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January 1988

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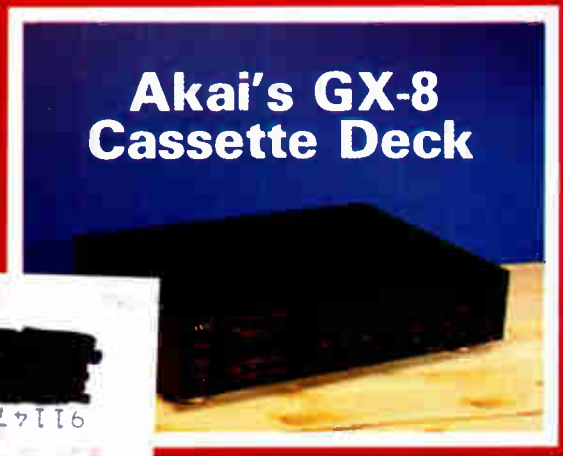

Akai's GX-8 Cassette Deck

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Our Cover

The video controller project and Akai's GX-8 were photographed by Bill Markwick.

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Electronics & Technology Today

Canada's Magazine for High-tech Discovery

Volume 12, Number 1 *January, 1988*

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INFORMATION

For Your Information

With this issue we begin a new monthly column entitled "The Scientists Tell Me..." It will be a column identifying new and interesting, and sometimes "oddball" news from the world of science and technology. It is compiled, edited and written by David P. Dempster, President of David P. Dempster & Associates, International Technology Transfer Consultants. David was formerly a senior consultant and policy advisor with the Ontario Ministry of Industry, Trade and Technology and traveled extensively, domestically and offshore, identifying, sourcing, and transferring new technologies. He is a member of the Canadian Science Writers Association, The Technology Transfer Society, the Society of Plastics Engineers, and is a Life Member of The Society of the Plastics Industry of Canada. He is a prolific writer whose work appears in numerous journals, both in Canada and abroad.

The Scientists Tell Me...

By David P. Dempster

Ancient Artifacts' Origin Identified Without Harm

Every time an archaeologist picks up an artifact to study, he does so carefully and very gingerly. But now, scientists have developed a new approach that will make life little easier – at least, if the artifact is of basaltic material.

Researchers studying the chemical composition of lava flows have developed a technique that allows archaeologists to determine the origin of basaltic artifacts without harming them.

The process uses X-rays to determine 11 ratios of trace metals in artifacts. These ratios then are compared to those found in lava flows, each of which has its own chemical signature. The artifacts can be analyzed whole, rather than as powdered samples required by previous techniques. People have been doing this with obsidian for a long time, but no one had done it with basalts, says Kenneth Verosub, a professor in the Department of Geology at the University of California, Davis, who heads the investigative team.

Canadian advances in Archaeometry

Canada's own McMaster University is recognized as the current world centre in the development of electron spin resonance (ESR) dating methods in archaeology. Both Dr. Henry P. Schwarcz and Rainer Grun are masters of ESR in dating lower and middle paleolithic industries.

The lower and middle paleolithic ages in human history are characterized by a transition in the use of stone tools: lower paleolithic cultures used broken chunks of flint as tools, but more sophisticated middle-paleolithic cultures had learned flake the stone and to recognize the flakes as superior tools. However, the middle paleolithic age is estimated to have ended 40,000 years ago and, until recently, the standard archaeological dating method, using Carbon-14, was unable to fix dates any earlier than that.

Dr. Schwarcz describes four new methods of dating archaeological materials and fossil human remains that can determine dates earlier than this limit. Uranium-series (U-series) dating can go back 400,000 years, but depends on the presence of the mineral calcite, found in caves and fossil springs.

ESR dating, developed in Japan and Germany and further refined by Grun and Schwarcz, can go back as far as 3 million years ago. The process counts electrons that have been produced in a material by exposure to radioactivity. Again, ESR depends on a particular material, apatite, found in the teeth of large mammals, but fortunately this is a much more widely available material and one that is frequently associated with sites of human habitation.

A third method, thermoluminescence (TL) dating, is similar to ESR in physical principle, and can be applied to the burnt flint of ancient fireplaces. A fourth method, amino acid dating, which works with the proteins found in sea shells and egg shells, has exciting possibilities but currently is considered somewhat controversial.

"These methods represent just some of the potential of the interactions of physical science and archaeology in broadening our understanding of the timing of human evolution," says Dr. Schwarcz, a Geology professor.

And a New System For Checking Gold Bars

If you are planning on disposing of some of your surplus gold bars to the Canadian Imperial Bank of Commence, don't bring in any that contain a core of tungsten rods or other non-gold fillers. CIBC is the bank that recently installed a rather unique piece of equipment which very quickly detects foreign material illegally included in gold bars.

Research leading to the sophisticated device which produces a three-dimensional image of flaws in a material, was initiated in 1980 by the Canada Centre for Mineral and Energy Technology (CANMET), a branch of Energy, Mines and Resources Canada.

A Woodbridge, Ontario-based firm, Techno Scientific Inc. (TSI) is marketing the system called AUFIS – automated ultrasonic flaw imaging system, which they are producing under license from CANMET.

In a recent ceremony at TIS laboratories, the firm demonstrated the AUFIS system for its first customer, the Canadian Imperial Bank of Commerce. The bank will use AUFIS to scan gold bars at its treasury department in Toronto.

CIBC helped fund the development of an early prototype of similar technology, which the bank has used to detect foreign materials in precious metals since 1981. The bank sees this new technology helping them protect bank customers and the bank itself from precious metals fraud.

Actually, detection of foreign materials in gold bars was not the primary purpose envisioned for AUFIS. The system's effectiveness in the application is indicative of its versatility, according to Dr. Mirek Macecek, president of TSI. He states AUFIS has excellent commercial potential for detecting metal fatigue in offshore petroleum rigs, petrochemical plants, aircraft, nuclear facilities, and defence and research industries.

Brain Mapping underway at Los Alamos

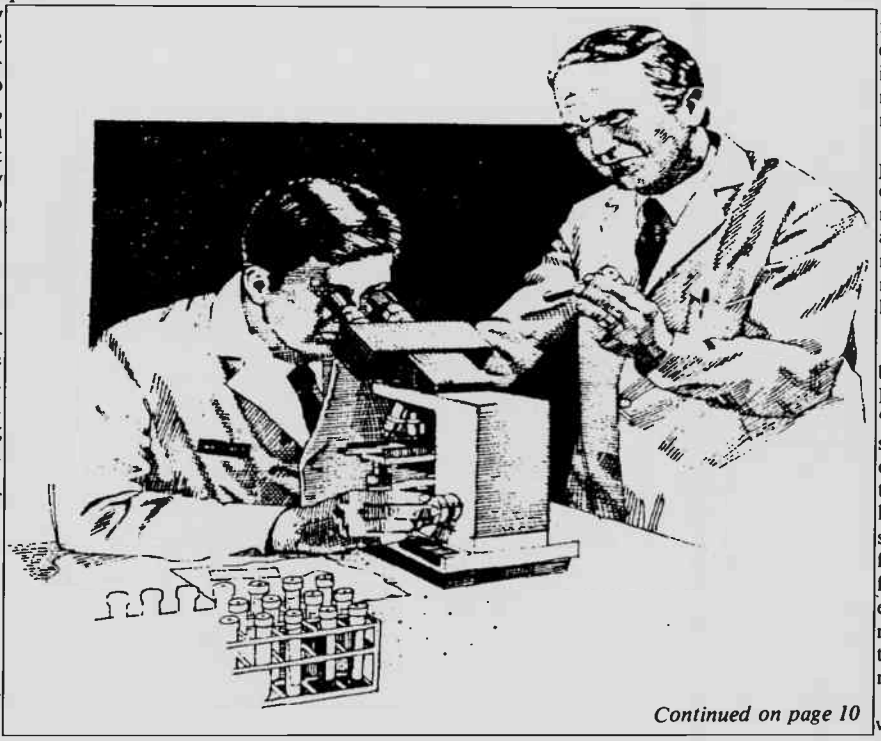
Clinical research of an extremely precise, non-invasive method of 'mapping' the human brain will soon begin at Los Alamos National Laboratory, Los Alamos, New Mexico. The (U.S.) $4 million project will be undertaken in collaboration with the Veterans Administration Medical Center, Albuquerque, New Mexico.

The technical term for the research is magnetoencephalography (MEG), and, it could ultimately have a significant impact on modern medicine.

MEG works on a basic principle of physics: the flow of electric currents produce magnetic fields. In this case, advanced technology measures the miniscule magnetic fields produced by human brain cells.

These fields are one one-billionth the strength of the Earth's magnetic field. They 'flicker' every time brain cells send and receive the myriad of electric signals that whiz through the body's 80-km-long neural network every second. Indeed, magnetic fields loop out every time a flash of electric current emanates from brain cells mentally processing a sound, thought, perception, or movement.

The signals, though very weak, do extend outside the



Continued on page 10

Akai GX-8 Cassette Deck

A feature-packed cassette deck that performs well in this era of digital audio.

By Timothy B. Palmer-Benson

The biggest thing going for Akai's new GX-8 Cassette deck is that it has three sets of heads so that it is possible to monitor the signal as it is being recorded and so ensure that you are making a good recording. Also, it lets you tweak the bias for the best possible performance. There are not many cassette machines out there that can provide these features for a suggested list price of $799.95. Of course, the Akai GX-8 is loaded with a lot of other features as well that are designed to lure a potential user. Features like a real-time counter and automatic tape formula sensing and dbx noise reduction. It has a quartz locked direct drive system, separately regulated power supplies for its audio and noise reduction circuitry and IPLS (Instant Program Locating System) which means the deck can sense a no-signal condition on a tape and thus locate the beginning of a track. The GX-8 also comes with a set of linear crystal, oxygen free copper phone cables and gold-plated input and output jacks. The player weighs 6.5 kg and measures 440 (W) x 111 (H) x 353 (D) mm.

Front panel controls on the GX-8 are laid out in logical fashion except for the fact that the designers have put all tape transport controls on the extreme right hand side of the unit, while the cassette drawer is on the left. When I first began playing with this unit, I had to hunt around a few seconds to look for the cassette drawer eject button. The drawer has that well-oiled feel of a power assisted mechanism, but it cannot be opened or closed, of course, unless the machine is turned on. Next to the drawer is the power switch, a timer switch for use with an optional timer and a headphone socket. Approximately 1.3mW is available for 8 ohm phones.

The transport mechanism is an impressive affair with two big flywheels to drive the closed loop dual capstan system. Akai's separate record and playback super GX heads are grouped together in one housing and are easily accessible for cleaning once the facia of the cassette drawer is removed which is easily done by sliding it upwards. Holes are provided in the drawer frame so that a small Philips type screwdriver can be inserted for tape head alignment.

Signal levels are controlled by a group of knobs in the centre of the front panel under a large fluorescent display. A headphone volume control is provided as well as a double-ganged input level control. There is a separate control for adjusting input balance. The bias control provides a range of -20% to + 20% on either side of selected tape formula. The machine comes set up for Maxell Normal, TDK chrome and TDK metal.

The fluorescent display contains a bar graph type peak level meter that also automatically shows, by the means of dotted lines, the proper recording level for different types of tape and the type of noise reduction being used. The display will show, for instance, that when chrome tape is used, the maximum record level should be +4dB, but that if normal tape is used, the maximum level should be + 2dB. A digital tape counter built into the display also functions as real-time counter, displaying minutes and seconds both in elapsed time and remaining time on a cassette. As with all cassette machines the fluorescent display also shows all tape transport functions, whether Dolby B, C, or dbx is engaged and whether the output mode is in source or tape. Recording mode is displayed in red.

As mentioned earlier, the transport controls are grouped on the right hand side. These finger touch controls allow one to go directly into record mode from play, to go automatically into play after rewind and to create four second blank spaces automatically for the IPLS function. Beneath these controls is a row of push button switches for selecting the three different noise reduction circuits. Selection of tape type is automatic. There are no manual switches to override the system.

The input sensitivity of GX-8 for a 0dB reading is 70mv. This level along with one at -10dB were used for my bench testing. Bias was set at its the two o'clock position because this gave the flattest response for the first two types of TDK tape used, normal and chromium. All noise reduction circuitry was switched out.

With TDK's normal bias tape, response was flat between 30 Hz and 10kHz, as can be seen in the accompanying oscillograph (see Fig. 1; each division represents 3dB, a scale chosen because it can be compared directly

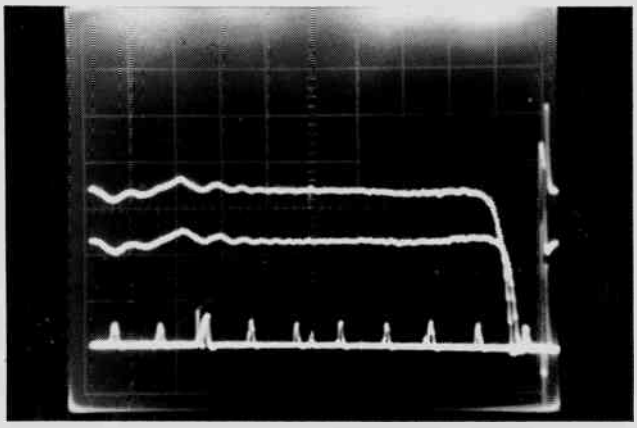


Fig. 1 Frequency response curves of TDK Type 1 tape. Curves are at 0dB and 10dB respectively.

with Akai's own + or - 3dB specifications). The response was much the same at zero and at -10dB. With the flattest response, but once I had done that I obtained the most even and extended response of all three tape

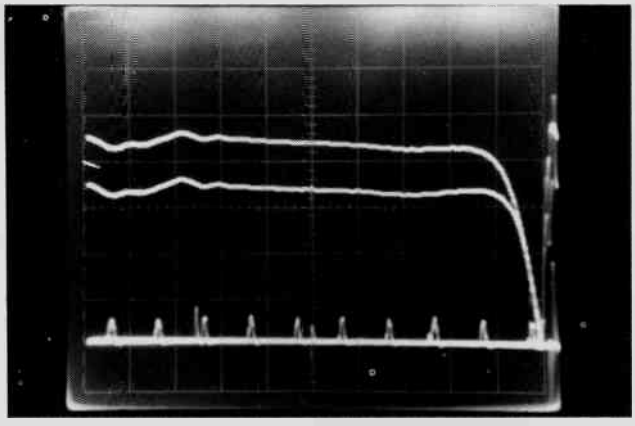


Fig. 2 Frequency response curves using TDK chrome tape. Curves are at 0dB and 10dB respectively.

chrome tape, there is a substantial improvement; response is essentially flat out to 16kHz with a -10dB signal level (see Fig.2). With TDK's metal tape, I had to decrease the bias, i.e. turn the control to the 10 o'clock position to get types used. Once again, keep in mind the scale used for these measurements and the amplitude response of the Akai GX-8. Some RIAA curves don't look this good!

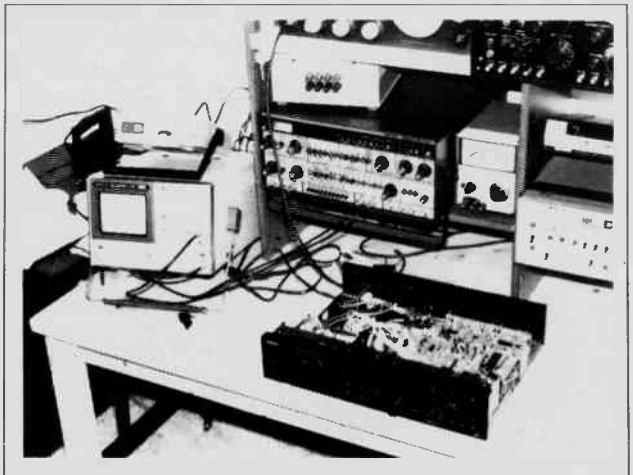


Fig. 3 The Akai GX-8 on the testbench.

Wow and flutter measured 0.12% unweighted and 0.07% DIN, using a calibrated 3,150kHz test tone tape from Standard Tape Laboratories in California. I used a Bruno Volkey wow and flutter meter for these readings. There was negligible speed drift. Total harmonic distortion, reference a 1kHz tone recorded on metal tape at 0dB, measured 0.8% and dropped to 0.6% at -10dB. THD at +6dB, the maximum permitted recording level as denoted by the dots on the peak level meter was 3%. This matches Akai's specification. Fast rewind or fast forward time for a C-60 cassette was one minute and 20 seconds.

Throughout the bench testing, the GX-8's controls performed flawlessly. The logic operated solenoid controls were not fooled by having to go from fast rewind into record or play. When recording begins, the output of the deck automatically switches from source to tape so that one can monitor the quality of the recording immediately. I found the real-time indicator particular useful later on when it came to making some tapes for the car. By using a CD player with a remaining time counter as well, there was ample warning that about a particular selection not fitting onto the remaining tape. The deck was also useful to me when I wanted to play back automatically the first ten seconds of a cassette that I had forgotten to label properly. This scan function can be disabled simply by pushing the play button.

While one may think the bench test results are not as good as they should be in this age of the compact disc, they are representative of good performance in a cassette recorder. Manufacturers are already testing the limits of this media and until DAT or something else gets established, these specifications are about the best that are possible in a home type cassette machine. The Akai GX-8 is capable of producing excellent quality sound provided that a good quality tape is used.

Tim Benson is a freelance audio/video reviewer based in Montreal, Quebec. ■

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body. As a result, arrays of sensitive sensors placed over and outside someone's head can non-invasively record brain activity from several positions simultaneously. In fact, brain signals can be pinpointed within about eight-hundredths of an inch.

"The ultimate goal is to create a 3-dimensional, functional map of the human brain," says physicist Ed Flynn, a Laboratory Fellow who has helped establish one of the world's most sophisticated MEG units.

"Combined with other techniques, MEG may ultimately show medical researchers how the entire brain is organized", he added. Like other neruo-magnetism units, the facility will be housed in a specially shielded room that buffers equipment from natural magnetic forces. Clinical research is expected to begin by spring. Meanwhile, Los Alamos will continue working to advance MEG technology, such as developing sensors made from new ceramic materials which are superconducting at relatively warm temperatures. Advances in hardware, in addition to software improvements, will be shared with the Veterans Administration Medical Center.

According to one spokesman, MEG's greatest advantage is its ability to show precisely where neural activity takes place. Specific functions can be related to specific areas of the brain.

The technology will allow researchers to specify not only malfunctioning areas of the brain, but also areas important to the recovery of function. Moreover, MEG adds the dimensions of time, indicating what the brain is doing and in what order. It means that doctors will now be able to study the brain's activities in detail previously impossible, short of invasive diagnostic techniques or surgery.

Getting A Rundown On Global Climate — 10,000 Years Ago

Scientists have a fairly good grasp of how global climate has changed over tens of thousands, to hundreds of thousands of years. They also know rather a lot about weather, monitored and charted daily in many parts of the world since the late 19th century. But what is understood about climate change on time scales from years to more than a millennium is limited, and these time scales are arguably the most important to human society.

Some tree species very sensitively record not only annual but seasonal climate change over thousands of years. The problem is, these tree types grow mostly in Earth's temperate zones, and most of the Southern Hemisphere's temperate zone is ocean. Further, global-climate researchers need to monitor climate change in such places as the tropics, where trees don't put down neat, annual rings.

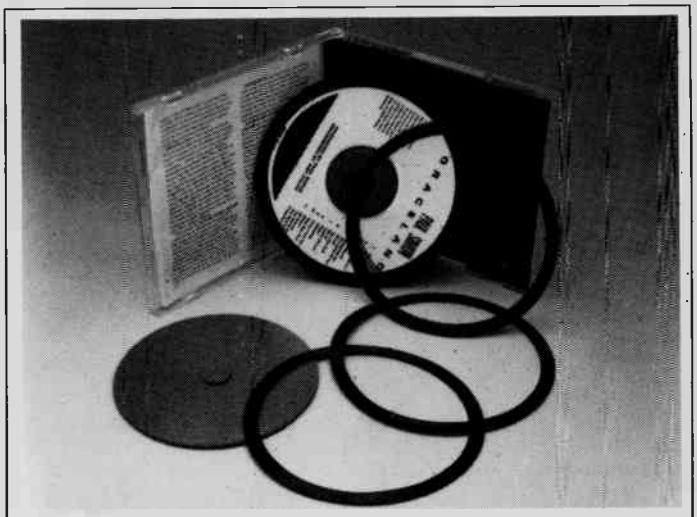
"But it seems to me we face an exciting prospect of breaking out of our geographical limitations and looking at something close to global climate on these intermediate time scales," said Malcom K. Hughes in a paper presented to the 100th annual meeting of the Geological Society of America in Phoenix, Arizona recently. The prospect referred to is integrating what is known from the tree-ring record with what is known from other datable biological and geological records, he said.

Hughes is director of the University of Arizona Laboratory of Tree-Ring Research, the world's largest and foremost center of tree-ring collection and study. The lab was the first of its kind when established 50 years ago by the father of dendrochronology, Andrew E. Douglass. ("Dendro-" from the Greek word for tree and "chronology" meaning the study of time.) UA tree-ring scientists have constructed a more than 8,000-year continuous chronology for trees in western North America.

Already planned is a framework of ideas within which to put all the different records together, says Hughes. He envisions collaboration between tree-ring researchers, ice core scientists, expert interpreters of annual layered coral reefs or deep ocean sediments, and others.

For areas where the tree ring record is poor, the ice core record can be good. This is the case not only at the polar ice caps, but, for example, in the glacier-bearing Andes Mountains of South America or in the glaciated ranges of Tibet. For the ocean-covered tropics, changes in climate are recorded in layers of floor sediment or coral. By piecing all the records together, collaborating scientists could develop global climate maps that show climate change season by season, year by year, over a long period of time, Hughes said.

UA tree-ring laboratory scientist Charles Stockton has drawn a picture of periodic large-scale drought in North America, and UA dendrochronologist Harold Fritts has mapped North American climate change back to the 1600s. Now, global scientists should be able to study the effects of El Nino, the southern oscillation; or how volcanic eruptions affect climate; or the consequences of increased atmospheric carbon dioxide.



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The cost of the Sims starter kit which includes 10 rings and a centering device is $19.95 Cdn, and the cost of 10 rings only is $14.95.

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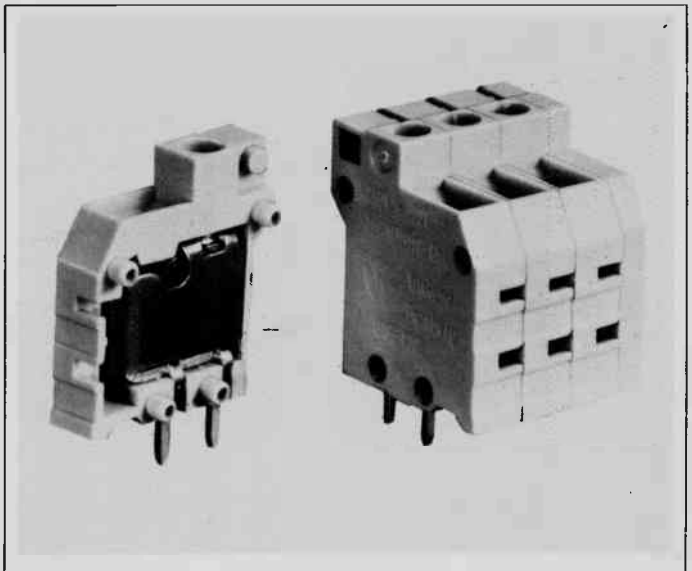

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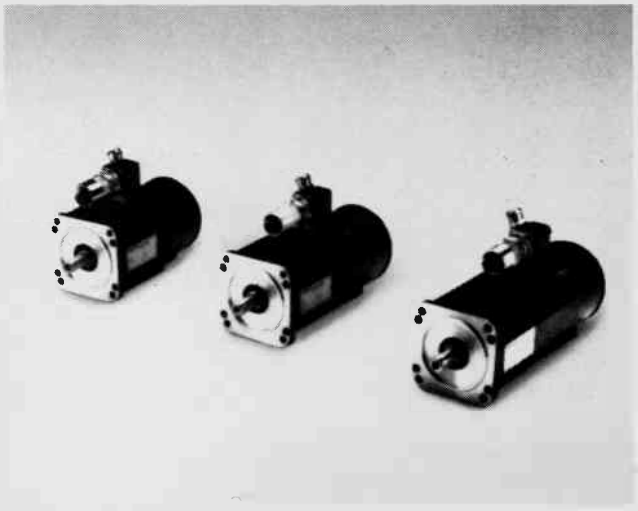

Rare-Earth Magnet Servomotors

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The servomotors are supplied with brushless tachometer feedback, and options include: integrated incremental encoder, stub shaft for mounting feedback assemblies and an electrically- released brake.

Agnes Flutur, Hymatic Controls Ltd., 3426 Mainway, Burlington, Ontario L7M 1A9. (416) 335-5511.

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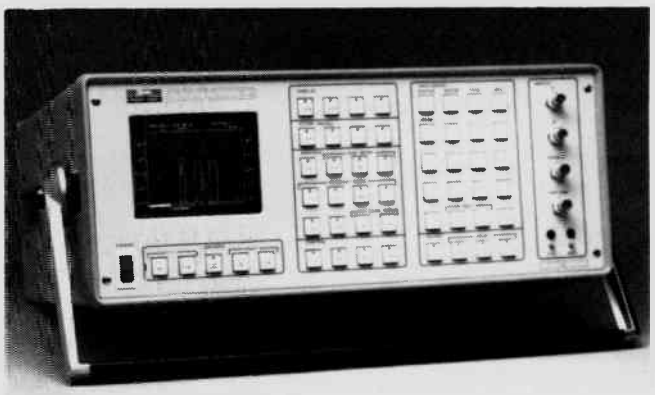

Time Interval Analyzer

Capable of 800,000 time interval measurements per second with one nanosecond resolution, the TIA 2001A from Kode evaluates the bit shift, margin and error rate performance of rigid, optical and floppy disk drives and magnetic tape drives. The unit performs a series of time interval measurements, logs how often each measured interval occurs and displays the result as a histogram.

Other features include: delayed enable function for stripping out headers, sync and gaps; automatic segment operation for automatic centering of a selected segment; and an IEEE interface which provides access to all measured and calculated data.

Contact Don Greenspan, Kode, 1515 S. Manchester Ave., Anaheim, CA 92802-2907. (714) 758-0400.

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New Frequency Counter

The P6000 from Newport Electronics is a microcomputer-based, 6-digit, 1/8 DIN panel instrument which can be configured by five front panel keys or by a personal computer to run as a frequency meter/tachometer, FB/FA frequency-ratio meter, period/period average meter, time interval meter, or totalizer.

The unit allows exceptionally fast low-frequency measurements with 6-digit accuracy by using 1/x reciprocal counting and dynamically adjusting the gate time for any partial signal periods. Measurements above 10Hz can be taken every 150 msec, below 10Hz at every 50 msec plus one signal period. The maximum frequency is 7MHz.

The basic unit includes dual TTL-level inputs with protections to 25V. An optional single or dual channel isolated signal conditioner makes the P6000 compatible with virtually all pulse senors, including low-level magnetic pickups, contact closures, and active sensors with PNP, NPN, or NAMUR output.

For more information contact: Metermaster, 80 Vinyl Court, Woodbridge, Ontario L4L 4A3. (416) 851-8871

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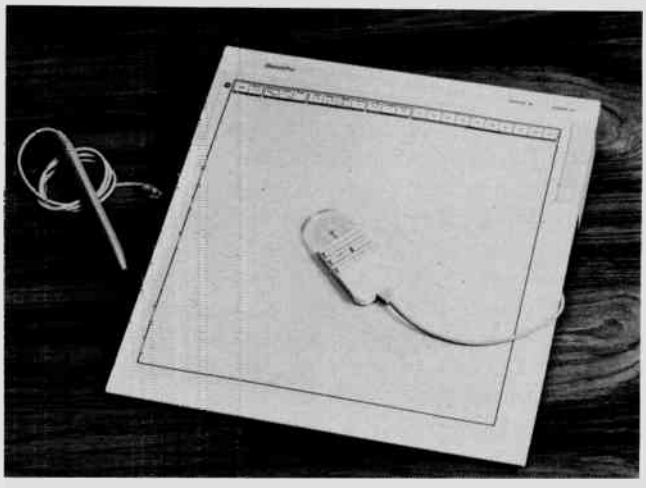

HP SketchPro

The new SketchPro graphics tablet from Hewlett-Packard comes with a complete package of accessories including a lightweight stylus, four-button cursor, serial interface cable and adapter, menu-overlay hold-down/protector, Mirosoft Mouse driver files and setup instructions for major PC CAD software packages.

Inquiries Manager, Customer Support Centre, Hewlett-Packard (Can.) Ltd., 3710 Nahsua Drive, Unit A-E, Mississauga, Ontario L4V 1M8.

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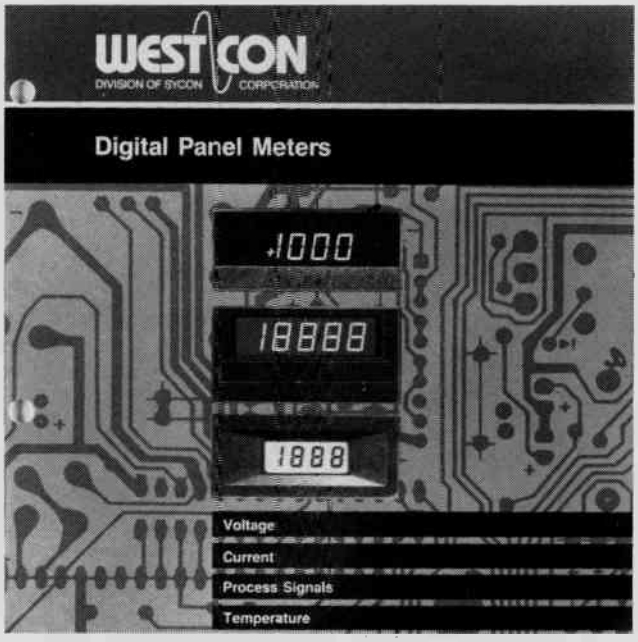

New WestCon Catalog

An all-new 29-page digital panel meter catalog has been issued by WestCon. The catalog contains complete specs on 3 1/2 and 4 1/2 digtit DPMs with a choice of LED, LCD, or gas discharge displays. Over 1000 meters are listed, measuring DC and AC voltage, current, resistance, frequency/rate/flow, temperature and process signals.

The catalog is available, free of charge, by contacting Anna Greashaber, WestCon, P.O. Box 491, 959 Cheney Ave., Marion Ohio 43302 (614) 382-5771.

Circle No. 55 on Reader Service Card

HC 4510 DMM

The HC 4510 Digital Multimeter is a top-of-the-line meter providing 4 1/2 digit accuracy with measurement functions to 1000VDC, 750VAC, 10A AC/DC current, and 20Mohm resistance.

The meter also has diode check, audible continuity check, data hold and "lo bat" indicators, and overload protection on all ranges.

The meter is also equipped with an adjustable stand for easy use in either bench top ro handheld applications.

Jim Peffers, KB Electronics, 355 Iroquois Shore Rd., Oakville, Ontario L6H 1M3 (416) 842-6888.

Circle No. 58 on Reader Service Card

250W Servo Amplifier IC

The AMC-250 from Advanced Motion Controls features 30KHz PWM frequency operation, protection against output shortcircuits, overheating and overvoltage, and adjustable current limit.

No external heatsink or forced-air cooling is required for most duty cycles, even at the maximum output rating of ±50V at ±5A. The unit also contains a complete DC velocity servo, a supply voltage capability of 20 to 50 volts, and molex or IC socket connections.

S. Barta, Advanced Motion Controls, 15921 Haynes St., Van Nuys, CA 91406.

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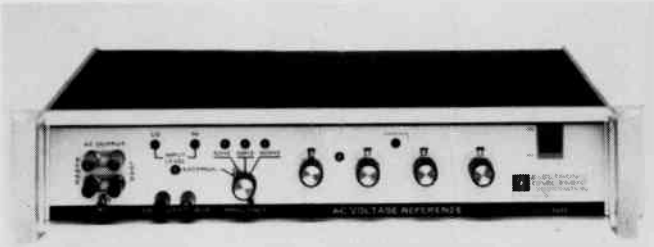

AC Reference/Calibrator

The model 4032 from Electronic Development Corp. is an easy-to-use, lightweight, inexpensive AC voltage calibrator for meters. It also doubles as a reference for A/D converters, amplifiers, RMS converters, AC gain control circuits and oscillators.

In addition, the unit can serve as the AC voltage input to transconductance (AC current) amplifiers. The specs include: amplitude output range of 10VAC, rms; frequency range of 50Hz to 400Hz; accuracy of 0.06% of setting; and harmonic distortion of 0.03%.

Cost of the unit: $945.00(US). Contact: Bob Ross, Electronic Development Corp., 11 Hamelin St., Boston, MA 02127 (617) 268-9696.

