two to five years is reckoned a good life time. ●

Audio Today

Still stacking your stereo speakers one atop the other? No, no, no. . . Wally Parsons introduces separation.

IF YOU INDULGE in the practice of reading product reviews, you'll have noticed that, in reviewing loudspeakers, frequency response is reported for the on-axis condition as well as for specified degrees off-axis, usually 30° and 60°. Alternatively, the on-axis response may be reported, along with a polar response showing directionality at different, arbitrarily selected frequencies.

Generally speaking, most manufacturers appear to aim for a wide polar response at all frequencies. Indeed, reviewers will usually draw attention to this characteristic, in such a way as to imply that wide polar response, or dispersion, is a virtue in a particular speaker, or that lack of same is a fault.

One gets the impression, then, that wide dispersion, uniform with frequency, is a Good Thing, and there are those who would go so far as to suggest that it is the most important single characteristic, assuming that other characteristics such as frequency response, distortion, etc., are "reasonable", whatever that means.

It is also common practice to place a pair of loudspeakers flat against an end or side wall of a room, sometimes angled inwards a little, by an amount which is calculated using a technique called "by guess and by golly", to the accompaniment of much crossing of the fingers. A variation of this arrangement brings the speakers forward and away from all walls, the results judged by ear, and rationalized by reference to "boundary reflections" and similar esoteric terms said to enhance the imaging process.

Not long ago I had occasion, in a dealer's showroom, to audition a pair of speakers, highly regarded in avant garde circles, whose manufacturer recommends that they be placed flat against the wall. The salesman pulled them out from the wall, about a third of the room's length, because there was no other way of using them.

So much for optimum placement.

A Toronto dealer asks, disdainfully, in a television commercial: "Are you a robot? A robot selects audio components by a computer readout. A human being uses his ears". We are shown what purports to be his showroom with customers apparently selecting speakers by ear. Too bad they can't have a computer readout instead; with the random array of speaker placements they haven't a prayer of making a valid judgement by ear alone.

Obfuscation!

Evidently, stereophonic reproduction is not very well understood by many people in the business.

Those of you who visited this corner last month will recall that sound localization is accomplished by a complex process of interaural level and time differences, either together, or with one

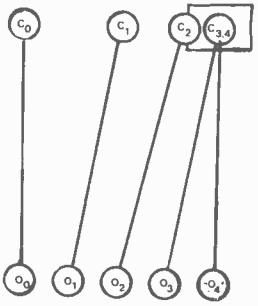


Fig.1. Centre image shifts with listener position

or the other predominant, depending on frequency. Thus, binaural mechanisms are used to localize single sound sources, although several individual sources may be perceived simultaneously.

In reproducing stereo information, we do not attempt to recreate each individual sound source. Instead, we create the *illusion* of each sound source by presenting to the ears *two* sonic signals in such a way as to reach the listeners' ears with the same relationship which a *real* individual source would present to each ear.

Thus, a front and centre source would arrive at each ear with the same intensity and at the same time. So, we must arrange for each channel to deliver a signal to the ears with the same relationship, thus fooling the listener into hearing a sound from front and centre.

If a signal is supposed to appear somewhere to the right of centre, then a signal from the right channel must be louder and/or arrive slightly sooner than the otherwise identical signal from the left channel. This is reasonably easy to accomplish if the listener is equidistant from each speaker.

But what if he isn't?

Optimum Listening Field

Much is said about the sound field produced by musical instruments and loudspeakers. But what of the *listening* field? Obviously, it's quite possible to arrange for a single listener to be placed equidistant between two speakers, but since two people cannot occupy the same space at the same time, except perhaps at the Outer Limits of the Twilight Zone, it becomes quite difficult for several persons to share the same listening experience with equal satisfaction.

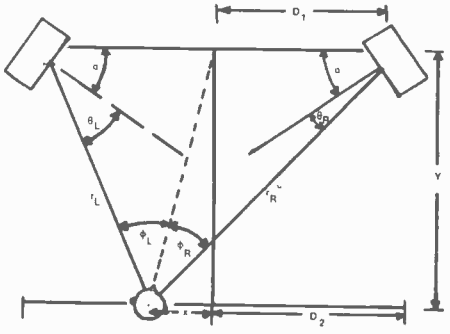


Fig. 2. Arrangement for stable image

Fig. 1 shows the effect on a centre image of listener position. It's quite apparent that the only listeners who could perceive correct localization would be those along the line C_0-0_0, and the further from C_0 the listener is the narrower the total image width. As the listener moves to either side the speaker on that side becomes more prominant and the far one's output becomes inaudible except for signals radiated only from that speaker. The net result is an image in which only left and right can be localized, and the centre sounds shift to the nearest speaker. This is particularly true for middle and high frequencies, but even bass suffers from this effect due to phase differences.

A Different Angle

The solution to this problem lies in angling the speakers inward toward the listening area. This is fairly common

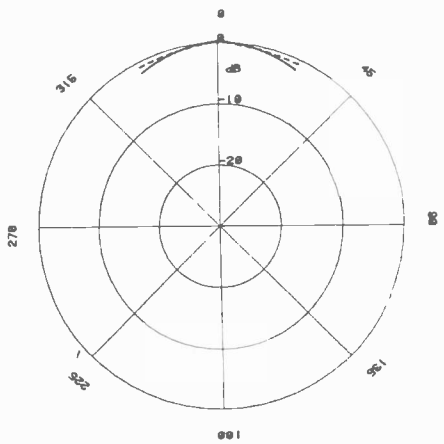


Fig. 3. Shallow angle

knowledge, but usually the methods used are cut and try, and often unsatisfactory. As it turns out, this is due to the fact that for this to work the speakers must have the *correct* dispersion patterns at all frequencies.

As it happens, James M. Kates, formerly of Acoustic Research, has an excellent paper in the November 1980 issue of the Journal of the Audio Engineering Society, available at most major public libraries, dealing with the subject of optimum dispersion patterns for use with a variety of listening geometries. One of the more interesting aspects of this work lies in the need for a radiation pattern at low frequencies which is *narrower* than at high frequencies, with the provision that the front of the lobe should not begin to fall off as rapidly. Moreover, the greater the angle between listener and speakers, the *narrower* the beamwidths must be (Fig. 3-6).

These requirements are completely at odds with conventional practice.

Indeed, it can be quite difficult to achieve a narrow beam at low frequencies with single drivers.

But, to return to the subject of placement and orientation, it's apparant that, for a central listener, arrival times and intensity are equal for identical signals whether the listener is on axis or off, and the actual radiation pattern is immaterial. Only frequency balance is affected.

Suppose a listener is located at the extreme right along line D_2 of Fig. 2. Suppose further that the left channel speaker is arranged so that the listener is on axis, and the right channel speaker is oriented to the same angle *a*. If the right channel speaker's response off axis is down by a sufficient amount, the on-axis signal from the left speaker will appear to be equal, thus preserving the central localization. As the listener moves closer to the central positon he will move off axis from the left speaker, and closer to on-axis for the right speaker. If the patterns are symmetrical, and the shapes appropriate, the image will remain stable.

If a room is arranged in such a way that the maximum listening distance involves listeners at the rear wall, and their maxium off-centre position is extreme left or right, it follows that the speakers should be oriented to the appropriate opposite corners of the room, and for maximum separation, should be placed in room corners.

