Electronics Today INTERNATIONAL

The Magazine for Electronics & Computing Enthusiasts

$1.95 MM70924

February 1982

Sound Bender

A Ring-modulator for your Guitar

Enlarger Timer

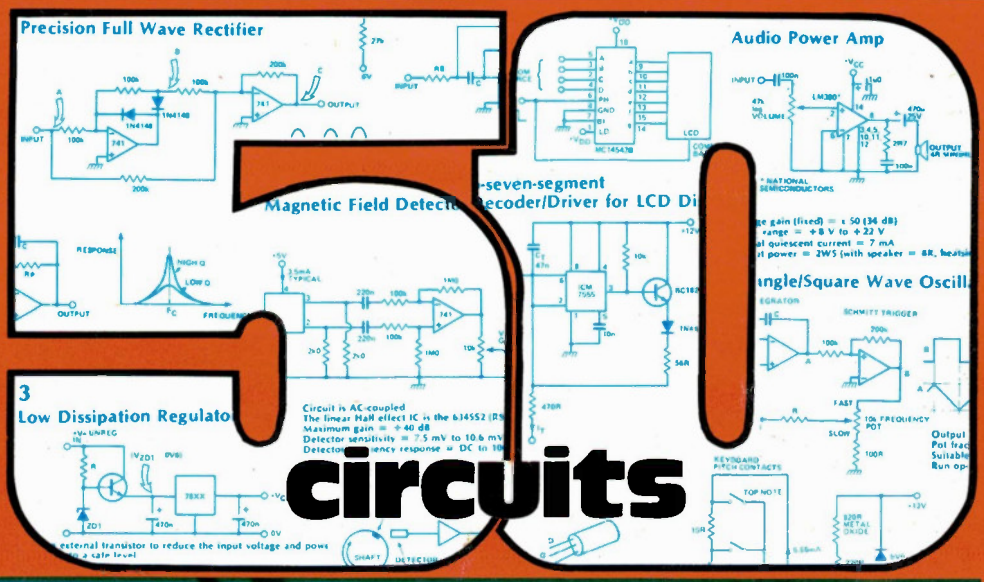
A Project for the Darkroom

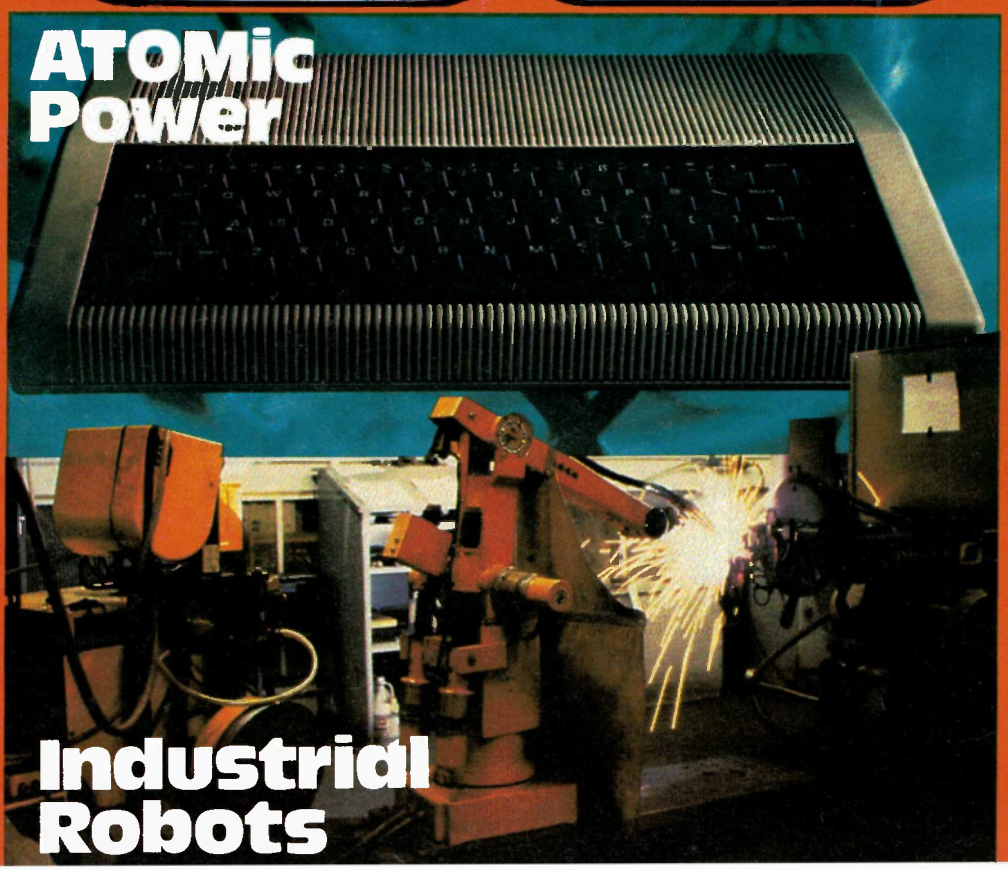
A Touch of Class

The ABC of Amplifier Classification

Flash Sequencer

Special Effects for the Photographer





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What you should know about the Multiflex Z80A computer

Exceltronix Components & Computing Inc.

MULTIFLEX is a young, fast-growing Canadian computer company. Most people have only just heard of us within the past year, because previous to that we were involved in intensive, low-profile research and development.

THE Z80A SYSTEM was developed over a two-year period. The company's intent was to produce a computer suitable for both hobbyists and industry, capable of functioning as a stand-alone trainer yet infinitely expandable. That goal has been attained, with the added benefit of a very low price.

STAND-ALONE FEATURES Selected for maximum usefulness and lowest cost, include the following:

Separate motherboard and CPU card, which communicate over the industry-standard S-100 bus. The motherboard can accommodate up to four S-100 cards.

Space on the CPU card for up to 4K of RAM and up to 16K of EPROM. The RAM is organized as two blocks of 2K bytes each, (200 nS 2114 devices are used) which can be located within any 2K block in the address-space by hardware jumpers. An 8K or 16K block size may be selected for the EPROMs and this, too, may be located at any address. 2708 and 2716 devices may be used exclusively or in combinations.

A resident 3.5K Monitor which facilitates machine-language program entry, execution and debugging, and controls all input/output hardware on the motherboard. The Monitor is in two 2716 EPROMs which may be removed and re-used if the user wishes to implement a more powerful operating system.

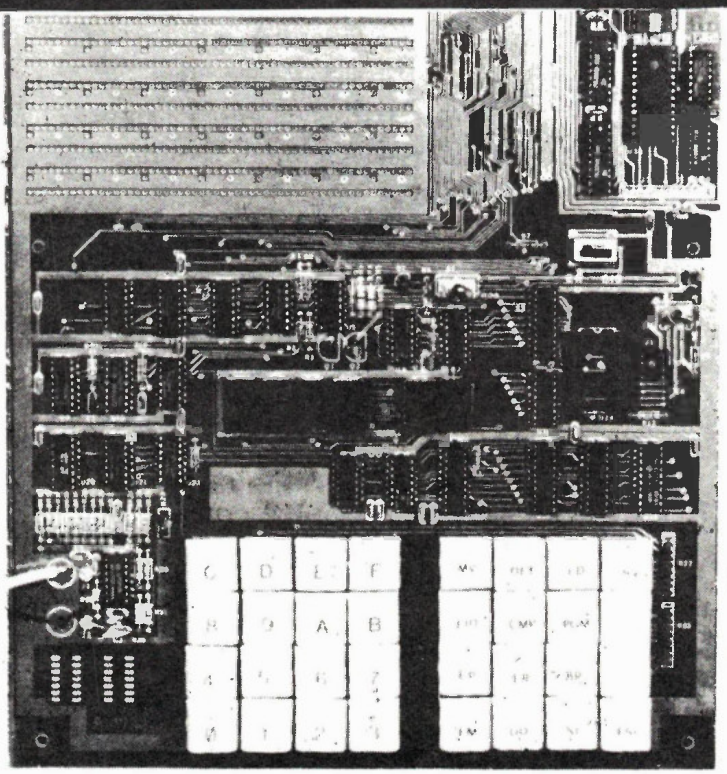
A hex keyboard, fourteen Monitor function keys, and two unassigned keys for user routines.

A six-digit hex LED display organized as a four-digit address field and a two-digit data field.

An interface to a conventional cassette recorder, which sends and receives data at 2000 bits per second with exceptional reliability. The Monitor includes a special routine which simplifies precise calibration of the recorder and interface.

An EPROM programmer for 2708 and 2716 devices. The contents of any block of system memory may be written out to EPROM, and programmed EPROMs may also be read into RAM through the programming socket for duplication. Many industrial buyers have used Multiflex Z80A systems just to download data from larger computers, to be programmed into EPROMs.

A parallel interface based on the 8255 PPI chip. Twenty-four I/O lines are available, which can be programmed in several configurations.



Read the independent review of this product in ETI May 1981.

An optional RS-232C serial interface, already wired on the motherboard. The components for this may be purchased and installed at any time, allowing communication with a modem, printer, or other device using the RS-232C standard. Eight jumper-selectable baud rates are available, from 110 to 9600 baud.

A 40-chip wire-wrap area on the motherboard for custom hardware development or modifications. The wire-wrap plane is centrally located for easy access to bus signals and all I/O hardware.

$375. in kit form.

$450. Assembled & tested.

EXPANDABILITY is assured by the use of the S-100 bus system. Almost any product, made by any manufacturer for use with S-100 computer systems, may be used with the Multiflex Z80A. Also, all bus signals are heavily buffered in the Multiflex computer, to facilitate expansion to many extra boards. Multiflex is now developing an entire line of support products designed specifically for the Z80A. These include:

A 64K dynamic memory board with automatic refresh, based on the Intel 8202 Dynamic Memory Controller chip. Each board may be loaded with 16K, 32K, 48K or 64K of 4116 RAM devices, and up to eight full boards may be used on the same bus because of the bank-select feature.

A low-cost video board for displaying text on an ordinary black-and-white television set, with an interface to a standard ASCII keyboard.

A high-resolution colour text/graphics board and I/O subsystem, based on the Motorola 6847 Video Display Controller. The video circuitry offers eight display modes and can be interfaced to a standard ASCII keyboard. The I/O section includes two 8255 PPI chips for up to 48 bits of parallel I/O, an 8253 programmable real-time clock, a fully handshaked RS-232C interface with baud rate programmable through the 8253, and up to 6K of static RAM. The board may be used with any colour television set, because a complete RF modulator is provided on-board.

An EPROM emulator for use in the development of stand-alone microprocessor systems. This board appears to a host computer as ordinary RAM on the S-100 bus, but to an external device connected to it by a 24-pin DIP jumper, it completely simulates a 2716 or 2732 EPROM.

A bipolar PROM programmer which connects directly to the EPROM programming socket of the Z80A system. This board and the software package sold with it, are capable of programming all of the popular Schottky PROMs.

All of the above-mentioned products except the PROM programmer may be interfaced to any S-100 computer, regardless of manufacturer.

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2114L-200ns low power 2.95
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NOTE: 1 of these can do the job of 4 2114's but uses only one 24 pin socket
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INTERNATIONAL EDITIONS
Electronics Today International,
145 Charing Cross Road,
London WC2H 0EE, UK

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

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

Electronica Top Internationaal
Postbus 93, Bilthoven, Holland

ETI Magazine is Published by:
Electronics Today International (Canada) Limited

Newsstand Distribution: Master Media, Oakville, Ontario

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

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POSTAL INFORMATION
Second Class Mail Registration No.3955.
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Features

50 Circuits 10
Half a hundred small projects to try, each devised by circuit wizard Tim Orr. Build them all and wind up very short of solder.

ATOMic Power 29
The operating system of the Acorn ATOM unveiled. Steve Rimmmer POKEs beneath the case of this powerful little machine.

ETI ELECTRONICS TODAY

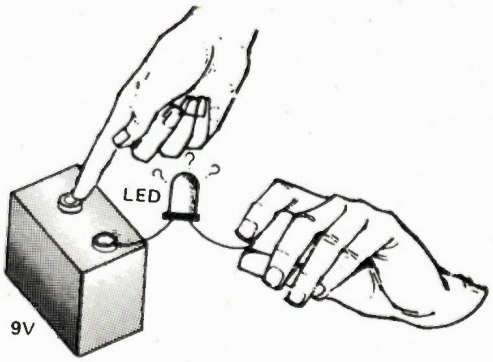
Signs 35
While not exactly a breakthrough in flat screen technology, Versa-Digital's LED matrix sign display represents an unusual application of state of the art technology. By Steve Rimmer.

POKEing the ZX-80 36
More marvelous memory modifications for this splendid little machine. Also included is a short program to try.

Industrial Robots 38
Far from being relegates from 1960's science fiction flicks, robots are very much a thing of the present. They are doing a lot of the work that humans would rather avoid, as Roger Allan explains.

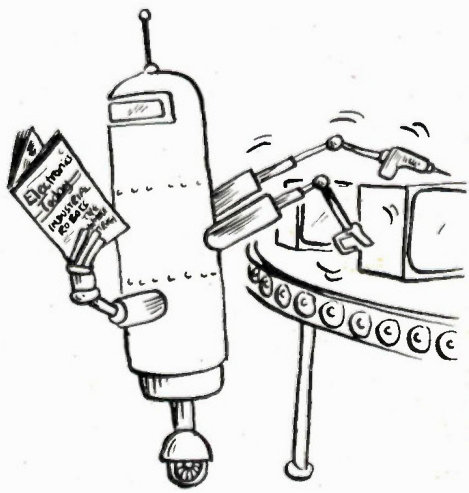
Amplifier Class 61
Unless you've got one of those Distort-o-phone Stereos with a speaker in the lid, your amp has some kind of class. Wally Parsons explains why.

dbx 64
The astounding part about dbx is what you don't hear; plug in a dynamic range expander and all your tape noise vanishes. The secret of silence, by Peter Green.

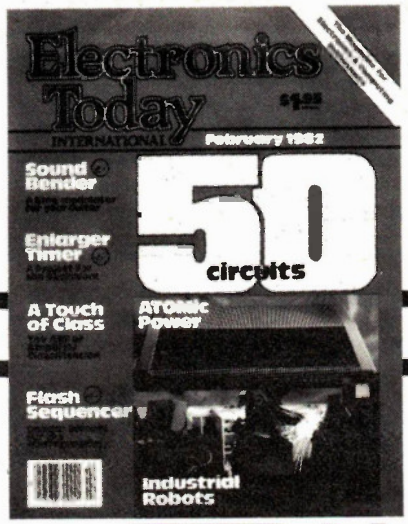


Can enough current pass through your fingers to light an LED?

Into Linear ICs 69
This month, Ian Sinclair deals with the 741 op amp, crafting it into a number of illustrative circuits.



Short Wave Aerials 66
A well designed aerial is almost as good as being there. . . better if "there" is under attack.



Our Cover: Fifty circuits, each one certain to be more useful than either a digital water clock or a four slice, pop up salad drier, page 10

ISSN 0703-8984

Projects

Flash Sequencer 23
Yes, you can hook nine flash units up to this thing for exciting stop action photography. Locating nine flashes is entirely up to you.

Enlarger Timer 59
This little project will precisely time the exposure of any print for up to four minutes and fifteen seconds. Something to bring joy to the heart of any photographer.

Sound Bender 75
Make your guitar sound like a cathedral bell, a gong, or any of a number of percussive chimes with this amazing effect.

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

Component Notation and Units
We normally specify components using an international standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for sooner!
Firstly decimal points are dropped and substituted with the multiplier: thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100nF, 5600pF is 5n6. Other examples are 5.6pF = 5p6 and 0.5pF = 0p5.
Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is the same, 4.7kohms is 4k7, 100ohms is 100R and 5.60hms is 5R6.

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

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INSTALLATION: Attach to antenna terminals of your color TV set and plug into 120 VAC wall outlet. Computer includes built-in RF modulator, FCC approved and UL and CSA listed.

PROGRAMING: Most Micro-computers start you off with an abbreviated 4K BASIC, and then later you have to relearn the more powerful language. Since this computer has 16K of RAM, we start you with Level II Microsoft 4.7 BASIC. BASIC is the most popular Micro-computer language using commands that are words we are ordinarily used to; such as, PRINT, NEW, GOTO (For go to), END, COLOR, JOY, INPUT, etc. To help you learn programming we have included an 84 page instruction manual, plus a 20 page book of program examples.

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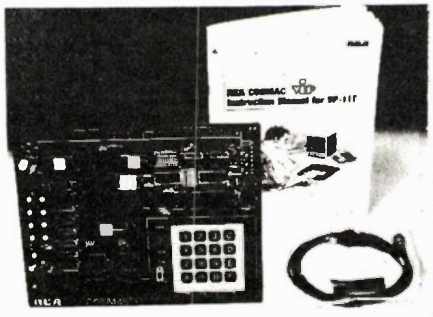

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The ZX81's advanced capability.
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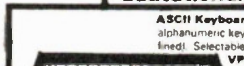
New, improved specification.
*Unique 'one-touch' key word entry: eliminates a great deal of tiresome typing. Key words (PRINT, LIST, RUN, etc.) have their own single-key entry. *Unique syntax-check and report codes identify programming errors immediately. *Full range of mathematical and scientific functions accurate to eight decimal places. *Graph-drawing and animated-display facilities. *Multi-dimensional string and numeric arrays. *Up to 26 FOR/NEXT loops. *Randomize function. *Programmable in machine code. *Cassette LOAD and SAVE with named programs. *1K-byte RAM expandable to 16K. *Full editing facilities. *Able to drive the new Sinclair ZX Printer (to be available shortly).

If you own a ZX80...
The new 8K BASIC ROM as used in the ZX81 is available as a drop-in replacement chip. (Complete with new keyboard template and operating manual). With the exception of animated graphics, all the advanced features of the ZX81 are now available on your ZX80 — including the ability to drive the Sinclair ZX Printer.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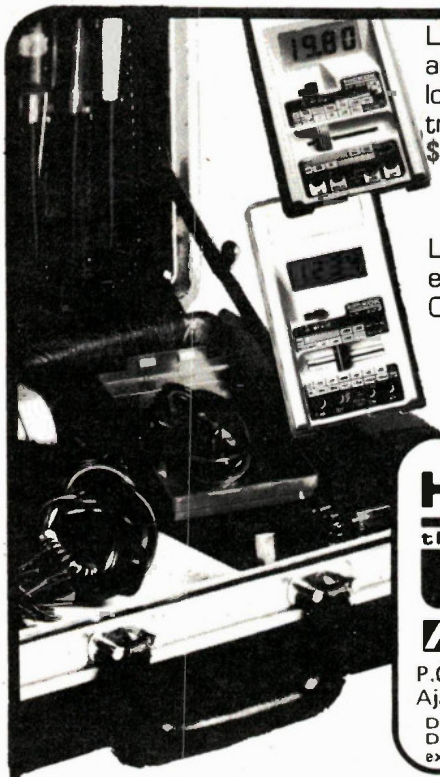
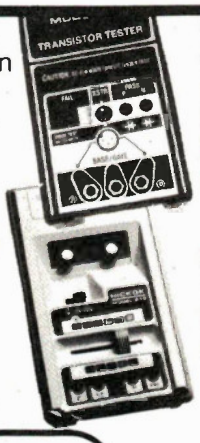


LX304 digital multimeter with automatic decimal point, built in low battery indicator and transistor testing capability. **$129.00**

LX303 digital multimeter with easy-to-read LCD display. Only **$110.00**



Model 216 Transistor Tester with fast, automatic switching for instant good-bad analysis of NPN's, PNP's, FET's, diodes and SCR's in or out of circuit. **$165.00**

Model 240 Video Generator with 10 step gray scale staircase for VTR, CCTV monitor and TV applications. **$215.00**

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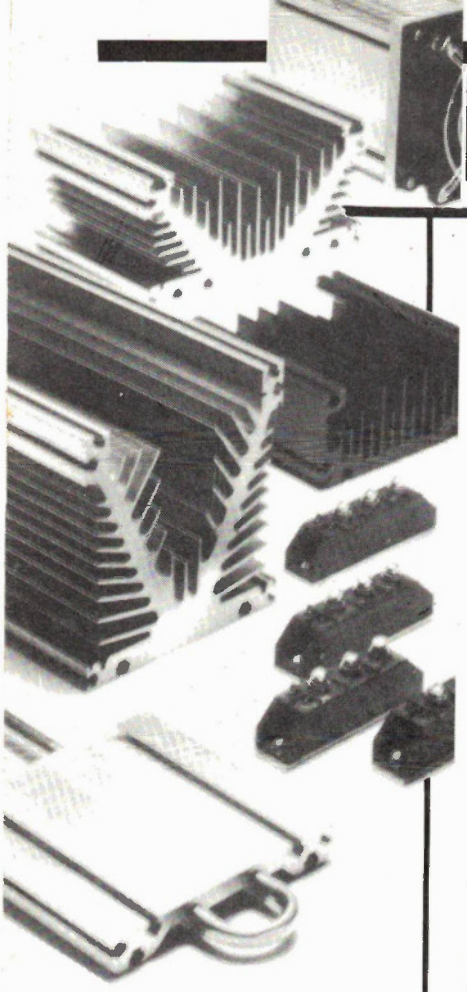
Circle No. 1 on Reader Service Card.

News



Demand for ZX81 outstrips supply

When the history of the microcomputer is written, the ZX81 is going to deserve a prominent mention: it could well be the watershed for introducing computers into the home.

From the first day it was launched in Britain, sales have been at 1000 units a day and worldwide sales in October are reported at 40,000!

The demand has quite outstripped supply. Gladstone Electronics, who import the ZX81 direct from Britain placed the first order from North America but still have an enormous backlog of orders. "We've managed to keep the good will of most of those ordering by being totally honest about the supply situation" said Howard Gladstone. " We feel bad about customers who have been waiting now up to 2½ months but there's nothing we can do. People are being remarkably patient and they do understand that they'll all be supplied in order. We're hoping that the situation will be much better by the time your readers see their February issue of ETI".

A printer for these computers is now on sale in Britain and is expected to be available in North America in the near future.

For the complete inner workings of the ZX81, see the review in next month's ETI.

Power Module Coolers

Designed specifically for power module cooling applications, EG&G Wakefield Engineering announces the availability of a new family of heat sinks for cooling power modules. Four aluminum extrusions, three air-cooled and one liquid-cooled, use industry standardized spacing and mounting configurations to offer a versatile approach to power module related cooling tasks.

Three different lengths are available for each series of both the air– and liquid-cooled heat sinks. Single high power or combinations of lower power devices may be mounted on a single heat sink. In addition to the individual extrusions, kits are available, which convert three of them into confined, forced convection systems to further increase their power handling capabilities.

Additional information on these new extrusions may be obtained by contacting Melvin Tracey at EG&G Wakefield Engineering, 60 Audubon Road, Wakefield, MA 01880, telephone (617) 245-5900.

Transducer Pressure Sensors

Motorola has announced two new silicon piezoresistive pressure sensors designed for medical, automotive and industrial applications. The "X-ducer"™ pressure sensor elements are the MPX50D — 0 to 50 kPa (0 to 7.3 PSI) pressure range, and the MPX200A — 0 to 200 kPa (0 to 29 PSI) pressure range. A or D refers to absolute or differential pressure types.

The MPX50D has an unconditioned output of up to 100mV (@ 5V excitation). It is particularly useful for medical applications such as bloodpressure measurement, although it is also suitable for environment and industrial controls. It is sensitive enough for measurement of inches of water column. Overpressure capability is 200 kPa (29 PSI). The new part is also available as a temperature compensated and signal-conditioned "gauge" sensor.

The MPX200A is an absolute pressure transducer having an operating pressure range from 0 to 200 kPa (0 to 30 PSI), 100% overpressure capability and typical linearity of ±0.05% full scale. This device is especially suited to automotive uses in turbo-chargers, as well as many other industrial applications requiring good repeatability over a broad pressure range. The device is also available as a signal-conditioned and temperature-compensated sensor module, the MPX200MA.

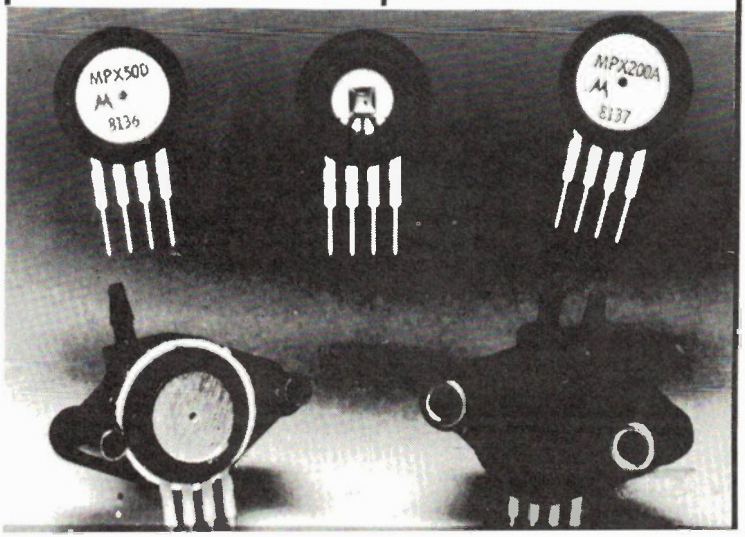
Motorola has also designed a universal recepticle for quick connection to 1/8" diameter or 1/16" diameter hoses. This pressure "port" fitting permits printed circuit board, chassis, and panel mounting. The hose fitting is barbed to prevent hose ejection due to pressure changes. The pressure port is supplied with metal rivets to secure the package for reliable chassis type mounting, and long term protection against vibration. The universal feature of the port fitting allows the MPX50D to be used as a gauge, vacuum gauge, or true differential sensor. A double-port fitting is used in applications where a true differential pressure reading is required.

The output signal is directly compatible with most microprocessor inputs and the part has virtually no "popcorn" noise.

Prices, including the optional new single and double hose ports, are:

Device	1-24
MPX50D	$26.00
MPX200A	$26.00

All parts are now in inventory and are available through the factory and authorized Motorola distributors.



Versatile Instrumentation Peripheral

Automated Control Systems has announced a multifunction S100 card that supports both analog and digital I/O. The V.I.P.—Versatile Instrumentation Peripheral enables the designer of S100-based process control or data acquisition systems to save card cage space and money. It combines 12-bit analog and high current, high voltage digital I/O, functions which previously required up to three card slots. Two dual utility relays are also included.

The analog portion is software configurable. It includes the following four elements:

1. An instrumentation amplifier input with resistor programmable gains from .1 to 1000.
2. An analog gain block with trimmerr adjustable offset.
3. A 12-bit A/D converter offering 25 micro-second conversion time and software selectable input ranges.
4. A 12-bit multiplying D/A converter with simultaneous voltage and current source outputs, double buffered for signal synthesis capabilities.

These functions can be variously configured, offering maximum versatility. The board is capable of self-check as well as parametric measurement.

The digital features include 8 TTL inputs and 48 TTL-compatible 30-volt, 100 mA open collector outputs. Selectable ROM decoding allows BCD programming of 5 digits of 7 segment LED displays. The board occupies 16 contiguous read and write I/O locations and offers switch selectable addressing. There are full Z80 interrupt and WAIT state capabilities.

Additionally, the V.I.P. has two uncommitted dual utility relays that can be used for multiplexing and other switching. A small IC patch area allows further customization.

The V.I.P. is ideal for use in stand alone instrumentation as a system "housekeeper" card, combining the functions of an LED display controller, utility volt meter, voltage and current sources, parametric measurement system, utility relays, and front panel interface. The V.I.P. can also be used as a component of industrial and scientific data acquisition and process control systems.

For more information contact Automated Control Systems, 1105 Broadway, Somerville, MA 02144. telephone (617) 628-5373.

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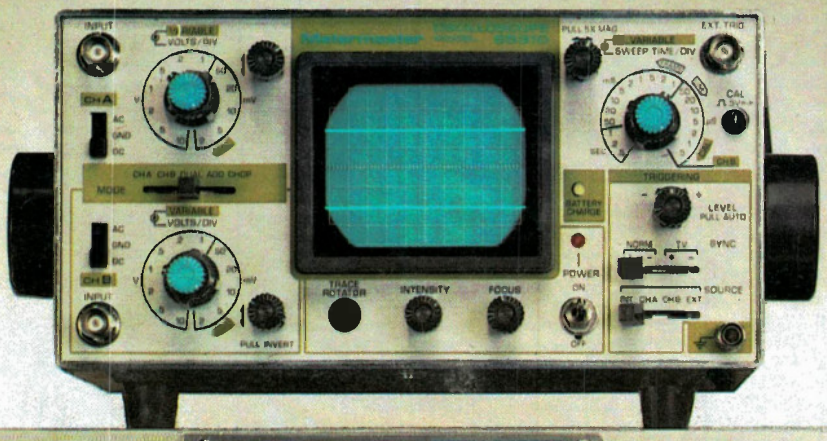
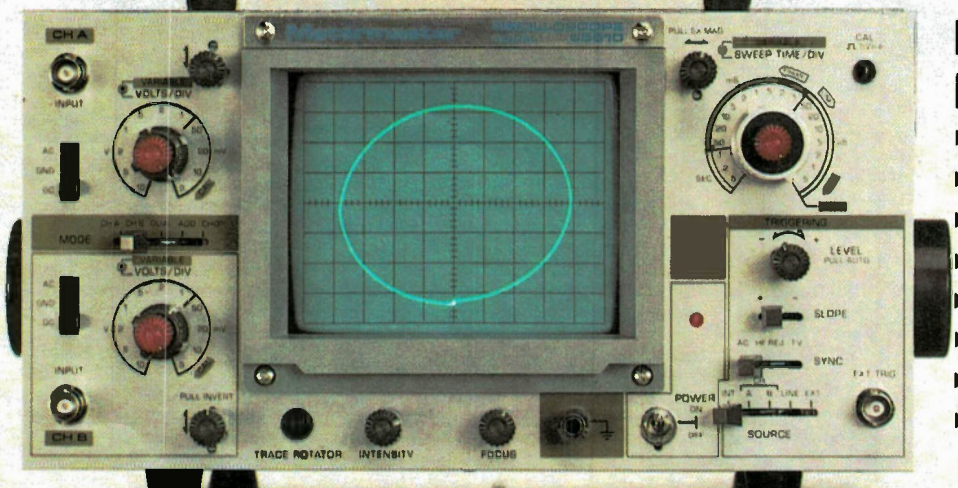


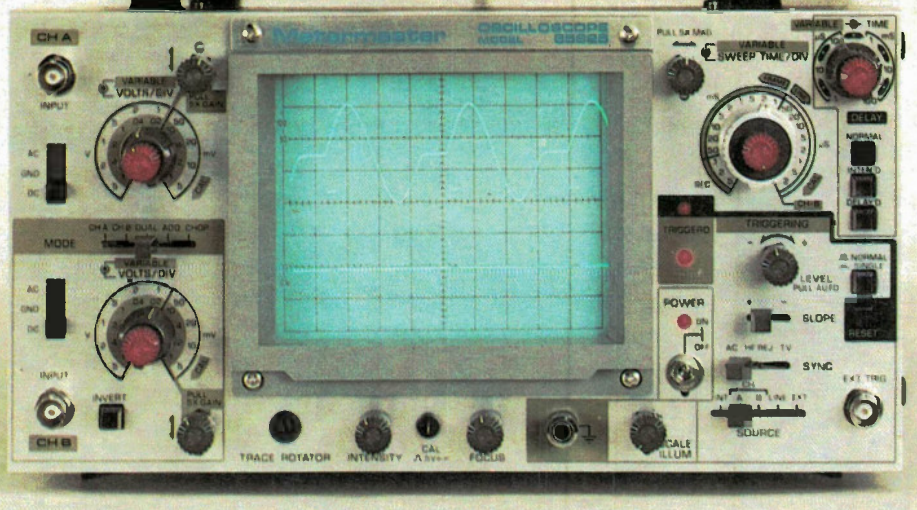
Model 65310
Dual Trace Portable

- 15MHz (-3dB) Bandwidth
- X5 Sweep Magnifier
- Battery, 12VDC & AC Operation
- 2mV Vertical Sensitivity
- Trace Rotator
- Price $775.00 taxes not included



Model 65610
Dual Trace Bench

- 15MHz (-3dB) Bandwidth
- 5" CRT Display
- 120VAC & 12VDC Operation
- Fully Automatic Triggering
- Trace Rotator
- 5mV Vertical Sensitivity
- HF Rejection
- Price $795.00 taxes not included



Model 65625
Dual Trace Bench

- 45MHz (-3dB) Bandwidth
- Delayed Sweep (selectable)
- Single Sweep (selectable)
- Extremely Bright 5" CRT
- Illumuninated Internal Graticule
- Optimal Sensitivity of 1mV
- X-Y or X-Y-Z Operation
- 120VAC Line Operation
- Price $1630.00 taxes not included

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Circle No. 11 on Reader Service Card.

Introduction to Word Processing

Introduction to Word Processing by Hal Glatzer has just been released by Sybex. No longer a luxury reserved for the corporate environment, affordable word processing is now accessible to the personal user. This book is the first of its kind to explain in non-technical language what word processing is and why and how using it can increase personal productivity. The author presents an easy, step-by-step guide on how to use a word processor and provides a complete, feature-by-feature comparative analysis of currently available equipment for anyone considering buying a system.

Why process words? Why not just type? A typewriter — even the best — can only perform one job: convert keystrokes into letters on paper. But a word processor is a computer. With memory, the word processor can not only automatically type faster than any human, but also edit and correct spelling errors. For executives, researchers, secretaries, authors, students, and countless others, the use of word processing can result in dramatic increases in both personal and business productivity.

Introduction to Word Processing reveals to us all in understandable terms the why and hows and what-ifs connected with the world of word processing. For anyone who is thinking about buying a word processor, or who has just started using one and wants to get the most mileage from it, this book is required reading.

For more information, contact Sybex, 2344 Sixth Street, Berkeley, CA 94710, telephone (415) 848-8233.

Switching Power Supplies

A new MK Series of NJE switching power supplies is reportedly designed for continuous and extended operation in critical applications. To back up this claim, the manufacturer warrants each of 40 standard models against defects in materials and workmanship for five years from date of shipment.

With the supplies housed in industry standard cases (5" x 8" x 11"), features include loss of sense protection, remote sensing, remote inhibit, power fail signal, overload and overvoltage protection, plus inrush limiting on turn-on. Also available is an optional crowbar for use along with OVP.

MK Series power supplies come with inputs ranging from 120 VAC (+10%-25%), 47-63 Hz to 240 VAC (+10%-25%), 47-63 Hz. Outputs vary from 2 V at 150 to 300 A up to 48 V at 18 to 36 A. Voltage adjustment is ±5% minimum. Line regulation is 0.2% for 100% full line change. Load regulation is 0.2% for 100% load change.

The output recovers to within 1% in less than 400 microseconds for a load change of 25% within the range of 25% to 100% load. Output will also remain within the regulation limits for 20 milliseconds after loss of AC input power (from nominal line voltage) at full load.

The new suppliles will operate at full output from 0° to 50°C and at full output derated 2% per °C from 51° to 71°C. Units can be stored at temperatures from -20°C to 85°C.

More detailed information can be obtained without charge by requesting Product Data Bulletin MK-101 from NJE, P.O. Box 50, Culver Road, Dayton, N.J. 08810. Telephone (201) 329-4611.

DATAlink service

A new circuit switched digital data communications service has been announced by CCG, The Computer Communications Group of the TransCanada Telephone System. Information on the new network service, called DATAlink™, was released to computer specialists and other management attendees at the Canadian Computer show.

Aimed at data users who must have the ability to access a host computer from remote sites and transmit data into the centralized processing unit in a batch or remote job entry (RJE) fashion, DATAlink will be most efficient for the low-to-medium volume users requiring a transparent service to move data within this structure. A pay-as-you-use, end-to-end digital, circuit-switched data service, DATAlink offers an upgrade to digital technology for current Multicom 2 data service users. It provides synchronous, full-duplex data transmission at speeds of 2400, 4800 and 9600 bits-per-second (bps), with half-duplex (single direction) transmission also accommodated.

DATAlink provides the high reliability and accuracy of digital transmission plus a range of basic features including alternate routing, itemized billing, auto answer and multi-frequency signalling.

Touch-Tone signalling provides simple seven-digit access to all stations. Access to the network is via a dedicated loop from the customer's location to the DATAlink switch.

Enhanced network security is possible through a closed user group option which prevents unauthorized users from accessing a DATAlink customer database. Another option is fixed reverse charging which automatically transfers the charges for all calls to the receiving terminal.

DATAlink will employ the Canadian-designed and manufactured DMS-100 digital multiplex system from Northern Telecom Limited. The DMS-100 switcher will take the computer communications signals from the customer's premises and switch them into the national digital data network. Any city in Canada which is designated a DATApac Serving Area constitutes a DATAlink access location and can subscribe to all the features and benefits of this digital service. Initially, DMS-100 switchers will be located in Toronto, Hamilton, Ottawa and Montreal to handle the circuit-switching requirements of DATAlink traffic. Over the next decade, additional DMS-100 switching systems will be phased into the network to handle the increasing volume of circuit-switched data communications traffic.

Rates for the new service will be filed early next year with appropriate federal (CRTC) and provincial regulatory agencies, with start of commercial DATAlink service requested for the second quarter of 1982. For further information, contact Brian M. Fraser, CCG Public Relations, telephone (613) 567-3748.

Graph Array With 101 LED's

A new red 101-element LED bar graph array, the HDSP-8820, has been announced by Hewlett-Packard (Canada) Ltd. This 10.58 centimetre (4.16 inch) display is an easy to read alternative to mechanical meters. Its 1% resolution and wide LED elements (1.52 mm or 0.06 inches) offer accurate and reliable meter indication.

Package design and drive requirements make the HDSP-8820 easy and economical to design into a system or instrument. Standard SIP sockets and PC board layouts are accommodated by the single-in-line package. The common cathode LED arrangement simplifies microprocessor interface for support electronics. The inherent low power requirements of LED's keeps drive requirements economical.

The HDSP-8820 101 element bar graph array is particularly suited to industrial process control systems as a status or position indicator for controller panels. It is also well suited for instrument and panel meter applications.

For more information, write Inquiries Manager, Hewlett-Packard (Canada) Ltd., 6877 Goreway Drive, Mississauga, Ontario L4V 1M8.

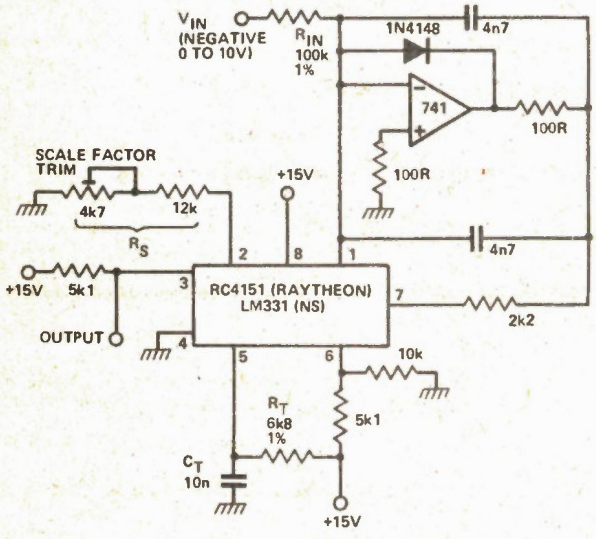
Measurement Error

Due to general crossing of wires (we generally try to blame our mistakes on technology), there was an error in our oscilloscope survey in the October 1981 issue. Thumbing through your carefully bound back issues, you will find that we said that we couldn't get any prices for Hitachi Denshi's 'scopes because they were in the process of being raised. In fact, this is only partially true, as some of them were actually reduced by as much as 20%.

For more information contact Hitach Denshi, Ltd. (Canada), 65 Melford Drive, Scarborough, Ontario, M1B 2G6 telephone (416) 299-5900.

50 circuits

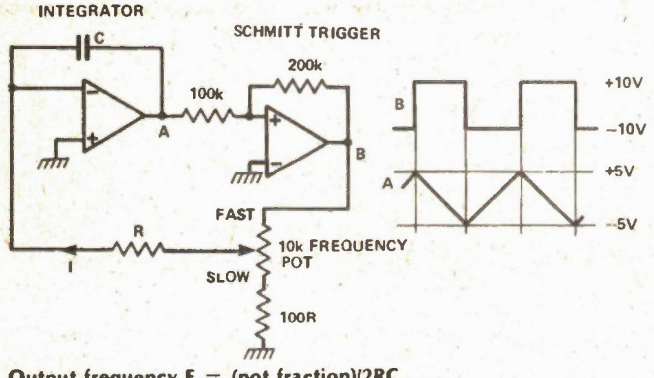
1
Precision VCO



$F = (-V_{IN})/2.09 \times (R_S/R_{IN}) \times 1/(R_T C_T)$ Hz

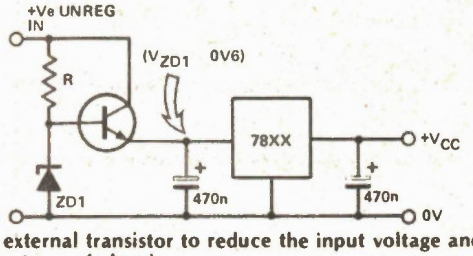
Maximum frequency = 10 kHz
Linearity = 0.05%
Response time = 10 us
Op-amp powered from ± 15 V

2
Triangle/Square Wave Oscillator



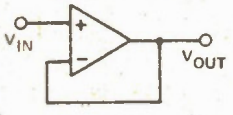
Output frequency F = (pot fraction)/2RC
Pot fraction can be 1/1 to 1/100, giving a 100 to 1 range from the pot
Suitable frequency range = 0.01 Hz to 50 kHz
Run op-amps from ± 12 V

3
Low Dissipation Regulator



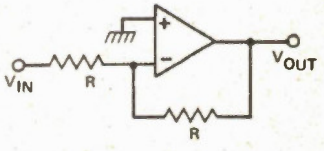
Using an external transistor to reduce the input voltage and power dissipation to a safe level.

