

ETI

for Electronics & Computing Enthusiasts

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Electronics Today

February 1984

INTERNATIONAL

Product Review: Hitachi VC-6041 Storage Scope



Flash Sequencer
Multiple exposures



Supply Protector
Simple computer backup



Travelling Wave Tubes
Amplifying microwaves



Computer Review
Columbia 1600

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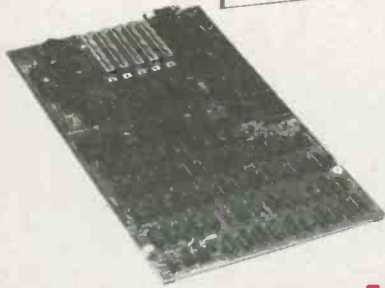
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COMPONENT NOTATION AND UNITS
We normally specify components using an International standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be widely used everywhere sooner or later. ETI has opted for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

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

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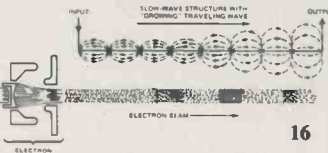
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Our Cover

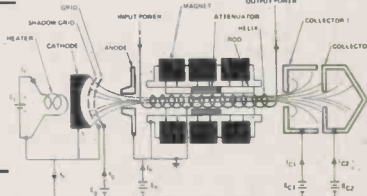
The Hitachi VC-6041 Scope is reviewed on Page 30. Photos by Bill Markwick. The Columbia computer is reviewed on Page 37. Photo by Steve Rimmer.



10



16



26



30

Features

10 Flying Clocks
Time flies, and these clocks are phenomenally accurate, as James W. Essex reports.

16 The Potent Helix
Roger Allan reports that travelling wave tubes amplify up to 2 GHz and make super tweeters.

26 Designer's Notebook
The Hall Effect. A handy way to join rooms.

30 Product Review:
Hitachi VC-6041 Scope

37 Computer Review: Columbia 1600
The Wired City goes IBM-compatible.

43 Colossus
The first large computer cracks the Nazi code.

46 Designing Micros, Part 6.
I/O circuitry.

58 Book Review:
Megabucks From Your Microcomputer

62 Computing Today:
More on Assemblers

Projects



24 Supply Protector
Chivalry is not dead; protect your 5V computer supply against the fearsome Brownout.

32 Flash Sequencer
Make multiple exposures using four camera flashes and keep your photo store owner smiling.

40 R/C Substitution Box
Dwight Patrick returns with a low-cost, simple unit for your testbench.

64 More Pop Amps
Handy circuits for learning or experimenting.

Columns, News and Information

For Your Information ..	6	Fun of Electronics	36
Next Month	14	Back Issues	48

ETI Binders	51
Product Mart	54
Order Form	59
Subscriptions	60
Tech Tips	68
Specials	69

for your information

Brother Update

No sooner did we complete our review of the Brother EP20 electronic typewriter (Dec. ETI) than they announced the new EP22. The EP20 has been expanded to include a 2K memory buffer and an RS232C interface which allows it to become a printer for your personal computer. It still retains the correction buffer and LCD readout that allows you to correct mistakes before they're typed. It works on flashlight batteries or an AC adapter, and seems to be one of the lowest-cost ways to get yourself a computer printer. Judging from the EP20, it should be a winner.



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

Systems Mart

Located a 6900 Airport Road, Mississauga, Ontario, Systems Mart is a large complex serving the computer marketing industry. In the photo, Bud Rodda, general manager of the Mart, and Helen Briggs, project director, welcome David Whiteside, President of Lanpar Technologies Inc., following the announcement of his involvement with Systems Mart. The Mart offers a total of 256,000 square feet, including 15,000 square feet of meeting and seminar facilities. The complex includes many other of Canada's business system dealers.

International Resource Development, 30 High St., Norwalk, Ct., has come out with a comprehensive study of the supply/demand situation regarding communications satellites. According to the report, the demand for channels is slightly ahead of the supply of new transponders, and this will inevitably mean a rise in prices, perhaps as much as 30 to 40%. Of course, this trickles down to you and me. That's what we're here for. The matter will be worsened by the channel demand of the direct-to-home satellite broadcasting system now in the works. Watch for a future issue of ETI for Roger Allan's coverage of direct broadcasting.

New Microphone

The most significant effect of using a PZM (Pressure Zone Microphone) is the fact that distance and angle of sound source from the microphone make virtually no difference to the quality of pickup. It has a hemispherical pickup pattern and any sound source within that hemisphere will sound "on-mike", without that familiar and annoying "hollow" sound of traditional microphones. The PZM can thus be placed on the floor, desk, wall, ceiling, table, or anywhere sound can be best captured, and deliver clear, distortion-free reproduction. And its low-profile design makes it better to use where traditional types of microphones would be obtrusive or unsightly. PZM technology results in increased clarity and range, whether used in a small room or on a large stage, for a single speaker or a large vocal or instrumental group. Frequency response is 20-18,000 Hz at 600 ohms, and it will accurately reproduce sounds up to 135 dB pressure level. It requires an "AA" battery. The Realistic PZM microphone (33-1090) is available at any Radio Shack store or participating dealer for \$46.95.

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for your information



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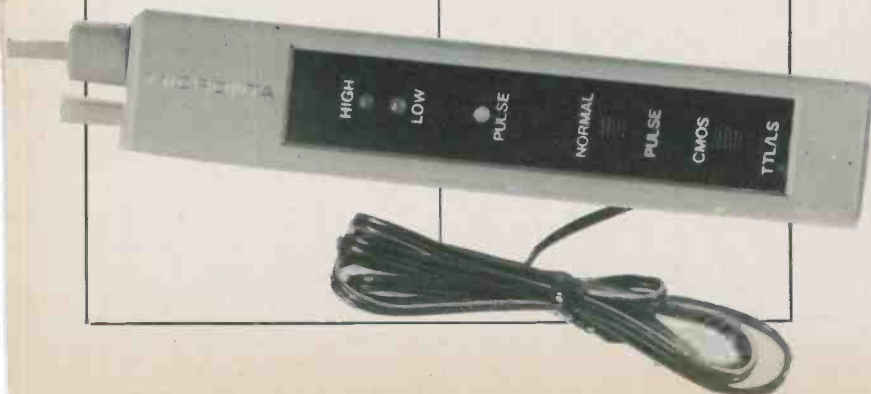
A new low-cost wide range digital tachometer designed for AC powered panel mounted applications has been introduced by Metermaster. The instrument operates from a wide range of optical or proximity sensors providing one pulse per revolution. The ACT-1 is direct reading to the nearest RPM over the range of 50 to 20,000 RPM on a 4½ digit .4" high LED display. For low speed applications, the instrument may be switched to read to the nearest

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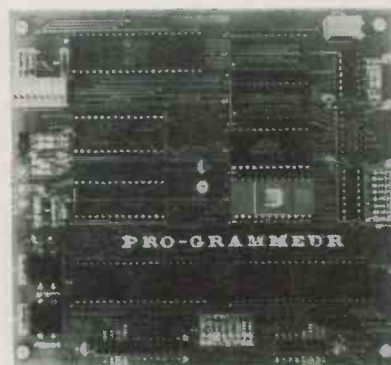
Low Cost Daisywheel

Canadian General Electric will market a new daisywheel printer priced at \$949. The model 6100 printer, manufactured by Tokyo Juki, has a printing speed of 18 characters a second. It uses standard daisywheels which can be dropped into place. The ribbon too is an easily installed, easily obtained IBM selectric type. The operator can select printing at 10, 12 or 15 characters per inch or proportioned spacing by means of a switch. Both horizontal and vertical tabbing is standard, as is half line spacing. Graphic mode, forward or reverse paper feeding and

unidirectional or bidirectional printing can be selected. A new feature of the model 6100 is that the printer head is moved by a linear motor.

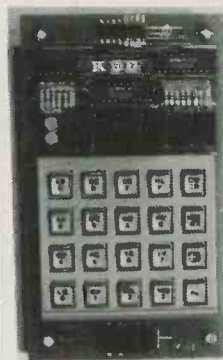


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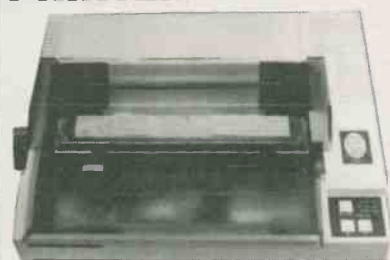
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Flying Clocks

Are you the proud owner of one of those watches that are guaranteed to be accurate to within a second per year? Prepare to turn green with envy as James W. Essex looks at world time standards.



IF SOME DAYS seem longer than others, don't blame yourself — they could be longer. In June of 1982, for example, was "the longest day of the year", by exactly one second.

The leap second was inserted just before 8 p.m. on June 30, 1982, because atomic clocks had gotten slightly out of whack with the earth's rotation.

"The earth's behaviour is erratic," explained Collier Smith of the National Bureau of Standards in Boulder, Colorado. "Since we can't do anything about the spinning of the earth, we have to adjust the atomic clocks."

The leap second was ordered by the International Bureau of Time, in Paris, of which the United States and Canada are members.

One second is defined internationally as the time required for 9,192,631,770 vibrations of the Cesium 133 atom. For the last 10 years or so, the discrepancy between the second that is defined atomically and the second that is defined by the earth's rotation has amounted to about one second a year. Except for 1980, leap seconds have been added to every year since 1972. Canadians have been time conscious for nearly a century.

For us, it all began ninety years ago when a Canadian engineer, Sir Sandford Fleming, first published a proposal to divide

the earth into time zones. This was the first real attempt to bring some degree of order to what was then a chaotic situation. In 1884 the U.S. and Canada adopted the idea of standard time from which our present time zones (Atlantic, Eastern, Central, Mountain, and Pacific) are derived.

The more recent move by the British to tie their clocks into Western Europe shows how arbitrary "time" can be. They have long related local time to Greenwich, where zero meridian runs through that community near London, and to which all time is referenced. For the traveller, keeping time exerts

itself in practical ways that most of us are aware of. Going east, you advance your watch an hour in crossing a time zone. Going west, you do just the opposite and "take off" time. If you go far enough west you cross the International Date Line — clear into the next day! This invisible "line", located at longitude 180 degrees, runs from the north to the south Pole, bisecting the Pacific Ocean. Going west, you skip a day; going East, you repeat a day. You don't seem to get "psychologically untangled" until you return.

These time tricks are nothing compared

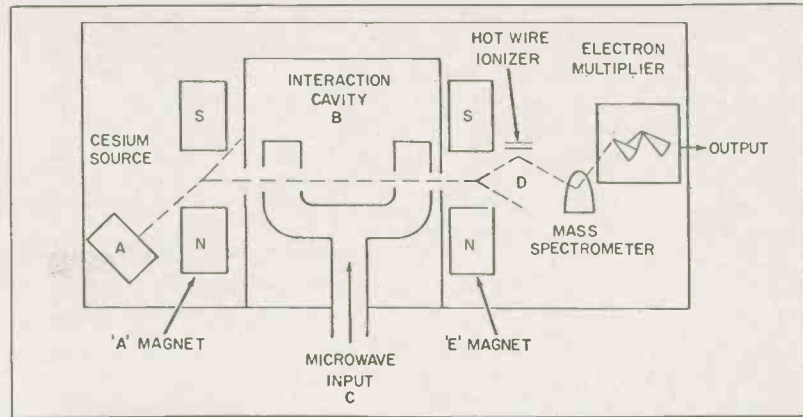


Figure 1: A Cesium-Beam Resonator

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Flying Clocks

to the difficulties placed on man when considering the smaller fraction of time — the second. To bring the interval of time between seconds to an accuracy approaching a billionth of a second or better, is work. But it pays dividends in useful applications! The early advocates of time standards likely never envisaged the wide use that the smallest increment of time, the second, would find.

Radio Time

It's not too long ago that the first accurate time signals were produced, with the generally wide acceptance of radio waves as carriers. It's been said the regular transmission of the time signal from the Eiffel Tower in France in the early part of this century was one of the wonders of the world!

To have time accurate to a fraction of a second wherever you are, you can do one of two things: be dependant on radio propagation of accurate time signals from stations such as WWV in the U.S. and CHU in Canada, or have at hand an independent "local standard" with an accuracy equal to or better than the radiated signals. Up until recently this was not easily done — even if cost wasn't involved — because science wasn't advanced enough to make it possible.

In the early use of radio time signals, a knowledge of the time delay inherent in radio waves between transmitter and receiver was an integral part of the system. The navigational aid Loran uses the delay factor of radio waves in a system whereby the difference in time from two known locations (usually fixed land stations a known distance apart) allows a ship at sea to determine its exact position merely by the delay interval between the two signals! This demonstrates an indisputable fact: that the time delay imposed by radio transmission puts limitations on its use for carrying accurate time signals.

to the location where time comparisons are to be made. Because they are relatively compact as well, they can be shipped via aircraft to any part of the world. These Cesium Beam Frequency Standards are referred to as "flying clocks" by Hewlett-Packard, the manufacturers.

“Flying clocks” eliminate the problem of time delay in radio transmission, because you carry your time with you.”

How do they work? First, something of the basic construction. As seen in Fig. 1, the primary source of the signal, whose accuracy is 1 part in 10^{11} , is from a Cesium 133 atom. In the Cesium beam resonator a beam of cesium atoms is generated at A. Atoms at a particular energy state enter the cavity B. Here, they interact with a microwave field developed from a quartz crystal source C. The interaction of the two causes some atoms to "flip", or undergo transition to a different energy state. These are directed by the second set of magnets at E to the hot wire ionizer where they are given a positive charge. Passing through a mass spectrometer at D, they reach the electron multiplier which boosts the output to usable levels, which control the frequency control loop of a quartz oscillator.

Though a crystal is used as a frequency source, it is maintained accurately by the beam-tube resonant frequency. Because of this, the long-term stability of the standard is high. Final alignment can be done without reference to any other standard as the cesium-beam standard itself serves. It thus becomes a primary frequency standard with a high order of stability. Because it is relatively compact, the complete unit can be

clock going around the globe in a westerly direction and the other going east as far as Europe and return, they covered 25 time-keeping facilities including the Tokyo Observatory in Japan, the Royal Greenwich Observatory in England, the Swiss National Observatory, National Research Council in Ottawa, and the National Bureau of Standards in Boulder, Colorado. It is believed to be the first time a system of two mobile clocks maintained time in mutual agreement to within a microsecond in independent operation. They were checked when they crossed paths in Switzerland and again with the "house" standard at their home base in Palo Alto, California.

The experiment confirmed the accuracy of the official Swiss and U.S. time scales. Correlation between the two countries had previously been done using high frequency radio signals with a precision of only about 1 millisecond.

Worldwide Slowdown

With precision time come new aids to man. Among these, and perhaps the most exciting, is the locating of satellites in their proper orbit. The old standard second, based on the earth's rotation in a 24 hour period of 86,400 seconds, has actually been found wanting. More precise methods have shown that the earth is actually slowing down! Thus, the interval between successive seconds, however slight over several years, is nonetheless there. It is of little use as precision time when time intervals within one hundred billionths (one part in 10^{11}) of a second are involved. Orbital placement of satellites is a time oriented procedure, and accurate time is of the essence!

It is interesting to note that permanently installed laboratory constructed "long-beam" cesium standards (of which the "flying clocks" are mini-versions) are located at various locations around the globe. They have been verified as primary frequency standards of extremely high accuracy. For example, the use of the portable Flying clock enabled a check to be made between the 4 meter cesium beam standard of the Swiss Horological Research Lab and the one at the National Bureau of Standards in the U.S. They were within 1 part in 10^{11} (or one hundred thousand million). Most of the world's frequency standards now use cesium-beam resonators as an absolute reference. Canada also has a "long-beam" resonator, at NRC Ottawa, and it similarly agreed with the travelling clocks.

Next time you hear the Dominion Observatory time signal at 1 p.m., you can rest assured that it is about as accurate as any time known — past or present! The CHU frequencies are synthesized from a rubidium frequency standard, in turn reference to the Canadian cesium standard daily. CHU may be received on 3.33 MHz, 7.335 MHz and 14.67 MHz.

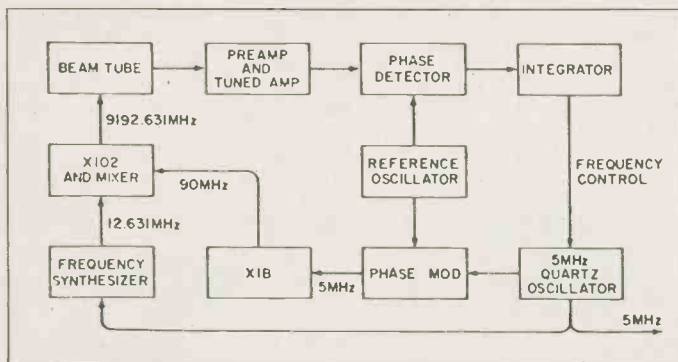


Figure 2: Block diagram of a "Flying Clock".

Cesium Time

A newer and more accurate time source has now been introduced, which eliminates this problem because you carry your "time" with you. By making the standard light in weight and portable, it can be carried right

carried easily and airlines can transport the unit, all the while functioning, to almost any location on earth (as shown in our heading picture).

Some years ago a pair of these Cesium Beam Frequency Standards were used in a round-the-world experiment. With one

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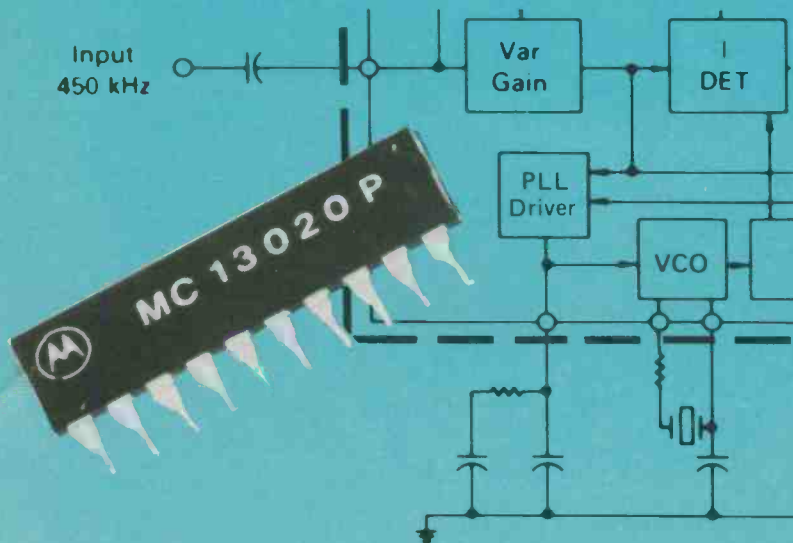
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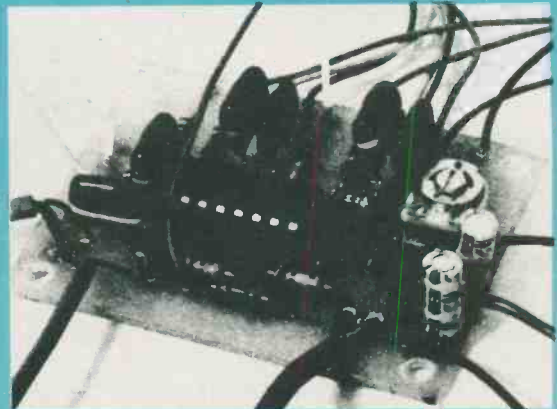
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AM Stereo

For years now, AM has been regarded as being fit only for news and for that kind of music that to many is not music at all. FM was the only mode of wireless high fidelity available. That's changed now, thanks to some good old Japanese know-how, not to mention a bit of American corporate warfare.



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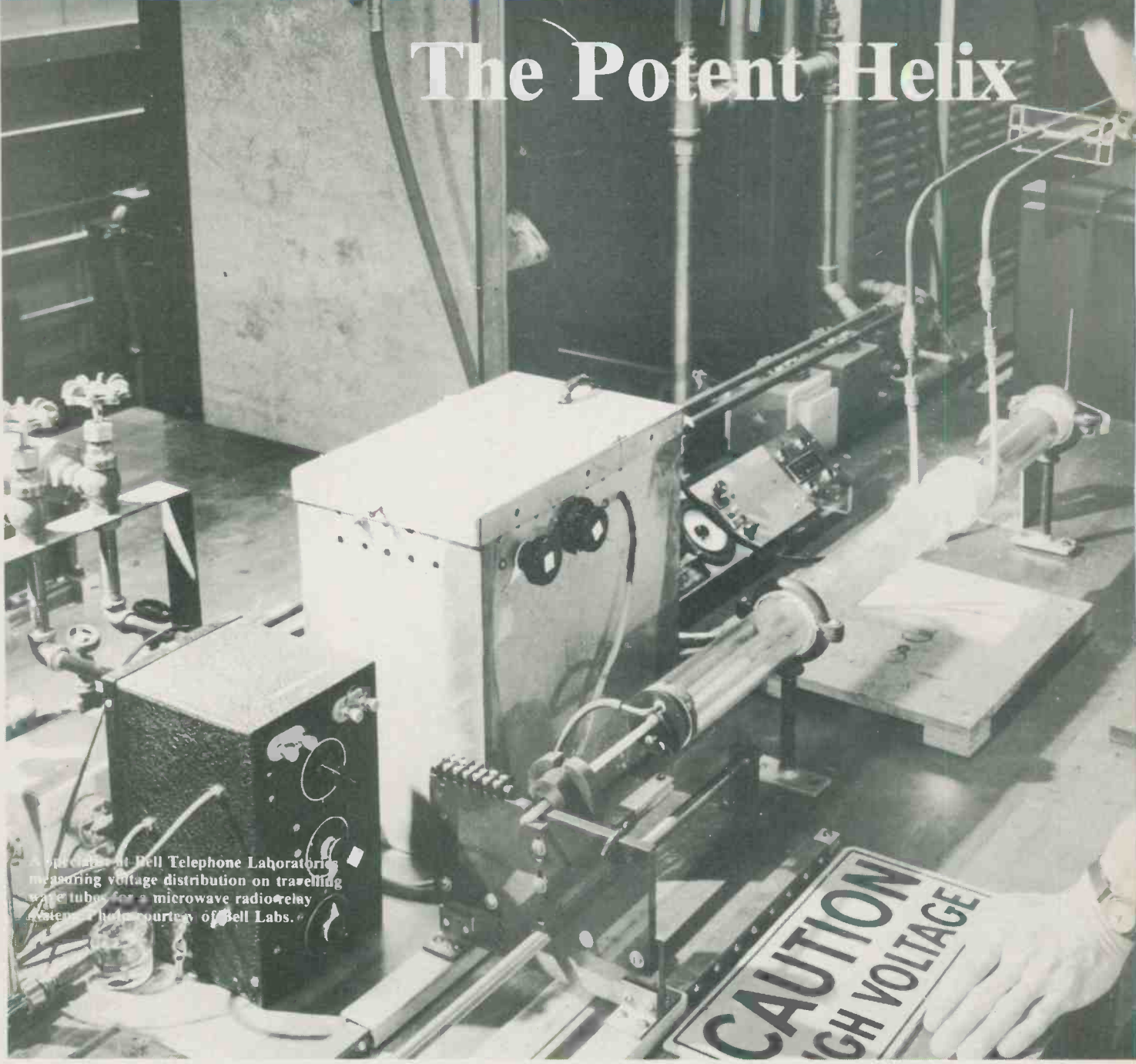
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A specialist at Bell Telephone Laboratories measuring voltage distribution on travelling wave tubes for a microwave radio-relay system. Photo courtesy of Bell Labs.

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The TWT is not a new device. Its remarkable capabilities and some of its potential applications have been known for more than thirty years, ever since it was invented during the latter part of World War II by an Austrian refugee, Dr. Rudolf Kompfner, while working on microwave tubes for the British Admiralty at the Clarendon Laboratory at Cambridge.

The TWT was not utilized during the war and remained an experimental laboratory device until the first practical tube was developed by J.R. Pierce (now Professor Emeritus of Electronics at Stanford) and L.M. Field at Bell Telephone Laboratories (BTL) in 1945, with first publication of the data in 1947.

From 1945 to 1950 most of the development work was done at BTL and Stanford University. The efforts were relatively low key. Meanwhile, the military services had other potential applications in mind — specifically radar and electronic countermeasures. The development of radars during World War II had been rapidly followed by the development of countermeasure techniques to deceive and jam them (see "History of Radar", ETI, May 1983). The evolution of new radars in subsequent years has therefore been particularly predicated by continuous need to stay ahead of any new countermeasure tactics which might compromise the radar's effectiveness. The trend has been toward much higher powers and toward new techniques which would have the effect of increasing visibility even while being jammed. A good anti-jamming radar must be able to shift frequency over a wide

bandwidth quickly to avoid dwelling on the jamming source frequency.

Similarly, the trend in countermeasures has been toward wide bandwidth system capabilities where the jammer amplifies wideband noise, or may deceptively retransmit the hostile radar pulse to offset the radar's ability to determine the target's position or track.

Since wide frequency bandwidths are essential to the employment of all these tactics, an amplifying device capable of broad operating ranges with sufficient gain, output power and efficiency is needed, and the TWT is ideally suited for the job.

Spin off developments from the military are in the area of space applications where TWTs and Travelling Wave Tube Amplifiers (TWTAs) have been used in scientific experiments, manned missions, and commercial communication applications including Syncom, the ATS series, Intelsat, Alouette, Hermes, Project Galileo, the Saturn mission, DSCS-III, the Space Shuttle, and TDRSS programs. Terrestrially, TWTAs are used in point-to-point microwave systems, so much so that one wag remarked that a microwave relay station is nothing more than a receiving antenna, a TWT, a battery, and a broadcasting antenna.

How to Make One

One of the great beauties of the TWT is its simplicity. Essentially, a TWT is an RF amplifier which consists of an electron gun, a slow-wave structure, a collector, a beam focussing structure, a vacuum envelope, and a package or housing. It is customarily integrated with a power converter which accepts a single voltage from a power bus and generates the various voltages required. The combination of a TWT and its power converter is called a Travelling Wave Tube Amplifier or TWT.

The first element is an electron gun. Its purpose is to generate an electron beam, and constitutes the basic mechanism of RF amplification in the TWT. It consists of five parts: a cathode, heater, focus electrode, and one or more anodes.

The emitting surface of the cathode is much greater than the required cross-sectional area of the electron beam entering the slow wave structure. This is called area compression and allows the electron beam to have the high current density which is necessary for efficient TWT operation while keeping the current density at the cathode emitting surface at the relatively low values

The Potent Helix

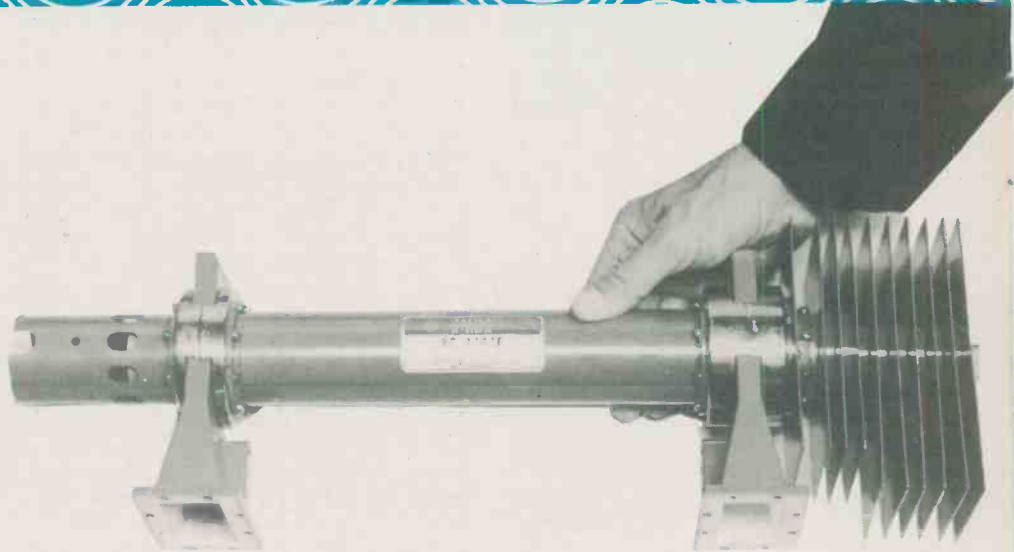
which are required for long-life cathodes. Typical values for the area compression ratios are from 15:1 to 50:1.

Customarily, two types of cathodes are used. The oxide cathode type operates at temperatures in the range of 650°C to 750°C and can provide emission current densities up to about 300 milliamperes per square centimeter. The impregnated or dispenser cathode operates at temperatures in the range of 750°C to 1200°C and can provide emission current densities up to about 6 amperes per square centimeter. The current densities are therefore directly related to the operational temperature, with the temperature being increased if the emission current density obtained from the cathode is to be increased. The life expectancy of the cathode is also temperature dependent, with evaporation of the active material from the cathode surface increasing as the operating temperature increases.

Wound in a bifilar manner, the heater brings the cathode up to operating temperature. It is wound in this fashion so that no appreciable amount of magnetic field will be introduced into the electron gun by the heater current. Any introduction of a magnetic field into the electron gun would result in difficulty in electron beam focussing, particularly in TWTAs having large compression ratios which are particularly sensitive to magnetic perturbations.

Out of Focus

The focus electrode surrounds the cathode and controls the electrical field near its surface. The size and shape of this electrode is chosen to cause the electrons to leave the cathode on the proper trajectories and to converge into a well-defined electron beam as they pass through the anode. Usually, the focus electrode is electrically connected to the cathode within the electron gun, but in some cases the focus electrode connection is brought out so that a bias may be applied. This bias on the focus electrode can then be used to turn the electron beam off or to control the current in the electron beam. TWTs used in pulse applications, such as military radar systems, often have an additional element, called a grid, built into the electron gun. The grid permits the electron beam to be turned on and off with a smaller swing in the applied bias than is required with a plain focus electrode. The grid thus partially obscures the path of the electron beam, causing some perturbation to the electron beam. For this reason, high reliability devices usually use ungridded focus electrodes



A Canadian-made travelling wave tube by Varian Associates. Photo by Ed Zapletal.

which provide more uniform electron beams.

Most TWTs have a single anode which controls the electric field in the region between it and the cathode. This field provides the accelerating force for the electrons. The voltage on the anode therefore provides control over the current in the electron beam, permitting the gain and RF power output of the TWT to be adjusted over a small range. Typically, the voltage on the anode is selected during TWT testing and maintained at that voltage thereafter.

“TWTs have become the fundamental amplification process in most high power relay, satellite, and radar applications.”

B-type impregnated or dispenser cathodes differ from oxide cathodes in that the B-type cathode exhibits what is pleasantly described as a “graceful degradation” of electron emission as a function of operational life. A TWT using a B-type dispenser cathode will suffer a gradual decline in gain and RF output unless the anode voltage is adjusted to maintain a constant cathode current. This can be accomplished by using a power converter and a servo-loop.

A more recent development, the M-type or coated dispenser cathode, com-

bines the high current density capability of a dispenser cathode with substantially less variation in electron emission over operational life.

In most applications, the design of the electron gun is chosen to permit the anode to operate at a positive voltage with respect to the body (ground) of the TWT. This positive voltage provides a barrier which repels positive ions inevitably generated within the electron beam. Without the positive anode, the positive ions would be attracted to the negative cathode and cause destructive etching of the cathode surface. In a few applications, the anode is at ground potential and no ion barrier is provided.

In some applications, there are two anodes. This is especially true for multi-mode TWTs where it is necessary to adjust the electron beam current over a wide range to permit the RF output power to be set at several levels. The first anode close to the cathode) is used for beam current control. The second anode operates at a fixed positive voltage to provide the ion barrier.

Turtle Waves

After leaving the electron gun, the electron beam passes through the slow-wave structure. The purpose of the slow-wave structure is to reduce the velocity of the RF wave that propagates along the TWT so that the RF wave is travelling through the TWT at a velocity slightly slower than that of the electron beam. As the RF wave travels from the input end of the TWT toward the output end, it participates in a cumulative interaction with the electron beam. The RF elec-

tric fields on the slow-wave structure penetrate into the electron beam and cause some of the electrons to be accelerated and some of the electrons to be decelerated. As a result of this interaction, the electrons receive a periodic velocity modulation approximately in phase with the RF wave. As the beam travels along the length of the TWT this results in the electrons "bunching" into regions where the electron beam is more dense separated by regions where the electron beam is less dense.

As a result of the accelerating and decelerating fields, the electron bunches will tend to concentrate ahead of the accelerating fields and behind the decelerating fields. Since the average velocity of the electron beam is slightly greater than that of the RF wave, these bunches will tend to move "back" into regions where the RF fields will decelerate the electrons. Most of the electrons will therefore be decelerated. As the electrons lose velocity, they therefore lose kinetic energy, and this energy is transferred to the RF wave. This growing wave is characterized by a nearly constant gain per unit

length under conditions of fixed beam current and beam velocity. In other words, the TWT gain is proportional to the length of the interaction region where the electron beam is coupled to the RF wave on the slow-wave structure.

The velocity of the electron beam is determined by the voltage difference between the cathode and the slow-wave structure. The slow-wave structure is nearly always operated at ground potential because the input and output RF ports, either coaxial or waveguide, will connect directly to the slow-wave structure. To provide the proper relative voltages, the cathode is operated at a negative potential so the electrons "see" an increase in voltage as they travel toward the grounded slow-wave structure.

The Law of Conservation of Energy determines how and where the RF energy comes from. The RF wave on the slow-wave structure grows at the expense of the kinetic energy of the electron beam. Since the electron beam loses kinetic energy as it interacts with the RF wave, the electron beam loses velocity as it progresses toward the output

end of the TWT. This is part of the reason that the RF wave is caused to travel at a velocity somewhat slower than the electron beam. This arrangement causes the electrons to more or less "fall into synchronism" with the RF wave as the electron beam gives up energy to the RF wave. In all TWTs, it is possible to control the velocity of the electron beam as it enters the slow-wave structure by simply adjusting the cathode voltage. It is not possible to predict exactly what this velocity should be, so it is necessary to select the voltage to account for tolerances in the manufacture of individual slow-wave structures.

In addition, some high efficiency TWTs employ slow-wave structures in which the velocity of propagation is purposely changed along the length of the structure in order to maintain the desired synchronism as energy is extracted from the electron gun and its velocity is reduced.

The physical characteristics of the slow-wave structure can be of two types: helix structured or coupled-cavity structured.

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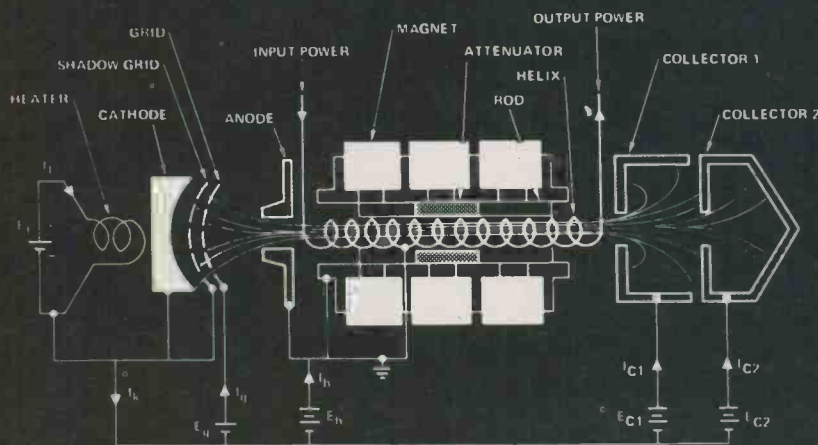


Fig. 1. A schematic of a travelling wave tube and power supplies.

Helical Visions

In a helical slow-wave structure (the original design and still the most common), the helix itself is made of tungsten or molybdenum wire, supported by three or four ceramic rods which isolate the RF fields in or on the helix from the metallic wall of the surrounding vacuum envelope. Customarily, the support rods are made of aluminum oxide (Al_2O_3), beryllium oxide (BeO) or boron nitrate (BN). In some specialized applications, sapphire and diamond are used. The selection of materials has a major influence upon the power output capability and efficiency of a TWT.