I am aware that corner placement presents advantages and disadvantages, and that such a placement is not always the best one from the standpoint of speaker/room interaction, but the angular relationships still hold.

It will be noted that for short

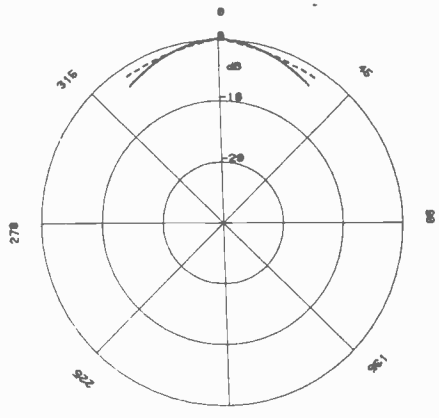


Fig. 4. Moderate angle

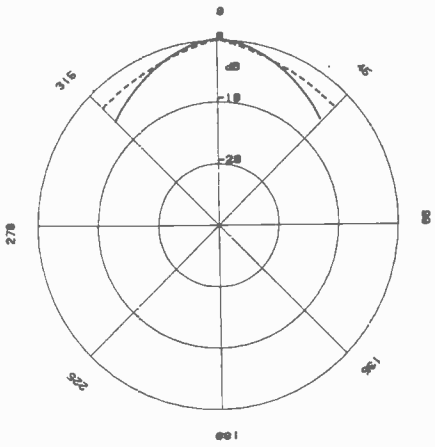


Fig. 5. Steep angle

distances *Y* relative to D_1 in Fig 2, the level differences between speakers will greater and the angle *a* smaller, than for longer distances. This accounts for the differences in required beam widths for different optimum angles. A short distance *Y* requires a narrow beam precisely because we need to bring down the level of the near speaker by a greater amount than for a long distance *Y*, where the differences are less.

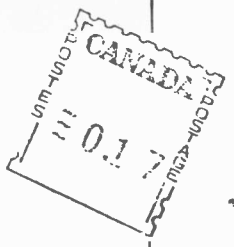
The Shape of Things

It should be apparent, too, that for any listening distance other than the one for which the speakers and their orientation have been optimized, the satisfactory listening field width $2D_2$ is bounded by the axis of the speakers. This is seen when you consider a listener moving from the extreme right hand position along the axis of the left channel speaker. As he moves closer to front and centre, he moves to a more nearly equidistant location between speakers. At the same time he moves closer to the on-axis position of the right channel speaker, thus preserving localization, assuming of course that the combination of listening angle and recording characteristic is such that the sound field does not break up into separate left and right sources.

Thus, the most satisfactory listening positions are found within a triangle bounded by the speaker axis and $2D_2$.

The same listener moving towards the *rear* and centre positions will be moving off axis for the left speaker and nearer to on-axis for the right speaker but will never quite arrive at an on-axis location. Rear listening areas are therefore less well defined, but even so the shift in balance will be such that localization will remain substantially unaltered if the rear boundaries parallel the opposite front boundaries.

AUDIO TODAY LETTERS



I am presently building a "Noise Reduction System" and "Dynamic Range Expander" using the Signetics NE570 Compander IC.

The design that I am using is a Signetics design, similar to the ETI design, except that the internal 741 Op Amp is bypassed by an external high performance Op Amp, to improve performance.

I would like to use an 18 dB/Octave hp/lp filter with these circuits, enabling me to tailor the control capacitors of the compander IC's for optimum control for each band. The output of each circuit will then be added in an Op Amp Mixer to restore full compressed/expanded bandwidth.

My question is, What will be the effect, due to compression and expansion at the crossover point.

R.K. Calgary

The way I read this letter, you plan on a complementary system, with bass and treble processed separately and independently. This is the same basic approach used in the Dolby "A" system (with more channels), and DBX using a Model 2BX Compander

Since the slope of the filters is not infinite, signal components at or near the crossover will modulate both channels to some extent. At the crossover point this will not matter but at frequencies slightly to either side there will be some effect.

I would suggest using an adjustable crossover. Start at 1 kHz and experiment upwards. The idea is to select a point at which normal frequency distribution results in minimum energy. Thus, you would not select either 500 Hz or 5 kHz.

I'd like to know how it works out. ●

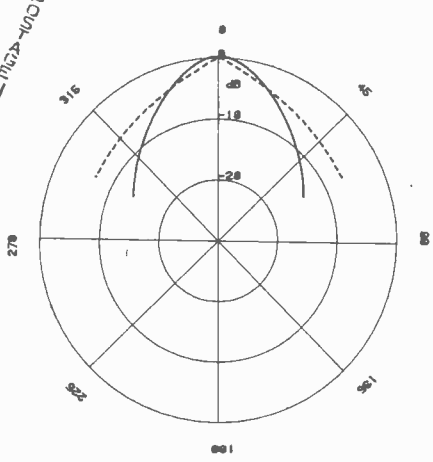


Fig. 6. Very steep angle.

All of the above assumes a reasonably well damped room so that direct sound predominates, and room geometry is such that there is no conflict between optimum imaging and optimum low frequency response.

When these considerations are properly applied, you don't have to nail yourself to the middle of the room. In my own system, even with a listening position near the left side wall, about a third in from the rear, and with speakers oriented to that position, I can still detect the right channel dominance which CBC Stereo frequently exhibits. And yet properly balanced signals require no correction.

I shall now sit down to watch a Sherlock Holmes movie, confident that Dr. Watson's *soto voce* mumblings will appear from stage centre --- where the television screen is.

All the drawings are from the Journal of the Audio Engineering Society, Volume 28, No. 11, November 1980.