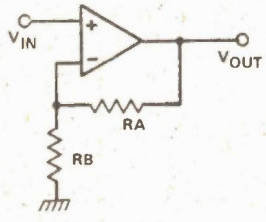
4
Basic Op-amp Building Blocks



Voltage follower/buffer
Input must have a DC path to ground

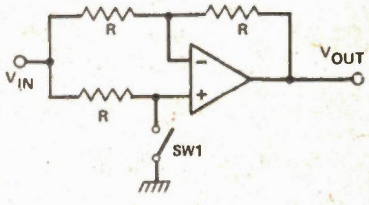
Inverter
Voltage gain = −1
input impedance = R

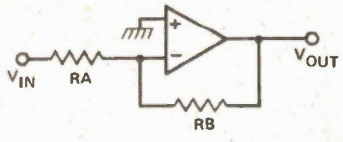




Non-inverting amplifier
Input must have a DC path to ground
Voltage gain = (RA + RB)/RP

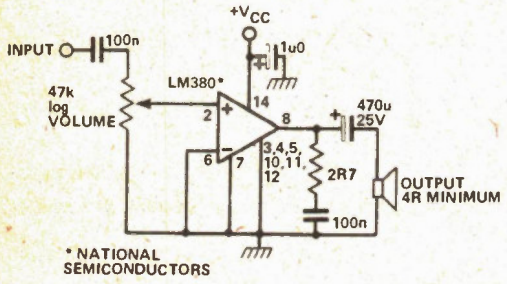
Inverter/non-inverter amplifier
Voltage gain = +1 with SW1 open
Voltage gain = −1 with SW1 closed





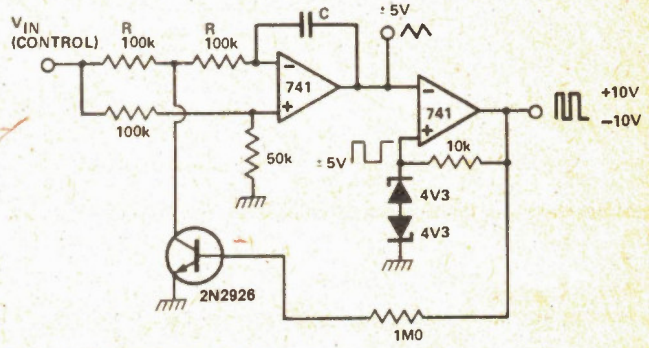
Inverting Amplifier
Voltage gain = −RB/RA
Input impedance = RA

5
Audio Power Amp



Voltage gain (fixed) = x 50 (34 dB)
$+V_{CC}$ range = +8 V to +22 V
Typical quiescent current = 7 mA
Output power = 2W5 (with speaker = 8R, heatsink fitted)

6
Linear VCO



Triangle and square wave outputs

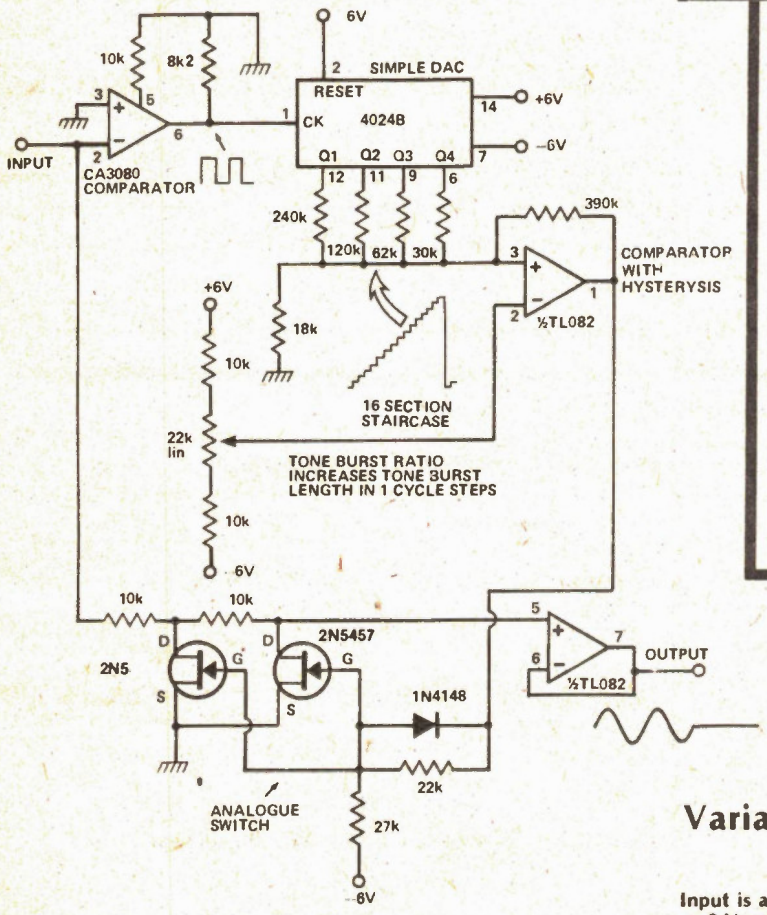
Output frequency F = $(1.667 \times 10^{-7} \times V_{IN})/C$ Hz

If C = 1n0 and V_{IN} = 10V, then F = 1.66 kHz

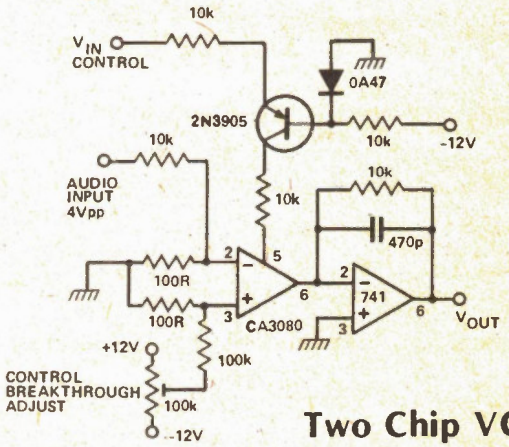
Changing both R's from 100k to 10k will increase F by x 10

For low frequencies use TL081 op-amps
Frequency range 0.1 Hz to 10 kHz

8



7

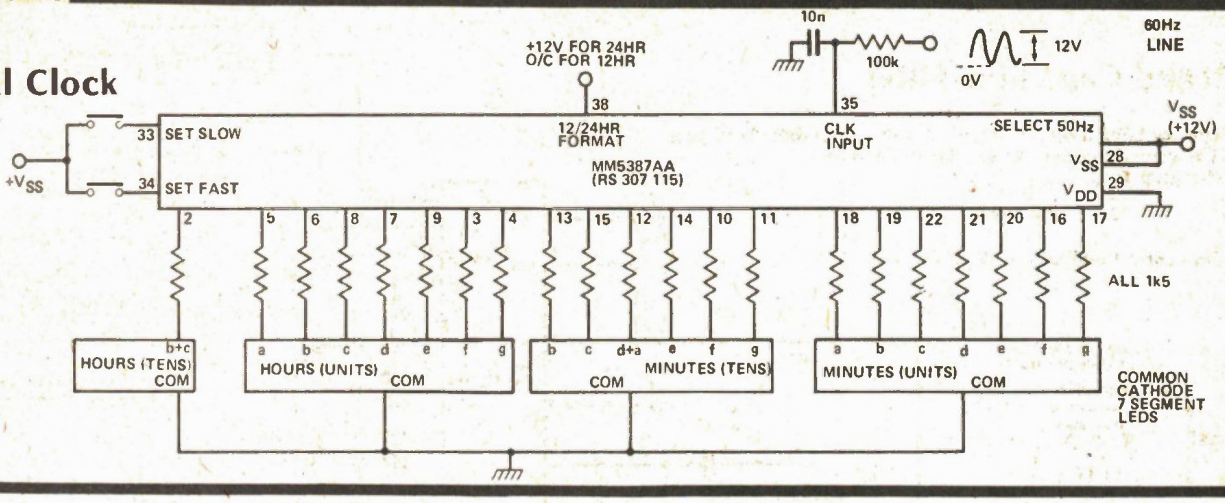


Two Chip VCA

Variable Length Tone Burst Generator

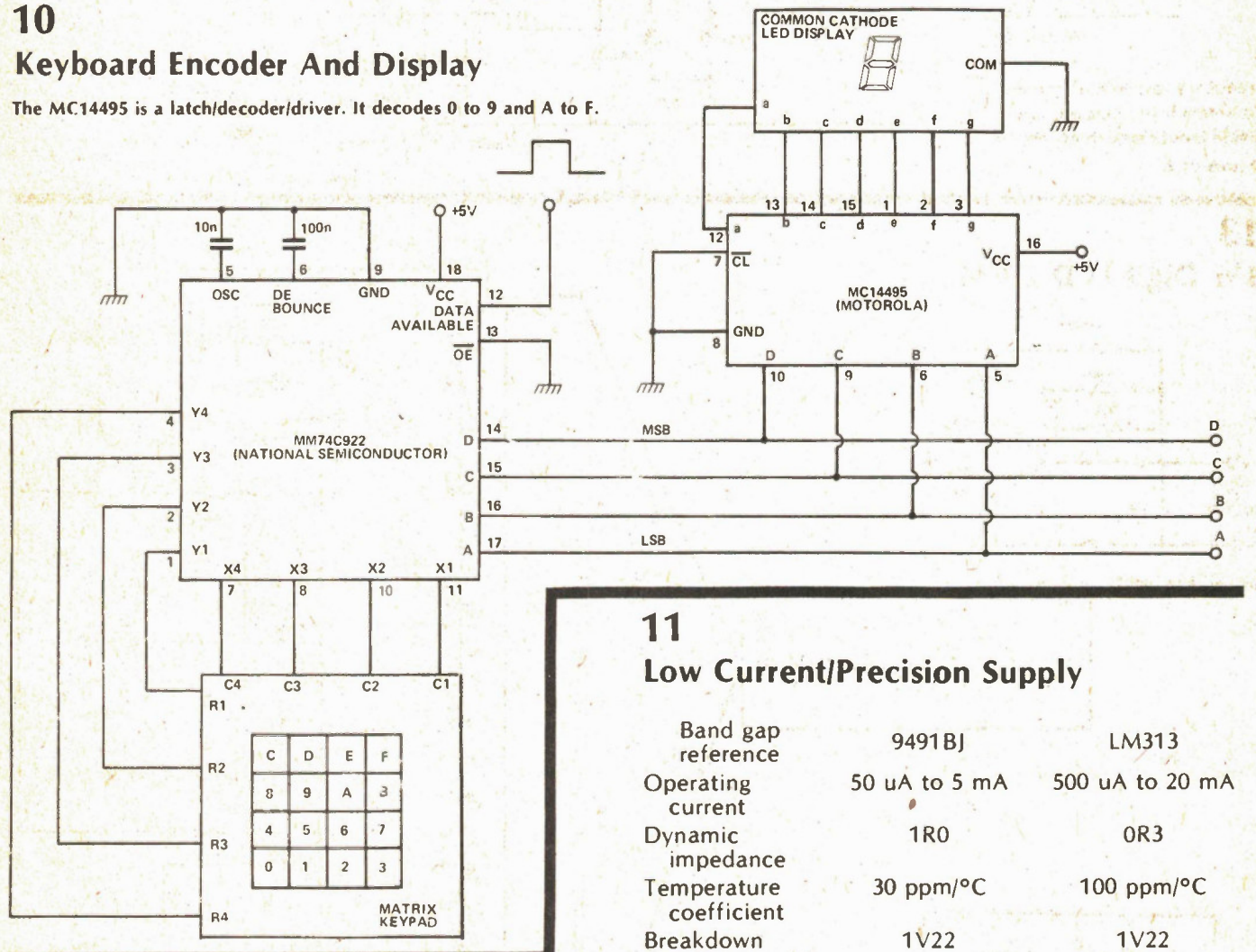
Input is a sinewave or any other periodic waveform, maximum level ± 2 V, maximum frequency 100 kHz
Output is a tone burst variable from one cycle on, 15 cycles off to 15 cycles on, one cycle off
All devices powered from ± 6 V

9
Digital Clock



10
Keyboard Encoder And Display

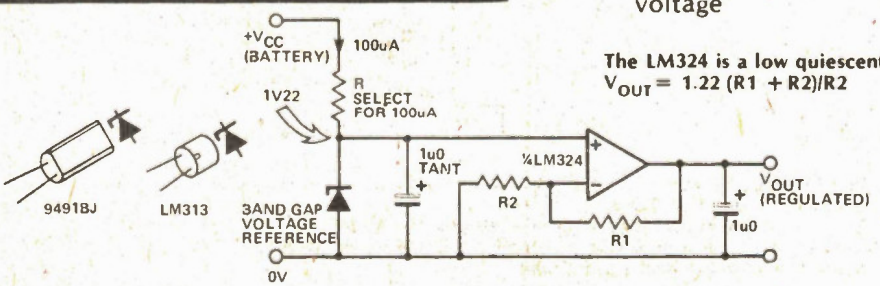
The MC14495 is a latch/decoder/driver. It decodes 0 to 9 and A to F.



11
Low Current/Precision Supply

Band gap reference	9491BJ	LM313
Operating current	50 uA to 5 mA	500 uA to 20 mA
Dynamic impedance	1R0	0R3
Temperature coefficient	30 ppm/°C	100 ppm/°C
Breakdown voltage	1V22	1V22

The LM324 is a low quiescent current, ground sensing op-amp
$V_{OUT} = 1.22 (R1 + R2)/R2$

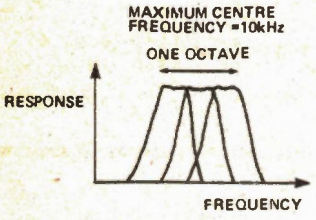


Very useful for battery equipment where only low current and low voltages are available. Also used as voltage references in DVM units.

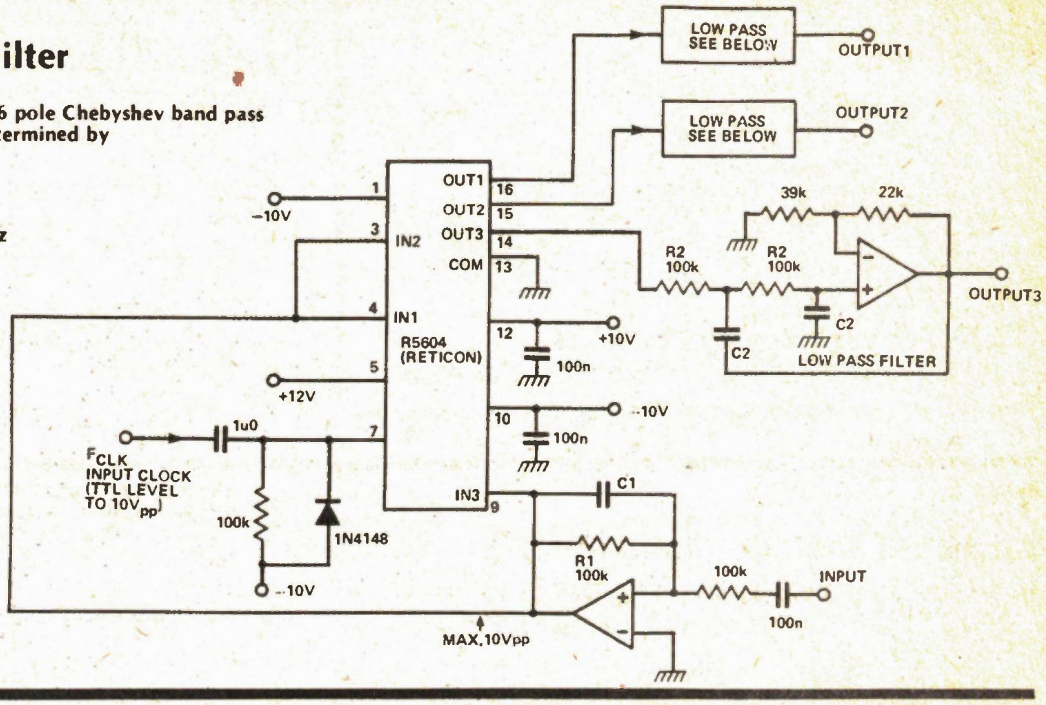
12
Switched Capacitor Filter

The R5604 contains three ⅓ octave, 6 pole Chebyshev band pass filters. The centre frequencies are determined by the relationship $\frac{F_{CLK}}{135}$, $\frac{F_{CLK}}{108}$, $\frac{F_{CLK}}{86.5}$

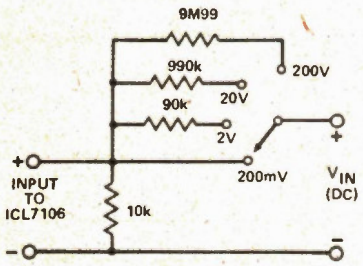
Maximum centre frequency = 10 kHz



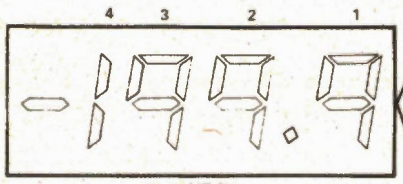
Frequency response of one device. To obtain lower octaves, merely divide input clock frequency by factors of 2.



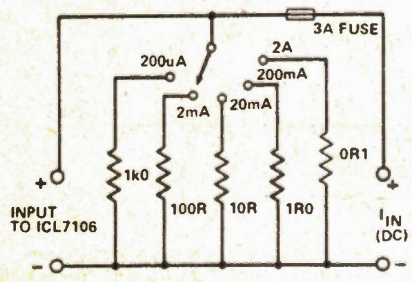
13
3½ Digit LCD DVM



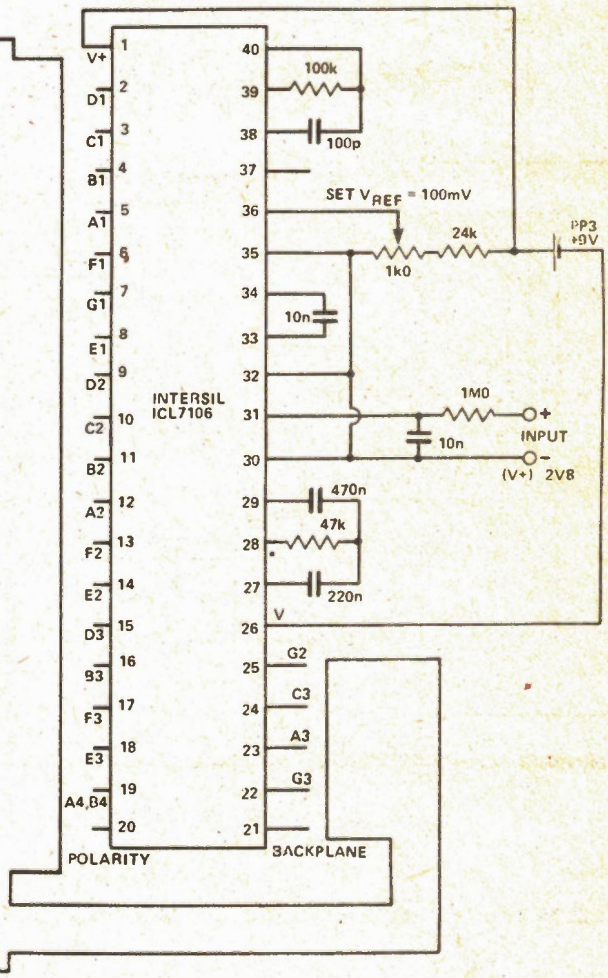
DC voltage inputs



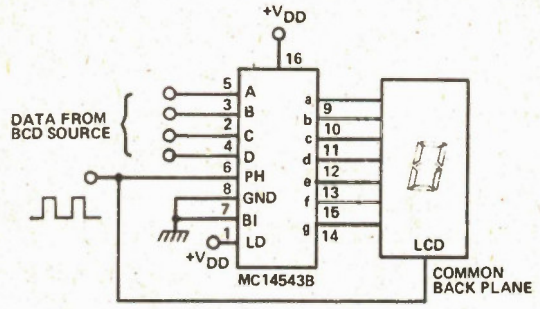
3½ DIGIT 9V LCD DISPLAY



DC current inputs

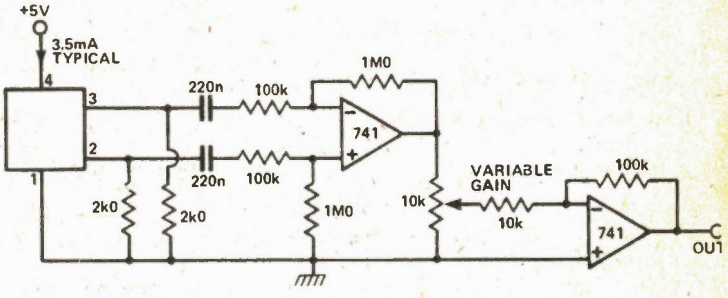


Input voltage range = ±200 mV
Quiescent current = 0.8 mA
Common mode input range = (V+)−0V5 to (V−)+1V
Decimal point must be driven externally by EXORing the decimal point data with the backplane strobe

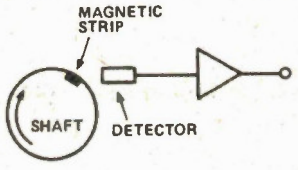


14
BCD-to-seven-segment Latch/Decoder/Driver for LCD Display

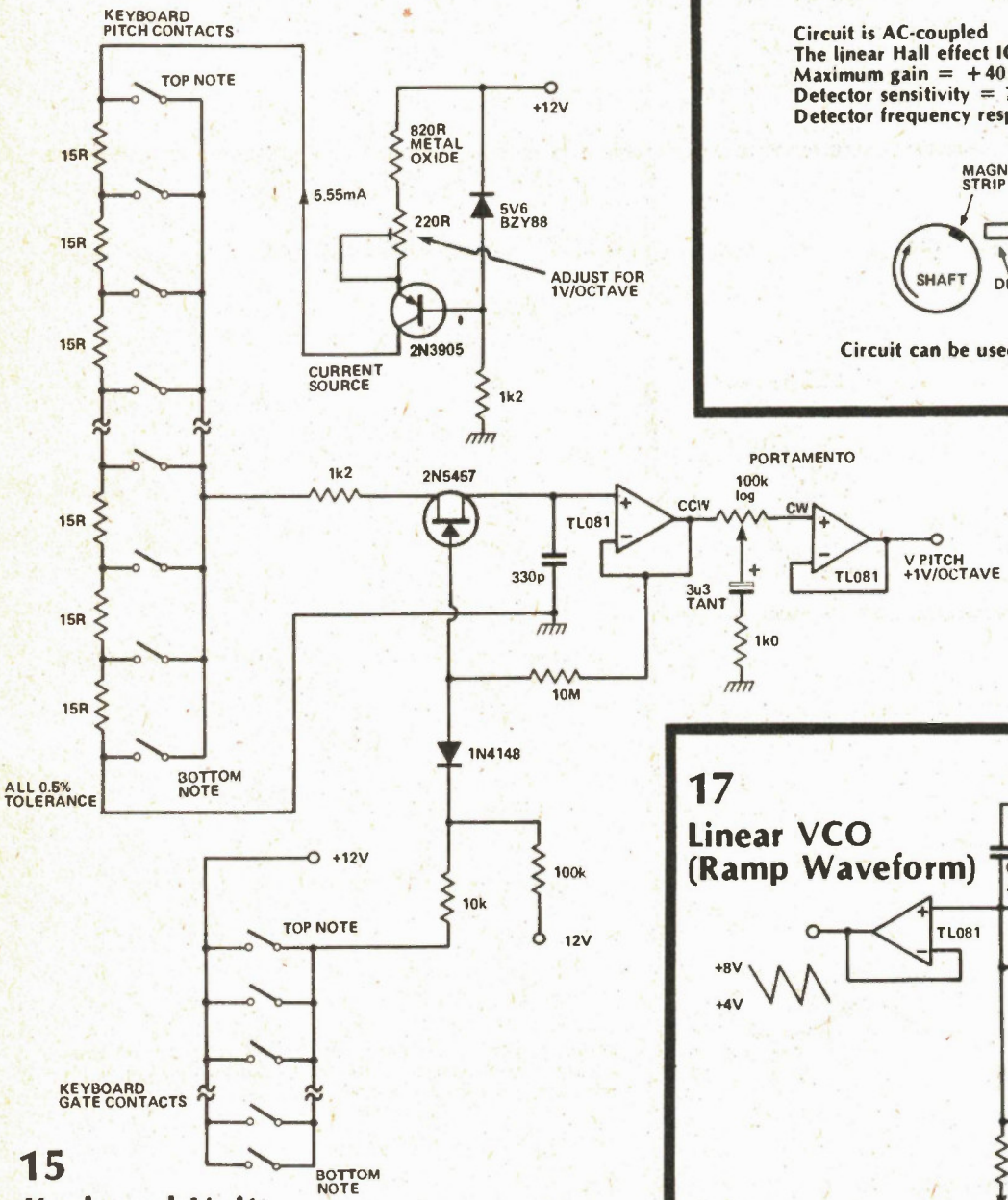
16
Magnetic Field Detector



Circuit is AC-coupled
The linear Hall effect IC is the 634SS2
Maximum gain = +40 dB
Detector sensitivity = 7.5 mV to 10.6 mV/mT
Detector frequency response = DC to 100 kHz



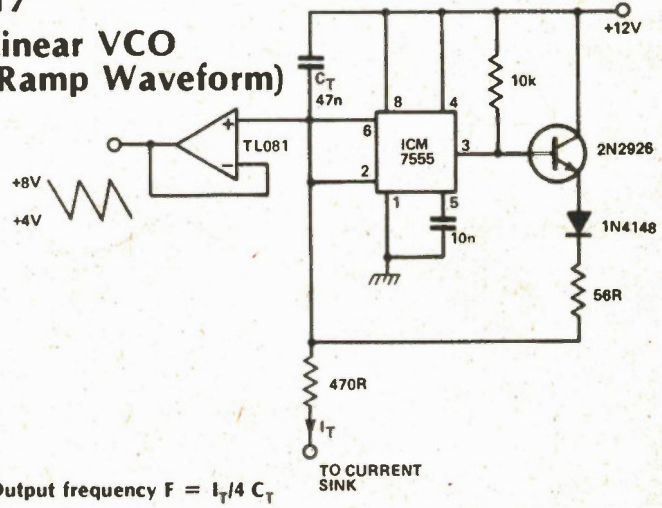
Circuit can be used as a tachometer



15
Keyboard Unit

Adjust the keyboard contacts so that the pitch contacts make before the gate contacts

17
Linear VCO (Ramp Waveform)



Output frequency $F = I_T/4\ C_T$

If I_T = 1mA, C_T = 47n, then F = 5.3 kHz

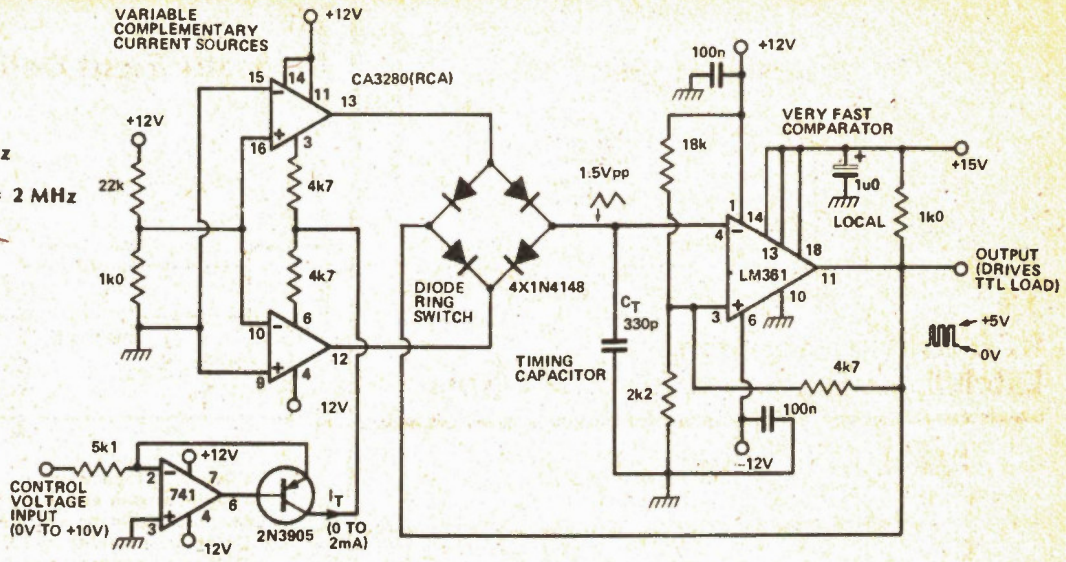
18
Fast VCO

Oscillation frequency $F = I_T/3C_T$ Hz

If I_T = 2 mA, C_T = 330p, then F = 2 MHz

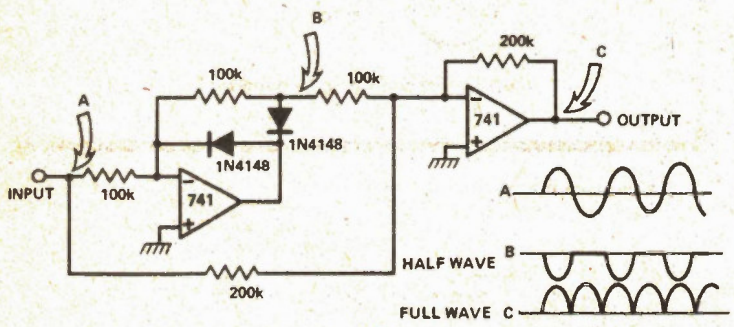
Alter C_T to increase F

Maximum frequency = 10 MHz



VOLTAGE TO CURRENT CONVERTER

19
Precision Full Wave Rectifier

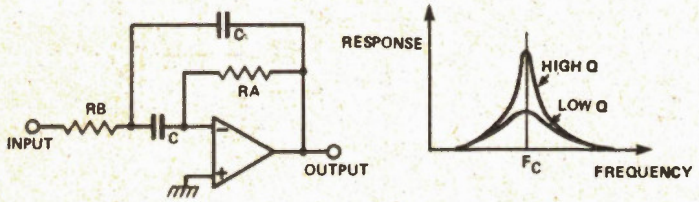


20
Band Pass Active Filter

$F_C = 1/2\pi C\sqrt{RA+RB}$

$Q = 1/2\sqrt{RA/RB}$

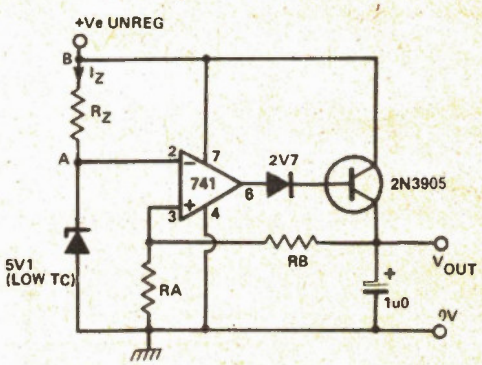
Gain $= 2Q^2$



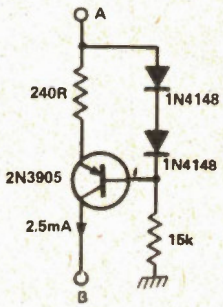
F_C = 1kHz, C = 15n

RA	RB	Q	GAIN
10k6	10k6	0.5	x 0.5
21k2	5k3	1.0	x 2.0
42k4	2k65	2.0	x 8.0
84k8	1k32	4.0	x 32.0

21
Battery Regulator



A very low dropout voltage can be obtained by allowing Q1 to saturate. This gives maximum lifetime on battery power.



Better regulation can be obtained by replacing RZ with this 2.5 mA current source. However, the unregulated supply rail must not drop below (5V1 + 1V2) = 6V3

Select R_Z for an I_Z of about 2.5 mA

V_{OUT} = 5V1 X (RA + RB)/RA

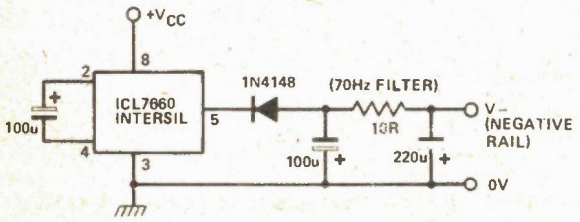
Minimum V_{OUT} ~6V

Dropout voltage = V_{CE}(Q1 saturated) ~ 0V3

Keep I_{OUT} less than 50 mA

22

Generating Negative Supply Rails

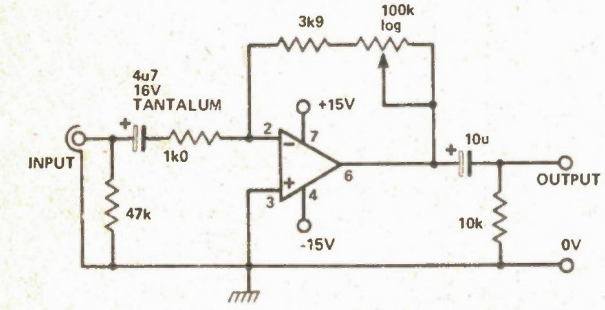


V– = (+V_{CC} – 0V7)
Typical efficiency = 98%
Quiescent current = 170 uA
+V_{CC} range = 3 to 10 V
Maximum output current = 40 mA
Output resistance = 55R

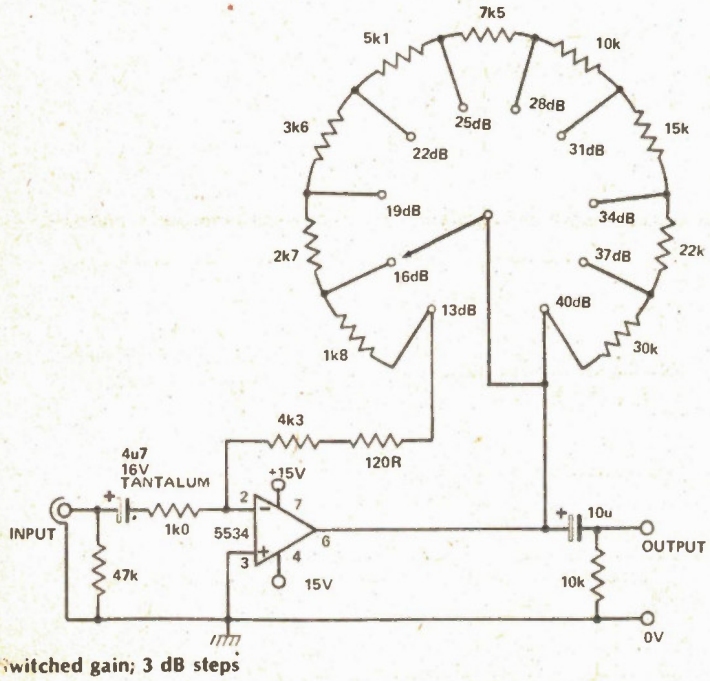
23

Low Impedance Source Preamp

Very low input noise
Input noise = 4 nV$\sqrt{Hz}$
Equivalent input noise voltage = 0.56 uV_{RMS} (20 kHz bandwidth)
Input impedance = 1k0 (suitable for microphone)



Variable gain; x 3.9 to x 100 (12 dB to 40 dB)

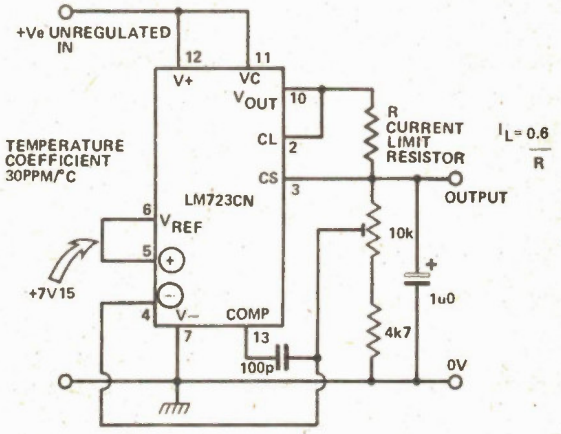


Switched gain; 3 dB steps

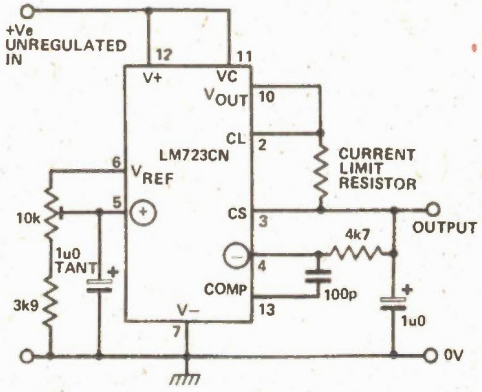
24

Precision Power Supplies

723 general specifications:
Maximum input voltage = 40 V
Maximum current output = 150 mA
Output voltage range = 2 to 37 V



Adjustable +7 V to +21 V

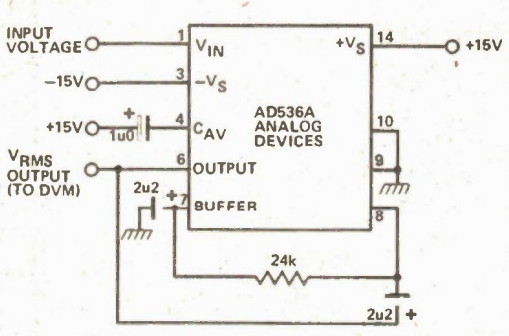


Adjustable +2 V to +7 V

25

True RMS Measurement

Input voltage 7 V_{RMS} maximum
Bandwidth: 300 kHz, V_{RMS} > 0V1
Error of 1% for a crest factor of 7
Quiescent current = 1mA
60 dB range



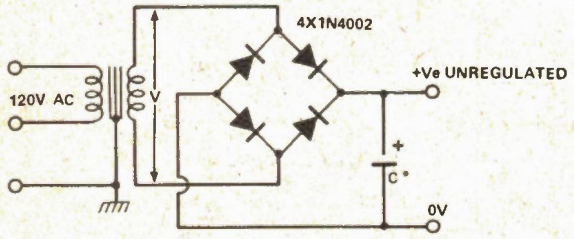
26
Unregulated Power Supplies

*** Smoothing capacitor must have a voltage rating greater than the rail voltage.**

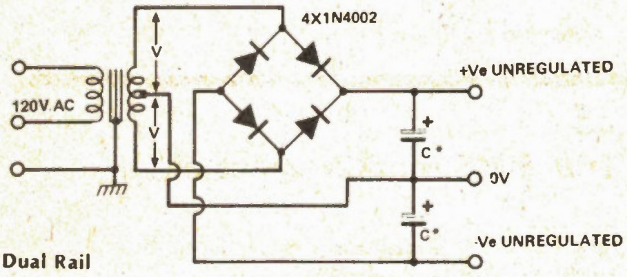
TRANSFORMER SECONDARY VOLTAGE (V_{RMS})	TYPICAL UNREGULATED DC VOLTAGE
4.5	6.3
6.0	8.4
9.0	12.6
12.0	16.8
15.0	21.0
20.0	28.0

APPROXIMATE RIPPLE VOLTAGES (V_{pp})

OUTPUT CURRENT	C = 470u	C = 1000u	C = 2200u
30 mA	0.42	0.21	0.10
100 mA	1.4	0.7	0.32
300 mA	4.2	2.1	0.96
1 A	14.0	7.0	3.20

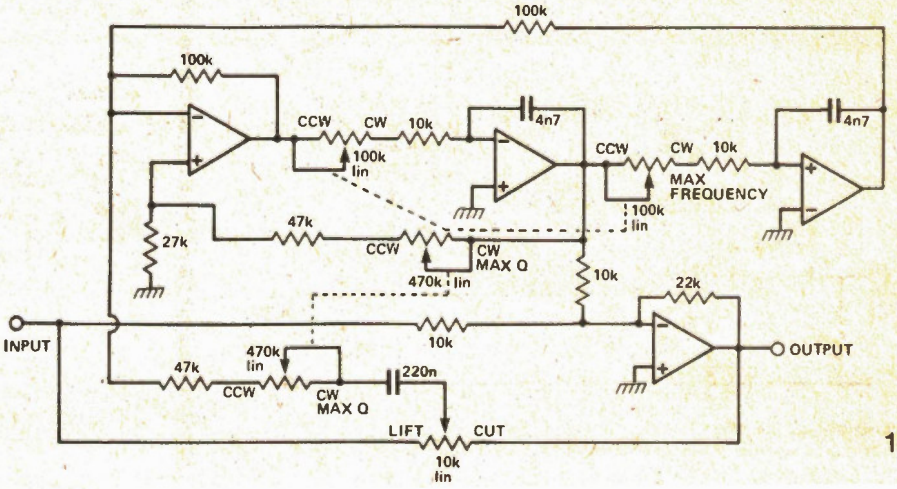


Single Rail



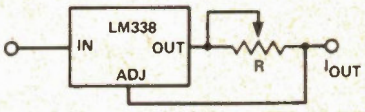
Dual Rail

27
Parametric Equaliser



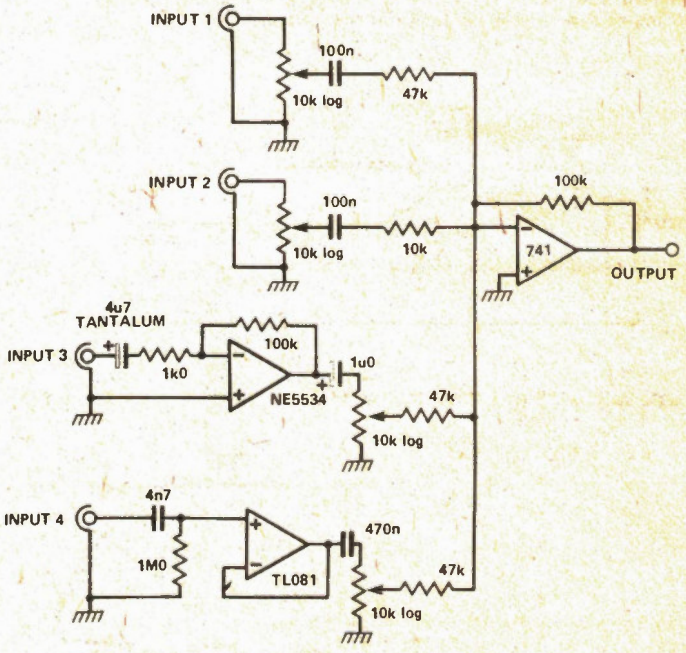
28
Current Limiter

0R4 < R < 120R

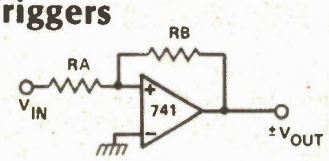


29
Simple Mixer

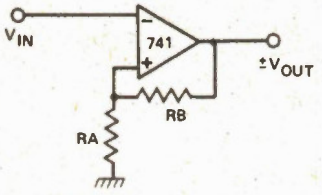
INPUT	MAX GAIN	INPUT IMPEDANCE	SOURCE
1	+6 dB	10k	line level
2	+20 dB	5 to 10k	line level
3	+46 dB	1k0	low impedance microphone
4	+6 dB	1M0	high impedance input



30
Schmitt Triggers

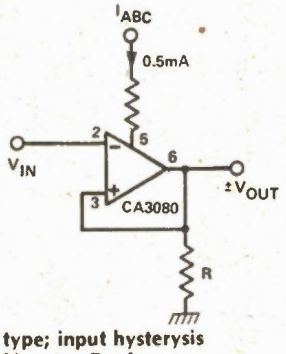


Non-inverting; input hysterysis levels = $\pm(RA/RB)) \times V_{OUT}$



Inverting; input hysterysis levels = $\pm(RA/(RA+RB)) \times V_{OUT}$

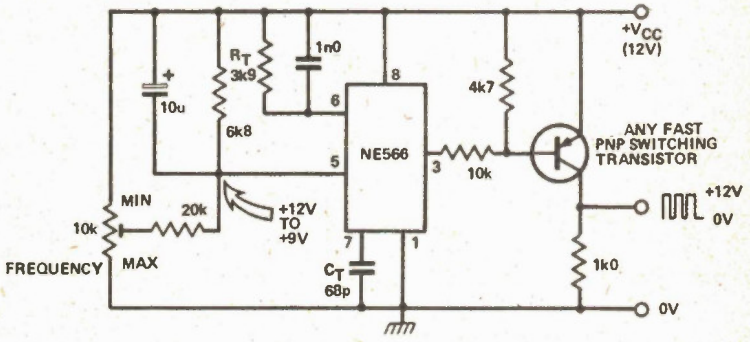
Note that V_{OUT} depends on the supply voltage and the individual op-amp



Transconductance type; input hysterysis levels = $\pm V_{OUT}$; $V_{OUT} = R \times I_{ABC}$

