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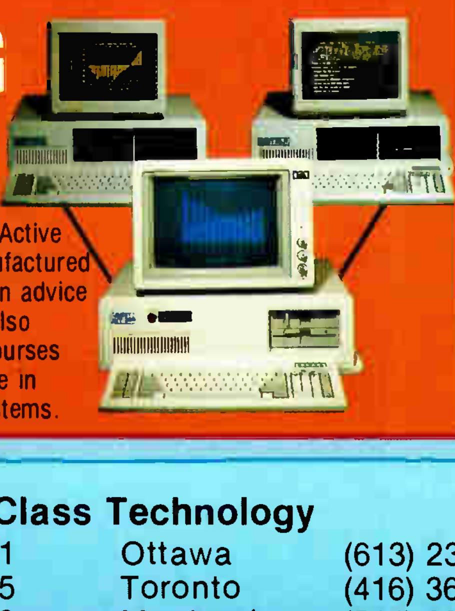

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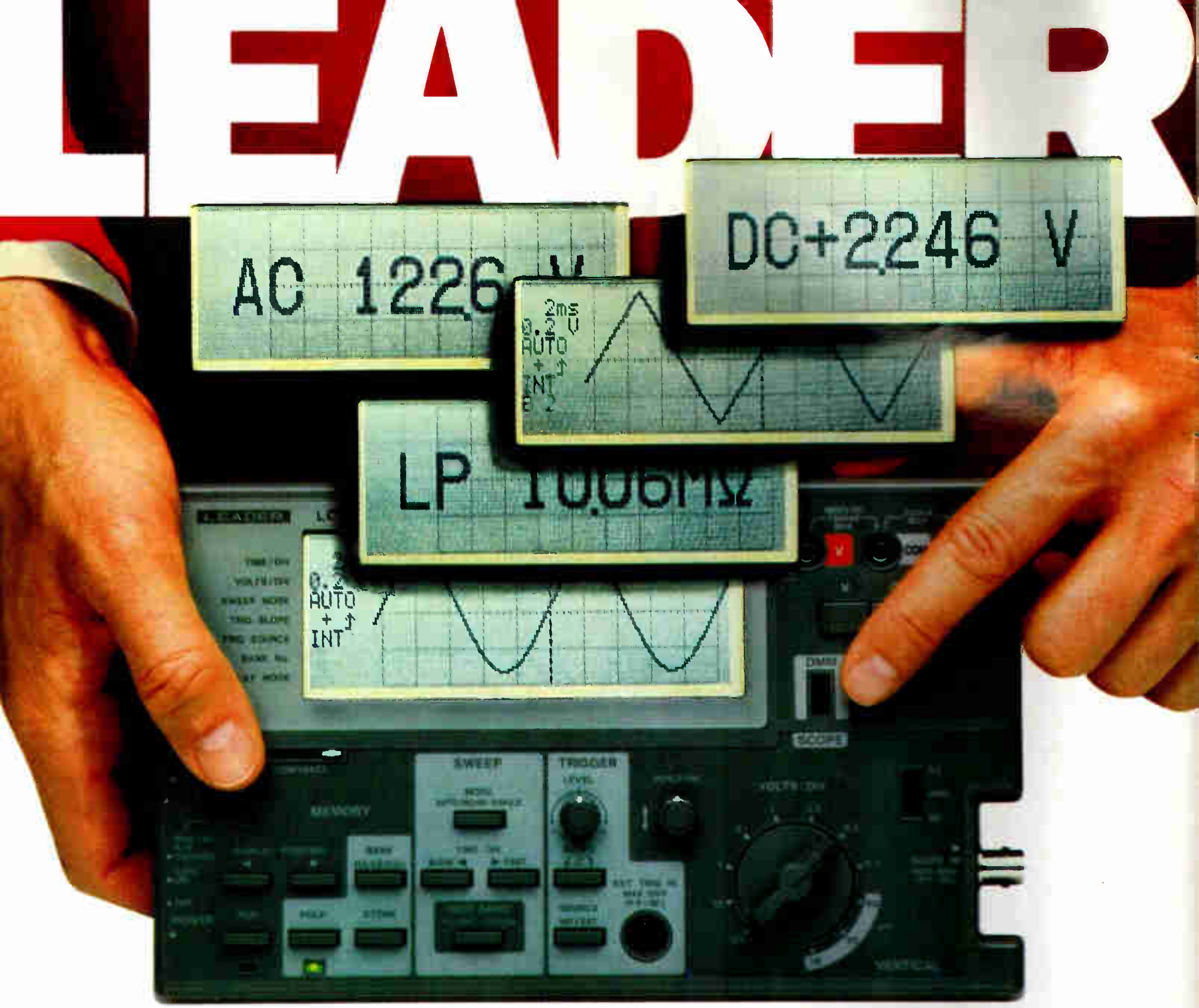

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Our microprocessor course is symbolized by a 68030 CPU chip; photo courtesy of Motorola. The Atari 1020 was photographed by Bill Markwick.

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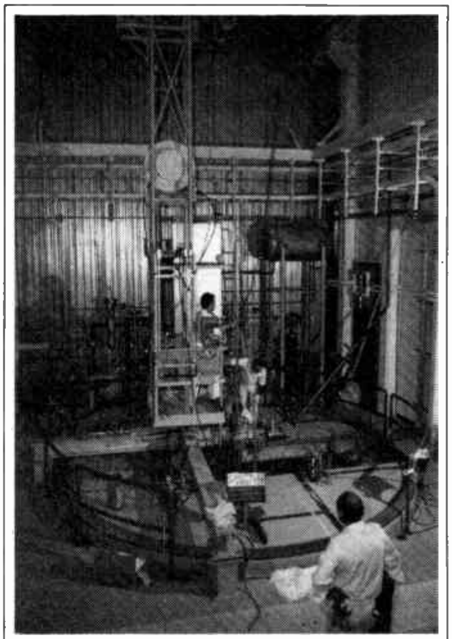

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Happenings

Event: State of the Art 32-bit-Microprocessor Technology Seminar
Date: March 10, 1988
Location: OCM, Nepean, Ontario
Contact: Ontario Centre for Microelectronics, 30 Colonnade Rd., Nepean, Ontario K2E 7J6 1-800-267-7039

Event: Worst Case Circuit Analysis Training Seminar
Date: April 4 – 6, 1988
Location: Orlando, Florida
Contact: Design & Evaluation Inc., 1000 White Horse Rd., Suite 304, Voorhees, NJ 08043. (609) 770 – 0800.

Event: The Business Computer Show
Date: March 2 – 4, 1988
Location: Exhibition Place, Toronto, Ontario
Contact: Marion Hart (416) 252 – 7791

Event: C.I.T.E.X '88 Telecom Exhibition
Date: May 18 – 19, 1988
Location: International Centre, Mississauga, Ontario
Contact: ECM 324 Lakeshore Rd., E., Mississauga, Ontario L5G 1H4 (416) 274 – 5505.

Event: AutoCAD Expo '88
Date: May 2 – 5, 1988
Location: McCormick Place North, Chicago
Contact: Autodesk Inc., 2320 Marinship Way, Sausilito, CA 94965 (415) 332 – 2344 ext. 799.

Event: High – Speed Heterojunction Electronic and Optoelectronic Devices Course
Date: June 6 – 10, 1988
Location: College of Engineering, University of Michigan
Contact: Janie Lee (313) 764 – 8491

Event: Supercomputing Symposium '88
Date: June 19 – 21, 1988
Location: University of Alberta, Edmonton
Contact: Clement Leibovitz, Computing Services, U of A Edmonton, Alta., T6G 2H1

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World Radio History

RIAA Equalization

Designing RIAA networks that will accurately replay your analog discs.

By Wilfred Harms

RIAA equalization is an important feature of any amplifier designed to reproduce music from analog disc. Suitable circuit designs can be found in any number of published sources.

Unfortunately, the circuits contained in many handbooks, electronics journals and even inside some expensive pieces of audio equipment are often inaccurate. Incorrect designs are often repeated without question and the original requirements are simply forgotten.

This is a pity because it doesn't cost any more to use a resistor and capacitor of the correct value and the results are well worth the extra time and trouble. The purpose of this article is to show why RIAA equalization is important and how to go about choosing the right filter components when designing disc equalization networks.

In The Groove

From the earliest days of electrical recording it has been standard practice to modulate record grooves using a constant- velocity recording characteristic and to replay the signal with a velocity-dependent pickup. The maximum velocity is set at a certain value and the amplitude of the signal voltage is varied with frequency so this maximum is always achieved.

The system is illustrated in Fig.1. The maximum velocity is represented by the greatest rate of change of signal voltage, the steepest part of the waveform slope. On a sinewave this will always occur at the zero-crossing points.

On lower frequency signals, the maximum velocity will be less as the rising edge of the waveform is less steep. If, however, the amplitude of lower-frequency signals is increased, a point will be reached at which the rising edge is as steep as that of a higher frequency signal with lower amplitude. This is the principle on which constant velocity recording works, the maximum velocity remaining constant across the audio band while the amplitude varies according to the signal frequency.

The main drawback with this system is that bass frequencies require a very large amplitude. The result would be wide groove spacing and correspondingly little recording time on each disc. In addition, the comparatively small amplitude at high signal frequencies would yield a poor signal-to-noise ratio.

To overcome these problems, the basic constant-velocity characteristic is modified to a constant-amplitude characteristic over certain parts of the frequency range by means of a corrective network.

In the early days this was done very much at the whim of individual record manufacturers and a number of different replay characteristics grew up side by side. In order to handle the different recording characteristics correctly, amplifiers were fitted with a number of switch-selectable equalization networks.

The situation was eventually rationalized by agreement. British Standard 1928 (issued in 1955 and re-issued without changes in 1965) recommends a recording characteristic similar to that put forward by the Comite Consultatif International des Radiocommunications (CCIR) in Europe and the Recording Industries Association of America (RIAA). The latter term is the one most commonly used today.

Changing Shape

The RIAA characteristic modifies the basic constant-velocity characteristic to a constant amplitude characteristic at two points in the audio frequency band.

At very low frequencies the constant-velocity characteristic is retained so that the gain does not go on increasing right down to the lowest recorded frequencies. Using a constant-amplitude characteristic here would emphasize turntable rumble and vibration.

At bass frequencies the characteristic changes to constant-amplitude to limit groove pitch before switching back to a constant-velocity characteristic for the middle frequencies. At high frequencies the characteristic again becomes constant amplitude and remains so to the limits of the audio band.

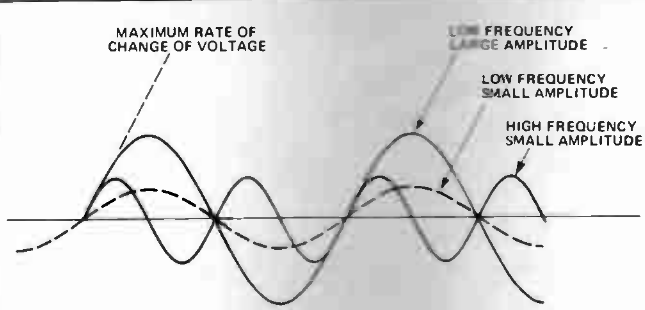

Fig. 1 For optimum modulation of the record groove when a velocity-dependent pick-up is used, all signal frequencies should have the same max. rate of change of voltage. To achieve this, lower frequencies are recorded with a correspondingly greater amplitude so as to give a steeper rising edge.

These four distinct regions give the RIAA characteristic its familiar flat-steep-flat-steep shape. The shape is sometimes shown instead as a series of angular lines but these are merely asymptotes to the curves. Provided the recording and replay networks are as near identical as possible, the exact shape of the response does not make a lot of difference. It therefore makes sense to use a series of curves which can easily be replicated to a high level of accuracy rather than an idealized, sharp-cornered response which could only be approximated with difficulty.

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Calculated Curves

The response shape is described in terms of three curves (flat becoming steep, steep becoming flat and flat becoming steep again) which 'turn over' at frequencies of 50.05Hz, 500.5Hz and 2.115kHz. The slope of the curves is that given by a first order (6dB/octave) filter network comprising one resistor and one capacitor.

The RIAA replay characteristic is the exact opposite of the recording characteristic and is shown in Fig.2. The complete characteristic can, in theory, be reproduced using three capacitors, and three resistors in series and parallel pairs, although this is not necessarily the best way of doing it as we shall see later.

The actual values of the resistors and capacitors used will vary according to the individual circuit configuration, but the CR time constant for each filter curve is determined solely by the turn-over frequency and is therefore fixed. For this reason, it is usual to define the three curves in terms of CR time constants.

The values required must, at the frequency concerned, give CR values which result in C and R having equal impedances. This can be determined from the formula:

$$CR = \frac{1}{2\pi f}$$

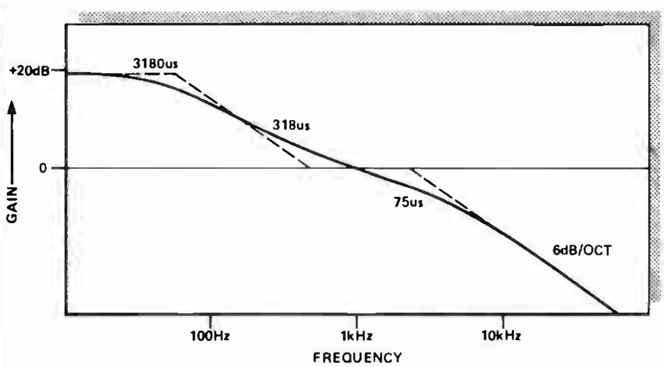

Fig. 2 The RIAA replay characteristic.

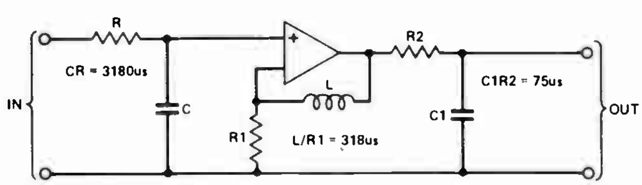

Fig. 3 A simple replay equalization circuit using separate filter networks for each of the three time constants.

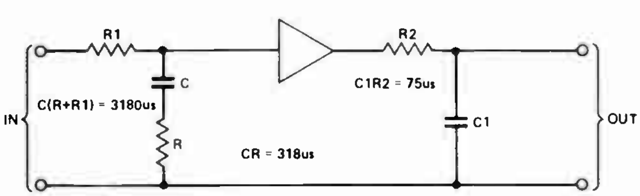

Fig. 4 A two-stage replay circuit in which one compound filter stage provides two of the time constants.

and for the RIAA characteristic gives time constants of 3180, 318 and 75 microseconds. These time constants are, incidentally, the period of one radian of one cycle at thee frequency concerned.

Fig. 3 shows a simple equation network which uses three separate stages to realize the RIAA characteristic. This will work but a much better approach is to merge two of the networks in the way shown in Fig.4.

In practice, all three stages are usually combined into a single network and some examples are shown in Fig.5. All of these circuits give similar results but in each case there will be a degree of interaction between the three time constants and this will affect all four circuit components.

The response curves for an RIAA network are defined in terms of a single reference frequency, 1kHz. Taking the circuit of Fig.4 as an example, the output level from the 318/3180µs section (the network comprising R, R1 and C) will be 11.17% of the input signal level. Similarly, the output from the 75µs section (the network comprising R2 and C1) will be 90.46% of the its input level.

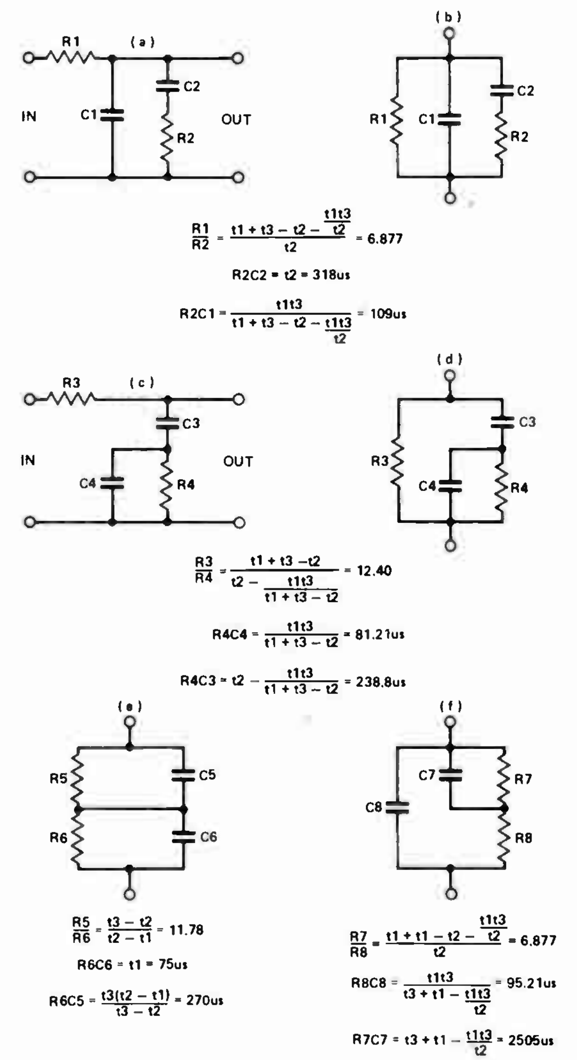

Fig. 5 Some examples of RIAA replay networks in which all three time constants are set using a single network.

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Taking these two together, the final output level from the circuit at 1kHz will be (0.1117 x 0.9046) = 0.10103 times the input level or 10.103%. Therefore the input or zero frequency response for the network should be set at (1/0.10103 =) 9.898 times the reference response at 1kHz.

Network Design

Designing a network of the type shown in Figs.2 and 3 is quite straightforward but the single network of Fig.4 require a different approach.

For those who want to go into the mathematics of it all, the figure for output level/input level of an RIAA network is given by

$$\frac{(1 + st_2)}{(1 + st_1)(1 + st_3)}$$

Where t is the period of the CR time constant and $s = j\omega$ (ω, of course, is shorthand for $2\pi f$). Taking the circuit of Fig. 5a as an example, the output level/input level at a given frequency will be equal to

$$\frac{(1 + sR_2C_2)}{1 + s(R_1C_1 + R_2C_2 + R_1C_2 + s^2R_1R_2C_1C_2)}$$

The two expressions can be equated and the component ratios determined.

Thankfully, there is little need to go through all of this because a full set of data has been available for nearly thirty years. In 1957, in the British magazine Wireless World, W.H. Livvy of EMI Studios presented a set of formulae which allow the ratios between resistor and capacitor values to be determined accurately for different time constants. Two of the networks, he suggested were suitable for passive de-emphasis but all could be used in feedback circuits because the overall impedance/frequency variations were in accordance with the RIAA requirements.

The data is presented in an even simpler and more readily-useable form in a technical paper written by Peter Baxandall. Entitled 'Pick-Up Equalization' it appears in the Radio TV and Audio Technical Reference Book edited by S.W. Amos (Newnes-Butterworth, 1977). Baxandall uses formulae for the component ratios based on the original 1957 data and describes the operation and use of several types of network. The article is just five pages long yet it covers not only the networks but also such questions as where the equalization should be placed, the problem of inverted feedback, aspects of pick-up response correction and sensitivity and the minimum levels of gain in feedback circuits.

Network Accuracy

If the accuracy of an RIAA network is to be assessed against the published standard it is helpful to be able to calculate the response figures in decibels. The formula for any frequency, f is

$$10_{\log} \frac{441.18\,(r^2 + 0.2505)}{(100r^2 + 0.2502)(r^2 + 4.503)}\ \text{dB}$$

where r = f/1000. if it is desired to check the characteristic of one network against another, the impedance must first be determined at any frequency and compared with the impedance at 1kHz to give

$$20_{\log} \frac{Z}{Z_{1k0}}$$

Design Misconceptions

Fig. 6a shows a type of network which is frequently used, and component values in similar proportions will be found in many RIAA circuits.

The zero-frequency impedance is 1M1 while the impedance at 1kHz is 122k which is too high. The result is a loss in response below 1kHz of up to 1dB.

Here R_5C_3 = 75µs and R_6C_4 = 3300ms which is acceptable. The error is in the false assumption that R_5C_4 should equal 318µs. A check with the basic formulae in Fig. 5(e) shows that R_6R_5 = 11.78, and to meet this R_6 must be increased to 1M2 and C_4 reduced to 2n7.

Figure 6b shows another commonly used RIAA network, and again it is possible to find component values in similar proportions in many other networks. As with the previous circuit, the impedance at 1kHz is high resulting in a loss in response at both lower and higher frequencies. Since R_5R_3 = 3300, R_4C_3 = 330 and R_4C_2 = 72.6, what is wrong?

In this case, everything, because interaction affects all values. Fig 6(b) requires that R_5C_3 = 2937µs, R_4C_2 = 81.2µs and R/R_4 = 12.40 and three components must be changed. If it is desirable to retain the 33k resistor, then suitable values for the others would be R_2 = 2.7k, C_2 = 30n and C_3 = 91n.

The noticeable common error in faulty networks is that one of the two larger resistors is ten times the other, a circumstance which cannot arise if it is correctly designed.

The ratios of component values in Fig.4 in terms of time constants (t_1 = 75µs, t_2 = 318µs, t_3 = 3180µs) are those originally given by EMI Studios which have been checked and evaluated to facilitate their use. The theoretical differences appropriate to a feedback circuit are within the normal component tolerances (1% recommended) provided the 1kHz gain exceeds 65.

In conclusion, one must realize that the final design of any RIAA replay network depends upon the equalization circuit as a whole and particularly upon the impedances associated with it. But perfection cannot be obtained without an understanding of the underlying principles. •

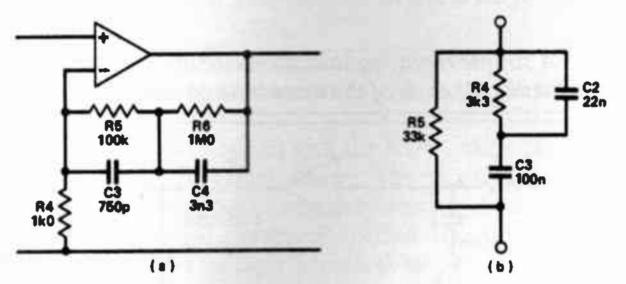

Fig. 6 Two commonly encountered RIAA network configurations with interaction problems. ■

World Radio History

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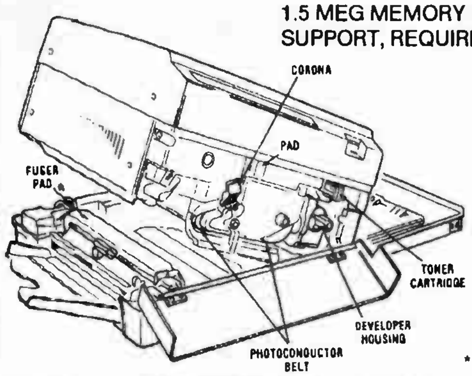

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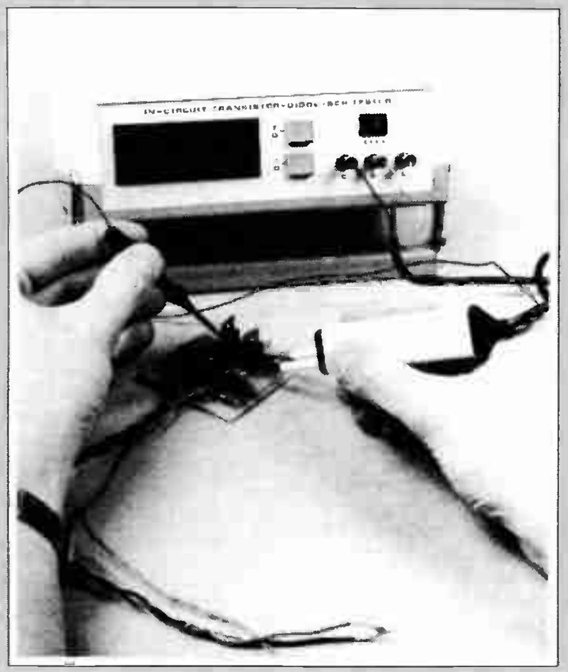


Build a Transistor Tester!

With a few logic gates and transistors, you can make an in- circuit tester for transistors, diodes and SCRs. A handy supplementary tester to go with our microprocessor course.

How Coaxial Cable Works!

Since cable TV, coaxial cable is second only to the telephone system for communications wiring. Why it's used and how to use it.

Electrochemical Computers!

Computer designers, always looking for ways around the limitations of present-day chips, are investigating electrochemical and bioelectronic circuits. Here's what they've discovered so far.

The DMA Demystified!

Direct Memory Access is supposed to be a good thing to have among your computer's circuits, but it's rarely explained. Here's what it's all about.

World Radio History

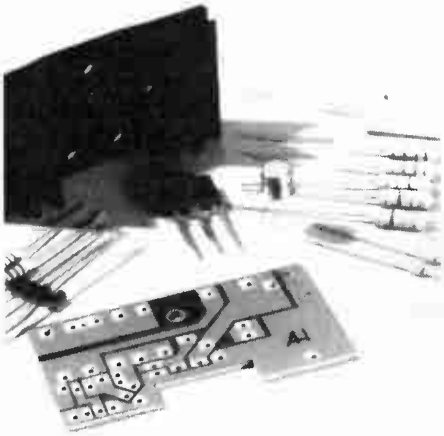
Velleman Kits

Transistorize your ignition and build a mono/stereo booster for your car.

By D.E. Ward

For those die-hard tinkerers out there who are always on the lookout for good kits, look no more. The Velleman Company, of Belgium, produces a number of kits and this month we're taking a look at two automotive types: the Transistor Ignition and the Mono/Stereo Booster.

Ignition Upgrade



The very design of the conventional ignition, although it served us well for many years, was a little less than adequate. These systems were prone to difficult starts in cold weather, excessively burned breaker points, and long voltage rise times of the ignition system when spark plugs were fouled or when damp weather prevailed.

Major advantages of TI are: breaker point life is prolonged due to the low switching current used; good spark energy and voltage are maintained during cold starts; and the fast 2 msec rise time of the ignition waveform provides a strong spark energy with fouled plugs or in damp weather.

The Velleman 2543 TI kit includes everything you'll need to convert a conventional ignition system to TI. Component locations and off-board connections on the PC board are well-marked, and the unit can be mounted into a suitable weatherproof enclosure.

Mounting the unit under the dash or hood should pose no real difficulties, especially in older vehicles with lots of room in the engine compartment. Remember, the heatsink must be well ventilated, so choose a case and mounting location which will be suitable. Also protect the completed PCB by spraying it with a couple of coats of non-conductive varnish.

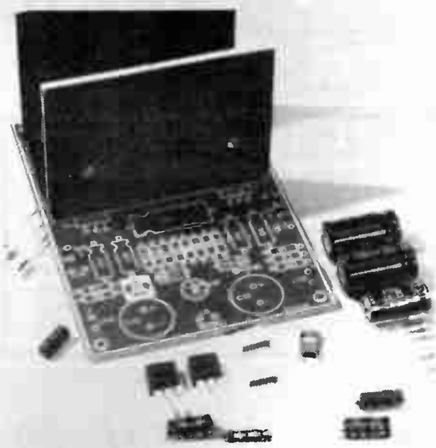
Four connections to the TI unit are required: switched +12VDC (before the ballast resistor if present); chassis ground; breaker points (disconnect external condenser if present); and to the side of the coil previously connected to the points.

The English instructions which accompany the kit are barely readable due to poor translation from the original French. However, construction is supplemented with a circuit diagram and a good exploded-view drawing of the assembly procedure. The cost of the K2543 is $29.95US

10 - 30W Mono/Stereo Booster

If you car or truck radio needs a little boost in the output department, the Velleman 2598 Mono/Stereo booster kit may be just the ticket.

This unit is capable of providing 10 watts of power at 4 ohms from a 12V supply, 2 x 5 watts at 4 ohms in stereo mode, or 2 x 15 watts at 4 ohms from a 24V supply. Power can be supplied from any suitable 12 - 24V DC supply capable of delivering 2A. The design of the Mono/Stereo booster also includes thermal and short circuit protection.



The entire kit is assembled onto a 119mm x 85mm PCB including the heatsink. Good quality reference diagrams are supplied for the circuit, parts placement, and mono/stereo configuration connections; the written instructions are, unfortunately, the same quality as those for the Transistor Ignition. The price for the Mono/Stereo Booster is $29.95US

Technical Specs

Absorbed current:	50 to 2000 mA
Quiescent current:	typ. 40 mA
Input sensitivity:	typ. 200 mV
Input imp:	100 Kohms (Inp. A and B)
Freq. Resp:	20 to 20,000 Hz ±2dB Mono
PSU Hum Compression:	typ. 50 dB
Thermal Cut-off:	110°C
Output Impedance:	4 to 8 ohms

All in all, these kits are great value for the money. The quality of the translation in the instruction manual can be overlooked if you're patient enough.

Velleman kits and catalogs are available from Hobby Electronics, P.O. Box 44247, Denver, Colorado 80201 USA. Tel: (303) 296-5544 or FAX (303) 296-5542.

Circle No. 80 on Reader Service Card

World Radio History

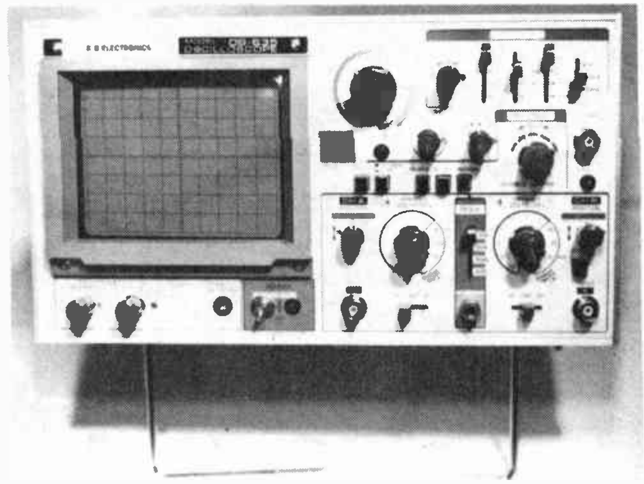
Diamond Vision Stereo TV

Mitsubishi Electric Sales Canada Inc., is pleased to announce the availability of their 21-inch (MTS/SAP) Diamond Vision TV.

The Diamond Vision CRT provides vivid life-like color as well as uniquely absorbing ambient light and automatically increasing contrast.

In addition, the new set also includes: 41-function integrated TV/VCR remote control; on-screen display of time and channel; 125-channel cable ready tuner; auto picture latituted circuitry; channel lockout/program timer; separate bass and treble controls; double sets of stereo audio inputs/outputs; dual video inputs/outputs; and external speaker terminals.
Product Manager, Mitsubishi Electric Sales Canada Inc.,
8885 Woodbine Avenue, Markham, Ontario L3R 5G1.

Circle No. 67 on Reader Service Card



New KB Scope

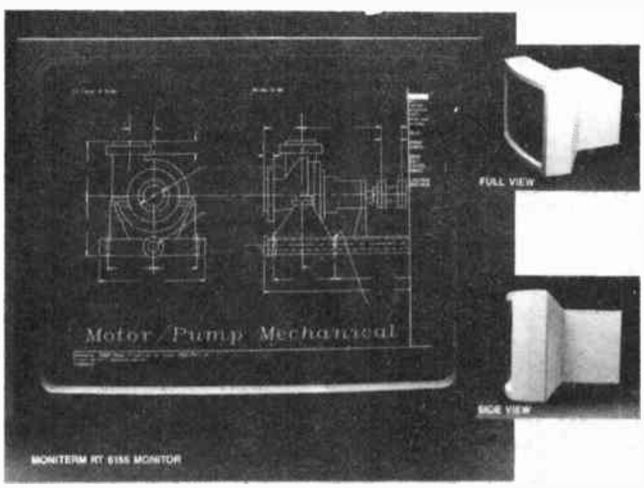
KB Electronics has announced the addition of the OS−635 Dual Trace Oscilloscope to its line of electronic test bench equipment.

The 35MHz scope features a 6kV accelerating voltage for high brightness and sensitivity to 1mV/div. The unit operates in CH−A, CH−B, dual add and sub modes with the possibility of inverting CH−B. The OS−635 incorporates a quick rise time of 10ns, delayed triggering sweep which is available at any point on the waveform, variable hold−off and alternate triggering capability.

The combination of features make this unit ideal for general purpose and computer service work.

For more information contact: Jim Peffers, KB Electronics, 355 Iroquois Shore Rd., Oakville, Ontario L6H 1M3. Ph: (416) 842−6888

Circle No. 53 on Reader Service Card



Moniterm RT6155 Display

IBM RT users now have a 19" high-res monochrome monitor available to them.

Based on Moniterm's popular VY monitor, the RT6155 will plug directly into the IBM 4768 Extended Monochrome Graphics Display Adapter. Featuring a format of 1024 x 768, refreshed at 60Hz, the RT6155 displays flicker-free monochrome images.

The 6155 is ideal for a number of applications including desktop publishing, windowing, and multiple terminal emulations.