DOUBLE DICE

Continued from page 20

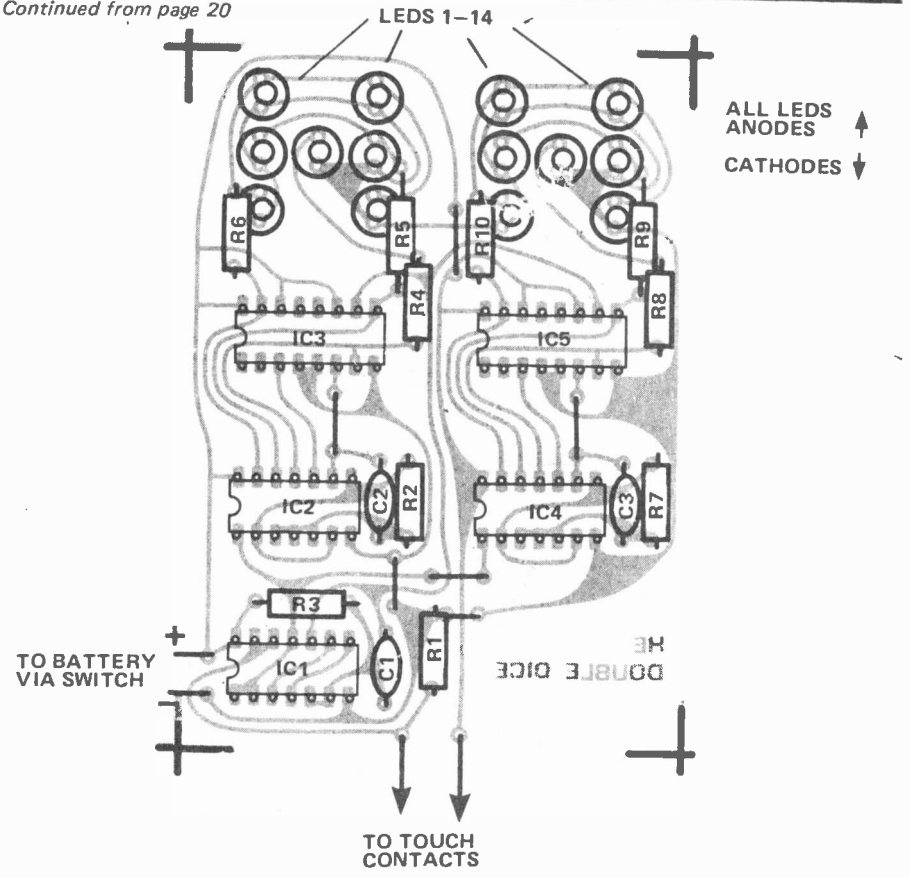


Figure 2. Overlay diagram for the Double Dice

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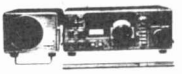

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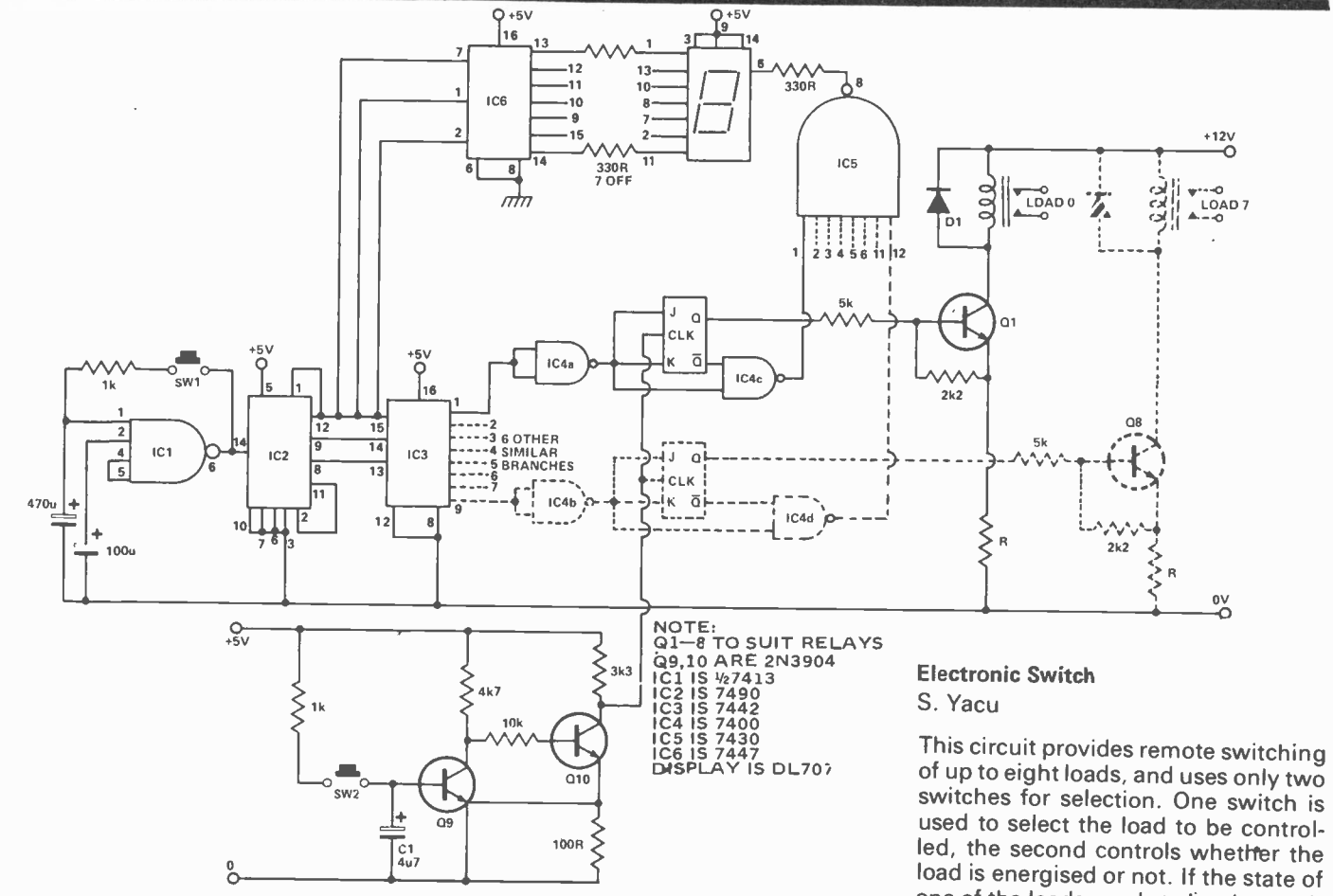


Electronic Switch

S. Yacu

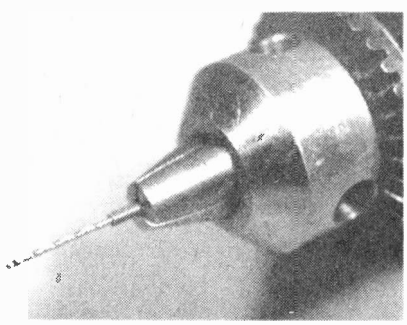
This circuit provides remote switching of up to eight loads, and uses only two switches for selection. One switch is used to select the load to be controlled, the second controls whether the load is energised or not. If the state of one of the loads needs to be changed, SW1 is depressed until the number of the load appears on the 7-segment display. The decimal point then indicates whether or not the load is energised. To change the state of the load, SW2 is depressed (pressing SW2 again will change the loads state again).

The circuit is based on a 7442,1 of 8 multiplexer and a 7490 binary counter. When SW1 is closed, the Schmitt trigger IC1 will oscillate and clock the 4-bit counter. This drives the 7-segment decoder and the 1 of 8 multiplexer. The outputs from the multiplexer are inverted and fed to the J-K flip-flops. When SW2 is pressed and released, a pulse will occur at the collector of Q10. The pulse will clock the selected flip-flop and activate or deactivate the relevant relay driver transistor (Q1-8).

Chucking Small Bits

Theo Boon

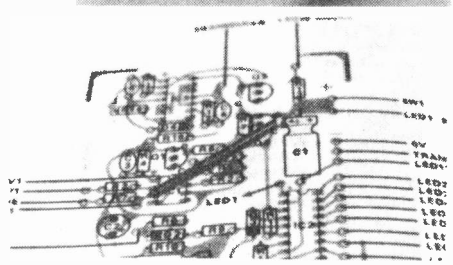
A major problem in drilling printed circuit boards is finding some method of holding 3/64" and 1/32" twist drills in a standard 3/8" drill chuck. The author (being a machinist) found that roll pins serve as excellent sleeves (check the yellow pages under Machine Shop Supplies).



Incinerated ICs — Stopped!