R can be replaced by two 1N4148 diodes back-to-back

31
Fast Oscillator

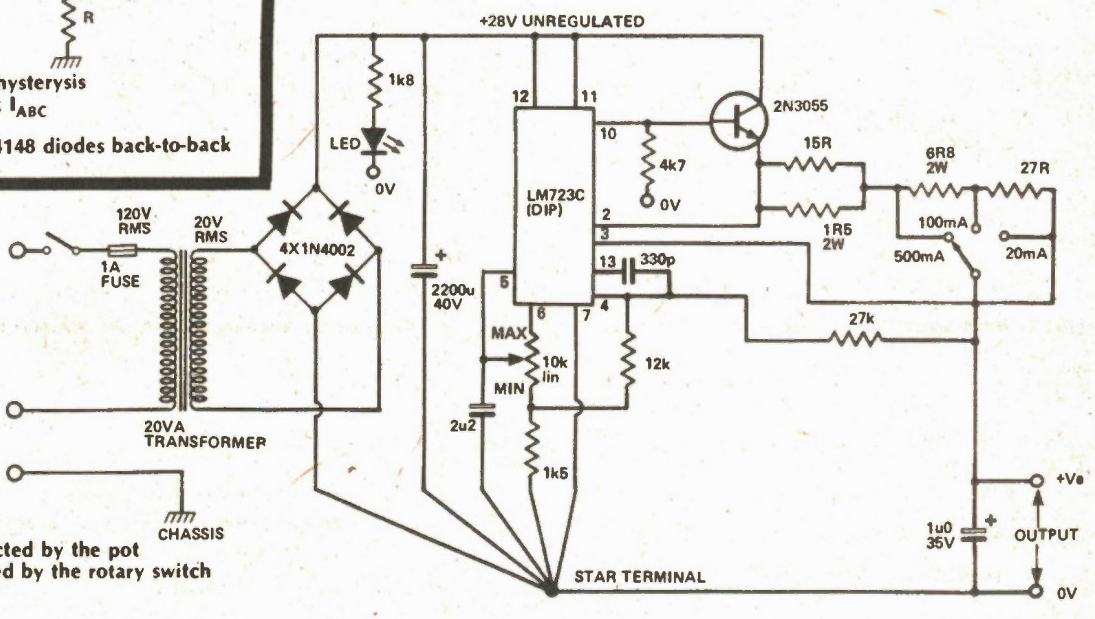


Bias voltage on pin 5, V_B = ¾ V_{CC} to V_{CC}

V_B gives a 10 to 1 control range

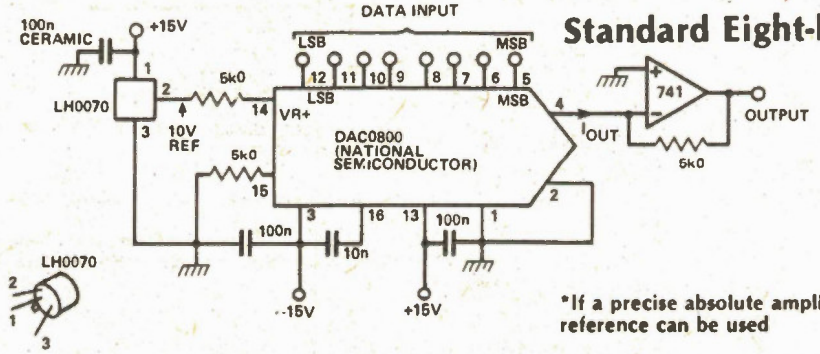
Typical frequency = 1 MHz

32
Power Supply Unit



Variable output voltage is selected by the pot
Variable current limit is selected by the rotary switch
Output voltage is 0 to +20 V

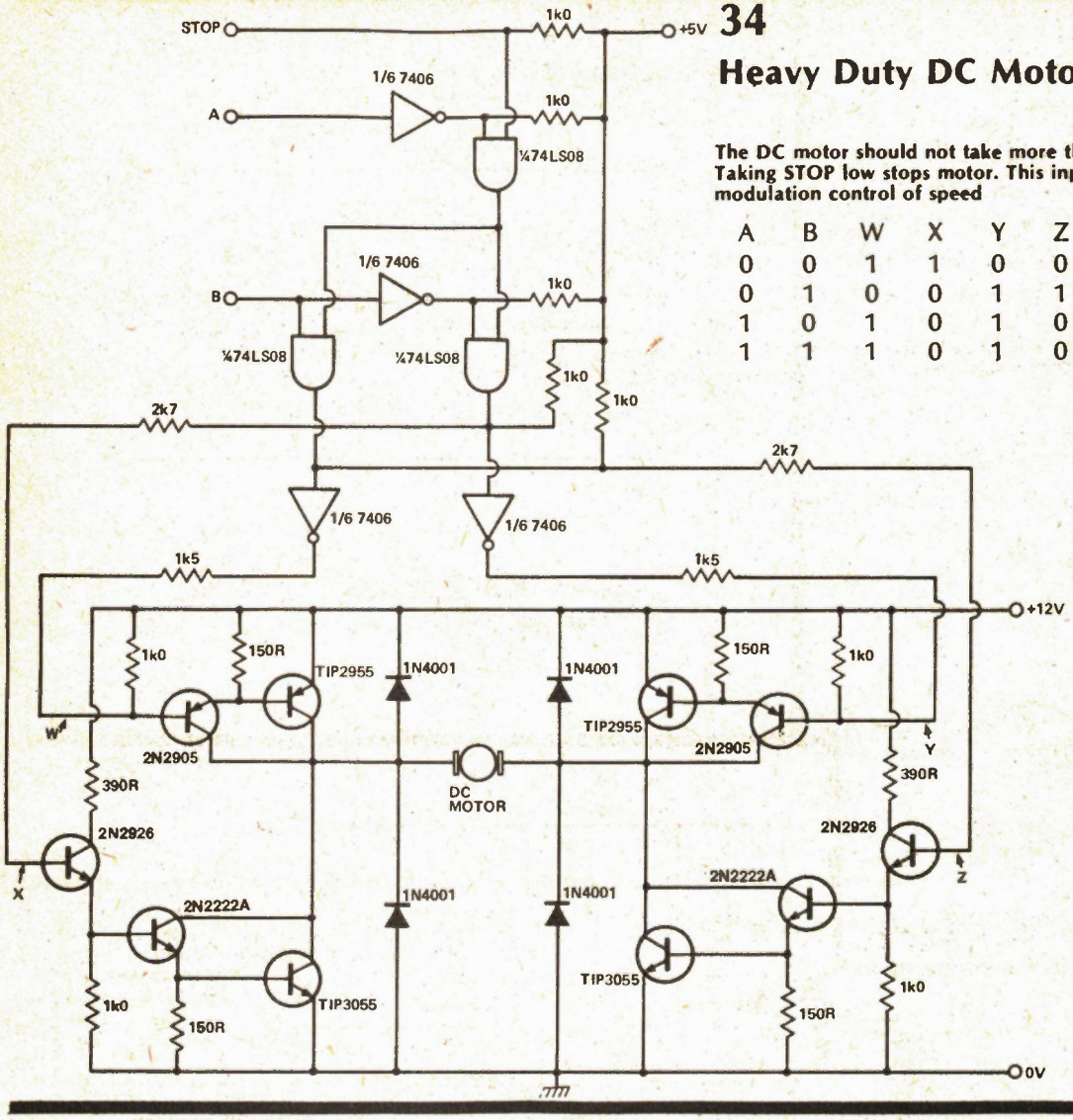
33
Standard Eight-bit DAC



*If a precise absolute amplitude is not needed, then a zener diode reference can be used

34

Heavy Duty DC Motor Control

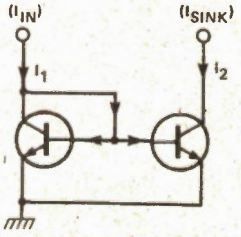


The DC motor should not take more than 3 to 4 A continuous current Taking STOP low stops motor. This input can be used for mark/space modulation control of speed

A	B	W	X	Y	Z	
0	0	1	1	0	0	REVERSE
0	1	0	0	1	1	FORWARD
1	0	1	0	1	0	OFF
1	1	1	0	1	0	OFF

35

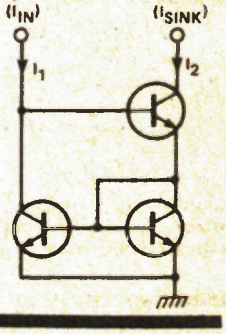
Current Mirrors



If ß = 100, I_2/I_1 = 0.98

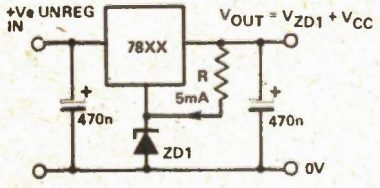
*Matched transistors with the same ß

This improved mirror gives a better I_2/I_1 performance with lower values of ß. Also the I_{SINK} current sink has a much higher output slope resistance.



36

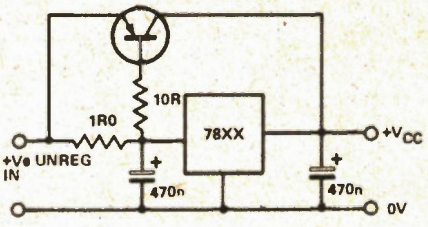
Increasing Regulator Voltages



Increasing the output voltage using a zener diode.

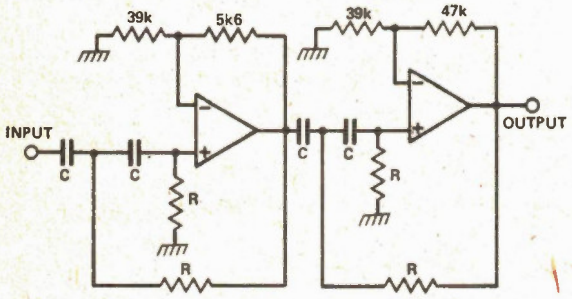
37

Increasing Regulator Currents

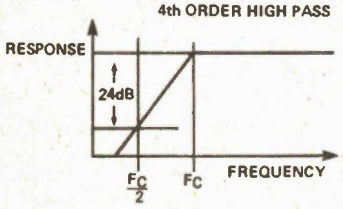


Using a bypass transistor to increase the output current drive. The first 600 mA flows through the regulator, the rest via the external transistor.

38
Rumble Filter



4th ORDER HIGH PASS

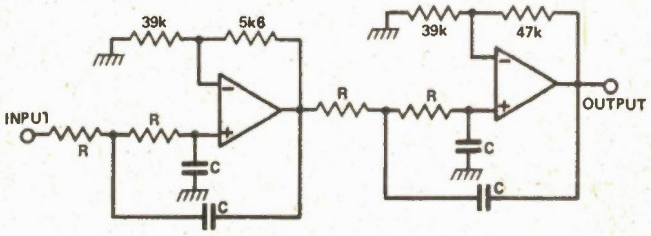


Roll-off slope = 24dB/octave
Overall voltage gain = x 2.6 (8.3 dB)
Op-amps are 741's or RC4558

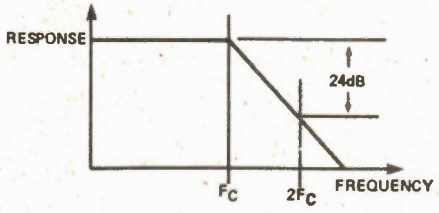
F_C	C	R
25 Hz	100n	62k
50 Hz	100n	30k
100 Hz	100n	15k
200 Hz	100n	7k5

(5% tolerance)

40
Scratch Filter



4th ORDER LOW PASS

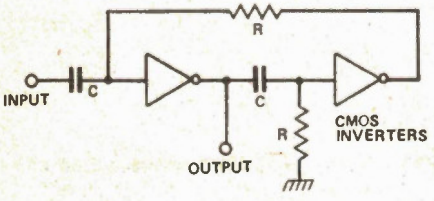


Input must have a DC path to ground
Roll-off slope = 24 dB/octave
Overall voltage gain = x 2.6 (8.3 dB)
Op-amps are 741's or RC4558

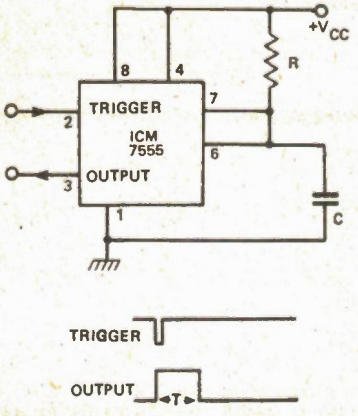
F_C	C	R
10 kHz	1n5	10k
7.5 kHz	1n5	14k
5 kHz	1n5	20k

(5% tolerance)

39 Monostables

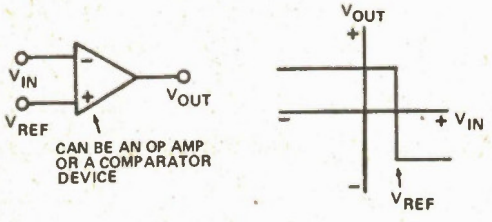


CMOS inverters
T = 1.38RC
Keep R greater than 47k

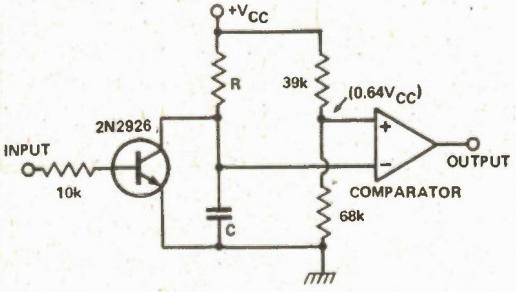


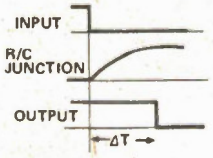
CMOS 555
T = 1.1RC

41 Comparators



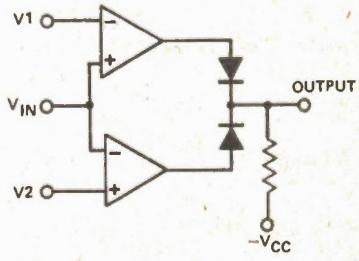
Response of a simple comparator

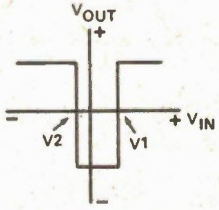




Time delay generator; ΔT = RC

Window comparator
V1 and V2 can be defined by resistors or can be set by any voltage
Note that V1 must be more positive than V2



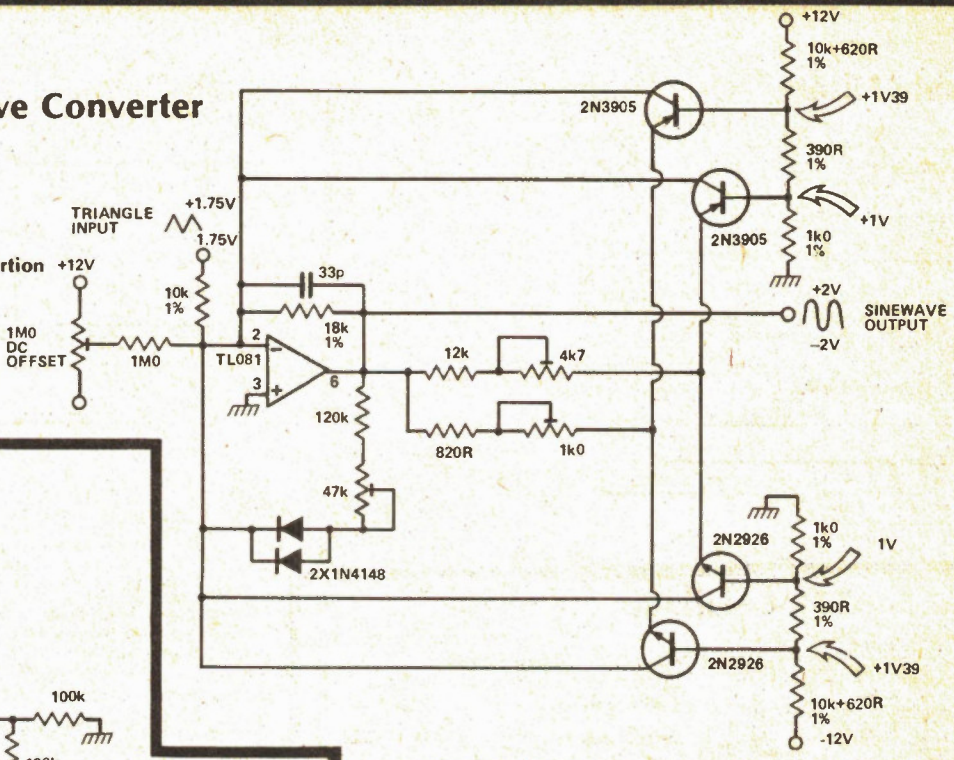


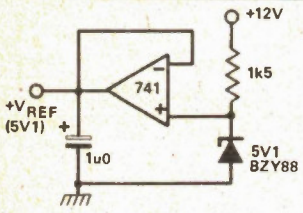
Standard comparators
LM311 single
LM339 quad
LM361 very fast single
LM3914 linear 10-section
LM3915 log 10-section

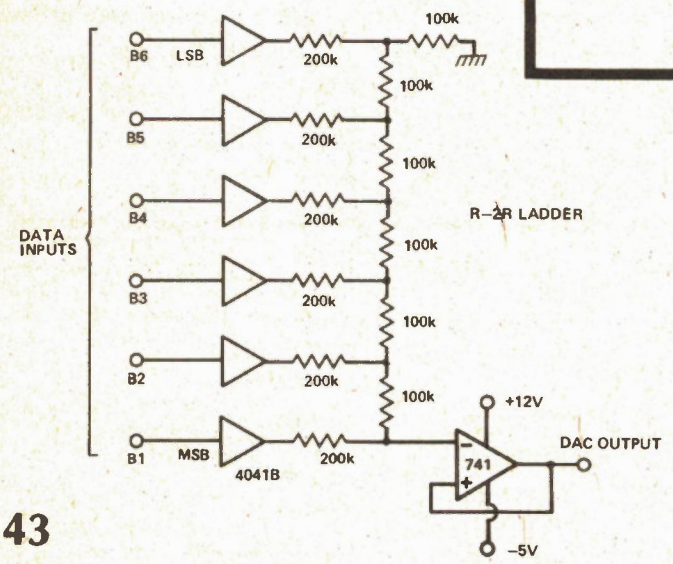
42

Triangle To Sine Wave Converter

Adjust all presets for minimum distortion
Typical THD = 1%
Best THD = 0.5%







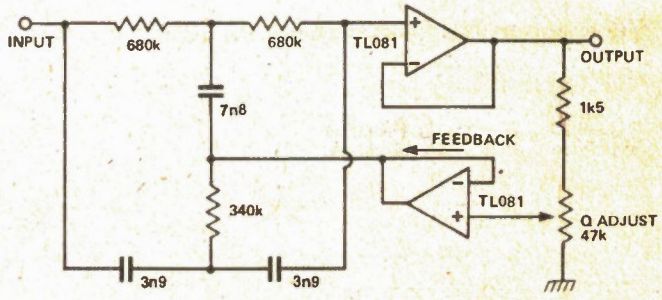
43

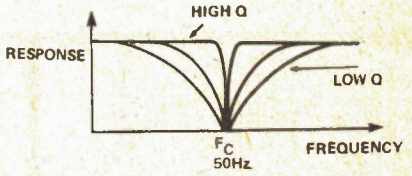
Six-bit DAC — 10-bit Precision

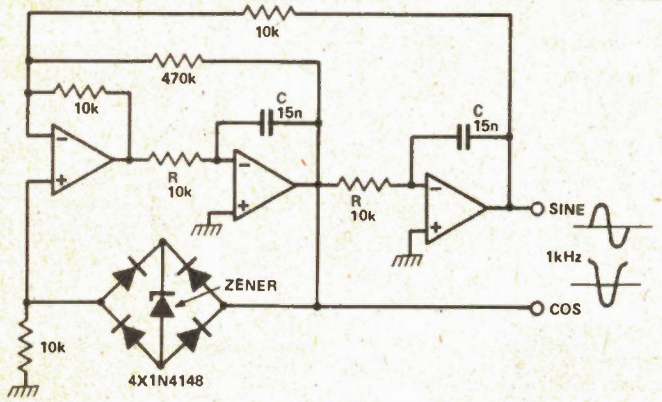
Buffers powered from 0 V and $+V_{REF}$
Resistors in ladder need 0.1% tolerance
DAC output has 64 steps

44

60 Hz Notch, Variable Q







45

Dual Integrator Oscillator

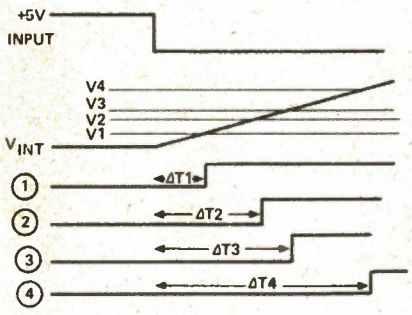
Quadrature outputs (ie sine and cosine)

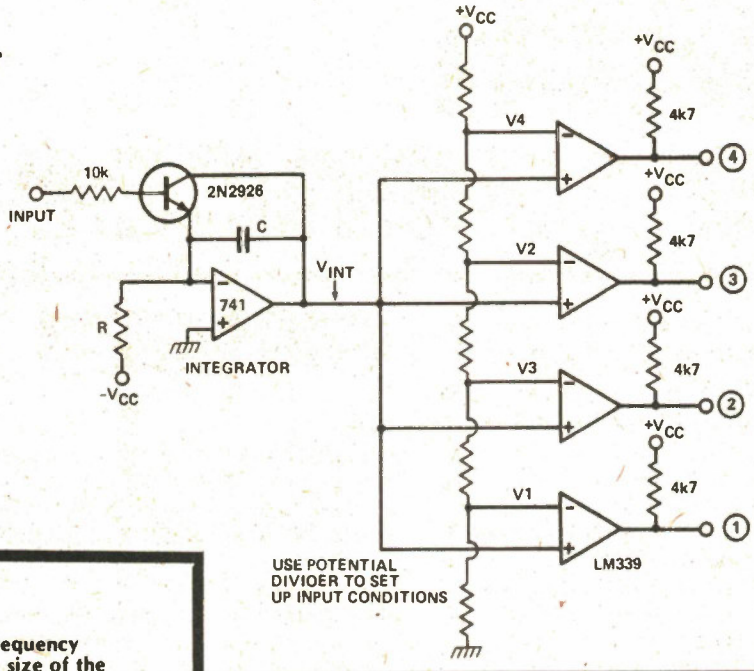
Output frequency $F = \frac{1}{2\pi RC}$ Hz

To change frequency, change both R's or both C's.
Maximum frequency ~ 20 kHz
Minimum frequency ~ 0.016 Hz using C = 1u0, R = 10M, and TL081 op-amps
Oscillation amplitude = 2x(zener voltage + 1V2) V_{pp}

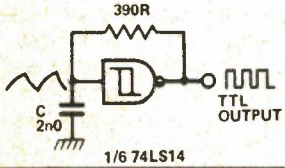
46
Multiple Time Delay Generator

Ramp rate = $-(-V_{cc}/CR)$ volts per second





47
TTL Oscillator



Vary C to change frequency
Do not increase the size of the 390R resistor

Frequency range = 1 Hz to 1 MHz

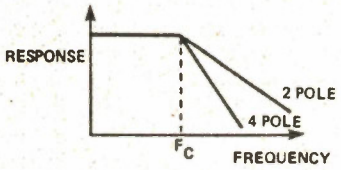
48
Low Pass Active Filters

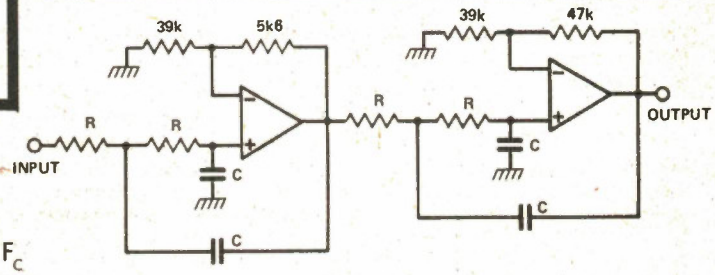
Inputs must have a DC path to ground

$$F_c = \frac{1}{2\pi RC}$$

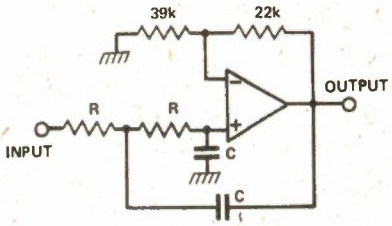
2 pole roll-off = −12 dB/octave
4 pole roll-off = −24 dB/octave

R	C	F_C
107k	15n	100 Hz
10k7	15n	1 kHz
10k7	1n5	10 kHz





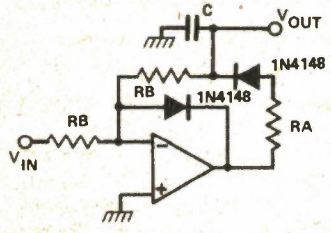
4 pole Butterworth



2 pole Butterworth

49
Inverting Peak Voltage Detector

Attack time constant = C.RA
Decay time constant = C.RB



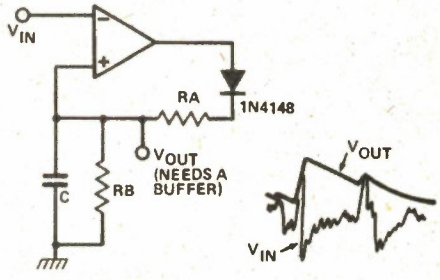
This circuit works well at high frequencies

50
Non-inverting Peak Voltage Detector

Input must have a DC path to ground

Keep RA grater than 1k0 to avoid dumping large currents to ground via C

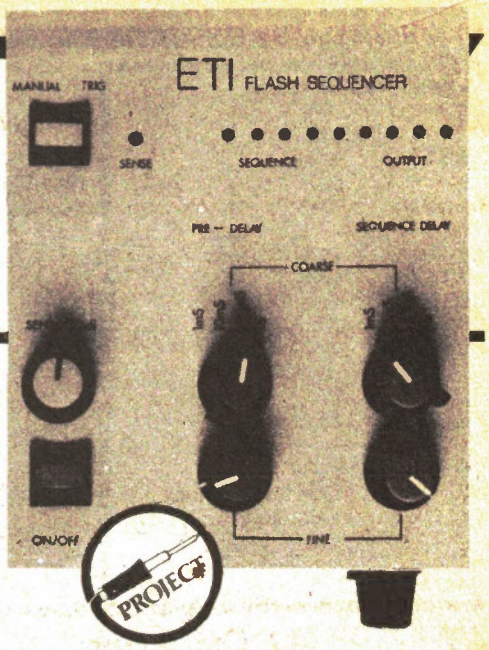
Attack time constant = C.RA
Decay time constant = C.RB



This circuit is not suited for high frequency operation

If you liked this article, please circle Reader Service Card number 51. If you didn't, circle number 52.

Flash Sequencer



Here's a project that lets you do something new with a flashgun, or nine. Make mobile matter into marvellous multiple images.

If you liked this project, please circle Reader Service Card number 57. If you didn't, circle number 58.

THE HUMAN eye is an extremely complex sensor, capable of discriminating shapes and colours in an extremely high optical noise environment. Researchers are only just realising the computational complexity of image analysis, shape recognition, perspective compensation, telemetry and all the other tasks that our eyes and brain perform continuously.

Yet, probably because of this complexity, there is one area in which the eye's performance is rather poor: speed. Any discrete movement shorter than an eighth of a second becomes blurred and at a repetition rate of 18 to 25 events per second, everything blends into a continuous movement. Unfortunately, in real life, events happen a lot faster than that and to try to analyse and understand them, we need some device that can effectively reduce the flow rate of information.

Strobe Shots

When the number of images of the subject is small, we can simply superimpose them. The result is strobography. The pioneers of this method (Mach, Foucault, Helmholtz) used the high intensity discharges of Leyden jars (the first capacitors) as the light sources. Nowadays, you can obtain much more accurate results with a battery of electronic flashes, a camera and our flash sequencer!

The basic idea is that when an event occurs, it triggers a series of flashes at a constant and known rate. Being of very short duration (on the order of a microsecond), the flashes effectively immobilise the subject in its consecutive positions, which can be recorded with a camera. As an example of possible analysis, the change in position during a known time can give the velocity. The change of velocity to the next frame gives the acceleration, and so on. The position, intensity and colour of each flash can give further meaning to the recorded positions.

Multi-option Multiflash

One of the basic practical problems in strobography is the triggering of the sequence. The most useful sensors are contact, audio and optical, and all three are provided for in our design. Furthermore, an adjustable pre-delay allows the flash sequence to commence a short time after the triggering pulse, should this be necessary for the right effect. Both the pre-delay and sequence delay can be continuously adjusted from 100 uS to 1 S per flash and thus practically all situations are allowed for. A manual trigger and LED readout are provided to make the time settings for a particular picture easier to adjust. A camera X flash socket allows for a sequence to be triggered from the camera, in exactly the same way as a single flash. In this case, make sure that the exposure time is longer than the total sequence time.

Using The Unit

There are two possible modes of operation for this device. It is either:

- Triggered by the event to be recorded, using a suitable sensor (adjusted just below the triggering point) and the pre- and sequence delays being set for the desired effect. In this case, the camera shutter has to be open during the whole of

HOW IT WORKS

The sensor is a simple level crossing comparator, the signal source being selected by SW1. Resistor R6 at the offset compensation input of IC1 provides an imbalance of the input differential stage, so that RV1 can set the threshold level both over and under 0V. LED1 is an aid to adjustment and should be just flickering when RV1 is properly set.

A manual trigger is provided for test purposes. Irrespective of the input conditions of IC1, when PB1 is activated the strobe pin (pin 8) has direct control of the output. Thus pin 6 of IC1 is sent high and the flash sequence is triggered.

The next two stages are the pre-and sequence timers. They work in the same way, except for the enable conditions. The difficulty here is a reliable and repeatable delay. In all monostables, energy is charged and discharged between two levels. Our problem is that the stable level must be the same as the power off state; it must be reached in a much shorter time than the shortest delay (100 uS) without a negative supply to draw on; and the time control must be linear.

The stage works as follows: IC2a and IC2b lock to the charging position (low and high outputs respectively) as soon as an impulse is received through C1. C2 begins to charge through the range resistor. The output of IC3a is high, so IC4's inverting input is higher than its non-inverting input and its output is low. This output is fed back to IC3a's input so we have a steady state. As soon as the voltage on C2 reaches the limit set by RV2, IC4 switches high; IC3a switches low; the voltage at the inverting input of IC4 is zero, giving a Schmitt trigger action. A change of state can only occur now when C2 is discharged to 0V (power off state). This is done by IC3b and C3, which was initially positively charged. As IC4 goes high, IC3b goes low. The voltage on the negative side of C3 is driven below zero potential. D4 is now forward biased and passes a current from C2 into C3. D3 and IC2b suppress the charging current. This continues until the voltage on C2 is just under 0V, at which point IC4 switches over to its low position again.

The low to high transition of IC4 has been transmitted through IC2c and IC2d to the IC6 clock input. This results in the '0' output, which was at logic 1, going low, thus disabling the pre-delay stage and enabling the sequence timer through IC3c. At the same time output '1' goes high, triggering triac SCR1 and firing the first flash. The sequence timer (still enabled) operates in the same way as the previous stage, except that the charging current is continuously enabled and astable operation results. Each one of the impulses shifts the high output of IC6, successively triggering the following flashes until the '0' output is reached again. This disables the sequence timer and allows the pre-timer to receive a new impulse from the sensor, ready for a new cycle.

The output control elements are triacs, rather than SCRs, because not all electronic flashes conform to the 'positive centre/ground shield' standard connection.

PARTS LIST

Resistors (all ¼W, 5%)

R1	1M5
R2,4,44	1M0
R3,9	22k
R5	680k
R6,16,17, R18,19	10k
R7,26-34	1k0
R8,12,22	470k
R10,20	4k7
R11,21	47k
R13,23	4M7
R14,24	120k
R15,25	12k
R35-43	470R

Potentiometers

RV1	100k logarithmic
RV2,3	100k linear

Capacitors

C1	100n polycarbonate
C2,5	1u0 polycarbonate
C3,6	100u 10V tantalum
C4	47u 16V tantalum
C7	100n ceramic

Semiconductors

IC1,4,5	CA3140
IC2	4001B
IC3	4049B
IC6	4017B
SCR1-9	TIC206D
D1-6	1N4148
LED1	0.125" yellow LED
LED2-10	0.125" red LED

Miscellaneous

PB1	push-button N.O.
PB2	push-button N.C.
SW1,2,3	one-pole rotary switch
SK1,3	phono socket
SK2,4-12	3mm coaxial flashgun sockets

9v battery holder , case

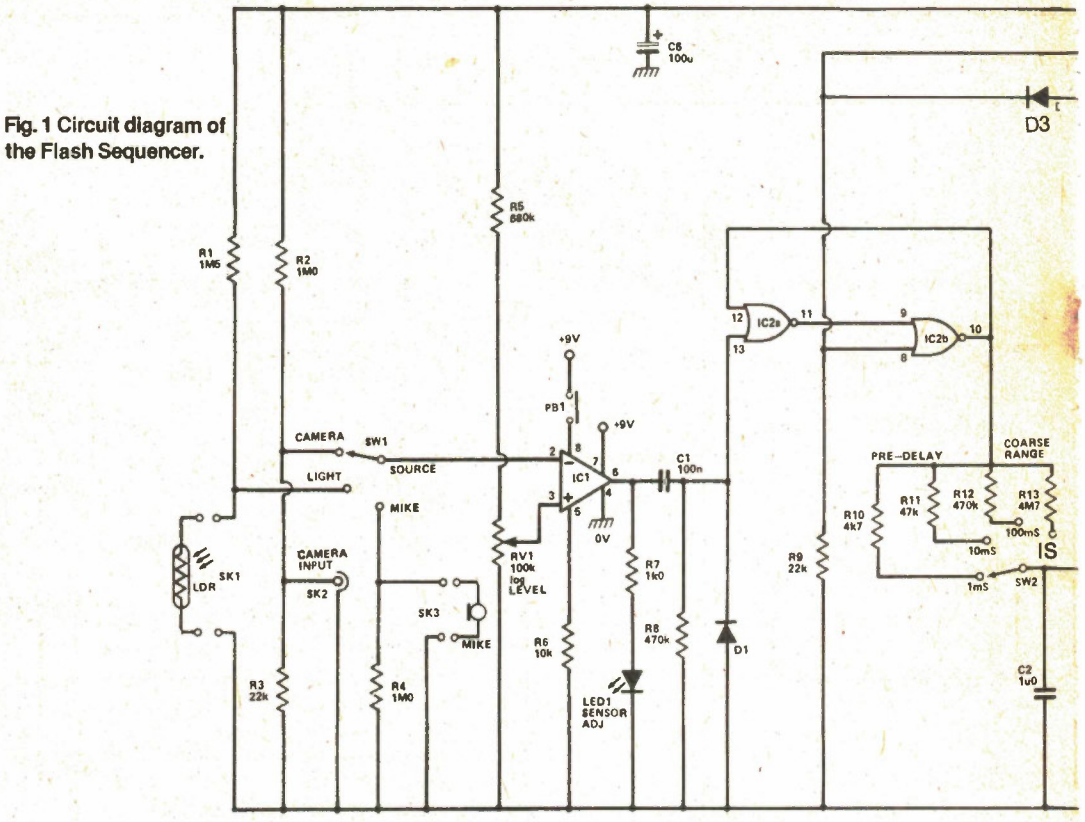


Fig. 1 Circuit diagram of the Flash Sequencer.

the sequence. Therefore a manual operation of the shutter (B setting) and very little or no ambient light will be necessary. The diaphragm should be set to one stop less than the calculated aperture for the flash and subject-camera distance used.

- Set off by the camera in exactly the same way as a single flash. This method is somewhat more flexible for event durations of the same order as the human reaction time (about a tenth of a second). In that case, the synchronisation is made through an ordinary extension lead from the X socket of the camera to the 'contact' input of the sequencer. Care must be taken to set an exposure time longer than the total sequence time. The diaphragm setting is determined in the same way as in the previous method.

In both cases, the flashes are connected to the sequencer either directly or through ordinary extension leads, and can be distributed along the path of the subject or grouped as a battery. It is generally easier to work with flashes of the same type or at least of the same intensity. In the case of flashes with auto-exposure circuitry ('computer' flashes), the setting should be to manual (or the sensors masked with opaque tape), in order to avoid interactions from the previous flash.

Construction

Construction should be fairly straightforward, as all the components (except PB1, SW1, SW4 and the LEDs) are mounted on a single PCB to minimise interwiring.

Note that the number of output stages is entirely up to you; if you want less than nine flashguns to be triggered, leave out the unwanted triacs together with their associated LEDs, resistors and sockets.

When fitting the rotary switches, the tags will have to be trimmed off to fit the PCB holes. Some of the unused tags have been cut off completely to allow PCB tracks to pass through — the overlay shows which ones remain.

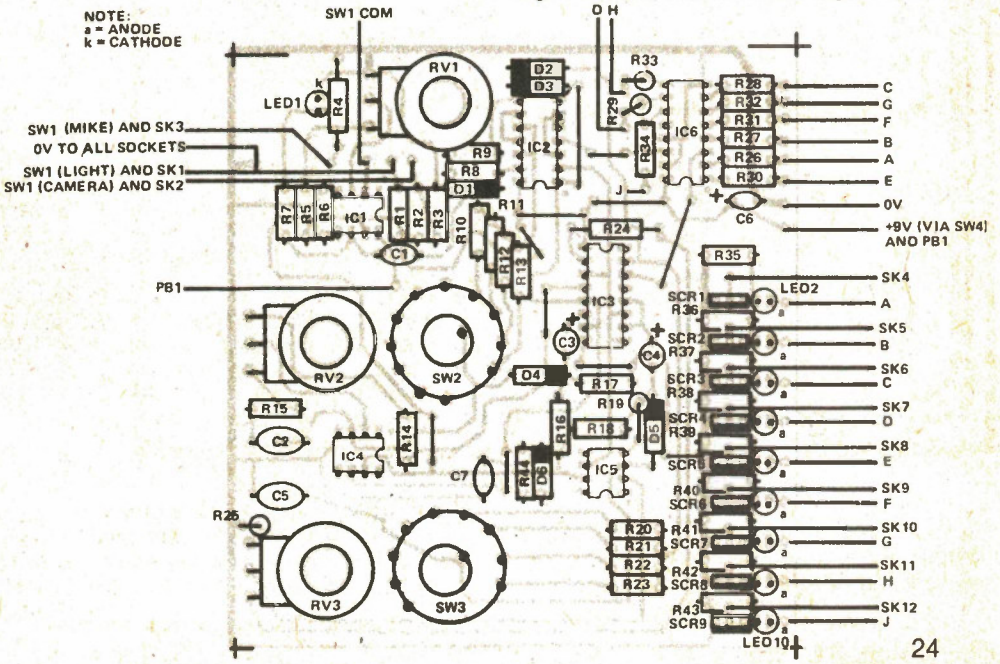
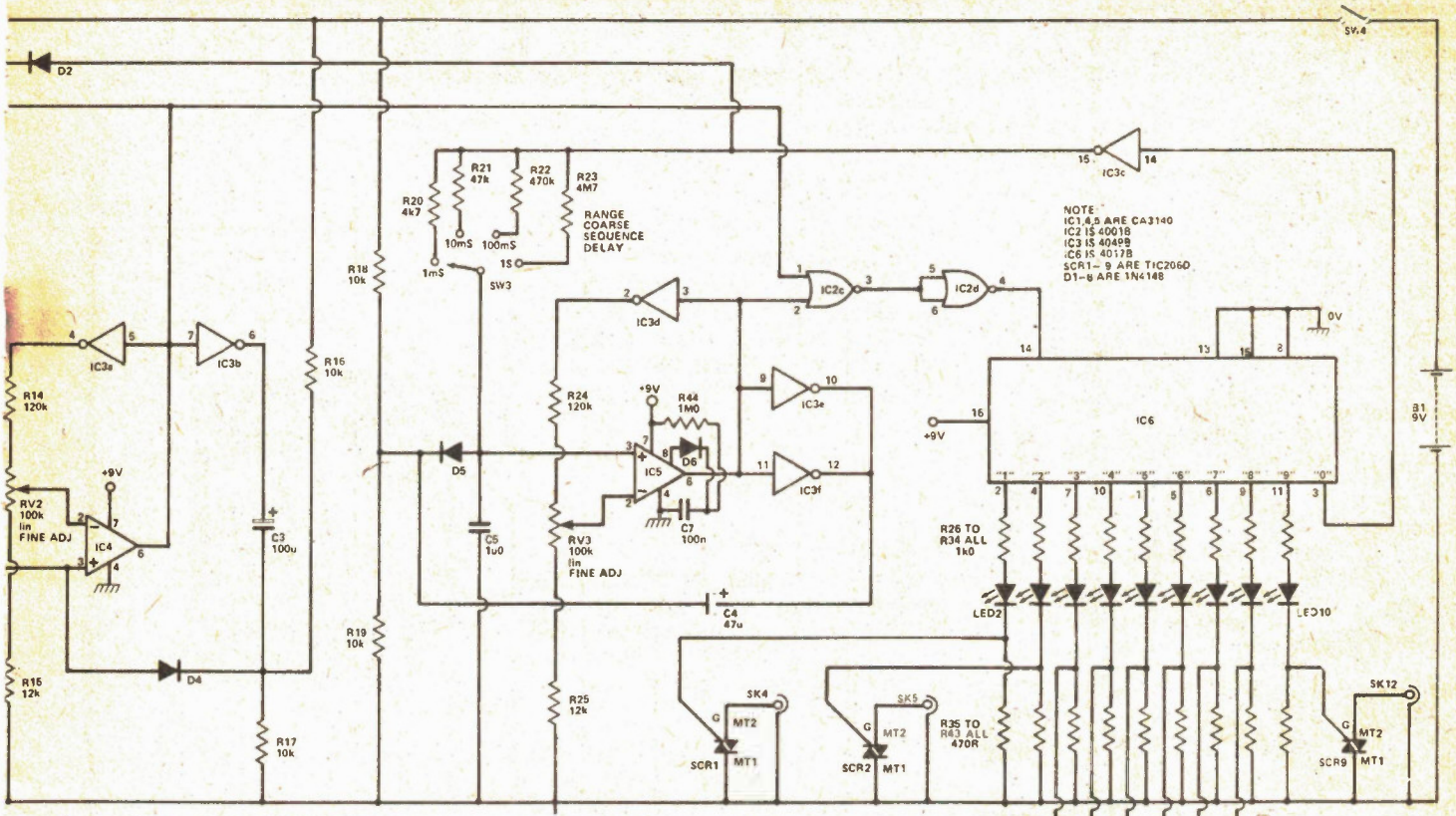
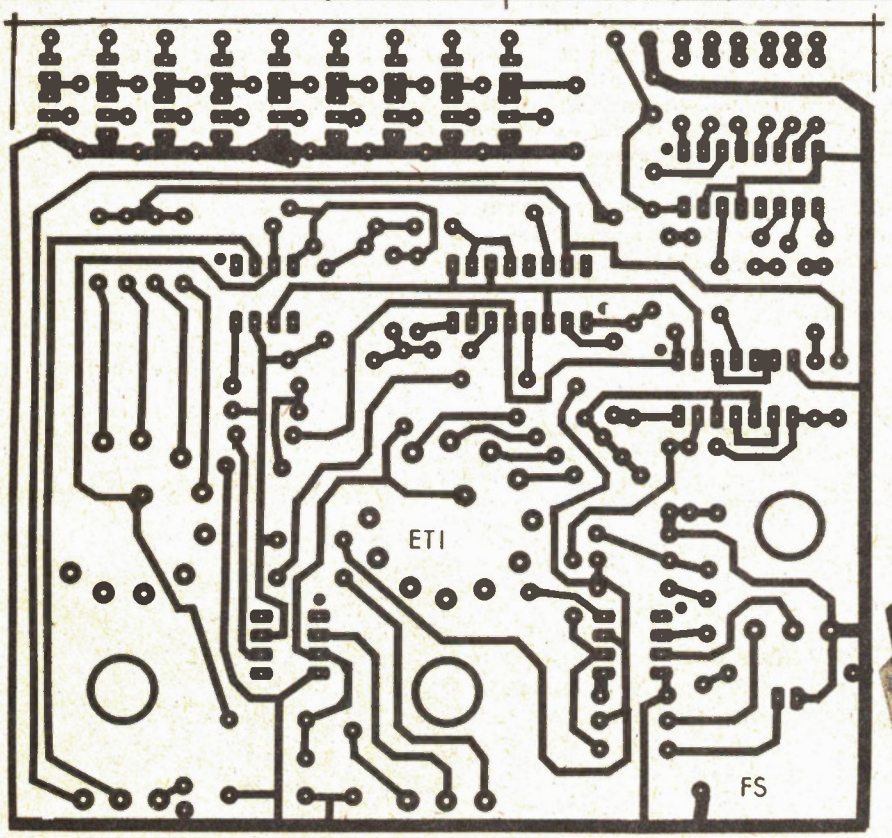
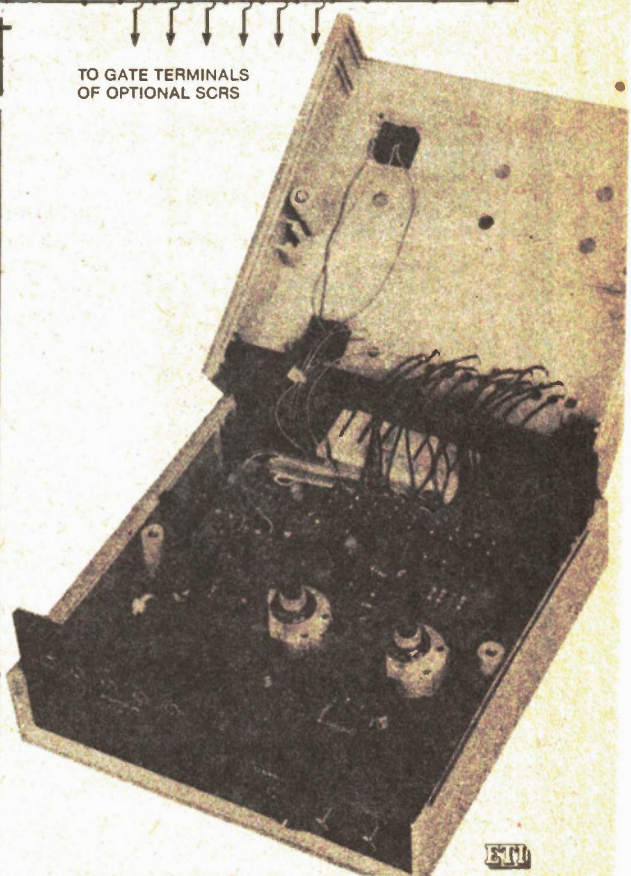


Fig. 2 Overlay for the sequencer. Some of the tags of SW2 and SW3 are cut off before mounting — the dots indicate which tags remain.