SAK Data Products, 4500 Dixie Road, Unit 12B, Mississauga, Ontario L4W 1V7. (416) 624-6763

Circle No. 68 on Reader Service Card

150 Meg RF Signal Generator

The new B&K 2005 RF signal generator is capable of a frequency range from 100KHz to 150MHz in fundamental frequencies up to 450MHz on harmonics.

The ouput level is 100mV with 20dB of level control. An internal amplitude modulation of 1KHz continuously variable from 0 to 100% is provided as well as external modulation capabilities. It also features frequency monitor output to provide connection to an external frequency counter, and variable attenuation to 40dB.

Jo-Anne Enzel, Atlas Electronics Ltd., 50 Wingold Ave., Toronto, Ontario M6B 1P7. (416) 789-7761

Circle No. 70 on Reader Service Card

World Radio History

DMM/Scanner

Keithley Instruments has introduced a new product that combines a 5 1/2 digit System DMM with an optional eight — channel scanner into one rack — mountable instrument.

The new Model 199 System DMM/Scanner combines two instrument capabilities into one half — rack size package. The mainframe is a complete six — function (AC and DC volts, AC and DC current, ohms and dB), IEEE — 488 programmable DMM. The optional scanner turns the 199 into a complete multi — channel measurement system. The price of the DMM is $1725.00 and the scanner is priced at $680.

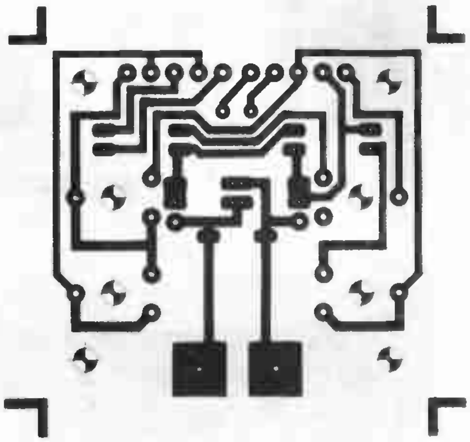
Specifications of the DMM include: 1μV sensitivity; 1 milli — ohm sensitivity; 100nA sensitivity; best one year DC voltage accuracy of 0.007% of reading + 2 counts; maximum 150 readings/second (4 1/2 digit res.) externally triggered into an internal buffer; and an internal memory capable of storing 500 readings for data logging.

The scanner specs include a switching speed of 40 chan/sec; two — pole and four — pole switching; and less than 1μV thermal offset in switch contacts.

For more information contact: Nicholas Home, DigiDyne Inc., 2294 32nd Ave., Lachine, Quebec H8T 3H4. Ph: (514) 631 — 1891.

Circle No. 66 on Reader Service Card

Oops!



The PCB artwork for the Power Meter project in our February issue was supplied at 50% full size. The full size artwork is given above.

Oops, the second. In Fig. 1 of the Car Alarm project from the same issue, Q7 is not numbered and its emitter is shown unconnected. This should connect to ground. Also, the transistors in the parts list are numbered incorrectly. They should read Q2 — 6 2N5825 and Q7 is the TIP31.

20mV Full Scale DPM

Believed to be the world's first production 3 1/2 digit DPM to offer 20mV full scale resolution, the SM-35MV from Texmatecomes in LED and LCD versions.

Both versions are designed for low-voltage inputs and provide three header-programmable input ranges of 20mV, 200mV, and 2V full sclae.

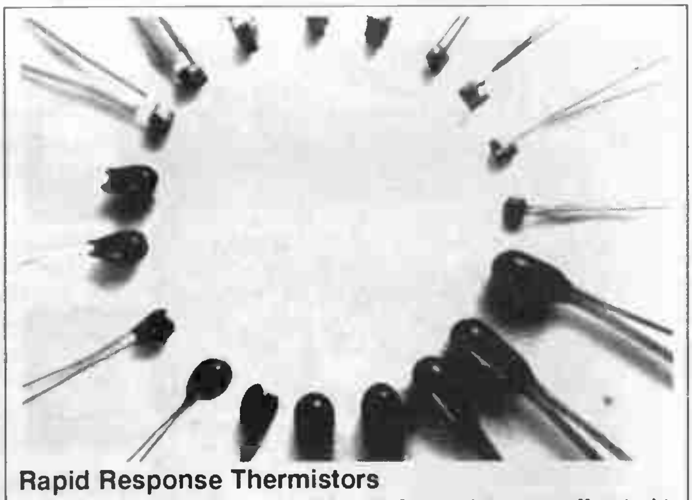
The meters can be user-scaled to almost any engineering unit of readout with internal multi-turn potentiometers that provide zero offset capability, continuous fine and coarse full scale adjustment.

The 20 mV and 200mV ranges enable the meters to be scaled for direct reading of all standard 50mV and 75mV current shunts. The unique pinout design of the SM series provides for either screw terminal or PCB edge connector inputs.

The LED version is priced at $69.00US and the LCD is $79.00US in single quantities.

For more complete info contact; Texmate Inc., 348 South Cedros Ave., P.O. Box 2000, Solana Beach, CA 92075-0980. Ph: (619) 481-7177

Circle No. 71 on Reader Service Card



Rapid Response Thermistors

Fenwal's Uni — Chip Series Standard NTC thermistors are offered with either insulated or uninsulated, and coated or uncoated leads in a wide range of customer resistance values. These components may be trimmed to a tight resistance or temperature tolerance

Design Engineers are offered a wide variety of applications usage in areas such as: communications; medical; computers; fire detection; instrumentation test equipment; automotive; aerospace and electronic design devices.

Free technical literature is available on request and provides a comprehensive Electrical Characteristics Table, as well as Resistance — Temperature Conversion Tables. Fourteen standard resistance values are available from 100 ohms to 200,000 ohms.

For more information on Fenwal's Rapid Response NTC thermistors contact: Sales and Applications Engineering Department, Fenwal Electronics/APD, 450 Fortune Blvd., Milford, MA 01757 U.S.A. Ph: (617) 478 — 5255. FAX (617) 473 — 6035

Circle No. 61 on Reader Service Card

World Radio History

World's Smallest DAT Player

Shortly after the recent Winter Consumer Electronics Show in Las Vegas, both U.S. and Canadian divisions of Casio announced that their DA–1 Digital Audio Tape recorder will be on the market (hopefully) by the summer of this year.

The DA–1 is portable and compact, measuring only 4.7" x 1.7" x 5.7" and weighing a mere 1.6 lbs. According to Casio the units small size was made possible by the employment of four–layered, custom LSI circuitry with all controls handled by a single CPU chip.

The DA–1 sports low power consumption: only 3.5W and the rechargeable battery pack is good for four hours on a charge.

Up to 28 characters of information, such as letters and numbers, can be programmed together with recorded material. For example, a user can program a song title, search for the particular song by keying in the first five letters, and the unit will then find the song and play it.

The unit also features Program Number Play, Skip Play, Intro Play (plays nine seconds of each song) and a Repeat Play function. Timer recording/playback and auto power off are also included.

The current suggested retail price of the DA–1 is $1099US. At press time no Canadian price was available but expect it to be somehat higher.

If you'd like more information on the Casio DA–1 Digital Audio Tape recorder contact: George Staleos, National Sales Manager – Audio/Video, Casio Canada, 2100 Ellesmere Rd., Suite 240, Scarborough, Ontario M1H 3B7.

Circle No. 51 on Reader Service Card

Portable TDR Test Set

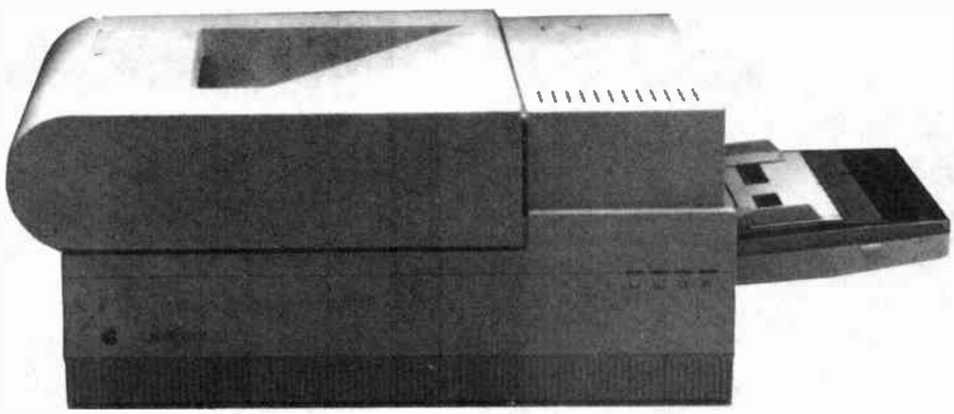
The Model 535 digital TDR/Radar Cable Test Set from Biddle Instruments is a lightweight and battery–powered, long– range test set for locating faults and impedance mismatches on control, power, and telecommunications cables.

The instrument has a maximum range of 50,000 feet with direct distant measurements made easily by moving a cursor to the trace discontinuity displayed on the CRT. A digital measurement appears simultaneously on a separate LCD display with no multipliers or calculations necessary.

The unit also contains a built–in memory which can store a scope trace, even with the power turned off. The memory feature helps identify difficult cable faults by permitting the storage of a "good" pair or phase in memory which can be redisplayed on the CRT and compared simultaneously with the trace being tested. The "dual trace" mode also includes two output ports permitting two cable pairs or coaxial cables to be tested and compared in the direct mode. Transposed cable pairs can also be detected and verified from one end of the cable. Accuracy is 1% of any of the ten selectable ranges.

For more information contact Biddle Instruments in Blue Bell, PA 19422. Ph: (215) 646–9200.

Circle No. 62 on Reader Service Card



New Apple LaserWriters

Apple Canada has introduced their new line of LaserWriter II printers, replacing the previous LaserWriter and LaserWriter Plus.

Three new configurations are available including the LaserWriter II NTX, II NT, and II SC which offer features ranging from improved print quality and high–speed throughput to networking and expansion capabilities. The modular design, based on the second–generation Canon printing engine, provides an easy method of upgrading the printers as users' needs grow.

The NTX version is the industry's first Motorola 16 MHz 68020–based laser printer offering 300 dot per inch, PostScript capability. The standard NTX includes 1MB of ROM, 2MB of RAM (expandable to 12MB), 35 standard typefaces, built–in AppleTalk support for sharing the printer on networks, and three expansion interfaces for ROM, RAM and additional SCSI hard–drives.

The NTX provides a RS–232 serial port for connection to a host computer, and is capable of emulating the Diablo 630 and HP LaserJet Plus, insuring compatibility with two of the most popular MS–DOS and OS/2 print drivers.

Prices for the new line are as follows: LaserWriter II NTX is $10,795, NT – $7549, and the SC version – $4595.

For more information contact an authorized Apple Computer dealer or Apple Canada, 7495 Birchmount Rd., Markham, Ontario, L3R 5G2. Ph: (416) 477–5800.

Circle No. 63 on Reader Service Card

World Radio History

New Digital Storage Scope

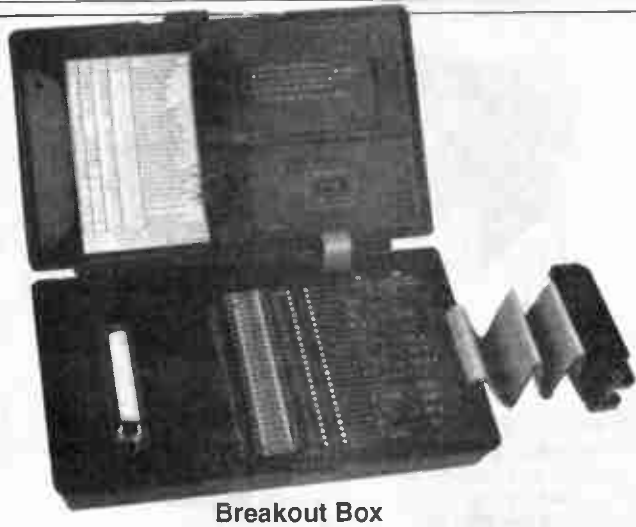
Gould Test and Measurement has announced the availability of its new 1604 digital storage oscilloscope that is ideal for applications such as transducer–based mechanical, physiological testing and low–frequency electronic measurements.

The 1604 is a 4–channel instrument incorporating two 20 MHz, 8–bit analog–to–digital converters for signal acquisition, plus an exceptionally large memory capacity – 10k words per channel for signal storage. An optional waveform processing keypad and plug–in non–volatile memory modules combine to provide powerful signal processing capabilities and the ability to store reference traces for comparison and analysis.

The unit also offers full analog operation including delay trigger functions; a built–in digital color plotter provides hard–copy output.

The price starts at $8350. For more information contact: David Green, ACA Marketing, 5835 Coopers Ave., Mississauga, Ontario L4Z 1Y2. Ph: (416) 890–2010.

Circle No. 58 on Reader Service Card



Breakout Box

The M–Test Model 225 is a high–quality RS–232C serial breakout box which also includes a parallel interface testing capability.

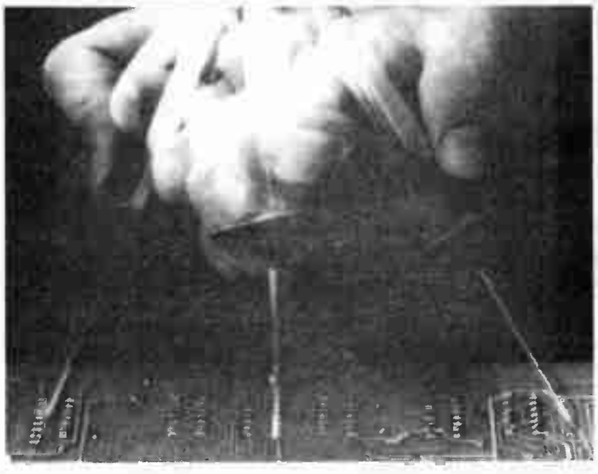
The unit has 52 LEDs which give 4–state signal indication, 26 in–line switches and 52 sockets for breaking and redirecting of all 25 lines plus one unassigned line. A battery simulates high or low signals.

It also displays parallel interface information and indicates standard TTL signals. This makes trouble–shooting desktop computer and parallel printer configurations possible.

The 225 includes: cable test; jumper cables and an attached 8" ribbon cable with dual gender connector; ABS plastic case; and gold–plated connectors. Options include: pulse trap/current loop for storing short duration pulses and testing short haul modems.

The cost of the unit is $229US. The option is $65US. For more information contact: Chris Ray, M–Test Equipment, P.O. Box 146008, San Francisco, CA 941114–6008. Ph: (415) 861–2382 or FAX (415) 864–1076.

Circle No. 59 on Reader Service Card



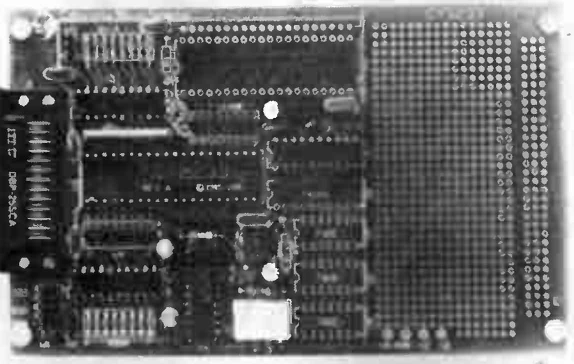
Miniature Soldering Iron

The Antex G/3U lightweight miniature soldering iron heats up to 725°F operating temperature in just 45 seconds and recovers instantly after soldering each joint. Directly grounded to protect sensitive electronic components, tips are available in over 40 different styles for all types of assembly work.

Comfortable to work with in production operations, the unit only weighs 3/4 of an ounce and has a 6 1/2" thin plastic handle that stays cool because the tip slides–on directly over the heating element for optimum thermal efficiency. Tips come in sizes from a0.012" tapered needle point, up to 3/16" diameter.

This Antex G/3U is priced at $17.95US and includes a standard tip. Replacement tips are priced from $1.20US each. For more information and a free catalog contact: Charles Loutrel, Sales Manager, M.M. Newman Corp., 24 Tioga Way / P.O. Box 615, Marblehead, MA 01945. Ph: (617) 631–7100.

Circle No. 60 on Reader Service Card



8051 Proto Board

A low–cost, flexible 8051 prototyping board, available as a kit, provides RS–232 interface, power connector, crystal, LEDs, latches, buffers, and wire–wrap area. The board can also be used with an optional network interface chip (CY233).

The Proto–51 actually contains two 8051 sockets with power, crystal and standard pins wired as required, while all user–defined pins are available at wire–wrap posts. Several 8051 ports are buffered and can drive LEDs (16 on the board), but these ports are available for any desired prototyping use.

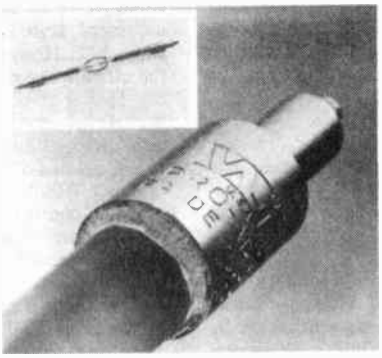
If one of the sockets is used for the CY233 network interface chip, it is possible to connect many Proto–51 boards to an IBM–PC or other host via RS–232C, allowing a unique, distributed prototyping system to be implemented.

The 4" x 6" single height Eurocard format board with holes for VME connectors is available for $170US in kit form. The kit with the additional CY233 chip will cost you $245US.

Available from Cybernetic Micro Systems, P.O. Box 3000, San Gregorio, CA 94074 USA. Ph: (415) 726–3000. Telex 910–350–5842.

Circle No. 54 on Reader Service Card

World Radio History



High–Temp Cement

Anyone out there in the need of high temperature, heat–resistant cement should look to Sauereisen Cements' inorganic Low Expansion Cement No. 29.

This adhesive is ideal in applications where bonded components must withstand extremely high temperatures. An example is in the compact arc lamps used in stage lighting. Venture Lighting Intl. of Ohio is one such company using No. 29 to adhere the quartz filament cylinder to the nickel–plated brass bases of the lamp. These lamps produce 12,000 watts of light with 575°F (302°C) temperatures; however, the maximum service temperature of the adhesive is considerably higher at 1550°F (843°C).

In addition to embedding heating elements, the cement is used to insulate thermocouples, coat resistors and coils. No. 29 also displays excellent resistance to electricity, chemicals and thermal shock.

The cement is supplied in a two–part, powder–liquid form and is mixed together as it is used. It can applied by brushing, dipping, pouring, molding or mechanical dispensing, and it adheres to glass, ceramics, porcelain and metals.

For more information on Sauereisen's No. 29 cement, contact: Sauereisen Cements Company, 160 Gamma Drive, RIDC Industrial Park, Pittsburgh, PA 15238. Ph: (412) 963–0303.

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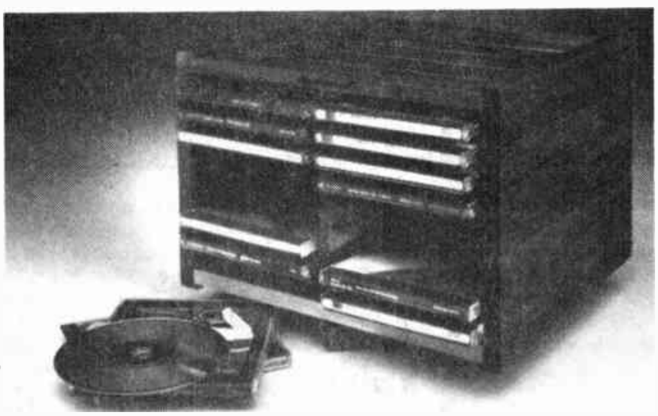

CD Storage Unit

Discwasher has announced the availability of this handcrafted, solid American Walnut, CD storage unit. The cabinet holds up to 36 discs (18 per side) and has a swivel base that allows the user to store more discs in less space.

Available from Discwasher dealers. For more information contact: Donna Austi, HWH Enterprises Inc., Ph: (212) 355–5049.

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A complete selection of R-DAT tape cassettes and pancake reels is now available from DIC Digital Supply Corp. DIC Digital is introducing the digital audio tape in a range of sizes and formats to fit a variety of anticipated recording and duplicating industry requirements.

Included are professional format pancake reels as well as cassettes in 46, 60, 90, and 120-minute formats.

For more information contact: Joseph Martinez, DIC Digital Supply Corp., 2 Universtiy Plaza, Hackensack, NJ 07601. Ph: (201) 487-1026.

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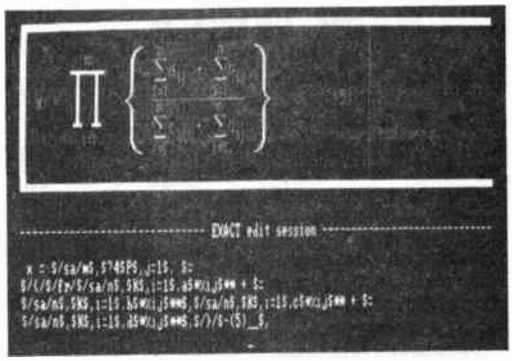

Exact Formatting

If you've ever had to get complex math equations in amongst the text of your document, but had to Letraset them in, despair no more.

Exact 3.0, an advanced RAM resident math typesetting program that cooperates with all PC based word processors has been released by Technical Support Software Inc. According to TSS, Exact is the only PC math typesetting which combines WYSIWYG on–screen interactive editing with the ability to continue using your existing word processor.

The software supports all printers which can use IBM Graphics or Epson emulation modes including QMS, AST, and IBM laser printers.

The program can be accessed at any time from your word processor through a pop–up, split–screen Edit Session. The user types Exact commands on the bottom screen and sees the math expression instantly appear on the top screen. When the expression looks correct, the user exits the program, and places the cursor in amongst the text at the desired location. When a print is executed, Exact translates the codes into the expression at the selected location in the document.

The package includes twenty fonts with over one thousand symbols and characters. Any character can be rescaled up to 81 times its size. A font editor is also included which allows users to create their own characters and use them as easily as the standard fonts. Drivers are available for all common dot matrix and laser printers. The program requires 64K to 128K of RAM depending on the number of fonts loaded at one time. For the IBM PC, XT, AT and compatibles, with any graphics card (including the Hercules).

A free interactive demo disk is available by calling (617) 734–4130. For more information contact: Glenn Wright, TSSI, 72 Kent St., Brookline, MA 02146.

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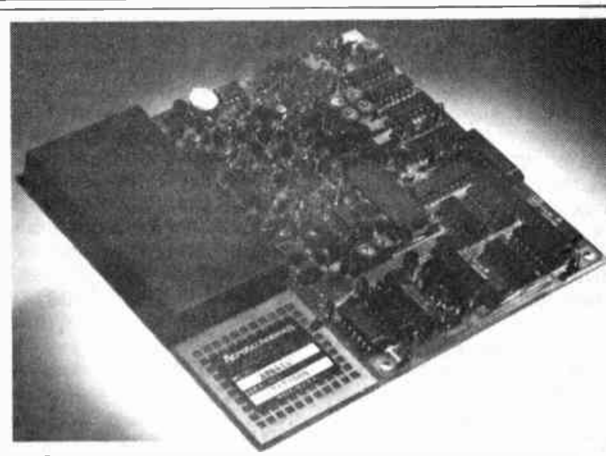


A/D Converter

A new 14-bit, 1 MHz A/D converter from Acrotechnology is targeted primarily at OEMs and manufacturers of equipment used for speech and acoustics, automotive, seismic, medical, and vibration applications.

The AT6414 is built on a single 5.5 x 6 inch board and includes Sample and Hold and sufficient board space for a multiplexer and a second Sample and Hold if required.

For further information on the AT6414 or other products manufactured by Acrotechnology contact: Bill Sapankevych, VP, Acrotechnology, 66 Cherry Hill Dr., P.O. Box 487, Beverly, MA 01915. Ph: (617) 927-6400.

Circle No. 72 on Reader Service Card

World Radio History

Norton Back With a Rotary Engine

The famous Norton motorcycle returns with a Wankel rotary engine - how they overcame some of the engine's limitations.

By Peter Hartley

After almost 18 years of careful development, the rotary-engined Norton motorcycle is all set for sale to the public by the end of this year. Its successful launch will mark a watershed in motorcycle design and possibly a significant upturn in the fortunes of the resurgent, but at present small, British motorcycle industry.

The end of 1987 should see a civilian version of Norton Motors' 588 cm^3 rotary-engined machine in full-scale production at its plant at Shenstone in the English midlands. Furthermore, the company intends to field a full works' team on specially developed, high performance versions of this model in road racing events, starting in 1988.

Philippe Le Roux, the company's managing director, said: "we plan to race next season, probably in the World Endurance Championship, and certainly in the British Grand Prix. We will enter whatever class the racing authorities permit."

Overcoming Wear Problem

The work that was to lead eventually to the development of the twin rotor engine used in the new Norton machine, was initiated by the former BSA company as far back in 1969 and the present engineering director of Norton Motors, David Garside, was involved in that project.

The Wankel type engines produced by NSU, Mazda and Curtiss Wright have oil-cooled rotors. Of necessity, therefore, each had an oil sump, pressure pump and filter, and the rotor had to have oil seals. All these components are similar to those used in a conventional four-stroke reciprocating engine.

The oil sealing system for the orbiting rotor has always presented both wear and sealing problems at high speeds. This is the reason why the crankshaft speeds of these engines have always been limited to only 20% higher than those of the equivalent reciprocating power units.

A different and more effective approach was adopted in the design of the Fichtel & Sachs 13.5kW (crankshaft) industrial engine, which BSA bought at the commencement of its development programme in 1969. Its arrangement entailed the use of induction air for cooling the rotor. The outcome was a simpler engine that cost less to produce and did not suffer the limitation of oil scraper rings becoming progressively less effective as speeds rose.

Twin Rotors

Lubrication in the Fichtel & Sachs engine was on the total loss principle, using a petroil mixture as with traditional two-stroke motors. This mixture was drawn through the passages within the rotor, lubricating all the wear surfaces and rolling elements of the bearings before being burned in the combustion chamber. An outstanding advantage of this arrangement was remarkably low friction loss and therefore high mechanical efficiency, despite the relatively low brake mean effective pressure (BMEP) produced.

Since the power produced by the F & S engine was inadequate for competing in the motorcycle market, BSA carried out a succession of modifications designed to bring it up to 30kW (crankshaft).

Initial tests with forced air-cooling and charge-cooling of the rotor, showed that the front wheel slowed the passage of cooling air to an unacceptable extent. To correct this, the engine was doubled up to a twin rotor configuration so that a rotor chamber stuck out on either side of the wheel into an uninterrupted flow of cooling air.

This led to the adoption of the air-cooled unit's characteristic circumferential cooling fins which support the chambers and provide heat paths away from the sparking plug areas, as well as providing an attractive styling feature.

Economical On Fuel

Other changes introduced by the BSA research and development team, with the object of improving the power output, included an arrangement whereby the rotor was cooled by induction air only, the fuel being introduced just before the air entered the tuned inlet pipes to the combustion chambers. A pressure wave damping chamber, or plenum chamber, was also introduced to improve engine breathing.

By adopting the twin rotor, air-cooled layout BSA was able to achieve a power output of 60kW (crankshaft) as early as 1971. One version of the BSA engine which weighed considerably less than 45.4kg was soon developing up to 74.5kW (crankshaft). Its specific fuel consumption was about 0.3kg/kWh at maximum torque. This high degree of fuel economy was achieved with the novel arrangement of twin side-by-side sparking plugs and an intercooler in the induction system.

Manganese Bronze Holdings, the former owner of Norton Motors prior to the latter's acquisition by the Norton Villiers Triumph (NWT) Group, has invested some (pound sign)3 million in developing the rotary over the last five years. This has culminated in the evolution of the power unit used in the Norton Interpol 2 police machine and that used by the Royal Automobile Club highway patrolmen throughout Britain. The engine follows the lines adopted in the final BSA design.

Improved Power Output

In the new civilian model's engine, air enters the power unit through a filter and passes into a chamber between the two rotors. It is then drawn through the rotors and over the crankshaft, to emerge via ducts on each side of the top of the crankcase.

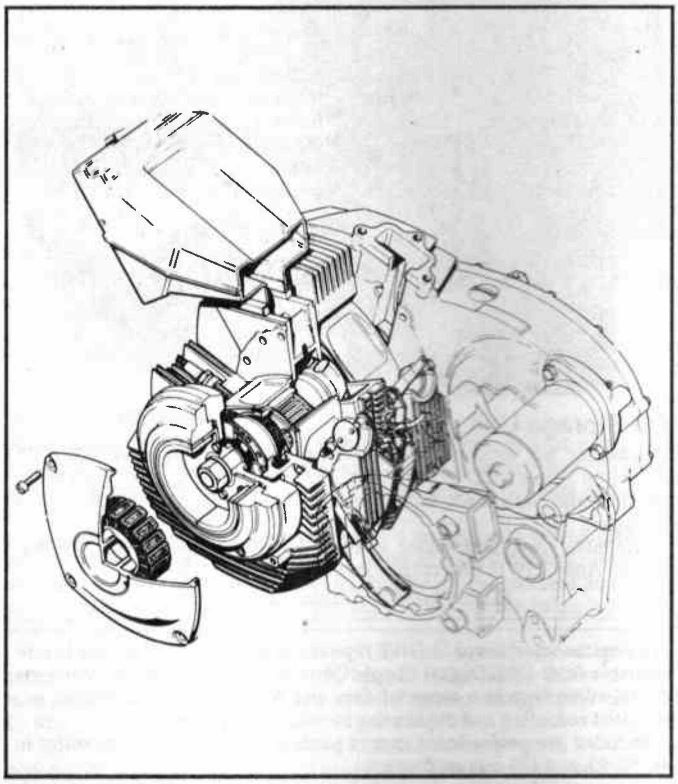
The hot air then enters a plenum chamber built into the box- section spine frame of the machine where its temperature is said to fall by some 30°C. However, when it leaves the plenum chamber and enters the constant-velocity SU carburetors, the air is still at a much higher temperature than the optimum. This leads to a disappointing BMEP of about 760kPa. The butterfly valves that control mixture flow are sited as close as possible to the inlet ports to provide optimal throttle response.

The water-cooled version of the engine to be adopted on the civilian model uses exactly the same layout but gives a BMEP of between 900 and 970kPa which compares with the latest Japanese multi-cylinder motor cycle engines. The Norton factory claims a power output for the water-cooled version of 60kW (crankshaft) at 7000 rev/min and a torque output of 68.5Nm at the same crankshaft speed.

Little Maintenance Needed

The twin-rotor engine, of course, has no valve gear or other highly stressed parts. Moreover it has only three major rotating components, a crankshaft and two three-lobe rotors each orbiting around inside a two-chamber housing. As a result, its reliability is exceptionally high and very little maintenance is needed.

The perennial rotary problems of



A part-sectional view of the Norton rotary motorcycle engine. The problem of seal wear was overcome by the use of air cooling.

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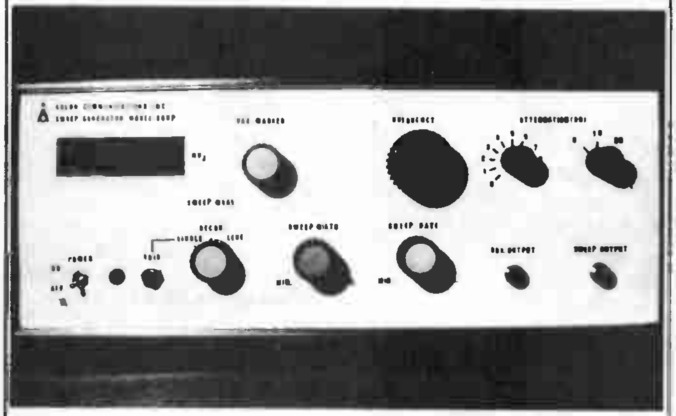

Wide Band Sweep Generator

The Kalun Model 6082 Wide Band Sweep Generator is designed with RF and digital electronics to provide accurate and effective sweep frequency measurements. The sweep signal covers the 600MHz frequency range in one sweep with 0.5dB flatness. The marker frequency is displayed as an intensified spot on the frequency response trace, while also being indicated by a digital frequency counter.

Spectral purity is -30dBc including all harmonics and non- harmonics; sweep width is continuously variable from 200kHz to full bandwidth. Output is 75 ohms, 50dBmV; an output attenuator is continuously variable from 0-10dB and also has steps of 10 and 20dB.

Contact Kalun Communications, 11A Glen Watford Drive, Unit 17, Scarborough, Ontario M1S 2B8, (416) 293-1346.

Circle No. 19 on Reader Service Card

rotor-tip seal wear and heavy fuel consumption were solved relatively early on in the Norton power unit's development. The trochoidal surface of the casings against which the rotor tip seals bear, are plated with Elnisil, a nickel containing 4% by volume of silicon carbide particles, to form a very hard and durable bearing material. The combination of the plates surface and the seals has been shown to last for over 160 000km of road operation in a motorcycle engine.

As is well known, the flanks of the rotors of the Wankel type engine at all times run just clear of the walls of the chamber with only the seals in the rotor tips and end-faces bearing upon them. Furthermore, the rotor and crankshaft rotate on roller or needle-roller bearings of substantial dimensions, enabling them to last the whole life of the engine without attention. The tip seals are honed from a specialized steel that is heat treated.