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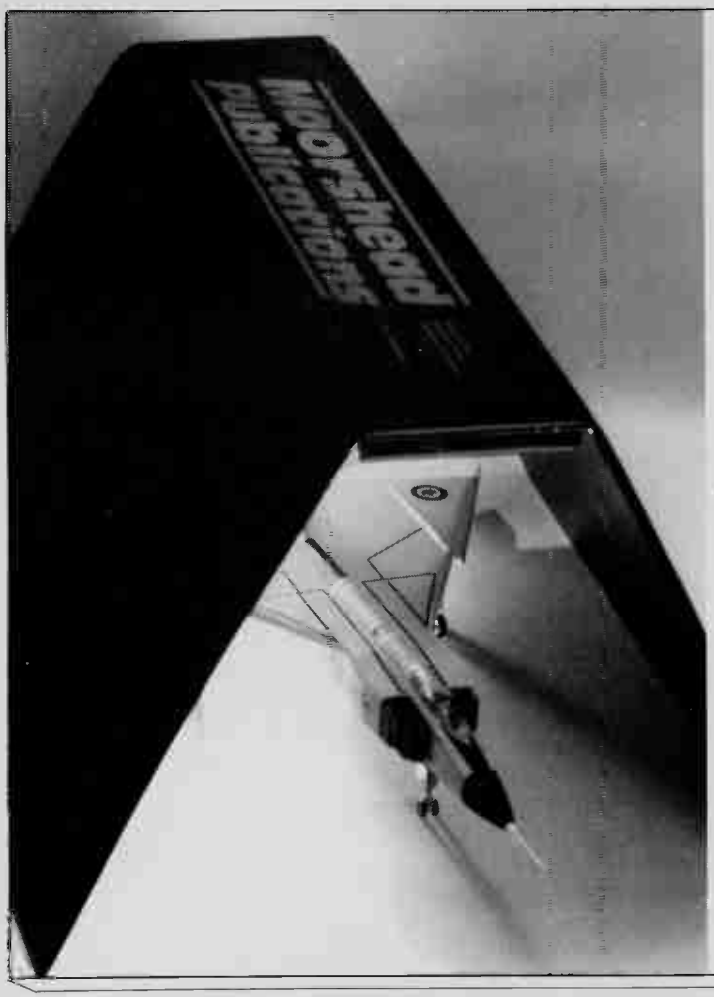

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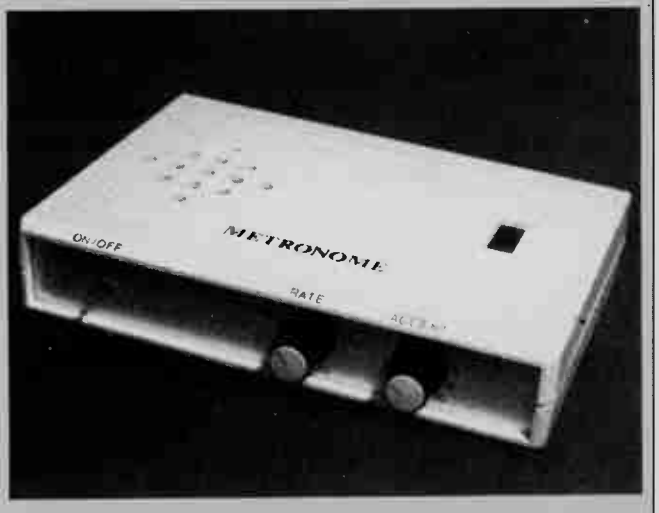
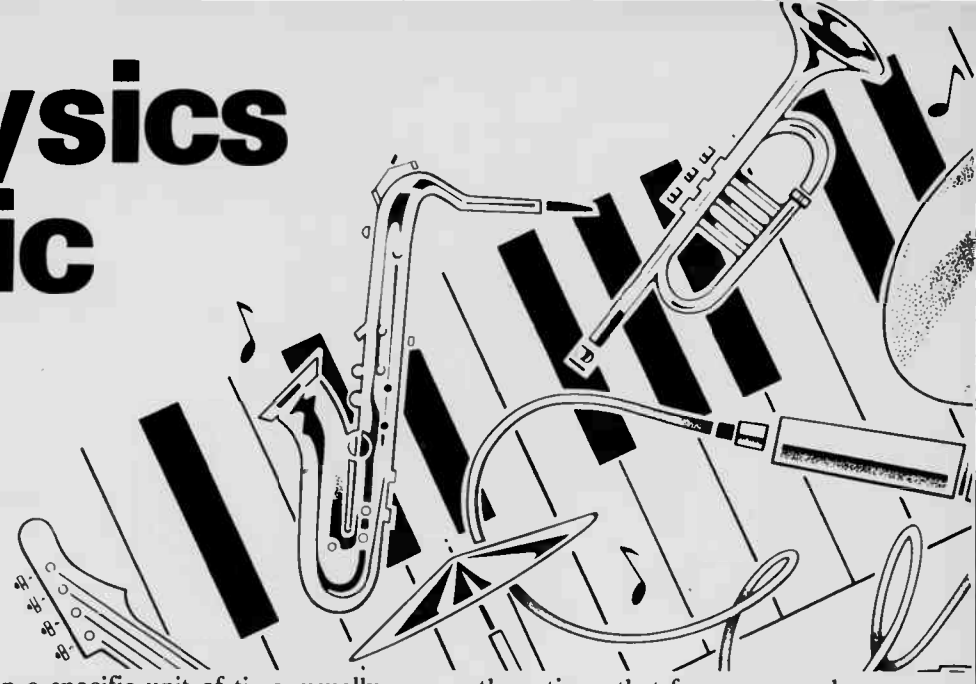


The Physics Of Music Part 3



An introduction to waves, complex sounds and localization.

By Carol Thomas

In last month's article, the second in this series, we talked about the ear and how we interpret sounds as loud (intensity) or high (pitch), and how we distinguish between different tones. This month we'll get into sound waves, how we hear and localize complex sounds, such as speech, and a little on acoustics, for all you stereo fans.

Sound Wave Review

Sound waves act a lot like the waves you see in the ocean, a wave tank, or your bathtub. Once made, they spread out in concentric circles from their source, and if they bump into something, they bounce off it and go in a different direction. However, the regularity of form of sound waves far surpasses those of water waves.

The sine wave that you might remember from high school trigonometry is a more accurate representation of the shape of a sound wave from a source such as a tuning fork. When you hit a tuning fork against a hard surface, the sound it makes is caused by its vibrations. It alternately compresses and rarefies the air adjoining it, in a sinusoidal manner. A sound wave is simply the progressive movement of such alternate compressions and rarefactions through a compressible medium such as air or water, and all sound-producing sources use this same mechanism.

Frequency

The frequency of the sound wave which hits our eardrums is what causes us to hear the sound as high or low in pitch: the higher the frequency, the higher the pitch. The frequency simply refers to the number of complete cycles of compression and rarefaction in a specific unit of time, usually one second, which allows us to measure sound frequency in Hertz, abbreviated Hz. The frequency is inversely related to the wavelength, and if the frequency of any sound wave, in Hz, is multiplied by its wavelength (the length of one complete cycle) in centimetres, we get the speed of sound: about 344 metres per second.

The range of hearing for humans is usually recognized as 20 to 20,000Hz, or put another way, we can hear sounds of wavelengths from about 1.7 centimetres to over 17 metres. To give you an idea of which sounds correspond to which frequencies, middle C is tuned to about 262Hz, C above middle C has a frequency of 524Hz, and each octave higher doubles the frequency, until we reach the limit of human hearing. You'll often see middle C specified as 256Hz in physics books; this is a handy pitch for acoustics work, but is not concert pitch, a subject for a future issue.

Musical instruments which produce the same note don't sound the same to us: a trumpet's middle C and an organ's are apparently different. This is because musical instruments don't produce pure tones, but instead a *fundamental frequency* plus variations on this frequency, called overtones or harmonics.

The fundamental vibration of a stretched string occurs when the string bounces back and forth, like the tines of our tuning fork, and compresses and rarefies the air adjoining it. If it vibrates 100 times per second, its fundamental frequency is 100Hz. However, at the same time that a string is producing a tone of 100 Hz, it is also vibrating at twice that frequency, and three times that frequency, and so on. These are the harmonics, or overtones, and all instruments produce them, not just strings. Because of the simultaneous production of all these frequencies, in varying degrees of strength, the sound is different in different instruments, and this is what we call *timbre*. The sound produced is no longer a simple wave, but a complex wave, and the strength of the various frequencies which comprise it depends on factors such as absorption and resonance within the instrument producing the sound.

Sound Localization

Because our ears are located on opposite sides of our heads, we don't hear exactly the same sound in each ear, even though the sound comes from a single source. It is this fortunate anatomical quirk that allows us to determine the location of sounds without ever having to give it conscious thought. As a by-the-way, this is also why our species has developed stereophonic equipment, which would, of course, not be necessary if humans had only one ear, or two ears on one side of our head.

The localization of sounds comes from four differences in how each ear hear a certain sound. The ear which is closer to the sound will hear it earlier, and hear it louder than the other; pure or near-pure tone frequencies may be out of phase at the two ears; and, sounds made up of complex combinations of high and low frequencies, such as speech, will arrive at each ear with differing amounts of distortion because of differences in absorption, reflection and bending patterns of the different frequencies.

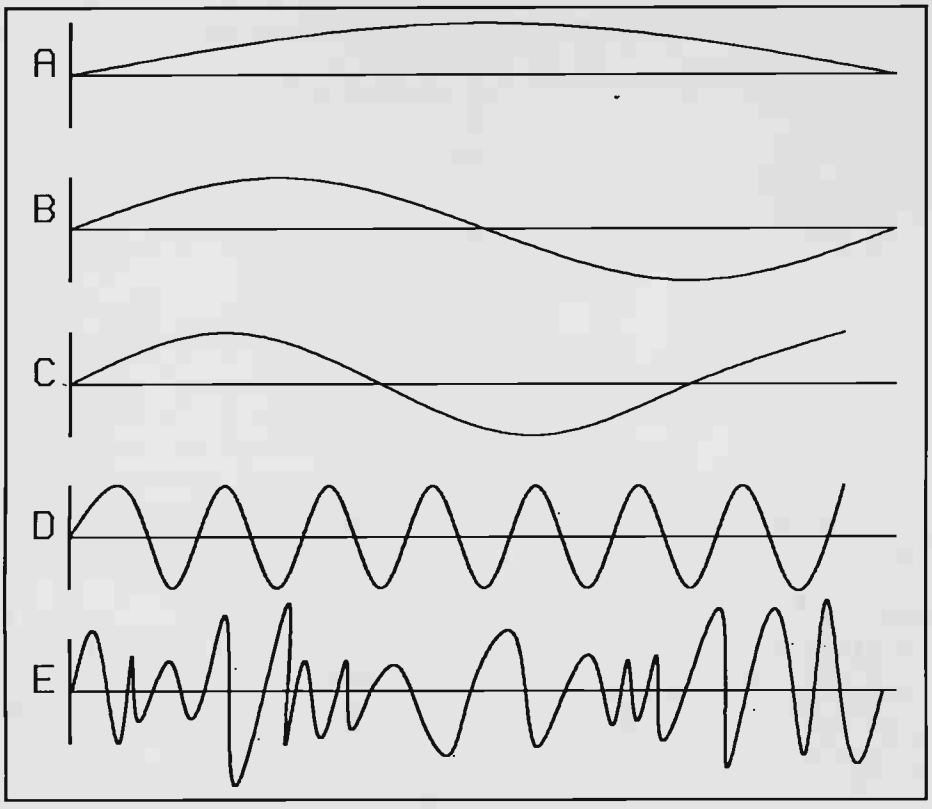


Fig. 1. In (a) a string has been set in motion to provide the fundamental. In (b) it has divided in half, giving the second harmonic (the octave). In (c) and (d) further subdivisions produce the 3rd and Nth harmonics. All of these sum at once to produce the complex waveform of (e). The harmonics would not necessarily be of equal amplitude in an actual sound.

Way back in 1920, researchers in this field demonstrated that time of arrival of a sound was more important in localization than its loudness in each ear. A sound coming from the side of the head takes about 0.65 additional milliseconds to reach the distant ear, while one three degrees from the sagittal plane (straight ahead of us) requires 0.27 milliseconds. Since we can interpret as little as 0.03 millisecond differences directionally, this means we can discriminate sounds that are only just over three degrees apart.

Because of the time differences between arrivals of a sound in each ear, the sounds heard are slightly out of phase. The eardrums receive the air compressions with a delay corresponding to the phase difference. It is still not entirely known whether it is this phase difference or the time difference which allows detection of the source of a sound. Either way, it is limited by the frequency of the signal: frequencies above 1,500Hz cannot be localized as accurately as those below 1,500Hz.

To localize high-frequency sounds, we use the sound's intensity (loudness) difference in each ear. Although intensity decreases only six decibels for each doubling of distance, it is significant because high frequencies don't bend around the head to get to the more distant ear as well as lower frequencies do; they tend to get blocked off, reflected or absorbed by the head. (Think: next time you hear an ear-piercingly high-pitched noise, your head may be absorbing that racket.) It appears that for frequencies with wavelengths longer than the distance between the ears, i.e. above 1,500Hz, intensity differences are more important that temporal ones.

The timbre of a sound, or the complexity of its wave pattern, is a composite of the three variables just described: intensity, time difference, and phase difference. This may mean that it is not an independent method of sound localization. However, since the ear nearer to a sound will hear more of the higher frequencies, the complex sounds of speech will be differentially attenuated in each ear. Humans' particularly good ability to locate a speaker may be partly due to a learning process that occurs when we are very young, whereby we learn to interpret differing timbres as spatial localization. Very complex sounds may be the only ones which we actually have to learn to interpret in this way.

Intelligibility and Speech

Speech is a combination of high and low frequencies, and its intelligibility is more affected by background noise that our hearing of single frequencies (pure tones) is. The Articulation Index (AI) has been used as a measure of speech intelligibility, with 1.0 on the scale representing perfectly clear speech, and 0.0 the entirely indecipherable opposite extreme. At an AI of 0.5, individual syllables are about 70 per cent intelligible and complete sentences almost 100 per cent so.

The auditory spectrum from 200 to 6,100Hz can be divided into 20 bands, each of which contributes equally to speech intelligibility. Loss of any frequencies will result in some intelligibility loss, which can be stated in terms of the AI. The AI is determined by adding up the contributions of each of the 20 bands, based on the amount of signal above the threshold of hearing.

The AI can also be used to predict the effect of various noises and bandwidth restrictions on the intelligibility of speech, especially in the case of electronic transmissions, where the bandwidths and background noise level can be determined in advance.

A simpler calculation than the AI is the Speech-Interference Level (SIL). The SIL is the arithmetic average of the sound- pressure levels in each of three bands: 600 to 1,200, 1,200 to 2,400, and 2,400 to 4,800Hz. If the level in the 300 to 600Hz band is at least ten decibels greater than the level in the 600 to 1,200Hz band, it is also included in the mean. The SIL is useful for predicting intelligibility in noisy environments such as offices.

Yet another measure of noise effects is the Noise Criterion curve, called the NCA curve. This curve considers the entire gamut of effects of noise, such as annoyance and damage as well as speech interference, and is basically a maximum-tolerance level for various conditions. NCA curves are

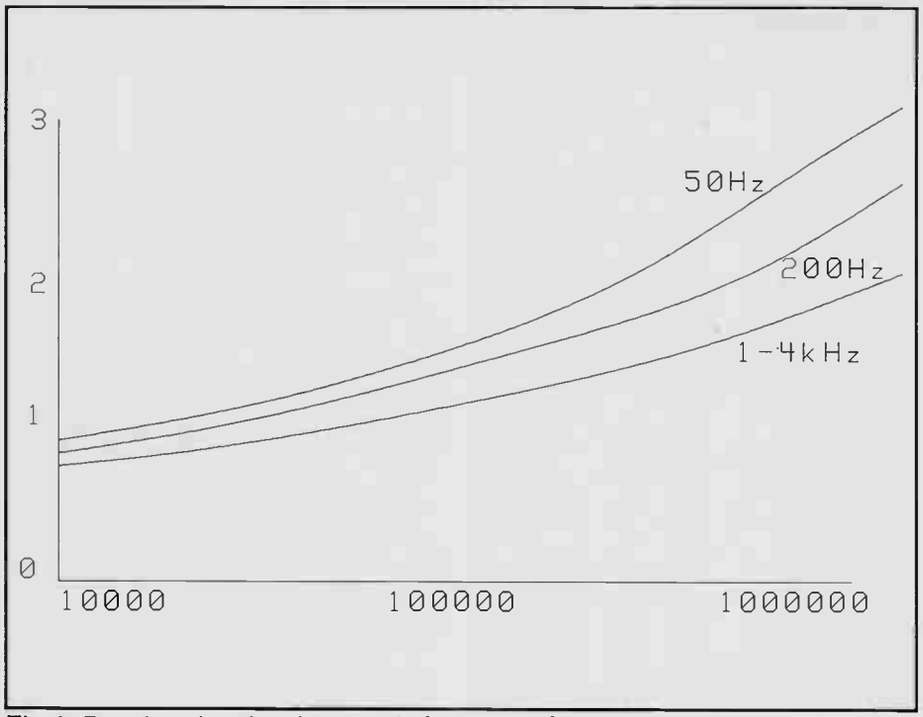


Fig. 2. Reverberation time in seconds for various frequencies and room volumes (in cubic feet). The longest reverb time occurs for low frequencies in large rooms.

used by acousticians interested in reducing the effects of noisy workplaces.

Acoustics

...did I say acousticians? One field of interest to any of us who listen to music (I think I mean all of us), is acoustics. Although the science of acoustics includes everything related to the production and transmission of sound and how this is related to our sense of hearing, I'm talking now about the acoustics of rooms, or *reverberation*.

Once sound waves are produced, we know they travel outward from their source in concentric circles, until they reach a solid object. They will then bounce off the object and continue to travel (and bounce off objects) until their intensity is reduced so far that they are no longer audible. This repeated reflection is termed reverberation. Similarly, a single reflection of a sound off an object, which is distinct from the original sound, is what we call an echo.

If the walls of a room are of a very hard substance, such as marble, and are thus good reflectors, any sound made will persist for an appreciable time after the original sound stops. In some environments (like your office), this is undesirable, and is solved by covering part of the walls with some sound-absorbent material, usually a porous substance like cloth or rough plaster. Some of the motion of the air molecules which constitutes the sound is then converted to heat in the material, and less sound is reflected back.

If a sound whose intensity is a million times the intensity of the faintest possible sound is produced in a given room, the time it takes that sound to die away to inaudibility is called the *reverberation time* of the room. For a medium-sized auditorium, a good reverberation time would be one to two seconds. The approximate reverberation time of a room is given by the expression:

$$T = 0.015V/kA$$

where T is the time in seconds, V is the volume of the room in cubic metres and kA is the total absorption of all the materials in it. The total absorption is computed by multiplying the area, A, in square metres, of each kind of material in the room, by its absorption coefficient, k, and adding these products together.

The absorption coefficient is just the fraction of the sound energy that a given material will absorb at each reflection. So, an open window has an absorption coefficient of 1.0 (you don't get much sound reflected from that!) while marble has a coefficient of 0.01; it absorbs only one per cent of the sound energy at each reflection. Another way of expressing absorption in the imperial system is the *sabin*; one sabin represents one square foot of surface which absorbs all the incident sound energy.

When a sound, especially one which goes on for some time, reverberates in a room, its apparent intensity increases, as we hear not only the original sound, but also its reflections. The longer the duration of the original sound, the greater its intensity will be if it is not completely absorbed. The reflected sound has its energy reduced at each reflection, therefore the succeeding increments of reflected sound become progressively smaller, until they disappear entirely. A steady-state condition occurs when the walls are absorbing the same amount of energy as the sound source is producing. When the original sound stops, some time is required for the sound energy to be completely absorbed; for example, a 60 decibel sound in a damped room can take over two seconds to be completely dissipated.

Reverberation can interfere with the intelligibility of speech, because instead of one sound being heard, the sound being made plus the reflections of previous sounds are all heard together. The overlapping speech sounds mask and interfere with each other, and under conditions of very long reverberation time, speech can become practically unintelligible.

For you concert lovers, the optimum reverberation time for a theater or concert hall can be calculated as a function of the volume of the room for different frequencies of sound. The reverberation time increases as the frequency decreases.

In the next article, we'll be looking at the characteristics of various musical instruments and how they produce their individual sounds.

Carol Thomas is a freelance science writer from Toronto. ■

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Wireless Photoflash Trigger

Build this simple, reliable light-operated unit that lets one flash trigger another.

By Bill Markwick

Using one photoflash has some big disadvantages in photography, despite all the hard-sell advertising to the contrary. No matter how smart the flash's electronics are, a single burst of light causes severe shadows on the subject's opposite side, or dark backgrounds as the light intensity falls off with distance.

Two flash units can go a long way toward solving these problems, especially if the second unit is softened by bouncing it off a wall or white card (to prevent two sets of shadows). The difficulty here is in hooking two flash units together. Will they affect each other's circuitry? If not, you still have the nuisance of running cords across the room.

This photoflash trigger project couldn't be much simpler, and it solves a number of problems. It merely plugs into the second flash's sync cord, and will trigger it when the main flash goes off. It's wireless, and it gets along with any type of flash circuitry.

The Circuit

The circuit schematic is shown in **Fig. 1.** The opto- device is a Motorola MRD3010 light-activated triac. It's normally used for applications such as controlling lamp dimmers according to the ambient light, and it just happens that the sensitivity and voltage rating are perfect for what we want.

The triac is like a pair of diodes in inverse parallel, except that it's normally non-conducting until triggered by a signal on the gate lead, or in our case, a strong enough light on the device lens.

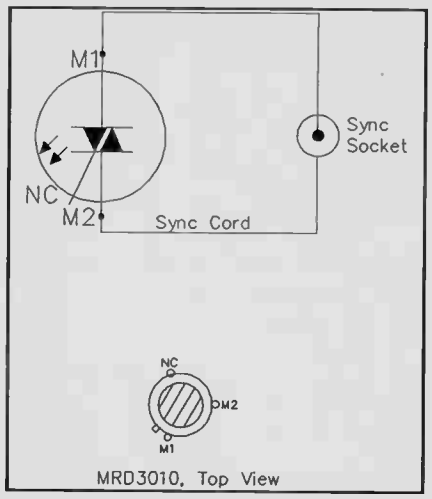


Fig. 1 (top) The schematic of the flash trigger; note that the third lead of the triac is not used and can be cut off; (bottom) the pinout of the MRD3010 triac.

Since a triac conducts in either direction, there is no problem with polarity; it will work properly even if you reverse the leads. The MRD3010 has a maximum voltage rating of 250V, more than the triggering voltage of flash units.

In the upper part of **Fig. 2** is the triggering circuit used by almost all low-cost portable flash units. The main high-voltage supply is reduced to about half by two resistors and charges a small capacitor, usually in the range of 0.02u to 0.1u. When the camera contacts close, the capacitor's charge is dumped into the primary winding of a small high-voltage coil; its secondary winding provides a short pulse of about 4kV. This pulse is applied to the xenon flash tube, where it ionizes the gas, making it conductive enough to discharge the main capacitor and produce a burst of light.

In the lower part of Fig. 2 is the electronic trigger used on the more expensive flashes. A solid-state circuit buffers the triggering capacitor from the sync socket, reducing both the volt-

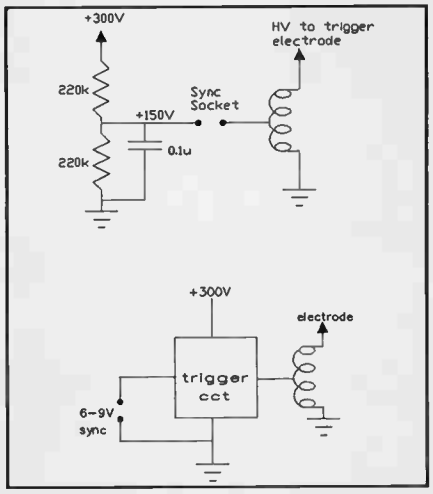


Fig. 2 (top) the firing circuit found in most low-cost flashes, and (bottom) the isolated low-voltage type.

age and the current applied to the camera shutter contacts.

The MRD3010 is happy with either of these systems. Incidentally, if you can't locate a Motorola dealer, we got our triac (under $3) from Electro-Sonic, 1100 Gordon Baker Rd., Willowdale, Ont. M2H 3B3, (416) 494-1555.

Construction

We couldn't locate any sync-socket connectors, so we bought a flash extender cord from a camera store and cut off the required socket end, leaving a few inches of wire. The triac is soldered to the wire, using tape or plastic sleeving to insulate the joints. Note that there is no connection to one of the triac leads and it can be cut off.

We then drilled a hole in one end of a plastic pen top, dropped in the triac until it protruded, and filled the pen top with epoxy. It was then epoxied to a large plastic paper clip to allow convenient mounting to various things.

Use

Just plug it into the remote flash. The main flash will trigger it in a short enough time that for practical purposes, the flashes can be considered to fire simultaneously.

The trigger is quite sensitive; we had it working reliably at about 30m distance.

If the remote flash causes even more shadows, try bouncing it from the ceiling, the wall, or a large white card.

Disadvantages

Well, there are limits to the simplicity route. The trigger will respond to *any* flash; if you use it at a wedding or similar, other people's flashes will soon discharge your remote for you. Secondly, it isn't reliable in sunlight. Bright light of any sort will fire it if it's strong enough. The more adventurous of you might try cardboard snouts or baffles or filters.

Triacs also have the characteristic of latching; once they start to conduct, they stay conducting even if the gate or light signal is removed. They don't turn off until the current falls below a certain minimum. This didn't cause any problems with our unit, because firing the triac discharged the flash completely and reduced the current to zero. If it does latch, the symptom will be a neon ready light that refuses to come on; if this happens, just disconnect the sync cord for a moment to let the triac switch off. ■

Continued from page 12

For Your Information

Omnicrom Color Copy System

Convert black and white artwork, photo copies, or laser printer output into multi-color images using the Omnicrom 2000.

Omnicrom can produce multi-colored proofs, color printing, foil stamping, laminating, report cover binding, signage, overhead projectuals and color overlays.

All that is required, apart from the Omnicrom unit, is a "zoom" photocopier to use as a camera to resize and copy originals up to 11" x 17". The Omnicrom unit carries a price of $1595 for the 12" model and $1095 for the 9" model.

For complete technical information on the Omnicrom system contact: Trans Art Supplies, 720 King Street, Toronto, Ontario M5V 2T3. (416) 363-6156.

Circle No. 72 on Reader Service Card

Nicolet Digital Scope

The new Nicolet 310 digital scope can capture and save 176 waveforms on its dual 3.5" floppy disk system (43 waveforms on a single 5.25" drive).

Because the data is stored in IBM/PC file format, users can recall waveforms on a PC without the hassle of computer interfacing. PC software is provided free of charge for printing waveform values and for formatting data for use with LOTUS 1-2-3 or Nicolet's WAVEFORM BASIC data analysis package. For testing in harsh, dusty environments, the portable 310 may be purchased with a rugged Bubble Memory Cartridge.

The 310's Advanced I/O options link it over the IEEE- 488 (GPIB) and RS232 interfaces to digital plotters for hardcopy records, and to computers for further data manipulation.

The price is $7295.00 (Cdn). For more information contact: Nicolet Instrument Canada Inc., 1-1200 Aerowood Dr., Mississauga, Ontario L4W 2S7. (416) 625-8302.

Circle No. 71 on Reader Service Card

Continued on page 31

Electronic Warfare In The World Of Intelligent Machines

Using AI for more than just peaceful purposes.

By K. Tahir Shah

One day in June of 1967, a wave of fighter and fighter bomber aircraft of the Israeli air force, packed with their electronic counter-measure gadgets, flew over the clear and bright skies of the Mediterranean. They were heading towards, Egypt, and avoiding detection by the long range radar network, they penetrated to destroy the Egyptian air force on the ground. The outcome of that war was a verification of the generally accepted military principle, that victory in a modern war will go to the side that can best control the electromagnetic spectrum. That was twenty years ago. Now it is true more than ever.

Star wars of tomorrow will be fought by electronics and computers; controlling decoding, jamming and avoiding those little chunks of electromagnetic waves moving back and forth at the speed of light. It will be the battle of intelligent computers and the electromagnetic spectrum. Today's war machines are heavily dependent on electronics and computer technology due to their design complexities, ultra-high speed and performance requirements which no human can match. At the same time, communication between various sub-systems of a defensive or offensive system is more important than ever. Other system functions, such as detection and tracking of enemy aircraft, ships or missiles, are an essential part of the warfare.

Electromagnetic Manipulation

Electromagnetic emission or radio waves of many different wave lengths are used for communication. The basic concept of electronic warfare is to exploit the enemy's electromagnetic emission in all of the electromagnetic spectrum in order to provide "intelligence" or information on the enemy's abilities. This includes the enemy's order of battle, his intentions and the capabilities to use counter-measure etc.

Before we proceed any further with this discussion, an important semantical issue needs clarification. The word "intelligence" is used widely in two well known contexts. Since we are dealing with both of these contexts, it is vital that we have two semantically unrelated uses.

One noted use of this word is in the context of human, animal and machine capabilities, such as language understanding, proving theorems, creating art and music and infinitely many other tasks requiring complex processing of information. The other use of this term is in the context of military, political and economic information which has specific interpretation and meaning vis-a-vis some well defined objectives.

In the first case, "intelligence" is referred to knowledge processing from which all human intellectual capabilities are derived. In the second case, it is the knowledge itself which is referred to as the intelligence, the information of some kind which is meaningful only in a particular context. To summarize, human and machine intelligence is derived from knowledge processing while the other, e.g., military intelligence is a goal-oriented interpretation of the knowledge or data.

Coming back to electronic warfare, there is an interesting mathematical formula which we can used to understand why electronic counter-measures are important. According to the Lanchester equation, the effective military strength of a force is proportional to the product of the effective-

ness of its weapons and the square of its number. Such a force, when faced with a numerically superior force of N - to - 1 ratio, it is necessary to counter this with a weapon which is N square times more effective than the enemy's weapon in order to achieve equality.

This equation is used to analyze the force divider or force multiplier effect in a given combat situation. It is achieved in practice by command, control and communications (C3) systems through the localized concentration of forces and asymmetry in weapon power. That is, a favorable imbalance is achieved at a small section of battle field by increasing the quantitative and qualitative firepower. For example, asymmetry is achieved in a local engagement by employing air-delivered weapons against a tank for higher effectiveness ratio.

When C3 systems are employed as force multipliers they become the target of enemy attack. Neutralization of C3 has a force divider effect and it is accomplished by the use of C3 countermeasures (C3CM). Exploitation, deception, jamming and destruction of C3 hardware are methods generally employed for C3 counter measures. The electronic warfare can be considered as a subdomain of C3 countermeasures. In the tactical and rapid deployment force, the quality of real time decision making (especially in command, control and communication systems) can influence significantly the outcome of an engagement. Both types of systems are inherently mobile. The tactical conflict, as well as rapid deployment, are characterized by rapid changes and thus impose strong limitations on their C3 systems affecting the ability of respective human elements to perceive over all situations and reach a decision in real-time. It is in this situation that computer based intelligent systems for decision making are useful.

AI Techniques In Warfare

The expert systems based on artificial intelligence techniques differ from conventional computer systems. The expert systems are capable of inferring like humans and thus go far beyond than just presenting data in a convenient form. Since military application of artificial intelligence is mostly classified research, I would like to speculate on two specific domains of AI applications in electronic warfare only on technical grounds. The two application areas are:

> Automatics interpretation of sensor data into useful C3CM intelligence, and ultra-high precision signal-to-noise separation for possible application to the detection of stealth objects.

Artificial intelligence is considered to be one of the top ten technologies by the U.S. Department of Defense for the 1980's. It is an interdisciplinary science with its origin in logic, theory of knowledge, computation theories and cognitive psychology. Intelligent systems can, for example, learn from experience, prove or refute a hypothesis using facts, and other similar tasks.

AI has progressed from a laboratory science to an expanding technology only in the last few years. Rule based expert systems were the first intelligent systems introduced commercially. A large number of expert systems used in military science are of this type. An expert system is an intelligent program which has knowledge in a narrow domain along with knowledge manipulation facility, called an inference engine. There are many generic categories of expert systems with skills in such tasks as:

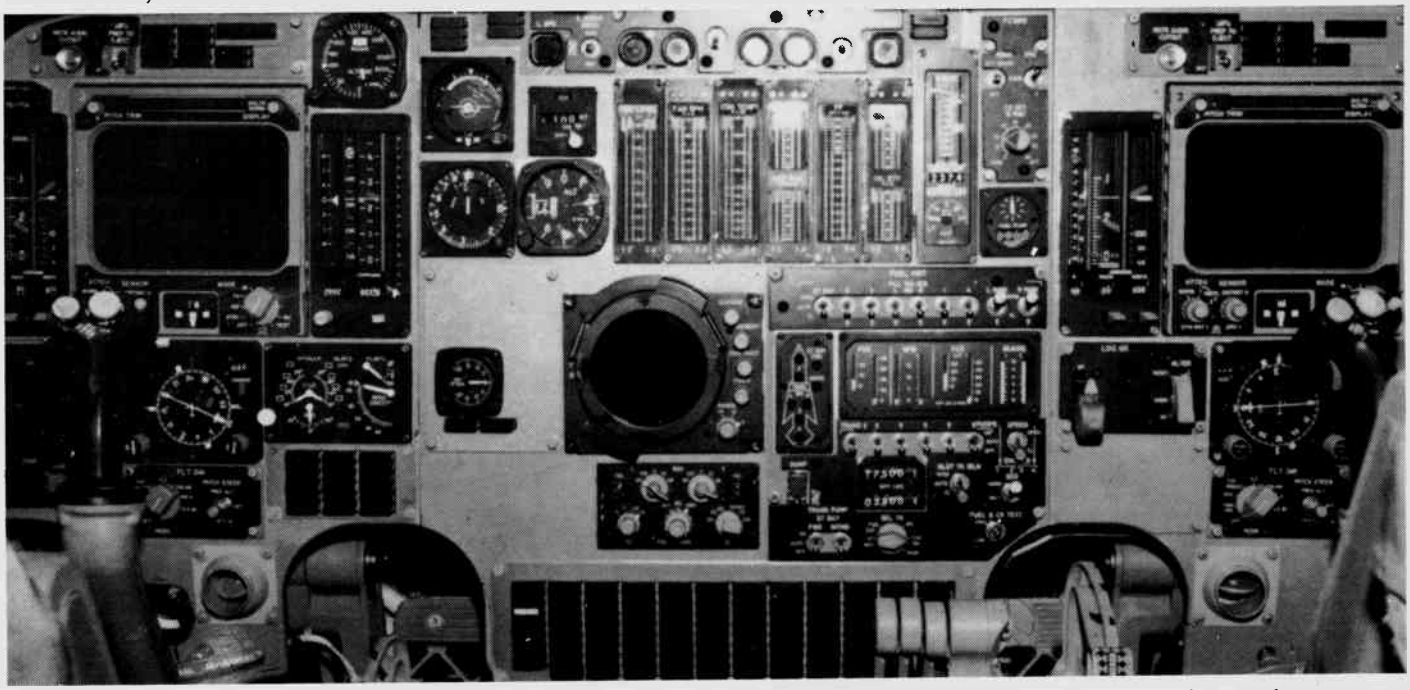
-Interpretation: Infer situation description from the sensor data,

-Prediction: Infer likely consequences of given situation,

-Diagnosis: Infer system malfunctions from the observed data,

-Planning: Designing actions for future achievement of goals,

Monitoring: Comparing collected state data with the desirable values and inferring alarm states



Currently one of the world's most advanced military aircraft, the Rockwell B-1B is controlled by an enormously complex onboard computer system.

