Electronics Today

INTERNATIONAL OCTOBER 1980

$1.75
MM70924

20 Audio Amp Circuits

Easy to build, sensitive

METAL LOCATOR

Also:

- Solar Cells
- Electronic Fences
- Foolproof PSU
- Music Synthesisers
- Linear Scale Capacitance Meter

INTO ELECTRONICS
New introductory series starts this month

arkon electronics ltd

PRINTERS

TRENDCOM Thermal

TC-200, 80 chr. .... $795.
TC-100, 40 chr. .... $595.
(Interfaces extra)

ANADEX DP-8000

Bidirectional, buffered, 80 chr. .... $1350.

EPSON TX-80

Dot Matrix 80 chr. .... $995.
Interfaces available for Pet Apple, TRS80, IEEE, RS232

MEMORY

2102	1K 450ns static memory	$ 1.25
2102	1K 350ns static memory	$ 1.35
21L14	4K 450ns low power static ram	$ 7.95
2114	4K 300ns	$ 8.95
2114	4K 200ns	$10.45
4116	16K 200ns dynamic memory	$ 9.95
	8 for	$72.00
1702	256 by 8 EPROM	$ 4.00
2708	1K by 8 EPROM	$10.00
2716	2K by 8 EPROM	$21.95

COMPUTER

OHIO SCIENTIFIC

Superboard II Computer, 4K, on board $415.00
Superboard 8K, memory expansion, 8 chips $60.00
Superboard memory expansion PCB (24K) with data $50.00
Challenger 4P-8K, with sound colour, IO $1,045.00
Challenger 4PMF-4P with 24K minifloppy & IO $2,559.00

OSI, CIP SOFTWARE

Star fighter	$ 8.95	Fighter pilot	$ 5.95
Alien invaders	$ 8.95	Killerbot	$ 5.95
Seawolfe	$ 8.95	Lunar Lander	$ 4.95
Tank for two	$ 7.95	Concentrtion	$ 5.95
Bomber	$ 8.95	Chess for OSI	$24.95
Barrierball	$ 7.95	Time Trek	$12.95
Breakthru	$ 7.95	Backgammon	$12.95

DATA SHEETS

Graphic instruction $4.00
RS 232 for the C1P and superboard $3.95
Joystick instruction and plans $3.95
Reverse video for the C1P $3.95
G.T. conversion $1.00
Saving data on tape $4.00

UTILITIES

C1P cursor control $12.95
Renumberer .... $ 7.95
Autoloader .... $ 7.95

WE ALSO STOCK CPM!

DISKETTES

8" Control Data or Wabash $6.50
8" Dysan $7.95
5¼" Control Data or Dysan $7.50

S-100 COMPUTER BOARDS

CPIO

CPM Computer on a single S-100 card. Add memory card for a complete system. $495.00

ASC11 KEYBOARD & KIT

RCA VP-601, Touch Kbd. Full ASC11 chr set. $99.95
ARKON standard full ASC11 Kbd. Kit $99.95
Power supply kit (+5V) $7.95

VIDEO TERMINAL KIT

Serial 64 × 16 with selectable baud rate. Kit $169.95
Lower case option .... $ 16.95
5 volt power supply option .... $ 16.95

S-100 MOTHER BOARD

Six slot with passive termination A6S 100 Board $24.95
S-100 Edge Connector .... $5.00ea /6 for $25.00

MULLEN S-100 EXTENDER BOARD TB-4 .... $69.00

SD SYSTEMS

SBC-100	$415.	Expando Prom	$250.
SBC-200	$450.	VDB 8024	$500.
Z-80 Starter Kit	$475.	Versa Floppy I	$350.
MPB-100	$350.	Versa Floppy II	$490.
Prom 100	$275.		

Expandoram I (without ram) .... $299.
Expandoram II (without ram) .... $325.

ARKON KITS

All ARKON kits are complete with PCB.

Colour Video Modulator Kit $24.95
Logic Probe Kit (with case) $24.95
555 Code Oscillator Kit .... $ 3.95
RS 232 to TTL Converter Kit .... $ 9.95
BN-9 (LM 380) Audio Amp Kit .... $ 5.95
TRS-80, Apple II 16K Upgrade Kit $89.95
VD-1 Video Modulator Kit .... $ 8.95
TD-1567 Tone Decoder Kit .... $ 6.95
FM-2 Wireless Mike w/ Preamp Kit .... $ 5.95
Music Light Kit $12.95
LED Blinky Kit .... $ 2.95
Mad Blaster Noise Generator Kit .... $ 4.95
UT-1 Universal Timer Board Kit .... $ 3.95
MA 1003 Car Clock Module $19.95
MA 1023 Car Clock Module $19.95
MA 1008 (State 12 or 24 Hr.) $12.95
12V Clock Transformer .... $ 4.95
LCD Alarm Clock Module $29.95
ETI Sound Generator Kit $44.95

Kits by Jana PCB included.

0-20 volt 1 ampere power supply $34.50
Xenon strobe kit $18.95
3 chnl. colour organ, 300W. $22.75

ETI PROJECT BOARDS

5 Watt Stereo .... $ 6.25
Fuzz Box .... $ 1.50
Two Tone Door Bell .... $ 2.25
Logic Tester .... $ 5.25
Stereo Rumble Filter .... $ 1.50
Graphic Equalizer $12.25
Expander Compresser .... $ 6.25
Digital Panel Meter .... $ 4.75
Bucket Brigade Audio Delay Line .... $ 5.25
Ultrasonic Switch .... $ 3.25
Proximity Switch .... $ 4.25
Two Chip Siren .... $ 1.50
Eprom Programmer $12.25
Easy Colour Organ .... $ 3.75
Two Octave Organ .... $ 3.25
Audio Power Meter .... $ 6.75
Simple Graphic Equalizer .... $ 5.25
60 Watt Amplifier .... $ 5.25
High Performance Stereo Pre Amp. .... $ 9.25
Complex Sound Generator .... $ 9.25
Click Eliminator .... $ 8.25
300 Watt Amplifier $11.25
Guitar Effects Amplifier .... $ 3.75
Led Bar Power Meter .... $ 5.95
(Elementry Electronics)

new items

CASSETTE TAPES

Maxell UDXLI 90 min. $6.95
Maxell UDXLII 90 min. $7.45
FUJI FX1 90 min. $5.95
Sony LNX 90 min. $4.95
TDK SAC90 90 min. $6.80

IC SOCKETS

10% off orders of 20 pieces or more. Mix or match.

#Pins	Standard	Amp.	Wire Wrap
8	$ .15	$ .25	$ .65
14	$ .25	$ .35	$ .95
16	$ .25	$ .45	$1.00
18	$ .35	$ .60	$1.25
20	$ .35	$ .75	$1.50
24	$ .40	$ .80	$1.60
28	$ .45	$ .85	$1.80
40	$ .65	$ .95	$3.00

REGULATOR

78L05+5V 1A	$ .65	7824+24V 1A	$1.50
78L12+12V 1A	$ .65	7905−5V 1A	$1.95
79L05−5V 1A	$1.50	7915−15V 1A	$2.00
79L12−12V 1A	$1.50	78H05+5V 5A	$6.00
7805+5V 1A	$1.65	78MG+adj 5A	$2.00
7808+8V 1A	$1.40	78MG−adj 5A	$2.00
7815+15V 1A	$1.50	78GU+adj 1A	$2.00

Small Medium Large LEDS

Red .... 5 for $1.00
Green .... 4 for $1.00
Orange .... 4 for $1.00
Bi Polar .... 2 for $1.50
Flashing Red .... 2 for $1.50
Jumbo Red .... 6 for $1.00
High Quality Green (Panel Mount) .... 2 for $1.00
Metal Case, Panel Mount, Small or Large $1.50

RECHARGEABLE BATTERIES

4 × "AA" NICAD (used) .... $ 7.00
1 × "C" NICAD .... $ 3.50
1 × Sub "C" NICAD .... $ 1.95
4 × Sub "C" NICAD .... $ 5.95
6 × Sub "C" NICAD $10.95
1 × 2 volt 5 amp./hr. lead acid with charger .... $ 7.95
1 × 6 volt .9 amp/hr. Gell Cell .... $ 5.95

special

ARKON GRAB BAGS

1 lb Capacitors	$ .75	2 lbs Potentiometers	$1.00
1 lb Hardware	$ .50	100 Grommets	$1.50
2.5 lbs Resistors	$1.25	50 Trim Pots	$5.00
50 Assorted Switches	$5.00	30 Tantalums	$5.00

COMPUTER POWER SUPPLY

+5V at 10A, −5V at 2A, 12V at 5A, −12V at 2A
110/220 VAC 60/50 Hz,
16" × 10" × 7" $45.00
Mail order add $10.00 per unit.

SUPER S-100 XFORMER

8V at 18A for +5V supply
28Vct at 4.5A for ±5V supply
22V at 4.5A for disc drives $49.95

LS

74LS00	$ 1.50	74LS138	$ 2.50
74LS02	$ .80	74LS139	$ .95
74LS04	$ .60	74LS145	$ 2.65
74LS10	$ 3.15	74LS148	$ 1.45
74LS14	$ 1.50	74LS160	$ 2.80
74LS20	$ .75	74LS161	$ 2.10
74LS27	$ 1.60	74LS162	$ 1.30
74LS30	$ .35	74LS174	$ 1.70
74LS32	$ .90	74LS175	$ 1.25
74LS40	$ 1.10	74LS190	$ 4.75
74LS73	$ .65	74LS240	$ 4.95
74LS74	$ 1.10	74LS241	$ 2.15
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74LS91	$ 1.95	74LS244	$ 4.00
74LS92	$ .95	74LS245	$10.95
74LS93	$ 5.60	74LS266	$ 2.95
74LS123	$ 1.10	74LS290	$ 2.00
		74LS393	$ 3.40

LINEAR

301	$ .55
307	$ .75
308	3/$1.00
311	$ .65
224	$1.50
324	$1.10
339	$1.00
358	$ .85
377	$4.00
380	$2.10
380	$ .50
381	$2.00
382	$1.80
555	$ .60
7555	$2.00
556	$ .95
565	$1.80
566	$1.75
567	$1.80
709	$ .45
733	$1.75
739	$1.40
741	$ .65
747	$ .85
1312	$2.50
1314	$2.50
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1458	$ .75
1488	$1.95
1489	$1.50
1496	$1.50
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2206	$7.50
2567	$3.00
3046	$1.25
3140	$2.50
3302	$ .95
3401	$ .95
3900	$1.25
3914	$5.95
3915	$5.95
4136	$1.60
13741	$ .65
TLO71	$ .80
TLO72	$1.75
TLO74	$2.75
TLO80	$ .75
TLO81	$ .80
TLO82	$1.55
TLO84	$2.50
TL489	$2.95
TL490	$3.95
SOC16	$ .50
4N26	$1.20
4N30	$1.50
4N33	$1.45
4N37	$1.65

CMOS

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4001	$ .50
4002	$ .50
4006	$1.50
4007	$ .20
4011	$ .70
4012	$ .60
4013	$ .75
4015	$1.65
4016	$ .60
4017	$2.00
4018	$1.60
4019	$1.60
4020	$1.50
4021	$1.50
4022	$1.80
4023	$ .50
4024	$1.50
4025	$ .50
4026	$1.90
4027	$ .95
4028	$1.75
4029	$1.60
4030	$ .50
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4034	$4.25
4040	$2.15
4042	$1.70
4044	$2.50
4046	$1.75
4049	$ .50
4050	$1.30
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4086	$1.95
4089	$3.50
4093	$1.00
4094	$2.50
4501	$3.25
4502	$2.10
4508	$3.50
4510	$2.00
4511	$2.00
4512	$1.60
4515	$5.50
4516	$1.45
4518	$2.00
4519	$1.00
4520	$2.00
4522	$2.15
4526	$2.50
4528	$1.65
4531	$1.90
74C08	$ .75
74C10	$ .60
74C165	$1.50
74C922	$9.95
4584	$1.20
4585	$1.50
4532	$3.50
4543	$2.25
4555	$1.25

TTL

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7402	$ .60
7403	$ .41
7404	$2.00
7405	$ .60
7406	$ .50
7408	$ .83
7410	$ .30
7416	$ .80
7420	$ .48
7427	$1.10
7430	$ .50
7432	$ .90
7433	$ .75
7437	$ .63
7440	$1.10
7441	$1.15
7442	$1.40
7447	$1.75
7448	$1.65
7451	$ .65
7454	$ .65
7473	$ .75
7474	$1.40
7475	$ .75
7476	$ .60
7483	$1.80
7484	$1.50
7485	$1.40
7490	$ .50
7491	$ .70
7492	$ .85
7493	$ .85
7495	$1.00
74107	$ .85
74121	$ .60
74122	$1.10
74123	$1.05
74125	$1.15
74141	$1.00
74145	$1.75
74151	$ .95
74153	$ .75
74154	$1.65
74157	$1.10
74161	$1.60
74162	$1.75
74163	$1.25
74164	$1.00
74165	$1.75
74175	$1.45
74176	$ .95
74190	$1.40
74191	$1.60
74192	$1.20
74193	$ .95
74194	$1.70
74365	$1.40

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8080	$ 8.95
8212	$ 3.05
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6800	$ 9.95
6802	$ 9.95
6810	$ 5.35
6821	$ 8.50
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1857	$ 1.95
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AY 3 1015	$12.95
TR1863	$ 4.00
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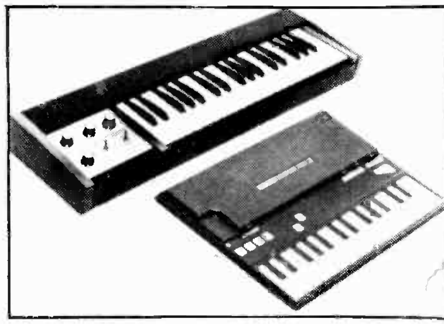
FEATURES



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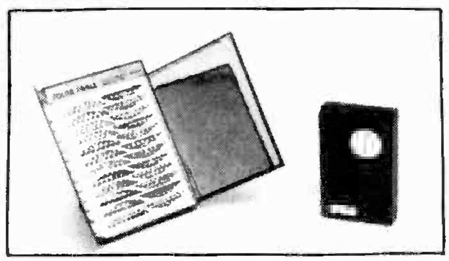
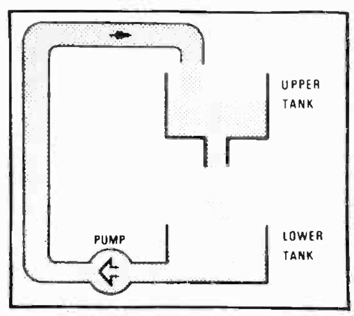
Electronic Fences, p.35



Solar Cells, p.39

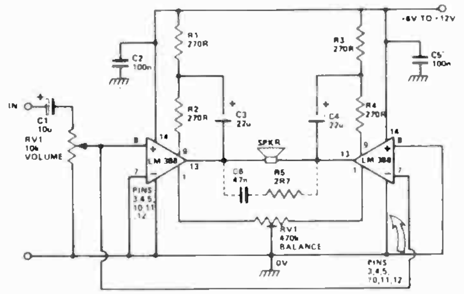
PROJECTS



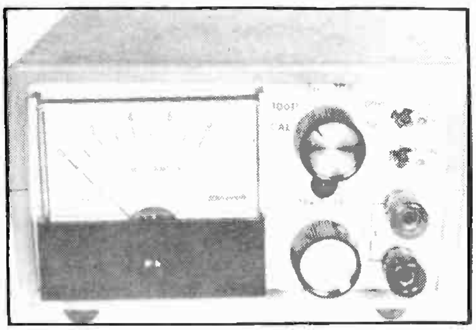
Into Electronics, p.53

Cover Photo: With the price of gold at its present levels, metal locators are more popular than ever. See our project on page 11.

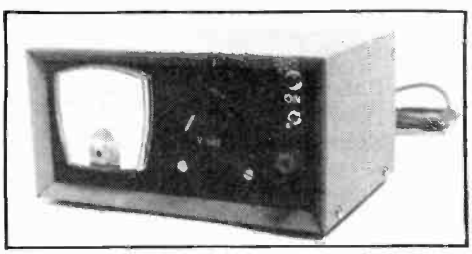
ISSN 0703-8984



Audio Amplifier Circuits, p.61



Linear Scale Capacitance Meter, p.29



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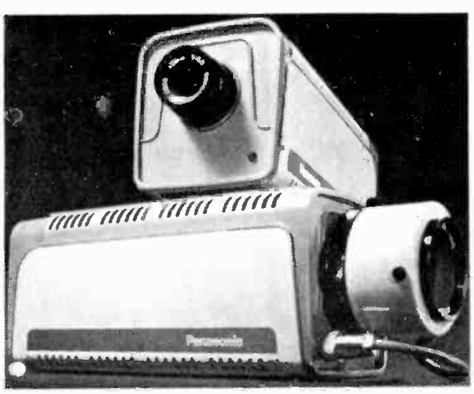

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COLUMNS

NEWS / INFO

ADVERTISERS' INDEX

LIABILITY
Whilst every effort has been made to ensure that all constructional projects referred to in this magazine will operate as indicated efficiently and properly and that all necessary components to manufacture the same are available, no responsibility whatsoever is accepted in respect of the failure for any reason at all of the project to operate efficiently or at all whether due to any fault in design or otherwise and no responsibility is accepted for the failure to obtain component parts in respect of any such project. Further no responsibility is accepted in respect of any injury or damage caused by any fault in the design of any such project as aforesaid.

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

BINDERS
For ETI are available for $6.75 including postage and handling. Ontario residents add 7% PST.

SELL ETI
ETI is available for resale by component stores. We can offer a good discount and quite a big bonus, the chances are customers buying the magazine will come back to you to buy their components. Readers having trouble in buying ETI could ask their component store manager 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!

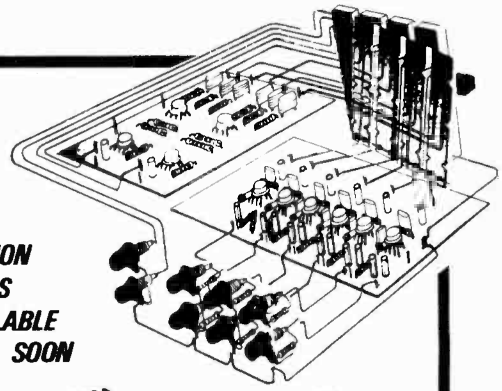
Firstly decimal points are dropped and substituted with the multiplier, thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100n, 5600pF is 5n6. Other examples are 5.6pF=5p6, 0.5pF=0p5.

Resistors are treated similarly: 1.8M ohms is 1M8, 56k ohms is the same, 4.7k ohms is 4k7, 100 ohms is 100R and 5.6 ohms is 5R6.

PCB SUPPLIERS
The magazine does not supply PCBs but these are available from the following companies. Not all companies supply all boards. Contact these companies direct for ordering information.
B&R Electronics, P.O. Box 6326F, Hamilton, Ontario, L9C 6L9
Spectrum Electronics, Box 4166, Stn 'O', Hamilton, Ontario, L8V 4L5
Wentworth Electronics, R.R. No.1, Waterdown, Ontario L0R 2H0
Danocinths Inc. P.O. Box 261, Westland, MI 48185, USA.
Exceltronix Inc., 319 College St., Toronto, Ontario, M5T 1S2
Arkon Electronics Ltd., 409 Queen St. W., Toronto, Ontario, M5V 2A5.
A-1 Electronics, 5062 Dundas St. West, Islington, Ontario M9A 1B9. (416) 231-4331.

Edu Kit LTD.

STEREO AUDIO MIXER Kit
$49.95



2-PHONO
1-AUX.
1-MASTER
EXPANDABLE
RESP. 20Hz - 20KHz
5V OUTPUT
.01% DIST.

EXPANSION BOARDS AVAILABLE SOON

16 CHANNEL LED CHASER KIT

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)

Model # EK80LC016 — PRICE: $22.95

16 CHANNEL MULTI-MODE LED CHASER KIT

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 are: Up, Down, Skip, Pulse, Scramble, Single Pulse, Multi Pulse and many more. An optional 120 vac board is available. (Extra)

Model # EK80LCM16 — PRICE: $32.95

POWER SUPPORT 120

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.

Model # EK80PLC120 — PRICE: $24.95

STROBE LITE KIT

Fantastic for special effects. Variable speed Xenon flash gives you a "STILL MOTION" effect. A real attention getter.

Model # EK80SL001 — PRICE: $21.95

CRYSTAL RADIO KIT

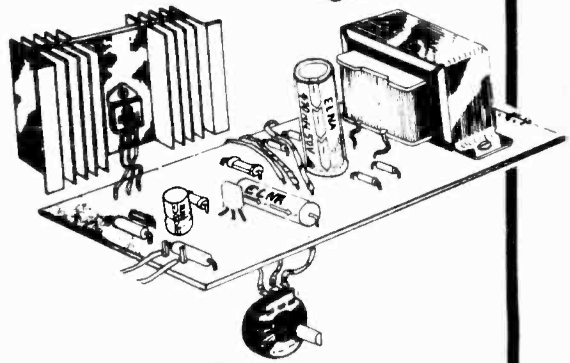
A self powered radio which uses a resonant circuit and detector for AM radio reception. An ideal project for the beginner.

Model # EK80CR001 — PRICE: $8.95

BBD AUDIO DELAY LINE KIT

A unique Special Effects Unit which gives a variable or fixed delay of Analog Signals, Reverb, Echo and Flanging.

MODEL #EK80BBD01 — PRICE: $69.95



1.5 to 24v POWER SUPPLY KIT

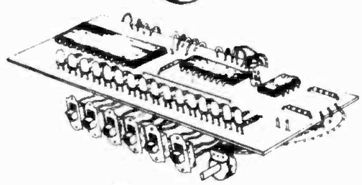
A variable Power Supply suitable for many digital and linear applications. Delivers an output current of 100ma. from 1.5v to 15v and 500ma. from 16v to 24v.

MODEL # EK80PS024 — PRICE $24.95

0-28 VOLT POWER SUPPLY KIT

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.

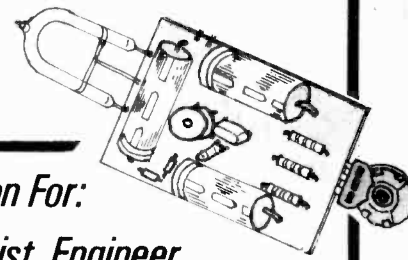
Model # EK80PS028 — PRICE: $39.95



5 WATT IC AUDIO AMPLIFIER KIT

A general purpose 5 watt amplifier with Thermal Overload and Short Circuit Protection. Because of its low operating voltage and high power output, it allows the user to use it as an add-on amplifier for car stereo.

Model # EK80A005 — PRICE: $19.95



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3.5 Inch Super Horn
MODEL
KSN 1005A

$11.95

2x5 Inch Wide Dispersion Horn
MODEL
KSN 1016A — **$12.95**

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DOME MID RANGE	AD0211SQ
DOME TWEETER	AD0163/T
THREE-WAY CROSSOVER	ADF700/3000/8

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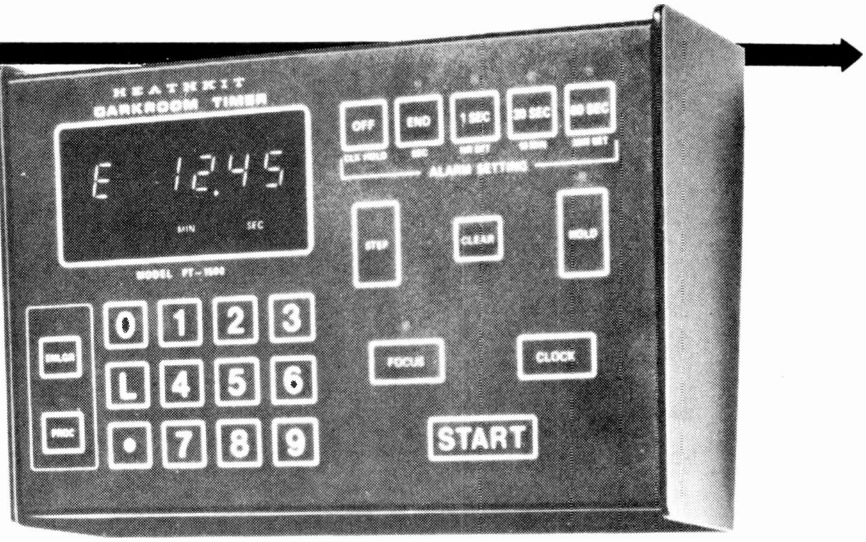
NEWS



Darkroom Timer

Heathkit announces a new microprocessor-controlled darkroom timer kit. Priced at $189.95 the PT-1500's programmable memory can hold times for up to nine processing steps and an enlarger step.

The enlarger and safelight outlets are designed so one goes on when the other goes off. If the optional PTA-1500-3 auxiliary outlet accessory is used to connect the timer to an external device (such as a colour drum), the PT-1500 turns on the auxiliary outlet during countdowns in the process mode.

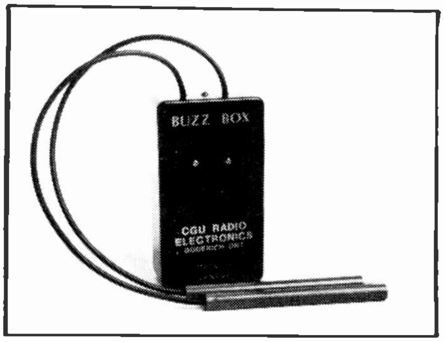
A four-digit LED display times to 99 minutes, 59 seconds or 999.9 seconds. A display switch turns off the LEDs and backlighting, without effecting countdowns or memory, when you need complete darkness. Also, the front panel is impervious to darkroom chemicals, and provides touch control of the PT-1500's functions.

The PT-1500 is available from Heathkit Electronic Centres in Vancouver, Edmonton, Winnipeg, Mississauga, Ottawa and Montreal, or you can write to Heath Company, 1480 Dundas Highway East, Mississauga, Ontario L4X 2R7.

Continuous Buzz

CGU Radio Electronics announces the Buzz Box, a solid state audible continuity tester. It's uses include quick checks of circuit board foils, wiring cables, relays, transformers and a variety of components to determine the presence of open circuits, shorts and intermittent connections. Additional applications include code practice oscillator and capacitor checker.

Price is $34.95. From HRB, Box 400, Goderich, Ontario. While your at it, ask for their product catalogue.



Expose Yourself

News Digest is a regular feature of ETI Magazine. Manufacturers, dealers and clubs are invited to submit news releases to News Digest, c/o ETI Magazine. Sorry, submissions cannot be returned.

The Link Contest

We have to admit, we handed you a real toughie, but our reader's response was tremendous. The answer was, in fact, $2/\pi$ ohms.

First prize goes to Jon Davis of Kingston, Ontario who sent in an eleven page proof of how he did it. Second and third runners up were B.C. Burden of Willowdale, Ontario and Wayne Duplessis of Verdun, Quebec respectively. Both sent in answers of 0.64 ohms.

Special thanks to Motorola for supplying the prizes.

Leaderscope Contest

We also held the drawing for the Leader LBO 514 dual trace oscilloscope. The winner was Bill Paquette of Schumacher, Ontario. Where's Schumacher? Apparently it's right near Timmins, in Northern Ontario.

Second prize winners were M. Elliot of Calgary, Alta. and Pierre Beaudry of Otterburn Park, Quebec.

Special thanks are due to Omnitronix Ltd. for supplying our first prize.

The correct answers were: A/ no.6, B/ no.4, C/ no.3, D/ no.1, E/ no.2, and F/ no.5.

SUPERB 8-BIT MICROCOMPUTER AT A SPECTACULAR PRICE

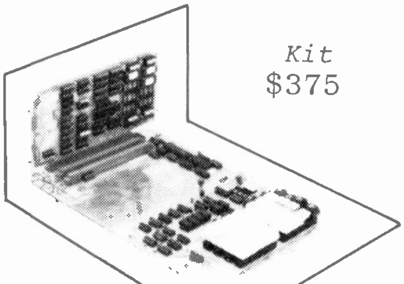
MADE IN CANADA

MULTIFLEX Z80A COMPUTER

The Multiflex computer system consists of an S-100 processor board (which can be purchased separately and is described below), a motherboard, and a monitor software package.

Features of the motherboard:

* 4 S-100 card-edge connectors;
* Hex keyboard and LED display with 4 address digits and 2 data digits;
* 14 monitor function keys;
* 2000 bit per second cassette tape interface;
* 24 parallel I/O lines (on-board PIA uses 8255 IC);
* 2708/2716 EPROM programmer;
* 40-chip wirewrap area for customizing.
* Optional RS-232 interface with baud rate generator;



Kit $375

$450 *assembled & tested*

4K MONITOR SOFTWARE

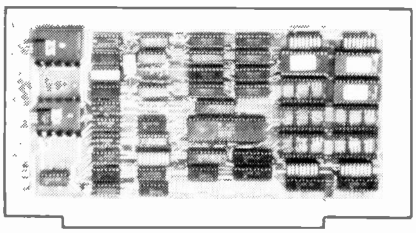
The 4K monitor which comes with the Multiflex computer is one of the most sophisticated on the market. Some of the functions available are:

* Examining and modifying memory locations, Z80 registers, and I/O ports;
* Start-stop-continue program execution;
* Single-instruction step execution;
* Breakpoints and delayed breakpoints: you can specify a number of times (up to 2^{16} or 65,536) a breakpoint must be encountered in a program, before the break actually occurs;
* Whole blocks of memory, from 1 byte to all the locations in the system, can be compared and moved;
* 2708/2716 programming routines with automatic verification;
* relative branch offset calculation.

S-100 PROCESSOR BOARD

The Multiflex Z80A processor board is an S-100 device designed specifically for the motherboard described above. As a stand-alone unit it has the following features:

* Z80A CPU, guaranteed 4MHz operation;
* space for 2 banks of 2K bytes of RAM, address-locatable by hardware jumpers;
* comes with 1K of RAM;
* 8 EPROM sockets for 2708 or 2716, also jumper located;
* Jumper-selectable reset starting address,
* Provision for on-board regulation from standard S-100 power supplies.



64K DYNAMIC RAM BOARD

This memory board can be used with any S-100 computer. Its features are:

* Automatic on-board refresh, or jumper-selectable response to Z80 refresh;
* any part of the board may be used, as jumpers select which parts respond;
* up to 8 full boards may be used, each enabled by software, for up to 512K.

BIPOLAR PROM PROGRAMMER

A bipolar PROM programmer attachment is available for the Multiflex Z80 computer to program 74S-188, 287, 288, 387, 470, 471, 472, 473, 474, and 475 PROMs.

A NEW WAY TO TEST DIGITAL SYSTEMS

MULTIFLEX LOW-COST LOGIC STATE ANALYZER

Logic State Analyzers are not new in the computer industry. What's new about the Multiflex Analyzer is its price. With comparable professional units selling for over $5000, it starts at $349.

The Multiflex Logic State Analyzer allows you to monitor up to 16 points in a digital system, which carry continually changing signals. When a specified 16-bit pattern is received, the unit will record the next 1023 consecutive bit patterns so that they can be examined step by step. A more advanced version of the Analyzer, available soon, will also allow recording the 1023 bit patterns preceding the trigger word. Logic State Analyzers are invaluable tools in industry for software and hardware development, especially for dedicated microprocessor systems. You can use the Analyzer to monitor Data, Address, or Control lines in your system, or any combination of digital signals, so long as they are all stable during clock transitions.

Any number of Analyzers may be interconnected to handle more than 16 inputs. The readout is in 4 Hex digits and also in binary on 16 LEDs so you can read either numerical values or examine individual bits. A further 3 Hex digits give the "entry number" for each word (how many clock pulses after the trigger word it occurred). Once data has been collected, you can step through and examine it either forwards or backwards, at either a slow or a fast rate. For convenience, the logic polarity and clocking edge are switch-selectable. Analyzers are available with maximum clock rates of 5 MHz and 6.6 MHz, and all are TTL compatible.

MULTIFLEX

Exclusive distributors:

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Components & Computing Inc.

319 College Street
TORONTO, ONTARIO M5T 1S2
Phone 921-5295

Write, phone, or come in soon for information on all Multiflex products.

Circle No. 31 on Reader Service Card.

Cat News

Two new catalogues available now. Cesco Electronic's 1981 catalogue can be had for $2.00. Your two dollars will get you 272 pages of switches, connectors, transformers and anything else you could want. No listings on semiconductors, just a two-page spread that says they have 'millions of dollars of inventory' so you'd have to write and advise them of your needs. You can get it from Cesco Electronics Limited, 4050 Jean Talon Street West, Montreal, Quebec. Phone (514) 735-5511.

Electro Sonic's catalogue No.801 is now out. At 1166 pages, it's one of the most comprehensive catalogues we've seen. Although we're a few months late in reporting it, we've been assured that there are lots of them in stock. You can get one for $15.00 (it's worth it) by writing to Electro Sonic, 1100 Gordon Baker Road, Willowdale, Ontario M2H 3B3. Phone (416) 494-1555.

Also

A 160-page Engineering Catalogue is available from Grayhill, Inc. DIP Switches, Keyboards, Pushbutton Switches, Rotary Switches, Solid State Relays and Termination Hardware are listed in this catalogue. Each product group is described dimensionally and electrically.

Request a Grayhill Engineering Catalogue No. 1 from A.C. Simmonds & Sons Limited, 975 Dillingham Road, Pickering, Ontario L1W 3B2. Phone (416) 839-8041.

Audiovision's new Catalogue (no. C2) is now available. Some new products are featured. These include a 10 band graphic equalizer, frequency level display as well as a transistor tester, electronic lock and more.

You can order catalogue No. C2 from Audiovision Service, P.O. Box 955, Stn. B, Willowdale, Ontario M2K 2T6.

Calendar Date

The 1981 International Electrical, Electronics Conference and Exposition will be held October 5, 6 and 7, at Exhibition Place, Toronto. Evening functions will take place at the Royal York Hotel, the conference headquarters.

Celebrating its 25th Anniversary, this biennial conference and exposition will again create an international scientific marketplace for buyers and sellers in all aspects of electronics, with particular emphasis on telecommunications.

Pre-registration is free for qualified industry personnel; the student rate is $2.00 and non-member $10.00. Write to The Institute of Electrical and Electronics Engineers, 1450 Don Mills Road, Don Mills, Ontario M3B 2X7.

Looking Back

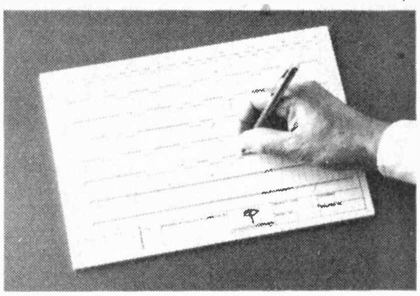
Simple Intercoms, Hobby Projects

A 25u, 25V capacitor (C5) is specified for the power supply but does not appear in the schematic. It goes in parallel with C4.

Click Eliminator, May 1980

Two minor overlay problems here. C10 at the top right corner should be C11. Also the R103 that appears just to the right of RV101 is actually C103.

Also C12 and C13 were not specified, they should be 4u7 tantalums. R23 was listed twice, its value is 10k.

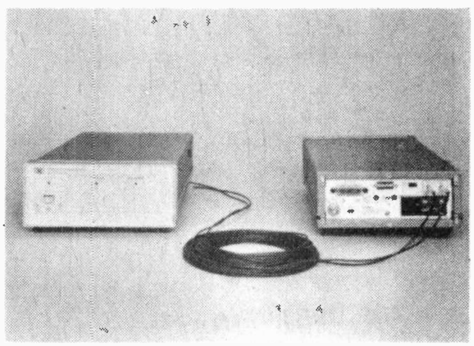


A Timely Notion

AP Products Incorporated introduces the Logic Timing Recorder, a timesaving device for charting logic timing.

The Logic Timing Recorder is an ABS plastic board with 320 slides arranged in eight horizontal rows. Moving vertically between two click-stop positions the slides represent the two logic levels of a circuit. The board is designed to be placed on an ordinary copying machine to make a record for the permanent files.

AP Products Incorporated Logic Timing Recorder, P/N 923758, carries a suggested sale price of $44.95US. For more information write to Weber Electronics, 105 Brisbane Road, Downsview, Ontario M3J 2K6. Phone (416) 663-5670.

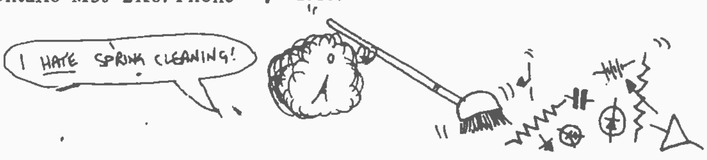


Optional Interface

This new extender for the Hewlett-Packard Interface Bus (IEE488) provides a high-speed, low-cost solution for extension up to 1000 meters. Operating in pairs, each unit serializes the HP-IB information and transmits it over coaxial cable or fiber optic link to a remote unit which reconverts the serial data to parallel HP-IB format.

Called the HP Model 37203A, the extender provides information transfer at rates up to 50 kilobytes per second. Integrity is assured by isolating the data from electrical interferences. Further protection is provided by an error detection/ correction algorithm which automatically identifies and corrects any transmission errors.

Canadian price of the standard Hewlett-Packard Model 37203A is $1435. Option 001, Fiber Optic Interface, is $797. You can find out more by writing to Inquires Manager, Hewlett-Packard Company, 6877 Goreway Drive, Mississauga, Ontario L4V 1M8.



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 circuit 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.

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 available to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses.

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

BP51: Electronic Music and Creative Tape Recording $5.50

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

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

BP69: Electronic Games $7.55

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

BP70: Transistor Radio Fault-Finding Chart $2.40

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

BP71: Electronic Household Projects $7.70

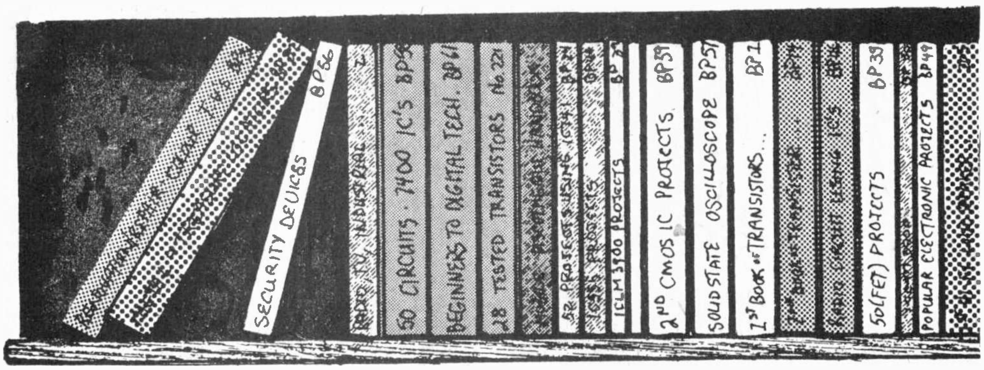
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. These circuits range from such things as '2 Tone Door Buzzer' and Intercom through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP72: A Microprocessor Primer $7.70

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

BP 73: Remote Control Projects $8.58

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



BP74: Electronic Music Projects $7.70

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

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

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.

These books are specially imported from England by us. If someone has already used the form in this issue, please write to: ETI Magazine, Unit 6, 25 Overlea Boulevard, Toronto, Ontario M4H 1B1.

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

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

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

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

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

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

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

BP44: IC 555 Projects $7.55

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

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

BP46: Radio Circuits Using ICs $5.90

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

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

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

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

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 be used on its own. However, latter 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 alternating current theory.

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

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.

BP66: Beginners Guide To Microprocessors & Computing $7.55

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

BP67: Counter Driver & Numeral Display Projects $7.55

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

BP68: Choosing & Using Your HI-FI $7.25

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

NO.213: Electronic Circuits For Model Railways $4.50

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

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

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

NO.221: Tested Transistor Projects $5.50

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

NO. 223: 50 Projects Using IC CA3130 $5.50

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

NO.224: 50 CMOS IC Projects $4.25

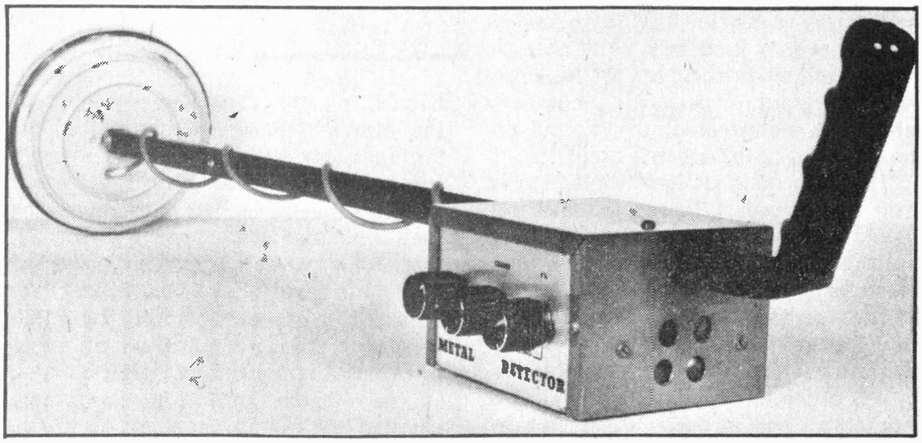
CMOS IC's are suitable for an extraordinary wide range of applications and are now also some of the most inexpensive and easily available types of ICs. The author has designed and developed a number of interesting and useful projects. The four general categories discussed in the book are: Multivibrators,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

ALL PRICES INCLUDE POSTAGE & HANDLING

Prices subject to change without notice.

METAL DETECTOR

The metal detecting hobby is enjoying quite a boom at the moment and treasure hunters are not just after gold. Though the price of the precious metal has fallen in recent months, at around $600 an ounce it's worth going after. Old coins and relics fetch high prices too, so there's lots to find out there . . .



METAL DETECTORS depend upon sensing one of several effects that can be observed when a metal object influences the magnetic field surrounding a coil of wire carrying an alternating current. The principal effects are: the pattern of the magnetic field surrounding the coil will be altered and the inductance of the coil will change.

The various types of metal detector devised exploit these changes, electronically detecting the alteration induced in the coil by the metallic object. Non-metallic objects or material can also affect the coil in similar ways.

There are three basic methods employed to exploit the above effects. "Induction Balance" (IB) metal detectors employ two coils. One is driven by a modulated oscillator. The other is connected to a detector and amplifier. The two coils are carefully positioned with respect to one another such that the receiver coil picks up very little of the energy radiated by the transmitter coil when no metal or mineral material is nearby. When the coils are brought near a metal object, the field pattern is distorted, greatly increasing the transmitted energy picked up by the receiver coil. The modulated signal is detected and can be indicated by amplifying the recovered modulation to speaker level as well as indicating it on a meter. For obvious reasons, this type of metal detector is often referred to as a "transmit-receive" or TR detector, sometimes as an IB/TR detector. Chief advantages are good pinpointing ability and good depth penetration, and they are not sensitive to small ferrous objects. Sensitivity suffers badly in mineralised or ironstone ground. We described an IB/TR metal detector back in our August '78 issue, but the problem for the home constructor lies in correct construction and alignment of the coils.

Most IB detectors operate at a frequency between 85kHz and 150kHz. As they are badly affected by mineralised ground a technique was developed using very low frequency to energize the transmit coil. The 'VLF' types operate at frequencies around 4–6kHz, a frequency range which penetrates all types of soil quite well. However, they achieve sufficient sensitivity with small objects, hence battery drain is quite high, and pinpointing ability is poor.