Smooth At Low Speed

Even the spark plugs specially developed for the engine by Champion, are the long-life surface discharge type with a platinum central electrode, and the higher power capacitor discharge (CD) electronic triggering and distributor ignition system again have no moving parts.

Norton claims fuel consumption figures of 15 to 18km/litre, based on data from police vehicles. The rotor temperature is in fact much the same as on the original F & S motor. The cooling system is also self-regulating in that the air flow increases with engine speed and hence heat production. Over-cooling of the rotors, however, can lead to heavy fuel consumption and high hydrocarbon emissions from the exhaust. Indeed, it took until 1979 for Norton engineers to get the unburned hydrocarbon levels in the exhaust below the statutory emission requirements of the United States, one of its potential export markets.

A major problem in developing the rotary for motorcycles was the idling system. On its first customer machines, Norton Motors used a dead-chamber system. In this the sparks to one combustion chamber were cut so that it pumped cold air via a bypass directly into the plenum chamber. This also put enough drag on the crank to ensure that the working chamber was filled efficiently. Unfortunately, the early users — the police and armed forces — used their machines for a lot of slow speed escort work. The idling system, cutting in and out, made for an unacceptably jerky low-speed ride. This led to the carburation and ignition systems being refined to cope with both cambers firing at idle speeds.

No Vibration

The transverse 180-degree crankshaft of the new rotary-engined Norton is machined from a single casting supplied by Laystall of Wolverhampton, in the English midlands. Just about every other engine component is machined from either stock metal or castings in Norton's own factory.

The primary drive is taken from the offside of the crankshaft via a duplex chain to the clutch drum, which also engages the starter motor. The other end of the crankshaft carries the alternator. This all adds up to an engine that displaces a nominal 588cm^3 but produces over 60kW (crankshaft). It is also extremely compact and is said to be free from vibration. The design of the engine has been discussed at length here because of its unusual configuration and the somewhat chequered history of previous attempts at applying Wankel type power units to motorcycles. However, a motorcycle is not just an engine and some mention should be made of the gearbox and cycle parts of the new Norton.

The transmission uses a five-speed gearbox and the final drive is by chain. The box section spine frame has an integral oil tank and features swinging-fork rear suspension fitted with twin gas/oil damped Marzocchi suspension units having a five- position preload capability. The front and rear wheels are both cast in light alloy.

Racing Model.

The front wheel is mounted in a pair of 38mm diameter tubing, Marzocchi damped telescopic forks, while the braking is taken care of by twin 280mm diameter discs at the front and a single 280mm disc at the rear. The civilian version of the Norton rotary motorcycle is scheduled to go on sale direct from the factory on 20 December, at a price that should be competitive with BMW's K100 four-cylinder machine and with a 225km/h top gear performance. According to Mr Le Roux the NVT Group, which owns Norton Motors, is looking to produce up to 5000 of the 588cm^3 rotary engines a year, of which 2000 or so will go into the Interpol 2 machine and the new water-cooled civilian model. The remaining engines will be sold to the aerospace and defence industries for applications where their high power-to-weight coefficient is required, such as in portable generating sets and for powering remotely piloted aircraft.

Already in the United States the Teledyne company, which makes Continental aircraft engines, is licensed to manufacture Norton rotary power units, and the Mercury marine company is assessing the rotaries as replacements for two-stroke outboard motors. In Britain, Thorn EMI is buying engines for it Cymbeline radar programme.

Meanwhile, on the motorcycle front, the Norton rotary racer is still in its infancy, but the company claims to have already achieved a power output of 97kW (crankshaft) with another 15kW confidently expected after further tuning. Such tuning, incidentally, is similar in approach to that adopted with two-stroke engines. The rotary has been found to respond to alterations in the length of its induction systems, port timings and exhaust dimensions.

Peter Hartley is the deputy editor of Engineering, a publication from London, England.

Bromine and the Ozone Layer

The seasonal depletion of the earth's protective ozone layer above Antarctica has both intrigued and concerned scientists for several years. Chlorofluorocarbons have generally received the blame, buut some researchers belive catalytic bromine reactions may also play a role. To study the theory, researchers at the Georgia Institute of Technology are using laser photolysis to create the suspect chemicals in an atmosphere simulating the frigid cold of the Antarctic winter.

A possible explanation is a catalytic reaction involving bromine monoxide and chlorine monoxide. The two highly reactive chemicals are commonly found the atmosphere as a result of photochemical degradation of halocarbons used in refrigeration, foam insulation and fire extinguishing. Through a series of reactions, the bromine and chlorine monoxides could catalytically break the ozone into diatomic oxygen. Because they act as catalysts, the chemicals are not broken down, but remain to continue their destructive work.

Under normal conditions, atmospheric nitrogen dioxide reacts with the chemicals to tie up the more damaging forms. However, another set of reactions causes nitrogen dioxide levels to drop during the cold winter months.

The Georgia Tech group will create the bromine monoxide and chlorine monoxide with laser photolysis and follow the reactions with spectroscopic techniques.

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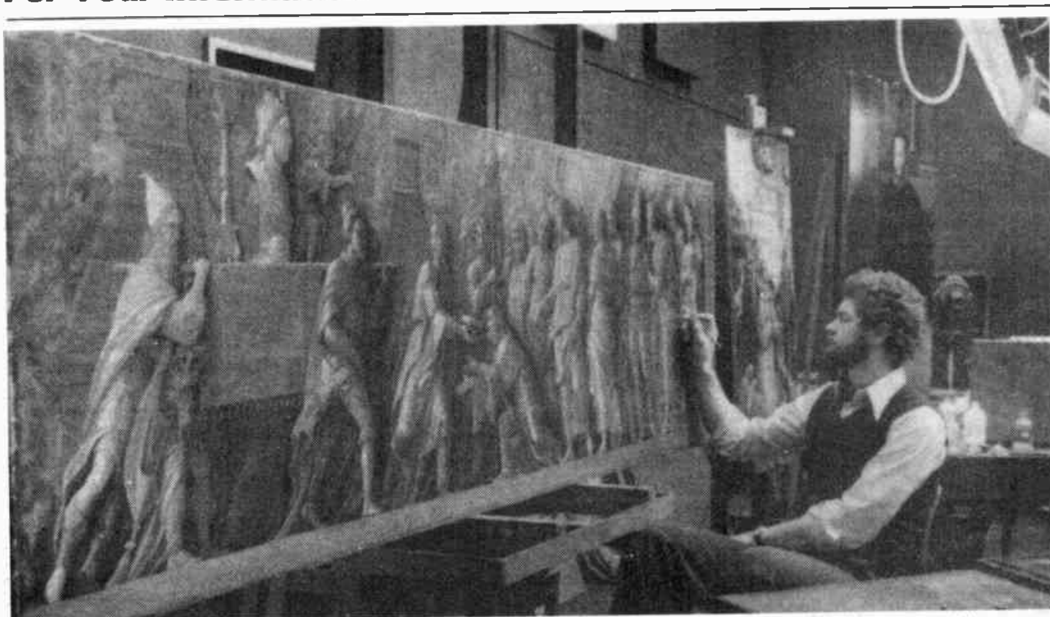

Science and Conservation at the National Gallery

By Lindsey Callander

Founded in 1834, Britain's National Gallery in London today houses one of the world's greatest collections of European paintings. These number more than 2000 and, unusual for a major national collection, almost all are on public display at any one time. There are two exceptions to this: works on loan to temporary exhibitions or to regional collections, and those undergoing cleaning and restoration.

The National Gallery conservation department was established in 1946 to preserve and safeguard the sensitive, often frail and complex structures that form the collection. Broadly speaking, the conservator's work falls into two categories.

The first involves the painted surface of pictures: examination, cleaning, restoration and the treatment of blistering or flaking paint, processes that can transform the appearance of a painting. The second involves the conservation of the support layers on which the work is painted, such as wood or canvas.

Paintings on canvas often have to be relined, using the hot table, low pressure table or hand-lining methods, But almost half the collection, mostly works predating 1650, consists of works on wood panel. It also falls to the National Gallery's restorers to compile and maintain a full conservation record for every picture in their care, and for each newly acquired painting. In addition, regular checks are made on every picture in the collection.

The conditions of the conservation studios are tailored to the work undertaken. The walls are painted in dark, matt colours to avoid unnecessary reflections; the axis of the studios runs east-west so that by shutting out light from the south-facing slope of each roof it is possible to obtain pure northern light, and steady, cool illumination unaffected by the fluctuations of sunshine. The studios are air-conditioned to maintain a constant temperature and relative humidity, and these are monitored and checked at least twice daily.

Microscopy Fundamentals

The work of the conservation and scientific departments is often inextricably linked. The latter was instituted in 1934 with a staff of one. Today it comprises a team of six whose work centres on research on the effects of the environment, organic analysis (on pigments, ground materials and so on). Fundamental to the work of most museum research laboratories is microscopy, both optical and chemical. By means of microscopical examination and chemical tests, most pigments can be identified in minute samples and the species of wood used in panel paintings or the textile fibres of canvas can be identified.

The greatest value of microscopy lies in the analysis of the layer structure of paintings. The usual procedure is to embed a flake of paint no more than 0.5mm in diameter in a block of transparent plastic, which is then ground down until the edge of the paint flake is exposed. It can now be examined under the microscope, showing the sequence of layers: from the ground (layer of preparation), to the drawing, paint layers, glazes and final varnish. This is illuminating both to scientists and to art historians in revealing facts about the artist's techniques and materials. Of course, samples are only taken when a picture is undergoing cleaning or chemical analysis might help solve problems and treatment.

Crucial to the paintings' well-being is the scientific department's research on environmental conditions. The effects of factors that can cause deterioration, such as light, air and its impurities, humidity, heat, can often be ascertained in laboratory conditions and the results related to real conditions of exhibition.

Never Varnished

Color measurements on paintings to assess the extent of color change are made regularly by means of colorimetry or spectrophotometry. At present, a group of paintings, chosen for their susceptibility, is being measured at five-year intervals, and at the same time, data on the environment is being recorded for illuminance, humidity, lighting, proportion of ultraviolet in the light, and pollutants. The ultimate aim is to link environmental factors to colour changes, with a view to preventive measures being adopted in the future.

"A Cornfield with Cypresses" by Vincent Van Gogh is one of the very few paintings that have never been varnished, either by the artist or by subsequent generations. Over the decades a heavy layer of dirt accumulated on the surface and the painting was beginning to lose its golden aura. In 1985 it was removed from the galleries to be cleaned by conservator Tony Reeve.

Describing the work from a technical point of view, he explains: "Almost all late 19th century paintings have been varnished at a later date. Happily, this one is a rare exception. The use of varnish was contrary to the Impressionists' concept of colour, so to varnish it would be totally wrong. On the whole, the picture was cleaned using distilled water, although to remove earlier dirt a small amount of potassium oleate was used. The surface dirt was removed using brushes rather than the more usual cotton-wool swabs, because of the high impasto (the thickness and texture of the paint).

"In certain areas the paint structure showed cracking and surface deformation, but it was possible to counteract these using the low pressure table. Under pressure, the aqeuous glue preparations in the picture were moistened, relaxed and then reformed to a flat configuration. Flaking paint was attached using sturgeon glue while the painting was still on the table. Finally, the edges of the painting, which had been pulled around the stretcher years ago, were reclaimed by putting the canvas on a larger stretcher."

Challenging Task

The restoration of Cima de Conegliano's immense altarpiece, "The Incredulity of St Thomas", was one of the most challenging tasks to be undertaken by the gallery's conservators. After extensive treatment, it was returned to public view in 1986, a triumph of early 16th century painting and 20th century restoration.

The painting was acquired by the National Gallery in 1870 with a long history of flaking paint and attempted restoration. By 1947 the paint was flaking to such an extent that the altarpiece had to be withdrawn from display.

So in 1969, the then chief restorer decided that the paint and gesso layer should be transferred to a new support, an extreme and irreversible treatment used as a last resort.

Transfer and restoration were to take many years. First, the paint surface was faced with layers of tissue, cheesecloth and wax. The piece was then placed face down and removal of the wooden panel commenced, layer by layer, with the final layer removed with a scalpel.

After removal, the gesso layer was reinforced with an acrylic primer and then attached to fine linen. This in turn was attached to a new support of aluminum honeycomb and glass fibre. Finally, retouching was done, based on an analysis of Cima's pigments.

"Our knowledge of Cima's techniques," said conservator Jill Dunkerton, "proved invaluable when making the colour retouchings because it enabled us to imitate the layer structure of the original more accurately. Cima used an exceptionally wide range of pigments of a very high quality. He was well placed to do so, since Venice was the centre of the European pigment trade."

The altarpiece is once again on public display.

Continued on page 25

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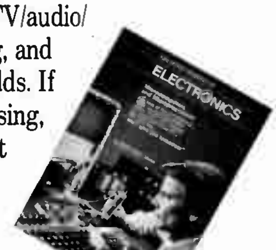

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Logic Pulser

A simple, inexpensive companion for your logic probe

By Mike Tooley

This instrument is designed for use in conjunction with a logic probe but it can also be used in its own right as a means of changing the logical state of a digital circuit without the need to make any soldered connections. The pulser is fully compatible with both CMOS and TTL devices.

Circuit Description

The complete circuit diagram of the Logic Pulser is shown in Fig. 1. A 555 timer, IC1, is connected as a monostable pulse generator.

The output of IC1 (at pin 3) will go high for a period determined by the time constant, R2 x C2, whenever the pulse button, S2, is depressed. With the values specified, the pulse duration is approximately 5ms.

The polarity of the output pulse is switched by means of S1. Transistor TR1 acts as an inverter while TR2 and TR3 operate as saturated switches (providing positive and negative output drive respectively). The output current is limited by resistors R7 and R8. With the component values shown and assuming a standard TTL 5V supply, the peak current sourced or sunk into a short circuit will be limited to several hundred milliamps.

When no output pulse is being produced, TR1 conducts but both TR2 and TR3 are in a non-conducting (switched off) state. The output at the probe tip thus floats in a high- impedance state.

Diode, D1, is incorporated in order to provide protection against inadvertent reversal of the supply leads.

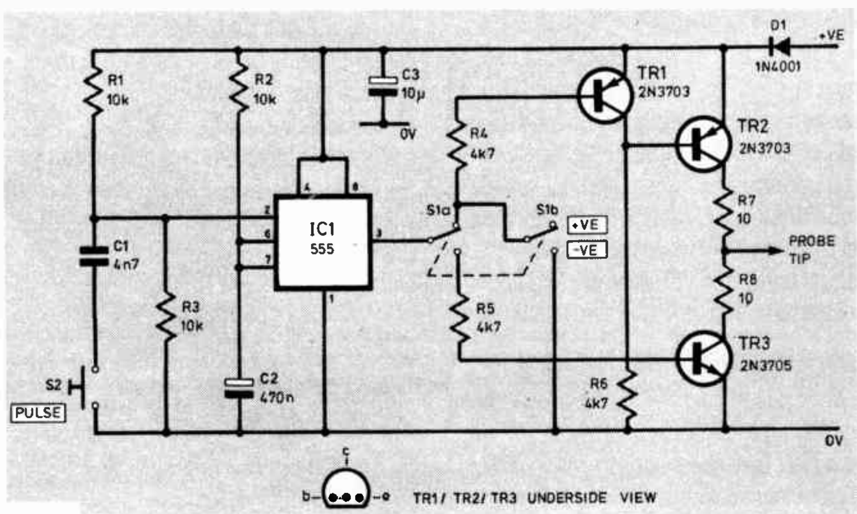

Fig. 1 Complete circuit diagram for the Logic Pulser.

Construction

All components for the logic probe are mounted on a 0.1 in matrix board comprising 9 strips of 37 holes.

The component layout of the Logic Pulser is shown in Fig. 2. The following sequence of component assembly is recommended; button switch, IC socket, terminal pins, links, transistors, resistors, diode, and capacitors.

The probe tip boss and supply lead should be connected last. In the latter case, care should be taken to ensure the correct polarity (red crocodile clip/striped lead to positive).

Constructors should note that a total of 18 track breaks are required and these should be made using a spot face cutter. If such a tool is unavailable, a sharp drill bit of appropriate size may be substituted. Three links should also be made under the board, shown dotted on the topside view in Fig. 2.

Before inserting the IC into its holder and mounting the circuit board in its final position, carefully check the components, links, and track breaks. Furthermore, it is worth checking that all of the polarized components (including transistors, diode and electrolytic

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capacitors) have been correctly oriented. Also, carefully examine the underside of the stripboard for dry joints, solder splashes, and bridges between adjacent tracks.

Probe Case

When the board has been thoroughly checked, the integrated circuit should be inserted into its holder. The circuit board should then be temporarily placed in the base of a suitable probe case (approx. 140mm x 30mm x 20mm). Depending on the case used, it may be necessary to fasten the board with screws; some cases may allow friction fitting within the two halves.

The upper half of the probe case should then be marked for drilling and cutting the apertures that will be necessary in order to permit access to switches S1 and S2. Switch S1 will require a rectangular hole measuring approximately 8mm x 3mm, while S2 will require a square aperture measuring 12mm x 12mm. In both cases it will be necessary to drill several small round holes and then apply a small square or rectangular section file.

When complete, the two case halves should be screwed together (using the countersunk screws supplied with the case) and the probe tip should then be fitted.

Testing

The probe should be tested using a current limited 5V supply of the type normally employed with TTL and CMOS circuits together with a logic probe. Connect the pulser and logic probe supply leads together and to the power supply (taking care to observe correct polarity). Then link the two probe tips together using a short length of insulated wire fitted with two crocodile clips.

Switch S1 should first be set to produce a positive pulse. Do not, at this stage, operate the pulse button, S2, but check that the output of the pulser is in a tri-state condition (none of the logic probe's LEDs should be illuminated). If this is not the case, disconnect the pulser, dismantle and check the pulser's circuit board again.

Having verified that the pulser operates in the quiescent state, a pulse should be generated by depressing S2. At the same time the state of the logic probe's LEDs should be examined. Hopefully, these should confirm that a positive pulse is produced. If no pulse is produced or if the logic pulser generates a continuous low or high state output, the pulser should be dismantled and the circuit layout should be carefully checked again. Finally, the foregoing procedure should be repeated with S1 switched to produce a negative going output pulse.

Parts List

Resistors
All Resistors are 0.25W 5%

R1,2,3	10k
R4,5,6	10k
R7,8	10R

Capacitors

C1	4n7
C2	470n tant. 35V
C3	10m tant. 16V

Semiconductors

IC1	555 Timer
D1	1N4001
TR1,2	2N3703 pnp
TR3	2N3705 npn

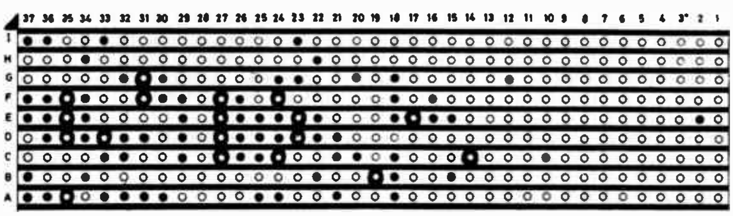
Miscellaneous

S1	Low profile PCB mounting keyboard sw.
S2	Ultra-min. DPDT vertical slide sw.

8-pin low-profile IC socket; probe case (140mm x 30mm x 20mm); single-sided 1mm terminal pins (3); stripboard, 0.1 inch matrix, see text.

Specifications

Output Pulse Duration:	5.2ms
Pulse Polarity:	Switched positive or negative
Peak Output Current (short circuit):	200mA (approx.)
Quiescent Resistance at Probe Tip:	Greater than 200k
Power Supply Requirements:	4.5V to 15V at less than 15mA quiescent



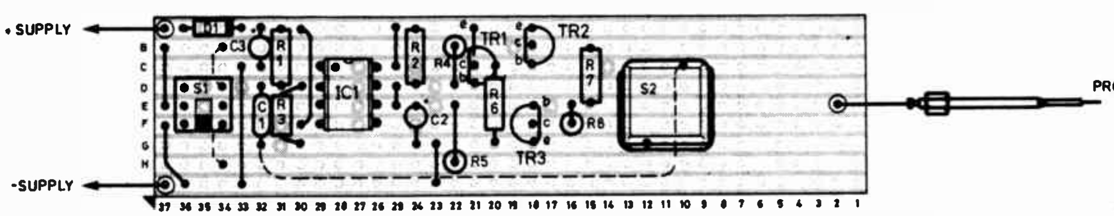


Fig. 2 Component layout and wiring for the Pulser. The link wires shown dotted must be soldered to the underside of the board. The breaks to be made in the underside copper tracks are shown left.

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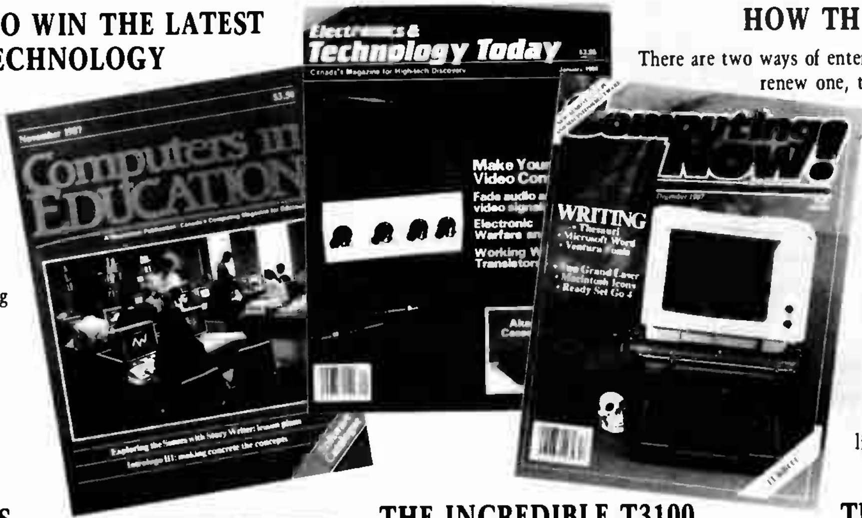

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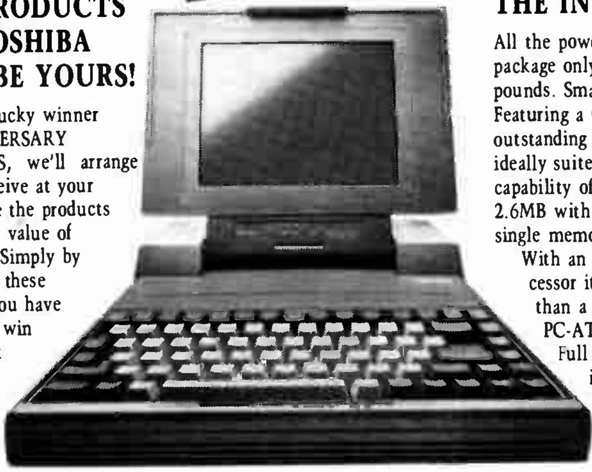

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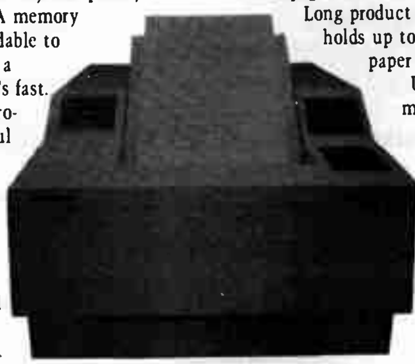

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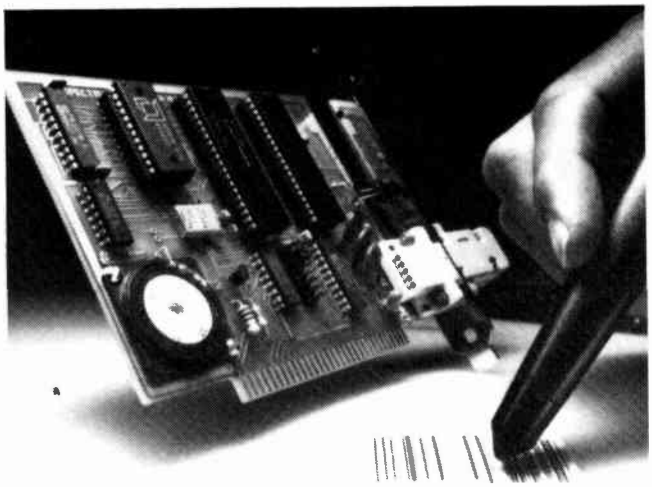

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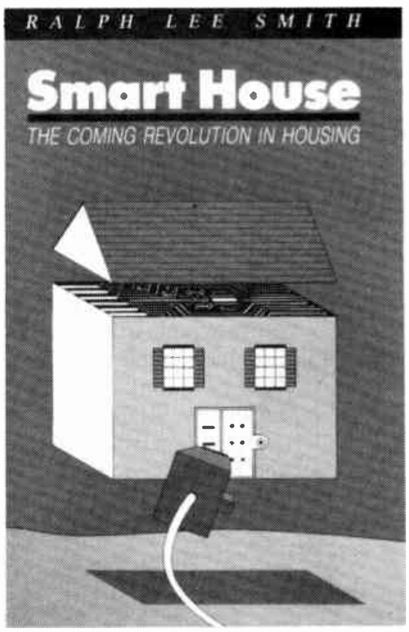

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Continued on page 45

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Hyper-Fuzz

More distorted effects for your muscial instrument

By Charles Dancer

Distortion or fuzz units are used to make the sound of a musical instrument more 'interesting' by adding harmonics to it. This is usually achieved by using a non-linear amplifier of some kind to clip or round-off the peaks and troughs of the audio signal. The resultant distortion consists of a wide range of harmonics at multiples of the input frequency.

The input/output characteristic of the Hyper-fuzz is shown in Fig. 1. Each half-cycle of the audio signal is 'folded over' three times before being clipped. This gives rise to a narrow band of harmonics, the frequency of which is dependent on the amplitude of the input signal. When used with a guitar a filter-sweep effect is produced as each note dies away.

In addition, the circuit can produce conventional clipping distortion and an intermediate effect, selected by a three position toggle switch, SW1. These extra characteristics are also shown in Fig. 1.

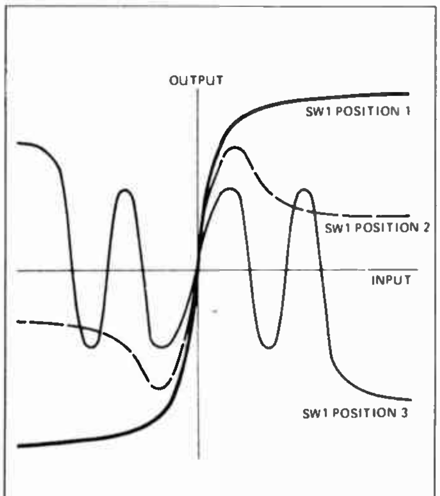

Fig. 1 The input/output characteristic of the circuit with the effect switch in each of its three positions.

The circuit board is mounted in a small diecast box fitted with a foot switch (SW2) which is used to switch between the effect and a 'straight through' signal. A metal box was chosen in preference to a ready-made foot switch case because of it's lower cost and better screening properties. The other controls on the unit are DEPTH (RV1) which varies the severity of the distortion, and LEVEL (RV2) which is used to match the distorted and straight-through signals in volume.

Power for the effect comes from a 9V battery, or from an external 9V supply, the current consumption being only about 2mA. The internal battery is connected when a jack is plugged into the input socket, so there is no need for an on/off switch.

Construction

If the recommended case is used, it should be drilled as accurately as possible as shown in Fig. 2. The positioning of the holes is fairly critical. The PCB should be assembled (Fig. 4) starting with the smaller components ensuring that all leads are cropped close to the board.

When the two pots are mounted, their spindle centres should be about 15mm above the top of the PCB.

If the jack sockets have break contacts fitted, the tags for these should either be cut off or bent under the socket. The sockets should then be attached to the board by 15mm lengths of flexible wire. The toggle switch and RV2 case can then be connected to the board along with the battery clip and six 45mm pieces of wire, for the foot switch.

The PCB spacer is a piece of 4mm thick perspex or wood 22 x 26mm, with a 1/2" central hole. To make assembly easier the spacer can be lightly glued to the track side of the PCB. Before the unit is assembled an insulating grommet should be fitted to the hole for the power connector.

The PCB assembly can then be inserted into the case. To do this, the output jack and the two pots should first be located in their respective holes (the pots may need to be bent back a little).

Once the pots are pushed through, the board should fit neatly inside the case and the other socket and toggle

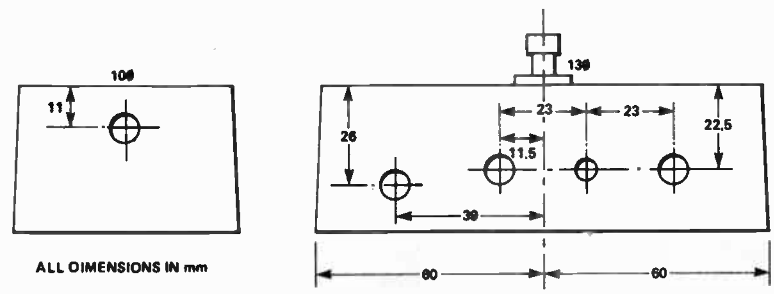

Fig. 2 Drilling the case for the Hyper-Fuzz.

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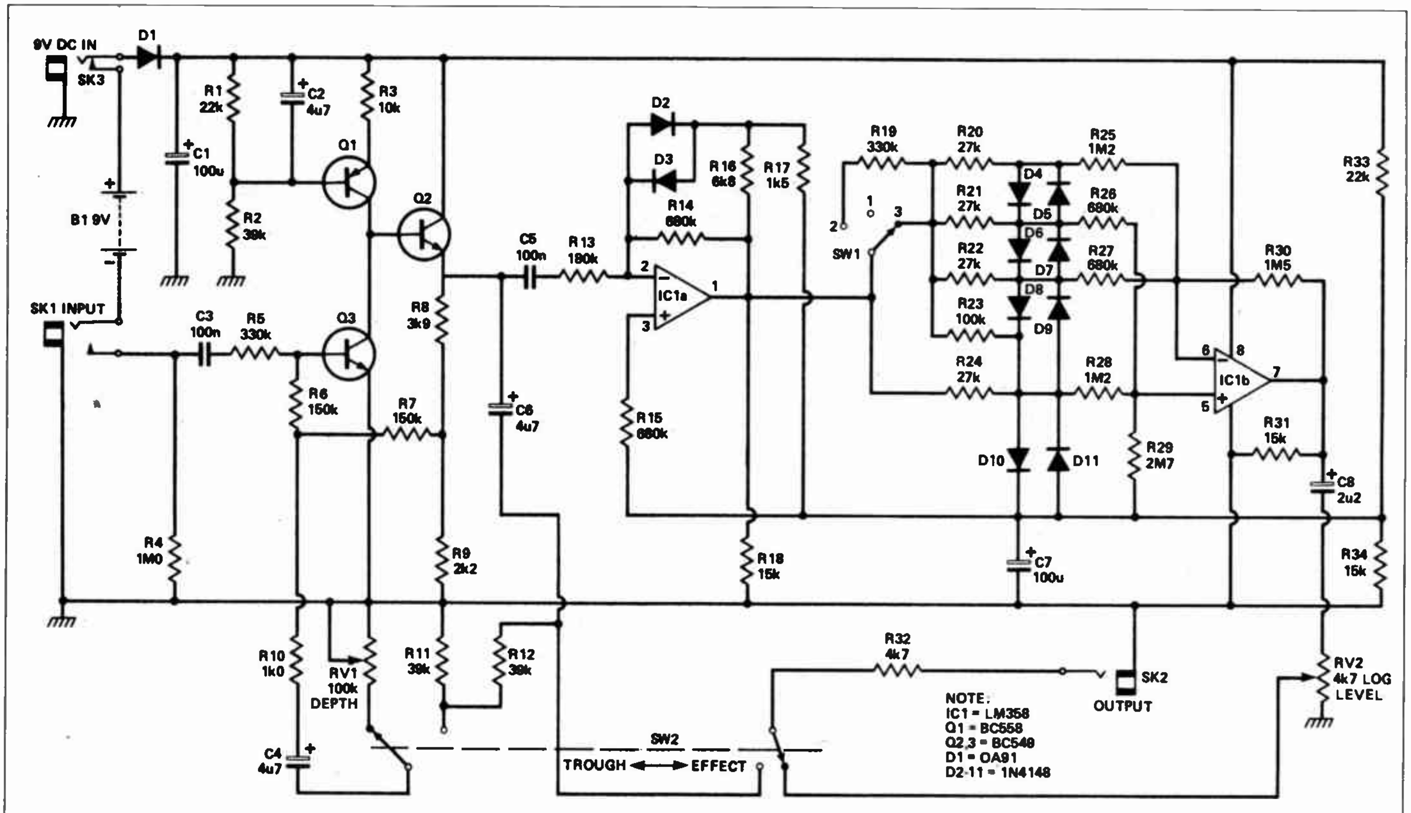

Fig. 3 The circuit diagram of th Hyper-Fuzz.

switch can then be fitted. The foot switch should be fitted through the holes in the board, spacer and case so that it holds them together, and it's leads soldered as shown on the component overlay.