The electron beam passes through the inside diameter of the helix, where the moderately high RF electric fields can interact effectively with the electrons in the beam. The dielectric in the helix support rods competes with the electron beam for the RF electric field, so it is desirable to select rods having the lowest possible dielectric constant (resulting in minimum competition for the RF fields). At the same time, these dielectric rods provide the only thermal path between the helix wire and the outside surfaces of the TWT vacuum envelope. The necessary compromises between these somewhat conflicting requirements place an upper limit on the capability of the helix structure to handle high power. This upper limit is different for each design since the frequency requirement dictates the size of the helix structure (as the design frequency is increased so the size of the structure is necessarily decreased).

Feedback

It is important to observe that a slow-wave structure will support RF energy travelling from output to input as well as from input to output. The wave travelling from input to output will experience gain, but the wave travelling from output to input will not experience gain.

In the presence of the inevitable reflections at the output and input couplers, some of the RF energy could be reflected back toward the input along the helix and upon reflection from the input coupler, this signal would present RF feedback. All practical TWTs have sufficient gain that this feedback mechanism would result in self-oscillation. It is fairly simple to interrupt this feedback path by placing RF attenuation on one or more of the helix support rods. The attenuation is formed by placing a carefully controlled pattern of lossy material on the rods prior to their installation into the helix structure, pyrolytic graphite and titanium

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carbide being the most commonly used substances. The density of this attenuation pattern is selected to provide a very low reflection of RF energy so that any energy reflected from the output of the TWT is absorbed in the process. The region of the helix structure containing the attenuation is called a "sever" because the RF wave on the helix is terminated or "severed" at this point. Fortunately, the bunching of the electrons has been established by the time the beam reaches the sever. At the output end of the sever, the bunched electron beam re-establishes the RF wave on the helix and the interaction continues. This severing and re-launching process results in a reduction of RF gain by about 6 dB with only a small effect upon the efficiency of the TWT. This is considered to be a small price to pay for having a TWT which is unconditionally stable instead of having a TWT which would oscillate at the slightest provocation, such as turning it on. In very high gain TWTs, more than one sever may be used as a precaution to insure that each section is stable. The usual practice in modern designs is to avoid having more than 35 decibels of gain in any one section of a TWT.

In a coupled-cavity structure, the cavity sections are usually made of copper brazed together to form a structure consisting of many cavities in cascade. There is a hole in the centre of the structure through which the electron beam passes. The ferrule surrounding the beam hole concentrates the RF electric field in the vicinity of the electron beam to enhance the interaction between the RF wave and the electron beam. The dimensions of the cavity determine the frequency of operation of the TWT. The coupling hole in the wall of each cavity serves to couple RF energy from one cavity to the next. Coupling holes are oriented on alternate sides of the beam hole so RF energy is directed through one cavity before being coupled to the adjacent cavity. The bandwidth of the TWT is determined by the size and shape of the coupling holes.

Since it is made of copper, which has high thermal conductance, the coupled-cavity structure is capable of handling much higher power levels than the helix structure, and is capable of operating over much narrower bandwidths than the non-resonant helix structure. The design of the coupled-cavities is tailored to the frequency and bandwidth for each application. When the application requires narrow bandwidths, the coupling hole is relatively small and the interaction impedance is high. This impedance determines the amount of interaction be-

The only Canadian connection in TWT development and manufacture today is at Varian Canada, a branch plant of the international Varian Corporation but with world patent rights to manufacture items, including TWTs and klystrons, for the corporation as a whole. Some 70-80% of production at their Georgetown, Ontario, plant is earmarked for export.

The development and manufacture of TWTs in Canada was closely linked with US developments. There, the predominant interest was found in the Bell Telephone System, who for years did not follow up TWT developments very extensively due to their reliance on and satisfaction with ground lines; this despite the presence of Pierce on their research staff. These ground lines were predominantly dependent on equipment manufactured by Western Electric. By the time it became apparent that point-to-point microwave systems were the order of the day, in the early 60's, Europe and particularly Japan were far ahead in their development and implementation — Japan for example having a very extensive TWT dependent microwave system already in place using TWTs of proven design and reliability.

In Canada, there was some manufacturing by RCA (the M 600) which it sold to CNCP, and at Marconi in Montreal, using their parent company's English Electric design. The RCA TWT was used in the first Canadian transcontinental microwave system. The Marconi design, a PPM solenoid, was used in the ADCAM II military radio communication system along the Pine Tree Line between 1958 and 1962.

In 1964 Bell Northern Research commenced manufacturing the RA 1 used in radio.

When Marconi, in 1962, decided to pull out of the TWT manufacturing market, some of the staff, in particular Connell Smith, now General

Manager of Varian's Microwave Division, came to Varian and helped establish their TWT manufacturing division, Varian already being involved in klystrons. Since the Japanese, in particular Nippon Electric, were so far ahead in TWT design, and since, in Smith's words, "there was no need to re-invent the wheel," Varian entered into a cross-licencing arrangement with Nippon Electric, Varian getting NE's TWT designs and NE getting Varian's klystron designs. This cross-licencing arrangement has continued to the present day.

Some years later, when Western Electric decided to manufacture higher powered TWTs, it was decided to close down their Reading, Pennsylvania plant, selling the equipment to Varian: Varian taking over the manufacture of their designs, particularly the TH 1 tube. This tube only ceased production some two or three years ago, having been in continuous manufacture for some 20 years by either Western Electric or Varian, and as such represents one of the more successful designs in the recent history of electronics.

Varian's plant in Georgetown, now the only manufacturer of TWTs in Canada, is fully equipped, including its own glass blowing department, cleaning, and plating facilities, outgassing capability, and laser welding technology.

As for the future of TWTs? According to Connell Smith, their "life expectancy is limited. They'll be used, I think, for another 10-20 years in some systems, but I think after another five years or so there won't be many new systems developed using TWTs", their place being taken by laser powered solid state devices.

But if you want to buy one, off the shelf, it will cost you some \$2-4,000, unless you are into radar, in which case one will set you back, say, \$30,000, without modifications.

"The only Canadian connection in TWT development and manufacture today is at Varian Canada. Some 70-80% of production at their Georgetown, Ontario, plant is earmarked for export. Varian has its own glass-blowing department, cleaning, and laser-welding technology."

tween the RF wave on the slow-wave structure and the electron beam. When greater bandwidths are required, the coupling hole is enlarged, the interaction impedance reduced, and the resulting TWT displays less gain per cavity and slightly reduced efficiency.

Coupled cavity TWTs must include attenuators to absorb RF energy reflected from the RF output port, for the same reason as in the helix TWT. In some cases the attenuator is implemented by brazing lossy ceramic directly to the last cavity section in the portion of the circuit which is to

The Potent Helix

be severed. In other cases, the attenuator is placed in a section of the waveguide which is coupled to the last cavity in the section to be severed. In either case, the loss of gain due to the presence of the sever is about 6 dB for each sever. As with the helix TWT, the gain in each section is usually limited to no more than 35 decibels.

Electron Disposal

Having generated an electron beam in the electron gun and having used some of the kinetic energy in that electron beam to amplify the RF signal, it is necessary to dispose of the electron beam. The collector does this job. In an elementary TWT, the collector would consist of a metallic surface upon which the electron beam impinges. This would be simple enough if the collector were to operate at ground potential, that is, the same potential as the slow wave structure, but this would be wasteful. The RF amplification process only extracts a very small amount of the kinetic energy in the electron beam, typically 10 to 30 percent,

causing the electron beam to possess a great deal of kinetic energy which would be dissipated should the beam strike the grounded collector. It is far more efficient to purposefully decelerate the electron beam prior to allowing the beam to strike the collector surface, but this requires that the collector surface be operated at a potential voltage below ground potential, known as "depressed collector" operation. Ideally, the negative potential on the collector would be chosen so the electrons lose all of their remaining kinetic energy just as they reach the collector surface. However, the collector cannot be operated at this highly negative (depressed) voltage for three reasons. Firstly, the charge on the electrons already in the collector region creates electric fields which tend to repel electrons about to enter the collector. As the collector voltage is reduced toward the value at which electrons would strike the surface at zero kinetic energy, the "space charge" due to electrons inside the collector would block any additional electrons from entering the collector.

Secondly, the electrons striking the

collector cause secondary electrons to be emitted from the collector surface. These secondary electrons create additional "space charge" within the collector and create an additional limit on the voltage at which electrons can be collected.

Thirdly, electrons do not all lose the same kinetic energy as they interact with the RF fields in the slow-wave structure. Some electrons lose far more kinetic energy than others. These electrons could not be collected at the same potential as electrons which did not lose so much of their kinetic energy. The voltage on the collector must be chosen so that all electrons are collected, otherwise some electrons would be reflected back toward the slow-wave structure and either collected at ground potential or "backstreamed" into the beam causing RF regeneration.

Because of these limitations, the collector voltage in a practical TWT cannot be "depressed" to the voltage at which little or no kinetic energy is dissipated in the collector. As such, practical TWTs usually operate with the collector voltage depressed

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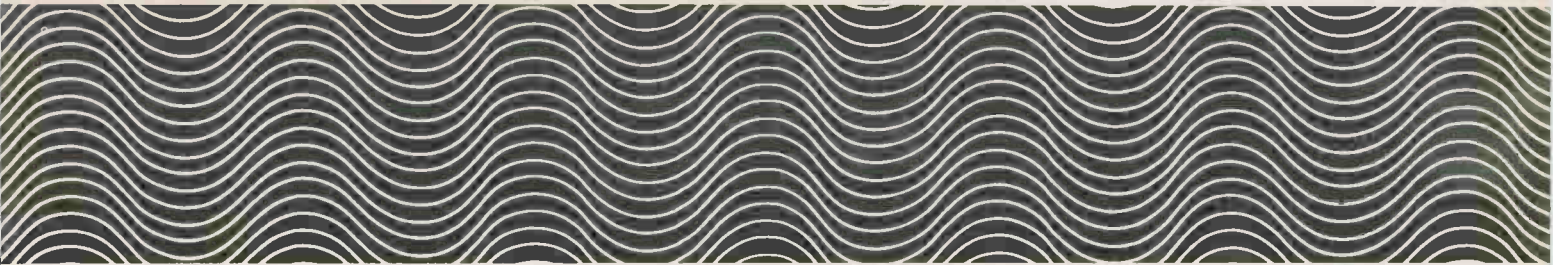


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to a value which is 30 to 60 percent of the original accelerating voltage. This creates heat. Low and medium power TWTs dissipate this heat by thermal conduction into the TWT baseplate. At higher power levels it is often necessary to provide a heat exchange medium such as cooling fluid, water, or high velocity air flow. In rare cases, such as for high power spacecraft TWTs, the collector is cooled by radiation directly into space.

The amount of power dissipated in the collector can be reduced by making use of a collector which has multiple velocity sorting, or depressed stages. A collector of this design is commonly referred to as having two depressed stages. The voltage on the third stage is closer to the cathode voltage than would be possible in a single stage collector. This third stage, being the most depressed, collects those electrons which have the most kinetic energy. The first stage collects those "rogue" electrons which have very low kinetic energy as they have interacted with the RF fields very little. The middle stage collects those electrons with medium kinetic energy.

Magnetic Charm

As for beam focussing, the electron beam must pass through a rather long slow-wave structure as it interacts with the RF fields. Upon leaving the cathode surface, the electron beam is formed into a stream of electrons in which the current density is fairly high. The electrons within this beam all possess negative charge and these negative charges cause the electrons to repel one another. This space charge effect, if left to its own devices, could cause the beam to expand in diameter and intercept the slow-wave structure. It is necessary, therefore, to provide a means of keeping the electron beam confined to a diameter which is smaller than the inside diameter of the slow-wave structure. This is usually accomplished by providing a magnetic field parallel to the direction of the flow. Electrons tending to stray away from the proper direction of flow will then cross lines of magnetic field and, in doing so, will experience a restoring force which tends to push them back to their original trajectory. Historically, this magnetic field was produced by surrounding the TWT with a large electromagnet (solenoid) or a large permanent magnet. Solenoid focussing is now used only on very high power TWTs where beams having very high current densities must be focussed. The solenoid is large and heavy, dissipates a large

amount of power, and usually must be cooled by forced air or liquid. Permanent magnet focussing is seldom used, as the magnet is large and heavy and produces a large amount of stray magnetic field which might interfere with nearby equipment.

In an efficient scheme, the magnetic field is concentrated along the axis of the TWT by placing iron pole-pieces along the outside of the slow-wave structure and small cylindrical magnets between these pole pieces. These magnets are magnetized parallel to their axes, the polarity of adjacent magnets being reversed. This arrangement is called Periodic Permanent Magnet (PPM) focussing because of the periodic reversal of magnetic field operating direction. The PPM focussing system creates a series of convergent magnetic lenses. The ferrules on the iron pole pieces help to concentrate the magnetic field into the region occupied by the electron beam. The RMS value of the magnetic field produced in the electron beam is roughly equivalent to a continuous DC magnetic field of the same value, provided that the period of the magnetic field

generated by the PPM focussing scheme is shorter than the plasma wavelength of the electron beam. The plasma wavelength of the electron beam is the natural period at which the electron beam would undulate if the beam were perturbed by an external influence (such as bunching produced by the amplification of an RF signal). The whole idea is for the magnetic field of the PPM focussing structure to redirect the electrons before they are permitted to stray too far away from their nominal trajectory. The PPM focussing scheme occupies much less space and weighs far less than an equivalent solenoid or permanent magnet focussing scheme. A further advantage is that the external stray magnetic field is very small for the PPM focussing scheme, especially if the PPM focussing "stack" has an even number of magnets.

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Supply Protector



Does that flickering of the house lights all too often indicate that your ZX has just had its memory corrupted? Here's a very simple remedy, designed by Phil Walker.

DESIGNED PRIMARILY with the ZX81 home computer in mind but applicable to many others, this project aims to protect the program that you've just spent three hours correcting from short term power failure or accidental supply disconnection. The sort of thing we mean is the temporary (or worse) dimming of the lights caused by lightning strikes on the grid lines or load switching at a sub-station. These effects usually only last a few tenths of a second but can cause your computer to forget itself and delete your program — resulting in instant frustration!

The solution is embodied in this project. What is needed is that the computer should be rapidly switched over to a standby battery. This need only be able to supply the current drawn for a few minutes until the normal supply is restored. The ETI Zippy does this and also sounds an alarm to tell you that something is wrong.

The Circuit

The main part of the circuit consists of B1, D1 and IC1. B1 is a Nickel-Cadmium rechargeable battery with a capacity of 110 mAh at a voltage of around 8.4 volts. This means that when fully charged it should be able to supply a ZX81 for at least 6 minutes — longer if you do not have many extras plugged in. This will even give you time to save your program on tape (provided you have a battery powered tape recorder). D1 effects the switch-over from normal supply to Zippy's internal battery while IC1 recharges the battery while power is available. The rest of the circuit provides the audible warning signal from the piezo-electric sounder when the normal supply voltage drops too low.

It is probably a good idea to charge the battery periodically so that you don't get caught out.

Construction

The project can be built into a small plastic box. It is a tight fit, so some care must be taken when siting the switch and input socket. The PCB is designed to fit along one side of the box with the battery along the other. Don't forget to cut the corners off the PCB where marked.

Assembly of the PCB is straightforward but care should be taken when fitting the diodes, transistor and ICs that they are the right way round. Connect all the lead-out wires except those to the

PARTS LIST

Resistors (¼ W 5% carbon film)

R1	68R
R2	10k
R3	100R
R4	10M
R5	1M

Capacitors (disc or plate ceramic etc.)

C1	47nF
C2	470pF

Semiconductors

IC1	LM334Z
IC2	CD4093
D1	1N4001 (Germanium or Schottky of 1A+ rating may improve performance)
ZD1	15V zener
Q1	2N3904

Miscellaneous

X1	PB2720 piezo sounder
B1	8.4 V 110 mAh 9V size NiCd
SW1	min. on/off slide switch
Box	to suit
	3.5 mm jack plug & socket or as required; 9V battery connector; PCB; small grommet; wire; etc.

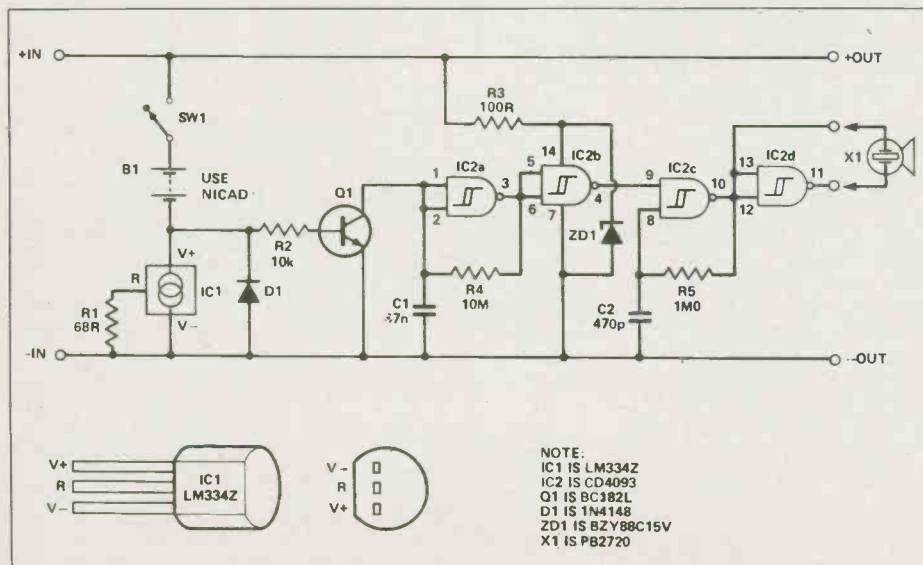


Fig. 1 Circuit diagram of Zippy

sounder before assembling the complete unit.

In our unit, the sounder was glued to the outside of the case and the wires taken inside through a small hole. Holes should also be cut for the switch, input socket and output wire. Make sure everything will fit before deciding where these holes will be.

For a ZX81, the input connector is a 3.5mm jack socket and the output wire is terminated in a matching plug (after assembly), but for your system these can be as required. Beware... not all power supplies have the centre conductor positive, so check this before wiring up.

When everything is ready, put the PCB, switch and input socket in the case, thread the output lead through the hole provided for it (you did cut one, didn't you?) fit a grommet if you want it to look nice, and wire up the sounder and other components as neatly as possible. Do not have the battery connected while you do this, as it has a very low impedance and can discharge with some violence. The PCB can be fastened in with a bit of sticky tape if you want but it cannot move about much in the limited space available.

HOW IT WORKS

B1 is the main energy store with a capacity of 110 mAh and a terminal voltage of 8.4 volts. IC1 is a constant current device whose operating current is set at about 0.6 mA by R1. This level of current can be sent through the battery constantly with little degradation of performance and will keep it ready for use.

D1 blocks current flow from the power pack to the battery but will allow current to flow from the battery on to the supply lines if the power pack voltage drops below about 7.7 volts. This ensures that the supply lines never drop below this level. The internal regulator in

a ZX81 needs about 6.5 to 7 volts minimum at its input pin to keep it working correctly.

While the input voltage from the power pack is more than a volt or so greater than the battery voltage, Q1 will be turned on by current flowing through R3. This will keep C1 discharged. This will cause the outputs of IC2a and IC2c to stay high and IC2b and IC2d to stay low.

If the input voltage falls below this level, Q1 will turn off and allow C1 to be charged via R4 until it reaches the switching threshold of IC2a. The output of IC2a will now go low

and IC1 will be discharged via R4 until it reaches the lower switching threshold of IC2a whereupon IC2a output will go high again to repeat the cycle. While IC2a output is low the output of IC2b will be high. This enables a similar oscillator configured around IC2c. The frequency of IC2a oscillator is of the order of 2 Hz while that of IC2c is around 2 kHz; the resulting output from IC2c is bursts of 2 kHz which when applied to the piezo sounder make a slow bleep-bleep noise. IC2d is used to invert the output from IC2c and increase the signal voltage applied to the sounder.

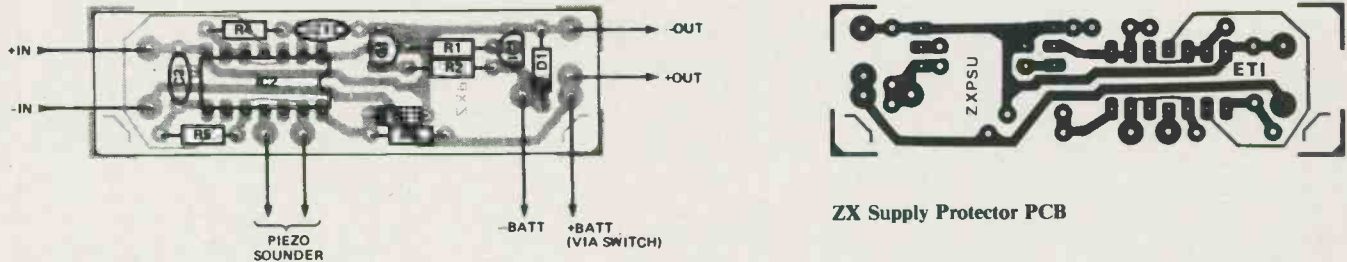


Fig. 2 Component overlay for the PCB

ZX Supply Protector PCB

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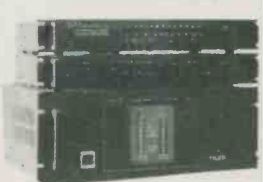
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Magnetic fields can be mind-bending when you try to understand what's going on. They can also bend the paths of poor little innocent electrons, too. John Dance shows us a practical import of this phenomenon.

DISCOVERED AS LONG ago as 28th October, 1879 by Edwin Hall of the John Hopkins University, Baltimore, the Hall effect found few applications until high quality semi-conductor materials became available since it is so small that it is difficult to detect in metals. Hall found that if a magnetic field is applied to a current carrying conductor at right angles to the direction of the current flow, a potential difference appears across the material in a direction which is at right angles to both the direction of the current flow and to that of the magnetic field.

In Fig. 1(a), the potential applied between the two electrodes causes an electric current to flow through the material. If this material is homogeneous and no magnetic field is present, the current flow through it is of uniform density. In the case of the P-type semiconductor material shown, current is effectively carried by the majority hole carriers which behave as positive charges, and these move in the same direction as the conventional current flow in the external wires.

If a magnetic field is now applied so that its direction is into the paper, Fleming's left-hand motor rule indicates that the moving holes will experience a force towards the left and will tend to curve in this direction, as shown in Fig. 1(b). As holes cannot flow out of the left-hand face of the block of P-type material, some positive charges will accumulate there. Similarly, negative charges will accumulate on the right-hand face of the block of material since no holes can flow into this face. The electric field created by these charges tends to repel the holes from the positively charged left-hand face towards the negatively charged right-hand face.

The field increases until the positive charges are again moving uniformly across the block of semiconductor material as shown in Fig. 1(c). Any tendency on the part of the positive charges to move to the left will increase the electric field, causing the charges to move directly across the block of material so that the balance is accurately stored. A pair of Hall electrodes placed in the position shown in Fig. 1(c) can be used to detect the Hall voltage produced in this way.

In the case of N-type semiconductor materials in which the majority of carriers are electrons, the flow is in the opposite direction to that of the conventional current in the external wires. The left-hand rule again shows that the charge carrier movement is towards the left, but in this case, the negative charge carriers build up

DESIGNER'S Notebook

The Hall Effect



a negative charge on the left-hand side and a positive charge on the right-hand side. Thus, we can use the Hall effect to distinguish between N and P-type materials by detecting the polarity of the Hall effect voltage produced.

In most metals one obtains a Hall effect voltage with the same polarity as in an N-type semiconductor material, since conduction is by means of electrons. However, the Hall voltage is much smaller than in semiconductor materials and a few metals, such as zinc, produce a Hall voltage of the opposite polarity; in such metals the interaction of the moving electrons with fixed positive ions results in the current being effectively carried by holes. Intrinsic (pure) semiconductor materials show a small Hall effect; although the numbers of electrons and holes per unit volume are approximately equal, the electrons are more mobile, and the overall behaviour is normally like that of an N-type material.

The Hall effect in semiconductor materials produces a much larger Hall voltage than in metals because the number of charge carriers per unit volume is far smaller. The Hall voltage, V_H , is given by the equation:

$$V_H = \frac{BI}{Net}$$

where:

B is the magnetic flux density

I is the current flowing through the specimen

N is the number of charge carriers per unit volume

e is the charge of an electron (1.6×10^{-19} coulombs)

t is the thickness of the specimen.

If one considers a piece of copper of thickness 1 mm carrying a current of 1 A in a magnetic field of 1 Tesla (10,000 Gauss), V_H works out as a mere 62.5 nV, since N is about 10^{29} electrons per m^3 for copper.

It is extremely difficult to measure 60 nV in such a circuit. In silicon, however, N may be 10,000 times smaller, so under the same conditions, one obtains a V_H value of 625 μ V which is a much more reasonable voltage for measurement.

Hall first detected the effect using a thin gold foil.

The Hall effect has been widely used in materials science research, where it enables information to be obtained about the charge carriers. When indium antimonide semiconductor Hall cells became available, they were used for the measurement of magnetic fields, but indium arsenide produces a Hall cell with about one-tenth of the temperature coefficient of indium antimonide, although its Hall output voltage is lower. Hall cells can be used as multiplying devices, for example, in wattmeters, where a voltage is used to generate a proportional current

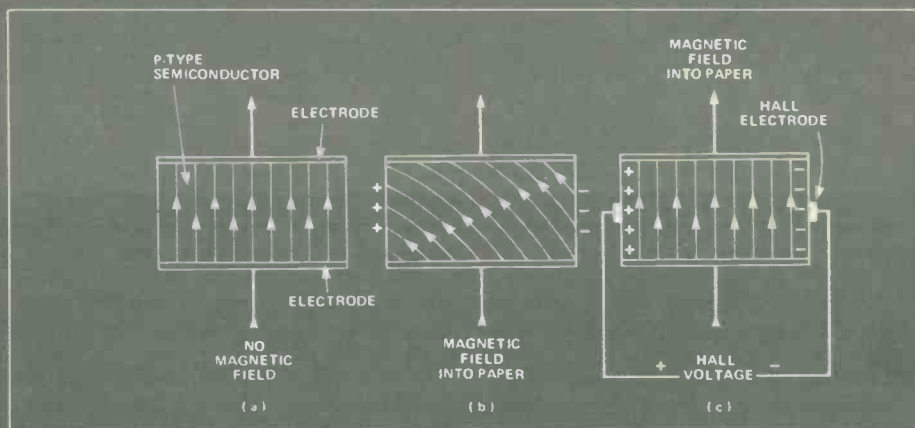


Fig. 1. The Hall effect illustrated by hole flow.

through a Hall cell using a series resistor, while the load current passes through coils which generate the magnetic field, in which the Hall cell is placed. Thus the output is proportional to the product of the voltage and current. Hall cell using a series resistor, while the load current passes through coils which generate the magnetic field in which the Hall cell is placed. Thus the output is proportional to the product of the voltage and current.

Other important applications of discrete Hall devices include their use in brushless DC motors in which the conventional brush and commutator system is replaced by Hall effect devices and suitable amplifiers. The use of such brushless motors avoids the inconveniences of brush replacement and improves reliability, but the elimination of sparking at the brushes is perhaps the most important advantage where low electrical noise is important (such as in high quality tape recording equipment).

Hitachi developed a Hall effect tape replay head in 1977 which is stated to have a high signal-to-noise ratio and excellent transient response (since it is non-inductive). A thin film of indium antimonide is employed, the output being determined only by the magnetic flux present so that a constant response is obtained at the lower frequencies — even down to zero frequency.

Monolithic Hall Devices

Silicon Hall effect devices have the great advantage that other circuitry can be integrated on the same silicon chip using normal IC production processes. Unfortunately, the Hall voltage from silicon cells is about a hundred times smaller than that of Hall devices made from indium arsenide, but the temperature stability of silicon devices is far better and the small output levels can be amplified by on-chip components. Typical Hall voltage outputs from silicon cells are in the millivolt to tens of mV region, depending on the operating conditions.

Although most Hall effect devices are used in switching circuits, there are plenty of applications for linear Hall devices. The basic internal circuit of the Sprague UGN-3501M linear device is shown in Fig. 2; it can be seen that the small output from the Hall cell itself is amplified by an op-amp. Offset output nulling facilities are included in this eight-pin DIL device, but not in the UGN-3501T which has only 3 connections. The UGN-3501T operates on from 8 to 12 V and the UGN-3501M from 8 to 16 V power supplies. The output voltage from a UGN-3501M device at various values of magnetic flux density with a 12 V supply, a 10 k load and two different values of resistor between pins 5 and 6 are shown in Fig. 3. The frequency response of these devices extends to about 25 kHz (-3dB). The sensitivity of the UGN-3501T is roughly twice that of the UGN-3501M.

Fig. 4(a) shows an application of the UGN-3501T as a ferrous metal detector and Fig. 4(b) is the circuit used. The pole of the magnet is fixed in contact with the Hall device and the output falls by 20 mV

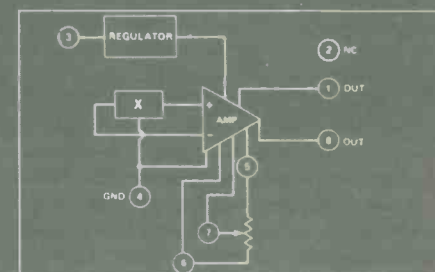


Fig. 2. Block diagram of a monolithic linear Hall effect device.

peak as the 25 mm steel ball rolls above the sensing device. This signal is amplified by a 741 device and drives the 2N8512 to conduction so that 0.5 A passes through the load. The low frequency response may be controlled by changing the value of the 22 μ F coupling capacitor and high frequency attenuation may be introduced by using a small capacitor to shunt the feedback resistor of the 741.

By attaching the opposite pole of the magnet to the Hall device, it can be made to sense the *absence* of ferromagnetic material rather than its *presence*.

Fig. 5 shows the use of an LM324 operational amplifier to supply a voltage gain and to transform the differential output of a UGN-3501M into a single-ended output so that the circuit can drive a load which has one side grounded. The LM324 can be operated from a single power supply provided that the output does not swing below 0 V. The connections shown are suitable for the detection of the field from a south pole, but if that from a north pole is to be detected, pins 1 and 8 should be reversed.

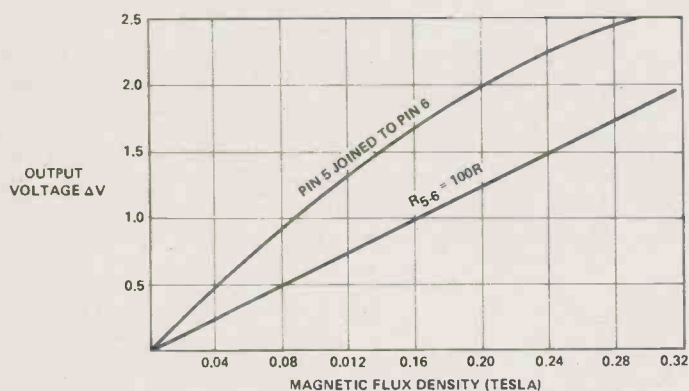


Fig. 3. Output voltage versus magnetic flux density for a UGN-3501M.

Another application for linear devices is in fluxmeters, but calibration will be required. A typical UGN-3501M provides a differential output of about 1.4 mV in a 0.1 T field. The response is quite linear to 0.1 T, but the useful linear range can be extended to 0.3 T, if a resistor of about 47R is placed between pins 5 and 6 (see Fig. 2).

Linear devices can also be employed in current measurement applications. The device may be placed in the gap of a toroid and the current passed through a coil on the toroid. This may be used for overload detection in electric motors, current limiting, etc.

Siemens have recently introduced a KSY10 linear Hall effect position sensor in which a gallium arsenide (GaAs) substrate is employed. This device is unique in that it is manufactured by an ion implantation planar technique which produces a doped layer only 0.3 μm in thickness; the use of this thin layer enables a sensitivity of 200 ± 30 V/AT to be obtained with a temperature coefficient of only about ± 5 × 10⁻⁴ per degree K. For example, it will provide a Hall output of about 200 mV with a 5 mA control current in a field of flux density 0.2 T. The sensitivity can be selected in the range 30 to 300 V/AT by choosing the appropriate ion doping level during manufacture. The

two Hall voltage output connections and the two control current connections are interchangeable, since the active sub-regions are symmetrical.

The output from the KSY10 device is proportional to the effective magnetic field and to the control current passing through the device. The sensor is only 1 mm deep, so it can easily be positioned in the magnet yoke of current converters for current measurements. The active area itself is a mere 0.2 mm by 0.2 mm and lies 0.35 mm behind the front of its mini-plastic case. The device is very suitable for determining the position or speed of toothed gears or of rack and pinion mechanisms. The wide band gap of the

gallium arsenide material used, enables this device to be used at temperatures of up to 150°C, so applications in the engine compartment of motor vehicles are envisaged and it may also be used in brushless DC motors.

It is interesting to note that Yoshito Takehana's Group, of the Electronic

Devices Development Division of the Sony Corporation of Tokyo, have developed a very sensitive silicon Hall effect sensor inside a special transistor. The output terminals of this magnetic sensor are in the reverse biased depletion layer; a magnetic field, perpendicular to the flow of the charge carriers between the base and collector terminals, will produce an output of about 85 V/cm at a flux density of 0.1 T. If such a linear device is successfully developed to the production stage, a much wider field of application may be opened to Hall effect sensor devices at some future date.

Switching Devices

Switching or digital Hall effect monolithic devices are especially easy to use and are finding many applications in keyboards, in vehicle circuits, in toys and in any applications where movement must be converted into an electrical digital type of signal.

The basic circuit of a typical Hall effect switching device is shown in Fig. 6. An on-chip regulator is usually incorporated in the device, since this is necessary to produce a constantly repeatable performance, especially in automobile applications where the supply voltage can vary over a wide range. The regulator supplies at constant current through the Hall cell (shown by an X in Fig. 6) and the two connections which supply the Hall output voltage, feed the inverting and non-inverting inputs of a comparator device, which in turn drives a Schmitt trigger circuit and an output stage.

When the magnetic flux density in the Hall cell changes, the Hall voltage from this cell will change so that the com-

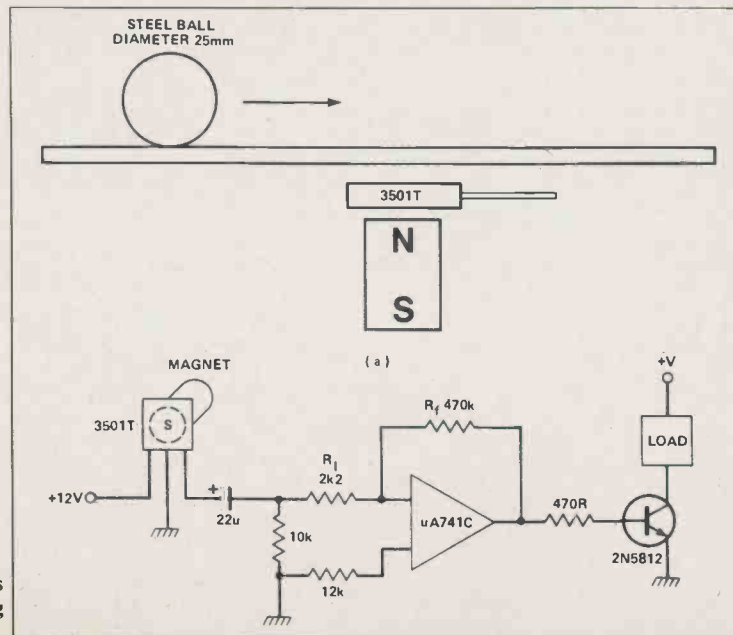


Fig. 4. A ferrous metal detector using the UGN-3501T.

parator will switch the state of the Schmitt trigger circuit. A suitable amount of hysteresis is built into the circuit so that if a small increase in the magnetic flux density causes the output to switch into its other state, an appreciably larger decrease in the flux density will be required to cause the circuit to switch back to its former state. This prevents repeated rapid switching between the two states for very small changes in the flux density.

The Sprague UGN-3019T device (formerly coded ULN-3006T), is an economical product very suitable in most applications for the experimenter. This is

The output falls to its low state with a typical value of +0.15 V and a maximum value of +0.4 V. The UGN-3019T can sink a current to its output of up to 15 mA, so the load resistor R1 of Fig. 8 must be chosen so that not more than 15 mA will flow into pin 3 with the particular value of positive supply voltage used.