TO GATE TERMINALS OF OPTIONAL SCRS



The board can now be mounted on ¾" spacers and holes marked out and drilled to accommodate the LEDs and switch and potentiometer spindles.

The next stage is to wire the LEDs, sockets and off-board switches. When this is completed a visual check of the whole project should be made.

Fig. 3 Inside the sequencer. Although the overlay shows the LEDs mounted on the PCB for clarity, they are actually mounted on the case top and connected to the board by flying leads.

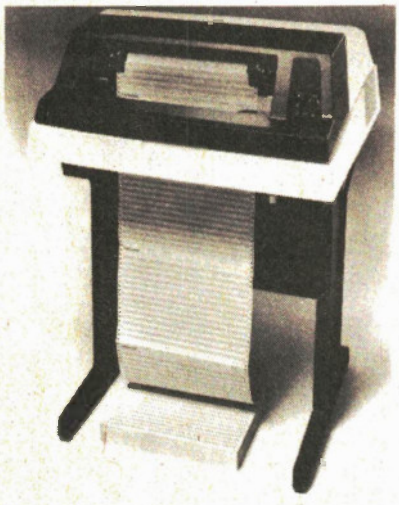
next month

Music Processor

It's a flanger, phaser, automatic double tracker and echo box all in one, and, if you glue a sixteen bit micro-processor to the bottom of the board it'll have one of those, too.

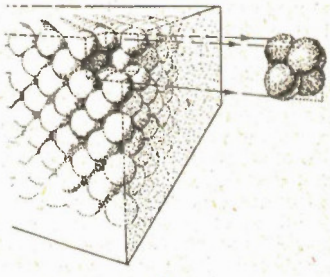
NI-Cads

When regular batteries die, there is naught for them but to blow "taps" and plant them. Ni-Cads, however, can be re-incarnated. . . and, if you don't know how to use them right, may return to haunt you.



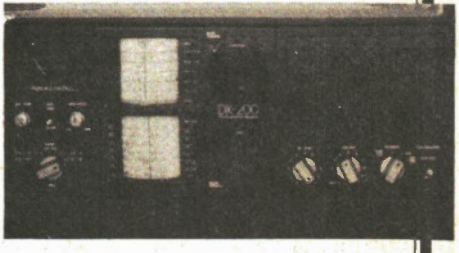
Printers

It is very often the case that a printer costs more than the computer it's hooked to. Thus, it is highly worthwhile finding out just what these expensive little peripherals are all about *before* whipping out the Visa card. Stay your hand 'til next month.



Gluons

Gluons are the theoretical particles which stick all matter together. Extremely dense matter is comprised of a slightly different variety, called Crazy-gluons.

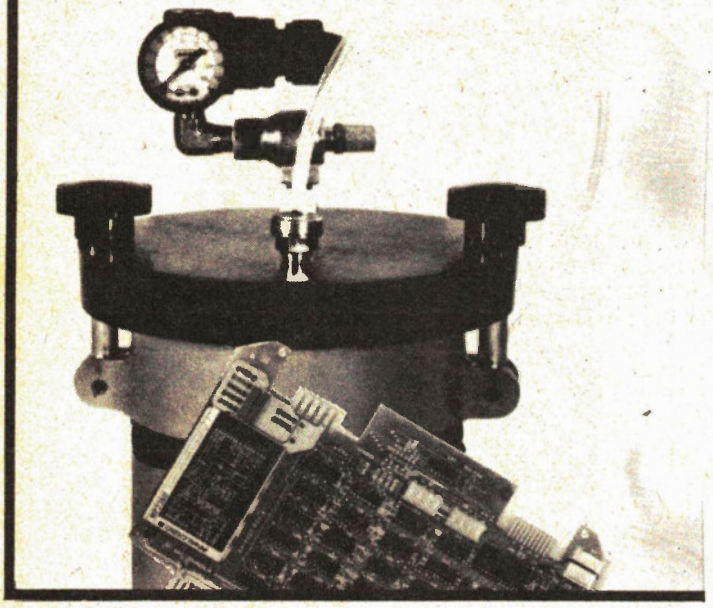


Crystal Marker

A simple circuit for short wave listeners to keep from getting hopelessly lost in the E layer.

COMING TO ETI

PULLING THE PLUG



Compu-Still

THERE AIN'T NOTHIN' BETTER'N ol' Unca' Revulso's moonshine. It's a wild, mean mountain brew with that tangy flavour of sweat socks soaked in stale gasoline. It has a kick to it that can flatten medium sized buildings, and an after effect that you can read by. It tastes as grimy as all out doors, and carries a three to five year jail term in most areas.

Best white lightning going.

Only thing is, Unc's been gettin' on in years some, ain't quite as spry as he once was, and what with his eyes a' gettin a mite dim, he can't always spot them revinoors what like he could when he's just a young pup o' seventy five. What Unc really wanted was a way to be able to leave the old still up there in the bush for a couple days, and not have to worry about her exploding, going cold, running out of makin's or getting clogged up and reaching critical mass.

That was when Unc found out about *Compu-Still*!

Compu-Still is an amazing new micro-processor controlled illicit alchoholic beverage distillation system produced by Rotgut Enterprises of Berrybrain, Arkansas. It consists of a stand alone dedicated controller based on a Z-80 CPU, capable of handling up to 1024 sequential instructions. It is interfaced with a servo controlled manipulator arm, which can split logs, stoke the fire, add ingeredients, sample the brew and pass out in a dilerium, all under macro supervision. There is also a fully sensorized distillation tank, which can be interfaced to the processor to measure the temperature, pH, chemical content, pressure and overall toxicity of the contents (see figure 1).

The system utilizes a bi-directional bus system capable of addressing eight stills and sixteen arms. These extra arms can be used to jam in plugs where the mixture's eating through the side of a still, hold the funnel over the jugs, and handle a shotgun to perforate the deputy.

Compu-Still utilizes a special control and software-in-ROM system to permit it to be fully utilized by inexperianced and/or slighty demented operators, including the patented *Squirty-QWERTY* keyboard with doorknob sized keys made with fluid filled shock absorber caps to resist punching. A remote 32 character readout system permits the still to be monitored back at the shack, and the user can select a readout in either English or Hillbilly. Thus, complex messages such as 'EIGHTH BIT OVERFLOW DETECTED IN PORT NUMBER 4' can be translated by the software to read 'GRAB THE WOMENFOLK, PA: SHE'S A GONNA BLOW!'.

The basic starter system, consisting of one still, one arm and the processor card, plus a buckshot proof enclosure and fully self standing power generator that will run on either regular gas or rejected batches, plus a software package and illustrated owner's manual, goes for the low price of $3495.00, not payable in confederate money no matter who actually won the war.

For more information, contact Rotgut Enterprises Limited, Second Shack after the Swamp, Berrybrain, Arkansas, 65489.

ETI ORDER FORM

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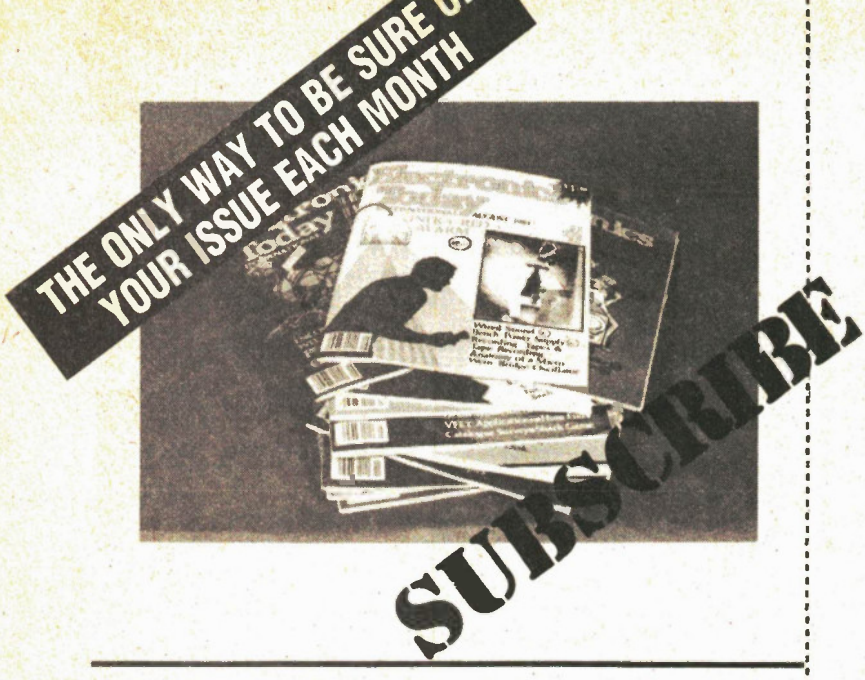

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CRISIS!

Having discovered that our offices are not actually haunted, and that toenail clippers do not cause cancer of anything at all, our manager in charge of editorial paranoia has decided to begin fearing an impending paper shortage. In the event that one should actually take place (it would certainly come as a surprise to us), we would be forced to reduce the size of ETI. We don't really want to cut down on the number of pages, as we use the back issues for stabilizing furniture, and they'd be no real good for this if they were very thin. We have therefore made plans to produce the magazine as shown in this life size illustration, at 12.5% of its current size.

Needless to say, we have considered the difficulty some readers may have in actually attempting to read the resulting 1 point type, or trying to build things from circuit diagrams smaller than the IC's they contain. Many of you might be concerned about this too.

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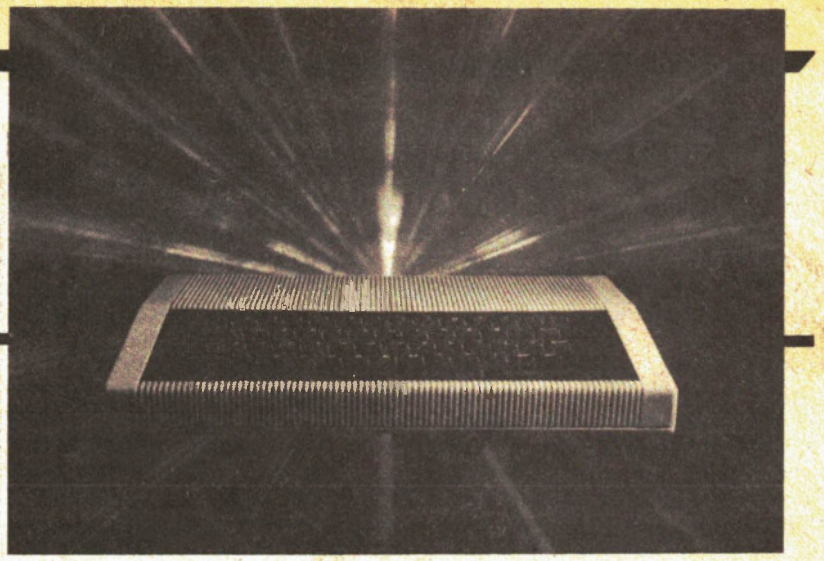
ATOMic Power



The further adventures of the mighty ATOM computer, faster than a speeding bullet and able to leap tall buildings if shot out of a cannon. By Steve Rimmer.

LAST MONTH, we had a brief peek at the Acorn ATOM, one of the newest small computers to show its face. However, aside from having great thundering herds of externals and dandies to play with, the ATOM has a splendid, if slightly weird, operating system, which we're going to have a peer at this month. Ultimately much more powerful than the architectures of many popular systems, an unadorned 12K ATOM can do such things as high resolution graphics, machine language in BASIC, and sophisticated string manipulation.

It does take some getting used to, though. (Gadzooks. . . not another new language!)

Another New Language

The ATOM comes with a resident BASIC, but it isn't the familiar Microsoft BASIC by any means. If you thought the variations between, say, PET BASIC and TRS-80 BASIC were arduous, this one will very nearly fry your senses. Combining aspects of BASIC, FORTRAN and C, plus a few totally unique variations, ATOM BASIC will provide you with a rather impressive assortment of error messages if you try to use the machine with Microsoft syntax. You can get away with quite a lot if you use the proper BASIC forms, such as PRINT, LIST, etc, but the little fellow really gets upset on abbreviations. One of the most potentially troublesome is the "?" symbol; a PRINT to any of us, but a combination PEEK and POKE to ATOM (oh, really), which likes "P." for PRINT. Most of its abbreviations are, in fact, the first letter of the expanded keyword followed by a period. Much easier than the complexities of, say PET tokenization, but still demanding of a bit of instinct suppression.

If you're a seasoned BASIC programmer, it will probably take about two hours to get fully comfortable with the ATOM, but after that you should begin to see the magnificence of it all.

The first interesting variation in the BASIC is the aforementioned combination PEEK and POKE deal, "?". Exactly which it is at any given time is determined by which side of the equal sign it finds itself on. POKE X,255 would translate to ?255=X. X=PEEK(255) would become X=?255. It's actually fairly reasonable this way, as, in effect, PEEK and POKE are complementary functions.

Another newcomer to BASIC is the DO UNTIL loop. The ATOM also has the more familiar FOR NEXT loop structure. The DO UNTIL loop, or, just DO loop, is a refugee from FORTRAN. It takes the form of DO UNTIL K, where K is a variable and presumably there are statements modifying K in between the DO and the UNTIL. If the UNTIL condition of K is that K=255, and there's a statement in there incrementing K by 1, the loop will repeat 255 times and then proceed to the next statement. However, K need not be incremented, or even mentioned within the loop to produce loops of indeterminite, or infinite, length. DO loops are a lot more flexible as to jumping in and out of them.

The WAIT statement in ATOM BASIC is quite a bit different than that in most other systems. When encountered, it will sit and vegetate until the next video flyback on the TV monitor, or for about a sixtieth of a second. This has two very important functions. First off, for animated graphics, it permits one to conveniently hold off doing anything until the picture is being blanked, virtually eliminating snow and picture glitches. Secondly, it allows the insertion of meaningful time delay loops, as the ATOM's BASIC is so fast that the usual FOR X=0 TO 10000: NEXT X approach just wouldn't hang on long enough.

The ATOM system also permits the use of labels on statements. This means that instead of saying GOSUB 1000, one can (if you'd rather), use GOSUB a. The first statement of the subroutine would then be labeled 1000aREM CAMEL KILLER, or whatever.

String manipulation and its associated trappings have also been mutated to a degree. To extract, say, the leftmost five characters from the string A$, one doesn't just resort to the familiar LEFT$(A$,5) approach. Instead, the machine lets you play with the string pointer to actually extract specific bytes from where it happens to be storing A$ in RAM. Hence, you would move the pointer to the beginning of A$ in RAM, and then over five more. This permits a great deal more flexibility in string handling, as you can extract and insert stuff with relative ease.

Perhaps one of the most important statements in ATOM BASIC is one that doesn't actually exist anywhere else; "[".

The Mighty "["

One of the things one realizes about the ATOM fairly early on is that its higher level language isn't quite so higher level as many of its peers. In fact, there is considerably more interrelation with the actual internals of the machine's 6502 processor than one would find on almost any other system. For instance, you can choose to specify constants as hexadecimal at any point simply by placing a "#" in front of the number. This is because the ATOM is very much into machine language programming, and contains one of most sophisticated assemblers around.

Machine code is programmed right into BASIC text. The first line of a machine code section must be a "[", and the last a "]". In between these, all coding can be done in 6502 mnemonics. The ATOM manual has an excellent section to introduce you to ML programming.

If you've ever tried to machete your way through the undergrowth of ML programming unassisted, the ATOM will be like a flamethrower in the jungle. You don't, for instance, have to calculate relative branches; all branching is to labels. There are no op codes to deal with; the system figures them out from the mnemonics and a bit of syntax. The system assembles all machine code modules when the program is run, checking for any heavy errors, and will print a complete (annotated) assembly if desired. (Printing a NAK character suppresses listing the assembly.) Best of all, if you totally fry the thing, and send the system into a time warp loop, the BREAK key will get you out of it *without* losing your program. There's a statement, OLD, that lets you retrieve it.

The capacity of this kind of thing Is quite staggering. ML programming is orders of magnitude faster than BASIC, and, using this system, not much harder to do. Thus, the higher mathematical functions of BASIC can be combined with the speed of ML code for much more effective programs.

Pitchurs

The graphics of the ATOM are of a resolution equal to that of the APPLE in high resolution mode; 256 X 192 pixels. The BASIC graphics commands are DRAW, MOVE and PLOT, plus CLEAR X, where X is a graphics mode from 0 (regular mode: graphics off) to 4 (high resolution, very slow). The in-betweens trade off resolution for speed.

The graphics instructions are very easy to use, and probably don't require much explaination. Points are specified In whatever size matrix has been selected by the CLEAR command; (0,0) is in the lower left. To produce a vertical line down the middle of the screen in high resoution mode, one would first MOVE (128,0) and then DRAW (128,192). PLOT, of which DRAW and MOVE are subsets, offers several different options, but is slightly more complex to use.

Interesting effects can be achieved with a DO loop and a DRAW statement in which both co-ordinates are random.

While the system does not have CIRCLE and ARC functions per se, you can illuminate Individual pixels easily enough, and thus generate non-straight lines. Three dimensional plotting routines are also quite easy.

Bits and Nibbles

Actually using the ATOM. . . you knew we'd get to this eventually. . . is fairly easy. While there are a few operating systems that are easier to use in this respect, the ATOM's is by no means unpleasant to work with. Text is entered in the usual way. Shifted characters come up reversed out. In fact, the reversed upper case characters can very easily be replaced by lower case, un-reversed ones, and Acorn sells a software package that provides a full upper-lower character set plus a character programming routine to generate your own symbols. Character sets, nothing more than a string of bytes, can be saved on tape.

The character set also contains a moderate group of graphics characters, including some that are grey. Neat, that.

Screen editing is where most systems fall down; the ATOM does stumble a bit. In order to change a line, one cursors up to it, and uses a key marked COPY to enter it back into the BASIC line buffer along with any changes. This is not quite so convenient as the PET/VIC system (which spoils one), but not nearly so bad as having to retype every line you want to change.

There are a number of control characters for use on the ATOM which live in the lower range of the ASCII character set. These do things like cause the internal speaker to beep, suppress and unsuppress the listing of ML code assemblies, and set and unset the page listing mode. This last bit is quite convenient for debugging programs, as it allows you to list a program 32 lines at a time: striking any key moves on down to the next page. The control characters never show up as PRINTable symbols, and, even if you type one between quotes, you just get what appears to be a null set. They do exist in these circumstances though, ghostly and haunting, and, for instance, you can use the ASC function on them and get real live numbers back.

The ATOM's error messages print out error codes, as opposed to word messages like "SYNTAX ER-

ROR". However, it doesn't take long to learn them (they are, of course, all listed in the manual), and they're good for beguiling friends and family into thinking you know what you're doing. Foolish friends and family.

Each and every ATOM comes with a little plastic card with all the error codes on it, and, if you don't use it as a bookmark somewhere, it comes in most handy.

All in all, the ATOM's operating system is quite workable. It represents a useful tradeoff between ease of operation and flexibility (as must all systems). Our ATOM didn't flash a "TILT" sign and emit smoke, even once. Must be a good sign.

ATOM vs VIC

One question that's bound to come up is which of the two small systems we've reviewed to date is better. Both the VIC and the ATOM are in same price range, and have many of the same features, but there are, obviously, differences.

The VIC has several advantages and a few failings. First off, its operating system, specifically, its screen editor, is easier to use. Its cassette system is second to none, although, at $120.00 for a bona fide Commodore cassette recorder to take advantage of this, it's also fairly costly. It has four sound generators to the ATOM's one, although they can't be as accurately programmed. The VIC's sound is also not dependant upon an internal squeaker-speaker, but plays through the TV (which may well have its own internal squeaker-speaker). The VIC can accept games-in-ROM, while the ATOM must have them loaded from tape.

The advantages of the ATOM are also fairly impressive. The graphics commands are all on board, while they must be purchased separately and plugged into the VIC. In addition, the ATOM's resolution is higher — 256 X 192 to the VIC's 160 X 160. (The VIC's claim to 1024 X 1024 point graphics is a bit tricky; you can specify plotting in this size plane, and VIC picks the nearest dot in its 160 X 160 matrix.) The VIC's plug-ins hang outside the machine, while the ATOM manages to contain most of its within its case. The ATOM's machine code assembler is a big plus, and, even though one can be bought for the VIC and plugged in, it is not as sophisticated, and doesn't allow ML programming in BASIC (yes, I was rather impressed with that bit). While the ATOM does not have a games port with A/D converters like the VIC, it does have two general I/O ports which could easily be used to impliment a joystick, or any of a number of other functions. For about the same price, the ATOM comes with 12K of RAM, while the VIC has only 5K. Both are, of course, expandable.

The VIC utilizes an external VHF modulator to feed a TV. The ATOM's modulator is built in, and runs on UHF channel 36. This latter approach is nice, because one need not switch between the computer and broadcast TV signals (unless you actually want to look at something on UHF).

The ATOM's cassette system is not as easy to use as the VIC's, 'tis true, but this may not be too heavy a trip if you're eventually going to spring for a disk. Disks are getting cheaper all the time.

At the moment, the ATOM is a black and white machine, although a colour card will be available shortly, and will, according to the machine's masters, be very cheap.

The answer to the question of which is better is, of course, dynamically fuzzy. If you're new to computers, and want an easy system

Continued on page 78

ATOMic Software

Aside from the ATOM, Torch Computers, Acorn's Canadian manifestation, also offer a flock of software. When you review a computer, computer makers are prone to lending you a bunch of this to mess with. The following is a list of some of our favourites.

● *Green Things* According to its description, this should be a exceedingly dull game, but, in fact, it's wholly captivating. You wander through a deserted space ship, the map of which is provided. There are small green things, big green things and eggs here, there and everywhere. There are also weapons, of which you can carry two, with which to fry the filthy things. They shrink, they shrivel, and, in time, you usually snuff it. Good family fun. A bit like Devil's Dungeon.

● *Space Invaders* The pub game of all pub games, and nicely done. Save Earth and the human race in the privacy of your own home. The machine also does sound effects. What more needs be said?

● *Dodgems* A game in which you try to steer your car around a track without getting mashed by other traffic. Fast, but too much like real life at 5:00 in the afternoon for my taste. Besides, there're no pedestrians to hit.

● *Asteroids* In fairness, not quite as good as the pub Asteroids, but really close. You pilot a tiny space ship around the galaxy mindlessly blowing up helpless rocks, trying not to get crunched yourself. Intensely stupid, but satisfying to play.

● *Breakout* As near as I have ever been able to figure, Breakout simulates playing squash with a ball made out of anti-matter. Every time you fling it against the wall a brick vanishes. A bit of a classic, and if you buy Asteroids you get it anyway.

● *Zombie* Right up there with Interstellar Camel Killer for sensible plots, Zombie is based on the premise that your plane crash lands on Zombie island, which is populated by, yes, you've guessed it, *Zombies!*. Your only hope of surviving is to lure them into the swamp *or* jump into hyper-space. Still, there are very few good computer games around with swamps in them. The only other one that comes quickly to mind is bog chess.

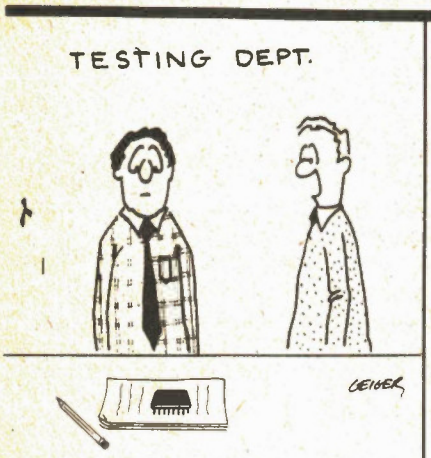
● *Soft VDU* In the non-game catagory, Acorn has several very nicely put together utilities. Soft VDU replaces the ATOM's regular character set with upper and lower case letters in your choice of either black on white or the obvious white on black. A third program on the tape lets you generate your own characters.

● *Utility Pack 1* This tape has three useful programs, which, though not so exciting as Space Invaders, are, none the less, quite valuable once you get into all this. *Disassembler* digs out machine language op code and turns it back into source code. *Fast COS* increases the baud rate of the cassette operating system by a factor of four. *Renumber* takes that horrible mess of a BASIC program you wrote last night at 5:00 AM and makes it come out looking almost logical, with statements at fixed intervals.

The software tapes each cost about $29.00, and come with complete operating instructions. The games are, for the most part, very good. On the average, of the three games on each tape, one is superb and the other two make you feel like you're getting a little extra for your bread.

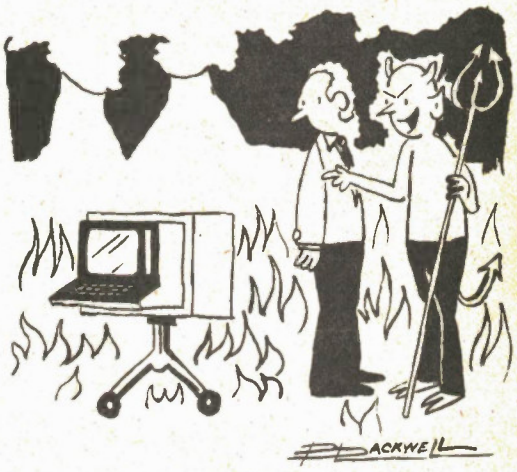
Torch Computers informs us that more software is even now spied upon the horizon, and should be docking shortly.

The Fun of Electronics



After we test them electrically, we give them a short written exam.

No I'm not de-bugging my program I'm searching for a contact lense.



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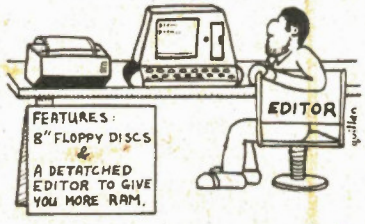

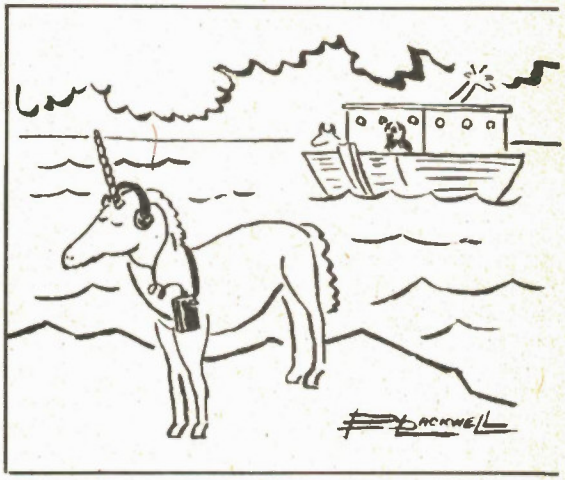

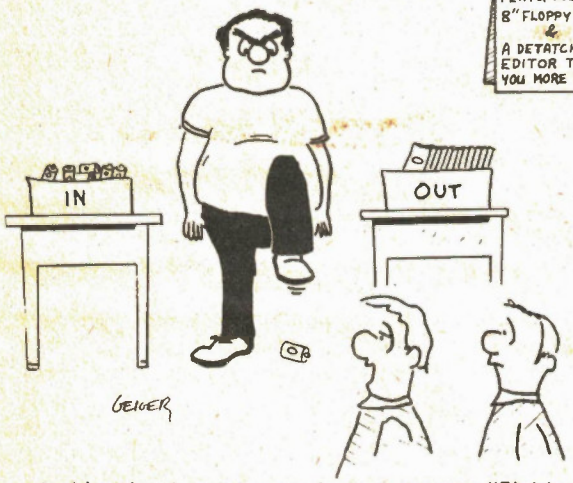

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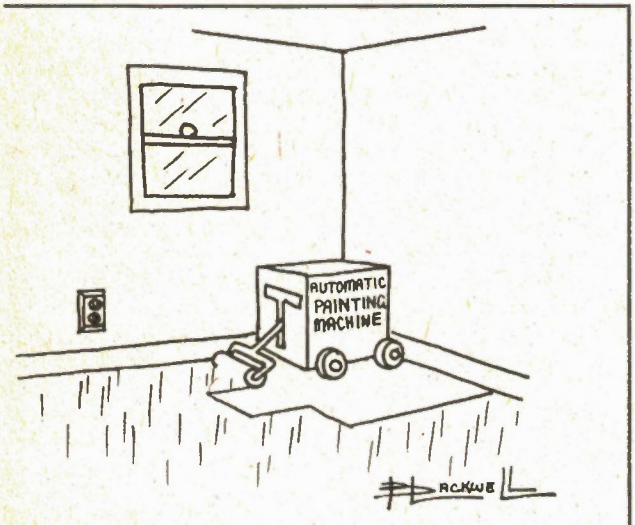

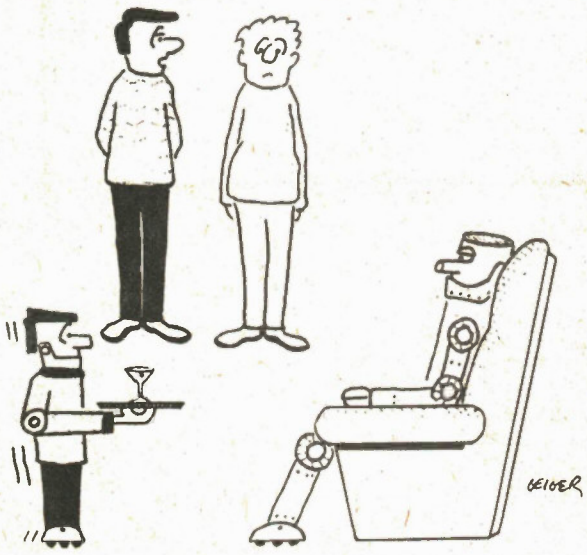

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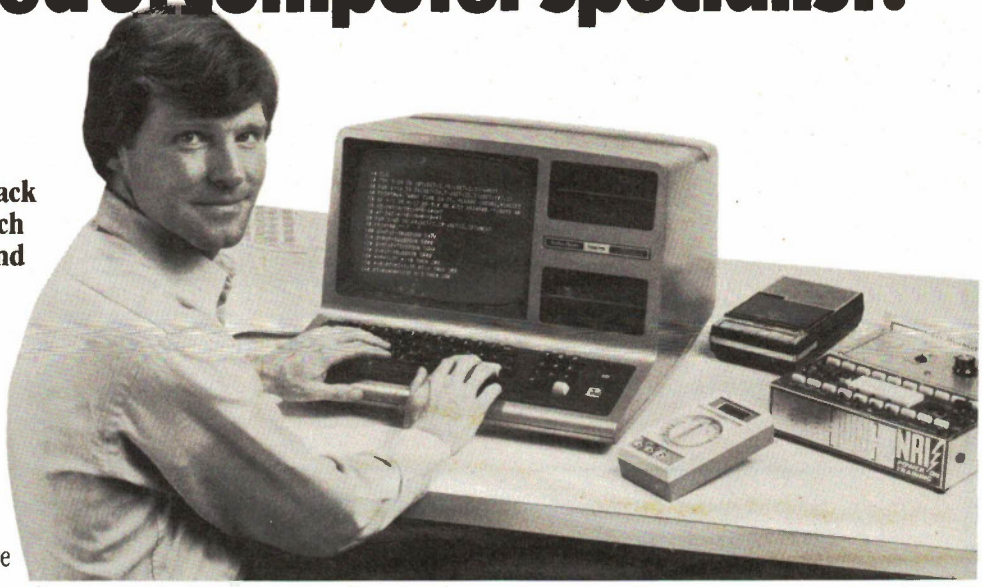

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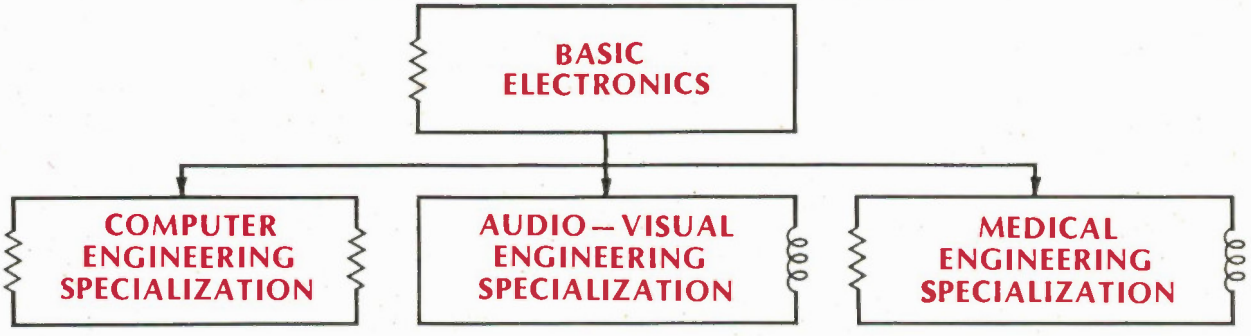

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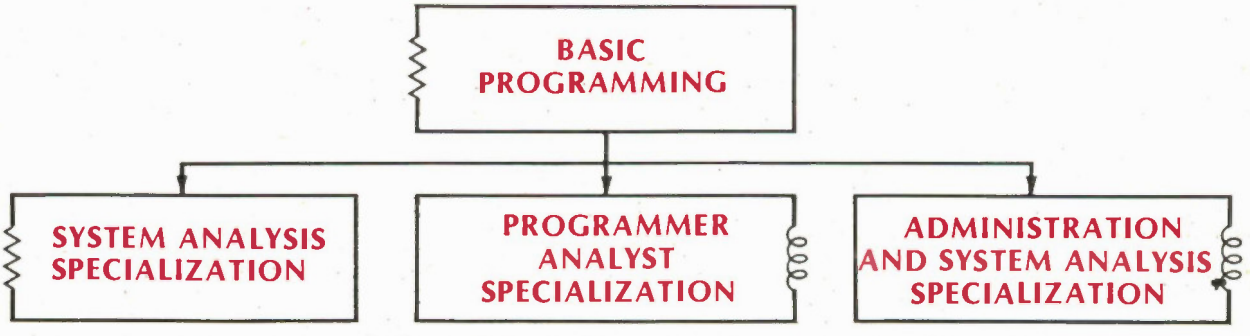

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Signs of the Times

Imagine a teeny tiny Times Square sign made out of a truckload of LEDs. Decidedly *not* a construction project, but a fascinating application of technology. Steve Rimmer observes.

If you liked this article, please circle Reader Service Card number 49. If you didn't, circle number 50.

MOST OF US REGARD computers as the universally programmable sorts of machines one usually runs into. By their definition, computers are not dedicated to single tasks, but are capable of being "taught" to do any one of many. However, this is not always true; microprocessors are so cheap and so powerful that it's eminently practical to utilize them for other than general computer functions. They are frequently found incorporated into non-computer applications, often in place of more primitive mechanical devices. The result is usually a twofold improvement in whatever is happening; power consumption, noise, heat, time delay and down time are reduced, and the overall sophistication of the system is frequently increased.

We found a really nice example of this in a group of electronic signs offered by Versa-Digital Technology Incorporated of Toronto. Essentially "Times Square" type moving character displays made up of rather large arrays of LEDs (or incandecent bulbs for larger signs), these things seem to represent electronic sign technology taken to its most extreme limit. For example, how often does one see a plain neon sign. . . with an RS-232 interface?

The basic sign consists of an extruded aluminum case with decorator-type wood ends, and a glass front panel covering a PCB just encrusted with red LEDs. It can display a single row of twenty-one characters created by 5 x 8 dot matrixes of illuminated LEDs. The 5x8 matrix, as opposed to the more common 5x7 approach used with some CRT dot matrix character generators, allows for proper decenders on lower case characters.

The LED display is most easily thought of as a CRT, actually, and many of the functions found on the signs are equivalent to those encountered when using a small computer hooked up to the tube.

The signs are available in larger arrays, too. Thus, the single 21 character display can be extended to a single row of 42, and four 21 character boards can be arranged to produce two lines of 42 characters each. In this case, the display can also produce a single row of characters which are double sized. More on the permutations in a second.

Now, at one time, the news sign in Times Square, the great granddaddy of these things, was, in fact, operated by a revolving wooden disk that used nail heads as contacts to switch on the lights. Fig. 1, a block diagram of the internals of one of *these* signs, will give you an idea of just how far things have come since then. The controller for the LED display is a Z80A based computer, and not a shabby one at that.

A far cry from shirt cardboard and a Doodle-Art pen, to be sure.

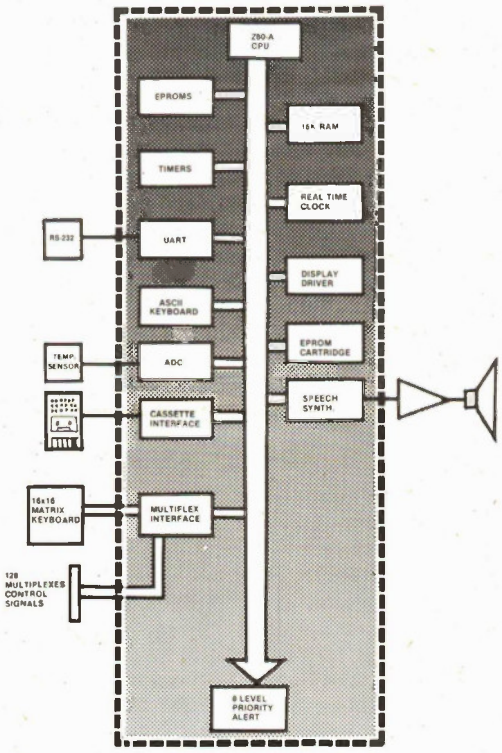

Fig. 1 Block diagram of the Versa Digital Electronic Sign.

Hardware

The stuff that hangs off the Z80A bus is really only moderately sophisticated; it's just so unusual to find it in one box, and that for the sole purpose of advertising a sale on Coke. Let's have a look at all this regalia.

- The EPROMS hold the operating system, which, as we'll see, is quite something. They also hold any basic messages that the user wishes to have available all the time, plus the character set. There are 100 user definable characters which the manufacturer can set up to suit any application.
- The 16K of RAM is partially used by the operating system. However, 13K is available to hold up to 128 user defined messages, which can be entered via an ASCII keyboard.
- The three software programmable timers are involved with the speed with which things on the display happen, such as crawl and scroll rates, message change rate, and so forth.
- The real time clock will provide a display of the correct time and date. As well, it permits programmed sequences of messages to be set up for months in advance.
- The UART will feed an optional RS-232 interface so that the sign can be re-programmed over a phone or radio link.
- The ASCII keyboard allows the user to program and change messages. Messages can also be loaded via pre-programmed EPROM packs. One example of a use for this latter feature is that if every MacDonalds had one of these signs and Ronald MacDonald died of a special sauce overdose, head office could send out proper obituaries to all the locations on chips.
- The Analog to Digital Converter allows the sign to display as a message any analog quantity, such as the temperature, as reported by a remotely located sensor.
- The cassette interface allows messages and other programming to be loaded from tape. . . useful if you have a whole raft of different

things to display under different circumstances.

● Now for the weirdies. The 256 key input keyboard is separate from the ASCII keyboard, and is used so that people looking at the sign can communicate with it. Oh, really? Yes, well, signs like conversation too, you know. For example, the sign might display a general message about a list of items. Passers by could hit a key on the keyboard corresponding to an item of interest, which would interrupt the general message for more detailed information regarding whatever it is they're interested in.

● Next, we have 128 multiplexed output lines, which can control other sorts of attention getting displays. For instance, if the sign were to be displaying a directory of a store, and someone was to ask it for the location of the elephant gun section, some of these lines might be used to light up an arrow pointing the way. The arrow to be made up out of red LEDs, of course; it goes with the decor.

● No intelligent sign would be complete without a speech synthesizer, of course. Ah, you don't think so, either. Well, then, you'll be pleased to find one herein, as well. It uses the TI voice synthesis chip set, which is ROM programmable, and can emit any sorts of verbalizings the user desires. Custom speech sets can be ROM'd by TI from a tape. The processor can annunciate at any programmed time to proclaim store specials, 8 bit ballyhoo or the end of civilization.

The bus also controls the display, of course.

Fig. 2 A sign in real life, with two rows of 42 characters each.

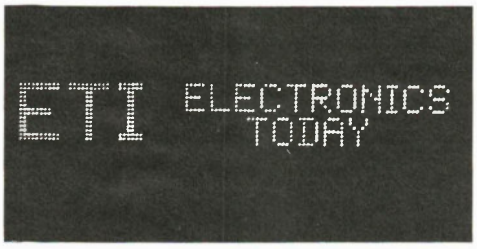

Fig. 3 Advertising.

Fig. 4 More advertising.

Furthermore

Versa-Digital also custom build signs, if their standard ones aren't sufficiently strange for a particular application. Variations are available to drive incandescent bulbs instead of LEDs, and we've heard rumours of a four foot high version. More LED display boards can also be stacked to increase the width or depth of the screen.

Versa Digital Technology is a relation of Exeltronix, which produces the Multiflex Z80A computer system (see ETI May 1981). The signs start at $1350.00 Canadian. For more information contact Exeltronix Components and Computing Inc., 319 College Street., Toronto, Ontario M5T 1S2, telephone (416) 921-5295

POKEing on the ZX80 again

A few months back we showed you the basics of using screen POKEs on your ZX80. This month we round it all off with an example program.