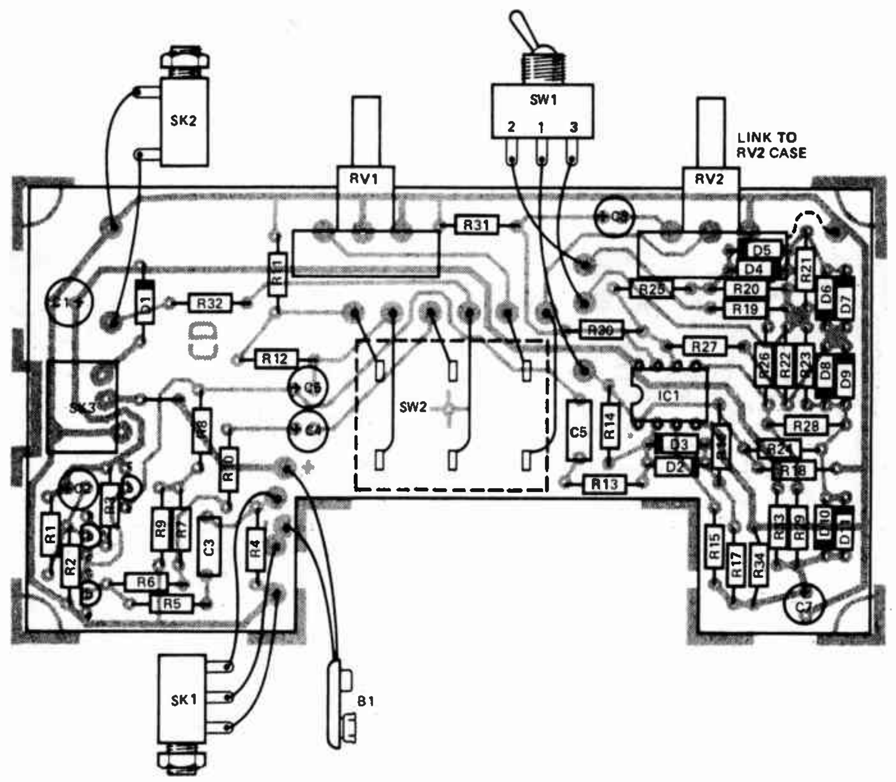

Fig. 4 The components overlay.

If you intend to drill the base plate to take screw- mounting feet, make sure that the screws will not interfere with the jack sockets. With care, they can be positioned so that the feet slightly overlap the retaining screws, thus preventing them getting lost. The battery can be cushioned using strips of foam weatherstripping stuck inside the case and on the side of the switch, and held in place by a piece of foam rubber glued to the base plate.

Operation

The unit should be set up in the same way as a standard distortion unit. Adjust RV1 and SW1 until the desired effect is heard, then adjust RV2 so that there is little change in volume when the foot switch is pressed. Because of the severity of the distortion the full Hyper-fuzz effect (Setting 3) works best with simple 'pure' signals. Playing chords produces harsh ring-modulator-like effects which are interesting but not exactly musical. Although the unit was designed for use with electric guitar and bass, it can also be used to alter the sound of keyboard instruments, drum synthesizers and even vocals.

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How It Works

The input signal is fed to a pre-amplifier comprising Q3, which provides the gain, a constant current source (Q1), and an emitter-follower (Q2) to buffer the output. With SW2 in the 'Through' position, the gain of the pre-amp is set at about one by negative feedback through R10 and R6 and its output goes to the output socket (SK2) via C6. With SW2 switched to 'Effect', RV1 is used to vary the amount of feedback and hence the gain of the pre-amp.

The distortion-generating part of the circuit uses an LM358 dual op-amp, which was chosen because of its low current consumption and wide output voltage range. R33/34 and C7 provide a stable 3.5V mid-rail for the op-amps. The signal from the pre- amp is further amplified by IC1a. The op-amp is prevented from clipping by D2 and D3, which limit its output to about 6V peak to peak. With SW1 in position 3, the output of IC1a will drive the four pairs of diodes, D4-11, to produce four wave forms clipped at 0.5, 1, 1.5 and 2V. These are then fed to alternate inputs of a difference amplifier (IC1b). So, as each diode begins to conduct, the gain of the circuit reverses polarity.

With SW1 in position 1, only the lower pair of diodes is driven, so the circuit produces 'ordinary' fuzz. For the intermediate effect, R19 is used to attenuate the signal reaching the upper diodes. R23 is necessary to match the three effects in volume.

Parts List

Resistors

R1,33	22k
R2,22,12	39k
R3	10k
R4	1M0
R5,19	330k
R6,7	150k
R8	3k9
R9	2k2
R10	1k0
R13	180k
R14,15,26,27	680k
R16	6k8
R17	1k5
R18,31,34	15k
R20,21,22,24	27k
R23	100k
R25,28,30	1M5
R29	2M7
R32	4k7
RV1	100k lin PCB mounting
RV2	4k7 log PCB mounting

Capacitors

C1,7	100u 16V rad. elect.
C2,4,6	4u7 63V rad. elect.
C3,5	100n polyester
C8	2u2 63V rad. elect.

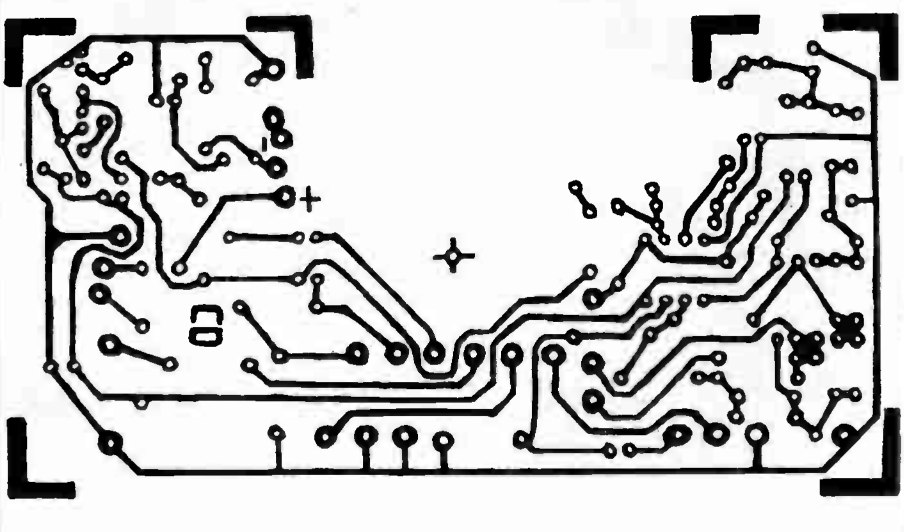
Semiconductors

IC1	LM358
Q1	2N6015 or BC558
Q2,3	2N5818 or BC549
D1	1N4001 or equiv
D2-11	1N4148

Miscellaneous

SW1	SPDT centre-off tog.
SW2	DPDT foot sw.
SK1	1/4" stereo socket
SK2	1/4" mono socket
SK3	2.1mm power socket (PCB mnt)

PCB; case; battery clip; knobs; feet; PCB spacer; 3/4in grommet; foam rubber, washers.



The printed circuit board artwork for the Hypr Fuzz.

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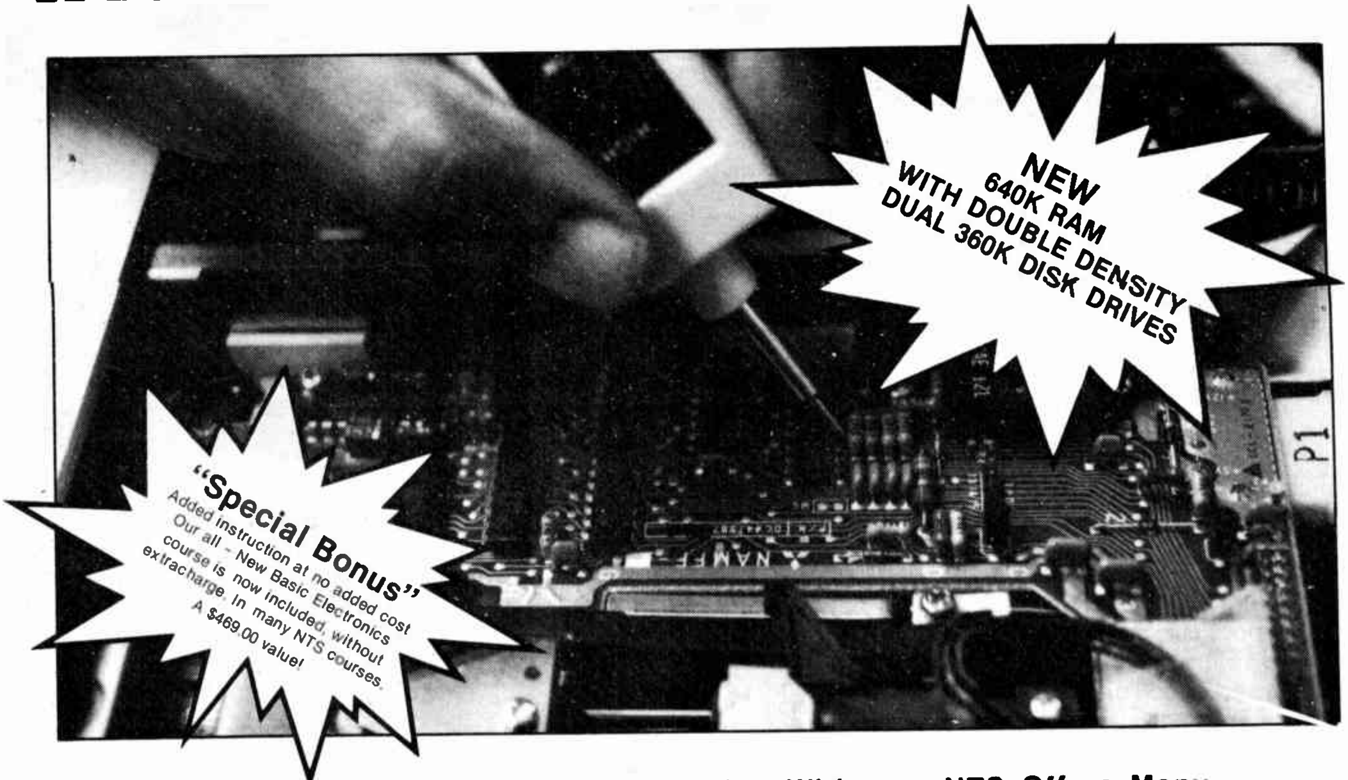

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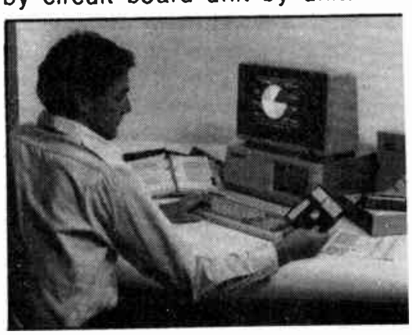

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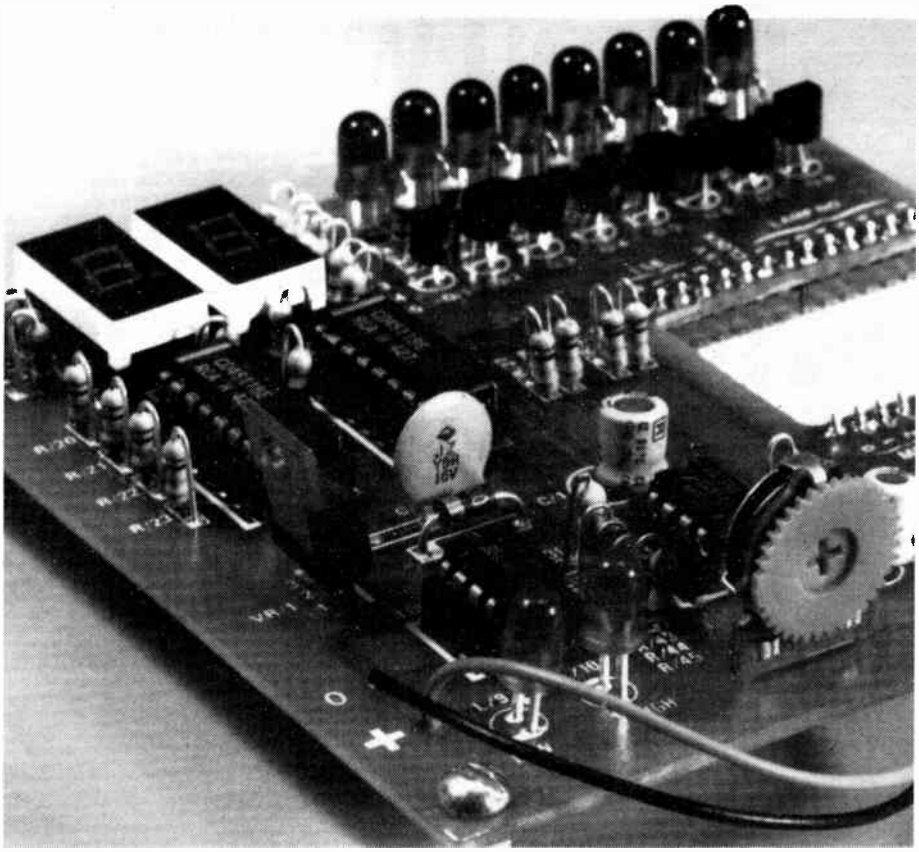
The Digital Designer



Learn the basics of digital electronics with the EduKit DD-200.

By Edward Zapletal

Single-chip microprocessor technology certainly has eased the burden for many a designer of electronic gadgetry. But the important thing to remember here is that, although microprocessors make it easy, understanding the principles of how they work is still a necessity. This is the idea behind the DD-200 Digital Designer from EduKit.

The Purpose

The DD-200 is designed to give the individual a solid introduction into digital electronics through hands-on experience. It won't make anyone into a wiz-bang computer technician right away, but it does provide enough background to pave the way to more complex study.

The Hardware

The DD-200 is actually a fully built and tested version of the EduKit DD-100 with a few extras added. Included with the 200 are the 9V plugpack and solderless breadboard.

The motherboard is designed so that it plugs directly onto a 65-column solderless breadboard leaving easy access to the 28 connection points for such things as switches, LEDs, clock, logic probe, and regulated 5V power.

A number of display devices are supplied including two seven-segment LEDs, a row of ten single LEDs, and two single LEDs to indicate the clock operation.

Courseware

The 62-page workbook provided with the DD-200 package provides the individual with a number of experiments and problems in varying degrees of complexity.

The first two chapters deal with setting up the unit, getting to know some of its basic functions, and a review of simple electronic circuits and principles. The transistor is also discussed here as it's the basis for all logic-based electronics.

Chapter three introduces the various logic gates which are the basis for digital electronics, and simple circuits using individual components, as well as ICs, are provided for hands-on involvement.

Remaining chapters are comprised of the following: Boolean algebra; Demorgan's Theorem; numbering systems such as BCD, Octal, and hexadecimal; combination circuits; and sequential circuits including flip-flops, shift registers, and counters.

Six comprehensive appendices provide additional information for resistor identification, reference texts, pinouts of the ICs used, trouble shooting for circuit construction, details of the logic probe, and plans for a switch de-bouncer circuit.

The basis behind all EduKit products is to teach, whether it's to hobbyists, or students in the classroom, and each chapter contains a modest number of questions for the purpose of testing comprehension. A teacher's workbook is available, as part of the package, for checking answers.

Bottom Line

According to EduKit, the DD-200 has gained Canada- wide acceptance from the educational community, with the unit being used extensively in schools as a basic introduction to digital electronics.

On completing DD-200 workbook, the student will by no means be an expert on digital electronics, but will have a good footing on which to build a more solid understanding of how digital electronics contributes to the more complex world of microprocessors.

The complete DD-200 is priced at $189.95 which includes the teacher's workbook; there is also special pricing available for schools. For those who wish to purchase the DD-100 kit, it's available for $59.95 without the above-mentioned extras.

Available from EduKit, P.O. Box 38, Station N, Toronto, Ontario M8V 3S4. Phone: (416) 897-1217. Also available from Active dealers across Canada. Phone: 1-800-361-5884 (Canada, excluding Quebec and Ottawa Valley); 1-800-361-9046 (Que. & O.V.) ■

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Introducing Microprocessors

A new series on understanding microprocessors and how they work.

By Mike Tooley

The general learning objectives for part one of Introducing Microprocessors are that readers should be able to:
(a) understand the terminology used to describe microcomputer and microprocessor based systems
(b) identify the major logic families and scale of integration employed within integrated circuits
(c) draw a diagram showing the architecture of a representative microcomputer system and state the function of the principal internal elements
(d) understand binary and hexadecimal number systems and convert from/to decimal
The specific objectives for this part are as follows:

1.1 Terminology

1.1.1 State the meaning of any of the terms listed in the glossary 1.1.2 Distinguish between the terms; computer, microprocessor, microcomputer, and single-chip microcomputer.

1.2 Integrated Circuit Terminology and Logic Families

1.2.1 Define the terms SSI, MSI, LSI and VLSI as applied to integrated circuits.
1.2.2 State the characteristics of CMOS and TTL semiconductor technologies.
1.2.3 State the basic properties of CMOS and TTL logic families.

1.3 System Architecture

1.3.1 Draw a block diagram showing the internal architecture of a representative microcomputer system.
1.3.2 State the function of each of the principal internal elements of a representative microcomputer system.
1.3.3 Explain the bus system used to link the internal elements of a microcomputer system.
1.3.4 Distinguish between the following types of bus; address, data and control.

Related Theory

Explain the binary and hexadecimal number systems.

Convert binary, hexadecimal and decimal numbers over the range 0 to 65535 (decimal).

Explain how negative numbers are represented in microprocessor systems.

Perform addition and subtraction of binary and hexadecimal numbers over the range 0 to 255 (decimal).
Note: Rather than publish a complete glossary of terms, we shall be producing a mini-glossary for each part; introducing new terms as we progress through the series.

Integrated Circuits

The vast majority of today's electronic systems rely on the use of integrated circuits in which hundreds of thousands of components are fabricated on a single chip of silicon. A relative measure of the number of individual semiconductor devices within the chip is given by referring to its "scale of integration", as shown below:

Scale of integration	Abbreviation	Logic gate equivalent
Small	SSI	1 to10
Medium	MSI	10 to 100
Large	LSI	100 to 1000
Very large	VLSI	1000 to 10000
Super large	SLSI	10000 to 100000

The "logic gate equivalent" referred to in the table provides us with a rough measure of the complexity of integrated circuit and simply gives the equivalent number of standard logic gates. A logic gate is a basic circuit element capable of performing a logical function (such as AND, OR, NAND or NOR). A basic logic gate (e.g. a standard TTL two-input AND) would typically employ the equivalent of six transistors, three diodes and six resistors. At this stage, readers need not worry too much about the function of a logic gate as we shall be returning to this later on. Readers need only be aware that such devices form the basis of circuits which can perform logical decisions.

Integrated circuits are encapsulated in a variety of packages but the most popular type (and that with which most readers will already be familiar) is the plastic dual in-line (DIL) type. These are available with a differing number of pins depending upon the complexity of the integrated circuit in question and, in particular, the need to provide external connections to the device.

Conventional logic gates, for example, are often supplied in 14- pin or 16-pin DIL packages while microprocessors (and their more com-

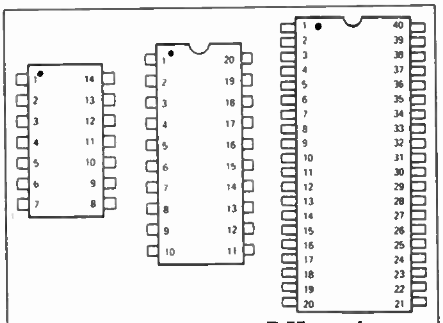

Fig. 1 Some common DIL package outlines (top view).

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plex support devices) often require 40-pins or more. Fig. 1 shows some common DIL package outlines together with pin numbering. It should be noted that these are TOP views of the devices, i.e. they show how the device appears when viewed from the component side of the PCB, NOT from the underside.
In each case, the pins of the IC are numbered sequentially (starting at the indentation) moving in an anti-clockwise direction. Thus, in the case of a 14-pin DIL package viewed from the top, pins one and 14 appear respectively on the left and-right-hand side of the indentation.

Problem 1.1

Fig. 2 shows the outline of an 8-pin DIL device viewed from above. Identify the pin numbers for this device.

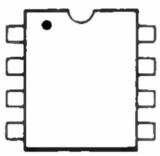

Fig. 2. An 8-pin DIL package.

Logic Families

The integrated circuit devices on which modern digital circuitry depends belong to one of the other of several "logic families". Readers should note this term refers to the type of semiconductor technology employed in the fabrication of the integrated circuit.

The semiconductor technology employed in the fabrication of an integrated circuit is instrumental in determining its characteristics. This encompasses such important criteria as supply voltage, power dissipation, switching speed, and immunity to noise.

The most popular logic families, at least as far as the more basic general purpose devices are concerned, are Complementary Metal Oxide Semiconductor (CMOS) and Transistor Logic (TTL), TTL also has a number of sub-families including the popular Low Power Schottky (LS-TTL) variants.

For the curious we have shown the internal circuitry of representative CMOS and TTL two-input AND gates in Fig. 3. Despite the obvious dissimilarity of these two arrangements, it must be stressed that they have IDENTICAL logical functions.

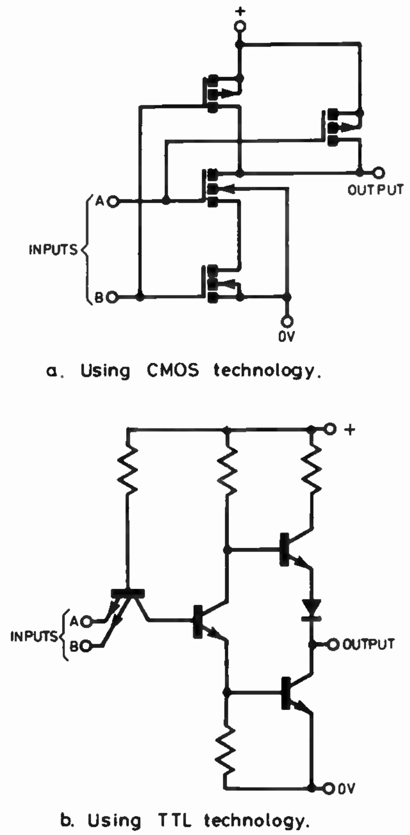

Fig. 3. Representative circuitry of two-input AND gates.

TTL logic

The most common range of conventional TTL logic devices is known as the "74" series. These devices are, not surprisingly, distinguished by the prefix number 74 in their coding. Thus devices coded with the numbers 7400, 7408, 7432, and 74121 are all members of this family which is often referred to as "Standard TTL". Other versions (or "subfamilies") of standard TTL exist and these are distinguished by appropriate letters placed after the "74" coding. Where "Low Power Schottky" technology is used in the manufacture of a TTL logic gate, for example, device coding include the letters "LS". Thus a 74LS00 device is a Low Power Schottky version of a standard 7400 device.

CMOS Logic

The most popular CMOS family is the "4000" series and devices have an initial prefix of 4. Thus 4001, 4174, 4501 and 4574 are all CMOS devices. CMOS devices are sometimes also given a suffix letter; A to denote the "original" (now obsolete) unbuffered series, and B to denote the improved (buffered) series. A UB suffix denotes an unbuffered B-series device.

Problem 1.2

To which logic families do each of the following devices belong?
(a) 7407
(b) 74LS74
(c) 4052

Power supplies

Most TTL and CMOS logic systems are designed to operate from a single supply voltage rail of nominally +5V. With TTL devices, it is important for this voltage to be very closely regulated. Typical TTL IC specifications call for regulation of better than 5% (i.e. the supply voltage should not fall outside the range 4.75V to 5.25V).

CMOS logic devices are fortunately very much more tolerant of their supply voltage than their TTL counterparts. Most CMOS devices will operate from a supply rail of anything between +3V and + 15V. This, coupled with a minimal requirement for supply current (a CMOS gate typically requires a supply current of only a few microamps in the quiescent state) makes them eminently suited to portable battery powered equipment.

TTL devices require considerably more supply current than their CMOS equivalents. A typical TTL logic gate requires a supply current of around 8mA; approximately 1000 times that of its CMOS counterparts when operating at a typical switching speed of 10kHz.

CMOS versus TTL

Having spent some time in discussing the merits of CMOS and TTL devices it is now worth summarizing three of the important differences between these logic families in tabular form:

Problem 1.3

Which logic family would be most suited for use in a piece of equipment which has to operate over long periods from dry batteries?

Microprocessors

Having dealt with the basic building blocks of digital circuits we have at last

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	CMOS	TTL
Speed of operation	Relatively slow (power consumption increases as switching speed increases)	Fast (power consumption substantially constant)
Power consumption	Negligible (but see above)	Appreciable
Supply voltage	Operates over a wide voltage range (typically 3V to 15V)	Must be closely regulated at, or near 5V

arrived at the point at which we can introduce the microprocessor.

Microprocessors are VLSI and SLSI integrated circuit devices which are capable of accepting, decoding and executing instructions presented to them in binary coded form. Microprocessors thus form the heart of all microcomputer systems in which they act as the central processing unit (CPU). Despite this, the majority of microprocessors are not capable of providing the complete range of facilities expected of a computer (i.e. input, processing, memory and output). Microprocessors require a certain amount of external hardware and other support devices, not the least important of which are those which provide a memory for the sequences of software instructions (i.e. programs) and transient information (i.e. data) used during processing.

Some specialized microprocessors incorporate their own internal memory for data and program storage as well as input/output ports for the connection of external devices such as keyboards and displays. These devices are aptly known as "single-chip microcomputers" and they are ideal for use in low-cost stand- alone control systems.

Microprocessors are often divided into categories depending upon the size of the binary number on which they fundamentally perform operations. Most modern microprocessors perform operations on groups of either eight or 16 binary digits (bits). Whilst 16-bit microprocessors tend to be more powerful than their 8-bit counterparts this is unimportant in many simple applications.

The first generation of 8-bit microprocessors appeared a little over 14 years ago in the shape of an Intel device, the 8008. At the time, this was something of a minor miracle - a device which could replace countless other chips and which could address a staggering 16K of memory! By modern standards, the 8008 is extremely crude but it was not long before Intel introduced another device, the 8080. This time NMOS technology was employed instead of the PMOS technology which was used in the 8008. The 8080 had 16 address lines (thus being able to address 64K of memory) and 78 software instructions for the programmer to use. The 8080 was an instant success and led the way to enhanced devices such as the 8085 and the Z80.

Other manufacturers were also developing microprocessor chips hard on the heels of Intel. These included Motorola (with the 6800) and MOS Technology (with the 6502). In subsequent years industry has not been content to stand still and much effort has been devoted into huge advances into 16 and 32-bit technology. Despite this, all of these simple 8-bit microprocessors (and their various enhancements and derivatives) are still in common use today.

Costs have fallen very significantly and it is eminently possible to put together a microprocessor system (comprising CPU and a handful of support chips) at a very moderate cost. Therefore, if one had the task of designing, for example, a simple control system, one would almost certainly use a microprocessor (or single-chip microcomputer) to form the basis of the controller.

Such a system would not only be capable of fulfilling all of the functions of its conventional counterpart but it would also provide a far more sophisticated means of processing our data coupled with the ability to store it and examine it at a later date or even transmit it to a remote supervisory computer installation. The vast saving in hardware development can usefully be devoted to the software aspects of a project and future modifications can simply involve the substitution of "firmware" (ROM based software).

Bits, Bytes and Buses

An 8-bit microprocessor fetches and outputs data in groups of 8- bits (known as "bytes"). This data is moved around on eight separate lines (labelled D0 to D7) which collectively form a "data bus". For the curious, the word "bus" is a contraction of the Greek work "omnibus" which simply means "to all", thus aptly describing the concept of a system of wiring which links together all of the components of a microprocessor system using a common set of shared lines.

Microprocessors determine the source of data (when it is being "read") and the destination of data (when it is being "written") by outputting the location of the data in the form of a unique "address". This process involves placing a binary pattern on an "address bus". In the case of 8-bit microprocessors, the address bus invariably comprises 16 separate lines, labelled A0 to A15.

The address at which the data is to be placed or from which it is to be fetched can either constitute part of the "memory" of the system (i.e. RAM or ROM) or can be considered to be "input/output" (I/O). The allocation of the 64K memory address range of an 8-bit microprocessor can usefully be described using a "memory map". We shall discuss this in greater detail later in the series.

A further bus is used for a variety of general housekeeping functions such as determining the direction of data movement (i.e. whether a "read" or "write" operation is being performed), and placing the machine in an orderly state of power-up. This bus is known as the "control bus" and often has between five and 13 lines depending upon the microprocessor.

System Architecture

We have already identified the principal elements within a microprocessor system as CPU (i.e. the microprocessor), RAM, ROM, and I/O. Before showing how they are interconnected within a typical microprocessor system,

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it is worth briefly restating the function of each:

Central processing unit (CPU)

The central processing unit in a microcomputer is a single VLSI device, the microprocessor. The device accepts instructions and data for processing. It also provides control and synchronizing information for the rest of the system. We shall look more closely at the function of the microprocessor in Part Two.

Random Access Memory (RAM)

All microprocessors require access to read/write memory and, while single-chip microcomputers contain their own low-capacity area of read/write memory, read/write memory is invariably provided by a number of semiconductor random access memories (RAM).

Read-only Memory (ROM)

Microprocessors generally also require more permanent storage for their control programs and, where appropriate operating systems and high-level language interpreters. This facility is invariably provided by means of semiconductor read-only memories (ROM).

Input/Output Devices (I/O)

To fulfil any useful function, the microprocessor needs to have links with the outside world. These are usually supplied by means of one, or more, VLSI devices which may be configured under software control and are thus said to be "programmable". I/O devices fall into two general categories; "parallel" (a byte is transferred at a time) or "serial" (one byte is transferred after another along a single line).

The basic configuration of a microprocessor system is shown in Fig. 4, the principal elements; microprocessor, ROM, RAM, and I/O have been shown. Note that the three bus systems; address, data, and control are used to link the elements and thus an essential requirement of a support device is that it should have "tri- state" outputs. It can thus be disconnected from the bus when it is not required.

Support devices (such as ROM, RAM, etc.) are fitted with select or enable inputs. These lines are usually driven by address decoding logic (not shown in Fig. 4). The inputs of the address decoding logic are derived from one, or more, of the address bus lines. The address decoder effectively divides the available memory into blocks which each correspond to a particular support device. Therefore, where the processor is reading and writing to RAM, for example, the address decoding logic will ensure that only the RAM is selected and the internal buffers in the ROM and I/O chips are kept in the tri-state output condition.

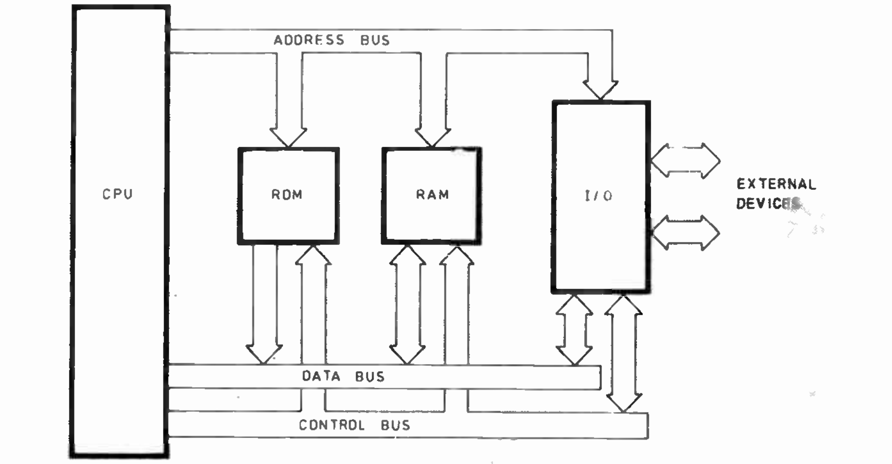

Fig. 4. Principal elements of a microprocessor system.

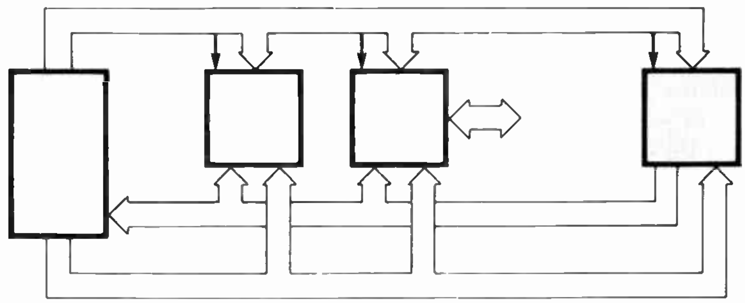

Fig. 5. Microprocessor system (see problem 1.4).

Table 1 Powers of two

n	2^n
0	1
1	2
2	4
3	8
4	16
5	32
6	64
7	128
8	256
9	512
10	1024
11	2048
12	4096
13	8192
14	16384
15	32768

Problem 1.4

The diagram shown in Fig. 5 represents a microprocessor system. Compare this diagram with that shown in Fig. 4 and hence label the diagram fully.