B. D. Dever

Now here's a good idea if your soldering iron is a bit too hot for soldering delicate components to a printed circuit board — why not use a standard light dimmer between the iron and the wall socket?

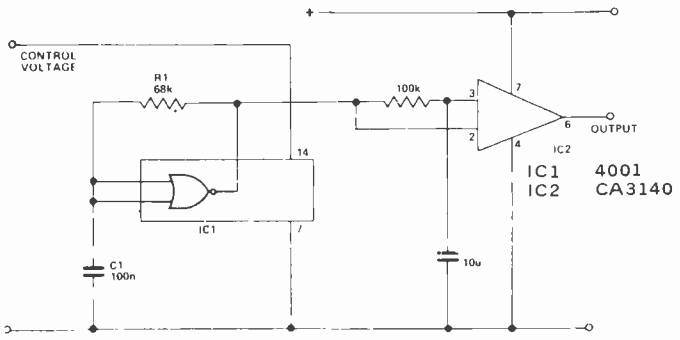


Wide Range Voltage Controlled Oscillator

Any section of IC1 can be used but all unused inputs must be grounded – otherwise the CMOS will pick up line hum and operate in its linear region, overheating as a result.

With the values shown, a frequency range of about 50Hz to 2kHz is obtained – just right for an audio sweep oscillator. If the mark/space ratio is unimportant, it can go down to 1Hz.

The control voltage, which ideally should be in the range 1.5V to 3.5V, is applied to the power supply connections. IC2 is used to square up and buffer the output.



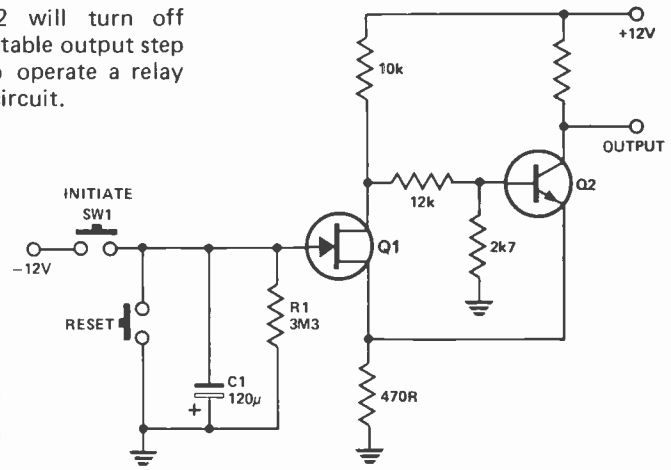
Ten-minute Timer

Roger Harrison

The circuit is a hybrid Schmitt trigger, using a FET and a bipolar transistor. Initially, Q1 will be on and Q2 will be off. The output will be high (+12V). The timer is initiated by pressing S1. C1 will rapidly charge to –12V and Q1 will be cut off. Q2 will then turn on.

When S1 is released, C1 discharges through R1 until the voltage across C1 equals Vp of Q1. The circuit will now change state and Q2 will turn off rapidly, providing a suitable output step which can be used to operate a relay driver or any external circuit.

A delay of approximately 10 to 12 minutes can be obtained with the values shown if the Vp of Q1 is around 1.5 volts. Longer delays can be obtained by using a FET with a lower Vp and increasing the value of C1



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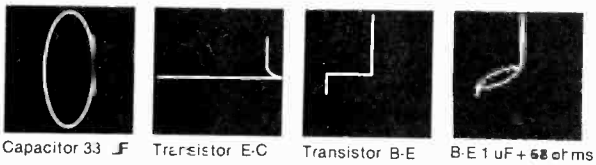

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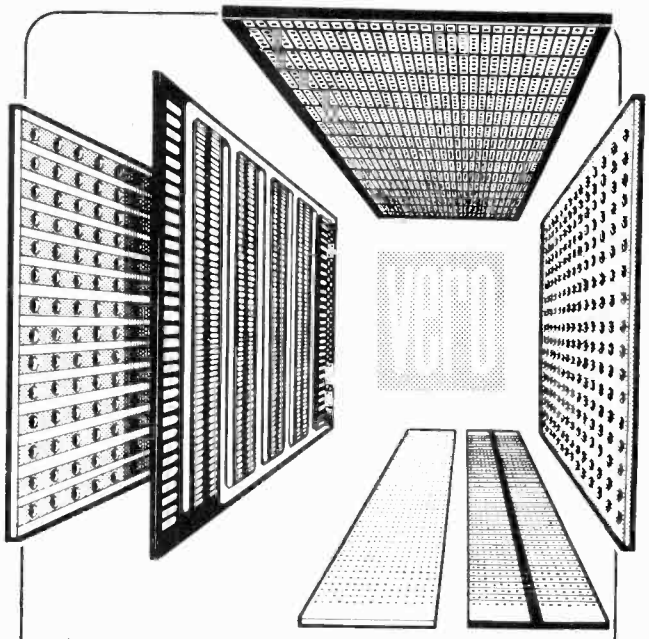

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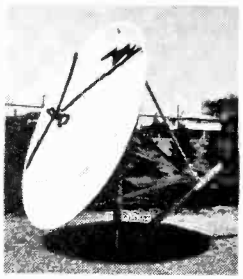

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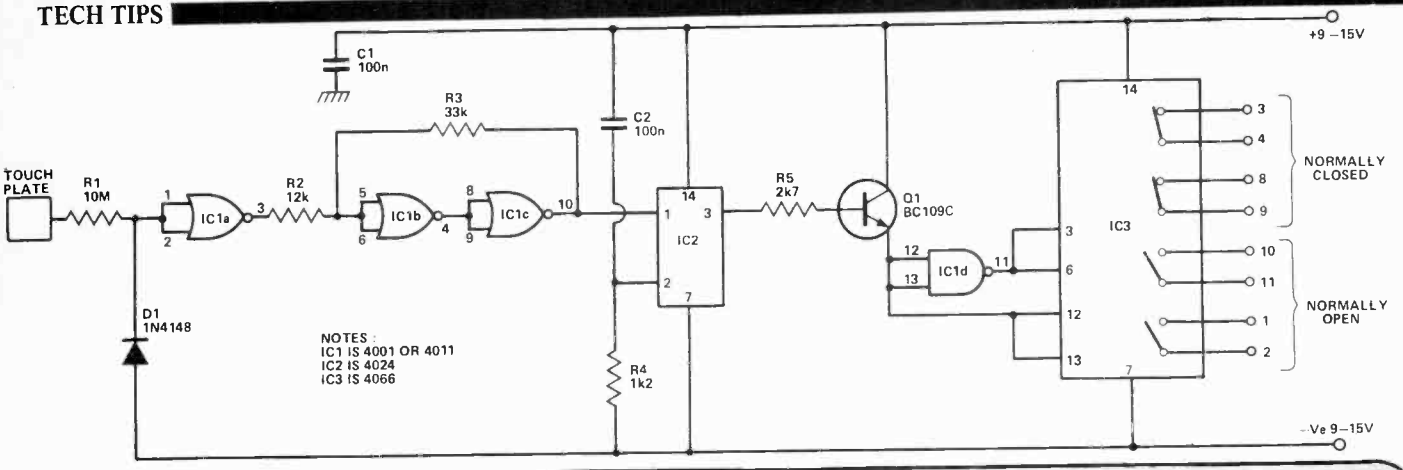


One Contact Touch Switch

G.N. Durant

The switch is operated by stray line hum, connected to the touch plate when briefly touched. The hum is coupled to the input of IC1a (used as an inverter) via R1 (a low pass filter). The output of IC1a is not sufficient to operate the final stage, so it goes through a Schmitt trigger (IC1b,c). Once the trigger output starts to change, R3 provides the trigger for a rapid change.