Naval training simulators such as the one above, provide crews with actual situations for using weapon systems, reducing the cost of training on actual equipment.

-Control: Interpreting, predicting, monitoring and planning system behaviors.

Several applications of AI in the Electronic Warfare field have been identified, for example:
The fusion of multi-sensor data as a decision aid to threat analysis systems. In intelligent C3 (C31) and C3CM systems to act as an expert advisor to decision makers, reconnaissance, surveillance and intelligence data processing and assessment, Sensor resource allocation and planning, information retrieval and routing

There have been many expert systems built during the last decade for military use. Some of the known expert system one may find in AI literature are:

DART: This system gives advice to the analyst on the identification of critical enemy C3 network nodes and assists in the processing of messages related to battle situation.

ASTA: It helps identify the type of radar that generated an intercepted signal. The system analyzes radar signals in light of the general knowledge it has about the physics of radar and the specific knowledge it has about the particular types of radar systems.

ATR: detects and classifies military targets from sensor images.

HANNIBAL: performs situation assessments in the area of communications intelligence. It identifies enemy organizational units and their communication order of battle by interpreting data from sensors that monitor radio communications. These data include information about the location and signal characteristics (e.g., frequency, modulation, channel class, etc.) of the detected communication. The knowledge representation scheme in is the so-called black board architecture using multiple specialists.

Royal Navy ES: An expert system for evaluating electronic warfare tasking plans is built at the Admiralty Research Establishment, in the United Kingdom. It is a knowledge based system which provides advice on naval resource allocations.

Computational Models

The effectiveness of (military) intelligence depends on two factors. The availability of correct and complete data, and the correct and complete conceptual model of interpretation to convert this data into an effective intelligence.

In practice, complete date is not available due to many reasons. For example, in tactical and rapid deployment situations there is not enough time to obtain a complete situation picture. Since there are a large number of choices possible for data interpretation, the conceptual model is not necessarily optimal and in some cases does not represent the situation correctly.

The data interpretation is a human expertise at present. To copy with incomplete and sometime misleading data, human experts rely on indirect and unrelated information and the knowledge about the "world" to deduce relevant intelligence (in the second sense as defined above) through a series of cause-to- effect relationships. During this process it is possible to discard faulty and inconsistent data. The state transformation may not be strictly a logical rule, such

as resolution principle in PROLOG (a subset of predicate logic), but it could be a "common sense" argument or other inference rule (e.g., property inheritance).

To achieve a reasonably good interpretation of data into intelligence, a complete model of the world is required. This model must include such factors as; human intentionality, planning methods, organizational principles, short and long term goals, and the information on hardware physics.

The goal oriented interpretation of the data, from sensors and other resources, is different from the usual semantics. The usual semantics do not depend on goals but the over all model of the world. To develop an expert system which can automatically convert data into intelligence, a computational model of C3 countermeasure intelligence is to be investigated. One must remember that goal definition is essential in defining military intelligence of any kind in this model. A collection of data may be useless in some context but which can be of vital importance in another context with different goals.

In a simple situation, even under severe stress, an expert may be able to reach a correct decision regarding intelligence, but in a complex situation it is easy to confuse and discard valid data while interpreting irrelevant ones. There is another problem with humans. Each expert's model of the world is dependent on his/her own experience and the understanding of the situation. This problem can also be reduced by agreeing upon some well tested models. Thus a machine interpretation of data into intelligence will not be dependent on many human factors.

Putting It All In Use

A similar computational model (with casual relationships) can possibly be useful in the detection of low visibility radar (stealth) objects. When the radar echo is weak and difficult to detect, other information should be used to deduce the presence of a stealth object.

For example, infrared emission and other radio transmission, not related directly, can be fed into an expert systems real time knowledge base. The expert system then deduces the existence of an object which is not observable directly through radar. When signal intensity is very close to the noise level and both having the same characteristics, then the one possible way to detect it is to deduce the presence of the signal through inference. Usually statistical methods are not good to filter a signal out of such a noise level. This situation occurs when the signal resolution is such that the noise can either suppress or enhance a signal leading to a false conclusion.

Although, one may set signal threshold in a standard statistical way, a chain of casual inferences can reduce the number of false signals and false suppressions.

K. Tahir Shah is a consulting scientist in artificial intelligence and a freelance writer from Mississauga, Ontario. ■

Video Controller

A simple unit which provides a video fader and an audio mono/stereo mixer and fader.

By Robert Penfold

Home video production appears to be an increasingly popular hobby and seems likely to gain a larger following than home movies of the film variety ever managed. Methods of production are very different to the old film techniques, and there is no absolute equivalent to splicing pieces of film together to edit the individual scenes into the finished product. The accepted technique with videos is to copy the scenes from tapes placed in one recorder to a single tape in a second recorder where the full video is built up.

This can actually be done without the need for any extra equipment apart from the connecting lead, albeit rather crudely. More professional results can be obtained with the aid of a video controller of some kind, and the most basic type is just a video fader. The idea is to fade down the signal at the end of one scene, and them fade it up again at the beginning of the next scene. This gives what is generally a better effect than an abrupt cut from one scene to the next, and it is a technique that is much used by professional program makers.

For best results an audio fader should also be fitted to suit the unit, so that the sound signal can be faded in unison with the video signal of desired. The normal approach is to have separate video and audio fader controls so that the two signals can be controlled in precisely the required manner, but to use slider controls mounted side-by-side so that they ar easily operated together when necessary. For greater versatility an audio mixer should be included, so that background music or a commentary are easily added to the original sound track.

The System

This video controller uses the arrangement shown in the block diagram of Fig. 1. The top set of three blocks form the video fader, which is separate from the audio section of the unit apart from a common on/off switch and battery supply. Although an audio signal can be faded up and down using nothing more than a simple potentiometer connected to act as a variable attenuator, things are far less straightforward with a video signal. This is due to the fact that a video signal is really a mixture of two signals. The main one is the positive modulation signal which varies the brightness of the spot which is scanned across the screen to produce the image. This is the signal which must be attenuated in order to fade down the picture. The other part of the signal is the negative-going synchronization pulses. There are two

Fig. 1. The block diagram of the Video Controller.

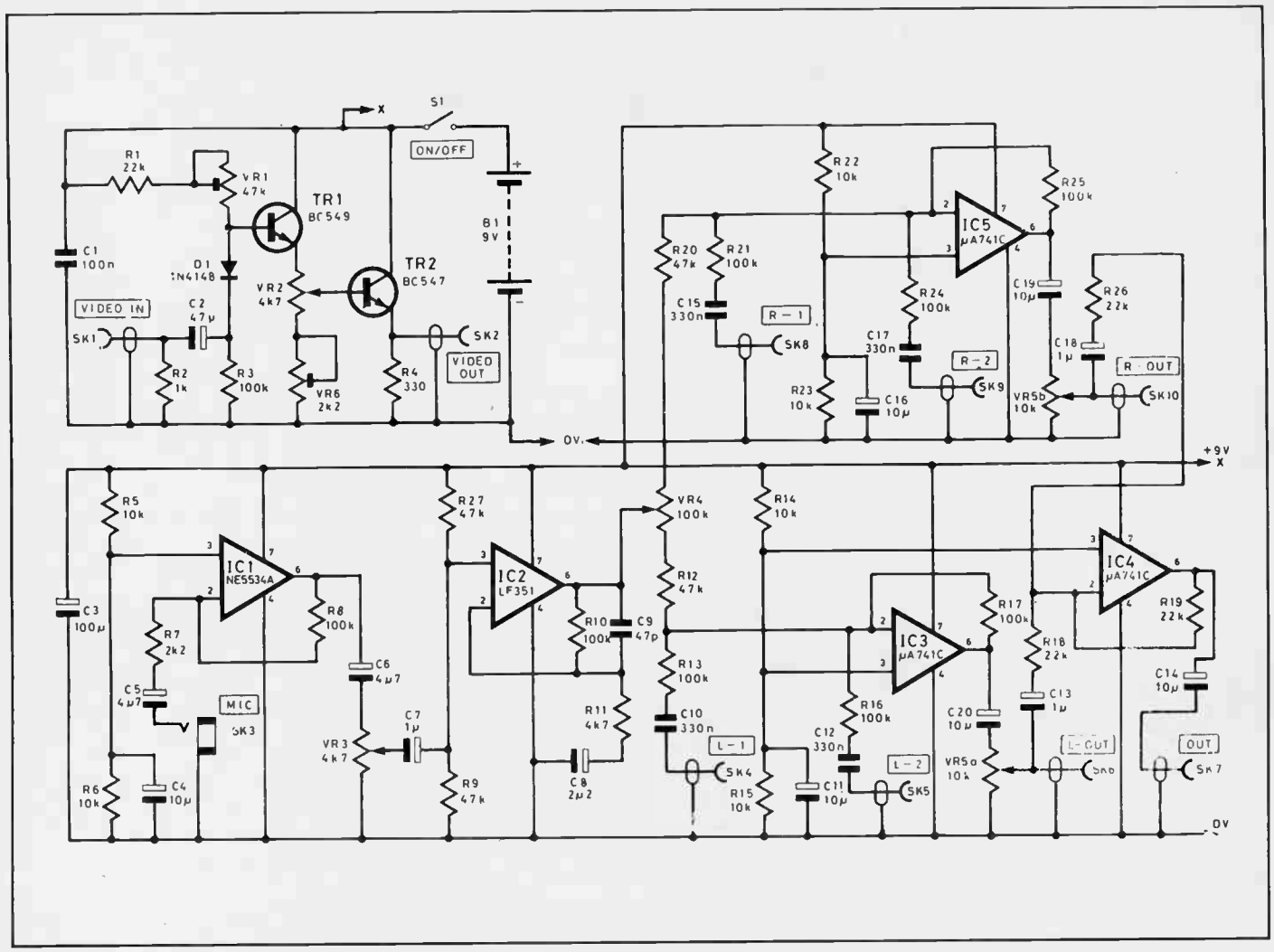


Fig. 2. The circuit schematic. See the text for substitutions for parts that may be difficult to locate.

types of synchronization pulses, the frame pulses at a frequency of 60 Hz, and the line synchronization pulses which are shorter and at a much higher frequency of about 15kHz. This second frequency may seem to be too low at first sight. However, it should be remembered that although there are 60 frames per second, a system of interlacing is used, and two frames are needed to product one complete picture. In the present context the important point is that a simple attenuator will not just fade down the modulation signal, but will also affect the synchronization pulses. It will give the desired fading effect, but there is a strong likelihood of proper synchronization being lost before the picture is fully faded down. At best this would give a grossly distorted picture, and at worst synchronization would be lost completely with the picture breaking up as a result. There are quite complex fader circuits which split the signal into its modulation and synchronization pulse elements, process the modulation signal, and then recombine the signals. It is not essential to do things in this way though, and it is possible to devise a circuit that will fade out the main picture signal while leaving a perfectly adequate modulation signal .

In this case the general scheme of things is to use some preprocessing ahead of a variable attenuator to ensure that the faded signal retains a sufficiently strong synchronization signal.

A buffer amplifier at the output of the video section ensures that the unit has a low enough output impedance to drive a composite video input properly. Note that the unit will only work with a composite video signal, and it can not be used with a UHF or VHF signal.

Audio Section

The audio section includes a two-stage microphone preamplifier which incorporates a microphone level control. There are three mixer stages, which can make the unit look a bit confusing at first, but the extra mixer is needed because the unit is designed to give both mono and stereo outputs. The microphone signal is fed to both inputs of the stereo mixer, and a channel balance control is included here. There are two high level inputs for each channel of the stereo mixer circuit, but there are no level controls for either of these. It has been assumed that the output controls of the tape decks (or whatever equipment feeds these inputs) will be used to get the signal levels right. Of course there would be no difficulty in adding volume control style variable attenuators at each input if desired.

Parts List

See text for parts substitutions.

Resistors
(.25 OR .5 watt, 5%)

R1	22k
R2	1k
R3	100k
R4	330
R5,6,14 15,22,23	10k
R7	2k2
R8,10,13,16,17 21,24,25	47k
R11	4k7
R18,19,26	22k

Potentiometers

VR1	47k trim
VR2	4k7 linear
VR3	4k7 audio
VR4	100k linear
VR5	10k dual audio
VR6	2k2 trim

Capacitors

C1	100n
C2	47u 16V
C3	100u 10V
C4,11,14 16,19,20	10u 25V
C5,6	4u7 63V
C7,C13,C18	1u 63V
C8	2u2 63V
C9	47p
C10,12,15,17	330n

Semiconductors

TR1,2	BC549 or 2N3904
IC1	NE5534A (see text)
IC2	LF351 (see text)
IC3,4,5	741
D1	1N4148 or 1N914

Miscellaneous

SK1,2 4,5,6,7	phono socket
SK3	3.5mm jack, or to suit mic.
S1	SPST switch
B1	9V batt. (see text)

Case such as Radio Shack 270-250 (used in cover photo), knobs, battery connector, shielded wire, hookup wire, 4-40 nuts and bolts.

A dual gang potentiometer can be used to control the output level from both channels of the mixer. It is the outputs from this main fader control that constitute the stereo output signal. The third mixer stage is simply used to combine the stereo output signals to provide a mono output. If the mono output is used, then obviously the microphone balance control is superfluous, and will have little effect.

Video Circuit

The circuit diagram for the video stages of the unit appears in **Fig. 2.** There is nothing much to the preprocessing circuit which is basically just a diode and potential divider circuit which ensures that suitable voltages are fed to the video fader potentiometer VR2. Transistor TR1 acts as a buffer amplifier which provides a low enough output impedance to drive the fader circuit properly. VR1 and VR6 are adjusted to give a good control characteristic from VR2. This avoids having the fade- down introduced over a short length of track towards the middle of VR2's adjustment range.

By having the fade-down introduced over virtually all VR2's adjustment range it is much easier to precisely control things and to have a very slow fadeout is desired. It also gives a better match with the audio fade-down control. The effect on the picture as the signal is faded out is much the same as turning down the brightness control of a television contrast as the signal is attenuated.

Audio Circuit

The audio stages are somewhat more complete, as can be seen from the preamplifier and mixer circuit diagram which appears in Fig. 2. IC1 acts as the preamplifier stage, and this is a special low noise operational amplifier which operates here in the inverting mode. It has a voltage gain of about 45 times and gives an input impedance of 2K2. The circuit will work using a less expensive device in the IC1 position, including the standard uA741C type. The NE5534A is much to be preferred though, as the output from a microphone is at a very low level, and noise from the preamplifier can be excessive when using a device which offers anything less than excellent noise performance. The noise level is actually about 20dB lower (one-tenth in terms of voltage) using the NE5534A instead of an ordinary uA741C or a similar device.

The input characteristics of the microphone input are suitable for most types of microphone. Low or medium impedance dynamic types will work well with the unit, as will any types that have similar output properties. With some low impedance types it may be better to reduce R7 to 1k so as to give slightly increased gain. The unit will work with high impedance dynamic microphones and similar types, but better results are likely with these if R7 is raised to about 22k in value. This reduces gain and boosts the input impedance.

Crystal microphones are unsuitable for use with this project.

Potentiometer VR3 is the microphone gain control, and this is followed by the second stage of the microphone preamplifier. This is a non-inverting circuit based in IC2, and it provides a voltage gain of approximately 22 times. Its output feeds straight into the channel balance control, VR4.

The stereo mixer uses IC3 and IC5 as conventional summing mode mixers, one in each stereo channel. These have unit voltage gain and provide an input impedance of about 100k at each input. VR4 forms part of one input resistance for each channel, and it gives approximately unity voltage gain from the output if IC2 to the output of each mixer, but only when it is at a central setting. By adjusting VR4 so that the wiper is right at one end of its track or the other, the two input resistances become unequal. One becomes just the 47k of the fixed input resistor, while the other become this 47k plus the full 100k of VR4's track (totalling 147k).

The gain of each mixer circuit is equal to 100k divided by the input resistance. Therefore at the extremes of its settings VR4 boosts the microphone signal in one channel by about 6dB, and reduces it by a few dB in the other channel. This does not permit the microphone signal to be panned from full-left to full- right. In terms of position in the sound stage, as little as 6dB difference between the two channels is adequate to place a signal well over to one side or the other. VR4 can therefore be used to pan the microphone signal over to one

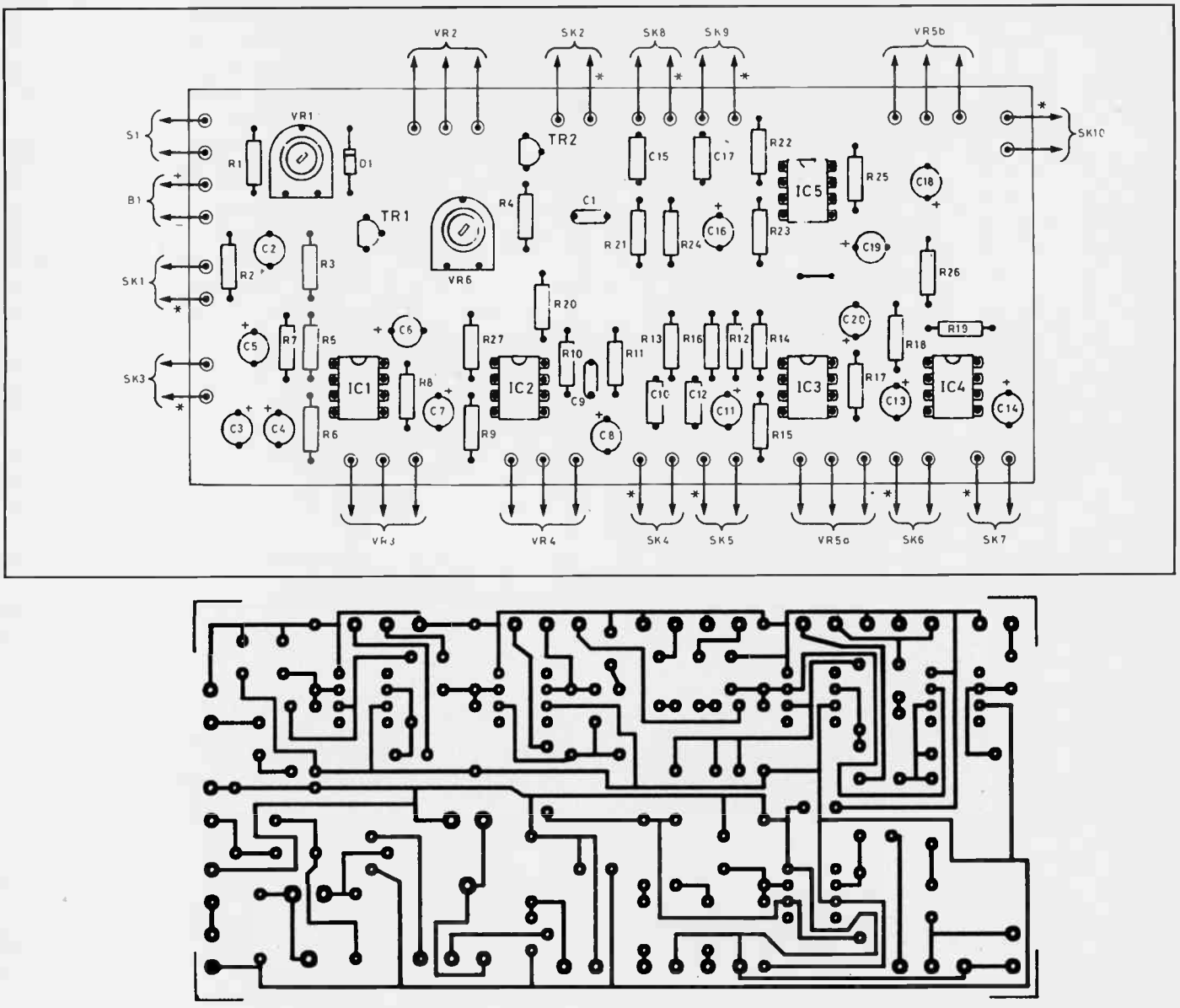


Fig. 3. The component location and printed circuit board. The asterisks on the location diagram mark the ground connections.

side of the sound stage if desired, instead of using it to balance the signal for a central image. The main audio fader control of VR5 and the stereo outputs are fed directly from its wiper terminals. The two signals are combined into the mono output by IC4 which acts as another summing mode mixer circuit.

Power is provided by a nine volt battery, and as the current consumption is quite high at around 17 milliamps an alkaline 9V battery is a good idea.

Parts Substitution

As mentioned above, the 5534 op amp can be replaced with a 741 general-purpose type at the expense of noise (though video sound is less than hifi anyway). This also applies to the 351, IC2.

Presets VR1 and VR6 should be fairly close to the stated value; a 5k linear taper (Radio Shack, etc.) is ideal for VR2. VR3 can be any value from 5k to 50k, preferably with an audio taper, though a linear tap will work (though the volume jumps up suddenly from zero). VR4 is an easily obtainable 100k.

The 10k dual audio taper is an ideal value, but it's rather hard to find one; many component stores don't have a good stock of duals. Complicating this is the fact that the pot's sliders are used as outputs (L-Out and R-Out on the schematic). If you use an easily obtainable pot, such as Radio Shack's 100k dual, the output resistance will be ten times higher than we'd like. This higher impedance might be susceptible to noise, but it's a possibility if you want to try it. Another way is to use Radio Shack's 1k dual linear balance control as a volume pot. It works, but the control range will be somewhat compressed compared to an audio taper.

Construction

Details of the printed circuit board are provided in **Fig.3**. None of the integrated circuits are MOS types, but I

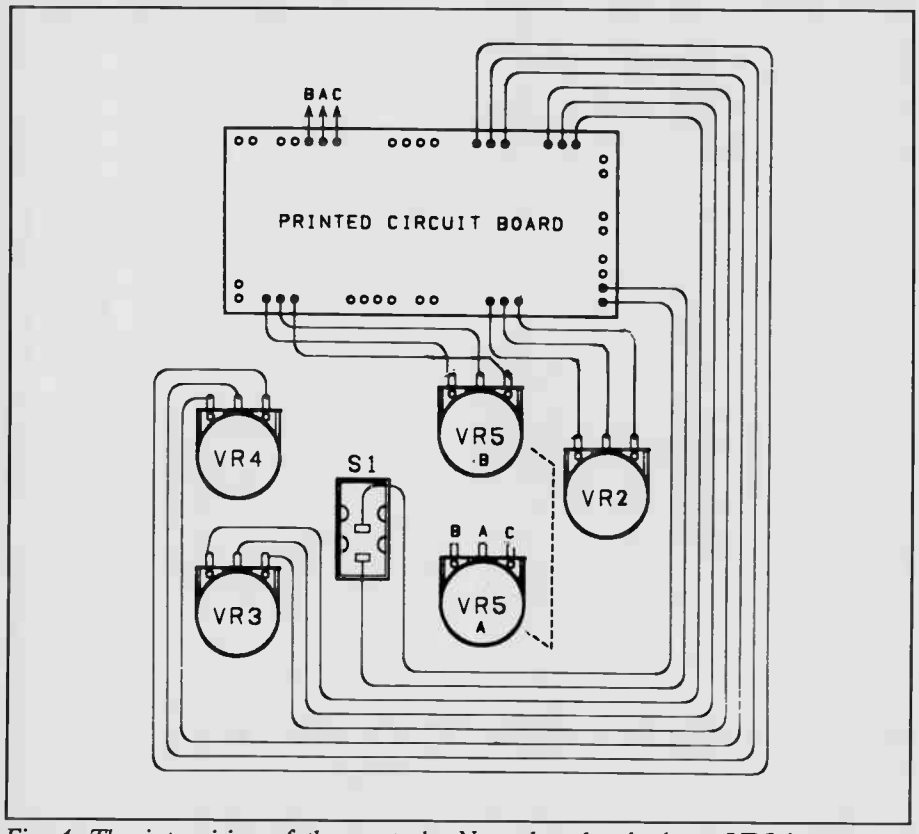


Fig. 4. The interwiring of the controls. Note that the dual pot VR5 is shown as separate sections for clarity.

would still strongly advocate the use of a holder for IC1 at least. The NE5534A is rather more expensive than the average operational amplifier. The capacitors must all be miniature printed circuit mounting types if they are to fit onto the board neatly and without difficulty.

Be careful not to omit the single link wire which is situated about half way between IC3 and IC5. A piece of wire trimmed from a resistor lead can be used for this link. Be careful to fit the integrated circuits and the polarized components the right way around. At points where connections to off-board components will be made only single-sided pins are fitted to the board at this stage.

From the electrical point of view the exact layout used is not too important, and it is really a matter of arranging the components in a manner that makes the unit easy to use. Phono sockets were used for all the input and output sockets, apart from SK3 (the microphone socket) which is a 3.5 millimetre jack type. If necessary though, these can be changed to any types which fit in with your particular audio and video equipment. You might find it better to use BNC connectors for SK1 and SK2 for example. The phono jacks can be separate units, or the type with 8 jacks mounted on a phenolic board.

The completed printed circuit board is mounted on the base panel of the case using small nuts and bolts. An extra nut on the bolt shaft can hold the board clear of the case. Make sure that it is mounted where it will not come into contact with any of the front panel mounted components when the top/front panel is fitted into place. Also be careful to leave sufficient space for the battery somewhere in the case.

Wiring

There is a substantial amount of hard wiring needed to complete the unit. It is probably best to start with the wiring to the sockets, and this is fairly straightforward. The only point to watch is that each ground terminal on the board connects to the appropriate tag on its corresponding socket. The cable which connects the board to SK3 must be a shielded type (with the outer braiding carrying the ground connection) as the microphone input is very sensitive to stray pick up. It is advisable to use shielded lead for the connections from SK1 and SK2 to the board. This is to prevent radiation of the video signal and stray pick up in the microphone preamplifier wiring. It is also advisable to keep the wiring to VR2 as far away from the microphone preamplifier components as possible. It is not essential to use shielded cable for the connections to the other sockets, but it is probably best to play safe and do so for any leads that are more than about 25 millimetres long.

The wiring to the controls is shown in Fig. 4. I would recommend the use of twin shielded cable for the leads which connect to VR3, VR4 and VR5. In the case of VR4 there is no track connection to the negative supply rail that can be connected to the outer braiding in order to provide screening. Connecting the braiding to the wiper (middle) terminal of VR4 will give effective screening of the other two leads though, and these are the ones that are sensitive to stray pick up.

Adjustment and Use

Exactly how the unit is wired into your system will obviously depend on precisely what equipment is in use. All the connecting leads should be of the appropriate shielded variety. There should be no difficulty in testing the audio mixer section of the unit, and this does not require any setting up or adjustment before it is ready to use.

There are two trim pots (presets) to be set up in the video fader section and initially VR1 should be adjusted to a roughly mid- point setting. VR6 should be set at maximum value (turned fully clockwise). The unit may well work perfectly satisfactorily with the presets at these initial settings, but it might be found that there is still some picture evident when VR2 is fully backed off. VR6 should then be adjusted in an counterclockwise direction just far enough to fully blank the screen of the monitor. VR1 is given any setting that provides a good fade-up characteristic. A little experimentation is called for here, and with some systems virtually any setting of VR1 will give good results.

AR-140 DMM Kit

An affordable, five-function, digital multimeter that you can assemble from a kit.

By Edward Zapletal

If you've always wanted to build your very own DMM but have hesitated because you thought the parts were hard to get — hesitate no more. The AR-140K from American Reliance contains all the bits necessary for building an excellent quality DMM, right down to the LCD display, PCB and case. If the kit form isn't for you, though, you could buy the AR-140 in its assembled state as well.

Why Build Your Own?

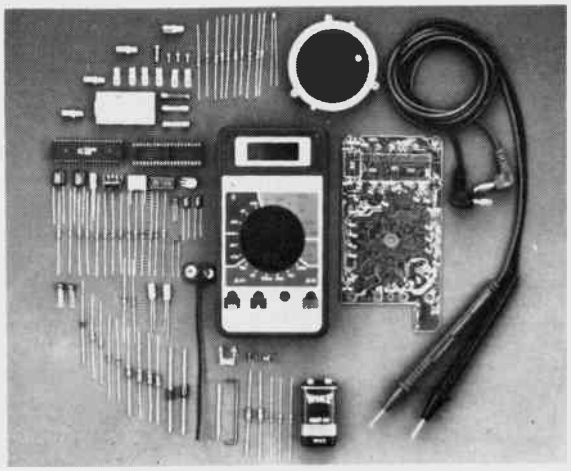
Regardless of whether you're an electronics expert or a novice, the bottom line is the same: building kits is just downright fun. Both enjoy the satisfaction of building a professional-looking piece of test equipment, but the novice gets an added bonus: hands-on experience in electronic fundamentals. What better way to learn about voltage, resistance, and current?

What You Get

The AR-140K, in its completed form, is capable of performing measurements in DCV, ACV, DCA, Resistance, as well as doing diode checks. You can expect 1000 hours of use from the standard 9V battery, and there is overload protection on all ranges except the 10A DC range. The 3 1/2 digit, 0.4-inch LCD display is equipped with "LOBAT", "−", and decimal annunciators. Probes are also supplied.

To aid in the construction of the meter, a comprehensive manual is supplied which contains the circuit diagram on a large fold-out sheet for easy reference. In addition to this, there is yet another fold-out sheet displaying resistor and capacitor ID charts, legends to the LCD display connections, ICs, diode, and transistors.

The assembly portion of the manual is divided into seven parts, with the components for each portion packaged in a marked, separate envelope for easy identification. A complete parts list is also included and this should be checked against all components before construction is started. Other sections include: theory of operation, general trouble-shooting, and tools required. Apart from your soldering iron, all you'll require is a pair of diagonal cutters, long-nose pliers, and a screw driver.



The printed circuit board is a double-sided affair with component locations clearly marked. The case is a standard AR-140 DMM case with the necessary openings for the rotary switch, probes etc.

Meter Specs

Five DC voltage ranges are available on the AR-140K with accuracies of ±0.5% at 200mV, ±1% at 2, 20, 200, and 1000V. Overload protection is listed as being 700VDC and 500VAC at 200mV level, with 1000VDC and 750VAC on all other ranges. Input impedance on all ranges is 10M.

AC voltage can be measured in two ranges, 200v and 750V, in frequencies ranging from 40Hz to 500Hz. Accuracy is ±1.2% on the lower range, and ±1.5% on the higher. Overload protection is 1000VDC and 750VAC rms, with an input impedance of 9M on all ranges. AC voltage is measure as the average value of the input AC signal and the result is the equivalent rms value for a sine wave.

Six resistance ranges are possible from 200 ohms to 20M. Accuracy here is ±1% in the five lower ranges and ±1.2% on the 20M range. Overload protection in the resistance mode is given as being 300VDC and 250VAC rms on all ranges.

Last, but not least, the six DC current measuring functions of the meter go from 200uA up to 10A. Accuracy, here, is ±1% with a voltage drop at full scale of 250mV in the lower five ranges and 350mV on the 10A range. Overload protection is provided only on the lower five ranges by way of a 2A fuse. There is no overload protection on the 10A range.

Bottom Line

The price of the AR-140K is a reasonable $70. However, you will find that the assembled version costs about $5 less. The reason: packaging and handling costs for the loose components. Yes, it used to be that you could save a little if you assembled it yourself, but, the high-tech robotic assembly methods in use today have pretty well put end to this. For die- hards though, this small price discrepancy will be insignificant in comparison to the satisfaction that they'll get from building their own meter.

The AR-140K DMM is available from BCS Electronics, 980 Alness St., Unit 7, Downsview, Ontario M3J 2S2. (416) 661-5585. ■

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- A-type. Infrared Tx, Rx. Max. distance 40 feet.
- B-type. Wireless FM. Tx, Rx. Max. distance 300 feet.

Complete Kit — A-type ..... $87.00 B-Type $145.00

Stepping motor driver kit comes with mini motor

- Good for drive small motor. Max. 12V 1.2A, 3000pps.
- Manual or computer control are selectable.
  Special price ..... $ 68.00

High Speed EP-ROm erasing Lamp Kit.

- High intensity type. Erase 20pcs Rom in 5 to 10 minutes.
- Also. P.C. Board exposing UV Lamp sold by K.E.M.
  1 set with timer ..... $ 41.98

$6.00 for shipping. Plus P.S.T. for B.C. residence. Plus C.O.D. fee, if required. We do not accept invoice orders.

K.E.M. Electronics Ltd.
Mail to Box 69126, Station (K),
Vancouver, B.C. V5K 4W4
Office 879E. Hastings, Vancouver
(604) 251-1514

PRO AUDIO and STAGE LIGHTING

- Faders all values and tapers.
- Rotary and trim pots. - * Knobs all sizes.
- NEUTRIK audio connectors. - * Chemicals.
- Resistors and capacitors all values.
- Led's, diodes, transistors and IC's.
- Tone generators 1 hz-100 khz.
- Pink noise generator. - * Summing, line and preamps.
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- Regulated power supply circuit boards for all Radio Shack and Hammond 161 and 229 series transformers. - * Power supply kits.
- Low distortion digitally or manual controlled auido attenuators.
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- 3 wire communication module compatible with others.
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- 1,4 and 8 ch. 120 vac dimmer cards.
- 4,6 and 10 ch. solid state relay boards 15 - 40A RMS.
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- 24 ch. random generator.
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- Rate controlled auto fade with presets and remote control.
- 4 wire analog multiplexer compatible with others.
- All circuits operate at standard levels.