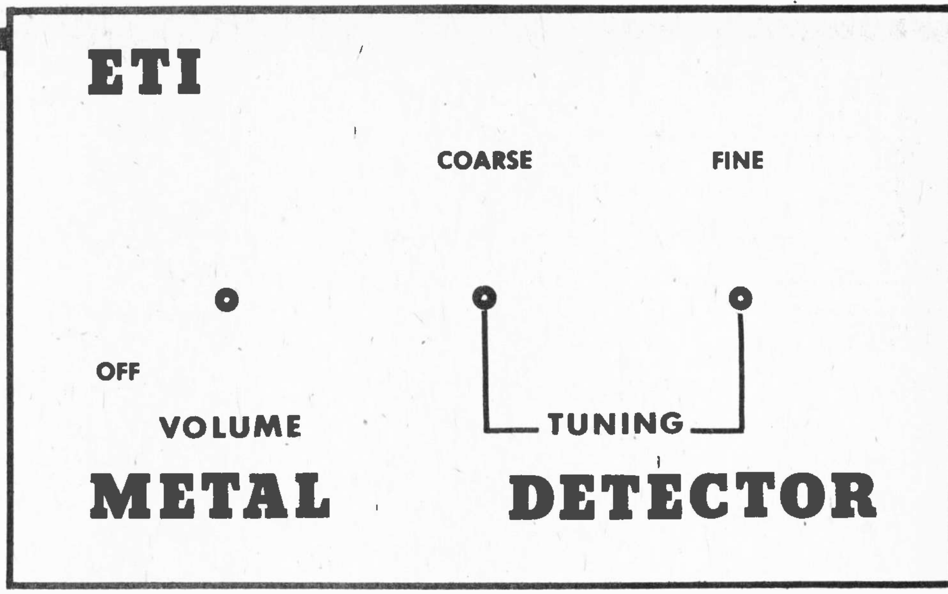
"Pulse Induction" dectectors employ coils in the search head that are set up in much the same manner as the IB detector. However, the transmitter is pulsed so that high energy bursts are transmitted by the search coil. The receiver then compares the phase of portion to the received pulse with the transmit signal. When a ferrous or magnetic object is brought near the search coils the phase of the received signal is *advanced* with respect to the transmit signal. The *opposite* occurs when a non-magnetic conductor is brought near the search coils. Thus, this type of detector can effectively 'discriminate' between ferrous and non-ferrous metals as well as exclude ground effects — simply by setting the detection circuitry to exclude signals of the unwanted phase characteristics. Thus, a "Ground Exclusion" control is often featured with these detectors. As the strength of the received signal also varies, depending on the 'target' object's characteristics, this effect may also be included in the detection process.

Clearly, a PI detector presents many problems to the home constructor.

BFO Principles

The simplest technique detects the change in inductance of a single search coil. If this coil is part of the tuned circuit of an oscillator, then comparing the frequency of the 'search' oscillator with a stable reference oscillator will indicate the presence of a metal object. This detector is called the "Beat Frequency Oscillator" or BFO type. The two oscillators are set such that there is a slight difference in their frequencies and their outputs mixed. The resultant will be a 'beat' frequency which is equal to the difference between the two oscillator frequencies. The main advantages of this type are simple circuitry and setting up along with good pinpointing ability. Most designs suffer from a distinct lack of sensitivity as well as poor tuning stability. A cunning mixing technique and a few other fillips can overcome these problems.

Hence, our new metal detector is a BFO type incorporating some modern refinements. It has proved to have simi-



Full size print of the front panel.

lar sensitivity to our IB detector, but is generally easier to build and set up, there being no critical adjustments.

Design Features

Our new metal detector has three controls: COARSE frequency adjust, FINE frequency adjust and VOLUME on/off. The coarse frequency control is used initially to set the frequency of the search oscillator, compensating for the varous factors affecting any drift in this oscillator (mainly temperature and battery voltage). The fine frequency control is then used to set the note to a low pitch when the detector is placed over the ground permitting compensation for the effect of the ground on the frequency of the search oscillator.

The two main design problems this type of detector presents are the frequency stability of the two oscillators and the minute frequency change which has to be detected.

The search oscillator we finally used was settled on after some experimentation. Our first try employed an LC oscillator built around a CMOS gate chip. This proved to be not as stable as we required and we found that trying to obtain DC control of the frequency by varying the supply rail voltage had drawbacks. After some experimentation with oscillator configurations we hit on a discrete component oscillator which we found behaved much as we were seeking.

The search coil in the circuit we used is the inductor in a Colpitts oscillator. However, this particular circuit may be a little unfamiliar to many readers. To increase the RF current in the coil, it is placed in the collector circuit of Q1. Feedback is between collector and emitter and the base is effectively at RF ground. The frequency determining capacitance of the tuned circuit is 'tapped' to provide feedback, C2 and C3 performing this function. Careful attention has been paid to the basic frequency stability of this oscillator. Good quality polystyrene capacitors have been used for C2 and C3. These have a temperature coefficient roughly opposite to that of other temperature influences on the frequency of the oscillator. In general, the short-term stability of this oscillator is quite good.

The particular circuit configuration of the oscillator gave us a very useful bonus — DC control of the oscillator frequency over a small range. Varying the base bias on a transistor will vary the collector-base capacitance. In this circuit, the c-b capacitance is part of the overall 'stray' capacitance that determines the exact frequency of oscillation. As the base bias is increased the c-b capacitance decreases, increasing the oscillator frequency. In this way, the oscillator frequency can be varied over a range of about ten percent. We have provided two controls, the FINE control providng a variation of about one-tenth that of the COARSE control.

The search oscillator is loosely coupled via a 47p capacitor to a following CMOS Schmitt trigger and two inverters which square the output. The loose coupling isolates the oscillator from the subsequent circuitry, further enchancing the stability of the search oscillator.

For the reference oscillator, we chose to use a crystal, because of its inherent stability. It has been argued that if an ordinary LC circuit is used for the reference oscillator it will have similar drift characteristics as the search oscillator and the overall drift will be reduced. In fact, the reference oscillator can be made using a standard 455kHz IF transformer. In practice however, the two tend to drift at markedly different rates. We think the best approach is to make both oscillators as stable as possible. Hence the crystal — which is an easily available type.

The reference oscillator is a simple inverter' crystal oscillator built around one gate from a CMOS quad NAND gate IC2. This has a square wave output and drives a divide-by-four circuit, IC3, via the other three gates in IC2, acting as buffers.

The crystal we used is a 3.579545 MHz type (NTSC chrominance subcarrier frequency) commonly available from a number of suppliers. The output of IC3 is at frequency of about 890kHz. The *exact* frequency is unimportant, just so long as it's *stable*.

Features

- Good sensitivity
- Excellent stability
- Good pinpointing ability
- Loudspeaker output
- Simple construction and set-up
- Tuning allows for ground
- Low cost

The search oscillator operates at a little above 100kHz, about one-eighth of this frequency.

The secret of our metal detector's overall sensitivity lies in the mixer circuit. This employs one section of a 4013 flip-flop. The reference oscillator's divider output (at 890kHz) is applied to the D input of IC4a and the squared-up search oscillator's output is applied to the clock input. If the clock frequency (ie: the search oscillator frequency) changes by 1Hz, the output beat (from the Q output of IC4a) will change by 8Hz (see 'How It Works'), thus considerably *multiplying* the smallest changes in oscillator frequency.

The output of the mixer is fed to a simple audio amplifier driving a loudspeaker. The search and reference oscillators must be well decoupled from each other and buffered from the mixer stage to prevent 'pulling' of the oscillators, which would result in erratic operation, especially when set for a low frequency output. We have used supply line decoupling as well as buffer stages after each oscillator. We also found it necessary to use a separate battery for the audio stage to prevent the very short, but high current pulses to the audio stage affecting the oscillators.

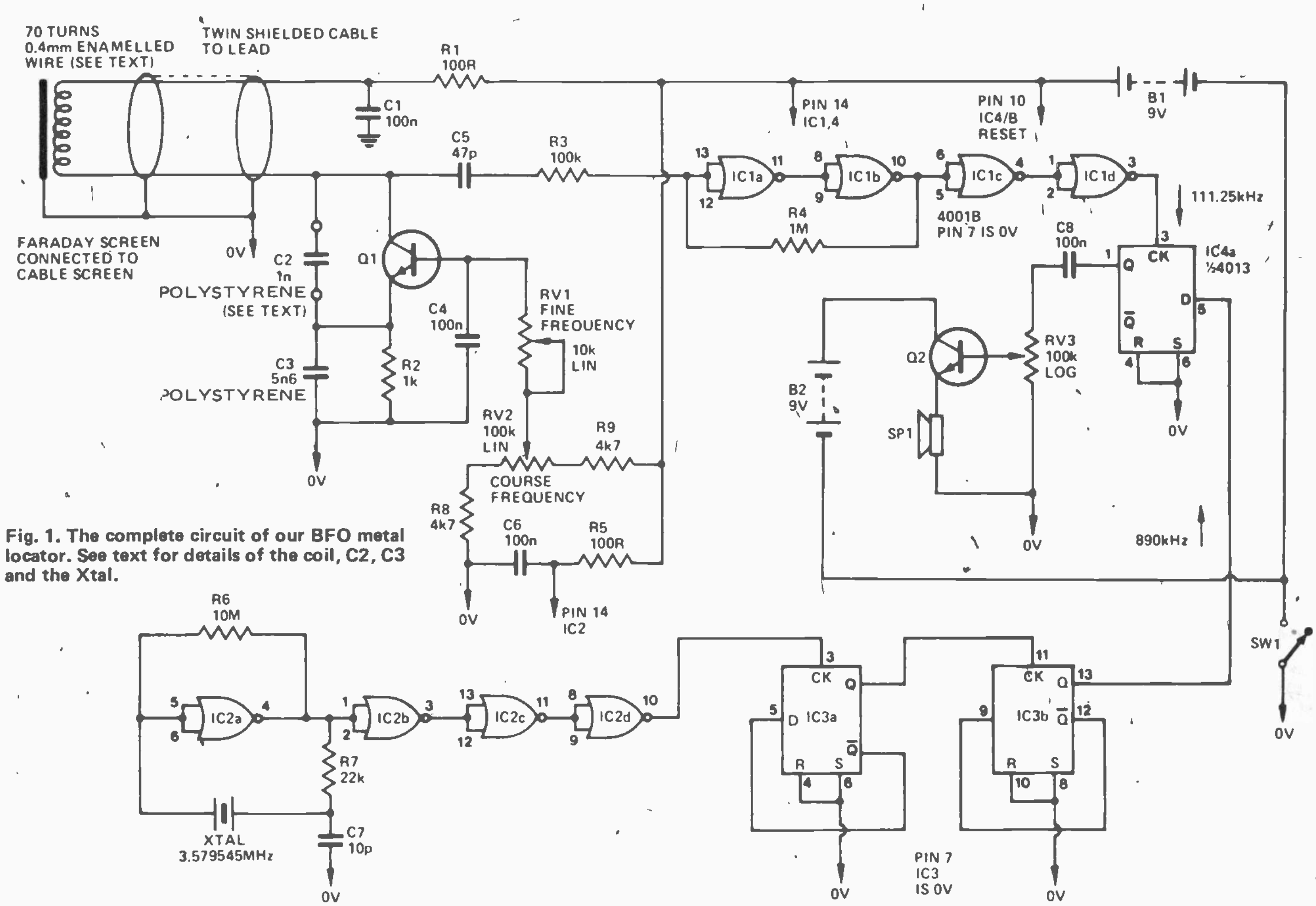


Fig. 1. The complete circuit of our BFO metal locator. See text for details of the coil, C2, C3 and the Xtal.

HOW IT WORKS

The beat frequency metal detector employs two oscillators: a very stable reference oscillator and a search oscillator. The search oscillator uses a tuned circuit designed to be influenced by metal or mineral objects which are brought into its field. The two oscillators are adjusted so they are harmonically related and fed to a mixer. When the search frequency is adjusted so the reference frequency fed to the mixer is eight times the search frequency, the output of the mixer is zero. The search frequency is slightly adjusted so that an output appears from the mixer which is the difference between the two input frequencies. This can be adjusted to an audio tone.

When a piece of metal or mineral is brought near the search coil the frequency of the oscillator varies, which in turn varies the output frequency from the mixer. The change in pitch can easily be heard from the speaker.

The reference oscillator employs a crystal in a CMOS oscillator circuit using one gate from IC2a. The resistor R6 biases the gate into its linear region. IC2 b, c and d, are used as buffer stages to prevent oscillator "pulling" and to further square its output waveform. Two flip-flops, IC3a and b, divide the reference signal by four to 890kHz.

The search oscillator uses a discrete transistor in grounded base configuration, with the search coil in the collector. Using the coil in the collector increases the strength of the field around the coil and hopefully overcomes some of the losses in the ground. Feedback is set by the ratio of C2 to C3 from collector to emitter and their value determines the frequency of the oscillator. The base is grounded at RF by C4.

By varying the bias on the transistor the inter-element capacitances can be varied. This varies the oscillator frequency as the transistor capacitances form part of the 'strays' in the LC circuit. RV1 and RV2 provide fine and course frequency control. The resistors R8 and R9 limit the maximum and minimum voltage on the base to prevent over-dissipation in the transistor or dropout of the oscillator.

The output of the search oscillator is fed to a Schmitt trigger, consisting of IC1a and b, where is is squared and further buffered by IC1c and d. The search frequency is then fed to the mixer.

Both oscillators are decoupled from each other by supply line decoupling R1–C1 and R5–R6.

The mixer consists of half a dual-D flip-flop. The search and reference frequencies are fed to the clock and D inputs respectively. The flip-flop looks at the reference oscillator (D) on every positive transition of the search oscillator (clock), and transfers this level to the Q output until the next clock transition. If the two oscillators are exactly evenly harmonically related (ie: 2nd, 4th, 6th, or in our case 8th, harmonic) the D output will always be the same level at each clock pulse. The output from the mixer at the Q pin will always be the same – no pulses.

However, if the search frequency is varied and the D and clock inputs are no longer harmonically related but are changing in phase with respect to each other, after a few clock pulses the D input will no longer be the same – the output will change state. The effect of all this is to produce a chain of square waves at the Q output, the frequency of which is eight times the change in frequency of the search oscillator.

Capacitors C8 and RV2 form a differentiating network which feeds a pulse to the audio amplifier, Q2, for each output transition from the mixer. Each cycle from the mixer produces two pulses in the speaker. If the frequency of the search oscillator is shifted one hertz the output of the mixer changes by eight hertz.

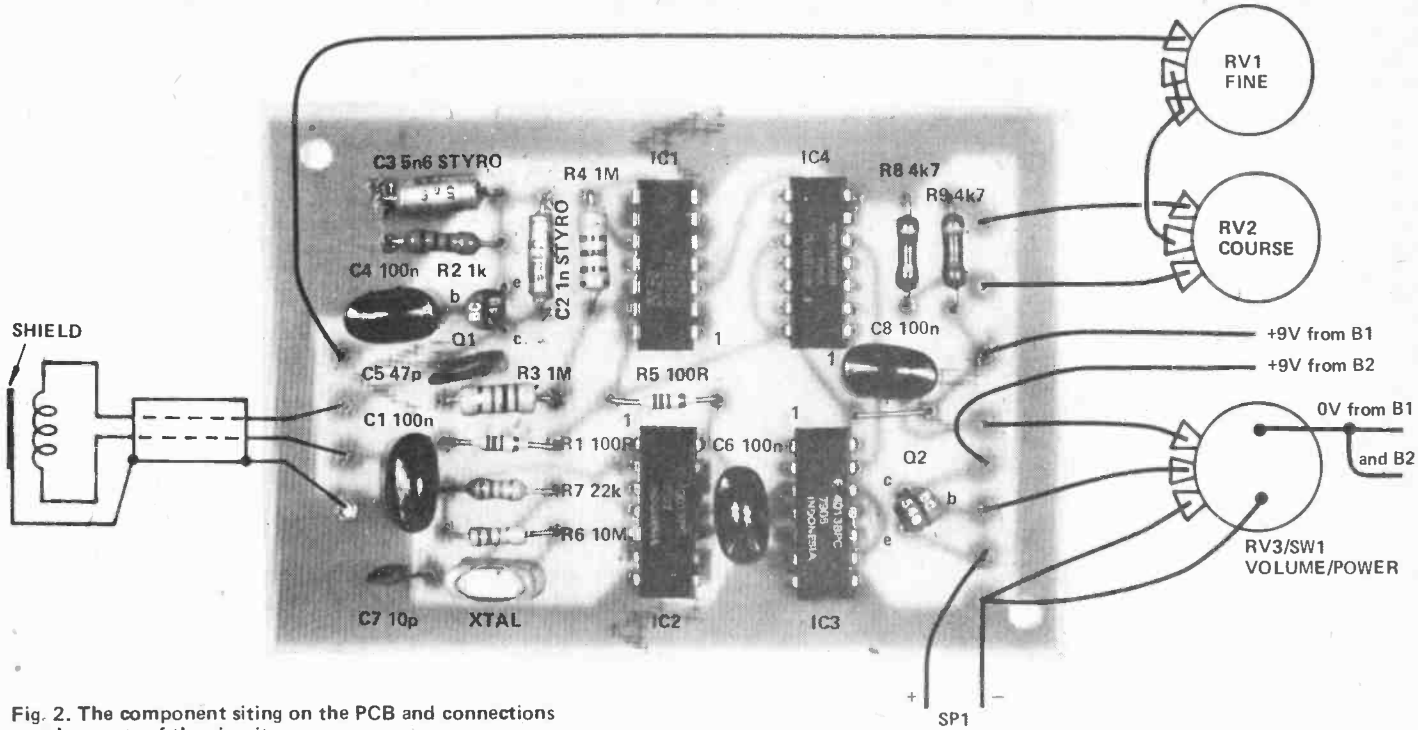


Fig. 2. The component siting on the PCB and connections to other parts of the circuit.

The Search Coil

The most important characteristic of the search coil is its size. Surprisingly enough the actual inductance doesn't seem to have much effect on sensitivity. The greater the coil diameter the greater the penetration depth, but the less sensitive it is to small objects. As a general rule the penetration is about equal to the search coil diameter, while the sensitivity is roughly proportional to the cube of the object diameter (as expressed as a function of the search coil diameter). Sensitivity is also inversely proportional to the sixth power of the distance between the coil and the object.

All this means is that if the object size is halved the sensitivity is reduced to one-eighth. Also, if the depth is doubled the sensitivity is reduced to one-sixty-fourth. It's easy to see why all metal detectors which are designed to pick up small objects use small coils, (150 to 300mm diameter) and really only skim the soil surface. If the search coil is doubled in diameter for greater penetration the sensitivity to small objects falls to one-eighth. You rapidly encounter the law of diminishing returns.

Some of the more expensive metal detectors improve the penetration, while retaining sensitivity, by using a very complex arrangement of coils which modifies the field pattern. This can be done to some extent by making the coil on the BFO detector oval in shape.

We chose a round coil of 150mm diameter to give good sensitivity to small objects giving about 100–150mm penetration which is easy to build, but this is open to considerable experimentation. Remember though, that if the coil diameter is increased the number of turns will have to be reduced so that the search oscillator remains at the same frequency (about 110kHz).

Faraday Shield

If the search coil is moved around, the capacitance between it and the ground or other objects changes. This changing capacitance 'pulls' the oscillator frequency and can completely swamp out the small change in inductance we are looking for. The coil can be screened from this capacitance effect by using a Faraday Shield around the coil. This consists of a ring of tubing, or in our case – a wrapping of aluminum foil, around the coil but broken at one point so it does not make a shorted turn. This shield is then connected to the common supply rail (OV) on the oscillator.

PARTS LIST

Resistors all ½W, 5%

R1	100R
R2	1k
R3	100k
R4	1M
R5	100R
R6	10M
R7	22k
R8, R9	4k7

Potentiometers

RV1	10k lin
RV2	100k lin
RV3	100k log switch pot

Capacitors

C1	100n plastic film
C2	1n polystyrene
C3	5n6 polystyrene
C4	100n plastic film
C5	47p ceramic
C6	100n plastic film
C7	10p ceramic
C8	100n plastic film

Semiconductors

Q1, Q2	MPS 6515
IC1, IC2	4001B
IC3, IC4	4013

Miscellaneous

SP1	8 ohm speaker
B1, B2	9 Volt battery
XTAL	3.579545 MHz NTSC colour xtal

Length of twin shielded cable, plastic pot stand (approx. 150mm dia.), length of steel or aluminum tube (approx. 600mm long, 20mm dia.), length of plastic rod or wood dowel to fit inside pipe (approx. 200mm long), 0.4mm enamelled wire, aluminum foil, epoxy, box to suit (approx. 105 X 125 X 75mm), three knobs, battery clips, insulation tape, two right angle brackets.

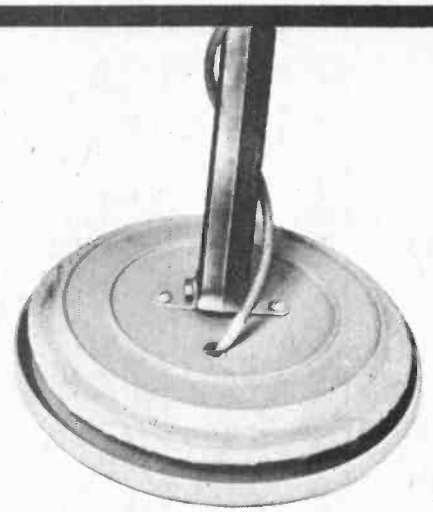
Construction

We have attempted to use commonly available mechanical ånd electronic components so that construction of this project is as easy as possible. The search coil is mounted on a 165mm diameter plastic pot stand which may be purchased at hardware stores and nurseries. The electronics is mounted inside a simple aluminum box attached to a stem made from a length of tube which extends down to the search coil and serves as the handle. Connection to the search coil is via a length of shielded cable. The controls mount on one side of the box housing the electronics. Which side you mount them depends on whether you are right or left handed. The speaker mounts on the end of the box facing the operator. As can be seen from the picture, the handle was made with an upwards bend at the end which you grip. This balances the instrument reasonably well, avoiding arm strain.

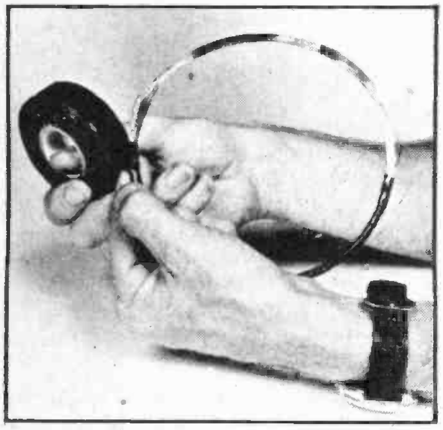
Construction should commence with the electronics. Mount the components on the pc board, taking care with the orientation of the transistor (Q1) and the ICs. Do not substitute another type of capacitor for the polystyrene types. The crystal specified comes with flying leads and may be soldered in place. Don't use too much heat though, solder quickly and you will avoid possible damage to the crystal.

The next step is to make the stem. The easiest way is to take a length of 25mm diameter PVC tubing about 850mm long and make a bend about 100mm from one end for the grip. To do this, heat the point of the bend over a flame (not *in* the flame) until it softens and then carefully bend it about 60° from straight.

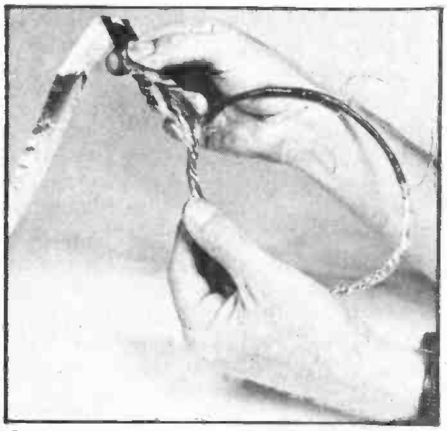
A length of aluminum tube may also be used for the handle. The bend for the grip can be made by first flattening the point of the bend somewhat with a hammer then placing the short piece in a vice and carefully making the bend. A section of wood dowel or plastic tube should be placed between the search coil and the end of the metal tube to keep the mass of metal about 200–250mm away from the search coil. A piece of wood dowel of the right size, jammed in the end of the aluminum tube, is generally the easiest way to go about it.



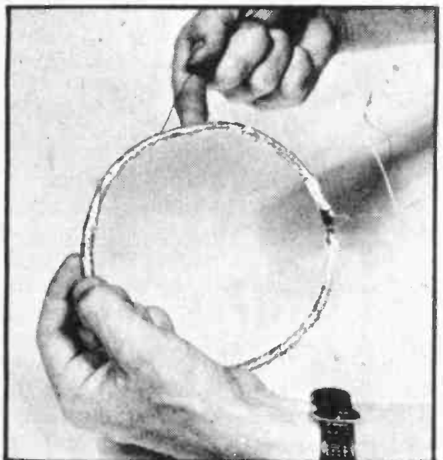
5: Press the assembled coil into the rim of the pot stand, terminate the wires as described and epoxy the coil to the pot stand.



1: Having wound the coil as described, wrap it with two layers of insulation tape.



2: Next wind the Faraday shield using two strips of aluminium foil, leaving a break where the coil ends come out.



3: Wind tinned copper wire over the shield, passing the end out where the coil leads pass out.

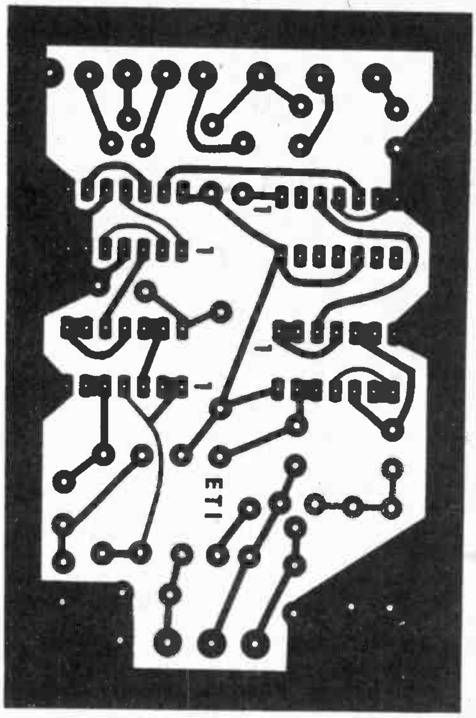
4: Cover the whole coil assembly with two more layers of insulation tape.

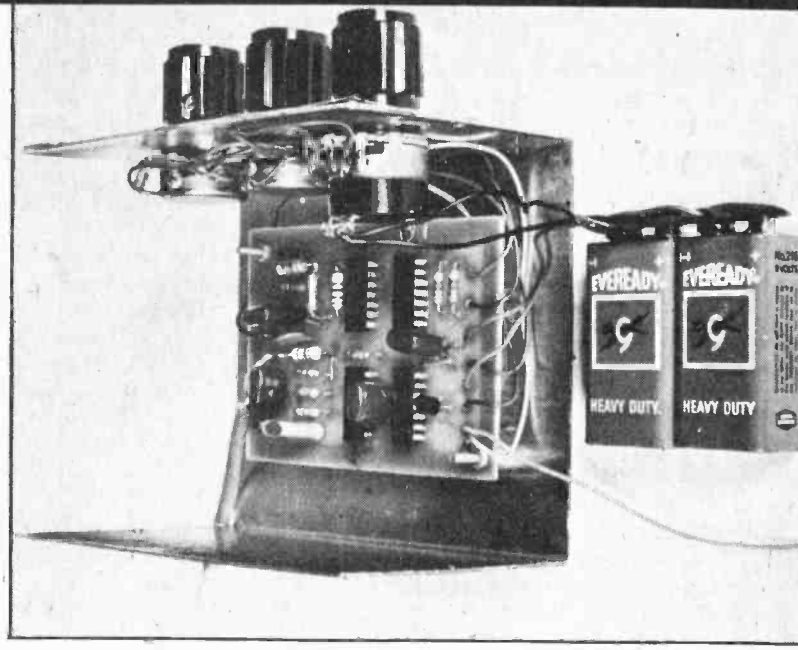
We used a small aluminum box which comes in two pieces. We drilled a hole in either end of the 'bottom' of this box so that it could be slipped over the stem (see accompanying photograph). A nut and bolt was used to secure it to the stem on the side 'below' the grip. The small speaker is mounted in this part of the box, before it is secured to the stem, on the end which faces upward toward the operator. A small hole is drilled in the opposite end and a grommet inserted. This permits entry of the cable to the search coil.

The pc board and controls are mounted to the 'lid' of the box. Position the controls on the side that suits your handedness. Our model was made for right handed operators.

Now for the search coil. This is wound so that it can be tucked inside the rim of the up-turned plastic pot stand. First make a cardboard former of the appropriate diameter. Roll a strip of heavy cardboard around the rim such that it fits loosely and tape or staple it securely (to avoid it popping open at an awkward moment).

Lift the former off the pot stand and then wind the coil onto this former as per the details given in the parts list. Leave a short length of wire spare on each end to make the connection. Tie the coil up with a few lengths of string at various places and then slide it off the former. Now wind two layers of insulation tape around the coil, leading the two ends out at the same place.





Internal view of the metal detector electronics showing general placement of the major components. We mounted the pc board using some 12 mm spacers, nuts and bolts. The speaker mounts on the box 'lid'.

Next, wind the Faraday screen. Cut some aluminum kitchen foil into strips about 15mm wide and wind this around the coil to make two layers but leaving a small gap about 5mm to 10mm wide where the coil ends come out. It is very important that the two ends of the Faraday shield do not connect as this would make a 'shorted turn' and the coil would not work as intended.

To secure the foil tightly around the coil, and to make connection to the shield, wind a length of tinned copper wire around the shield with about a 10mm pitch (ie: about 10mm between successive turns). The end of this wire is taken out at the same place as the coil connections.

Now wind another two layers of insulation tape around the whole assembly. Drill a 3mm hole in the side of the pot stand and then press the coil down into the rim with the connecting wires adjacent to the hole. Pass the wires through the hole. Pour quick-setting epoxy over the coil to hold it in place.

The search head is mounted to the stem using two right-angle brackets and a bolt passed right through the end of the stem. Small pieces of metal here don't seem adversely to affect the operation of the detector.

Solder the coil connections to the twin shielded cable, the Faraday shield connecting to the cable's shield, and glue the cable and wires underneath the pot stand to hold them rigid. If you wish, the 'underside' of the pot stand may be completely filled with epoxy.

Wind the cable around the stem to keep it mechanically rigid and pass it through a grommeted hole in the box. Terminate the cable to the pc board.

Using It

When the construction is complete, turn on the detector, advance the frequency knob. You will hear a number of 'heterodynes' or beats, one being very strong. This heterodyne is the one commonly used, the other being odd multiples of the reference signal beating with multiples of the search oscillator. You may find that some of these weaker signals are more sensitive to buried objects than the stronger one.

Set the fine frequency control to midrange and set the course frequency control to near the strong heterodyne with the search head held away from the ground. Lower the detector to the ground and you will notice a frequency shift. This is the effect of the ground and will vary between different types of soil. Use the fine frequency control to set the beat to a low pitch and sweep across the surface. A metal object will cause a change in the pitch which is clearly audible.

The ear is more sensitive to changes in pitch at low frequencies than at high frequencies and thus it is best to adjust the fine frequency control to a low pitch that can be heard at a comfortable volume from the loudspeaker.

Theoretically, the frequency of the search oscillator should *increase* when a non-ferrous object comes within range of the search coil and *decrease* when a ferrous (or diamagnetic) object is within range. This effect is difficult to detect in practice as eddy currents in ferrous materials swamp the effect and they react much the same as non-ferrous metals. However, some minerals may show the effect. With the search oscillator set on one side of zero beat, metal objects near the search coil will cause the pitch to *increase*, while magnetic minerals will cause the pitch to *decrease*. With the search oscillator set to the other side of zero beat, the opposite will occur.

You could try a few experiments to show up this effect.

Enough theorising. In general operation, try to keep the search head a constant distance from the ground and sweep from side to side in a regular pattern. The right technique is easily developed with a little practice.

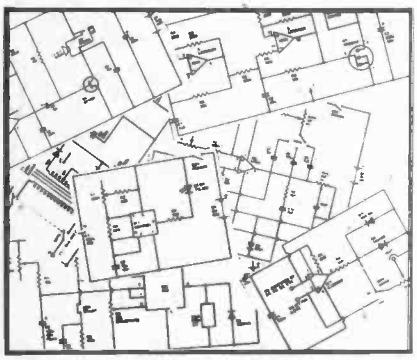
There are a number of books on metal detecting available and these show the sort of techniques the successful treasure hunter employs. ●

Electronics Today INTERNATIONAL NOV 1980

NEXT MONTH

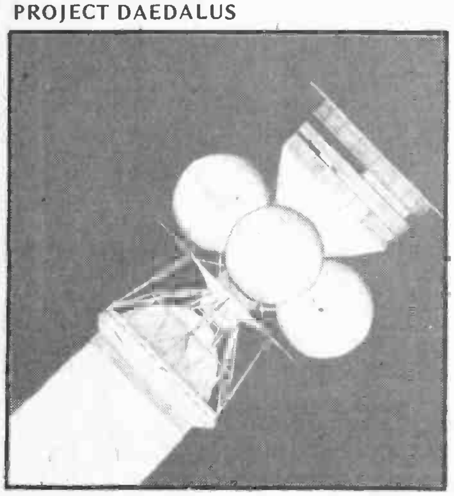
At the time of going to press, the articles mentioned are in an advanced stage of preparation. However, circumstances may result in changes to the final contents of the magazine.

SPECIAL SUPPLEMENT: 8-PAGES OF DESIGNERS CIRCUITS



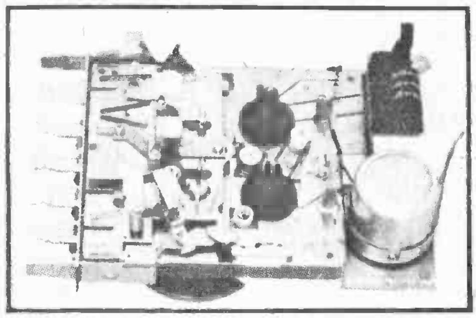
A recent introduction to ETI is the Designer Circuits page. Next month we'll be giving you a real bonus: an 8 page supplement crammed with tested circuits prepared by professional designers.

PROJECT DAEDALUS



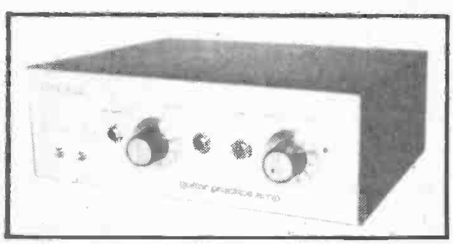
'Fly me to the stars' isn't just a song, it's the dream of some people. Although the nearest star is over four light years away, a group of scientists have designed a star-ship using known technology. Next month we report on this venture: Project Daedalus.

CASSETTE DECKS AND TAPES



Gordon King looks at the popular field of tape recording and describes how it works and the technicalities of modern systems.

GUITAR PRACTICE AMPLIFIER



A project for the musician, an amp specifically designed for guitar practice which includes all the features you'd expect from a professional design.

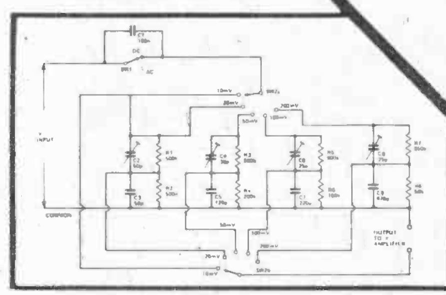
THE WEIN BRIDGE

This circuit arrangement has a number of uses in electronics, especially in the area of audio oscillators, yet the way that this circuit actually works needs some explanation; we do that next month.

SURVIVAL

An easily built electronic game where you match your skills against those of an IC!

ATTENUATOR DESIGN



Not a subject to stir most of us from our arm-chairs, but there's a lot more to attenuators than a couple of resistors in some applications. Next month Ray Marston considers attenuator design and gives several practical circuits.

IDENTIMAT

How do you protect a computer from unauthorised access? Many ways have been tried with varying degrees of success but now there's Identimat, a tried and tested Canadian system which requires a full palm-print from the operator; Roger Allan reports.

INFRA RED REMOTE CONTROL

A state-of-the-art project that enables you to turn on and off any electrically powered device using a remote control transmitter. The circuit uses infra-red as the data link and has a useful range of about 10 metres.

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Designer Circuits

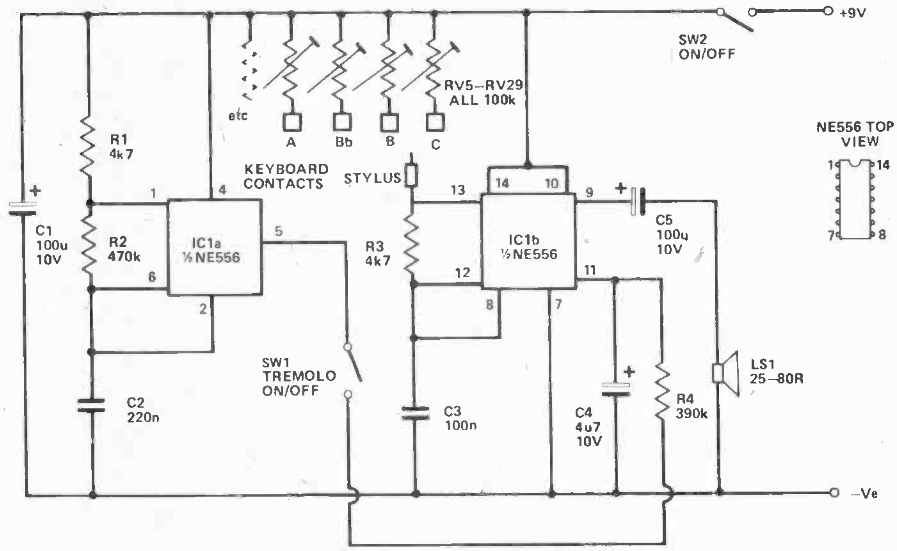
SINGLE IC ORGAN

This single monophonic organ (ie it can only produce one note at a time) is intended to be used with a stylus operated keyboard. This can be made using printed circuit techniques, or it can be made from stripboard etc. if preferred. In fact anything that will provide the necessary 25 connection points will do. The organ covers two octaves including semitones; one either side of middle C. It utilises a 556 dual timer IC which contains two 555 type timer circuits, both of which are used in the astable (oscillator) mode in this circuit.

The right hand section of the circuit is the actual tone generator and its output feeds a miniature speaker via DC blocking capacitor C5. The frequency of operation is determined by C3, R3 and whichever of the 25 presets (RV5 to RV29) is selected using the stylus and keyboard.

Each preset is tuned to a different note ranging from the C below middle C (130.81 Hz) at RV5 to the C above middle C (523.25 Hz) at RV29. The presets are adjusted to the correct notes by aural means using pitch pipes or a tuned musical instrument to provide the reference notes. When the stylus is not connected to the keyboard the oscillator circuit is not complete and no output is produced.

The tone generator produces a straightforward rectangular waveform which is not particularly musical. Results can be considerably enhanced by slightly frequency modulating the tone generator to produce a tremolo effect and a richer sounding output. It is an easy matter to do this and it is merely necessary to couple a control signal to IC1 pin 11. The low frequency modulating signal (about 4Hz or so) is generated by the other section of the 556. This has its output loosely coupled to the tone generator via R4 and tremolo on/off switch SW1. The squarewave output of IC1a would give a rather abrupt tremelo effect and so C4 is used filter out the high frequency harmonics on the signal so as to give a much smoother and pleasant tremolo effect.



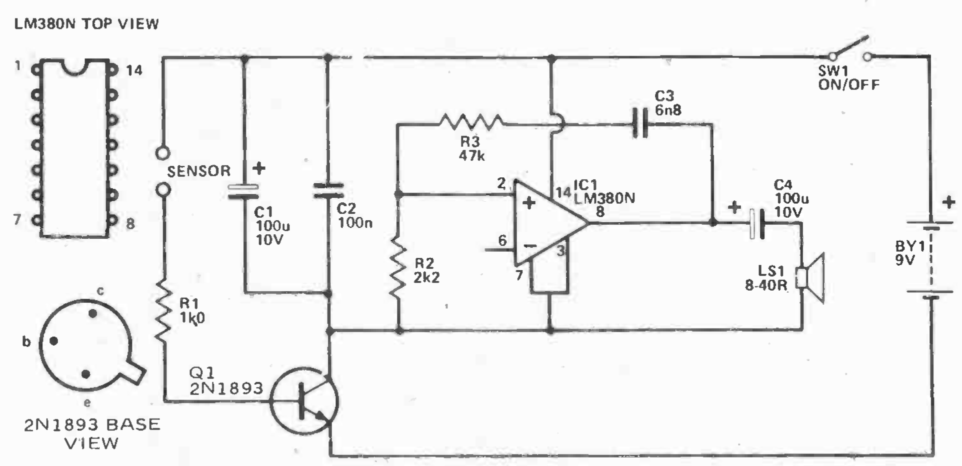
WATER ALARM

This simple water detector circuit can be used in such applications as a rain alarm, cistern overflow alarm, or just to indicate when the water in a bath has reached the required depth.

The circuit really consists of two sections; an electronic switch and an audio alarm generator. Q1 is used as the switch, and under normal conditions it is cut off, supplying no significant current to the alarm generator circuit which forms its collector load. The sensor in Q1's base circuit merely consists of two pieces of metal insulated from one another. However, the sensor is arranged so that when the rain, bath water, or whatever touches the sensor, it bridges the two pieces of metal. Although pure water is a very poor conductor of electricity, the water in practical applications is likely to contain small amounts of impurities which will be sufficient to make the water conduct reasonably well. Thus when water is detected by the sensor, the resistance it exhibits falls to a relatively low level (typically a few kilohms), biasing Q1 hard into conduction. Virtually the full supply voltage is then supplied to the alarm circuit, and the alarm sounds. R1 is a current limiting resistor which prevents Q1 from passing an excessive base current if a short circuit or very low impedance should appear across the sensor.

An LM380N audio power amplifier device (IC1) is used to generate the audio alarm signal. It is made to oscillate by using C3, R3, and R2 to give frequency selective positive feedback between the output and non-inverting (+) input of the device. The circuit oscillates at approximately 600 Hz, and provides an output of a few hundred milliwatts to a miniature loudspeaker. This gives a reasonably loud and penetrating sound.

Under quiescent conditions the circuit consumes less than one microamp, and so even with continuous use the battery will have virtually its shelf life. With the alarm sounding, the current consumption increases to about 30 to 100 mA (depending on the speaker impedance). Note that C2 should be mounted physically close to IC1.



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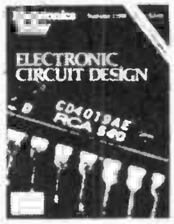

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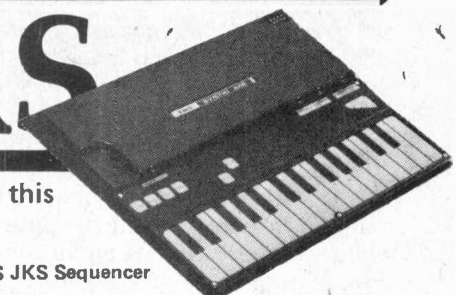


The EMS JKS Sequencer

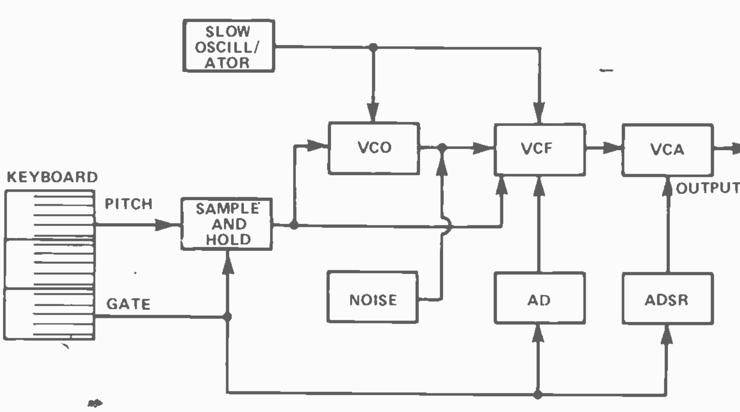
The mysteries of electronic music and music synthesisers are unravelled for you in this feature by Tim Orr.