The writer found that a UGN-3019T would switch to its low voltage output state when a small bar magnet was brought within about 3 mm of the centre of the body of the device. Owing to the built-in hysteresis in the internal circuit of the device, it did not revert back to the

particular advantage of Hall effect switching devices over mechanical contact switching is their high speed of operation, the rise and fall times being measured in nanoseconds with operating speeds of up to about 100 kHz. The output pulses are 'clean' without the 'bouncing' which is characteristic of mechanical contacts. Monolithic Hall effect devices are comparable in price to reed switches.

Using Hall Switches

An important use of Hall effect switching devices is for the detection and measure-

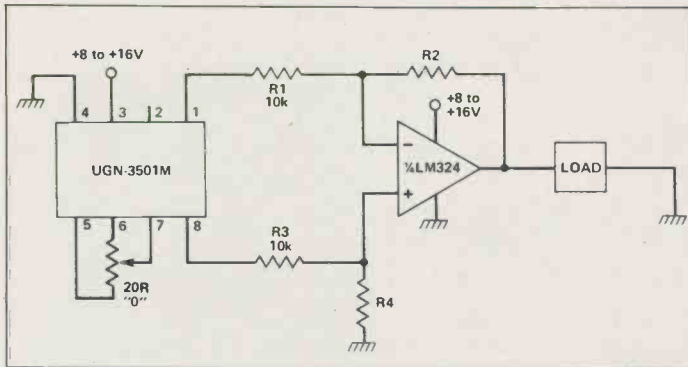


Fig. 5. A Hall effect switch using the UGN 3501M.

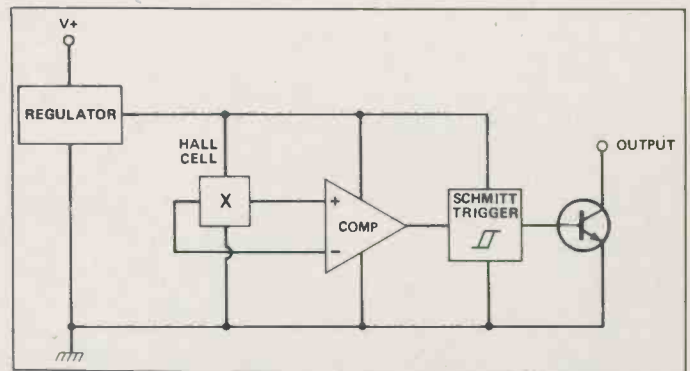


Fig. 6. Block diagram of a monolithic switching Hall effect device.

encapsulated in the T-type package shown in Fig. 7; the Hall element itself being at the centre of one face of the device as indicated. As Hall effect devices are used in conjunction with a magnetic field, it is obviously important that the package used should allow the device to be easily orientated with respect to the field and to be easily mounted. The type of package shown is, in the opinion of the writer, usually more convenient for magnetic field sensing than the dual-inline packages sometimes used for Hall effect sensors. The UGN-3201M (formerly designated ULN-3006M) is very similar to the UGN-3019T, but is mounted in an 8-pin dual-inline package.

The UGN-3019T may be used in the basic circuit of Fig. 8. In the absence of any magnetic field, the internal output transistor is cut off and passes only a very small collector current (typically, 1 μ A, maximum 20 μ A). The output voltage is therefore 'high' and has a value which is almost equal to the positive supply voltage; this supply voltage may have any value from + 5 V to + 16 V with an absolute maximum of + 20 V (above which the device may be damaged).

If a magnetic field of adequate flux density and of the correct polarity is now applied perpendicular to the face of the device, the internal Hall cell provides a voltage to the comparator of Fig. 6 which switches the Schmitt trigger so that the output transistor in the device conducts.

'high' output state until the bar magnet was withdrawn to a distance of over 10 mm. The hysteresis characteristics of the ULN-3019T are shown in Fig. 9. A typical device switches to the 'low' output state at a field of 0.05 T and all devices are certain to switch at a field of 0.075 T at the centre of their face. A typical device reverts to the 'high' output at 0.0225 T and all devices at a value not less than 0.01 T. The device is unaffected by small stray magnetic fields from any transformers, relays, etc. which may be near to it.

UGN-3019T circuits are unaffected by the application of a field of the opposite polarity to that required to switch the output to the low voltage state. If the field is too weak to cause switching to the low output state, an improvement in the sensitivity can be obtained by placing a piece of iron or other ferromagnetic material on the far side of the device from the magnet as close to the device as possible. A greater increase in sensitivity can be obtained if the device is placed between two magnets with opposite poles on each side of the device. It is important that the magnet should be moved on a line directly towards the centre of the device, since a displacement of about 3 mm from the centre line can more than double the required flux density.

The UGN-3019T requires a supply current of about 7 mA (maximum 9 mA) with a 5 V supply and about 12 mA (maximum 16 mA) with a 12 V supply. A par-

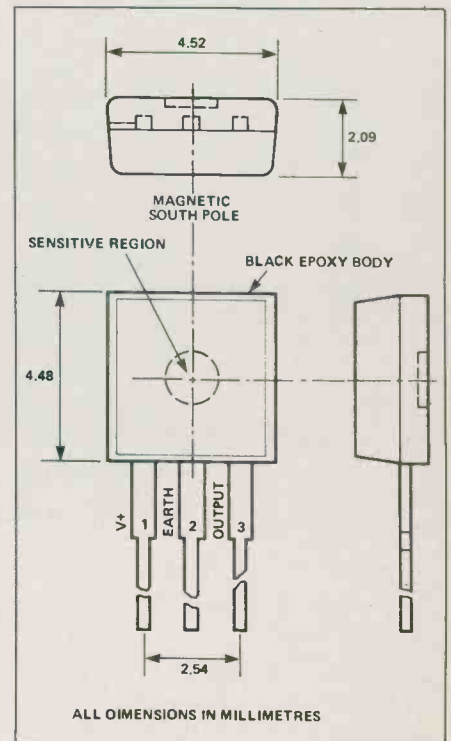


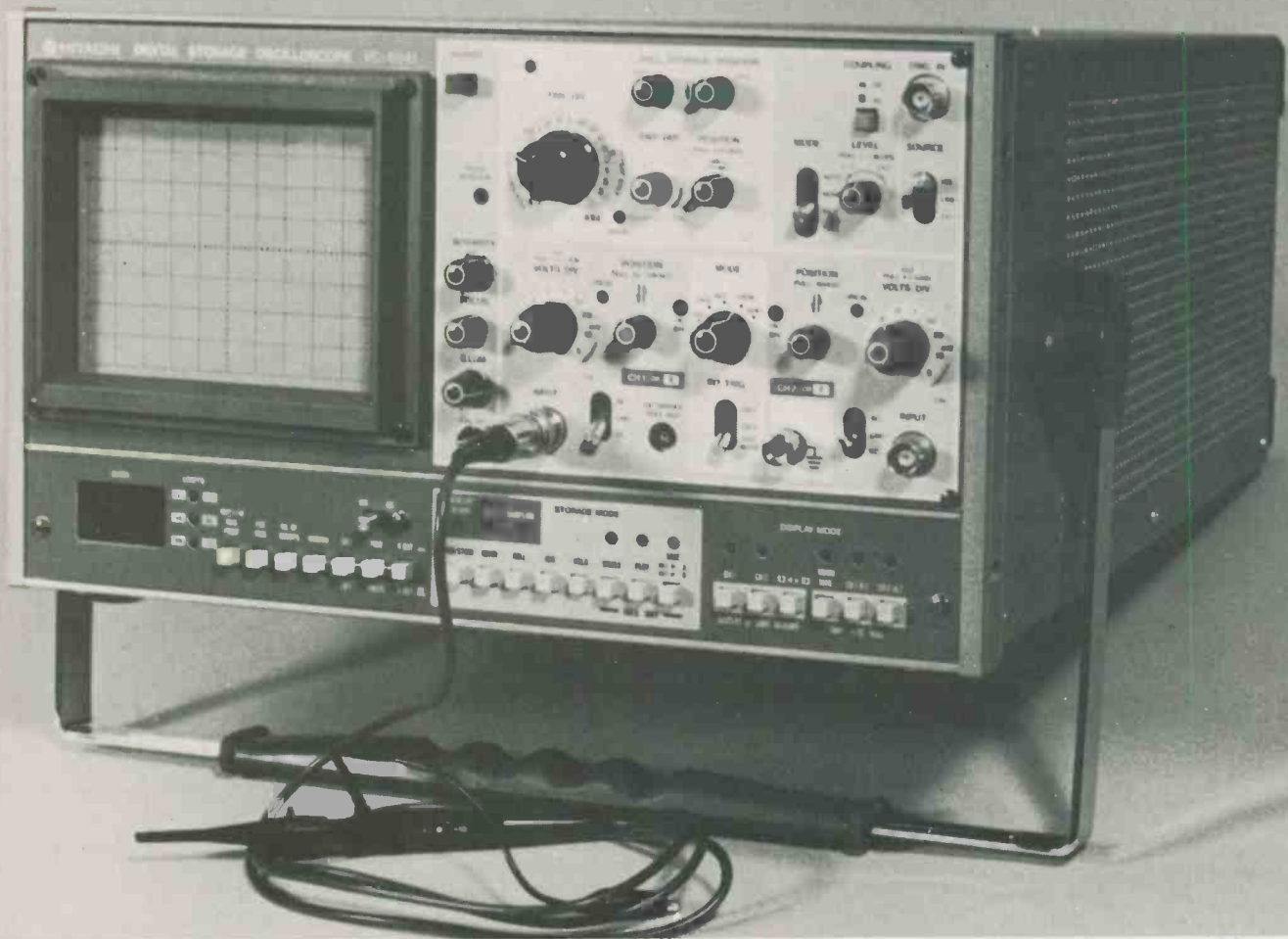
Fig. 7. The UGN-3019T — "T" type package.

ment of rotation. Many types of mechanical system arrangement are possible. In the 'slide by' mode, one or more small

continued on page 61

Product Review

Hitachi VCi-6041 Storage Oscilloscope



IF YOU'RE like me, your first oscilloscope probably came from a surplus bin, probably took about 100 hours of repair time, and probably still sits on your testbench with its image rolling and swaying and occasionally capturing a signal. For this reason, I jumped at the chance to review the super-deluxe Hitachi VC-6041 digital storage scope.

The price, as you might expect, is also super-deluxe, in the range of \$8000 to \$9000, so my surplus scope is going to have to make do for a while longer. The VC-6041 is obviously not aimed at the hobbyist market; you'll have to convince

the boss that you just have to have one, for reasons of efficiency, of course. Or you can just drool...

The scope arrives wrapped in its own soft vinyl protective case; a pocket on the case holds the manual and test probes. Unsnap the flaps, and to the right of the CRT you'll see the same controls that appear on your typical scope. There the resemblance ends. Before we get to the good stuff, though, let's look at the features of the scope in its 'normal' mode.

The Good Stuff

The bandwidth is 40 MHz; the horizontal

circuit is switchable from 0.2 seconds to 0.2 microseconds, and has a multiplier to increase things by a factor of 100. There are the expected controls for variable sweep, trace rotate, and position; over on the right we find the triggering control section. It looks rather standard: AC or DC, level, external input, and so on, but this is one of the sections where you begin to realize some of your investment. If you've used a sub-standard scope, or even a fairly good one, you've probably found out right away that a poor triggering amplifier can make the best of equipment rank with the worst. The VC-6041 shines

in the trigger department; the trace was always rock-solid, even with jittery or noisy signals.

Of course, you can fool the best of them: there's nothing like a TV video signal to muddle their little brains — they don't know whether to trigger on the sync pulse or the brightness levels. You can solidify the signal in general with fine adjustments, but you can't quite make it nice and clear. The Hitachi was certainly one of the easiest to use in this regard. The TV field position of the trigger mode switch actually cuts in a real sync separator; the trace just freezes. The higher-frequency components were a little wavy, but the storage mode can lock them right up — more on this later.

There are no surprises in the vertical amplifier. It has all the gubbins you'd want for your nine grand: 5 mV sensitivity, ALT and CHOP modes (which are crystal-clear), channels switchable to X and Y modes, and an AC-GND-DC switch. Well, there's one neat surprise. If you pull the position control out, it will now apply a DC voltage to the vertical for use in cancelling out any DC component in the signal. As you adjust it, this voltage appears for measurement on a front-panel output jack. Just the thing for troubleshooting if there's an evil DC there that shouldn't be. Click the control in again, and the trace returns to normal positioning.

There was a 0.5 V square wave at 1 KHz available from the front panel for self-calibration. It was a textbook squarewave.

And, of course, the included probes: they were compact, with a spring-loaded hook and a switch for x 1 and x 10.

The Really Good Stuff

Have you used an analog storage scope? You have? Then we shall all bow our heads and thank Whoever Runs Things for letting us in on digital storage functions.

The analog scope accomplishes its task by storing the passing trace in its phosphor; it's kept lit up by a bias voltage applied through an embedded mesh or an electron gun. It works well enough from

DC to, say, 100 KHz, but if the writing speed increases past this, the stored line gets fainter and fainter. The only way to have a look at your signal is to let it build up via a mode usually called 'Integrate'.

To get rid of the stored trace and return to normal, a 'wash' of electrons is blitzed across the screen, clearing things up. It's called 'Erase' and looks like a small green flashbulb going off.

Digital, now, is the cat's pajamas for this sort of application. In the Hitachi, the screen is sampled at the rate of 40 MHz in the single channel mode. This means that you can snare a useable image with signal bandwidths up to 40 MHz! The sampled signal consists of 4000 horizontal and 2048 vertical points. They're packed off to the scope's memory circuit to await your pleasure.

Even More Storage

If you'd like to hang on to a particular display, the 'Hold' button will keep painting it on the screen forever, or until the hydro fails. If you should suddenly have a pressing need to look at some other source, but don't want to lose the original, you can send it off to one of two memories, from whence it can be recalled to either channel. This would be ideal if you're looking for weird glitches and things that go bump in the trace; you could recall several different versions of the signal and compare them. In fact, you could compare today's signal to last week's, assuming that the cleaners haven't pulled out the power cord.

Trying It Out

As I mentioned, video outputs tend to

“The storage mode was as steady as a pencil drawing, with the tiniest of traces clearly defined. This is largely due to the high bandwidth and fine resolution of the sampling circuit.”

The Storage Mode

Being impatient to see it work, the internal calibrator seemed a good a place as any to start. Press the storage mode, and there it was, preserved in blue and white, as pristine as the day it left the square-wave generator. Well, almost; a tiny bit of fuzz appeared on the horizontal part of the wave. The manual said it would on low-frequency signals, though they didn't elaborate. Mind you, it was infinitely better than the blooms and fuzzies that appear on an analog storage scope.

Got a noisy, uncooperative signal? Press 'Number of Sweeps', and the LED readout comes to life. A lever makes it count up or down from 2 to 256, with the readout being the number of sweeps that are being averaged before display. It works beautifully to present you with a steady, cleaned-up signal.

make scopes get dizzy, and even with the Hitachi's sync separator, there was a noticeable wander to the high-frequency components. The storage cures that. Just push the storage mode button and there you are: as steady as a pencil drawing, with the tiniest of traces clearly defined. This excellent performance is largely due to the high bandwidth and fine resolution of the digital sampling circuit.

This standard of performance alone would seem to justify the price, but we're not done yet. After you've frozen a complex signal, you may want to find out more about its components. Have you ever counted divisions on the scope face and tried to turn it into data about voltages and periods? The VC-6041 has a wee button marked 'Cursor'. Press this, and two cursor dots appear on the signal; they can be maneuvered around with the control lever. Put them where you prefer,

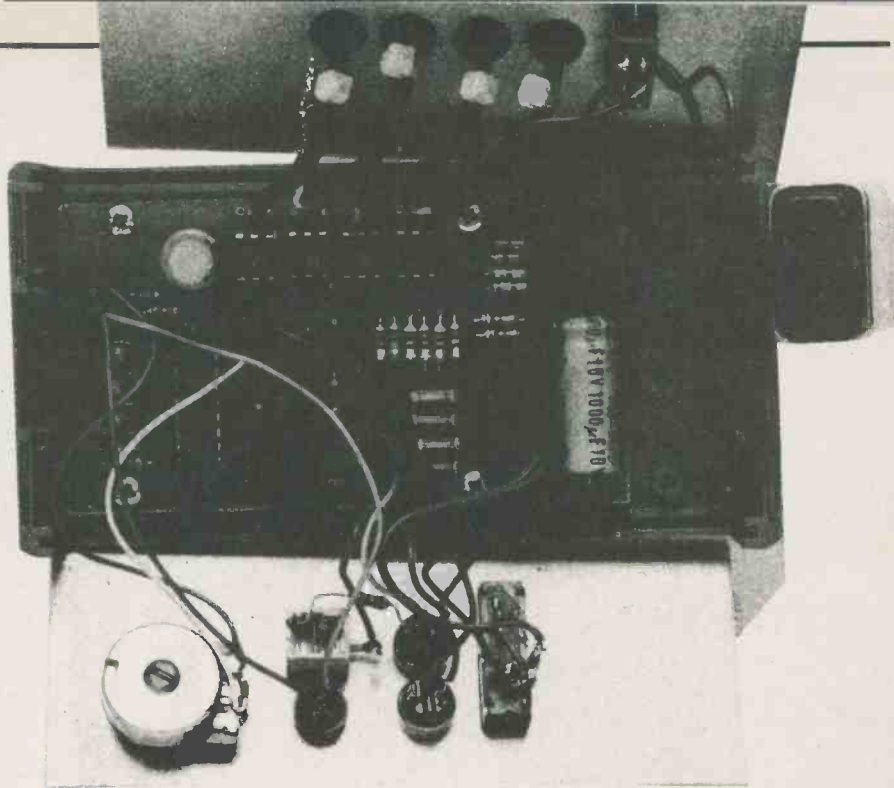
continued on page 42

quence generator consisting of IC2, IC1a, b, c and d, and the output pulse generators IC3, 4, 5, 6, 7 and Q2, 3, 4 and 5. The input latch can be reset to the READY condition by SW2 and will force the timing network to discharge all its capacitors by means of Q1 and D4 to 7. This state is indicated by the LED.

A negative-going pulse at the input or a press on SW1 will make the latch change state and allow the sequence to start. After the first delay period the LED in IC4 will be turned on for about 10 mS, causing its associated SCR (or triac) to turn on and trigger the flashgun to which it is connected. This action occurs when C3 has been charged by the current through RV1 and R6 to the upper threshold voltage of IC1b. The output from IC1b is coupled via a differentiating network (C7 and R8) to IC3c — also a Schmitt trigger. This negative-going pulse causes the output from IC3c to go high for about 10 mS, thus turning Q2 on and hence IC4.

IC1b having changed state, the current from RV1 is now diverted to C4 and will charge this up at the same rate until its voltage reaches the upper threshold of IC1d. A similar set of actions now occurs in IC3b and IC5, resulting in another flashgun being triggered and the timing current being diverted yet again to C5.

The sequence ends when C6 charges



and the final flashgun triggers. The circuit is now ready to be reset for another operation.

By means of SW3, a negative pulse generated by C2 and R7 can be routed to the sections of IC3 such that one or all the out-

puts can be triggered with no delay. This could be used to advantage if the unit is triggered direct from a camera socket and no other lighting is used for special effects or just to get as much light as possible. Beware

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ETI—FEBRUARY—1984—33

Flash Sequencer

PARTS LIST

Resistors (all 1/4W, 5%)

R1	100R
R2	100k
R3,4,7-13	1M0
R5	10k
R6	1k0

Potentiometer

RV1	1M0 logarithmic
-----	-----------------

Capacitors

C1	10nF miniature disc ceramic
C2	33nF miniature polyester
C3-6	1u0 35 V tantalum bead
C7-10	10nF miniature polyester
C11	470uF 10 V aluminum PCB electrolytic
C12	1000uF 10 V aluminum axial electrolytic

Semiconductors

IC1	40106B
IC2	4053B
IC3	4093B
IC4-7	H11C4 (opto-SCR) or MOC3020 (opto-triac). See text.
Q1	2N3905
Q2-5	2N3904
D1-11	1N4148
LED1	any red LED

Miscellaneous

SW1,2	miniature push-to-make push-button switch
SW3	three-way slide switch
SW4	miniature on/off slide switch

PCB; case to suit; 3.5 mm jack socket and plug; 9V battery and clip; four small grommets; four 1 metre flash extension cables; wire, cable ties etc.

HOW IT WORKS

IC1e and f are connected together to form a simple latch: R4 is included to avoid shorting the output of IC1e. When SW2 is pressed the output from this latch is set high, this will cause C2 to discharge via R7 and turn Q1 on. Q1 will discharge C3, 4, 5, 6 via D4, 5, 6 and 7 while lighting LED1 via R6. At the same time IC2 will be disabled by the high level on pin 6 from the input latch. This prevents LED1 from being bypassed by the switches in IC2.

In this condition the outputs from IC1a, b, c and d will be high and C7, 8, 9 and 10 can discharge via their associated resistors. This will set the inputs to IC3a, b, c and d to high levels and thus the outputs to a low. Q2, 3, 4 and 5 will be off and the outputs of IC4, 5, 6 and 7 will not conduct.

Assume for the moment that SW3 is in the open position (delayed sequence). If SW1 is now closed or a negative-going pulse appears at the input, this will be passed on via C1 and D3 to the latch formed by IC1e and f causing its output to go low. Q1 will now turn off, extinguishing LED1 and releasing C3, 4, 5 and 6. IC2 will now be enabled and current can now flow in C3 via R6, RV1 and the three switch sections of IC2. This capacitor will charge up until its voltage reaches the upper threshold of IC1b (this is a Schmitt trigger

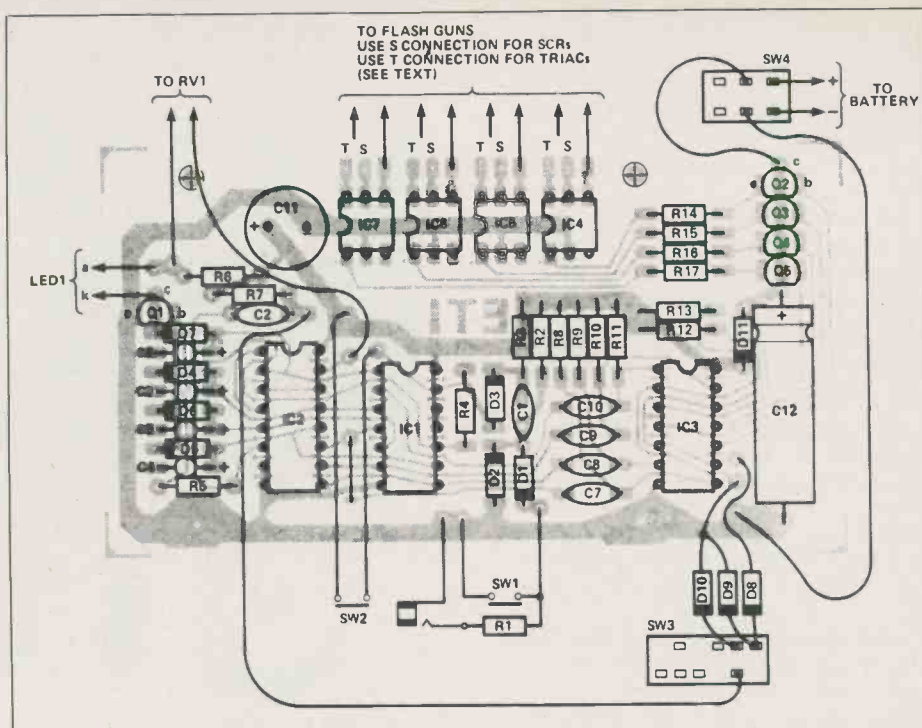
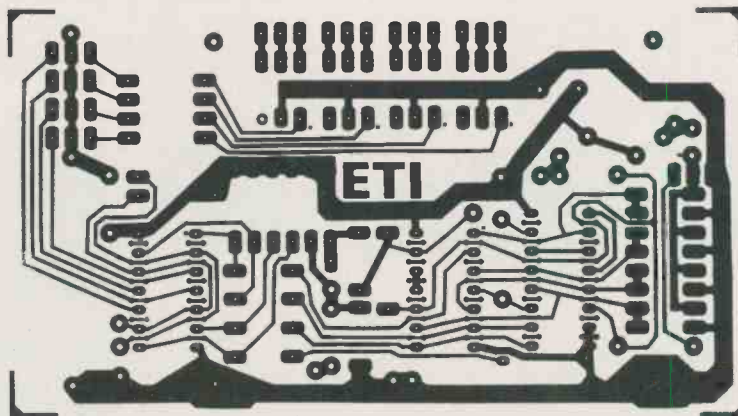


Fig. 2 Component overlay of the ETI Flash Se



The Flash Sequencer PCB.

device), whereupon IC1b output will go low. This causes the current to be diverted to C4, where a similar process occurs. At the same time the high-to-low transition is passed through C7 to IC3c whose output will go high from 10 mS or so. This will turn Q2 on and thus IC4 will turn on.

Some time later C4 will charge up to the Schmitt threshold and IC1d will go low, diverting the current into C5 while also causing IC5 to conduct. The cycle of events will continue with IC1c/IC6 and IC1a/IC7. The result of all this is that flashguns connected to the outputs of IC4, 5, 6 and 7 will be fired in sequence with a delay between each one determined by R6 and the setting of RV1 (and the residual resistance of IC2). IC2 is in fact a triple CMOS changeover switch with a typical on state resistance of 200 ohms.

C7, 8, 9 and 10 have been included to ensure that the opto-coupler LED inputs are not driven continuously, as this would take a lot of current. These capacitors and R8, 9, 10 and

11 define the 'on' time to be about 10 mS. C12 will hold enough charge to provide this even from an aging battery. C11 and D11 isolate the rest of the circuitry from the LED drivers to maintain proper operation.

C2 and R7 (via SW3, D8, 9, 10) provide the alternative operating modes. The initial trigger pulse can be fed via these components to the sections of IC3 such that IC7 will turn on immediately or all the outputs will come on together. Care must be used here as the outputs may pulse again after the set delay time and thus trigger the flashgun(s) again if they recharge in time.

You may notice that the inputs to IC1a, b, c and d will only have their capacitors connected, and no DC path exists to bias them, once the switches have been operated. This will not cause any problems over the 5 seconds maximum of the timing period, as the leakage of the tantalum bead capacitors is quite low and they will have to discharge a long way before the Schmitt trigger gates change state.

when using this facility with long delay times set on RV1, as one or more flashguns may recharge and trigger again as the delay operates.

The circuit should not take more than about 10 mA when READY and much less than that when timed out.

The negative-going input pulse to trigger the unit can be derived from a switch or logic source.

Construction

Construction of this project should pose no great problems. Take care when positioning the front panel components that they do not foul the parts on the assembled PCB. Note that R1, D8, 9 and 10 are mounted on the panel. It is essential that all the diodes, ICs, and any other polarized components are mounted the correct way round.

We recommend that IC sockets are used for the CMOS devices and that care is taken to avoid static discharge damage to these devices.

Output Connections

There are two different connection points for the output from the opto-couplers. This is to accommodate either opto-SCR or opto-triac devices. If opto-SCR devices are

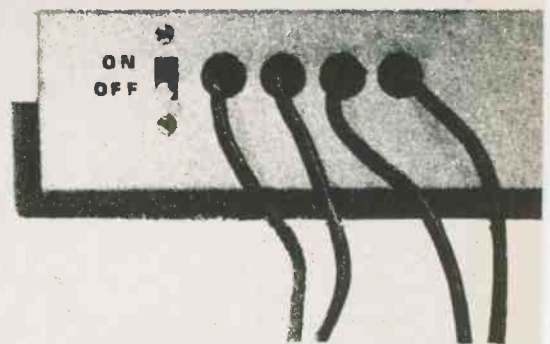
used, the flashgun trigger leads must be connected across pins 4 and 5 with pin 4 negative and pin 5 positive. You will have to check the polarity of the connections to the base of the flashguns you use, and this will vary from make to make (ours had a positive inner). If you connect up for one particular make, the trigger unit may not work on another.

If you use opto-triacs, the flashgun trigger leads should be connected across pins 4 and 6; polarity is unimportant, which will save all the above messing about, so we recommend this option.

Other Points

As we found that sockets for flashgun connectors are unobtainable (unless already connected to something such as a camera) we bought four flash extension cables and cut the unwanted ends off. These were then taken into the box via small grommets and wired directly to the proper terminals. A small cable tie on each lead just inside the box served to take the strain off the connections. It may be a good idea to buy three one-metre extension cables and one much longer one, so that you can use the extra length from this for the camera-to-unit link (it will have the correct connector).

For greater protection the unit could be built inside a diecast box. This may also be



The rear of the sequencer carries the on-off switch. We bought four flash extension cables in order to get the right connectors.

necessary if static discharge causes premature triggering of a flashgun.

Calibration of the delay control would need special apparatus and would depend on the quality of RV1. But the type of device specified should give a reasonable subjective control over the required range.

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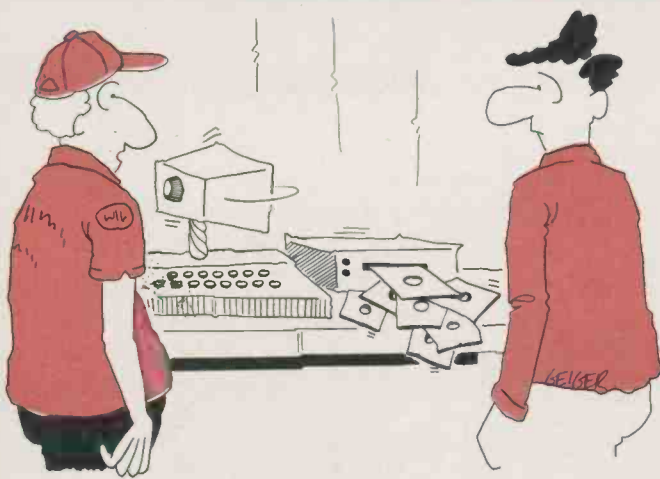
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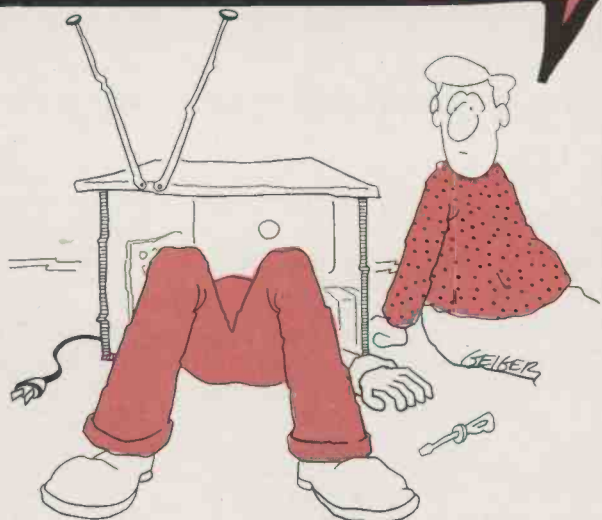
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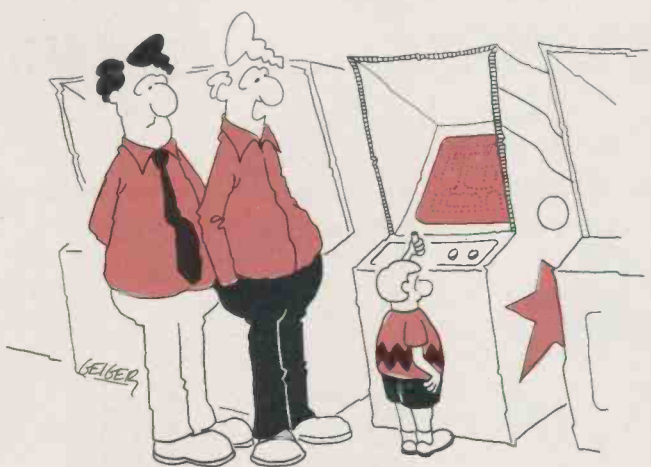
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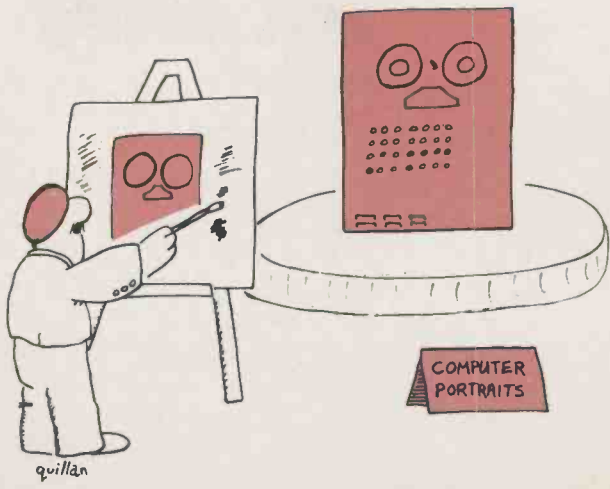
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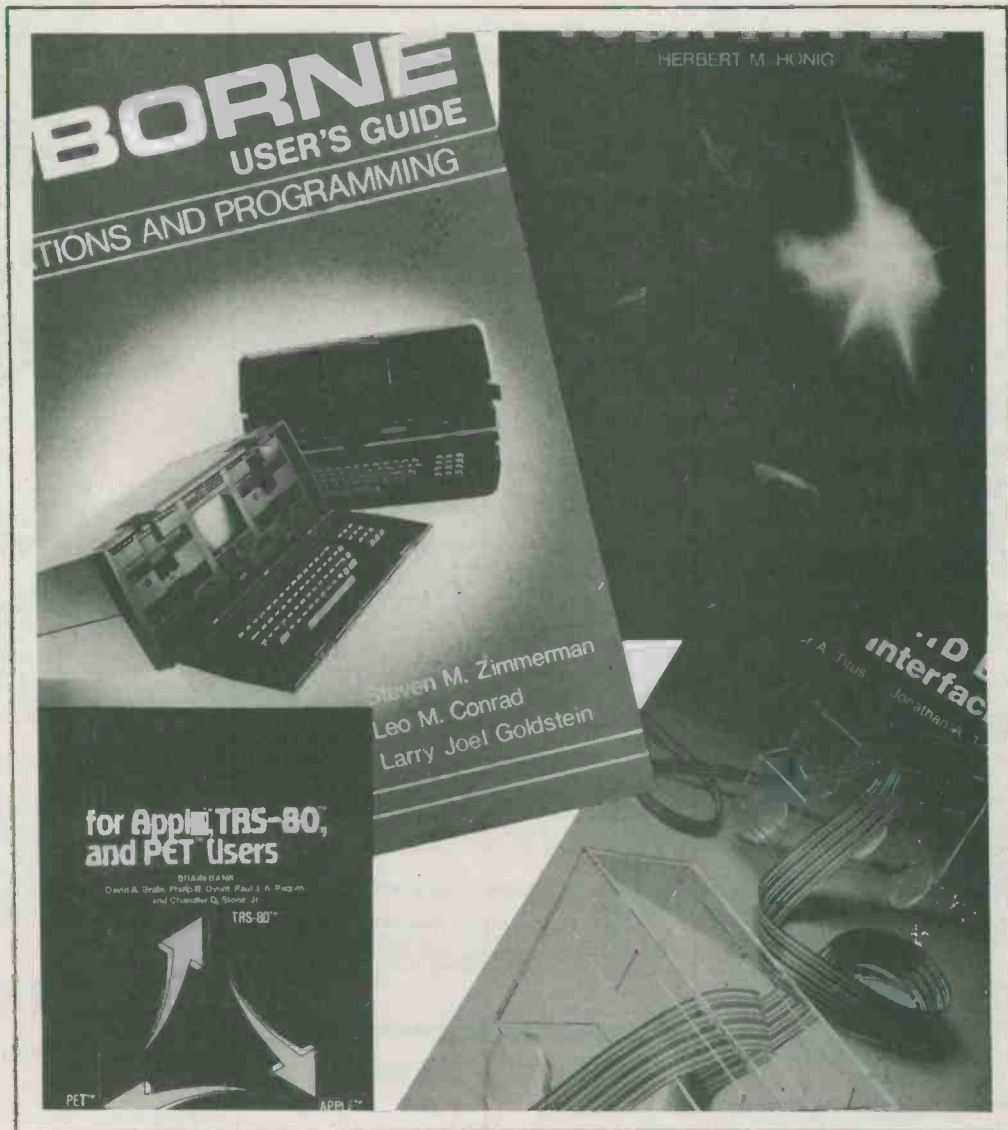
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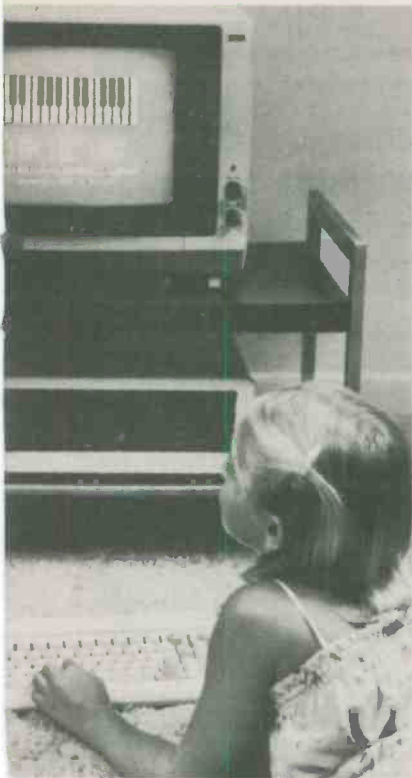
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Save time and money with this collection of 114 ready-to-run BASIC programs for the hobbyist and engineer. There are programs to do such statistical operations as means, standard deviation averages, curve-fitting, and interpolation. There are programs that design antennas, filters, attenuators, matching networks, plotting, and histogram programs.