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PATOR COMPONENTS
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Classifieds

ADVERTISING FORM

Rates: The basic one time insertion rate is $1.50 per word (Minimum 25 words) The rate of $3.50 per word allows your advertisement to run in all three publications (Computing Now!, Electronics Today, and Computers in Education) Headings, logos and reverse advertisements are available for an additional $30.00

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25% for 12 consecutive insertions
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These rates apply only to the prepayment of the entire sum

Send a cheque (deduct applicable discounts) along with this order form

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1300 Don Mills Rd., Don Mills, Ontario M3B-3M8
(416) 445-5600

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Dreams can come true if you "Get Active".

Our remuneration and benefits package is well above average. Our Managers and Sales Representatives have unlimited earnings potential! If you dream of the "good life", we can help you realize that goal.

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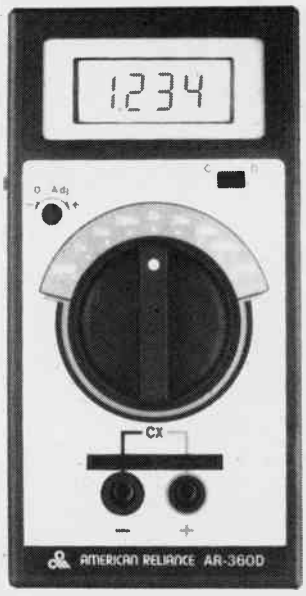
Active

The entrepreneurial spirit lives on at Active Electronics. Active is one of the fastest growing electronic retailer/MRO distributors in North America. We plan on opening new branches from coast to coast, and need management trainees and sales reps to help us grow. This is a once in a lifetime opportunity that will appeal to the person who would like the next best thing to running one's own business!

If you are an above average person, with a great deal of ambition and drive, prior experience in sales, telemarketing, management, or electronics, we would like to hear from you!

Forward your resume to:

Hank Boyer, General Manager
Active Electronics
237 Hymus Boulevard
Pointe Claire, PQ H9R 5C7



American Reliance DMM

The AR-360D from American Reliance is a 3 1/2 digit DMM which measures Dissipation Factor in addition to direct readout of capacitance. This greatly enhances teh reliability of capacitor measurements because DF directly relates to a capacitor's leakage current.

Capacitors can be measured from 0.1pF up to 20,000uF, and their leakage can also be determined for greater validity. The unit includes: leather carrying case; spare fuse; test leads; and operator's manual. The 360D comes with a full one year parts and labour warranty.

For more information contact: BCS Electronics, Units 6- 7, 980 Alness Street, Downsview, Ontario M3J 2S2. (416) 661-5585.

Circle No. 63 on Reader Service Card

Quantec Programmer

As a plug-on mate for the Q-2000 Universal Programmer, the Q-2003 will allow fast and reliable programming of Bipolar PROMs.

The unit operates on either stand-alone or remote modes for easy interface to a PC or development system. No personality modules are required as device selection is software selectable on the instrument itself, or when running with a PC and Quantec's Q-2000 PC interface program. Files can be uploaded or downloaded from the Q-2000/2003 in a number of various formats including Intel Hex, Motorola Exorcisor, etc.

For more information on this and other Quantec products contact: Interfax Systems; Toronto (416) 671-3920; Montreal (514) 336-0392; Ottawa (613) 726-8888 and Vancouver (604) 430-1410. Or, Quantec Systems Inc., 500 Alden Rd., Unit 8, Markham, Ontario L3R 5H5. (416) 477-6950.

Circle No. 65 on Reader Service Card

Recharged Laser Printer Carts

Canadian Laser Products Inc., offers a complete recharging service to those who use Canon EP, PC 70 and 80 series micrographic equipment and Canon Personal Copiers.

The process involves completely dismantling, cleaning and replacing the parts that are subject to wear (without drilling holes). Recharged carts provide print quality, as well as quantity of pages, equivalent to new cartridges. Recharged cartridges are available.

Canadian Laser Products Inc., 400 Matheson Blvd., Unit 28, Mississauga, Ontario L4Z 1N8.

Circle No. 64 on Reader Service Card

Hygrothermometer

A new portable digital hygrothermometer from AOIP provides instantaneous measurements of relative humidity and temperature in the air.

The unit is ideal for environment checks needed in industries sensitive to humidity and temperature such as engineering, computer rooms, maunfacturing facilities, and calibraton labs etc.

The hygrothermometer is capable of measuring temperature between -20 to +60°C accurate to ±0.6°C, and humidity from 3 to 100% ±3%. Resolution is 0.1% on both humidity and temperature readings.

For more information contact: Morriss Gordon, Omnitronix Ltd., 2410 Dunwin Dr., Unit 4, Mississauga, Ontario L5L 1J9. (416) 828-6221.

Circle No. 66 on Reader Service Card

New EMI Test Facility

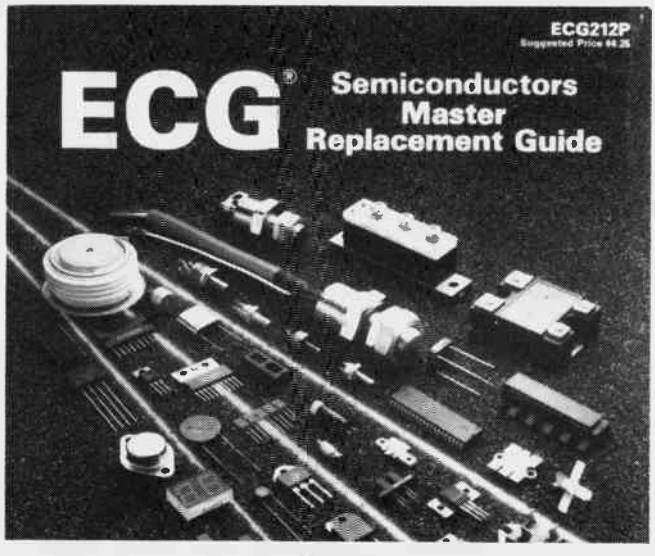
The Standards Approval Group Inc., of Mississauga Ontario, has recently begun operations at its new EMI test site in the Caledon Hills, north of Toronto.

The area has very low radio interference levels because of its rocky environment, which screens out most radio broadcasts and other outside electromagnetic interference (EMI). The low level allows technicians working on sensitive testing analyzers to interpret signals from antennae monitoring computer equipment, with greater accuracy.

Established in 1986, the Standards Approval Group has had a corporate mandate to assist manufacturers of electrical and electronic products acquire necessary government approvals, to market their products. The company has years of experience in testing and modifying all types of electronic data processing and telecommunications equipment. In addition, the company also offers a "one-stop shop" certification service to its customers, with fast product turnaround and cost-effective product analysis.

For more information on the services provided by the Standards Approval Group contact Duane Sharp or Michael Ivezic at: 120 Matheson Blvd. E., Suite 104, Mississauga, Ontario L4Z 1N5. (416) 890-2801.

Circle No. 60 on Reader Service Card



New Semiconductor Replacement Guide

A newly updated and expanded ECG Semiconductors Master Replacement Guide is available from Philips ECG.

The new guide lists almost 4000 ECG solid-state devices used as replacements for domestic and foreign types in entertainment, commercial, and industrial equipment, as well as 230 new types added since the last update.

Included are such devices as: transistors; high voltage rectifiers and triplers; small signal switching, zener and microwave diodes; rectifiers from 1 to 2200A; SCRs and TRIACs; thyristors; the list goes on.

For your copy of the ECG catalog or more information on ECG semiconductor products contact: J. Lovat, ECG Can., 1928 St. Regis Blvd., Dorval Que.bec H9P 1H6 (514) 685-5800 or 685-5804 (FAX).

Circle No. 61 on Reader Service Card

Brother Laser Printer

The Brother HL-8 Laser Printer features the lates laser engine and a standard 1MB buffer memory. The buffer memory expands to 3MB, more memory than is generally available in laser printers. Print speed is eight pages per minute and there is a changeable graphics resolution capability from 75 to 300 DPI.

The HL-8 is capable of emulating the Diablo 630, Twinriter, IBM Proprinter XL, Epson FX 80, and HP LaserJet/LaserJet Plus. Five resident fonts, each available in bold, italic, and bold italic, can be selected in double or quadruple size. Additional typestyles can be selected via optional font cartridges.

For more information contact: Mrs. A. Goldman, National Advertising Mgr., Brother International Corp., 1515 Pitfield Blvd., Montreal, Quebec H4S 1G5. (514) 334-5590.

Circle No. 62 on Reader Service Card

INSTRUMENT RENTALS
CANADA

IRC Equipment Leasing Inc.
6815 Rexwood Rd., Unit 6.
Mississauga, Ontario L4V 1S4

1-800-387-3411
(for Ontario Quebec)

1-800-268-4928
(for the rest of Canada)

equipment clearance

Winter 1987 - 1988

Dear Customer,

This is our latest list of discounted new and premium pre-owned test equipment for sale. As in our other Equipment Clearance Catalogs we're selling equipment fast and we're offering great deals to those of you who are ready to buy, now.

This equipment has warranties extending from 30 to 90 days. If you are looking for financing, we may be able to help with that, too. Best of all, we'll get it to you within one or two days of your order.

Remember, equipment is selling fast and it's first come, first serve. The sooner you call us, the better chance you'll have to get what you want.

Call the sales specialist at your local Instrument Rentals office for more details about our clearance. It's the best bargain in test.

Headquarters Office
Inventory Center
6815 Rexwood Road
Mississauga, Ontario
Tel: (416) 678-7831 Fax: 416-678-6288

Sales
4026 Steinberg
Vill St-Laurent, Quebec
H4R 267 Tel: (514) 336-1625

Sales
948 Wellington St.,
Ottawa K1Y 2X8
Tel: 613-722-4956

Who is DataPlus?

DataPlus is part of US Leasing's worldwide organization which includes Hertz Car Leasing and Instrument Rentals Canada. The latter has been established in Canada for over 10 years and is a major supplier of rental and leasing packages for electronic test and measurement equipment.

What is our Strategy?

We select the most popular Personal Computers and Peripherals for our inventory. We offer these products for rent at very attractive rates with buy-out options whereby up to 50% of the previously paid rent is credited against the purchase price. We also lease the same equipment for up to 3 years with a preset buy-out option. Finally, we provide installation and on-site service in the Greater Toronto area plus Canada wide hotline telephone support.

What does this mean to you?

You will be able to acquire equipment in a trouble free way. Any one or all of the reasons given on the next page may be applicable to you but more important than that you will not get stuck with equipment that is used only sparingly or is obsolete or does not meet your expectations. Our basic installation policy helps you on your way fast and if required we can provide additional hands-on training as part of our installation.

DATA PLUS

Unbelievable but true!

Imagine a system for only $88 per month! Yes, that's all it costs to lease a usable system. It is a 30 Megabyte XT compatible PC complete with graphics display, 360K floppy, 640K of memory plus ports to hookup peripherals such as printers and modems. Also included is the latest version of MS-DOS and that's not all...

Depot service is part of the deal!

Add a 24-pin NEC Printer P2200 for just $29. Now you're off and running for the next 3 years without a worry about repairs or absolescence. No worry about repairs because service is included. No worry about absolescence because you have the option to upgrade at anytime during the term of the lease.

Don't forget, your lease payments are fully deductible due to our "Operating Lease" with its optional buy-out of $267 for the system and $88 for the printer. This lease reduces the monthly rates and allows you to make the "BUY" decision at the end of the term.

In the Greater Toronto Area, we recommend that you take advantage of our installation option. For $95 plus $25 for the printer we:

Deliver the systems	No	courier charges
Unpack the system	No	empty boxes to store
Set-up the system	No	worry about what to connect where
Check performance	No	guessing if all is O.K.
De-install	No	worry about lost accessories
Re-pack	No	time wasted
Return the system	No	courier charges

This is just one example of one of our products. We can provide you with practically any piece of hardware at financing terms to suit your needs. You can choose from month-to-month rentals for temporary requirements to 1-2 and 3-year leases with attractive buy-outs.

Just call Kevin Cooper, Harold Lucas or Michael Robinson, they'll be glad to give you all the specifics and take your orders.

WE ACCEPT AMERICAN EXPRESS

Toronto: 678-7831
Ontario and Quebec: 1 (800) 387-3411
Rest of Canada: 1 (800) 268-4928

MODEL #	PRODUCT DESCRIPTION	LIST PRICE	SALE PRICE	QTY IN STOCK
ANDERSON-JACOBSEN				
AJ/1212-AD2	MODEM	1,040	124	2
AJ/1233	TRIPLE COUPLER	1,147	137	9
AJ/1234	COUPLER	1,121	134	1
AJ/1255RTA	MODEM/DATAPHONE	1,175	141	1
ANRITSU				
ANR/MA911A	OPTICAL PWR SENSOR	688	403	1
APPLIED MICROSYSTEMS				
AMC/EM-189	EMULATOR	4,805	2,645	1
BEEHIVE				
BEE/ATL-004	TERMINAL	1,532	183	5
BEE/ATL-008	CRT TERMINAL	2,302	276	1
BEE/CC76	CONTROLLER	4,897	587	1
BEE/DM3270	CRT TERMINAL	3,072	368	1
BERKELEY INST				
BER/3021	LINE NOISE GENERATOR	4,920	598	1
BRUEL AND KJAER				
B&K/2635	CHARGE AMP	3,051	1,386	1
BRUSH/GOULD				
BRU/13-4615-10	GP DC AMPLIFIER	1,209	690	3
BRU/13-4618-20	FREQ.-VOLT CONV	1,579	799	1
CYBERNEX (AS IS)				
CYB/APL-100	CRT TERMINAL	2,841	340	1
CYB/MDL-110	TERMINAL	1,968	236	1
DATA I/O				
DIO/351A-071	40 PINOUT CARTRIDGE	668	176	1
DATA SOUTH (AS IS)				
DS/180	RO PRINTER	2,148	257	1
DIABLO				
DAB/301180-11	FORMS TRACTOR	424	50	1
DAB/320781-01	INTERFACE CABLE	108	12	2
DAB/320837-01	CABLE	51	6	1
DAB/320839-01	CABLE	108	17	2
DAB/630API	PRINTER	2,995	359	4

** INSTRUMENT RENTALS CANADA **
FALL EXPERIENCED EQUIPMENT SALES LIST

MODEL #	PRODUCT DESCRIPTION	LIST PRICE	SALE PRICE	QTY IN STOCK
DIABLO				
DAB/F32	SHEET FEEDER	2,695	323	2
DIGITAL EQUIPMENT CORP				
DEC/VT102	TERMINAL	2,633	315	1
DEC/VT1XX-AA	CURRENT LOOP OPTION	185	26	1
DEC/VT1XX-AB	ADVANCED VIDEO	416	49	7
DEC/VT1XX-AC	PRINTER PORT OPTION	593	71	4
DEC/VT220-A	TERMINAL	1,687	402	1
DORIC				
DOR/235A/FEM	FEM	1,906	720	2
DRANETZ				
DRA/626	DIST ANAL	12,719	6,899	4
DRA/626PA600R1	PLUG-IN	2,618	1,261	3
ELGAR				
ELG/403SD	PLUG-IN OSCILLATOR	1,415	919	1
ELG/501A	AC POWER SOURCE	4,065	2,412	1
EPSON				
EPS/FX-286E	WIDE PRINTER	1,319	718	1
FLUKE MFG., JOHN				
FLU/2030A	PTI PRINTER	2,195	759	2
FLU/2190A	THERMOMETER	2,288	622	2
FLU/2280A	DATALOGGER	21,138	10,001	4
FLU/2280A/162	T/C DCV SCANNER	963	619	8
FLU/2280A/171	INPUT ASSY	320	176	1
FLU/2280A/176	INPUT ASSY	154	84	1
FLU/2280A/179	DIG CONNECTOR	154	88	1
FLU/2280A/341	RS232 INTERFACE	1,525	901	1
FLU/2300A	TEMP. SCANNER	2,881	1,552	2
FLU/5200A	AC CALIBRATOR	18,172	10,004	1
FLU/7261A	COUNTER/TIMER	3,442	1,724	1
FLU/8922A	TRMS AC VOLTMETER	2,971	1,231	1
FLU/9010A	LOGIC TROUBLESHOOTER	10,665	5,726	3
FLU/9010A/Z80	INTERFACE POD	1,667	862	1
FLU/Y7204	PTI CABLE	99	33	2
GENRAD				
GR/1657-9600	EXTENDER CABLE	300	192	2
GR/1658	RLC DIGIBRIDGE	5,159	2,913	4
GR/1689-9701	RLC DIGIBRIDGE	9,025	5,518	1

** INSTRUMENT RENTALS CANADA **
FALL EXPERIENCED EQUIPMENT SALES LIST

MODEL #	PRODUCT DESCRIPTION	LIST PRICE	SALE PRICE	QTY IN STOCK
GENRAD				
GR/1982-9720	SND ANALYS SYST	6,072	3,687	1
HEWLETT PACKARD				
HP/10269A/070	68000 INTERFACE	2,556	1,243	1
HP/10276A	Q-BUS INTERFACE	785	94	1
HP/10369A	CAMERA ADAPTER	169	20	1
HP/10833B	HP-IB CABLE	139	53	2
HP/13222N	HP CABLE	122	14	23
HP/13296A	HP-IB INTERFACE	1,132	135	3
HP/15508B	CONVERTER	316	177	3
HP/1611A	LOGIC STATE ANALYZER	8,470	1,016	1
HP/17255	CABLE	69	10	1
HP/18137A	INTERFACE	1,463	917	1
HP/18180A	INTERFACE POD	1,232	438	1
HP/182T	SCOPE MAINFRAME	7,106	2,288	1
HP/2624B/050	TERMINAL	6,537	784	1
HP/2631B	RO PRINTER	4,706	564	1
HP/3325A	SYNTHESIZER	9,239	4,173	1
HP/3497A	CONTROL UNIT	7,161	3,749	3
HP/3497A/020	ASSEMBLY	1,155	608	3
HP/3575A	NETWORK ANALYZER	8,362	4,271	1
HP/3781B	PATTERN GENERATOR	12,210	4,535	2
HP/3782B	ERROR DETECTOR	10,723	5,796	2
HP/4328A	MILLIOHMMETER	2,264	1,301	1
HP/436A	POWER METER	5,236	3,377	1
HP/4925A	BERT TESTER	2,895	1,823	1
HP/4935A	TIMS	5,736	3,763	3
HP/4951B	PROTOCOL ANALYZER	9,150	5,750	1
HP/6206B	POWER SUPPLY	1,050	383	1
HP/6236B	POWER SUPPLY	1,095	459	1
HP/64100A	MDS STATION	25,349	10,411	1
HP/7475A	PLOTTER	3,250	2,083	2
HP/8018A	DATA GENERATOR	9,256	4,797	1
HP/8481A	POWER SENSOR	1,235	497	1
HP/8482B	POWER SENSOR	2,082	1,209	1
HP/8483A	POWER SENSOR	893	524	2
HP/8565A	ANALYZER	44,006	24,054	1
HP/85F	COMPUTER	5,500	660	1
HP/8614A	GENERATOR	11,704	2,215	1
HP/98432A	I/O ROM	1,345	161	1
HONEYWELL				
HON/1881HGD	AMPLIFIER	1,671	200	3

CALL NOW, ALL ASSETS ARE SUBJECT TO PRIOR SALE OR RENTAL!
DEC 4/87 PRICES SUBJECT TO CHANGE WITHOUT NOTICE PAGE - 3

** INSTRUMENT RENTALS CANADA **
FALL EXPERIENCED EQUIPMENT SALES LIST

MODEL #	PRODUCT DESCRIPTION	LIST PRICE	SALE PRICE	QTY IN STOCK
I.B.M.				
IBM/HIRES MONI	EHNCD W EGA CRD	2,189	1,437	2
IBM/XT	MICROCOMPUTER	4,667	2,526	3
KAYE INSTRUMENTS				
KAY/DR3-1A	DIGISTRIP III	10,241	3,783	1
LEAR-SIEGLER (AS IS)				
LSI/ADM-31	CRT TERMINAL	2,387	286	1
LSI/ADM-31-1	CRT TERMINAL	3,850	462	1
MICROTEK (AS IS)				
MIC/MICE8086-8	MICE 8086-88 POD	5,999	719	2
MIC/PWR SPLY	MICE POWER SUPPLY	395	114	2
NEC - NIPPON ELECTRIC				
NC/3550	PRINTER	2,218	266	7
NC/35XX-7	CUT SHEET FEEDER	1,532	266	2
NC/35XX-8	PRINTER ACC.	347	60	1
NC/35XX-9	PAPER GUIDE	139	44	3
NC/7710	PRINTER	3,773	511	1
NC/77XX-6	TRACTOR	539	158	1
NEC/APC H501S		5,945	3,449	2
OKIDATA				
OKI/92P	PRINTER	750	178	1
PHOTODYNE				
PHO/1950XR	FIBRE OPTIC ATTENUAT	6,040	3,194	2
QUADRAM				
QAD/QB5356	MEMORY BOARD	560	200	6
QAD/QUADMEG-AT	QUADRAM AM0128	895	298	3
RAYTEK				
RAY/R2-LT	THERMOMETER	3,250	2,070	1
RIXON				
RIX/905-6611-0	PERSMISSIVE CBL	108	15	2
RIX/905-6675-0	CABLE	125	38	1
RIX/LDM710-L1/	MODEM LMTD DIST	460	55	9
RIX/PC212A	MODEM	768	150	4
RIX/R212 EXEC	SMART MODEM	750	259	7
RIX/T202T	MODEM	768	92	2

CALL NOW, ALL ASSETS ARE SUBJECT TO PRIOR SALE OR RENTAL!

MODEL #	PRODUCT DESCRIPTION	LIST PRICE	SALE PRICE	QTY IN STOCK
RIXON				
RIX/T209A	MODEM	6,152	738	2
RIX/TA201C	MODEM	1,538	184	3
RIX/TA208A/B	MODEM	2,918	947	2
SORENSON				
SOR/DCR40-40B	POWER SUPPLY	2,464	1,430	1
STAG MICRO SYSTEMS				
STG/ZL30	PROM PROGRAMMER	6,700	2,702	1
TAU-TRON				
TAU/S5104	DS1 TESTER	18,110	11,500	2
TEK-TRAN				
TKN/951	MINI-FLOPPY STO	2,302	276	1
TEKTRONIX				
TEK/016-0249-0	ADAPTER	100	12	1
TEK/016-0359-0	ADAPTER	31	16	2
TEK/1240	LOGIC ANALYZER	9,856	5,807	1
TEK/1240D1	DATA I/P CARD	4,543	2,689	2
TEK/1240D2	DATA I/P CARD	5,698	3,557	3
TEK/1470	GENERATOR	6,550	3,308	1
TEK/2215	OSCILLOSCOPE	2,233	1,023	1
TEK/475A	SCOPE	7,130	4,024	1
TEK/7623A	MAINFRAME SCOPE	10,318	6,008	1
TEK/9129	DAS MAINFRAME	20,020	12,191	1
TEK/91A08	DATA MODULE	6,137	3,482	3
TEK/91A32	DATA MODULE	7,685	3,973	1
TEK/91P16	P.G. MODULE	6,145	2,938	1
TEK/C5C	CAMERA	808	438	2
TEK/J16	PHOTOMETER	2,104	977	2
TEK/J6505	PROBE	901	591	1
TEK/J6523	PROBE	2,625	1,592	1
TEK/P6201	PROBE	1,863	861	5
TEK/P6302	CURRENT PROBE	862	347	1
TEK/PG502	GENERATOR	4,235	2,730	1
TEK/TM501	MAINFRAME	539	308	1
TEK/TM504	MAINFRAME	1,250	459	1
TELECOMMUNICATIONS TECH				
TTC/2000	DATA ANALYZER	12,730	8,328	1
TELEVIDEO (AS IS)				
TVI/914	CRT TERMINAL	1,076	129	1

** INSTRUMENT RENTALS CANADA **
FALL EXPERIENCED EQUIPMENT SALES LIST

MODEL #	PRODUCT DESCRIPTION	LIST PRICE	SALE PRICE	QTY IN STOCK
TELEVIDEO (AS IS)				
TVI/924	CRT TERMINAL	1,384	166	10
TVI/970	CRT TERMINAL	2,302	276	3
TVI/PT-300/120	TERMINAL	1,614	193	1
TVI/TP750	PRINTER	1,840	229	1
TVI/TPC2	MICROCOMPUTER	3,688	442	1
TVI/TS1605	"PC" COMPATIBLE	2,590	310	1
TVI/TS1605H	"XT" COMPATIBLE	3,250	690	1
TEXAS INSTRUMENTS				
TI/743-2	KSR TERMINAL	1,802	216	1
TI/745	KSR TERMINAL	3,727	447	2
TOPAZ				
TOP/500GZ	INVERTER	2,988	1,149	1
VENTEL				
VEN/MD212-3	MODEM	906	108	3
WANG LABS (AS IS)				
WANG/WOA-20/55	OFFICE ASST. MICRO	7,846	1,149	1
WESTERN GRAPHTEC				
WAT/AL3101	DC AMPLIFIER	385	204	12
WAT/KD3101	AC/DC SIGNAL COND.	1,310	646	4
WAT/WTA8101-J	THERMOCOUPLE PREAMP	250	74	3
WAT/WTA8101-K	THERMOCOUPLE PREAMP	250	74	6
Z - ODDS AND ENDS				
EIA/RS232-10MF	CABLE, 10', MF	62	28	16
EIA/RS232-10MM	CABLE, 10', MM	65	28	20
EIA/RS232-25	CABLE, 25', MM	75	49	7

** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
ACUREX		
ACU/1040-10	1,662	405
ACU/1060-31	481	94
ACU/1061-33	280	109
ADVANCED DIG PRECISION		
ADP/610	3,491	2,359
ADP/620;A	11,366	7,679
ADP/620;B	11,366	8,439
ADP/681	4,191	2,969
ADP/D-6000;B	16,948	11,923
ADP/D-6000;C	16,948	12,257
ADP/D-6000;D	16,686	10,262
AILTECH		
AIL/13505	2,625	1,032
AIL/13611	10,412	1,487
AIL/13635	2,546	470
AIL/185	10,281	5,422
AIL/187	11,077	6,895
AIL/445	11,401	3,515
AIL/7615	2,091	840
AIL/7617	4,243	606
AIL/7618	2,493	983
AMERITEC		
AM/1-111;D	17,692	10,868
AM/1E-11	14,507	9,099
ANRITSU		
ANR/ME-538C;A	41,982	21,264
ANR/ME-538C;B	44,327	25,457
APPLIED MICROSYSTEMS		
AMC/EM-149	8,741	3,225
AMC/EM-180B	4,103	2,400
AMC/EM-180B;A	4,103	2,385
AMC/EM-180B;C	6,938	3,786
AMC/EM-180B;D	4,322	3,012
AMC/EM-186	5,836	2,098
AMC/EM-186;A	6,711	3,865
AMC/EM-188;A	6,938	3,444
AMC/EM-188;B	6,063	2,331

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
APPLIED MICROSYSTEMS		
AMC/EM-189	5,845	2,203
AMC/EM-800	6,991	4,696
AMC/EMPAK	875	514
AMC/EP-6800	2,887	1,054
AMC/EP-6802	2,887	855
AMC/EP-6809	2,887	817
AMC/EP-6809E	2,887	1,092
AMC/EP-8085	2,887	850
AMC/EP-N68000P	5,591	2,267
AMC/ES-1800;A	17,386	8,465
AMC/ES-1800;E	19,486	10,731
AMC/ES-1800;F	17,211	6,232
AMC/ES-68000B	4,768	1,541
AMC/ES-68000P	2,931	1,091
AMC/ES-68020P	7,341	4,567
AMC/ES-8001P	7,341	3,836
AMC/ES-Z8001B	6,212	1,200
AMC/ES-Z8001P	3,841	847
AMC/RC-149 A1	875	125
BELL, F.W.		
BEL/620	2,791	1,669
BEL/640	3,718	531
BEL/HAB4-2508	428	195
BEL/HTB4-0608	358	162
BERKELEY INST		
BER/3021	5,591	3,808
BIDDLE		
BID/21159	945	610
BIOMATION/GOULD		
BIO/10X	577	82
BIO/4500	34,737	22,498
BIO/K100D	23,100	3,300
BIO/K101D	34,562	20,695
BIO/K101D/8086	3,403	2,226
BIO/K101D;A	38,850	26,343
BIO/K102D	27,562	10,448
BIO/K105-D	31,298	15,206
BIO/K105-D;A	24,307	13,599
BIO/K105-D;B	29,548	13,038

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
BIOMATION/GOULD		
BIO/K105-D;C	38,290	18,453
BIO/RTE-68000	1,225	900
BLH ELECTRONICS		
BLH/1200	1,841	263
BOONTON		
BON/42BD;B	5,460	3,410
BON/42BD;C	6,623	3,882
BRADLEY		
BRA/2A/2B	11,200	5,764
BRUEL AND KJAER		
B&K/1545	7,948	1,135
B&K/1613	2,292	987
B&K/1616	6,601	4,007
B&K/1623	13,331	7,100
B&K/2033A	20,440	12,859
B&K/2209	6,105	872
B&K/2218	7,071	2,785
B&K/2221	4,515	2,341
B&K/2306	6,753	3,817
B&K/2312	9,772	2,825
B&K/2503	15,552	8,544
B&K/2619	1,328	676
B&K/2644	521	356
B&K/2808	777	356
B&K/2976	5,558	2,653
B&K/4133	1,373	196
B&K/4230	707	305
B&K/4339	570	81
B&K/4366	1,044	446
B&K/4426	12,390	7,784
B&K/4431	1,939	1,151
B&K/4431;A	2,399	1,038
B&K/8202	3,522	2,367
B&K/A00027	661	340
B&K/A00028	843	120
B&K/A00029	1,120	675
B&K/A00089	215	104
B&K/A00122	259	176
B&K/A00128	556	98

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
BRUEL AND KJAER		
B&K/A00194	586	384
B&K/JP0144	110	75
B&K/UA0026	129	75
B&K/ZE0299	2,079	971
B&K/ZE0300	539	318
B&K/ZM0045	437	90
B&K/ZM0046	560	147
BRUSH/GOULD		
BRU/11-4123-01	875	125
BRU/13-4615-10	1,373	896
BRU/13-4615-42	1,837	720
BRU/13-4615-47	1,802	1,222
BRU/13-4618-20	1,793	779
BRU/220	6,282	4,521
BRU/2200S	8,715	6,382
BRU/2400S;I	15,872	11,266
BRU/2800	26,495	6,424
BRU/2800S	27,431	16,982
BRU/8188-4	9,047	6,548
CLARKE-HESS		
CHS/255	2,476	1,711
CUSHMAN		
CUS/CE-50A-1	18,375	9,718
DATA I/O		
DIO/121A	18,375	3,669
DIO/121A;D	18,375	5,601
DIO/121A;E	18,375	3,303
DIO/121A;H	18,375	5,080
DIO/121A;I	18,375	5,582
DIO/121A;L	18,375	5,543
DIO/121A;Q	18,375	7,232
DIO/121A;R	18,375	5,499
DIO/121A;T	18,375	6,052
DIO/121A;U	18,375	6,118
DIO/1310A	3,491	1,054
DIO/1320A	4,707	2,228
DIO/175	5,775	3,253
DIO/22A;F	8,653	3,735
DIO/22A;G	8,653	3,952

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
DATA I/O		
DIO/22A;I	8,653	4,345
DIO/22B	5,328	2,150
DIO/22B;C	5,328	3,704
DIO/22B;D	5,328	2,802
DIO/22B;E	5,328	2,085
DIO/22B;F	5,328	2,813
DIO/29A;B	7,218	1,653
DIO/29A;C	8,268	3,585
DIO/29A;F	8,268	3,161
DIO/29A;G	8,268	3,060
DIO/29A;H	7,218	1,866
DIO/29B;D	7,315	4,541
DIO/303A-002;A	691	336
DIO/303A-002;B	691	375
DIO/303A-002;D	691	364
DIO/303A-002;E	691	179
DIO/303A-002;F	691	368
DIO/303A-004;A	691	406
DIO/303A-004;B	691	292
DIO/303A-006	691	237
DIO/303A-006;B	691	461
DIO/303A-006;C	691	402
DIO/303A-009	691	417
DIO/303A-101	691	294
DIO/303A-101;A	691	328
DIO/308A	3,937	678
DIO/308A;A	3,937	563
DIO/308A;C	3,937	815
DIO/714-1862-001	166	60
DIO/715-1946-001	691	132
DIO/715-1951-001	691	141
DIO/715-1951-002	691	116
DIO/950-0109-004	1,216	721
DIO/GANGPAK	4,812	1,220
DIO/GANGPAK;A	4,812	1,880
DIO/GANGPAK;C	4,812	2,427
DIO/MOSPAK;A	2,187	968
DIO/MOSPAK;B	2,187	312
DIO/MOSPAK;C	2,187	564
DIO/UNIPAK	4,375	625
DIO/UNIPAK II	4,506	981
DIO/UNIPAK II;A	4,506	1,923
DATA MANAGEMENT LABS		
DML/1010	12,775	4,879

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
DATUM		
DAT/5300	10,491	6,756
DAT/9300	4,637	662
DIEGO SYSTEMS		
DIE/101	1,303	191
DIE/106	630	138
DIE/113	516	97
DIGILOG		
DGL/600	24,753	14,255
DGL/600;A	24,928	18,505
DGL/DLM3;A	5,556	3,688
DGL/DLM4	5,766	3,546
DIGITAL EQUIPMENT CORP		
DEC/VT101 GP	2,362	1,141
DIGITECH		
DIG/100;A	43,793	7,646
DIG/200	28,875	17,083
DIG/200;A	31,500	17,447
DIG/2302-04	3,666	523
DOLCH		
DLI/3250A	7,612	4,321
DLI/64300-IV	26,127	17,507
DLI/64300S-IV	31,762	19,537
DLI/ALP 3250-88	3,675	1,870
DLI/ALP 4850-44	5,775	1,389
DLI/PDD-6502	1,741	881
DLI/PPD-IEEE43	1,741	1,115
DLI/PPDZ80A	2,091	1,149
DLI/TMD68000A	6,125	3,582
DLI/TMD8086/88A	6,125	3,568
DORIC		
DOR/205B2/FEM	1,120	750
DOR/235A	8,408	3,816
DOR/235A/DIG	2,100	831
DOR/235A/FEM	1,741	841
DOR/235A/FEM3	1,741	910
DOR/235A;B	12,416	4,938