Electronic music of one form or another has been around for almost as long as electronics. In fact, I have seen a complete music synthesiser built in 1926 which used only two tubes. Fifteen years ago electronic music was produced by studios that contained lots of special purpose electronic processors, mixing discs, tape recorders, reverberation units, and then it all changed! Someone (several people claim that it was themselves), decided to pack most of the electronic processors into one unit, so that an integrated system for electronic music production in one box was obtained. This device, known as the synthesiser, took EM out of the studio and on to the stage, and since then things have just proliferated. The pioneers of EM were Moog and ARP in the States and EMS (Peter Zinovieff and David Cockerell) in England. Now there are very many companies throughout the world producing synthesisers although it is fair to say that very few of them are producing new and interesting ideas. In fact it is quite difficult to define what devices are in the EM area, because it has been merged with professional audio (studio) processors and musical (generally guitar) effects devices.

Voltage Control

The fundamental concept that makes synthesisers what they are is that of voltage control. Voltages that are generated control the pitch of the oscillators, they control the harmonic structure of the sound (enabling dynamic filtering), they control volume and many other parameters. A typical synthesiser system is shown in Fig.1. A conventional musical keyboard is used as the interface between the musician and the machine. When

Fig.1. Block diagram of a typical synthesiser, the text explains the abbreviations.



a note is pressed, two signals are generated, a pitch voltage and a gate voltage. The keyboard would generally be tuned so as to produce semitone tuning, that is twelve notes per octave, each note spaced at intervals of one twelfth of the square root of two!! What this means in terms of voltages is +1V per octave or 1/12V per semitone. This voltage is used to control the pitch of VCO's, (voltage controlled oscillators), and the resonant frequency of VCF's (voltage controlled filters). The pitch voltage is stored in a device known as a sample and hold. This is an analogue memory that is controlled by the gate voltage. When the gate is high the unit 'samples' the pitch voltage and when it goes low the unit 'holds'. The gate merely tells the synthesiser that a note has been pressed, which in this case triggers off two waveform generators, the AD (Attack Decay) and the ADSR (Attack, Decay, Sustain, Release). The AD sweeps the VCF producing dynamic filtering and the ADSR generates an amplitude envelope.

The sound generation process is as follows. The musician selects a note. This tells the VCO what the pitch must be. The waveform from the VCO is filtered by the VCF, but the filtering is controlled by the AD waveform. This could make the sound go AH-OW-OO or even OO-OW-AH. The filtered sound then passes through the VCA which gives it an envelope that is controlled by the ADSR. Fast attacks give the sound a percussive quality, slow attacks a 'backward' quality. There is also a slow oscillator for generating vibrato and swept filtering effects and a noise generator for producing pitchless sounds, such as explosions. All the parameters are controllable via potentiometers (about 16 in this case) and so an enormous range of effects can be synthesised.

Controlling It

Most synthesisers are monophonic, that is they produce only one note even if several are pressed. Generally the keyboard selects the highest note played. This is simply done by passing a constant current through a series resistor chain, (Fig. 2). A voltage is picked up on the pitch bus which is linearly proportional to the highest note pressed. This voltage then passes through an analogue switch (Q1) which is controlled by the gate signal. When a note is pressed, the gate is high and the switch is ON. The pitch voltage charges up C1. When the keyboard is released the gate voltage goes low, the switch turns OFF and the pitch voltage is held on C1. A voltage follower (IC1) is used to buffer this voltage to the rest of the synthesiser. A FET op amp is used because this doesn't discharge the capacitor C1. A portamento control (RV1) has also been included. This allows the player to glide rather than change instantly from one note to the other.

A musical keyboard is the most common control medium for the player, but conventional instruments have many other types of control. These include levers, valves, tension bars, dampers, percussive devices, string tensioners, elongatable resonators, air pressure sacks, etc. It is not practical to include all of these controls into one synthesiser, although some of them do appear in various machines. For instance there is a 'wind' synthi and several drum and guitar synthesisers.

Two common types of controls are the XY joystick and the pitch bend wheel. The performer can play keyboards with one hand and operate a control with the other. For instance the pitch bend wheel can be used to bend notes just like a guitar player does by stretching (bending) the string.

The primary generator in a synthesiser is the VCO. This produces the fundamental waveform which the synthesiser manipulates. It is usually controlled by a manual knob so that it can be tuned to other instruments by the keyboard voltage and a voltage control input. If a slow sinewave is injected then vibrato effects (frequency modulation) can be produced. Most VCO's are logarithmic in response. That is a control voltage increase of +1V will increase their frequency of operation by one octave (double). Thus a control voltage change of 4V will change the frequency by a factor of 2^4 which is 16. Generally most VCO's have a wide range of operation, often greater than 1000 to 1, although for musical purposes a range from 100 Hz to 1.6 kHz is sufficient. If the synthesiser has more than one VCO then they can be arranged to produce a musical chord. This chord can then be controlled by the pitch voltage from the keyboard, producing a very rich musical sound. It is, however, possible to produce interesting sounds from a single VCO.

The waveforms typically generated by a VCO are sawtooth, triangle, squarewave, (sometimes with a variable mark/space ratio) and sinusoidal. These all have different harmonic structures which characterise them, (Fig. 4.). A sawtooth can be constructed out of a sinewave at frequency fo, plus a smaller one at 2fo plus a smaller one at 3fo, plus a smaller one at 4fo etc. These are known as harmonics and a sawtooth has an infinite series of even and odd harmonics. The squarewave has only odd harmonics (fo, 3fo, 5fo, 7fo). A triangle waveform, which is, in fact, just an integrated squarewave has only odd harmonics, but they die away faster than those of the squarewave.

A squarewave with an uneven mark/space ratio has a mixture of both odd and even harmonics. This can produce some very interesting sounds if the mark/space ratio is slowly modulated by a control voltage. The sinewave has no harmonics, it is a pure sound and is generally not very interesting.

Voltage Controlled Filters

VCF's are used to manipulate the harmonic structure of a signal. They can selectively enhance or reject a particular frequency. By changing their resonant frequency they produce dynamic filtering. Your mouth is also a dynamic filter and this is one of the reasons for the popularity of synthesisers, that is the pseudo human quality of many EM sounds.

A typical VCF is a lowpass filter. It has a signal input and an output. The VCF has a manually controlled Q factor (resonance) and break frequency. Also the break frequency can be voltage controlled. If the VCF with a high Q is used to filter a low frequency squarewave it is possible to discriminate the individual harmonics that were discussed earlier. As the resonant peak of the filter passes over the harmonics, they are selectively amplified. This process is known as ringing or chiming the harmonics and produces the characteristic synthesiser 'swept filter' sound (Fig. 6). If an Ad wave form is used to sweep the VCF then a wide range of filter sounds can be generated.

A more elaborate filter structure is shown in Fig.7. This is the universal filter and only appears in larger synthesiser systems. The controls are the same as before, but there are four outputs, lowpass, highpass,

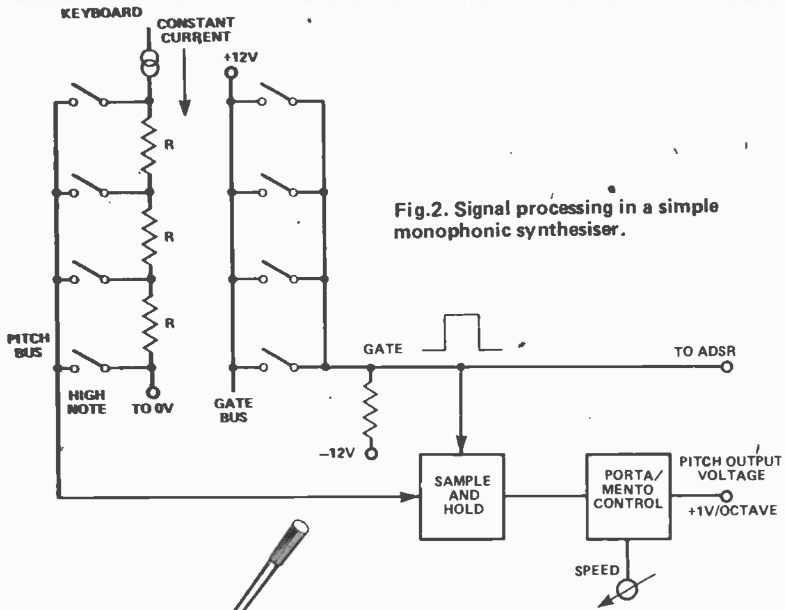


Fig.2. Signal processing in a simple monophonic synthesiser.

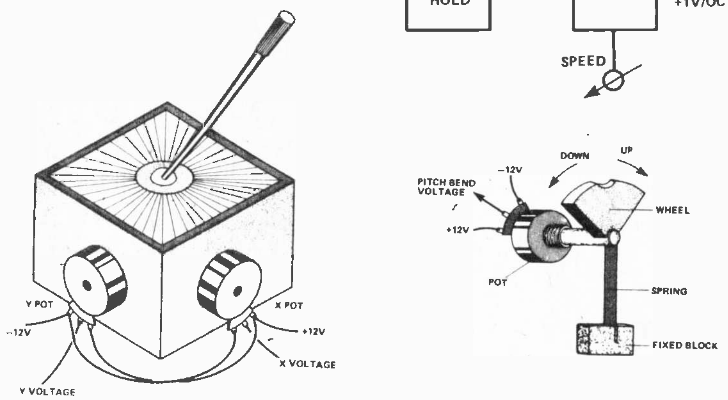
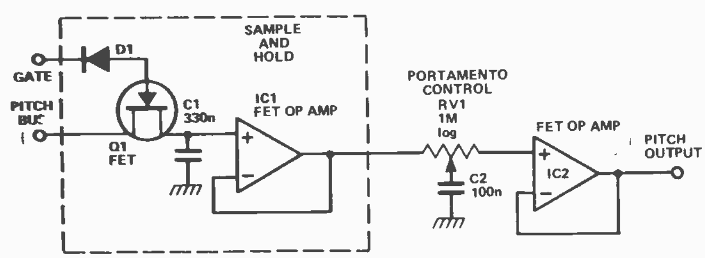


Fig.3. Two common controls – the xy joystick and the pitch bend wheel.



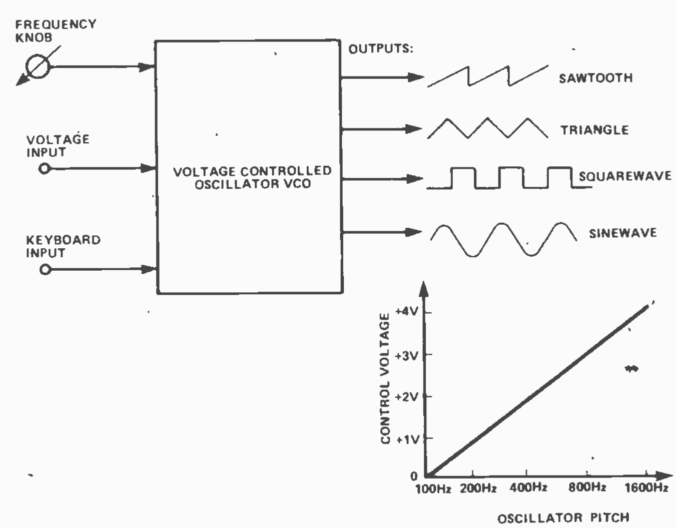
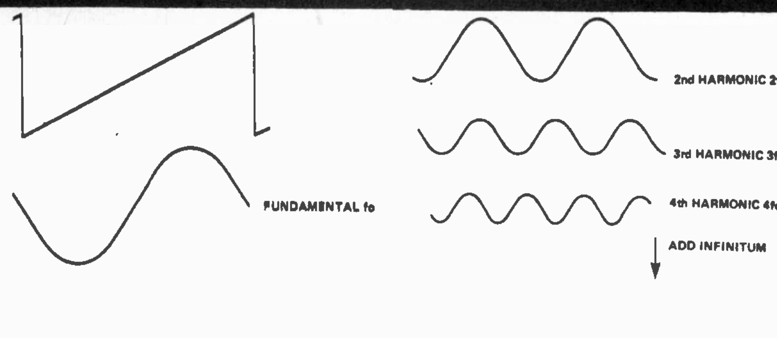


Fig.4. The waveforms typically generated by a VCO.



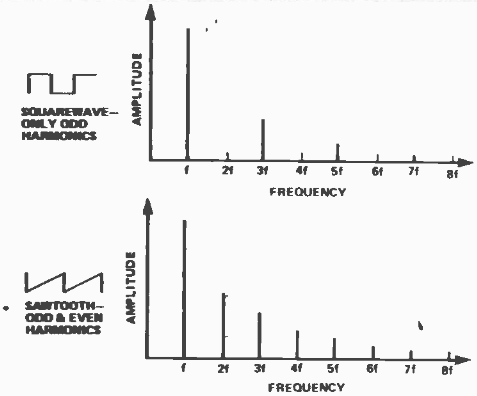
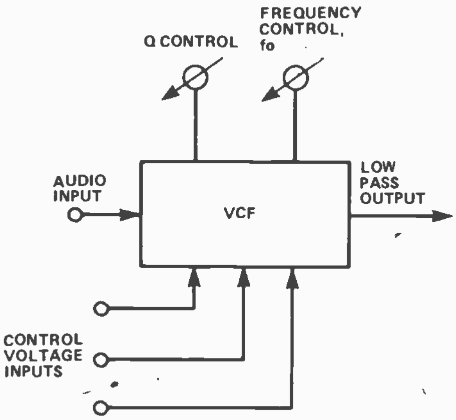
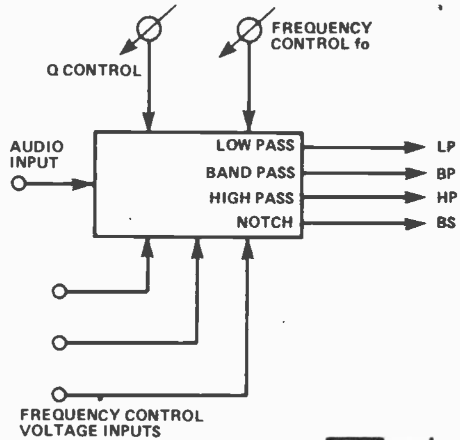


Fig.5. Discriminating between harmonics. Above and Right.





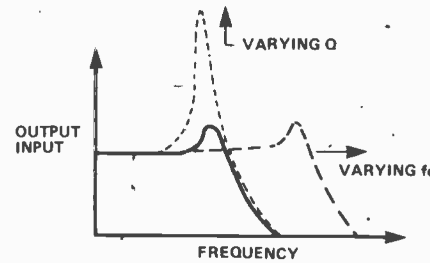


Fig.6. 'Chimming the harmonics' to produce a 'swept filter' sound.

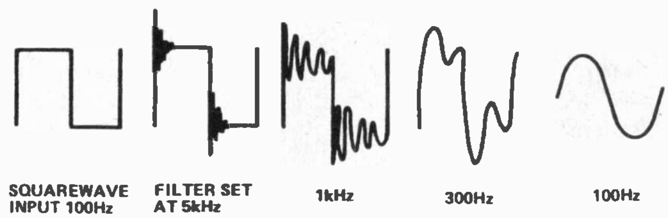


Fig.7. Using a low pass filter, with a Q of 5 to "ring" the harmonics of a square wave.

bandpass and bandstop (notch). These all have the same resonant frequency and can be used to further increase the range of filtered effects.

Another type of filter that has been recently introduced is the flanger, Fig.8. This is a recursive filter that works on the time delay rather than the phase delay principle. A bucket brigade delay line is used to delay the input signal. The original and delayed signals are then added together, their amplitudes being equal. Thus, when the two are in phase, they add up but when they are 180 out of phase they cancel out completely. This produces a notch, or rather a series of notches which is called a COMB filter response. These notches are equally spaced on a linear frequency scale, their spacing being controlled by the delay time. The shorter the delay time the fewer are the notches. There is also a feedback path around the unit. This makes the filter much more 'peaky' and the effect of the filtering greatly pronounced. Flanging is similar to the effect on jet engine noises that can be heard as they fly over head.

Contour Generators' produce the VCF sweep and the amplitude envelope of the waveform that comes out of the synthesiser. They are generally initiated and terminated by the gate voltage from the keyboard. Firstly the AD waveform. When the keyboard is pressed, it starts on an exponential charging curve which has an attack time constant determined by the setting of the ATTACK knob. When the keyboard is released the waveform discharges back to where it started from with a time constant set by the DECAY knob. This AD waveform is used to sweep the VCF and sometimes in simpler systems to generate an envelope waveform and even to modulate the VCO.

The ADSR is a similar process to that which occurs in some keyboard instruments. A note is played which then decays away with its natural time constant, but when the note is released the strings are damped and the note is muted. This system has three time constants, an initial attack, a decay and a release. The ADSR is able to synthesise these three time constant parameters, but it also has a sustain level control, thus enabling infinite sustain as long as a note is pressed.

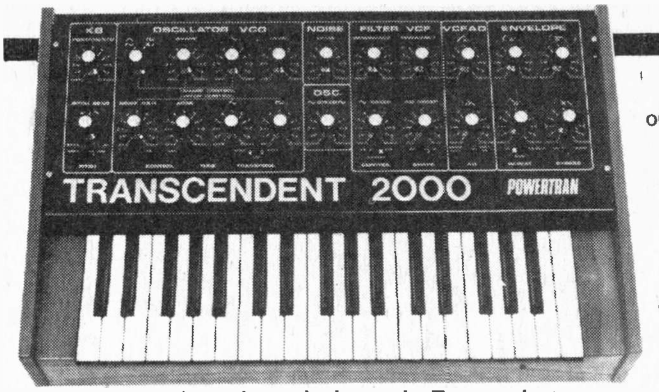
In conventional stringed keyboard instruments time constants are proportional to pitch of the note, low frequency notes have long decay times and vice versa. Also the harder the keyboard is hit the louder the note (keyboard dynamics) and the sharper the harmonic structure. It is possible to synthesise all these effects but with the present state of the art it is still rather complex and expensive. Most synthesisers go for the simple solutions as shown in Fig. 10.

Voltage Controlled Amplifier

The job of the VCA is to produce a signal which is the product of the audio signal times the contour signal. This type of unit is known as an amplitude modulator or a two quadrant multiplier. When the contour voltage returns to zero, the output of the VCA is zero.

Another type of modulator is a four quadrant multiplier some times known as a ring modulator. This has two inputs and produces an output which is the true arithmetic product of the inputs.

Ring modulators are typically used to manipulate natural sounds. If speech is used as one input and a low frequency (50-100 Hz) oscillator as the other, the ring-modulated output sounds rather mechanical, just like a 'Cylon'. What the ring modulator is doing is



A typical electronic music synthesiser — the Transcendent 2000.

producing two mixed outputs from the two inputs. If the two inputs were two sinewaves of frequencies fx and fy, then the output is made up of two sinewaves mixed together of frequencies f(x+y) and f(x—y). These are known as the upper and lower sidebands respectively.

Frequency Shifter

A frequency shifter acts similarly to the ring modulator except that it separates the upper and lower sidebands. This enables a natural sound to be shifted up or down in frequency. The process is known as single sideband modulation in telecommunication jargon. The overall effect is to make a harmonic sound in-harmonic. This is because all the harmonics will be shifted by the same frequency increment and so will lose their integer relationships.

The frequency shifter uses an oscillator that generates sine and cosine waveforms. The audio signal to be processed is passed through a dual phase shifting network such that two outputs in phase quadrature (always 90° apart) are generated. The audio signals and the sinewaves are multiplied together by two ring modulators, the outputs of which are added and subtracted to produce the 'down' and 'up' shifted outputs. The amount of frequency shift is the frequency of the quadrature oscillator.

Envelope Followers

When processing natural signals, from speech or a guitar say, it is sometimes desirable to have a voltage that follows the envelope of the signal. This can then be used to control VCA's or VCF's or other devices. A simple envelope follower is shown in Fig. 14.

The input signal is full wave rectified by a precision rectifier and then lowpass filtered. There are lots of problems with this method. If the filter is set too high then there will be lots of ripple on the envelope output. If it is set too low, the unit will be slow to respond and may even miss short signals. Perhaps the best system would be one that uses a true RMS detector which can now be bought in an IC.

Spring Line Reverberation

Synthesised sounds can very rapidly become uninteresting. This is partly due to the unchanging quality of their sound. Listen to a sustained note on a flute or a single piano note. There are lots of interesting things going on all the time. The pitch might be wobbling (also the amplitude). The harmonic structure will be changing. There will be, in the case of the piano, sympathetic resonances in the neighbouring strings. One way of reintroducing interest into synthesised sounds is by use of artificial reverberation.

The spring line reverberation unit is a small mechanical device that finds use in electronic organs, practice amplifiers and synthesisers. The unit consists of

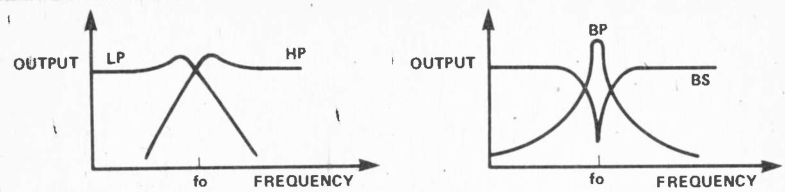


Fig.8. The flanger — a recursive filter working on time delay.

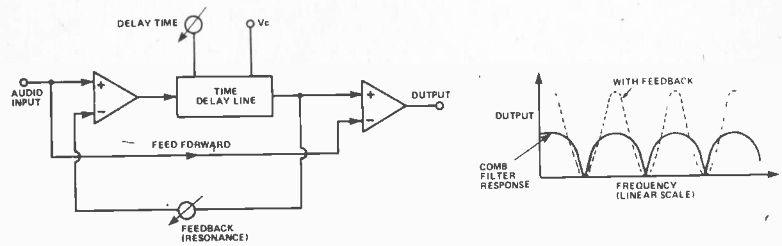


Fig.9. A COMB filter.

two long (10 inch) springs connected together at each end. At one end there is an electromagnetic driver, and at the other a magnetic pick up. The input signal is amplified and drives the driver coil. This causes the springs to vibrate and these vibrations propogate down the length of the springs. The pick-up coil receives these vibrations, the signal from which is amplified and mixed with the original. The result is a reverberant quality to the sound output.

Pitch Extractor

Several companies have recently introduced guitar synthesisers. These are synthesisers that are controlled by the normal controls of the guitar. In these cases, the guitar has been greatly modified so that its strings and frets act as various forms of electronic contacts. Thus it is possible to control a synthesiser from a guitar. There is, however, another way of doing this and that is by using a pitch extractor. This uses an unmodified guitar and analyses the signal from the pick-up. It performs various electronic processes on the signal so that the fundamental note is extracted, which is then converted into a control voltage that can drive a bank of VCO's say. If an envelope follower and a VCA are used as well then a tracking chord with the amplitude envelope of the guitar signal can be synthesised.

The problems of pitch extraction are numerous and possibly will never be properly solved, but to date there are several devices on the market which work quite well.

Sequencers

Sequencers are used to generate a repetitive rhythm or to memorise a relatively long passage of music. They do this by storing the control voltages necessary to resynthesise it. A digital sequencer memorises a musical melody that is 'played in' via a conventional keyboard. It remembers the pitch voltage and the gate signal as a function of time. Various controls such as 'record, play, stop, recirculate, transpose sequence', are usually available. One such machine, the EMS JKS, is shown above. Note that the keyboard is a 'touch' rather than a mechanical device.

An analogue sequencer is shown in Fig. 18. The sequence is programmed in on a series of pots. The electronics are usually very simple, a counter-decoder or a multiplexer is the usual solution. Also, as there is no keyboard, the parts costs are kept low, but it does suffer the problem of being more complicated to program.

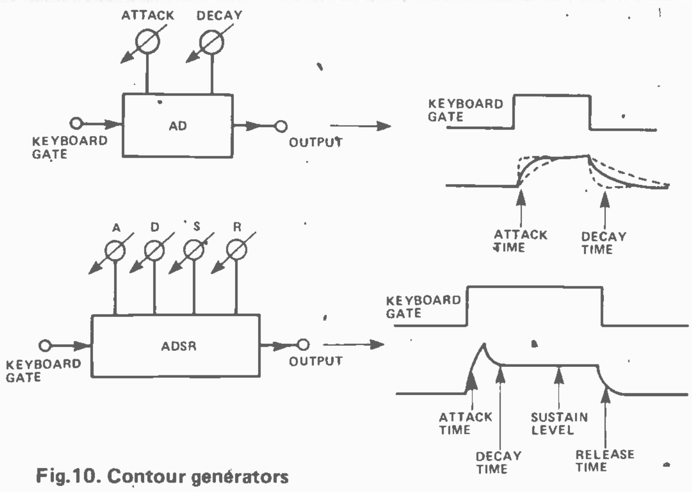


Fig.10. Contour generators

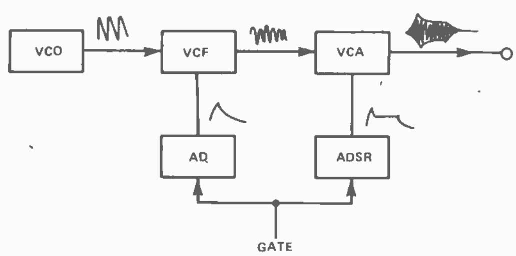


Fig.11. Typical synthesiser structure

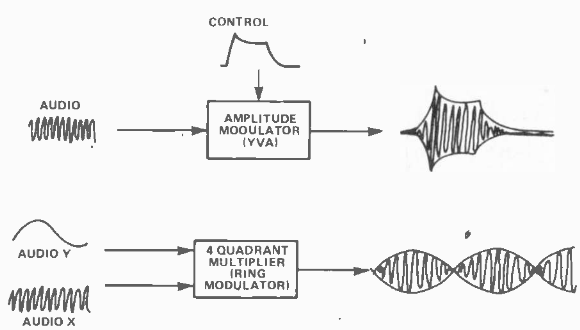


Fig.12. Voltage controlled amplifiers (VCA)

Channel Vocoders

The Vocoder is a recently introduced piece of EM equipment for processing speech and natural instruments. The concept of vocoders is quite old but it was not originally intended for anything other than telecommunications. The machine has two inputs, one for speech and one for excitation and one output. It analyses both inputs into lots of different frequency bands and then combines them into one output. This output has the articulation of speech and the line spectrum (the harmonic structure) of the excitation. If speech and an electric organ (excitation) are used, then the vocoded output is a 'talking organ'. The organ speaks and yet retains the sound structure and melody of the original organ. The vocoder can do other tricks like time compression and expansion, freezing sounds, changing peoples vocal characteristics. It can also operate on two instruments combining them to produce a new one. Fig. 20 shows a commercial unit.

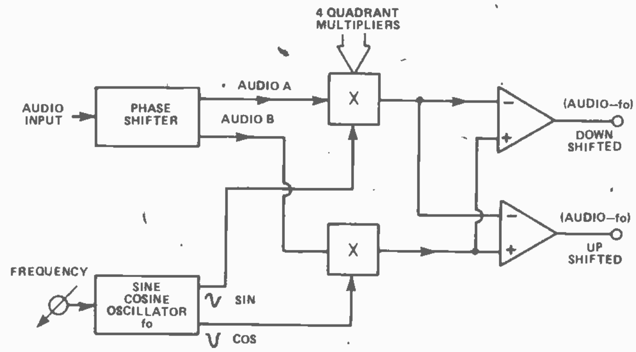


Fig.13. Arrangement of a frequency shifter

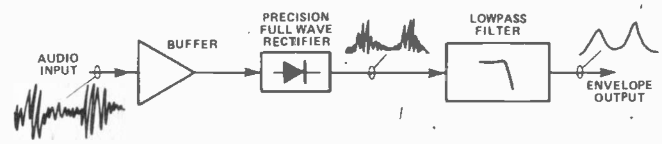


Fig.14. Envelope follower

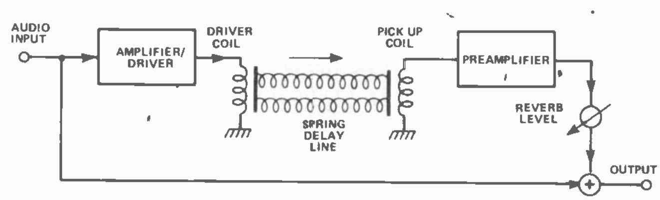


Fig.15. Spring Line Reverberation

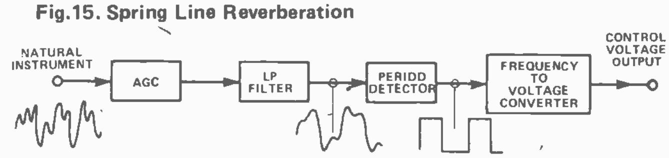
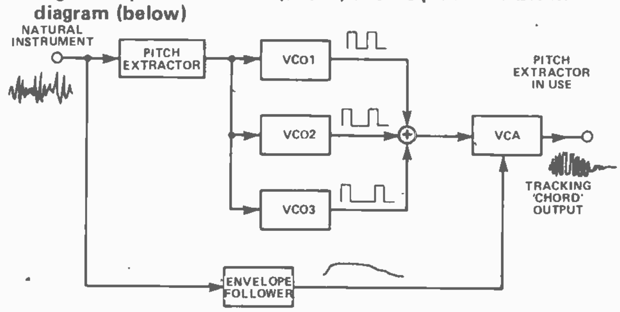


Fig.16. A pitch extractor (above) and its place in a block diagram (below)



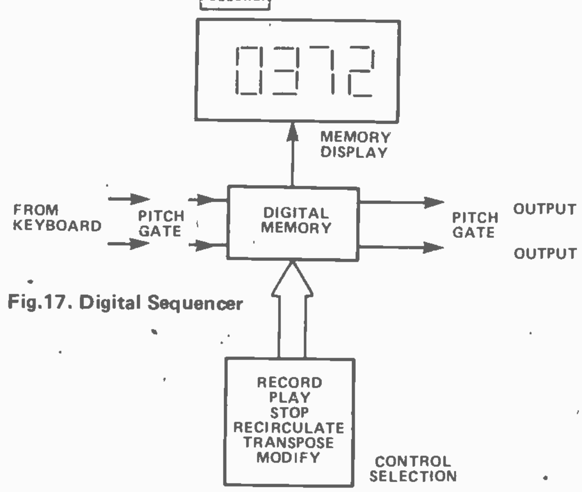


Fig.17. Digital Sequencer

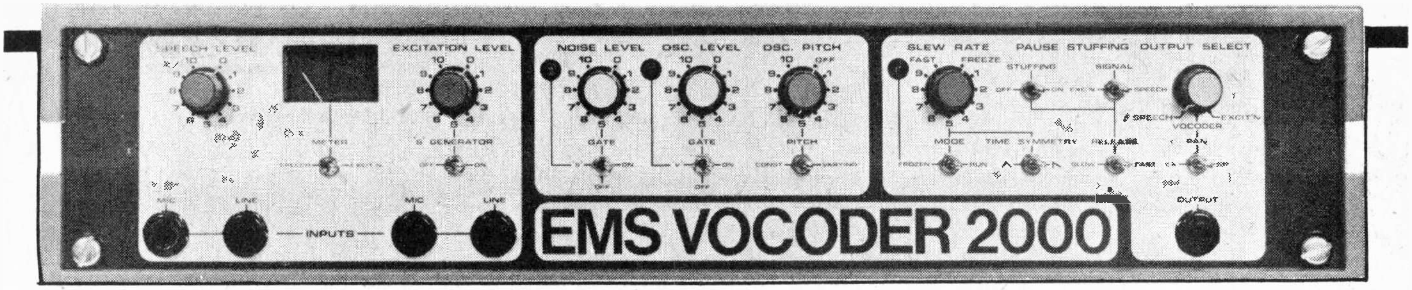


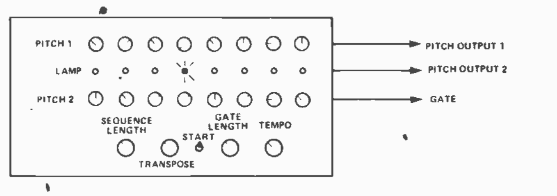
Fig.20. The EMS Vocoder 2000

Computer Manipulation and Synthesis

Originally EM was produced in studios and a lot of it was done by tape tricks. Synthesisers now produce most EM and some machines have a very high level of technology in their design. Computers have also produced EM for quite a while, but these have been large expensive installations. Using a computer it is possible to synthesise all the sounds or to use the computer as a sound processor. Apart from the computer there is no real hardware at all. All the processing is done using the computer program (the softwave). Natural sounds are introduced to the system via an ADC (analogue to digital converter) and sounds produced by the computer leave via a DAC (digital to analogue converter), Fig. 21. By using computer techniques it is possible to manipulate sounds in new and interesting ways. I heard one such manipulation whereby a piece of music performed on a saxophone gradually transmitted itself into a violin.

Perhaps as microprocessors get larger and faster we will see a growth in microprocessor EM peripherals.

Technology has got a firm grip on the music and EM industry, but the sounds generated are still almost totally dependent on the skills of the operator. To bear this out I can cite the following example. In the last few years I have designed seven synthesisers, two vocoders, six guitar effects units, one sequencer, one frequency shifter, two guitar amplifiers, one quadraphonics effects generator, a pair of high quality converters for computer music . . . and I still can't make any music! ●



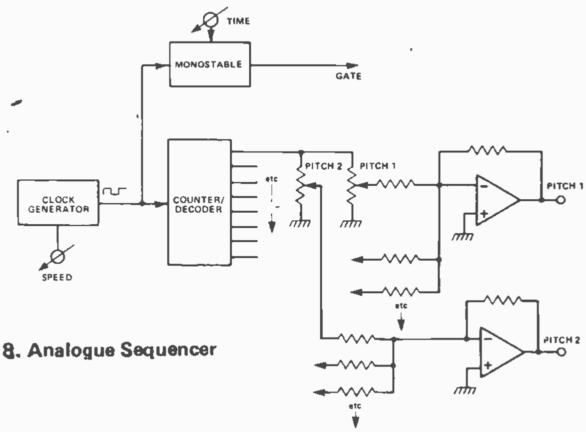


Fig.18. Analogue Sequencer

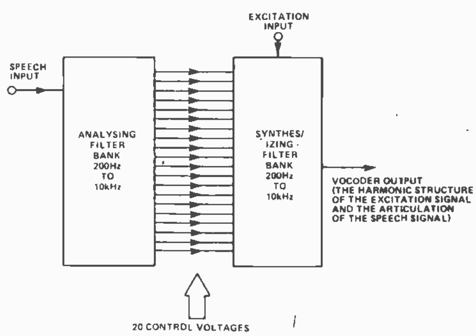
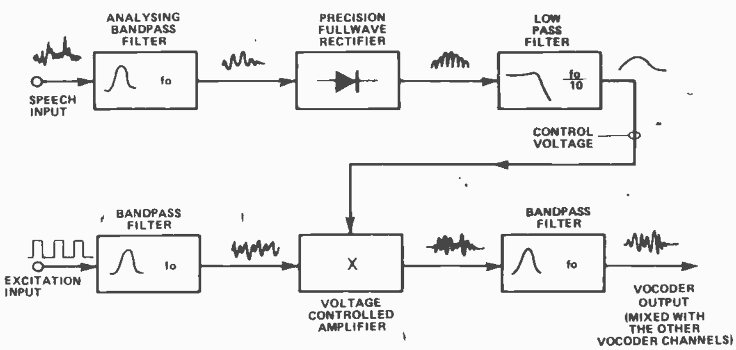


Fig.19. 20-Channel Music Vocoder, a breakdown of one channel is shown in greater detail



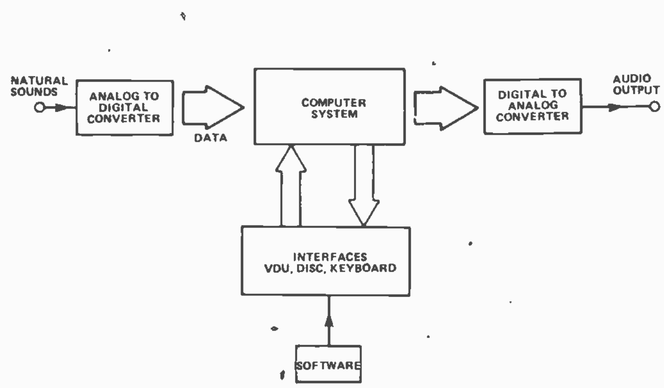
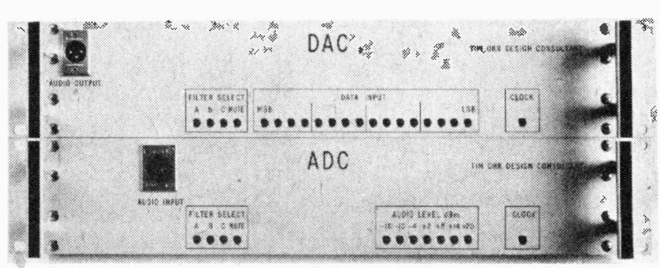


Fig.21. Computer manipulation and synthesis block diagram with a commercial unit shown in the picture.



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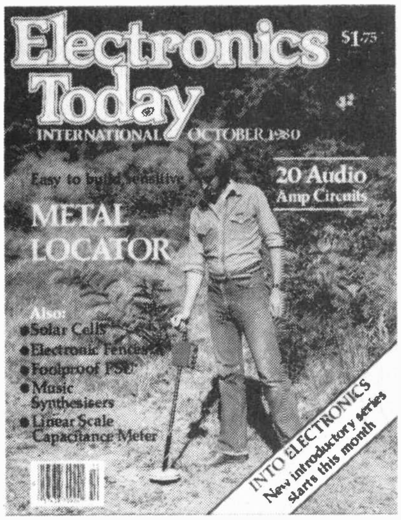

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1080

Market Place

For sale; B&W Bass/Midrange DW 200/2 and 200/4, also KEF T27 tweeter. Cabinets for Mac MC26, and HK Citation 11 preamp, also Marantz WC-1-1-U cabinet. Fairchild 240 mono tube preamp. LAMB power supply LPS10-24A. Tel. (416)-532-0296, Box 157, Stn. V, Toronto M6R 2V5.

Needed, F-8 Microprocessor – Cartridges, Cassettes, Information – APL/S Cassette for F-8 Video – Brain accessories – printer, interface, disc interface etc. G. Subasic PH 275-6139 or write; G. Subasic, 567 Minette Circle, Mississauga, Ont. L5A 3B9.

Shortwave for sale – RF2200 Panasonic high calibre 8-band/FM/AM. All accessories included. As new. Will sell $190., lists over $300.Chris Cottier, Apt 1116, 411 Duplex Ave. Toronto. 416-482-2103.

Wanted; schematic for U.S. Navy CCT-46076 Receiver, part of RBM3 equipment. John S. Zyla, Box 100, Minton, Sask. S0C 1T0

For Sale: Telstar Arcade (colour) with cartridges No. 1, 2 and 4. Has gun and two extra paddles. Asking $160. Jerome Erker, Box 482, Macklin, Sask., S0L 2C0.

Wanted: Heathkit Et-3400 Microprocessor trainer only in kit or assembled, also Radio Shack TRS-80, Level 11 16K with integral keyboard, power supply, video monitor and cassette recorder. All in good condition. Please write: Roland Dumont, 731 Jacques Berthiaume, Ste-Foy, Quebec, Canada G1V 3T2.

Computer nuts!!! For sale: Cosmac Elf. Plus accessories. Bargain, must sell. Contact Grant Shellborn. Dept. ETI 26095 Lougheed Hwy. R.R.No.1. Whonnock B.C. V0M 1S0 Phone: (604) 462-7470

Swap: 4A 8V reg. Single voltage power supply, Homebrewed. Short proof, LED, fuse switch etc. Adjustable 5-15 VDC, prime parts and schematic. Would like trade for COSMAC 1802 Superbasic software pref. on cassette or will consider best offer. Write to R. Levesque, 125 Principale, St. Andre de Kam. P.Q. G0L 2H0

Cosmac VIP micromputer VP711 for sale. $275. fully functional contact Joseph, 4 Cobbler Cr. Downsview. (416) 661-1872

PROJECT

LINEAR SCALE CAPACITANCE METER

A simple, inexpensive piece of test gear.

MOST PEOPLE take resistance measurements for granted, but capacitance is another quantity that the experimenter needs to know (what about that box of colour coded beasties you've never used?).

As in any piece of test gear, calibration is a major problem. We have eliminated this by using a linear scale and with our ultra simple calibration set up.

Ranges

The unit will measure capacitance from 5pF up to 1uF in five ranges with a X10 facility to extend the top range to 10uF. Full-scale values for each range are: 100pF; 10nF (0.01uF); 100nF (0.1 uF and 1 uF extended to 10uF with the X10 switch.

The X10 switch actually works on all ranges and is handy when checking capacitors that over-range when a particular range is selected, so that the appropriate range can be readily found.

Different ranges can be provided by selecting different values for the range resistors R7 to R11. For example 47pF to 0.47uF (in five ranges), 4.7uF with the X10 in, could be obtained by changing R7 to 470R, R8 to 4k7 etc. However, the meter scale would need to be recalibrated. As it stands, the scale reads capacitance directly.

The meter scale provides divisions of 5% and the actual capacitance value can be estimated to about 2% or so, once the unit is calibrated. Overall accuracy will depend on the meter and the calibration capacitor accuracy.

Specifications

Capacitance ranges (full scale)
Accuracy
Calibration
Supply voltage
100p, 1n, 10n, 100, 1u—to 10u on X10
5%, estimate to 2% on meter scale
from internal capacitor, 2%
9V from battery

Design

A pulse oscillator, Q1, running at a pulse repetition frequency of about 1kHz, triggers a 555 timer IC which is connected as a monostable multivibrator. The 555 in this configuration will produce a pulse at its output, pin 3, having a period determined by the values of the range resistor selected and the unknown capacitance. The lower the value of the unknown capacitance, the shorter the duration of the output pulse from the 555. Conversely, the higher the value of the unknown capacitance, the longer the duration of the output pulse.

The output pulse is passed through a moving-coil meter which will integrate the pulse waveform. The reading on the meter will thus be directly proportional to the ratio of the time the output pulse is on to the time it is off, resulting in a linear relationship of capacitance to meter reading. A low value of capacitance connected to the 'CX' terminals will produce a short duration pulse and thus a low meter reading, as illustrated on the accompanying diagram.

The output pulse of the 555 swings between values of about 2/3 of the supply voltage ('high') and 1/3 of the supply voltage ('low'). Thus, the meter needs to be returned to a voltage of about 1/3 of the supply, otherwise current would flow through it continuously. Conveniently, this voltage is set by a pot on the front panel which serves as a 'zero set' control. The meter is calibrated by varying the resistance in series with the meter, rather than having preset range resistors. This results in better accuracy and requires only one preset control. The CAL. position on the range switch is for occasional checking. Any significant variation in the calibration will generally indicate a low battery.

Construction

Start your construction with the pc board making sure that the integrated circuit is the right way around. Take care also with the transistor and UJT orientation. Capacitors C1 and C3 determine the overall accuracy of the instrument and should be close tolerance types. Some suppliers carry a range of close tolerance silver mica or polystyrene capacitors. Alternatively, if you have a friend or employer with a capacitance bridge you can select one close to the required value (1n) from standard tolerance types. The range resistors R7 to R12 should also be close tolerance (2%) types.

All other components, including the X10 range resistor, are mounted on the front panel. Mount the smaller switches and terminals first, followed by the potentiometers and last of all the meter. The resistor R14 is wired from the positive meter terminal to one of the contacts on the range switch, SW3.