Number Systems

Unfortunately, the decimal or decimal number system with which we are all very familiar, is not at all appropriate to microcomputers. The reason is simply that electronic logic circuits are used on devices which have only two states (variously known as "on/off" "high/low", and "true/false"). The number system most appropriate is therefore binary in which only two digits (0 and 1) are used. Powers of two are shown in Table 1.

The process of converting binary to decimal and decimal to binary is quite straightforward. The binary number 101, for example, can be converted to decimal as follows:

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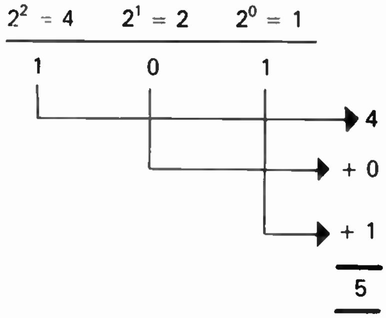
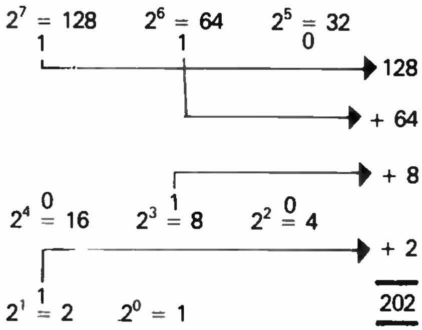


Now, taking a somewhat more difficult example, let's convert the binary number 11001010 to decimal. We shall again write the number using column headings but this time we shall simply ignore the zeros in our addition:



There are two basic methods for converting decimal to binary. One involves taking the decimal number and subtracting from it successively smaller numbers which are themselves powers of two. Where a power of two can be subtracted (to leave zero or a remainder), a 1 is placed in the appropriate column of the binary number. This all sounds very much more difficult than it really is, so here is a simple example to illustrate the process.

Suppose that we wish to convert the decimal number 21 to binary. The highest power of two which can be taken away from 21 is 2^4 (=16). This leaves a remainder of 21 - 16 = 5. 2^3 (=8) cannot be subtracted from the remainder but 2^2 can to leave a remainder of 5-4 = 1. 2^0 (=1) can now be subtracted from the second remainder to leave zero. Another way of putting this is that;

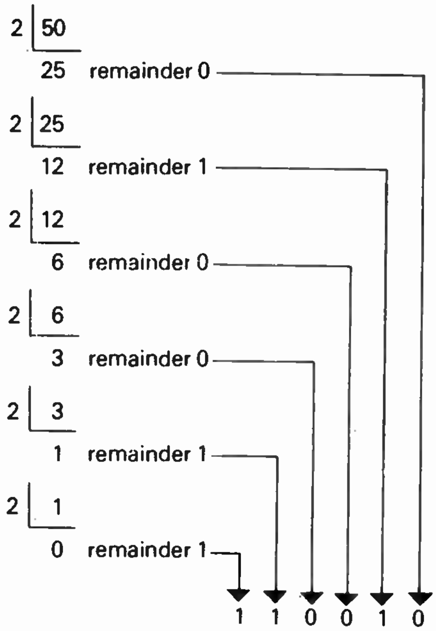
$$21 = 16 + 4 + 1 = 2^4 + 2^2 + 2^0$$

We can write this as a binary number by placing 1s and 0s in columns, as follows:

2^4	2^3	2^2	2^1	2^0
1	0	1	0	1

The second method involves successively diving the decimal number by two and noting down the remainder each stage. The binary number is then formed by reading the remainders as shown in the example below (note that the least significant remainder becomes the most significant bit of the binary number!).

Suppose we wish to convert the decimal number 50 to binary.



Therefore 50 decimal is equal to 110010 binary.

Which of the two methods you employ is entirely a matter of preference. If you can easily spot the powers of two present in a decimal number it is probably best to use the first method. If, on the other hand, you are uncertain as to which powers of two make up a number it is best to use the longer method. Remember that, in both cases, you can always convert back to decimal in order to check your results!

Problem 1.5

Convert the following binary numbers to decimal:
(a) 1011
(b) 100110
(c) 11100111

Problem 1.6

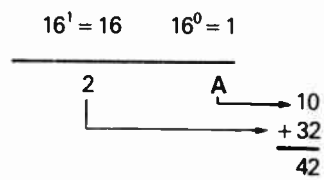
Convert the following decimal numbers to binary:
(a) 33
(b) 100
(c) 213

Hexadecimal

The binary number system is somewhat tedious for human use since numbers of any appreciable size are rather difficult to handle. For this reason we settle on the hexadecimal (base 16) number system. This has the advantage that it is relatively simple to convert from hexadecimal to binary and the hexadecimal numbers which can appear on an 8-bit data bus can be represented using just two digits (rather than the eight binary digits which would otherwise be necessary).

Since the hexadecimal numbering system employs more than 10 digits we have to make use of the first six letters of the alphabet to represent those equivalent to the decimal numbers 10 to 15. Hexadecimal digits thus range from 0 to F as shown below left.

Numbers in excess of fifteen will, of course, require more than one hexadecimal digit. Suppose, for example, we wish to convert the hexadecimal number 2A to decimal. Using a similar technique to that which we employed when converting from binary to decimal we would arrive at:



Now, suppose that we wish to convert 2A to binary rather than decimal. This is an easy process (if is NOT necessary to convert to decimal as an intermediate step!) as shown below:

Hexadecimal	2	A
Binary	0010	1010

Therefore hexadecimal 2A is equivalent to binary 00101010. Note that the leading zeros are optional (00101010 is exactly the same number as 101010). When dealing with numbers present on an 8-bit bus it is, however, a good idea to get into the habit of showing leading zeros in bi-

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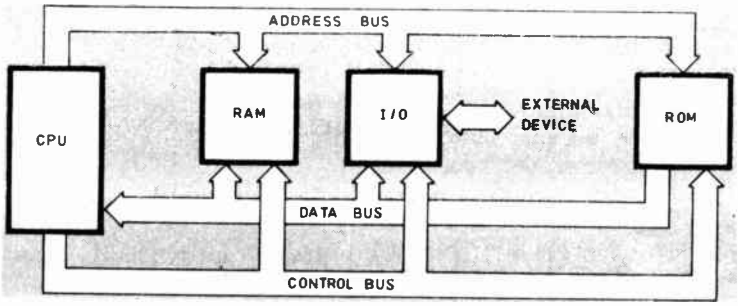

Fig. 6 Answer to problem 1.4

Decimal	Binary	Hexadecimal
0	0000	0
1	0001	1
2	0010	2
3	0011	3
4	0100	4
5	0101	5
6	0110	6
7	0111	7
8	1000	8
9	1001	9
10	1010	A
11	1011	B
12	1100	C
13	1101	D
14	1110	E
15	1111	F

nary numbers so that all 8-bits are clearly shown.

To convert from decimal (in the range 0 to 255) it is simply necessary to divide the decimal number by 16 to obtain the most significant digit and then take the remainder as the least significant digit. In both cases it will be necessary to convert a digit answer greater than nine to its corresponding hexadecimal digit (i.e. A to F). Suppose, for example, we had the task of converting decimal 75 to hexadecimal:

```
16 | 75
     4   Remainder 11
               = B
                   → 4B
```

Therefore, decimal 75 is equivalent to 4B hexadecimal.

Taking another example, suppose we had to convert 250 decimal to hexadecimal:

```
16 | 250
     15   Remainder 10
     = F            = A
                        → FA
```

So, 250 decimal is equivalent to FA hexadecimal.

Converting from binary to hexadecimal over the range 0 to 255 is extremely simple. All we need to do is to separate the binary number into two groups of four bits (known as "nibbles") and then convert each of these groups to its corresponding hexadecimal character.

As an example suppose we need to convert the binary number 10001001 to hexadecimal:

```
1000  1001
  8     9
```

The binary number 10001001 is equivalent to hexadecimal 89.

Taking one further example, suppose we have to find the hexadecimal equivalent of the binary number 101100 (note that this number consists of six rather than eight bits):

101100 = 00101100 (inserting two leading zeros to form an eight bit binary number)

```
0010  1100
  2     C
```

Therefore, the hexadecimal equivalent of 101200 is 2C.

Problem 1.7

Convert the following decimal numbers to hexadecimal:

(a) 27
(b) 511
(c) 4100
(Hint: Refer to Table 3 for powers of 16)

Problem 1.8

Convert the following hexadecimal numbers to decimal:

(a) BE
(b) 10B
(c) C000

Problem 1.9

Convert the following binary numbers to hexadecimal:

(a) 1011
(b) 10101111
(c) 1010101111001101

Problem 1.10

Convert the following hexadecimal numbers to binary:

(a) 3F
(b) 23A
(c) 812C

Addition

Binary and hexadecimal addition follows the same general rules as employed with decimal numbers. The rule for addition of two numbers (which MUST be expressed in the same base) is that digits in the corresponding position in each number are added, starting from the right most (least significant) and a carry into the next most significant position occurs if the sum of two digits equals or exceeds the value of the base used.

As an example, suppose we have to add the binary numbers 10010010 and 01010000.

```
        1 0 0 1 0 0 1 0
      + 0 1 0 1 0 0 0 0
Carry   0 0 1 0 0 0 0 0
        ---------------
        1 1 1 0 0 0 1 0
```

(Note that a carry is generated when the two 1s are added and the carry is added into the next more significant column.)

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To make the process clear it is worth taking another example in which we shall add the binary numbers 10001101 and 01001111:

		1	0	0	1	1	1	0	1
+		0	1	1	0	1	1	1	1
Carry	1	1	1	1	1	1	1	1	0
	1	0	0	0	0	1	1	0	0

Addition of hexadecimal numbers follows the same pattern. Suppose we have to find the sum of the hexadecimal numbers 14 and 23.

	1	4
+	2	3
Carry	0	0
	3	7

Therefore, the sum of hexadecimal numbers 14 and 23 is (not surprisingly!) equal to 37.

Now let's try something a little more difficult by finding the sum of 1F and 2C:

	1	F
+	2	C
Carry	1	0
	4	B

(Note that adding F to C gives 1B)

Therefore, adding 2C to 1F gives 4B hexadecimal.

Problem 1.11

Add:
(a) the binary number 01001111 to the binary number 10000101
(b) the hexadecimal number 5C to the hexadecimal number 71.

Subtraction

Subtraction of binary and hexadecimal numbers also follows the same general rules as employed with decimal numbers. The rule of subtraction of two numbers (which again MUST be expressed in the same base) is that digits of the number to be subtracted (the subtrahend) are subtracted from digits in the corresponding position of the minuend. If the difference obtained is less than zero (i.e. negative) a value equals to the base employed is BORROWED FROM the next most significant position. The value of the borrow (i.e. 1) must be ADDED TO the next most significant position of the subtrahend. Again all this sounds much more complicated than it really is so we shall again use several examples to illustrate the techniques.

Consider the problems of subtracting the binary number 0100 from the binary number 1101:

	1	1	0	1	(minuend)
−	0	1	0	0	(subtrahend)
Borrow	0	0	0	0	
	1	0	0	1	

(In this simple example we have not needed to borrow)

Now consider the slightly more difficult problem of subtracting the binary number 0110 from 1101.

	1	1	0	1	(minuend)
−	0	1	1	0	(subtrahend)
Borrow	1	1	0	0	
	0	1	1	1	

(Note that, if you are unsure of an answer, it is always permissible to convert the numbers to decimal in order to check the validity of a result. In the foregoing example we have the equivalent decimal calculation; 13−6 = 7)

Subtraction of hexadecimal numbers again follows the same pattern. Suppose we have to find the difference of the hexadecimal numbers 2F and 1A:

	2	F
−	1	A
Borrow	0	0
	1	5

(Note that subtracting A from F leaves 5)

So, the result of subtracting 1A hexadecimal from 2F hexadecimal is 15 hexadecimal.

Now let's try something a little more difficult by subtracting hexadecimal 14 from hexadecimal 23:

	2	3
−	1	4
Borrow	1	0
	0	F

Therefore, the result of subtracting the hexadecimal number 14 from the hexadecimal number 23 is 0F.

Problem 1.12

Subtract;
(a) the binary number 01001101 from the binary number 110000101
(b) the hexadecimal number 3C from the hexadecimal number F0

Negative Numbers

Thus far we have confined ourselves to positive numbers and many of you will be wondering how we go about representing negative numbers within a computer. One rather obvious method is that of using the first (most significant) bit of a number solely to indicate its sign (i.e. whether it is positive or negative). The convention used is that a 0 in the most significant bit (MSB) position indicates that the number is positive. An MSB of 1, on the other hand, indicates that the number is negative. The magnitude of the number is then given by the remaining bits. We refer to such a number as being "signed".

As an example the signed eight-bit binary number 01111111 represents the decimal number 127 (it is positive as the MSB is 0) whereas the signed binary number 11111111 represents the decimal number − 127 (the MSB is 1 and therefore the number is negative).

Problem 1.13

Convert the following signed binary numbers to decimal:
(a) 01000000
(b) 11000000
(c) 10001001

Problem 1.14

Convert the following decimal numbers to signed 8-bit binary:
(a) +5
(b) -99
(c) +99

One's and Two's Complement

The one's complement of a binary number is found by simply changing all of the 0s present to 1s and changing all of the 1s present to 0s. This process is called "inversion". The one's complement of the binary number 1010 is thus 0101. Note that the result of adding a number to its one's complement will produce a succession of 1s, as shown in the following example:

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Binary number	1 0 1 0 1 1 0 0
One's complement	0 1 0 1 0 0 1 1
Sum	1 1 1 1 1 1 1 1

The two's complement of a binary number is found by simply adding 1 to its one's complement. Therefore, the two's complement of 1010 is 0110 (i.e. 0101 + 0001).

The result of adding a binary number to its two's complement is not a succession of 1s but a succession of 0s with a leading 1 in the next more significant bit position. This is demonstrated by the following example:

Binary number	1 0 0 0 1 0 1 1
One's complement	0 1 1 1 0 1 0 0
Two's complement	0 1 1 1 0 1 0 1 (added 1)

Original number	1 0 0 0 1 0 1 1
Two's complement	+ 0 1 1 1 0 1 0 1
Sum	1 0 0 0 0 0 0 0 0

Problem 1.15

Find the one's and two's complements of each of the following:
(a) 1001
(b) 10110011
(c) 10001110

Readers can be excused for wondering what all this is leading up to. It actually yields a very neat method for performing subtraction. We simply form the two's complement of the number to be subtracted (the subtrahend) and ADD it to the first number (the minuend). Any leading 1 generated is ignored. To show how this works consider the following example which subtracts the binary number 00110110 from the binary number 10010101:

Subtrahend	0 0 1 1 0 1 1 0
One's complement	1 1 0 0 1 0 0 1
Two's complement	1 1 0 0 1 0 1 0

Minuend	1 0 0 1 0 1 0 1
Two's complement of subtrahend	+ 1 1 0 0 1 0 1 0
	1 0 1 0 1 1 1 1 1

Ignoring the leading 1 gives a result of 01011111.

It is usually much easier to use two's complements to perform subtraction than to use conventional subtraction (using borrow). Readers can easily check the validity of the statement by performing the foregoing example using conventional techniques!

Problem 1.16

Use the two's complement to subtract the binary number 00011001 from the binary number 11010100.

Representing Number Bases

So far we have been quite explicit in stating (rather long-windedly) the number base which we have been working in. Methods commonly used to indicate the base include:

(a) using a suffix to indicate the base e.g. 101000_2 is a number having base 2 (i.e. binary)
127_{10} is a number having base 10 (i.e. decimal)
76_{16} is a number having base 16 (i.e. Hexadecimal)
(b) adding a trailing H to indicate that a number is hexadecimal
e.g. 9FH, C9H and FFH are all hexadecimal
(c) adding a leading $ to indicate that a number is hexadecimal
e.g. $2A is the same as 2AH which is the same as 2A

Problem 1.17

Determine the decimal equivalent of each of the following:
(a) 10_2
(b) 10^2
(c) $$10^{10}$

Glossary for Part One

Address
A number which indicates the position of a word in memory. Addresses typically comprise 16 bits and therefore can range from 0 to 65535

Address bus
A set of lines (usually 16) used to transmit addresses, usually from the microprocessor to a memory or I/O device.

Address decoding
The process of selecting a specific address or range of addresses to enable unique support devices.

Binary
A system of numbers using base 2. Binary numbers thus use only two characters; 0 and 1.

Bit
A contraction of binary digit. A single digit in a binary number.

Bus
A path of signals having some common function. Most microprocessor systems have three buses; an address bus, data bus and control bus.

Byte
A group of eight bits.

Central Processing Unit
The part of a computer that decodes instructions and controls the other hardware elements of the system. The CPU comprises a control unit, arithmetic/logic unit and internal storage.

Chip
The term commonly used to describe an integrated circuit.

Complement
The process of changing a 1 to a 0 and vice versa.

Control Bus
The set of control signal lines in a computer system. The control bus provides

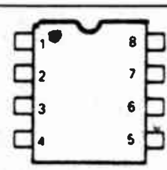

Fig. 6.

ANSWERS TO PROBLEMS

1.1	See Fig. 6.		
1.2	(a) standard TTL	(b) low-power Schottky	(c) CMOS
1.3	CMOS (reasons are wide supply voltage range and very low current requirements)		
1.4	See Fig. 7.		
1.5	(a) 11	(b) 38	(c) 231
1.6	(a) 100001	(b) 1100100	(c) 11010101
1.7	(a) 1B	(b) 1FF	(c) 1004
1.8	(a) 190	(b) 267	(c) 49152
1.9	(a) B	(b) AF	(c) ABCD
1.10	(a) 111111	(b) 1000111010	(c) 1000000100101100
1.11	(a) 11010100	(b) CD	
1.12	(a) 1111000	(b) B4	
1.13	(a) +64	(b) −64	(c) −9
1.14	(a) 10000101	(b) 11100011	(c) 01100011
1.15	(a) 0110 and 0111	(b) 01001100 and 01001101	(c) 01110001 and 01110010
1.16	10111011		
1.17	(a) 2	(b) 10	(c) 16

World Radio History

the synchronization and control information to operate the system.

CMOS
Complementary metal oxide semiconductor. A family of integrated circuit devices based on unipolar field effect devices.

Data
General term used to describe numbers, letters and symbols present within a computer during processing.

Data Bus
The set of electrical conductors which carries data between the different elements of a computer system.

Digital
A system which only allows discrete states. Most digital logic uses only two states (on/off, low/high or 0/1).

Firmware
A program (software) stored in read-only memory.

Hardware
The physical components of a computer system.

Hexadecimal
A number system with base 16. The first six letters of the alphabet (A to F) are used to represent the hexadecimal equivalents of the decimal numbers 10 to 16.

Input/output
Lines of devices used to transfer information outside the computer system.

Input port
A circuit that connects signals from external devices as inputs to a microcomputer system.

Integrated circuit
An electronic circuit fabricated on a single wafer (chip) and packaged as a single component.

Memory
The part of a computer system into which information can be placed and held for future use. Storage and memory are interchangeable terms. Digital memories accept and hold binary numbers only. Common types of memory are magnetic disc, magnetic tape, and semiconductor (which includes RAM and ROM)

Microcomputer
A small computer based upon a microprocessor CPU. Backing storage is usually provided by magnetic disc or tape; input is provided by means of a keyboard and output by a VDU.

Microprocessor
A central processing unit fabricated on one or two chips. The processor contains an arithmetic logic unit (ALU), control block and registers.

One's complement
The inverse of a binary number which is formed by changing all 0s to 1s and vice versa.

Output port
A circuit that allows a microprocessor system to output signals to other devices.

Peripheral
Any device that is connected to a computer whose activity is under the control of the central processing unit.

Program
A procedure of solving a problem coded into a form suitable for use by a computer and frequently described as software.

RAM (random access memory)
Usually used to mean semiconductor read/write memory. Strictly speaking, ROM devices are also random access!

Random access
An access method in which each word can be retrieved in the same amount of time (i.e. the storage locations can be accessed in any desired order).

Read
The process of transferring information from memory or I/O into a register in the central processor.

Register
A single word of memory. The CPU contains a number of registers for temporary storage of data.

ROM (read-only memory)
A permanently programmed memory. Mask-programmed ROMs are programmed by the chip manufacturer. PROMS (programmable ROM devices) can be programmed by the user. EPROMs (erasable PROM devices) can be erased under ultraviolet light before reprogramming.

TTL (transistor transistor logic)
Transistor transistor logic. A family of integrated circuit devices based on conventional bipolar transistors.

Two's complement numbers
A number system used to represent both positive and negative numbers. The positive numbers in two's complement representation are identical to the positive numbers in standard binary, however the two's complement representation of a negative number is the complement of the absolute binary value plus 1. Note that the most significant bit (usually the eight) indicates the sign; 0 = positive, 1 = negative).

Visual display unit (VDU)
A VDU is an output device (usually based on a cathode ray tube) on which text and/or graphics can be displayed. A VDU is normally used in conjunction with an integral keyboard when it is sometimes referred to as a console.

Word
A set of characters that occupies one storage location in memory and is treated by the computer as a unit. Program instructions and program data both have the same word length (equal to 8-bits or 1-byte in the case of 8-bit microprocessors)

Write
The process of transferring information from a register within the central processor to memory or I/O.

Sources For Microprocessor Training Materials.

Active, Division of Future Electronics
Carries the full Edukit line including the "Digital Designer" in teacher's version or a home-study version, and the Motorola MC68000 kit.
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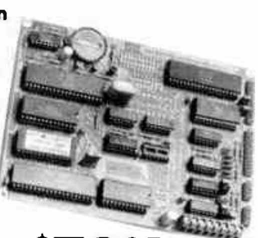

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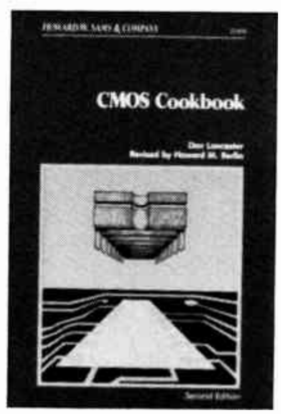

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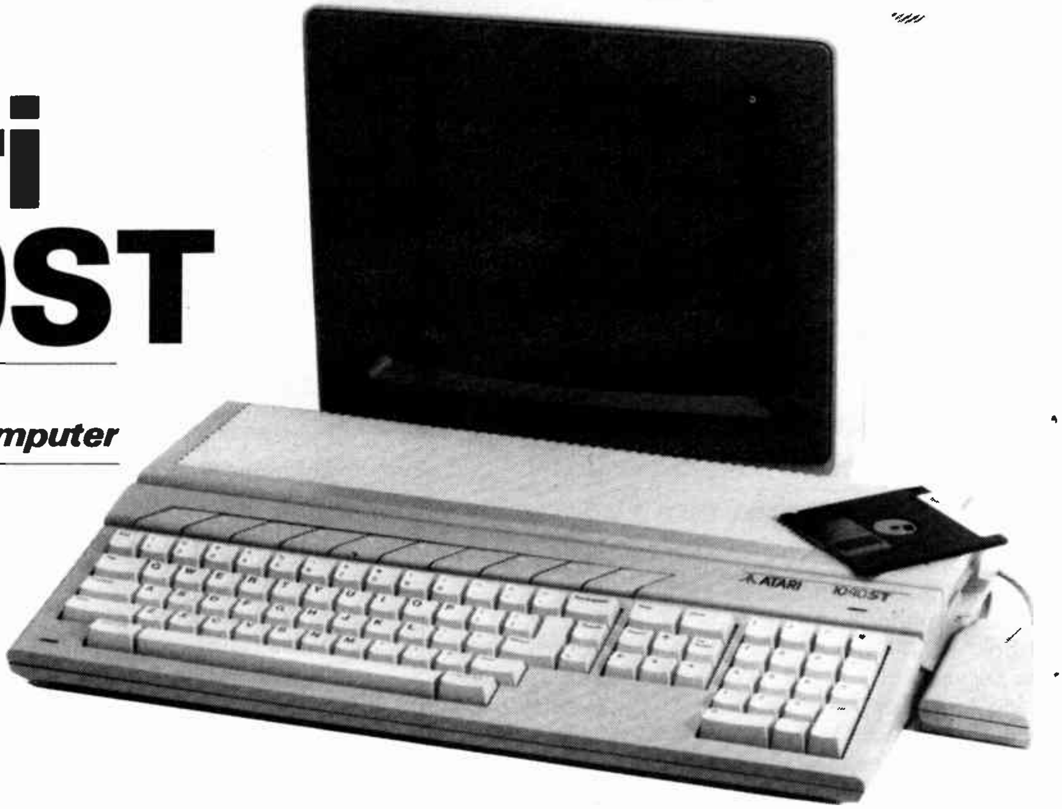
The Atari 1040ST



An all-purpose, versatile 32-bit computer

By E. Penn

We've come a long way with computers in the last few years. Not that long ago, we thought that little plastic box with 8K, BASIC and a game in it was intimidating because it could do so much. Now we expect the power and speed of a midi-computer on our desks, and for cheap, too. And the amazing thing is, we can *have* it.

While the Intel 80386 chip is now out trying to capture the IBM and compatibles crowd, the Motorola 68000 32-bit CPU has been around for years, having made its name with the Apple Macintosh.

The Atari 1040ST 32-bit machine with an 8MHz 68000 first appeared as the 520, having 512K of RAM; the 1040 has one megabyte of RAM and nearly 200K of ROM. Since a 1040ST system comes in at less than $1500 these days for a computer that will do all the usual computing tasks at a high speed with super graphics, you could hardly ask for a better deal.

A Tour

The 1040 is self-contained: everything, including the keyboard and power supply and one 3.5" disk drive, is in one gray wedge. The power supply, incidentally, will handle only the internals; if you add a second external drive, it comes with its own external power box.

On the lower front right, under the numeric keypad area, are two D-type connectors for the mouse and a joystick, or two joysticks. On the right side is the micro-floppy slot for a 3.5", double-sided, double density, 720K disk. Turning the corner to the back panel, we find three D-connectors. The first is labelled "Modem", leading you to believe that there's a modem inside. There isn't. It means that this is where you would connect your modem if you had one; in other words, it's an RS232 serial port.

The next D-type is a standard parallel printer port, and next to that the connector for adding Atari's hard disk. The second, optional, floppy drive uses a DIN-type connector, as does the color monitor, in our case an Atari SC1224 12" RGB set. A power switch and Reset button complete the back panel.

On the left side are two DIN-type connectors for the MIDI In and Out ports, simplifying the hookup of electronic musical instruments to the computer. Next to these is a ROM cartridge port with 128K of capacity.

The keyboard is pretty standard with the usual QWERTY layout and ten function keys, though it does have cursor keys separate from the numeric pad. Mind you, it doesn't need them that much since all its software takes advantage of the mouse. It also has Undo and Help keys which some software can access.

That's pretty much everything you'll need for doing most computing jobs for a long time to come. The 1040 has all the basics.

Booting

When you switch the computer on without a disk in drive A (and bless 'em, the drives are called A and B) the ROM will boot the computer in the low resolution mode (320 by 200 for color) or high-res (640 by 400 for monochrome monitors) and you'll see two floppy disk icons. You can use the mouse to pull down the View and Options menus and set the display to either icons or text as you prefer, and also boost the color resolution to medium (640 by 200). There are four colors in low-res, 16 in medium, out of a palette of 512.

Once you set the preferences the

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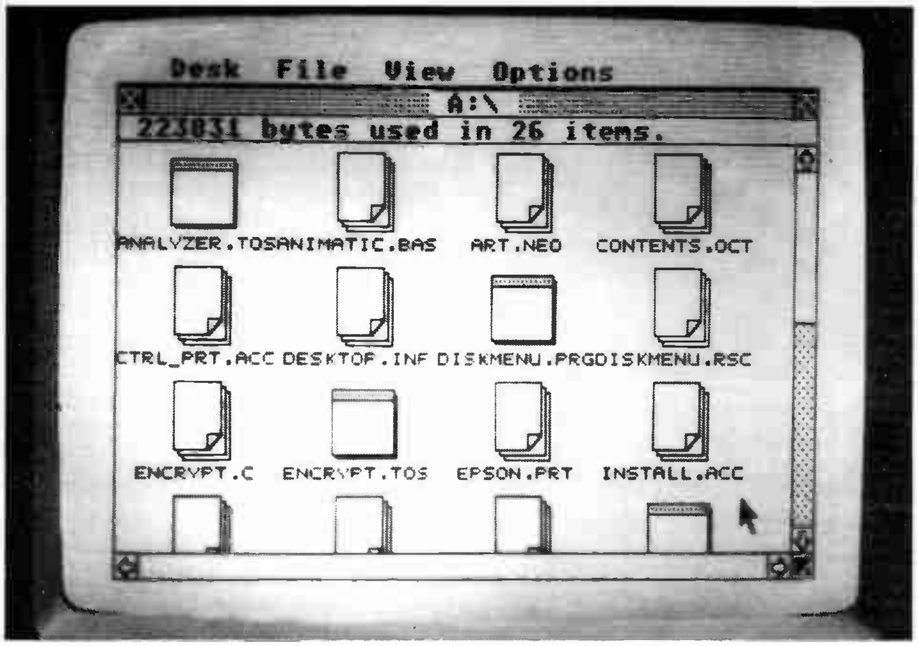

Fig. 1. The GEM Desktop display system represents the disk directory as a series of file folder icons. These can be easily run or copied with the mouse.

way you like, you can put in your disk that has the desktop accessories in it and save the format for future use. The desktop accessories are files that set up the icon display if you boot using a disk with the accessories files on it, things like the Control Panel for setting many more of the system parameters (palette, keyboard and mouse response, etc).

Software

The operating system in use is the GEM Desktop, or Graphics Environment Manager. It produces a desktop-and-icon display somewhat similar to the operating system of the Mac or to Windows. I'm not all that keen on icons, but I love pulldown menus and mouses.

One of the biggest selling points of the GEM/MAC/Windows style of software is that you can open multiple windows at the same time, size them the way you like and position them anywhere. You can have several disk directories side by side for comparison, or two completely different functions waiting up in a corner of the screen until you're ready. Atari BASIC uses three windows so you can see what's going on: a command line area, an area which LISTs the program, and the Output area, which shows the result of the command you just entered. You can also size and move these windows; you might prefer a larger output window, for instance.

Underneath the GEM pictures is TOS, which stands for The Operating System (good name, non?). This actually takes care of executing the programs and controlling the peripherals. It lives in ROM. It's said to be a porting of MS-DOS into the 68000 environment, and that it's disk format is identical. We didn't get to prove this out.

The software included with the 1040ST, aside from the GEM system and accessories, includes BASIC, Logo, and the Neochrome paint program; the performance of the latter has to be seen in Atari color to be appreciated. You'll probably also get some other software, depending on the current marketing: a word processor, a game, a utilities disk, etc.

By this time, there is a wealth of third-party software, including games, word processors, spreadsheets and others. You know, what with the high speed and excellent graphics, I wouldn't be surprised if people buy this computer for sensible, practical reasons and then spend all their time playing games on it.

Speaking of games, if you'd like to see the Atari wrung out, the SubLogic Flight Simulator will put it through its paces. I know that the Fright Stimulator gets talked about a lot in these pages, but it really is quite a test: for smooth, airplane-like performance, it needs lightning calculations for the display changes, great graphics for the 16-color scenery, and windowing to overcome the lack of peripheral vision. The Atari could display four windows:

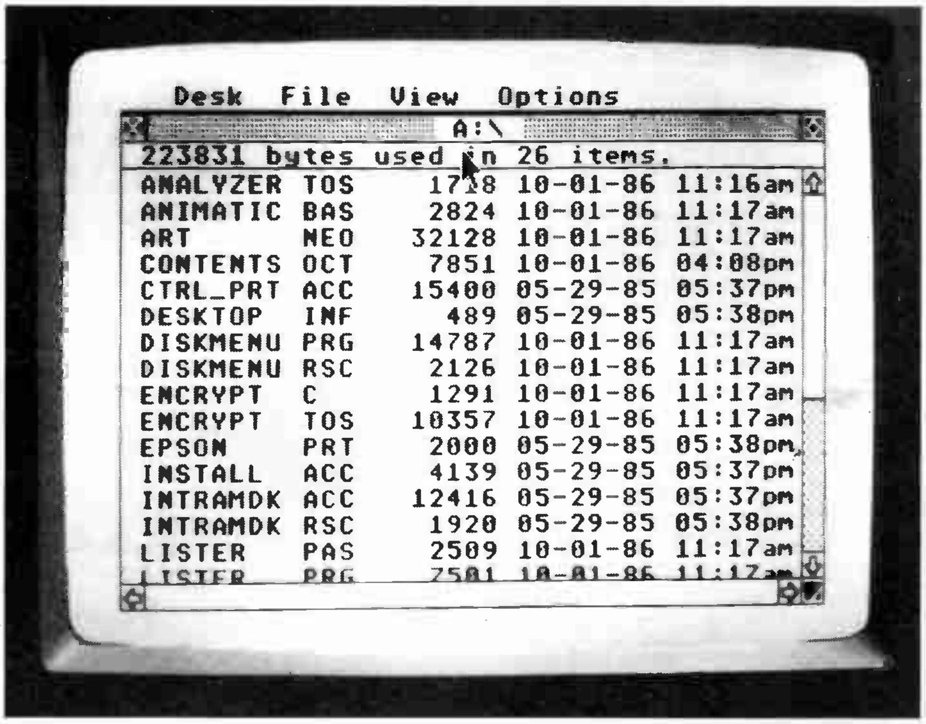

Fig. 2. A feature that will appeal to those who have learned on MS-DOS systems is the Atari's ability to change instantly from the icon format to the standard filename format.