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
DRANETZ		
DRA/305-PA-3007	3,412	2,045
DRA/626;A	10,885	8,017
DYNATECH		
DYN/1500	9,100	4,022
DYN/1500:A	13,755	3,628
DYN/1600	14,000	8,136
DYN/2000	23,905	3,415
DYN/2000B	24,150	8,538
EATON/SINGER		
ETN/90799-2	411	232
ETN/90995-2	463	146
ETN/91891-2	1,111	682
ETN/91932-2	455	315
ETN/92199-3	472	218
ETN/93490-1	2,406	880
ETN/94455-1	2,406	675
ETN/94592-1	2,668	942
ETN/94593-1	2,852	789
ETN/94607-1	2,117	1,350
ETN/94609-1	113	60
ETN/94612-1	2,782	1,691
ETN/DM105 KIT	9,625	5,772
ETN/NM-17/27	46,873	31,629
ETN/NM-37/57	50,583	30,313
EIP		
EIP/548;C	13,125	9,733
EIP/591	1,662	600
ELECTRO MAGNETIC DIV		
EMD/ACC-25B	245	172
ELECTRONIC NAVIGATION		
ENI/3100L	11,375	6,330
ENI/3200L	15,400	9,791
ENI/503L	2,362	1,602
ENI/A300	12,600	7,507
ELGAR		
ELG/1001B	7,043	3,938

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
ELGAR		
ELG/1001B;A	7,183	5,237
ELG/1751	8,811	4,018
ELG/1751;A	8,951	5,327
ELG/3226B	10,018	6,508
ELG/4 UNIT CABLE	218	99
ELG/443-.1T	735	373
ELG/461-.1T	463	231
ELG/TG704A-3D	8,793	5,185
EMI TECHNOLOGY		
EMI/7000D	12,311	7,948
EMI/7000DIRREC	393	215
EMI/7000DIRREP	778	570
EMI/FMREC28	463	258
EMI/FMREPRO28	962	612
EMI/TAPESERV28	813	572
EMULOGIC		
EMU/3252	42,875	29,647
EMU/ECL-3211	39,025	25,490
EMU/ESP-68000	7,875	4,972
EMU/ESP-8086	8,662	6,200
EMU/ESP-NSC800	4,812	3,172
EMU/ESP-Z80	4,812	3,102
EMU/HSM-55	4,375	2,931
EMU/MSC-RX02	7,875	4,970
EPICOM		
EPI/200	11,541	1,648
EPI/320	7,262	1,037
EPI/400	9,625	1,375
EPSON		
EPS/FX-100+	1,223	383
EPS/FX-185	1,223	491
ESTERLINE-ANGUS		
EA/804B909	210	78
EA/804D918	1,662	1,180
EA/A620T	3,225	1,486
EA/MRL-25000/8	1,216	781
EA/S21019-1	3,456	493
EA/S22616	2,695	405

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
ESTERLINE-ANGUS		
EA/S22904	7,910	4,577
EA/S22904;A	8,216	5,219
EA/S22906	6,991	3,783
EA/S22906;A	7,315	4,585
FLUKE MFG., JOHN		
FLU/1720A	20,737	3,629
FLU/1722A	11,200	6,417
FLU/1722A/002	1,732	650
FLU/1722A/004	5,687	2,962
FLU/1722A/005	9,537	6,507
FLU/1722A/008	1,277	477
FLU/1722A/009	1,732	793
FLU/1722A;A	11,200	7,039
FLU/1900A;A	875	539
FLU/1912A;A	1,750	777
FLU/1953A	5,608	4,061
FLU/1953A;A	6,107	1,953
FLU/2030A	2,476	1,065
FLU/2180A	2,362	1,580
FLU/2205A	4,760	2,472
FLU/2205A/300	630	401
FLU/2205A/600	892	408
FLU/2240A-05	472	339
FLU/2240A-06	621	158
FLU/2280A/168	1,225	906
FLU/2280A/169	175	124
FLU/2280A/179	175	123
FLU/2280A/341	1,732	1,087
FLU/2280A/342	1,732	1,203
FLU/2280A;B	18,613	8,489
FLU/2280A;H	24,020	11,274
FLU/2281A	1,400	879
FLU/2281A;A	2,800	2,031
FLU/335D	17,762	10,671
FLU/5101B;A	29,767	14,287
FLU/515A	7,262	4,432
FLU/5440A	22,662	15,180
FLU/6011A	10,412	6,559
FLU/6071A;A	35,297	22,928
FLU/8012A	628	461
FLU/8012A;A	698	295
FLU/8030A;A	768	506

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
FLUKE MFG., JOHN		
FLU/8050A;A	768	299
FLU/8400A	6,335	3,317
FLU/8520A	5,617	3,856
FLU/8600A;A	1,496	992
FLU/8810A	2,518	1,600
FLU/8922A	3,596	1,494
FLU/9010A	9,686	5,700
FLU/9010A/6802	1,907	1,197
FLU/9010A/6802;A	2,248	1,404
FLU/9010A/8085	1,907	442
FLU/9010A/8086	4,366	2,618
FLU/9010A/9900	3,491	2,469
FLU/9010A/Z80AA	2,266	1,592
FLU/Y7204	113	57
FLU/Y8023	183	132
FUTURENET		
FUN/D-CV	2,100	998
FUN/D-PLOT/HP	1,575	412
FUN/D-PLOT/HP;A	1,575	451
FUN/D-PLOT/HP;B	1,575	1,016
FUN/D-PLOT;A	1,575	498
FUN/D-SCICARD	2,100	1,056
FUN/DASH-2/AT;B	11,865	5,969
FUN/DASH-3/AT;A	11,865	6,691
FUN/DASH-ABEL	1,400	744
FUN/DASH-ABEL;A	1,400	862
FUN/FLO PLAN	175	66
FUN/MAT PROG.;B	350	95
GENRAD		
GR/1382	3,983	2,725
GR/1433H	3,577	2,396
GR/1557A	2,075	296
GR/1565D	1,330	978
GR/1658-4020	1,137	782
GR/1666	7,624	4,743
GR/1982-9720	7,218	3,485
HALCYON		
HAL/520B3	17,491	12,908
HAL/520B;A	19,241	9,375
HAL/801A	6,991	5,147

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEKIMIAN LABS		
HLI/3701	13,317	9,863
HLI/3701;B	24,010	16,969
HLI/3901	12,600	7,762
HLI/3901;A	13,037	9,447
HLI/3912	2,975	2,163
HLI/3913	3,237	2,356
HLI/3914	3,088	2,255
HLI/3915-12	1,137	482
HLI/3916	1,925	1,353
HLI/3918	1,662	1,123
HLI/3923	1,951	458
HLI/3925-232	4,812	3,522
HLI/3925-488	4,812	3,514
HLI/3934	5,250	2,653
HLI/3980	4,200	3,061
HEWLETT PACKARD		
HP/00085-15001	348	116
HP/00085-15002	348	158
HP/00085-15005	348	111
HP/00085-15007	525	263
HP/00085-15013	525	312
HP/0980-74010	875	125
HP/10233A	341	181
HP/10235A	4,200	1,035
HP/10269A/053	2,747	1,985
HP/10269A/070	2,905	1,800
HP/10269A/071	2,555	1,861
HP/10269A/081	2,310	1,710
HP/10269A/083	2,135	1,530
HP/10302B	1,715	1,267
HP/10309C	1,925	275
HP/10312B	3,570	2,534
HP/10326A	3,981	2,349
HP/10352B	612	87
HP/10367A	192	106
HP/10375A	376	131
HP/10376A	612	87
HP/10525T	227	110
HP/10920A	3,850	550
HP/11604A	4,742	677
HP/11610B	1,146	335

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/11652A	1,137	505
HP/11658A	271	185
HP/11664B	1,190	882
HP/11665B	1,575	811
HP/11666A	6,055	4,285
HP/11667A	1,627	1,197
HP/11675B	1,575	225
HP/11679B	621	445
HP/11687A	367	52
HP/11716B	507	370
HP/11720A	5,862	4,071
HP/11852A	358	225
HP/11854A	612	436
HP/11857A	1,758	855
HP/11869A	875	556
HP/141T	8,478	4,845
HP/15507A	411	216
HP/15508B	358	245
HP/15509A	542	218
HP/16022A	1,872	898
HP/16034B	638	429
HP/16061A	392	227
HP/16062A	213	124
HP/16093B	409	229
HP/1610B	23,625	3,375
HP/1611A	9,625	3,893
HP/1611A/080	2,975	794
HP/1611A/A65	3,325	475
HP/1611A/A68	2,975	425
HP/1611A/OF8	3,325	696
HP/1611A/Z80	2,975	1,931
HP/1611A;B	27,825	6,066
HP/1630D;A	21,612	11,938
HP/1640B;B	14,385	10,244
HP/16470A	4,812	2,375
HP/17090A	1,225	790
HP/17255B	87	58
HP/1725A;A	10,071	4,896
HP/17400A	2,450	350
HP/17401A	875	617
HP/17401A;A	1,225	719
HP/17500A	1,050	150
HP/17501A	1,312	187

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** INSTRUMENT RENTALS CANADA **
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MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/17603A	1,312	196
HP/17655A	87	54
HP/18140A	883	417
HP/18174A	875	572
HP/182T	7,052	3,170
HP/1950A	5,775	3,084
HP/197B	2,616	1,621
HP/1980B;D	28,973	14,071
HP/201C	2,187	1,326
HP/204D	1,601	1,113
HP/204D;A	1,776	1,250
HP/209A	1,662	237
HP/2631B GP	2,668	1,678
HP/2671G	3,045	922
HP/2671G;A	3,045	797
HP/2673A	3,920	1,521
HP/27128A	1,627	966
HP/27130A	3,675	2,729
HP/2934A;A	5,503	2,839
HP/3310A	2,100	1,341
HP/3310B	2,275	1,283
HP/3335A	19,775	10,005
HP/3336A	9,100	4,934
HP/3336B	9,100	6,339
HP/3336B;A	11,427	6,457
HP/3400A	3,132	1,617
HP/3403C	7,000	4,790
HP/3403C;A	7,358	3,467
HP/3421A/020	673	467
HP/3421A/040	166	73
HP/3421A/050	673	358
HP/3421A/561	962	622
HP/3437A	5,897	4,163
HP/3456A	7,315	4,888
HP/3456A;A	7,402	4,656
HP/3465A	1,050	150
HP/3466A	2,135	940
HP/3467A	5,250	2,049
HP/346B;A	2,537	1,522
HP/3488A/012	1,076	635
HP/3488A/013	892	620
HP/3488A/014	717	493
HP/3495A/003	1,837	280

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** INSTRUMENT RENTALS CANADA **
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MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/3495A/004	1,575	600
HP/3497A/020;A	1,338	978
HP/3497A/030	1,338	896
HP/3497A/050	980	318
HP/3497A/120	1,785	1,272
HP/3551A	6,256	3,031
HP/355C	761	518
HP/3580A;A	15,155	7,464
HP/3581A	10,675	4,841
HP/3581C	12,075	8,046
HP/3717A;A	26,512	11,896
HP/3717A;B	26,512	11,776
HP/3717A;C	26,845	13,571
HP/37267A	743	272
HP/37267A;A	743	272
HP/37267A;B	743	266
HP/37269A	595	220
HP/3726A	4,672	1,733
HP/3730B;A	10,850	7,218
HP/3736B	10,675	7,072
HP/3737B	12,775	8,626
HP/3739B	21,700	13,939
HP/3746A;A	27,711	16,438
HP/3750A	1,295	735
HP/3762A	15,925	9,829
HP/3763A	14,262	9,090
HP/3771B	13,501	7,805
HP/3776B	25,287	15,843
HP/3776B;A	25,383	16,758
HP/3777A;A	8,277	3,019
HP/3780A	14,761	9,547
HP/3780A;B	14,752	9,284
HP/3781B	16,065	9,233
HP/3782B	14;175	8,364
HP/3964A/001	1,165	166
HP/3964A/002	1,058	462
HP/3964A;A	19,565	3,502
HP/3968A;A	22,505	10,998
HP/400EL	1,750	1,006
HP/435B;B	2,590	1,698
HP/436A	5,075	3,700
HP/436A;C	6,002	3,788
HP/4800A	8,785	6,077

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/4918A	3,795	2,550
HP/493A	13,693	8,535
HP/4940A	32,480	9,502
HP/4940A;A	34,947	17,647
HP/4940A;B	35,831	19,375
HP/4944A	17,412	2,487
HP/4945A	28,402	19,052
HP/4945A;B	29,277	19,465
HP/4955A;A	37,275	22,920
HP/4955A;B	35,262	21,650
HP/4955A;C	36,225	26,745
HP/4955A;E	35,262	21,552
HP/5150A	4,200	2,032
HP/5150A/002	262	167
HP/5180A;A	35,612	18,563
HP/5181A	10,675	5,962
HP/5182A	41,825	30,545
HP/5300B	1,750	1,126
HP/5300B;A	2,143	1,329
HP/5305B	2,275	1,371
HP/5314A;A	1,487	1,022
HP/5315A;A	2,712	1,993
HP/5335A	6,825	3,793
HP/5342A	12,075	7,828
HP/5342A;A	17,325	10,961
HP/5359A	18,375	9,540
HP/5363B	7,350	5,068
HP/5370A	15,750	3,264
HP/5384A	2,782	1,899
HP/5385A;A	3,850	2,829
HP/5423A;A	78,513	54,321
HP/59303A	4,200	1,503
HP/59313A	4,025	1,659
HP/59401A	7,140	2,804
HP/59501B	1,356	766
HP/6034A	5,250	3,651
HP/6034A;A	5,250	3,771
HP/6111A	2,537	1,250
HP/6112A	2,537	1,054
HP/6115A	2,887	1,900
HP/618C	18,462	7,872
HP/6200B	1,429	856
HP/6260B	3,683	1,661

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** INSTRUMENT RENTALS CANADA **
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MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/6264B	2,625	1,930
HP/6266B	2,450	1,504
HP/6289A	1,338	915
HP/64001S/009	17,675	8,761
HP/64001S/012	25,900	11,237
HP/64100A	23,703	9,999
HP/64100A;A	19,862	2,837
HP/64100AF;A	1,251	620
HP/64100AF;F	1,251	816
HP/64100AF;G	1,251	427
HP/64100AF;H	1,251	588
HP/64100AF;J	1,251	831
HP/64100AF;M	1,251	209
HP/64110A	19,862	8,611
HP/64110A;A	20,219	11,971
HP/64110A;B	21,113	9,827
HP/64110A;C	21,470	11,495
HP/64151A	1,785	1,278
HP/64151S;A	11,331	1,618
HP/64152S	4,462	1,885
HP/64155S	7,875	1,125
HP/64156S	5,180	2,458
HP/64156S;A	6,431	2,860
HP/64192S	8,382	4,049
HP/64202S	6,781	3,575
HP/64212S	6,781	3,793
HP/64213S	6,650	2,865
HP/64213S;A	6,650	2,745
HP/64215S	8,925	2,664
HP/64221S	10,710	7,663
HP/64222S	10,150	5,743
HP/64226S	10,150	2,740
HP/64226S;A	10,150	4,429
HP/64226S;B	10,150	5,134
HP/64232S	10,351	2,847
HP/64233S;A	10,351	6,792
HP/64242S	10,150	2,994
HP/64242S;A	10,150	3,572
HP/64242S;B	10,150	3,193
HP/64249S	10,150	4,217
HP/64249S;A	10,150	5,061
HP/64249S;B	10,150	5,402
HP/64252S;A	6,650	3,318

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MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/64252S;B	6,650	3,985
HP/64252S;C	6,650	3,414
HP/64253S	10,885	7,360
HP/64256S	8,382	2,750
HP/64256S;A	8,382	3,897
HP/64262S	8,382	4,211
HP/64262S;A	8,382	4,132
HP/64262S;B	8,382	4,588
HP/64271A	2,222	1,122
HP/64274S	5,713	3,498
HP/64292S	8,382	2,448
HP/64300A	3,727	1,978
HP/64303A;A	1,785	966
HP/64500S	2,336	1,021
HP/64500S;A	2,336	802
HP/64500S;B	2,336	990
HP/64509A	533	152
HP/64510B	910	506
HP/64515A	525	144
HP/64517A	892	461
HP/6459A	7,000	1,625
HP/64600S	11,865	6,324
HP/64600S;A	20,265	9,099
HP/64600S;B	11,865	2,029
HP/64650A	5,600	2,524
HP/64651B	3,307	1,355
HP/64651B;B	3,482	2,480
HP/64658A	3,570	1,939
HP/64683A	1,531	478
HP/64810AF	3,535	1,978
HP/64811AF	5,355	2,388
HP/64812AF	3,535	2,152
HP/64813AF	5,355	2,236
HP/64813AF;A	5,355	2,641
HP/64814AF	5,355	3,190
HP/64817AF	5,355	2,151
HP/64817AF;A	5,355	3,598
HP/64818AF;A	5,355	3,657
HP/64818AF;B	5,355	3,652
HP/64818AF;C	5,355	3,432
HP/64821AF	5,355	2,883
HP/64851AF	2,143	1,420
HP/654A	3,885	2,671

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/680	4,200	2,635
HP/69330A	586	129
HP/69331B	446	162
HP/69431A	446	246
HP/69435A	350	57
HP/69602A	708	101
HP/7035B	4,375	2,808
HP/7045B	6,125	3,968
HP/7155B;A	6,125	1,353
HP/7245B	11,550	5,032
HP/7402A	7,700	2,867
HP/7470A;B	1,916	1,274
HP/7475A;A	3,316	1,544
HP/7475A;B	3,316	2,373
HP/778D	1,837	1,036
HP/779D	1,715	908
HP/7908P	17,675	7,482
HP/7912P	28,875	13,738
HP/8007B	6,912	4,809
HP/8012B	3,062	1,088
HP/8016A	15,225	11,079
HP/8016A;A	16,625	8,567
HP/8016A;B	16,957	7,306
HP/8111A	5,106	3,176
HP/8120-2208	96	63
HP/8170A;A	13,335	4,423
HP/82901M	3,349	1,451
HP/82903A	393	152
HP/82905A	1,391	425
HP/82906A	1,391	842
HP/82908A	778	319
HP/82938A	516	296
HP/82939A	691	288
HP/83522A;A	14,297	7,286
HP/83525A;C	22,400	13,461
HP/83545A;A	17,115	12,345
HP/83570A;A	20,973	13,485
HP/83572A	26,250	17,384
HP/83572A;A	29,408	21,096
HP/8403A	4,497	2,369
HP/8405A	9,957	5,056
HP/8405A;A	10,001	6,220
HP/8407A	15,802	9,628

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/8411A	10,622	7,594
HP/8412B	7,910	5,350
HP/8414B	6,763	3,769
HP/8418A	3,850	1,441
HP/8445B	12,495	8,145
HP/8447E	2,852	1,315
HP/8472A	428	89
HP/8483A	1,102	687
HP/8485A	1,662	1,155
HP/8491A;A	218	128
HP/8491B;A	245	176
HP/8495B	1,146	763
HP/85020B	1,837	1,308
HP/85031A	2,012	974
HP/85032A	2,625	1,305
HP/8505A;A	73,281	53,282
HP/8552B	9,712	5,355
HP/8553B	9,108	2,001
HP/8554B	16,065	8,025
HP/8554B;A	16,362	7,731
HP/8555A	19,993	14,329
HP/8556A	8,032	4,108
HP/8557A	14,638	8,325
HP/8558B	18,637	9,908
HP/8558B;A	18,812	11,875
HP/8566A	118,737	58,188
HP/8566A;A	119,087	71,006
HP/8568A;A	67,655	43,718
HP/8569A;A	53,375	27,547
HP/8569B	57,120	32,638
HP/8569B;A	59,613	37,494
HP/85860A	647	92
HP/85F;A	6,615	945
HP/85F;B	6,615	945
HP/8600A	5,267	3,065
HP/8601A	9,563	5,800
HP/8614A	15,925	6,579
HP/86240C	13,168	6,554
HP/86245A;A	14,175	8,768
HP/86250D	9,625	6,077
HP/86250D;A	17,806	2,543
HP/86260A	11,375	6,706
HP/8640B;B	22,916	14,070

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FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/8654B	11,576	6,447
HP/8656A	12,582	6,843
HP/8656A;A	14,078	9,586
HP/8656A;B	14,175	10,011
HP/86602B	14,280	7,888
HP/86603A;A	21,262	12,139
HP/8660C;D	35,822	21,765
HP/86631B	1,050	557
HP/86632B	6,072	3,508
HP/86634A	4,200	3,090
HP/8663A;A	85,382	53,540
HP/8663A;C	87,666	64,399
HP/8672A	66,552	48,288
HP/8672A;D	96,398	65,249
HP/8683B	28,000	16,460
HP/8684B	37,065	19,464
HP/8731B	2,590	1,674
HP/8743B	15,085	10,082
HP/8745A	17,990	2,725
HP/8746B	23,415	10,689
HP/8750A;A	5,390	2,978
HP/8755C	5,180	3,153
HP/8755C;A	7,428	1,193
HP/8901A;B	20,457	7,699
HP/8901B	25,865	18,790
HP/908A	175	91
HP/9111A	3,981	1,143
HP/9121D	2,126	845
HP/9133XV	5,853	2,487
HP/9134D	5,320	2,711
HP/9134XV	5,320	2,209
HP/9135A	9,625	2,587
HP/97050A	4,375	2,737
HP/97052B	2,100	1,313
HP/97056A	883	495
HP/97056A;A	883	486
HP/97070A	3,535	2,427
HP/97071A	3,535	1,971
HP/97074A	1,400	773
HP/97076A	883	486
HP/97080B	8,750	2,737
HP/97080B;A	8,750	2,485
HP/97082A	7,875	4,926

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FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
HEWLETT PACKARD		
HP/98217A	906	129
HP/98254A	1,750	250
HP/98256A	1,050	484
HP/98261A	2,476	1,133
HP/98261A/001	2,476	498
HP/98261A/004	2,476	491
HP/98261A/011	2,476	401
HP/98261A/011;A	2,476	617
HP/98261A/014	2,476	831
HP/98261A/715	2,651	1,200
HP/9826S	26,950	8,386
HP/9836A	21,822	4,369
HP/9836CS	30,642	10,723
HP/9836S	27,886	9,548
HP/98432A	1,382	197
HP/98601A/655	2,476	753
HP/98613A	1,505	362
HP/98613A;A	1,505	810
HP/98613A;B	1,505	394
HP/98615A/655	2,651	879
HP/98615C;A	1,741	1,035
HP/98622A	630	195
HP/98622A;B	1,037	638
HP/98624A	586	397
HP/98626A	665	376
HP/98626A;A	796	183
HP/98626A;B	796	195
HP/98627A	1,802	579
HP/98628A	848	463
HP/9872C	10,150	2,705
HP/CONTEXT MBA	1,391	541
HP/J910A	481	166
HP/MODEL 226S	23,975	8,978
HP/MODEL 226S;A	26,950	10,672
HP/MODEL 236CS	30,642	12,805
HP/MODEL 236S	25,235	11,301
HONEYWELL		
HON/101	43,977	23,626
HON/101;A	43,977	19,799
HON/101;B	44,310	25,021
HON/101;C	44,310	25,773
HON/101IBHEAD1/2	5,818	1,832

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MODEL #	LIST PRICE	SALE PRICE
HONEYWELL		
HON/101REMCD	1,627	232
HON/122	1,968	281
HON/122-RACK	1,548	221
HON/1858 RACK	402	276
HON/1858;C	19,880	11,783
HON/1886TCU	1,828	1,038
HON/1887TCD	1,828	1,078
HON/1889FVC	1,977	1,285
HON/218	2,835	1,151
HON/218-RACK	1,496	780
HON/218;A	3,036	433
HON/218;D	3,036	896
HON/LATENSIFIER	761	108
HUGHES		
HUG/1177H02	14,306	6,841
HUG/1177H03	13,440	7,893
HUG/1177H04	15,137	9,033
HUG/1277H01	15,916	10,000
HUG/1277H02	16,695	11,469
HUG/1277H04	18,348	12,975
INTEL		
INT/923C	875	183
INT/D86PLM51NL	1,312	660
INT/ICE-51	10,500	4,676
INT/ICE-85B	9,625	5,759
INT/ICE-86A	14,000	8,526
INT/ICE-88A	14,000	7,876
INT/III 286	9,187	5,116
INT/III 286;A	9,187	5,323
INT/III 520	3,150	1,815
INT/III 530	218	113
INT/III 810	16,625	10,508
INT/IMDX 431	43,575	20,793
INT/IMDX 431;C	43,575	17,883
INT/IMDX 434	8,575	3,559
INT/IMDX 456	3,500	1,890
INT/IMDX-750A	19,862	14,062
INT/IUP-200	3,456	1,892
INT/IUP-F27/128	1,338	863
INT/IUP-F87/44	1,478	893
INT/MCI-51-ASM	3,412	1,854

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MODEL #	LIST PRICE	SALE PRICE
INTEL		
INT/MDS-201	3,893	1,872
INT/MDS-225A	21,875	12,012
INT/MDS-286	33,075	10,506
INT/MDS-286A	33,075	17,976
INT/MDS-720	8,750	3,264
INT/MDS-720A	8,750	4,832
INT/PRN CABLE	358	51
INT/SBC-012B	2,807	1,591
INTERFACE TECHNOLOGY		
IFT/RS-660	13,387	8,298
IFT/RS-660/002	1,618	1,068
IFT/RS-660;A	13,781	7,321
INTL DATA SCIENCES		
IDS/MODEL 60	278	55
JERROLD/TEXSCAN		
JER/727	1,776	264
KAYE INSTRUMENTS		
KAY/DR-1A	6,475	925
KAY/DR-1A;A	8,575	1,225
KAY/DR3-1A	11,375	3,784
KAY/DR3-1A;A	12,643	5,532
KAY/U0930	1,050	297
KEITHLEY INSTRUMENTS		
KEI/616	5,591	3,170
KROHN-HITE		
KRO/3750;A	2,922	2,091
LEAR-SIEGLER		
LSI/ADM-5 GP	1,002	143
LP-COM		
LPC/TC-2000-01	14,735	10,305
LPC/TC-2000-04	6,125	4,216
LPC/TC-2000-27	1,312	957
MACOM		
MA/2P-RX	18,747	4,399

EQUIPMENT SUBJECT TO PRIOR SALE OR RENTAL
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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
MACOM		
MA/806064-1	2,843	655
MA/806746-1	1,141	436
MA/807619-1	663	212
MA/807628-2/5.8	1,746	560
MA/807628-3/6.2	1,746	511
MA/807872-1	5,250	1,537
MA/808542-1	1,643	420
MA/809114	5,600	3,091
MARCONI		
MAR/TF2091B	8,225	4,249
MAR/TF2092B	8,225	4,938
MAR/TK2094/10BP	787	186
MAR/TK2094/10BS	787	372
MAR/TK2094/10OS	787	289
MAR/TK2094/12OS	787	372
MAR/TK2094/14BP	787	215
MAR/TK2094/14BS	787	215
MAR/TK2094/14OS	787	249
MAR/TK2094/15BP	787	303
MAR/TK2094/15BS	787	308
MAR/TK2094/15OS	787	272
MAR/TK2094/16OS	787	293
MAR/TK2094/17OS	845	238
MAR/TK2094/18	3,018	985
MAR/TK2094/19BP	845	418
MAR/TK2094/19BS	845	418
MAR/TK2094/19OS	845	418
MAR/TK2094/2BP	845	423
MAR/TK2094/2BS	845	448
MAR/TK2094/2OS	845	458
MAR/TK2094/31BP	1,459	608
MAR/TK2094/31BS	1,459	736
MAR/TK2094/31OS	1,459	737
MAR/TK2094/3BP	845	548
MAR/TK2094/3BS	845	540
MAR/TK2094/3OS	845	593
MAR/TK2094/4BP	845	587
MAR/TK2094/4BS	845	262
MAR/TK2094/4OS	845	516
MAR/TK2094/5BP	1,195	778
MAR/TK2094/5OS	1,195	831
MAR/TK2094/6BP	1,195	857

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
MARCONI		
MAR/TK2094/60S	1,195	866
MAR/TK2094/90S	686	303
MAR/TK2094/OS	696	330
MAR/TK2095	1,006	499
MAR/TK2095/1	1,006	569
MAR/TK2095/18	1,251	518
MAR/TK2095/2	1,006	729
MAR/TK2095/22	1,295	836
MAR/TK2095/24	1,295	571
MAR/TK2095/4	1,006	490
MAR/TK2095/5	1,006	393
MAR/TK2096/2	1,006	249
MILLENNIUM		
MIL/32K RAM	3,141	1,904
MIL/9501	3,062	1,860
MIL/9508S	9,100	5,728
MIL/9516S	35,446	21,433
MIL/9516S;A	35,446	25,047
MIL/9520	12,250	5,215
MIL/9520/10MB	19,250	6,312
MIL/9520;A	14,787	6,158
MIL/CA8049	1,312	793
MIL/CPM	306	163
MIL/DEBUG	5,468	3,442
MIL/LTA	3,500	2,121
MIL/SA8T16	1,662	699
MIL/WDSTR	866	588
MIL/XE6801	5,197	3,054
MIL/XE6809	4,025	2,451
MIL/XE8041	4,497	2,109
MIL/XE8048	4,497	2,574
MIL/XM6809E	2,625	1,482
MIL/XS68000	9,266	6,670
MIL/XS8088	5,066	2,495
MIL/XSZ8001	4,681	3,272
MIL/XSZ8002	4,681	2,932
MOTOROLA		
MOT/M146805E2EM	3,500	1,802
MOT/M146805E2HM	3,500	2,475
MOT/M68010HDS4	5,775	3,372
MOT/M6805FIM	1,750	1,062

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
MOTOROLA		
MOT/M6805RU23HM	3,500	2,221
MOT/M6809EXOR	10,106	5,496
MOT/M6809SYMBUG	1,312	779
MOT/M6809USE	1,890	1,095
MOT/M68BSAC	6,125	4,095
MOT/M68DSK3	9,091	4,678
MOT/M68KEXORC	39,611	13,669
MOT/M68KHDS4	875	641
MOT/M68KHDS4;A	875	641
MOT/M68KHDSDLC	6,125	3,992
MOT/M68KUSE	2,625	1,434
MOT/M68PP3-1	262	165
MOT/M68SXD10155	4,532	2,580
MOT/MEX6801	5,250	2,843
MOT/MEX6805	3,780	1,647
MOT/MEX6816-22S	2,905	970
MOT/MEX6832-22	1,811	930
MOT/MEX68USEC	3,272	1,280
MOT/MEXPI2	936	433
MOT/SMM1196	58,782	11,280
NICOLET		
NIC/100A;A	19,950	11,959
NIC/2010	105	57
NIC/2090 INTRFCE	2,625	515
NIC/4094-2;A	20,300	13,526
NIC/4562	8,225	5,056
NIC/4851	10,150	3,152
NIC/58-4A	1,312	738
NIC/64-4A	2,625	1,698
NIC/70-1	1,312	642
NIC/824	17,325	10,218
NIC/MDL 87	2,537	1,847
NIC/NPC-764	32,637	20,263
NIC/XF-44/1	4,375	3,076
NIC/XF-44/2	6,300	3,168
NORTHEAST ELECTRONICS		
NEC/TTS2762	8,050	1,150
NEC/TTS35BAQ-CN	6,650	4,328
NEC/TTS41-3A;A	19,950	11,813
NEC/TTS41-3A;C	19,950	14,331
OKIDATA		
OKI/93P GP	1,748	249

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MODEL #	LIST PRICE	SALE PRICE
P-CAD		
PCD/CADPLAN	4,191	1,299
PCD/CAE-1	9,003	3,274
PCD/CAE-2	13,466	4,447
PCD/PCB-1	10,841	4,826
PCD/PCB-2	18,628	7,078
PACIFIC MEASUREMENTS		
PMI/1038-D14	14,175	6,916
PMI/1038-R	19,311	5,734
PMI/13786	1,015	732
PACIFIC POWER SOURCE		
PPS/110-ET	6,513	3,038
PPS/1V	1,253	484
PHILIPS		
PHI/3362	5,048	2,192
PHI/3363	6,125	4,469
PHI/6671;A	2,091	1,100
POTOMAC INSTRUMENTS		
PI/FIM-72	9,187	6,537
PROLOG		
PRO/GC-11	262	72
PRO/GC-4	262	83
PRO/M980;D	4,348	621
PRO/PA28-80	350	80
PRO/PM9052	787	112
PRO/PM9052A	787	112
PRO/PM9074	962	142
PRO/PM9075A	2,100	300
PRO/PM9077	2,975	823
PRO/PM9080	2,537	693
PRO/PM9080;A	2,537	725
RACAL RECORDERS		
RRI/DIR CHANNEL	1,155	851
RRI/FM CHANNEL	1,207	885
RRI/STORE 141	30,975	21,150
RAYTEK		
RAY/R2-LT	3,491	2,520