The printed circuit must be mounted so the lead length from the Cx terminals is as short as possible to avoid stray capacitance. Mount the pc board to the bottom of the case just behind the terminals and use tinned copper wire to make the connections making sure that the wires are well spaced from each other and well away from the rest of the circuit. Wire each connection from the board to the components on the front panel carefully to avoid errors.

When the construction is complete check all the wiring but don't assemble the lid to the box yet. Switch to the 1n range and turn the instrument on. Adjust the ZERO SET pot and see that the meter pointer varies about the zero scale reading. If it doesn't, check the PCB and panel wiring. If all is well, set the control so the meter pointer is on the scale zero mark. Then, switch to the CAL position and the meter pointer should move up the scale. Adjust the CAL trimpot on the pc board, RV1, so that the meter reads '1'. Switch to any range and you're ready to go!

You will find that stray capacitance affects the meter zero reading on the 100p scale. Simply adjust the ZERO SET control so that the meter reads zero before taking a measurement on this range. You'll find that once the instrument is zeroed on the 1n range, the higher ranges will not require further adjustment of the zero set.

In use, occasionally check the calibration. If grossly in error, your battery is about to go flat. A No.216 battery should give quite a long life as the unit draws 50-60mA. If you operate the unit from an AC adapter, one rated at 6Vdc output should deliver more than 8V at this low load, which is perfectly adequate.

Remember that any devices used to grip the leads of capacitors being measured will add stray capacitance and you will need to compensate for this by readjusting the zero set control. However, this will only have to be done on the 100p and 1n ranges as the added capacitance will be negligible on the higher ranges.

The 'X10' switch is primarily intended to extend the 1u range to 10u, although it is useful on the other ranges — when a capacitor being measured over-ranges you can assess whether it is just above the range selected or many ranges up in value. ●

PARTS LIST

Resistors all ½W, 5% (except R7—R12)

R1	560k
R2	470R
R3	1k5
R4	120R
R5	10k
R6	1k5
R7	1k 2%
R8	10k 2%
R9	100k 2%
R10	1M 2%
R11	10M 2%
R12	1M 2%
R13	1k5
R14	12R

Potentiometers

RV1	10k min vert mounting trim pot
RV2	500R lin pot

Capacitors

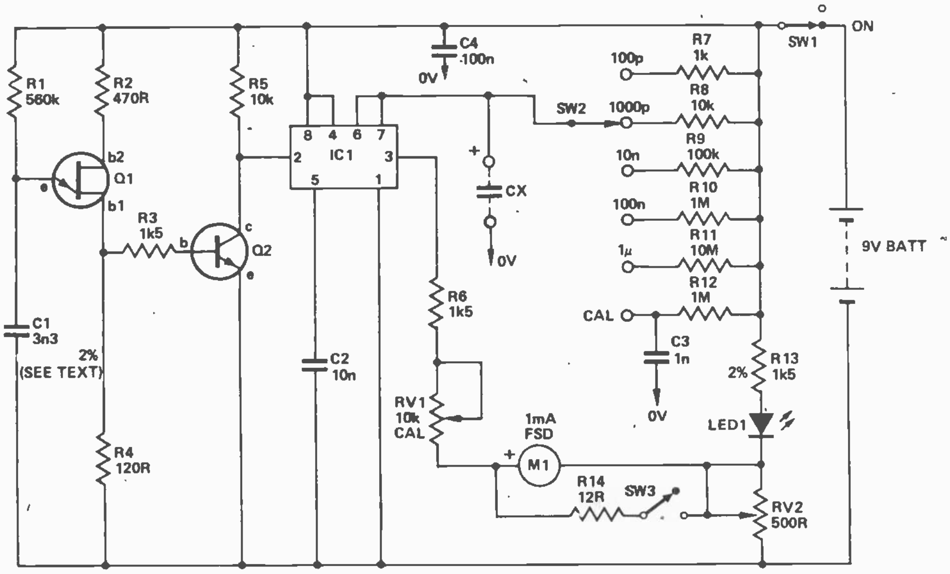
C1	3n3 2% tolerance - see text
C2	10n
C3	1n 2% tolerance - see text
C4	100n

Semiconductors

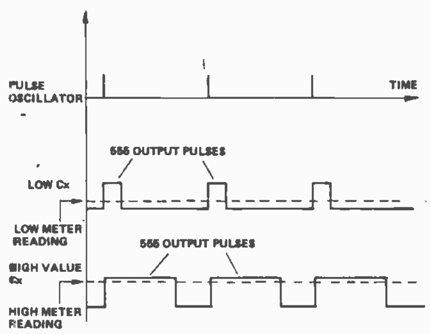
LED1	TIL220R or similar LED
Q1	2N2646, 2N2647 unijunction
Q2	2N3904
IC1	555 timer

Miscellaneous

M1	1mA FSD meter 60 mm square
SW1	SPST miniature toggle switch
SW2	one pole six pos wafer switch
SW3	SPST miniature toggle switch
SK1, SK2	screw terminals



Schematic for the Capacitance Meter.



The unknown capacitance, Cx, determines the width of the output pulses from the 555 monostable. The meter integrates these pulses to produce a reading which is directly proportional to the unknown capacitor's value.

HOW IT WORKS

A unijunction transistor, Q1, is connected as a relaxation oscillator with a frequency determined by R1-C1. The frequency of oscillation in this instance is about 1kHz.

Pulses of about 1us duration are produced across R4 each time the UJT "fires". The resistance between b2 and b1 of the UJT reduces to a low value each time the emitter conducts. Much of the charge stored in C1 is "dumped" across R4 for the short duration that the e-b1 junction of Q1 conducts.

The narrow pulses across R4 drive the base of Q2 via R3, which serves as a base-current limiting resistor. The pulses cause Q2 to conduct for the same duration, that is, about 1us, and negative-going pulses from the collector of Q2 drive the "TRIGGER" input of the 555 timer, IC1. This is connected to operate as a monostable in this circuit.

When IC1 receives a trigger pulse at pin 2, the flip-flop is set, releasing the short circuit across Cx and driving the output, pin 3, high. The voltage across the capacitor then increases exponentially for a period that depends on the value of the unknown capacitance Cx. The period is determined according to the formula:

$$t = 1.1\ RrCx$$

– where 'Rr' is the range resistor, and 'Cx' the capacitor being measured.

At the end of the period, the comparator inside the 555 resets the flip-flop which in turn discharges the unknown capacitor, Cx, and drives the output to its low state.

This cycle is repeated each time a negative going trigger pulse appears at pin 2 of IC1.

Thus, as the range resistor value (Rr) is fixed, the ON/OFF ratio of the output voltage will be determined by the value of the relaxation oscillator frequency and trigger pulse duration.

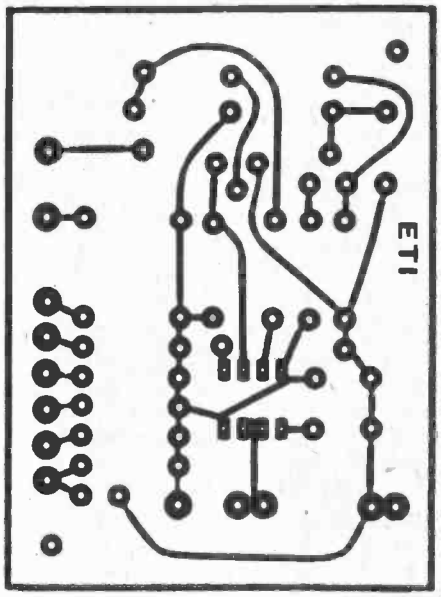
The current measured through the 'load' resistor on the output (R6) of IC1 will thus be directly proportional to the value of the unknown capacitor Cx.

The meter, M1, measures the current through R6, the meter inertia 'averaging' the current.

As the voltage at the output pin swings between about 2/3 of the supply voltage and less than 1/3 of the supply in its 'high' and 'low' states respectively, the dc offset is compensated for by returning the 'load' current through an offset voltage developed across RV2 via R13 from the supply rail.

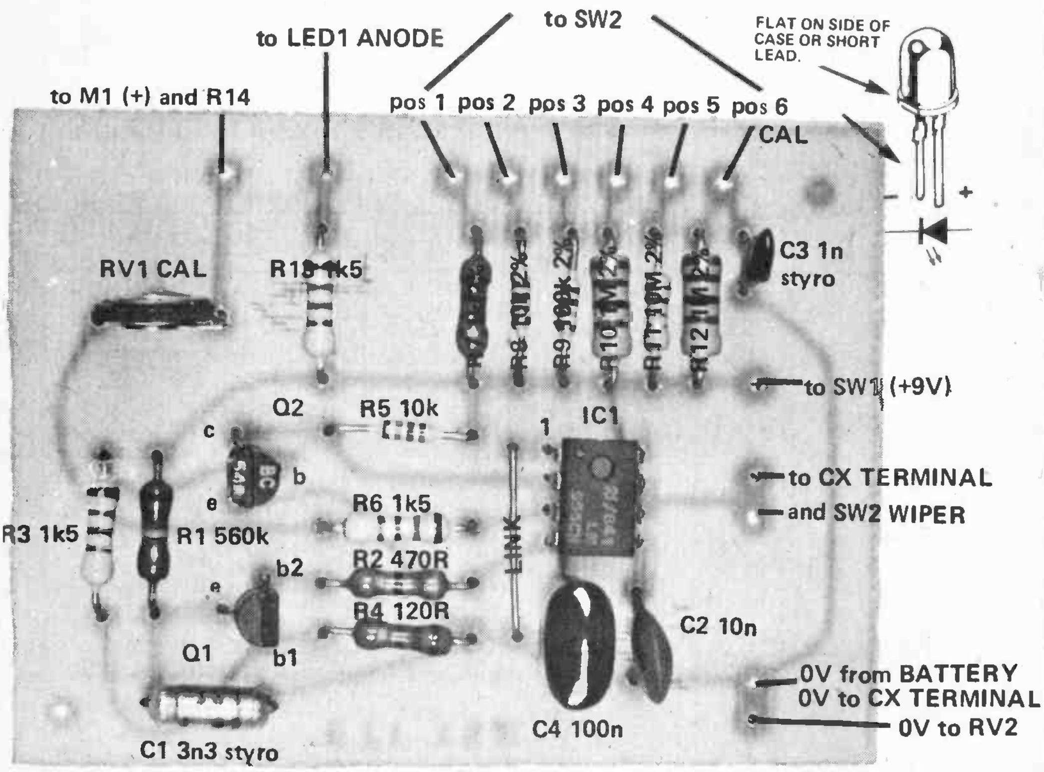
Zero-setting is accomplished by making RV2 variable. A calibration control is provided by making a portion of the 'load' resistance variable – RV1 here.

The 'x10' switch simply reduces the sensitivity of the meter, allowing measurement of a high output pulse-on to pulse-off ratio.

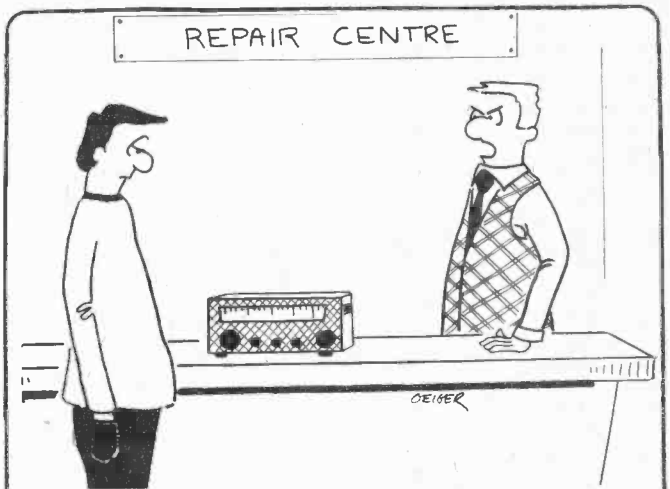


Same-size reproduction of the pc board artwork.

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.



The component overlay.

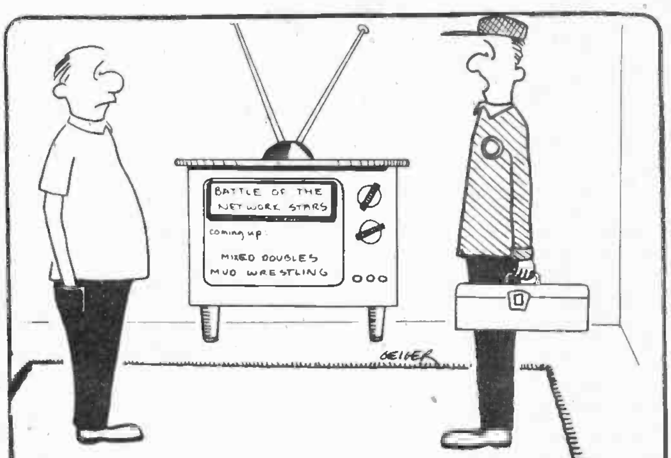


You were told when you bought it that this was a sensitive receiver. Our tests show that you've gone and hurt its feelings.

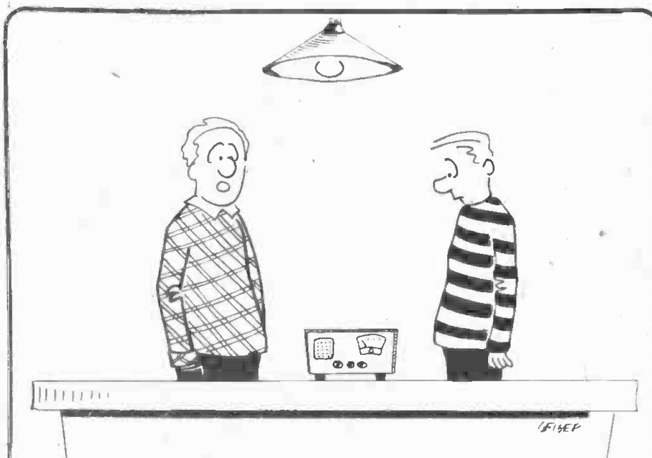

I just can't seem to tune you in properly — your voice is still coming over with a "Donald Duck" quality to it.


The manual says that for better performance you might try adjusting the calibration pots at the back of the set.

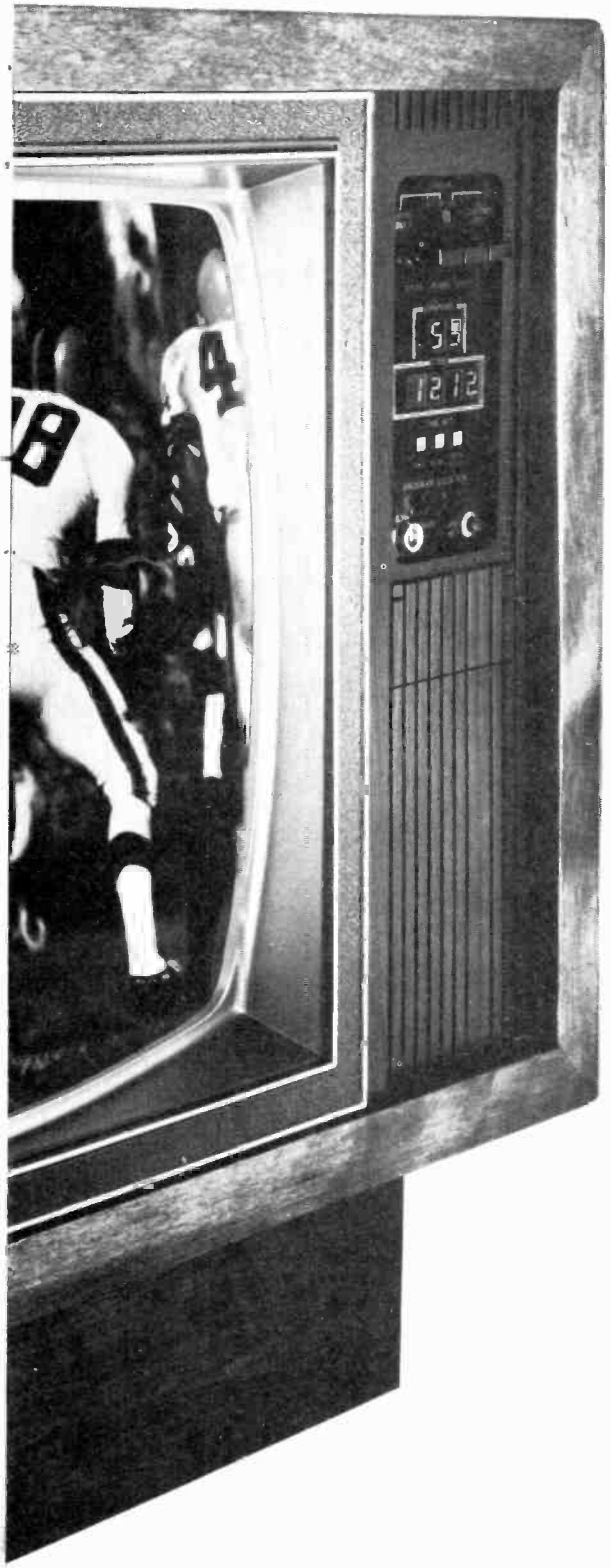
Of course it doesn't work. How do you expect it to work if it hasn't got any wires in it?



I'm telling you Mr. Schwartz, There's nothing wrong with your set-that's the kind of stuff they're putting on TV these days.


It's a new device for measuring RPM's; You stick your finger in whatever it is that's rotating, and this thing measures how long you scream.

New from NRI! 25" DIAGONAL color TV that tunes by computer, programs an entire evening's entertainment.



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X10 Oscilloscope Probes

P100

Specification

Bandwidth	100 MHz
Rise Time:	3.5 nanoseconds
Input Resistance:	10 MΩ when used with Oscilloscopes with 1MΩ input (Probe resistance 9MΩ ± 1%)
Input Capacity	9.5pF when used with oscilloscopes which have 30 pF input capacity
Compensation Range	10-60 pF
Working Voltage	600 Volts D.C. (including Pk A.C.)
Cable Length	1.5 Metres

$33.15

2P150

Specification

Bandwidth	D.C. to 150 MHz
Risetime	2.3 nanoseconds
Input Resistance	10MΩ when used with oscilloscopes with a 1MΩ input (Probe resistance 9MΩ ± 1%)
Input Capacity	11.0 pF when used with oscilloscopes which have 30pF input capacity
Compensation Range	10-60 pF
Working Voltage	600 Volts D.C. (including Pk A.C.)
Cable Length	2 Metres

$44.50

3P100

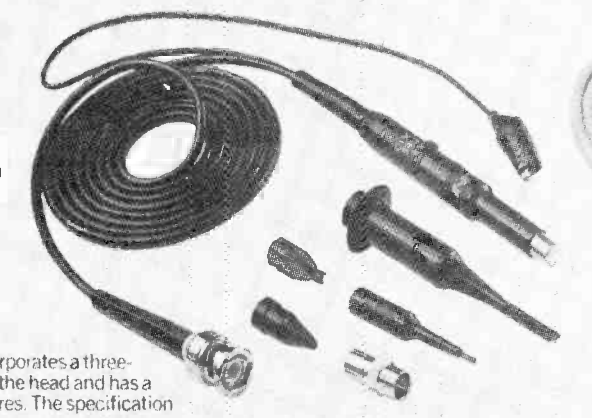
Specification

Bandwidth:	D.C. to 100 MHz
Risetime	3.5 nanoseconds
Input Resistance	10MΩ when used with oscilloscopes with 1MΩ input (Probe resistance 9MΩ ± 1%)
Input Capacity	13.5 pF when used with oscilloscopes which have 30 pF input capacity.
Compensation Range	10-60 pF
Working Voltage	600 Volts D.C. (including Pk A.C.)
Cable Length	3 Metres

$38.85

SP100 Oscilloscope Probe

$47·35



This passive probe incorporates a three-position slide switch in the head and has a cable length of 1.5 metres. The specification is as follows.

Position x 1

Bandwidth:	D.C. to 10MHz
Input Resistance:	1MΩ (oscilloscope input)
Input Capacity:	40 pF. Plus oscilloscope capacity
Working Voltage:	600 Volts D.C. (including Peak A.C.)
Cable Length:	1.5 Metres

Position Ref.
Probe tip grounded via 9MΩ resistor, oscilloscope input grounded

Position x 10

Bandwidth:	D.C. to 100 MHz
Risetime:	3.5 nanoseconds
Input Resistance:	10MΩ when used with oscilloscopes which have 1MΩ input. (Probe resistance 9MΩ ± 1%)
Input Capacity:	11.5 pF when used with oscilloscopes which have a 30pF input capacity.
Compensation Range:	10-60 pF
Working Voltage:	600 Volts D.C. (including Peak A.C.)

$24.65

1P20 X1 Oscilloscope Probe

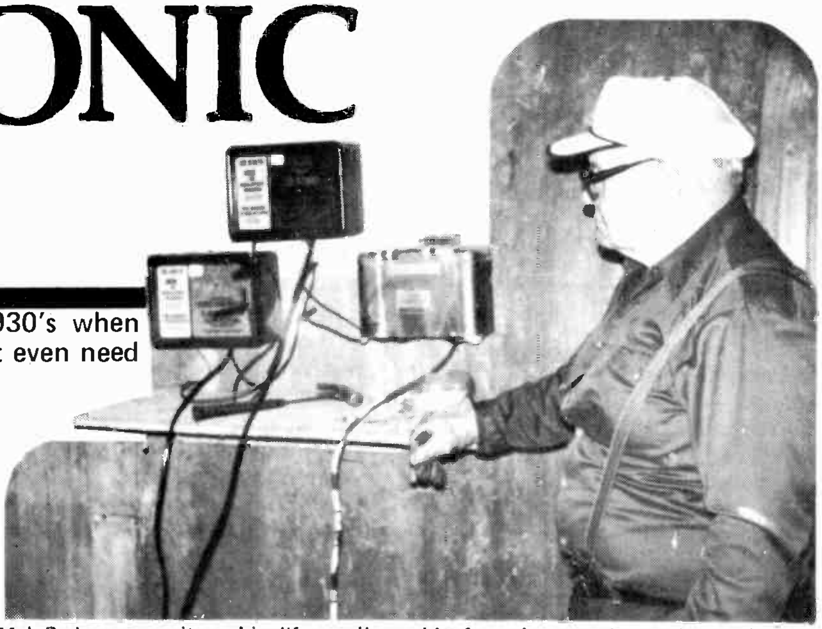
Specification

Bandwidth:	D.C. to 20 MHz
Input Resistance:	1MΩ (oscilloscope input)
Input Capacity:	47 pF. Plus oscilloscope input
Working Voltage:	600 Volts D.C. (including Peak A.C.)
Cable Length:	1.5 Metres

Circle No.17 on Reader Service Card.

ELECTRONIC FENCES

Things have come a long way since the 1930's when electric fences were first used—now you don't even need insulators! Jim Essex reports.



Mel Perkes monitors his "fencers" on his farm in petersburg, Ont. three at a time. He carries a spare (not shown) — just in case.

WHEN "JAKE" HALLMAN first came up with the idea for containing his cattle on his farm near Kitchener by a single electric wire strung on insulators in the early 30's, he couldn't foresee the changes he'd bring to modern farming. Now, you don't even need insulators!

"Jake's " idea was a crude device, it's true; but the basics are still the same today — even if refinements have led to the solid state version, essentially a low impedance device but still having the "kick" of the old high-voltage rigs. Even at the beginning, "Jake" respected voltage and what it can do; not as so many novices have done since — connecting raw hydro to wires in an attempt to produce an effective foil for predators.

Don Stapells, Chief Engineer at Hallman's Manufacturing who incidentally have captured about 90% of the electric fence market in Canada and who still use "Jake's" basic idea on their battery operated model — has nothing but condemnation for people who think an electric fence is nothing more than electricity connected to a wire. He has sat on several boards of law hearing cases of people who — unwittingly — have electrocuted someone in their zeal. Stappells says he's for anything which will help farmers to a safer use of the electric fence. He claims there's too much misinformation and not enough information and this led him to accept a Government representative position in the field. He is an expert witness (Federal) to do with standards, as well as advising insurance companies on the hazards of "amateur" equipment and installations. You've likely read about some cases, yourself; an example comes to mind of the zealous neighbour — determined to keep kids from his garbage can — who wired it to the hydro. He was responsible for killing a young boy! Another strung a wire around his newly sown lawn and connected it to the hydro in series with an electric light bulb. He killed his mother-in-law (it was never established whether or not it was intentional).

Another case involved a man who designed what he called a *"weed chopper"*. The fence was so *"hot"*, it would literally singe the weeds as they grew up along the fence line, not to mention keeping cattle in — which is what it was meant to do. He was tried and convicted in local court (Kitchener) and wasn't allowed to build them anymore. His defence was that he needed all that power because he said *"the farmers are always grumbling that there isn't enough power in the ones they've got to go any more than half a mile"*. Hardware stores selling the units were fined $100. The judge reminded the builder that only devices with a certain electrical output were permitted for sale — *"and I have to uphold the law"*.

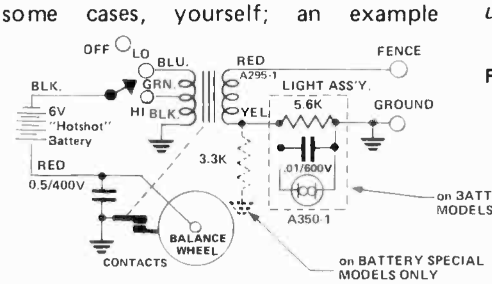
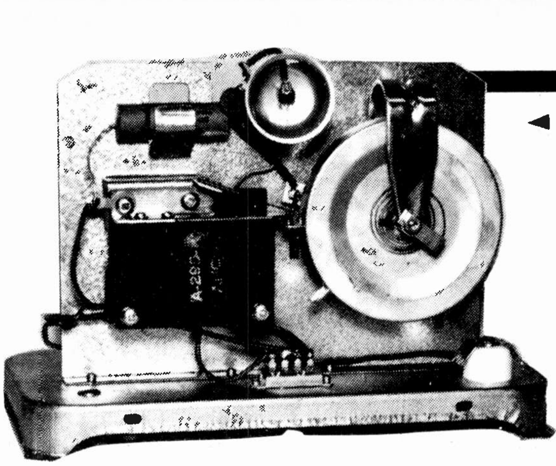


Fig.1. A basic battery model fencer.

According to Stappells, the law is specific. No unit must be connected direct to hydro, and AC, if used, must be severely limited. This is beacause AC allows the muscles to *"relax"*, resulting in a person's hold being maintained after grabbing a wire — and they can't let go. It's the current which does the killing, not the voltage, and there's plenty of that in Hydro!

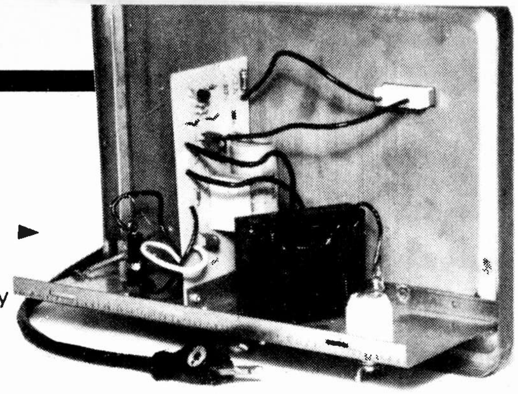
Stappells sites a Prof. Dalziel in California who's an expert on shock. For example, Dalziel has shown a Caucasian female, 4 to 7 years of age, is most susceptible to shock —and AC is seven times more lethal than DC! The notorious *"Wisconsin Fence"*, nothing more than a 100W bulb in series with Hydro (or a 60 watt if you wished more resistance) was an example of a complete lack of responsibility, but at one time were popular in the U.S.

Stappells points to the difference in a properly designed *"fencer"*. These do not emit AC but rather a series of DC pulses at a predetermined interval. AC — if used — cannot exceed 10mA to a fence and preferably 5mA. The Kitchener lawbreaker's electric fence delivered 20mA — more than twice the danger level. Stappells said there are still some around and warns all it takes is one to kill. Although some AC units are considered safe, these rarely exceed 5mA and are good for only a few hundred yards. Insurance people don't like AC fences as they claim they're more hazardous and susceptible to fires where cob-webs in barn installations, for example, are easily ignited when insulation breaks down, when the control box is inside.



Rear view of conventional "fencer" using the balance wheel for timing and pulse interruption. Note "wheel" in foreground.

The business-end of the "Super Hornet". . . . the solid state module eliminates the bulky "balance wheel" as used in earlier models.



By comparison, Stappells' firm makes only fencers which emit a DC voltage — and these give out short *"bursts"*. This allows the recipient time to release his or her hold if they inadvertantly happened to touch an electric fence. The brief *"kick"* is sufficient to remind them not to do it again: the same goes for cattle.

The basic fencer circuit shown in Fig. 1. is a simple primary induction coil, *"timed"* by a balance wheel, usually once per second and inductively coupled to the secondary. Each time the contacts close, it induces a pulse into the secondary, which, stepped-up, charges the fence with a DC pulse of about 500 microseconds at approximately one second intervals. Through observation they've found cattle won't be husbanded with a pulse repetition rate of only one every two seconds nor will they move if too frequent. Therefore, a median rate of about 1.3 seconds — with each individual pulse duration has been found the best. This *"Balance-Wheel"* unit can be operated from a DC source such as a hot shot battery, for about 6 months continuous duty in the field. The 5.6k resistor monitors the "fence" and if current becomes excessive, the voltage drop across the resistor ignites the neon bulb (usually about 70V) causing it to flash brightly, indicating a short on your fence. The battery models are mounted in a weather-proof case which also houses the battery and protects both from the weather. Most farmers today use line operated models — transformer isolated — which allows them to mount them in the barn — out of the weather and where they can more easily be monitored.

A typical set-up is a farm in Petersburg. Mel Perkes — who believes in electric fences so much he has all his operation under electricity and doesn't use a conventional wire fence, has three mounted on a wood panel where he can check them all at a glance. The Hydro mains is isolated after going through a step-down transformer where it's rectified, replacing the battery — and it's safe. The balance-wheel operation is essentially the same for hydro or battery supply. A typical outdoor "fencer" is shown — with the "Ballance-wheel" and electrics shown.

The trend to hydro operated "fencers" brought about the concept of the fence that needs no insulators. Although, as Stappells points out, the saving of insulator costs is insignificant, but the idea of no insulators is a catchy one and has caught the market's imagination. Now, you can wind your single strand wire around any wooden post and have your fence working — up to two miles! As for the claim by unknowing farmers you need "gobs" of electricity to control cattle at the "end of the line", Stappells points out they now make fencers good for up to 25 miles — without the danger of killing anyone.

Using the formula W/secs = $\frac{1}{2}CV^2$, Stappells found you can get a reasonably low-voltage, high current burst which is essentially low-impedance and hence the classic insulator is no longer required. This circuit produces a pulse of roughly 200 microseconds every second. A special toroidal tranformer and capacitor were designed to accommodate this. Jake's first units sold for about $30.00 and came complete with battery, 5 insulators, accommodating four corners and a spare — and 50 feet of wire to get you started. He built about 300 a year. Today, the units — both battery operated and electric — don't cost too much more — at around $50.00 each and they turn out 22,000 units a year of all types. The new "Super Hornet", low impedance, solid-state unit is pictured. Note the traditional "balance-wheel" is missing, solid state electronics now does all the work.

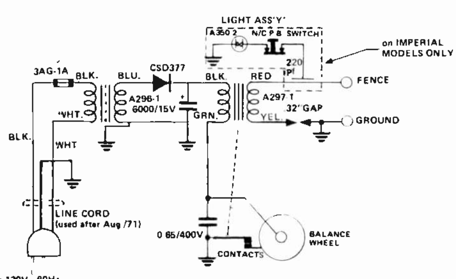


Fig.2. An A.C. powered fencer.

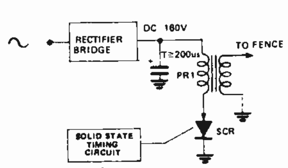


Fig.3. Hallman's Manufacturings solid state fencer.

With improved safety has come wider use of "electric fences". Clarkson Boucher; an apartment dweller in Brampton, Ontario, incensed at multitudes of pigeons roosting on his outside porch, decided to do something about it. He strung four wires along the base of the inside floor, with a single wire running around the perimeter. A single layer of mesh chicken-wire quarantees a good "ground", serving as earth where the floor is devoid of the usual ground. A slight contact with anyone of the wires and the pigeons "take off". He has no droppings to clean up now, making his porch once more attractive. Another man, concerned about a blue heron taking his prize gold-fish in his outdoor pond in British Columbia solved his problem by surrounding it with an electric fence.

Farmers find them ideal in hilly locations, where conventional rigid fences won't follow the contours too readily. A strand or two of electric fence is inexpensive and can easily be adjusted to conform to the terrain where the rigid fence — when pulled taut for example — allows no sag, leaving openings under which small cattle can easily crawl. Although insulated steel stakes are available — allowing easy installation a popular arrangement is with the ordinary steel "T" bars commonly used for supporting snow fences. Handy insulators now available slid conveniently onto the "T", allowing you one, two or three strands as necessary. These can also be adjusted up or down to suit.

Increases in battery costs are making hydro operated units prominent. Whereas 16 years ago, 80% of the units sold were battery operated now 70% are line operated with only 30% battery.

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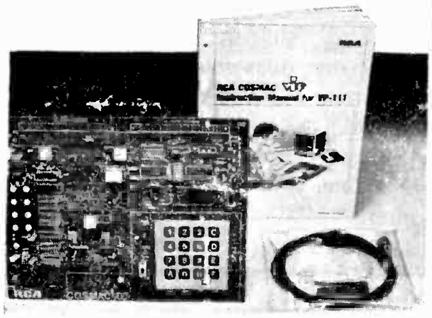

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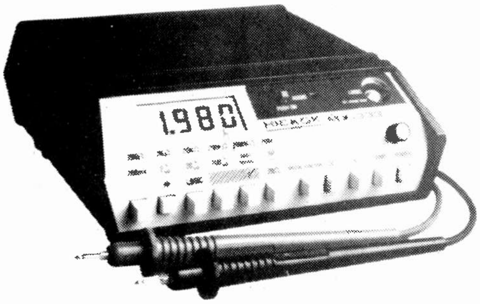

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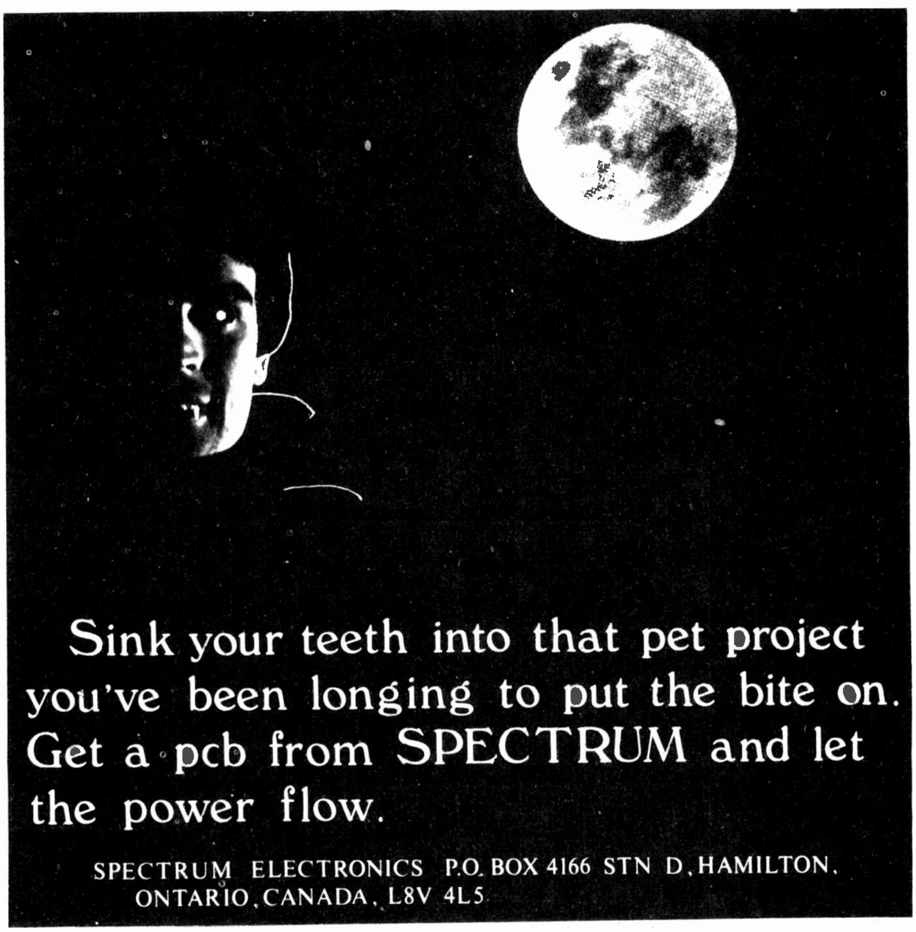

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SOLAR CELLS

Energy derived from fossil fuels — the world's major source of energy today — was originally provided by the sun, converted by photosynthesis with an efficiency of about 0.025%! Compared to modern solar cells, which have an efficiency around 12%, we're on a real loser with fossil fuels. However, at the moment, they're convenient — but they won't always be so.

Here is a short guide to solar cells, their uses and abuses.

WE HAVE ALL become vitally concerned about our energy resources, and rightfully so. Most people see the energy crisis in terms of paying more for a tank of gas, but the implications run much deeper than that. Just think how many commodities are based on the oil industry — the pen I use to write this with is plastic, the table top is plastic veneer, even the carpet is synthetic — all made from petroleum products.

A very large percentage of our business trade is in oil-based products eg. clothing, photography, medicine, and household goods, to mention just a few. In fact, Western economies are based so heavily on oil products that, if anything suddenly happened to the supply, most western nations would collapse.

An enormous amount of energy is radiated by the sun. It is, in fact, our primary energy source. On a clear day the Earth receives about one kilowatt of solar energy per square metre on its surface. About 30% is reflected back into space, 47% is converted into heat, the rain cycle uses another 23% (which can be tapped to provide hydro-electric power in suitable mountainous areas). while wind, waves and convection currents account for about 0.25%.

The remainder, about 0.025% (!), is stored by photosynthesis in plants. It is this energy that eventually goes to make coal, oil and shale oil. The energy derived from petroleum which we use so extensively today is the accumulation of this trickle of energy into photosynthesis over millions of years. No wonder it's running out!

In fact it has been estimated it would take six million years of photosynthesis to provide us with an extra six months of coal and oil!

Solar energy can be harnessed in many different ways. Hydro-electric power is a result of the rain cycle; thermal gradients in tropical oceans have been used in an experimental generating station off Cuba as long ago as 1929; wind power is showing promise with experimental generating stations using large windmills and solar collectors have been devised to capture some of the heat which would otherwise be reradiated and lost, converting it to hot water for domestic and commercial heating.

What Solar Cells Offer

Solar cells offer a much brighter future (. . . pardon the pun) as a source of electrical energy. Firstly, they provide energy in a clean, transportable, convenient form — electricity. The predominant source of energy for electrical generation today comes from fossil fuels and hydro-electric schemes. A very few generating schemes use hydrothermal energy from natural hot springs.

Secondly, solar cells can provide energy very close to the point of consumption without requiring the transmission of energy across a distance or replenishment of fuel. Very handy in isolated locations.

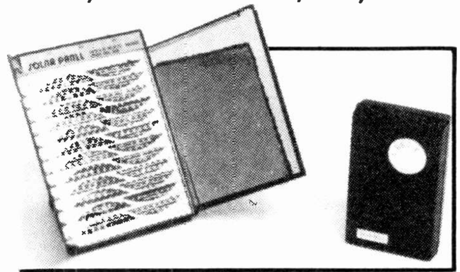
Thirdly, they're relatively efficient . . . and they have a long life.

One shouldn't forget, too, that they are made from one of the most common substances on Earth — silicon.

To date, the most extensive use of solar cells has been in space. They have been employed as power sources for satellites for many years. Research has improved the efficiency of solar cells over the years, and the position is likely to improve steadily with continuing research.

Solar power satellites are currently being studied (see ETI, Sept. 79). It is proposed to assemble huge solar cell arrays in space and beam the energy back to Earth via a high power microwave transmission, enormous antennas ("rectennas") on Earth converting the microwave energy directly to electricity for distribution.

Terrestrial use of solar cells has expanded rapidly in the last few years. Remote telecommunications installations seem to be making the greatest use of the advantages offered. Some radio amateur VHF repeater stations employ solar cells to maintain charge in storage batteries used to power the installation. They are also used to charge batteries on ocean-going yachts. So you can see that hobbyists as well as professionals have been getting into the act.



Pic 1. An experimental solar panel. This one, Solarex No. 9994, can deliver 3, 6 and 9 volts at 50 ma. It can be used for powering small radios such as the one shown, or for recharging batteries. The mirrored 'wings' concentrate the sunlight for great efficiency.

Solar Cell Characteristics

The voltage/current characteristics of a typical single solar cell are illustrated in Fig. 1. Power output contours are also shown.

At low levels (relatively high load resistance), output from the cell will be pretty nearly a constant voltage — around 0.55V to 0.6V — depending on the amount of energy received. If the load is increased (by reducing the load resistance), output current (and load power) will increase in proportion until a point is reached where the output voltage rapidly 'turns over', dropping sharply if the load resistance is further decreased. In this region, the load current will remain virtually constant. Maximum power output, for a given level of energy falling on the cell, occurs at the 'knee' region of the characteristics.

The performance of a solar cell depends on the spectral distribution, of the irradiation impinging on it, thus, the amount of power per unit area falling on a solar cell is not a measure of the total irradiation. The term *insolation* is used to specify both the amount of power and the spectral distribution of radiation falling on a solar cell.

The relative spectral response of a typical solar cell is illustrated in Fig. 2. Part of the efficiency loss in solar cells results from the fact that their spectral response does not match the spectral output of the sun. Further energy is lost in the unused excess of energy of the absorbed photons. Conversion efficiencies at an insolation of $1kW/m^2$ ($100mW/cm^2$) for typical solar cells ranges between 8% and 12%.

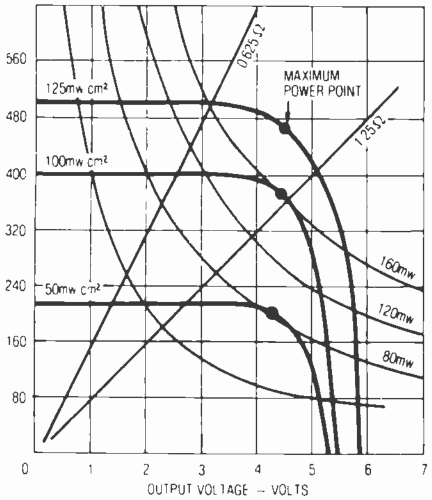


Figure 1. **Typical voltage/current characteristics of a solar cell. (Sensor Technology, type C200.**

Solar Cell Arrays

The most convenient way to obtain power from solar cells is to mount a number of them in a array and connect them so as to provide a useful voltage at some convenient current or power rating. Accordingly, manufacturers make 'panels' of solar cells, constructed by encapsulating individual cells in silicon resin between two plates of glass, generally with an extruded aluminum surround for the edge, with the cells connected in series. The glass plates are chemically hardened (tempered) and made very smooth to reduce the build up of dust or other residues. This is especially important where the panels are used in remote locations.

Since most of the energy falling on the panels is converted to heat and lost, the panels have to be able to conduct the heat away by convection (primarily) or conduction. Some panels are provided with a sturdy cast aluminum frame at the rear which serves as a heat dissipator for the array.

High temperatures on a solar cell panel have to be avoided, otherwise damage may result. Although individual cells can withstand quite high temperatures before they suffer structural damage, the resin potting compound cannot. Excessive heat induces strains in the resin, causing it to tear away from the surface of the cell, leaving a gap, and decomposition of the resin due to excessive temperatures can cause discolouration. The results of these two effects combine to attenuate the light falling on the cell, decreasing its efficiency.