GAME PLAYING WITH BASIC \$16.95
SPENCER
HB10
The writing is nontechnical, allowing almost anyone to understand computerized game playing. The book includes the rules of each game, how each game works, illustrative flowcharts, diagrams, and the output produced by each program. The last chapter contains 26 games for reader solution.

PH179: BASIC PROGRAMS FOR HOME FINANCIAL MANAGEMENT \$16.95
W. GOLDSMITH, Jr.
This book is a 33 program home financial management system written in BASIC. It includes descriptions, listings, and sample runs and programs that are adaptable to TRS-80, Apple II, and other home computers.

SB22047: 26 BASIC PROGRAMS FOR YOUR MICRO \$16.95
Features 26 previously unpublished, simple-to-complex games you can run on almost any brand of microcomputer as long as you have enough RAM on board. Most take between 500 and 5000 bytes, with the highest taking 13K. Conversion charts that let you key them into your Radio Shack, TRS-80, Apple II, Timex/Sinclair 1000 (ZX81), Spectrum, Atari, or PET are included. Also features notes on program techniques and structures.

Tab1380: 30 COMPUTER PROGRAMS FOR THE HOMEOWNER IN BASIC \$15.95
Programs include a telephone timer, decor redesign, checkbook program, a "coupon" organizer, menu planner and calorie planner.

Tab1533: GRAPHICS PROGRAM IN MICROSOFT BASIC \$19.25
Generate computer art including mathematically defined art and animated graphics; draw still pictures — realistic and abstract; create an interactive space shuttle simulation; plot architectural and landscape drawings with both high and low resolution graphics; construct a 3-dimensional model of a function; plot 2-dimensional graphics, statistical relations, maps and diagrams. All these are written in Microsoft BASIC that is adaptable to just about any BASIC micro system.

SB21941: BASIC: FUNDAMENTAL CONCEPTS \$32.50
Introduces the BASIC language and compares its two major dialects by Microsoft and Digital Equipment Corporation. Teaches you the elements you need to convert programs from one BASIC dialect to another and helps you understand what happens when your computer tries to run a program in a dialect it can't understand. Third in Sam's computing series.

SB21841: BASIC PROGRAMMER'S NOTEBOOK \$20.95
E. SAVAGE
A valuable book that provides you with many timesaving BASIC sub-routines and programming practices usually known only to highly experienced programmers. Also contains several debugged and easily modified program samples you can use.

SB21942: BASIC: ADVANCED CONCEPTS \$32.50
Last in Sam's special four-volume series on computers and computing. Uses BASIC as a tool to help you study program storage within the computer, explore the limitations of floating-point arithmetic, and examine number systems commonly used in computing. Complements and adds to the fundamental commands and concepts of No. 21941, the preceding volume.

THE MOST POPULAR SUBROUTINES IN BASIC \$9.95
TAB No.1050
An understandable guide to BASIC subroutines which enables the reader to avoid tedium, economize on computer time and makes programs run faster. It is a practical rather than a theoretical manual.

PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS \$12.95
AB015
This book emphasizes the sort of analytical thinking that lets you use a specific tool — the BASIC language — to transform your own ideas into workable programs. The text is designed to help you to intelligently analyse and design a wide diversity of useful and interesting programs.

COMPUTER PROGRAMS IN BASIC \$14.95
AB001
A catalogue of over 1,600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine.

BP86: AN INTRODUCTION TO BASIC PROGRAMMING TECHNIQUES \$7.75
S. DALY
This book is based on the author's own experience in learning BASIC and in helping others, mostly beginners, to program and understand the language. Also included are a program library containing various programs, that the author has actually written and run. These are for biorhythms, plotting a graph of Y against X, standard deviation, regression, generating a musical note sequence and a card game. The book is complemented by a number of appendices which include test questions and answers on each chapter and a glossary.

THE BASIC COOKBOOK. \$9.95
TAB No.1055
BASIC is a surprisingly powerful language if you understand it completely. This book, picks up where most manufacturers' documentation gives up. With it, any computer owner can develop programs to make the most out of his or her machine.

BASIC FROM THE GROUND UP \$18.95
SIMON
HB15
Here's a BASIC text for high school students and hobbyists that explores computers and the BASIC language in a simple direct way, without relying on a heavy mathematical background on the reader's part. All the features of BASIC are included as well as some of the inside workings of a computer. The book covers one version of each of the BASIC statements and points out some of the variations, leaving readers well prepared to write programs in any version they encounter. A selection of exercises and six worked out problems round out the reader's experience. A glossary and a summary of BASIC statements are included at the end of the book for quick reference.

AHG2: UNDERSTANDING BASIC \$3.95
PEDDICORD
BASIC is the universal microcomputer language and Understanding Basic teaches the novice to write programs right from the beginning. Emphasizes fundamental programming concepts and covers most features common to all popular versions of BASIC.

PH166: IMPLEMENTING BASICS: HOW BASICS WORK \$19.95
W. & P. PAYNE
Shows the reader how to write progressively more complex and advanced programs. Uses the stack-oriented method, tells how to develop table-driven software, and gives techniques for writing programs.

PH167: MAKING BASIC WORK FOR YOU \$11.95
C. DeROSSI
Learn to program with BASIC, one of the most useful computer languages around. Whether you are entering a computer-related field or simply have access to a computer and would like to use it more effectively, this book has everything you need to know.

PH168: PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS \$12.95
D. HEISERMAN
This complete guide to BASIC computer programming, adaptable to the TRS-80, Apple II, and PET computers; covers a wide range of topics, from programmable video games to engineering and business programs.

SB22014: BASIC PROGRAMMING PRIMER (2nd EDITION) \$24.95
Improved and expanded version of the 5-year Sams/Waite best seller, now featuring keywords, statements, and functions usable with any computer running a variation of Microsoft BASIC, including the IBM PC. Advanced BASIC coverage shows use of special statements, professional-style program coding, and more! New game-program listings include Rubik's Cube, Microspace Invaders, and Word Scrambler! New self-tests and answers help you learn and check your BASIC programming progress as you go! Still user-friendly to beginners and more advanced users, regardless of occupation.

HB125: INTRODUCTION TO TI BASIC \$18.75
INMAN, ZAMORA, ALBRECHT
Written by three of the foremost microcomputing programming experts in the country, this comprehensive work teaches you BASIC for use with the Texas Instruments Home Computer. The authors have carefully constructed this introduction so that you will soon be writing BASIC programs and exploiting all of the excellent features of the TI machine. Covers all the essential programming statements and machine features.

HB108: PROGRAMMING IN BASIC: A COMPLETE COURSE TBA
MCRITCHIE
Suitable for use in both data processing and business courses, this introduction to BASIC provides foundation instruction in the use of the computer terminal, flowcharting, and programming concepts. Since it presupposes no previous experience with computers, McRitchie is accessible to a wide range of students with varying reading abilities. It teaches programming through hands-on student work, and reinforces basic principles through numerous examples and assignments.

HB101: I SPEAK BASIC TO MY TRS-80
HB102: I SPEAK BASIC TO MY APPLE
HB103: I SPEAK BASIC TO MY PET \$12.25
JONES
I SPEAK BASIC A field-tested computer literacy course that introduces students (and teachers) to BASIC language programming. NO PREVIOUS COMPUTER EXPERIENCE IS REQUIRED. This complete 15-session course is machine specific for Apple™, PET™, and TRS-80™ microcomputers and provides a complete understanding of the machine's operations and functions. The Student Text begins each lesson with learning objectives, followed by definitions of key terms, programming examples, in-class exercises, assignments, a summary, programming practices, and a quiz. Special annotations and suggestions in the Teacher's Manual aid in lesson planning and teaching methods, including answers to all quizzes and practices. Exam Set provided on spirit duplicating masters.

PH237: COMPUTER PROGRAMS IN BASIC \$14.95
P. FRIEDMAN
Covering six major discipline fields of Business/Finance, Games, Math, Science/Education, Personal Interest and Utility, this directory provides program reviews in over 173 categories and briefly describes what the program does, tells where it can be found, and lists the equipment needed to make the program run.

HB121: BASIC WITH STYLE: PROGRAMMING PROVERBS \$12.80
NAGIN and LEDGARD
Covers structured BASIC programming. Essential and surprisingly simple principles help BASIC programmers upgrade the quality and efficiency of their work. Each proverb is accompanied by discussion, explanations, and sample programs demonstrating the techniques.

HB111: BASIC BASIC: AN INTRODUCTION TO COMPUTER PROGRAMMING IN BASIC LANGUAGE, 2nd Ed. \$18.75
COAN
"An excellent introduction to the use of BASIC... clearly written and well organized." COMPUTING REVIEWS "It is a well written book... there are many good examples, complete with results." COMPUTER WORLD. Over 100 sample programs present the essential statements of BASIC. Each new language statement or capability is clearly explained at the time it is first used in a sample program. Every section is followed by practice problems; solutions to even-numbered problems appear in the text; the remainder in the separate Teacher's Guide.

HB118: ADVANCED BASIC: APPLICATIONS AND PROBLEMS \$18.50
COAN
"... a useful textbook to the student in a follow-up course, or the programmer acquiring BASIC as his second or third language... well above average." DATA PROCESSING DIGEST. Advanced techniques and applications, including coordinate geometry, area, sequences and series, polynomials, graphing, simulations, and games.

Computing — Languages & Operating Systems

ASSEMBLY LANGUAGES

Z-80 AND 8080 ASSEMBLY LANGUAGE PROGRAMMING

SPRACKLEN HB05 \$15.50
Provides just about everything the applications programmer needs to know for Z-80 and 8080 processors. Programming techniques are presented along with the instructions. Exercises and answers included with each chapter.

HB126: Z-80 AND 8080 ASSEMBLY LANGUAGE PROGRAMMING

SPRACKLEN \$15.60
Provides just about everything the applications programmer needs to know for Z-80 and 8080 processors. Programming techniques are presented along with the instructions. Exercises and answers included with each chapter.

Tab1389: MACHINE AND ASSEMBLY LANGUAGE PROGRAMMING

\$14.95
This book assumes no prior programming knowledge and starts by explaining the advantages of ML. Several sample programs are included and each chapter ends with a quiz to check your understanding of that section.

SARGON: A COMPUTER CHESS PROGRAM

SPRACKLEN HB12 \$25.50
"I must rate this chess program an excellent buy for anyone who loves the game." Kilobaud.

Here is the computer chess program that won first place in the first chess tournament at the 1978 West Coast Computer Faire. It is written in Z-80 assembly language, using the TDL macro assembler. It comes complete with block diagram and sample printouts.

FORTH

PH174: STARTING FORTH

L BRODIE, FORTH, INC. \$23.95
Here is valuable reading material for anyone interested in computer programming. "Starting Forth" presents a clear and complete guide to FORTH — the revolutionary approach to computer programming.

SB21842: INTRODUCTION TO FORTH

K. KNECHT \$15.50
Most complete book you can find on the MMS FORTH version of FORTH, and also a fundamental approach to programming in all versions of that language. Many programming examples are provided with direct comparisons to the Microsoft Level II BASIC version of the same program.

AHG17: UNDERSTANDING FORTH

REYMANN \$3.95
An introduction and overview of this highly flexible programming language that is enjoying increasing interest.

SB22007: FORTH PROGRAMMING

L SCANLON \$23.95
Only book on the market that shows you the differences between FORTH-79 and fig-FORTH, and how to write or modify software using either dialect! Teaches you how to manipulate the stack and add new operations. Lists all FORTH commands. Includes more than 50 fast-acting, useful programs that will execute with little or no modification on any FORTH system.

FORTRAN

HB119: BASIC FORTRAN

COAN \$15.90
This book will enable novice programmers to write FORTRAN programs immediately. The author has developed more readable programs by taking you step by step through the programming process. Short, complete programs are developed into longer, more comprehensive ones. Over 80 program examples are included.

HB123: FORTRAN WITH STYLE: PROGRAMMING PROVERBS

LEDGARD and CHMURA \$14.45
This FORTRAN 76 style guide is intended for programmers who want to write carefully constructed, readable programs. Provides simple rules of style that enable the programmer to focus creatively on the deeper issues in programming.

AHG4: UNDERSTANDING FORTRAN

LUDWIG \$3.95
FORTRAN is the most widely used language for engineering, scientific, and economic forecasting applications. Understanding FORTRAN acquaints the reader with this type of programming and covers the essential features of the language.

COBOL

Tab1398: COBOL \$15.95

Cobol for Common Business Orientated Language is a high level language which has gained high acceptance as the language for expressing business data processing procedures in standard English. This title answers the questions you may have on purpose, use, environment, data and procedures.

AHG5: UNDERSTANDING COBOL

PEDDICORD \$3.95
COBOL is the most commonly used language in large, business computers. Understanding COBOL is the ideal introduction for the beginning programmer or curious business manager.

PASCAL

PH169: THE FIRST BOOK OF JOSEF: AN INTRODUCTION TO COMPUTER PROGRAMMING USING PASCAL

I. TOMEK, ACADIA UNIVERSITY \$16.95
Who said learning programming principles has to be dull? Now there's an entertaining and enjoyable way to learn! Readers learn and apply fundamental programming concepts by manipulating a simulated robot, Josef, via a simple programming language consisting of ordinary words governed by simple rules.

PH170: UCSD PASCAL: A CONSIDERATE APPROACH

D. PRICE \$16.95
For anyone who wants to learn how to write programs in UCSD Pascal, this book offers the simplest, most effective way to write programs that are easy to read and easy to use. Written specifically for the novice programmer, it offers a solid, low-level introduction and focuses on basic, essential programming skills without going into unnecessary technical detail. Includes many simple programs.

PH171: UCSD PASCAL: A BEGINNER'S GUIDE TO PROGRAMMING MICROCOMPUTERS

J. HUME & R. HOLD \$19.45
Everything beginners need to know for effective use of the "hot" new computer language, UCSD Pascal, is readily available in this exciting introduction to programming microcomputers.

PH172: THE UCSD PASCAL HANDBOOK

R. CLARK & S. KOEHLER \$20.95
The UCSD Pascal Handbook contains language description organized especially for quick and easy reference. Built around example programs that demonstrate common and useful techniques.

PH173: PASCAL: A CONSIDERATE APPROACH

D. PRICE \$12.95
Here is a straightforward introduction to the programming language Pascal. The emphasis is on "considerate programming," using an easy-to-follow approach that aims to ease the learning process by using simple programs.

AHG3: UNDERSTANDING PASCAL

LEDIN \$3.95
PASCAL is available on most microcomputers and is one of the newest and most popular of all programming languages. By teaching this ideal "learning language," Understanding Pascal helps the novice develop good programming methods and understand the main programming structures.

HB120: PASCAL WITH STYLE: PROGRAMMING PROVERBS

LEDGARD, NAGIN, and HUERAS \$13.75
A style guide specifically written to help Pascal users write more accurate, error-free programs the first time. Offers rules or guidelines that stress overall program organization and "Logical thinking." Special chapter on how to use the top-down approach with Pascal.

PASCAL PROGRAMMING FOR THE APPLE

AB008 \$19.95
A great book to upgrade your programming skills to the UCSD Pascal as implemented on the Apple II. Statements and techniques are discussed and there are many practical and ready to run programs.

PASCAL

TAB No.1205 \$15.95
Aimed specifically at TRS-80 users, this book discusses how to load, use and write PASCAL programs. Graphic techniques are discussed and numerous programs are presented.

SPEAKING PASCAL

BOWEN HB16 \$18.95
An excellent introduction to programming in the Pascal language! Written in clear, concise, non-mathematical language, the text requires no technical background or previous programming experience on the reader's behalf. Top-down structured analysis and key examples illustrate each new idea and the reader is encouraged to construct programs in an organized manner.

CP/M

PH175: CP/M ASSEMBLY PROGRAMMING

K. BARIER \$16.95
This book is a self-teaching manual that will enable readers to learn the details of microcomputer hardware, its operating system, and assembly language programming. These three topics are integrated in a learn-by-doing environment of the most popular microcomputer operating system.

PH176: SYSTEM PROGRAMMING UNDER CP/M-80

L HUGHES \$20.95
How to use and program under the CP/M operating system. How to install and modify the CP/M o.s.

HB106: CP/M REVEALED

DENNON \$19.95
This book is intended for CP/M users to improve their skills. It is a guide to the CP/M operating system: the console monitor (CCP), the system manager (BDOS), and the input/output driver package (CBIOS). In addition to providing a clear understanding of the data structure of the CP/M disk and other essentials to using CP/M effectively, this text fills many of the information gaps left by the Digital Research CP/M manuals. Coverage includes buying CP/M, booting up, logging in, changing memory size, mapping disk space, calling all programs, interfacing I/O devices, and more.

HB109: INSIDE CP/M: A GUIDE FOR USERS AND PROGRAMMERS, WITH CP/M-86 AND MP/M 2

CORTESI \$32.95
This guide and reference manual for CP/M (an operating system for small computers) is divided into two sections. The Tutorial presents the basics of the management, use, and programming of a small computer and CP/M. In the Reference section, CP/M information is organized for quick access by programmers and users. The answer to any question about the day-to-day use of CP/M can be found in a few seconds in the reference section. Most of this text applies correctly to most CP/M systems; however, the book was developed on, and for, CP/M 2.2.

SB21791: CP/M® PRIMER

Helps microcomputer veterans and novices alike find the answers about CP/M in a complete, one-stop sourcebook that's a Sams best-seller! Gives you complete CP/M terminology, hardware and software concepts, startup details, and more for this popular 8080/8085/Z-80 operating system. Helps you begin using and working with CP/M immediately, and includes a list of compatible software, too.

PH515: A PROGRAMMER'S NOTEBOOK: UTILITIES FOR CP/M-80

D. CORTESI \$46.50
This book/disk package, designed from the professional programmer's point of view, offers the nuts and bolts of programming in 8080 assembly language. With it, the user will be able to build an impressive software library that would cost a fortune if bought elsewhere. Book/Disk Package.

UNIX

PH177: USING THE UNIX SYSTEM

R. GAUTHIER \$20.95
The book provides computer professionals with an excellent handbook that shows how to handle everything from specific commands to files to overall system design for new applications.

SB22028: UNIX PRIMER PLUS

\$27.95
This newest Sams/Waite Primer introduces you to the powerful UNIX operating system. Perfect for students, office workers, home-computer owners, new computer users and others learning about or starting on a UNIX-based system.

MISCELLANEOUS

PH514: COMAL HANDBOOK

L. LINDSAY \$39.00
COMAL (COMMon Algorithmic Language) takes the simplicity of BASIC and the power and structure of Pascal and combines them into one language that's easy to learn and powerful to use. Includes 100 sample programs and procedures. Book/Disk Package.

AHG18: UNDERSTANDING LOGO

McLEAN \$3.95
LOGO is easy to learn, but capable of great sophistication. This Handy Guide is an introduction for the beginner and an overview for the advanced programmer.

HB124: MY MICRO SPEAKS BASEX (AND LOVES IT!)

WARME \$13.45
An in-depth examination of BASEX, a versatile language for 8080 and Z-80 type microcomputers, which combines the best features of BASIC and executable machine code. The major advantage of BASEX is speed — programs run up to ten times faster than similar programs in BASIC.

AHG11: UNDERSTANDING APL

BRYSON \$3.95
APL, rapidly growing in popularity, is one of the most concise computer languages, particularly well-suited to the efficient solution of mathematical and business problems. This Handy Guide is a concise introduction to the terms and functions of this language. For the beginning to advanced programmer.

AHG12: UNDERSTANDING LISP

GLOESS \$3.95
LISP is the most widely used language in the Artificial Intelligence community, an area of growing importance in the computer world, and is available on a growing number of personal computers. This Handy Guide is a detailed introduction to this language. For the reader with at least some programming experience.

BUSINESS (GENERAL)

PH180: 1983 CANADIAN BUSINESS GUIDE TO MICRO-COMPUTERS

K. DORRICO \$8.95
Written by the managing director of Deloitte, Haskins & Sells, a Canadian partnership of public accountants and other professional advisors to management, this book is one of the most complete comprehensive guides to microcomputers available. Starting with a general overview of microcomputers and their business applications, the author helps you assess your computer needs, compares and evaluates computer systems and application packages, and gives you tips on "doing it right". A must for anyone thinking of purchasing a microcomputer for business.

PH183: HOW TO BUY A BUSINESS COMPUTER AND GET IT RIGHT THE FIRST TIME
CROSS \$20.95
246 pages

THE JOY OF MINIS AND MICROS: DATA PROCESSING WITH SMALL COMPUTERS

STEIN AND SHAPIRO
HB03 \$17.50

A collection of pieces covering technical and management aspects of the use of small computers for business or science. It emphasizes the use of common sense and good systems design for every computer project. Because a strong technical background is not necessary, the book is easy to read and understand. Considerable material is devoted to the question of what size computer should be used for a particular job, and how to choose the right machine for you.

SB21890: UNDERSTANDING AND BUYING A SMALL BUSINESS COMPUTER

B. DONOHUE \$13.95
A lively, practical guide intended primarily for small-business owners but equally usable by any businessperson considering purchase of a micro- or minicomputer for business use. Presented in a careful, nontechnical style and filled with examples, diagrams, and case studies of other business-users to help build your knowledge and confidence. Not a shopping guide. Helps you avoid hidden costs, spot reliable suppliers, and ask intelligent questions.

PH190: HOW TO BUY AN OFFICE COMPUTER OR WORD PROCESSOR

B. DONOHUE \$11.95
A single-source of detailed instructions on how to find and contract the right computer or word processor, this book lays out a step-by-step procedure for selecting a system and for protecting one's self with a solid contract.

PH191: HOW TO SELECT YOUR SMALL COMPUTER ... WITHOUT FRUSTRATION

H. SEGAL & J. BERTS \$19.95
Presents the latest tested and proven techniques to help the prospective computer buyer avoid the most common pitfalls that plague new users. Includes 18 worksheets leading the reader through each step of the way and "shopping lists" of features to look for in the most popular hardware and software.

PH182: THE ELECTRONIC OFFICE

N. FINN \$16.95
Specific suggestions on how to implement office automation, as well as the factors to consider in computer contract negotiations, selection of hardware, database input and management, and 'ergonomics' of computer design.

PH184: MICROCOMPUTERS IN SMALL BUSINESS

R. RANDALL \$11.95
Written specifically for the business-person with little or no experience with computers. Provides a basic, detailed introduction to the use of microcomputers in the small business environment.

PH185: A GUIDE FOR SELECTING COMPUTERS AND PROGRAMS FOR SMALL BUSINESS

P. ENOCKSON \$19.95
An overview of all the aspects of the selection of a computer, including software and the installation of the entire system in any small business.

PH187: THE COMPLETE BOOK OF WORD PROCESSING AND BUSINESS GRAPHICS

W. SIKONOWIZ \$19.95
Designed as an introduction to word processing and business graphic systems, this easy-to-understand guide features comparisons between dedicated machines and general purpose computers configured for these same applications.

PH188: A MANAGER'S GUIDE TO LOCAL NETWORKS

F. DERFLER, JR. & W. STALLINGS \$19.95
Informative, yet easy to understand, this book explains how business managers and corporate decision-makers can improve productivity with a better understanding of local network systems.



PH198: TAMING YOUR COMPUTER: A GUIDE FOR BUSINESS AND PROFESSIONAL PEOPLE

J. KANTER \$11.95
'Taming Your Computer' will show you how to use your computer to reach peak efficiency in your daily functions as businessman or professional. Perfect for businessmen who want to streamline their production.

PH200: MICROCOMPUTERS FOR BUSINESS

SUMMER & LEVY, editors \$10.95
Just about everything the small business operator or manager should know when considering the cost efficiency of microcomputer systems. Includes comparisons of various systems, cost evaluation, choosing the right system, much more. 40 case studies.

PH201: COMPUTER POWER FOR THE SMALL BUSINESS

C. SIPPL & F. DAHL \$10.95
Explains how computers work in simple terms. Step-by-step instructions tell how to develop a plan for an individualized computer system.

PH202: HOW TO COMPUTERIZE YOUR SMALL BUSINESS

J. COHEN & C. MCKINNEY \$10.95
A complete guide to selecting data processing equipment and services, this book shows how to plan a computer system tailored to the needs of any small business.

HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: PROFESSIONAL, BUSINESS, AND HOME APPLICATIONS

LEWIS \$18.95
HB01
Describes the uses of personal computers in common business applications, such as accounting, managing, inventory, sorting mailing lists, and many others. The discussion includes terms, notations, and techniques commonly used by programmers. A full glossary of terms.

PH192: HOW TO MANAGE YOUR SMALL COMPUTER ... WITHOUT FRUSTRATION

H. SEGAL & J. BERTS \$19.95
Readers will learn how to guarantee a hassle-free installation; how to overcome the staff's computer phobia; how to hire, train and motivate DP personnel, and how to sell excess computer capacity for bonus profits.

PH193: DEVELOPING COMPUTER SOLUTIONS FOR YOUR BUSINESS PROBLEMS

H. PETERSOHN \$19.95
A computer expert shows managers how to effectively implement, and evaluate automation alternatives. Written specifically for managers in both large and small business environments, it guides the reader in defining problems explaining them to data processing people, and finding the fastest and least expensive installation method.

PH194: MICROCOMPUTERS IN LARGE ORGANIZATIONS

T. MADRON \$16.95
Here is the first — and only — book that discusses planned implementation of microcomputers in large organizations. Written specifically for business and data processing managers, it provides a complete description of software for the development of the Executive Workstation. Also included are implementation techniques on the IBM-PC and the Osborne 1.

PH195: SO YOU ARE THINKING ABOUT A SMALL BUSINESS COMPUTER

R. CANNING & N. LEEPER \$14.95
Specially designed for the business person with little or no knowledge of computers, this book gives practical step-by-step guidelines for successfully selecting a small computer system and using it in daily office routines. It describes the benefits of having a computer system, how computers work, hardware and software characteristics, and how to use the services of a consultant.

PH189: THE COMPUTER IN YOUR LEGAL PRACTICE

M. MARCUS & L. BROWN \$26.00
At last — here's the answer every lawyer has been waiting for! A complete, authoritative guide to computerizing a legal practice, this book will help readers better understand how computers work — and how to use them for increased efficiency and productivity in a business. Applications include law office management, accounting, finance, word processing, database and research, document control, records management, electronic mail, administration, and more.

PH186: MICROCOMPUTERS FOR ACCOUNTANTS

T. NEEDLEMAN \$19.95
Written by a consultant who specializes in the financial application of microcomputers, this book shows accountants how to make their business more profitable by implementing microcomputers for better practice management, improved client support, and such new services as tax accounting, modelling, budgeting, and forecasting.

PH196: THE PHYSICIAN'S GUIDE TO DESKTOP COMPUTERS

M. SPOHR, M.D. \$20.00
Designed for medical practitioners—doctors, dentists, nurses — who use or plan to use microcomputers in their practice. Written for the uninitiated computer user, the book covers the special capabilities of the desktop computer that make it valuable in a medical office/clinic.

USING MICROCOMPUTERS IN BUSINESS

VEIT \$15.95
HB04
An essential background briefing for any purchaser of microcomputer systems or software. In a fast-moving style, without the usual buzz words and technical jargon. Veit answers the most often asked questions.

Computing — Business

DATA BASE MANAGEMENT

PH199: DATA BASE SYSTEMS: DESIGN, IMPLEMENTATION AND MANAGEMENT
R. ROSS \$29.00

Here's a practical, comprehensive resource that covers Data Base Management Systems. Examines CODASYL, inverted DBBMs, mini-DBMS, the relationship model and physically-linked DBMS.

PH181: THE DATA BASE GUIDE
C. BENTON \$26.00

Complete step-by-step book detailing the necessary elements for selecting, organizing, and implementing database systems for microcomputers. Presents material at a beginner's level yet thorough enough to aid the professional data processing person.

SB21875: MICROCOMPUTER DATA BASE MANAGEMENT \$18.50

A practical guide for anyone who needs to control and access large amounts of data with a microcomputer. Complete tutorial shows routines you can use to write and implement your own data-base programs. Also explains step-by-step operation of WHATSIT, SELECTOR, and PROFILE, just 3 of many data-base packages on the market, and evaluates their performance. If you know the fundamentals of BASIC programming, you'll do fine with this book.

AHG10: UNDERSTANDING DATA BASE MANAGEMENT FREILING \$3.95

This Handy Guide explains how data bases are created, maintained and utilized, and surveys the latest techniques, providing an easy overview for business managers and programmers alike.

PH230: EVERYMAN'S DATABASE PRIMER
BYERS \$19.95

BUSINESS SOFTWARE

PH203: THE POWER OF MULTIPLAN™
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Covers: Accounts receivable, invoicing, cost recovery, production scheduling, estimating, checkbook, and engineering problem solving, accounts payable, payroll, monthly sales report, inventory and financial forecast.

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Residential income property analysis, amortization schedule, condominium conversion or tract home development cash flow analysis, project operating case flow analysis, property-tenant income revenue calculations, construction disbursements, construction loan draw, project cost analysis, cash flow analysis.

PH205: THE POWER OF VISIPILOT — VISICALC — VISIFILE:
MANAGEMENT INFORMATION SOURCE \$19.95

Line graphs, Bar graphs, Area graph, Pie and Hi-Lo overlaying plots, storage management, VisiCalc data plotted, VisiFile data plotted.

PH206: dBASE II USER'S GUIDE
A. GREEN \$38.00

This instructional handbook for novices and experienced users alike presents a simple, highly effective approach to learning how to use this powerful software program available for microcomputers.

PH207: SUPERCALC! THE BOOK
D. BEIL \$22.95

This practical programming guide is designed to help users of a SuperCalc system discover its real power! It teaches readers how to design the right "model" so that they can examine every step of their business operation and includes practice problems to help along the way.

PH208: THE VISICALC APPLICATIONS BOOK
J. GRUSHCOW \$22.95

Designed for both the novice and advanced VisiCalc user, this practical guide explains WHY VisiCalc should be used as well as HOW to use it in six key business areas: credit control, financial statement analysis, forecasting, budgeting cost management, and portfolio management.

PH209: THE POWER OF VISICALC
R. WILLIAMS & B. TAYLOR \$12.95

A must for anyone who owns — or is thinking about getting — a microcomputer, this instructional handbook presents a simple and effective approach to learning how to use the most powerful software program available for personal size computers. It demonstrates the use of VISICALC features through specific examples in a wide range of applications.

PH210: THE POWER OF SUPERCALC
R. WILLIAMS & B. TAYLOR \$12.95

Here is the first book that demonstrates the use of SUPERCALC features through specific application examples. Written for business owners, accountants, teachers, students, and homeowners, it presents several easy-to-follow exercises for developing and expanding problem-solving skills with SUPERCALC.

AHG8: HOW TO USE VISICALC/SUPERCALC
SHRUM \$3.95

A step-by-step, detailed guide to the two best-selling software for personal computers, used to make budgeting and forecasting easy. This Handy Guide clearly and simply explains all VisiCalc/SuperCalc functions and helps the reader creatively solve problems. For the complete novice.

HB104: BASIC COMPUTER PROGRAMS FOR BUSINESS
(Vol. 2)
STERNBERG \$19.95

A must for small businesses and entrepreneurs using micros. Over 60 practical business applications, each documented with a description of its functions and operation, a listing in BASIC, a symbol table, sample data, and one or more samples.

PH197: SIMPLE: BASIC PROGRAMS FOR BUSINESS APPLICATION
J. ALONSO \$19.95

This book includes BASIC programs that even a new user can use with as little as 3 minutes of instruction! And for experienced users, these programs can be easily modified to better suit particular needs. Covers a wide range of statistical, business, and mathematical techniques.

BASIC COMPUTER PROGRAMS FOR BUSINESS:
STERNBERG (Vol. 1)
HB13 \$17.95

A must for small businesses utilizing micros as well as for entrepreneurs, volume provides a wealth of practical business applications. Each program is documented with a description of its functions and operation, a listing in BASIC, a symbol table, sample data, and one or more samples.

WORD PROCESSING

PH211: WORD PROCESSORS AND INFORMATION PROCESSING
D. POYNTER \$15.95

A clear, readable word processing book that provides business and lay people with the means to effectively evaluate word processing equipment and choose the appropriate machine for their specific needs.

PH212: CHOOSING A WORD PROCESSOR
P. GOOD \$16.95

Provides a head-to-head comparison of 157 features of the 21 leading word processing systems, plus extensive checklists to help pick the system that is most flexible and most cost efficient for the work that must be done.

PH213: WORD PROCESSING SIMPLIFIED AND SELF- TAUGHT
J. CHRISTENSEN \$6.95

Illustrates how word processing functions in a typical office environment and explains the basic components and applications that all potential users need to know, whether for business or personal use.

PH214: THE WORD PROCESSING HANDBOOK
R. STULTZ \$11.95

Convenient and easy to use, this handbook is designed for the business manager responsible for the operation of high technology word processing systems. It is written in a style which cuts through the usual technical doubletalk to give the reader a better understanding of word processing systems — what they are, what they do, and which one to select, as well as the bottom line cost of owning and operating a system.

SB21929: WORD PROCESSING FOR SMALL BUSINESSES \$16.95

Tells you about doing practical word processing on a personal computer, how word-processing software works, what benefits you can expect from W/P, and what you should avoid. Compares micro- and minicomputer W/P systems, discusses W/P software and its documentation, points out the effects of different hardware designs, and presents details for more than 50 word-processing systems, including applicable hardware and W/P software.

AHG7: HOW TO BUY A WORD PROCESSOR
SCRIVEN \$3.95

A buying guide and short course on word processing wrapped into one book; covering electronic typewriters, personal computers, and specialized word processing systems. Includes a comparison chart of the most popular systems and software.

GENERAL

DESIGNING MICROCOMPUTER SYSTEMS
HB18: POOCH AND CHATTERGY \$17.50

This book provides both hobbyists and electronic engineers with the background information necessary to build microcomputer systems. It discusses the hardware aspects of microcomputer systems. Timing devices are provided to explain sequences of operations in detail. Then, the book goes on to describe three of the most popular microcomputer families: the Intel 8080, Zilog Z-80, and Motorola 6800. Also covered are designs of interfaces for peripheral devices, and information on building microcomputer systems from kits.

S-100 BUS HANDBOOK
HB19: BURSKEY \$25.50

Here is a comprehensive book that exclusively discusses S-100 bus computer systems and how they are organized. The book covers computer fundamentals, basic electronics, and the parts of the computer. Individual chapters discuss the CPU, memory, input/output, bulk-memory devices, and specialized peripheral controllers. It explains all the operating details of commonly available S-100 systems. Schematic drawings.