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** INSTRUMENT RENTALS CANADA **
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MODEL #	LIST PRICE	SALE PRICE
SCIENTIFIC ATLANTA		
SCA/4651	7,035	4,616
SCA/4651;A	7,560	3,879
SCA/4651A	6,510	4,720
SCA/4652;B	12,425	3,991
SCA/4657	8,557	6,153
SOLATRON		
SOL/1250	31,675	21,555
SORENSON		
SOR/DCR150-3B	1,723	1,027
SOR/DCR20-25B	1,662	1,122
SOR/DCR300-3B	2,100	1,466
SOR/DCR300-9B	3,500	2,428
SOR/DCR40-13B	1,723	528
SOR/DCR40-40B	2,887	1,745
SPECTRAL DYNAMICS		
SDY/345	22,575	12,296
SDY/345;A	24,325	17,303
SDY/375	35,000	23,592
SDY/375;A	37,625	27,764
SDY/SD340	12,075	1,725
STAG MICRO SYSTEMS		
STG/AM16-24T	787	170
STG/AM16-28T	787	112
STG/AM16-T28B	787	483
STG/AM16-T41	1,662	977
STG/AM16-T42	1,662	586
STG/AM8T-43	1,662	868
STG/CM1607	323	73
STG/CM1608	323	58
STG/CM1620	323	82
STG/CM1624	498	75
STG/CM1661	673	395
STG/CM1665	673	237
STG/CM1666	673	352
STG/CMS1626	673	432
STG/PP16A	5,250	1,147
STG/PP16A;A	6,737	1,166
STG/ZL30	4,987	1,648

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MODEL #	LIST PRICE	SALE PRICE
STAG MICRO SYSTEMS		
STG/ZL30;A	6,553	2,553
TEKTRONIX		
TEK/016-0327-01	297	149
TEK/016-0342-00	402	133
TEK/020-00849-03	787	255
TEK/067-1037-00	2,100	1,201
TEK/1105	2,843	543
TEK/1106	2,100	765
TEK/1240D2;A	4,025	2,657
TEK/134	1,093	790
TEK/1410R;C	17,071	8,130
TEK/1420;A	5,101	3,368
TEK/147A	17,062	10,706
TEK/149A	17,062	11,829
TEK/172	8,706	4,887
TEK/176	9,835	6,576
TEK/178	5,932	1,948
TEK/200C	577	138
TEK/205	857	502
TEK/212	3,491	1,914
TEK/2213	2,100	957
TEK/2213A	2,231	1,572
TEK/2236	4,637	1,188
TEK/2445;A	6,720	4,612
TEK/2465CTS	12,547	9,113
TEK/305	4,357	2,654
TEK/314	7,332	3,980
TEK/336	8,505	6,050
TEK/338	10,150	6,705
TEK/338;A	12,250	7,202
TEK/380	9,135	3,740
TEK/4052/10	962	137
TEK/4105	6,991	3,653
TEK/4612	8,032	2,941
TEK/4631	11,375	3,081
TEK/4631;A	12,652	1,807
TEK/4632	11,375	3,537
TEK/4632;A	13,335	7,626
TEK/466/DM44	14,455	7,875
TEK/468;A	12,880	9,116
TEK/485	15,925	9,906
TEK/492;A	57,321	38,773

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MODEL #	LIST PRICE	SALE PRICE
TEKTRONIX		
TEK/492P;A	72,248	53,103
TEK/5103N/D11	4,620	3,237
TEK/520A	14,918	8,051
TEK/520A;A	14,918	10,384
TEK/528	4,077	2,643
TEK/528A	4,077	2,910
TEK/5441	8,793	3,637
TEK/5A48	2,100	1,409
TEK/5CT1N	1,881	1,037
TEK/5D10	3,850	2,778
TEK/655HR-1	12,118	5,488
TEK/671A	9,388	3,707
TEK/7603	7,586	3,272
TEK/7612D	49,131	35,404
TEK/7623A	13,615	9,705
TEK/7633	16,975	12,503
TEK/7704A	12,941	5,576
TEK/7834	24,543	15,735
TEK/7844	27,160	16,353
TEK/7844;A	27,335	14,187
TEK/7904	15,417	6,603
TEK/7904;A	15,942	9,250
TEK/7904A	20,335	12,212
TEK/7A11	5,197	1,857
TEK/7A12	1,487	844
TEK/7A13	6,160	3,470
TEK/7A18	2,257	479
TEK/7A18A	2,651	1,757
TEK/7A22	3,167	2,057
TEK/7A24	4,690	3,255
TEK/7A26	4,156	2,624
TEK/7B15	5,127	3,805
TEK/7B53A	3,368	1,895
TEK/7B70	1,268	821
TEK/7B80	2,931	1,952
TEK/7B85	3,508	2,363
TEK/7B87	3,307	2,393
TEK/7B92A	6,615	4,886
TEK/7D01	9,100	3,269
TEK/7D02	8,662	5,557
TEK/7D02;A	12,425	2,497
TEK/7D02;B	11,025	6,611
TEK/7D02;C	14,787	9,040

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FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
TEKTRONIX		
TEK/7D11	5,810	2,602
TEK/7D20	13,028	8,664
TEK/8300A01	1,487	341
TEK/8300A04	1,487	901
TEK/8300B15	2,275	1,094
TEK/8300B26	2,275	1,241
TEK/8300B28	2,100	955
TEK/8300C01	875	452
TEK/8300E01	4,900	2,391
TEK/8300E01;A	4,900	700
TEK/8300E04;A	4,900	1,732
TEK/8300E04;B	4,900	2,113
TEK/8300E04;C	4,900	2,487
TEK/8300E15	10,675	4,337
TEK/8300E20	7,700	3,545
TEK/8300E26	8,400	4,713
TEK/8300E28	6,825	3,387
TEK/8300E33;A	7,700	3,268
TEK/8300E33;B	7,700	4,788
TEK/8300E36	8,400	4,109
TEK/8300E36;A	8,400	3,305
TEK/8300E38	8,925	6,288
TEK/8300E39	17,150	12,546
TEK/8300E40	8,925	4,828
TEK/8300E40;B	8,925	6,430
TEK/8300P01	2,625	1,734
TEK/8300P02	2,625	1,816
TEK/8300P04	2,625	782
TEK/8300P16	4,725	2,488
TEK/8300P22;A	4,025	575
TEK/8300P22;B	4,025	1,646
TEK/8300P22;C	4,025	1,263
TEK/8300P26	4,375	2,798
TEK/8300P26;A	4,375	1,778
TEK/8300P31	3,150	1,579
TEK/8300P34	3,675	2,061
TEK/8300P35	3,675	1,781
TEK/8300P38	7,175	3,512
TEK/8300P40	7,175	3,726
TEK/8300P45	8,575	5,632
TEK/8301	29,750	17,297
TEK/8301;A	35,175	5,967
TEK/8301;B	35,000	19,845

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
TEKTRONIX		
TEK/833	4,812	3,057
TEK/834R01	490	297
TEK/834R02	612	148
TEK/834R02A	612	317
TEK/834R03	647	370
TEK/834R04	787	537
TEK/834R05	306	93
TEK/834R06	612	242
TEK/834R01	490	194
TEK/8540/3U	5,425	2,743
TEK/8540;A	17,325	8,072
TEK/8540;C	18,025	11,400
TEK/8540;E	18,025	12,871
TEK/8540F03	7,875	3,231
TEK/8540F03;A	7,875	4,156
TEK/8540F03;B	9,625	4,812
TEK/8540U04	700	467
TEK/8550 SP	35,437	23,410
TEK/8550F01	4,725	1,286
TEK/8550F03	6,825	2,984
TEK/8550F04	8,225	5,448
TEK/8550F05	12,075	6,073
TEK/8550F06	4,375	2,054
TEK/8560;A	44,275	28,897
TEK/8560;C	40,075	23,532
TEK/8560;D	40,075	24,979
TEK/8560B01	2,975	1,654
TEK/8560B04	2,975	1,654
TEK/8560F03	8,750	4,391
TEK/8560F05	4,375	3,225
TEK/8560F06	8,575	4,992
TEK/8560F21	875	486
TEK/8560U01	1,750	1,169
TEK/8560U02	1,750	1,071
TEK/8560U03	875	535
TEK/8560U05	1,750	1,219
TEK/8561	24,325	8,806
TEK/8561;A	24,325	9,396
TEK/9109/003	1,400	735
TEK/9109;A	15,575	7,714
TEK/9109;D	16,975	7,963
TEK/9109;E	15,575	7,894
TEK/9109;G	19,075	12,624

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MODEL #	LIST PRICE	SALE PRICE
TEKTRONIX		
TEK/9129;B	15,697	8,800
TEK/9129;D	20,650	11,456
TEK/9129;E	21,350	14,846
TEK/9129;F	22,750	12,982
TEK/9129;G	22,050	11,110
TEK/9129;H	20,650	11,056
TEK/9129;L	22,750	11,872
TEK/91A04	13,912	9,561
TEK/91A08	6,973	4,763
TEK/91A24	8,732	6,020
TEK/91A32	8,732	5,435
TEK/91AE24	8,225	5,509
TEK/91P16	6,982	3,744
TEK/91P32	12,075	8,566
TEK/AM503	1,968	1,081
TEK/ASM1750	5,250	3,809
TEK/ASM1802	2,975	2,180
TEK/ASM6800	2,975	1,870
TEK/ASM8048	2,975	2,094
TEK/ASM8048;A	1,750	1,119
TEK/ASM8085	1,750	696
TEK/ASM8085;A	2,975	2,111
TEK/ASM8086	2,975	1,910
TEK/ASMZ8K;A	2,275	1,554
TEK/ASMZ8K;B	2,275	1,553
TEK/C30B	2,590	1,243
TEK/C30B;A	2,667	1,745
TEK/C31B	2,975	2,022
TEK/C51	4,130	2,173
TEK/C59P	2,336	1,577
TEK/CT8500	4,725	675
TEK/DC503	1,575	225
TEK/DC503A	2,485	1,517
TEK/DD501	3,325	1,332
TEK/DF1	4,112	1,725
TEK/DF2	5,162	2,674
TEK/DM501A	1,487	814
TEK/DM502A	1,575	611
TEK/FG503	1,181	629
TEK/FG504	5,643	3,193
TEK/FG507	3,885	1,875
TEK/J16	2,196	1,593
TEK/J6502	1,032	651

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MODEL #	LIST PRICE	SALE PRICE
TEKTRONIX		
TEK/J6503	1,032	470
TEK/J6511	997	581
TEK/J6512	1,006	609
TEK/J6523	2,922	1,590
TEK/P6022	866	285
TEK/P6046	3,062	1,710
TEK/P6060	166	87
TEK/P6062B	306	98
TEK/P6063B	376	279
TEK/P6105	192	134
TEK/P6106-01	245	174
TEK/P6106-03	245	170
TEK/P6106-05	245	175
TEK/P6108	175	126
TEK/P6201	2,135	1,186
TEK/P6202	1,190	804
TEK/P6302	988	628
TEK/P6303	1,872	717
TEK/P6406	997	723
TEK/PG501	1,487	754
TEK/PLAN68K	15,750	11,237
TEK/PM101	2,450	1,667
TEK/PM101;A	2,975	1,443
TEK/PM103	2,450	1,615
TEK/PM105	2,450	1,431
TEK/PM107	3,150	1,871
TEK/PM109	3,500	2,323
TEK/PM111	2,800	1,667
TEK/PS503A	1,312	896
TEK/SC503	7,166	3,654
TEK/SI5010	3,972	1,777
TEK/STRUCTA	16,625	10,928
TEK/TM503	883	563
TEK/TM504	1,225	543
TEK/TR502	12,390	3,354
TELECOMMUNICATIONS TECH		
TTC/1500	9,056	4,058
TTC/1500/002	1,032	527
TTC/1500/005	1,137	604
TTC/1500/006	1,041	591
TTC/1500/006;A	1,137	758
TTC/1500;A	9,056	6,368

EQUIPMENT SUBJECT TO PRIOR SALE OR RENTAL
PRICES SUBJECT TO CHANGE WITHOUT NOTICE
DECEMBER DELIVERY 5-10 DAYS, ARO

** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
TELECOMMUNICATIONS TECH		
TTC/1500A	9,266	5,807
TTC/1500A;A	9,791	6,863
TTC/1500A;C	8,435	5,808
TTC/2000/112	638	472
TTC/2000/138	997	637
TTC/2000/151	1,172	678
TTC/2000/204	1,391	959
TTC/2000/213	96	69
TTC/2000;E	14,778	9,287
TTC/2000;K	14,866	10,073
TEXAS INSTRUMENTS		
TI/810 GP;A	3,001	1,292
TEXSCAN		
TEX/7272	2,231	1,287
TEX/AFS-1	245	69
TEX/SB7270	481	232
TOPAZ		
TOP/1000GZ	4,716	1,825
VARIAN		
VAR/VZM6991G5	20,650	4,333
VELONEX		
VEL/V-2269	2,213	1,172
WANDEL & GOLTERMANN		
WG/PCD-1/REMOTE	1,356	251
WG/PCG-1	11,200	7,249
WG/PCG-1/REMOTE	1,452	239
WAVETEK		
WAV/143	2,966	1,722
WAV/159	5,416	2,121
WAV/159;A	6,807	3,307
WAV/175	8,662	3,527
WAV/185	2,441	1,281
WAV/1855B	8,225	4,063
WAV/189	2,616	1,512
WAV/278	6,116	1,712
WAV/3002	9,616	5,747

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** INSTRUMENT RENTALS CANADA **
FALL 87 EXPERIENCED EQUIPMENT SALES LIST

MODEL #	LIST PRICE	SALE PRICE
WAVETEK		
WAV/3006	9,616	5,570
WAV/5820A	20,562	13,113
WAV/5820A;A	20,562	11,972
WAV/5830A	32,812	23,709
WAV/A-2	218	148
WESTERN GRAPHTEC		
WAT/6735-3	5,337	3,600
WILCOM		
WLC/T207	5,766	3,231
WILTRON		
WIL/640E	813	220
WIL/9330	3,762	797
WIL/9361B;B	8,585	1,226
Z - ODDS AND ENDS		
ADT/EM-6809/E	5,241	3,003
ADT/IF-0003	516	255
AXM/EX-850	2,791	951
BBC/101-1	437	202
EXP/101-1	402	71
GRI/ETS15	3,325	1,811
MCI/5201CR	2,406	343
MCI/5205	6,037	862
MCI/5209D	6,116	873
MIT/C-3920LP	5,757	2,859
MIT/C-3920LP;A	5,757	3,185
PAN/1420-104	437	151
PPI/3604	10,150	2,802
SEG/LSCC	638	310
SIE/418A-1	5,880	4,079
SPC/D-101X	6,641	4,328
SPC/D-101X;A	6,903	3,946
SPC/D601C-1	15,750	2,250
SPC/D901	43,400	6,626
SPC/RCU-DDCMP	2,537	1,312
SPC/T511	11,375	1,625
STE/DMS-303	7,717	1,677
STE/PG303A	7,717	1,447
TM/26044	1,048	523

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PRICES SUBJECT TO CHANGE WITHOUT NOTICE
DECEMBER DELIVERY 5-10 DAYS, ARO

INSTRUMENT RENTALS CANADA

1-800-387-3411

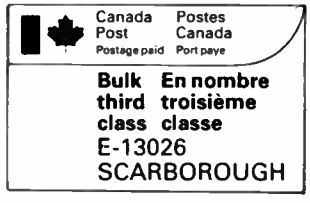
(for Ontario, Quebec)

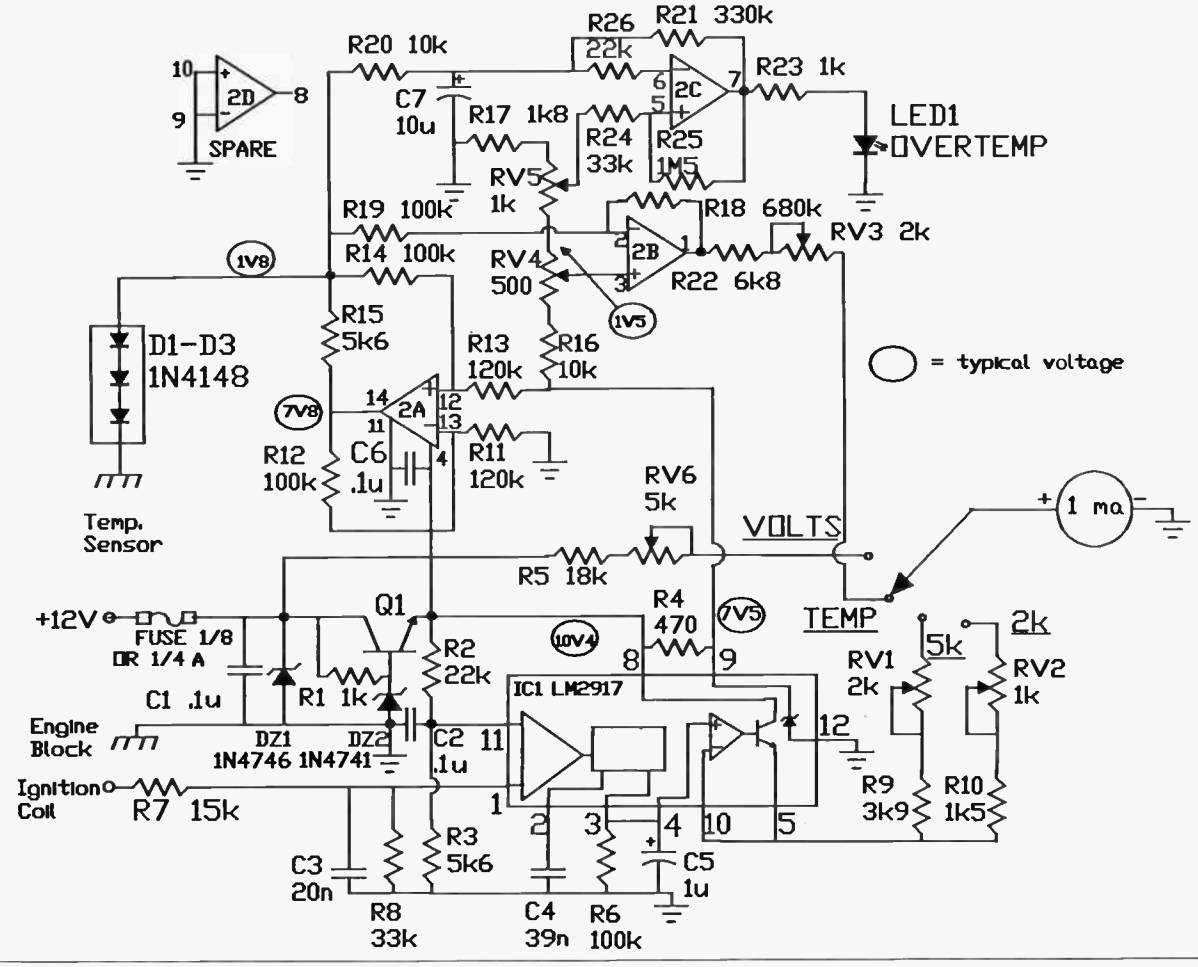
1-800-268-4928

(for the rest of Canada)

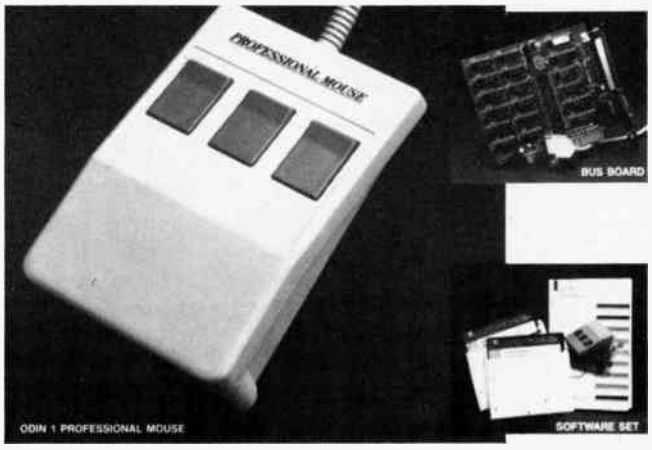
INSTRUMENT RENTALS CANADA

6815 Rexwood Rd.,
Unit 6,
Mississauga, Ontario L4V 1S4





In our November issue, the schematic diagram of the Automotive Multifunction meter was less than clear because of (a) a new drafting system that deleted some of the symbols, and (b) hasty proofreading. Our apologies to the author and to readers who had difficulty with this one. The corrected schematic is shown above. Also, the various leads such as 12V, ground, sensor, etc. can be put through a multi-lead connector for convenience.

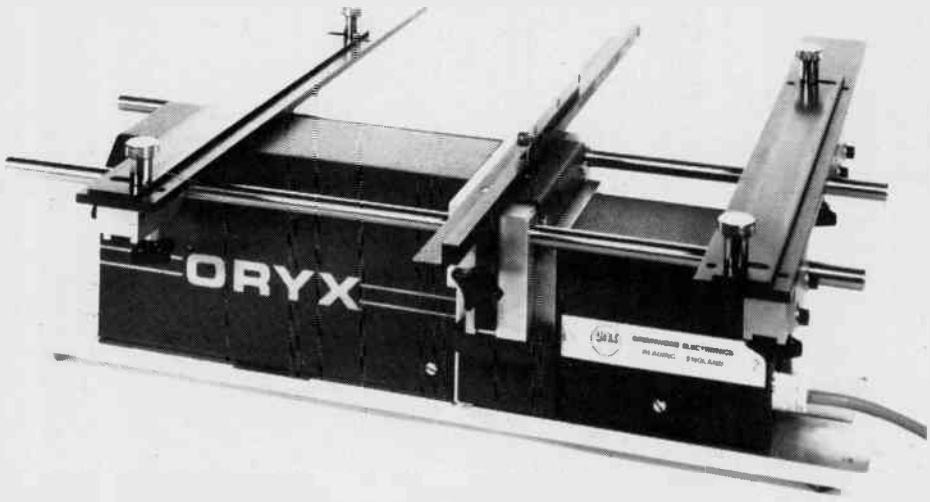


Pro Mouse

If you work with demanding applications such as desktop publishing or CAD, Sak Data Products has introduced the ODIN 1 Professional Mouse from Moniterm. The resolution is 320 dots per inch, with mechanical tracking and optical encoding for reliability. The accompanying bus board installs in a standard half slot of an IBM PC, XT, AT PS/2 or compatible, leaving the serial port free. For further information, contact Sak Data Products Ltd., 4500 Dixie Road, Unit 12B, Mississauga, Ontario L4W 1V7, (416) 624-6763.

Debugger for Intel Micros

Applied Microsystems Corp. has introduced VALIDATE Soft-Scope, a source-level debugger for INtel's 16- and 32-bit microprocessors. Soft-Scope is designed to work with the 8086, 8088, 80186, 80188 and 80286 microprocessors, including a version which supports the virtual protect mode of the 80286. It can be used to debug code written in C, Pascal, PL/M, Fortran, and PSS's Jovial on any PC or compatible with MS-DOS 3.0 or above. Contact Allan Crawford Associates – Marketing, 5835 Coopers Ave., Mississauga, Ontario L4Z 1Y2, (416) 890-2010.



Oryx PCB Cutter

With the introduction of surface mount technology, there is an increasing need to cut assembled printed circuit boards. The Oryx PCC is designed specifically for accurate cutting of both assembled and bare PCBs.

Cutting is achieved by a guarded, high-speed diamond abrasive wheel that minimizes the shock to components. Adjustable supports enable boards up to 18" square to be cut, and assemblies with components on both sides can be cut with underside components mounted to within 0.16" of the edge.

A variety of grades and widths of cutting wheel are available and the unit will cut virtually all known PCB materials. The unit also comes with a power take-off that drives an optional dust collection system.

For more information on the Oryx PCC contact: Tom Harlan, Harlan Associates, 3612 Silverside Rd., Wilmington, Delaware 19810.

Circle No. 75 on Reader Service Card

Hands-On Primer

Simple trigger circuits from transistors

By Owen Bishop

Circuits which are triggered into action are usually done so by a relatively small change in voltage at some part of the circuit. The essential point about a circuit that is triggered (as opposed to one that is merely switched on or off) is that reversing the condition which triggered the action does not cause the action to cease.

Schmitt Trigger Circuit

One of the classical triggering circuits is the Schmitt Trigger.

First set up the circuit of Fig. 1 on a piece of "breadboard". In this circuit you can vary the voltage at the base of TR1 from 0V to 6V by simply adjusting VR1.

Start with the wiper of VR1 nearest to the 0V end (fully anticlockwise). Now turn the knob slowly clockwise and watch what happens to the lamp LP1.

At first it is not lit, because the base voltage is too low and the base current is too small. As VR1 is turned the lamp starts to come on and brightens gradually. After a little more turning it is fully lit and further turning does not make it any brighter. The transistor is said to be *saturated.*

If you reverse the direction of turning just as the lamp begins to come on, it immediately goes out again. The change in voltage simply turns the lamp on or off, acting in a similar way to an ordinary switch.

Now set up the circuit of Fig. 3 in which there is an extra transistor between VR1 and TR1. This is one form of the type of circuit generally referred to as a Schmitt Trigger. Start with VR1 fully anticlockwise, as before. In this position the lamp is on. Since TR2 is off, its collector voltage is high and current flows through resistor R3 to the base of TR1, turning it on. This switches the lamp LP1 on, too.

Turn the potentiometer VR1 slowly, as before. At a certain point the lamp LP1 goes out suddenly, even though it was previously glowing at full brightness.

This circuit has a much more definite "on-off" switching action than the one in Fig. 1. This is the first distinguishing feature of the Schmitt Trigger.

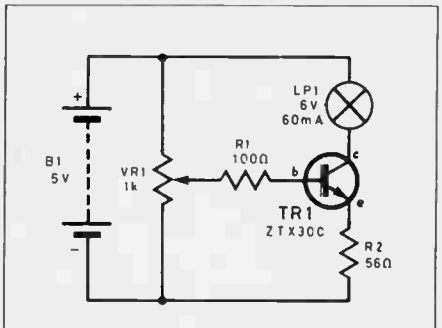


Fig. 1 Circuit demonstrating simple switching action of a single transistor.

As soon as the lamp goes out, stop turning VR1. Now slowly turn it back again. The lamp does not immediately light again. You have to turn the knob an appreciable distance before the lamp lights. Once turned off, the lamp

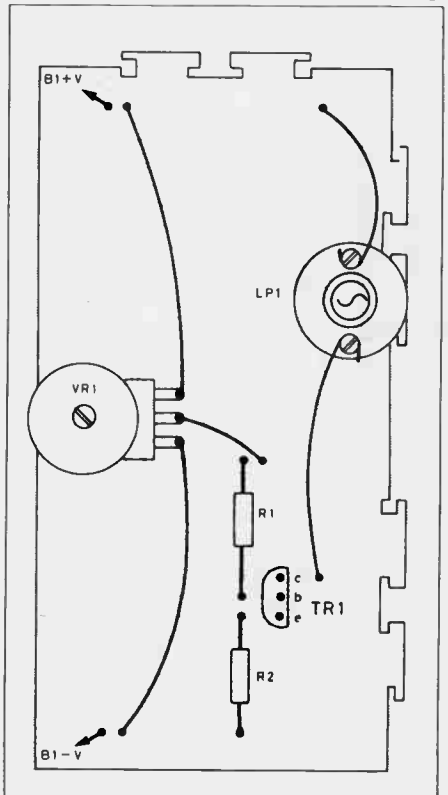


Fig. 2 Breadboard layout of circuit in Fig. 1.

stays off until the control has been reversed by a fairly large amount.

This is the second important feature of the Schmitt trigger circuit. Note also that, when the lamp comes on again, it is at full brightness.

How It Works

A better understanding of the circuit action of Fig. 3 can be obtained by studying Fig. 5 and Fig. 6.

With transistor TR1 fully on and the lamp LP1 shining brightly, Fig. 5 a current of about 60mA flows through LP1, TR1 and R2. The potential difference across resistor R2 is V = 1R = 0.06 x 56 = 3.36V (approx. 3.4V).

Potentiometer VR1 is turned to increase the voltage at the base of TR2. TR2 does not begin to turn on until its base is 0.6V higher than its emitter (which is at 3.4V, the same as the "upper" end of resistor R2). So TR2 remains off until the voltage at VR1 exceeds 4V (3.4V + 0.6V).

As soon as TR2 begins to turn on, the voltage at its collector falls, see Fig. 6. TR1 receives less base current and begins to turn off. The current through LP1, TR1 and R2 is reduced.

Reduction of current through resistor R2 reduces the p.d. across it. The voltage at its upper end begins to fall. Consequently, without turning VR1 any further, the p.d. between the base and emitter of TR2 is greatly increased. This turns it "hard" on turning TR1 hard off, extinguishing the lamp. This type of circuit has a sharp "snap" action, giving a quick response for a small change of voltage at VR1.

As we start to turn VR1 to switch the lamp on again, there is no current through resistor R2, so its "upper" end is at 0V (Fig. 6). There is 4V p.d. between the base and emitter of TR2, so it is firmly on. Reducing the voltage slightly at VR1 has no effect.

In order to turn TR2 off, we have to turn VR1 until the voltage at its wiper is only 0.6V. As soon as this point is reached, TR2 starts turning off, the voltage at its collector rises, TR1 starts turning on, current starts to flow through LP1, TR1 and R2 and a p.d. appears across R2. The voltage at the "upper" end of R2 rises, making the p.d. between the base and emitter of TR2 much less than 0.6V. TR2 snaps off, TR1 snaps on and the lamp comes on.

It is therefore said that this circuit has a "snap" action for turning the lamp on and off. It also has a differential between the voltage required at VR1 for turning the lamp off (4V) and voltage required for turning it on (0.6V).

Light Triggered Switch

A circuit diagram for a simple Light Triggered Switch is shown in Fig. 7. A stripboard layout is shown in Fig. 8, with an additional transistor to drive an audible warning device (see Fig. 9).

This circuit switches on a lamp whenever it detects a fall in the level of illumination. It could turn on a small lamp when it begins to get dark each evening.

It can also be used to detect when a beam of light has been broken, for example when a person walks between a source of light and the sensor of the circuit. The lamp can be placed at a distance from the rest of the circuit, so a remote warning can be given.

The light switch Fig. 7 is a Schmitt trigger circuit using a pair of resistors to control the current to the base of

Parts List

Resistors All .25W 5% carbon

R1	100R
R2	56R
R3,5	1k

Potentiometers

VR1	1k carbon track lin.
VR2	10k carbon track lin.

Semiconductors

TR1,2,3	2N4401 npn

Miscellaneous

R4, Cadmium Sulphide photo cell. Available from Electro Sonic, 1100 Gordon Baker Rd., Willowdale, Ontario (416) 494-1555. Part number 600-95003.

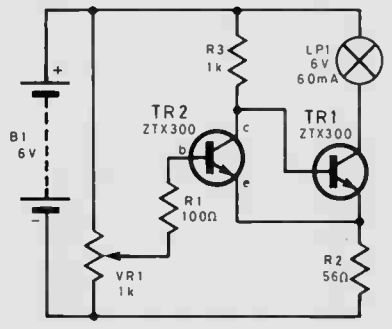


Fig. 3. Circuit with Schmitt trigger action.

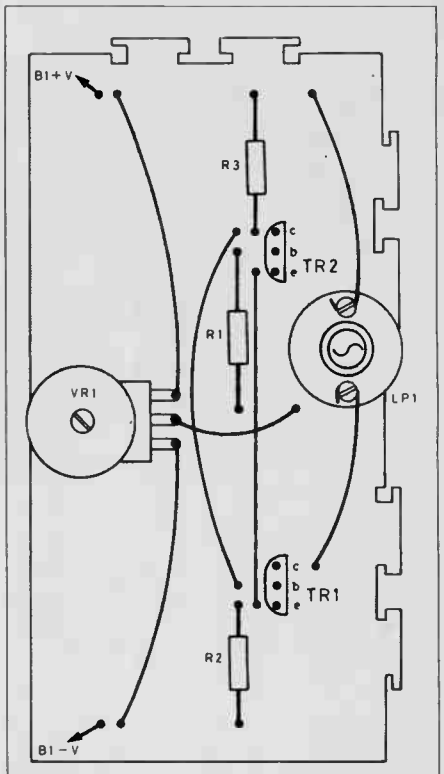


Fig. 4. Breadboard layout for demonstrating Schmitt trigger action of Fig. 3.

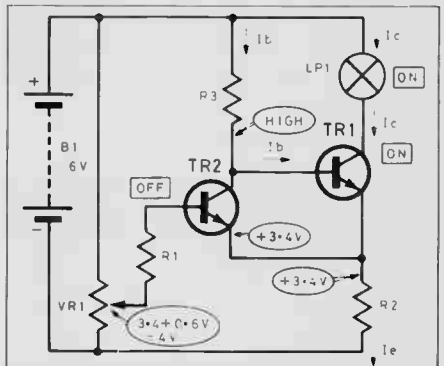


Fig. 5. Circuit depicting the action of the Schmitt trigger during lamp switch-on.

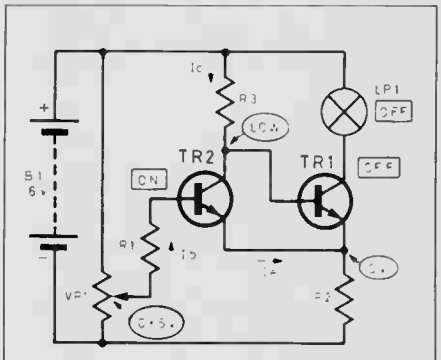


Fig. 6. Circuit showing the condition of the Schmitt trigger during lamp switch-off.

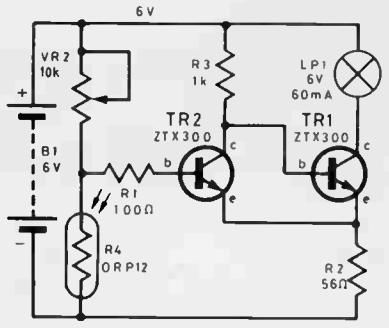


Fig. 7. Circuit modification to Fig. 3. to give a simple Light Triggered Switch.