It is important that solar panels are used within the Safe Operating Area Range (SOAR) given in manufacturers' data. Most panels are designed so that, when used singly – for charging a storage battery, for example – they cannot be damaged. Series and parallel connection requires care to avoid excessive dissipation in particular cells. Notes on avoiding problems are given a little later in the article.

Load Considerations

Operating solar cell arrays into a fixed load resistance is not ideal since, at different levels of insolation the output voltage and current will vary and thus the maximum power output point varies. Thus, the optimum load resistance should be different for different levels of insolation. If a secondary battery (an accumulator – such as a lead-acid or nickel-cadmium type) is used as a load, this problem is largely overcome.

As an example, let's examine the characteristics of a typical solar panel (Fig. 3.). It delivers a maximum power output of almost 10 watts at a peak insolation of 1kW/m^2 into a load resistance of 20 ohms. At half that insolation level (500W/m^2), power in a 20 ohm load would only be 2.9 watts. For a 12 volt accumulator (see the 'battery load line'), power delivered to the battery at peak insolation would be a little under 10 watts, but at 500W/m^2 insolation it would be 4.8 watts.

For this reason, solar panels are manufactured with the correct number of cells to charge a (nominal) 12V storage battery (33 in the MSP23A20). The solar cells are able to work at near-optimum efficiency and the storage batteries can provide peak demands of the power-consuming equipment and bridge overcast periods and night time when the panel receives little or no energy.

Series Connection Of Solar Cells

Any number of solar cells may be connected in series to give a desired output voltage. There are however, some points to remember. If all but one of the cells are in shadow, the irradiated cell will not be able to overcome the barrier potentials of the shadowed cells (since all their barrier potentials are in series) and no current will flow. Taking that a little further, sufficient cells in a solar array must receive irradiation so that the barrier potentials of the remaining cells can be overcome. In the extreme case, what happens when only one cell in an array does not receive sufficient irradiation? The irradiated cells will then force a current though it and the cell will develop a

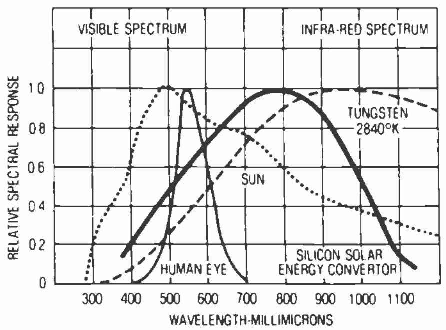


Figure 2. **Relative spectral response of a solar cell. Efficiency would be better if the response matched the Sun's output more closely.**

reverse voltage across it and thus dissipate power. The actual dissipation will depend on the amount of shadowing. If the irradiance to shadowed cell increases, the power dissipated will *increase* as more current will be able to flow through it, but until the cell can produce the same current as the others – by receiving the same irradiation – it will remain reverse-baised.

The maximum dissipation of a cell is limited by its area. As a guide, the dissipation should be less than the maximum power received at an insolation of 1kW/m^2. For example, if the area of one cell is 26 cm^2 the maximum dissipation is 2.6W. For the Sensor Tech. C200 (characteristics given in Fig. 1.), which has an area of 20cm^2, maximum dissipation is 2.0W.

An effective way of limiting the dissipation is to place a protection diode across each cell to short out any reverse voltage across the cell. This is a rather expensive solution and is unnessary if the cells are used to charge a battery as the constant voltage characteristic of the battery will limit the maximum voltage which can be developed across any one cell. This is another reason why solar panels are designed to feed a storage battery. If however, several panels are connected in series a protection diode must be connected across each panel to limit the maximum reverse logic.

Parallel Connection

If cells are connected in parallel to supply a higher current the voltage across each cell will obviously be the same. However if one cell receives less insolation than the others, the shadowed cell will be biased into its forward region and current will be forced through it from the other cells receiving full insolation.

In the worst case one cell in a parallel-connected array will be shadowed

Continued on page 71

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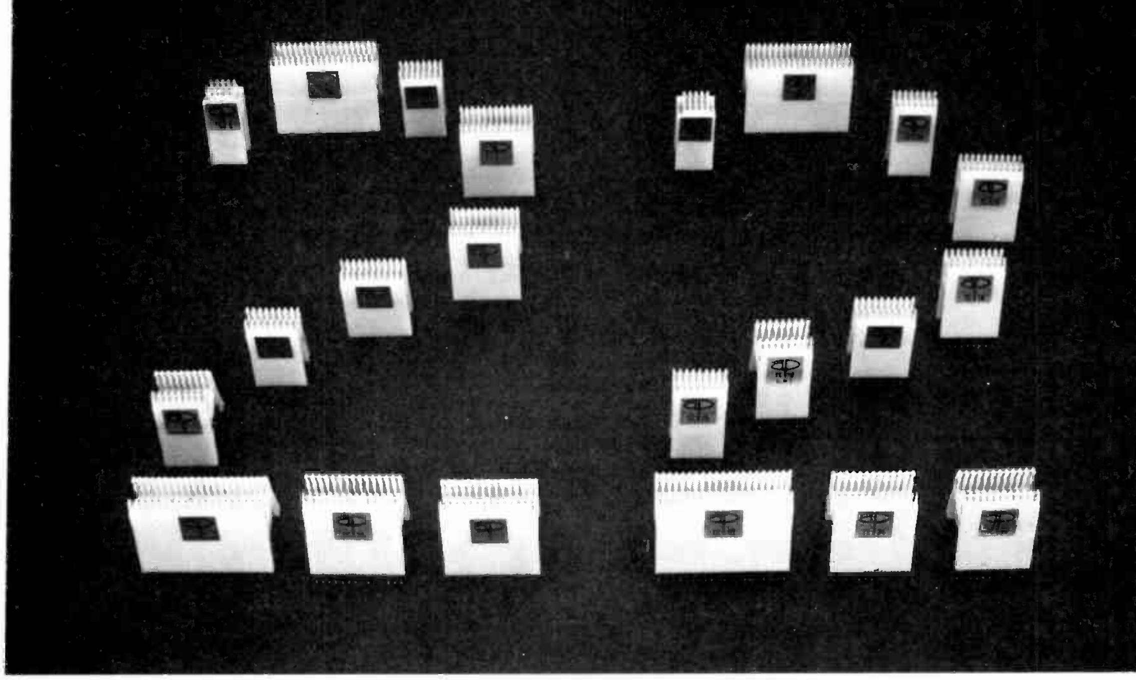

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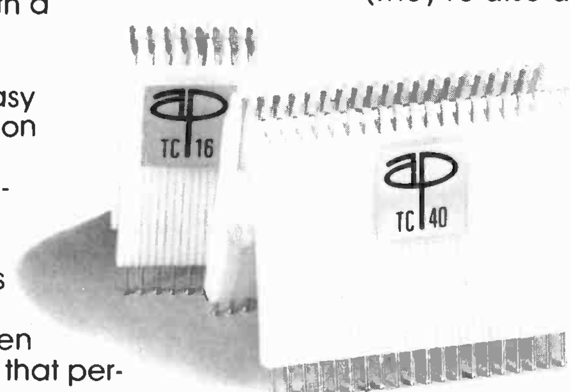

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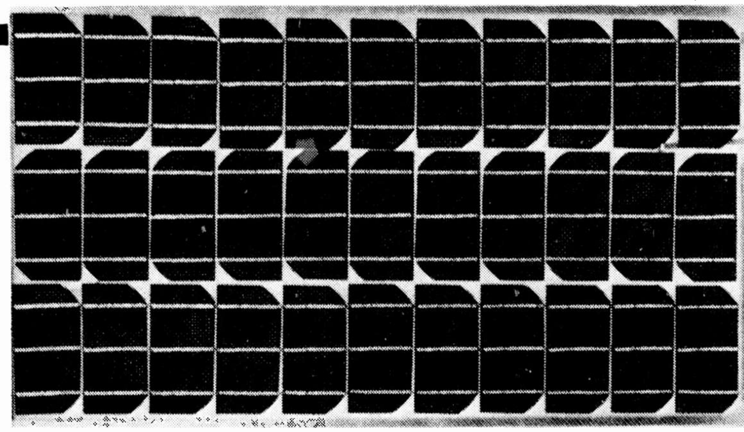
and the rest will receive full light. All the energy from the irradiated cells will be dissipated in the shadowed cell and it will heat up. For this reason individual cells should not be connected in parallel.

When solar panels, or chains of series-connected cells are connected in parallel, the dissipation in a shadowed panel will be equally divided between each of its cells.

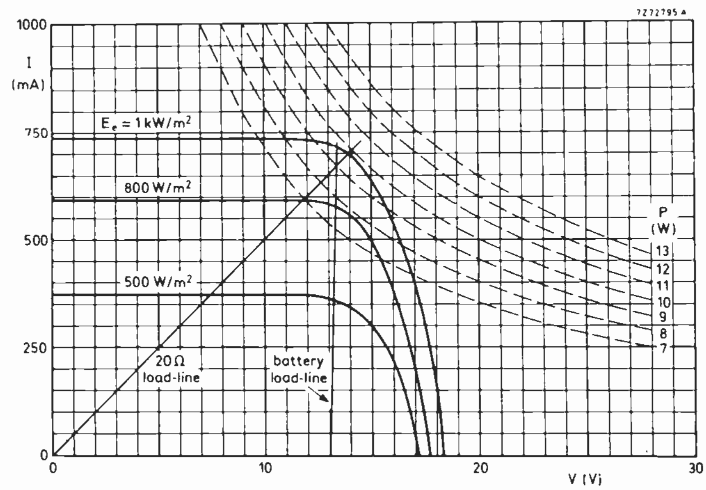
Solar Panels In Series & Parallel

For higher voltages and higher currents a number of solar panels can be connected in a series-parallel combination. To limit the dissipation in any panel a matrix is used as shown. With the MPS 23A20 panel, for example, the matrix must be three series by two parallel. Protection diodes are still required across each panel to limit the dissipation in individual cells; Fig. 4. shows how.



Pic 2. Motorola's MSP23A20 solar module can produce 20 Watts of peak power. Dimentions are 355x660mm.

Figure 3. **Characteristics of Philips' 3PX47A solar panel.**



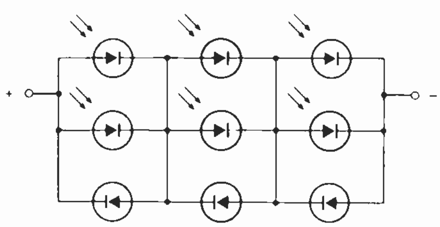


Figure 4. **Matrix connection of a solar panel to imporve output. Note protection diodes.**

SILICON SOLAR CELL – HOW IT WORKS

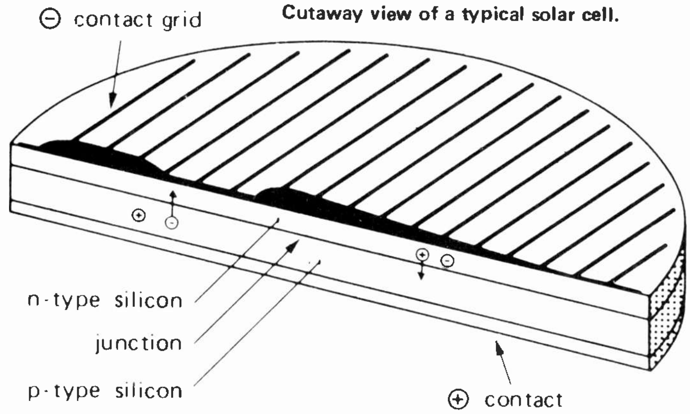
A SOLAR CELL can be considered as a large-area silicon diode. Because it consists of a p-n junction, the junction will have a barrier potential associated with it (harking back to your diode theory) when no radiation falls on the cell. There will be an excess of electrons on the n-side of the junction (supplied by donor atoms from the doping material), some of which will diffuse across into the low electron density region on the p-side of the junction. This diffusion leaves ionised donor atoms ('holes') which create a positive space charge in the n-region close to the junction. The electrons which diffuse into the p-region will find acceptor atoms and will no longer be free to roam. This creates a negative space charge near the junction. That's how the barrier potential comes about. But, you won't be able to measure it.

The barrier potential, V_B, can be thought of as a contact potential. If contacts are made to the p-region and the n-region (with the same metal) and a high impedance voltmeter connected, no voltage will be measured. The contact potentials will cancel. Looking at the diagram, with no light falling on the cell, V_B will typically be −0.7 V, V_{C1} +0.5 V and V_{C2} +0.2 V. Hence, you won't read a thing on the meter.

If the cell is now irradiated with light, electron-hole pairs will be generated in the junction region, separated by the field associated with V_B, the holes being forced to the p-side and the electrons to the n-side. i.e.: they move across the junction. Consequently, the barrier potential will fall considerably, to say 0.1 V!

However, the p-contact will then be at a potential 0.6 V above that of the n-contact. Now, you can measure this! With sufficient irradiation, electrons charge across the junction from the p-region to the n-region — via a load and round again if you want the solar cell to do work.

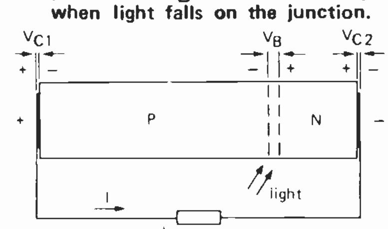
Cutaway view of a typical solar cell.



Thus, convential current flow will be from the p-contact (which becomes the positive terminal) to the n-contact via a load. The maximum current obtainable is approximately proportional to the level of irradiance and the area of the cell.

Conversion efficiency of solar cells ranges between 8% and 15%, typically 10-12%, under a standard solar irradiance of 1 kW/m² (100 mW/cm²). It is limited by three main factors: firstly, only part of the Sun's available spectrum is used: second, the absorbed photons have an unused excess of energy and lastly, some of the electron-hole pairs created are lost through recombination.

Representation of a solar cell showing the contact and barrier potentials. V_B falls considerably when light falls on the junction.



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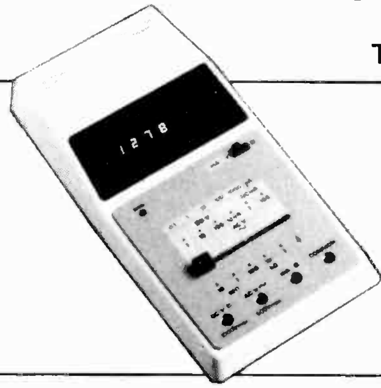

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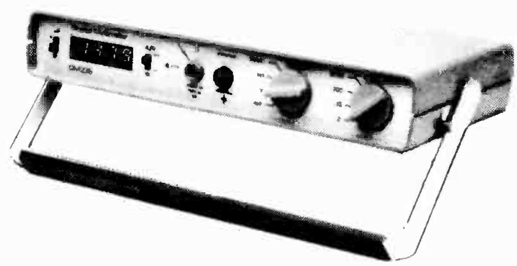

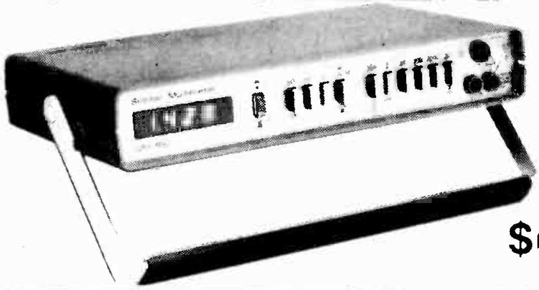

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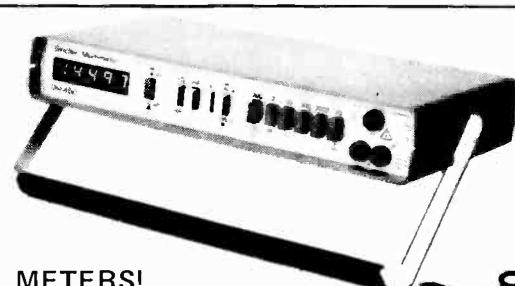

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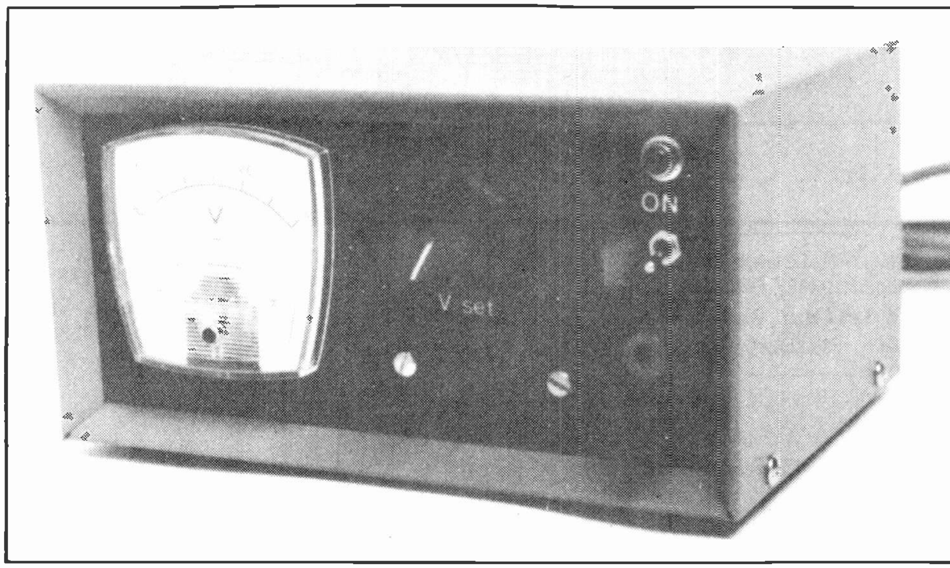
POWER SUPPLY

Whether you need a lab power supply, a CB or ham base station power supply or a car battery charger, this project from Ashley Kimber is about the simplest solution you can find.



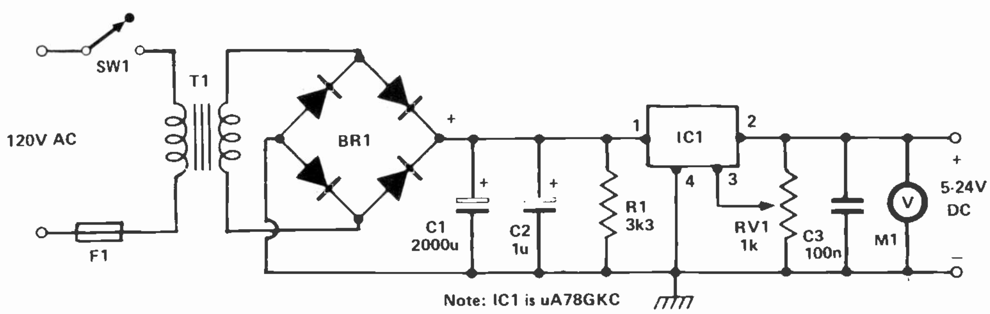
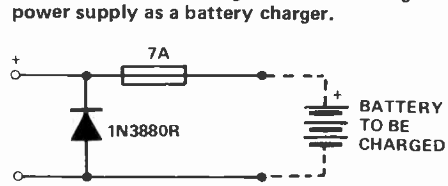


Fig.1. The circuit of the power supply.

Fig.2. Additional arrangement when using the power supply as a battery charger.



THIS CIRCUIT was originally submitted to us by Ashley Kimber. We liked it so much we subsequently decided to build one ourselves.

The power supply's main virtue is that it gives excellent variable performance at high current with only one IC. Only a minimum of additional parts are required to get it going. The power supply is capable of delivering 5A at voltages from 5 to 24V. The IC is protected against both current and thermal overloads.

Mr. Kimber claims this to be a 'Murphy Proof' power supply. We have to agree.

Construction

The circuit is quite straight forward and consequently there is no PCB. If you feel that 5A is too hefty for your purposes, you might consider IC1's smaller brother, the uA78G. This IC costs considerably less and will deliver 1 amp into a load.

Start construction by locating the major components, T1, C1, IC1 (and heatsink), RV1, and M1. IC1s heatsink should be mounted with its fins oriented vertically for maximum cooling. Connections should be made with wire no thinner than 18 gauge.

The smaller components can be attached to their larger brothers and the wiring completed.

IC1 comes in a T03 case with four pins. The heatsink should be drilled to accomodate the extra pins. Make the holes large enough to slip insulating tubing over the connections. The heatsink you use will be largely decided by the intended application. High current, low voltage operation will require a larger heatsink than other modes.

In general, IC1 should not be called upon to sink more than 50W. If this is the case, reducing the input voltage will keep the device running cooler.

IC1 requires no insulation from the heatsink. However, make sure you use an adequate amount of silicon grease between it and the heatsink; this baby can get hot!

Using It

After assembling all components check your wiring carefully, in particular make sure that the connections to IC1 are not shorted to ground.

If all is well, plug the power supply in and turn it on. Rotating RV1 should cause the output to vary between 5 and 24VDC. The output should drop to zero shortly after power is removed.

This power supply also makes a useful battery charger. If you plan to use it for this purpose, the circuit in Fig. 2. should be incorporated to prevent damage to the battery or the power supply in the event of an improper connection. ●

HOW IT WORKS

The 18 VAC output from T1 is rectified by BR1 and filtered by C1 and C2. R1 is used as a bleeder to drain C1 when power has been removed.

The unregulated DC is then applied to pin 1 of IC1 and the regulated output appears at pin 2. RV1 is used as a potential divider to provide feedback to pin 3. No matter what RV1 is set at, IC1 will endeavour to keep the voltage at RV1's wiper at 5V. Consequently the closer the wiper is to ground, the higher the output voltage.

C3 is used as a bypass capacitor to improve transient response.

If you use the circuit as a battery charger, some form of protection against reverse connection is required. If a battery is improperly connected to the circuit in Fig. 2. (ie: positive to ground), the diode will conduct and put a complete short across the battery. Under these conditions, the fuse will blow and effectively remove the battery from the circuit.

PARTS LIST

Resistors

R1	3k3	5%, 1/4W

Capacitors

C1	2 300u	electrolytic
C2	1u0	tantalum
C3	100n	polyester

Potentiometers

RV1	1k	2W

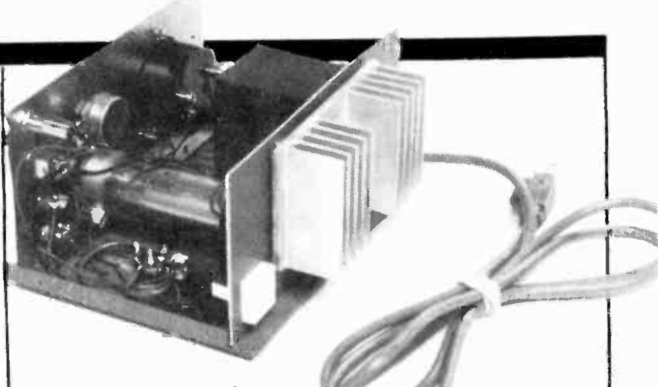
Semiconductors

BR1	200V	6A
IC1	uA 78GKC	

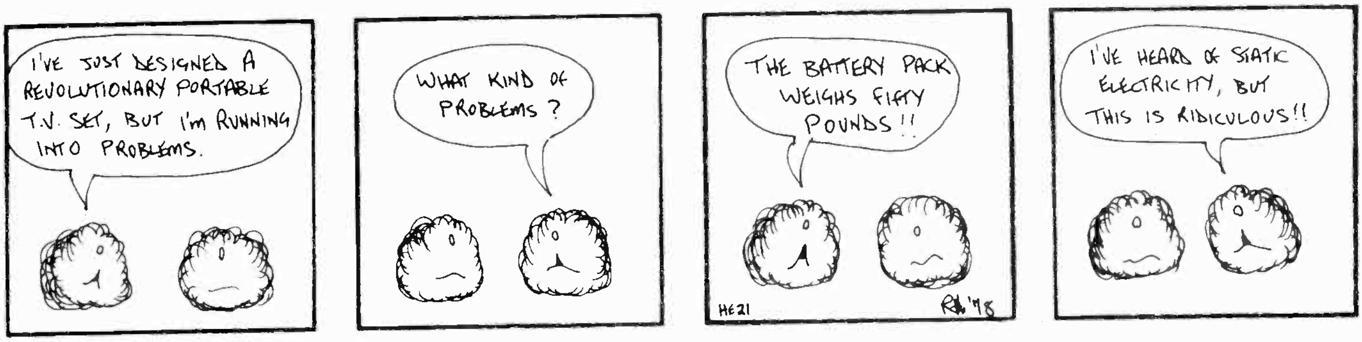
Miscellaneous

T1	24V 5A
M1	30V panel meter
F1	1A
SW1	toggle switch

case (254 x 178 x 100mm), binding, posts, heatsink, line cord, fuse holders, hardware, etc.



Inside and rear view of our foolproof power supply.



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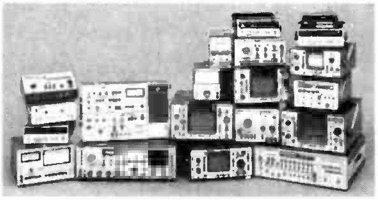

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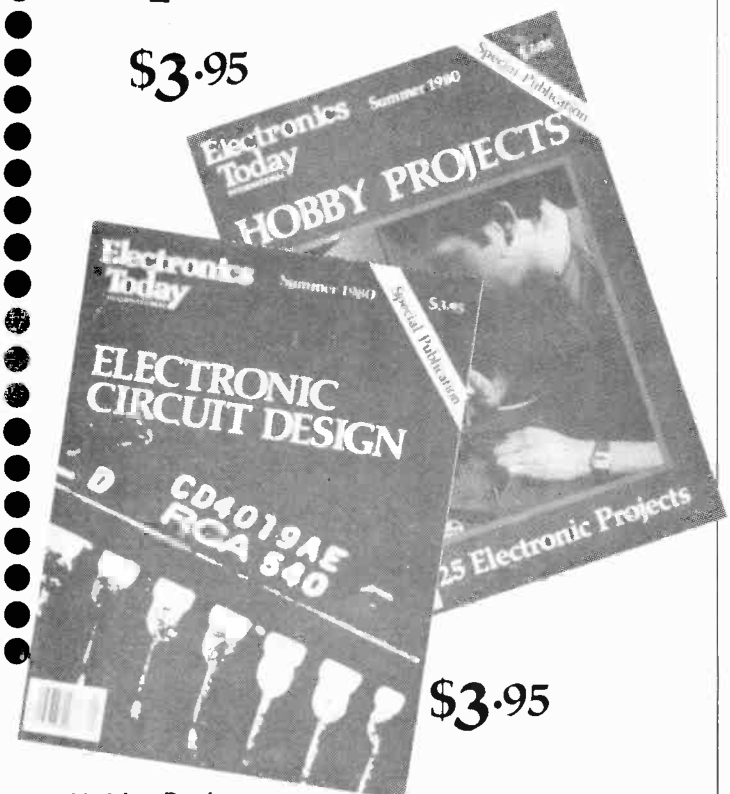

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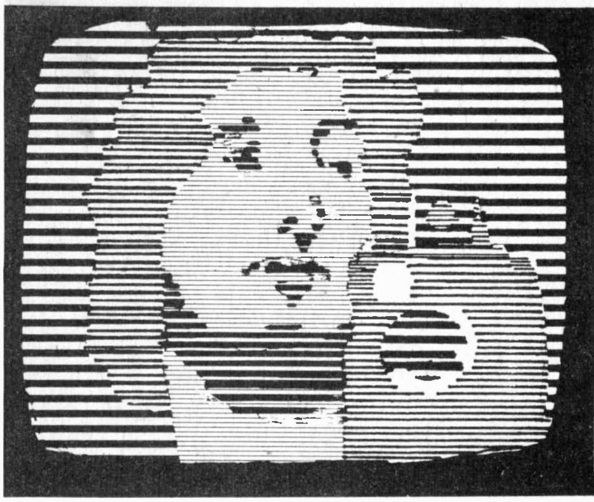


WHAT'S ON

Steve Rimmer looks at TV surveillance equipment.

The Eyes Have It

JOSI IS ONE of the few practicing witches around these days. That, and I think she's a communist. Used to be a Methodist. I don't hold it against her, though; I used to be an alchemist. Politics makes strange bedfellows and usually gets one of them pregnant in time.

Her primary concern these days seems to be in keeping her paranoia down to a manageable hugeness. "I'm being watched," she was saying the other night, "Like, I get that feeling all the time now."

"Ya, I get that feeling a lot too. Like the other day at the airport wearing that vampire outfit . . ."

"It's more than just that," she intoned, (and here I was thinking she was intone deaf), "I think the government has, y'know, a file on me or somethin'." Her voice dropped to a whisper. "I think they've got a tap on my phone."

"How do you know?" I whispered back. The walls had ears. Also several noses. She had really weird wallpaper.

"I can hear voices when I pick up the receiver."

"What're they sayin'?"

"I dunno. It's hard to make out, y'know . . ."

"What do you think they're sayin?"

"It sounds like; 'Hey, Joe, she's talkin' again. Turn on the tape recorder.' "

I pondered this momentarily. "Yes, it sounds like somebody's tapped your phone. Or they think you're Margaret Trudeau."

"Ya. And another thing. There's this great humungeous lens stickin' outa the window across the lane, lookin' right at my place."

"Is that the place out back?" I inquired.

"Ya."

"That's Max's dive." Max is my neighbour. A wee bit abnormal, Max is. If you come by at about six in the morning, you might catch him out in the yard with a Black and Decker drill and a big box of bit extenders searching for oil. "Is this here lens about — oh, yea big around and attached to an old grey TV camera that looks like it was used to shoot the Milton Berle show?"

"Uh, ya." she said "Does this mean Max works for the heat?"

"No, Max swiped that outa my garage about a month ago. If you were to do your sunbathing on the other side of your roof for a few days, I'm sure he'd put it back." The mighty mind of Max had finally brought peeping Toms into the electronic age.

As night fell, and the windows of the neighbourhood began to dance with the flickering of 25" colour consoles, she began to suggest that I really didn't believe that she was being checked out by the powers that be. Clearly, this was untrue. After all, we are all under surveillance. Or, didn't you realize that either? You see, for every two of us, there is one of them. And for every two of them, there is one them-them, to keep them honest. And then there are even tighter elites of triple-thems and quad-ruple-thems, penta-thems, and deca-thems, finally all answerable to the national head snoop. I'll leave you to figure out who that is.

Now, you may be thinking that, if all this is true, our civil liberties are being invaded, our human rights dispatched, 1984 has surely come and we are no longer names but just numbers. There are bugs in our bedrooms and we have no secrets. Shortly the information will be used to run out lives. Well, it's nothing to really get bent out of shape over. The move is purely economic, not social. It's not a plot, or a scheme.

It's a government make-work project (so it'll never actually do anything).

Surveillance Video

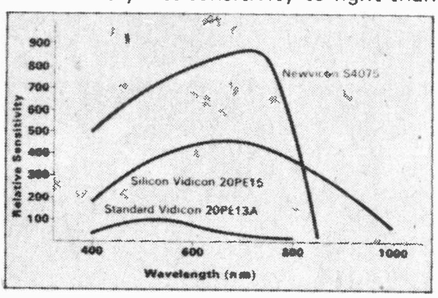
Those big, two-colour signs that read, "Warning! These Premises Protected Electronically!", with a picture of a long-haired fellow getting busted, sketched behind the lettering . . . . yes, they really strike fear into the hearts of would-be crooks and other little nasties. Check it out; it's two in the morning, and two bearded undesirables, probably on drugs, (one is probably Max) are prowling around the periphery of the establishment of a respectable local businessman. Knowing that his wife's in Florida and he's downtown trolling the bars, they can be pretty sure that the place is unguarded. They begin investigating possible places of entry. Then they notice . . . the sign. Suddenly, they begin to tremble in their North Star joggers. Their palms get sweaty. Their faces become ashen pale . . . . not easy to see through shoe polish. They begin to whisper about the argus-eyed, unsleeping, sentinel within and the virtual impossibility of escaping its steely gaze. Their nerve disappears into the cracks of the parking lot. They huddle transfixed, realization dawning upon them that, once again, their vile and nefarious lives have been thwarted by the hand of truth, clean living and marital infidelity.

Fortunately, one of them notices that the brand name on the sign is a phony. Ya, the old man would be too cheap to pop for a surveillance system. All he bought was a couple of these signs from a mail order place in Vermont. Their nerve returns and they clean the place out. I do so love happy endings.

The first rule of surveillance is that you can't bluff people like this any more. You have to have equipment, even if you don't have it hooked up.

Surveillance systems begin, naturally enough, with surveillance cameras. Ten or fifteen years ago, these would have been simply "general purpose" vidicon types, designed for everything from guarding the family jewels to filming high school drama classes. However, over the span of time, they have evolved into quite sophisticated, dedicated instruments. One of the big advances has been the introduction of a new type of pick-up tube, called the Newvicon, replacing the Vidicon in many applications. There should be a chart around here somewhere, showing the relative sensitivity of this tube as compared to a standard Vidicon. Not only can it deal with much less light but its spectral response is considerably different, with a shift toward the infrared. This means that it can "see" areas of heat, even in the absence of visible light. It can operate in as little as 0.05 footcandles of light, as opposed to about one footcandle for the standard tube.

Panasonic's WV-1000A series magic eyes are illustrative of this generation of systems and they're illustrated in Fig. 1. The lower one is a Newvicon type. Aside from these two, there is also a 1000AD model, the "D" standing for, yes friends, dummy. The AD model has considerably less sensitivity to light than



A comparison of the spectral sensitivities of standard videocons and Panasonic's Newvicon.

do its functioning counterparts, but this is at least partially compensated for by its substantially lower power consumption. It comes with a choice of three types of pick-ups; Vidicon tube, Newvicon tube or inner tube. It is supposed to deter our friends with the klepto complexes of a few paragraphs back . . . although the dummy sign was too.

In many applications, the cameras are installed in the splendid exterior vastness of the true North, strong and twenty below. If left to their own devices, most of which say right on their spec sheets they don't work below freezing, they would soon close their little glass eyes and do some heavy hibernation 'till spring. These being the just and righteous facts (brothers), the manufacturers on high, or whatever they get on to think these things up, devised some pretty elaborate environmental enclosures to seal the cameras up in. These range from simple boxes with glass fronts to one of my favourites, illustrated in Fig.3., which has built-in thermostat to control its internal fan and heater, a sun shield, defroster, and . . . get this . . . a teeny, tiny windshield

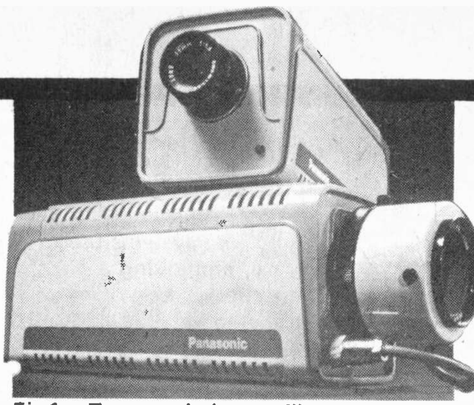


Fig.1. Two typical surveillance cameras. The one on top is a WV-1000A and the one below, the WV1050A, is a Newvicon unit

wiper. It also has a big mother heavy-duty support structure, because it weighs about thirty pounds empty.

Actually, these enclosures suggest one of the few practical applications for surveillance video in the average home . . . unless of course you're excessively paranoid and want a camera to eye the silver or the cookie jar. Many pool owners hang a few in with the bug

Fig.2. How to keep your camera happy. This enclosure for Panasonic has provisions for a tilt/pan mechanism, wiper unit, heater/ defroster and a sunshield.

zappers and plastic Japanese lanterns so as to be able to keep an eye on the kids without having to stay glued to the sundeck. The monitor can be couched in the kitchen, den, or other conditioned locale. The versatility of the system can be further enhanced by adding a PA, with the mike beside the monitor. With this, you can scream "Marcia. Stop throwing the cat off the diving board. You know it gets caught in the filters . . .!" without leaving your chair.

Switchers

In the more sophisticated — i.e. expensive-surveillance systems where there might be two diving boards and any number of cats . . . and more to the point, great seething hordes of battle-weary, hard-bitten cameras, dealing with the signals produced by the electronic eyes may be far more demanding than the actual production thereof. If a large area is to be covered, several dozen cameras may be involved. If the number of personnel required to watch the outputs of these things is to be kept within the confines of economic practicality . . . after all, there's no point in having surveillance if it costs more than anyone could reasonably rip off . . . , some method of compressing the number of lines in must be found. Alternately, some of the human functions must be relegated to non-humans. That's machines, as opposed to the Liberal party.

The most practical way of reducing, say, a dozen images into three or four monitors is by using time division multiplexing. If you're not trying to confuse someone, this means that you look at one picture for awhile, and then at another, and then at the next one and so on. The techniques for doing this . . . it seems simple enough now but it won't in another minute or two . . . are largely dependent upon the type of surveillance and the desired coverage involved. However, all have the common aspect of a device called a switcher.

A very simple type of switcher can be seen in the WV-900 monitor, in Fig. 4. It is comprised of the three buttons on the right side of the set, just below the power switch. The set has three, instead of just one, inputs, and the buttons allow the operator to select which one will be shown. This arrangement is elegantly compact but leads to a few hassles. It requires that the hairy

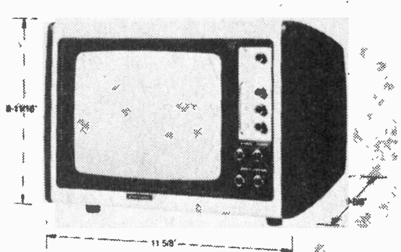


Fig.3. The Panasonic WV-900 CCTV monitor has facilities for monitoring up to 3 cameras.

brute watching the box either sits very close to the screen, which taxes the eyes and blurs the brain even more than watching TV for eight hours a night usually would, or keep moving back and forth to change "channels". Humans, being a relatively lazy lot when not themselves under surveillance, one might expect that many operators would leave the thing switched into one line for extended periods of time with the result that portions of the protected area are, in fact, not protected at all. A sad state of affairs, this. Someone could come and steal the other two cameras.

One solution to this is the external video switcher which can be mounted in a rack conveniently located chair-side. This can be the same rack where you mount the PA for screaming at the kids, if you still have an aquatic application in mind. Switchers come in denominations of six and twelve input lines and by grouping these together, any number of inputs can be handled. They also come in both passive and active designs. The passive ones, which are relatively cheap, are simply sets of switches in metal cases. The active systems contain buffer amps, which permit the inputted lines to be looped out again, to be sent on to other devices for additional processing. We'll get to that in the fullness of time.

The manual switchers still have one major drawback in common with the simple, set-mounted switcher discussed a moment ago . . . this being that they require a manual (or womanual) with sufficient motivation to keep switching them. Fortunately, the technology that produced the self-scanning CB and the electronic roulette wheel have made even this gruelling physical exertion unnecessary. It is no longer necessary to hire people with the dexterity to operate the buttons for we now have automatic switchers. Even a gorilla can use one.

The present approach to automatic switchers has turned up quite a clever bunch of machines. The WJ-507A is an example of one of these. It accepts up to ten inputs, and automatically switches each one to its output, presumably to be fed to a monitor, for a period of between one and thirty seconds. Red LEDs indicate which line is up at any given moment. It is possible to switch any of the lines out of the sequence. If there is no video on one or more of the inputs, the machine can leave these lines out and skip along until if finds a picture. The sequencer also has a second, "spot", output and it is possible to switch any line so that it shows up continuously on this spot monitor, as well as being included in the switching sequence. One can also get a version of it that has a built-in alarm. When an external trigger switch, like a wired door-mat or window, electric eye or a doppler detector, is set off, the switcher automatically goes into spasms and locks onto the camera which is looking at the location of the disturbed sensor. It also starts to scream like Jimmy at Billy. Once the trouble has been found, the system can be reset.

Automatic switchers are usually designed to be interfaced with a time lapse video recorder, of which we will speak at length presently. As such, they also produce a trigger pulse every time they change lines, which is used to start the recorder.

Automation

As mentioned earlier, there is considerable interest in having electronics do a lot of the monitoring in surveillance applications. First of all, hardware is cheaper than employees and rarely gets involved in labour disputes. It doesn't get sleepy and miss things and it doesn't get lazy. It also requires considerably less space than would a human operator.

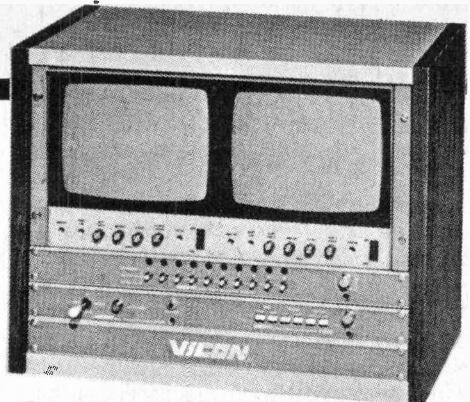
Probably the most sophistacated electronic monitoring device is the automatic motion detector, such as the Vicon V222MD. These systems used to be fairly primitive, employing a photo cell in a suction cup which stuck onto the surface of the monitor CRT. The photo cell was part of an adjustable balanced bridge. When something moved in the picture, presuming it was, in fact, directly beneath the photo cell at the time, the brightness of the image changed, which in turn, upset the bridge and rang an alarm. This, of course, also happened when the suction cup lost its vacuum and fell off the screen.

The newer detectors, such as the Vicon, are all solid state and don't have any suction cups at all. (No, and they don't attach the photo cell with tape; there isn't one of those either). The circuitry in the detector superimposes one or two "windows" over the image and scans these areas continuously. The size of the windows can be adjusted to cover any part of the picture. The area inside the windows must remain at a constant brightness level, within 2%, or the thing throws a fit.

Another problem with human operators is in having to keep track of what they're watching, especially when the bells and buzzers start going off. The solution to this is the automatic time generator, which superimposes the time, date, and even a stop-watch function, on the screen. This one, built by FOR-A Manufacturing, is seen here keeping track of a city, lest someone should swipe a building.

This Company also builds a video switcher which superimposes a title on the screen, so that each line can come with its own on-screen identification. It might be possible to interface this with Vicon motion detector's alarm alarm circuit so that it will display "Pardon me. We appear to be experiencing a robbery, " in the event that the detector is set off.

Lastly, we come to the monitors themselves , and the video recorder. The basic monitors are very similar to to regular video monitors. The exception is usually in that they have a provision for underscanning. In most video displays, the picture actually extends beyond the edges of the tube, in order to compensate for the possible eventual shrinkage of the raster. In a new set, about twenty percent of the picture can get lost under the little plastic escutcheon around the periphery of the mighty orb. In a surveillance application this would be something of a drag if a plot was being hatched somewhere in this twenty percent. Thus, the raster is always adjustable so as to permit the operator to make it smaller than the screen itself, rendering a slightly reduced view, perhaps, but one which takes in everything the camera sees.



For more sophisticated systems, Vicon Industries offers a modular series that allows mixing of monitors, switches, motion detectors and more.

More sophistacated, perhaps, are the monitoring systems, such as the Vicon 920 and 931 series, which allow the operator to feed back to the camera. The monitoring console is provided with servo controls which actuate motors driving the camera's zoom, focus, aperture and positioning.

This permits one camera to cover a larger bit of terrain, although we do return to the weary operator difficulty again. Fortunately, these systems also include an "auto pan" feature, which permits the arm chair security guard to sit back, crack open a brew and get peacefully seasick watching the tube.

The output of the monitor is very often sent to a video tape recorder to provide permanent records of what was going on while surveillance was coming down. This usually results in miles of really exciting footage of the inside of a dark, empty store. However, because, if something does happen, the event would usually have passed by the time the operator managed to get the recorder running, the VTR is of a special type, called a time lapse recorder. The Panasonic NV-8030 is an example of this type of machine.