THE BASIC CONVERSIONS HANDBOOK FOR APPLE, TRS-80, AND PET USERS
BRAIN BANK

HB17 \$12.95

Convert a BASIC program for the TRS-80, Apple II, or PET to the form of BASIC used by any other one of those machines. This is a complete guide to converting Apple II and PET programs to TRS-80, TRS-80 and PET programs to Apple II, TRS-80 and Apple II programs to PET. Equivalent commands are listed for TRS-80 BASIC (Model I, Level II), Applesoft BASIC and PET BASIC, as well as variations for the TRS-80 Model III and Apple Integer BASIC.

AHG6: UNDERSTANDING ARTIFICIAL INTELLIGENCE
GLOESS \$3.95

This Handy Guide surveys current developments and applications of artificial intelligence and explains them in easy-to-understand language. Readers need not know programming.



Computing — General

HB116: THE BASIC CONVERSIONS HANDBOOK FOR APPLE^{II}, TRS-80^{II}, and PET^{II} USERS BRAIN BANK

\$12.95
A complete guide to converting Apple II and PET programs to TRS-80, TRS-80 and PET programs to Apple II, and TRS-80 and Apple II programs to PET. Equivalent commands are listed for TRS-80 BASIC (Model I, Level II), Applesoft BASIC, and PET BASIC, as well as variations for TRS-80 Model III and Apple Integer BASIC. Also describes variations in graphics capabilities.

SB21927: MICROCOMPUTER MATH

W. BARDEN \$16.95
A step-by-step introduction to binary, octal, and hexadecimal numbers, and arithmetic operations on all types of microcomputers. Excellent for serious BASIC beginners and intermediates as well as assembly-language programmers. Treats addition and subtraction of binary, multiple-precision and floating-point operations, fractions and scaling, flag bits, and more. Many practical examples and self-tests.

PH240: THE COMPUTER COOKBOOKTM

W. BATES \$16.95
A guidebook to putting together microcomputer systems from various components available on the market. Offering factual and specific information (not a lot of jargon), it explains how to integrate assorted "ingredients" into finished systems.

HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS

AB013 \$12.95
Learn how to find the cause of a problem or malfunction in the central or peripheral unit of any microcomputer and then repair it. The tips and techniques in this guide can be applied to any equipment that uses the microprocessor as the primary control element.

TROUBLESHOOTING MICROPROCESSORS AND DIGITAL LOGIC

TAB No. 1183 \$15.95
The influence of digital techniques on commercial and home equipment is enormous and increasing yearly. This book discusses digital theory and looks at how to service Video Cassette Recorders, microprocessors and more.

HOW TO DEBUG YOUR PERSONAL COMPUTER

AB012 \$12.95
When you feel like reaching for a sledge hammer to reduce your computer to fiberglass and epoxy dust, don't. Reach for this book instead and learn all about program bug tracking, recognition and elimination techniques.

PH178: INCOME FROM YOUR HOME COMPUTER

E. LIAS \$16.95
Presents 30 ways to earn income with a home microcomputer. One third of the innovative ideas are applicable to the novice, and much of the text appeals to game players as well as skilled system designers. Includes names and addresses of software agents, microcomputer manufacturers, journals, user clubs, microcomputer directories, workshop resources, and publishers who buy software.

HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR

AB006 \$11.95
Calculator programming, by its very nature, often is an obstacle to effective use. This book endeavours to show how to use a programmable calculator to its full capabilities. The TI 57 and the HP 33E calculators are discussed although the principles extend to similar models.

BP33: ELECTRONIC CALCULATOR USERS HANDBOOK

M.H. BABANI, B.Sc.(Eng.) \$3.75
An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples. Includes the way to calculate using only a simple four function calculator: Trigonometric Functions (Sin, Cos, Tan), Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers.

SB21960: COMPUTER PROGRAMS FOR MACHINE DESIGN

\$30.95
Aids mechanical and material engineers, machinists, technicians, and students in solving the day-to-day problems that come up in their involvement with various facets of machine technology. Organized by major subject area in a logical, problem-solving order that features a statement of the problem, the formula used for solution, and a working example. You can manipulate data repeatedly to observe specific design variables. Programs are in BASIC.

AHG16: UNDERSTANDING DATA COMMUNICATIONS

BUCKWALTER \$3.95
A non-technical introduction to all aspects of communications between computers. Emphasizes the practical requirements of electronic mail, networking, and shared systems.

SB21896: INTRODUCTION TO ELECTRONIC SPEECH SYNTHESIS

N. SCLATER \$12.95
Helps you understand how a human "voice" is electronically created, explains the three current digital synthesis technologies used, and tells you what you can expect in speech quality as it relates to data rate and the cost of memory devices. Also evaluates complexity and cost of commercial voice-synthesis subsystems.

PH220: MICROCOMPUTER DATA COMMUNICATIONS SYSTEMS

F. DERFLER, Jr. \$16.95
This guide explains microcomputers as data communications terminals and electronic message systems. Covers TRS-80, Apple II, Heath H-89, and other systems.

PH221: CAI SOURCEBOOK

R. BURKE \$15.95
CAI stands for Computer Assisted Instruction, and this step-by-step introduction to the systematic development and validation of CAI includes a complete set of forms and procedures for implementing the systems approach to computer assisted instruction.

PH222: THE ABC'S OF MICROCOMPUTERS: A COMPUTER LITERACY PRIMER

L. CHRISTIE & J. CURRY, Jr. \$10.95
An invaluable collection of informative discussions on applications, equipment, programming, and operations of microcomputers. Focuses on those topics essential for the novice to know, and defines all technical terms as they appear.

PH223: COMPUTERS AND DATA PROCESSING SIMPLIFIED AND SELF-TAUGHT

R. STRACKBEIN & D. STRACKBEIN \$6.95
Shows in non-technical language how computers work, what their applications are, and how these applications are being utilized in the everyday world.

PH224: SIMPLIFIED GUIDE TO MICROCOMPUTERS

W. BOCCINO \$26.00
Features 10 model programs (worth hundreds of dollars) for business and personal use, a special glossary of microcomputer terms, and dozens of photos, diagrams, charts and checklists.

PH225: MICROCOMPUTERS GRAPHICS

D. HEARN & M. BAKER \$24.95
Provides the reader with a solid grasp of the graphic capabilities of microcomputers and the variety of uses to which they can be put. Graphics methods are illustrated with programs written in BASIC.

PH226: COMPUTER ANATOMY FOR BEGINNERS

M. OUVERSON \$14.95
Specifically written for the thousands of readers who simply want to know what the microcomputer revolution is all about and how it might affect, or even benefit them.

PH227: SOFTWARE ENGINEERING FOR SMALL COMPUTERS: A PROGRAMMER'S COMPANION

R.B. COATS \$22.95
For more advanced programmers who want to extend their skills beyond simple programming, this reference guide takes the reader from analysis to design, through construction and implementation.

PH228: PROGRAMMING A PERSONAL COMPUTER

P. HANSEN \$24.95
Describes a software system powerful enough to support the development of new operating systems, compilers, and text processing programs on a small, personal computer, yet is simple enough to be studied in detail at all levels of programming. The software system is written in the programming language Edison — a Pascal-like language that supports program modularity and concurrent execution on microprocessor. 11 line illustrations.

PH229: VIDEOTEXT: THE MESSAGE IN THE MEDIUM

P. STORFER \$19.95
Here is a complete, authoritative guide to videotext services. It explores their potential impact on: advertising, personal computer use, banking and financial services, libraries, publishing, and broadcasting.

PH231: MICROS AND MODEMS

J. NILLES \$30.00

MICROCOMPUTERS AND THE 3 R'S

DOERR \$15.95
HB09
This book educates educators on the various ways computers, especially microcomputers, can be used in the classroom. It describes microcomputers, how to organize a computer-based program, the five instructional application types (with examples from subjects such as the hard sciences, life sciences, English, history, and government), and resources listings of today's products. The book includes preprogrammed examples to start up a microcomputer program; while chapters on resources and products direct the reader to useful additional information. All programs are written in the BASIC language.

PH232: MATHEMATICAL PROBLEM SOLVING WITH THE MICROCOMPUTER: PROJECTS TO INCREASE YOUR BASIC PROGRAMMING SKILL

S. SNOVER & M. SPIKELL \$11.95
Whether it is for educational or recreational purposes, this collection of programs is written with BASIC instructions that are general enough to work on virtually every computer that uses BASIC language.

PH233: A 60-MINUTE GUIDE TO MICROCOMPUTERS

L. HOLLERBACH \$9.95
Specifically designed for beginners who want a quick course in personal and business computing, this book provides a solid, low-level introduction to microcomputers. It gives a lucid presentation of microcomputer use in both business and personal spheres and clarifies all the technical buzz words in a simple and entertaining fashion.

PH234: EXPLORING THE WORLD OF THE PERSONAL COMPUTER

J. NILLES \$16.95
"Exploring the World of the Personal Computer" takes this technology to the individual and societal level, examining the positive and negative aspects of the present and future widespread use of low cost microcomputers.

PH235: BIG THINGS FROM LITTLE COMPUTERS

D. PETERSON \$16.95
Written in a non-technical style, this book will appeal to the increasing number of people interested in personal computing — whether or not they have a professional background in the area. Computer enthusiasts will learn about such topics as how a computer works, and what can actually be done with a computer.

PH236: THE PRENTICE-HALL CONCISE BOOK OF COMPUTERS

M. FRANK \$13.95
"The Prentice-Hall Concise Book of Computers" explains clearly what computers are, how they operate, and the sort of work they perform. It examines every aspect of this fascinating subject, from the simplest type of machine to the most sophisticated, which are astoundingly fast, and shows that, far from being the mystery that most people consider them, computers are useful, comprehensible tools of benefit to all of us, whether we use one directly or not. Over 150 illustrations in colour and black and white.

CONSTRUCTIONAL

TAB1491: 101 PROJECTS FOR THE Z80 \$29.95

Gives you hands-on experience in interfacing fundamentals plus a thorough grounding in creative programming. There are hardware and software applications and several that combine both.

TAB1449: COMPUTER PERIPHERALS YOU CAN BUILD \$20.95

Shows you how to build A/D and D/A converters, cassette interfaces, light pens, disk drives, AC and DC control mechanisms, music boards and much more.

HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER \$15.95

TAB No. 1200
An excellent reference or how-to manual on building your own microcomputer. All aspects of hardware and software are developed as well as many practical circuits.

BP78: PRACTICAL COMPUTER EXPERIMENTS \$6.80

E.A. PARR, B.Sc., C.Eng., M.I.E.E.
Curiously most published material on the microprocessor tends to be of two sorts, the first treats the microprocessor as a black box and deals at length with programming and using the "beast". The second type of book deals with the social impact. None of these books deal with the background to the chip, and this is a shame as the basic ideas are both interesting and simple.

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

KIDS

PH215: KIDS AND THE APPLE

E. CARLSON & DATAMOST \$26.00
Written primarily for 10 to 14 year-olds, this book helps kids (as well as parents and teachers) become pros at writing Applesoft Basic Programs for home computers. Through a series of 33 sequential, easy-to-follow lessons, examples and exercises, learn how to program Apple computers, to play board games, word games, action games, store and recall personal data, debug, edit, create graphics, even create a program.

PH216: KIDS AND THE VIC

E. CARLSON & DATAMOST \$26.00
Written primarily to 10 for 14 year-olds plus parents and teachers, this new guide offers sequential, easy-to-follow lessons, examples, and exercises that illustrate how to program the VIC personal computer to play board games, word games, and action games, store and recall personal data, debug, edit, create graphics, and more!

PH217: BASIC COMPUTER PROGRAMMING FOR KIDS

P. CASSIDY & J. CLOSE \$15.95
Fully illustrated with photographs and drawings, this book teaches the reader the history of computers and computing and gently introduces binary mathematics and the basic theory of how computers work. Written in an easy, conversational tone.

PH218: COMPUTER GRAPHICS AND GAMES FOR KIDS: APPLE II

P. CASSIDY & J. CLOSE \$15.95
An entertaining, educational approach to teaching kids to use computers, this book explains the principles of programming through computer graphics and games. Readers are given a series of simple, easy-to-follow graphics problems to solve for quick, effective mastery over the material and over the machine. Readers are then encouraged to create and modify their own computer games.

PH219: BASICALLY SPEAKING: A YOUNG PERSON'S GUIDE TO COMPUTING

COHEN \$16.95

Computing Systems

APPLE

ARCP3: 101 APPLE COMPUTER PROGRAMMING TIPS & TRICKS
F. WHITE \$12.50
 Practical ready-to-type-and-run software. 96 pages.

HB105: BASIC APPLE™ BASIC
COAN \$18.75
 A complete guide to Applesoft BASIC. Takes you from beginning concepts, such as entering data and obtaining output and planning programs, to more advanced topics, such as numeric and string arrays and sequential and random-access files. Alternate techniques for programming in Apple Integer BASIC are also covered. Discusses Lo-Res and Hi-Res graphics.

HB107: GRAPHICS COOKBOOK FOR THE APPLE
WADSWORTH \$14.45
 Learn how to use your Apple II to "paint" shapes, objects, and letters in low-resolution graphics. The author provides a library of microcomputer graphics including such multicolored illustrations as robots and flying saucers, trees, sailboats, and colourful picture backgrounds. Contains complete annotated Applesoft BASIC programs to draw all the pictures described in the book as well as suggestions for improving programming techniques.

HB110: APPLE PASCAL: A PROGRAMMING GUIDE
TUCKER \$26.95
 This class-tested text offers a complete, self-contained introduction to programming using the Apple UCSD Pascal language. Tucker's accessible coverage introduces Pascal via a subset language (Eight Statement Pascal) to orient and involve students from the start. He teaches Apple editor and file commands early and provides extensive examples, exercises, and lab problems keyed to a variety of fields from business to science. Structured programming is used throughout.

SB21959: THE APPLE® II CIRCUIT DESCRIPTION
D. HEISERMAN \$32.50
 Provides you with a detailed circuit description of the Apple II motherboard, including the keyboard and power supply. Comes complete with timing diagrams for major signals and discussion of differences between the various revisions. Good for technicians, serious hobbyists, and others with some knowledge of digital hardware.

SB21889: INTERMEDIATE LEVEL APPLE® II HANDBOOK
D. HEISERMAN \$23.95
 Hands-on aid for exploring the entire internal firmware of your Apple II and finding out what you can accomplish with its 6502 microprocessor through machine- and assembly-language programming. Good introduction if you're ready to move out of BASIC but don't want to buy more hardware.

PH51: PASCAL FOR THE APPLE
JAIN MacCALLUM \$33.80
 A step-by-step introduction to Pascal for Apple II and Apple II Plus users. The package of text and software diskette provides readers with worthwhile and interesting programs which can be run immediately and the results studied. Includes over 200 exercises with full solutions. Book/Disk Package.

PH52: APPLE GRAPHICS GAMES
PAUL COLLETTA \$33.00
 Contains 10 arcade-style games written especially for the Apple II, including Spider, Piano, Pairs and Poker, as well as education, math, and designing games. Book/Disk Package.

PH517: MULTIPLOY (APPLE II)
P. COLETTA \$29.95
 "Arithmetic can be fun!"
 "YES!" Simply slip MULTIPLOY into an Apple II and you're under attack; math problems come down the screen and unless you answer them correctly — WHAM! — you're a goner. Four math operations — three levels of play. Software Package.

PH518: WORDWORX (APPLE II)
Tab1513: APPLE II BASIC \$60.00
 WordWorx consists of two fantastic word games — "Myspeller" and "Sentence Builder." Each game can be played competitively or solo, and at a variety of difficulty levels. They're both challenging learning tools for kids and brain-teasing fun for adults. Software Package.

Tab1513: APPLE II BASIC \$22.95
 Does far more than teach you BASIC vocabulary. Includes a library of subroutines that form the cornerstone of this unique programming approach. Other topics include formatting hard copy, PEEKs, POKEs, CALLs and other output techniques, sequential text files; random access files; sorting routines; number crunching, etc.

SB21846: ENHANCING YOUR APPLE® II — VOLUME 1
D. LANCASTER \$22.50
 Who but Mother Nature or Don Lancaster could successfully enhance an Apple? YOU can, with help from Volume 1 in Don's newest series for Sams. Among other things, you'll learn (1) to mix text, LORES, and HIRES together anywhere on the screen in any combination, (2) how to make a one-wire modification that will open up whole new worlds of 3-D graphics and other special effects, plus (3) a fast and easy way to tear apart and understand somebody else's machine-language program. Other goodies abound!

SB21863: CIRCUIT DESIGN PROGRAMS FOR THE APPLE® II \$22.50
 A series of ready-to-run Applesoft programs that show you "what happens if" and "what's needed when" as they apply to periodic waveform, rms and average values, the solution of simultaneous equations, and more. Ideal for electronics design engineers and others faced with solving problems related to plotting and simple verification of experimental data.

SB21862: APPLE® INTERFACING \$15.50
 Describes the internal Apple II control signals available for I/O interfacing and shows you how to use them with Applesoft BASIC to control devices and communicate with other computers, modems, serial printers, and more. Furnishes real, tested interfacing circuits that work, plus complete breadboarding to help you check out your own interfacing ideas.

SB21864: MOSTLY BASIC: APPLICATIONS FOR YOUR APPLE® II, BOOK 2 \$18.50
 A second goldmine of fascinating BASIC programs, including two dungeons that test your math and history abilities and another one that's strictly for fun, eleven household programs, a monthly savings plan and six more on money or investment, two that test your level of ESP, and more — 32 in all! Excellent for beginning or advanced computerists.

SB21911: APPLE® FORTRAN \$20.95
 Gives you full programming details on Apple FORTRAN 77, plus an introduction to Apple's Pascal language card, the use of FORTRAN on single or multiple disk drives, and several programs in FORTRAN that you can use immediately! Excellent for any Apple II owner who uses or would like to use FORTRAN, including beginning or advanced programmers, businessmen, and other professionals.

SB21894: APPLE® II ASSEMBLY LANGUAGE \$22.50
 Specifically directed to the beginning programmer who has no prior experience with assembly language. Shows you how to use the 3-character, 56-word assembly language vocabulary of Apple's 6502 microprocessor to create powerful programs that bring you inside the brain of the Apple itself! Can be read by Apple owners in all walks of life simply as a learning experience or used in a conscientiously applied assembly language study program.

SB22026: POLISHING YOUR APPLE® \$6.95
 Clearly written, highly practical, concise assembly of all procedures needed for writing, disk-filing, and printing programs with an Apple II. Positively ends your search through endless manuals to find the routine you need! Should be in the hands of every new Apple user, regardless of experience level. Ideal for Apple classrooms too!

APPLE MACHINE LANGUAGE PROGRAMMING
AB009 \$19.95
 The best way to learn machine language programming the Apple II in no time at all. The book combines colour, graphics, and sound generation together with clear cut demonstrations to help the user learn quickly and effectively.

PH101: ELEMENTARY APPLE
W. SANDERS & DATAMOST (1983) \$19.95
 For new owners of the Apple Personal Computer, this entertaining guide is like having a friendly, cheerful teacher at the user's side — clearly explaining everything the beginner wants to know — and carefully leading him from point to point.

PH102: HOW TO WRITE AN APPLE PROGRAM
E. FAULK & DATAMOST (1983) \$19.95
 Proven-successful, simple techniques for programming the Apple personal computer in BASIC. The authors develop an actual program with the reader to provide a simple set of examples for the topics discussed.

PH103: PROGRAMMING THE APPLE: A STRUCTURED APPROACH
J. CAMPBELL & I. ZIMMERMAN (1983) \$26.00
 Offers a unique, structured approach to programming by presenting the BASIC language as a problem-solving tool. This book unravels the intricacies of programming — where to start, what to do, and how to write code more effectively.

PH104: ACCOUNTANT'S BASIC PROGRAMMING FOR THE APPLE II
A. PARKER & J. STEWART (1983) \$19.95
 Shows the reader how to program the Apple II to perform a variety of accounting functions, such as payroll, accounts payable, accounts receivable, tax, inventory, customer statements, and more.

PH105: APPLE COMPUTER GRAPHICS
K. WILLIAMS (1983) \$26.00
 Offers a complete, clear, state-of-the-art explanation of the graphic capabilities of the Apple II — and how to use them. Requires only a knowledge of BASIC; no assembler or machine language skills are required.

PH106: PROGRAMMING TIPS AND TECHNIQUES FOR THE APPLE II
J. CAMPBELL (1983) \$22.95
 An advanced exploration of the intricacies of structures programming. Further develops the skills necessary to solve programming problems. Special chapter on sound and graphics which discusses both high and low resolution graphics for the Apple II.

PH107: APPLE LOGO PRIMER
G. BITTER & N. WATSON (1983) \$16.95
 A pictorial starter book that will make LOGO easy for anyone. Includes easy to follow examples and reference tables. Also included is a workshop outline for teachers and leaders who want to train others.

PH108: THE ACADEMIC APPLE
R. MOWE (1983) \$14.95
 Written for parents and teachers using the Apple II in the education process. Topics discussed include choosing commercial software, educational software, sample programs and teaching BASIC programming.

PH109: APPLE II PROGRAMMER'S HANDBOOK
R. VILE (1982) \$22.95
 Written specifically for the beginning programmer, here's a hands-on approach to programming. It includes tips and techniques for Integer BASIC, APPLESOFT BASIC, APPLE PASCAL, and 6502 Assembly Language on the APPLE II computer and gives complete programs — each tested and ready to use — for applications in graphics, education, utilities, languages, and entertainment.

PH110: THE APPLE PERSONAL COMPUTER FOR BEGINNERS
S. DUNN & VALERIE MORGAN (1982) \$17.95
 Written for those who have no experience in computers, this informative book teaches the fundamentals of BASIC and computing, using the Apple computer system.

PH111: BASIC FOR THE APPLE II
L. GOLDSTEIN & M. GOLDSTEIN (1982) \$19.95
 A new start-to-finish "hands-on" guide covering BASIC programming and practical real-life applications for the Apple II. Includes detailed information for setting up and using a computer system with discussions of such diverse applications as games, graphics, file management, and word processing.

PH112: APPLE FILES
D. MILLER (1982) \$19.95
 Aimed at the Apple user who is familiar with BASIC and wants to set up or expand files for home or business. Includes programs for mailing lists, a medical records system, home inventory and more.

PH113: THE VISICALC BOOK: APPLE EDITION
D. BEIL (1982) \$19.95
 A helpful and informative guide to using VISICALC, the "electronic spreadsheet" software program that's perfect for pricing/costing estimates, profit/loss forecasting and hundreds of other business "what if" questions. Specifically written for Apple computer systems.

PH114: BASIC BASIC
R. HASKELL \$16.95
 Gives the beginner a thorough introduction to BASIC programming using the Apple computer. Includes home financial management, games, graphics, math programs and more. Appropriate for classroom use or self instruction.

PH115: APPLE BASIC FOR BUSINESS/FOR THE APPLE II
A. PARKER & J. STEWART \$20.95
 Shows how to use BASIC and the Apple II system to solve practical business problems quickly and efficiently. Contains flowcharts and sample programs.

PH116: APPLE MACHINE LANGUAGE
D. & K. INMAN \$19.95
 Allows Apple users to move from BASIC to the more powerful machine language programming quickly and easily.

PH117: PASCAL PROGRAMMING FOR THE APPLE
T. LEWIS \$19.95
 This manual provides easy-to-follow instructions on programming with Pascal. The author begins with the basics: the shell of a Pascal program, type casting the data, simple sequences, choice and looping. He then moves on to subjects of greater complexity and challenge.

PH118: INTERFACE PROJECTS FOR THE APPLE II
R. HALLIGREN \$16.95
 Provides Apple II users with a series of interface projects that are easily built and enable the user to discover the computer's capabilities through project construction.

MOORSHEAD PUBLICATIONS Return Policy

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Computing Systems

IBM P.C.

PH150: IBM BASIC
D. PAYNE, Ph.D. \$20.95
Focusing on developing the proper attitudes, techniques and skills for good problem-solving, the book's approach facilitates the reader's understanding of computing by presenting procedural reasoning problems accompanied by programs written in BASIC.

PH151: IBM PC ASSEMBLY LANGUAGE PROGRAMMING
L. SCANLON \$30.00
An introduction to the fundamental principles of microprocessors, numbering systems, and assemblers for those with little or no experience with microcomputers or assembly language programming. Focuses on a "real" assembler that will probably become the de facto standard of the IBM PC.

PH152: PASCAL PROGRAMMING FOR THE IBM PC
K. BOWYER & S. TOMBOULIAN \$23.95
Here's the "first of its kind" book that brings Pascal programming and the IBM Personal Computer together. Working interactively, this book is perfect for users who want to move beyond BASIC but don't know where to start. It emphasizes graphics and sound applications with reference to both the IBM Personal Computer and UCSD p-system Pascal.

PH153: SCIENCE AND ENGINEERING SOURCEBOOK FOR THE IBM PERSONAL COMPUTER
C. LEWART \$16.95
Designed for the electronic and communication engineer, programmer, student, and advanced electronic hobbyist, this collection of 20 programs covers the areas of electronic engineering, number theory, computer program design, data communication, probability, statistics, operations research, and applied math.

PH154: SYSTEMS MADE SIMPLE ON THE IBM PC
R. FLANDERS & D. FLANDERS \$26.00
Now the techniques used to design major computer systems have been reduced to terms that average personal computer users can apply. Through Structured Analysis and Structured Programming approaches, the user is taken step-by-step through the design and implementation of the systems.

PH155: HOW TO WRITE AN IBM-PC PROGRAM
E. FAULK & DATAMOST \$19.95
Assuming only a minimal knowledge of the computer, coverage includes everything from where to get programming ideas to fixing the bus the easy way. Illustrated.

PH156: BUSINESS APPLICATIONS FOR THE IBM PC
S. ZIMMERMAN & L. CONRAD \$23.95
Designed for the first-time business user of the IBM PC. Offers step-by-step instructions on the use and customization of existing business software programs. Provides actual programs that are essential to many business functions.

PH157: INTRODUCTION TO CICS PROGRAMMING
L. MILLER & L. VIANDS \$33.00
Presents a step-by-step, easy-to-follow introduction to the practical use of CICS — an IBM software product for data communications and the development of on-line computer applications. All examples shown are independent of the operating system, but they assume a basic knowledge of COBOL.

PH158: IBM FILES
D. MILLER \$19.95
Shows how to access your IBM-PC's full potential. Takes the mystery and misery out of creating your own files. Written for both the beginning and advanced programmer.

PH159: BASIC FOR BUSINESS FOR IBM-PC
PARKER \$26.00

PH160: USING THE IBM PERSONAL COMPUTER
T. LEWIS \$19.95
A guide to general use of the IBM Personal Computer, covering BASIC commands, how to use word processing software, the use of VISICALC and creating new programs.

PH161: IBM BASIC FOR BUSINESS & HOME
R. FUNKHOUSER \$19.95
Without the ponderous detail of the manufacturer's manual, this book shows the new micro user how to write programs for the IBM PC. No prior knowledge of computers or electronics is necessary to understand and use the information.

PH162: THE VISICALC BOOK FOR THE IBM PERSONAL COMPUTER
D. BEIL \$20.95
This book is designed to help the user to get more out of VISICALC (an extremely useful "electronic spreadsheet" software program) on the IBM Personal Computer.

Tab1540: 100 READY TO RUN PROGRAMS AND SUB-ROUTINES FOR THE IBM PC \$27.95
Includes programs for Business (Text Editor, Mailing List, Alphabetizing and Sorting, Checking Account); Mathematics (Functions Analysis, Complex Number Math, Simultaneous Equations, etc.); Education (Spelling Bee, Trig lesson); Electronics (Colour Monitor Alignment, Ohms Law Equations, Circuit and Component Graphics); Graphics (Hi-Res Designs, Animated Graphics, Painting); Games (Several) and lots more. You'll learn how to use advanced programming features and how to start tailoring programs to your own special needs.

HB111: PROGRAMMING THE IBM PERSONAL COMPUTER: BASIC
GRAHAM \$23.95
An introduction to programming in BASIC language. Users can apply material directly to their machine, with no adaptation necessary. An ideal introductory text to be used informally, or in classroom or training situations. Covers the unique features of the IBM Personal Computer, elements of BASIC and programming, and various applications (text editor programs, program for storing and retrieving information from random files, etc.).

HB112: PROGRAMMING THE IBM PERSONAL COMPUTER: UCSD PASCAL
POLLACK \$23.95
"The Portable IBM PC Pascal!" Emphasizes the syntax of UCSD Pascal and good program design. An ideal introductory text to be used informally, or in classroom or training situations. Includes full coverage of the system and its uses, basic and advanced UCSD p-System™ functions. Easy to understand, user-oriented, reinforces working knowledge and application.

HB113: YOUR IBM PERSONAL COMPUTER: BASIC AND APPLICATIONS
CORTESI \$23.95
Intended to get the first-time user over the hurdle of the initial introduction to the new machine. Provides a non-threatening, "confidence-building" introduction to the Personal Computer and to computing, BASIC language and software. (VisiCalc®, word processing, etc.). An ideal introductory text to be used informally, or in classroom or training situations. Focuses on central programming concepts, emphasizing IBM's version of MICROSOFT BASIC.

AHG14: HOW TO USE THE IBM PERSONAL COMPUTER
NOLAN \$3.95
A simple introduction to one of the fastest selling personal computers. Filled with clear instructions and tips on set-up, expansion, specific applications, and maintenance.

SB22000: USING YOUR IBM® PERSONAL COMPUTER \$23.95
Here's the most practical, most thorough guide on the market for computing with the IBM PC! Part One helps you get started with off-the-shelf programs, and shows you how to use the PC's system unit, keyboard, display screen, disk drives, and printer. Part Two teaches you to program in PC BASIC, with scores of examples to help you learn quickly. Fully explains all commonly used PC BASIC commands, including those for graphics, music, sound effects, and more.

PHS3: IBM PERSONAL COMPUTER: AN INTRODUCTION TO PROGRAMMING AND APPLICATIONS
L. GOLDSTEIN & M. GOLDSTEIN \$46.00
Specifically designed for the computer novice. Offers immediate applications to business graphics, games and word processing. Book/Disk Package.

PHS4: EXECUTIVE'S GUIDE TO THE IBM PERSONAL COMPUTER: BASIC PROGRAMMING AND VISICALC
A. PARKER \$59.95
Designed to give the business executive an introduction to BASIC programming. Demonstrates business programs for accounts receivable, general ledger, VisiCalc, and more. Book/Disk Package.

PHS5: CROSS REFERENCE UTILITY (CRF): A PROGRAMMING AID FOR THE IBM PC
J. HART, D. MAHAN, G. REYNOLDS, & THE SUMAR CORPORATION \$44.95
Specifically designed to help the IBM PC programmer improve the quality of programs, this utility software provides a complete reference listing of variables in a BASIC program in order to review, analyze, and modify software. Software Package.

ATARI COMPUTERS

ARCP8: 101 ATARI COMPUTER PROGRAMMING TIPS & TRICKS
A. NORTH \$12.50
Learn-by-doing instruction, hints, secrets, shortcuts, techniques, for models 400/800/1200XL. Includes 101 ready-to-run programs. 128 pages.

ARCP9: 31 NEW ATARI COMPUTER PROGRAMS FOR HOME, SCHOOL & OFFICE
A. NORTH \$12.50
Practical type-and-run software for models 400/800/1200XL. 96 pages.

AHG9: UNDERSTANDING ATARI GRAPHICS BOOM \$3.95
The popular Atari computers are ideal for writing graphic programs, such as games, charts, or object representations. This Handy Guide works the reader through the logic and mechanics of developing good graphics. For the beginning to advanced programmer.

AHG15: HOW TO USE THE ATARI COMPUTERS BOOM \$3.95
A simple introduction to these fast-selling personal computers. Filled with clear instructions and tips on set-up, expansion, specific application, and maintenance.

PHS16: PAINT (48K ATARI WITH JOYSTICK) CAPITAL CHILDREN'S MUSEUM \$52.00
Users actually create their own computer "paintings". The PAINT diskette provides access to hundreds of artistic textures, allowing a virtually limitless number of artistic patterns. Book/Disk Package.

OSBORNE

PH163: USING THE OSBORNE 1 COMPUTER
T. LEWIS \$19.95
The Osborne 1 is fast becoming one of the hottest selling personal/business computers on the market. This informative book shows the reader how to use it with word processing, databasing, VISICALC and programming.

PH164: OSBORNE USER'S GUIDE
L. GOLDSTEIN \$19.95
The "applications handbook" that boosts the personal computer to full potential. This book uses the Osborne to guide readers to an understanding of BASIC. Using a relaxed, informal style, it explains programming, applications, peripheral devices, and software.



'PHS Codings include software disk or cassette'

Computing Systems

TRS-80

PH119: HOW TO WRITE A TRS-80 PROGRAM
E. FAULK & DATAMOST (1983) \$19.95
The authors develop an actual program with the reader to provide a simple set of examples for the topics discussed, and to add to the user's library of subroutines.

PH120: TRS-80 COBOL
R. GRAUER (1983) \$22.95
Written specifically for the Radio Shack Model II and III computers, here is a learn-by-doing introduction to ANS-74 COBOL as implemented on the TRS-80. Includes many programs and exercises.

PH121: HARDWARE INTERFACING WITH THE TRS-80
J. UFFENBECK (1983) \$18.95
TRS-80 Model I and Model III owners now have a book to help them understand how to use their personal computers to monitor and control electronics interfaces between the computer and the home or industrial environment. Contains 14 hands-on experiments using BASIC.

PH122: TRS-80 EXTENDED COLOR BASIC
R. HASKELL (1983) \$16.95
Suitable for both classroom use and home self-instruction, this comprehensive, hands-on approach to BASIC programming on the TRS-80 colour computer comes complete with illustrated examples for the computer's video screen.

PH122B: EXPLORE COMPUTING WITH THE TRS-80 (AND COMMON SENSE) WITH PROGRAMMING IN BASIC
R. & J. ANDREE (1982) \$15.95
The guide teaches the keyboard, programming, and how to solve problems using the computer. Different starting points are provided so that complete beginners — as well as more advanced enthusiasts — can find material suited to their level of study.

PH123: TRS-80 DISK BASIC FOR BUSINESS MODEL II AND MODEL III
A. PARKER (1982) \$19.95
An introductory guide for the popular TRS-80 computer and the BASIC Language that's sure to answer all the questions with chapters on how to use a computer, why use BASIC, writing and running a program, entering data from a keyboard, report writing by computer, using canned programming, and more!

PH124: THE TRS-80 PROGRAMS AND APPLICATIONS FOR THE COLOR COMPUTER
A. BAKER (1982) \$19.95
A Baker shows how to use the TRS-80 colour computer to best advantage for storing important data, balancing the cheque book, playing games, and much more — while sharpening programming skills.

PH125: INTRODUCTION TO TRS-80 BASIC AND COMPUTER PROGRAMMING
M. ZABINSKI \$14.95
Designed for use with the Radio-Shack TRS-80 computer this book discusses all the important concepts and applications of computer programming. Illustrated with many flowcharts, the book contains over 200 exercises.

PH126: TRS-80 MODEL III: PROGRAMMING AND APPLICATIONS
L. GOLDSTEIN \$19.95
A top-notch introduction to computer programming using the TRS-80 Model III. Quickly brings the neophyte to near-professional levels.

PH127: TRS-80 ASSEMBLY LANGUAGE
H. HOWE, Jr. \$12.95
Now for the first time user as well as the experienced user of the TRS-80 microcomputer, here is a book that explains assembly language programming in a thorough, yet easy to understand style.

PH128: TRS-80 ASSEMBLY LANGUAGE SUBROUTINES
W. BARDERN, Jr. \$24.95
Easy-to-use "pre-canned" routines that can be run as is, modified, or simply studied. Requires minimum effort from the user, all programs ready-to-run, covers the widest possible range of applications.

PH129: INTERFACE PROJECTS FOR THE TRS-80
R. HALLIGREN \$16.95
Provides TRS-80 users with a series of interface projects that are easily built and enable the user to discover the computer's capabilities through project construction. Projects are primarily hardware oriented but have programs supplied to support the hardware.