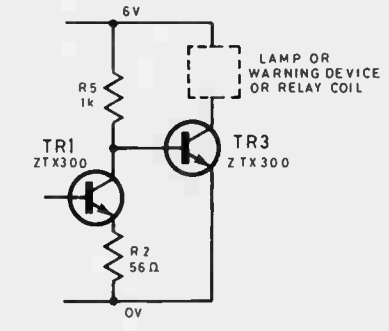


Fig. 9. Modification of Fig. 3. to allow switching of a larger current. For even greater currents use a power transistor in place of TR3.

TR2. One resistor R4 is a light-dependent resistor (LDR). It has high resistance in the dark, and its resistance decreases as the level of light falling on it is increased. The other resistor VR1 is used for setting the level at which the circuit triggers.

Construction

The Light Triggered Switch circuit may be constructed using a piece of 0.1in. matrix stripboard having 10 strips x 24 holes.

The components layout for the stripboard is shown in Fig. 8. No special construction techniques are used, except care should be exercised when soldering the transistors in position.

Apart from ensuring the transistors are inserted with their leads in the correct order, be sure to make the break in the underside copper strip at point D16. Also, remember to insert the wire link. Use solder pins to anchor the lead-off wires to the board.

No problems should be experienced in setting the circuit up and getting it to

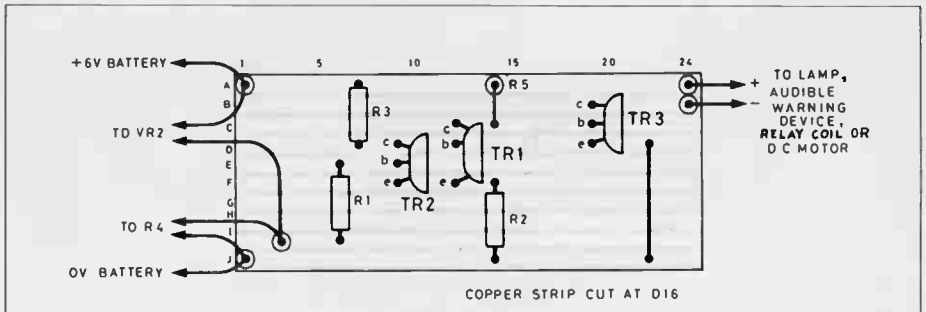


Fig. 8. Stripboard components layout for the Light Triggered Switch.

work. When it is switched on, turn VR1 until the lamp lights; then turn it slowly until it just goes out.

If you now place your hand over the LDR to shade it, the lamp should come on again. It should go out when you take your hand away.

It can switch on a lamp at dusk, for example, and turn it off the next morning. The advantage is that, having switched a lamp on at dusk, it will not switch it off again should the sky temporarily clear and light intensity increase for a while.

You can use the circuit in other way. Turn VR1 until the lamp lights, then until it just goes out. Now turn VR1 back a little way, but not far enough to switch the lamp on again. You should be able to find a setting of VR1 in which the lamp comes on when the LDR is shaded, and then stays on, even when you take your hand away. It could be used to detect when an intruder breaks a light beam. Once triggered, the lamp remains on after the beam is restored by the person moving out of he beam.

More Power

The Schmitt trigger circuit must have a resistor (R2) between the emitter of TR1 and the 0V line. This cuts down the amount of current that flows through the lamp, so it does not shine at its full brightness.

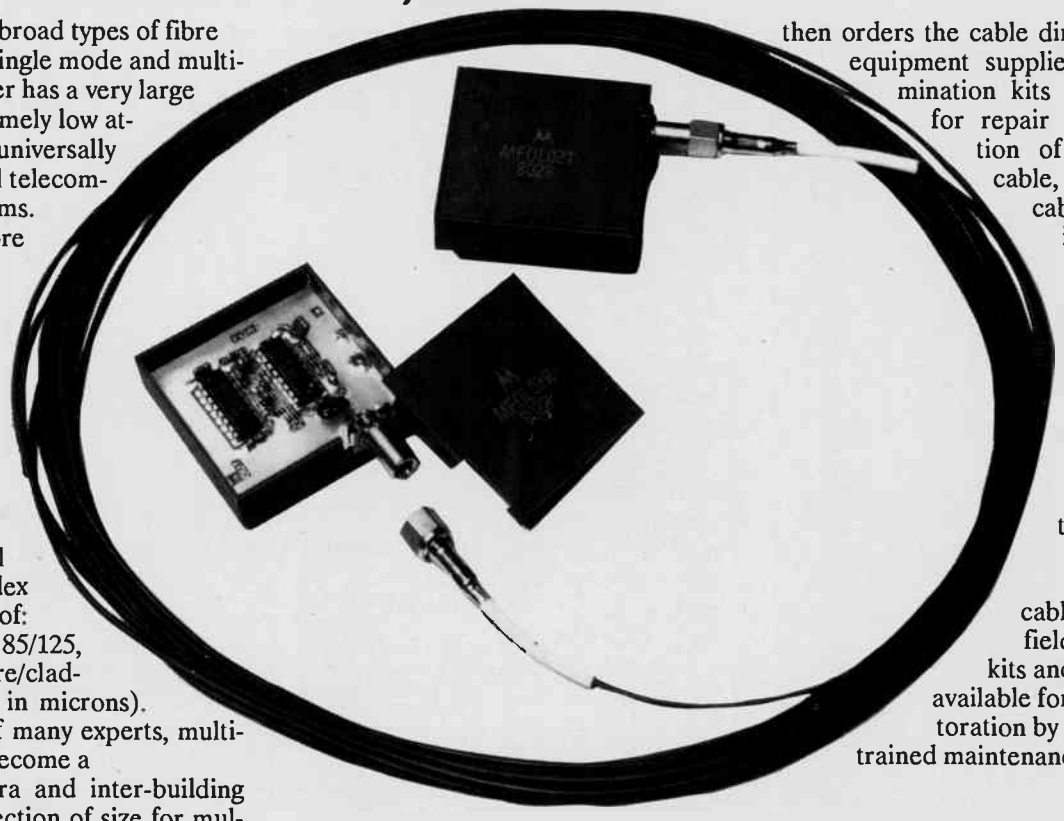
To make it shine really brightly we use the Schmitt circuit to switch a third transistor, as shown in Fig. 9. The third transistor TR3 switches the lamp fully on.

A small audible warning device could be wired in place of the lamp LP1, or, you could substitute a small relay to operate an AC-powered lamp, bell or motor. ■

Fibre Optics

The ins and outs of installing fibre optic assemblies.

By Dr. H. Virani



There are two broad types of fibre optic cable: single mode and multimode. The former has a very large bandwidth, extremely low attenuation and is universally used in long-haul telecommunication systems. Multimode is more appropriate for short-haul data/-voice communication requirements.

There are various types of multimode fibre. The predominant type being all glass, grade-index fibre in sizes of: 50/125, 62.5/125, 85/125, and 100/140 (core/cladding dimensions in microns). In the opinion of many experts, multimode fibre will become a standard for intra and inter-building installations. Selection of size for multimode fibres is not critical to a successful installation. Like the choice between 25, 24 or 22 gauge copper wire for twisted pairs, there are customer preferences and performance distinctions but fibre size is not a major installation decision. In fact, of the two most popular connector types, the same connector can be used on 50, 62.5 and 85 micron core fibres, and only an insert change is required to accommodate the 100/140 size. These fibres are available in all types of cable: indoor and outdoor; single fibre (simplex); dual fibre (duplex); and up to hundreds of fibres within a single cable sheath (Fig. 1).

Outdoor cable is available with special jell filling; steel jacketing for rodent protection; for aerial, buried or duct installations; and with a variety of sheath materials.

Connectors

There are basically two popular types of connectors used on multimode cable: SMA type and BICONICAL (Fig. 2).

Despite advances in the art of fibre optic connectors, the problems involved in properly terminating this thin filament of glass should not be underestimated. Because of th difficulty of field termination with either of the standard connectors, it is highly desirable to have connectors factory installed. This is easily handled and has worked quite successfully.

The customer typically "walks off" the distance between the two devices to be interconnected (either through the use of blue prints or physically walking this distance), adds a safety factor of perhaps 10% (to permit circumventing obstructions, etc.), and then orders the cable direct from the equipment supplier. Field termination kits are available for repair and restoration of a damaged cable, however, a cable disruption is highly unlikely.

Once installed, fibre optic cable is no more likely to be damaged than the common, copper, twisted-pair cables. However, field termination kits and training are available for on-site- restoration by relatively untrained maintenance personnel.

Test Equipment

There is a large variety of test equipment available for fibre optic systems. Some of these devices are extremely sophisticated and used primarily by telecommunication carriers where attenuation and bandwidth are highly critical to the proper functioning of a system. For short-haul fibre optic cable installations, relatively inexpensive fibre optic test equipment is available. A standard attenuation test may by all that is required to install and maintain a link. In the event that an installed fibre optic cable develops a break or discontinuity, instruments are available for locating the fault. Such instruments are quite expensive even for short-haul multimode systems but it is also possible to obtain assistance from a fibre optic supplier or rent such equipment in the unlikely event that it is needed.

Installation

One thing should be made clear about the installation of fibre optic cable. Although it is glass, it need not be handled like fine crystal glasses. The fibre is quite flexible and many fibres are available that can be tied into a loose knot without any permanent damage to the fibre.

Furthermore, fibre optic cables are provided with a high strength member (that is also dielectric) that allows the cable to be subjected to heavy pulling tension during installation. Perhaps the only caution that need be exercised is that the fibre should not be pulled around very sharp corners.

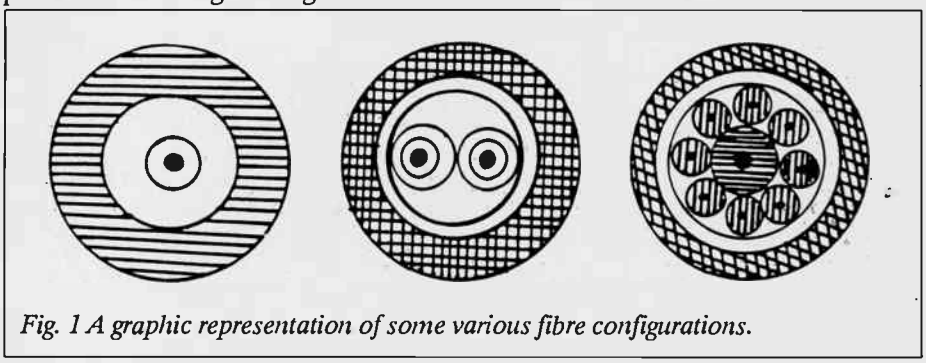


Fig. 1 A graphic representation of some various fibre configurations.

By comparison with pulling in copper cables, either multi-twisted pair or coaxial cables, fibre is much easier to install. Because of its small size it can be pulled through relatively small openings with ease. Also because of its small size, it has a small surface and thus creates very little friction when pulled in relatively confined space. It is extremely light so the reel of cable may be easily handled in one hand as opposed to the heavy and cumbersome copper cables.

In most indoor fibre optic cable installations, which are typically less than a thousand feet in length, it is usually recommended that the customer installs it themselves. The customer can order a factory terminated cable supplied on a light-weight reel (which allows it to be air expressed for emergency delivery at relatively low cost) and install it with no previous experience.

The cable may be laid in a raceway which contains either communication or power cables (remember that fibre optic cable is immune to EMI/RFI). The fibre optic cable may also be installed under a raised floor where the only precaution is that the cable may require crush protection and the use of a split plastic conduit may be recommended. The conduit also will aid in the "pulling- in" and more importantly protect the fibre against subsequent rearranging of large cumbersome copper cables. Finally, the fibre could be laid in a cable tray with other fibres and is preferably left loose, not attached to other cables or to the tray itself.

Perhaps the easiest installation method for fibre optic cable is to simply lay the fibre over a dropped ceiling providing almost a line-of-sight direct connection between the two pieces of equipment. When installing the fibre optic cable over a dropped ceiling some care must be taken to avoid pulling around sharp corners, ceiling hangers, metal studs and around areas of continuous maintenance activity (for example, away from heating vents or lighting fixtures).

In some installations where there is a great deal of activity in the above ceiling area, a split-plastic conduit may be desirable. Fibre optic cable laid on a dropped ceiling meets building code requirements without the expense of metallic duct, trays, or conduit.

In vertical installations, fibre optic cable may be installed in an elevator shaft or a pipe chase. Since an elevator shaft is typically filled with electromagnetic energy from the rotating electrical motors that are used to move the elevator, fibre optic cables are ideal for installation without the large expense of shielded copper cable. Cable ties may be desirable to maintain the cable in an out-of-the-way position. Ties should not be crimped too tightly. Most fibre optic cables can be self-supported (without any hangars to relieve the weight of the cable itself), for a distance of up to 300 ft. or approximately 30 stories in a highrise building.

The installation of fibre optic cable outdoors is a more complex situation. In the first place, most outdoor cable installations involve greater distances, multiple buildings, and thus more planning and support. Of course, the user must have the right- of-way to install the cable. While it is the responsibility of the user to obtain such right-of-way, many local contractors can assist the user in dealing with the proper authorities. The actual physical installation of the cable may be done on telephone poles, buried, or run in ducts or conduits.

In the planning for installation of cable outdoors, the three methods of laying the cable as described above will largely determine the type of cable to

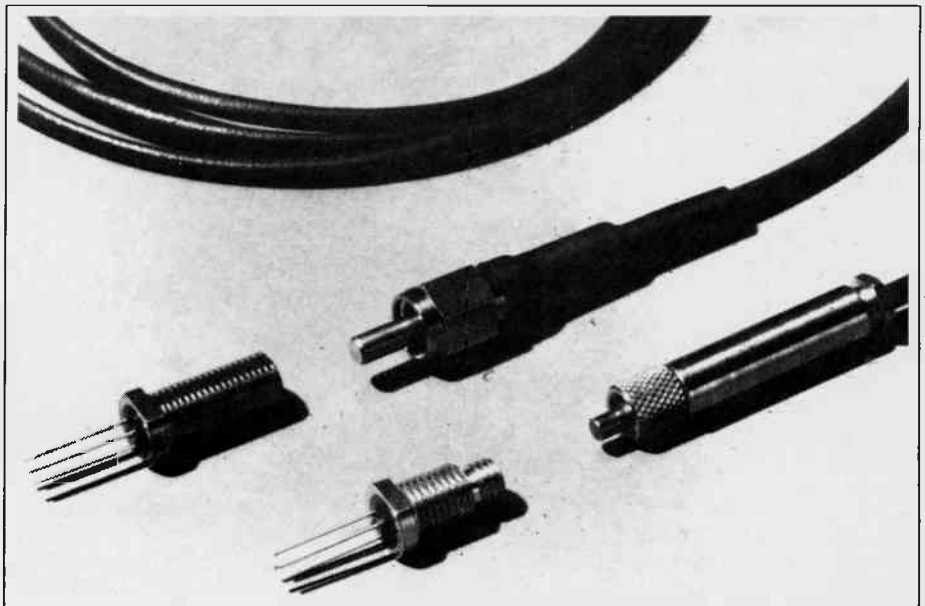


Fig. 2 The two types of popular connectors: SMA and biconical.

be selected. This selection should be done with the assistance of experienced fibre optic cable specialists. They can assist in selecting the right

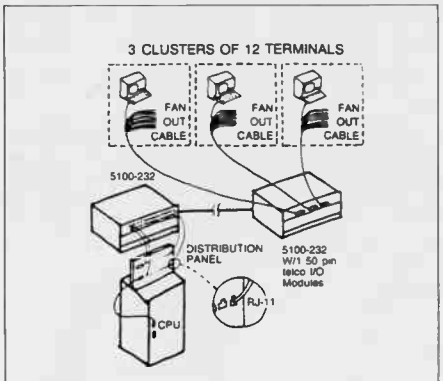


Fig. 3 Terminal clusters linked together with fibre technology.

type of fibre, cable, sheathing, diameter, connectors, splicing, and all accessories. In many "campus" fibre optic installations, it is desirable to terminate the outdoor cable at a patch panel providing manual reconfigurability for restoration or rearrangement. Patch panels, patch cords, termination panels and termination boxes are available through most cables and equipment suppliers.

Cable splicing is simplified using specialized test equipment, such as the LLD-220 from Performed Line Products.

A typical indoor installation of fibre optic cable would be used to inter-connect a pair of RS232 fibre optic multiplexers. In this system, one multiplexer would be mounted in the computer or data processing room within a 19 in. rack. Each individual asynchronous channel on the rear panel of the multiplexers would be connected through a DB25 connector and a standard RS232 cable to a port on the computer distribution panel (see Figure 3).

This portion of the installation is similar to that of a standard statistical multiplexer operating on copper cable. The fibre optic cable would be connected on the real panel of the multiplexer. The multiplexer is then provided with a standard SMA-type connector which mates with the SMA connectors that are factory installed on the cable. It is desirable to provide a fairly large radius, say 10 ins., of the fibre after connection to the multiplexer to prevent any undue stress or inadvertent pulling on the fibre which may disturb or damage the connection. The fibre could then be run down beneath the raised computer floor to a suitable riser that would provide access to the space above the dropped ceiling. Alternatively, the fibre could be run upward directly through an opening in the dropped ceiling. It is also possible to run the fibre optic cable, together with copper cables, through a suitable conduit that is terminated at the equipment rack to provide access out of the computer room and into a cable tray, raceway, or continuation of the conduit. Once the cable is pulled in, it is simply attached to the multiplexer at each end taking care that the transmit fibre at one end is connected to the receiver at the opposite end. In general, most fibre optic systems will have a sufficient system gain, so that the short distances normally traversed within a building will provide excess loss margin.

Summary

The installation of fibre optic cable is neither difficult nor time consuming. There are many suppliers for all of the system components, Motorola, GTE, Corning, HP to name a few, required for a complete turnkey installation. Training courses for personnel are readily available and experienced installation companies are available for large system requirements. Fibre optic systems are widely used throughout the telephone industry and accumulated experience with fibre optics is mounting fast. Leading edge users have committed themselves and are enjoying the benefits of this highly attractive technology.

Dr. Virani is a freelance writer from Mississauga, Ontario. ■

SDI: The Battle of Software and Hardware

In this issue, we begin a forum of discovery and debate on the subject of SDI. Comments are invited.

By K. Tahir Shah.

Foreword: the year was 1968. Outside the Italian resort city of Trieste, hidden beneath pine trees and overlooking the Adriatic sea, a newly built concrete and steel structure was teeming with activity. This was the new home of the United Nation's International Centre for Theoretical Physics. That June, the world's most precious asset, some three hundred scientists, including a dozen Noble Laureates, gathered there to discuss contemporary physics. Great names of this century, names which are to remain in the history of science forever: Werner Heisenberg, Paul Adrien Dirac, Francis Crick, Hans Bethe and others, came to share their experience of discovery. Many of the participants were honored with the Noble prize in later years such as Abdus Salam, Steven Weinberg and others. As a young research fellow at the Centre, I had the opportunity to meet, listen and discuss with these giants of modern science.

What impressed me most was the simplicity and the modesty of these great people who have contributed so much to out civilization, so different from the commonly conceived image of the scientist sitting in isolation from the rest of mankind. They were always willing to discuss, scrutinize, discard, and refine their ideas. From them I learned that science progresses from open discussion. *Nil sine dialogo* – without discussion, nothing.

The purpose of this regular section is to initiate a reader writer dialogue in the hope that our readers will come forward and discuss, criticize and put forth new ideas – in the true spirit and traditions of science. The science of today, the technology of tomorrow, and the impact of science and technology on our life are some of the issues we will confront.

Since 1983 we have heard about the Star Wars project of the U.S. government. What is the Strategic Defense Initiative and what new technologies are involved? I am, therefore, dedicating our first debate topic to SDI. Please feel free and write to me your comments, concerns, questions and how you see SDI technologies effecting our future. Some of these letters will be published in later issues of E&TT.

Minerva, the roman goddess of wisdom, the daughter of Jupiter, king of gods, was the embodiment of wisdom, purity and reason and the patron of all arts, handicrafts and trades. This section of discovery and debate is named after her.

Minerva and Star Wars

"... I call upon the scientific community in our country, those who gave us nuclear weapons, to turn their great talents now to the cause of mankind and world peace, to give us the means of rendering these nuclear weapons impotent and obsolete." – March 23, 1983, U.S. President Reagan's public statement on Star Wars.

The story of star wars is older than it is known to the public. It goes back to 1967 when Mr. Ronald Reagan, as a newly elected Governor of California, made a visit to the University of California Lawrence Livermore Research Laboratory. He was given a tour of the facility by Professor Edward Teller, a co-founder of the laboratory and a major proponent of the hydrogen bomb in the 1950s. The Livermore facility, with its credible reputation in weapon development and long involvement in defense projects, was already manipulating exotic ideas. Teller mentioned the possibility of new kinds of weapons, such as high powered lasers, which can shoot down attacking ICBMs. In those days, the only anti-ballistic missile (ABM) defense idea being pursued was by the Air Force, for shooting down missiles with a bullet. The idea was dropped later on. Using a laser beam or a high energy particles beam was certainly an exotic idea in those days.

However, with the progress in laser technology and the experience gained by building and operating large particle accelerators, it became not only attractive but seemed feasible. That is what had happened. When Reagan became the President of United States, physicist Edward Teller became one of the key figures in selling the star wars concept to his administration. Teller's passionate involvement in weapons of wonderland and his fairly close association with the President finally led to the star wars announcement.

Since that day of March, 1983, when the U.S. scientific and engineering community was called upon to make a major intellectual effort and to change U.S. nuclear strategy, there has been a continuous debate on all aspects of this new and somewhat alluring concept of ballistic missile defense. It apparently seemed for a brief period that the epoch of nuclear warheads and ballistic missiles was coming to an end. The so-called Mutual Assured Destruction (MAD) and detente were going to be the obsolete doctrines of the past.

SDI is born

Shortly after Reagan's speech, the Defense Technologies Study Team (DTST), later called the Fletcher Panel, was formed to reexamine the readiness and the potential technologies with respect to ballistic missile defense. The Fletcher Panel concluded that since none of the problems could be solved with the existing technology, it suggested a major development effort would be needed over an extended period of time. The project was named Strategic Defense Initiative (SDI), and an organization was formed to deal with all research and development on the ballistic missile defense namely, the SDI Organization (SDIO).

In recent months, the debate over the technical feasibility of the Strategic Defense Initiative has focused on two main issues; the software to operate an integrated ballistic missile defense system and the physics of directed energy weapons. The battle over hardware and software is still raging and will continue for some time.

In 1985, at least two well-known scientists were casualties. They resigned, because both of them felt that it is not possible to deliver what SDIO had promised. The issue of reliable software lead to the resignation from the panel of Dr. David L. Parnas, a Lansdowne Professor of Computer Science at the University of Victoria, B.C.; the question of X-ray lasers led to the resignation of Dr. Roy Woodruff, the former director of the X-ray laser project at Lawrence Livermore Laboratory.

In the sequel, I would like to address the software issue while describing the SDI system complexity and the physics of directed energy weapons.

Every ballistic missile defense system must perform at least the following tasks to achieve its goal of neutralizing an attack.

- Target acquisition, *ie*, search for and detection of attacking missiles and warheads.
- Tracking of these objects while determining their precise trajectories.
- Discrimination between real warheads and decoys which are sent to confuse a defensive system.
- Interception, *ie*, the defensive system must be able to point correctly and fire, leading to the destruction of incoming targets.

The technologies

In the SDI concept there are two classes of technologies involved.

The directed energy weapons (DEW). Under this category comes kinetic kill weapons, electromagnetic guns, short wave length lasers, *(ie X-rays and possibly Gamma-rays lasers), microwave weapons, neutral and charged particle beam and long wavelength chemical lasers.*

The supporting systems. All other systems which are not DEWs, come under this category such as sensors, computer and command, control and communication (C3), and the software to run all of these supporting systems.

The development of new sensor technologies is required by the high performance requirement of the signal acquisition in active tracking radars and passive infrared devices. The computer technology and the science of artificial intelligence is critical to all phases of a ballistic missile defense system.

For a ballistic missile defense system, the technologies are evaluated on the basis of their optimal use in a particular flight-phase of the attacking ICBMs. This is because in each of its flight phases, a missile produces different degrees of detectable radiation and its contents of military value, such as number of warheads, decoys and countermeasure equipment, are different. In the initial phase of a flight from the ground silo (or submarine) to orbit, a ballistic missile carries all of its "assets". There are two kinds of factors which effect the detection and the operation of the directed energy weapons. For example, the intense heat produced by the attacking rocket propulsion system is used to detect its flight by the space-based short wave length infrared sensors. The interference effect caused by the Earth's atmosphere on lasers and the Earth's magnetic field effect on the charge particles beams, creates some limitations on the DEW's operation. This is the other influencing factor, which is favorable to the attacking missile.

Detection

The changes in the flight phase affects ease of detection and consequently the value of the target from a defensive point of view. Typically, boost, post-boost, mid-course and reentry are four relevant flight phases. The boost phase, the earliest flight segment lasting to about five minutes, generates an intense heat which can be detected very easily by a space based detection and warning satellite. This part of the flight is considered to be very important because all decoys and warheads are still posed as a single target. However, it is safe at least up to 200,000 feet or so, because laser and particle beam weapons stationed in space are less effective due to their interaction with the high density atmosphere. In this boost phase, the infrared tracking of missile plumes will have to be supplemented by other means to support the sub-microradian aiming requirements.

In the post boost phase the offensive missile spreads MIRV (Multiple Independent Reentry Vehicles) along with decoys and chaffs. Still, the detection is relatively easy because of the heat generated by the maneuvering motors. Once chaffs, warhead and decoys are released and they cool down to background temperature, it is very difficult to detect them by the heat and short wavelength infrared sensors. Only the long wavelength infrared radiation remains to be of any use for detection. Usually, this situation is typical of a mid-course phase lasting between 15 to 20 minutes. In this phase more complex detection and discrimination technology is required.

The next flight segment is reentry into the atmosphere. Because of the intense frictional heat generated by warheads moving in the atmosphere at high speed, the detection and discrimination process is easier. Chaffs and light weight decoys burn up in the atmosphere, leaving only warheads. At this point, extremely quick detection and interception is required as the

flight lasts only 30 seconds to about 100 seconds before a warhead hits its target.

The APS Report

On November 20, 1983, the American Physical Society (APS) commissioned a study to compile and make technical information available to the public. The science and technology of the directed energy weapon was the subject of their scrutiny. The seventeen member commission presented a 424-page report this year. It was reviewed by an APS Council Review Committee as well as by the Department of Defense. The report is unclassified now and is published recently. The APS commission concludes "... the Study Group finds significant gaps in the scientific and engineering understanding of many issues associated with the development of these technologies... At present, there is insufficient information to decide whether the required extrapolations can or cannot be achieved. *We estimate that even in the best of circumstances, a decade or more of intensive research would be required to provide the technical knowledge needed for an informed decision about the potential effectiveness and survivability of directed energy weapon systems."* The report confirms that the physics, the software science in general and artificial intelligence in particular, and many related computational capabilities need a decade or more of progress before they can be applied to directed energy weapons.

The complexity of the star war software reflects in the following statement in the APS report "... The tracking and discrimination of tens of hundreds of thousands of objects during the mid-course phase poses formidable challenges to sensors and battle management computers. If discrimination requires birth-to-death tracking of all threat objects, these problems become even more demanding... Given the present number of Soviet boosters and their capability, the offense can deploy half a million or more threat objects (reentry vehicles, decoys etc.)... Even an 80% effective boost phase defense would leave 100,000 or more objects entering the mid-course phase...".

The Software Issue

Given the complexity and the size of a directed energy weapon based ballistic missile defense system, the software issue is, its reliability and the errors that are likely to remain in any SDI operational software system. This is a fundamental issue because the reliability and effectiveness of the ABM shield against incoming ICBMs depends on its performance as a whole. Assuming that all hardware will become available in the future and that they function properly, the task of designing an error free software remains more than a challenge, especially without any comprehensive and exact knowledge about the characteristics of future weapons.

There is a direct relationship between the size of a software and its reliability. As in any engineering system, the more components it has, the more chances there are for its failure. The number of errors appear to increase almost exponentially with the size of the software. There is a general belief among software experts that there is always some residual errors left in a system of any non-trivial functionality, whatever one may do to remove them. The only way it seems to avoid them, is to prove program correctness, which of course is not possible at present any systems, except those very small in size.

It is estimated that for SDI support software there will be some 30 million lines of code. The Safeguard ballistic missile defense system developed during the period 1969-75 by Bell Laboratories, contains 2,261,000 lines of code including 789,000 lines for the real-time operation. It is common in the software industry to measure the size of a system by the number of lines it contains. The biggest problem is not its size, but the conceptual complexity and the vagueness of its model-of-the-world. In such circumstances, the real-world simulation is almost impossible. Nobody knows what situation will arise in the future. In the world of counter-measures and counter-counter-measures, making assumptions about the model-of-the-world is a matter of guess work. This problem becomes more prominent as one talks about expert systems. For ordinary industrial and commercial expert systems, the knowledge is acquired by interviewing experts in a given domain. In star wars,

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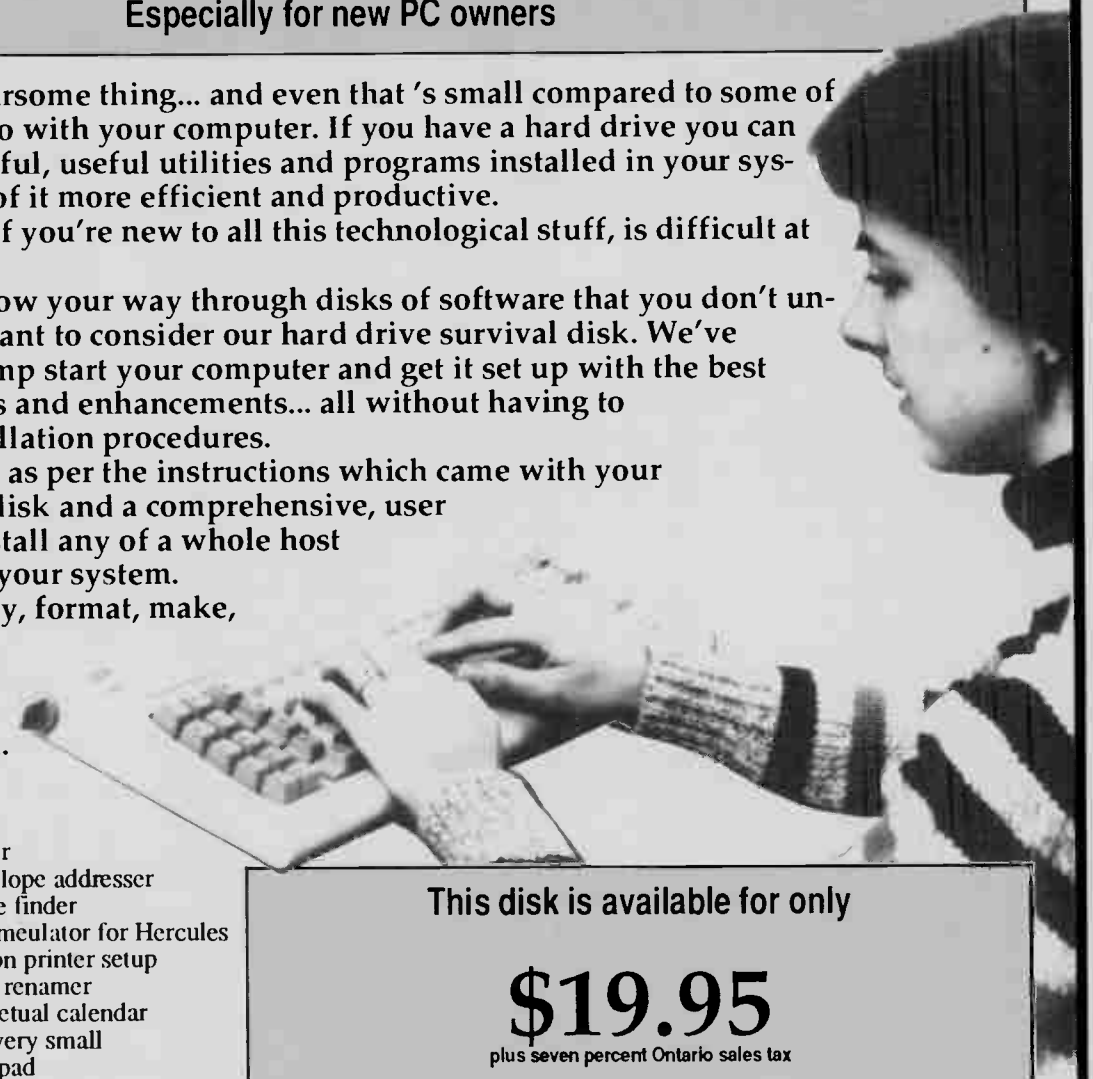

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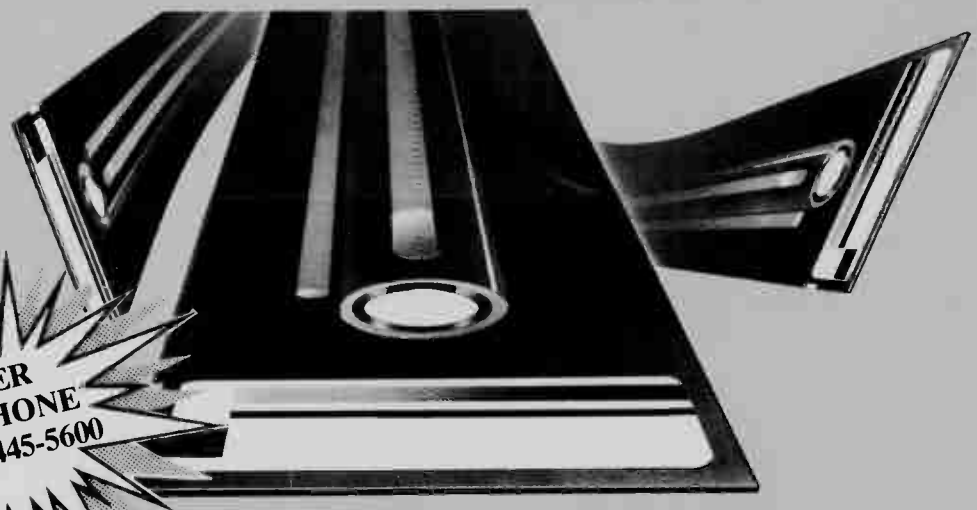

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Relays, silicon controlled rectifiers (SCR's) and bi-directional triodes (TRIACs) have a wide range of applications in electronics today. This book gives tried and practical working circuits which should present the minimum of difficulty for the enthusiast 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 miscellaneous 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, 556 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 fairly recent and have made possible an amazing degree of realism. The projects covered include controllers, signals and sound effects: striboard layouts are provided for each project.