Graphic Example

Just for fun, here is a simple program that demonstrates the features discussed in the last article. It just fits in the 1K ZX80. The computer prints up a display consisting of black and grey squares in a pattern determined by a number input at the beginning of each series of games. The object of the game is to get the "woodworm" (an asterisk), which first appears at line 8 column 1, to eat its way across the screen to column 32 in the least number of moves. The snag is that the black squares represent a particularly tough kind of wood and each time one is eaten a penalty of 5 moves is incurred. Numerals 6, 7 or 8 are input as pseudo-cursor controls to move the insect down, up, or forwards respectively. The computer keeps track of the number of moves to reach column 32 and displays the total at the end of each game together with the best performance in the present series. Pressing NEWLINE after a game sets up another game in the same series. Entering a character starts a new series.

```
 2 LET Y = 32000                    No. of moves – best so far!
 4 INPUT R                          Seed for random number
                                    generator
 8 LET P = 0
10 LET W = 0                        Assign variables prior to PEEK
12 LET B = 1                        and POKE
14 LET A = 8
16 LET Z = -1
18 LET M = 0
20 RANDOMISE R                      Set seed for random number
                                    generator
22 FOR N = 1 TO 352
24 LET D = 9
26 LET X = RND(2)
28 IF X = 1 THEN LET D = 128        Print eleven lines with black and
30 PRINT CHR$(D);                   grey squares at random. Pattern
                                    determined by R.
32 NEXT N
34 GOSUB 500                        Locate display-file
36 POKE W + 232, 20                 Insect in initial position
38 LET Z = Z + 1                    Count No. of moves
40 INPUT C                          Which way?
42 GOSUB 500                        Locate display-file
44 LET M = W + (A-1)*33 + B         Put a space where insect is
46 POKE M, 0                        Set A and
48 IF C = 6 AND A<11 OR C = 7 AND   way and make sure we don't
   A>1 THEN LET A=A-2*C+13          POKE off-screen
50 IF C = 8 THEN LET B = B+1
52 LET M = W + (A-1)*33 + B         Set M to next insect location
                                    address
54 IF PEEK(M) = 128 THEN LET Z=Z+5  If there's a black square in the
                                    way, add penalty
56 POKE M, 20                       Put insect in next location
58 IF B = 32 THEN GOTO 62           Watch for end of game
60 GOTO 38                          Next move
62 IF Z<Y THEN LET Y = Z            Set Y to best so far
64 PRINT "END OF GAME IN ";Z;"
   MOVES"
66 PRINT "BEST SO FAR ";Y;" MOVES"
68 INPUT X$
70 CLS
72 IF X$ = " " THEN GOTO 8          NEWLINE for another game
74 RUN                              Any character for another series
500 LET P = PEEK(16397)
510 IF P>127 THEN LET P = P-256     Subroutine for setting W to
520 LET W = PEEK(16396) + P*256     address of start of display-file
530 RETURN
```

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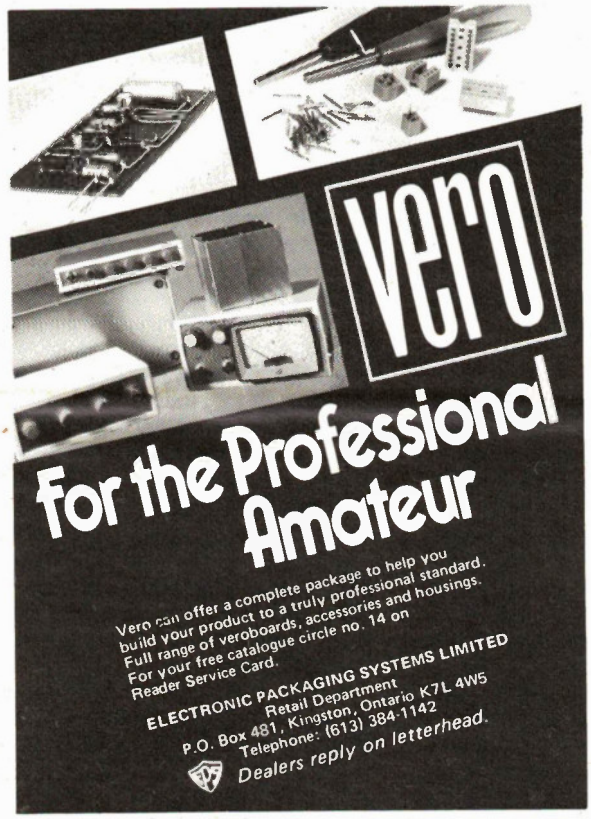

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Industrial Robots

Roger Allan Reports

Robots in Waiting; new piston ring assembly machines at the Ford plant in Windsor, Ontario.

ROBOT: a more than humanly efficient automaton — Chambers Twentieth Century Dictionary.

ROBOT: a machine in the form of a human being that performs the mechanical functions of a human being — Websters Dictionary.

ROBOT: a reprogrammable multifunctional manipulator designed to move material, parts, tools or specialized devices through variable programmed motions for the performance of a variety of tasks — Robot Institute of America.

ROBOT: a manipulator whose function is similar to that of human upper limbs — Japanese industrial definition.

SO WHAT IS A ROBOT? Best, as the Red King said to Alice, to "Begin at the beginning, proceed to the end and then stop."

Actually, the word robot is derived from the Czech word 'robotus' meaning 'forced labour'. It first appeared in 1921 in the title for the stage play R.U.R. (Rossom's Universal Robots) by Karel Capek — a self styled 'fantastic melodrama' in which robots, constructed without any feelings or soul ("God hasn't the slightest notion of modern engineering") do all the world's work, wage all the world's wars and finally rebel and destroy their makers. After all, as the leader of the robot rebels tells the General Manager of the factory that produced him (it?), "You are neither as strong nor as skillful as we robots. I want to be master."

But despite the 60 year age of the word 'robot', robots have been cropping up in history for quite some time. In about 375 BC Archytas of Tarentum built a robot bird which flew, or at least so he records. *De Automattis* written by Hero of Alexandria in the 2nd century BC tells of a theatre in which robot figures danced for temple ceremonies. Johan Nepomuk Maelzel in the early 1800's built a robot orchestra of some seven instruments, for which he commissioned Beethoven to compose his *Vittoria Symphony*. Regretfully, Maelzel's other robot, this one a robot chess player and taken on a grand tour through Europe and North America, left something to be desired. It was actually operated from the inside by a hunchbacked Alsatian dwarf named Schlumberger. But giving credit where credit is due, Maelzel's Panharmonium did work.

There are many other examples of descriptions of robots in history. In the realm of mythology the first humans were robots formed out of clay by the Titan Prometheus. In the realm of literature, perhaps the most noted example, courtesy of the fertile mind of Mary Shelley, is Dr. Victor Frankenstein's triumph in creating The Monster. And so on.

With such a panoply of possible definitions to be derived from history, combined with the apparent inability of the dictionaries to agree on a definition, compounded by the unwillingness of American and Japanese industrialists to agree on a definition, coupled with the layman's mental image of an R2D2 or a 3CP0 running around in the midst of an intergalactic civil war, it is perhaps best to just arbitrarily pick a definition: in this case the Robot Institute of America's: a reprogrammable multifunctional manipulator designed to move (things) through variable programmed motions for the performance of a variety of tasks.

Not very elegant, but certainly utilitarian. Just like a robot.

Six Different Types.

If one takes the RIA general definition, one then has to divide robots into six different types, based on coordinate systemsused and the incorporation of servo units.

Basically, robots can be either servo-operated or non-servo operated. In a non-servo operated system there are only two positions for each axis to assume, eg. either end. Occasionally it's possible to incorporate intermediate stops on some axes to provide more than two positions, but this is rare. They are therefore limited to the performance of a single program. Programming is determined by setting up the desired sequence of moves and adjusting the end stops of the various axes. They are customarily cheaper than servo operated robots, as they are simpler in their mechanics and cheaper to maintain and program.

The servo-operated robots have the fundamental difference in that they can be programmed to move and stop within their limits of axis at any point. The number of axes may number up to seven. Due to the servos it is possible to control the acceleration, and velocity of movement. Further, as the memory is larger, more positions can be programmed into the memory, permitting them to adjust to different needs. An example is the truck spraying robot at the GM plant in Oshawa which has memorized the configuration of four different truck bodies, can automatically determine which body is currently to be sprayed, and therefore which combination of movements of the spray head are necessary. Further, the robot automatically determines which of 20 different colors are to be used, making a grand total of 80 different combinations of movement and color. Needless to say, servo operated industrial robots are far more expensive than non-servo operated ones.

The next major division of industrial robots is based on the coordinate system. Basically, there are three types. In the Cylindrical Coordinate System, the arm moves horizontally and vertically about a hypothetical column shape. All the

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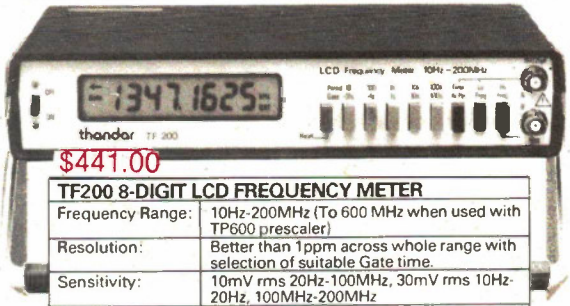

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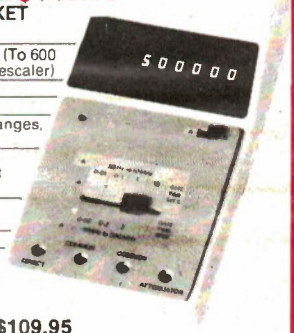
Size: 155 × 75 × 30mm
Weight: 180gms excluding batteries



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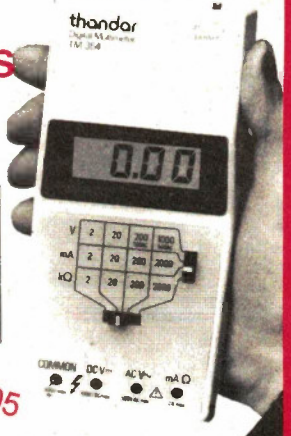

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Battery life:	Typically 3000 hours from 6 alkaline 'C' cells
Size:	255 × 150 × 50mm
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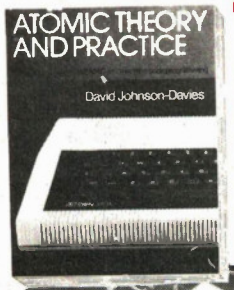

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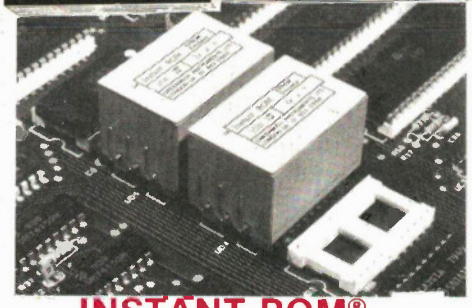

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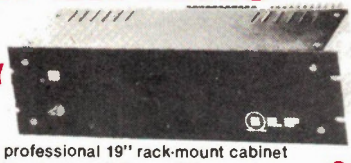

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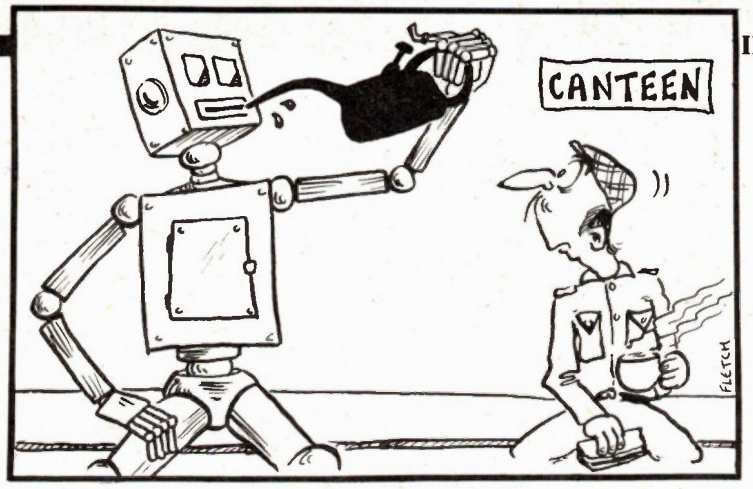

positions at the extremity of the arm describe a portion of a cylinder. In a Spherical Co-ordinate System, the movements are up/down, left/right and in/out. All movements at the end of the arm therefore describe a portion of a sphere. In a Jointed Spherical System the co-ordinates produced are roughly similar to a Spherical Co-ordinate System, but the movements are obtained through arms which roughly approximate the human upper torso: forearm, elbow, upper arm and shoulder. The positions described by the movements are portions of a sphere.

Within the context of servo or non-servo operated robots, the next prime consideration is their means of control. Essentially, there are four general control processes ranging from simplistic to state of the art, with appropriate price tags to match.

The least common control mechanism is the numerically controlled robot. Its command sequence is dependent upon numerical data contained on punched tapes, cards and digital switches. A very simple command structure.

The next most popular system is called a "play back robot" which produces from memory operations originally executed under human control. All the information necessary to run the robot is inscribed in its memory, the information is played back resulting in the operations being repetitively executed.

The most popular control system is the variable sequence robot whereby a robot repetitively repeats the steps of a given predetermined operation. The advantage of this system is that the control program can be very easily changed.

The top of the line, state of the art, control system is the so called intelligent robot. This is a robot with sensory perception primarily visual or tactile but also heat sensitive and chemical compostion sensitive, which is capable of detecting changes in the working condition and environment and thus, by computation within its own memory, proceed with the operation by modifying its movements to fit the changed reality. Very expensive.

Selling Points

The economic justification of robot utilization is both its strongest selling point and rational for existence at all: they save money — lots of it. The average industrial robot is operational 98% of the time, whereas workers in precise heavy machinery can rarely better 80% uptime. It will work where men can't or won't or prefer not to — in areas of high heat, where continuous heavy lifting is required, and in areas that are dangerous to human health. In fact, among the first industrial robots introduced into Canada removed jobs that the workers and their union didn't like doing: spray painting (GM plant in Oshawa) and heavy lifting (Ford plant in St. Catherines). They don't take holidays, require pension and health plans and can be run three shifts a day. Their tolerances are far superior to a working man, who tends to slow down and become sloppy over an eight hour shift, and their rejection rate is infinitesimal. So reliable are their tolerances and lack of down time that industrial robots can be left unattended for long periods leaving them to work away with only an occasional night security guard wandering around on hourly patrols to make sure the factory hasn't burnt down in his absence. The state of the art of this element in robotic money saving opened in February 1981 by the Fujitsu Fanuc company in Japan, where they created an automatic factory to produce industrial robots at the rate of 100 a month (later scheduled to rise to 360/month) using industrial robots for the assembly of other industrial robots. The firm operates 24 hours a day, is unmanned at night when the robots continue to work, and saves enormous sums of peripheral support money by not having the factory heated, lit or air conditioned during the night shift. After all, what robot is going to launch a union grievance because it's too dark or too chilly? Further, with robots, model changes can be made easily — the machines need not be rebuilt or replaced, only the memory program need by modified. This has enormous cost saving benefits particularly in the automotive industry that customarily has to shut down for weeks on end to incorporate new model changes. Combined with the low average running costs (1975 $5.00/hr: 1980 $5.25/hr) and the average high industrial worker's pay and fringe benefit package (1980 average $16.40/hr) the reasonably high prices ($10,000 to $105,000) can be amortized over three years at the worst. With an average life expectancy of eight years an industrial robot, while not quite a licence to print money, certainly makes more than economic sense.

But what of the workers the robot replaces?

Three World Models

There are, essentially, three managerial models: the Japanese, the Communist and The Rest of Us.

The simplest to define is the Communist: To each according to his need, from each according to his ability. Every worker displaced is automatically guaranteed a job, with no loss of benefits. One's replacement job may not be in the same company, nor may it be a job one might wish to hold — but at least it's a job. There is no worker resistance to the introduction of industrial robots as the robots do not threaten one's livelihood. Enough said.

The Japanese model might be subtitled Communalistic: one joins a company as a young person and the company looks after you for the rest of your life. Japanese workers don't get fired for anything other than criminal actions or gross deriliction of duty. Further, there is an added support to the introduction of industrial robots due to their union agreements. Every employee in a Japanese industry has a stake in the profits of the company derived from two annual bonuses. If the company is profitable by the formula worked out by their union negotiators, the

sum total of each bonus can be as high as five months pay. The lowest general bonus is about two months pay. If the company loses money, one receives no bonus. Therefore, every decrease in production costs per unit product, every increase in production output, every instance of gaining a further edge on the market, directly results in an increase in the workers' bi-annual bonus. It is therefore unsurprising that Japanese industrial workers are clamouring for more robots, are frequently the proposers of where in a production process a robot can be used, and have not once complained about them.

A second element in the Japanese model is government policy: it encourages the development of a worker-free manufacturing environment, believing that by taking the workers out of the manufacturing sector they can lead happier and more productive lives doing those things that machines can't do — though specifically what those things are the government doesn't mention, only speaking in generalities such as, "freeing the person to do higher things than repetitive work" (composing Haiku, perhaps?).

The third element in the Japanese model is a derivative of the economic philosphy that you work for a company for life (generally to age 55-60). As such, workers are shifted around from one job to another, trained, re-trained, and re-re-trained over the course of their careers. They tend to be generalists, as are the managers who are frequently shifted to head departments, even to head subsidiary companies, the internal workings of which they may have no prior knowledge. As such, there is an implicit understanding on the part of workers and management that outside specialists will not be hired for specific jobs, but rather that internal workers will be trained for the jobs — such as running the robots.

So far, the system has worked, and worked well — the Japanese being the acknowledged leaders in industrial robots both as to manufacturing them and the absolute numbers employed. However, Japanese economists are already warning that the success of this economic model is dependent on expanding export markets and a permanent shortage of workers — an economic reality which they warn will not exist after 1990 when the manufacturing sector becomes saturated with industrial robots. If, after the 1990 saturation point is reached Japanese industrialists continue to include more industrial robots on their production lines, then unemployment will of necessity result with catastrophic social consequences.

The model I term The Rest of Us includes North American and European industrial management realities. Workers are not loyal to an individual company, they only work where they can get what they think is the best job, 'best' customarily being defined as the highest paid. They are 'loyal' not to the company but to their trade and their union — an electrician is an electrician first and an employee of the XYZ Company second. (In Japan, a worker might reply that he works for, say, Kowasaki Heavy Industries with eight years seniority currently doing electrical work). They are not tied into the company's profitability — any decrease in cost per unit due to the introduction of robots doesn't increase their take home pay, it only takes away their job.

With the lack of cross fertilization in our industries (e.g. an electrician if he loses his job as an electrician has to go to another company to work as their electrician, rather than losing his job and being re-trained for something else), the potential for resistance to the introduction of industrial robots is very real, though it has not appeared in any widespread way. Primarily the lack of the appearance of Luddite-like violence (when British crofters smashed the cloth looms, c1812, believing them to be a threat to their jobs at home and thereby their way of life) has been due to the introduction of industrial robots to do jobs that nobody wants: spray painting trucks which can affect health and is a bad strain on the back, lifting heavy items into and out of heat treatment furnaces, repetitive spot welding, work in environmentally dangerous areas, etc.

Mork and Mindy Employed

There has been very little unemployment caused by industrial robots, the workers being shifted into vacancies elsewhere in the plants, vacancies created by natural attrition. No unions have as yet propounded policies which deny the introduction of robots, believing them, as yet, not to be a threat to their workers. So much so, that those that have been introduced tend to be treated quite fondly by the workers, being given names such as Laverne and Shirley at GM Oshawa, or Mork and Mindy at the Ford plant in St. Catherines, as well as being treated somewhat as friends. When a University of Florida robot ran amuck, attacked and tore off its own shoulder, it is reported that it received a number of Get Well Quick cards; and when a robot in an electrical company in the States was put out of action due to a passing fork lift truck crashing into it, the workers held a party to 'cheer it up'.

The difficulties that have arisen, and there are many instances, involve lower and middle management personnel feeling threatened by this new technology, believing the industrial robots represent an undermining of their traditional authority and job stature. In fact, a GM study in the States showed that those who truly feared the introduction of industrial robots were not the workers, who believed that if the crunch ever came between robots and human jobs that their union would protect them, nor among upper echelon managers who could take the broad view and can read a ledger sheet, but among lower and lower-middle management personnel. So much so, that there are many instances of quarrels between production engineers attempting to introduce the new technology and production managers fighting a rear guard action to protect the inherent

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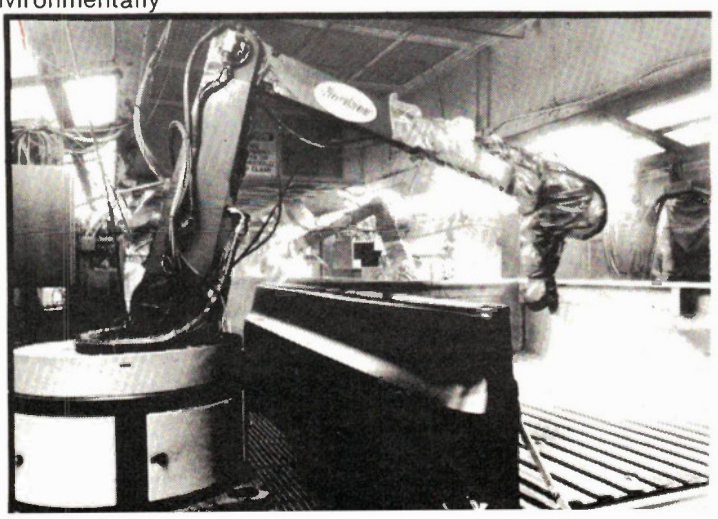

Laverne and Shirley GM (Oshawa) robot spray painters.

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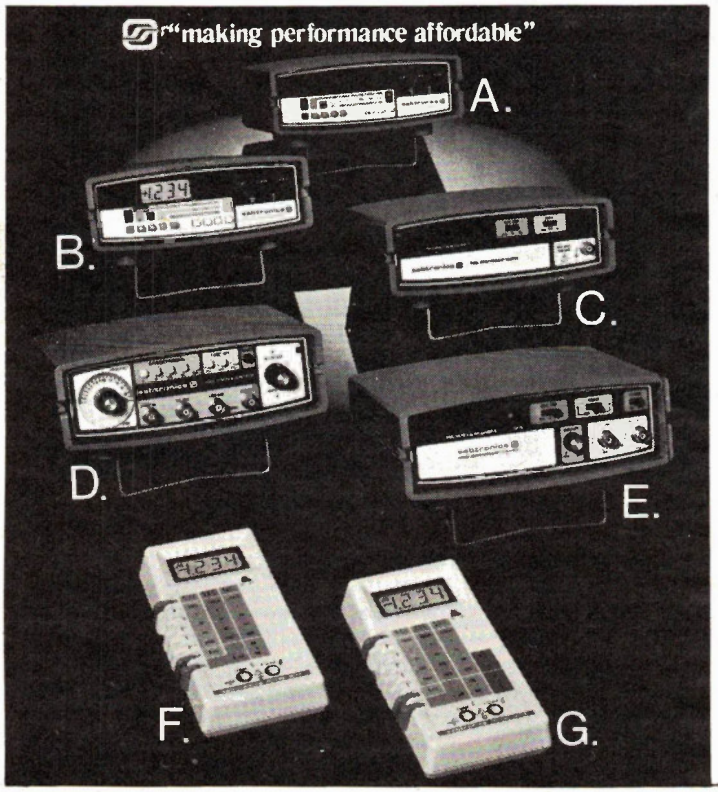

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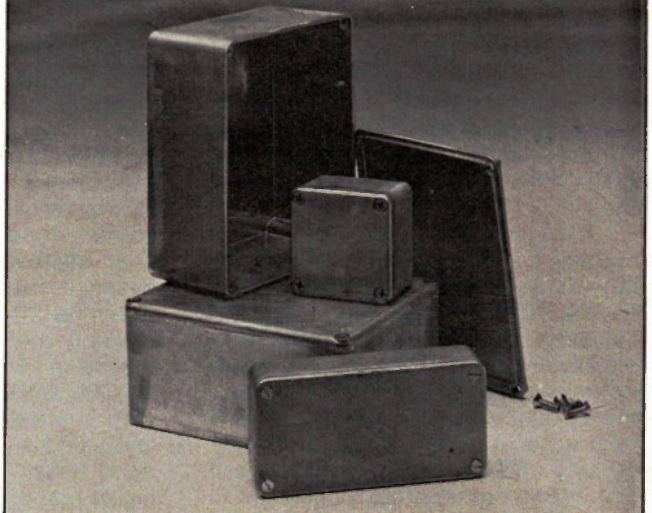

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characteristics of their jobs whereby they hold traditional power over their workers. After all, how can one gain the respect of or discipline a robot?

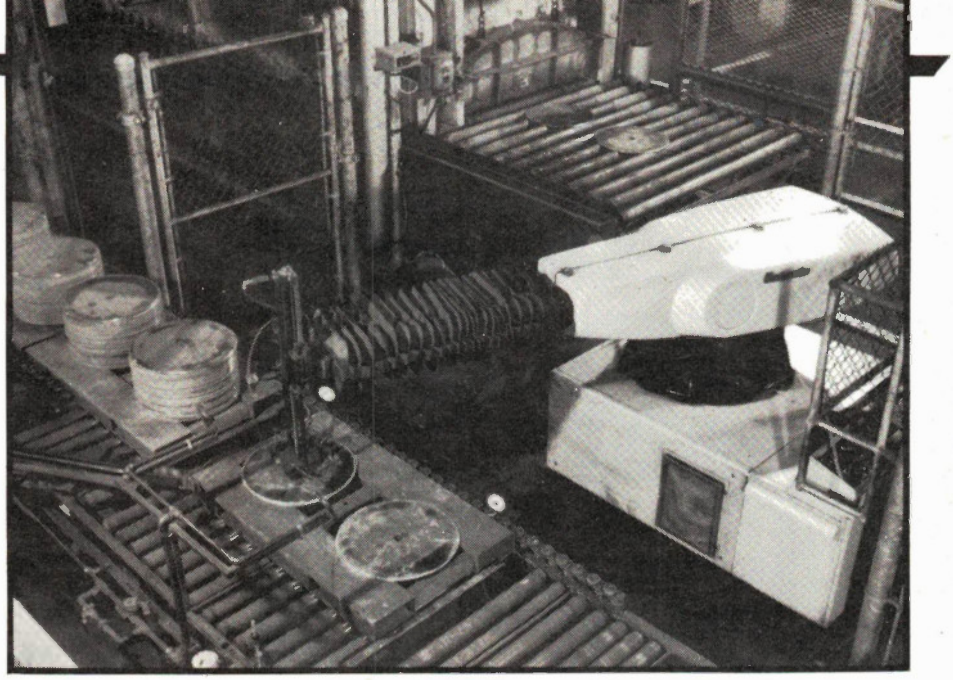
A Booming Market

Fortunately, or unfortunately if you happen to be an industrial robot saleman over the past few years, the number of such devices currently in use in the western world is not very high, though the market is booming with an expected annual increase of 25-30%. Canada has about 150 scattered here and there in ones and twos (the largest group being at a Ford plant in St. Thomas where there are 14 spot welders), and as this writer can report, they're the devil to track down and find. The United States, which was the world leader in industrial robotics (Unimation producing the first one in 1961 on patents granted in 1954), has about 4,500 tops, manufactured by about 25 companies. Japan, which commenced manufacturing industrial robots fully eight years after the Americans now leads the pack with 11,000+ using the RIA Definition or 45,000+ using their own definition, manufactured by some 139 companies. Europe, which commenced producing them two years after the Japanese has about 4,525. Unfortunately, the actual numbers are somewhat inexact, not only due to the inherent difficulties in determining what actually is an industrial robot, but due to the difficulties in gaining production data from source: so much so that the actual numbers tends to depend on who one asks, and is usually out of date by the time the data reaches publication.

However, be that as it may, nothing can excuse such poor reportage as occured in the feature article on robotics in the prestigous TIME Magazine in Dec/80 which stated that the USSR only had 25 of them, an error analogous to the blunder committed by our own sister publication, ETI International (UK), which not only grossly understated the USSR robot population but reported a decrease in their robot population from a high of 400 in 1975 to a low of 150+ in 1980.

In fact, the USSR has developed over 200 prototype industrial robots, of which no less than 72 models are in production. In the Five Year Plan 1976-80 they produced some 3,500 with another 25,000 to be built over the next Five Year Plan. Hence, far from being deficient in robotics, in actual numbers the USSR is only slightly behind the US. The only comforting thought, (western strategic industrial considerations coming to the fore), is that the Soviet industrial robots tend to be less technologically subtle than their Western counterparts, customarily being big solid machines capable of lifting heavy weights, and do not posses the memory elegance found in Western or Asian models. This is primarily due to the USSR's current relative poverty in microprocessing capability on a massed scale, and results in their control systems being less universally applicable and harder to program. Having said that, as an accompanying photograph shows, the Soviet's can turn out small, elegant robots apparently in quantity. But all things considered, the Soviet industrial robots remain relatively primitive by current world wide standards and can only improve dramatically with the passage of time.

It is interesting to note just in passing that the Soviet's expect to displace between 150,000 and 200,000 workers by the introduction of industrial workers over the next five years — mostly in jobs that require heavy lifting, are life threatening or just plain unpleasant. No comparable figures are available for Canadian or American industry — though with only 150 robots in place, the Canadian experience to date would suggest that some 6-800 workers have been shifted to other jobs, jobs customarily higher paying and more personally rewarding. An extrapolation to American industry would suggest that some 20-25,000 American workers have been shifted to date.



An industrial robot at International Harvester's Hamilton Plant.

All in a Day's Work

So what, in fact, are they used for?

Pretty near anything that a human being can do, at least in theoretical terms involving repetitive actions. Western experience has generally been in jobs that require heavy lifting, such as moving metal parts into and out of heat treatment furnaces, such as at the international Harvester Plant in Hamilton, spray painting of automotive products, repetive spot welding such as at the Ford plant in St. Thomas, grinding of heavy machine parts such as the wheel grinder at the CN repair shop in Winnipeg, the movement of pallets, and so on.

It is to the Japanese experience that one must look to see the shape of things to come. There, industrial robots not only do the above, but other things ranging from the complicated to the sublime. They are used in the manufacture of pens and pencils, furniture, a window cleaner designed for skyscrapers (with the reported added advantage that it protects the privacy of offices and hotel rooms while doing its job), a dry noodle factory, underwater geological surveying, welding and machining (under 300 meters), underwater bridge building, and are being designed for building construction (especially multi-storied office blocks, which could be useful in the Canadian climate) and road construction. In the service industry, robots are being developed to clean walls and floors, clean boat hulls, clean electrical insulators and in the nuclear industry. In Australia, technicians are testing robots to shear sheep. To date

Continued on page 49

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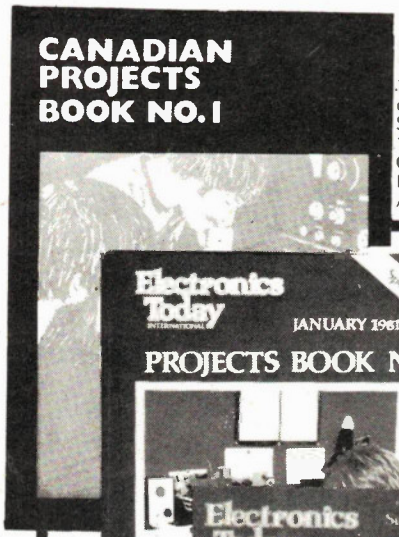

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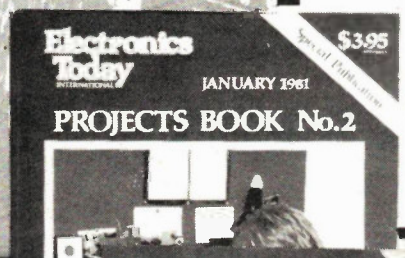

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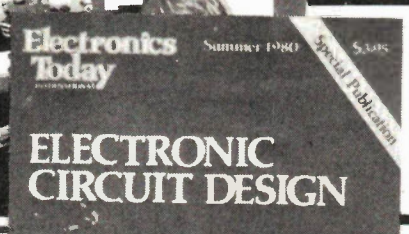

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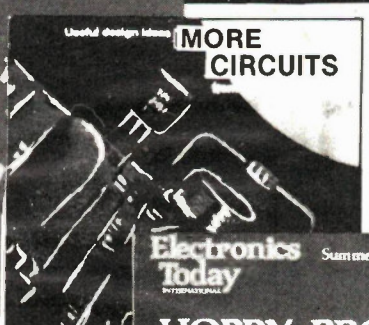

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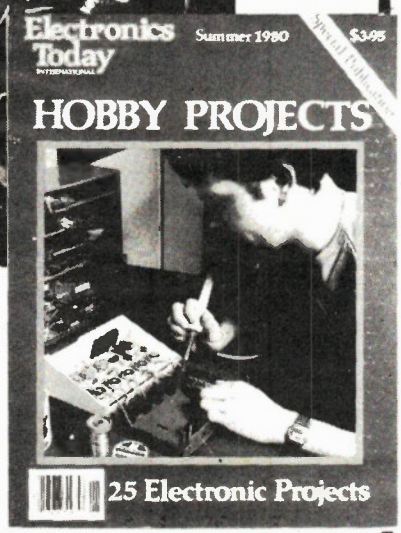

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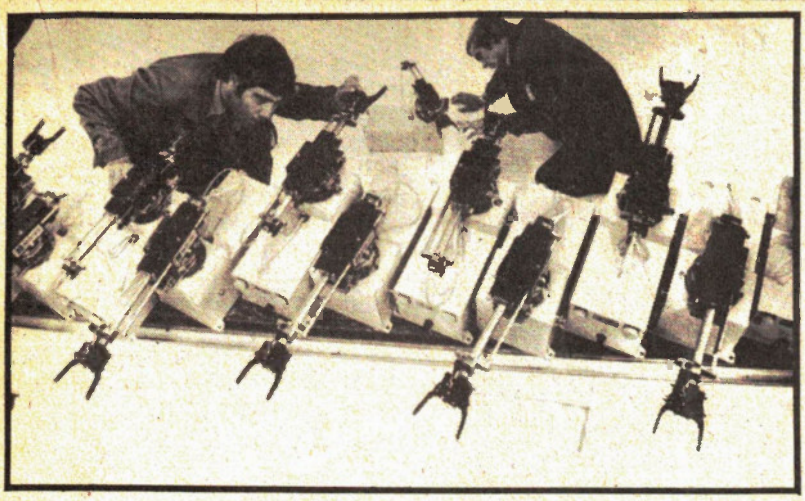

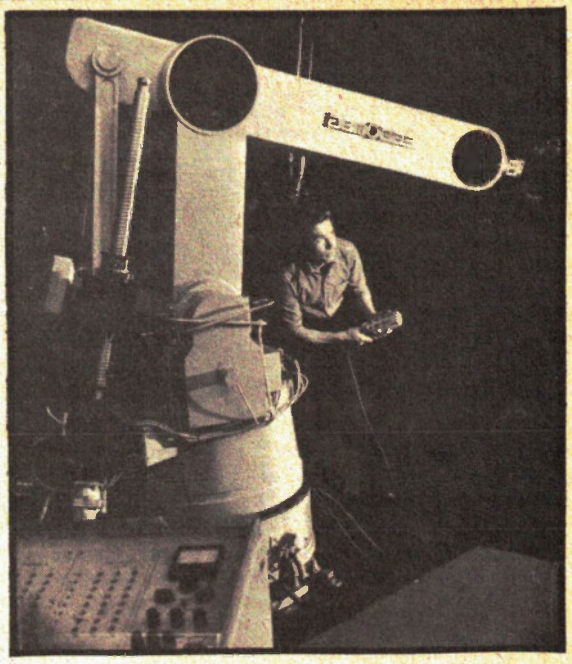

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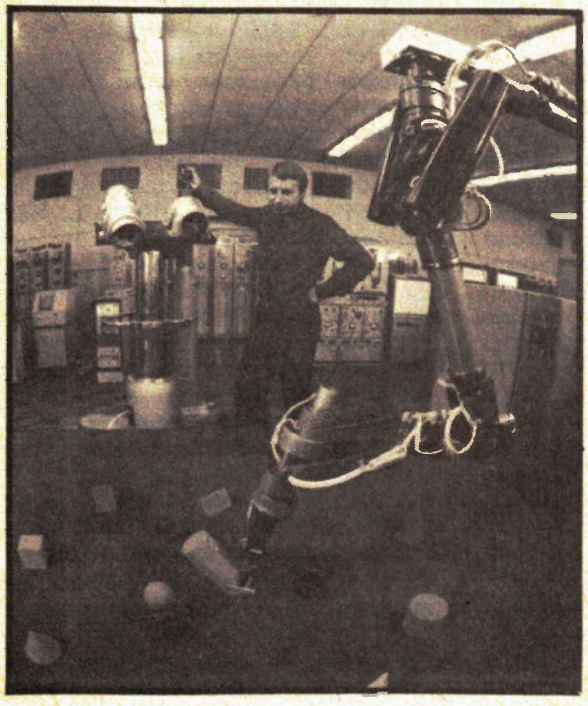
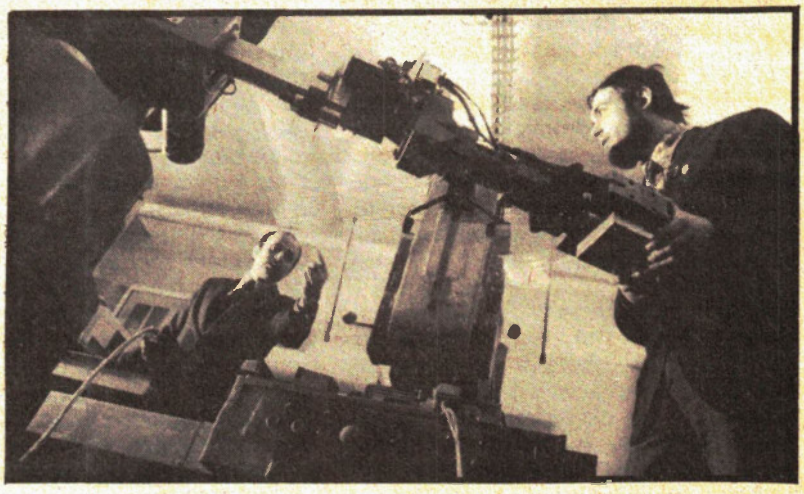


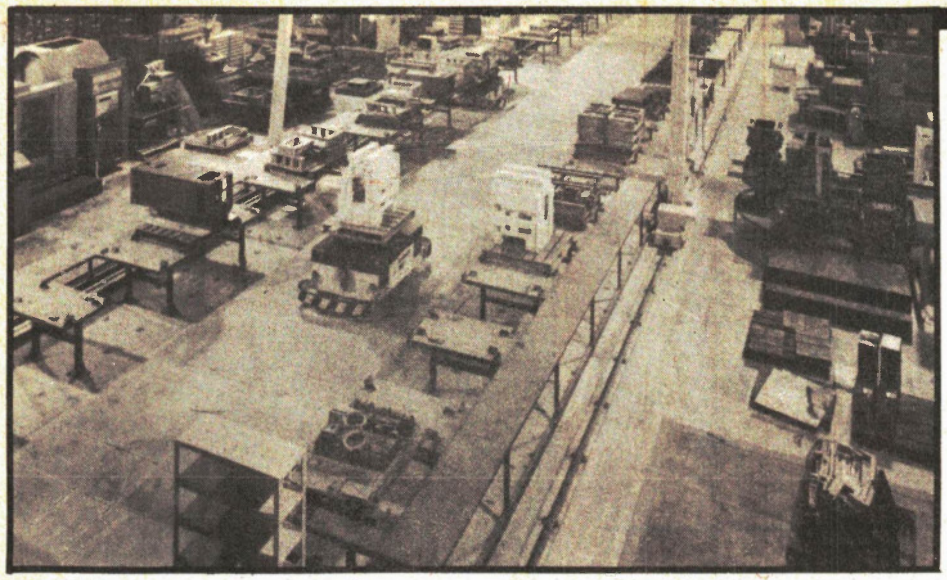


SEEN HERE FOR THE FIRST TIME IN NORTH AMERICA AN ETI CANADA EXCLUSIVE!

Upper left: Foreman Alexei Gaiton and inspector Alexei Ovchinnkov checking robots produced at the LADA auto production association. The use of such robots at Leningrad's enterprises has released some 500 skilled workers. Photo by Yu. Belozerov (TASS)
Upper right: Viktor Borisov, head of the adjustments section, checks the operation of the experimental robot intended to lift and move loads of up to 30 kg. Photo by Yu. Belozerov (TASS)
Lower left: Institute of Cybernetics under the UkrSSR Academy of Sciences at the laboratory of the "arm — eye" type robots.
Lower right: Designers Yevgeny Vronsky /I/ and Sergei Lukashevich adjust the ITEKAR automated control unit operating drilling and milling machines. Photo by Arkady Nikolayev (TASS)

ROBOT POPULATION BY COUNTRY BEST AVAILABLE FIGURES TO END OF 1981.

JAPAN	11,000
USA	4,500
USSR	3,500
SWEDEN	1,500
W. GERMANY	1,350
ITALY	500
FRANCE	375
POLAND	350
UK	300
FINLAND	150
CANADA	150



Fujitsu Fanuc's state of the art robot assembly plant that utilizes industrial robots to build other industrial robots. Completed assemblies are to the left of the picture.

they report that they have no difficulty in clipping the back and sides but the neck and head sequences currently elude them — so much so that there are unconfirmed reports of malfunctions resulting in a flock of earless sheep. Right the way across to what this writer considers to be the current intellectual ultimate: the Fujitsu Fanuc's factory that uses industrial robots to assemble other industrial robots.

Robots can be used for anything that is repetitive, from putting bottles into cartons, to drilling holes and tightening bolts, with increased accuracy and a decrease in the rejection rate and a marked decrease in the scrap produced.

But Can They Think?

Yet despite the ever increasing utilization of robots in all sorts of jobs, there remains a big stumbling block, the overcoming of which represents the major thrust in industrial robots R and D — the robots' lack of intelligence.

Current robots are just plain dumb and are totally dependent on the input from the programmers. The major stumbling block is the lack of vision which currently appears to be stuck at the two dimensional level. But advances are being made.

General Motors has developed a system it calls Consight which consists of a robot equiped with an electronic camera. The camera surveys parts on a conveyor belt, Indentifies them, and transfers them in the proper sequence to another conveyor belt. As yet it is still too slow to work on an assembly line. The Machine Intelligence Corp. has developed a system which scans objects against a brightly lit background, transmits the hundreds of pixels (the dots that make up a television image) to a computer. The computer translates the pixels into binary code and compares the data with recorded descriptions of various objects. As yet it is only capable of differentiating between nine different objects. The Lockheed Missile and Space Co. are testing a technique called 'gray imaging' which uses 100,000 different pixels each graded from 0 (pure white) to 255 (pure black). This enables the robot to have a much better three dimensional image of objects.

In the realm of touch, robots as yet remain very insensitive. They will grasp with a pre-determined pressure, but as yet the technology to grasp an item and identify it by touch eludes researchers. But to that end, the Lord Corp. hopes to market (withing 5 years) a hand made out of a spongy material with a grid of many sensitive wires embedded in it. It is hoped that these sensitive wires will permit a reasonable facsimile of touch to be achieved.

Yet despite the advances in computers and television cameras the interface between the two still remains the major stumbling block, for while computers can compute mathematical formulas the state of the art remains plateaued at the level of a robot which will waste enormous amounts of time inspecting cubes and cylinders when instructed to find a triangle, for instance.

In broad based industrial applications, the shape of things to come is the fully automated factory which can manufacture large numbers of different items in small batch quantities of each — just by changing the programming in the robot's memory. To date, the most definitive example is the Japanese completely unmanned computer-run dry noodle factory — which includes an automatic warehouse, battery operated cars, loading and unloading robots, automatic manufacturing and inspection, and packing. A close second is Fujitsu Fanuc's robot factory. Nothing like them exists in the western world.

Threat to Mankind?

It is in the fully automated factories that industrial robots perhaps present their greatest threat to mankind in general. For no matter how successful our diplomats may be in achieving SALT agreements, even with fully acceptable international inspection processes, with factories capable of being switched over from manufacturing one item to another merely by a quick re-programming, the spectre arises of the XYZ Hula Hoop Company being transformed, almost immediately into an armaments factory capable of producing weapons three shifts a day, seven days a week with superior accuracy and reliability. A further element in this spectre is that in the event of a national military emergency those robot utilizing factories producing non-strategic items can be almost immediately switched over to the manufacture and assembly of other industrial robots which in turn can be used either to manufacture still more industrial robots which in turn can be switched directly to the manufacture of arms. Hence, a weak, non-threatening nation possessing a high degree of industrial robot capabilities, and the necessary blueprints for strategic arms, could transform itself into a major world power literally in a matter of months, or possibly even weeks. Verily, a pussycat today, a Hitler tomorrow.

Hopefully not, but then Industrial robots are already being used in the manufacture of tanks, warplanes and gun pieces. And much of the R and D money originates in military budgets.

After all, the initial rational for the Lockheed 'gray imaging' process, which if successful will be very useful in commercial applications, was to check for defective artillery shells.