SB22009: TRS-80* MODEL I, III, AND COLOUR COMPUTER INTERFACING PROJECTS \$20.95
A unique book for beginning interfacers which includes 14 simple, useful, and easy-to-build construction projects to help you make use of your TRS-80 computer in the real world. Presents an easily understood, complete tutorial with full documented, debugged software written specifically for the TRS-80 models I and III, and the Colour Computer.

SB21865: MOSTLY BASIC: APPLICATIONS FOR YOUR TRS-80*, BOOK 2
H. BERENBON \$18.50
Another goldmine of ready-to-run BASIC programs — 32 in all! Includes two dungeons that test your ability in history and math, a Dungeon of Danger that's strictly for fun, eleven household programs, seven on money and investment (three of which are on the stock market), two that test your ESP level, and more! Complete with an explanation, sample run, and listing for each program.

SB22046: TRS-80* FOR KIDS FROM 8 TO 80, VOL.1
M. ZABINSKI \$13.95
An enjoyable, easy to follow, and amazingly effective book suitable for beginning TRS-80 programmers of any age, especially youngsters. No special background is needed. Same principles used at National Computer Camp help you quickly begin writing computer programs and encourage you to try many examples. Excellent as a classroom text or for self-study.

PH56: TRS-80 MOD III ASSEMBLY LANGUAGE TUTOR
H. HOWE, Jr. \$38.95
A book/software tutorial that makes it easy to learn assembly language programming and interfacing with the TRS-80 Model III. Requires only a basic knowledge of level II BASIC. Book/Disk Package.

ARCP5: 101 COLOUR COMPUTER PROGRAMMING TIPS & TRICKS
R. CLARK \$11.15
Learn-by-doing instructions, hints, secrets, shortcuts, techniques, insights, includes 101 ready-to-run programs. 128 pages.

ARCP6: 55 COLOUR COMPUTER PROGRAMS FOR HOME, SCHOOL & OFFICE
R. CLARK \$13.95
Practical ready-to-run software with colourful graphics. 128 pages.

ARCP7: 55 MORE COLOUR COMPUTER PROGRAMS FOR HOME, SCHOOL & OFFICE
R. CLARK \$13.95
Handy companion volume packed with different useful type-and-run software. 112 pages.

SB21893: TRS-80* COLOUR COMPUTER INTERFACING \$20.95
Teaches you the interfacing techniques, inner workings, and operation of the TRS-80 Colour Computer as well as its high-performance 6809 microprocessor. Find out how to control and monitor various equipment and events by means of the Computer's expansion connectors. Excellent info for budding electronic and computer engineers and technicians at all levels.

TIMEX/SINCLAIR

BP109: THE ART OF PROGRAMMING THE 1K ZX81 \$7.60
M. JAMES and S.M. GEE
This book shows you how to use the features of the ZX81 in programs that fit into the 1K machine and are still fun to use. Chapter Two explains the random number generator and uses it to simulate coin tossing and dice throwing and to play pool. Chapter Three shows the patterns you can display using the ZX81's graphics. Its animated graphics capabilities, explored in Chapter Four, have lots of potential for use in games of skill, such as Lunar Lander and Cannon-ball which are given as complete programs. Chapter Five explains PEEK and POKE and uses them to display large characters. The ZX81's timer is explained in Chapter Six and used for a digital clock, a chess clock and a reaction time game. Chapter Seven is about handling character strings and includes three more ready-to-run programs — Hangman, Coded Messages and a number guessing game. In Chapter Eight there are extra programming hints to help you get even more out of your 1K ZX81.

BP114: THE ART OF PROGRAMMING THE 16K ZX81 \$9.90
M. JAMES & S.M. GEE
The book starts by introducing the 16K RAM pack and the printer. It continues by explaining how the extra storage is used and presents a memory test program to check that the 16K RAM pack is operational. Chapter Three covers some utilities that you will find useful in writing longer programs. Chapter Four is an interlude from serious applications, presenting four games programs that make the most of the extended graphics capabilities now available to you. Chapters Five to Eight deal with writing and debugging large programs, storing them on cassettes and printing out both programs themselves and their results. These chapters also introduce programs for editing data bases and statistical analysis for financial management and covers text and graphics printing. Chapter Nine takes a look at randomness. Chapter Ten introduces machine code and explains why you might like to use it.

SELF-TEACHING SOFTWARE FOR THE ZX81 AND TIMEX SINCLAIR 1000: MATHEMATICS I-VI
J. GLADSTONE
Software Package:
I. PHS8, \$44.95
II. PHS9, \$44.95
III. PHS10, \$44.95
IV. PHS11, \$44.95
V. PHS12, \$44.95
VI. PHS13, \$44.95
Designed to give children ages 5-12 the learning advantage! Each program contains 4 cassette tapes with 32 lessons, games, and activities, and a 32 page activities book, all packaged in a handsome vinyl binder. Written by a leading Canadian educator.

SB21957: TIMEX SINCLAIR 1000/ZX81 BASIC BOOK
R. NORMAN \$18.95
A practical, usable book that neatly and effectively teaches ZX81 BASIC language and programming techniques to owners of the ZX81 personal computer. Includes many programming tips to help make your ZX81 programs more efficient. Ideal for the novice computerist as well as any new owner of the ZX81.

ARCP1: 101 TIMEX 1000/SINCLAIR ZX-81 PROGRAMMING TIPS & TRICKS
E. PAGE \$11.15
Secrets, hints, shortcuts, learn-by-doing instructions, techniques, includes 101 ready-to-run programs. 128 pages.

ARCP2: 37 TIMEX 1000/SINCLAIR ZX-81 COMPUTER PROGRAMS FOR HOME, SCHOOL AND OFFICE
E. PAGE \$12.50
Practical type-and-run software. 96 pages.

PH139: FIFTY 1K/2K GAMES FOR THE TIMEX/SINCLAIR 1000 AND THE ZX-81
A. GOURLAY, J. WALSH & P. HOLMES (1983) \$14.95
The most complete selection of games ever assembled for the Sinclair ZX-81 and Timex 1000 personal computers. Dogfight, Breakout, Outlaw, Galaxian, Roadracer, Alien Invasion, and dozens more!

PH140: THE EXPLORER'S GUIDE TO THE ZX81 AND THE TIMEX SINCLAIR 1000
M. LORD (1983) \$16.95
Coverage includes features of BASIC not found in beginner's guides, as well as machine code programming, 30 games and other programs, application routines, programming utilities, and more.

PH141: 30 PROGRAMS FOR THE TIMEX-PC 1000
MELBOURNE HOUSE PUBLISHERS (1983) \$12.95
Presents a collection of 30 interesting and varied programs for the Timex-PC 1000/ZX81. Complete with fully explained programs, scores of programming hints and space-saving techniques.

PH 142: PROGRAMMING YOUR TIMEX/SINCLAIR 1000 IN BASIC
M. EISENBACHER (1983) \$12.95
A simple, straightforward introduction to BASIC programming on the TIMEX/Sinclair 1000 written specifically for those with no previous computer experience.

PH143: BASICS OF TIMEX SINCLAIR BASIC
WALACH \$14.95

PH144: MAKING THE MOST OF YOUR ZX-81
T. HARTNELL \$14.95
This handbook focuses on all the additional features of the ZX-81. There are new games, and useful learning tricks, plus instructions on how to write programs that really work. It guides the reader from start to finish using each feature of the computer.

PH145: THE ZX-81 POCKET BOOK
T. TOMS \$14.95
This handy manual teaches how to create new programs and helps the creator understand why they work. Here's what the ZX-81 can do... which extras will enable it to do even more... how to use ZX-81 BASIC in the best ways... and, for ZX80 owners, how to convert their system into the advanced ZX-81.

PH146: 49 EXPLOSIVE GAMES FOR THE ZX-81
T. HARTNELL \$14.95
Galactic Intruders, Breakout, Checkers, Death Maze, Star Trek, Smugglers Mold, and forty-three other favourites are all here and especially adapted for the ZX-81. This fascinating gamebook gives programming instructions for all 49 marvelous games PLUS complete and easy-to-understand rules.

PH147: PET BASIC I
R. ZAMORA, et al \$19.95
Filled with many examples, do-it-yourself exercises, and thought provoking explorations, this concise yet complete guide encourages readers to experiment with the machine's numerous features and capabilities.

PH148: PET GAMES AND RECREATION
M. OGELSBY, et al \$16.95
Easy-to-understand directions included for each game provide: a game description and the objective — a summary of instructions for both player and computer — the level of difficulty — strategy hints — and more!

PH149: MASTERING MACHINE CODE ON YOUR ZX-81
T. BAKER \$16.95
This comprehensive, easy-to-understand handbook is virtually the first material available on ZX machine code. It includes the ins and outs of machine code translation, the secrets of the ZX-81, how to adapt the code to the ZX-80, and language translation between BASIC and ZX machine code.

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PET/CBM/VIC

PH130: PET/CBM: AN INTRODUCTION TO BASIC PROGRAMMING AND APPLICATIONS

G. STREITMATTER & L. GOLDSTEIN (1983) \$19.95
Includes an introduction to BASIC as well as a survey of applications, peripheral devices, and software. Immediate applications for business, graphics, games, and word processing make this book a useful tool for any PET owner.

PH131: ZAP! POW! BOOM!

ARCADE GAMES FOR THE VIC 20
T. HARTNELL & M. RAMSHAW (1983) \$16.95
Move through the maze eating dots with MAZEMAN. Sail through space zapping the ASTEROIDS. Outshoot the fastest draw in town GUNFIGHT. Owners of the VIC 20 can now play these games — and more — simply by following the programs outlined in this handy guide.

PH132: VIC BASIC: A USER-FRIENDLY GUIDE

R. ZAMORA, D. INMAN, R. ALBRECHT, & DYMAX \$16.95
This is a practical guide to the Commodore VIC, one of the first low-cost computers that allows the user to combine colour, sound, and graphics easily. Here, the reader will learn to write programs taking full advantage of all these capabilities.

PH133: 25 ADVANCED GAMES FOR PET/CBM HATCH (1983)

\$19.95

PH134: THE PET PERSONAL COMPUTER FOR BEGINNERS

S. DUNN & V. MORGAN (1982) \$20.20
Authors Dunn and Morgan have developed a learn-by-doing approach for using the popular, personal PET computer. The book is written not for the mathematician or computer specialist, but for the hobbyist, child, student and small business.

PH135: PET/CBM: AN INTRODUCTION TO BASIC PROGRAMMING AND APPLICATIONS

L. GOLDSTEIN (1982) \$19.95
This well-written introduction to programming in BASIC for the popular PET computer is a must for the novice programmer. It includes an introduction to BASIC as well as a survey of applications, peripheral devices and software. Immediate applications for business, graphics, games, and word processing make this book a useful tool for any PET owner.

PH136: PET/CBM BASIC

R. HASKELL (1982) \$16.95
Ideal for the beginning or advanced programmer, this book offers a step-by-step approach to top-down programming that can help students and business people apply fundamental concepts and program a computer with ease and expertise.

PH137: STARTING WITH BASIC ON THE COMMODORE VIC-20

D. MONRO/ill. B. TIDY (1982) \$14.95
Here's a real computer book for real people! It's designed for true beginners who own — or are considering purchasing — the Commodore VIC-20. It helps these novices learn to program the VIC in BASIC computer language, and goes on to teach them the unlimited capabilities of their machine.

PH138: THE COMAL HANDBOOK

L. LINDSAY (1982) \$24.95
The COMAL Handbook is a reference to assist the COMAL (a language developed for use with Commodore computers that combines the best features of BASIC and PASCAL) use in learning by doing rather than strictly by reading.

PH57: START WITH BASIC FOR THE COMMODORE VIC 20

D. MONRO \$32.95
This book/cassette package shows the reader how easy it really is to create programs using the full capability of the machine. Includes helpful exercises and step-by-step instructions to put the full power of the VIC 20 at the user's fingertips. Book/Cassette Package.

HB132: COMPUTE!'S FIRST BOOK OF VIC

\$19.95
In the style of our First Books of Atari and PET/CBM, this book contains many of the articles and applications featured in past issues of COMPUTE! Magazine. Approximately 20-30% of the book is material that has not been previously published. An excellent resource book for Commodore VIC-20 owners.

SB22056: COMMODORE 64 PROGRAMMER'S REFERENCE GUIDE

\$27.95
A creative programmer's working tool and reference source, packed with professional tips and special information for getting the most out of your Commodore 64! Includes a complete, details dictionary of all Commodore BASIC commands, statements, and functions, followed by BASIC program samples showing how each item works. Also tells you how to mix machine language with BASIC, use hi-res effectively, and much more! By Commodore Computer, 486 pages.

SB21948: VIC 20 PROGRAMMER'S REFERENCE GUIDE

\$23.45
Provides a complete VIC 20 BASIC vocabulary guide, a section on machine-language programming, a programming tips guide with suggestions on how to improve your programming skills, and a special section on VIC 20 input/output operations. An easy-to-use, detailed manual that helps you program your VIC 20 like a pro! By Commodore Computer. 289 pages.

SB22001: MOSTLY BASIC: APPLICATIONS FOR YOUR PET, BOOK 2

H. BERENSON \$19.95

A second collection of ready-to-run BASIC programs that includes a history dungeon, a math dungeon, a Dungeon of Danger that's strictly for fun, eleven household programs, seven on money and investment (three of which are on the stock market), two that test your ESP level, and more! Thirty-seven programs in all, each complete with an explanation, sample run, and listing.

PET GAMES AND RECREATION

AB002 \$16.95
A variety of interesting games designed to amuse and educate. Games include such names as Capture, Tic Tac Toe, Watchperson, Motie, Sinners, Martian Hunt and more.

PET BASIC — TRAINING YOUR PET COMPUTER

AB014 \$19.95
Officially approved by Commodore, this is the ideal reference book for long time PET owners or novices. In an easy to read and humorous style, this book describes techniques and experiments, all designed to provide a strong understanding of this versatile machine.

SB22010: COMMODORE 64 USER'S GUIDE

\$18.50
The same book that comes packed with every Commodore 64 computer! Shows you how to set up, program, and operate your Commodore 64, including how to do arcade-type colour animation, music, and sound effects, how to interface with a host of peripherals, and how to use packaged programs from Commodore and other manufacturers. Helps you get into computing in a big way, even if you've never used a computer before. By Commodore Computer.

SB21944: COMMODORE SOFTWARE ENCYCLOPEDIA

(2nd EDITION) \$13.95
Most comprehensive directory you'll find of software for the Commodore PET. Lists materials in 10 categories, including personal aids, technical aids, and firmware. Ranges from business to education, to games, and shows Canadian and European PET software too. By Commodore Computer.

PET M GRAPHICS

HAMPSHIRE \$26.95

HB127: All subroutines available on PET disk, \$35.00
HB128: Written to instruct the PET user on how to program grid displays. Provides a collection of machine language subroutines, enabling the PET owner to write more efficient programs. Provides a wide range normally unavailable graphic functions. Includes fine resolution plotting, double density plotting, multiple screen page displays, interfacing a light pen with the PET, and appendices on circuit diagrams of PET Video Circuitry and ASCII codes used by the PET.

LIBRARY OF PET M SUBROUTINES

HAMPSHIRE \$23.95

HB129: All subroutines available on PET disk, \$35.00
HB130: PET software designers will save considerable time writing applications programs with this book. Provides more than 53 proven subroutines as well as a logical framework to build new programs. Each subroutine is supported with complete information describing its purpose and the problems that may arise in its implementation.

ADDITIONAL BOOKS

BP113: 30 Solderless Breadboard Projects-Book 2

R.A. Penfold \$8.85

A companion to BP107. Describes a variety of projects that can be built on plug-in breadboards using CMOS logic IC's. Each project contains a schematic, parts list and operational notes.

BP128: 20 Programs for the ZX Spectrum and 16K ZX81

S. Daly \$7.60

Although designed for two specific machines, notes are included on conversion. Flow charts are often included together with a description of program operation. The programs themselves run from card and other games, through sorting and filing applications to uses in statistics and engineering.

BP112: A Z-80 Workshop Manual

E.A. Parr \$10.95

This book is intended for people who want to progress beyond the stage of BASIC to topics such as machine code and assembly language programming. Also given are hardware details and the use of associated I/O devices such as UARTs, PIOs and CTCs. Additional reference data are also given.

BP124: Easy Add-on Projects for Spectrum, ZX81 & Ace

Owen Bishop \$10.95

Projects include a Pulse Detector, Picture Digitiser, Five-key Pad, Model Controller, Bleeper, Light Flasher, Magnetic Catch, Lap Sensor, Photo-flash, Games Control and six more projects that make up a weather station.

BP121: How to Design and Make Your Own PCBs

R.A. Penfold \$7.60

The emphasis is on practical rather than theoretical techniques. Starts by giving simple methods of copying from magazines, carries on with photographic methods of producing PCBs and continues with layout design.

BP129: An Introduction to Programming the ORIC-1

R.A.s J.W. Penfold \$7.60

Designed to complement the manual of the ORIC computer. Deals with animated graphics with a heavy emphasis on games. Covers Variables and Codes, In and Outs; Animation and Loops, Attributes, Characters and Time, The Sound Generator, Decisions, Structured Programming, Data Filing Ideas and Interfacing.

BP125: 25 Simple Amateur Band Aerials

E.M. Noll \$7.60

Starting from simple dipoles through beam, triangle and even mini-rhombics (made from TV masts and 400ft of wire) this title describes several simple and inexpensive aerials to construct yourself. A complete set of dimension table are included.

BP104: Electronic Science Projects

Owen Bishop \$8.85

Contains 12 electronic projects with a strong scientific flavour. Includes Simple Colour Temperature Meter, Infra-Red Laser, Electronic clock regulated by a resonating spring, a Scope with a solid state display, pH meter and electrocardiograph.

BP118: PRACTICAL ELECTRONIC BUILDING BLOCKS - Book 2

R.A. PENFOLD \$7.60

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.

BP119: THE ART OF PROGRAMMING THE ZX SPECTRUM

M. JAMES \$9.95

The ZX Spectrum gives the user almost unlimited scope with colour, offers high and low resolution graphics as well as sound — with these you can do some excellent programs. Text covers: Getting to Know the Spectrum, Low Res Graphics, Fun at Random, Hi Res Graphics, Sound, Moving Graphics, PEEK and POKE, A Sense of Time, Strings and Words and Advanced Graphics.

BP-126 BASIC AND PASCAL IN PARALLEL

S.J. WAINWRIGHT \$5.75

This book takes the two languages and develops programs in both simultaneously. Emphasis is placed on structured programming by the systematic use of control structures and modular program design is used throughout. Examples of programs are used to illustrate the structures as they are introduced and the reader learns by example.



Electronics

ELECTRONICS BEGINNERS

PH255: COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS, 2nd Edition
J. DOUGLAS-YOUNG \$9.95
Packed with scores of easy-to-understand diagrams and invaluable troubleshooting tips as well as a circuit finder chart and a new section on logic circuits.

PH251: BEGINNER'S HANDBOOK OF IC PROJECTS
D. HEISERMAN \$16.95
Welcome to the world of integrated circuit (IC) electronic projects. This book contains over 100 projects (each including a schematic diagram, parts list, and descriptive notes.)

PH252: DIGITAL ICs: HOW THEY WORK AND HOW TO USE THEM
A. BARBER \$10.95
The dozens of illustrations included in this essential reference book will help explain time-saving test procedures, interpreting values, performing voltage measurements, and much more!

PH249: THE BEGINNER'S HANDBOOK OF ELECTRONICS
C. OLSEN & M. MIMS III \$10.95
In this basic book, the authors cover the entire spectrum of modern electronics, including the use of such components as integrated circuits and semiconductor devices in record players, radio receivers, airplane guidance systems, and many others.

THE BEGINNER'S HANDBOOK OF ELECTRONICS
AB003 \$10.95
An excellent textbook for those interested in the fundamentals of Electronics. This book covers all major aspects of power supplies, amplifiers, oscillators, radio, television and more.

ELECTRONIC THEORY

ELEMENTS OF ELECTRONICS — AN ON-GOING SERIES

F.A. WILSON, C.G.I.A., C.Eng.,
BP62: BOOK 1. The Simple Electronic Circuit and Components \$8.45
BP63: BOOK 2. Alternating Current Theory \$8.45
BP64: BOOK 3. Semiconductor Technology \$8.45
BP77: BOOK 4. Microprocessing Systems And Circuits \$11.70
BP89: BOOK 5. Communication \$11.70
The aim of this series of books can be stated quite simply — it is to provide an inexpensive introduction to modern electronics so that the reader will start on the right road by thoroughly understanding the fundamental principles involved.

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

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

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

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

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

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

BOOK 5: A book covering the whole communication scene.

PH241: DC ELECTRONICS \$16.95
Covers everything from voltage current, and resistance relationships to more advanced studies of electrical measurements, circuits, resistors, capacitors, and inductors.

PH242: AC ELECTRONICS \$16.95
Covers AC fundamentals and theory. Includes discussions and experiments in resonance and reactance; RC, RL, and RLC circuits; and how to work with formulas to analyze the operations of AC circuitry.

PH243: ELECTRONICS CIRCUITS \$16.95
Covers all of the most popular electronic circuits, with emphasis on integrated circuits.

PH244: SEMICONDUCTOR DEVICES \$16.95
Covers semi-conductor fundamentals, diodes, zeners, bipolar transistor operation and characteristics, FETs, thyristors, ICs, and optoelectronics.

PH247: DIGITAL TECHNIQUES \$19.95
Covers logic circuits, Boolean Algebra, flip-flops, registers, combinational logic circuitry, and digital design.

Tab1531: CONCEPTS OF DIGITAL ELECTRONICS \$21.95
This book erases the mysteries surrounding digital electronics theory. Understand and use low-cost 7400 series IC's to produce working digital devices including a power supply and a breadboard experimenter.

PROJECTS

BP48: ELECTRONIC PROJECTS FOR BEGINNERS \$5.40
F.G. RAYER, T.Eng.(CEI), Assoc.IERE
Another book written by the very experienced author — Mr. F.G. Rayer — and in it the newcomer to electronics, will find a wide range of easily made projects. Also, there are a considerable number of actual component and wiring layouts, to aid the beginner.

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

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

221: 28 TESTED TRANSISTOR PROJECTS \$5.00
R.TORRENS
Mr. Richard Torrens is a well experienced electronics development engineer and has designed, developed, built and tested the many useful and interesting circuits included in this book. The projects themselves can be split down into simpler building blocks, which are shown separated by boxes in the circuits for ease of description, and also to enable any reader who wishes to combine boxes from different projects to realise ideas of his own.

BP49: POPULAR ELECTRONIC PROJECTS \$5.75
R.A. PENFOLD
Includes a collection of the most popular types of circuits and projects which, we feel sure, will provide a number of designs to interest most electronics constructors. The projects selected cover a very wide range and are divided into four basic types: Radio Projects, Audio Projects, Household Projects and Test Equipment.

EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS \$9.95
AB007
An ideal sourcebook of Solid State circuits and techniques with many practical circuits. Also included are many useful types of experimenter gear.

BP71: ELECTRONIC HOUSEHOLD PROJECTS \$7.20
R. A. PENFOLD
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

BP94: ELECTRONIC PROJECTS FOR CARS AND BOATS \$8.10
R.A. PENFOLD \$7.60
Projects, fifteen in all, which use a 12V supply are the basis of this book. Included are projects on Windscreen Wiper Control, Courtesy Light Delay, Battery Monitor, Cassette Power Supply, Lights Timer, Vehicle Immobiliser, Gas and Smoke Alarm, Depth Warning and Shaver Inverter.

BP69: ELECTRONIC GAMES \$7.05
R.A. PENFOLD
In this book Mr. R. A. Penfold has designed and developed a number of interesting electronic game projects using modern integrated circuits. The text is divided into two sections, the first dealing with simple games and the latter dealing with more complex circuits.

BP95: MODEL RAILWAY PROJECTS \$7.60
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 \$7.60
F.G. RAYER
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.

110 OP-AMP PROJECTS
MARSTON \$12.95
HB24
This handbook outlines the characteristics of the op-amp and present 110 highly useful projects—ranging from simple amplifiers to sophisticated instrumentation circuits.

110 IC TIMER PROJECTS
GILDER \$10.95
HB25
This sourcebook maps out applications for the 555 timer IC. It covers the operation of the IC itself to aid you in learning how to design your own circuits with the IC. There are application chapters for timer-based instruments, automotive applications, alarm and control circuits, and power supply and converter applications.

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING \$7.60
R.A. PENFOLD
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

PH250: EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONICS PROJECTS \$9.95
A. BARBER
This book takes the mystery out of solid state electronics and enables the reader to build such useful devices as: series regulated power supplies, light dimmers, solar cell operated radios, hi-fi amplifiers, light indicators for battery operated equipment and much more.

110 THYRISTOR PROJECTS USING SCRs AND TRIACS
MARSTON \$12.95
HB22
A grab bag of challenging and useful semiconductor projects for the hobbyist, experimenter, and student. The projects range from simple burglar, fire, and water level alarms to sophisticated power control devices for electric tools and trains. Integrated circuits are incorporated wherever their use reduces project costs.

110 CMOS DIGITAL IC PROJECTS
MARSTON \$11.25
HB23
Outlines the operating characteristics of CMOS digital ICs and then presents and discusses 110 CMOS digital IC circuits ranging from inverter gate and logic circuits to electronic alarm circuits. Ideal for amateurs, students and professional engineers.

BP76: POWER SUPPLY PROJECTS \$6.80
R.A. PENFOLD
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unregulated types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

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

BP84: DIGITAL IC PROJECTS \$7.60
F.G. RAYER, T.Eng.(CEI), Assoc.IERE
This book contains both simple and more advanced projects and it is hoped that these will be found of help to the reader developing a knowledge of the workings of digital circuits. To help the newcomer to the hobby the author has included a number of board layouts and wiring diagrams. Also the more ambitious projects can be built and tested section by section and this should help avoid or correct faults that could otherwise be troublesome. An ideal book for both beginner and more advanced enthusiast alike.

BP67: COUNTER DRIVER AND NUMERAL DISPLAY PROJECTS \$7.05
F.G. RAYER, T.Eng.(CEI), Assoc. IERE
Numeral indicating devices have come very much to the forefront in recent years and will, undoubtedly, find increasing applications in all sorts of equipment. With present day integrated circuits, it is easy to count, divide and display numerically the electrical pulses obtained from a great range of driver circuits.

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

BP73: REMOTE CONTROL PROJECTS \$8.10
OWEN BISHOP
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP99: MINI — MATRIX BOARD PROJECTS \$7.60
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 \$7.60
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.

Tab1431: DIGITAL ELECTRONIC PROJECTS \$20.95
Build a deluxe code oscillator, a digital game called Climb-the-Mountain, a clock with alarm, a metric measuring wheel, a modular decade counter, even a 14-note music generator. 17 projects in all.

BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1 \$8.85
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 featured in this book have been specially designed 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 OP-AMP PROJECTS \$7.60
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

BP80: POPULAR ELECTRONIC CIRCUITS — BOOK 1 \$7.75
R.A. PENFOLD

Another book by the very popular author, Mr. R.A. Penfold, who has designed and developed a large number of various circuits. These are grouped under the following general headings: Audio Circuits, Radio Circuits, Test Gear Circuits, Music Project Circuits, Household Project Circuits and Miscellaneous Circuits.

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 \$8.85
R.A. PENFOLD
 70 plus circuits based on modern components aimed at those with some experience.

The GIANT HANDBOOK OF ELECTRONIC CIRCUITS \$27.95
TAB No.1300
 About as twice as thick as the Webster's dictionary, and having many more circuit diagrams, this book is ideal for any experimenter who wants to keep amused for several centuries. If there isn't a circuit for it in here, you should have no difficulty convincing yourself you don't really want to build it.

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS \$5.00

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.

BP87: SIMPLE L.E.D. CIRCUITS \$5.40
R.N. SOAR

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

BP42: 50 SIMPLE L.E.D. CIRCUITS \$3.05
R.N. SOAR

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

BP82: ELECTRONIC PROJECTS USING SOLAR CELLS \$7.60
OWEN BISHOP

The book contains simple circuits, almost all of which operate at low voltage and low currents, making them suitable for being powered by a small array of silicon cells. The projects cover a wide range from a bicycle speedometer to a novelty 'Duck Shoot'; a number of power supply circuits are included.

BP37: 50 PROJECTS USING RELAYS, SCR'S & TRIACS \$5.00

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

BP24: 50 PROJECTS USING IC741 \$3.75
RUDI & UWE REDMER

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

BP83: VMOS PROJECTS \$7.70
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.

BP44: IC 555 PROJECTS \$7.05
E.A. PARR, B.Sc., C.Eng., M.I.E.E.

Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

BP65: SINGLE IC PROJECTS \$6.05
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.

BP97: IC PROJECTS FOR BEGINNERS \$7.60
F.G. RAYER

Covers power supplies, radio, audio, oscillators, timers and switches. Aimed at the less experienced reader, the components used are popular and inexpensive.

BP88: HOW TO USE OP AMPS \$8.85
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 non-mathematical as possible.

IC ARRAY COOKBOOK \$13.75
JUNG

HB26
 A practical handbook aimed at solving electronic circuit application problems by using IC arrays. An IC array, unlike specific-purpose ICs, is made up of uncommitted IC active devices, such as transistors, resistors, etc. This book covers the basic types of such ICs and illustrates with examples how to design with them. Circuit examples are included, as well as general design information useful in applying arrays.

BP50: IC LM3900 PROJECTS \$5.40
H. KYBETT, B.Sc., C.Eng.

The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.

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

223: 50 PROJECTS USING IC CA3130 \$5.00
R.A. PENFOLD

In this book, the author has designed and developed a number of interesting and useful projects which are divided into five general categories: I — Audio Projects II — R.F. Projects III — Test Equipment IV — Household Projects V — Miscellaneous Projects.

224: 50 CMOS IC PROJECTS \$3.75
R.A. PENFOLD

CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.

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

THE ACTIVE FILTER HANDBOOK \$13.95
TAB No.1133

Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design.

The book introduces filters and their uses. The basic math is discussed so that the reader can tell where all design equations come from. The book also presents many practical circuits including a graphic equalizer, computer tape interface and more.

DIGITAL ICs — HOW THEY WORK AND HOW TO USE THEM \$10.95
AB004

An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

MASTER HANDBOOK OF 1001 PRACTICAL CIRCUITS \$19.95
TAB No.800

MASTER HANDBOOK OF 1001 MORE PRACTICAL CIRCUITS \$23.95
TAB No.804

Here are transistor and IC circuits for just about any application you might have. An ideal source book for the engineer, technician or hobbyist. Circuits are classified according to function, and all sections appear in alphabetical order.

THE MASTER IC COOKBOOK \$17.95
TAB No.1199

If you've ever tried to find specs for a so called 'standard' chip, then you'll appreciate this book. C.I. Hallmark has compiled specs and pinout for most types of ICs that you'd ever want to use.

ELECTRONIC DESIGN WITH OFF THE SHELF INTEGRATED CIRCUITS \$12.95
AB016

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

BP117: PRACTICAL ELECTRONIC BUILDING BLOCKS \$7.60
BOOK 1

Virtually any electronic circuit will be found to consist of a number of distinct stages when analysed. Some circuits inevitably have unusual stages using specialised circuitry, but in most cases circuits are built up from building blocks of standard types.

This book is designed to aid electronics enthusiasts who like to experiment with circuits and produce their own projects rather than simply follow published project designs.

The circuits for a number of useful building blocks are included in this book. Where relevant, details of how to change the parameters of each circuit are given so that they can easily be modified to suit individual requirements.

PH253: ELECTRONIC DESIGN WITH OFF-THE-SHELF INTEGRATED CIRCUITS \$12.95
Z. MEIKIN & P. TACKRAY

A real help for do-it-yourselfers, this handy guide tells professionals and hobbyists alike, how to take components off the shelves, arrange them into circuitry, and make any system perform its desired function.



RADIO AND COMMUNICATIONS

BP79: RADIO CONTROL FOR BEGINNERS \$6.80
F.G. RAYER, T.Eng.(CEI), Assoc. IERE.

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

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

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

BP96: CB PROJECTS \$7.60
R.A. PENFOLD

Projects include speech processor, aerial booster, cordless mike, aerial and harmonic filters, field strength meter, power supply, CB receiver and more.

222: SOLID STATE SHORT WAVE RECEIVERS FOR BEGINNERS \$4.70
R.A. PENFOLD

In this book, R.A. Penfold has designed and developed several modern solid state short wave receiver circuits that will give a fairly high level of performance, despite the fact that they use only relatively few and inexpensive components.

BP91: AN INTRODUCTION TO RADIO DXing \$7.60

This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

BP105: AERIAL PROJECTS \$7.60
R.A. PENFOLD

The subject of aerials is vast but in this book the author has considered practical designs including active, loop and ferrite aerials, which give good performances and are reasonably simple and inexpensive to build. The complex theory and math of aerial design are avoided.

BP46: RADIO CIRCUITS USING IC's \$5.40
J.B. DANCE, M.Sc.

This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

BP92: ELECTRONICS SIMPLIFIED—CRYSTAL SET CONSTRUCTION \$6.80
F.A. WILSON

Aimed at those who want to get into construction without much theoretical study. Homewound coils are used and all projects are very inexpensive to build.

PH245: ELECTRONIC COMMUNICATIONS \$16.95
Covers amplitude modulation, AM and FM transmitters, pulse modulation, and antennas. Includes discussions of applications.

BP70: TRANSISTOR RADIO FAULT-FINDING CHART \$1.90
CHAS. E. MILLER

Across the top of the chart will be found four rectangles containing brief descriptions of various faults; viz: — sound weak but undistorted; set dead; sound low or distorted and background noises. One then selects the most appropriate of these and following the arrows, carries out the suggested checks in sequence until the fault is cleared.

MOORSHEAD PUBLICATIONS Return Policy

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AUDIO

BP90: AUDIO PROJECTS \$7.60
F.G. RAYER

Covers in detail the construction of a wide range of audio projects. The text has been divided into preamplifiers and mixers, power amplifiers, tone controls and matching and miscellaneous projects.

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES \$3.05
B.B. BABANI

This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

BP47: MOBILE DISCOTHEQUE HANDBOOK \$5.40
COLIN CARSON

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

The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

HOW TO BUILD A SMALL BUDGET RECORDING STUDIO FROM SCRATCH \$15.95
TAB No.1166

The author, F. Alton Everest, has gotten studios together several times, and presents twelve complete, tested designs for a wide variety of applications. If all you own is a mono cassette recorder, you don't need this book. If you don't want your new four track to wind up sounding like one, though, you shouldn't be without it.

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING \$5.00
M.K. BERRY

Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.

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

BP74: ELECTRONIC MUSIC PROJECTS \$7.20
R.A. PENFOLD

Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverbation and Phaser-Units, Tremelo Generator etc.

BP81: ELECTRONIC SYNTHESISER PROJECTS \$6.80
M.K. BERRY

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

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MAURICE L. JAY

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REFERENCE

BP85: INTERNATIONAL TRANSISTOR EQUIVALENTS GUIDE

ADRIAN MICHAELS \$11.75
This book will help the reader to find possible substitutes for a popular user-orientated selection of modern transistors. Also shown are the material type, polarity, manufacturer selection of modern transistors. Also shown are the material type, polarity, manufacturer and use. The Equivalents are sub-divided into European, American and Japanese. The products of over 100 manufacturers are included. An essential addition to the library of all those interested in electronics, be they technicians, designers, engineers or hobbyists. Fantastic value for the amount of information it contains.

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MISCELLANEOUS

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Literally everything the amateur or professional musician needs to know to properly maintain his instruments, plus all the how-to's for making repairs from simple tuning to major overhauls.