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 BREAD-BOARD 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 deisgned 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.

BP106: 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 $8.00
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.

BP116: 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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Microcomputer Home Study

Two views of the NRI microcomputers and microprocessors correspondence course.

By Frank White

(Editor's note: In his original manuscript, Mr. White gave numerous worked-out examples from the course. For reasons of space, it was necessary to condense the review to the following points.)

Recently I completed a home study computer course with "high distinction". I am now a fully certified computer technician. I even have a fancy diploma to prove it. The problem is, while I now know more about electronics, I don't seem to know that much more about computers today than I knew two years ago when I began the course.

Doubtless you have seen the course advertised in this magazine and other popular computing journals. Although this evaluation applies specifically to the NRI program, I suspect it could apply generally to the two or three other similar correspondence courses that are available in the United States and Canada.

I selected the NRI program because it is well advertised and seemed to meet my goals. I was looking for something more than a programming course. I wanted to learn how computers work. I wanted to improve my understanding of these remarkable mechanical extensions of our brains.

I chose a correspondence course because I had no other choice; it was training by correspondence or no training. Living in a rural community forty miles away from the nearest metropolitan area has its pluses, but educational and cultural facilities are not among them. Moreover, nighttime driving in Canadian winters discourages even the hardiest among us.

Structure and Format

At first glance the NRI program seems to provide a nice balance between passive textbook learning and active hands-on practical applications: forty-nine reading lessons are combined with ten discovery kits. In the process you assemble your own computer. The reading material is sent in batches of two or three booklets at a time with three, sometimes two, lessons per booklet. Each lesson is, on average, 25 to 35 pages in length. For each of the first 45 of 49 reading lessons students are required to answer ten multiple choice questions by penciling in coded boxes on a card. The card is returned to NRI, and two to three weeks later you receive the results. A score of less than six out of ten is unsatisfactory and you must repeat the same test. Additional booklets are sent as you finish the lessons you have previously received.

The procedure with the kits is similar. The first kit is sent after completion of reading lesson seven. Thereafter they are sent intermittently. The computer components kit is sent last of all, after lesson 45, and conditional upon the successful completion of all previous assignments. The kits contain instructions, background reading material and the parts required to build or assemble equipment and to do the hands-on assignments. Students are again required to answer correctly at least six of ten multiple choice questions for each of the ten lessons.

You proceed at your own pace. Support service and help is there if you need it, by phone or mail. NRI provides replacement parts on request at no extra cost, within reason, of course.

So why didn't it work for me, a capable, interested and motivated student?

Criteria for Evaluation

My professional training and teaching experience have convinced me that a course of study is best conceived, designed and presented as an integrated whole. A properly balanced and integrated course of studies has four fundamental characteristics:

1. Clear definition of broad learning goals that answer the question - What should the student know or be able to do at the conclusion of this program that he/she did not know or was unable to do at the beginning?
2. Within the framework of these broad goals, development and presentation of highly specific, measurable instructional objectives for each lesson, again in terms of the results to be achieved.
3. Effective design and delivery of course content to ensure the achievement of goals and objectives.
4. Appropriate course evaluation to measure the extent to which the learner has achieved the objectives.

Flaws of the NRI program

Evaluated in terms of these criteria, the NRI program, in my estimation, does not measure up. Here are its deficiencies:

1. NRI's course is not a unified, integrated, coherent whole because it is modular in design;
2. There is no clear statement of course goals or measurable lesson objectives;
3. Lesson content and presentation is verbose, not indexed to permit easy searching and retrieval, insufficiently supported with informative illustrations, provides no conceptual model of how a computer works, sometimes overlapping and repetitious, sometimes dated or irrelevant, and, to top it all, the central piece of equipment, the computer, is not sent until towards the end of the course; and
4. Evaluation is inadequate and fails to give the learner sufficient useful feedback about performance.

Let's look at some of these inadequacies in greater detail.

NRI's course is not a unified, integrated, coherent whole because it is modular in design.

Upon receipt of the first batch of booklets it was evident to me that the curriculum had not been developed as an integrated whole. Instead, what we have is a set of modularly designed lessons loosely strung together and called a course. By modular I mean that the same lessons are used repeatedly in several different courses; the lessons I studied as part of a computer course are undoubtedly used for other NRI programs as well.

Modular curriculum design may have certain administrative and cost-saving benefits, but only at the sacrifice of course integrity or wholeness and program balance. It is the learner who loses. NRI's modular approach is, in my opinion, a design error and a major flaw of the program.

What is the evidence to support my contention of course unevenness and disunity? Consider this example of curriculum imbalance. Of the 45 reading lessons on which students are tested, fully 18 lessons pertain to the fundamentals of electronics. That's forty per cent of the tested reading course work! One hundred and eighty questions on electronics. Furthermore, 68 of the 100 questions asked in the training kits are also about electronics. In total, then, 248 of 550 questions are about electronics. An astonishing 45% of the course content!

Does one really need to know that much about electronics in order to understand how computers work? I think not. NRI's course content is obviously distorted. One gets the impression that rather than having asked themselves - What do our students need to know and how shall we help them to know it? - NRI people seem to have asked something more along the lines of: what lessons do we already have available from our other programs that we can fit in to a computer course? That may not have been how the course was put together, but it seems that way. How else does one explain the electronics bias?

What about the remaining 31 lessons on computers? Unfortunately, things don't improve. If anything, they get worse. Consider these facts. Of the remaining 270 questions on the reading material, 110 are devoted to only four topics, none of which deserve this emphasis. Here is the breakdown:

- Introductory & concept definition: 20 questions (7.4%)
- Computer arithmetic: 30 questions (11.1%)
- Boolean algebra and logic circuits: 30 questions (11.1%)
- Assembly language: 30 questions (11.1%)

So, the unevenness continues. Worse still, although there is an effort at rational lesson organization, they are not organized as a coherent whole and course overlap and content duplication occur. Once again, this is a result of modular curriculum design.

Training kit material is no better. The question breakdown for 100 questions is as follows:

- Electronics: 68 questions, BASIC language: 1, Computer keyboard: 7, Assembly language: 2, MS-DOS: 5, Computer architecture: 8, WordStar: 2, Computer arithmetic: 1, CalcStar: 2, Misc: 1, Easy Writer: 3.

Conclusion

In retrospect, NRI, and I suspect, others providing similar kinds of correspondence courses, must do the following to correct the flaws:

1. Tighten up, if not abandon entirely, modular program design to provide a course that is an integrated, unified, coherent whole.
2. Formulate course goals and lesson objectives that are clear, concise, measurable and attainable.
3. Revise and rewrite course material so that it is designed to achieve goals and objectives, places less emphasis on electronics, is concise and clear, is profusely illustrated with well-labeled diagrams, provides a framework or model of the computer to enable students to integrate new learning, teaches by analogy, that is, by relating the unknown to the known, provides for systematic review, facilitates the retrieval of information through provision of indexing, and introduces the computer equipment early in the course.
4. Evaluate learning in a way that provides meaningful and useful feedback to the student; evaluation based on the extent to which students achieve measurable goals and objectives.

In addition to this, NRI should consider using the new technology, such as video cassettes and computer software, including CD-ROM technology, in the presentation and delivery of lessons.

NRI Replies

Mr. William Coleman, NRI's Director of Development, replied to author White's review:

Dear Mr. White:

I am very sorry that our course did not measure up to your expectations. While we have many satisfied students and successful graduates, it disturbs us when any of our students are unhappy with their course. And, while I do not entirely agree with your assessment of our course, I do respect your opinions and constructive criticisms. I see you did complete the course which is a sign it did have some rewarding or educational value.

I would like to thank you for taking the time to offer us your suggestions. Some of your suggestions will be considered during the next revision. Some simply can not be considered, such as providing the computer at the front of the course.

Frank, as our catalog says on page 11, the micro course will train you to be a bench or field technician. It is also a valuable training aid if you were going to sell computers, for example. It clearly implies that the course is not a programming course or a computer literacy course. To be a complete computer electronic technician course, it needs to have a considerable amount of electronic training. We would be foolish to offer an electronic technician course without offering the electronics basics from which the course is built. Most of our students seek additional electronic training, not less.

We do not think our course is "modular" in design. Nor is it loosely strung together. I do not know why you object to lessons being used in other courses. The course starts you out in basic electronics and ends up with a logical approach to microcomputer repair.

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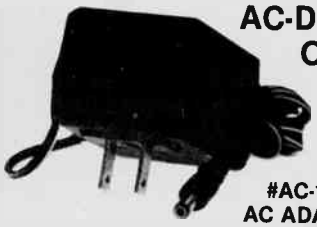

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Flight Simulators and Eye-tracking

The eye-tracking helmet provides a high resolution visual display only where the pilot is looking.

By Carol Thomas

Aircraft simulators are used to train pilots in both commercial and military fields, at great savings and reduced risk to the pilots-to-be. What has been used for this purpose in the past is an array of video screens or large domes and gimballed projectors, either of which is expensive and provides low image resolution. However, the latest development, by CAE Electronics Ltd. of Montreal, is a helmet which the pilot wears which shows computer-generated visual images of the simulated surroundings.

This helmet, called the Fiber-Optic Helmet Mounted Display (FOHMD) system, displays a detailed stereoscopic visual image of everything the pilot would see in the cockpit and outside the plane. It uses advanced head and eye tracking techniques to follow the movement of the pilot's head and pupils, and changes the image accordingly.

One of the newest parts of the helmet is the eye tracker, developed by researchers at the University of Toronto. A team headed by Professor Richard Frecker and Professor Moshe Eizenman, at U of T's Institute of Biomedical Engineering (IBME), developed the tracker, which provides a high-resolution "area of interest" insert within a large, low-resolution field of view. The image-generating computer reads where the pilot's eye fixation is, and generates the high-resolution image only in that area. Previously, only a central section of the field of view was in high resolution.

"We create the illusion that the entire display is in high resolution," said Terry Williams, Co-ordinator of the Eye Tracking Project at CAE. Since peripheral vision input does not appreciate high resolution, the pilot does not consciously notice that the entire field of view is not at the same resolution.

The system uses a low-level beam of invisible infra-red light shone onto the eye. The reflections, changing as the pilot's eye moves, are captured by multi-element arrays, and the information is digitized and processed in real time by a fast signal processing unit. The difference in position between the light reflected from the cornea and the centre of the pupil shows the instantaneous direction of the pilot's gaze. Developments by the IBME team have also significantly increased the speed of signal processing.

Because of the constraints on their head motion in high G- force situations, pilots tend to make large eye movements. The eye tracker can record and analyze accurately up to 500 eye positions per second. Since the human eye can make a 10 movement in 50 milliseconds, previous trackers, which only did 60 scans per second, produced a noticeable delay in the system, which is now absent.

The helmet itself weighs about two kilograms, mostly due to the weight of the optical package, and is custom-fitted to each user. The images come through fiber-optic cables from the main computer, and are corrected by relay-combining optics for size and scale. The helmet display system consists of two 7.5 cm diameter window displays mounted in front of the eyes like eyeglasses, with an optical interface to the fiber-optic cables. The display is semi-transparent, permitting cockpit controls and indicators to be viewed normally, with an instantaneous field of view of 64 vertically by 135 horizontally.

"Simulated flight environments are very important both because of the cost savings, and because it gives an opportunity for pilots to experience dangerous situations and manoeuvres which could be life-threatening in real life," Mr. Williams said.

John Patterson, Manager of Public Relations at CAE, added that "most commercial training is done in the simulator because now the fidelity has reached the point where it can be trusted for training." Commercially, simulators are generally used for the purpose of teaching pilots how to fly new types of planes, he said, while in the military, they are used to fly through a mission in advance, or practice landing, for example, at a new airport.

The cost savings by using the helmet and eye tracker rather than screens and projectors could be up to one order of magnitude, according to Professor Eizenman, since the current installation can cost up to $20 million.

The helmet, which was under development for four and a half years, is currently in use at Williams Air Force Base in Arizona, where the eye tracking system is still being integrated. Preliminary testing should be completed in approximately nine months.

"It might be the way to go in the future," said Professor Eizenman. "The Air Force, as well as everybody else, is very hopeful about it, but there are many hurdles yet to overcome."

Carol Thomas is a freelance science writer from Toronto. ■

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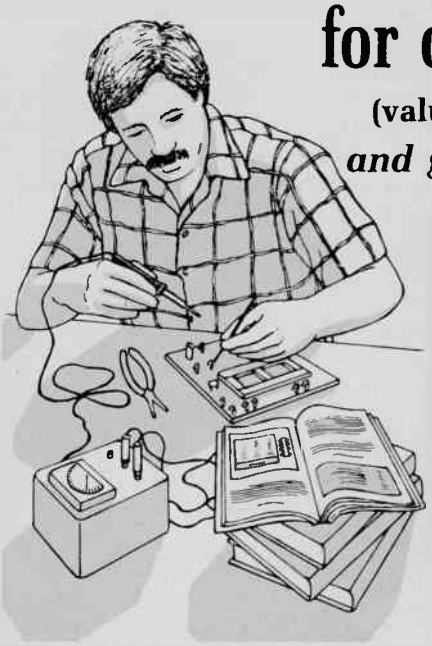

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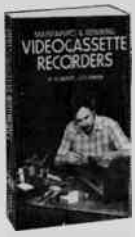

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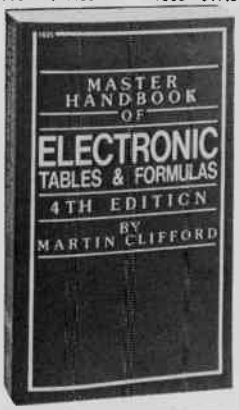

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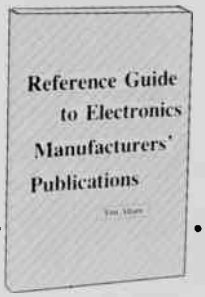

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electronic course? Computers and the peripherals that work with them are all electronic devices which use electronic components and circuits.

I agree with you that you do not have to have an in-depth knowledge of electronics to understand how computers work. However, just knowing how computers work does not give you the knowledge you need to be a good computer technician.

I am surprised that you did not notice the amount of electronics training in the course when you read the catalog. We give complete descriptions of all lessons and kits.

You also mention dated and irrelevant materials that are unrelated to your interests. Much of what we cover is needed by anyone who is training to become a computer technician. It is obvious that this was not your intent. Our catalog clearly points out that the objective of the course is to teach you to service and repair computers. Our ads also state this.

While I am sure that some lessons may be somewhat wordy, I do not feel this is as bad as you say it is. Our writing style has been developed over a long time to be especially well-suited for people studying at home. It is intentionally "conversational" in style to make readers feel more at ease with the lessons. We receive many letters from students and graduates telling us about how much they like our writing style. And, when a learner is enjoying the learning experience, comprehension is much easier.

I am certain there are places where we can improve our explanations. We are constantly revising and improving our lesson materials to make them better. We closely monitor student exam results and letters to try to pinpoint areas where students are having trouble.

I agree with you that an index would be a big help. However, we have not been able to find a practical way to do this. We frequently revise and rewrite lessons to up-to-date and improve them. And, we have many students that for one reason or another take several years to complete their course. Often the lessons and kits are changed along the way. We are on the sixth version of the computer kits in 8 years. We have also made numerous lesson revisions and rewritten the first 18 lessons of the course.

As far as sending the computer at the beginning of the course is concerned, it is just not practical. For one thing, you are not ready for it then. Remember, we are training you to become a technician. Another, and perhaps the most important reason, is that we would probably be out of business within a year. Our courses must be affordable, and most or our students cannot pay for the course all at once. They need to pay for it in reasonable monthly payments. Now, if we were to send out $1000 worth of material at the beginning of the course, with only a small down payment, we would have to go into the finance business. Also, many states have cancellation laws that are based on lesson completion rates. These laws allow the student to cancel at once and owe us only $75. This creates serious financial problems.

We would very much like to offer a computer literacy course that would teach people how to use a computer and would include word processing, spread sheet, file management, etc. However, we have not done so due to the requirements of a computer at the front of the course.

We would also like to use the latest state-of-the-art computer in our training. But, and I believe you will agree, the cost of adding such a machine would raise the course tuition far above what most people could afford. It also takes us about a year to develop training materials for a new machine.

The same problem exists for much of the new educational technology such as CD ROM, video, CAI. It is simply not affordable for the average student. The best educational course is worthless if no one can afford it.

We are also currently reviewing our lesson questions to see how we can improve them. I personally do not like negatively phrased ("the following is not"...) or true/false questions, nor do I like "tricky" questions. However, some questions that may appear to be tricky questions may really be intended to make you think.

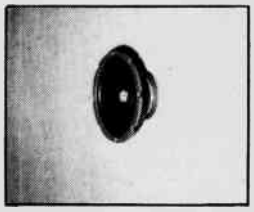
We feel that our course is a good effective training course. We have many satisfied graduates who are successfully using the training in their careers. However, we always feel there is need for improvement and we will be making improvements in some of the areas you discussed in your letter.

Thank you again for taking the time to send us your constructive criticisms of our course. I am only sorry that you feel you gained nothing from it.

Sincerely yours,
William Coleman
Director of Development

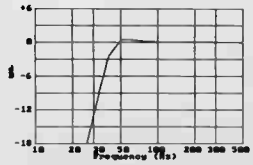
■

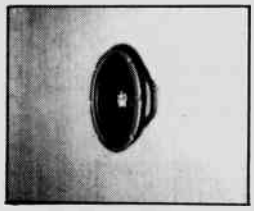
LOUDSPEAKER



CROWN 8" WOOFER

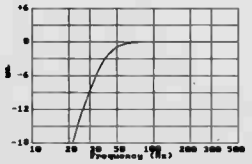
Magnet Weight	20 oz
Nominal Power	80 W
Impedance	8Ω
Resonance	49 Hz
Re	5.23Ω
Qms	3.39
Qes	0.53
Qts	0.46
Vas	1.8 cu.ft.
Box Design	Ported
Box Volume	3.1 cu.ft.
Port Diameter	3 in.
Port Length	1 in.
F3	39.2 Hz
FB	43.9 Hz

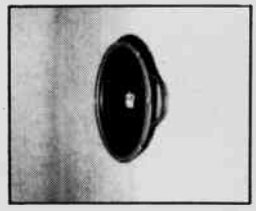




CROWN 10" WOOFER

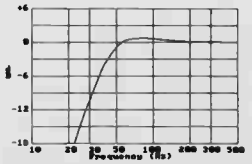
Magnet Weight	20 oz
Nominal Power	100 W
Impedance	8Ω
Resonance	31 Hz
Re	5.47Ω
Qms	4.35
Qes	0.38
Qts	0.35
Vas	7.2 cu.ft.
Box Design	Ported
Box Volume	3.98 cu.ft.
Port Diameter	4 in.
Port Length	3.9 in.
F3	39.4 Hz
FB	35.3 Hz

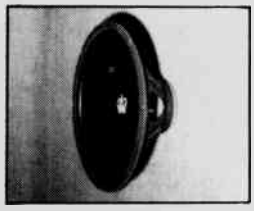




CROWN 12" WOOFER

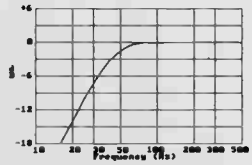
Magnet Weight	28 oz
Nominal Power	100 W
Impedance	8Ω
Resonance	30.5 Hz
Re	5.08Ω
Qms	5.40
Qes	0.39
Qts	0.36
Vas	11 cu.ft.
Box Design	Ported
Box Volume	5 cu.ft.
Port Diameter	4 in.
Port Length	1.8 in.
F3	44 Hz
FB	37.7 Hz

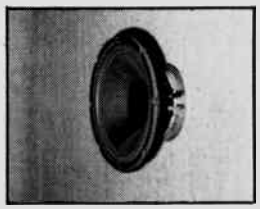




CROWN 15" WOOFER

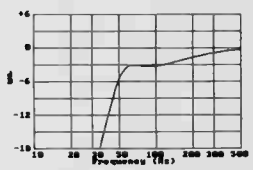
Magnet Weight	40 oz
Nominal Power	150 W
Impedance	8Ω
Resonance	20 Hz
Re	6.3Ω
Qms	4.08
Qes	0.37
Qts	0.34
Vas	26.7 cu.ft.
Box Design	Closed
Box Volume	5 cu.ft.
Port Diameter	N/A
Port Length	N/A.
F3	41.9 Hz
Qt (System Q)	0.759

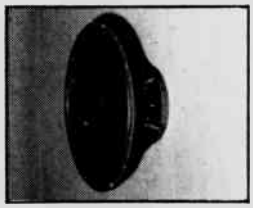




PRO 12" WOOFER

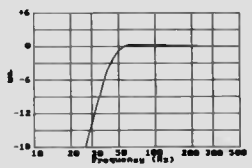
Magnet Weight	90 oz
Nominal Power	150 W
Impedance	8Ω
Resonance	49.5 Hz
Re	5.6Ω
Qms	5.53
Qes	0.27
Qts	0.26
Vas	3.7 cu.ft.
Box Design	Ported
Box Volume	3 cu.ft.
Port Diameter	5 in.
Port Length	2.8 in.
F3	55.2 Hz
FB	52.4 Hz





PRO 15" WOOFER

Magnet Weight	90 oz
Nominal Power	200 W
Impedance	8Ω
Resonance	46.5 Hz
Re	7.1Ω
Qms	5.10
Qes	0.48
Qts	0.44
Vas	8.5 cu.ft.
Box Design	Ported
Box Volume	10 cu.ft.
Port Diameter	10 in.
Port Length	3.2 in.
F3	43.2 Hz
FB	45.0 Hz



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LabWindows

National Instruments announces a new scientific and engineering software system for the IBM PC, XT, AT and PS/2 family of personal computers.

LabWindows features an interactive environment and several libraries for developing software for applications involving data acquisition, reduction, analysis, presentation and instrument control.

The initial release of LabWindows supports applications development using Microsoft C and Microsoft Quick BASIC. Because there is no new language to learn, the user can generate sequences of code by invoking pulldown menus and selecting library functions and parameters with a mouse or keyboard.

The instrument library lets the user perform high-level programming of GPIB instruments without knowing specific details of the instrument or of GPIB programming. A function panel can simulate the front panel of a GPIB instrument and allows the user to program the instrument as though they were using its front panel.

LabWindows also provides a data analysis library, graphics library, and a data formatting library. A library of advanced routines is available as an option and includes digital signal processing, matrix and vector arithmetic, advanced statistics, and curve fitting functions.

The package carries a price of $695 in its standard configuration, and an optional add-on package with advanced graphics and data analysis libraries will be available in the first quarter of 1988 for $1250.

Contact David Green, Allan Crawford Associates Marketing, 5835 Coopers Avenue, Mississauga, Ontario L4Z 1Y2 (416) 890-2010.

Circle No. 57 on Reader Service Card

Continued on page 59

Billion-Byte Disc Drive

Control Data has recently announced the computer industry's first billion-byte, eight-inch data storage device.

The Sabre 1230 quarter-rack disc drive has a total capacity of 1,236 million bytes and features a transfer rate of 24.19MHz (3.02MB/sec), an average seek time of 16ms an uses both thin film media and thin film heads. Optional interfaces available will be SMD, IPI-2, or SCSI.

The Sabre 1230 was recently shown at the Fall COMDEX show in Las Vegas.

WordPerfect Course

Waterloo Distance Education Inc., has announced the release of an interactive course on WordPerfect from FlipTrack Learning Systems.

The course is contained in 4 audiocassettes and takes the first time user through creating, editing printing and merge printing a variety of documents.

Waterloo Distance Education Inc., 279 Weber St., #17, Waterloo Ontario N2J 3H8 (519) 884–4340

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Continued from page 43

SDI: The Battle of Software and Hardware

there are no experts who have gone through the experience of many star wars and "survived" to tell us what the "rules-of-thumb" are to deal with that kind of situation.

Thus, the fundamental issue is that there is no way to construct a model-of-the-world which fully represents the expected star war scenario realistically. One encounters this same dilemma in the DEWs hardware design.

What is needed to solve this problem? I think research on the psychology of warfare leading to the conceptual model of measures and countermeasures would be useful. Application of such a model, whether to star wars or some other situation of conflict, can be of great help in the design of a system for unpredictable conflict situations. Essentially, there is a need of a conceptual model (in computational-terms, a paradigm) on how an enemy will use countermeasures; a kind of model where two wise men are trying to fool each other. Obviously, it will involve many orders of interaction between the two parties, involving countermeasure, counter-countermeasure and so on.

The SDIO Panel on Computing, realizing all these problems, proposes to solve the software reliability problem in many different ways. For instance, they want improvement in computing hardware so that there is no need to use programming tricks in lieu of processing power. They also want to increase redundancy and the use of distributed architecture. Thus, basically their philosophy is now conceding that "All systems of useful complexity contain software errors". The fundamental question now is "how to design this system such that errors are first minimized and then tolerated". The computing panel does not expect that traditional software engineering can meet the requirements of the Strategic Defense Initiative Battle Management System, and they recommend new and innovative approaches. The final outcome is that the Reagan administration has to decide whether they want a less-than- perfect anti-ballistic missile shield. Obviously, that was not the original promise.

Hardware gaps

Coming back to the battle of hardware, according to the American Physical Society report, all existing candidates for DEWs require many orders (powers of 10) magnitude improvements in power output and beam quality before they can seriously be considered for ballistic missile defense systems. The same kind of improvement is required for most of the supporting technologies, *eg*, sensing, tracking and discrimination etc. The much debated nuclear-pumped X-ray lasers are currently under active research. The APS commission considers the X-ray laser potential in ballistic missile defense uncertain. On the other hand, particle beam devices for either neutral or charged particles is considered to be more attractive due to the existing knowledge and operational experience of particle accelerators. However, a significant improvement beyond their present level of performance is required without any doubt.

Again, the same caution is prescribed for the supporting technologies such as rapid steering of optical beam, or tracking with high precision. The proposed supporting technologies are

recommended for study as well, before they can be considered for the ballistic missile defense. On the other hand, the technical problem for countering DEWs, including a direct attack on them, is less difficult and does not require many orders of magnitude improvement in their performance as is the case with the directed energy weapons. For the Soviets, the problem of countering SDI is less difficult than its development and deployment by the American.

Now we come to the requirements for directed energy weapons to be a successful defensive system. For boost and post-boost phase operations, sufficient weapon energy, beam quality, pointing accuracy and retargetability to deliver lethal doses of energy within the available time is vital. Also, an accurate detection and localization system is required. The requirements during the mid- course phase are detection, reliable means of discrimination and tracking of very large number of object simultaneously, as well as rapid retargeting and sufficient energy from the DEW to destroy many targets. The American Physical Society committee does not expect directed energy weapons to play any important role in the terminal phase of the missile trajectory.

Orbital elements

With respect to space-based or orbital elements a fairly large number of nuclear reactors and other means of electrical power supply are required for housekeeping functions. Also, during an engagement adequate burst power is essential. Space-qualified reliability of all components and subsystems on the space platform, notwithstanding long periods of dormancy, is essential.

The system survivability is one of the major issues. All directed energy weapons must be able to operate in a hostile environment during a conflict. The DEWs must be integrated in an overall system that includes a survivable command, control and communication and intelligence system.

After examining all these issues in detail, the commission has reached the following major conclusions.

For chemical lasers the output powers at acceptable beam quality need to be increased by at least 10 times for Hydrogen Fluoride/Deuterium Fluoride lasers, and 100,000 times for Iodine lasers for use as an effective kill weapon in the boost phase. At least 20 million watts of power is needed for the least demanding strategic defense application. Chemical lasers face a special set of problems arising from vibrations and the exhaust of the burnt fuel in space. Similarly, the pulse energy from Excimer lasers needs improvement 10,000 times over that currently achieved value. Many other advances are needed to achieve the required repetitive pulsing of these lasers at full scale. The ground-based Excimer lasers must produce at least 100 megajoules of energy in a single pulse or pulse train with a total duration between several and several hundred microseconds. For thermal kill 1 billion watts of average power would be required. Not only that, a ground-based free electron laser should produced an average power about one billion watt and peak powers of 0.1 to 1.0 trillion watts, but for SDI application several physical concepts need validation.

Similarly, nuclear-explosion-pumped X-ray lasers require validation of many of the physical concepts before their application to SDI can be evaluated. The neutral particle beam (NPB) accelerators must be scaled up by 100 times in voltage and duty cycle. There is another problem with the charged particle beam due to its deflection in the Earth's magnetic field. High- energy electron beam requires propagation in laser-created plasma channels in order to avoid beam deflection. The laser needed for the creation of plasma channels requires development. Also, other factors are in need of scaling-up by many order of magnitude, such as accelerator voltage, pulse duration and the average power.

The dynamic phasing of arrays of telescopes requires extensive hardware and software development in order to obtain large effective aperture optical systems. The large primary mirrors are vulnerable in space-based optical systems and there is need for a cooling system and very low absorption coatings. To deal with the weather problem and cloudy times, ground-based laser systems for ballistic missile defense applications need geographical multiplicity and techniques for correcting atmospheric propagation aberrations. The APS commission concludes that the ground-based laser systems will require either linear or nonlinear adaptive optics of a very sophisticated nature in order to pre-compensate the laser beam for atmospheric aberrations caused by atmospheric turbulence and by thermal blooming induced by the laser itself. This technique requires an extensive computational capability and software of high complexity. Detection and acquisition of ICBM launches will pose stringent requirements for high detection probability and low false alarm rates.

■

Toshiba 5100 Portable

Toshiba's high performance, 16MHz, 80386-based portable computer features the following: a built-in EGA display with a high resolution gas plasma screen and EGA/CGA ports; four grey scales with 640 x 400 bit-mapped graphics; 82-key keyboard with embedded numeric and dedicated cursor keys; RS232, selectable parallel printer/5.25 inch floppy disk drive are included as well as a port for an optional, external 101-key AT style keyboard. The power supply operates at 110/240VAC and is autosensing. MS-DOS 3.2 is also included.

Options include an internal 1200 Baud Hayes-compatible modem, external 5.25 inch floppy drive, expansion card and chassis which houses up to 5 IBM-compatible cards.

The price? $11,499.00.

Contact: Julie Tipton, Marketing Specialist, Computers, Information Systems Division, 191 McNabb Street, Markham, Ontario L3R 8H2.

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DTP DESKTOP PUBLISHING DIGEST

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ODIN 1 Professional Mouse

Sak Data Products Ltd. has introduced the ODIN 1 Professional Mouse from Moniterm.

The ODIN 1 is the ideal input device for high-end CAD and desktop publishing workstations. It combines mechanical tracking and optical encoding for maximum precision, durability and reliability. Any user of large screen high resolution monitors such as Moniterm's popular Viking 1 will benefit by using this opto-mechanical pointing device.

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Moniterm RT 6155 Graphics Display Monitor

IBM RT system users now have a 19" hi-res monochrome monitor availabe to them. Based on Moniterm's popular VY monitor, the RT6155 will plug directly into the IBM 4768 Extended Mono-chrome Graphics Display Adapter. Featuring a format of 1024 x 768, refeshed at 60 Hz, the RT6155 displays flicker-free black and white images. The large RT-6155 screen addresses a variety of applications such as desktop publishing, windowing and multiple terminal emulations.

Circle No. 23 on Reader Service Card

Monolithic MSC 4940 8MB JustRAM/AT

Sak Data Products Ltd. has introduced the MSC 4940 8 MB memory expansion board from Monolithic Systems Corp. The MSC 4940 is an expansion memory board providing up to 8 MB of memory for the IBM PC AT or compatible in a single slot. The MSC 4940 meets Lotus/Intel/Miscrosoft Expanded Memory Specifications (LIM/EMS) and is fully compatible with Intel's Aboveboard software. Expanded memory in a DOS system greatly increases the speed of software packages such as Windows, 1-2-3, Symphony, Framework, Supercalc, and others which adhere to the LIM/EMS. The board operates at 12 Mhz within wait-states or 8 MHz with zero wait-states.

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Sak Data Products Ltd. introduces the MultiTech MultiCom 3270 terminal emulation system. Occupying one slot, the MC3270 fits right into the IBM PC, XT or AT and compatibles. This allows users to communicate with an IBM mainframe computer as a full featured 3278 or 3279 type terminal or function as a standalone personal computer.

Connection for file transfers between IBM mainframe and personal computer is through type-2 co-axial cabling from IBM 3174, 3274 or 3276 cluster controllers.

The MC3270 is IRMA compatible, and runs a number of industry standard 3270 software packages.

The Multitech MultiCom 3270 terminal emulation system is an economical way to better utilize personal computers in a mainframe environment.

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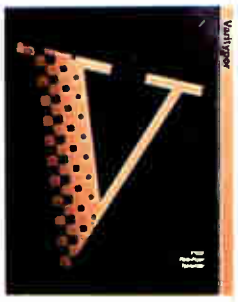

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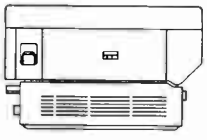

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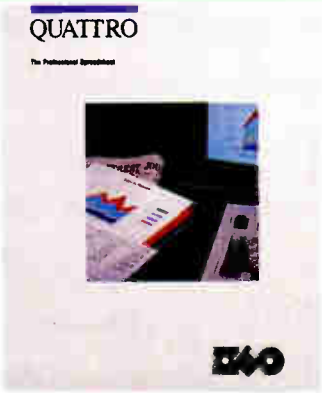

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