The recorder uses reels of half-inch tape, and lays down images in the conventional EIAJ No. 1 format, just as do most half-inch machines. However, when switched on it only records a single frame, and then waits to be triggered again to lay down one more. This can be via its internal switch or by an external pulse, such as that from a slow oscillator — say once every few seconds, or the trigger pulse from an automatic switcher, to produce one image each time the switcher goes to a new line. If the recorder is actuated at twelve second intervals, a reel of tape will last for a month.

The time lapse VTR also has an alarm mode. When it becomes riled by any sort of alarm signal or wisecracks made in its presence, it automatically speeds up to get in more of what's transpiring. It can be set to return to its regular glacial crawl after a preset time or upon receiving a "please return to your glacial crawl" signal.

Upon playback, the recorder can be made to just parade through the images on the tape, to stop and display one in still frame for closer scrutiny and nit-picking, or to just search around until it comes across a bit where the alarm mode has be actuated. This is a great leap from the earlier systems, which required that virtually hours of images had to be gone through to find the one in question, only to learn that the building was on fire and one should have split some time previous.

What's Off

Yes, I think that that will about do it. I believe that the time has truly arrived to find a proper way to put the nasty one-eyed monster out of its misery. A number of suggestion come to mind. One might simply place it atop thirty or forty sticks of CIL Gold Industrial dynamite and blow it to the moon. Or place it deftly beneath a pile driver. Drop it into a pit. Leave it in the middle of the highway one night. Tie it to the railway tracks. No, wait. Attack it with a chain saw. Drag it behind a horse. Ignore its piteous begging for mercy; it derserves whatever it gets. Hang it by the feet until all its electrons run into the tuner and it turns red. Put it to the rack, lock it away in the basement and never let it see another sensible human being for the rest of its life. No, forget that. You do that now. Pull out its tubes, one by one . . . well, I can't help it if your set's transistorized. Mine isn't. Throw it to a pack of voracious lions. Boil it in oil. No, that's too expensive. Boil it in gasohol. Wait, wait. I have it.

Put it in front of another set and turn them both on until they go mad.

I'll be back next month but in a different guise. After lengthy consultations with the Editors of ETI, and the official policy making blackjack deck, it has been decided (I think) to expand the ol' column to include other area of technology. We'll still be dealing with video from time to time but along with it will come some of the freaky new computer, LSI chips that do things you never thought you'd want done and even crazy Max, who'se become a development all to himself. He wants to program his personality into a ROM chip in case he's ever taken from among is. How many K do you need to program for gross over-indulgence and hairy feet, do you suppose?

Yes, that's it. Thumb screws. We'll use thumbscrews. Oh, but . . . where're a TV's thumbs? Hmm.

Stay tuned, y'all. ●

I should also offer three cheers and tiger for Mark Salusbury at Tel Tech electronics, who, at his own expense, mounted a fifteen elephant safari into the wilds of his file room to dig out the pictures used herein.

Next month Steve Rimmer returns with his wider brief in a column changed from What's On to What's New.

INTO ELECTRONICS

Part 1.

Are you baffled by volts, and toggle switches? If so, then this new major series, by Ian Sinclair, is for you.

ANYTHING CALLED ELECTRONIC is also electrical, so that we need to start by understanding and being able to use some common electrical terms. Let's start with current. Any current is a flow of something, perhaps of substances that can be seen, like water; sometimes of invisible materials, like air. Electric current is a flow of invisible particles. Luckily, they make themselves felt in other ways. The name we give these particles is electrons.

Electrons are tiny particles, parts of the atoms that all materials are made of. When we rip electrons away from their atoms, we find that they are strongly attracted back again. This is what happens when a plastic ruler is rubbed with a piece of cloth — some electrons are rubbed off the ruler and on to the cloth (or sometimes the other way round). The ruler will then pick up small pieces of paper because it is trying to get its electrons back (if it lost them), or trying to give them back if it gained them. This force between the electrons and the atoms which lost them is a strong force. It has to be when a ruler can pick up a few bits of paper which the entire Earth is attracting downwards with its gravity. Unlike gravity, though, the forces between particles like electrons can act to repel particles apart as well as to attract them together.

Electric Charge

The force of gravity that keeps the planets in their orbits is caused by the quantity we call mass, so shouldn't there be some quantity that causes these forces, called electrostatic forces, between electrons and the atoms? We call this invisible quantity 'charge', or 'electric charge', and careful measurements show that each electron carries the same amount of charge.

Two types of charge exist; we call them negative (—) and positive (+). These two types of charge cause the two directions of force, because a positive charge always attracts a negative charge, but two charges of the same sign (two positives or two negatives) repel each other. Which type appears on an electron? It doesn't matter, but we decided a couple of hundred years ago that we would call the sign of the charge on the electron negative.

When an electron, or any other charged particle, moves, it takes its charge with it and this movement of electron charge is what we call electric current. When charge moves like this, the average amount of charge passing a point per second is the quantity of current. We could, if we liked, take the unit of current as the amount flowing when electrons move past at the rate of one per second. Even with the sensitive instruments we use now, though, this would be too small a unit, so that we

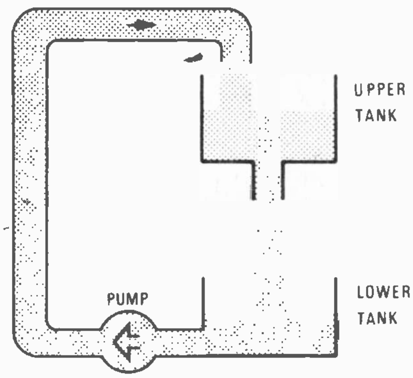


Fig.1. Currents. A water current, moved by a pump, can be kept moving if the same water is constantly re-cycled.

use the unit called the ampere, shortened to amp. We can measure one amp without counting electrons — which is just as well, because a current of amp means six and a quarter million million million electrons per second.

Because of the strong electrostatic forces, we can't take all these millions of electrons away from a material. If we are to move all these millions of electrons every second, we need to replace each electron that is separated from an atom. This can be done by using a circuit. To understand this, think of another type of example: Suppose we pump water from one tank to another, higher up. The pumping and the current of water has to stop when the lower tank is dry. We can keep the current flowing only if the lower tank fills again, and the easiest way is to allow water to flow back from the higher tank. What we have now is a water circuit in which the water can keep circulating — we use such a circuit for central heating systems. In an electrical circuit, electrons circulate through wires. The wires are already full of electrons — all materials are — but to have an electric current something has to move them. The pumping is carried out by a battery or generator, and electrons are pumped to a part of the circuit, a flashlight bulb perhaps, and allowed to flow back along another wire. In every electrical circuit, the amount of current leaving the battery or generator must be equal to the amount of current returning to the battery or generator. When electrons move in a circuit, causing an electric current, three effects can tell us that the electrons are moving. One effect is heat — when an electric current flows

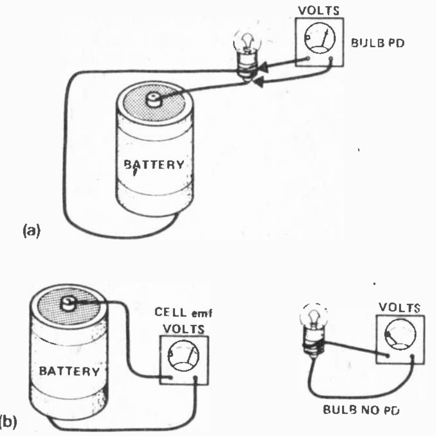


Fig.2. EMF and PD (a) When a cell and a bulb are connected, we measure a PD across the bulb (b) When the cell and bulb are disconnected , we measure as EMF across the cell, but no PD across the bulb.

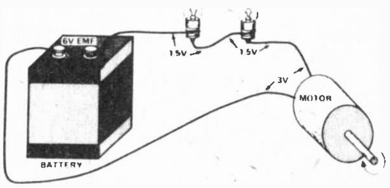


Fig.3. In a complete circuit, the PDs across each section of the circuit, with the same current flowing, add up to the EMF.

through a material heat is given out so that the temperature of the material rises. Another effect is magnetism. When electrons move they cause magnetism which can be detected by a compass needle. The third effect is the chemical separation which we make use of in electroplating.

Pushing It About

No current flows unless something moves it along. Water flows because the force of gravity pulls water from high places on Earth to lower places: air flows because the pressure of air at one place is higher than at another. The quantity that drives electric current is called electro-motive force (shortened to EMF) and is measured in units called volts (V). EMF exists wherever energy of some sort: heat, chemical energy, light or motion is converted into electrical energy, even if there is no flow of current. A battery will have an EMF, 9 V for example, whether it is connected to a circuit or not, because the chemical action inside the battery has created the 'push' which *could* move a current round a circuit. When we use an EMF to cause a current, energy is converted and the chemical action of the battery continues. The value of EMF can be measured by a 'voltmeter'.

When an electric current flows, we find that we can take 'voltage' readings with the voltmeter at parts of the circuit other than the battery. These readings are of 'potential difference', also measured in volts. The distinction is that these readings of potential difference (PD) are caused by the current and will disappear when the current stops flowing. The sequence is that EMF causes current which causes PD. If we divide any circuit into sections (Fig. 3) then the PD across each section can be measured. Adding all of these PD values gives just the amount of the EMF.

Power and more Power

When an EMF causes a current to flow, power is being converted into its electrical form. The amount of power is measured in units of watts (W), and the number of watts being converted in any part of the circuit is found by multiplying the number of volts of EMF or PD by the number of amps of current. Power is the rate at which energy is converted from one form to another (energy is never created nor destroyed), so that the amount of power equals

$$\frac{\text{Amount of energy changed}}{\text{Time taken}}$$

When we multiply the amount of EMF by the amount of current flowing in a complete circuit, the figure of power obtained is the amount of power converted into the electrical form. This power is converted back to other forms in the circuit: Perhaps somewhere in the circuit a wire is heated by the current, so that power is converted into the form of heat. The amount of power converted into this form can be found from electrical measurements. We measure the PD across the wire, and multiply this value by the amount of current flowing through the wire. For example, a 6V,0.3 A flashlight bulb will convert × 0.3 W, or 1.8 W of electrical power into heat and light. Whenever we multiply an EMF value by a current value, the result is power converted into the electrical form inside a battery or generator. When a PD value is multiplied by a current value, the result is the amount of power converted out of the electrical form into some other form such as heat, light, magnetism etc. in a circuit. When the conversion is into heat, we usually speak of the power being dissipated, because we cannot recover the energy again.

Ohm, Sweet Ohm

These quantities, EMF or PD, current and power are all related to each other, so that when we pick a value of EMF to use with a circuit we also settle how much current can flow and how much power is converted. In any circuit or part of a circuit, the ratio of the voltage reading across the circuit to the amount of current flowing through it, 'V/I', is called resistance, symbol R, units ohms. For example, a voltage of 6V and a current of 2A means that the resistance is 6 / 2 = 3 ohms.

The Greek capital Omega is also frequently used as a symbol for resistance.

For circuits made using metals, carbon, and many other conducting materials, the resistance of a conductor is constant while the temperature is constant, it does not change when the current or the PD are changed. This was discovered by Georg Ohm, and is called Ohm's law. If we know that a resistance value is constant, then we can calculate the amount of voltage across the resistance, knowing the amount of current; or we can calculate the amount of current, knowing the voltage. If Ohm's law is not followed, then the calculation is not so easy, as we shall see when we start to use semiconductors.

Multiples and Sub-Multiples

The measuring units of volts, ohms, amps and watts are just the right size for many *electrical* measurements. For electronics use, however, we often need larger units (particularly in ohms) or smaller units (especially for amps). This avoids having to use quantities such as 0.00016A or 1 200 000 ohms repeatedly. To cope with this we use a standard set of prefixes (see Table 1) to convert the units into multiples or submultiples, all powers of ten. For example, the prefix micro — means 10^{-6} (one millionth), so that 0.000 16A is 160u A, 160 microamps. Mega means one million (10^6) so that 1 200 000 ohms can be written as 1.2 M (the 'R' of ohms is often left out). By choosing our multiples or submultiples, we can avoid having to use very large or very small numbers, and we can also make calculations easier.

Using Ohm's law in the form V=R.I, for example, we would normally have R in units of ohms and I in units of amps, giving V in units of volts. If we use units of k for resistance and mA for current, the result is still in volts, because k x m is 1000 x 1/1000, which is 1. Similarly, a value of resistance in M multiplied by a current in uA will also give a value of V in volts. For example, 2uA flowing through 3.3M will cause a voltage of 6.6V, and 3mA flowing through 10 k will cause 30V

For each electronic circuit, there will be a correct value of 'supply voltage' which will cause the correct current for the circuit. For example, a battery-operated circuit rated at 9V might take a current of 60mA, so that the power drawn from the battery is 9 X 0.06=0.54W. We could not operate this circuit correctly from a 100V supply, because the higher voltage would cause the circuit to take a higher current and dissipate much more power, probably enough to destroy the components. Similarly, if we have a circuit that needs 150V at 0.3A (45W), we cannot expect it to operate from a 9V battery, because a 9V battery does not supply 150V, cannot push 0.3A through the circuit, and cannot provide 45 W to this circuit.

AC and DC

The EMF from a cell or battery has a steady value, almost constant for the whole of its life. This is a steady EMF;

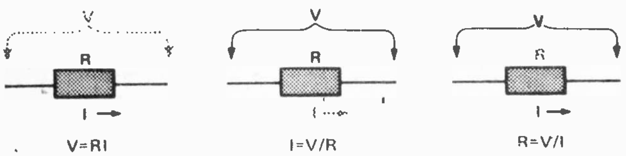


Fig. 4. Ohm's law in its three forms.

Prefix	Name	Value	Power of Ten
M	mega-	1 000 000	10^6
k	kilo-	1 000	10^3
m	milli-	1/1 000	10^3
u or µ	micro-	1/1 000 000	10^6
n	nano-	1/1 000 000 000	10^9
p	pico-	1/1 000 000 000 000	10^{12}

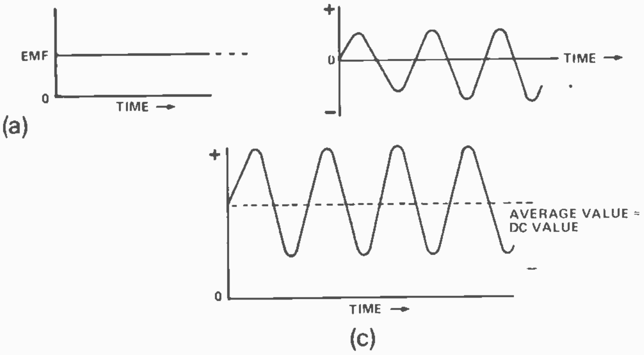
Note do not confuse M (mega) with m (milli).

TABLE 1. Prefixes for multiples and sub-multiples.

connect it to a circuit and you have a steady current if the circuit has a constant value of resistance. The cell gives DC (direct current), direct meaning that the current is steady and in one direction. This type of supply is essential for most types of electronic circuits, so that we need batteries or line-operated direct current power supply units (PSU) to operate our electronic circuits.

That's about all we use DC for, though. In almost every use of electronics we have voltages which are not steady but which change voltage in a definite pattern, so many times per second. Plotting a graph of voltage against time gives a recognisable shape, the waveform, so that we talk of sinewaves, squarewaves, or sawtooth waves, depending on the way in which voltage varies. Voltages like this are called alternating voltages, because their voltage value alternates from high to low, or positive to negative, and back again in a complete cycle.

Fig.5. AC and DC (a) The EMF from the a cell is steady — a graph fo EMF plotted against time is a horizontal straight line. (b) An alternating EMF has alternate + and — values which repeat at definite intervals. (c) When AC and DC exist together we may



An alternating voltage can exist alone, or along with DC or other alternating voltage. When we have an alternating voltage by itself, the value of voltage always alternates between + and — values, and the average value is zero. Because of this, a DC voltmeter connected to an alternating supply reads zero volts. When an alternating voltage and a steady voltage are present together, the average value of voltage is just the value of the steady voltage. We can, if we like, arrange the value of the steady voltage so that no negative voltages (or, if we like, no positive voltages) exist. This action goes by the splendid name of 'applying a steady bias'.

The 'smoothest' form of variation of voltage is the sinewave; which is the waveform that is generated when a coil of wire is rotated between the poles of a magnet. This is the waveform of the line supply (line voltage) used in every country in the world, and generated by alternators. A supply like this has an average voltage of zero, but in a circuit it will cause an alternating current to flow, and the alternating current will also have the same waveform, the sine wave. Because of this, the average value of current is also zero. Electrons are moving in all parts of the circuit, though, so that power will be converted to heat in each resistance in the circuit. Whatever our meter reads, power certainly isn't zero!

The disagreement is caused by the way the meter works. A DC meter is sensitive to the direction of current through it. A current in one direction deflects the needle clockwise, a current in the opposite direction deflects the needle anticlockwise. An AC (alternating current) wave, changing direction many times per second causes no deflection of the needle, because the DC meter simply cannot respond fast enough, and the needle remains at the average value of zero. A resistor will dissipate power no matter what the direction of current may be through it.

Since a DC meter gives no readings of AC, we need some method of measuring the AC waves we use so much. The best method is to measure the peak-to-peak voltage of the wave using an instrument called the cathode-ray oscilloscope (CRO) which can present a graph of the waveform on a screen of a cathode-ray tube. Peak-to-peak voltages of any waveform can be measured in this way.

Waveforms like sinewaves have a negative peak voltage equal to their positive peak voltage, so that we often measure only the peak voltage (half of the peak-to-peak voltage). In addition, power engineers have for many years used a measurement called RMS (root mean square) for sinewaves. This is based on the fact that if we multiply peak values of AC voltage and current together, we obtain a figure for power which is exactly twice as much as the true measured power. If, instead of using peak values we take 0.707 times each peak value, the power calculation comes out correctly, because 0.707 is

$$\frac{\ }{\sqrt{2}} \text{ and } \frac{\text{voltage}}{\sqrt{2}} \times \frac{\text{current}}{\sqrt{2}} = \frac{\text{power}}{2}$$

which is what we want. The name root mean square comes from the theory which also arrives at this figure of 0.707 for a sine wave only. For electronics purposes, RMS values are seldom of interest, the main exception being when the power output of an amplifier is being measured. RMS values using the factor of 0.707 can be used only when the waveform is a sine wave.

Transducers—The quick-change Experts

Microphones, loudspeakers, TV camera tubes, electric light bulbs; all are transducers. A transducer converts power from one form to another, sound, heat, light, electricity, mechanical movement, whatever is needed. A microphone converts the power of the sound waves reaching it into the power of an electrical waveform. A loudspeaker performs the opposite conversion, from electrical signal into sound output; both are transducers. For electronics purposes, the most interesting transducers are those which have electrical inputs or outputs. Using transducers with electrical outputs, for example, we can convert quantities such as temperature, sound intensity, light intensity, distance, speed or force into electrical quantities which may be steady or alternating voltages or currents. We can then use these electrical quantities, which we now call signals, in our electronic circuits to detect, measure or control the quantities that have been converted. This is what electronics is about, and it is the use of transducers that makes it possible, so that we can have electronic thermometers, sound

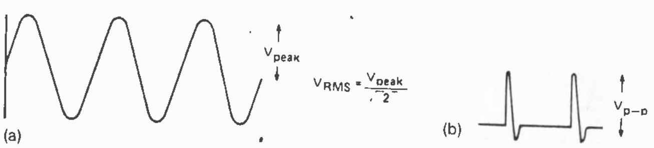


Fig.6. Peak and RMS. For a sinewave only, RMS voltage = peak voltage/$\sqrt{2}$. Using RMS values in power calculations will give true power (wrongly called RMS power) (b) Peak-to peak measurement, often used in electronics.

intensity meters, light meters as well as the familiar record players and tape recorders.

Transducers which work the other way round will convert electronic signals into other forms of power: heat, light, sound, motion and so on. Using both types of transducers means that we can make an electronic circuit part of any system, whether mechanical, acoustical (sound), optical (light) or thermal (heat). If there's a transducer for it, we can control it.

Most transducers have rather low efficiencies, meaning that the amount of power output of the form we want is pretty low compared with the amount of power at the input. The ratio

$$\frac{\text{power output in wanted form}}{\text{total power input}}$$

Transducer	Action	Notes
Thermocouple	Temperature *difference* generates a steady EMF of a few millivolts	Two thermocouples are needed EMF is proportional to temperature *difference*
Thermistor	Change of temperature causes change of resistance	Can be PTC — resistance increases as temperature increases, or NTC, with opposite action.
Microphone	Sound wave in gives AC wave out	Low efficiency, very small output voltage
Loudspeaker	AC wave to sound wave	Low efficiency, sometimes less than 1%
Photocells	Light intensity converted into EMF, or causing change of resistance	Photovoltaic cells give steady EMF output, photo-resistive type change resistance
Accelerometer	Acceleration causes steady EMF	Acceleration causes force on a crystal which generates EMF. Very high resistance. Output can be processed to obtain speed and distance readings
Strain gauges	Strain (stretch) causes change of resistance	Metal or semiconductor wires change resistance as they are stretched
Light Emitting Diode (LED)	PD to light	Operate at low PD and current
Tacho-generator	Rotational speed to EMF, AC or DC	Used in control of mechanical systems
Servo-motor	AC or DC to rotation	Used in control of mechanical systems

TABLE 2. Transducers.

is the quantity (usually written as a percentage) which is taken as the efficiency figure of the transducer. For many transducers this will be less than 5%, so that less than 5 parts per hundred or 1 in 20 of the power in gives a useful output—the rest converts to heat. Motors and generators usually manage higher figures for efficiency, up to 70% for small units, more for larger ones. Transducers for light and sound (photocells and microphones) always have very low efficiency figures. For most applications, the efficiency figure is not too important because we can amplify the power of the electronic signal to compensate for the loss in the transducers.

Resistors

Resistors are the circuit components that are used to control the amount of current that flows in a circuit, making use of Ohm's law. For example, if we want to have a current of 1.5 mA flowing in a circuit, using a 9 V supply, then (remembering that we can use units of mA, V, and k in the formula) we need a resistance value of 9/1.5mA, which is 6k, in the circuit.

Resistors are also used in 'potential divider' circuits. As the name suggests, the potential divider gives an output voltage which is a definite fraction of the input voltage: half, quarter or whatever we like. Suppose we have a 9V battery and we find we need a voltage of 1.5V at some part of a circuit. One solution would be to use a separate 1.5V battery, but the more usual method is the use of the potential divider arrangement as shown in Fig. 8. The circuit consists of two resistors connected in series as shown, so that the total resistance is the sum of the resistance values, R1+R2. If the supply voltage is V, then the amount of current flowing, by Ohm's law, is V/R1+R2. When a current passes through a resistor (Ohm again), there is a voltage across the resistor equal to resistance×current. Using this principle, the voltage across R2 must be R2×V/R1+R2 or V.R2/R1+R2. For example, if R1 is 10 k and R2 is 1 k, then for V=9 V, the voltage across R2 will be 9×1/10+1=9/11V or 0.82V. If we make R1=R2, whatever the values of R1 and R2, the output will be half of the input voltage. For our earlier example in which we wanted 1.5V from a 9V supply, we could use the values of 6.8k and 33k for R2 and R1 respectively. This does not give exactly 1.5 V but is as close as we can get using 'preferred values' (see later) of resistors. A point to remember about these potential dividers is that the calculated voltage holds good only if no current is drawn from the circuit. If current is to be taken from the divider, then the current flowing through R1 and R2 should be at least ten times the amount of current taken from across R2.

The potential divider acts in the same way to divide alternating voltages. One useful application is the 'potentiometer' or volume control. A potentiometer is a resistor fitted with a third sliding contact which can be moved from one end of the resistor to the other. The third contact converts the resistor into a potential divider and because the contact can be moved, the voltage at the contact can be varied. A potentiometer can be used to adjust a DC or AC voltage. When the adjustment has to be made frequently, the potentiometer will be fitted with a control knob and will be placed where it can be adjusted. 'Preset' potentiometers are used for adjustments which have to be made only during overhaul, and are fitted with screwdriver slots for adjustment.

A third use for resistors is in coverting current signals into voltage signals. 'Active' components, such as transistors, give, at their output terminals, alternating currents which we often need to change to alternating voltages. A resistor, called the load resistor does this because of Ohm's law. For example, if a transistor gives a current signal of 0.5 mA peak-to-peak, then passing the current signal through a 10 k load resistor will convert the current signal into a 5 V peak-to-peak voltage signal (because 0.5 mA×10 k=5 V).

Practical Points

Resistors can be made from any conducting material, provided it can be worked into the required shapes, but carbon is the most favoured material. The electrical resistance depends on the length and the diameter of the resistor, as well as on the material itself. For high resistance values we need long pieces of material with a small diameter and preferably a material with a high comparative resistance (high resistivity). Carbon composition resistors use a mixture of carbon and clay (like pencils) pressed into rods to achieve resistance values ranging from about 1 Ohm to several million, but the accuracy of value is not very good, usually about 20%. We can pick out values whose percentage accuracy or tolerance is closer, but this selection process makes the resistors much more expensive, so that we try as far as possible to work with 20% tolerances. More recently, resistors have been made by evaporating carbon or metal films on to ceramic rods and then cutting spiral

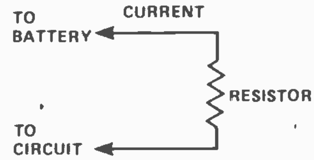


Fig.7. Using a resistor to control an amount of current.

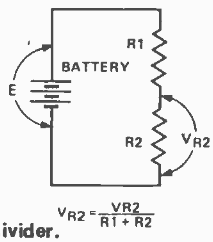


Fig.8. The potential divider.

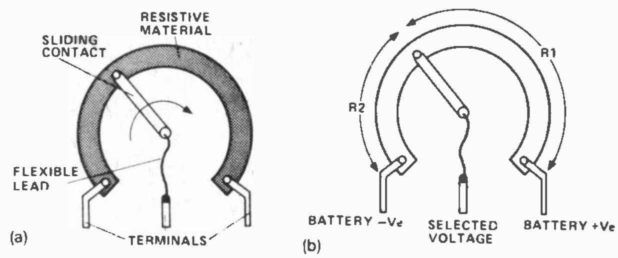


Fig.9. A volume control is a variable potential divider. (a) construction, (b), use in setting a steady voltage level.

patterns on the material to achieve resistance values with better tolerances. Such carbon or metal film resistors are now quite common, and are reasonably priced. For a few applications, resistors are made from wire wound on ceramic rods. Each type of resistor is protected by a hard plastics or ceramic casing which also has the colour-coded value printed on it.

There is no connection between the physical size of a resistor and its resistance value, but the physical size greatly affects how much power can be dissipated as heat. When a current, DC or AC (using RMS quantities) is passed through a resistor, the amount of electrical power converted to heat is given by $R.I^2$ (resistance value×square of current value). For example, a 10 k resistor with 5 mA flowing through it converts $10\,000 \times (0.005)^2$ watts of electrical power, which is 0.25 W, into heat which must be passed on (dissipated) into the air about it. If the heat is not passed on, the temperature of the resistor will rise until it melts, breaking the circuit. Small resistors will dissipate 0.25W or less, and the larger power ratings need larger sized bodies. For power dissipations of 3 W or more, large wire-wound (abbreviated to WW) resistors must be used.

Preferred Values

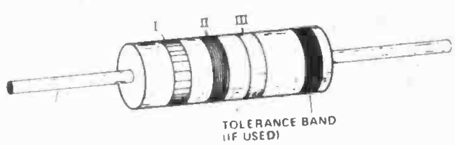
Just as we buy paint in tins of definite size we buy resistors in preferred values. These values are chosen so that all the resistors turned out by the manufacturing process can be used; there are no rejects. For example, if we aim to manufacture a 10 k resistor of 20% tolerance (between 8 k and 12 k), then a 7 k or a 13 k resistor is not reject, because the 7 k can be sold as a 6.8 k and the 13 k as a 15 k. In each case these values are well within the tolerance of 20% of the stated value, and the values in the preferred series have been chosen so that 20% up on one value overlaps with 20% down on another. The preferred values in the 20% range are also used for the 10% range and others, with intermediate values, as needed. Note that we can have a 6.8k resistor in any of the ranges, but a 5.6k resistor is not found in the 20% range. We use the same set of numbers, each of two figures, whether these are single ohms, tens hundreds, thousands or higher multiples. In Europe, you will find the decimal point replaced by a letter; R meaning ohms, k meaning thousands or M meaning

20%	10%	20%	10%
1.0	1.0	3.3	3.3
	1.2		3.9
1.5	1.5	4.7	4.7
	1.8		5.6
2.2	2.2	6.8	6.8
	2.7		8.2

Examples of values, 20% series 47k, 220, 3.3k, 150k
Examples of values, 10% series 47k, 120, 3.9k, 180k
The first line would now be written as 47k, 220R, 3k3, 150k using R to represent ohms, and placing k or R (or M) in place of the decimal point.

TABLE 3. Preferred values, used for resistors, capacitors and zener diodes.

Colour	Number
Black	0
Brown	1
Red	2
Orange	3
Yellow	4
Green	5
Blue	6
Purple/violet	7
Grey	8
White	9



Examples

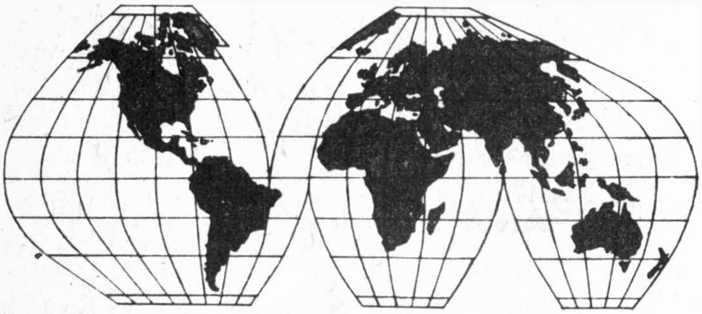
I	II	III	Value
Yellow	Purple	Orange	47 000 (47k)
Brown	Black	Yellow	10 0000 (100k)
Brown	Black	Black	10 —— (10R)
Black	Brown	Black	01 —— (1RO)

TABLE 4. Colour code, used to show values of resistance, capacitance or voltage.

millions. This system (British Standard 1852) is used so that the disappearance of a decimal point in copying or printing operations does not cause any confusion. The same system can be used for capacitance values such as 4u7 and voltage readings, such as 5V6. This convention is slowly gaining acceptance in North America.

Colour Coding

Because of the use of preferred values and multiples, we need only three figures to specify the value of a resistor, two figures for the preferred value and one to indicate what multiplier is used. These are coded on to the body of the resistor, using the colour code shown in Table 4. The colours are arranged in bands round the body of the resistor, starting at one end with the first figure of the preferred value, called the first significant figure. The second coloured band then indicates the second figure of the preferred value (second significant figure) and the third band shows what multiplier is being used: the number of zeros after the second significant figure. A fourth band, silver for 10%, gold for 5%, is sometimes used to show the tolerance value when this is closer then 20%, but not all manufacturers use the tolerance band. ●



SHORTWAVE WORLD

John Garner gives a comprehensive listing of international news broadcasts in English.

"HERE IS THE NEWS" — A summary of English language newscasts from around the world.

Probably the main reason most of us tune into shortwave stations is to hear the news from the country where it is happening. I can recall my first exposure to shortwave listening — it was during World War II when I would listen, along with my father, to the war news over the BBC. It is also interesting to compare the viewpoints of various countries, through their newscasts, regarding international events.

This month we will list times and frequencies of English language newscasts from countries all around the world. All times are in Co-ordinated Universal Time (UTC) which is the same as Greenwich Mean Time (GMT) and is equivalent to Eastern Daylight time plus five hours. Frequencies are listed in kilohertz and, as always, frequencies are subject to change to suit propagation conditions and to avoid interference with other broadcasters.

So now "Here is the news!"

Afghanistan — Radio Afghanistan has a news program at 1900 on 15077.

Albania — English news from Radio Tirana at 0000 on 7065 and 9750; 0130 and 0230 on 7120 and 9750; 0330 on 6200 and 7300; 0430 on 7300 and 9480; 0630 on 7080 and 9500; 0700 and 0930 on 9500 and 11985; 1230 on 9515 and 11965; 1400 on 9500 and 11985; 1630 on 7065 and 9480; 1730 on 11985 and 15440; 1830 on 7065 and 9480; 1930 on 7075 and 9500; 2030 on 7065; and 2200 on 7065 and 9480.

Algeria — English news from Radio Algiers at 2000 on 7195, 9510, 11740, 11810, 15157, 15215 and 15360.

Angola — Try for Radio Nacional Angola at 1130 on 7245, 9535 or 11955, (Mon. to Sat.).

Argentina — Radiodiffusion Argentina al Exterio (RAE) has news in English at 0300 and 0600 on 9690 and at 2300 on 11710.

Australia — There are a lot of news broadcasts out of Radio Australia, mostly beamed to Asia and the Pacific, so I will just list those that are directed to North America. 0100 and 0200 on 17795 and 21740; 1100, 1200 and 1230 on 9580.

Austria — The ORF has news at 0130 and 0330 on 5945 and 9770; 0430 on 12015; 0830 on 6155; 1230 on 6155, 9770 and 15290; 1830 on 6155.

Bangladesh — Try for news from Radio Bangladesh at 0445 on 15400, 17890, and 21685; at 1230 on 15285 and 21670; at 1815 and 1900 on 11765 and 15285.

Belgium — BRT has newscasts at 0020 on 15175 and 15385; 1330 on 17730; 1605 on 6010 and 17730.

Bulgaria — English news on Radio Sofia at 0000 on 15330; 0430 on 15135; 1830 on 15310 and 17825; 2030 on 11735, 15310 and 17825; 2130 on 11730 and 15135.

Canada — If you are out of the country why not take along a portable shortwave receiver and keep in touch with the news from Canada on Radio Canada International. At 0000 on 5960 and 9755; 0100 on 5960, 9755 and 17820; 0200 on 5960, 9655 and 11940; 0300 on 5960, 9535, 9655, 11845 and 11940; 0400 on 5960, 9535, 9655 and 11845; 0615 and 0645 on 6140, 7155, 9590, 9760, 11775, 11825, 11960, 15440 and 17860; 1545 on 9555, 11915, 11935, 15160, 15325, 17820; 1645 on 15325 and 17820; 1800 on 15260 and 17820; 1900 on 7130, 9555, 15325, 17875; 2000 on 7295, 9555, 15325, 17820, and 17875; 2130 on 11945, 15150, 15325 17820 and 17875.

China (People's Republic of China) — Radio Peking has news at 0000 on 15120, 17680 and 17855; 0100, 0200, 0300 and 0400 on 15120, 15230 and 17680; 0830 and 0930 on 9460, 11600, 11720, 15120 and 17635; 1200 on 15280, 15520, and 17700; 1300 on 15280 and 17700; 1400 and 1500 on 9860, 11650 and 15165; 1600 and 1700 on 9860 and 15120.

China (Taiwan) — The Voice of Free China has English news at 0100 on 11825, 15345 and 17890; at 0300 on 11825, 15270, 15345 and 17890; at 2130 on 9610, 9765, 11860, 15225 and 17720; at 2140 on 9685, 11825, 15270 and 17890.

Cuba — Radio Habana Cuba (RHC) transmits the news in English at 0100 and 0230 on 11725 and 11930; at 0330 on 11725, 11760 and 11930; at 0500 on 11725 and 11760; at 0630 on 9520; at 1700 on 17710; 2050 on 9770 and 17750; and at 2200 on 11705.

Czechoslovakia — News from Radio Prague at 0100 and 0300 on 5930, 7345, 9540, 9740, and 11990; at 0730 on 11855, 17840 and 21705; at 0745 on 6055, and 9505; at 0830 on 11855, 17840 and 21705; at 0945 and 1145 on 6055 and 9505; at 1430 on 11990 and 15110; at 1530 on 6055, 7345, 9605, 11990, 15110, 17705, 17840 and 21505; at 1730 on 5930, 7345, 9605, 11990, 17840, and 21505; at 1900 on 5930, 7245 and 7345; at 2000 on 5930 and 7345; and at 2130 on 6055.

Ecuador — News from Quito is on HCJB at 0035 on 9745 and 11915; at 0300 and 0400 on 9745, 11910 and 15155; at 0530 on 6095, 9745 and 11910; at 0800 on 11835 and 15200; at 1300 and 1400 on 11740, 15115 and 17890; at 1500 and 1555 on 15115 and 17890; and at 1915 on 15435, 17825 and 21480.

Egypt — From Radio Cairo listen to English news at 0215 on 9475 and 12050; at 1230 on 17920; at 1645 on 15255 or 15165; at 2100 on 15375; and at 2230 on 9805.

Ethiopia — The Voice of Revolutionary Ethiopia has the news at 1530 on 7165 and 9560.

Finland — News from Radio Finland in English at 0330 on 15400 and 15430; at 0930 on 6120, 11755, 15265 and 21465; at 1300 on 15265 and 15400 as well as 6120 and 11755 on Sundays only; 1430 on 6120, 11755, 15400 and 21475; at 1930 on 15265 and 15430; and at 2130 on 6120, 11755 and 15270.

France — The only English language programming from Radio France International is the 55-minute "Paris Calling Africa" at 1605 (1705 during Winter Time) on 11845, 15300, 17720, 17850, 21515, 21570, 21580, 21595, 21620, 25820, 25820 and 25900. International news along with news about France and Africa are carried during the program. There are many other interesting topics as well.

Germany (East) — Radio Berlin International carries these news broadcasts: 0000 and 0130 on 9730 and 11975; 0230 on 11840, 11890 and 11975; at 0345 on 11720 and 11795; 0545 on 17700, 21465 and 21540; 1100 on 15165, 17700, 21465 and 21540; 1215 on 21485; at 1300 on 17700, 21465 and 21540; 1315 on 9730, 11700, 15240 and 15285; at 1430 on 17700, 21465 and 21540; 1315 on 9730, 11700, 15240 and 15285; at 1430 on 17700 and 21540; at 1515 on 11978; at 1645 on 6080, 6115 and 7185; 1700 on 11978, 15145 and 15170; at 1815 on 6080, 6115 and 7185; 1900 on 9665 and 15390; 1930 on 7260; and at 2030 on 6080 and 6115.

Germany (West) — From the other side of Germany the Deutsche Welle puts out English news at 0120 on 6040, 6085, 6100, 6145 and 9545; at 0430 on 7150, 7225, 9565, 9765 and 11765; at 0530 on 5960, 6100, 6185, 9545, 9650, 11705 and 11905; at 0600 on 9700, 11765, 11905, 15275 and 17875; 0930 on 11850, 15225, 15275, 17780, 17800, 21540 and 21680; 1045 on 11785, 15410, 17765, 17875, 21500 and 21600; 1200 on 15410, 17765, 17875 and 21600; at 1715 on 9735, 11965, 15155 and 21600; 1720 on 9590, 11785, 15405, 17825 and 21620; at 1930 on 11905, 15150 and 17795; and at 2100 on 7130 and 9765.

Ghana — Radio Ghana have English news on 6130 kilohertz at 0730, 0830, 1630, 2030 and 2130.

Greece — News from the Voice of Greece at 0140 and 0340 from Tues. to Sun. on 9515, 9650 and 11730. The following newscasts are aired from Mon. thru Sat. — at 0940 on 17830 and 21455; 1040 on 11845 and 15345; 1235 and 1540 on 11730, 17835 and 21455; at 1840 on 11945, 15345 and 17830; 1920 on 7125, 9655 and 11860; and at 2340 on 7125 and 9615.

Hungary — From Radio Budapest, English news at 0100 and 0200 on 6105, 9585, 9835, 11910, 15220 and 17710; at 0930 on 9835, 11910, 15220, 17710, 17785 and 21525; at 1100 on 6025, 7155, 9585, 9835, 11910 and 15160; at 1330 on 6025, 9585, 9835, 11910, 15160 and 17710; and at 2000 on 6025, 7165, 9585, 9835, 11910 and 15160.

India — All India Radio (AIR) has the following English newscasts: at 0100 on 7215, 9535, 9605, 11765, 11810, 15110, and 15375; at 1000 on 11935, 15205, 15350, 17387, 17875, 21695; 1330 on 11810 and 15335; at 1800 and 1900 on 9715, 11620, 15165 and 15190; at 2000 on 9755, 9912, 11620, 11865 and 15165; at 2100 and 2200 on 9912, 11620, 11755, 15110 and 15165; and at 2300 on 7215, 9535, 9605, 11765, 11810, 15110 and 15375.

Indonesia — There are three English newscasts from the Voice of Indonesia — at 0100, 0800 and 1400 on 11790 and 15200.

Iran — The Voice of the Iranian Republic transmit the news in English at 1830 on 9022 or 9033.

Iraq — Two newscasts from Radio Baghdad: 0300 on 11935 and at 2130 on 9745.

Israel — From Kol Israel — 0000 and 0100 on 11637, 15582 and 21710; at 0200 on 9815, 11637 and 15582; at 0500 on 7465, 11637, 15105, 15582, 17685 and 21675; at 1200 on 7465, 11620, 15604, 17612, 21675 and 25640; at 1600 and 1800 on 7465; at 2000 on 9009, 9815, 11610, 17685, 17815, 21600 and 21675; and at 2230 on 9815, 11637, 15582, 17685, 17710, 21675 and 21710.

Italy — Radiotelevisione Italiana (RAI) transmits the following English news programs: at 0100 on 9575 and 11800; at 0350 on 15330, 17795 and 21560; 0425 on 5990 and 7275; at 1935 on 7275, 9710 and 11800; at 2025 on 7235, 9575 and 11800; and at 2200 on 9710, 11800 and 15315.

Ivory Coast — The news can be heard over Radio Abidjan at 1845 on 11920.

Japan — If there was a prize for the largest number of English language news broadcasts, Radio Japan would win easily. Some of these times and frequencies will be difficult to hear in Canada but most are heard quite often. At 0000 on 15310, 15195 and 17755; at 0100 on 15310, 17755 and 17880; 0130 on 15235, 17725, 17825, and 21640; 0200 and 0300 on 15310, 17755 and 17880; 0400 on 15310, 15195 and 17755; at 0500 on 15310, 15195 and 15270; 0600 on 15195, 15270 and 17810; 0700 on 15195, 15270, 15435 and 17810; 0800 and 0900 on 9505, 15195 and 17810; 0930 on 11875 and 15235; 1000and 1100 on 9505, 15195 and 17810; 1115 on 9674 and 11875; 1200, 1300, 1400, 1500 and 1600 on 9505, 11815 and 15310; at 1630 on 11705 and 15235; at 1700 and 1800 on 9505, 11815 and 15310; 1830 on 11855 and 15420; 1900 and 2000 on 11815, 15270 and 15310; 2015 on 11855 and 15235; 2100 on 11815, 15270 and 15310; 2200 on 15180, 15195, 15310 and 17755; at 2300 on 15195, 15310 and 17755; and at 2345 on 15270 and 17825. The 2345 broadcast is at the beginning of an hour long English program beamed to North America.

Jordan — Radio Jordan brings you the news at 1600 and 1700 on 9560.

Korea (North) — Newstime from Radio Pyongyang— 0600 on 9420 and 11905; 0800 on 9977 and 11780; 1100 and 1300 on 9977; 1500 and 1700 on 9977 and 11885; 2000 on 6576 and 9420; and at 2300 on 9977.

Korea (South) — These newscasts come from Radio Korea 0330 on 9640, 11620 and 15570; at 0730 on 9640, 9870, 11810 and 15570; 1000 on 6135, 7275, 9525, 9570 and 11725; 1245 on 7550, 9815 and 15570; 1600 on 6480, 9720. 9870 and 11830; at 1800 on 11830; at 2000 on 6480, 7550, 9870 and 11665; and at 2300 on 7550, 11590. 15375 and 15570

Kuwait — A couple of newscasts from Radio Kuwait — 0530 on 9650 and 21545; and at 1830 on 9650, 11665 and 15345.