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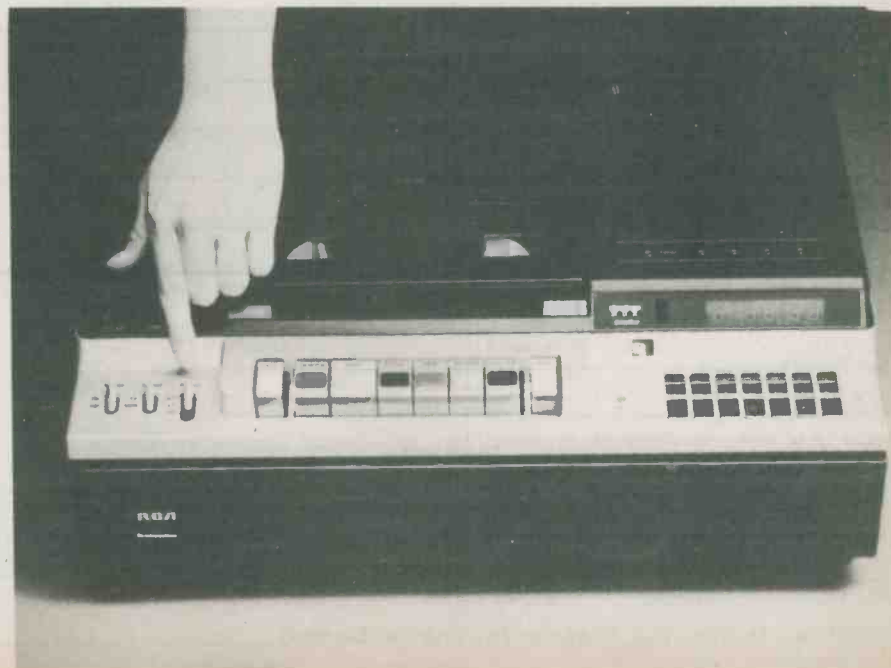
R.A. PENFOLD \$7.60
We have all built circuits from magazines and books only to find that they did not work correctly, or at all, when first switched on. The aim of this book is to help the reader overcome just these problems by indicating how and where to start looking for many of the common faults that can occur when building up projects.

ELECTRONIC TROUBLESHOOTING HANDBOOK

AB019 \$11.95
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COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS

AB018 \$9.95
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.



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WIRED CITY

The Columbia

FOR THE PAST FEW months, ETI has been reviewing a series of fairly low-priced computers. Last month, it was the Atari, the month before it was the Sord, and so on. We've seen how a manufacturer can remove the nonessentials and the high-priced features and try to give you reasonable computing power at a price you can afford. Well, this month we're looking at a no-holds-barred, let's-mortgage-the-dog-and-buy-one, full-featured, IBM-compatible, 16-bit machine. It's called the Columbia MPC 1600. MPC, by the way, stands for Multi-Personal Computer. More specifically, we're reviewing the model with the 5-megabyte hard disk drive.

Before looking at the Columbia, we should first look at the background facts. Specifically, at the IBM PC, a computer that bears a striking resemblance to the Columbia. So striking, in fact, that a lot of IBM executives would probably very much like to strike the designers of the Columbia with a blunt instrument. To be

Many of you may have thought, based on observations of the marketplace, that clones were inexpensive machines with fruity names. Well, there are some exceptions, including some whose reverse engineers may have never gone near an Apple. Anthony DeBoer takes a look.

perfectly honest, what we have here bears a striking resemblance to a certain situation involving Apple and a number of makers of a certain form of mechanical fruit. Well, they do say that imitation is the sincerest form of flattery.

It should probably be mentioned here that it is considered impolite to even mention the word *clone* in the vicinity of those who make and sell what are properly called 'IBM-compatible' systems.

Mechanicals

For a ten or eleven thousand or so dollar computer (most of this price tag being attached to the hard disk drive), even for one that looks like nothing so much as an oversized bar of soap with a disk drive on the front, some of the features are rather poorly thought out. For that much money, one would feel entitled to expect perfection, or something indistinguishable therefrom. Well, one must admit that it costs a lot of money to build a computer with all these features, and it would pro-



bably cost a lot more if everything had to be utterly perfect.

Take the keyboard, for example. Please, take the keyboard! Why is it that just because IBM puts a really silly keyboard on their PC, everybody who imitates it does the same? The Apple cloners added shift lock and lower case to Apple's original keyboard, so why couldn't the makers of PC 'compatibles' take a clue from them?

IBM probably put the bubblegum keyboard on the PC out of sheer blind arrogance. They probably figured the world didn't deserve better. Well, when you own half of western society, you can afford to do things like that. They put decent keyboards on their typewriters, so you can't say they don't know any better. Some people accuse Prime Minister Trudeau of being arrogant. Well, wait till they take a serious look at IBM. Am I sounding too much like Mary Gross? Or maybe IBM just wanted to see how many clone companies they could sucker into building exact replicas of the bubblegum keyboard (or maybe how many people they could sucker into buying the thing). What bugs me is that they're probably right now sitting around in the boardroom of their world corporate headquarters laughing themselves silly at the phenomenal success of their PC and at the number of companies blindly building carbon copies of it and its keyboard.

It should, of course, be added in the Columbia's defence that keyboards are a matter of personal preference among computer users, and that there may be some who will love the Columbia's. The same could apply to IBM itself. My advice: never buy a computer, or anything else that has a keyboard on it, without first at least typing in your name to see if you like the feel of the thing.

Getting back to the Columbia, let's look at the screen. Well, that's probably what you'll spend the most time looking at if you buy one, unless you're a hunt-and-peck typist, or unless you're going to have to spend more time worrying about how you're going to pay for it. The character set is really overdone, all of the characters having serifs. Those are those little doohickies on the tips of the various characters. The uppercase Y, for example, looks like a miniature wineglass. They look really classy, but for the long run, a sanserif character set, like the Apple's, is easier on the eyes.

Also, the screen *flashes* as it scrolls. Even the Apple clone I'm writing this review on doesn't do that. It's really distracting, and unworthy of an upper-financial-strata machine like the Columbia.

The machine does do high-res and colour graphics. The high-res is quite acceptably high — 640 by 200 pixels in black-and-white, and 320 by 200 in four colours. The manual refers to an 'old' colour board and a 'new' one, and the review system seems to have the 'old' one. There are a total of eight colours — black, white, the three primaries red, blue, and green, and the three secondaries yellow, cyan, and magenta — and you can select between two sets of three for your foreground colours and use any of the eight as your background colour. Text mode allows you to have all eight on the screen at once. The 'new' board is claimed to give more flexibility, in choosing any of sixteen colours as the four that you can use at any one time in graphics mode.

The Hard Facts

Being nice to the machine for just a moment, it does have a five-megabyte hard disk in it. There's room enough to burn in five megabytes. Right now, there are no less than sixty files on that disk, some of them quite good-sized, and yet less than one fifth of the available space is in use. Also, disk access is wonderfully fast. It isn't perfectly instantaneous, but it beats floppies. I must admit, however, that after having used floppies for so long, I don't really notice the disk access delays as much anymore, and so the improvement is not all that earth-shaking for me.

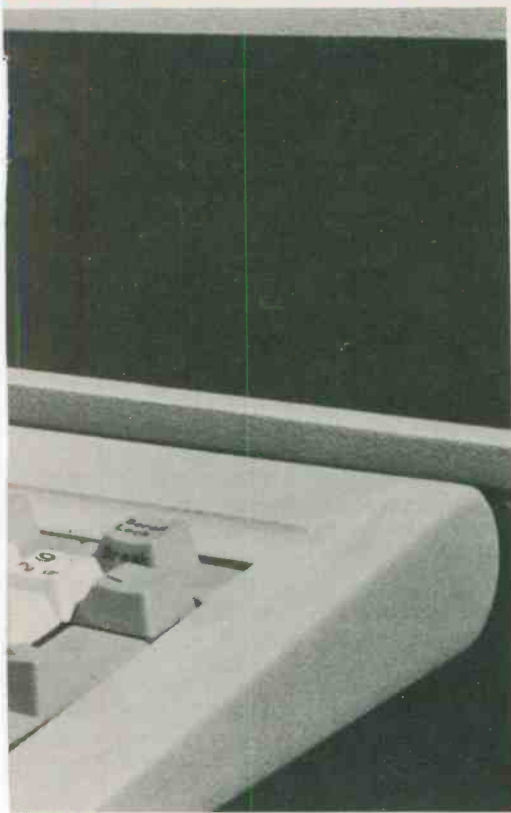
Somebody once did a study of computer delays, and came up with the idea that there are three classes thereof. The first is the type of delay that's so fast as to not be noticeable. The delay between striking a key and seeing it on the screen is an example of this. The second is the delay of up to a few seconds, enough to catch your breath, and is typical of disk accesses. The third is the long delay, as for a printout, or for saving a program on cassette tape (people still do that, believe it or not, archaic as it may seem), which gives you time to get up for a fresh cup of coffee. They found that the actual length of the delay mattered less than the class of delay. If you have to stop typing and wait for the computer, it doesn't matter if it's for half a second or for five. Thus, the



speed difference between a floppy and a hard disk, while noticeable, is not going to be earth-shattering. It's the storage capacity that makes the hard disks worthwhile, although it must be admitted that the speed could make the difference between a reasonable wait and a drastically longer wait when you're working with large files or spreadsheets.

One thing that is worthwhile is having huge amounts of RAM (random access memory, or *core* to an old-timer) in the computer. This one has 128k of memory inside, more than enough to run Space Invaders in, although if that isn't enough, you can add memory up to a limit of one full megabyte. BASICA (the machine's fancy version of BASIC — more on this later), for example, when you get it going, says it has 57418 bytes free. No, that's not a typo, that's fifty seven thousand and change. Most microcomputers don't have that much total memory. It's enough to make the owner of your typical garden-variety micro turn green with envy.

Every byte of this 128k of RAM has a parity bit on it that lets the machine verify



that no memory glitches are occurring. This can't tell you which bit went wrong, or correct things itself — and might even miss a multi-bit error — but at least should give you a feeling of security. As I discovered while editing this review on a lesser micro, memory glitches can be both elusive and maddening if you can't pin them down. When you start up the Columbia, by the way, it can verify its memory for you, if you wish.

The system comes with the expected Centronics-type parallel printer interface, and has not one but two serial ports, one each in the RS-232 standard's DTE and DCE configurations. You can add all manner of peripheral cards. The machine is hardware compatible with the IBM, so cards designed for the IBM should work in the Columbia. Typical peripherals include a Z-80 card (this is beginning to sound like an Apple clone, isn't it?) that lets you run good old CP/M, or an 8087 arithmetic chip in case you're into numerical analysis and you want tens of thousands of eighteen-digit computations done ten minutes ago.

One neat feature is the time/date

facility. Every time you turn the computer on, or hit reset, it wants to know what the date and time are. It then keeps time until you turn it back off. This means that programs can, for example, say 'Good morning, sir', 'Good afternoon, sir', or whatever, when they are run. What's more useful is that every file is marked with the time and date it was last modified. This is nice, because then you can tell exactly what you've modified recently. The only problem is that it's much too tempting to just hit the return key twice when you power the machine up. The machine will then assume zero o'clock on Tuesday, January first, 1980.

Software

The machine runs MSDOS, the 16-bit DOS from Microsoft. It's a lot like good old CP/M, but with various nice features, improvements, extras, luxuries, and so on. There's some heavy command line editing, for example. The command prompt becomes A: instead of A>, but otherwise almost anything that went in CP/M goes in MSDOS. The machine will boot off the hard disk, if it's happy with the thing. This could mean the death of floppies, but don't hold your breath.

The utility set changes slightly. An internal command, COPY, replaces PIP, and STAT, at least as far as checking for free space goes, is replaced by CHKDSK, which also checks the validity of the disk directory. DIR gives the sizes of the individual files.

The computer comes with a complete set of Perfect software. At least that's what the manufacturer has the temerity to call it. It's good software, but a basic programming principle states that no such thing as perfect software exists. The set of Perfect software that comes with the computer (note the difference between the uppercase and the lowercase 'p') includes Perfect Writer, Perfect Speller, Perfect Calc, and Perfect Filer. These programs are integrated, so the same basic set of command keys should do the same basic things in all four programs. Also, the calc program, for example, is set up so that you can transfer spreadsheets or portions thereof to the word processor for inclusion in a document.

If you're more into programming things yourself, you'll want to look at the languages. Microsoft includes an assembler, called Macro-86, with the operating system, in case anyone is into

hacking and wants to program the system directly. Normal human beings will likely, however, be more interested in the two BASICs.

GW-BASIC — at least that's what the manual called it, although it was BASICA on the disk, and was similar to what most people know better as MBASIC — ran beautifully. It is essentially upwards compatible from Microsoft's CP/M MBASIC, meaning that if you know MBASIC, you can be programming in GW-BASIC almost right away. This version adds statements to handle the hardware features of the PC, including graphics, sound, and the function keys. You can program the ten function keys with messages of up to fifteen characters each, including return keys. This means that, for example, you can set it up so that all you have to do is hit the F1 key to get 'LIST (return)'. Another key can RUN, and so on. Also, this BASIC gives you interrupts — you can tell BASIC to call a subroutine whenever one of the function keys is hit, whenever something is ready at the communications port, or whenever the optional light pen or joysticks do their thing. Your program can go on its merry way until this happens, and then zap — you're in the subroutine.

The other BASIC, called just plain BASIC, trades off the fancy frills that BASICA gives you for compactness and operating speed.

Conclusions

There are those who will insist that they buy a computer that has a genuine IBM nameplate on the front, and then there are those who resent IBM's dominance of western culture and will insist on buying a rebel machine. The IBM reputation works both ways.

A more practical consideration is that of availability. If your IBM dealer proposes putting your name on a three-month waiting list and back-ordering a PC for you, while your Columbia dealer is willing to load one into the back of your car, you might want to go for the one that you can be computing on this evening.

All I can say is, if you're planning on buying a big computer like this, know what you're doing.

ETI

RC Substitution Boxes

Build your own resistance, capacitance, or inductance substitution box, using D.E. Patrick's economical design.

BUILD THE junk box 1, 2, 3, 3 resistance subber in Fig. 1, and you can select any resistance from 1 ohm to 9,999,999 ohms in one-ohm steps, which will save 35 resistors over lab type decade units doing the same thing. Instead of nine resistors per decade, only four are required. Thus, instead of expensive 10-position switches, you can use cheap junk box and surplus slide or toggle switches along with critical resistors for lab grade quality at a fraction of the cost.

For example, in the first decade, any value from 0 through 9 ohms can be selected by switching in needed values, while the others are bypassed. The other decades operate in the same way, and since decades one through seven are in series, any value from zero to 9,999,999 ohms can be selected.

Another alternative is to use a 1, 2, 3, 5 resistance sequence, giving 11 ohms possible for the first four switches and a total possible resistance of 12,222,221 ohms for the same number of switches and resistors. Thus, any resistance from zero to 12,221,221 ohms can be selected in one-ohm steps. Also, switching in additive parallel capacitance using slide or toggle switches eliminates the need for fancy hard-to-find rotary switches. We can see this in the 1, 2, 3, 3 and 1, 2, 3, 5 capacitance subbers in Fig. 2.

In Fig. 2, instead of placing resistors in series or bypassing them as in Fig. 1, capacitors are placed in parallel. Further, using the same configuration as in Fig. 1, an inductor 1, 2, 3, 3 or 1, 2, 3, 5 subber can be built. Here inductors would be added in series or bypassed as described earlier.

Construction Hints

There's obviously nothing critical about construction. Use #14 to #12 solid copper wire to prevent copper losses and decent switches to prevent contact resistance losses. The resistors, capacitors, or inductors used should at least have a 5% tolerance; however, 1%, .01%, and .0025% values can also be used, especially since only 28 are required.

The same pattern for the resistance subber is used for the inductance subber.

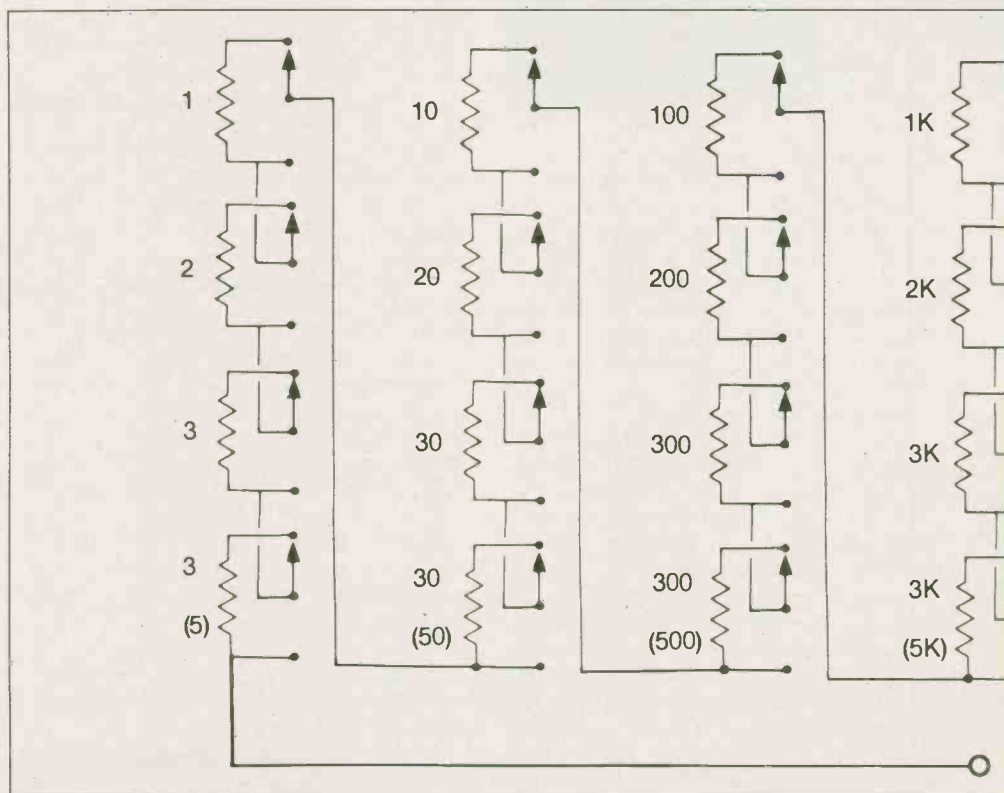
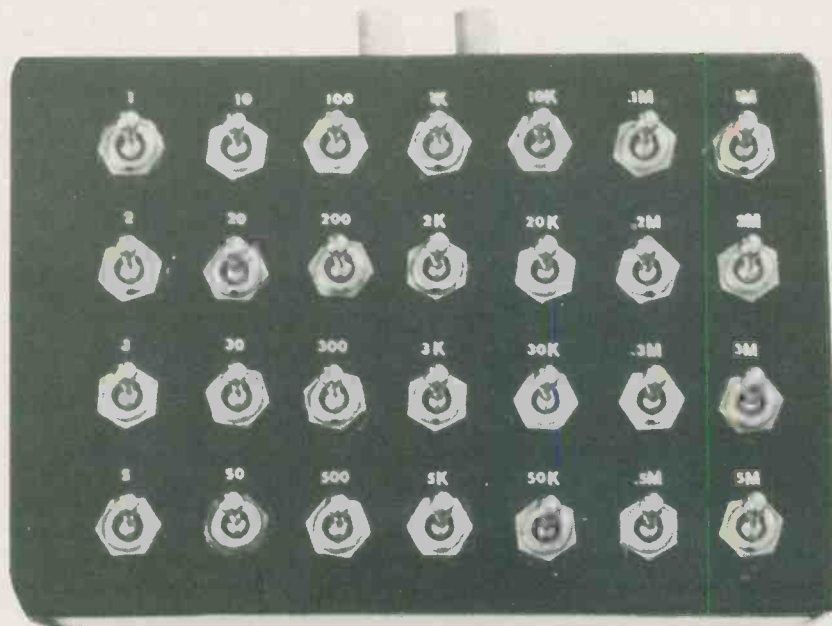


Figure 1. The resistance subber box. The values shown are in ohms for a 1, 2, 3, 3 sequence. For a 1, 2, 3, 5 sequence, substitute the values shown in brackets.

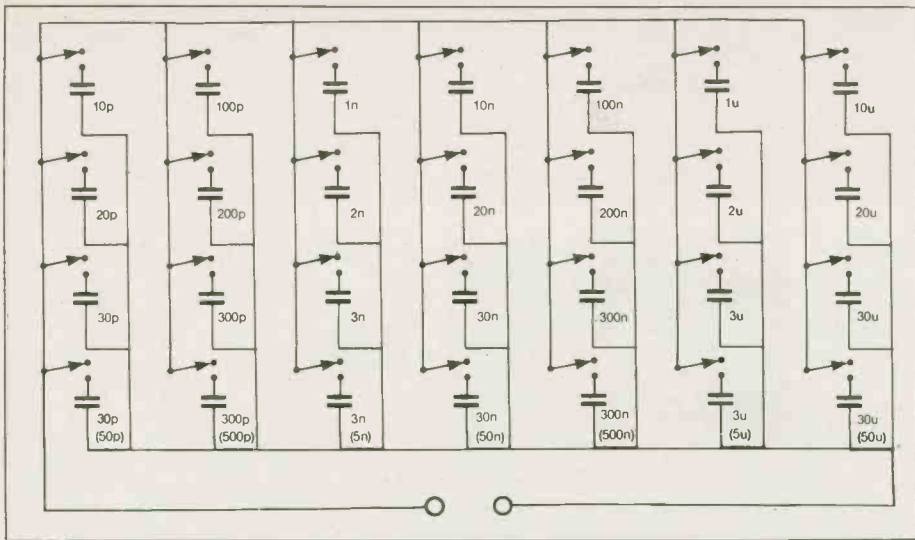
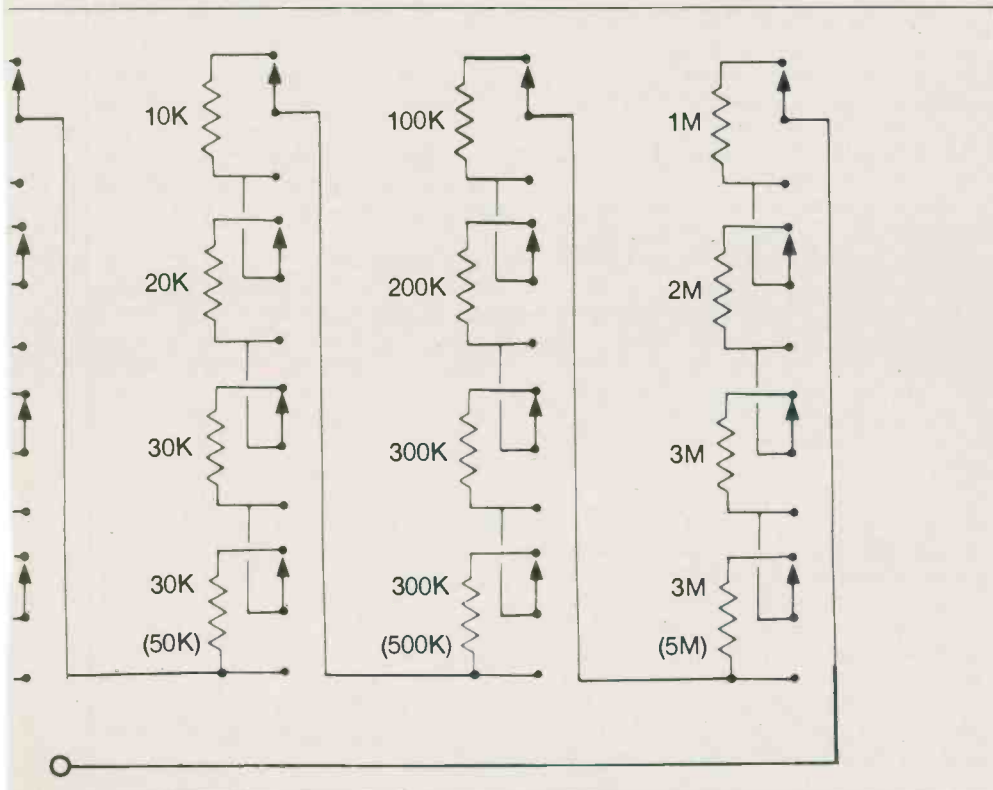


Figure 2. The capacitance subber box, with a 1, 2, 3, 3 sequence. For a 1, 2, 3, 5 sequence, substitute the values shown in brackets.

However, you are limited at the low end using very small inductors, generally under 50 uH or so without tuning coils because of wiring inductance and at the high end you've got to add iron or ferrite. But, if you've got access to an RCL bridge you can measure the inductance from the input terminal and tweak the coils to the desired inductance. Another problem in an inductance sub box is caused by mutual inductance from one coil to another. But this can be

overcome by using shielded coils or adding shielding between sections.

In a capacitance subber, you are again limited at top and bottom ends as described in the inductance sub box configuration. You can use caps below 50 pF, but because of interwire capacitance it is hard to really get any accuracy without using a cap tester or impedance bridge to measure capacitance from the input terminals. Also, for capacitors in excess of 1 uf, it's usually necessary



to use polarized tantalums, electrolytics, etc., which limits accuracy and can increase physical size.

Some Final Notes

The heart of any truly accurate subber is the tolerance of the components used more than the design. The 1, 2, 3, 3 and 1, 2, 3, 5 subbers described here are cost effective because of the fewer critical components required. However, buying new critical components should be avoided if possible to keep costs down. For example, high quality resistors with tolerances from .01% to .0025% can most easily be found in the surplus and scrap markets. Old surplus five and six digit nixie tube DVMs, differential voltmeters, damaged bridges, et al can usually be picked up at scrap prices, stripped out, and used. And where most scrap dealers are after aluminum and precious metals, it's relatively easy to buy critical components at scrap prices by the proud.

PARTS LIST

For capacitance 1, 2, 3, 3 subber: 10p, 20p, 30p, 30p, 100p, 200p, 300p, 300p, 1n, 2n, 3n, 3n, 10n, 20n, 30n, 30n, 100n, 200n, 300n, 300n, 1u, 2u, 3u, 3u, 10u, 20u, 30u, and 30u capacitors.

For capacitance 1, 2, 3, 5 subber: 10p, 20p, 30p, 50p, 100p, 200p, 300p, 500p, 1n, 2n, 3n, 5n, 10n, 20n, 30n, 50n, 100n, 200n, 300n, 500n, 1u, 2u, 3u, 5u, 10u, 20u, 30u, and 50u capacitors.

For resistance 1, 2, 3, 3 subber: 1R, 2R, 3R, 3R, 10R, 20R, 30R, 30R, 100R, 200R, 300R, 300R, 1K, 2K, 3K, 3K, 10K, 20K, 30K, 30K, 100K, 200K, 300K, 300K, 1M, 2M, 3M, and 3M precision resistors.

For resistance 1, 2, 3, 5 subber: 1R, 2R, 3R, 5R, 10R, 20R, 30R, 50R, 100R, 200R, 300R, 500R, 1K, 2K, 3K, 5K, 10K, 20K, 30K, 50K, 100K, 200K, 300K, 500K, 1M, 2M, 3M, and 5M precision resistors.

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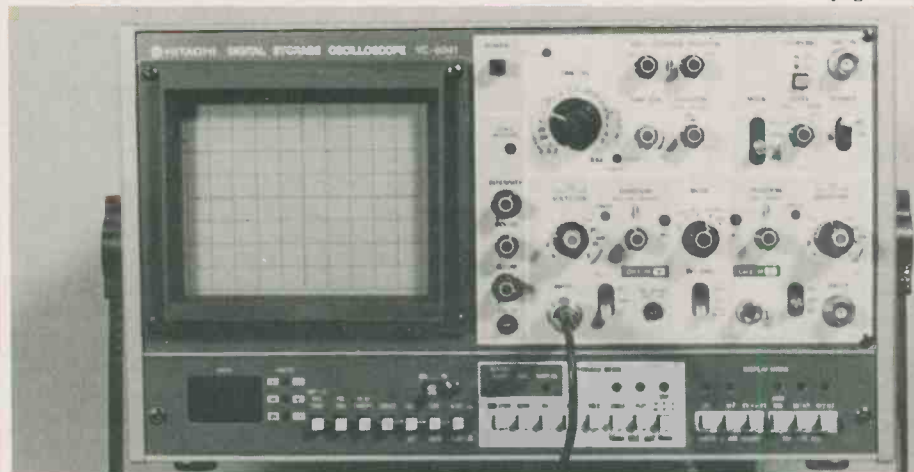
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Product Review

continued from page 31



and then select 'Volts' or 'Time'. The readout will display the voltage or time between the dots, with another set of LEDs to tell you the unit involved. If you have a calculator handy, inverting the time will give you an approximation of the frequency; there are only three digits, after all.

This feature proved to have one of the only immediately apparent design flaws in the VC-6041: the dots were so faint that the intensity control had to be turned down as far as possible without actually removing the signal, so that the dots, which were not affected by the control, would be visible.

There were several other modes available from the storage control panel. In 'Roll', each new sweep pushes the last one off-screen, rather than the usual overwriting; this sometimes made it easier to view changing signals. The 'Single' and 'Pulse' switches could be used to look at one-time transients; the useful bandwidth in this case was 10 MHz for single-channel use, or 5 MHz in the two-channel mode.

Other Features

On the back panel of a fully-equipped model live two sets of outputs. The first is for controlling a chart recorder, and consists of an analog output for each channel as well as a pen-lift output; the writing speed can be set from one to ten seconds per division. The second output, which is optional, is a digital interface for an external controller. It provides the data output for the channels, the waveforms saved, the horizontal and vertical settings, and the trigger point. The controller can also run the single-sweep function.

Applications

According to Hitachi, the VC-6041 is ideally suited for analysis of video and computer circuits; the averaging function is particularly good for noise analysis. The very high bandwidth of the storage function is superb for looking at any high-frequency source, such as ultrasonic equipment, and the single-sweep capability is suited to examining one-time phenomena such as impact testing. Medical technicians can make use of the plotter output for testing and recording physiological data.

In fact, it would be probably be impossible to find an application where this scope didn't make your life easier.

And Lastly...

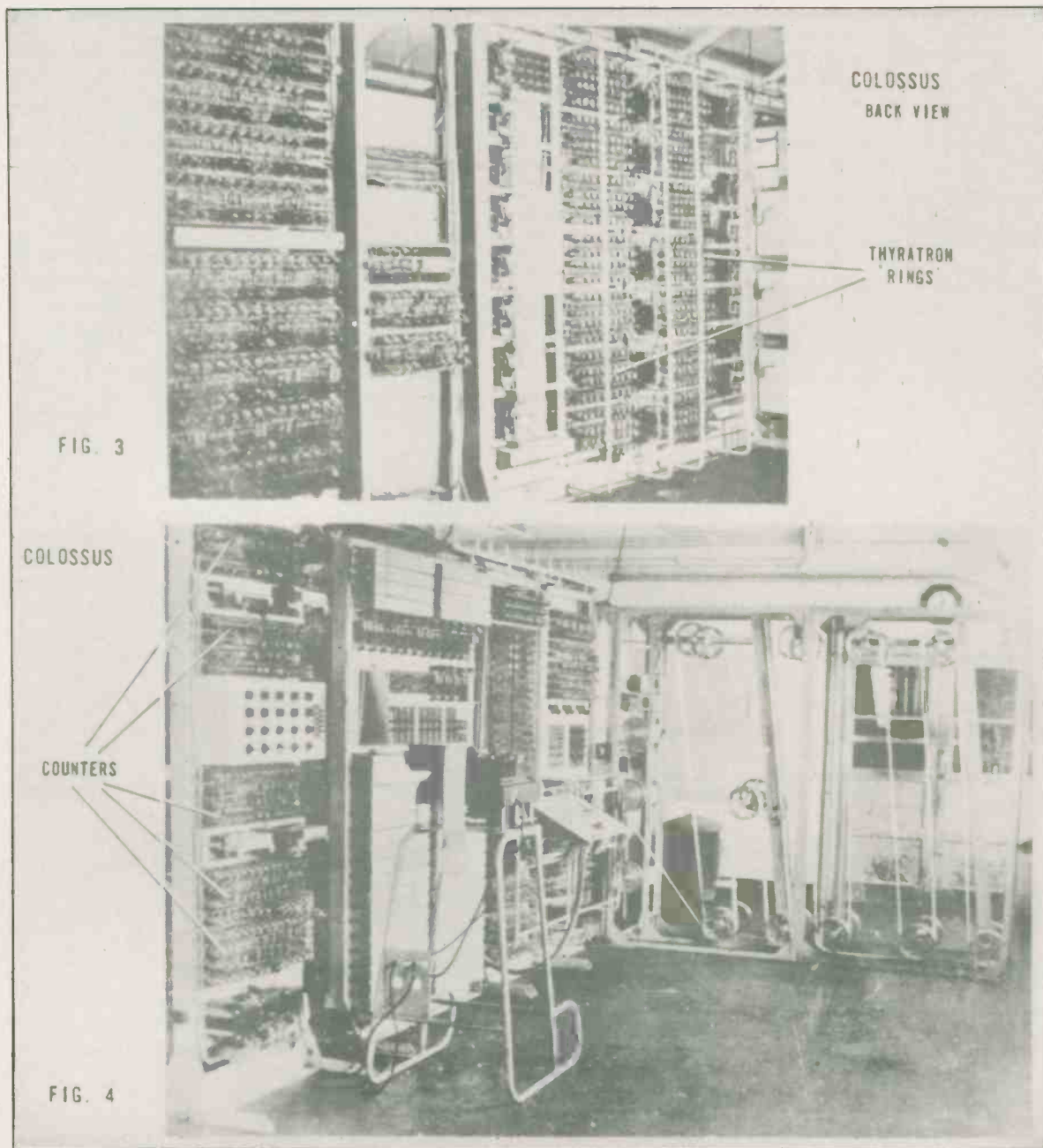
The price tag, while reasonable for equipment of this quality and flexibility, means that you aren't likely to get one for your birthday. On the other hand, reading about it will aid your fantasizing when it comes time to replace that war-surplus Dumont.

If the digital storage appeals to you, but you don't need all the bells and whistles, there's also a scaled-down version, the VC-6015. It has 100 KHz bandwidth, but no cursor or averaging. Further information on the scopes can be obtained from Hitachi Denshi Ltd., 65 Melford Drive, Scarborough, Ontario, M1B 2G6.

Now if you can just convince the boss that the lab equipment should be upgraded....

by Bill Markwick

The Colossus



Thirty years after the fact, the British reveal to the world that it was they, and not the Americans, who invented the first practical electronic computer. Roger Allan lets us in on the secret.

THE LIFTING of the British Official Secrets Act after it had run its customary thirty years has resulted in an absolute mother lode of detail and information concerning the wartime allies' *modus operandi*. So great is the volume of data now available, that virtually all general histories of the Second World War published before 1975 have been rendered redundant. Historians, utilizing their customary care, are slowly sifting through the mountain of information available, and while their work is far from complete (in fact, most of the documents haven't even been read yet), a number of interesting elements have come to light that touch on some rather peculiar subjects, including, odd as it may seem, computers — or more specifically, the very first computer, moreover, one which not only preceded ENIAC (customarily considered in all the textbooks as being the first) by several years, but one which had a computational ability not matched by mainframes for over a decade, capable as it was of working at some 25,000 logic decisions a second.

The history of the German *Enigma* machine and how it produced a seemingly unbreakable code is fairly well known — including how the Canadian, William Stephenson, and his colleagues at Bletchley Park, north of London, broke it (see *Stephenson*, ETI, Sept. 1982). Their methods of decipherment were slow even when the code was broken, and as the codes (dependent on the positions of a number of rotors internal to the transmitting machine) were changed regularly, sometimes as often as once a day, the decipherment of the new code produced by the machine produced great gaps in the available intelligence derived from this source.

Further, the Germans had a second machine known as the *Geheimschreiber* or 'secret writing machine'. Unlike *Enigma*, which was used by front line commanders as well as for communications to and from headquarters, the *Fish*, as it was known to the British, was only used by the upper echelons of the German High Command — Hitler using it for overall strategic directives, the Ministry of Foreign Affairs for communicating with neutral embassies, and so on.

When the British broke the *Geheimschreiber* code has not yet been determined (it is still buried in the pile of currently unread data at the Public Record Office, Britain's national archives, in London), but most probably it was late in 1941. Decipherment was slow and by hand, and as the code was changed on a daily basis, most often the decipherment, when it was completed (which was rare), was completed weeks or even months after it was sent. The machine, more complicated than the *Enigma*, worked on ten rotors,

each one of which could be set differently. This produced a code of several billion possibilities, rather a long job to sort out by hand, even when utilizing Boolean algebra. It had the great advantage in that it automatically enciphered a signal typed on it in clear and sent it to the telegraph or radio station at the rate of sixty-two words a minute, without the need for a cipher clerk (which was one of *Enigma's* great weaknesses). In order to receive the message a similar machine was needed, which automatically typed out the text. It was in essence a teleprinter, based on the telegraph code of Baudot and Murray. This code contained thirty-two separate elements embracing twenty-six letters, ten numbers, punctuation, teleprinter functions, line feed, carriage return, letter spacing and letter and number shift. In order to fit all this into thirty-two elements, the code had to be used twice over; in a lower case for letters and in an upper case for numbers and punctuation.