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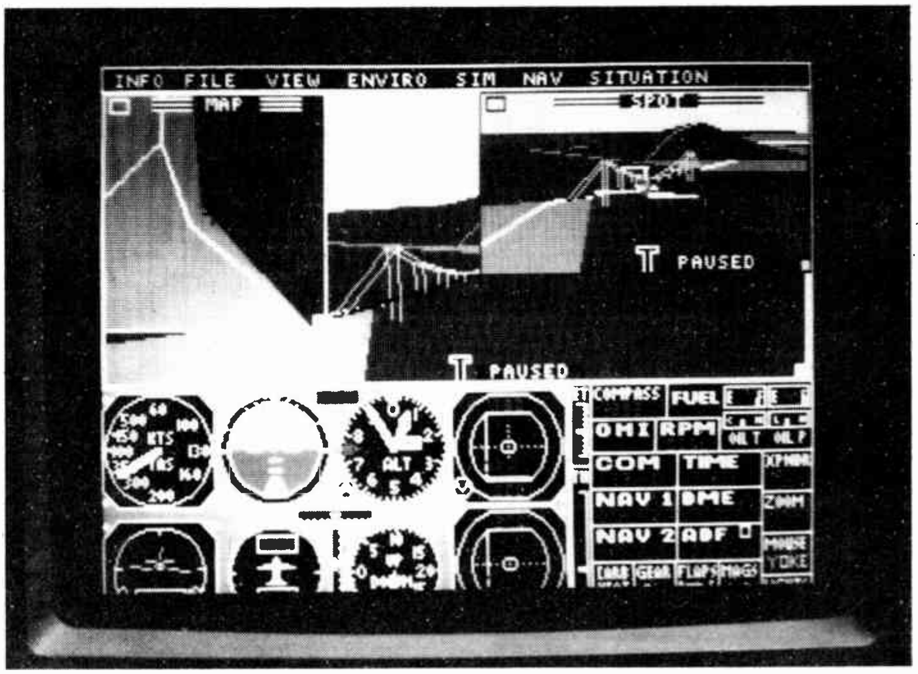

Fig. 3. Rapid manipulation of multiple windows is one of the advantages of a high-speed, 32-bit CPU. In this screen shot, the SubLogic Flight Simulator is displaying four screens: the overhead Map view (left), the main view, the spotter plane view (right) and the instrument panel. A good test of the operating system, since windows must be rapidly updated for a convincing effect.

the windshield view, the spotter plane view, the map view and the instruments. Mind you, all this slowed down the display refresh noticeably, but then you wouldn't really fly with three views on at once.

Langwidges

There are no surprises here, other than the aforementioned multiple windows. Atari BASIC contains all the features that programmers have come to know and love and never use (well, it's true... do you know anyone who writes music using SOUND?).

The graphics are comprehensive, what with 4 colors in high- res and 16 in low-res; with 512 to choose from, the screen pictures can be truly impressive, though not up to the 4096-color palette of the Amiga, the other contender in the 68000 class. The sound function sends its output to the monitor connector; audio amplification and speakerization has to be supplied by the monitor, which is what, in fact, the SC1224 did. The speaker is miniscule, but then computer sound isn't much anyway.

The commands and syntax of Atari BASIC seem to be identical (or at least very close) to the standard Microsoft version that seems to be everywhere. The programs should be transportable to other computers via paper or porting with a minimum of editing.

Logo is the language that will be familiar to a generation of schoolchildren – and no one else. I guess educators have their reasons for choosing computers and languages that have nothing to do with the outside world. Logo does have a certain charm to it, because you can define commands using other primitive commands in much the same way as Forth, a language that appeals to animators and instrument-watchers.

Hardware

The 1040ST is very well styled and assembled, but not everything will appeal to everybody. The keyboard has a very strange ultra- delicate feel to it, not good for type-intensive applications like, ah, typing. The mouse is not designed for the human hand, though then again, I've never come across a mouse that was easy to hold, with your fingers naturally falling onto smoothly operating buttons.

The internal power supply is a blessing, but if you add peripherals, you're soon back into the typical Atari/Amiga cable tangle. The cables are very thick and stiff, despite complaints from computer writers.

A 20M hard drive is about $1000, rather steep for a machine that cost $1500, since you'd be nudging into the price range of an AT compatible.

Still, the package price for the basics is good, the graphics second only to the Amiga and the speed more than acceptable for most applications.

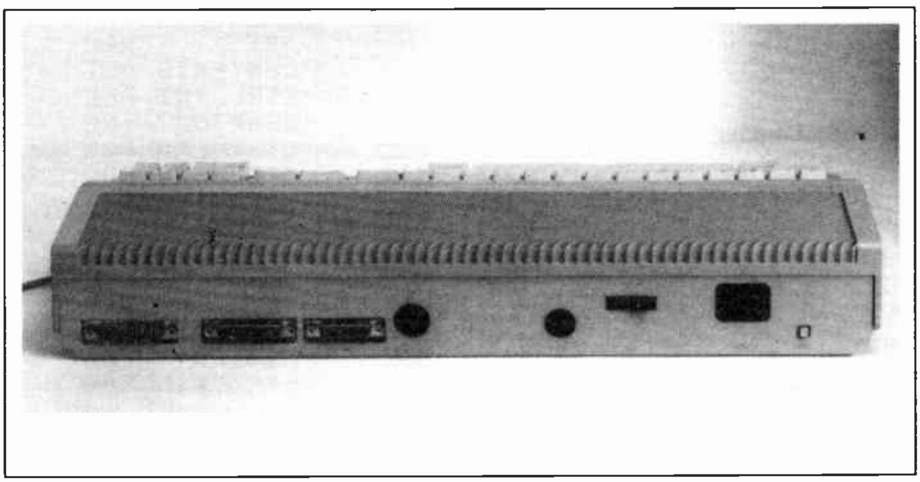

Fig. 4. The back panel of the Atari. Connections are easily made to the parallel port, hard disk (and expansion) port, audio/video connector and the serial port, which is actually labeled "modem". The power supply is internal, eliminating the necessity for a power supply box on the desk and floor. The on-off switch is in its proper place on the computer itself. ■

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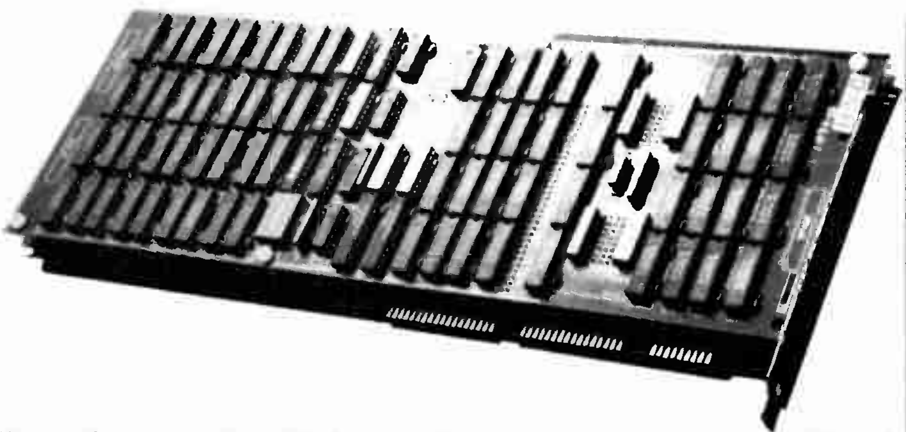
Neurocomputer Coprocessor



No, it's not a board that plugs into the bottom of your brain stem. It will, however, plug into your IBM PC/AT or 386 compatible making it into a powerful neurocomputer capable of real-time processing, so claims the manufacturer, Hecht-Nielsen Neurocomputers, of California.

The ANZA neurocomputer is capable of implementing neural networks containing up to 30,000 processing elements with up to 480,000 interconnects. It can update the interconnects at 25,000 interconnects per second (floating-point) during learning, and 45,000 interconnects per second in feed-forward mode.

An idea of the power of the ANZA can be garnered by considering that a neural network built by Terrence Sejnowski at John Hopkins, which was able to learn to translate ASCII text into English speech in about 16 hours, was implemented with only 309 processing elements.

The software supplied with the ANZA includes the User Interface Library, which allows for the seamless integration of neural network capabilities with C programs, and five Neural Net packages which implement six of the most popular neural network architectures so far discovered.

Neural networks are a new kind of computing architecture based on research into how the human brain encodes and processes information. Even simple neural networks exhibit complex behaviours such as learning, pattern recognition, and associative memory that are difficult or impossible to achieve with conventional computers. Neurocomputer applications include continuous, real-time speech recognition, image recognition, processing of imperfect or inexact knowledge, automatic extraction of knowledge from large databases ("instant" expert systems), and more.

This neurocomputing stuff obviously isn't for everyone with prices starting at $6900US (coprocessor board w/2MB of memory), and going to $24,900 for complete systems.

For further technical and sales information contact: Jacqueline Townsend, HNC, 5501 Oberlin Drive, San Diego, CA 92121. Tel: (619) 546-8877.

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Home Bus applications include: audio/video system control, computer/computer or computer/printer communications, and security control.

For more information contact: Marion Black-Ruffin, NEC Home Electronics (USA) Inc., 1255 Michael Dr., Wood Dale, IL 60191. Ph: (312) 860-9500 ext. 4244

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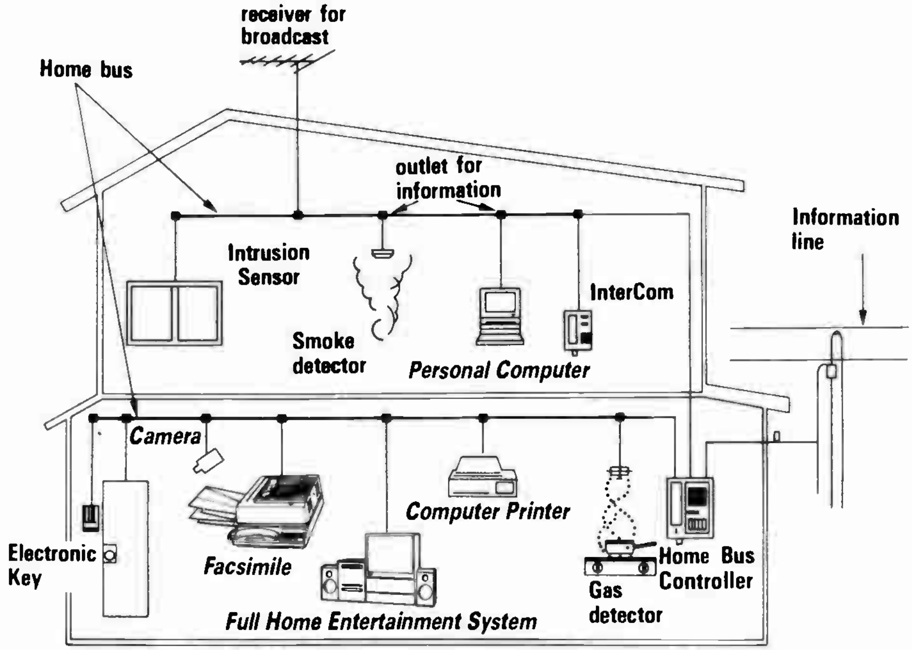
Home Bus Applications



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The Scientists Tell Me...

By David Dempster

Air Pollution Control Breakthrough

An electronic controller, developed to reduce particulate air pollution at NASA's Langley Research Center Refuse-Fired Steam Generating Facility, Hampton, Va., is called "a major technology breakthrough" by two major, international suppliers of pollution control equipment.

David F. Johnston, an electronics technician in Langley's Microelectronics Development Section, invented the automatic voltage controller for the facility's electrostatic precipitator. The precipitators remove particle matter from the combustion gases prior to their release into the atmosphere.

The controller proved to be the answer to efficient precipitator operation at the Hampton facility and is adaptable to any electrostatic precipitator. Advanced features have been added to the controller, offering a reliable, high technology method of upgrading existing precipitators, whether they burn coal or refuse.

Applications of this pollution control equipment has been expanded from refuse-fired incinerators to include power plants/utilities, steel mills, pulp and paper mills, cement plants and automobile industry incinerators.

Use of Johnston's equipment at chronic air pollution trouble spots has produced millions of dollars in savings in equipment and operation costs, including thousands of man-hours for installation and maintenance time. The controller, during testing, was projected to produce a $(US)400,000 (43 percent) annual savings in operating costs and to reduce equipment cost payback time to eight months at a coal-burning power plant in Saskatchewan.

A cement plant in Michigan was confronted with air pollution standard violations, Johnston's not only produced a $(US)2.9 million cost savings and a 90-percent reduction in installation time, but also reduced pollution level to 75 percent below Environmental Protection Agency standards.

At a steel mill in Kentucky, in violation of pollution standards, installation of Johnston's controller assured compliance of EPA particulate air pollution regulations in only one day and, in addition, produced a 50-percent savings in equipment cost.

Effective air pollution control required development of advanced electronic control for the Hampton facility's electrostatic precipitators, which remove particulate matter from the combustion gas before it is expelled through a smokestack. The gas is passed through a precipitator chamber and exposed to an electrostatic field. Particles in the gas become electrically charged and attracted to collecting surfaces under the influence of the electric field, thus cleaning the smoke.

To maximize particle capture, a precipitator must operate at the highest practical voltage. Limiting operational factors are the phenomena known as "sparking" and "arcing," essentially electrical breakdown of the gas that, uncontrolled, would damage the precipitator.

After the Hampton facility was built, researchers encountered a problem, according to Johnston. When standard fuels are burned, the smoke is of constant composition and the highest practical voltage is fairly constant. Once the voltage is set, only small changes in precipitator voltage are needed, as long as the same type of fuel is used.

When trash is used as a fuel, however, the composition of the smoke changes continuously, requiring corresponding changes in precipitator voltage over a very wide range. Johnson explained that if a constant voltage were applied in a refuse- burning facility, the voltage would have to be set very low to prevent sparking, resulting in lower operating efficiency.

To insure minimal atmospheric pollution, Johnston developed a microprocessor-based control that automatically senses changes in smoke composition and adjusts the precipitator voltage and current permit maximum particle collection.

Johnston's invention is now marketed internationally by California company and Johnston picked up a NASA Space Act Award of $5,000.00, a somewhat miserly amount considering the millions his invention has saved and will continue to save the utilities and industry.

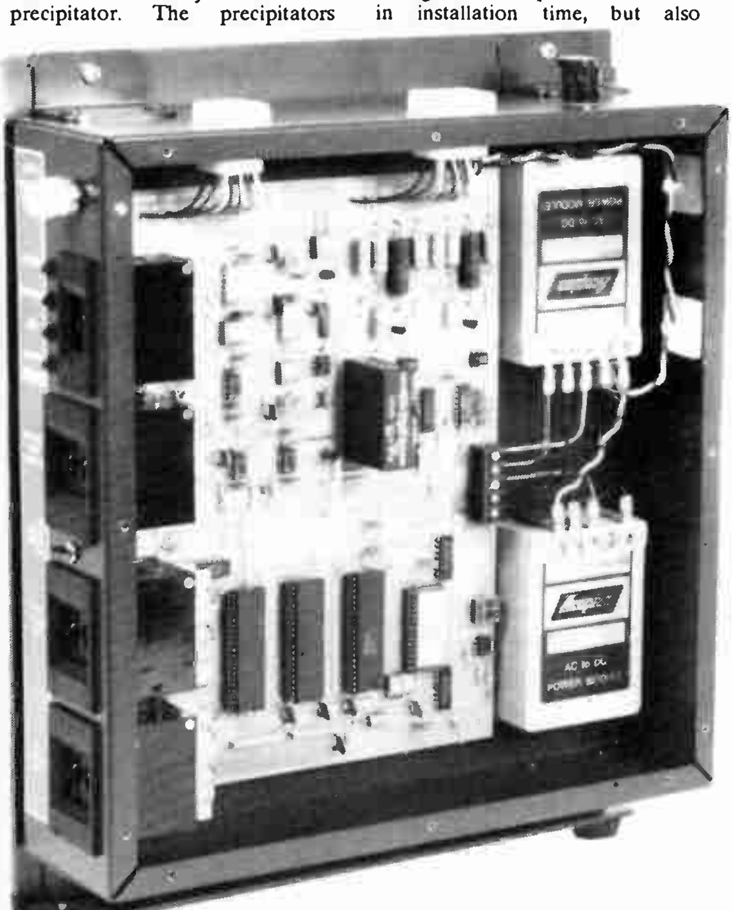

Photo courtesy of NASA

Flat Colour Imaging on the Way

Don't look for it tomorrow. Don't look for it the day after tomorrow. But, the first steps are being taken at the University of California, Irvine (UCI) to develop a new kind of imaging technology that will drastically change our colour televisions in the future.

Scientists at UCI in collaboration with Ford Aerospace and Communications Corp., are using electron transfer reactions to produce colour images on thin chemical films.

According to Dr. John C. Hemminger, principal investigator and professor chemistry, a thin layer of chemical dye is deposited on the surface of a semiconductor.

Ordinarily, electrons on the surface lack sufficient energy to pass through the semiconductor. However, when they are excited by ultraviolet light, the electrons are kicked into a higher energy state and migrate away, leaving electron "holes" on the semiconductor surface.

When a molecule of the dye, Prussian white, loses an electron into one of the electron holes, it undergoes a chemical reaction and turns into Prussian blue. If light is directed on specific parts of the surface, the dye turns blue only at the locations where electron holes are formed and remains clear elsewhere.

In this way, an image can be produced by masking portions of the semiconductor before light is shined on it. Images also may be drawn directly on the surface with a laser — a method which could provide artists with a totally new medium with which to work.

Once an image is formed, it remains stable until "erased" by applying an electric charge to the semiconductor, which returns electrons to the surface and reverses the chemical reaction: Prussian blue reverts to Prussian white.

But it doesn't end there. Says Hemminger, the existence of numerous chemical dyes gives the system potential to produce images in a wide range of colours. In principle, a multicolor system could be achieved by coating a semiconductor with different dyes, each activated by different wavelengths of light.

Like presently available flat screen black and white televisions, a "photoelectrochromic TV" could be small and easily portable. The low voltage needed to change images could be easily supplied by small batteries.

The basic chemistry developed so far at UCI also shows promise for applying coatings on microelectronic devices. For instance, a laser could activate chemical films, turning them into intricately patterned protective coatings and eliminating the need for complex masking and etching procedures. Similar chemistry has been developed by the UCI and Ford col-

Continued on page 66

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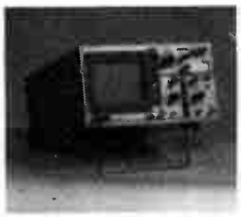

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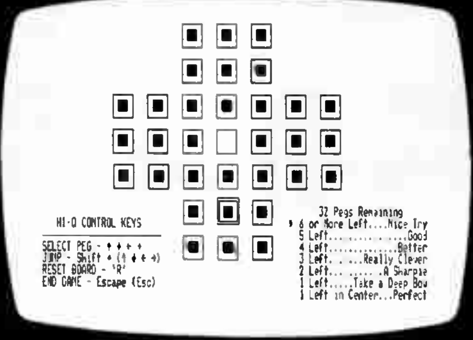

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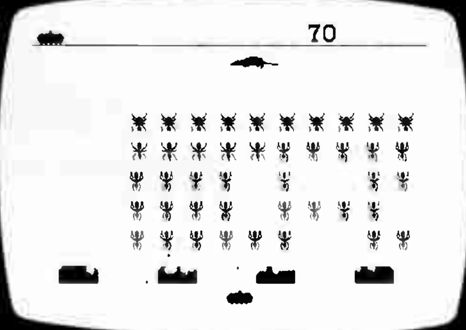

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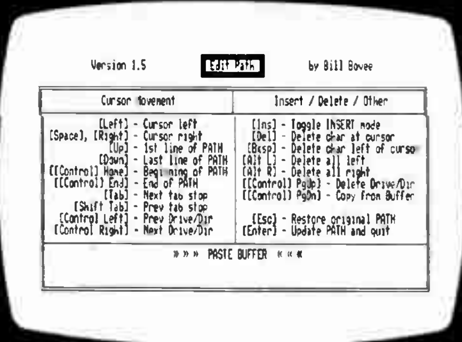

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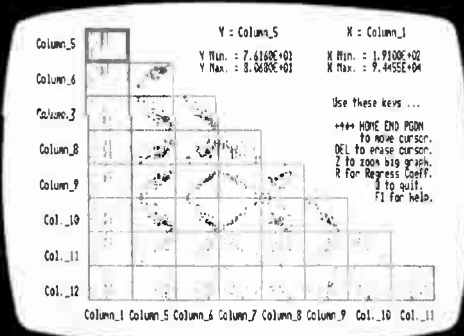

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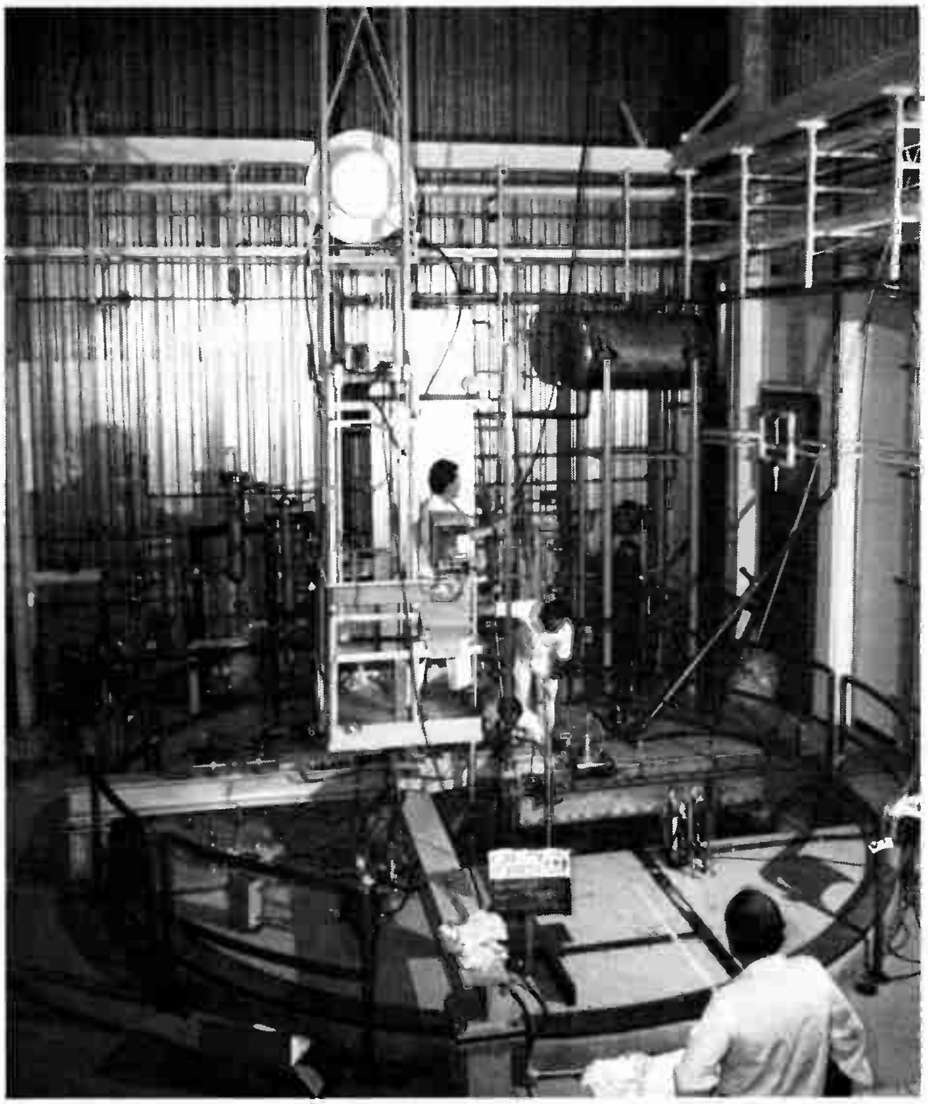
World Radio History

The Slowpoke Reactor

By Jim Eidt

Downsized nuclear technology for large scale heating systems. Is it safe? Will it sell?



There's a certain inevitability perhaps, in these days of calorie-free this, and low-sodium that, that someone would develop and try to market the first "lite" nuclear reactor. That's what Atomic Energy of Canada is attempting to do with its Slowpoke Energy System. And the federal crown corporation is hoping the experiment pays off worldwide.

The Slowpoke is a small nuclear reactor, designed to heat large buildings or clusters of buildings, such as a university campus. AECL prefers to call it a uranium-fired, hot water boiler, and it would probably prefer the public to think of it in those terms as well. The marketing of a small nuclear reactor, whatever it's called in the vernacular of the research community, is likely to be a difficult task.

AECL's operations branch manager, at its Whiteshell Nuclear Research Establishment in Manitoba, admits as much. Although the company is actively negotiating with a Canadian customer for the sale of the first Slowpoke, Larry Meyer says the company realizes it is also pitching the concept to all Canadians, in hopes they will accept it too.

"We have recognized that the greatest hurdle to the success of this product will be gaining public acceptance of it," says Meyer. "We have a demonstrator unit right now that we can show people. However, it's operating in a research atmosphere, and it's absolutely mandatory to the success of the product that we get a unit out into the real world and have it accepted by the public."

The Slowpoke Energy System evolved from the Slowpoke II research reactors that are found across Canada, generally in universities and other research institutions. The concept is markedly different than the nuclear power stations that generate electricity in Ontario, Quebec and New Brunswick. The sole function of the Slowpoke is to produce 80 degree Celsius water for circulation through a heating system.

"The device is ideal for areas requiring approximately ten megawatts of heating power, and that's suitable for something like an average-sized office tower, a shopping mall, a university complex or a large hospital," Meyer says. "I think we are getting a good reception from an interest point of view in Canada."

Competing Energy Source

The Slowpoke can compete on an economic basis with other standard sources of energy, according to AECL. It can heat buildings for an average of two cents per kilowatt hour, although it has a rather hefty start-up cost of $5-$7 million. On the other hand, the Slowpoke will give a minimum of 25 years of service with relatively little maintenance, and even the cost of the replacement fuel is included in the capital cost.

"Slowpoke would produce your heat at something in the order of 1-1/2 to 2-1/2 cents per kilowatt hour. Oil heating in Canada generally costs in the area of three cents a kilowatt hour," says the man in charge of marketing the Slowpoke, Metro Dmytriw. He adds, "Electricity is in the range of three to four cents a kilowatt hour, and natural gas ranges between one and two cents. We cannot compete with gas in all situations."

How It Works

The Slowpoke process is really quite simple. The uranium sits in a tank of water 13.5 metres deep, which is built into the ground. Even with standards governing the use of radioactive materials, the building to house the Slowpoke need not be specially designed or built, although AECL admits the reactor is more suited to a new

World Radio History

facility than a retrofit. The uranium fuel sits near the bottom of the tank, and through controlled fission, heats the water. The hot water rises naturally through a central column to a heat exchanger, which transfers the heat from the tank's water to water in pipes. Then, that is circulated through the building. And that's all it does, says Meyer, who cringes at comparisons with the much larger, electricty-producing nuclear power plant, called the CANDU.

Atomic Energy of Canada intends to emphasize the differences between the two energy systems to the Canadian public, and to the anti-nuclear lobby.

Selling the Idea

"We certainly have run across the anti-nuclear groups already. However, we are finding their arguments really do not apply to our product," says Meyer. "They are really based on a misconception of what our product is all about. And the product, just by due process, will not be put into any community where the public does not accept it."

Although the anti-nuclear lobby is powerful and persuasive, AECL is not without allies. There are more than half a dozen Slowpoke II reactors being used for research in Canada, including one at the University of Alberta. Researchers like reactor technologist Pete Ford say they have been models of efficiency and safety.

"We've never had a problem at all," says Ford. "You have the usual problems with trying to do things that haven't been done before, but that's what research is. We've never had any problem with the reactor itself."

The Slowpoke II is used by graduate students and academic staff for research involving isotope production and neutron activation analysis. It too, is a small reactor, barely the size of a garbage can, although the water and concrete shielding used make the total package considerably larger. Commissioned in 1977, the Slowpoke II at the University of Alberta has been operating problem-free.

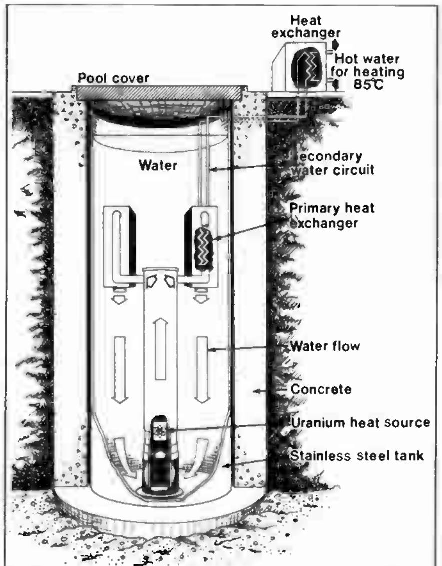
"It's been a very successful venture," according to Ford. However, it won't be Pete Ford and people in his field that AECL is going to have to convince about the Slowpoke heating system. The marketers at AECL, led by Metro Dmytriw, are careful not to call the Slowpoke anything that suggests its power source. Generally, it is called "the product" or "the device" and the uranium is referred to as the "heat source". After decades in the business, AECL is aware of the public's antipathy towards things nuclear.

Even the scientific community is mixed, although Dmytriw dismisses the opposition.

"There are still people who resist fluoridation, and there's still a Flat Earth Society. On any scientific question, there's going to be disagreement, and that's the nature of science."

Quite simply though, AECL needs the Slowpoke to succeed. Canada hasn't sold an electricity-generating CANDU reactor since the late 1970's, and thanks to nuclear debacles like Three Mile Island and Chernobyl, much of the planet has soured on nuclear energy. As a result, AECL's prospects for selling any more of its billion dollar CANDU reactors are dim at best. "It's not a good market out there for any kind of large energy system," argues Dmytriw. "If you look at the fate of coal-fired generating systems, hydro dams, things like that, those have all suffered a comparable setback in construction starts.

"The size of the market that Slowpoke can meet and the size of the income is, of course, not as large as the CANDU electricity generating systems. Those are huge, billion dollar systems. The initiative to start development of the Slowpoke comes from a general AECL philosophy that users of technology developed by AECL should pay for that technology. So we're following incentive now to go to our labs, and find things that are commercially viable. Slowpoke is part of that whole process." Given the moves by the federal government, though, to sell off unprofitable (and even some profitable) crown corporations, AECL may be gambling with its own future.



The internal workings of a Slowpoke Reactor.

It is betting on a product that, if accepted by the public, could have dozens of applications across the country. The world market is also ripe according to AECL, which had representatives from South Korea and Czechoslovakia on hand for the official commissioning of the Slowpoke demonstration unit in mid-October.

Although other nations are developing their own versions of small, heating reactors, Canada has a significant lead according to AECL, which also believes its product to be superior.

Meyer says the world market is very attractive, but he believes that potential can't be tapped until a Slowpoke is sold in Canada.

"We suspect that overseas customers will definitely want to see the product in action in our own country before they would consider it." Dmytriw isn't so sure.

"Business is business," he says. "And if a country can see that if it can guarantee its energy supply for a long time, and can make some major gains in its energy programs, it doesn't mind demonstrating the technology first."

AECL believes it might have an operating Slowpoke in place by 1990, if negotiations now underway bear fruit. The deal could be wrapped up early this year. Among the bumps in the road ahead, is the anti-nuclear lobby. It is distrustful of anything that uses uranium, especially while the problem of nuclear waste disposal remains unsolved. But even anti-nuclear activist Dr. Colin Park of Edmonton can see applications for the Slowpoke, particularly in northern Canada, where heating fuel must be trucked in at enormous expense.