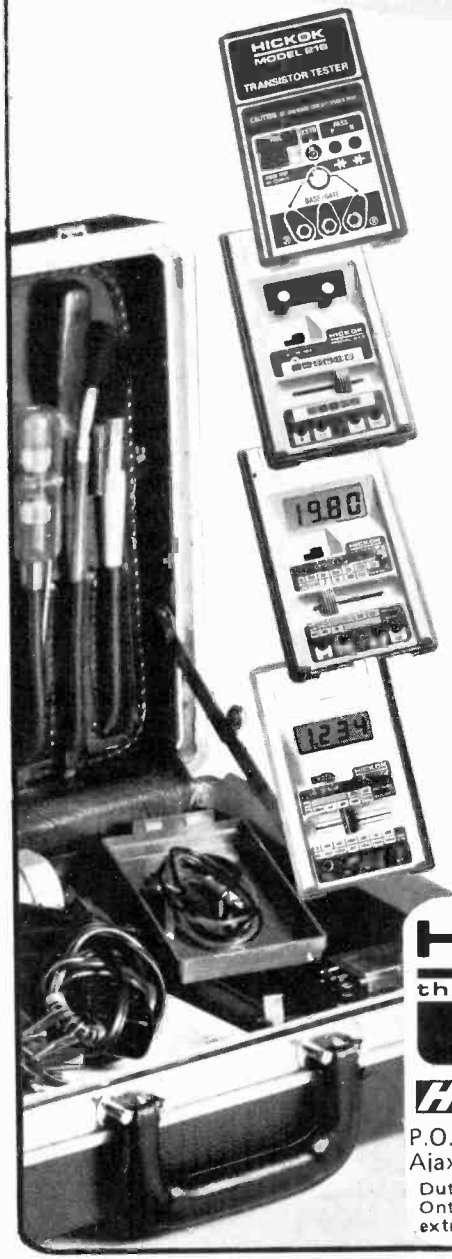
IC2 is a seven stage ripple counter. Q1 is driven from the output of the seventh stage via R5 (current limiter resistor). C2 and R4 reset IC2 at switch - on so the outputs are all low and the switching transistor is off. When the touch -plate is touched, IC2 will receive a 60 Hz signal. At pin 3 the logic state changes every 64 pulses, switching Q1 on and off. The plate is touched until the desired state obtained and then released.

Q1 sends a pulse through to IC3, a solid state CMOS switch. This can be fed via an inverter if desired. The switch must not be used at more than its supply voltage - up to 15 V. The 'off' switch resistance is about 10^{13} ohms and the 'on' resistance is about 80 ohms at 15 V V_{DD} (at 9 V V_{DD} it is 120 ohms).

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

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

Your Toolbox Test Bench



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Magnetic Light Dimmer

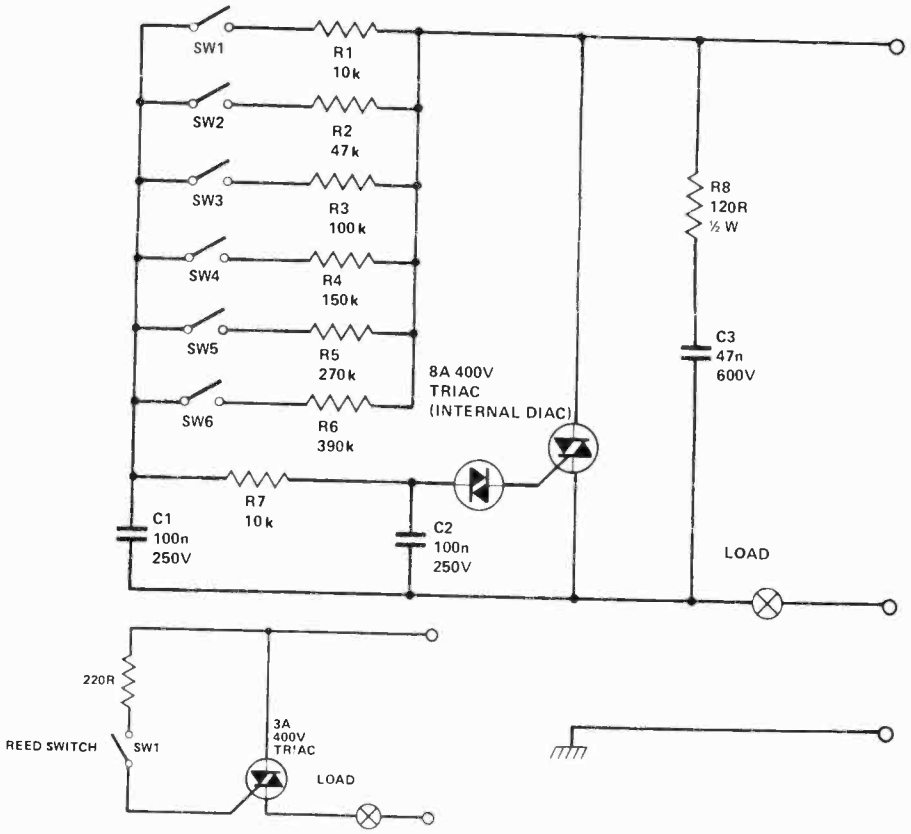
T. Hopkins

A partial solution to the problem of leaving lighting on unnecessarily is to have a reset - table timer in place of a switch. However, the choice of delay is difficult, particularly when the room may be used continuously.

Ideally, it should be impossible to leave the room without turning out the light. One solution, shown in Fig. 1 is to build the circuit into a wall box and carry a small magnet on a keyring. When the magnet is placed over the reed switch, the lights are turned on and, if the circuit is mounted on a steel front panel, the magnet will stay in place for as long as is required.

The magnetic dimmer shown in Fig. 2 allows a choice of six different light levels depending on which reed switch is operated. The resistor values shown were chosen to suit the available triac. Other triacs may require changes to some of these values.

The reed switches used measured approximately 1.125" and were mounted on a piece of tinplate with epoxy resin (Fig. 3). The front was then covered with a thin layer of plastic. A magnet of ½" diameter was used to operate the dimmer.