Lebanon — Not too well heard here but try for the news from Radio Lebanon at 0230 on 17890.

Libya — Radio Tripoli via Malta has English news at 1525 on 7120.

Malawi — The Malawi Broadcasting System (MBS) has news at 1600 on 3380 and 5995.

Malaysia — News from the Voice of Malaysia at 0530 and 0830 on 6175, 9750 and 15295.

Malta — Radio Mediterranean has an English newscast at 1835 on 5960.

Mozambique — Radio Mozambique has three newscasts although these are difficult to hear in Canada — 0400 and 1800 on 3265 and 4855; and at 1100 on 9660 and 11815.

Netherlands — Radio Nederlands broadcast several very good newscasts — at 0230 on 6165 and 9590; 0530 on 6165 and 9715; 0700 on 5955, 11720, 15235 and 17605; 0730 on 9715 and 9770; 0830 on 9715; at 0930 and 1330 on 5955, 6045, 9895, 11930 and 17605; 1430 on 11735 and 21480; 1830 on 6020, 15220 and 17605; and at 2030 on 9715, 15220, 17605, 17695 and 21640.

Netherlands Antilles — Trans World Radio broadcast the news from Bonaire at 0130 on 11925.

New Zealand — Quite a few times here but these are rather difficult. The best time is around 0600 — 0000, 0200, 0300, 0500 and 0600 on 15345 and 17860; 0830, 1000 and 1200 on 6105 and 11945; 1800, 1900 and 2100 on 11835 and 15485; and at 2300 on 15345 and 17860.

Nigeria — The Voice of Nigeria has English news at the following times and frequencies: 0530 on 7255 and 15119; 0830 and 0930 on 15119; 1630 on 7255; 1830 on 11770 and 15119; 1930 on 7255; 2030 on 11770; and at 2130 on 11770 and 15119.

Pakistan — Radio Pakistan have a number of English news broadcasts, some of which are read in slow English. At 0230 on 17835 and 21590; 0840 on 17644 and 21590; 1005 on 17662 and 21655; 1040 on 17641 and 21450; 1100 on 17662 and 21655; 1600 on 17660, 17910, 21485, 21635 and 21755; 1650 on 17641, 21605; at 1700 on 11675 and 15485; and at 1738 on 17660 and 21635.

Philippines — The Voice of the Philippines have three English newscasts — at 1000, 1200 and 1700 on 9580 kilohertz.

Radio Veritas also has three English newscasts — at 0055 on 15135, 15285 and 17790; at 1155 on 9615, 11775 and 15215; at 1455 on 9605, 11955 and 15215.

The Far East Broadcasting Corporation has these news programs: at 0030 on 11890, 17810 and 21515; at 0130, 0230, 0330 and 0430 on 15305, 17810 and 21515; 0830 and 0930 on 11765; 1330 and 1430 on 15440; and at 2330 on 11890, 15450 and 21515.

The Philippine News Agency uses FEBC facilities to present English news Mon. thru Fri. at 0230 on 15450.

Poland — Polish Radio brings the news at 0200 and 0300 on 6095, 6135, 7145, 7270, 9525, 11815 and 15120; 1200 on 6095 and 7285; 1230 on 9525, 9675, 11840 and 15120; 1600 on 6135 and 9540; 1630 on 7125, 9525, 9675 and 11840; 1830 on 6095, and 7285; at 2000 on 7125, 7145, 9525 and 9675; at 2030 on 6095 and 7285; and at 2230 on 5995, 6135, 7125 and 7270.

Portugal — Here is the news from Radio Portugal — at 0300 on 11925 and 15125; 0500 on 9575 and 11925; 1600 on 21530; 1800 on 17880 and 21530; and at 2030 on 6025.

Romania — News from Radio Bucharest at 0130 and 0400 on 5990, 9570, 9690, 11735, 11840 and 11940; 0530 on 11840, 15340 and 17745; 0645 on 11940, 15255, 15335 and 17805; 1200 on 15345 and 17825; 1300 on 11940, 15250, and 17850; 1500 on 11775, 15335 and 17805; 1730 on 11885, 15345 and 17720; 1930 on 9690 and 11940; and at 2100 on 7195 and 9690.

Saudi Arabia — The Broadcasting Service of the Kingdom of Saudi Arabia has one English newscast at 1915 on 11854.

Senegal — One newscast from this country at 1845 on 11895.

Seychelles — English news from this small island in the Indian Ocean comes from the Far East Broadcasting Association (FEBA) at 0700 on 15160 and 17785; and at 1530 on 11855 and 15325.

Somalia — Radio Somalia has one English newscast at 1100 on 9585.

South Africa — Radio RSA has their English news at 0200 on 5980, 9585, 9610 and 11900; at 0300 and 0400 on 3995, 4990, 5980, 7270 and 9585; at 0600 on 15220, 17780 and 21535; at 1100, 1300, 1400 and 1500 on 15220, 21535 and 25790; and at 2100 on 9585, 11900 and 15155.

Spain — From Spanish Foreign Radio we have news at 0030, 0130 and 0545 on 9630 and 11880; at 2030 on 9765 and 11840; and at 2130 on 7105, 9765 and 11840.

Sri Lanka — One newscast from here over the Sri Lanka Broadcasting Corporation (SLBC) at 1755 on 11800, 15120 and 17850.

Sweden — Radio Sweden has news at 0230 on 11705 and 15290; at 1100 on 9630 and 21690; at 1230 on 21635 and 21690; at 1400 on 21514 and 21700; 1830 on 6065 and 15240; 2100 on 15240 and 15320; and at 2300 on 11705 and 15380.

Switzerland — Swiss Radio International (SRI) has these English newscasts: 0145 on 6135, 9725, 11715, 15305; at 0430 on 9725 and 11715; 0700 on 3985, 6165, 9535, 9560, 15305, 21520 and 21695; 0900 on 9560, 15305, 21520 and 21695; 1100 on 15430, 17795, 21520 and 21630; 1315 on 3985, 6156, 9535, 15305, 17735, 17830, 21520 and 21570; 1530 on 3985, 6165, 9535, 15125, 17700, 17830, 21540 and 21570; and at 1815 on 3985, 6165, 9535, 15170, 17760, 17830, and 21585.

Tanzania — Radio Tanzania brings us the news at 0400 on 5985, 6105; at 1000 on 9750; at 1600 and 1800 on 4785 and 15435; and at 1900 on 15435.

Thailand — Radio Thailand has two news broadcasts in English — at 0415 and 1055 on 9655 and 11905.

Turkey — Four newscasts from the Voice of Turkey — at 1200 on 15185 and 17860; 1330 on 17860; 2030 on 11885 and 11895; and at 2200 on 7215, 9515, 15250 and 15360.

USSR — Radio Moscow transmits the news every hour on the hour during their World Service. Each broadcast is carried on many frequencies and to list all of them would require the whole magazine so I will just list a few of their North American frequencies. You should be able to hear Radio Moscow on

Continued on page 67

AUDIO AMP CIRCUITS

An audio amplifier seems to be one of the most trivial design problems there is, until you need one. Here Ray Marston describes twenty circuits to solve your audio gain blues.

AUDIO PREAMPLIFIER ICs are specifically designed to give very low noise figures, excellent supply 'ripple' rejection, low distortion and wide bandwidth. They give small-signal performances that are superior to those obtainable with conventional op-amps.

IC pre-amps usually come in the 'dual' form, with two identical but independent (apart from the supply connections) circuits in one package. National Semiconductors produce a range of five popular low-noise dual pre-amplifier ICs, the LM381A, the LM382, the LM387 and the LM387A. The 'A' suffix devices are premium versions of their type, with superior low-noise figures.

All five ICs use the same basic amplifier circuit and essentially differ only in minor details and in their pin-outs. All amplifiers accept differential or single ended inputs, use internal compensation, use internal power supply decoupler -regulator circuitry and can provide large output voltage swings and. wide power band widths. The LM381 and LM381A have provisions for externally narrow-band applications. The LM382 has a built-in resistor matrix that enables the user to select a variety of closed loop gain options and frequency response characteristics. The LM387 and LM387A are 9-pin 'utility' versions of the LM381/LM381A.

In most of the practical circuits shown here, only one amplifier of the IC is shown in use. Equivalent IC pin numbers for the remaining amplifier are shown in the paranthesis.

The LM382, with its built-in resistor matrix, enables many amplifier designs to be achieved with a minimal number of external components.

The small physical size of the 8-pin LM387 and LM387A IC makes it attractive for use in many low-noise pre-amplifier applications.

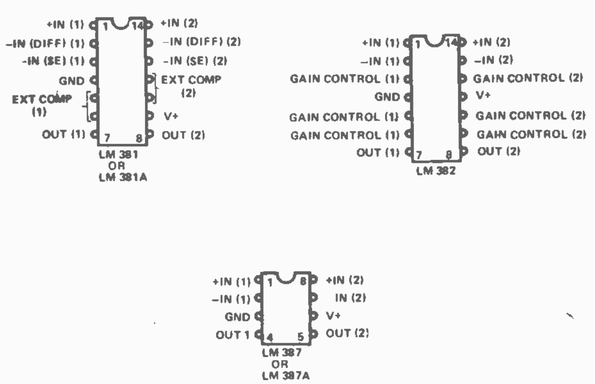


Fig. 1. Outlines and pin notations of the LM381, LM381A, LM382, LM387 and LM387A.

	LM 381	LM 381A	LM 382	LM 387	LM 387A
VSUPPLY	9V – 40V	9V – 40V	9V – 40V	9V – 30V	9V – 40V
IQUIESCENT (TYP)	10 mA	10 mA	10 mA	10 mA	10 mA
POWER BANDWIDTH (20V pk–pk)	75 kHz	75 kHz	75 kHz	75 kHz	75 kHz
SUPPLY REJECTION RATIO AT 1 kHz (TYP)	120 dB	120 dB	120 dB	110 dB	110 dB
EQUIVALENT NOISE INPUT FIGURE uV RMS — TYP	0.5	0.5	0.8	0.8	0.65
EQUIVALENT NOISE INPUT FIGURE uV RMS — MAX	1.0	0.7	1.2	1.2	0.9

Fig. 2. Typical performance of the five low-noise dual preamplifier ICs.

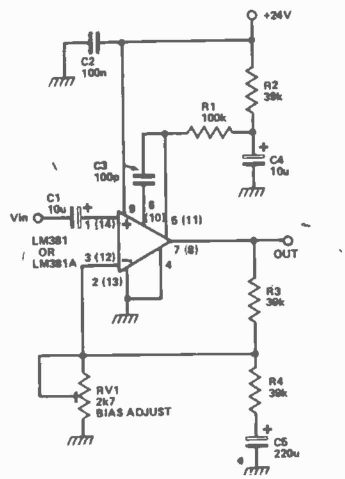


Fig. 3. A low-noise X1000 amplifier circuit. Bias is determined by R3-RV1 and gain by R3-R4, R1-R2 set the amplifier to optimum minimum noise conditions.

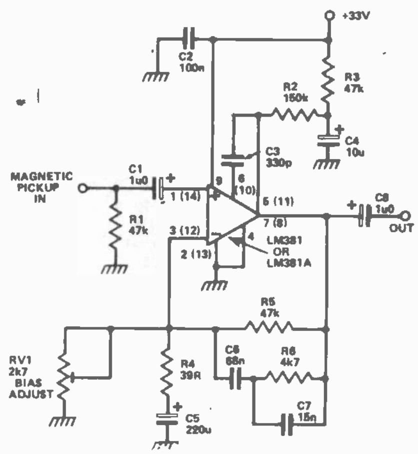


Fig. 4. The circuit shown in Fig. 3. can be modified for use as an ultra low-noise phono preamp, with RIAA equalisation given by the R5-R6-C6-C7 network. The circuit gives 42dB gain at 1kHz.

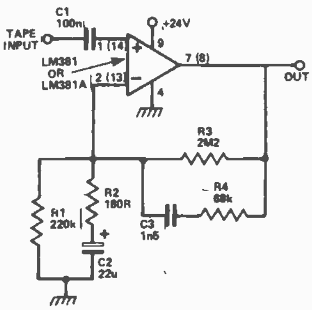


Fig. 5. A simplified version can be used as a low-noise tape playback amplifier, with NAB equalisation.

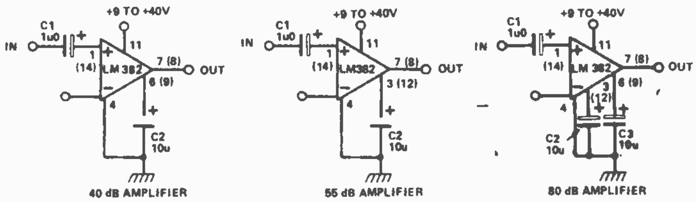


Fig. 6. Alternative methods of connecting the LM382 to make fixed gain non-inverting amplifiers.

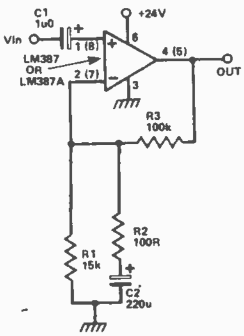


Fig. 7. Fixed gain (X1000) non-inverting preamplifier. The gain is determined by the ratio of R2 and R3. Alternative values of gain can be obtained by changing the value of R2. The circuit is biased by R1-R3.

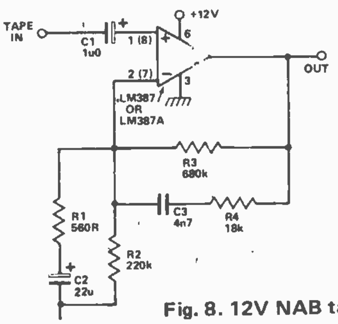


Fig. 8. 12V NAB tape playback preamp.

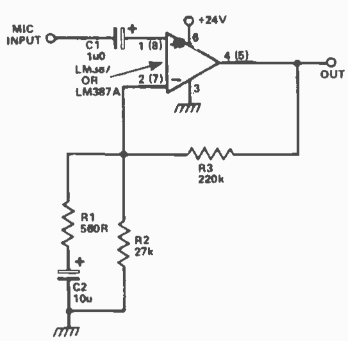


Fig.9. Low noise microphone preamp with a gain of 52dB. The circuit is intended for use with low to medium impedance microphones.

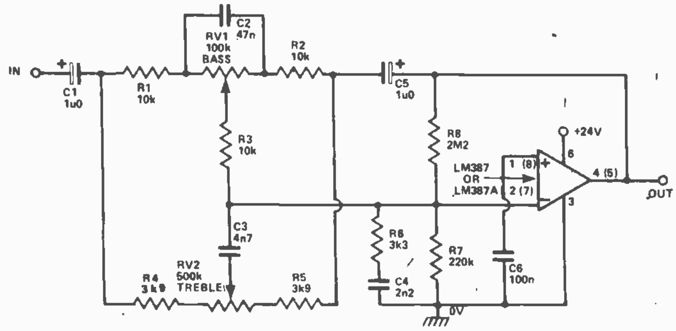


Fig. 10. A high performance active tone control.

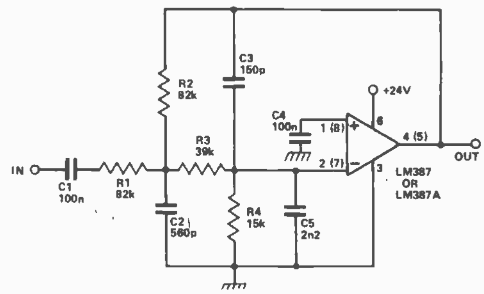


Fig. 11. 10kHz scratch filter with 12dB/octave roll-off.

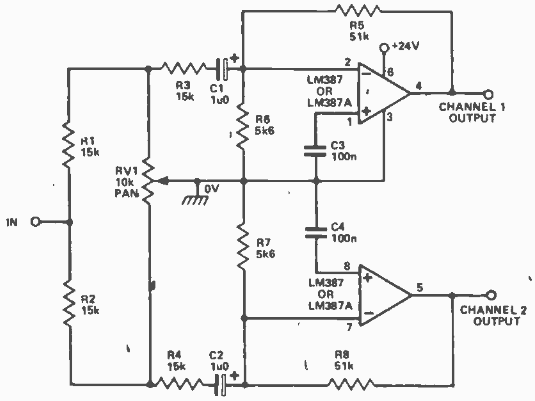


Fig. 12. This two channel panning circuit enables a mono input to be swept or 'panned' between two channels in any desired ratio determined by RV1. It can be used to make a sound source appear to originate from any point between two widely spaced speakers.

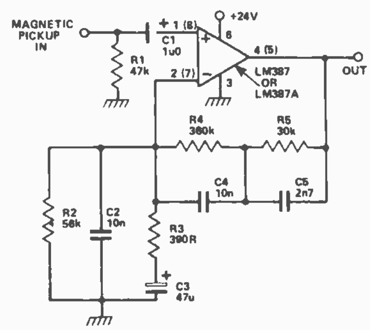


Fig. 13. RIAA equalised, single supply rail, pre-amplifier for magnetic pick-up cartridges. Input impedance 47k, determined by R1.

Power Amplifiers

A wide range of special-purpose single and dual ICs are available for use as audio power amplifiers giving maximum outputs from a few hundred milliwatts to a respectable 'several watts'. The specific IC chosen for a given application depends mainly on the constraints of the available power supply voltage and on the required output power level or levels.

In cases where supply voltages are restricted to the 6 to 12 volt range and power levels less than a few watts are needed, the National Semiconductor LM388 range of ICs can be used.

The LM388 uses a high-impedance gain-programmable ground-referenced differential input stage that is automatically biased to a quiescent half-supply value, for maximum non-clipped output swing. In the interest of power efficiency, the output stage has no short-circuit protection network.

The output stage of the LM388 is designed for use with a bootstrapped external bias network. The LM390 is a similar IC but has an improved output stage which enables 1 watt to be fed to a 4R speaker load from a 6 volt supply. The LM386 is also similar to the LM388, but has a simplified output stage incorporating a built-in bias network. Finally, the LM389 circuit is identical to the LM386 but additionally an array of three fully accessible NPN transistors are built in the IC package.

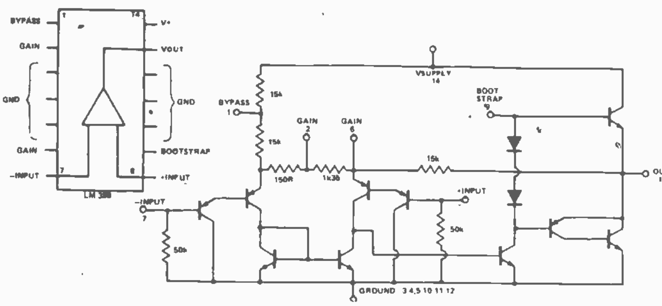


Fig. 14. The outline and equivalent circuit of the LM388. 1.5 watt device, specifically designed for low voltage applications the IC has a built-in 'frame', which acts as a heatsink and is connected to six of the IC pins. Power dissipation can be enhanced by soldering these pins to a large area of copper track on a PCB, which thus serves as an additional heatsink.

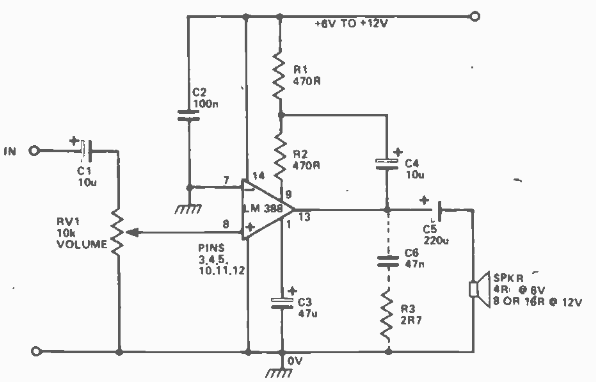


Fig. 15. One way of using the LM388 as a 1-watt non-inverting power amplifier with grounded speaker. The voltage gain is internally set at 20. R1-R2 are the output stage bias resistors, bootstrapped by C4. C3 improves supply ripple rejection and C2 provides high frequency decoupling. The dotted C6-R3 components (also shown in all other practical circuits in this section) form a Zobel network that is intended to damp parasitic oscillations from low-impedance loads and should *only* be used if instability problems are experienced.

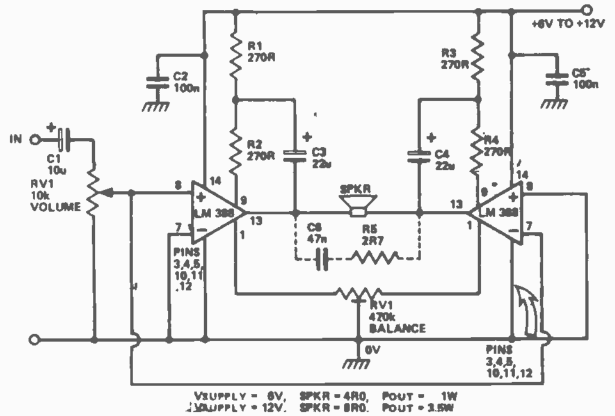


Fig. 16. Maximum available output power can be increased by bridge connection of a pair of LM388s, so that the power loses are shared between the two. RV1 is used to set the quiescent speaker current to zero.

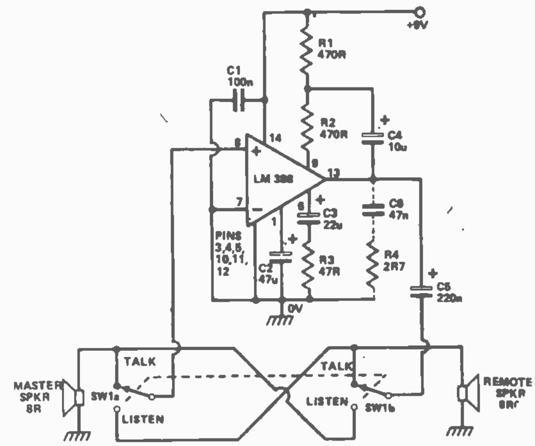


Fig. 17. A LM388 can be used as a simple intercom circuit. The IC voltage gain is set at 300 by the C3-R3 decoupling network.

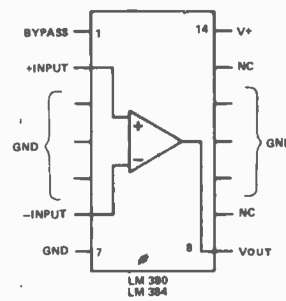
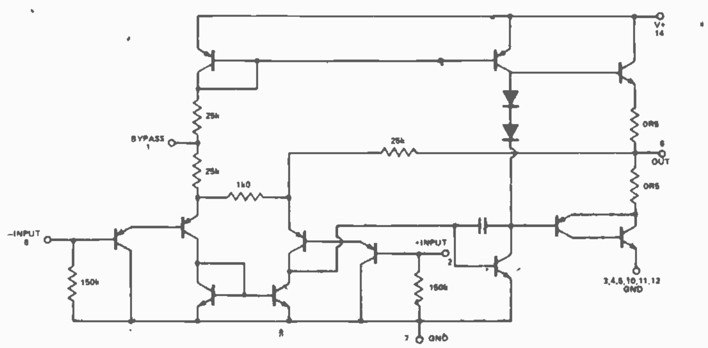


Fig. 18. In cases where supply voltages are not restricted to the 6 to 12 volts range and output powers of only a few watts are required, the popular LM380 2-watt or its identical, but uprated, LM384 5-watt 'brother' can be used. These ICs have full output short-circuit protection and use the same type of heatsink 'frame' as the LM388.



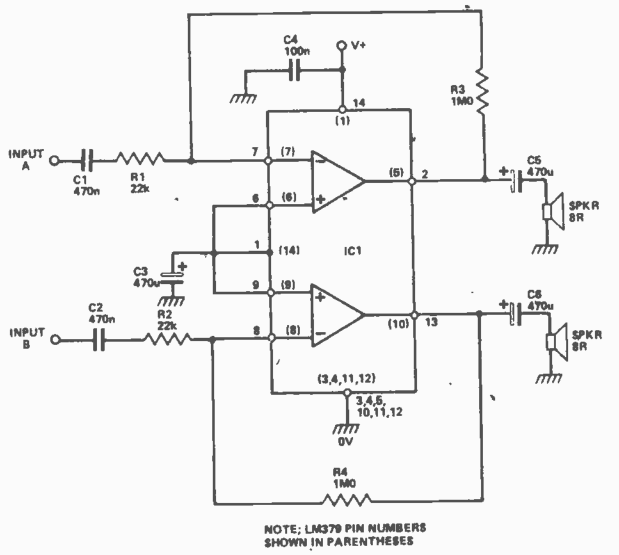


Fig. 19. A simple inverting stereo amplifier using the LM377, LM378 or LM379 dual amplifier IC.

V+	LM377	LM378	LM379	MAX OUTPUT POWER PER CHANNEL INTO: 8R	16R
12V	LIMIT TO 2.5W PER CHANNEL	LIMIT TO 5W PER CHANNEL	LIMIT TO 6W PER CHANNEL	1.6W	1W
16V				2.2W	1.5W
18V				3W	1.8W
20V				3.8W	2.4W
22V				4.6W	2.8W
24V				5.4W	3.6W
26V				6W	4.2W
28V				7W	5W
30W				—	5.5W

Fig. 22. The approximate performance characteristics of the three ICs. All three ICs have similar internal circuits with ground-referenced differential input stages and fully protected output stages.

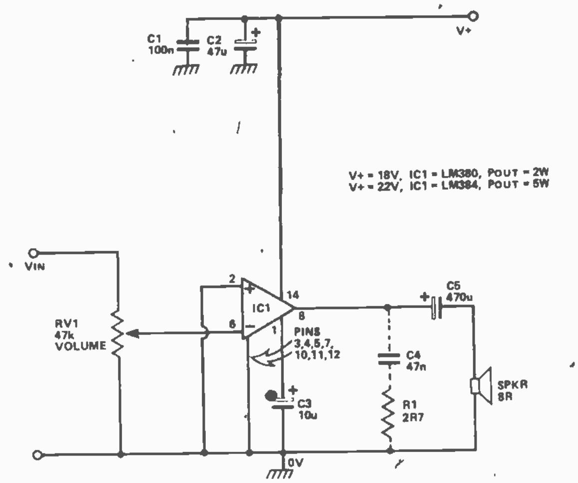


Fig. 20. A 2-watt or 5-watt amplifier with simple volume control and ripple rejection.

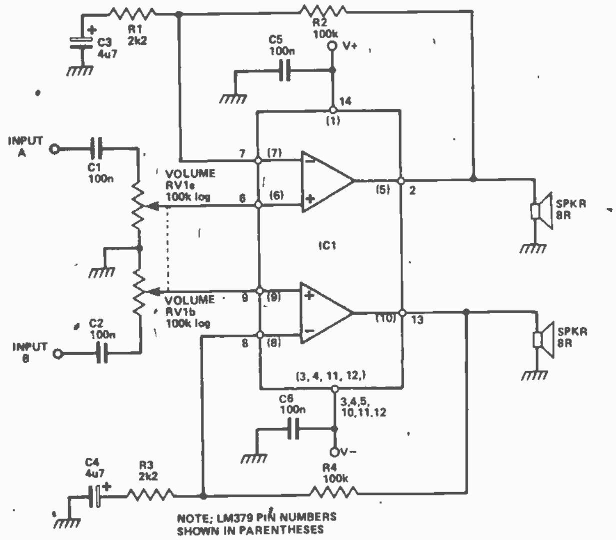


Fig. 23. A non-inverting stereo amplifier using a split supply.

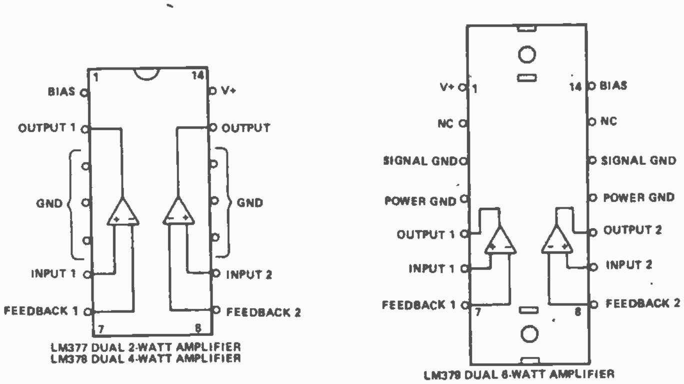


Fig. 21. The outlines and pin notations of the LM377, LM378 and LM379.

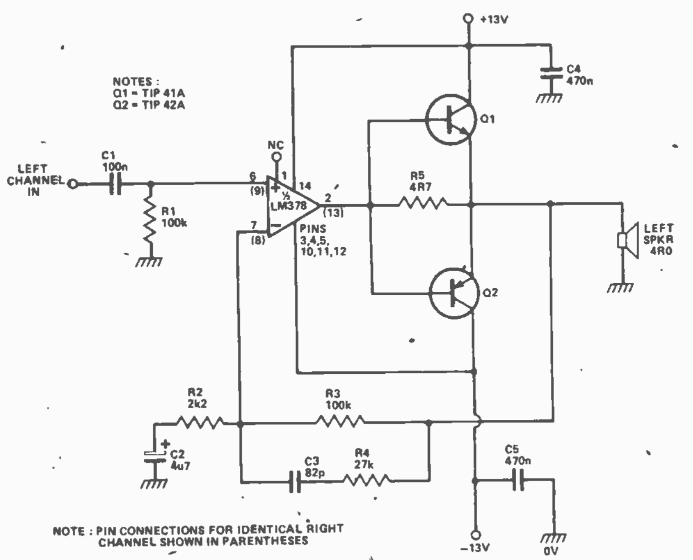
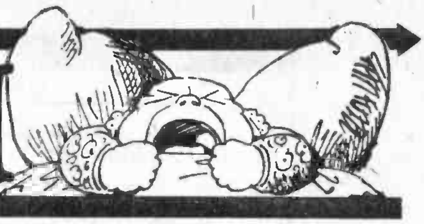


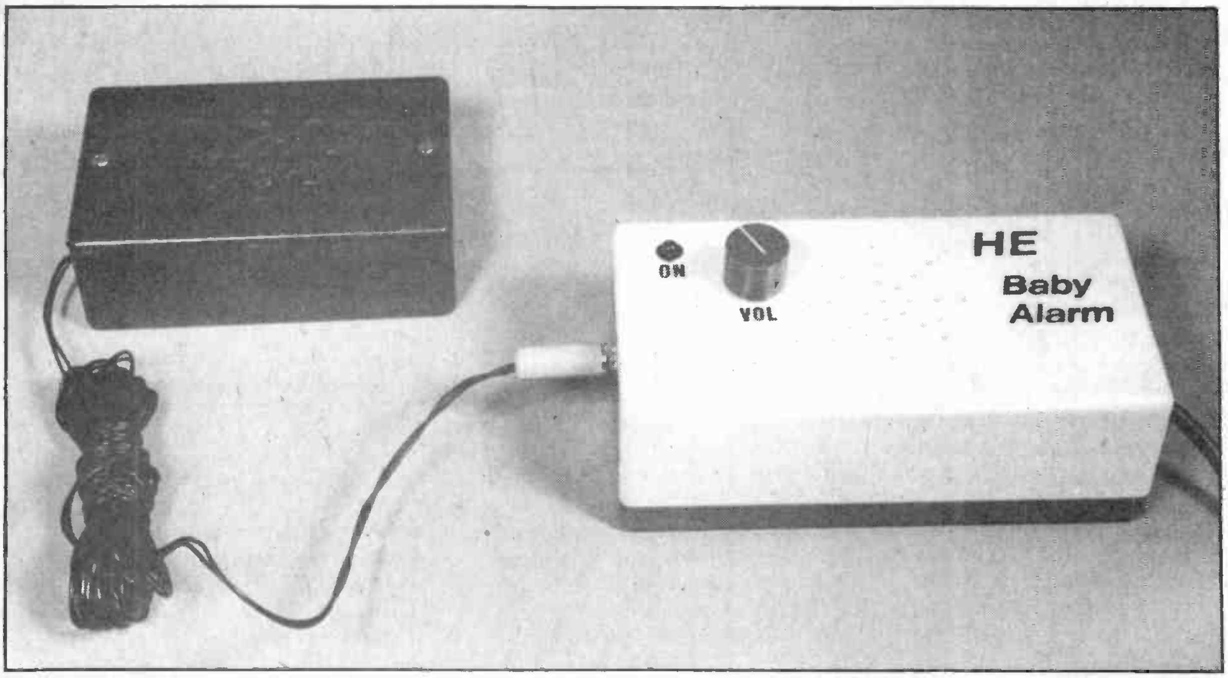
Fig. 24. One channel of 12-watts per channel stereo amplifier using a split supply. The circuit produces negligible output DC offset, so the quiescent output current is near zero.

PROJECT

BABY ALARM



Another Hobby Electronic project, this time for the loving parent. It's a line powered audio system that lets you keep one ear on the kids while you do your own thing elsewhere.



NO, A BABY ALARM IS NOT a pregnancy-detecting device. It is simply a gadget that lets the parent monitor the sounds of the baby's room from the comfort of his or her own living area. It consists of a simple audio amplifier/speaker unit that is placed in the parents room, and a microphone unit that is placed in the childs room: the two units are interconnected via a suitable length of 2-core lead.

The major problem with most commercial baby alarm units is that they are battery powered, and are thus expensive to run if they are in regular use. Our baby alarm, by contrast, is line powered, and thus has near-zero running costs. It has a built-in LED (light emitting diode) to indicate that the system is switched on, and has a volume control to allow for varying levels of sound. The unit is designed around an LM380 audio power amplifier integrated circuit, which is capable of deivering 2 watts of output power.

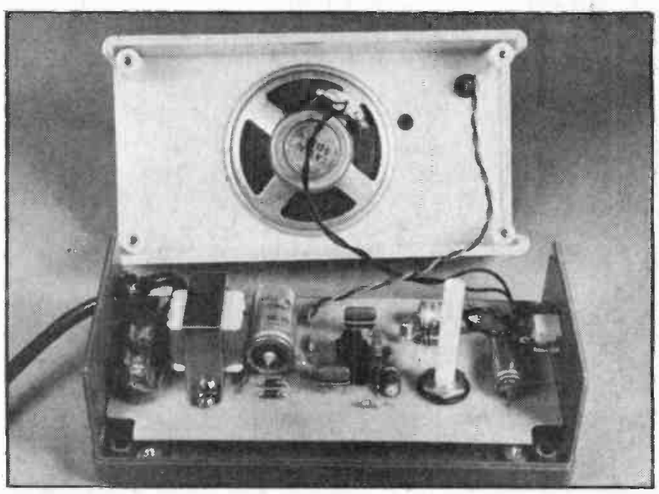
The 'microphone' that is used with the unit can be any inexpensive speaker with an impedance in the range four to forty ohms: this speaker can be housed in a suitable case.

Construction and Use

Construction of the unit should present few problems, providing that you follow the PCB overlay with care and pay the usual attention to component polarities. We suggest that you assemble the PCB components in two distinct stages, as follows.

Start by assembling T1, FS1, D1, D2, and C1 on the PCB, taking care to check that the centre tap of the transformer goes to the position indicated on the overlay. Temporarily connect T1 to the power via FS1, and check that a DC voltage reading of roughly 17 volts appears across C1. When this check is OK, remove the line connection and proceed with the rest of the construction. Note the positioning of volume control RV1 on the reverse side of the board, where three leads must be connected from its solder tags to the circuit board track.

When construction of the PCB is complete, fit the unit in a suitable case, together with the main speaker. Similarly, fit the remote 'microphone' speaker in a suitable case. The system is then ready for use, and the two units can be interconnected with a suitable length of 2-core wire.



Inside the baby alarm. Take particular care when building line powered equipment.

Note when using the unit that, if the two units are placed an insufficient distance apart (less than a few yards), accoustic feedback or howl-round can cause the system to oscillate when RV1 is set to a high-gain position. This feedback can be heard as a loud howl coming from the output speaker, and should not be allowed to occur for more than a few seconds. ●

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.

The Baby Alarm, looks very neat in a Vero Box, as well as preventing tiny fingers from straying inside.

HOW IT WORKS

Parts T1, D1 · D2 and C1 form a simple DC power supply. T1 gives an output of 12 volts AC from a line input. D1 and D2 rectify this to direct current and capacitor C1 smooths the supply. This provides an unregulated supply ie the output voltage will be reduced with the increasing current taken from it. However, as the rest of the circuit takes only about 25-30 mA there is no reason to suppose that the voltage should drop enough to stop the circuit from working correctly.

LED1 is used as an indicator to show that the circuit is on. The input speaker is a low impedance, transistor radio type speaker typically in the range 4-40 ohms, which acts as a microphone, picking up the baby's cries and is therefore placed in the nursery. The signal is amplified and matched to the input of ICI by Q1 and its associated components, C2, 3, R2, RV1.

ICI is an LM 380, which operates as a simple 2 watt integrated circuit amplifier which feeds the amplified signal to the output speaker. The sound from this speaker is quite loud enough so that you should hear baby's faintest cries.

According to manufacturer's specifications IC1 can sometimes develop high frequency oscillations at its output which can affect its lower frequency performance and so R4 and C8 are used to eliminate this whilst all audio frequencies pass through C9 to the output speaker.

C6 and 7 are decoupling capacitors, reducing mains hum which can often occur in such circuits.

PARTS LIST

RESISTORS (All ¼W 10%)	
R1	470R
R2	4K7
R3	2M2
R4	10K
R5	2R7
POTENTIOMETERS	
RV1	10K Log
CAPACITORS	
C1	1000u 25V
C2	10u 25V
C3	100u 25V
C4	1u0 25V
C5	22n Polyester
C6	47u 25V Tantalum
C7, 8	100n Polyester
C9	220u 25V
SEMICONDUCTORS	
IC1	LM380
Q1	BC109
D1, 2	1N4001
LED 1	TIL 220 or similar

MISCELLANEOUS
T1 12-0-12V 100mA Input speaker 4-40 Ohms, Output speaker 8 Ohms, FS1 100mA +suitable holder. P.C.B. Case to suit

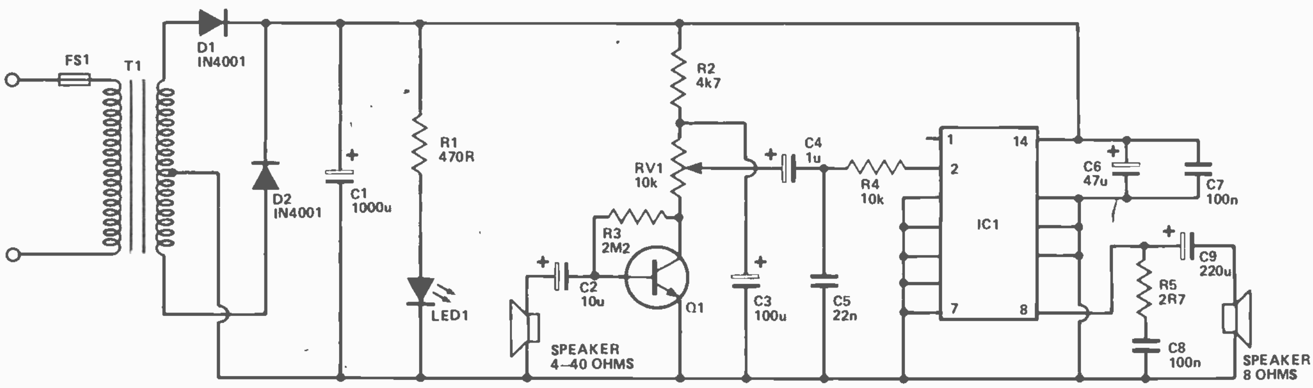
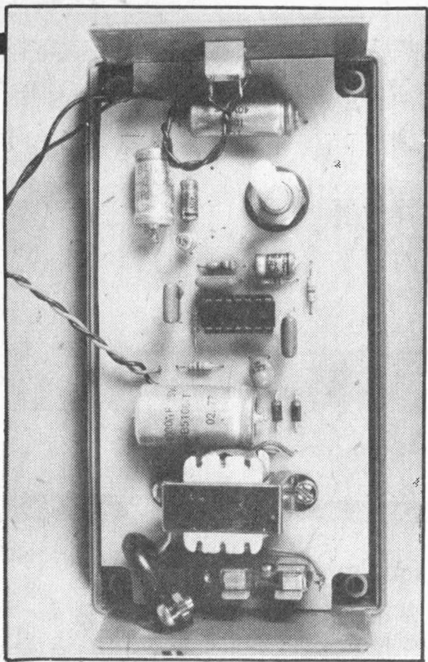


Fig.1. Circuit diagram for the Baby Alarm, using a line power supply enables the unit to be left on for prolonged periods.



The Baby Alarm with its lid removed, using a PCB keeps inter- wiring to a minimum.

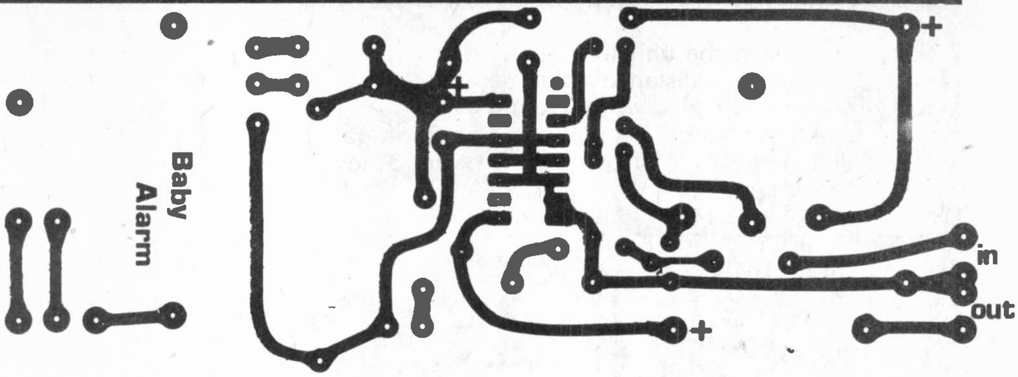
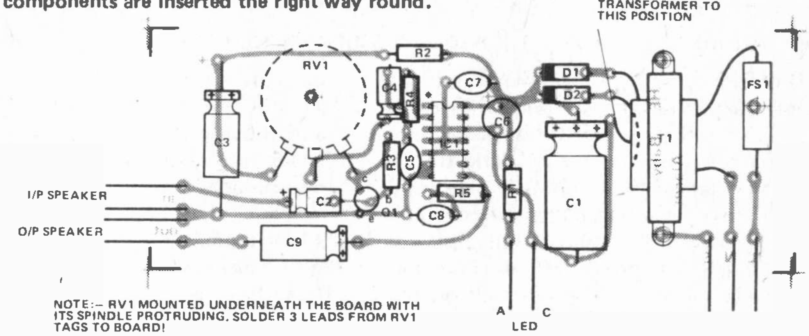


Fig.3. PCB foil pattern for the Baby Alarm, if you make your own PCB take particular care around the transformer area.

Fig.2. Component overlay, again as in all our projects be sure all polarised components are inserted the right way round.



SHORT WAVE WORLD

Continued from page 60

many frequencies throughout the day. Their North American Service uses these frequencies: North America East 2300-0400 on 7320, 7380, 9635, 11720, 11750, 11770, 11920, 11960, 12030, 12050, 15100, 15245, 15425 and 17700; North America West, 0400-0800 on 9590, 9635, 12050, 15100, 15180, 15245, 15425 and 17700.

Radiostation Peace and Progress also transmit from Moscow with news at 1300 on 15515, 17740, 17870 and 21585; 1330 on 15140, 15435, 15500, 17775, 17795, 21585 and 21690; 1430 on 15140, 15435 and 17880; 1530 on 15140, and 15185; 1630 on 11745, 11950, 15230, 17700, 21565 and 21615.

Radio Kiev in the Ukraine have English language news at 0030 and 0300 on 9800, 11735, 15180, 15405 and 17870; and at 2000 on 7175, 9560 and 11880.