Safety Concerns

That's not to say Park is a fan of the Slowpoke. He's still concerned about changing the uranium fuel source, which must be done very few years, and he says the potential for human error still exists, regardless of the simplicity of the system. What's more, Park, while

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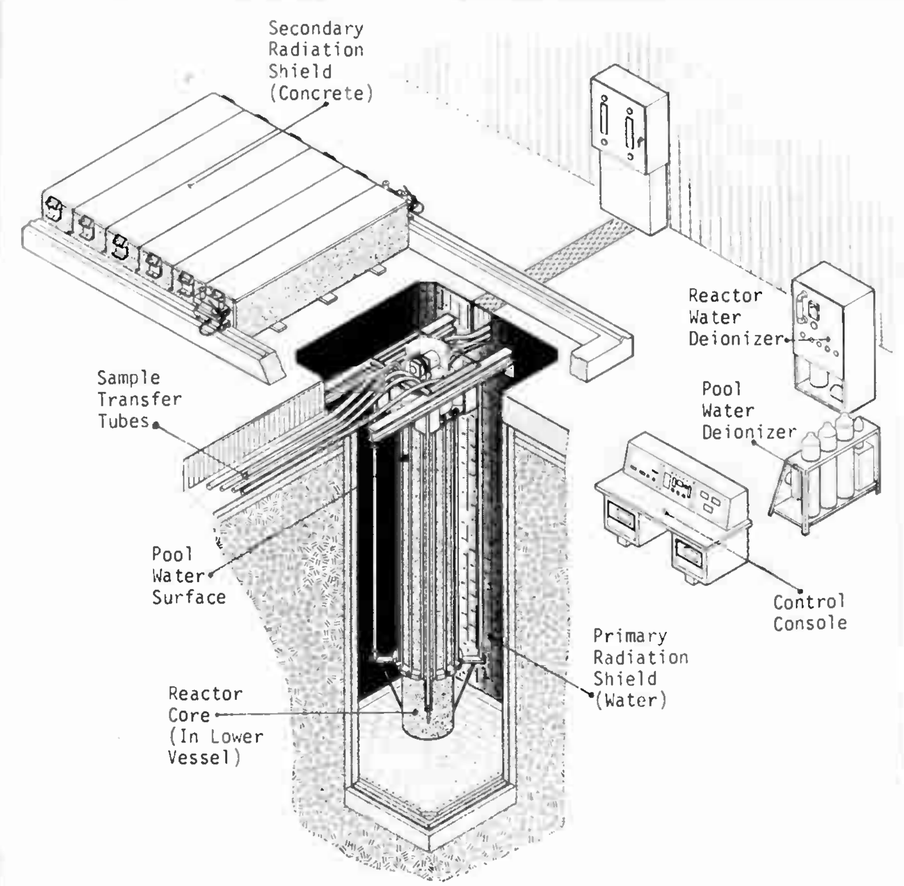
Commissioning of the Slowpoke demonstration reactor at Pinawa, Manitoba.



A schematic diagram of the Slowpoke Reactor Facility at the University of Edmonton.

admitting Canada's nuclear industry is better than most, still worries about exporting problems around the world. Unreliable local construction, he says, coupled with a lack of control over how the system is run once it is sold, make foreign sales risky. Park also alleges the nuclear industry is full of examples of deceit.

The public too, is leery about claims of safety from the nuclear industry. Studies are still being conducted, and statistics compiled, from the Three Mile Island accident nearly a decade ago, and there are indications that the resulting health problems have been worse than anticipated. The work on Chernobyl's worldwide impact is only getting underway.

Add to those major nuclear accidents, the 3000 or so small incidents reported at nuclear facilities in North America each year, and the public has a right to its concerns. Certainly, such information saps public confidence, despite the industry's best efforts to bolster it. Dmytriw thinks a sale would help considerably in that regard.

"We're talking with quite a number of people. We've already done a number of studies, where the answer was no. For example, Hay River in the Northwest Territories asked us to come up and look at whether we could heat the town using Slowpoke. It turned out we couldn't for a variety of engineering reasons. The major difficulty that we found there, was that the town was fairly well dispersed, and so the cost of putting in the distribution hot water lines was fairly high. It wasn't the source of heat itself, it was getting the heat to the buildings."

AECL plans to continue pointing out the differences in technology between its Slowpoke and the giant reactors that are the main sources of public fear. AECL takes the pounding of a hostile anti-nuclear lobby, a suspicious public and a divided scientific community, and tries to make a successful business out of a product that ranks somewhere between government and the tobacco industry in popularity. The little Slowpoke may help in that regard, although most early sales may end up in either remote Canadian communities, or other countries.

Jim Eidt is a freelance writer from Edmonton, Alberta. ■

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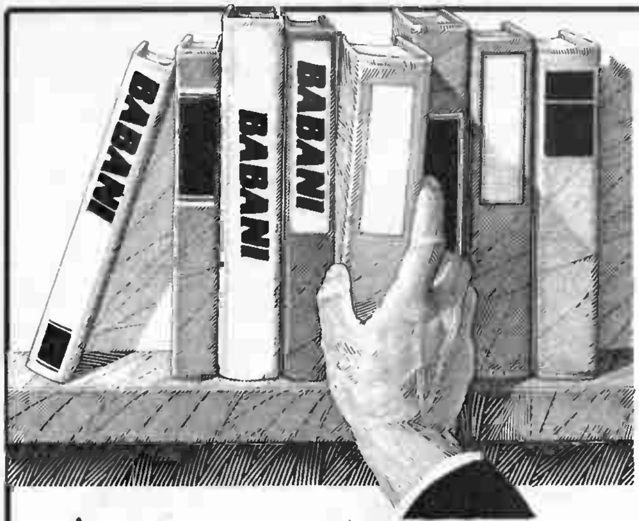

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Divided into six parts, this book covers such areas of mobile "disco" as: Basic Electricity, Audio, Ancillary Equipment, Cables and Plugs, Loudspeakers, and Lighting. All the information has been considerably subdivided for quick and easy reference.

BP131: MICRO INTERFACING CIRCUITS - BOOK 2 $9.00
Intended to carry on from Book 1, this book deals with practical applications beyond the parallel and serial interface. "Real world" interfacing such as sound and speech generators, temperature and optical sensors, and motor controls are discussed using practical circuit descriptions.

BP141: LINEAR IC EQUIVALENTS AND PIN CONNECTIONS
ADRIAN MICHAELS $23.80
Find equivalents and cross-references for both popular and unusual integrated circuits. Shows details of functions, manufacturer, country of origin, pinouts, etc.,. Includes National, Motorola, Fairchild, Harris, Motorola, Intersil, Philips ADC, AMD, SGS, Teledyne, and many other European, American, and Japanese brands.

BP156: AN INTRODUCTION TO QL MACHINE CODE $10.00
The powerful Sinclair QL microcomputer has some outstanding capabilities in terms of its internal structure. With a 32-bit architecture, the QL has a large address range, advanced instructions which include multiplication and division. These features give the budding machine code programmer a good start at advanced programming methods. This book assumes no previous knowledge of either the 68008 or machine code programming.

BP59: SECOND BOOK OF CMOS IC PROJECTS $7.80
This book carries on from its predecessor and provides a further selection of useful circuits, mainly of a simple nature. the book will be well within the capabilities of the beginner and more advanced constructor.

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BP32: HOW TO BUILD YOUR OWN METAL & TREASURE LOCATORS **$7.80**
Several fascinating applications with complete electronic and practical details on the simple, and inexpensive construction of Heterodyne Metal Locators.

ELECTRONIC THEORY

BP106: **$7.00**
Cross-references European American and Japanese diode part numbers. Besides rectifier diodes, it includes Zeners, LEDS, Diacs, Triacs, SCRs, OCIs, photodiodes and display diodes.

BP144: FURTHER PRACTICAL ELECTRONICS CALCULATIONS AND FORMULAE **$15.00**
This book covers many aspects of electronics where a knowledge and familiarity of the appropriate formulae is essential for a fuller understandings of the subejct. An essential addition to the library of all those interested in electronics be they amateur, professional or student.

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 **$11.70**

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

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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.

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

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BOOK5 A book covering the whole communication scene.

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The projects in this book consists of various types of controller, including a high quality pulse type, as well as circuits for train position sensing, signal and electronic points control and many more.

BP194:: MODERN OPTO DEVICE PROJECTS **$9.00**
This book provides a number of practical designs for beginners and experienced project builders. These projects utilize a range of modern opto-electric devices, including such things as fibre optics, ultra bright LEDs and passive IR detectors.

BP37: 50 PROJECTS USING RELAYS, SCR's & TRIACS **$7.80**
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.

BP71: ELECTRONIC HOUSEHOLD PROJECTS **$7.00**
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.

BP90: AUDIO PROJECTS **$7.80**
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 miscel laneous prospects.

BP44: IC 555 PROJECTS **$10.00**
E.A. PARR, B.Sx., 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.

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS **$7.80**
A collection of simple circuits which have applications in and around the home using the energy of the sun to power them. The book deals with practical solar power supplies including voltage doubler and tripler circuits, as well as a number of projects.

BP49: POPULAR ELECTRONIC PROJECTS **$10.00**
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.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS **$7.80**
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.

BP95: MODEL RAILWAY PROJECTS **$7.80**
Electronic projects for model railways are failry 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.

BP93: ELECTRONIC TIMER PROJECTS **$7.80**
Windscreen wiper delay, darkroom timer and metronome projects are included. Some of the more complex circuits are made up from simpler sub-circuits which are dealt with individually.

BP84: DIGITAL IC PROJECTS **$7.80**
F.G. RAYER, T.ENG (CEI), Assoc.IERE
This book contains both simple and more adanced 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 build 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.

BP99: MINI - MATRIX BOARD PROJECTS **$7.80**
R.A. PENFOLD
Twenty useful projects which can all be built on a 24 x 10 hole matrix board with copper strips. Includes Doorbuzzer, Low-voltage Alarm, AM Radio, Signal Generator, projector Timer, Guitar Headphone Amp. Transistor Checker and more.

BP103: MULTI-CIRCUIT BOARD PROJECTS **$7.80**
R.A. PENFOLD
This book allows, the reader to build 21 fairly simple electronic projects, all of which may be constructed on the same printed circuit board. Wherever possible, the same components have been used in each design so that with a relatively small number of components and hence low cost, it is possible to make any one of the projects or by re-using the components and P.C.B. all of the projects.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS - BOOK 1 **$9.00**
R.A. PENFOLD
A "Solderless Breadboard" is simply a special board on which electronic circuits can be built and tested. The components used are just plugged in and unplugged as desired. The 30 projects featued in this book have been specially delsgned to be built on a 'Verobloc" breadboard. Wherever possible the components used are common to several projects, hence with only a modest number of reasonably inexpensive components it is possible to build, in turn, every project shown.

BP108: MODERN ON AMP PROJECTS **$7.80**
R.A. PENFOLD
Features a wide range of constructional projects which make use of op-amps including low-noise, low distortion, ultra-high input impedance, high slew-rate and high output current types.

CIRCUITS

BP127:HOW TO DESIGN ELECTRONIC PROJECTS **$9.00**
Although information on stand circuit blocks is available, there is less information on combining these circuit parts together. This title does just that Practical examples are used and each is analysed to show what each does and how to apply this to other designs.

BP122: AUDIO AMPLIFIER CONSTRUCTION **$6.75**
A wide circuits is given, from low noise microphone and tape head preamps to a 100W MOSFET type. There is also the circuit for 12V bridge amp giving 18W. Circuit board or stripboard layout are included. Most of the circuits are well within the capabilities for even those with limited experience.

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 **$9.00**
R.A. PENFOLD
70 plus circuits based on modern components aimed at those with some experience.

BP179: ELECTRONIC CIRCUITS FOR THE COMPUTER CONTROL OF ROBOTS **$12.00**
The main stumbling block for most would-be robot builders is the electronics to interface the computer to the motors, and the sensors which provide feedback from the robot to the computer. The purpose of this book is to explain and provide some relatively simple electronic circuits which bridge the gap.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS **$7.00**
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.

BP88: HOW TO USE OP AMPS **$11.80**
E.A.PARR
A designer's guide covering several op amps, serving as a source book of circuits and a reference book for design calculations. The approach has been made as nonmathematical as possible.

BP65: SINGLE IC PROJECTS **$6.00**
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.

BP118: PRACTICAL ELECTRONIC BUILDING BLOCKS - BOOK 2 **$7.80**
R.A. PENFOLD
This sequel to BP117 is written to help the reader create and experiment with his own circuits by combining standard type circuit building blocks. Circuits concerned with generating signals were covered in Book 1, this one deals with processing signals. Amplifiers and filters account for most of the book but comparators, Schmitt triggers and other circuits are covered.

BP83: VMOS PROJECTS **$7.80**
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.

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Security Systems: A Basic Overview

Protecting your home and family from thieves and other disasters.

By Andrew Singmin

In today's society, with the number of unlawful entries into premises being on the increase, the security conscious home-owner is becoming more concerned about the protection of property and possessions. The statistics for a major Canadian city, reports that for every commercial premise broken into, a corresponding two residences are entered. The consequence of such incidents have led to the growth of a large number of security firms, supplying both products and services.

For the non-security specialist, a bewildering array of electronic security systems and support hardware can be had. In order to guide the concerned home-owner through the maze of available options, a very basic overview is presented on what essentially constitutes the fundamentals of any security system. Since the cost of many installed systems would leave little change from $1000, the prudent purchaser could benefit by knowing exactly what they were getting for their investment.

Definition

To begin; what is a security system? Very simply, a security system performs two separate and distinct functions, as shown in Fig. 1.

Depending upon the level of sophistication needed and the amount of funds available, the basic system can be configured to an infinite number of combinations. Current technology allows functions 1 and 2, i.e. "Detection" & "Communication", to be made possible to very high levels of complexity.

A more detailed examination of functions 1 and 2 shows that a further subdivision can be made as seen in Fig. 2.

In summary, a security system should perform the following:

1) Detect
- Entry into premises

and/or
- Movement within premises

2) Communicate
- Via internal/external siren

and/or
- Silent alarm to local police

Methods for Detection

Entry detection

Electromechanical hardware forms the prime source of sensor devices, which are typically of two types: contact switches and vibration sensors.

These are generally mounted onto/within window and door frames, usually at the normal entry points. These switches can either be hidden or exposed, but perform the same unique function - when the door or window is unlawfully opened an electrical circuit is completed, via the action of the switch.

Vibration detectors this type of sensor is usually mounted onto non-opening windows, detecting the act of breaking the window glass.

Both types of switches are very simple (electrically) to use; however, significant work on the door and window frames for locating the switches and associated wiring must be performed. The cost of installation would generally far exceed the cost of the switches themselves.

Movement detection

Electronic sensors are the main source of devices and again are split into two distinct types.

a) Infra-Red, Ultrasonic or Microwave systems, send out a beam of energy into a room and detect the reflected beam off an unlawful intrusion into the protected airspace. The basic principle is always detection of a reflected beam.

b) Thermal sensors, detect the presence of heat emission from a person entering the protected zone.

Both systems contain complex electronic circuitry, but nevertheless are simply plugged directly into the standard 125v power socket. A major undesirable characteristic of these systems however, is the susceptibility to false triggering, especially via the presence of pets around the house. Hence, it is generally stipulated by the manufacturers of such systems that operation should not be carried out in such an environment.

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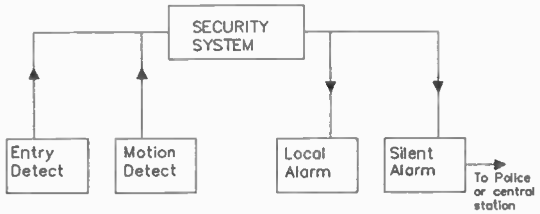

Fig. 1 Block diagram showing the two distinct functions of a security system.

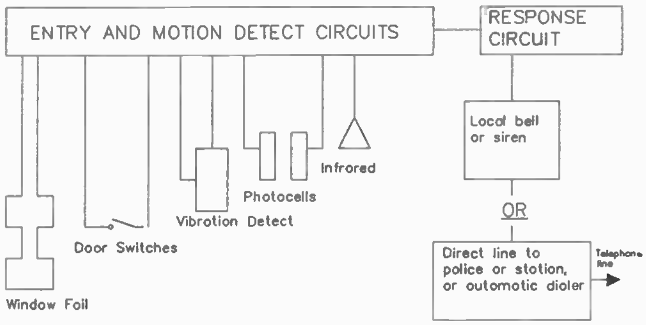

Fig. 2 A further breakdown of the two functions shown in Fig. 1.

Methods for Communication

Audible siren

The very familiar siren features most often found in security systems serve as a means of alerting the home-owner or neighbors to the fact that entry into the premises has occurred. Mounting of the siren can be either inside or outside the house. An additional purpose for the siren is to halt the intruder's activities.

Silent alarm

This service is generally offered by security firms specializing in monitoring services. When a silent alarm is set off, a check is made upon the state of the house. If no verification is received that the house is secure, then a call is made to the local police.

Conclusion

Security systems can be a significant monetary investment depending upon the level of sophistication required. It would be wise therefore, when comparing the merits of various systems offered, to separate the 'DETECTION' from the 'COMMUNICATION' functions in order that valid comparisons can be made.

Andrew Singmin is a freelance writer from Kanata, Ontario. ■

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Easy Sine Generator

A low cost, versatile auido signal generating with up to six volts of ouput.

By Mark Stuart

This simple low cost audio generator is extremely useful to have around. The output is a sine wave of up to six volts peak to peak and the frequency can be varied from 33Hz up to 33kHz. Two output sockets give variable outputs of 0-60mV, and 0-6 volts. A third socket gives a constant six volts output which can drive loads as low as eight ohms directly at up to 0.5 watts. This high power output level is ideal for checking loudspeakers and associated wiring. The compact construction makes the unit perfect for the tool box or pocket.

The Circuit

The circuit diagram of the oscillator is shown in **Fig.1**. A single audio amplifier IC, the LM386N-1, does everything. The frequency of oscillation is set by the dual variable control VR2a and VR2b, in conjunction with whichever pair of capacitors is selected by S1b and S1c. Capacitors C1 and C4 give the low frequency range of 33Hz to 330Hz, C2 and C5 give 330Hz to 3.3kHz, C2 and C5 give 330Hz to 3.3kHz, and C3 and C6 give 3.3kHz to 33kHz.

The components together form a frequency selective network known as a Wein Bridge. At the frequency of oscillation the circuit has its maximum voltage loss of one third, but most important, it also has a phase shift of zero. This means that the output signal is fed back to the input in-phase, creating the oscillation. Above or below this frequency the loss is less. Unlike the sort of tuned circuits used in radio receivers which can have very sharp peaks, this circuit has only a gentle hump in its frequency response. Its big advantage is that it does not use inductors (which would be very large for low frequencies) and that the frequency can be varied by changing just two resistor values. Feedback via this network is passed from the output of IC1 (pin five) to its non-inverting input (pin three) via R2 and R3. If the amplifier gain is exactly three, the losses of the feedback network are made up and the whole circuit will oscillate as required.

The problem in a practical circuit is that a gain of exactly three is impossible to achieve. If the gain is only slightly less than three the circuit will never oscillate, and if the gain is slightly more than three the oscillations will go on increasing the level until the amplifier is driven into clipping and the output is no longer a sine wave.

What is needed is a means of measuring the output level and increasing or decreasing the gain as the output voltage falls or rises. Many elaborate circuits have been designed to do this, some of which are very sophisticated and are used in top class audio measuring instruments. One of the most common methods is to use a pair of diodes or Zener diodes in the feedback network to introduce a controlled form of clipping and to set the gain to slightly over three. This method introduces a small amount of distortion but is adequate for some applications.

The Thermistor

An alternative is to use a thermistor which is driven by some of the output signal and as a result increases in temperature and changes resistance. This change in resistance is arranged to affect the feedback signal so that if the output rises and the thermistor gets hotter the gain is automatically reduced and vice-versa. In this way the gain is constantly controlled and sets itself to exactly three. Low distortion and simple circuitry are the merits of this method, the only drawback being the cost and availability of the thermistor. As this has to be heated by a very

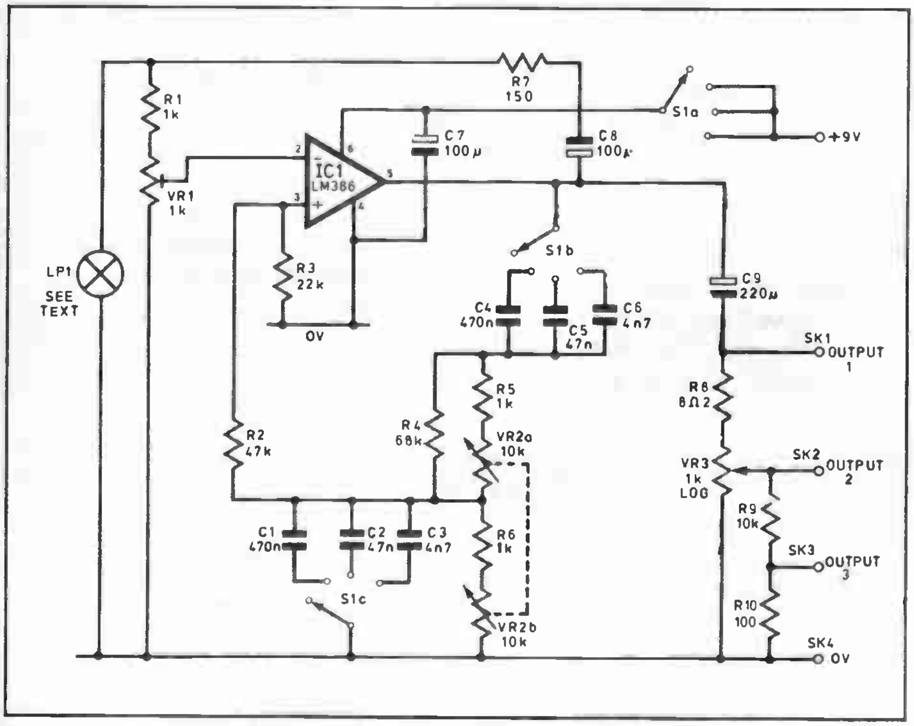


Fig. 1. The complete circuit diagram of the signal generator. See the text for further information on the stabilizing lamp and the potentiometers.

World Radio History

ALMOST FREE
PC SOFTWARE VOLUME XXVI

AWS Programs that turn WordStar documents into ASCII abound, but this one turns ASCII back into WordStar. Let those high bits roll.

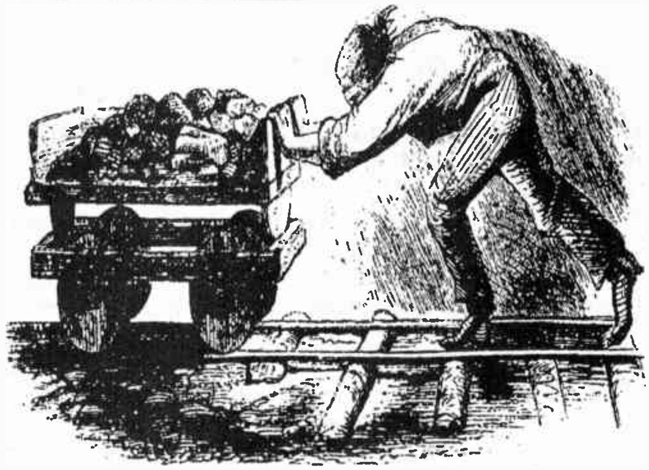
BADCLUST This program finds the bad clusters on cheap disks, preventing them from killing your data. If you must use low rent oxide, use it carefully.

CHEAPFMT Like BADCLUST, above, this program makes your life less freaky if you use cheap disks. It formats them very carefully, looking for unusable sectors.

CCC A C language programmer's dream, this is a "pretty print" program, that actually draws nesting loop and structure diagrams beside the source code it lists. It makes spotting even subtle bugs effortless.

CTP Somthing of a mutated fusion between snake and space invaders, this is a ruthlessly fast arcade style game in first rate high resolution graphics. Requires a colour card or HGC, below, and a Herc board.

HGC This is the first colour card simulator for a Hercules board that really seems to have its act together for the majority of colour card graphics software. Run it and your Herc card will display colour card high resolution graphics as if it was designed for the task.



STEEL RAIL BLUES

This month we've managed to compress more than the usual amount of software onto one disk... literally. By creating this disk with archive compression, you'll get well over half a megabyte of software when you unpack the files it includes. The unpacking utility is on the disk, and is easy and painless to use.

This month's disk includes some games, some serious stuff and a collection of unusual utilities. Some of these programs came from way down in the southern States... we found a new source of public domain code down there.

As always, each of these programs has been carefully checked out. You can trust Almost Free Software for programs that work... and don't contain any of the trojans and worm killers that can wipe out an unsuspecting hard drive.

All of this profound software, plus its attendant documentation and support files, is available for a mere

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BIGPRINT This program prints text files in very large characters. It requires an Epson compatible printer.

MBS This is one of the nicer fractal programs we've encountered, as well as being one of the faster ones. It runs on a colour card, or on a Herc board with HGC, above.

MOUSE This is the source code for the linkable MOUSE driver, as seen in the July 1987 edition of Computing Now!. It requires MASM to assemble it and a C compiler to use.

PCRR This is one of the most interesting programs we've yet encountered. It simulates a railroad in high resolution graphics. You can lay out your railroad, equip it with multiple trains and make the whole party go. It's good for hours of fun and there's no track to buy. Requires a colour card or HGC, above, and a Hercules board.

TASKER This is the most elaborate multitasking system yet devised for the PC. Install up to nine variable sized partitions, with a program running in each, and pop between them instantly.

WINDOW This is the source code for the C language window manager from the July 1987 edition of Computing Now! Written in lattice C.

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Fine Print: We check this software out very carefully. However, we cannot be responsible for any loss or damage caused by it, nor are we able to assist you in modifying it for specific purposes. All of this code was tested on PC compatible systems... if your computer is incompatible in some respect you may encounter difficulties with it. Disks do get damaged in the mail from time to time. If you are unable to read our disk when you get it, please return it to us for an immediate replacement. All of the software on this disk has been generated by us or gathered from public domain sources, and is believed to be in the public domain.

Our latest software catalogue lists a variety of interesting, low cost programs. Circle reader service card number 100 for a **free** copy.

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ALMOST FREE

PC SOFTWARE VOLUME XXVII

DECEIVE This is a resident program to be used if your boss likes to creep up behind you when you're supposed to be working. At the touch of a key your PacMan screen can be replaced by WordStar, Lotus or any other serious application until the powers that be are satisfied and play can resume.

DPATH Allows the opening and creating of files to be handled with a path, just as the running of programs is under DOS with the PATH command. This is the gift of the gods to programs that can't find their overlays and configuration files.

HXC A sophisticated hexidecimal calculator, this program will keep you from damaging your hands by trying to glue on four extra fingers.

IOMON This is a resident utility which monitors the disk I/O of your system and lets you see what the drives are doing. It's great for spotting the causes of system errors.

TREECOPY This is the best... and fastest... tree copy utility we've encountered to date. It will copy and entire subdirectory and all of its included sub-subdirectories into another tree.

TREEDEL This program will wipe out a whole subdirectory and any subdirecties in it with one command. Mass slaughter... what fun!

TREESIZE This program will tell you how much space is occupied by the aggregate contents of a subdirectory.

KC-PAL An EGA pallete editor and librarian. Comes with lots of support utilities and toys. Not surprisingly, it requires an EGA card.

This month we've tried to concoct a disk that will be useful to everyone. It has serious stuff, a good game and all manner of useful system utilities. It also has a way to help you keep your job.

As with all of our recent disks, this one is archived to allow us to get more software on it than would usually fit on a single floppy disk. The un-archiver is included, and is pretty painless to use. This collection will unpack onto three moderately full floppy disks.

Like all of our almost free software collection, these programs have been relentlessly scrutinized for trojans and disk killers. Beware the software collections that don't check for nasty code... some of those little beasts have become incredibly sneaky in recent months.

With the increasing popularity of EGA compatible display adapters, this disk also includes a number of programs custom written for the EGA card.

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VRAM This is an amazing bit of work for people with programs that want to see a Lotus-Intel AboveBoard memory card... if they lack one. It allows up to eight megabytes of hard drive space to pretent to be extended memory... sort of a RAM drive in reverse. Great for Lotus users with big sheets to spread. (Please note that this is a restricted version of this program: the author requires a $25.00 contribution for a complete copy.)

LQPRINT If you've ever wanted to print attractive documents without having to pop for an expensive fancy printing package, this thing was written for you. It does all the special effects you can imagine, runs under just about anything and supports all sorts of dot matrix printers. It includes a wide selection of very well done fonts.

ZANSI Another replacement for ANSI.SYS, this one increases your console printing speed by almost fifty percent without sacrificing any of the commonly used ANSI.SYS functions.

CYLON This makes your cursor go strange... deliberately. It's useless but it's very small. Reqires an EGA card.

EGAROIDS The best asteroids game ever written for the PC... when those rocks come at you start praying to the cosmic gods. Requires an EGA card.

NEWFONT Replace the austere, depressingly corporate IBM font of your PC with damn near anything you can think of. Several fonts are included. The screen interface is seamless, and the results can be extremely pleasing. Requires an EGA card.

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small signal it has to be physically small and contained inside an evacuated glass envelope. In this circuit the thermistor method has not been used but instead a small cheap filament lamp is employed.

Lamp Characteristics

It is generally known that the resistance of a filament lamp changes as it heats and cools. What is probably less well known is exactly how much. To get some idea of the figures involved a small bulb of 12 volts 60mA rating was tested. The voltage across it was varied and the current measured at different voltages from 25 millivolts upwards. The resulting curve is plotted in **Fig. 2**. A normal resistor would produce a straight line as shown by the dotted line for a 200 ohm resistor. The shape of the curve shows that initially the current increases rapidly for only a small increase in voltage but gradually increases less and less as the voltage gets higher.

At very low current and voltage (1mA, 25mV) the slope of the curve shows the resistance to be around 25 ohms. At higher currents the effective resistance rises, becoming 335 ohms at 12 volts. This has very interesting implications from the point of view of switch-on surges. In this case a 60mA bulb will actually look like a 25 ohm resistor at switch-on and will draw a current of 500mA. If the power supply can only provide 250mA, then a voltage dip will occur which could result in numerous undesirable circuit effects. If is assumed that all bulbs behave similarly it indicates that a car headlight bulb rated at 48 watts or four amps will draw an initial surge current at switch-on of around 35A. The headlamp switch must therefore be able to handle regular 60A current surges.

Getting back to the original purpose of all this, it is clear that the bulb filament can be used in the same way as a thermistor to control the gain of the oscillator circuit. The bulb resistance increases as the power in it increases and this must be arranged so that it causes a decrease of circuit gain.

Second Feedback Loop

The arrangement shown in Fig. 1 achieves the necessary control by introducing a second feedback loop around IC1. This loop is from the output to the inverting input, and so it is negative feedback. The output signal is coupled via C8 and R7 to the lamp LP1. The voltage across the lamp is tapped off via R1 and VR1 and fed to pin two of IC1. Operation is as follows: Initially when the circuit is switched on, LP1 is cold and so has a very low resistance. Any feedback via R7 is therefore shunted away and has little effect. Without negative feedback the circuit has high gain and so oscillation commences and builds up.

As LP1 is heated by the increasing output signal, its resistance increases and so the voltage across it also increases. This causes more negative

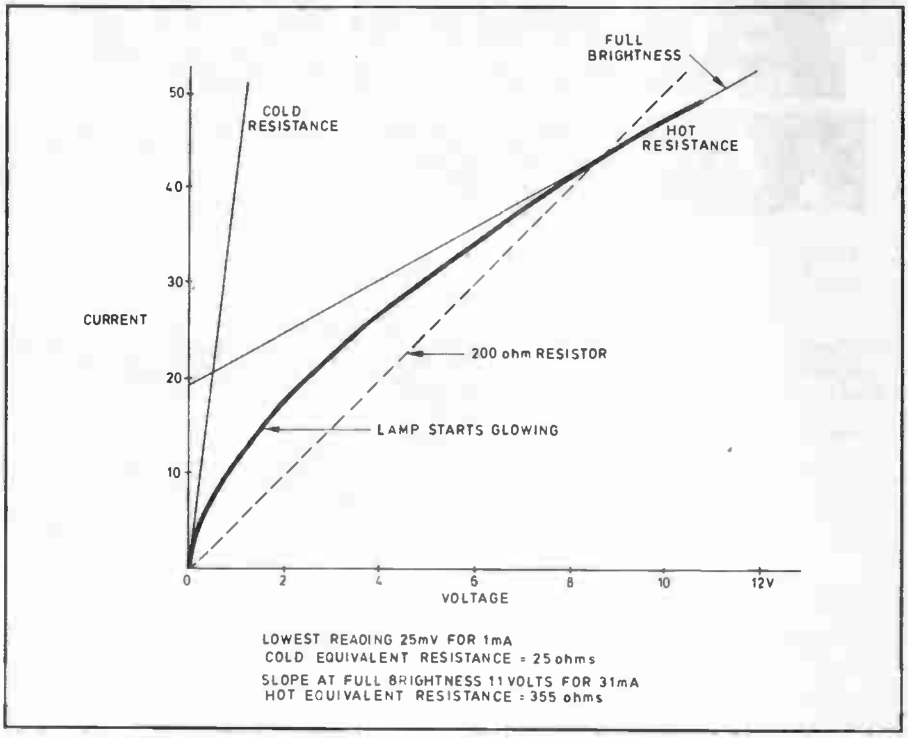

Fig. 2. Lamp resistance variation with current.