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BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES **$8.25**
S. DALY
This book is based on the author's own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language. Also included are a program library containing various programs, that the author has actually written and run. These are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game. The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

THE BASIC COOKBOOK.
TAB No.1055 **$9.45**
BASIC is a surprisingly powerful language . . . if you understand it completely. This book picks up where most manufacturers' documentation gives up. With it, any computer owner can develop programs to make the most out of his or her machine.

PET BASIC — TRAINING YOUR PET COMPUTER
AB014 **$16.45**
Officially approved by Commodore, this is the ideal reference book for long time PET owners or novices. In an easy to read and humorous style, this book describes techniques and experiments, all designed to provide a strong understanding of this versatile machine.

PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS
AB015 **$10.45**
This book emphasizes the sort of analytical thinking that lets you use a specific tool — the BASIC language — to transform your own ideas into workable programs. The text is designed to help you to intelligently analyse and design a wide diversity of useful and interesting programs.

COMPUTER PROGRAMS IN BASIC
AB001 **$14.45**
A catalogue of over 1 600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine.

PET GAMES AND RECREATION
AB002 **$12.45**
A variety of interesting games designed to amuse and educate. Games include such names as Capture, Tic Tac Toe, Watchperson, Motie, Sinners, Martian Hunt and more.

BRAIN TICKLERS
AB005 **$8.00**
If the usual games such as Bug Stomp and Invaders From the Time Warp are starting to pale, then this is the book for you. The authors have put together dozens of stimulating puzzles to show you just how challenging computing can be.

PASCAL
TAB No.1205 **$16.45**
Aimed specifically at TRS-80 users, this book discusses how to load, use and write PASCAL programs. Graphic techniques are discussed and numerous programs are presented.

PASCAL PROGRAMMING FOR THE APPLE
AB008 **$16.45**
A great book to upgrade your programming skills to the UCSD Pascal as implemented on the Apple II. Statements and techniques are discussed and there are many practical and ready to run programs.

APPLE MACHINE LANGUAGE PROGRAMMING
AB009 **$16.45**
The best way to learn machine language programming the Apple II in no time at all. The book combines colour, graphics, and sound generation together with clear cut demonstrations to help the user learn quickly and effectively.

Z80 USERS MANUAL
AB010 **$14.45**
The Z80 MPU can be found in many machines and is generally acknowledged to be one of the most powerful 8 bit chips around. This book provides an excellent 'right hand' for anyone involved in the application of this popular processor.

HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR
AB006 **$10.45**
Calculator programming, by its very nature, often is an obstacle to effective use. This book endeavours to show how to use a programmable calculator to its full capabilities. The TI 57 and the HP 33E calculators are discussed although the principles extend to similar models.

BP33: ELECTRONIC CALCULATOR USERS HANDBOOK **$4.25**
M.H. BABANI, B.Sc.(Eng.)
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. Includes the way to calculate using only a simple four function calculator: Trigonometric Functions (Sin, Cos, Tan) Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers.

PROJECTS

BP48: ELECTRONIC PROJECTS FOR BEGINNERS **$5.90**
F.G. RAYER, T.Eng.(CEI), Assoc.IERE
Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics, will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

Furthermore, a number of projects have been arranged so that they can be constructed without any need for soldering and, thus, avoid the need for a soldering iron.

Also, many of the later projects can be built along the lines as those in the 'No Soldering' section so this may considerably increase the scope of projects which the newcomer can build and use.

221: 28 TESTED TRANSISTOR PROJECTS **$5.50**
R.TORRENS
Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

BP49: POPULAR ELECTRONIC PROJECTS **$6.25**
R.A. PENFOLD
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS
AB007 **$9.45**
An ideal sourcebook of Solids State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

BP71: ELECTRONIC HOUSEHOLD PROJECTS **$7.70**
R. A. PENFOLD
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS **$8.10**
R.A. PENFOLD
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

BP69: ELECTRONIC GAMES **$7.55**
R.A. PENFOLD
In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP95: MODEL RAILWAY PROJECTS **$8.10**
Electronic projects for model railways are fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects: striboard layouts are provided for each project.

ETI BOOKS

PROJECTS
(CONTINUED)

BP76: POWER SUPPLY PROJECTS $7.30
R.A. PENFOLD
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

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

BP84: DIGITAL IC PROJECTS $8.10
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike.

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS $7.55
F.G. RAYER, T.Eng.(CEI), Assoc. IERE
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

In this book many applications and projects using various types of numeral displays, popular counter and driver IC's etc. are considered.

213: ELECTRONIC CIRCUITS FOR MODEL RAILWAYS $4.50
M.H. BABANI, B.Sc.(Eng.)
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.

BP73: REMOTE CONTROL PROJECTS $8.60
OWEN BISHOP
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. 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.

CIRCUITS

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 $8.25
R.A. PENFOLD
Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings; Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

THE GIANT HANDBOOK OF ELECTRONIC CIRCUITS
TAB No.1300 $24.45
About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS $5.50
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here 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.

BPB7: SIMPLE L.E.D. CIRCUITS $5.90
R.N. SOAR
Since it first appeared in 1977, Mr. R.N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on.

BP42: 50 SIMPLE L.E.D. CIRCUITS $3.55
R.N. SOAR
The author of this book, Mr. R.N. Soar, has compiled 50 interesting and useful circuits and applications, covering many different branches of electronics, using one of the most inexpensive and freely available components — the Light Emitting Diode (L.E.D.). A useful book for the library of both beginner and more advanced enthusiast alike.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS $8.10
OWEN BISHOP
The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicyle speedometer to a novelty 'Duck Shoot', a number of power supply circuits are included.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS $5.50
F.G.RAYER, T.Eng.(CEI),Assoc.IERE
Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast to construct. In most of the circuits there is a wide latitude in component values and types, allowing easy modification of circuits or ready adaptation of them to individual needs.

BP44: IC 555 PROJECTS $7.55
E.A. PARR, B.Sc.,C.Eng., M.I.E.E.
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. 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.

BP24: 50 PROJECTS USING IC741 $4.25
RUDI & UWE REDMER
This book, originally published in Germany by TOPP, has achieved phenomenal sales on the Continent and Babani decided, in view of the fact that the integrated circuit used in this book is inexpensive to buy, to make this unique book available to the English speaking reader. Translated from the original German with copious notes, data and circuitry, a "must" for everyone whatever their interest in electronics.

BP83: VMOS PROJECTS $8.20
R.A. PENFOLD
Although modern bipolar power transistors give excellent results in a wide range of applications, they are not without their drawbacks or limitations. This book will primarily be concerned with VMOS power FETs although power MOSFETs will be dealt with in the chapter on audio circuits. A number of varied and interesting projects are covered under the main headings of: Audio Circuits, Sound Generator Circuits, DC Control Circuits and Signal Control Circuits.

BP65: SINGLE IC PROJECTS $6.55
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

BP 50: IC LM3900 PROJECTS $5.90
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an Introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

223: 50 PROJECTS USING IC CA3130 $5.50
R.A.PENFOLD
In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

224: 50 CMOS IC PROJECTS $4.25
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

THE ACTIVE FILTER HANDBOOK
TAB No.1133 $11.45
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design. The book introduces filters and their uses also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICS — HOW THEY WORK AND HOW TO USE THEM
AB004 $10.45
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS
TAB No.800 $20.45
MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS
TAB No.804 $19.45
Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK
TAB No.1199 $16.45
If you've ever tried to find specs for a so called 'standard' chip, then you'll apppreciate this book. C.L. Hallmark has compiled specs and pinouts for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS
AB016 $10.45
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

AUDIO

BP90: AUDIO PROJECTS $8.10
F.G. RAYER
Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

HOW TO DESIGN, BUILD, AND TEST COMPLETE SPEAKER SYSTEMS.
TAB No.1064 $13.45
By far the greatest savings in assembling an audio system can be realized from the construction of speakers. This book contains information to build a variety of speakers as well as instructions on how to design your own.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES $3.55
B.B. BABANI
This book gives data for building most types 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 for every construction showing the dimensions necessary.

BP35: HANDBOOK OF IC AUDIO PRE-AMPLIFIER AND POWER AMPLIFIER CONSTRUCTION $5.50
F.G.RAYER, T.Eng.(CEI),Assoc.IERE
This book is divided into three parts: Part I, understanding audio IC's, 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.

BP47: MOBILE DISCOTHEQUE HANDBOOK $5.90
COLIN CARSON
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.

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.

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH. . .
TAB No.1166 $16.45
The author, F. Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications. If all you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.50
M.K. BERRY
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

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.

BP74: ELECTRONIC MUSIC PROJECTS $7.70
R.A. PENFOLD
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. 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 a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc.

P81: ELECTRONIC SYNTHESISER PROJECTS $7.30
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator. Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

ELECTRONIC MUSIC SYNTHESIZERS
TAB No.1167 $10.45
If you're fascinated by the potential of electronics in the field of music, then this is the book for you. Included is data on synthesizers in general as well as particular models. There is also a chapter on the various accessories that are available.

See the order form on page 27

ETI BOOKS

TEST EQUIPMENT

BP75: ELECTRONIC TEST EQUIPMENT CONSTRUCTION $7.30
F.G. RAYER, T.Eng. (CEI), Assoc. IERE
This book covers in detail the construction of a wide range of test equipment for both the Electronics Hobbyists and Radio Amateur. Included are projects ranging from an FET Amplified Voltmeter and Resistance Bridge to a Field Strength Indicator and Heterodyne Frequency Meter. Not only can the home constructor enjoy building the equipment but the finished projects can also be usefully utilised in the furtherance of his hobby.

99 TEST EQUIPMENT PROJECTS YOU CAN BUILD
TAB No.805 $14.45
An excellent source book for the hobbyist who wants to build up his work bench inexpensively. There are circuits to measure just about any electrical quantity. The variety is endless and includes just about anything you could wish for!

HOW TO GET THE MOST OUT OF LOW COST TEST EQUIPMENT
AB017 $9.45
Whether you want to get your vintage 1960 'TestRite'signal generator working, or you've got something to measure with nothing to measure it with, this is the book for you. The author discusses how to maximize the usefulness of cheap test gear, how to upgrade old equipment, and effective test set ups.

THE POWER SUPPLY HANDBOOK
TAB No.806 $16.45
A complete one stop reference for hobbyists and engineers. Contains high and low voltage power supplies of every conceivable type as well mobile and portable units.

BP70: TRANSISTOR RADIO FAULT-FINDING CHART $2.40
CHAS. E. MILLER
Across the top of the chart will be found four rectangles containing brief descriptions of various faults; vis: — sound weak but undistorted; set dead; sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 $9.45
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS
AB018 $9.45
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

RADIO AND COMMUNICATIONS

BP79: RADIO CONTROL FOR BEGINNERS $7.30
F.G. RAYER, T.Eng.(CEI),Assoc.IERE.
The aim of this book is to act as an introduction to Radio Control for beginners to the hobby. The book will commence by dealing with the conditions that are allowable for such things as frequency and power of transmission. This is followed by a "block" explanation of how control-device and transmitter operate and receiver and actuator(s) produce motion in a model.

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

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

BP91: AN INTRODUCTION TO RADIO DXing $8.10
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

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; coverter for 2MHz, 40 to 800 MHz RF amplifier, Aerials for the 52, 144MHz bands, Solid State Crystal Frequency Calibrator, etc.

BP46: RADIO CIRCUITS USING IC's $5.90
J.B. DANCE, M.Sc.
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

REFERENCE

THE BEGINNER'S HANDBOOK OF ELECTRONICS
AB003 $9.45
An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillators, radio, television and more.

ELEMENTS OF ELECTRONICS — An on-going series
F.A. WILSON, C.G.I.A., C.Eng.,
BP62: BOOK 1. The Simple Electronic Circuit and Components $8.95
BP63: BOOK 2. Alternating Current Theory $8.95
BP64: BOOK 3. Semiconductor Technology $8.95
BP77: BOOK 4. Microprocessing Systems And Circuits $12.30
BP89: BOOK 5. Communication $12.30
The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that 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 arithmetical skills, the use of mathematics is not avoided, and all the mathematics required is taught as the reader progresses.

Each book is a complete treatise of a particular branch of the subject and, therefore, can be used on its own with one proviso, that the later books do not duplicate material from their predecessors, thus a working knowledge of the subjects covered by the earlier books is assumed.

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

BOOK 2: This book continues with alternating current theory without which there can be no comprehension of speech, music, radio, television or even the electricity utilities.

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

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

BOOK 5: A book covering the whole communication scene.

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE $12.25
ADRIAN MICHAELS
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

BP1: FIRST BOOK OF TRANSISTOR EQUIVALENTS AND SUBSTITUTES $2.80
B.B. BABANI
This guide covers many thousands of transistors showing possible alternatives and equivalents. 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 AND SUBSTITUTES $4.80
B.B. BABANI
The "First Book of Transistor Equivalents" has had to be reprinted 15 times. The "Second Book" produced in the same style as the first book, in no way duplicates any of the data presented in it. The "Second Book" contains only additional material and the two books complement each other and make available some of the most complete and extensive information in this field. The interchangeability data covers semiconductors manufactured in Great Britain, USA, Germany, France, Poland, Italy, East Germany, Belgium, Austria, Netherlands and many other countries.

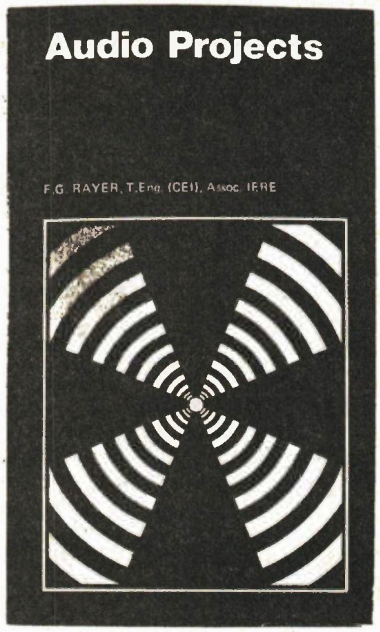
TOWER'S INTERNATIONAL OP-AMP LINEAR IC SELECTOR
TAB No.1216 $13.45
This book contains a wealth of useful data on over 5 000 Op-amps and linear ICs — both pinouts and essential characteristics. A comprehensive series of appendices contain information on specs, manufacturers, case outlines and so on.

CMOS DATABOOK
TAB No.984 $14.45
There are several books around with this title, but most are just collections of manufacturers' data sheets. This one, by Bill Hunter, explains all the intricacies of this useful family of logic devices... the missing link in getting your own designs working properly. Highly recommended to anyone working with digital circuits.

BP68: CHOOSING AND USING YOUR HI-FI $7.25
MAURICE L. JAY
The main aim of this book is to provide the reader with the fundamental information necessary to enable him to make a satisfactory choice from the extensive range of hi-fi equipment now on the market.

Help is given to the reader in understanding the equipment he is interested in buying and the author also gives his own opinion of the minimum standards and specifications one should look for. The book also offers helpful advice on how to use your hi-fi properly so as to realise its potential. A Glossary of terms is also included.

See the order form on page 27



Book of the Month
Audio Projects . . . . . BP90 . . . . . $8.10

You can always tell a guy with a good stereo set. He's the one down near the subway stop with a guitar and a sign that says "Throw money here". Even moderately decent audio is mind wrenchingly expensive; when you go for stuff where the knobs don't fall off it's really time to think about mortgaging the goldfish. Not surprising that sound projects are among the most popular things we run in ETI.

If you want to build your own sound system, or just play with pieces of it, *Audio Projects* is the ideal book. It covers the theory and construction of pre-amps, power amps, tone controls and audio test equipment. There are projects to suit everyone from the beginner to the real dedicated constructor who chants part numbers in his sleep.

Buy this book, truck on down to your favourite audio store and have a good sneer.

COMPUTING TODAY

Edited by Steve Rimmer

Do video-PONG players get testy and smash their rackets? Learn the untold story of this high powered sport.

PROBABLY THE BIGGEST attraction of the latest generation of home computers is that they can play video games, and one need not go down to the local saloon and shovel quarters into the pub attractions. The art of devising these games has risen to an astounding level, and the complexity of some of them boggles the mind. Video PONG seems like something they played back in the stone age.

Unfortunately, games like Asteroids and Allen Attack are almost always wholly written in machine code: this is the only way to get up the speed and complexity required to make the games fast and exciting. In fact, as we saw last month, machine code is not completely unfathomable, but it is a much more cumbersome medium than are the higher level languages like BASIC. One would have to be a bit fanatical or fairly well paid to want to write an Asteroids-class game in ML code.

The fundamentals of video games, however, can be explored in BASIC very easily. It's difficult to do complex real time animation in BASIC because, as one adds more and more operations to a game program, the time delay inherent in each operation begins to catch up with the thing, and the whole works starts to drag. Simple ball movings and missle firings, on the other hand, are well within the scope of even moderately fast BASICs. The techniques, once understood, can later be applied to machine code programs if you really want to get into it.

The video games we're going to have a look at involve the manipulation of projectiles and targets, and are called ballistic games. All the following programs were written on a TRS-80 Model II in Microsoft BASIC, and will run, with a few modifications, on most machines. The only thing that might present a problem is that some BASICs don't have the PRINT@ statement, which allows you to PRINT beginning at any location on the screen specified by the X and Y co-ordinates in the brackets after the PRINT@. PETs, for example, don't have this. However, the PRINT@ can be replaced with a regular PRINT by POKEing the page zero memory locations corresponding to the cursor row and column positions with the X and Y values prior to PRINTing.

PROGRAM 1

```
10 REM Basic Ballistic Ga
mes (Program 1)
20 PRINTCHR$(27):X=10:Y=40:J=1
:K=2:X1=10:Y1=40
30 GOSUB170
40 GOSUB100
50 PRINT@(X1,Y1),CHR$(2)" "
60 PRINT@(X,Y),CHR$(2)CHR$(26)
" "CHR$(25)
70 GOTO40
80 REM Decide Ball Direction a
nd Angles
90 REM J and K are ball direct
ion vectors
100 X1=X:Y1=Y
110 IFX<2THENJ=1
120 IFX>20THENJ=-1
130 IFY<4THENK=2
140 IFY>75THENK=-2
150 X=X+J:Y=Y+K
160 RETURN
170 REM print frame
180 PRINTCHR$(2)CHR$(128);:FOR
T=0TO75:PRINTCHR$(150);:NEXTT:
PRINTCHR$(129)
190 FORT=0TO20:PRINTCHR$(149)T
AB(77)CHR$(149):NEXTT
200 PRINTCHR$(131);:FORT=0TO75
:PRINTCHR$(150);:NEXTT:PRINTCH
R$(130)
210 RETURN
```

Log Table Tennis

Program 1 is the simplest iteration of PONG. It prints a boundary, the frame, and then makes a "ball", a white square, bounce around it. The way the ball works is fundamental to the operation of ballistic games.

First off, the ball is made to move by alternately printing it and erasing it. . . after it's been erased, it can be moved slightly and reprinted, giving the illusion that it's actually traversing the screen. Figuring out where the ball is going to be printed is what takes most of the time, so the idea is to have the ball "on" while this is happening. We want to erase it just before reprinting it to minimize the flicker. Thus, all the calculations for the new ball co-ordinates and old ball erase co-ordinates are done after reprinting the ball. The printing and erasing part of the program is actually just lines 40 to 70. GOSUB100 Is the co-ordinate calculation routine, and heart of the ballistics part of it all.

The ball has two qualities: position and direction. Direction is really just the delta position. The direction is provided by constantly adding to or subtracting from the two position determining variables, X and Y. If the ball starts out in the centre, and we keep incrementing X and Y by one, it will eventually hit one of the boundary walls, for the sake of discussion, let's say the bottom one. We can detect this by observing that the Y co-ordinate has become as large as the line number, or the Y co-ordinate, of the bottom line. At this point, we want to begin decrementing the Y variable, and keep on incrementing the X variable. This will give the appearance of the ball having bounced off the wall.

These increments and decrements are handled by repetitively adding the direction vectors J and K to X and Y. J and K can be either positive or negative, depending upon the last boundary X and Y hit. The values of J and K are determined by lines 100 to 140.

Coincidence

Program 2 adds to program 1 the facility of being able to intercept the ball with a bat and redirect it. The bat is moved up and down the right hand side of the screen by the F1 and F2 keys (you can use any two keys that strike your fancy by changing the CHR$ values in lines 160 and 170). The bat works just like a ball, except that one co-ordinate Is always fixed. Note that this co-ordinate must be an even number, as, since the ball moves horizontally by increments of two, it would never actually hit a bat that moved on an odd numbered column.

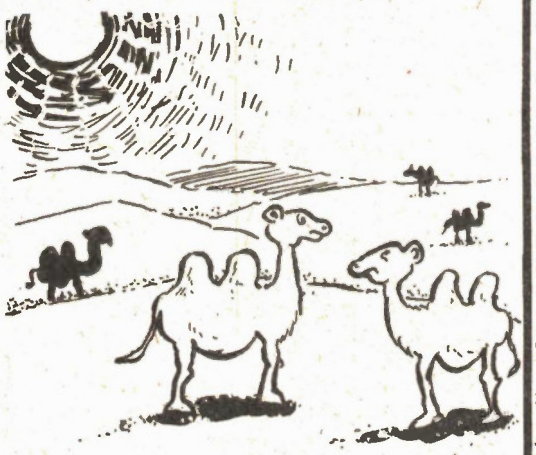
This type of approach eliminates a lot of heavy calculations while the game is actually running, and speeds things up considerably.

The tricky part about getting a ball and bat game to work is to find out when the ball and bat are occupying the same space, i.e., when they are co-incident. Since the TRS-80 Model II doesn't permit screen PEEKing, one must do this wholly within the program. Since the bat is always being erased and reprinted, unlike the frame, which is only done at the onset of the game, it doesn't matter if the ball actually hits the bat. Thus, to detect co-incidence, we have to see if the vertical co-ordinate of the ball is less than 3 greater than the upper limit of the bat, i.e., the co-ordinate where it's actually printed, at any time when the ball's horizontal co-ordinate is the same as that of the bat. Line 220 handles this.

The way the bat is printed is quite important, too. It is three characters stacked one on top of the other. We could just use three PRINT@ statements, but this would be quite slow. Instead, at the onset of the game, the program creates a string, B$,which consists of one bat character, a cursor move down character, a cursor move left character, another bat character, and so on. A similar erase character, E$, is also produced. Thus, anywhere B$ is printed, a bat showes up.

PROGRAM 2

```
R10 REM Basic Ballistic Ga
mes (Program 2)
20 PRINTCHR$(27):X=10:Y=40:J=1
:K=2:X1=10:Y1=40:Q=10:Q1=10
30 GOSUB240
40 GOSUB90
50 PRINT@(X1,Y1),CHR$(2)" ":PR
INT@(X,Y),CHR$(2)CHR$(26)" "CH
R$(25)
60 GOSUB150:GOTO40
70 REM Decide Ball Direction a
nd Angles
80 REM J and K are ball direct
ion vectors
90 X1=X:Y1=Y
100 IFX<2THENJ=1
110 IFX>20THENJ=-1
120 IFY<4THENK=2
130 IFY>75THENK=-2
140 X=X+J:Y=Y+K:RETURN
150 REM bat mover
160 Q$=INKEY$:IFQ$=CHR$(01)THE
NZ=-1
170 IFQ$=CHR$(02)THENZ=1
180 Q1=Q:Q=Q+Z
190 IFQ<3THENQ=3
200 IFQ>18THENQ=18
210 PRINT@(Q1,64),E$:PRINT@(Q,
64),B$
220 IFY=64ANDX-Q>-1ANDX-Q<4THE
NJ=J*-1:K=K*-1
230 RETURN
240 REM print frame
250 PRINTCHR$(2)CHR$(128);:FOR
T=0TO75:PRINTCHR$(150);:NEXTT:
PRINTCHR$(129)
260 FORT=0TO20:PRINTCHR$(149)T
AB(77)CHR$(149):NEXTT
270 PRINTCHR$(131);:FORT=0TO75
:PRINTCHR$(150);:NEXTT:PRINTCH
R$(130)
280 B$=CHR$(148)+CHR$(255)+CHR
$(252)
290 B$=B$+B$
300 E$=" "+CHR$(255)+CHR$(252)
310 E$=E$+E$
320 RETURN
```



TRS-80 to English Dictionary

The following are what the codes peculiar to the TRS-80 Model II do in these programs.

CHR$(1) is the F1 key.
CHR$(2) is the F2 key and turns off the cursor.
CHR$(13) is carriage return.
CHR$(25) turns off the reversed character mode
CHR$(26) turns on the reversed character mode
CHR$(27) is clear screen.
CHR$(32) is a blank space.
CHR$(128) is the upper left frame corner
CHR$(129) is the upper right frame corner.
CHR$(130) is the lower left frame corner
CHR$(131) is the lower right frame corner (and the camel's tail).
CHR$(148) is a vertical post (the camel's legs).
CHR$(149) is a thin vertical line character.
CHR$(150) is a horizontal line character.
CHR$(153) is a box that's about ½ filled in.
CHR$(155) is a box that's about ¾ filled in.
CHR$(158) is a box that's all filled in.
CHR$(159) is an upwards arrow character.
CHR$(252) moves the cursor left.
CHR$(255) moves the cursor down.

SYSTEM"TIME 00.00" sets the computer's internal clock to 0.
TIME$ returns the time from the clock.
RANDOM seeds the random number generator (might as well use it).
SPACE$(X) is a string of spaces X long.

Kill a Camel

Now for the crazy bit.

Video PONG, educational though it may be, is dull, man. Therefore, program 4 contains a *real* game; "Kill a Camel". It was going to be "Kill a Cow", but the tall characters on the TRS-80 made my cow into a dromedary. It might be more suitable as "Atomize a Martian", but I felt like some senseless slaughter when I wrote this.

You are the Galactic Commander Thrak, sent to Earth by a clerical error to kill all the camels you can. You have landed your ship in a gulch in the desert (or whatever), in

PROGRAM 3

```
10 REM Kill the Camel
20 PRINTCHR$(27):Q=40:Q1=40:I=
100:N$="":M$=""
30 GOSUB 270
40 GOSUB80
50 IFF1=0ANDINT(RND(10))=5THEN
GOSUB450:PRINT@(0,10),N" Dead
camels so far.":N=N+1
60 IFI<1THENGOTO540
70 GOTO40
80 REM bat mover
90 Q$=INKEY$:IFQ$=CHR$(01)THEN
Z=-1
100 IFQ$=CHR$(2)THENZ=1
110 IFQ$=CHR$(13)THENY=Q:X=20:
GOSUB170:PRINT@(0,40),I" Photo
n Torpedos left.":I=I-1
120 Q1=Q:Q=Q+Z
130 IFQ<2THENQ=2
140 IFQ>72THENQ=72
150 PRINT@(21,Q1),CHR$(2)"  ":
PRINT@(21,Q),CHR$(2)CHR$(153)C
HR$(153)
160 RETURN
170 REM bomb mover
180 J=ABS((Q-40)/5):IFQ<40THEN
J=J*-1
190 IFY<3ORY>70THENJ=J*-1
200 Y1=Y:Y=Y+J:IFY<1THENY=1
210 X1=X:X=X-2
220 PRINT@(X1,Y1),CHR$(2)" ";:
PRINT@(X,Y),CHR$(2)CHR$(159)
230 XT=ABS(XC-X):YT=ABS(YC-Y):
IFXT<2ANDYT<2THENGOSUB500:PRIN
T@(X,Y)," ":X=0
240 IFX>2THEN190
250 PRINT@(2,Y),CHR$(2)" "
260 RETURN
270 REM print frame
280 PRINTCHR$(2)CHR$(128);:FOR
T=0TO75:PRINTCHR$(150);:NEXTT:
PRINTCHR$(129)
290 FORT=0TO20:PRINTCHR$(149)T
AB(77)CHR$(149):NEXTT
300 PRINTCHR$(131);:FORT=0TO75
:PRINTCHR$(150);:NEXTT:PRINTCH
R$(130)
310 REM Camel
320 DATA 32,32,155,153,131,158
,158,32,32,148,148,32
330 FORR=1TO3
340 FORT=1TO4
350 READH
360 N$=N$+CHR$(H)
370 NEXTT
380 FORT=1TO4:N$=N$+CHR$(252):
NEXTT:N$=N$+CHR$(255)
390 NEXTR
400 FORR=1TO3
410 FORT=1TO4:M$=M$+" ":NEXTT
420 FORT=1TO4:M$=M$+CHR$(252):
NEXTT:M$=M$+CHR$(255)
430 NEXTR
440 RETURN
450 REM Print a camel
460 XC=RND(10)+2:YC=RND(60)+3
470 PRINT@(XC,YC),N$
480 F1=1
490 RETURN
500 REM Evaporate a camel
510 PRINT@(XC,YC),M$
520 F1=0
530 RETURN
540 REM finish game
550 PRINTCHR$(27):PRINT@(10,20
),"The sands are strewn with "
N" dead camels!":PRINT@(11,20)
,"Do you want to "CHR$(26)"R"C
HR$(25)"eturn to the ship"
560 PRINT@(12,20),"or "CHR$(26
)"K"CHR$(25)"ill some more";:I
NPUTW$
570 IFW$<>"R"ANDW$<>"K"THEN550
580 IFW$="R"THENPRINTCHR$(27):
END
590 IFW$="K"THENRESTORE:GOTO10
```

which a whole herd of very stupid camels are sleeping. Every time one wakes up, you have opportunity to atomize it with a photon torpedo. . . overkill to be sure. You have one hundred photon torpedos. For some reason I haven't made up yet, if you are closer to one wall of the gulch than the other, your photon torpedo will be attracted to the wall and, if it hits it, will ricochette off. The camels wake up and appear on the screen at random.

This program is offered as a representative of what you can do with BASIC ballistic games above and beyond PONG. It should be clear, in looking at it, that it uses many of the same elements and works in much the same way. The bat, representing Commander Thrak hiding behind a sand dune, works the same way except that it slides along the bottom. The photon torpedo (an arrow character in this case) is just a ball with a predetermined start and destination, and a more or less fixed direction. It does have a direction vector, though, which is a factor of the horizontal position of Commander Thrak. At 40, the centre of the screen, it has no lateral vector at all. Below 40 it gets increasingly negative and above 40, increasingly positive. At the extreme ends of the bat's travel, the photon torpedo rebounds off the wall immediately upon being discharged, so it actually appears to have the opposite vector.

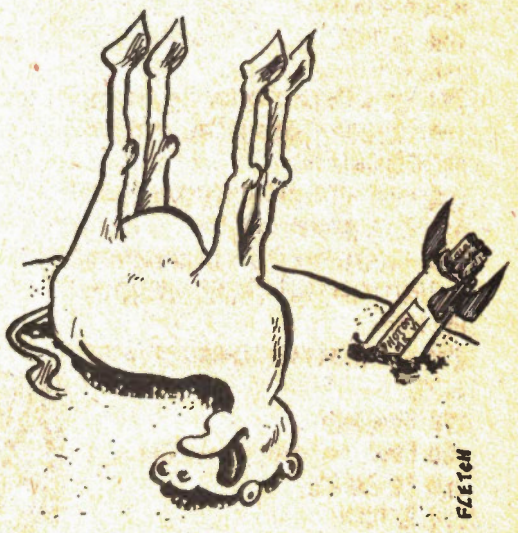
The camel character and its erasure are set up prior to the start of the game, just like the PONG bat. The DATA statement at 320 holds the characters that make up the camel; these will be unique to the Model II, and you'll probably have to devise a camel of your own. Or be daring: kill gnus.

As will be apparent, the location and appearance of the camels are both random, and you must plug one before you get another one. The coincidence window, set in line 230, is fairly small, making it possible to wound a camel, and knock off a few of its parts, without actually causing it to evaporate. You gots ta hit 'em square in da middle fer that.

Send us stuff. . .

If you have a favourite software bit, hardware modification, or a good design for a device to make data processing available to camel killers, send it to *Computing Today* and you could become a millionaire. We pay up to $30.00 for good bits; thirty or fourty thousand submissions and you're on your way. For full details, check out the December issue or PRINT us a letter.

END



Designer Circuits

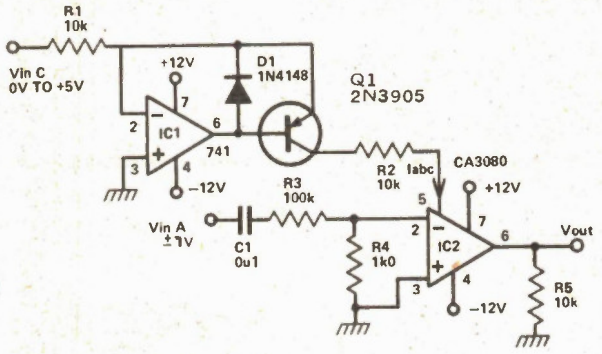
THE CA3080 USED AS A VCA

A simple voltage controlled amplifier (VCA) can be made using a CA3080 which is an Operational Transconductance Amplifier made by RCA. This is basically an op-amp with an extra input at pin 5. A curent I_{ABC} is injected into this input and this controls the gain of the device linearly. Thus by inserting an audio signal (±10 MV) between pin 2 and 3 and by controlling the current on pin 5, the level of the signal output (pin 6) is controlled.

In effect, the audio signal is multiplied by the current I_{ABC}. The output of the CA3080 is a current output and so a resistive load (R5) is needed; R5 in fact becomes the output impedance of the circuit.

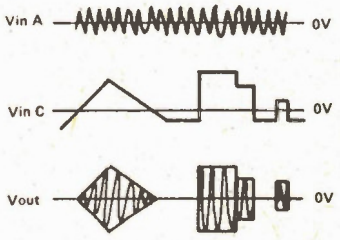
The current controlling the CA3080 is generated with a voltage to current converter IC1, Q1, R1. This circuit linearly converts V_{IN} C into a current (I_{ABC}) where:

$$I_{ABC} = \frac{V_{IN}\,C}{R1}$$



When V_{IN} C = 0V, I_{ABC} is 0 so the CA3080 is turned off. When V_{IN} C is positive, I_{ABC} is generated and so the VCA is turned on. When V_{IN} C goes negative, I_{ABC} is off so no output is produced from the VCA (see diagram).

The VCA finds many uses in the automatic control of signal levels and in generating envelope contours in electronic musical equipment.



NOTE: NO OUTPUT WHEN Vin C IS NEGATIVE

Teaching Electronics & Computing

If you're a teacher or lecturer in electronics or computing (in Canada), you should be receiving a FREE copy of our new publication in the second half of January. TEC will be mailed to all High Schools, Universities and School Boards.

The contents of TEC will be specifically aimed at this market and will include features on teaching techniques and experiences, reviews of equipment and books plus projects and technical notes free of the usual copyright restrictions and in fact designed for photocopying for use in the classroom.

If you feel that you qualify to receive TEC and don't see a copy by mid-February (to allow time for the mails) please write to us giving your position and establishment. If you qualify your name will be considered for inclusion.

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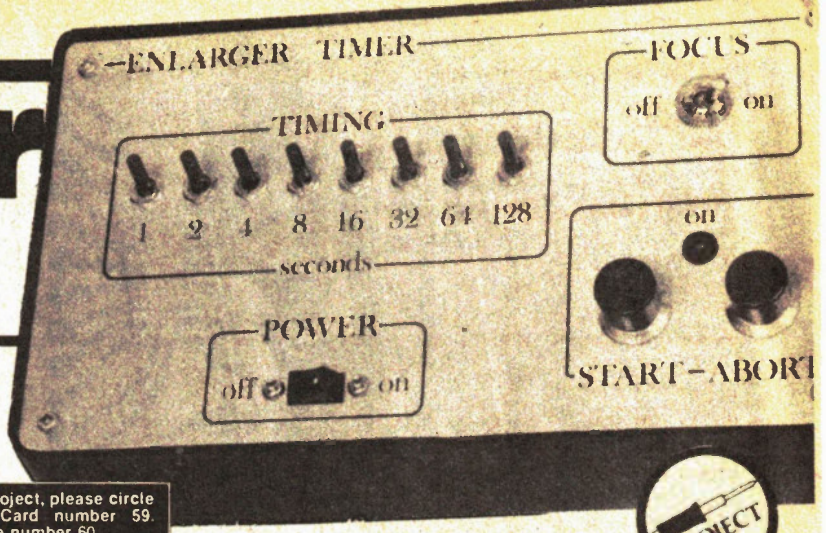
Enlarger Timer



At last — an enlarger timer designed for the photographer by a photographer.

MOST ENLARGER TIMERS use either potentiometers or rotary switches for time period selection; however, both these methods suffer from some drawbacks. First, the potentiometers, although inexpensive, are generally difficult to line up with a timing mark, especially under darkroom conditions, and also tend to wear out after long usage. The rotary switch overcomes the allgnment problem but the timing period range is normally limited to the number of click stop positions — mostly 12 ways, maximum 18 ways. The ETI Enlarger Timer does not suffer from either of these problems; it uses only eight toggle switches in conjunction with the 2240 programmable timer IC to offer a wide range of accurate and easily selected timing periods ranging from one second to 4 minutes 15 seconds in one-second steps.

This flexibility is due to the programmable eight bit counter, oscillator and control flip/flop featured within the timer IC. Having set the time base to 1S using PR1, R4 and C2, each single switch (SW1-8) will give the basic timing periods of 1,2,4,8,16,32,64 and 128 s; by switching in more than one switch, any combination of timing periods can be achieved as previously mentioned.

Construction.

As can be seen from the photographs, all switches and push-buttons are mounted on the front panel together with the LED Indicator. Suitable AC power input and output sockets are mounted on the rear case panel, input nearest the transformer, output (for the enlarger) by the PCB. The PCB design will enable an easier and neater assembly, but make sure to orientate components D1-D5, Q1, IC1, C2, C3 and LED1 as shown In the overlay diagram. Note that C2 must be a tantalum bead type.

Once all the components are mounted on the PCB and the switches, LED1, sockets and transformer are wired to the board, make sure that the panel assembly does not hit the transformer or the relay when fitted into the case.

If you liked this project, please circle Reader Service Card number 59. If you didn't, circle number 60.

PROJECT

Setting Up

This couldn't be easier; having checked all connections, connect the timer to the AC and the enlarger to the unit. First put switches SW1-8 and SW10 In the "off" positions, put SW9 (on/off switch) In the "on" position, operate focus switch SW10 and the enlarger lamp will light. Switch SW10 to the "off" position. Adjustment to the timing range can now be made; switch SW1 only (1 s switch) to "on" and adjust PR1 to give a timing period of 1 s after PB1 (start) is pushed — a stopwatch or digital watch is ideal for this.

Using The Timer

Switch on SW9 (on/off switch) and power will be applied to the circuitry. SW10 can be used for focusing the enlarger; switch off SW10 once this is done. Select the timing period required using a combination of SW1-8, push PB1 and the enlarger lamp timing cycle will commence; after this period the timer will stop/reset. LED1 will be on during timing period as a visual indication. If cancellation of a timing period is needed press PB2, which will abort and reset the timer. If any interference from RLA/2 is experienced, fit a 100n 600V capacitor as marked on the circuit and overlay diagrams (C4).

HOW IT WORKS

The heart of the ETI Enlarger Timer Is the 2240 programmable timer IC which features a time base oscillator, programmable eight bit counter and a control flip-flop that can be used in monostable or astable mode. Here it Is used In the monostable mode.

On application of a positive pulse to pin 11 (trigger) via PB1 and R1, the timing cycle is started. The trigger input activates the time base oscillator, enables the counter section and sets the counter outputs low from their normally high states. This switches on Q1 and activates RLA for the time duration as set by the SW1-8 combination. The timing sequence Is completed when a positive pulse Is applied to pin 10 (reset) via R3 from the output bus, disabling the time base and counter sections and returning the counter outputs to a high state.

The duration of the timing cycle T_0 is given as:

$$T_0 = nT = nRC \text{ seconds}$$

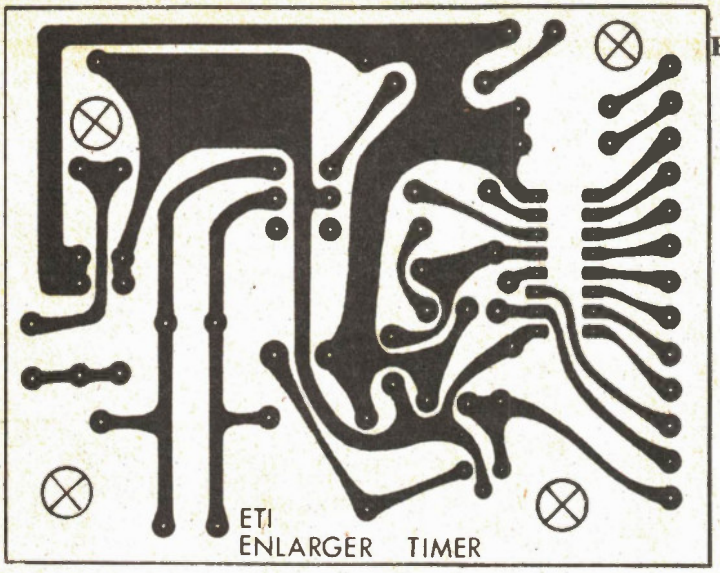
(R in ohms, C in farads)

where T (= RC) Is the time base period as set by the timing components at pin 13 (PR1, R4 and C2) and n Is an Integer in the range of 1 less than or equal to n less than or equal to 255 as determined by the combination of counter outputs (pins 1-8) via SW1-8 to the output bus. The time base as set by PR1, R4 and C2 is 1S.

The binary-counter outputs are the open collector type and can be shorted together to the common pull-up resistor R6. Thus the time delays associated with each counter input can be added together; for example, if pin 6 is connected by SW6 to the output bus the duration of the timing cycle, T_0 is 32 T. (T is 1S as previously stated). Similarly, if pins 1, 5, and 6 are all connected to the output bus via their appropriate switches SW1, SW5 and SW6, the total time delay is 49T (1 + 16 + 32). In this manner the timing cycle can be programmed to be from 1 S to 255 S (four minutes 15 S) in 1 S steps by proper choice of switches SW1-8.

The enlarger lamp Is powered from the AC outlet socket and receives Its current via the RLA/2 contacts for the duration of the selected timing period. An LED Is Incorporated as a visual Indicator; It is switched on by RLA/1 and remains on for the timing period. Manual cancellation Is provided for by PB2 which applies a positive pulse to pin 10; this can be used at any point In the timing period. SW10, the focusing switch, over-rides the RLA/2 contact regardless the output state of IC1 thus enabling the enlarger to be focused.

The power supply consists of T1, D2-D5 and C3 which provides filtering.



PARTS LIST

Resistors (all ¼ W, 5%)

R1,2,6	10k
R3	47k
R4	33k
R5	22k
R7	1k5

Potentiometer

PR1	22k miniature horizontal preset

Capacitors

C1	10n disc ceramic
C2	22u 16V tantalum
C3	1000u 25V axial electrolytic
C4	100n 600V mixed dielectric

Semicondutors

IC1	uA2240CP
Q1	2N3702
D1	1N4148
D2-5	1N4001
LED1	0.2" red LED

Miscellaneous

PB1,2	momentary action push-button
SW1-8	SPST miniature toggle
SW9	SPST 240V 3A miniature rocker
SW10	SPST 240V 3A toggle
RLA	12V DPDT PCB-mounting, 205R coil

Transformer (12V, 250mA or similar); AC outlet socket; PCB ; power cord; case to suit.

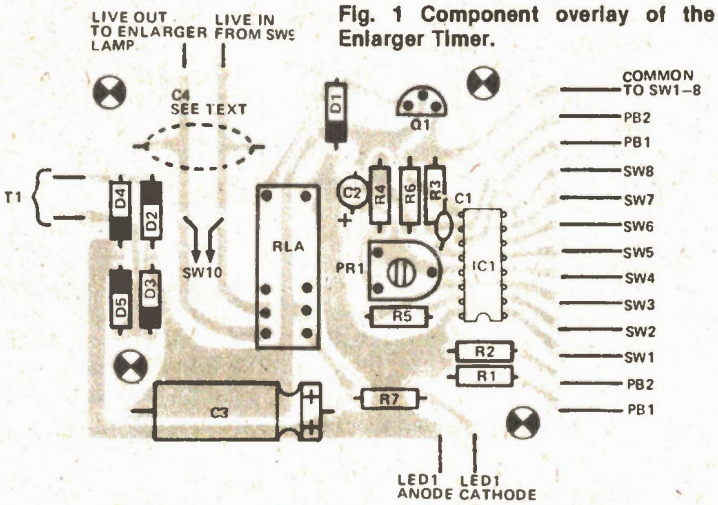


Fig. 1 Component overlay of the Enlarger Timer.