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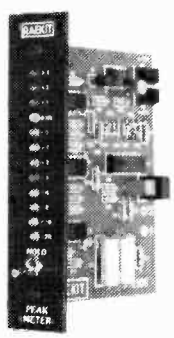

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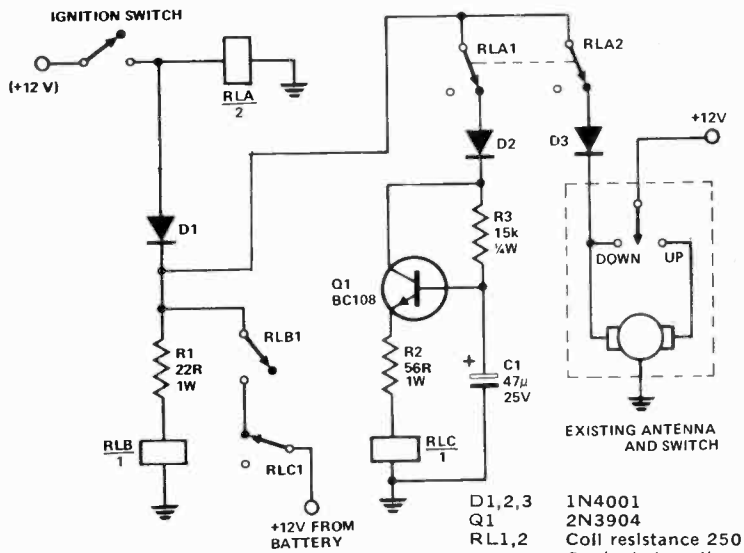
Automatic Antenna Retract

Ian Hawke

This circuit was designed to retract automatically a motorised car antenna every time the ignition is turned off. With ignition on, relays A and B are energised (total current drain about 100 mA). When the ignition is turned off, relay A is turned off and 12V from the battery drives the antenna down and charges C1 via R3. With the values shown for C1 and R3, after about a three second delay relay C is energised and interrupts power to relay B, removing supply voltage from the circuit. This circuit suits the two-wire control motorised antennas commonly available. The values of R2 and R3 may need to be adjusted to suit different motors as the retraction time varies.

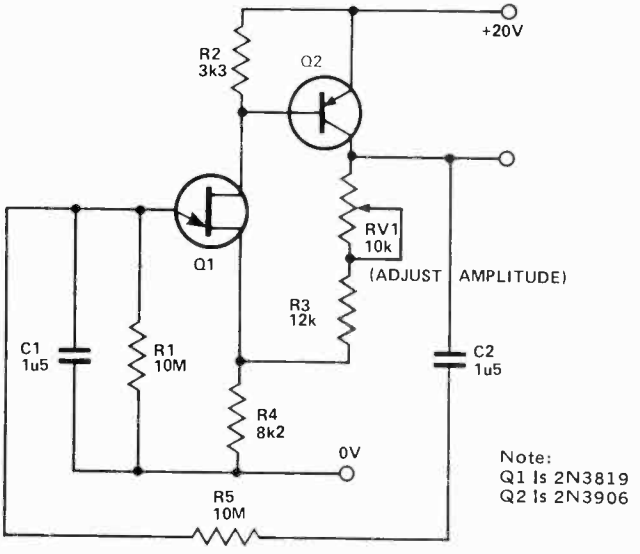


D1,2,3 1N4001
Q1 2N3904
RL1,2 Coil resistance 250R or greater. Contacts to suit.

VLF Sine Generator

G. Loveday

Generating very low frequency sine waves (i.e. less than 0.1 Hz) presents several problems. Timing capacitors usually have to be large valve electrolytics, any amplifier used must be D.C. coupled, and the amplifier's input impedance must be very high. One standard method is to first generate low frequency square waves, and then to shape these into an approximation of a sine wave by the use of several non linear devices, such as diodes. The circuit shown in Fig. 1 is a relatively simple approach based on the familiar wien bridge. An n-channel FET and a pnp transistor are arranged in a DC coupled circuit and the voltage gain is determined by the negative feedback R3 and R4. The gain need only be about three, thus if the bias required by the FET is 3V the output level will be approximately half the supply voltage.



Since R1 can be a high value resistor the value of the capacitor is only 1u5 for sine wave outputs of 0.01 Hz. This capacitor is available in polycarbonate. The amplitude of the output can be adjusted by RV1 to give low harmonic distortion and to be about 10V peak to peak. As expected, with this wien bridge circuit, frequency stability is good with changes in both supply voltage and temperature.

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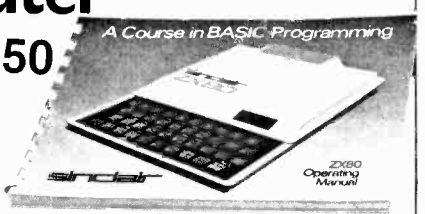

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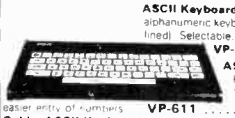

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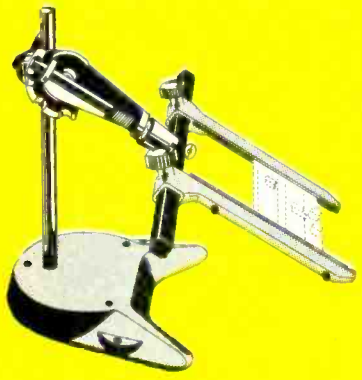

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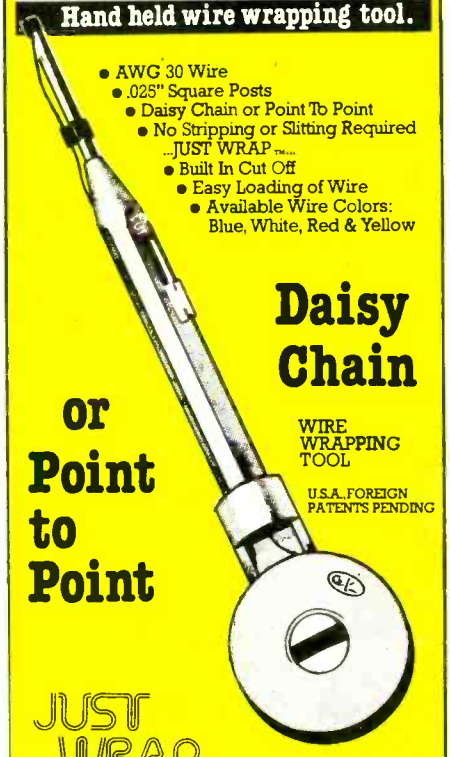

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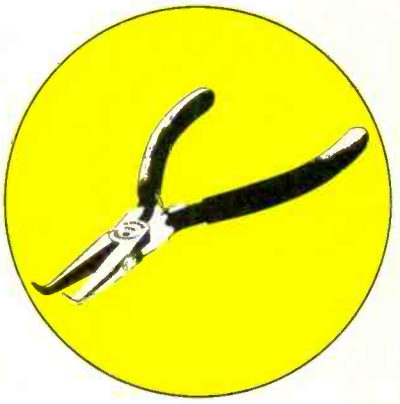

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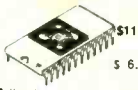
EPROM'S



C1702A — $11.64
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4164 64K (64K x 1) 200NS 16 PIN — $62.40

LINEAR I.C.'s

LM310AN-8	.42	LM348N-14	1.29	LM748CN-8	.51
LM307N-8	.38	LM358N-8	.68	LM1458N-8	.49
LM308N-8	1.14	LM555N-8	.33	LM1488N-14	.86
LM308CH	1.24	LM556N-14	.68	LM1489N-14	.86
LM309K	2.03	LM5570-N-8	1.09	LM1495CN-14	2.93
LM310HC	1.94	LM709CH	.77	LM1496CN-14	1.77
LM311CH	1.09	LM714CH	4.75	LM2211CN-14	3.58
LM311N-8	.68	LM723CH	1.09	LM2240PC	2.15
LM318N-8	1.29	LM723CN-14	.62	LM3081DC	2.03
LM318CH	1.48	LM725CN-8	1.63	LM3403N-14	1.11
LM323K	1.55	LM733CN-14	1.77	LM3524PC	6.44
LM324N	1.92	LM739CN-14	1.68	LM3900N	.62
LM339N	6.44	LM741CH	.82	LM4136N-14	1.14
		LM741CN-8	.36	ULN2003AN	1.09
		LM747CN-14	.73		