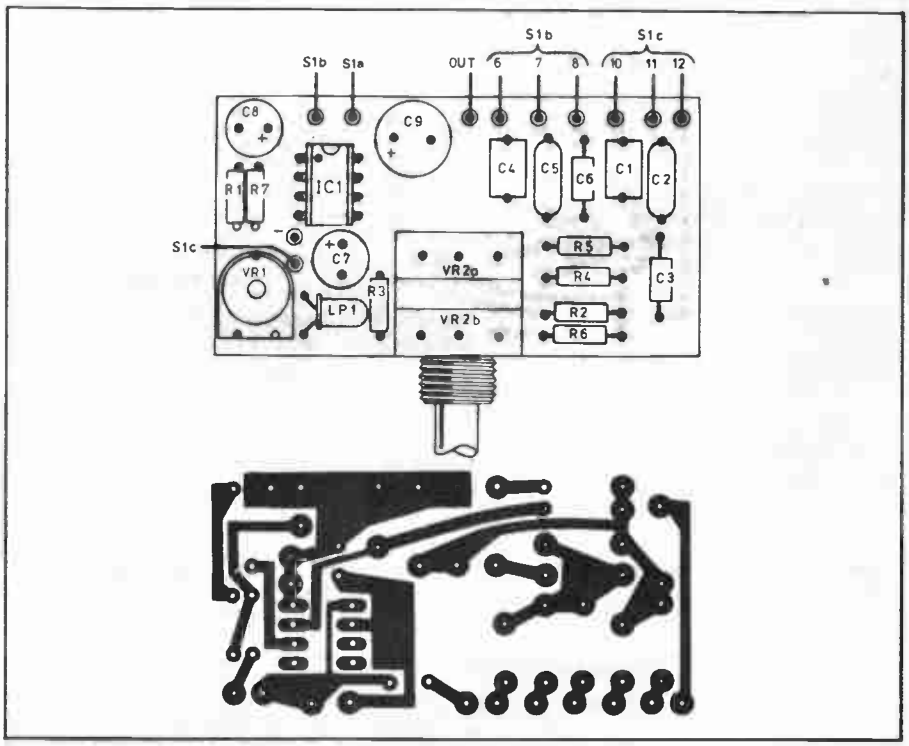

Fig. 3. The printed circuit layout and wiring details.

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feedback to be applied to the circuit which reduces its gain. This stabilizes the oscillations at a level which can then be preset by means of VR1. The result is a good stable sine wave output of 6V peak to peak.

Although the final circuit is very simple, the actual design of the negative feedback stabilization loop is quite difficult. The thermal inertia of the lamp puts a delay into the circuit which can cause the stabilization to overshoot. This means that the output level çan have a tendency to bounce up and down as the frequency is varied. Careful design is necessary to reduce this effect to a minimum.

Outputs

Three outputs are available from the circuit. One is straight from the IC output via C9, and is capable of driving a speaker at up to 0.5 watts. The second output is variable by means of VR3 from zero to six volts. R8 protects this output from short circuits. The third output is divided by 100 by R9 and R10 and so is suitable for use with sensitive input circuits.

Power

The circuit can be powered either by 9 or 12 volts. A 9V alkaline battery will give adequate power for intermittent use. An 9V or 12V AC-to-DC mains adaptor should be used if the unit is in use for longer periods, for example during bench testing. A section of S1 (S1a) is used as the on-off switch.

Pots

The main frequency control pot VR2 should be a 10k reverse-log taper. This allows the frequency dial markings to be spread out evenly around the dial; a linear pot will make the markings jam up together at one end. If you can't find a reverse-log pot, and they're very hard to find, you can (a) put up with the condensed range of a linear pot, or (b) use a standard dual log pot and mark the dial backwards (in other words, the frequency decreases with clockwise rotation.

Output pot VR3 should be a log pot to prevent its range being squeezed into one end, but you can get away with a 1k linear. It's not all that critical.

Construction

The whole circuit is built on a small printed circuit board which is shown in Fig. 3, the copper track pattern is also

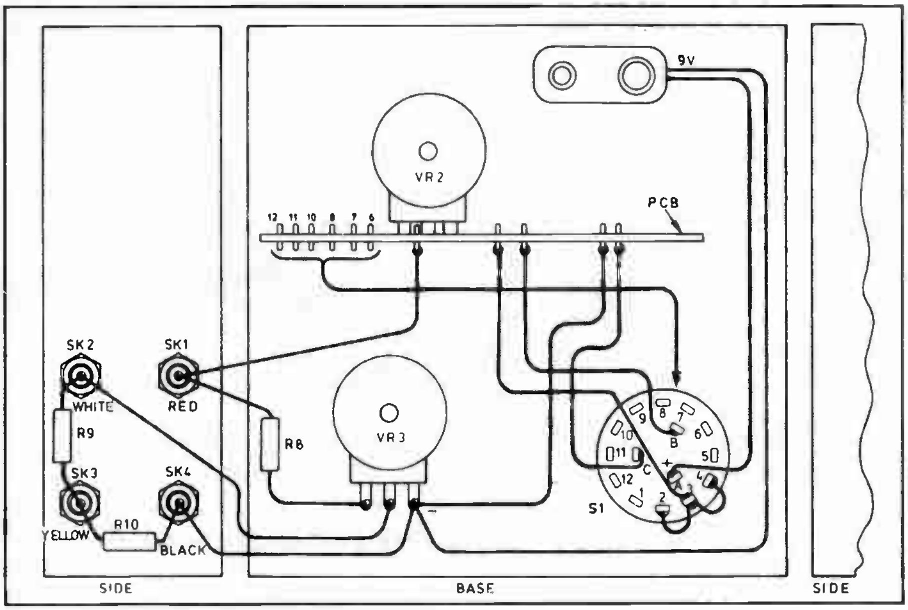

Fig. 4. Interwiring details.

shown. Assemble the board as shown taking care to get C7, C8 and C9 the right way around. A socket should be used for IC1 . The board should be fitted with flexible wire leads for the connections to VR3 and S1. These leads are best fitted directly to the board by stripping approximately 6mm of insulation and passing the bar ends through from the component side and soldering on the track side.

Refer to the wiring diagram of Fig. 5 for all of the necessary off-board connections. Switch S1 has all of its tags numbered or lettered for ease of identification. If different switches are used it may be necessary to make changes to this. The lamp LP1 should be secured to the board with a small blob of adhesive. It is important that the correct lamp is used for the stabilization circuit. Because of variations in lamp construction, it's wise to buy several and select the one that gives the most stable signal.

Setting Up

The circuit only requires adjustment of VR1 to be up and ready to use. Fortunately this adjustment is quite simple. Ensure that a fresh battery is fitted, select the lowest frequency range and set the dial to give approximately 50Hz. Connect a multimeter set to AC volts between OV and "Output 1". Adjust VR1 to give a reading of 2.1 volts, and that's it. The calibration of VR2 can be done by borrowing a frequency meter or oscilloscope, or in a slightly more primitive way by comparison with musical instruments (A above middle C is 440Hz).

Parts List

Resistors

R1,5,6 .... 1k
R2 .... 47k
R3 .... 22k
R4 .... 68k
R7 150
R8 .... 8R2
R9 .... 10k
R10 100

Potentiometers

VR1 .... 1k trim pot
VR2 .. 10k dual log (see text)
VR3 .... 1k log (see text)

Capacitors

C1,4 .... 470n
C2,5 .... 47n
C3,6 .... 4n7
C7,8 .... 100u, 16V
C9 .... 220u, 16V

Semiconductors

IC1 LM386N-1 power op amp

Miscellaneous

LP1 12V, 60mA miniature wire-ended lamp, S1 3-pole 4-way rotary switch, SK1 to SK4 panel sockets or binding posts to suit, 2 suitable knobs, optional 8-pin IC socket, 9V battery clip, metal case, wire, solder, etc.

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The Physics of Music, Part 5: Resonance

How strings and tubes produce tones

By Bill Markwick

If we leave electronic musical instruments aside for the moment, it's safe to say that all the music we listen to comes from something resonating, or emitting a tone at a specific frequency. Over the centuries, instrument makers seem to have tried every possible method of utilizing objects that can be made to emit desired tones. Some are simple and some are elaborate combinations of various resonator types.

In general, musical tones are emitted by stretched strings, strips or bars of various shapes (vibes, reeds, bells), pipes (whistles, organs, horns), diaphragms (drums) and a resonator that consists of an enclosed volume, the Helmholtz resonator (guitar bodies, etc). In addition, many instruments use combinations of the above.

Strings

The enormous string family includes guitars, the violin subfamily, banjos and a host of others. They may well have derived from the hunting bow, when somebody noticed that the twang could be changed in pitch by varying the tension. I'd also include the piano in our list; there's some dispute here, since it's actuated by hammers and might be called a percussion instrument, but there's no doubt that its tones come from stretched strings.

The textbook example usually consists of a string tensioned between two immovable posts. When plucked, it first forms a bow shape, like a skipping rope. This bow moves back and forth at a fixed rate; if the sound produced is picked up by a microphone and displayed, we see the familiar sine wave. The string can also generate overtones (called harmonics if they're musically related); the bow first splits in two, forming two equal bows. This produces a harmonic note (the second harmonic – the fundamental is the first harmonic in technical terminology) at twice the fundamental frequency. Now it splits into three, generating the third harmonic. The process continues, generating a whole series of notes at integer multiples of the fundamental frequency. Of course, all this happens in an instant, and all the harmonics sum together to form one complex tone.

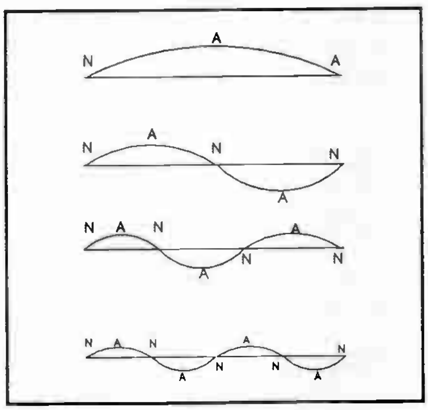
The points at which the string is at rest are called *nodes* and the maximum excursions called *antinodes*. Guitarists will be familiar with what happens when a string is plucked at a node point; the harmonics with that node are accentuated. If there's a guitar handy, strum the strings over the twelfth fret and compare it to plucking near the bridge. This is the midpoint of the string, and the even harmonics will be accentuated, producing a soft, mellow sound.

If you'd like to hear the second harmonic by itself (almost), put your finger lightly on any string over the twelfth fret and pluck the string sharply near the bridge. You'll hear the high-pitched, singing second harmonic quite loudly, mostly because we've damped out the fundamental with your finger over the fret. Other harmonics can be produced at other points; two octaves by touching the string over the fifth fret (one quarter of the string length), an octave-plus-fifth (third harmonic) over the seventh (which divides the string in the ratio of 3:2) and so on.

If you'd like to hear the fundamental pretty much by itself, touch the string firmly about half a finger's width from the bridge and pluck it sharply. It's a fairly loud but very dull sound because you've damped most of the harmonics.

Wooden Amplifiers

The classic case of the string stretched between two immovable points doesn't occur in musical instruments. If it did,



The nodes and antinodes of a vibrating string for four harmonics.

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you wouldn't hear much, because the string's small surface area won't set enough air in motion. It's necessary to direct the energy of the string via its termination (the bridge) into a panel which will match this energy to the surrounding air. Usually the panel is a thin wooden soundboard, as in the violin family, guitars, pianos, etc. To further enhance the tone, certain harmonics of the string/top combination can be controlled by mounting the panel on top of an enclosure. This enclosure, such as the violin or guitar body, has complex resonances itself, favoring the high frequencies in the stiffer areas and the low frequencies in the large, flexible areas. In addition, the air in the cavity has a resonance of its own (the Helmholtz resonance). The entire instrument forms an incredibly complicated sound generator.

Further, the resonating body feeds energy back into the string, greatly affecting the tone. This is why a solid-body electric guitar sounds quite different from an acoustic guitar with electric pickups; the solid body does not return as much energy to the strings.

The fundamental frequency at which the string vibrates varies inversely with its length, and also with the square root of its mass and the tension. The length is determined by the construction of the instrument; the tension and mass are more easily varied then the length to keep the size manageable. For instance, if you scale up the size of a violin exactly so that the pitch is lowered to that of an upright acoustic bass, the body alone would be about six feet high. To keep it playable, thicker strings under less tension are used.

The pitch of any given string is inversely proportional to its length; half the length produces the octave, and so on. It gets a little more complex with instruments that have fingerboards: when you press the string down, the tension is increased and the pitch goes up. The fret positions (or the violinist's fingering) must be adjusted to compensate for this. If you can accurately measure a guitar fingerboard, you'll find that the twelfth (octave) fret is not exactly half of the string's length. The banjo has an easily movable bridge, and banjo players will be familiar with the technique for replacing a removed bridge: its location is adjusted until the harmonic sounded over the twelfth fret is equal in pitch to the fretted note at the twelfth.

Windings

Musicians occasionally ask why the thicker strings of an instrument are wound with wire instead of being solid. The answer is that although the pitch depends only on tension, length and mass, the quality of the sound depends on many other factors, in particular the stiffness of the material. Short sections of a thick, solid string would be reluctant to vibrate, and this would attenuate the higher harmonics. Windings improve the flexibility and the brightness. Of course, they collect skin oils and dust, too, so the wound strings tend to go dull more rapidly than the solid upper strings. You can't have everything.

And can a string go out of tune with itself? The answer is yes. The ideal string's harmonics follow an integer rule: 1,2,3,4 times the fundamental and so on. If the string is dirty or starts to unwind, sections of it can vibrate at frequencies unrelated to the fundamental. In bad cases you can actually hear a sour tone or two floating above the fundamental, or the sound may be of indeterminate pitch. Lazy guitarists like myself who hate changing strings hear this effect all the time.

Bars

The vibrating bar is used in vibraphones, harmonicas, reed woodwinds and various percussion instruments, such as chimes. The bar is either clamped at one end (reeds) or free at both ends (chimes, etc). The bar's resonance depends entirely on its stiffness, unlike the string, which uses tension as the restoring force. The fundamental frequency is inversely proportional to the square of the length, and also depends on thickness, density and the type of material.

In the case of the bar clamped at one end, the overtones are not simple harmonics, but are related to the fundamental in ratios like 6.2:1 and 17.5:1. These non-integer relationships account for the "edge" on the sound of reed instruments.

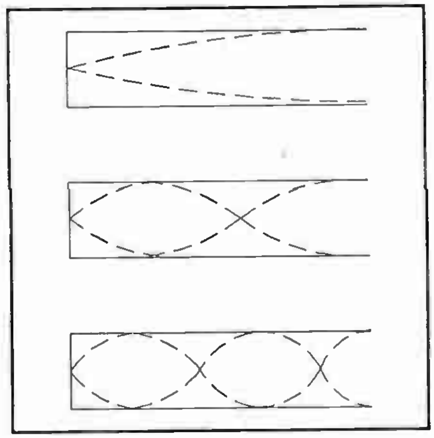
The bar free at both ends, as in vibes, xylophones, chimes, etc., has a somewhat different overtone structure, with ratios like 2.7:1, 5.4:1 and so on. These are still non-integer, but a little closer to musical harmonics, producing a mellow but rich bell- like sound. Pipes of certain lengths are often suspended under the bars to further accent the sound.

Pipes

The pipe open at both ends is a simple resonator: its resonant frequency is $c/2L$, where c is the speed of sound in air and L is the length. The overtones produced are integer harmonics: 1,2,3,4 times the fundamental and so on.

The pipe closed at one end has a frequency of $c/4L$ and its harmonics are odd integer multiples: 1,3,5, etc.

In both cases, the exact fundamental frequency depends on the shape of the end of the pipe: a flared pipe will have a slightly different effective length than a straight pipe. Since the correction is a fraction of the radius and is added to the physical length to get the acoustic length, it's often ignored for long pipes with a small radius.



The fundamental of a tube closed at one end is at one-half the wavelength. The first three harmonics show that an antinode is always at the closed end.

The resonance of the pipe gives us the pipe organ, woodwind instruments, brass instruments, and whistles; pipes are also used for special effects in other instruments (as in the vibraphone).

The whistle family and the pipe organ depend on the airflow over the pipe's aperture itself to make the sound (win a trivia contest: the sound-producing aperture of a pipe-style instrument is called a *fipple*); in brasses and woodwinds, the sound is produced by a reed (the lips function as a reed in the horn family). The pipe organ has a

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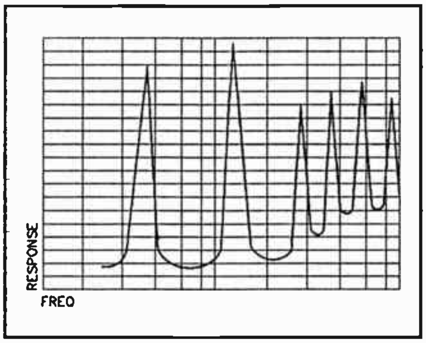
pipe for each note; other instruments depend on various methods of altering the pitch and producing a scale.

In the woodwinds and whistles, holes are covered or uncovered by fingertips or mechanical valves, effectively changing the length of the pipe. In the case of the inexpensive tin whistle (pennywhistle), over two octaves is possible from the six holes. If the holes are covered and the force of blowing increased, the pipe will jump to the octave note, twice the fundamental frequency. Now the player can start over and play the scale in the second octave. It's also possible to overblow even harder and jump to the next higher harmonic, which is the fifth above the octave (that is, on a C whistle the harmonic would be G plus an octave). On instruments like the recorder, a thumbhole is drilled into the back of the cylinder. Opening this hole encourages the instrument to jump to its octave note, minimizing the need for overblowing with its attendant jump in volume.

The brasses are capable of playing a scale without the use of holes, valves or slides. In fact, it wasn't until the 19th century that improved metalworking allowed the use of the now- familiar valves, as used on the trumpet or French horn. The scale is obtained partly by the player's skill in controlling lip tension and air pressure, and partly by the fact that the horn, being a pipe, will naturally play a harmonic series. This series in the key of C goes: C-C-G-C-E-G and on up; these notes correspond to the integer harmonics, 1,2,3,4 times the fundamental and so on. The notes become closer and closer together and eventually an entire scale is generated. It's not exactly a perfect scale, with many of the notes straying from the pitch of the same note played on a piano or fretted instrument; we'll be investigating why in a future issue.

The natural, or valveless, horn can only play in one key. To get around this in past centuries, players could insert a crook (a length of extra tubing) to change the fundamental, or insert a hand in the bell of the horn to get a sharp or flat. Still, the larger part of its lower range is rather gap-toothed; we can only marvel at the immense skill of horn players in the past, or today's players who use original instruments. Once smoothly-operating valves and slides were available, the brasses became chromatic instruments capable of playing any note. The valves add extra lengths of tubing; the extra length can be used to lower the pitch of any note. For instance, if you wanted an F note from a C trumpet, you'd vary lip tension to produce the harmonic G, but with a valve down that drops the pitch a whole tone. It sounds complicated (and beginning trumpeters will agree that it is).

It's of interest to note that horn players have complained that modern reproductions of early instruments are hard to play and keep in tune compared to museum-piece originals. The reason turned out to be technology: the older horns were individually hand-made, with the accompanying small errors and variations in diameters and symmetry. This asymmetry gave the older horns fairly wide peaks at the harmonic frequencies, rather like a low-Q bandpass filter, making it easy for the player to "bend" the pitch to suit. Modern machine-made horns, by contrast, are symmetrical throughout their construction, resulting in a high-Q bandpass (a very tight peak at the harmonic frequencies). It's more difficult to play smoothly on the latter instruments.



The response of a typical horn. The resonant peaks correspond to the notes C-C-G-C-E-G.

The Helmholtz Resonator

Sounding a note by blowing over the neck of a pop bottle is a demonstration of a Helmholtz resonator. It's defined as an enclosed volume of air coupled to the outside air by means of an aperture. It produces the sound from police whistles or ocarinas, and enriches the sound of other resonators, as in guitars, violins, etc. The formula for its resonance frequency is rather involved, but essentially it depends on internal volume and the radius of the orifice.

The bodies of the violins, guitar, or any instrument made of wood are complex resonators indeed, with different sections responding to different frequencies. Guitarists who have tried installing a pickup in an acoustic guitar will have discovered this; the soundboard around the bridge favors low frequencies, while the soundboard closer to the neck radiates the higher tones. When this plate resonance is added to the air (Helmholtz) resonance of the internal volume, a fine guitar or violin becomes much more complicated than first appears. In fact, physicists have been studying the violin in depth ever since its development in the 16th and 17th centuries, and some aspects of it still remain a mystery, probably because there are so many variables in construction and playing techniques.

Stretched Diaphragms

The stretched diaphragm is used in drums, cymbals, the tambourine and the banjo. They are all circular, very thin and supported either at the circumference or in the centre (or in the case of the gong, free-standing). Since they produce very complex overtones, their sound is not always perceived as having a definite pitch, though the boom of the kettle drum can be tuned to an easily recognizable note. The fundamental frequency is found in much the same way as the stretched string: it varies with mass, tension and the radius of the diaphragm. The many overtones are not harmonically related, but sum to produce an instantaneous sound that closer to "controlled noise". The tension of the drumhead or banjo head is adjusted until the predominant harmonics suit the player and the instruments. In guitar construction, the maker will often adjust the thickness of the top until it seems to agree nicely with an A note.

In the next issue, we'll look at the arithmetic of the musical scale. We'll compare the equal-tempered scale and the natural scale, with some explanations as to why horn players, violinists and singers sometimes seem to be at odds with the notes from pianos and fretted instruments. ■

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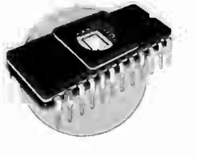

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laborators to produce protective coatings of cadmium sulfide on semiconductors used in infrared sensors.

The research is being carried out within the newly formed Institute for Surface and Interface Science (ISIS) at UCI, which Hemminger directs. The goal of the Institute is to bring together investigators from chemistry, physic and engineering to study phenomena that occur at the boundaries between different materials.

This Poseidon Adventure

It was last June that a unique project got underway in Norway's Foss Fjord which could ultimately create major savings and increased efficiencies in the production of oil and gas by offshore platforms around the world.

A joint venture research and development activity of the French petroleum company TOTAL CFP, France's Petroleum Institute (IFP) and the Norwegian oil giant Statoil, the project is known as the Poseidon System.

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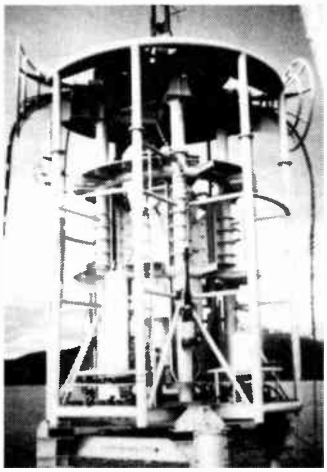
This involves separating the crude, gas and sea water. One pipeline then carries the crude to shore, another the gas after it has been dried and compressed and the water is pumped back into the sea.

These are major operations, requiring a great deal of space and enormous platforms that are either floating or fixed to the sea bed.

Enter the Poseidon System, a totally new and different approach to the way things are done. The crude, gas and water mixture is transported "as is" through a single pipeline and the processing (separation) is carried out on shore, making for much safer and more economical operations. And because water, gas and oil are transported in diphasic conditions, only one pipeline is required and huge platforms would no longer be needed.

The system consists of three major elements — satellite wells, equipped with underwater production well heads are linked with a central underwater station. This station ensures the proper performance of all of the components —



the connection of the feed pipes between the various well heads, the transportation of the oil-gas-seawater mixture in a pressurized state, the power supply to the pumps via a cable running from shore, and the remote control and monitoring of the entire system. The third component is a diphasic pipeline linking the underwater station with the shore-based processing facility.

Poseidon is completely robotized and its design is modular which means reduced maintenance because defective parts can be readily replaced, eliminating the need for underwater diving crews.

Each of the partners in there search project has a specific responsibility — IFP is in charge of developing the diphasic pump, a key element in the successful movement of the oil, gas and water mixture; Statoil is responsible for the transportation of the diphasic oil effluent over long distances. And in charge of the wells, well heads, collecting systems, the underwater station and the special motor for the diphasic pump is Total CFP.

Several pilot projects are planned following the completion of this initial project — first on platforms and then later, under the sea. It is anticipated that the techniques developed during the R and D phase will permit full industrial production of the equipment and subsequent widespread use throughout the industry.

Anyone interested in obtaining more information about Poseidon is invited to contact M. Bruno Darde, Technical Director, TOTAL CFP, 5 rue Michel Ange, 75116 Paris, France, Tel: (1) 47 43 80 00.

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Volt-Ammeter/Insulation Tester

The Model 6000 digital clamp-on volt-ammeter and optional insulation tester from Brunelle Instruments is a versatile unit featuring seven functions: AC/DC Volts, AC Amps, Resistance, Diode Check, Continuity Check and Insulation Tester with the optional Module 6001.

The instrument also has a PEAK HOLD function for transient signal measurements and a LO BAT indicator. The 3 1/2 digit LCD is easy to read even under bright daylight.

Additional features of this instrument are the ability of measuring DC voltage up to 1000 Volts, AC Current up to 1000 Amps from 50 to 500 Hz and Resistance from 0 to 2 MOhms.

The optional insulation tester is a plug-in module which features two ranges, 0 to 20 MOhms and 0 to 200 MOhms, and delivers an output voltage of 500 VDC

For more information contact: Richard Robinson, Brunelle Instruments Inc., 69, 6th Range S., St-Elie D'Orford, Quebec J0B 2S0. Tel: (819) 569-1408.

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PC Guardian

The PC Guardian security device for the Mac SE uses a key to activate the Mac's power supply, reserving data access to key holders. The device also locks the CPU cabinet to prevent theft of peripheral boards.

The unit can be installed easily by end users in minutes by using the existing cabinet screws and Zyton, a permanent chemical bonding agent. The device is compact, measuring 5 inches long, 1 3/4 inches deep, and 2 inches wide.

For more information about the PC Guardian, contact: Gayle Hagen or Ann Laurenson at Micro Security Devices, 118 Alto Street, San Rafael, California 94901.

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For Your Information

Apple MIDI

Apple Canada recently announced the introduction of the Apple MIDI Interface offering musicians, music educators and hobbyists a low-cost, high-quality Apple product.

MIDI, the Musical Instrument Digital Interface, is the music industry standard for communicating musical information electronically. With a MIDI-equipped instrument such as a synthesizer, performance information is exchanged via the interface with the personal computer, which retains the information for editing or playback. Using appropriate software, tasks such as sequencing, composition and editing are performed faster and more easily.

The Apple MIDI Interface has been designed for the IIGS and Macintosh family of computers, and is equipped with one MIDI IN plug and one MIDI OUT plug. It measures 3 inches long by 2 inches wide by 1 1/4 inches deep and connects to one of the computers two serial ports via Apple's standard circular eight connector. MIDI instruments are connected to the interface via two five-pin standard MIDI cables. Price of the unit is $162.00 and it's available from authorized dealers.

More information on the Apple MIDI Interface can be obtained from the Apple Canada's Media Relations Hotline: (416) 964-9064.

New STEbus Standard

The IEEE Standards Group has officially approved the STE microcomputer bus architecture specification as IEEE 1000, making it an internationally recognized standard.

The STEbus features a rugged 8-bit architecture, emphasizing processor, and manufacturer, independence as well as low cost. Most STEbus systems use a single Eurocard form factor (100mm x 160mm), although IEEE 1000 also provides for the double Eurocard (233.35mm x 160mm) format.

According to IEEE co-author Tim Elsmore of Wespercorp, San Diego, "It's possible to see the STEbus as a kind of low- cost VMEbus that provides the reliability and flexibility of VME for users who don't need all of VME's performance. STE is also well-suited for use as an I/O channel with VMEbus or Futurebus." IEEE 1000 defines the STEbus as an architecture that may be used to "...implement general purpose, high-performance, 8-bit microcomputer systems. Such a system may be used in a stand-alone configuration or, in larger multiple bus architectures, as a private (or secondary) bus or a high-speed I/O channel".

The authors of IEEE 1000 were careful to consider compatibility with the existing VMEbus standard, enabling the STEbus to form an I/O channel using the VME's undefined row A and C P2 connector pin-outs.

The STEbus features a 1Mbyte address field, 4Kbytes I/O space, and multi-master capability. Data transfer, which can occur at up speeds of up to 5 Mbytes/sec, is asynchronous and non-multiplexed. Processor-independence is also a key feature, as the architecture accommodates all 8-bit microprocessors as well as many 16 and 32-bit microprocessors.

For more information on the STEbus contact: STE Manufacturers and Users Group, P.O. Box 7529, Newark, DE 19714- 7529 USA.

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Serial/Parallel Breakout Box

The M-Test Model 250 is a full-featured, high-quality RS-232C serial breakout box that includes parallel interface test, a pulse trap for storing short duration pulses, and a cable test.

The unit has 102 LEDs which give 4-state signal indication, 26 in-line switches, and 52 sockets for breaking and re-directing all 25 lines plus one unassigned line. A 9V battery simulates high or low signals. The price of the unit is $299US.

For more information on the M-Test Model 250 contact Chris Ray, President, M-Test Equipment, P.O. Box 146008, San Francisco, CA 94114-6008. Tel: (415) 861-2382 or FAX (415) 864-1076.

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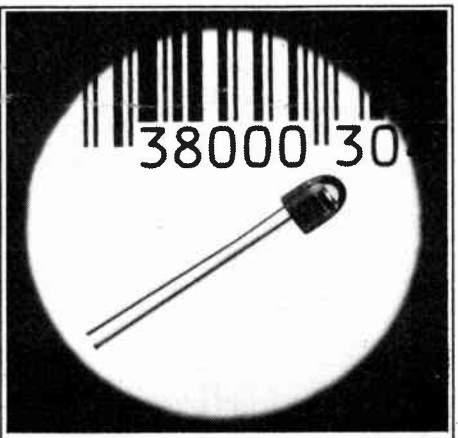

Silicon Photodiode

The CD-1705 is a P on N silicon device featuring exceptionally high dynamic resistance of a minimum 1000 megohms with a typical value of 5000 megohms.

Other characteristics include: spectral peak response at 850nm, maximum capacitance at 0 volts is 80pF, maximum reverse bias of 30V, black ceramic housing with epoxy lens, an overall diameter of 3mm and height of 4mm.

Applications include bar code readers, IR remotes, mark and sense readers. For more information contact: Centronic Inc., E-O Division, 1829-B DeHavilland Dr., Newbury Park, California 91320-1702.

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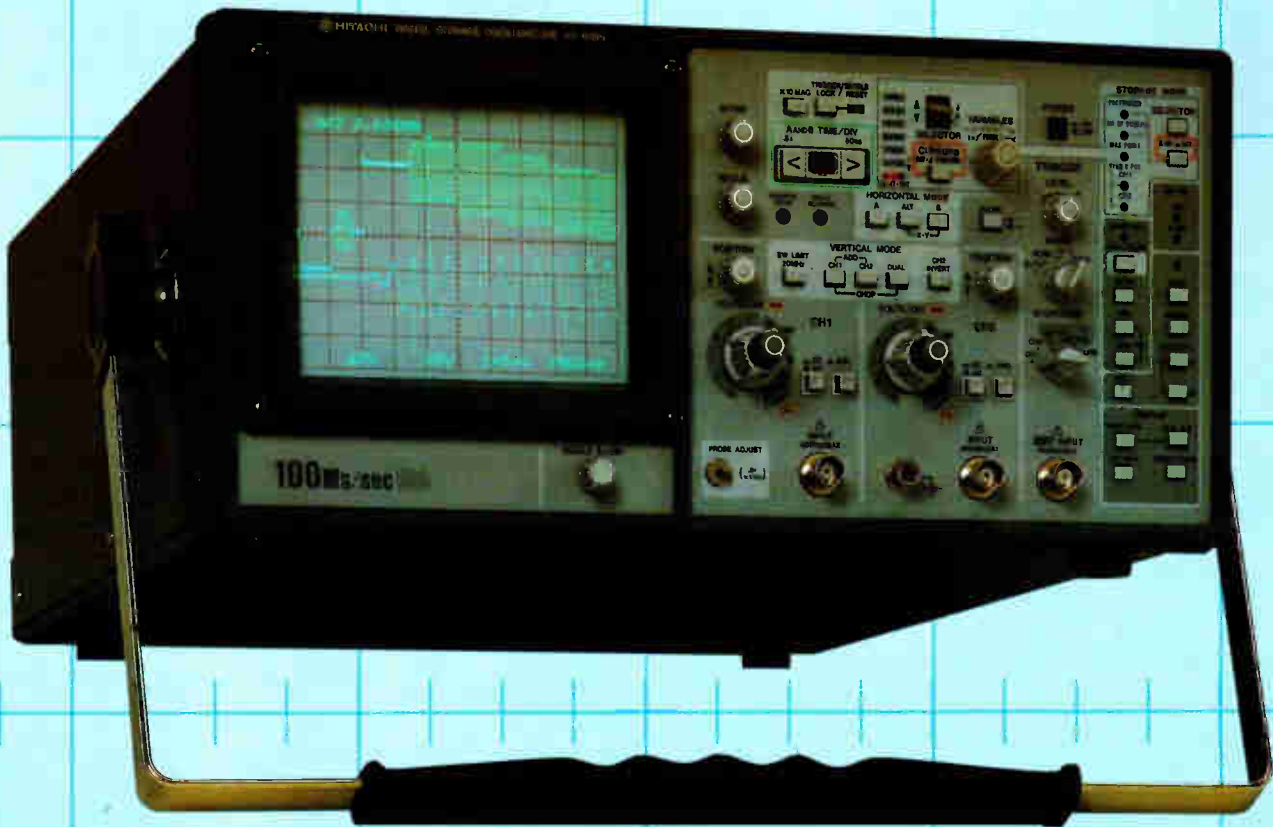

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