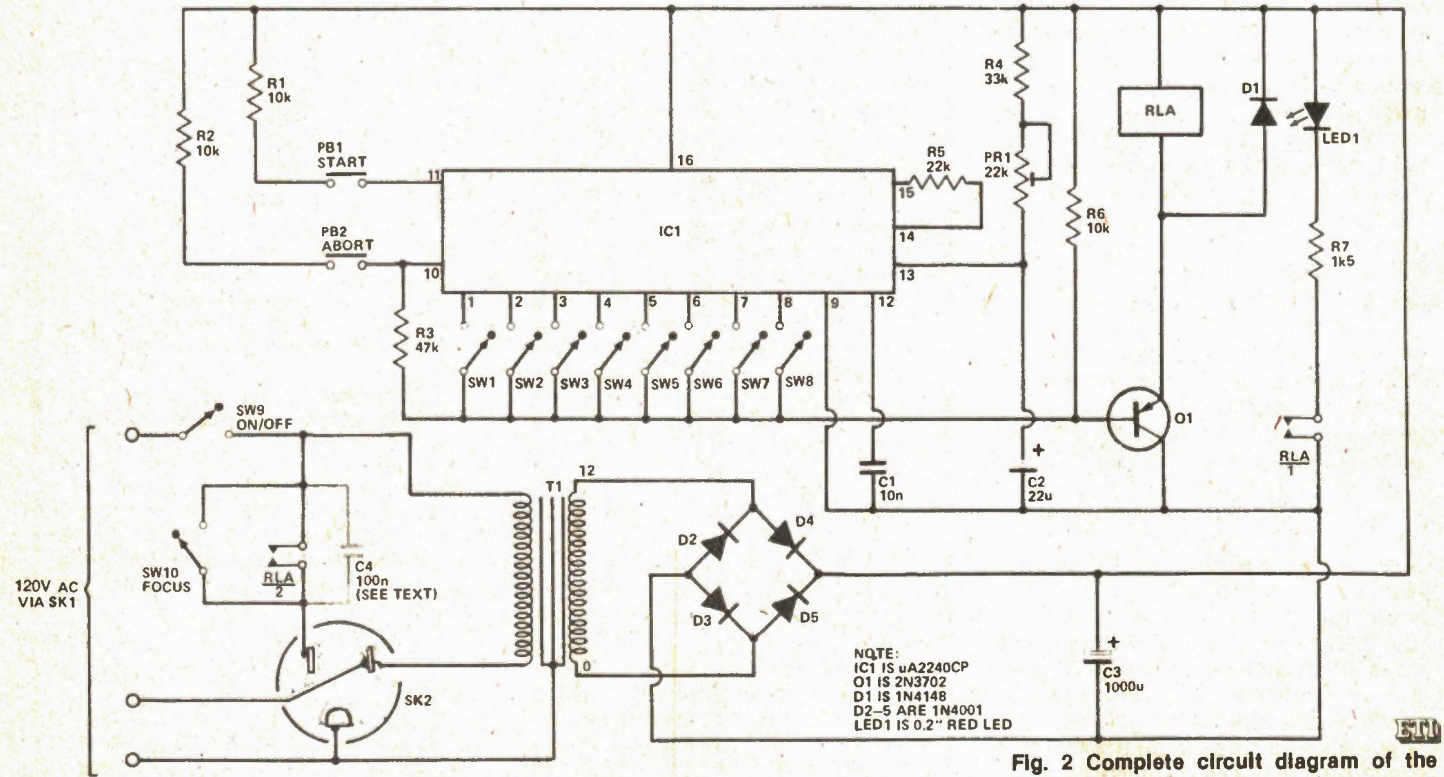
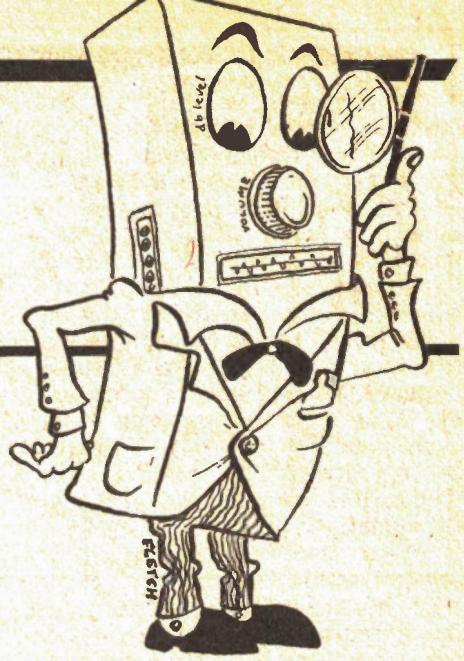


Fig. 2 Complete circuit diagram of the timer. C4 may be necessary to suppress switching noise from the relay contacts.

A Touch of Class



Our society need never be classless so long as we have power amplifiers. Wally Parsons explains.

EVEN SINCE THE EARLY TUBE DAYS, audio enthusiasts have been concerned about the relationship between efficiency, power output, sensitivity, and distortion of audio amplifying devices. Dissatisfied with the limited output capabilities of their simple 2A3 triode tubes, various circuit arrangements and operating conditions were developed to increase output and/or reduce distortion, although it was often felt that the two simply didn't go together.

The availability of better devices, first tubes, and later transistors, made life simpler, but the parallel development of loudspeakers of low efficiency increased the power requirements, thus effectively cancelling any benefits.

Today we have speakers of greater efficiency than was common a decade ago, but now we have programme sources of greater dynamic range, coupled with the desire, especially among rock fans, to play music very loud.

As Demosthenes might have said: "Plus ca change, c'est la meme chose".

One of the most important characteristics of amplifier design is the class of operation of each stage.

Any amplifier stage may be operated as a class A, class B, or class C amplifier. In addition, a tube stage may also operate in class B_1 or class B_2. Operation may even be described as class AB, with tubes offering AB_1 and AB_2 options.

To add to the confusion of all this alphabet soup, manufacturers advertise their products as "class A" or "class AB" amplifiers in a manner such as to imply that "class" was synonymous with "quality". Many have even taken more letters from the alphabet and dragged in OPEC and the anticipated energy crisis to justify a preoccupation with efficiency without the loss of quality alleged to accompany other classes of operation.

In an effort to clear up the confusion we shall examine the three principal classes and their characteristics.

As Simple As ABC

Class of operation is often thought of as a description of bias conditions, but in reality the term describes that fraction of a signal period during which the active device conducts. A period, for a single frequency, is one cycle, and can be divided into 360°, as shown in Fig. 1.

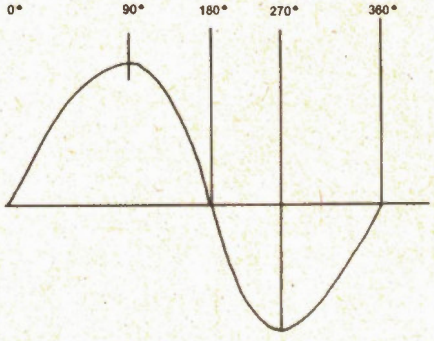


Fig. 1 One period.

Suppose that a tube or transistor is set up with electrode voltages such that with no signal input, a certain amount of current flows through the device. If a signal such as that shown in Fig. 1 is applied to the control electrode, that electrode's voltage or current will rise and fall around the quiescent point, causing the output current to rise and fall in step. Provided that the instantaneous sum of the signal and the quiescent voltage is never such as to cause the device to cut off, current will be passed during all portions of the input signal. The device is said to be operating in class A.

Class A is that condition of operation in which output current flows during 360° of the input signal cycle.

Fig. 2 and Fig. 2a show a family of curves and a transfer characteristic, respectively, for a hypothetical device. They are plotted for various values of grid voltage or base current against plate or collector voltage in the horizontal co-ordinates, and plate or collector current in the vertical co-ordinates. In addition, a load line has been drawn, so that, by following the changes in control electrode voltage or current where they intersect the load line, changes in plate or collector voltage or current can be read. The transfer characteristic redraws this showing control electrode change in the horizontal co-ordinate and output voltage in the vertical.

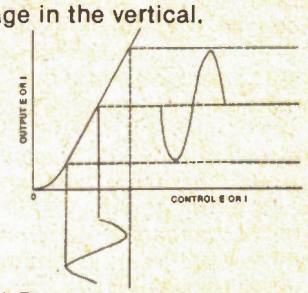


Fig. 2 Family of curves.

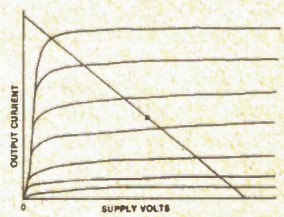


Fig. 2a Transfer curve.

It can be seen from Fig. 2 and 2a that maximum signal handling capacity occurs when bias is set at a point half way between cut-off and maximum current output. This has given rise to the popular concept of operation class which defines it in terms of bias.

What are the advantages of such a simple arrangement? Well, for one thing, it makes possible some pretty simple voltage and power amplifier circuitry. As long as the transfer characteristic is linear low distortion is possible at all levels.

Examination of Fig. 2a will disclose that, for symmetrical signal and a linear transfer characteristic the output current rises and falls by an equal amount above and below the quiescent level. The net result, through a period of one cycle, is that the average current is equal to the quiescent current no matter what the signal level. Consequently, the power supply can be quite simple, as it does not have to accommodate current demand variations greater than a one cycle period of the lowest period to be reproduced. This holds true as long as it is not required to amplify a DC signal.

And the disadvantages? In straight voltage amplifier applications, none. But getting a lot of power into a load can be a bit tricky, whether you use a single ended or a push-pull circuit. It's not just a question of getting current swing, but of internal power dissipation versus power delivered to a load. Consider what happens under zero signal conditions: current is constantly flowing through the device and may or may not be flowing through the load. Most power amplifiers use a push-pull circuit based on the "totem pole" arrangement with the load connected at the mid or zero point. No power is dissipated in the load, yet the transistors or tubes are required to dissipate all the input power. As signal levels increase a greater proportion of the input power is dissipated in the load. This increased efficiency at high levels might seem like an asset except for the fact that the ability to get rid of heat under idle conditions imposes a real limit on how much power we can get out of our device.

In addition, the power supply must be able to deliver full output at all times, imposing severe demands on power transformers and rectifiers, as well as any other series pass devices which may be used in the supply circuit.

A Different Class

The most common method of increasing the power output of a single active device is to use a pair of them in push pull. Because the input and output signals are opposite in phase, it is not necessary for each stage to handle the entire signal.

Referring again to Fig. 2 and Fig. 2a, consider the effect of moving the bias point to the extreme right of the load line. Under these conditions no current will flow in the output circuit. For a bi-polar transistor this occurs when no bias current is caused to flow in the base circuit, while for a vacuum tube it occurs at some value of negative grid bias determined by the design of the tube. If a sine wave is applied to the input, one half of the signal will cause an increase in current flow, while the other half cycle will force the device further into cutoff. Thus, current will flow only during one half cycle.

Class B is that condition of operation in which output current flows only during 180° of the input cycle.

Since only half the signal is passed, the output is obviously quite distorted by any standards. Therefore, for any linear applications such operation is only used in push-pull circuitry.

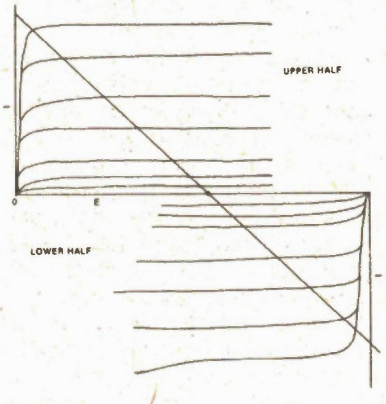


Fig. 3 Push-pull curves.

Figs. 3 and 3a are the same as Figs. 2 and 2a, only redrawn for a pair of devices in push-pull. Notice in the transfer curve how the curvature at the bottom of the curve results in severe waveform distortion at the point of crossover from positive to negative going signal. Because it occurs at the crossover point it is referred to as crossover distortion, and is the basis for the principal objection to this class of operation. To aggravate this condition, a transistor does not go smoothly to cut-off, but has a small voltage, usually about 0.5V, required just to turn on the device. Consequently, there is a region of about 0.5V on either side of the zero axis of the signal in which no conduction occurs at all. Because this is a non-linear condition, harmonic distortion is generated, and because it is constant level for all values of signal level, the distortion components are of constant value, resulting in a distortion figure due to this mechanism which *increases* at low levels.

Much has been made of this distortion mechanism and its contribution to amplifier quality, or lack of quality, but examination of Figs. 3 and 3a will indicate, and inspection of a real circuit on an oscilloscope will prove, that this is easily eliminated by shifting the bias point in such a way that, instead of cutting the device off completely at zero signal condition, it rests just on the junction point of the toe of the transfer curve (the curvature to the extreme left) and the linear portion.

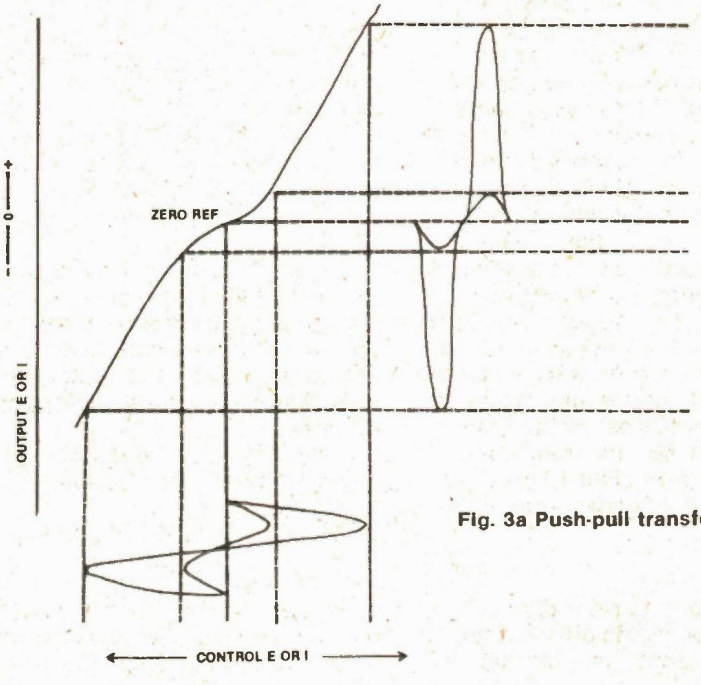


Fig. 3a Push-pull transfer curves.

Much of this is also prejudice carried over from tube days, when poor coupling between halves of the output transformer winding would cause ringing at the cross-over, and early transistor devices whose high base-emitter capacitance would discharge through the load at each crossover.

Most problems with Class B operation involve the power supply. Because output current does not swing symmetrically around a reference point, the load current *increases* with signal level. Consequently, the power supply must maintain good regulation over a wide range of load conditions, and be capable of delivering large amounts of current quickly when transients demand.

Advantages

All of the above problems can readily be dealt with by good design, and refraining from giving in to the temptation to do things on the cheap.

In return for all this trouble there are real benefits. The first of these is greater power.

In a push-pull circuit the instantaneous output voltage is taken between the two devices. Class B operation allows twice as much voltage swing on one device, but provides for zero swing on the opposite side of the circuit since they are out of phase. Consequently there is no voltage, and hence no power increase. However, the optimum load under class B conditions is different from class A and can be arranged to allow greater output swing without running into an area of excessive dissipation. Moreover, since at low signal levels little current is drawn, the device generates less heat. Since amplifiers spend most of their lives running at low levels, it's comparatively easy to get rid of the heat generated at higher levels. As a matter of fact, for reasons beyond the scope of this article, it is possible to show that maximum dissipation occurs at about 30% of maximum output. Therefore, an amplifier oeprated in such a way as to provide at least 10 dB of headroom most of the time will also be operating well below the maximum dissipation level most of the time.

This is a far cry from class A which is operating close to maximum dissipation even under zero signal conditions.

Class AB

The variations in current drawn from the power supply with different levels implies variations in internal impedance. It follows, then, that a class B stage is likely to be sensitive to variations in output load resistance. In addition, biasing a device at or close to cutoff results in high sensitivity to small changes in supply voltages such as may be caused by line fluctuations. A small change in bias current or voltage can make the difference between a device being just turned on and being off.

To overcome this, a stage may be operated at a point between class A and class B, or class AB. Usually the bias point and load are selected such that, at low levels, the stage operates a little above the toe of the transfer curve, so that for small signals it operates as a class A stage, since output current flows during the entire cycle. As signal level increases the stage is cut off during part of the cycle.

Class AB is that condition of operation in which output current flows for less than 360° but more than 180° of the input cycle. In fact, the most common practice allows current flow during about 235°.

Under small signal conditions the stage offers all the advantages of class A operation, with the added advantage of reduced dissipation, while at high levels it allows high power outputs without excessive dissipation problems, although it is not as good in this respect as true class A.

This means that since the amplifier operates at low levels most of the time, it also opeates in class A most of the time, with few of the disadvantages.

The power supply must still be capable of delivering varying currents without changing output voltage, but the variations are less severe than with class B.

And although somewhat sensitive to load variations, it is less severe than class B. Unfortuanately, it is at its worse under high signal levels.

With transistor circuits there is the possibility of some switching distortion when devices turn off and on, but with modern devices and appropriate circuitry this is not only inaudible but won't even show up on instruments.

All in all, an excellent way of getting the best of both worlds.

In The Interests Of Completeness

Reference was made earlier to class B_1, B_2, AB_1, and AB_2. Strictly speaking, the number suffixes refer to conditions which only apply to tube circuits. Ordinarily, a tube's grid is only driven in the positive direction to the point of zero volts. A positive voltage on the grid would result in grid current, with grid overheating and distortion. However, when driven from a low impedance source capable of some power output, it is possible to drive the grid into the positive region, with a resulting increase in power output. The suffix "2" is used to indicate this condition while "1" indicates that no grid current flows.

There is no counterpart to this operating condition with bi-polar transistors, but the possibility exists for operating junction FETs and MOSFETs of the depletion type in such a way that input voltage swings past the zero point. I haven't seen any audio power circuits in which this is done, but there seems no reason why it could not, with suitable devices.

It is normal for grid current to be drawn in class C tube circuits.

Class C is that condition in which output current is drawn during considerably less than 180° of the cycle.

Obviously, considerable distortion is generated, and this mode of operation is limited to RF and other fixed frequency circuits which can be tuned to the fundamental, thus removing the distortion components. Its main advantage is the extremely high efficiency possible. While it has no real use in audio work, I've included the reference for the sake of completeness.

Class D is another mode of operation, which does not really refer to operating points, but has a long audio history. In class D operation the device is operated in such a way as to be completely on or off. In other words, it is a switching mode. Although it applies to linear application, it also, in a sense, forms a bridge between analog and digital operation, and requires separate treatment.

But don't let anyone tell you that some particular class of operation is first class and all others second.

Just t'aint so!

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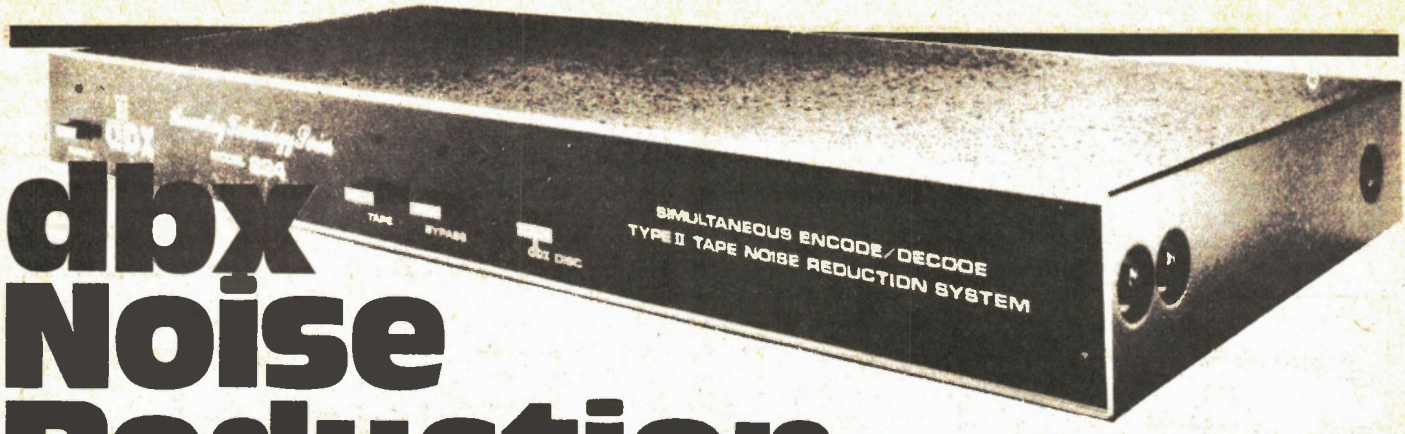

dbx Noise Reduction

If you liked this article, please circle Reader Service Card number 47.
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Overshadowed by Dolby despite its theoretical superiority, the dbx noise reduction system now seems poised to take the hi-fi market by storm. Peter Green expands our headroom.

UNTIL NOW it has been impossible to listen to music at home with anything like the quality of the original. However much you spend on your hi-fi, however low the distortion figures, however carefully you care for your records and however diligently you clean your tape heads, you cannot get away from the twin evils of surface noise and restricted dynamic range.

Surface noise is caused by the limited quality of the recording medium itself. Imperfections and inhomogeneity in the particles that make up the tape coating generate the familiar hissing we know and hate; the roughness of the vinyl surfaces of record grooves produces its share of hissing and pops. Surface noise also affects dynamic range. During a live performance it is possible for sound pressure levels to momentarily hit 120 dB during music transients; however, background noise levels in the audience can easily range from 30 to 50 dB and so this simplistic treatment indicates that live music has a perceived dynamic range of about 70 to 90 dB. Unfortunately a good cassette recorder has a dynamic range of only about 45 dB, while a conventional vinyl record is not much better at 55 dB. Recording engineers have to compress the signal by a factor of 2:1 so that the loudest passages are below the level that causes tape saturation or distortion, and the quietest passages are above the level of tape hiss or record surface noise (see Fig. 1). This squeezing of the signal into a restricted dynamic range makes the music sound flat, unexciting and unrealistic. You know it's a recording.

D Versus d

The noise reduction system that established a virtual monopoly in the world hi-fi market of the seventies was Dolby B, a system that reduced high frequency noise (the most objectionable kind) by boosting high frequencies on recording and attenuating them on playback, thus also reducing the noise added in the recording process.

dbx decided to tackle the other problem — restricted dynamic range. Since sounds have to be compressed to be recorded on tape or disc, a system that allowed 1:2 expansion on playback would recreate the range of the original performance (Fig. 2). This idea is quite old but difficult to apply, because the expander and compressor must track each other (be exactly complementary), especially on transients — this in turn requires accurate detection of the signal. The difficulties in this and the way the dbx overcame them are described later, but the important point is that when the recorded signal is expanded the tape noise drops below the level of audibility. dbx have killed two birds with one stone, together with an assortment of sacred cows; for example, they recommend that you use chromium dioxide rather than metal tapes, because it's pointless to pay extra money for an improvement of 2 to 3 dB when the system itself is giving you an extra 30 dB across the whole frequency range.

Paths Of Glory

Fig. 3 shows the block diagram of a Type II dbx noise reduction system for domestic use (the Type I system has certain differences in the turnover frequencies of the filters to suit professional situations). The encoder and decoder each have two paths — the signal and detection paths.

The music signal to be recorded first goes through a band pass filter to remove unwanted out-of-band components. Type II values are 30 Hz to 100 kHz, Type I are 22 Hz to 27 kHz. The lower limit is there to prevent subsonic noise from underground trains, traffic vibrations and the like from being recorded; the upper limit prevents pick-up of CB and other interference. The Type I value is much lower because studios often have very long leads which are more susceptible to pick-up. The signal passes through a pre-emphasis network that boosts high frequencies and helps to overcome tape modulation noise (which is caused by uneven magnetisation due to tape inconsistency), and into the voltage-controlled amplifier. The VCA is linear in dB with control voltage to make things simpler later on; it compresses the signal by a 2:1 ratio.

The output of the VCA is passed to the tape recorder, and also into the detector section. The first stage is a band pass filter which has a slope of 18 dB/octave above 10 kHz, so that the detector 'takes

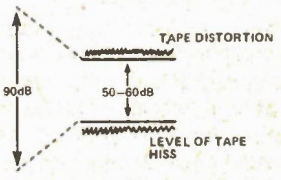


Fig. 1 When recording tapes or discs, engineers monitor the signal and turn the level up or down ('gain riding') to avoid distortion or hiss. This compression greatly reduces the dynamic range to an absolute maximum of about 60 dB.

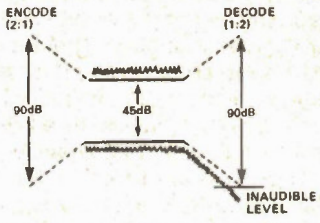


Fig. 2 By introducing 2:1 compression on recording, then accurately and automatically reversing the process on playback, the dbx noise reducton system reclaims the original dynamic range. As a bonus, tape hiss becomes inaudible.

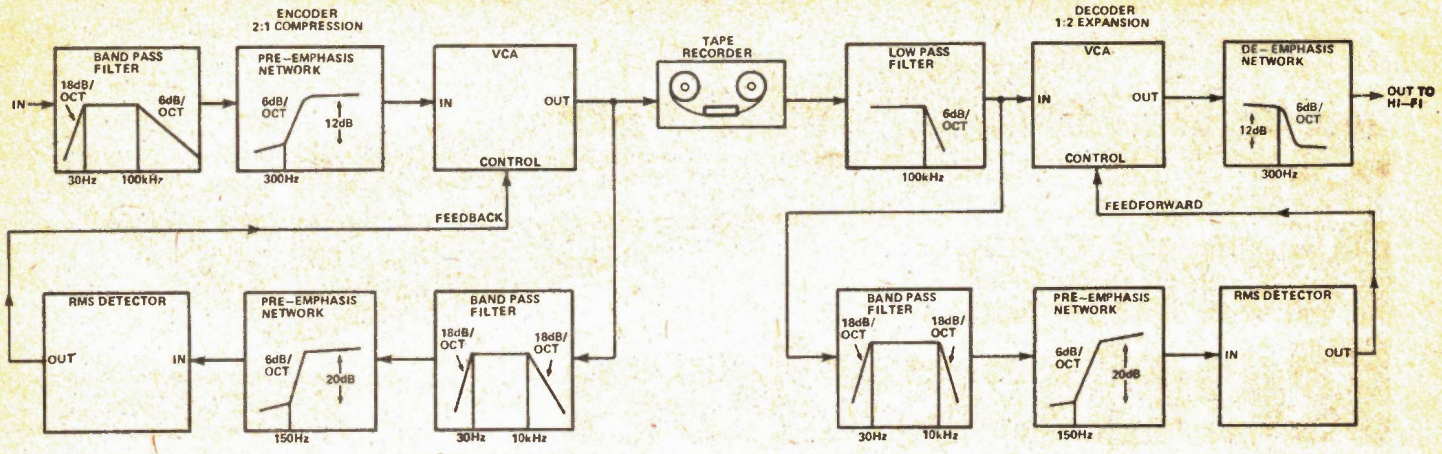


Fig. 3 Block diagram of the Type II dbx noise reduction system.

less notice' of high frequencies. Next comes another pre-emphasis network, this time to increase the compression of the signal at high frequencies and avoid the possibility that the pre-emphasis in the signal path will cause high frequency tape saturation. The RMS detector converts the AC signal into a DC voltage proportional to the level in dB; since the VCA also follows this law the whole system is linear in dB.

Mirror, Mirror

The encoder is a compressor with negative feedback; the higher the signal level the greater the gain reduction. The decoder must be a mirror image to give the correct tracking and recovery of the original performance, so it is configured as a feedforward system acting as a 1:2 expander. The importance of this is that if the tape recorder is considered to be 'transparent' the VCA control voltage in the decoder is being derived from exactly the same signal as that for the encoder VCA. The detector path in the decoder is identical to the one already described — band pass filter, pre-emphasis network, RMS detector — and so the control signals will also be identical (to within component tolerances). The decoder VCA has its control polarity reversed and gives a complementary gain change to that of the encoder; the de-emphasis network reverses the effect of the encoder pre-emphasis to restore a flat overall frequency response. It's interesting to note that this flat system response is due solely to the mirror-image nature of the signal processing — the frequency responses of encoder and decoder are complementary, but not flat.

Because a high value of loop gain (40 dB) is employed in the decoder, a low pass filter is needed at the input to prevent high-frequency oscillation caused by capacitive coupling. This keeps the system stable.

RMS detectors have been used because tape recorders aren't perfect, or 'transparent' — they introduce huge amounts of phase shift. This is not noticeable to the ear, but the effect of passing a 1V peak-to-peak square wave through a 90° phase shift filter is shown in Fig. 4; cheaper and simpler detectors such as peak or averaging types would not give identical outputs for the two waveforms and the mirror-imaging would be lost. An RMS detector is the only one that will give the same output level for both.

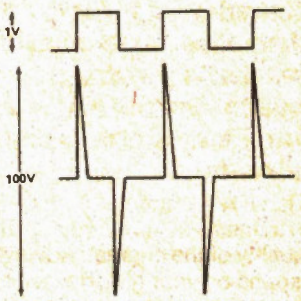


Fig. 4 Phase shift can have dramatic effects on the shape of waveforms!

Silence Is Golden

If anyone feels that the working of the system is hard to understand, rest assured that a practical demonstration isn't. A recent dbx press showing started with a hiss comparison using blank unencoded tape, first with no noise reduction, then Dolby B, Dolby C and finally dbx. Hiss was still significant with the two Dolby systems, although the improvement was noticeable — but when the dbx cut in, nothing could be heard except the gasps of amazement from hardened journalists. No hiss whatsoever! Listening to extracts from discs and tapes was a revelation; for the first time in my life I could shut my eyes and believe the orchestra was really there. I heard musicians fingering their instruments, I heard someone on the record sniff, and the music appeared out of a silent background — it was real!

Naturally the impact dbx has on the market will depend on how many encoded discs and tapes they can release, and how quickly. But several major cassette deck manufacturers (eg Technics, Teac, Yamaha, Marantz) are fitting dbx along side Dolby in some of their models, and Dolby must be thinking hard about their next move.

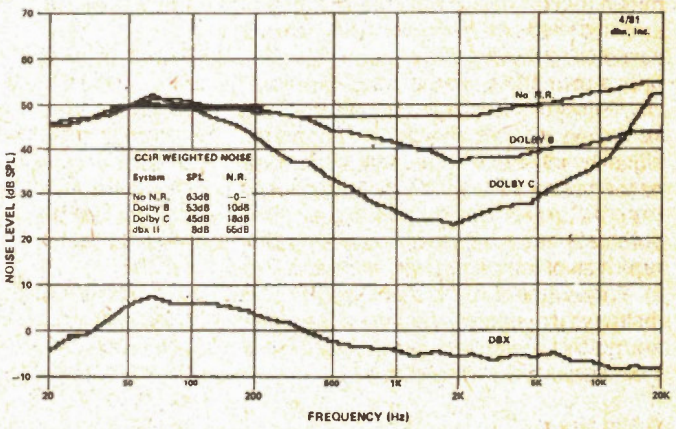


Fig. 5 A comparison graph of noise reduction systems, issued by dbx.

SW Aerials

The traditional long wire receiving aerial for short wave enthusiasts is cheap and easy to set up. These are alternatives, though . . . .

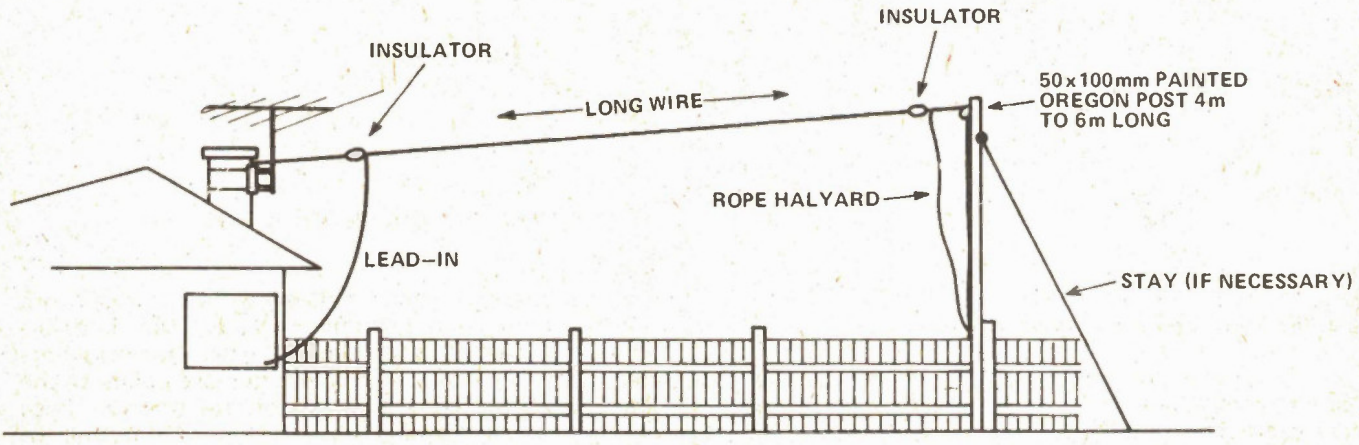


Fig. 1. Cheap and relatively simple – the long wire aerial.

SALES OF GOOD QUALITY 'general coverage' receivers with tuning ranges that cover the HF spectrum from 3 MHz to 30 MHz have boomed in recent years, bringing about an upsurge of interest in shortwave listening.

The price of receivers with good 'slow' tuning rates, dial readout to 5 kHz or better, excellent sensitivity and selectivity as well as good stability has decreased to the point where many enthusiasts can afford a 'communications quality' receiver.

However there remains a problem with aerials to suit such wide frequency coverage.

When Does Long Mean Long?

No discussion or description of wide coverage receiving aerials is complete without mention of the ubiquitous 'long wire'. The time-honoured long wire is simply what it says — any 'random' length of wire that it is possible to erect in a given space. Theoretically it is 'long' when its length is one wavelength or more at the lowest frequency of interest.

No matter, modern receivers are sufficiently sensitive that they only need a whisker of an aerial to pull in plenty of stations at good strength. It's for the weak ones that you need the big aerial.

A typical long wire installation is illustrated in Fig. 1. The actual height and length depend entirely on your circumstances. A piece of 50mm by 100 mm post is painted and bolted to a fence post or other support, as far from your receiver installation as you can reasonably manage. A pulley, obtainable at almost any hardware store, is fixed to the top and a loop of good quality hemp rope threaded through it, before erection.

An egg or strain insulator is attached to one end of the aerial which is also tied. The other end of the aerial is erected near the receiver installion. An insulator is also attached at this end and the lead-in taken down from it to the receiver installation. The aerial is then supported from this end by tying it off to a chimney, as illustrated

Having one end of the aerial higher than the other is of little consequence. It'll still work!

The lead-in should be taken in such that it clears the house guttering and may be fed through a ventilator opening or over a window sill — whatever is convenient. Avoid running it for any distance clamped to a wall or parallel to metal guttering, pipes, or wiring. The more direct the better.

Once your long wire is up, you're ready to go! The end of the lead-in can simply be attached directly to the aerial terminal of your receiver.

'Vee Have Ways of Tuning In'

A wideband ''inverted-vee'' style of aerial is illustrated in Fig. 2. This works extremely well across the range from about 5 MHz up to 30 MHz and uses ordinary TV ribbon for a feedline. However, a balun or an aerial tuner is necessary. A balun is simple but an aerial tuner will give better results.

Good signals will be picked up by this aerial right down to 2 MHz but at these low frequencies there's no substitute for size and different aerials, designed to operate in these regions, usually provide better performance.

Beggers can't be choosers though, in many circumstances!

Construction is quite simple. Again, a 4m or 6m length of 50 × 100 mm post, painted, is erected against a suitable support — shown here as the side of a house. A fence or garage is just as good.

If you can attach a length of aluminum pipe to a chimney mount or to your house gable — well and good. Just get the centre up as high as you reasonably can.

Each leg of the inverted-vee should be six metres long. However, they can be shorter — whatever you can fit, but the performance at low frequencies suffers.

Say It With Ribbon

The TV ribbon is connected where the opposite legs of the aerial join at the apex. Support the ribbon with standard screw-in TV ribbon insulator standoffs.

Each leg should be individually tensioned with the

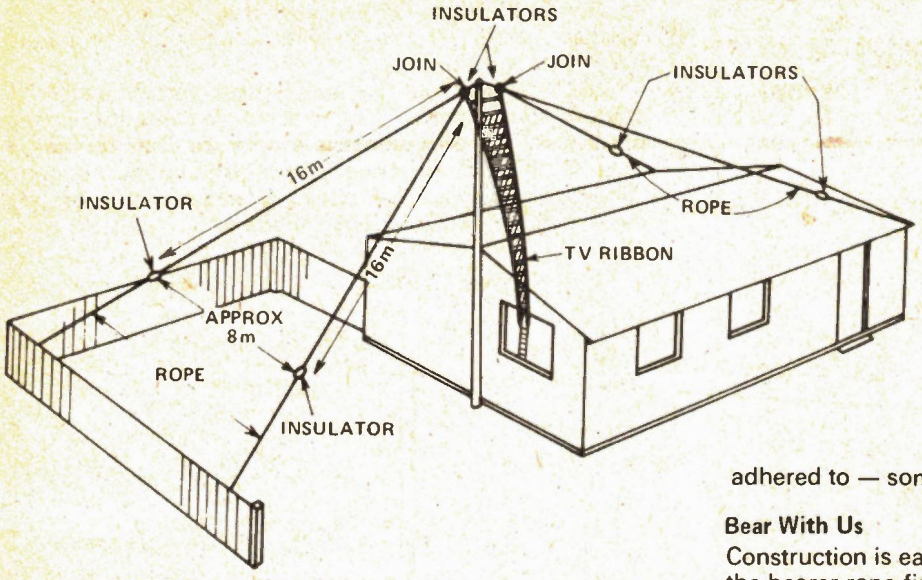


Fig. 2. The 'inverted-vee' aerial (wideband version)

rope strainers indicated in Fig. 2. Large screw-eyes, obtainable from most hardware stores, screwed into the supports, as illustrated, serve as excellent anchor points and allow the rope to be tightened using an appropriate slip knot (a round turn and two half half-hitches is excellent).

Balun and aerial tuner construction, whichever you choose to suit the inverted-vee aerial, will be described in a future article.

Straight Up

The familiar groundplane aerial, much used in commercial VHF two-way communications systems as base-station aerials becomes somewhat cumbersome at the frequencies that interest hams and shortwave listeners, although they are manageable above 14 MHz.

Loaded verticals, short verticals and other forms of the vertical aerial are popular for a variety of reasons, one good one being they have a low impedance, unbalanced feedpoint which suits most receivers on the market today.

If the *actual* ground is utilised as the ground plane for a HF groundplane aerial, a series of vertical elements can be connected in parallel at the feedpoint to provide a wideband vertical aerial system — which can give an excellent account of itself.

Such an aerial is illustrated in Fig. 3

Five elements, of different lengths, are arranged in a fan supported from a rope bearer. They are all brought down to a termination which is supported on the top of a piece of pipe which has been driven into the ground.

The joining of the bottom of all the elements at the terminal provides the feedpoint connection. The centre conductor of the 50 ohm coaxial feedline connects to this point and the outer conductor, or braid, of the coax connects to the earth via the pipe supporting the termination.

Details of the termination are shown in Fig. 4. The use of a coax socket is recommended as it is a simple matter to waterproof a coax connector; however, an alternative method is indicated. Waterproofing of the coax plug and cable will ensure that it has a long useful life. The aerial dimensions indicated in Fig.3 need not be strictly adhered to — some latitude is possible.

Bear With Us

Construction is easy if you follow this procedure: lay out the bearer rope first. Insert the insulator ties at intervals of two or three metres as indicated. Attach the insulators that go at the top of each element to these points on the bearer ropes using short lengths of rope or wire. These will have to be subsequently adjusted, so don't tie the insulators on permanently yet.

Next, lay out all the elements, using the lengths as a guide and allow at least one metre at the termination end of each wire so that they can be individually tightened from the termination and when the aerial is erected.

Hoist the bearer rope into position and adjust the termination ends of the elements so that they come together with the termination insulator about 300 mm above the ground.

Drive the pipe into the ground below this point. Finish everything off as illustrated in Fig. 4. If using a coax socket for the coax connection, mount it on a small aluminum or galvanised steel plate which is mounted to the pipe via a long bolt passed through the pipe, as illustrated.

If you wish, the coax may be buried. However it is advisable to pass it through some flexible plastic conduit and bury the whole assembly. This will prevent damage to the cable (from enthusiastic or ignorant gardeners, dogs, small brothers etc) as well as reducing moisture seepage.

If you want the ultimate in performance, a series of ground wires can be buried about 200-300 mm below the soil surface radiating out from the pipe for a distance of six to ten metres. They should all be connected together at the centre and bonded to the pipe.

However, keeping the area surrounding the pipe well-watered should satisfy most requirements.

Biconical Monopole

Yes I know it sounds funny — looks funny too (except to the dyed-in-the-wool enthusiast!) but this aerial really performs as is attested by the fact that many professional and military receiving installations throughout the world use them.

The biconical aerial is mentioned in all the classic textbooks — so I won't go into it here. Suffice to say that it will readily cover a 4:1 bandwidth and has a low impedance, unbalanced feed. Low frequency performance is reduced of course but it still works sufficiently well to provide reasonable signals well below the low frequency design limit.

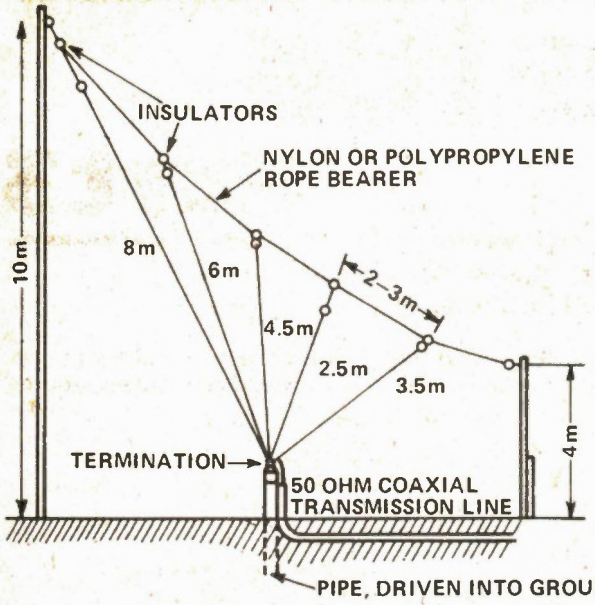


Fig. 3. A broadband version of the HF groundplane aerial.

Four Guys And A Pole

A biconical monopole suitable for home-construction (for the enthusiastic!) is illustrated in Fig. 5. A central pole has two cross-arms located low down around which is passed a length of rope. Twelve wires run from the top termination to the bottom termination. All wires being connected together at the termination points. The four wires which pass over the ends of the cross-arms are arranged to act as guys so that the whole assembly is self-supporting.