From the Uzbek SSR, Radio Tashkent has news at 1200 and 1400 on 9540, 9715, 11785, 15460.

Radio Vilnius in the Lithuanian SSR transmits English news at 2230 on 6100 and at 2300 on 11735, 15180, 15275, 15405 and 17870.

United Kingdom — No doubt the best station for the news is the BBC which can easily be heard at anytime, anywhere. Here are their times and frequencies: 0000 on 5975, 6120, 6175, 7325, 9510, 9580, 11750, 12095, 15070, 17715; 0200 on 5975, 6120, 7325, 9510, 9580, 11750, 15070; 0300 on 5975, 6120, 7325, 9510, 9580, 11750, 15070, 17715; 0400 on 5975, 6175, 7185, 9580, 11750, 15070 and 17885; 0500, 0600 and 0700 on 5975, 6180, 7120, 9510, 9580, 11750, 12095, 15070 and 17785; 0800 on 5975, 9510, 11760, 15070 and 17885; 0900, 1100, 1300 and 1600 on 5975, 9410, 9510, 11750, 12095, 15070, 17705 and 21550; at 1700, 1800, 2000, 2200 and 2300 on 5975, 6180, 9410, 11750, 12095, 15070; also on 17705 at 1700, 1800 and 2000; and on 21470 at 1700 and 1800. Many other frequencies are also used.

USA — The Voice of America has English news at 0000, 0100, 0200, 0300, 0400, 0500, 0600, 0700, 1100, 1200, 1300, 1400, 1500, 1600, 1700, 1800, 1900, 2000, 2100, 2200 and 2300. See the April issue of ETI for the frequencies used by the VoA along with all of their programmes.

The American Forces Radio and Television Service (AFRTS) also has relays of most network news broadcasts throughout the day. Best frequencies are 6030 (0200-0700), 15330 (0430-0700, 1100-0200), 15345 (1800-0200), 15430 (1100-0700).

Vatican — The news from Vatican Radio is on the air at 0608 and 1030 on 6210, 9645 and 11740; and at 1905 on 6190, 7250, 9625, 9645, 11700 and 15120.

Vietnam — The Voice of Vietnam is on with the news at 0900, 1000 and 1530 on 7470, 10040 and 12035; at 1800 and 2030 on 10040 and 15012.

Yugoslavia — Radio Yugoslavia airs English news at 1530 on 9620, 15240 and 15300; at 1830 on 6100, 9620 and 11735; at 2000 and 2215 on 6100, 7240 and 9620.

Zambia — Last on our list of English language news broadcasts is from Radio Zambia in Africa. They are on at 1600, 1800, 2000 and 2100 on 9580 kilohertz.

As you can see from the above there is no shortage of news broadcasts from all around the world. Good luck and good listening. ●

Audio Today

Our Audio Editor, Wally Parsons discusses expansion and compression of dynamic range.

ANYONE WHO has ever owned a high-powered sports car knows the frustration imposed by speed limits, especially on the open highway with little traffic except those multi-coloured family sedans with red flashing roof lights. Just staying within the speed limit can produce a charley horse in the right calf muscle as you try to hold back on the gas pedal.

And in town, every traffic light seems like the starting line of a drag race, no matter how lightly you touch the accelerator, leaving half your tire rubber behind you.

Something of the sort occurs when the audiophile with a high power sound system tries to listen at "live performance level". Despite the logarithmic nature of human hearing, a 300 Watt amplifier coupled with a sensitive speaker can produce an enormous amount of sound.

To complicate things further, with most programme sources in which the dynamic range is somewhat limited, setting levels to deliver realistic peaks can result in quiet portions sounding unrealistically loud.

Many people find that low level material reproduced at unnaturally high levels constitute a greater source of irritation than actual loud music signals reproduced at live levels.

A great deal of music can be recorded and reproduced with natural dynamic range, particularly smaller string ensembles, and solo voice, and small choirs, thus making it possible to set levels in such a way that peaks are realistic, and yet pianissimos neither sound unnaturally loud nor do they disappear below audibility (except, perhaps, the last movement of "The Planets").

There are frequent occasions when we find it either necessary or prudent to lower the volume level. This may occur at any time of the day if you live in one of those Gyproc-walled apartments which delight the voyeur, and most certainly occurs if you listen late at night in almost any apartment or non-detached house.

Along Comes dbx

We've already discussed at great lengths (see the previous three issues) the problems of recording and reproducing wide dynamic range, and the dbx solution. At last, it is possible to hear not only the entire audio frequency range, but the full dynamic range.

But what happens if your neighbours don't happen to share your musical tastes, or if they might just want to listen to something else? After all, you and I might agree that the Beethoven Ninth is a great masterpiece, but the neighbours might not agree, especially at three in the morning.

Ordinarily, we might simply turn it down, adding, perhaps, some loudness compensation to restore bass tones which would otherwise sink below audibility.

But suppose that, thanks to dbx, the dynamic range is now such that if we turn down the level enough to satisfy the neighbours on the crescendos, *all* the low signals disappear below audibility. Can you imagine playing Ravel's Bolero and only hearing the last five minutes? It's bad enough as it is that we might have to settle for only the last ten minutes with restricted dynamic range.

Of course, you might consider switching out the dbx decoder, and settle for losing all the lovely dynamic range for which you paid good money, simply out of deference to the Landlord and Tenants Act, but that won't work.

Why not? After all, we now have a compressed signal, don't we?

Yes, but not the compression we wish.

Consider: when levels are lowered, we add controlled bass boost to restore balance. Suppose, instead, we were to alter the playback equalization so as to raise the turnover frequency. That would provide bass boost, would it? Yes, but it would actually produce a flat response below 500 Hz, with a slope of 6 dB/Octave above that, levelling off somewhere according to the change introduced. This is not what is required.

Loudness and playback equalization are introduced for different purposes, and the requirements are different. Specifically, the disc playback curve satisfies technical requirements which pertain to the cutting and playback of the disc, whereas the loudness curve is intended to satisfy requirements of our hearing.

Conventional recordings use compression to satisfy technical requirements of the medium, as outlined in the previous issues. It's assumed during the recording process that no compensation will be introduced on playback, and the *intention* is to tailor compression and limiting in such a way as to remain within the limitations of the medium, yet give the listener the *impression* that no processing was used.

The analogue to this would be the insertion of equalization to alter tonality of a voice or instrument, or compensate for bandwidth limitations.

In fact, with good recordings, the signal remains uncompressed over much of its dynamic range, with peak levels reduced to avoid overload, and low levels raised above the noise of the medium.

Because these low levels are "upwardly compressed", they don't disappear below audibility when level is reduced unless we go to extremes. But if an expander, including a dbx decoder is added to the system, not only will low levels disappear, but the middle dynamic range will be exaggerated, no matter what the overall listening level, with moderately quiet sections be-coming whisper soft, and louder sections sounding too loud, without adding much in the way of unlimiting the peaks. In addition, if the dbx unit is used, there is a high frequency roll-off added, to offset the high-frequency boost introduced during recording, in addition to the normal equalization.

In other words, the results can be pretty weird.

Non-decoding

Consider the effect of attempting to play a dbx encoded disc without decoding. To begin with, since the signal is compressed in a linear manner, the dynamic range will be obviously restricted, because even middle levels will be compressed. Because of compression very quiet sections, including silence, will be raised in level, *including noise*. In other words, quiet sections will be quite noisy, with the noise suddenly disappearing in the presence of any substantial signal, much like the sound of some TV stations who set up their compressors improperly. To aggravate this situation, dbx introduces treble boost at the cutting stage, which increases the noise. It's sort of like a pumping reversed modulation noise.

Remember, though, that if a volume control preceeds a compressor, the control action will be reduced, while an expander will exaggerate it.

It follows, then, that any dbx encoded material, *must* be played back through a decoder. It also follows that such a decoder cannot be used satisfactorily for non-encoded material.

The obvious solution to the problem of low level listening lies in the use of an additional, adjustable compressor inserted in the system *after* the decoder. This would also be suitable for use where the speaker/amplifier cannot deliver adequate sound level to use the full dynamic range. The key to successful use of such a system lies in the adjustability of the rate of compression.

Readers interested in experimenting with this should consider building ETI's compressor-expander which can be found in January 1979, ETI. It can also be used to add some expansion to regular recordings, within the limitations discussed here.

Experimental Decoding

Since the Compressor-expander is a useful device anyway, many readers may have already built one. In that case, you might wish to experiment on some dbx encoded discs. For openers set the expansion rate at near maximum, then install a filter at the input, using a variable roll-off point. When the expansion rate and filter constants are correct, there should be no sign of noise "pumping".

This same device, or a duplicate unit, will also be useful in compressing dynamic range. Install it in the same loop normally used for tape recording and increase the compression rate as you lower the listening level.

Remember, though, that if a volume control *preceeds* a compressor, the control action will be reduced, while an expander will exaggerate it.

On the other hand, despite what you may have seen written by people who should know better, you *cannot* alter the range of a tone control by following it with a compressor or expander. A compressor/expander is a variable gain amplifier whose instantaneous gain is controlled by the instantaneous input signal level. It is the signal level which controls the gain. Anomalies in frequency response will result in modulation of the overall *level* rather than the spectral balance.

It follows, then, that inaccurate equalization, peaks and/or dips in pickup response, including the effects of pickup/preamp mismatching will result in amplitude modulation of the signal.

Public Acceptability

Whether or not the general public is prepared to pay for quality associated equipment will, in my opinion, have a marked effect on the acceptability of dbx encoded discs.

It seems to me that a first step would be for dbx to make available a more complex expander, which expands peaks and low levels, leaving the middle alone, or better still, providing this option in the form of a switch position of the decoder. Vigorous marketing of such an innovation would make wider dynamic range available to a greater percentage of the public, while making full decoding available for dbx discs.

This, in turn, would encourage record manufacturers to release more encoded discs, or perhaps encourage the industry to adopt a standard compress/expand curve, much as it standardized on RIAA equalization in 1954.

This system under proper conditions works superbly. But it seems to me that to survive requires public acceptance, and this is very much a marketing problem.

It would be nice, in the future, to see preamps and receivers routinely including dbx decoders, along with controlled curve compression, whose characteristics can be ganged with a level control very much as loudness compensation is.

Over to you, dbx.

Audio Today Letters

I'm about two-thirds of the way towards finishing my Series 4000 Amp. But when I'm finished I won't have any speakers to match the amplifier's quality.

So how about a speaker project. I also think you should have a column on speaker design.

G.E. Saskatoon Sask.

Although I find myself in agreement with you in principle as the the desireability of a speaker project, there are several practical obstacles which must be overcome, none of them technical.

To be worthwhile such a project should satisfy specific objectives. For example, there's little point in doing a project simply because it uses components which are currently glutting the market, or because a nice general purpose speaker would be handy in the shop.

Instead, it should represent a high level of performance quality for its type, should spotlight design and construction principles often overlooked by the home builder, and, if possible, explore innovations which are not readily available with commercially manufactured products.

Such a project, then, might range from a large transmission line system, with bi-amp capability, or sub-woofer/satellite system, to a book-shelf design. Or possibly a unit intended specifically for use as a wall-mounted rear or side channels.

No matter what form such a project takes, the carpentry involved should be within the capabilities of most readers, or at least reasonably priced if built by a cabinet maker. In addition, it should use components which are available locally or by mail order, in any location in Canada.

Clearly, this is a tall order with several conflicting requirements, and it can be expensive.

If readers would care to write outlining what they'd like to see in such a project, it might be useful in evaluating readers' needs, and the kind of response to be expected.

Likewise with respect to a series on speaker design (you don't really expect me to cover it in one column, do you?)

For my part, I'd enjoy doing both the series and projects. However, Ye Olde Editor is a man of conviction who could probably extract juice from a Mafia Don*. He is immune to threats, and cannot be bribed. But he *is* a push-over for such techniques as logic and reason, who does not dither over making a decision.

Need I say more?

**Editors Note. Trying to get Wally's copy for the column on time gives you a lot of practice.*

I've been reading your magazine for a couple of years and I have found a lot of interesting articles.

I'm writing you because I'm looking for an electronic crossover circuit or information.

I'm looking for one to cover a range of 20Hz to 100Hz and 100Hz to 20kHz.

I'm doing some D.J. work and would use it with two separate stereo amplifiers.

I would also like some information on bass driver units, 15", around 200W.

O.C. Trenton Ontario

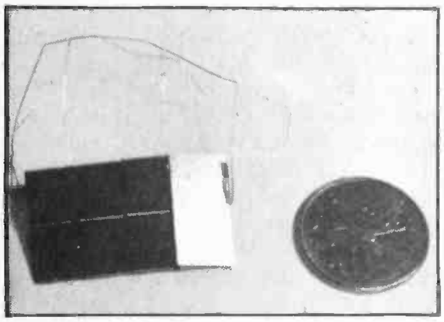
Without more information as to power amplifier and final system design, I cannot offer a specific circuit suitable for your needs. However, I would suggest that you obtain a copy of the Audio Handbook, published by National Semiconductor, and available from any electronics distributor who handles National products, as well as many Radio Shack outlets. Section 5 contains both circuit and design procedures, as well as the necessary math to set cross-over frequencies.

Basically, an electronic crossover consists of an active filter for each pass band, designed for identical cut-off points, and, usually, identical slopes. Some circuits use a single filter and extract its complement by means of a differential amplifier. Since you indicate that your first language is French and that you're more comfortable in that language, I hesitate to suggest any English language books other than the National handbook. Perhaps if you can get up to Montreal the public library might be of help. While you're there, check the Yellow Pages for professional audio dealers. Several manufacturers such as Altec Amcron offer electronic crossovers with variable crossover points.

For drivers, I would suggest looking at either JBL or Altec commercial units, especially if reliability is important, despite the price. At a lower price, you still might be able to acquire Marsland's "Linear B VHP" units. These were originally sold for use in high power Hi Fi applications, but were never really suitable. But they are quite efficient and would perform quite well in portable Disco setups.

If you wish to use them in parallel pairs, stick with the JBL or Altec models, and specify 15 Ohm impedances, wiring them in parallel. ●

Solar Cells continued from page 42.



Pic 3. A typical solar cell. This particular unit is actually four cells connected in series to deliver 40 ma at 1.5V.

Want To Know More?

Readers might be interested in 'The Solarex Guide to Solar Electricity' which discusses the theory and applications of solar cells. This book is available for $8.50 postpaid from:

Lenbrook Industries Limited
1145 Bellamy Road,
Scarborough, Ontario M1H 1H5.

They can also provide you with information on Solarex Products. If you wish to buy individual Solarex solar cells, write to:

Efston Science
3500 Bathurst Street,
Toronto, Ontario M6A 2C6.

Other cells, manufactured by Solec International can be obtained from:

H.W. Cowan Canada Limited,
P.O. Box 268,
Richmond Hill, Ontario L4C 4Y2.

Another useful reference is the People's Solar Sourcebook. We haven't been able to review a copy at the time of this writing, but it sounds like a useful reference/catalogue if you're into solar energy. This 350-page book is available for $12.95 from:

Solar Canada
4776 Wyandotte East,
Windsor, Ontario N8H 1H7. ●

EXPERIMENTING WITH SOLAR CELLS

There are a number of interesting and instructive little experiments you can perform with solar cells. There are a number of small hobby-type electric motors around which require only 100mA, or less, which run quite happily from 1½V. Four 4T206 Solarex cells, connected in series, will power one of these motors. Why not convert a small battery-driven toy? Use a few Solec Super Cells or Solarex 3" cells. 44T229

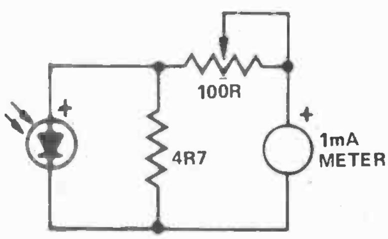
Electroplating, especially when doing it with precious metals, works best with low current density, long period operation. This method gives a beautifully smooth finish. A solar plater set-up is illustrated in the accompanying diagram.

The wirewound pot is adjusted to give 5-10mA of current for small items, three to five times that for larger items, and the process allowed to run for three to four hours or longer, depending on the results you want. There's plenty of room for experiment here.

Copper plating is quite easy, and probably simplest to start out with as the ingredients are readily obtainable. The plating solution is copper sulphate and a large piece of copper wire (sanded until it's bright) will serve as the anode. Don't use a metal plating bath — remember!

Another interesting device to experiment with is a sun (or light) intensity meter. The circuit and construction details are shown here. We mounted all the bits on

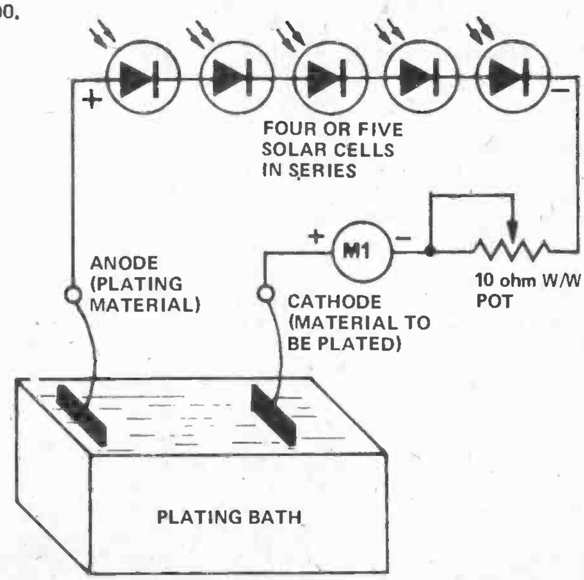
Front view of the sun intensity meter we made as an experiment. The cell we used is a Sensor Tech. C202, quarter of a C200.

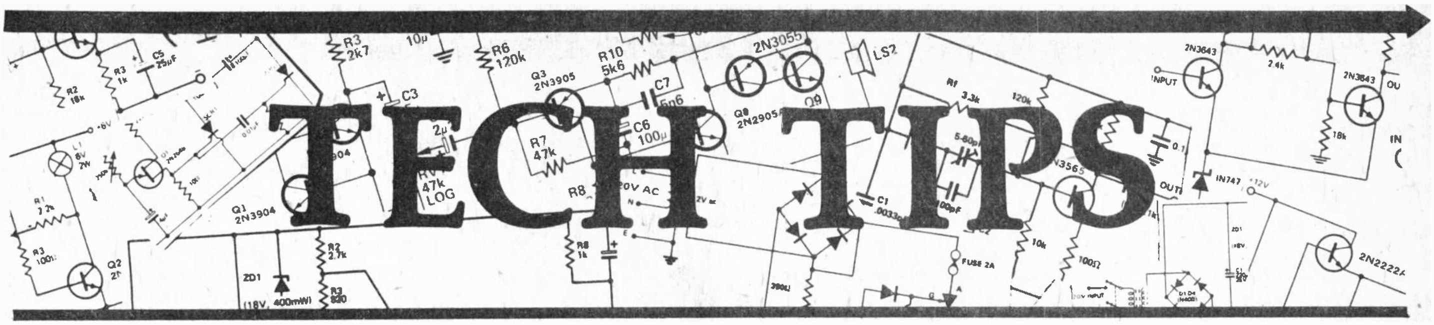


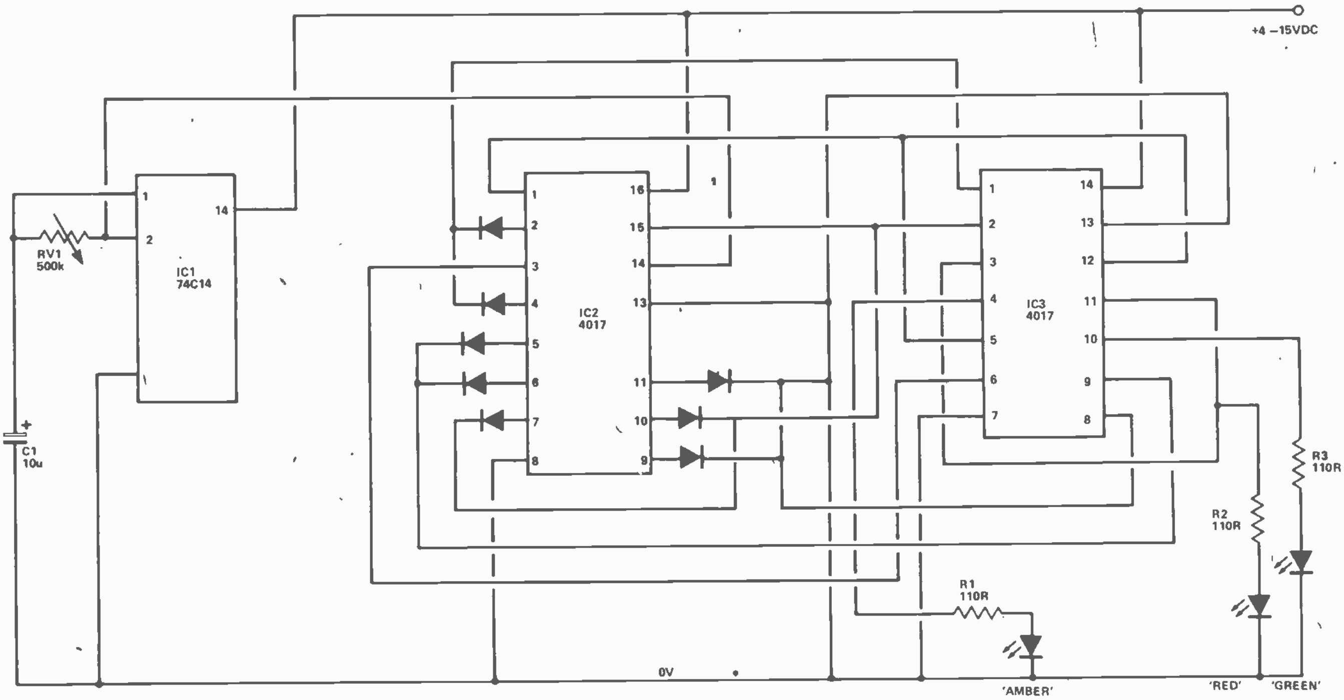
the terminals of a small 1mA meter. The solar cell we used was a single Sensor Tech. This unfortunately is hard to come across, but a Solarex 6T204 will work. The device works as follows: When driving a low resistance load, the current through the load is pretty well directly proportional to the insolation (energy falling on the cell), the voltage output varying only over a small range.

To use it, hold the device at arm's length and turn your back to the sun. Angle the unit to peak the current reading. Calibrate it by adjusting the trim pot to get a full scale reading on a bright, cloudless summer day. Full scale then represents something close to 100mW/cm^2 insolation. The scale is fairly linear.

Solar cells make excellent photosensors and may be used in such applications as light-operated relays, photodensitometers, receiver for a light-beam communicator etc, etc.





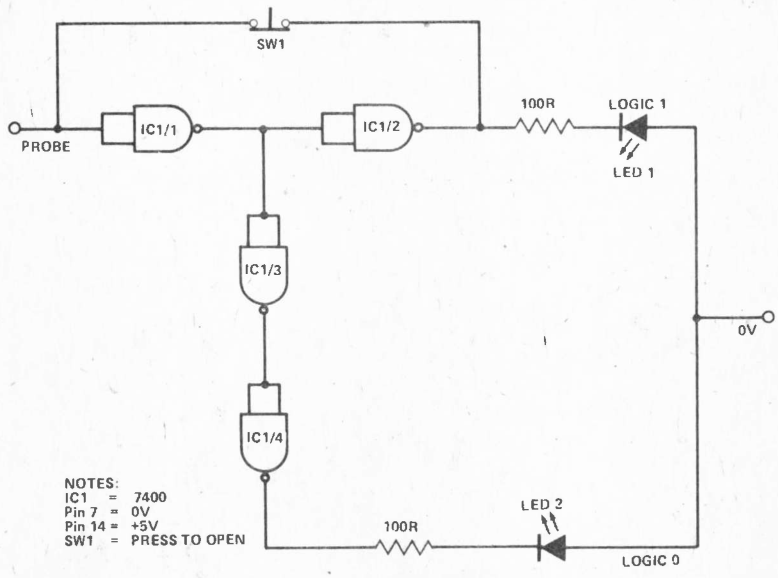


Traffic Light Controller

Michael Miller

This circuit is relatively simple and gives a realistic timing sequence. IC1 sets the timing clock pulse and can be adjusted by RV1. IC2 is a decade counter, whose output pulses are mainly fed through diode buffers (any small cheap diodes will do), to IC3, a quad OR gate, which sorts the consecutive decade pulses into three groups, monitored by the three coloured LEDs.

To couple this circuit to a similar one, for the other intersection of the crossroads, the pulse from pin 1 of IC2 should be taken to pin 15 of the IC2 of the other circuit. This second circuit should have pin 15 biased to 0V via a 100 k resistor. When the first circuit is showing red, the second circuit will be showing green.



One Chip Logic Probe

K.D.Hedger

This circuit, although very cheap and with a low component count, is very effective. When logic 1 is at the input of IC1/1 output goes low causing IC1/2 output to go to logic 1 lighting LED 1. Logic 0 at the input of IC1/1 causes the output to go high, IC1/3 goes low and IC1/4 goes to logic 1 lighting LED 2.

SW1 takes the output of the IC1/2 back to the input of IC1/1 so locking LED one on until the push to open switch is released.

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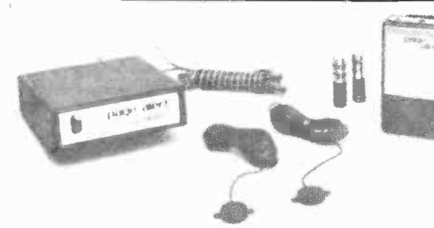

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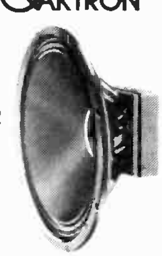

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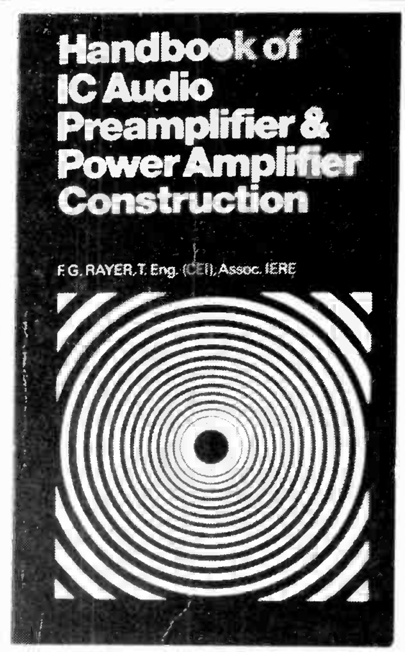

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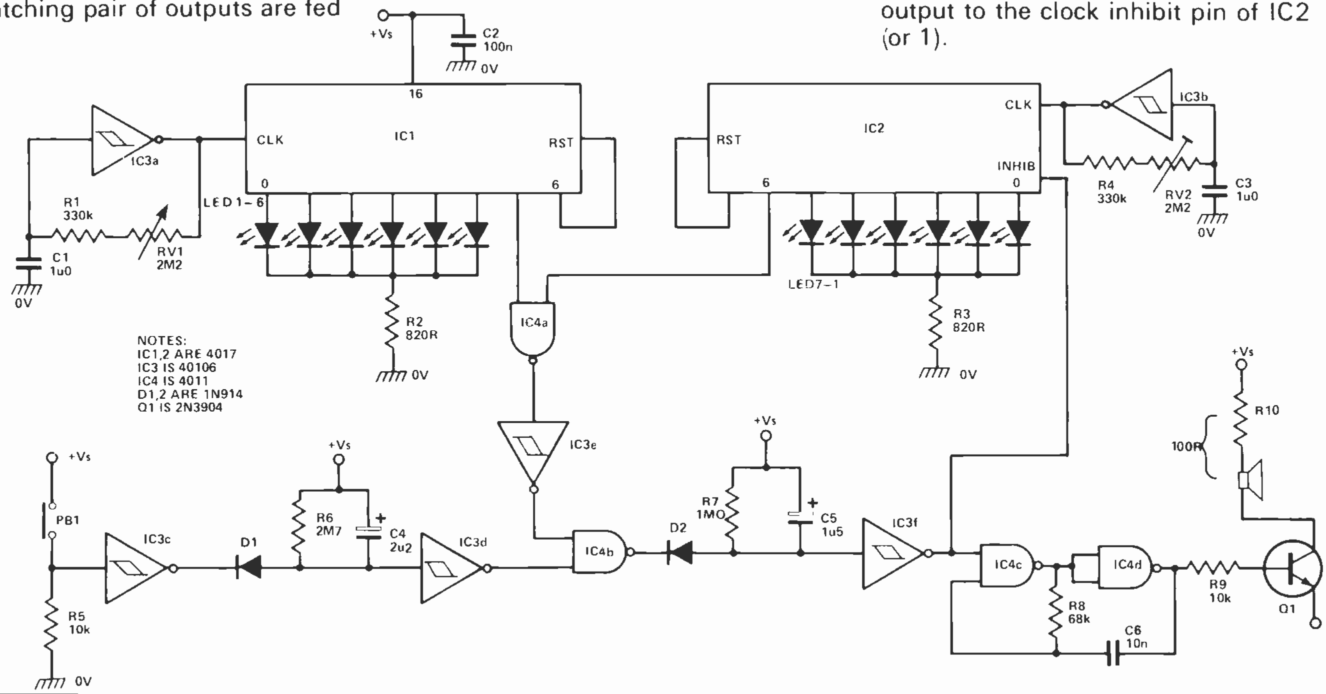
LED Chaser

P. Davidson

This game is a test of skill and patience. The aim is to align a LED chaser (under your control), with another preset chaser.

A matching pair of outputs are fed to an AND gate (IC4a, IC3e). This gate feeds the NAND gate IC4b, its other output taken from the monostable formed around IC3d. This has a duration of about 6 seconds to ensure the display is fully counted.

When you think you've matched the displays up PB1 is pressed. IC3d output goes high and if, while this is high, the two matching outputs both go high, the monostable formed around IC3f is triggered. This enables the astable formed by IC4c,d, to signal success. The unit can also be automatically reset by feeding IC3f's output to the clock inhibit pin of IC2 (or 1).



Solid State Tacho Circuit

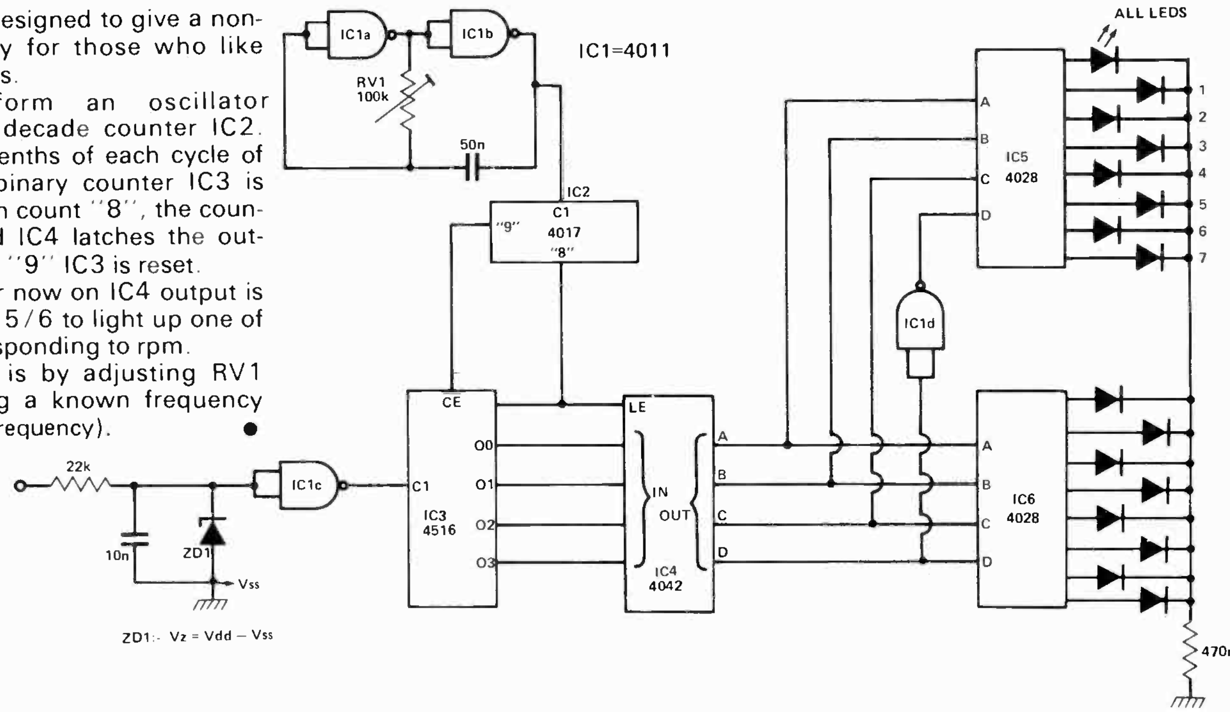
P. Stephenson

The circuit is designed to give a non-critical display for those who like (cheap) gadgets.

IC1a/b form an oscillator which drives decade counter IC2. During eight tenths of each cycle of this section, binary counter IC3 is counted up. On count "8", the counting stops and IC4 latches the outputs. On count "9" IC3 is reset.

The number now on IC4 output is decoded by IC 5/6 to light up one of 16 LEDs corresponding to rpm.

Calibration is by adjusting RV1 whilst inputing a known frequency (eg. 60Hz line frequency). ●



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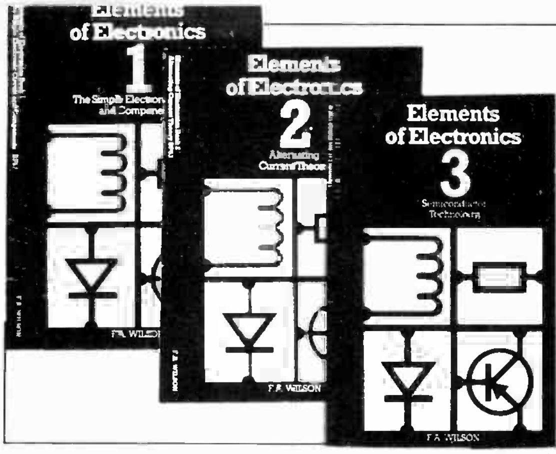

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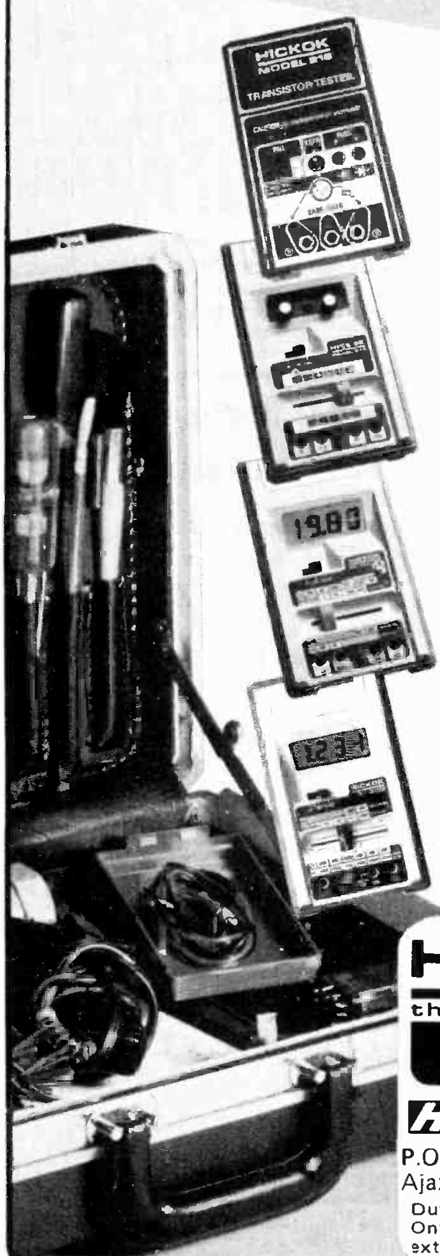

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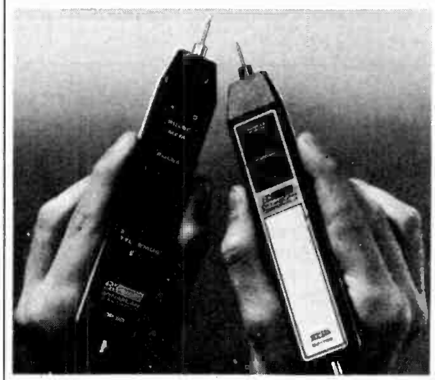

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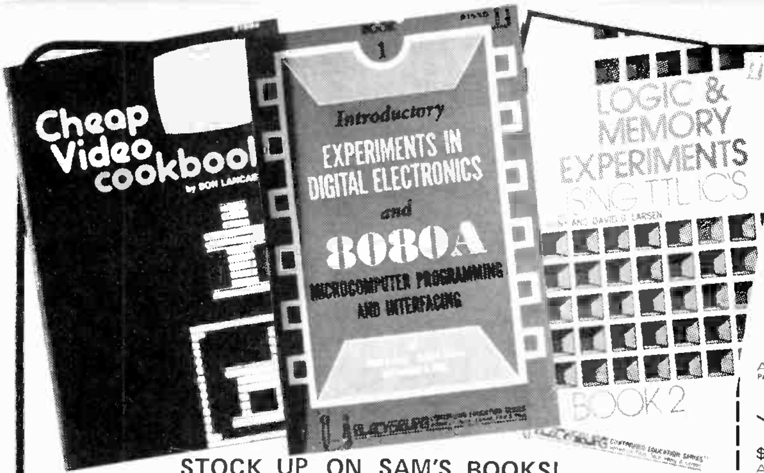

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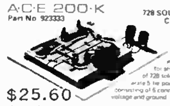
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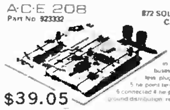
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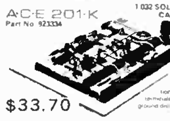
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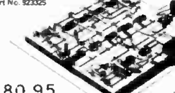
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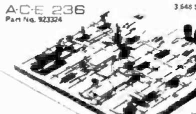
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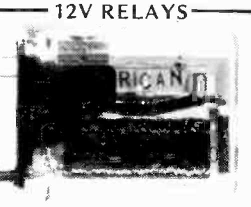

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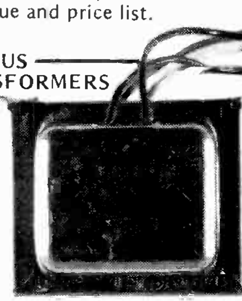

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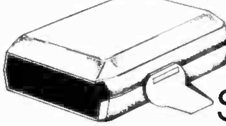

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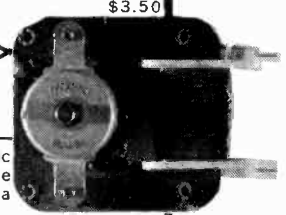

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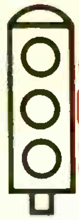

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CD4020BE	1.29	CD4044BE	1.03	CD4081BE	.35	CD4526BE	1.29		

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TIP29	.51	NPN	1 AMP	100V
TIP30	.51	PNP	1 AMP	100V
TIP31	.55	NPN	3 AMP	100V
TIP32	.56	PNP	3 AMP	100V
TIP41	.77	NPN	6 AMP	100V
TIP42	.83	PNP	6 AMP	100V
TIP115	.77	PNP	2 AMP	60V
TIP120	.83	NPN	5 AMP	60V
TIP122	.96	NPN	5 AMP	100V
TIP125	.96	PNP	5 AMP	60V
TIP127	1.11	PNP	5 AMP	100V
TIP2955	1.08	PNP	15 AMP	60V
TIP3055	.91	NPN	15 AMP	60V
FT3055	.77	NPN	10 AMP	60V

TTL ALL CIRCUITS IN STOCK FOR GUARANTEED IMMEDIATE DELIVERY

74LS00N	.33	74LS20N	.35	74LS55N	.38	74LS95N	.90	74LS137N	1.16
74LS01N	.29	74LS21N	.35	74LS73N	.55	74LS96N	1.01	74LS138N	1.03
74LS02N	.35	74LS26N	.73	74LS74N	.90	74LS107N	.59	74LS139N	1.03
74LS03N	.35	74LS27N	.42	74LS75N	.62	74LS109N	.62	74LS145N	1.63
74LS04N	.38	74LS30N	.31	74LS76N	.90	74LS112N	.59	74LS147N	2.93
74LS05N	.38	74LS32N	.57	74LS78N	.49	74LS122N	.73	74LS148N	2.93
74LS08N	.35	74LS38N	.44	74LS83N	1.09	74LS123N	1.12	74LS151N	.70
74LS09N	.38	74LS40N	.31	74LS85N	1.25	74LS124N	1.25	74LS153N	.59
74LS10N	.35	74LS42N	.70	74LS86N	.86	74LS125N	1.77	74LS155N	1.09
74LS11N	.38	74LS47N	1.09	74LS90N	.64	74LS126N	1.25	74LS156N	1.27
74LS12N	.29	74LS48N	1.09	74LS91N	1.03	74LS132N	.59	74LS157N	.90
74LS13N	.47	74LS51N	.35	74LS92N	1.25	74LS133N	3.71	74LS158N	1.01
74LS14N	.73	74LS54N	.35	74LS93N	.51	74LS136N	.88	74LS160N	1.56

74LS161N	1.68	74LS191N	1.68	74LS245N	4.16	74LS279N	1.03	74LS348N	3.84	74LS379N	2.86
74LS162N	1.68	74LS192N	1.01	74LS247N	.90	74LS280N	4.63	74LS352N	1.76	74LS390N	3.30
74LS163N	1.68	74LS193N	1.68	74LS248N	2.00	74LS283N	1.25	74LS353N	2.43	74LS393N	3.19
74LS164N	1.27	74LS194N	2.46	74LS249N	1.29	74LS290N	1.16	74LS362N	15.54	74LS395N	2.54
74LS165N	1.89	74LS195N	.90	74LS251N	1.77	74LS293N	.51	74LS365N	3.71	74LS447N	.48
74LS166N	4.60	74LS196N	2.43	74LS253N	1.03	74LS295N	1.81	74LS366N	.1.56	74LS490N	3.19
74LS169N	11.34	74LS197N	1.27	74LS257N	.88	74LS298N	1.66	74LS367N	2.00	74LS630N	143.00
74LS170N	3.58	74LS221N	1.50	74LS258N	.83	74LS299N	4.68	74LS368N	2.00	74LS631N	143.00
74LS173N	1.01	74LS240N	1.81	74LS259N	5.14	74LS320N	6.44	74LS373N	2.13	74LS669N	3.19
74LS174N	.70	74LS241N	1.55	74LS260N	1.25	74LS321N	6.44	74LS374N	2.13	74LS670N	4.75
74LS175N	.70	74LS242N	1.55	74LS266N	.90	74LS322N	6.44	74LS375N	3.84		
74LS181N	3.33	74LS243N	1.55	74LS273N	1.98	74LS323N	6.44	74LS377N	1.87		
74LS190N	1.68	74LS244N	1.81	74LS275N	9.01	74LS324N	1.91	74LS378N	2.20		

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				6505	12.94
8212	3.58	6810	4.88		
8214	5.14	6820	6.44	6520	9.04
8216	3.84	6821	4.88	6522	12.95
8224	4.49	6850	5.14	6532	18.14
8226	3.84	6582	4.88	6551	18.14
8228	6.47				
8238	6.47				
8251	9.04				
8253	14.24				
8255	9.04				
8257	14.24				
8259	16.84				

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TIC236D	1.89	Triac 12 amp 400V TO-220
TIC246D	1.89	Triac 16 amp 400V TO-220

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TL071CP	.77	Low noise	TL082CP	1.29	Dual J-FET input
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TL074CN	3.06	Quad low noise			

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