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CONTACTS	PRICE
8 PIN	.11
14 PIN	.16
16 PIN	.20
18 PIN	.27
20 PIN	.30
22 PIN	.33
24 PIN	.36
28 PIN	.42
40 PIN	.61

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CD4006BE	.77	CD4042BE	.70	CD4511BE	.83
CD4007BE	.35	CD4043BE	.77	CD4512BE	.98
CD4008BE	.90	CD4044BE	.62	CD4514BE	2.18
CD4009BE	.55	CD4046BE	.99	CD4515BE	2.82
CD4010BE	.51	CD4047BE	.90	CD4516BE	.98
CD4011BE	.25	CD4049BE	.51	CD4519BE	.68
CD4012BE	.25	CD4050BE	.47	CD4520BE	.82
CD4013BE	.42	CD4051BE	.99	CD4522BE	1.01
CD4014BE	.73	CD4052BE	1.03	CD4526BE	1.63
CD4015BE	.73	CD4053BE	1.03	CD4527BE	1.16
CD4016BE	.42	CD4060BE	1.29	CD4528BE	.94
CD4017BE	.73	CD4066BE	.62	CD4531BE	2.07
CD4018BE	.68	CD4068BE	.31	CD4532BE	1.16
CD4019BE	.70	CD4069BE	.25	CD4538BE	.77
CD4020BE	.88	CD4070BE	.31	CD4543BE	2.07
CD4021BE	.74	CD4071BE	.30	CD4553BE	2.46
CD4022BE	1.09	CD4072BE	.25	CD4555BE	.90
CD4023BE	.27	CD4073BE	.31	CD4556BE	.55
CD4024BE	.59	CD4075BE	.36	CD4581BE	2.46
CD4025BE	.31	CD4076BE	.77	CD4582BE	.90
CD4026BE	1.95	CD4078BE	.31	CD4584BE	.55
CD4027BE	.55	CD4081BE	.25	CD4585BE	1.03
CD4028BE	.70	CD4082BE	.25	CD4702BE	11.64
CD4029BE	.94	CD4085BE	.59	40097PC	1.16
CD4030BE	.94	CD4086BE	.62	40098PC	1.16
CD4033BE	.94	CD4093BE	.77	40161PC	1.63
CD4034BE	3.17	CD4099BE	2.28	40174PC	1.63
CD4035BE	1.01	CD4104BE	3.07	40175PC	1.29

OPTOELECTRONICS

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LED209	T-1 3 mm Red	.12
LED211	T-1 3 mm Green	.25
LED212	T-1 3 mm Yellow	.18
LED220	T-1¾ 5 mm Red	.14
LED222	T-1¾ 5 mm Green	.31
LED224	T-1¾ 5 mm Yellow	.21

DISPLAYS

FND357	.375" Common Cathode	1.29
FND500	.500" Common Cathode	1.29
FND507	.500" Common Anode	1.29
DL1416		32.50

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ILD74	Dual Opto Isolator	1500V	1.68
ILQ74	Quad Opto Isolator	1500V	5.14
ILCT6	Dual Opto Isolator	1500V	1.68
MCT2	Opto Coupler	1500V	.70
TIL111	Opto Coupler	1500V	.70
4N26	Opto Isolator	2500V	.70
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TIC116B	1.26	SCR	8 amp	200V TO-220
TIC116D	1.29	SCR	8 amp	400V TO-220
TIC126B	1.42	SCR	12 amp	200V TO-220
TIC126D	1.53	SCR	12 amp	400V TO-220
TIC216B	1.29	Triac	6 amp	200V TO-220
TIC216D	1.29	Triac	6 amp	400V TO-220
TIC226D	1.42	Triac	8 amp	400V TO-220
TIC236D	1.81	Triac	12 amp	400V TO-220
TIC246D	1.89	Triac	16 amp	400V TO-220
TIC263D	2.93	Triac	25 amp	400V TO-220
2N1595	1.16	SCR	1 amp	50V TO-5
2N6401	2.03	SCR	6 amp	100V TO-220

Bi-Fet OP AMPS

TL061CP	.94	Low Power
TL062CP	1.29	Dual Low Power
TL064CN	2.54	Quad Low Power
TL071CP	.70	Low Noise
TL072CP	1.25	Dual Low Noise
TL074CN	2.46	Quad Low Noise
TL081CP	.55	J-Fet Input
TL082CP	1.11	Dual J-Fet Input
TL084CN	2.07	Quad J-Fet Input
TL495CN	6.44	Switch. Volt. Reg. 25mA
TL497ACN	3.87	Switch. Volt. Reg. 500mA
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TL431CLP	1.01	Adj. Pos. Volt. Reg.

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TIP30C	.55	TIP110	.70	TIP141	2.13
TIP31A	.49	TIP111	.74	TIP142	2.55
TIP31B	.55	TIP112	.83	TIP145	2.39
TIP31C	.59	TIP115	.72	TIP146	2.57
TIP32A	.55	TIP116	.77	TIP147	2.93
TIP32B	.59	TIP117	.83	TIP2955	1.08
TIP32C	.62	TIP120	.83	TIP3055	.91
TIP41A	.70	TIP121	.88	FT3055	.77

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METAL CAN SMALL SIGNAL

2N404A	1.56	2N697	.38	2N706	.38	2N1613	.38
2N1711	.38	2N1893	.38	2N2222A	.25	2N2369A	.29
2N2484	.31	2N2905A	.51	2N2907A	.25	2N3053	.38

POWER

2N3055	.73	2N3440	.73	2N3771	1.68	2N3772	1.68
2N3773	2.46	2N6133	.73	2N6488	1.63	2N6545	6.18
2N3439	1.01	2N6059	3.19	2N6051	1.89	2N6079	5.01

TO-92 SMALL SIGNAL

2N3702	.13	2N3703	.13	2N3704	.13	2N3706	.13
2N3710	.13	2N3904	.09	2N3906	.09	2N3907	.13
2N4123	.09	2N4124	.09	2N4125	.09	2N4126	.09
2N4401	.10						

2N4402	.10	2N4403	.10	2N4410	.20	2N5087	.16
2N5088	.16	2N5172	.16	2N5220	.18	2N5221	.18
2N5223	.18	2N5226	.18	2N5227	.18	2N5401	.20
2N5550	.14	2N5551	.18				

2N5770	.16	2N5771	.17	2N5772	.18	P2222A	.12
P2369A	.12	P2907A	.12	PN3565	.16	PN3567	.16
PN4249	.16	PN5138	.13	MPSA05	.16	MPSA06	.16
MPSA13	.16						

MPSA18	.16	MPSA42	.21	MPSA43	.21	MPSA56	.16
MPSA70	.18	MPSA92	.18	MPSA93	.16	MPSA14	.16
MPS2925	.16	MPS2926	.16	MPS3391	.12	MPS3392	.16
MPS3393	.16						