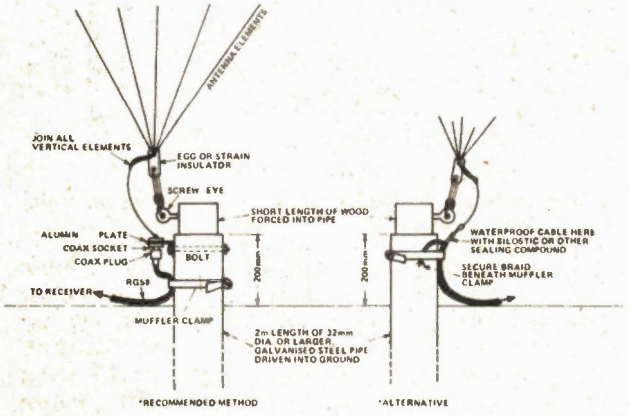


Fig. 4. Two methods of terminating the broadband ground-plane.

The most practical height for the central pole is about six metres, although if you can manage something higher, so much the better. The cross-arms are located about 40% of the pole height above the ground. Each cross-arm is about 40% of the pole height long.

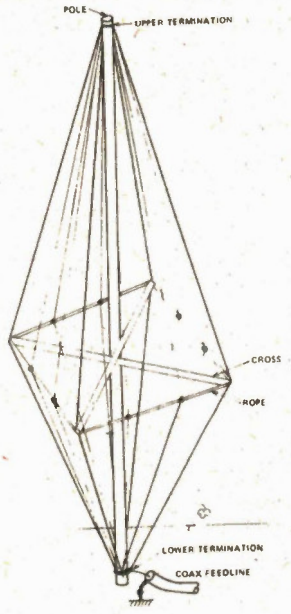
Dimensions are given in Fig. 6 for a biconical monopole that will cover the 7 to 30 MHz range.

Specific construction details are left up to the individual constructor. However, the following points should be noted.

Tying And Tensioning

All the wires should be insulated from the pole and cross-arms. wooden cross-arms are recommended (paint them though). Nylon or polypropylene rope is recommended to go around between the ends of the cross-arms to support the eight wires not used as the guys. Simply tie them with short lengths of wire to the rope to secure them, after tensioning.

All the wires should be joined together at the top and bottom terminations. The bottom termination is the feedpoint. An arrangement similar to that in Fig. 4 should be used to conect the coax feedline. A good ground stake should be used, or better still a ground radial system, as previously described.



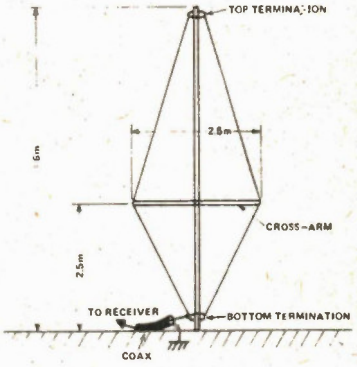


Fig. 6. Dimensions for the biconical monopole.

Fig. 5. A biconical monopole aerial.

Insulator Hints

The aerials described call for the use of insulators at various critical points to insulate the aerial elements from any support or tension rope.

There are two types generally available, the 'egg insulator and the 'strain' insulator — both illustrated in Fig. 7. Using them is very simple. However, the rope, or aerial wire must be firmly secured where it ties on to the insulator.

Get Knotted

Where heavy, standard wire is used, simply wrapping the wire around itself a number of times is usually sufficient. If flexible hookup wire, is used then it will have to be knotted to be properly secured. Usually a number of half-hitches following several turns through the insulator eye are sufficient.

Nylon and propylene rope, while cheap and water repellent, deteriorate under the ultra-violet light from the sun and weaken considerably with time. Frequent inspection will indicate when replacement is necessary. Both types creep considerably under strain and the tension will have to be adjusted periodically, but this is only a small chore.

Continued on page 74

Into Linear ICs

Part 3

This month, Ian Sinclair looks at the most popular of the linear IC's, the 741 op amp.

THE 741 IS GOING TO BE our introduction to linear ICs. It would be difficult to choose any other chip, because the 741 is probably the most frequently used of all linear ICs. It can come with a variety of letter codings (LM, MC, CA, NE and others), but as long as these letters are followed by the number 741, it's the same chip. It's also found in a variety of packages, but the one we shall use is the DIL 8-pin one, which is the most convenient one for our purposes.

The 741 is classed as an operational amplifier, meaning that it's a direct-coupled amplifier with a very large voltage gain — 100 000 times or more — and the usual two inputs to which signals or feedback can be connected.

The pinout for the 8-pin package is shown in Fig. 3.1. Note that not all of the pins are connected internally, and two of the pins that are connected are seldom used — we'll show later how and when they are used. Like most operational amplifiers, the 741 is intended for dual +ve and —ve power supplies, but the circuit designs can nearly always be adapted for a normal +ve and 0V type of supply as we shall see.

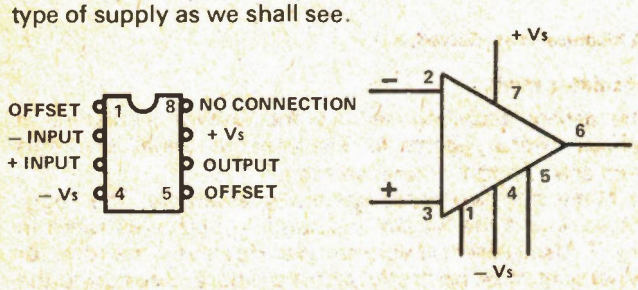


Fig. 3.1 The pin-out diagram of the 741 showing the chip appearance and the circuit symbol.

CIRCUITS AND MORE CIRCUITS

Now for some circuits. Fig. 3.2 shows what is called a voltage follower. The — (minus) input of the 741 is connected directly to the output through a resistor R1, with no other components in the way, so that there is 100% feedback of bias and signal voltages. The + (plus) input is grounded through another resistor R2, and is used as the signal input.

What does this do? There's no voltage gain, to start with. The signal voltage out is exactly equal, as far as we can measure, to the signal voltage in, which at first sight doesn't seem too encouraging. There is, however, a huge difference between the input and the output resistances. Remember what that's about? Any electronic device behaves as if it had a resistance at its input and another resistance at its output. When we connect these devices (transistors, ICs or whatever) together, these resistances form potential dividers, reducing the amount of signal which can be passed from one device to the next, as illustrated in Fig. 3.3. An ideal amplifier would have a very high input resistance and a very low output resistance. This way we could connect any source

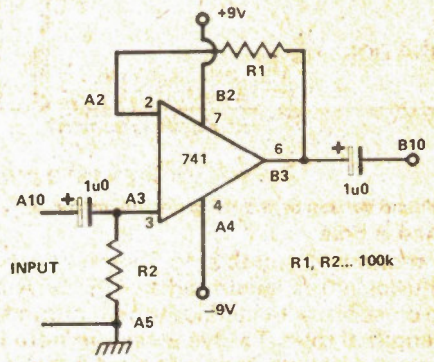


Fig. 3.2 The voltage follower circuit using dual power supplies.

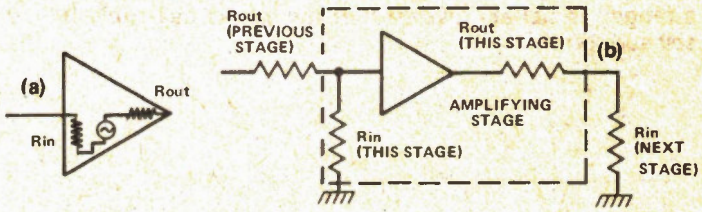


Fig. 3.3 Internal resistances (a) and how they act as potential dividers (b) for the signal.

of signal (tape, disc, microphone, radio . . .) to the input with no loss of signal, and in the same way have no loss of signal at the output even if we connected a very low resistance (such as a loudspeaker) to the output. Sometimes we prefer a lower input resistance for other reasons, but these are the rules for ensuring the greatest possible transfer of signal from one stage to the next.

The circuit of Fig. 3.2 certainly has the correct resistance values, very high at the input and very low at the output, so that the lack of gain isn't always a disadvantage. We can, for example, connect a very high resistance crystal pickup to the input and a low-resistance magnetic earpiece to the output and get a detectable signal at the output. If we connected the pickup directly to the earpiece, we don't hear a thing. This isn't because of a low signal from the pickup — crystal pickups can produce a volt or more of signal — but because of mis-match. The very high resistance of the crystal pickup is connected to the very low resistance of the magnetic earpiece, and the signal is simply divided out of existence! The 741 circuit of Fig. 3.2 is called a voltage follower, and it's a useful headphone amplifier. You can connect its input almost anywhere in an amplifier circuit without affecting the signal voltage

(why? Because of the high resistance) and that's not something you can risk with headphones. If you're going to use the voltage follower in this way, though, it's advisable to use a 0μ1 coupling capacitor at the input so that the 741 is not affected by any bias voltage at the place where it's connected. In addition, stick to battery-operated equipment until you have a lot of experience in servicing — you don't get a second chance where there are line voltages around.

BIASED TOWARDS COMPONENTS

Fig. 3.4 shows another version of this circuit, re-drawn this time so that a single supply of 18 V can be used. You can see that this needs more components because the bias on the + input has to be set at a voltage midway between the positive and the zero supply lines. In this circuit, equal value resistors R3 and R4 set the midway voltage to which the + input is returned. The — input is biased by feedback as before, but the input and output have to be capacitor coupled because of the bias voltages.

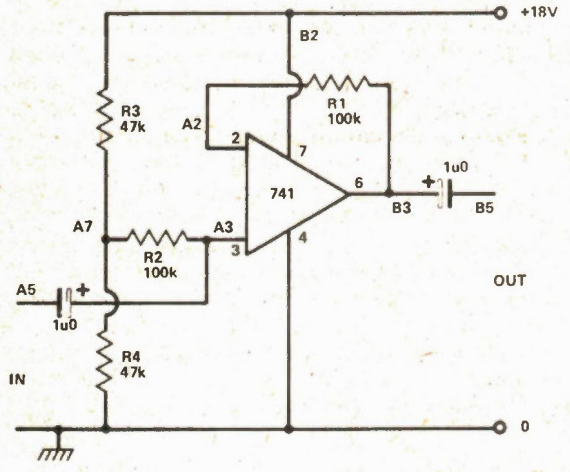


Fig. 3.4 The single-supply version of the circuit of Fig. 3.2.

A simple way to demonstrate the high input resistance goes like this. Connect an LED and a 2K2 resistor in series to the board as shown in Fig. 3.5: note the two possible connections according to whether you've built the dual or the single power supply version. Now, with no signal of any sort into the 741, the LED should not light, because the output voltage of the 741 is the same as the voltage at the cathode of the LED. Now touch the input of the 741 circuit with one finger and the +9V supply with another finger — what happens? Could the resistance between your fingers possible supply the LED directly (Fig. 3.6)? This 741 circuit is the basis for countless circuits which detect small voltages; circuits such as moisture detectors, "lie" detectors, continuity testers and so on.

We needn't, of course, use 100% feedback for our voltage amplifier. Fig. 3.7 shows a circuit which feeds back only a fraction of the output signal. Using a dual voltage supply, this is easily arranged by connecting a potential divider from the output to ground and taking the — input to the output of the potential divider. This kind of circuit is called a follower-with-gain. It has the same high input resistance as the simple voltage follower, but a voltage gain which is greater than one. The value of voltage gain is given by the ratio:

$$\frac{R1 + R2}{R2}$$

so that if, for example, R1 = 47K and R2 = 15K, then the gain is

$$\frac{47 + 15}{15}$$

which is 4.13, as near 4 as makes no difference. The single voltage version of this circuit isn't nearly so simple. The resistor R2 can't be connected directly to ground without disturbing the bias on the + input, so that an isolating capacitor is needed. The usual pair of resistors to set half-supply-voltage, and the coupling capacitors to avoid shorting out the bias will also be needed.

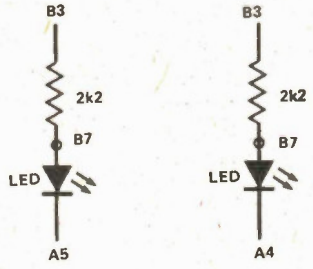


Fig. 3.5 Using an LED voltage detector (a) for the circuit of Fig. 3.2, (b) for the circuit of Fig. 3.4 R2 should be 1M in this circuit when the LED is being used as a detector.

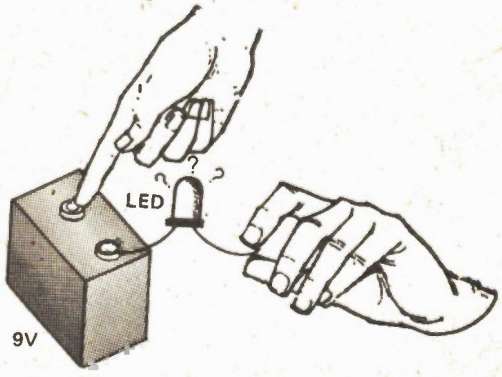


Fig. 3.6 Can enough current pass through your fingers to light an LED?

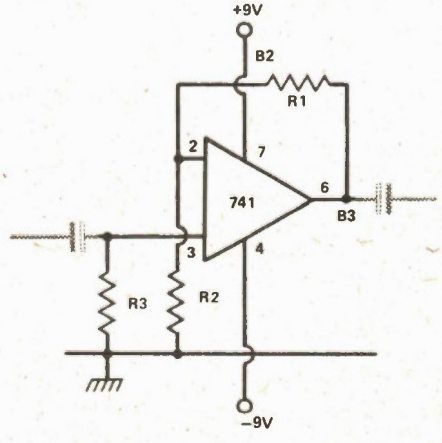


Fig. 3.7 The follower-with-gain. The (dotted) capacitors will be needed if the circuit is to be connected to any points which are not at ground voltage.

GAIN

The gain which this circuit can have makes it much more useful. It can, for example, be used to amplify the signal at a detector diode to form a modern version of the old-fashioned crystal set, as shown in Fig. 3.9. It's also an excellent pre-amplifier circuit, giving a moderate gain along with high input resistance and low output resistance. The output will drive magnetic earpieces quite happily, though the low-resistance earphones which are

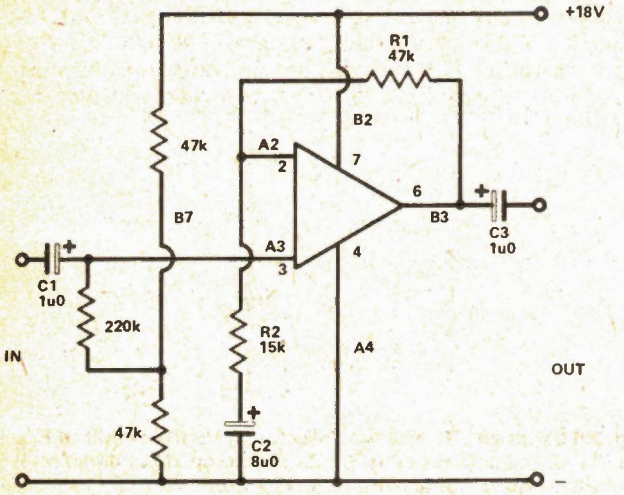


Fig. 3.8 Single-supply version of the follower-with-gain. C2 is needed to prevent the voltage at A from being reduced by the potential divider circuit, R1, R2.

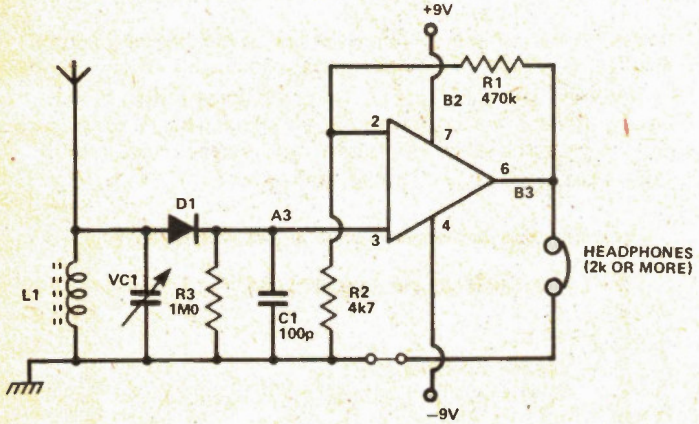


Fig. 3.9 A simple radio circuit, using the high gain of the 741 to amplify the feeble signals fromhe diode detector. D1 must be a germanium diode such as 1N36.

used along with stereo receivers usually need a bit of resistance connected in series if they are not to overload the 741. For the same reason, low resistance loudspeakers (4R to 15R) should not be used, though the old "transistor radio" 80R loudspeakers will work quite nicely.

Now for the next trick. This time, instead of using the + input for signals, we'll use the — input. Yes, I know that we take the feedback to this input as well, but we can get around that, as we'll see. The circuit of an inverting amplifier, as this type is called, which uses dual power supplies is shown in Fig. 3.10. As usual, the use of two separate supplies makes the circuitry simple, with the + input connected through a resistor to ground.

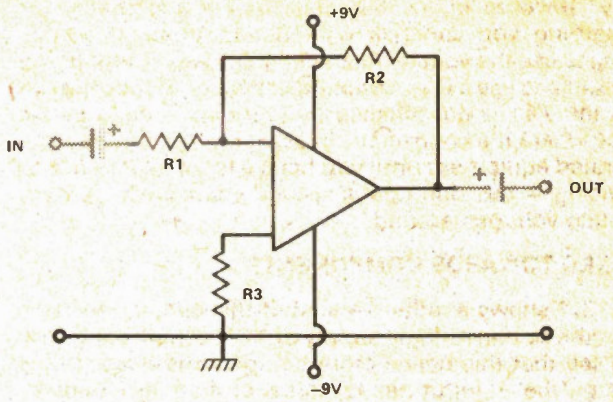


Fig. 3.10 The basic inverter-amplifier circuit. The value of R3 should be chosen so as to equal R1. Capacitors, shown dotted, should be used if the input or output is connected to points which are not at ground voltage.

This circuit is different in a number of ways. For one thing, we find that if we connect our signal directly to the — input, the input resistance is as near as we can measure, zero! It's so near zero in fact that the — input is often called a virtual ground — there's zero resistance to ground for signals at this point. We can add some resistance, however, in the shape of R1, and when we do the voltage gain of the circuit is easy to calculate — it's just R2/R1. The output resistance is low, the input resistance is R1, and the output signals are inverted compared to the input signals.

How can we try this one out? One way is to use it with a signal source which has a low resistance. We can, for example, use a small loudspeaker as a microphone. Fig. 3.11 shows a suitable circuit, with a magnetic earpiece used at the output, which can be used as a remote listening device — not everyone knows that a loudspeaker can double as a microphone.

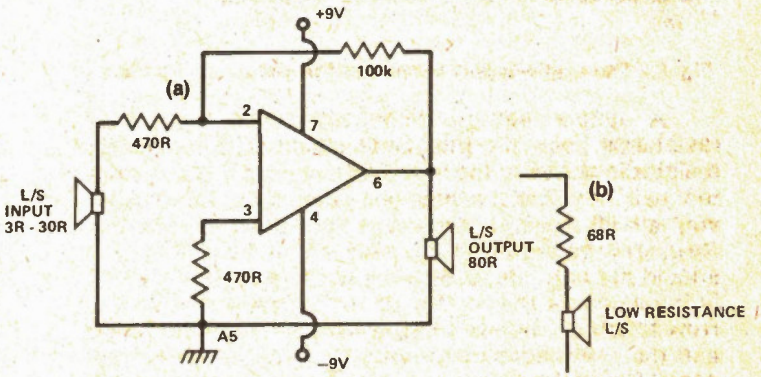


Fig. 3.11 An eavesdropper circuit. (a) The loudspeaker at the input can be of high or low resistance, but the loudspeaker at the output can be a high resistance type. (b) shows how a lower resistance loudspeaker can be used at the output.

As usual, the circuit is a bit more complicated when a single power supply is used, and coupling capacitors have to be connected to prevent the bias from being shorted out. Fig. 3.12 shows the single-supply version of the circuit of Fig. 3.11.

FOR OUR NEXT TRICK . . .

These circuits are basic circuits — they illustrate with only a few components what a 741 can do. By adding more components we can end up with a lot of useful

project ideas, and that's the next step. One such circuit is illustrated in Fig. 3.13. This one is an overload compressing amplifier; a boon if you use a microphone live or for tape recording. All microphones give a much greater output when you're close to them than when you're a few feet away, so if you set the gain of an amplifier to be just right when you're three feet from the mike, it's horribly overloaded and distorted when you come closer. The compressor circuit has a variable gain which corrects this situation — when the signals are small, the circuit has a large gain; when the signals are large the gain drops. It's like having a very smart operator at the volume control, but with the additional advantage of being automatic.

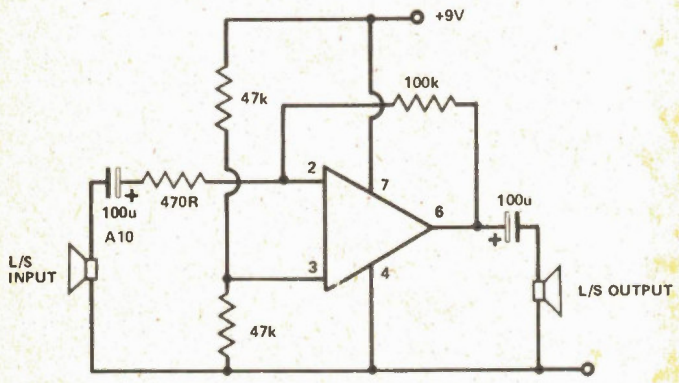


Fig. 3.12 A single-voltage supply version of the circuit of Fig. 3.11.

How does it work? The circuit (Fig. 3.13) is basically an inverting amplifier but the feedback is through a pair of diodes, D1 and D2. Now, as you'll recall, diodes conduct one way only, so that to ensure that both halves of a signal voltage will be fed back, we have to use two diodes connected back-to-back. Even when the anode of a diode is positive to the cathode, however, a diode does not conduct until there's enough voltage across it, about 0.15 V for a germanium diode, and 0.5 V for a silicon diode. Once the diode starts to conduct, what's more, it doesn't obey Ohm's law, or anything like it. There's no fixed single value of resistance for a diode, the value of resistance changes as the current through the diodes changes, becoming smaller when there's a lot of current through the diodes, and large when the diodes are almost cut off.

COMPRESSION

How does this achieve compression? Well, if the input signal is very small, the amplified signal at the output may be too small to make the diodes conduct, in which case there's no feedback and the circuit operates at full gain. When a larger input signal happens along, the diodes start to conduct, and their resistances act as a negative feedback resistor, reducing the gain of the amplifier. Still larger input signals make the diode resistance lower, causing more feedback and less gain. In the circuit which is shown, the gain for a 1 mV signal is about 20 times (output 20 mV), but the gain for a 1 V signal is about 0.6 times (output 500mV). One thousand times the original input signal has caused only 25 times the output signal— that's compression!

If you want to use this in a microphone circuit, you'll have to experiment with the best place to connect the compressor — either between the mike and the pre-amp,

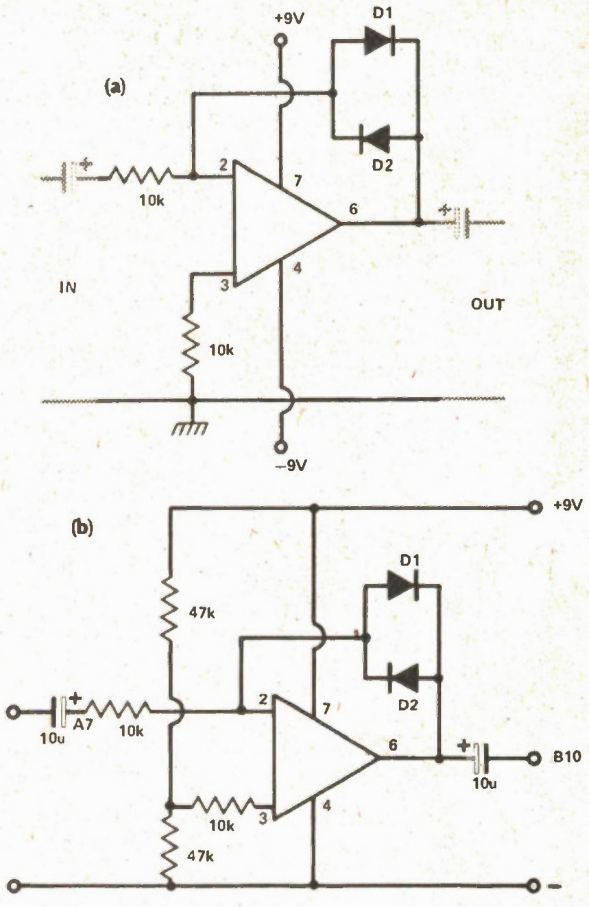


Fig. 3.13 The diode compressor circuit (a) dual voltage supply version, (b) single voltage supply version.

or between the first stage of the pre-amp and the second. Remember to use coupling capacitors if you're connecting to anywhere which has a bias voltage, and don't take risks with line-operated equipment.

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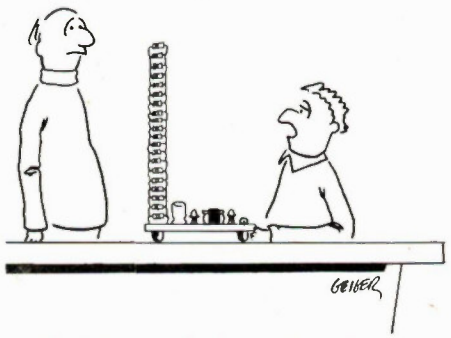
CORRECTION

GLADSTONE ELECTRONICS
January 1982 issue, page 30.

Price of 8K ROM/2K RAM Black & White ATOM was listed as $479.95 — should have been $399.00.

We apologise for any inconvenience caused.



I didn't have a 1 ohm resistor, but I had twenty 20 ohm resistors...

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20 pin	.24
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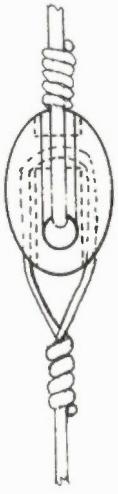
Circle No. 8 on Reader Service Card.

Continued from page 68

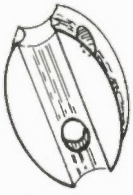
Fail-Safe

The insulators illustrated are available in porcelain, nylon and glass. The nylon type egg insulator is usually the least expensive — but they do have one drawback. After some time in use, the tension of the wire causes the nylon to creep or remould itself and the wire literally pulls itself through the insulator. This may cause the insulator to fail completely. It isn't so much of a disaster however as the aerial wire and support rope are looped through one another and the aerial won't fall down — an replacement will obviate any problems here.

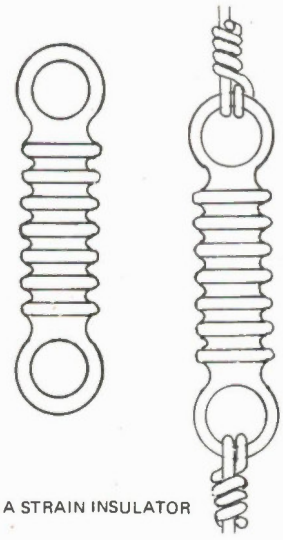
Good luck and good listening!



USING AN EGG INSULATOR



EGG INSULATOR



USING A STRAIN INSULATOR

Fig. 7. Two types of aerial insulator and how to attach them.

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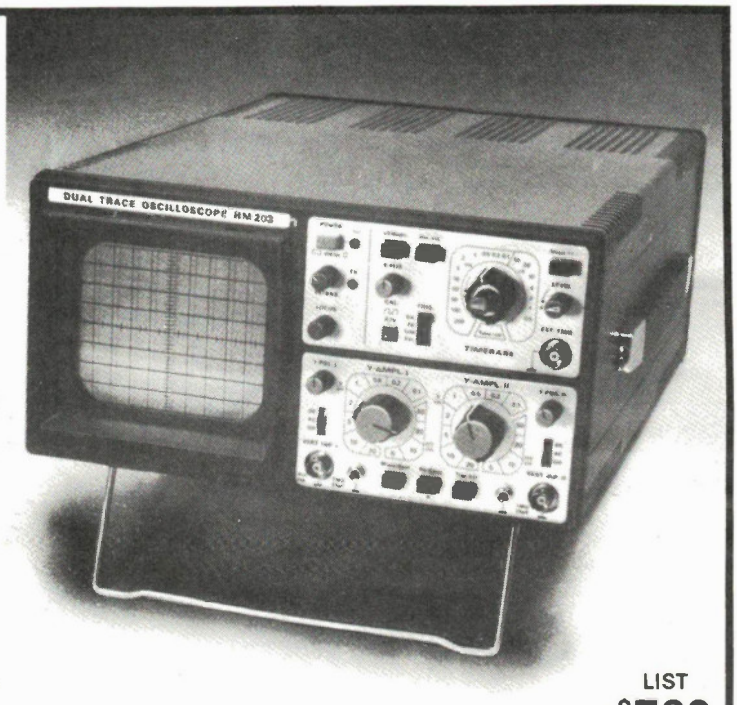

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Sound Bender

This neat little ring modulator has a built-in wide-range sine/triangle modulation oscillator and a 'pan pot' output mixer, but can be built (less the case) for under $25.00.

If you liked this project, please circle Reader Service Card number 55. If you didn't, circle number 56.

ONE OF THE MOST popular types of cheap sound-effects units is the so-called 'ring modulator' or four-quadrant multiplier. These units have two inputs, one being a voice or music audio signal and the other being a simple sine or triangle oscillator waveform: the output of the unit is equal to the product of the two instantaneous signal amplitudes. In other words, the oscillator effectively amplitude-modulates the voice/music signal, to give some very interesting changes in the apparent signal content of the original voice/music material.

The ETI Sound Bender is a fully self-contained version of the popular ring modulator circuit. Naturally, however, our project has few special features. First, it has a built-in modulation oscillator that can span the frequency range 3 Hz to 5 kHz using a single control pot and which can produce either sine or symmetrical-triangle output waveforms. Second, the actual ring modulator is based on a precision four-quadrant multiplier circuit that is integrated into the oscillator chip; the multiplier balance is externally adjustable, enabling the unit to be used either as a 'sound bender' or as a simple sine/triangle audio generator. Finally, the unit incorporates a two-channel audio mixer in its output stage, which enables the original and modulated audio signals to be mixed in any desired ratio (ranging from 'all original' to 'all modulated') by a single pan-pot type control.

Our unit is designed to operate from nominal audio input signal levels of about 100mV RMS or greater and can simply be interposed between the output of the preamplifier and the input of the main amplifier of an existing audio system. The unit is battery powered by a stack of eight 1V5 cells and typically consumes about 12 mA.

Construction

The ETI Sound Bender is a fairly simple project and construction should present very few problems. Build up the PCB as shown by the overlay, noting the use of 16 Veropins to facilitate the circuit interwiring, then fit the PCB into a suitable case and complete the interwiring to the off-board components, noting that the two halves of RV4 are connected in opposite directions. On our prototype unit the four control pots are fitted on the unit's front panel and the two switches and the input/output terminals are fitted on the rear panel. As you can see from the photographs,

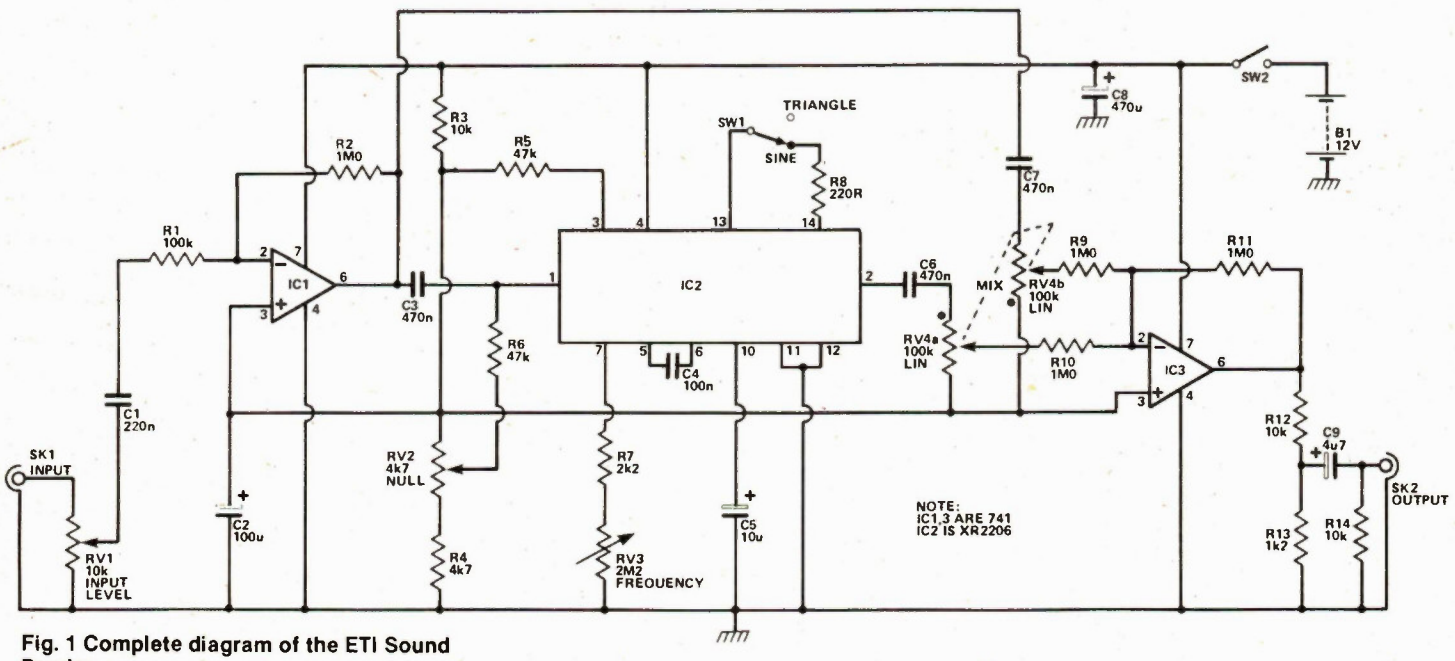
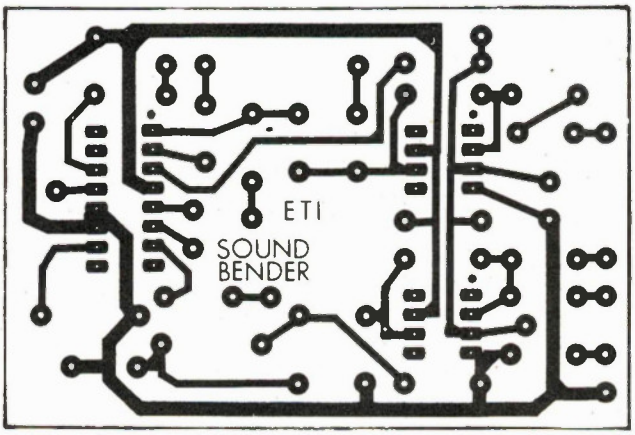


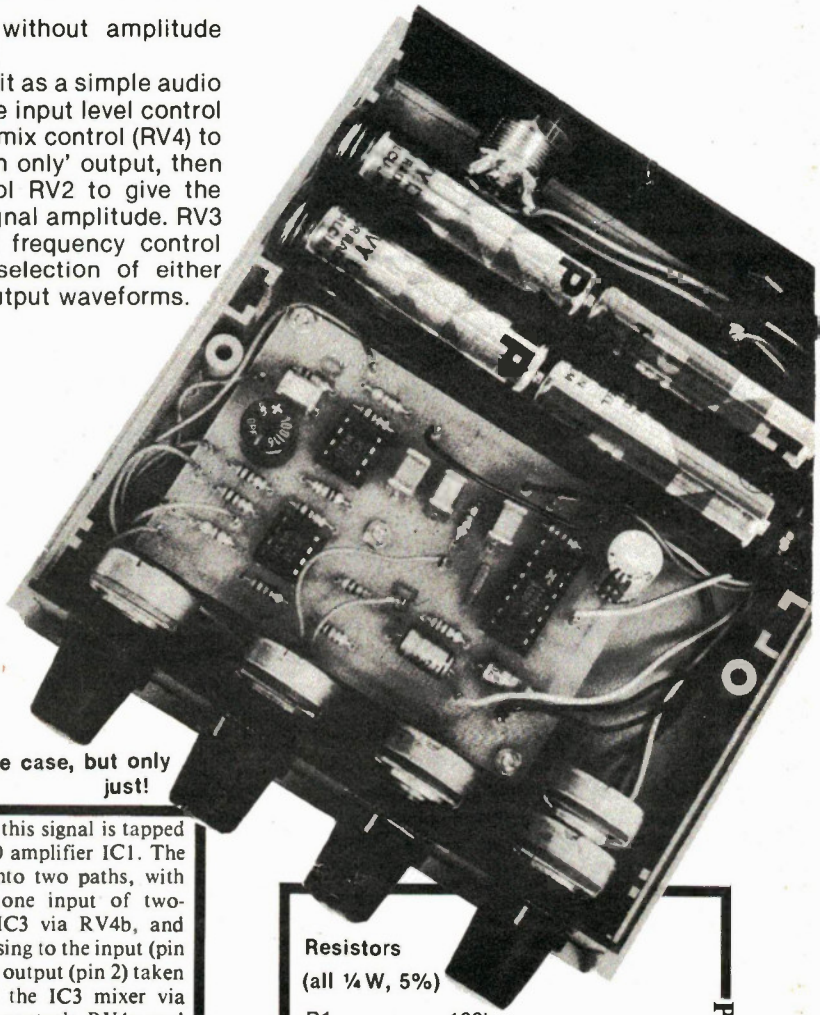
Fig. 1 Complete diagram of the ETI Sound Bender.

the circuitry and battery pack make a fairly tight fit in the case.

The unit is very easy to use. Simply connect the output to an audio power amplifier/speaker combination, adjust RV2 (null) for zero output tone, then connect a voice or music input signal and see how the sound can be 'bent' using the frequency and mix controls. Level control RV1 is simply adjusted to give good sensitivity without amplitude limiting (clipping).

To use the unit as a simple audio generator, turn the input level control down and set the mix control (RV4) to give a 'modulation only' output, then adjust null control RV2 to give the desired output signal amplitude. RV3 then acts as the frequency control and SW1 gives selection of either sine or triangle output waveforms.





Everything does fit in the case, but only just!

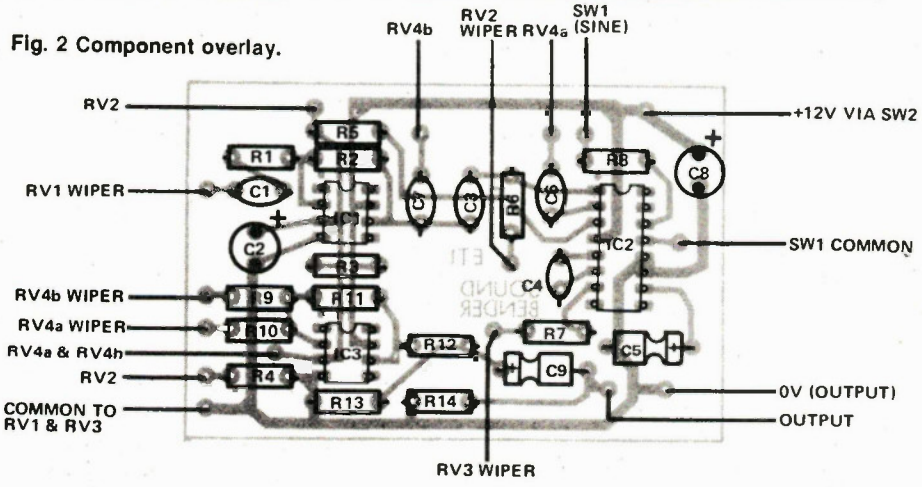
HOW IT WORKS

The heart of this unit is IC2, an XR2206 function generator chip that incorporates a wide-range sine/triangle waveform generator and a precision four-quadrant multiplier within a single package. The output of the waveform generator is internally connected to one input of the multiplier, and the other input of the multiplier is accessible at pin 1: the output is available at pin 2.

In our application, the generator can produce either sine or symmetrical-triangle waveforms, depending on the setting of SW1, and its frequency (determined by C4-R7-RV3) can be varied over the range 3 Hz to 5 kHz via RV3. The pin 1 input of the multiplier is biased by RV2, which is normally adjusted to balance the multiplier so that it produces zero output when zero signal input is applied to pin 1.

The audio input signal is applied across RV1 and a fraction of this signal is tapped off and applied to X10 amplifier IC1. The output of IC1 splits into two paths, with one path passing to one input of two-channel audio mixer IC3 via RV4b, and with the other path passing to the input (pin 1) of IC2, which has its output (pin 2) taken to the other input of the IC3 mixer via RV4a. Note that mix controls RV4a and RV4b are connected in opposite directions so that they control the mixing action in 'pan pot' fashion, giving a final output from IC3 that ranges from 'all original signal' to 'all modulated signal' in the extreme settings of RV4. The output amplitude of IC3 is divided by 10 (by R12-R13), so that the final output signal has an amplitude roughly equal to that of the input signal feeding IC1, thereby giving the Sound Bender a good overall signal-to-noise ratio.

Fig. 2 Component overlay.



PARTS LIST

Resistors
(all ¼ W, 5%)

R1	100k
R2,9,10,11	1M0
R3,12,14	10k
R4	4k7
R5,6	47k
R7	2k2
R8	220R

Potentiometers

RV1	10k linear
RV2	4k7 linear
RV3	2M2 linear
RV4	100k dual linear

Capacitors

C1	220n polycarbonate
C2	100u 16V PCB electrolytic
C3,6,7	470n polycarbonate
C4	100n ceramic
C5	10u 25V axial electrolytic
C8	470u 16V PCB electrolytic
C9	4u7 16V axial electrolytic

Semiconductors

IC1,3	741
IC2	XR2206

Miscellaneous

SW1,2	SPDT miniature toggle
SK1,2	phono sockets
PCB	
battery holders (two off).	

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Continued from page 31

to learn on, the VIC is a lot more "user friendly". On the other hand, it's a lot more limiting once you get going, too. If you're planning to get into more sophisticated computer applications, like word processing, record management, freaky graphics, and so on, the ATOM will take you further. Suitably ambiguous, I hope.

At the time of this writing, the basic black-and-white ATOM was going for $525.00 Canadian. In addition to this, you'll need a TV, a power supply and a cassette recorder. And coffee. Lot's of coffee. It's really hard to get to sleep when you've got one of these things to play with.

(As in the case of the VIC, we were so impressed with the ATOM we had for review that we ended up buying our review sample. It has occured to us, however, that we have gotten ourselves into a bit of a box in doing this, as, in future, if we review a computer and don't *decide to buy it, it will seem that we're not too impressed with it. In fact, it may very well be the case that we simply don't need another machine with these particular capabilities (it really is starting to look like a computer store around here). As such, while we may purchase review samples in the future, this is the last time we plan to mention it.)*

EXPANSION AND SOFTWARE

The optional extras available for the ATOM are very extensive: this is probably because Acorn as a company have a history in industrial control. We did not see or try any of these so we can't comment on them. However if this is an important consideration, we suggest you contact Torch.

Some options that will be of interest immediately are colour, serial printer interface and I/O ports.

There is also a 32K memory expansion board which fits inside the ATOM's case. We did not look at all the software but there are some very interesting business and word processing packages.

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Last month we incorrectly said that Torch were the manufacturers of the ATOM, in fact they are the Canadian Distributors.

If you liked this article, please circle Reader Service Card number 53. If you didn't, circle number 54.

Several months ago, we succeeded in building a full-blown computer on a chip the size of a pinhead. We've spent the last few months looking for it.

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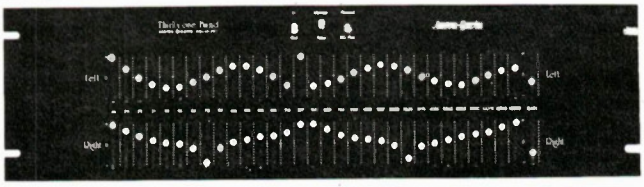

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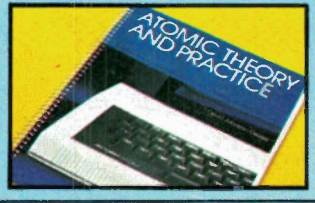

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