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7400N	.29	74246N	1.77	74LS54N	.27
7401N	.29	74247N	1.61	74LS55N	.31
7402N	.31	74251N	.99	74LS73N	.42
7403N	.31	74259N	2.93	74LS74N	.49
7404N	.31	74273N	2.93	74LS75N	.47
7405N	.31	74276N	1.68	74LS76N	.62
7406N	.47	74278N	3.09	74LS78N	.38
7407N	.47	74279N	.77	74LS83N	.98
7408N	.31	74283N	1.55	74LS85N	1.16
7409N	.31	74293N	.94	74LS86N	.55
7410N	.31	74298N	1.09	74LS90N	.51
7412N	.49	74351N	2.86	74LS91N	1.16
7413N	.57	74365AN	.90	74LS92N	.60
7414N	.58	74366N	.90	74LS93N	.55
7416N	.47	74367AN	.90	74LS95N	.62
7417N	.46	74368AN	.90	74LS96N	.75
7420N	.38	74390N	1.25	74LS107N	.48
7422N	.47	74393N	1.77	74LS109N	.49
7423N	.47			74LS112N	.49
7425N	.42	74S00N	.51	74LS122N	.62
7426N	.57	74S02N	.57	74LS123N	.83
7427N	.42	74S03N	.57	74LS125N	.70
7428N	.55	74S04N	.73	74LS126N	.60
7430N	.29	74S05N	.73	74LS132N	.65
7432N	.73	74S08N	.73	74LS133N	2.03
7433N	.57	74S09N	.83	74LS136N	.57
7437N	.46	74S10N	.73	74LS138N	.74
7438N	.46	74S11N	.83	74LS139N	.74
7440N	.29	74S15N	.83	74LS145N	1.55
7442N	.57	74S20N	.70	74LS147N	3.24
7445N	1.16	74S30N	.57	74LS148N	1.77
7446N	1.09	74S32N	.96	74LS151N	.55
7447AN	.85	74S37N	1.68	74LS153N	.47
7450N	.29	74S38N	1.68	74LS155N	.94
7451N	.42	74S40N	.55	74LS156N	1.89
7453N	.42	74S51N	.73	74LS157N	.70
7454N	.42	74S74N	.83	74LS158N	.68
7472N	.47	74S85N	2.93	74LS160N	.94
7473N	.49	74S86N	1.25	74LS161N	.90
7474N	.49	74S112N	1.25	74LS162N	2.05
7475N	.55	74S114N	1.68	74LS163N	.90
7476N	.49	74S124N	3.33	74LS164N	.77
7483AN	.62	74S132N	1.61	74LS165N	1.42
7484AN	1.77	74S133N	1.25	74LS166N	2.55
7485N	.86	74S134N	.90	74LS170N	2.39
7486N	.55	74S135N	1.92	74LS173N	.83
7490AN	.42	74S138N	1.42	74LS174N	.51
7491AN	.55	74S139N	1.42	74LS175N	.55
7492AN	.49	74S140N	1.42	74LS181N	2.85
7493AN	.49	74S151N	1.53	74LS189N	10.21
7494AN	.88	74S153N	1.50	74LS190N	1.09
7495AN	.77	74S157N	1.50	74LS191N	1.09
7496N	.77	74S158N	1.50	74LS192N	.90
7497N	2.93	74S161N	3.71	74LS193N	1.29
74100N	1.79	74S162N	4.81	74LS194N	2.55
74104N	.83	74S163N	4.60	74LS196N	1.14
74107AN	.62	74S168N	5.79	74LS197N	1.14
74109N	.59	74S169N	6.05	74LS221N	1.09
74110N	.59	74S174N	1.29	74LS240N	1.27
74111N	.75	74S175N	1.29	74LS241N	1.27
74116N	1.79	74S181N	5.79	74LS242N	1.27
74120N	1.63	74S182N	3.19	74LS243N	1.42
74121N	.70	74S189N	9.75	74LS244N	1.77
74122N	.68	74S194N	3.07	74LS245N	2.15
74123N	.62	74S195N	2.41	74LS247N	.99
74125N	.68	74S201N	11.25	74LS248N	1.56
74126AN	.68	74S225N	8.39	74LS249N	1.29
74128N	.90	74S240N	3.87	74LS251N	1.25
74132N	.59	74S241N	3.87	74LS253N	.73
74136N	.68	74S244N	3.87	74LS257N	.90
74141N	1.09	74S251N	1.89	74LS258N	.77
74142N	3.87	74S253N	6.05	74LS259N	2.57
74143N	4.47	74S257N	1.42	74LS260N	1.29
74144N	4.47	74S258N	1.42	74LS266N	.57
74145N	.87	74S260N	1.77	74LS273N	1.55
74147N	1.61	74S274N	25.94	74LS275N	6.44
74148N	1.16	74S275N	25.94	74LS279N	.70
74150N	1.87	74S280N	3.19	74LS280N	2.57
74151N	.55	74S283N	4.75	74LS283N	1.16
74153N	.49	74S299N	8.39	74LS290N	1.01
74154N	2.18	74S373N	4.16	74LS293N	.49
74155N	.68	74S374N	4.16	74LS298N	1.25
74157N	.68	74S381N	7.74	74LS299N	3.25
74159N	2.13	74S412N	3.87	74LS320N	3.58
74160N	.62	74S471N	9.69	74LS321N	5.14
74161AN	.90	74S472N	12.55	74LS322N	6.44
74162N	.77	74S474N	12.55	74LS323N	6.44
74163AN	.82	74S476N	10.99	74LS324N	3.25
74164N	.82			74LS348N	3.45
74165N	.82	74LS00N	.22	74LS352N	1.76
74166N	.94	74LS01N	.22	74LS353N	2.15
74170N	2.57	74LS02N	.29	74LS362N	12.94
74172N	7.63	74LS03N	.29	74LS365N	.88
74173N	1.03	74LS04N	.31	74LS366N	.88
74174N	.85	74LS05N	.31	74LS367N	.94
74175N	.77	74LS08N	.25	74LS368N	.94
74176N	1.03	74LS09N	.31	74LS373N	1.79
74178N	1.50	74LS10N	.25	74LS374N	1.79
74179N	1.50	74LS11N	.31	74LS375N	2.57
74180N	.98	74LS12N	.31	74LS377N	1.87
74182N	.62	74LS13N	.33	74LS378N	1.55
74184N	3.84	74LS14N	.55	74LS379N	1.55
74185N	3.84	74LS20N	.23	74LS390N	1.77
74190N	.90	74LS21N	.23	74LS393N	1.63
74191N	.99	74LS26N	.51	74LS395N	1.76
74192N	.90	74LS27N	.38	74LS447N	.48
74193N	1.14	74LS30N	.23	74LS490N	2.46
74194N	1.14	74LS32N	.47	74LS630N	110.50
74195N	.60	74LS37N	.42	74LS669N	1.55
74196N	1.01	74LS38N	.42	74LS670N	3.07
74197N	1.01	74LS42N	.57		
74198N	2.03	74LS47N	.88		
74199N	2.03	74LS48N	1.29		
74221N	.88	74LS51N	.27		

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