**“... a computational
ability not matched by
mainframes for over a
decade ...”**

In early 1942, Bletchley Park was a hodgepodge of interesting characters — mathematicians rubbing shoulders with archeologists, front line battle weary officers chatting with physicists, and so on. It was from this compendium of diverse sorts, producing a marvelous cross-fertilization of ideas, that the major British intelligence operations were determined and built, where the *Enigma* codes were cracked, for instance.

Not a ZX-81 Yet . . .

In early 1942 a Cambridge mathematician, M.H.A. Newman, joined the staff, and it occurred to him that perhaps it would be possible to build a machine that would automatically and very quickly do the sorting and comparison work currently done by hand, but would do it much more quickly. He persuaded the Powers That Be to act on his idea, and a section was set up under his direction, known as the “Newmanry”, in Hut F at Bletchley Park. Under his direction, a team of mathematicians, with the assistance of several engineers from the British Post Office Research Station at Dollis Hill, built a

machine. It used 80 valves, and stood in two general-issue Post Office equipment racks about 8 feet high. It utilized a photo-electric reader and could scan 2000 telegraph characters a second.

Its operation was quite straightforward. Five unit Murray Code elements were punched onto a paper tape, containing the German cipher, which was fed into one of the two readers. The tape was joined to form a large loop which ran continuously over a system of pulleys past photoelectric cells. A key tape, smaller in length than the first tape and containing the deciphering telegraph units, was fed into the second reader. Telegraph tape, like old style computer tape, had sprocket holes in it. As the sprockets rotated, they drove the two tapes. As one tape, the key tape, was shorter than the first tape by one character, every revolution of the tape produced a different key unit passing through the reader against the message units. Named the “Heath Robinson” after the constructor of crazy machines, it essentially depended on a statistical system of breaking codes. It could operate at two thousand characters a second — that is, when it worked, which it frequently didn't, as the tapes kept breaking.

As Odette Wylie, a WRNS who worked on the machine, has been quoted as recalling, “It was a long time before we found some sufficiently gluey material that would stand up under the strain of going round and round at a great speed. The fact that we had to get the two tapes to run exactly synchronized was also a very difficult operation. When they did break, it was not just a question of breaking and lying on the floor, they flew into the air and got entangled in the machine, in little corners, very difficult to get out again.”

Further, the binary system counting procedure was inaccurate, due to the unreliable relays, and the single loop of tape which provided the key was inadequate.

Invention

It was about this time, January 1943, that two Post Office engineers, T.H. Flowers and S.W. Broadhurst, specialists in high-speed switching, joined Bletchley Park. Familiar with Alan Turing's 1936 paper on the creation of an artificial brain, and realizing that vacuum tubes had a very high degree of reliability if kept in constant operation (rather than being switched on and off), they suggested the building of a “Super Heath Robinson.” After some opposition, the Powers That Be gave the go-ahead, and the first computer, the Colossus Mk I, was built. Design commenced in February 1943, and was delivered in working order in December of the same year.

Based on some 1500 valves, the ma-

for difference to the "Heath Robinson" was that the key tapes were replaced by electronically-generated keys. The ten *Geheimschreiber* rotors were simulated by ten rings of thyatron triode valves, which, containing argon gas, acted as very high speed switches and were capable of passing high current. One valve in a particular ring was conducting at any given moment, when its neighbour would take over, thus simulating the passage of the loop continuously through the photo-electric readers.

The interface between the machine and the operating cryptanalyst was via a bank of switches, whereby the cryptanalyst would ask the machine to make certain adjustments to the cipher keys. She would be sitting in front of an electric typewriter looking for the tell-tale letter recurrence which would indicate a gradual solving of the cipher text. Once the code was broken, it could reproduce the results *ad infinitum* for all further traffic using that code — to the extent of 10^{11} consecutive elementary Boolean (and/or) equations without error.

It was therefore the first electric computer, and the first statistical brain containing a memory which did not make mistakes.

Similar to the *Enigma* machine, the *Geheimschreiber* was constantly being improved, and during the war there appeared five versions (models 52AB, 52C and others). One of the modifications consisted of some of the rotors rotating irregularly, being driven by pawls, retaining an eccentricity. The Colossus Mk I was unable to handle this eccentricity. As such, an improved version, the Colossus Mk II, was designed to deal with this modification to the German *Fish*.

IF Unbroken THEN Keep Trying

The function built into Colossus Mk II to solve the eccentric rotors was Conditional (branching) IF logic — it could make decisions. While this is fundamental to modern computers, this machine was the first to use it. It utilized 2500 valves, and its reader could scan 5000 characters a second. Five such readers could be placed in parallel, giving it an overall operating speed of 25,000 characters a second — a speed not duplicated by other computers for over a decade. Output was fifteen characters a second on an electric line printer.

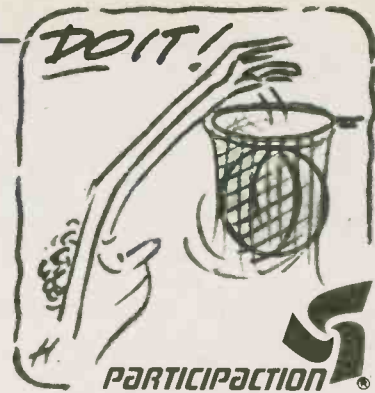
The speed at which this machine was designed and built is quite extraordinary. The go-ahead was given in March of 1944, with a delivery date by D-Day, June 6. The first of ten Colossus Mk IIs was delivered on June 1.

As to what the twenty cryptanalysts, twenty engineers and 250

WRNS operators at Bletchley Park attached to the "Newmanry" deciphered on the Colossus has as yet not been determined, other than that it was used for the *Ultra* intelligence, never on *Enigma* messages.

The story of what happened to them after the war is simply told. They were dismantled, and sold in unidentified lots to the surplus stores, along with the other electronic bits and pieces from Bletchley Park.

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ETI—FEBRUARY—1984—45

Designing Microsystems Part 6

So far we've covered the brains of a computer, but it's still deaf and dumb, electronically. This month Owen Bishop takes on the role of ear, nose and throat specialist.

THE CPU, its ROM and its RAM, the subjects of previous parts of this series, are a tightly-knit section of all computer systems. In most micros, they are mounted together on a single computer board. This month, we are concerned with the way in which this section of the computer circuit communicates with the rest of the circuit and with devices outside the computer proper. This aspect of computer design is known as *Input/Output*, or I/O for short.

In The Right Key

Leaving aside special purpose computers such as those used in control applications, the most important source of input to the computer is its keyboard. This is where our finger-tips send information (instructions on what to do, and data to do it with) to the computer. As I write this sentence, my fingers are pressing keys on a computer keyboard. Each key is marked with a letter of the alphabet, a numeral or other symbol. There is also a space bar and two shift keys. How does the computer know which keys I have pressed? If I press the fifth key from the left of the second row down, I want it to put 'r' on the screen. If I also press a shift key, I want 'R'. How does it know which key means which letter?

If a keyboard is to provide input to the CPU, it must somehow place information on the data bus. The keyboard of the computer which I use for word-processing does this in a simple way. The method is one which is commonly used in micros at the lower end of the price range. Figure 1 shows the main features of the circuit. The first point to note is that there is a bank of eight buffers between the keyboard circuit and the data bus. It would be no good if data were put directly on to the bus every time I happened to touch a key. That might be just the moment when the MPU is reading from RAM. My pressing key 'r' just then could have disastrous results! It is essential that there is something between the keyboard and the data bus. This is the function of the buffers.

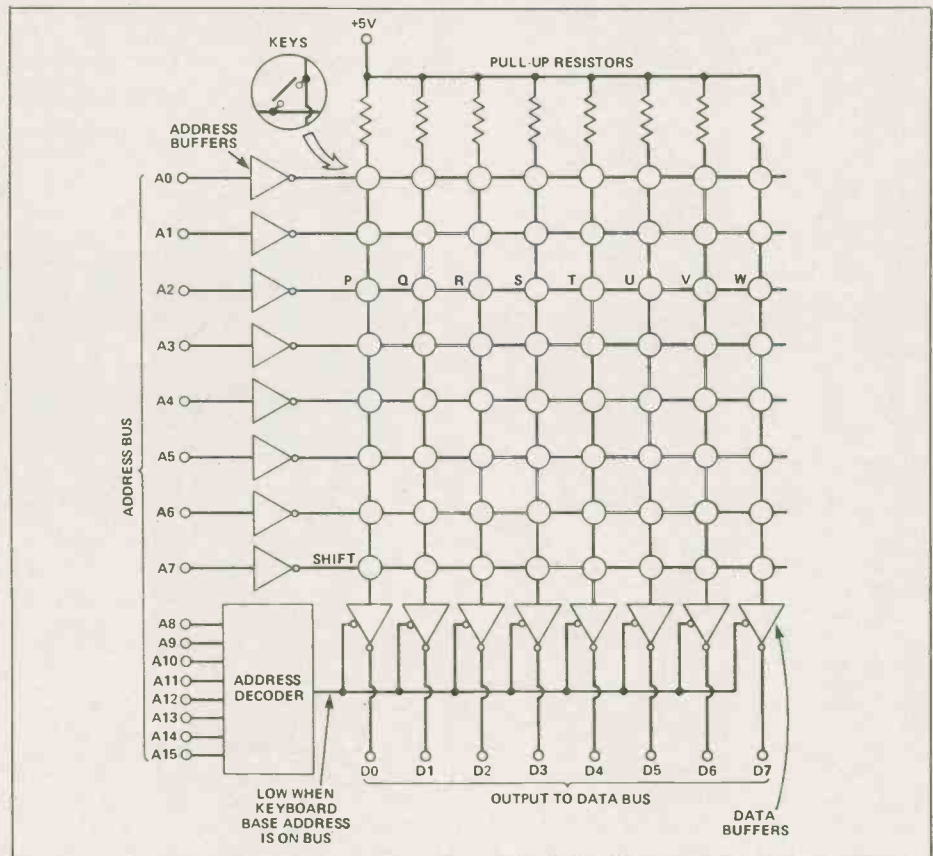


Fig. 1. A typical keyboard circuit. To simplify this, only one row of keys has been drawn.

The buffers are under the control of the MPU. Each buffer has a data input, a data output and an enable input. The keyboard uses eight such buffers and they are all enabled together. When the enable input is held high (+5 V) the buffers are in the high-impedance state: in effect, the outputs are disconnected from the data bus. The buffers are held in this state when the MPU is busy reading RAM, or, for any other reason, does not want to know what is happening at the keyboard. When the enable input is made low (0 V) the outputs of the buffers take the states opposite to their data inputs (they are inverting buffers). The data present at the inputs appears inverted on the data bus lines.

Addressing The Problem

Enabling is under the control of a logical circuit, an address decoder. In Part 3 we described how an address is decoded in order that a particular memory cell in ROM or RAM can be read from or writ-

ten to. The same technique is used here. Although the keyboard is not memory in the sense that it stores information, it is addressed in the same way as memory. Most addresses are allocated to RAM or ROM, but a few are allocated to the keyboard.

In my computer, the keyboard is addressed at 3800 to 38FF, though only a few of these addresses are actually used. The address-decoding logic gives a low output (to enable the buffers) whenever '0011 1000' appears on the upper eight address lines (A15 to A8). The lower eight address lines (A7 to A0) go to the keyboard matrix. As it enters the matrix, each line goes to a buffer. These are inverting buffers with open-collector outputs.

You will see from Fig. 1 that the matrix consists of eight address buffer output lines crossed by eight data buffer input lines. The keys are simple press-to-make pushbuttons, joining an address output to a data input. The buffer input lines are normally held high because of the

resistors connecting them to the +5 V supply line. When a key is pressed, an address buffer output becomes connected to a data buffer input. The fact that the address buffers have open-collector outputs means that if a buffer has a low output, it pulls the level down to 0 V. Otherwise the level remains at +5 V.

The Soft Solution

The rest of the input procedure depends on software: the monitor program in ROM contains a routine for reading the keyboard. The MPU addresses the keyboard by putting '0011 1000' (= 38 in hex) on the high address lines (A15 to A8) and putting '1' on only one of the remaining address lines. For example, to address the first row of keys, the full address is '0011 1000 0000 0001' (= 3801). For the next row we have '0011 1000 0000 0010' (= 3802), then '0011 1000 0000 0100' (= 3804) and so on through 3808, 3810, 3820 and 3840 to 3880 (all hex numbers, remember). The MPU puts these eight addresses in rotation on the address bus. When any one of these addresses is on the bus, the address decoder circuit enables all the data buffers. If no key is being pressed at that moment, all data outputs are low. But if one of the keys is being pressed at the same time as its address buffer output is low, a 'high' appears on one of the data lines. Thus if I press key 'r' when the MPU is addressing 3802, line A2 is high, so its buffer output is low. Since key 'r' connects this output to the buffer for data

line D2, '0000 0010' (= 02 in hex) appears on the data bus. The MPU now has to go to a monitor routine to interpret this data. Using this routine, it finds out that if the data is '02' when the address is 3802, then key 'r' has been pressed. An instant later, it will be addressing 3880 and, if the data becomes '0000 0001' (= 01), it can then tell that the shift key also has been pressed, and that the upper-case 'R' is intended.

The MPU continually scans the keyboard in this way when waiting for input, decoding the data according to which address is in force at that instant. This approach to input relies heavily on software, and it takes several operations to detect and decode each keystroke. Response is relatively slow. The routine required is further complicated by the need to deal with two keys being pressed simultaneously or in very rapid succession. It is necessary to check that a pressed key has been released before attempting to decode the next key that is pressed. This feature is known as two-key rollover. Fortunately, microprocessors work so quickly that even an experienced touch-typist is not able to outpace the keyboard decoding routines.

Encoding Made Easy

Although the circuit described above is simple and cheap to build, the MPU is required to do a lot of work. If this work could be done elsewhere, it would leave the MPU with more time to spend on

other and perhaps less routine jobs. The alternative approach to keyboard decoding is to employ a special decoder IC (Fig. 2). Again, the keys are connected at the intersections of a matrix, but now both sets of lines come from the encoder IC. The IC has its own clock circuit and scans the matrix rapidly to find which X line and which Y line have been connected by a pressed key. Having detected a key-press, the output latches of the IC are set to produce a seven-bit code corresponding to the pressed key, taking into account whether or not the shift key or possibly the 'control' key has been pressed at the same time.

You can think of the keyboard encoder as having some of the features of a ROM. When a set of eight memory cells in ROM is addressed for reading by the MPU, its output latches deliver to the data bus the byte stored in that cell. Similarly, the memory cells of the keyboard encoder each contain one code byte. The X and Y lines from the keyboard correspond to address lines. When a particular address is set up by pressing a particular key or combination of keys, the corresponding memory cells place their stored byte in the output registers of the IC. The data stored in the registers remains there until the MPU addresses the encoder. Then its register puts the stored code on the data bus and the MPU reads the code. Note that the MPU only has to perform one addressing operation: the keyboard address in the Apple II for example, is C000. This operation is much quicker than the laborious scanning operation described earlier. The only other thing the MPU has to do is to address the encoder reset (address C001) to reset the latches, ready for them to be set by the next key-press. Note that the encoder holds the code until the MPU requests it. In the previously described system, if the MPU is expecting input from the keyboard, it must continually scan the keyboard in case it should miss a key-press.

Ask Me In ASCII

Whereas the code generated by the circuit of Fig. 1 depends on how the circuit is wired, the code generated in Fig. 2 depends on the codes programmed into the memory of the IC during manufacture. In order to promote good communication between keyboards, MPUs and other I/O devices, a standard code has been drawn up for use in computer systems. This is the American Standard Code for Information Interchange, known as the ASCII code (Table 1). Most keyboard encoders produce ASCII code and most computers understand it!

A quick glance at Table 1 reveals that the seven-bit codes cover more than the printable alphabetical and numerical

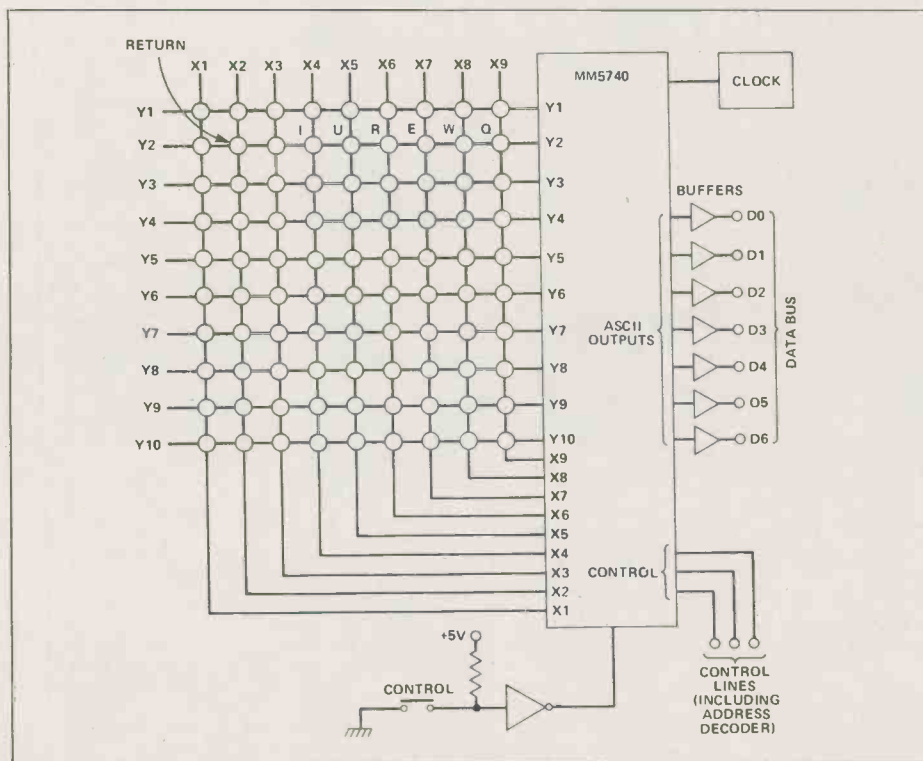


Fig. 2. A keyboard circuit using an ASCII encoder (simplified circuit; only a few keys drawn).

Designing Micros Part 6

characters and symbols. The first two columns contain what are usually termed *control codes*. These are instructions for the control of peripheral devices, especially printers. They are generated when the CONTROL key is pressed at the same time as one of the alphabetical keys. The code BS, for example, is generated by pressing CONTROL and H, and means 'backspace'. Since this is a frequently used command, many keyboards have a special 'backspace' key () which generates this command with a single keystroke. CR means 'carriage return'. When you press the RETURN (or ENTER) key, the keyboard sends a CR code (000 1101) to the computer. This can be used, for example, to tell the computer that the program line which has just been typed in, is complete and ready to be stored in program RAM. If the MPU sends such a signal to the printer, it instructs the print-head to return to the left-hand edge of the page. The DC1 to DC4 codes are Device Control codes, available for miscellaneous functions differing from one machine to another. On the TRS-80, code DC4 instructs the line printer to print at 16.7 cpi, whereas, on the Apple II, it is a toggle instruction to the Silentype printer to echo its printout to the monitor screen.

A further refinement found on some

TABLE 1 : THE ASCII CODE

High nibble	0	1	2	3	4	5	6	7
Low nibble								
0	NUL	DLE		0	@	P		p
1	SOH	DC1	!	1	A	Q	a	q
2	STX	DC2	"	2	B	R	b	r
3	EXT	DC3	#	3	C	S	c	s
4	EOT	DC4	\$	4	D	T	d	t
5	ENQ	NAK	%	5	E	U	e	u
6	ACK	SYN	&	6	F	V	f	v
7	BEL	ETB	'	7	G	W	g	w
8	BS	CAN	(	8	H	X	h	x
9	HT	EM	)	9	I	Y	i	y
A	LF	SUB	*	:	J	Z	j	z
B	VT	ESC	+	;	K	[	k	{
C	FF	FS	,	<	L	\	l	|
D	CR	GS	-	=	M	]	m	}
E	SO	RS	.	>	N	_	n	~
F	SI	US	/	?	O	—	o	DEL

The code is obtained by combining the high nibble (top margin) with the low nibble (left margin) to make a byte. For example the code for upper case W is '57'. The code '20' represents a space.

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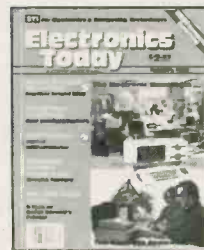
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systems is a FIFO or *first-in-first-out* device. It is wired between the encoder IC and the data line buffers. As each key is pressed, the encoder sends the corresponding ASCII code to the FIFO, which stores it. Typically, it can store up to 16 ASCII codes. The codes are sent out to the buffers in the same order as they are fed in. When the MPU is ready to read a code, a strobe signal to the FIFO results in the next available code being sent to the buffers. In this way, we have *asynchronous transfer* of data between keyboard and CPU. 'Asynchronous' means that the MPU and keyboard do not have to keep in step. If the MPU is temporarily busy and not able to accept input from the keyboard, the data queues up in the FIFO until the MPU is ready to accept it.

Plugging In Peripherals

Now that micros are becoming more commonplace, people are beginning to recognize that they are capable of far more than just playing arcade games or taking charge of the bookkeeping. There is an increasing interest in being able to connect external devices to the micro — anything from a simple games control to a robot arm. The more recently made micros, even those in the lower price range, now incorporate ICs which allow a variety of peripherals to be attached. These I/O channels are often referred to as 'ports'.

There are two main types of port IC. The *parallel I/O* device (or PIO) allows data to be transferred between the computer and the peripheral several bits at a time. Commonly there are eight lines, allowing transfer of one byte at a time. The *serial I/O* device (SIO) transfers data a bit at a time, but groups bits into eights (usually) so that a byte is transmitted as a series of eight bits. We will deal with SIOs in a later issue.

Parallel Lines

Although it is only recently that PIOs have become standard on many low-cost micros, they have always been an almost essential feature of the simple computers intended principally for control applications. A well-known example of a PIO is the INS8154 (Fig. 3). Our old favourite, the Sinclair MK-14, had a socket to take an 8154, though the MPU used in this system (the 8060 or SC/MP) has a few direct I/O terminals of its own. Its three 'Flag' outputs can be programmed to have high or low outputs, giving a three-bit data output. The MPU also has two 'Serial' inputs which allow two sets of input data to be fed directly to the MPU. This feature of built-in I/O is quite enough for simple control applications and may dispense with the need for a separate I/O IC.

The Acorn System 1 is a well-

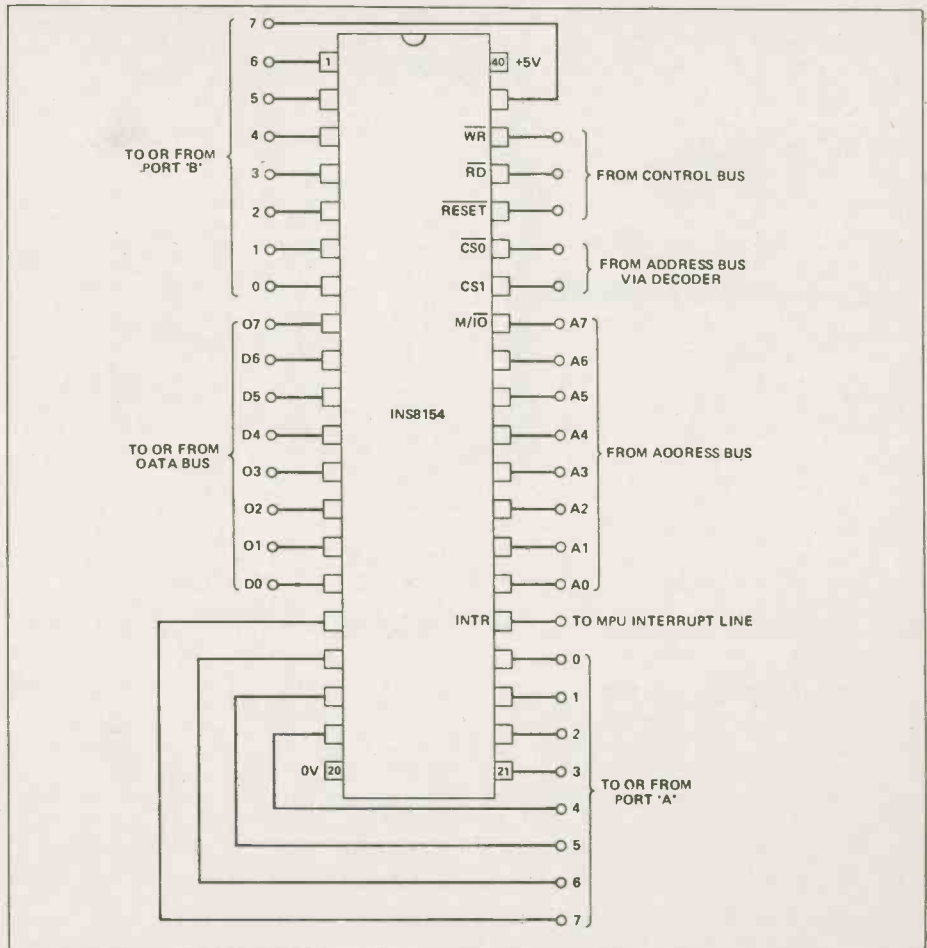


Fig. 3. Pin connections for the INS8154 I/O device.

established control computer. It has sockets for two 8154s, the second of which is used for I/O between the CPU and the cassette recorder. As with the keyboard, an I/O device has to be 'located' in a certain part of memory: we say that it is 'memory-mapped'. When addressing the 8154, the top eight address bits (A15 to A8) are used for establishing the base address of the IC in the way we have already described. The IC has two chip-select inputs, one of which (CS1) is active-high, and the other ($\overline{CS0}$) is active-low. Either or both inputs can be used to enable the chip, making it easier to work out an economical address-decoding circuit.

The $\overline{M/I O}$ input is unusual, for as well as being an I/O device, the 8154 carries 128 bytes of RAM. This memory/I/O combination is handy for control systems, for which 128 bytes may be all the RAM that is needed. The $\overline{M/I O}$ input is usually controlled by line A7. The remaining lines (A6 to A0) are decoded inside the 8154. To operate the 8154 as RAM, the $\overline{M/I O}$ input is made high. If the base address is A000 (as in the Acorn System 1), RAM extends from A080 to A0FF (bit A7 always high for memory operations).

To use the IC for I/O, the $\overline{M/I O}$ input is made low (bit 7 always low for I/O). This section of the IC thus comes in the range A000 to A0FF. Actually, only a few of these addresses are used. Some of the addresses are used to initiate certain modes of operation; others are used when sending or receiving data. The method of programming the IC is too complex to go into here, but we can outline what it is possible to do.

Data is passed between the CPU and the IC by way of the eight-bit data bus. Data is passed between the IC and the outside world (TTL levels only) by the 16 I/O lines. These are organized as two eight-bit ports, A and B. Each port can be controlled and addressed separately. Reading and writing to the device is totally under the control of the MPU. The registers in each port can be instructed by the MPU to act as outputs, or as inputs. It is also possible to control each line of a port individually, so that some of them are inputs and others are outputs.

When data is being output, it is transferred to the IC and appears on those lines which have been selected as outputs. The data stays there, even though the original signals may have been removed

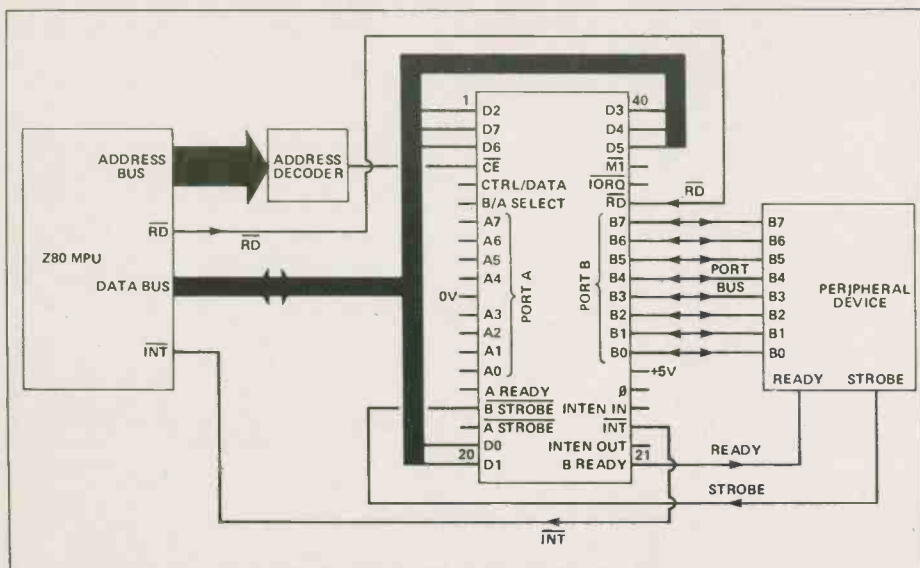


Fig. 4. The Z80 PIO, showing its main connections when linking the Z80 to a peripheral device.

from the data bus and the MPU is busy doing something else. The data can remain until the external device is ready for it, allowing the asynchronous transfer of data, as mentioned earlier. When the CPU reads from input lines, the data it receives is that which is being transmitted from the peripheral at that instant.

The Hardware Handshake

Obviously there can be problems in transmitting data through an I/O. How does the MPU know that the peripheral has received the data which has been sent to it? It is no use for the MPU to send a new set of data until it is sure that the peripheral has actually received the previous set. Conversely, how does the MPU know that there is a set of data waiting at the input port? How does the peripheral know when this data has been read by the MPU? Again, it is no good for the peripheral to be inputting data to a

port if the CPU has switched that port to the output function.

In some systems, the sequence of operations and their timing may be such that complete transfer of data is assured. In other systems, it is necessary to provide for signals to be sent between the MPU and a peripheral to control the flow of data. This is known as 'handshaking'.

The Z80-PIO (Fig. 4) has special control inputs and outputs and the necessary logic circuits to provide for handshaking. Like the 8154, it has two eight-bit ports, each of which can be individually programmed to act as an input port or an output port. Port A can also be programmed as a bidirectional port, allowing direct communication between the peripheral and the data bus. Alternatively, the individual lines of the port can be set for input or output, as described for the 8154. Figure 5a shows how data is sent from the MPU to a peripheral. As soon as data has

been written to the IC and has appeared at an output port, the READY output goes high; this is a signal to the peripheral. When the peripheral receives this signal it knows that it must read the data. As soon as it has read the data, the peripheral puts a low pulse on the STROBE line. This causes the IC to generate a low pulse on the INT line. This goes to the MPU, telling it that the data has been read. The MPU may now send a further byte of data to the peripheral.

When inputting data (Fig. 5b), the peripheral begins by making STROBE low. The INT pulse generated by the I/O device interrupts the MPU to tell it that there is data to be read. At the same time, the READY output goes low, indicating to the peripheral that the data is being held, waiting for the MPU to read it, and that no more data should be sent in the meantime. As soon as the computer has read the data, the end of the RD pulse resets READY, so that the peripheral knows that reading is complete and more data can be sent. Thus the sender and receiver each know which state the other has reached. Data is transferred between them in either direction without loss.

The 8154 has a similar handshaking procedure, but this is limited to port A. The INT R line has the same function as the INT line, but Fig. 3 shows that there are no special control lines to correspond with READY and STROBE. Instead, two of the lines of port B are taken over for this purpose when port A is to be used in the handshake mode. The remaining six lines of port B can be used independently, in the usual way.

Dealing With Interruptions

We have seen how the interrupt is an essential part of handshaking by PIO devices. The interrupt may also be used when other peripherals want to communicate with the MPU, either through an I/O device or directly to the data bus. Often, there are several peripherals connected to a system, yet all give the same interrupt signal. How is the MPU to know which one of these peripherals it is dealing with?

One method is 'device polling'. Each device has a latch circuit which gives a high output when the device is trying to input data to the MPU. The latches are enabled by an address decoder, and each is separately addressed. When interrupted, the MPU goes to its interrupt routine program, disabling the interrupt function for the time being; this prevents it from being interrupted again while it is attending to the current interrupt. The interrupt routine instructs it to read each register in turn to find out which device is interrupting and to jump to a particular subroutine according to which device has interrupted. Note that this program polls

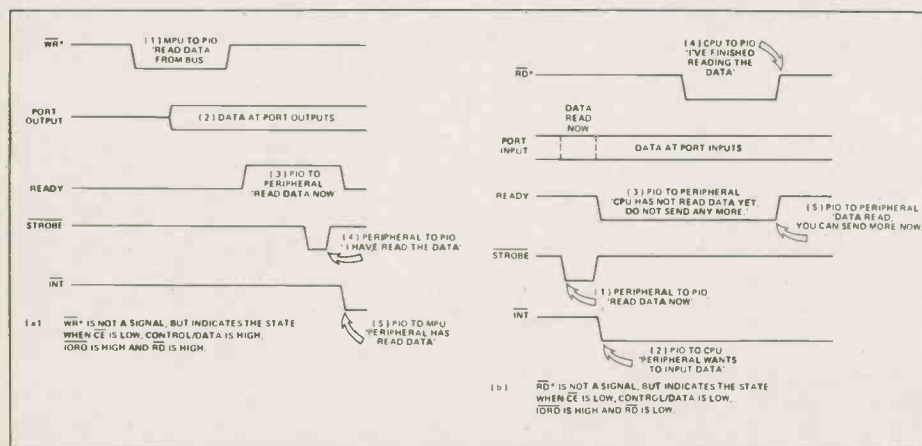


Fig. 5. Timing diagram for the transfer of data between the MPU and peripheral. Output handshaking (a) and input handshaking (b) are shown.

the devices one at a time in a pre-determined order. We can program the MPU to test first the registers of devices which cannot wait long to be serviced, leaving other less urgent devices until later. In this way, the software establishes a system of *priorities*.

The Z80 has a vectored interrupt mode which simplifies the process of finding out which device is interrupting; at the same time as the device interrupts, it puts certain data on the bus. This data is read by the MPU and combined with other data already in memory to form the address where the appropriate interrupt routine begins. Each peripheral identifies itself by putting this particular set of data on the bus, causing the MPU to jump to the corresponding servicing subroutine.

Who's Shouting The Loudest?

Most I/O devices have two ports, some have three, and many computers have more than one I/O device. If the MPU has two or more peripherals and all are trying to communicate with it at the same time, the situation is like a political meeting with everyone trying to shout at once! There must be a system of priorities so that, when one of the more important peripherals is communicating, the less important ones are ignored. We have seen

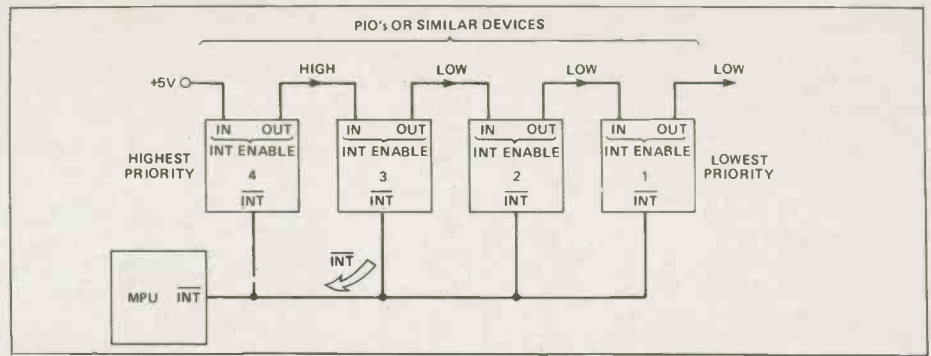


Fig. 6. Daisy-chain priority control: all PIOs are connected to the \overline{INT} line. PIO no. 3 is interrupting and passing a low signal to nos. 2 and 1 to prevent them interrupting.

that software provides priority, but only after the interrupt has occurred. Hardware priority ensures that a high-priority peripheral will always get preference whenever it interrupts. The most commonly used method is known as daisy-chaining.

Daisy-chaining works like this. All the PIOs or other peripherals are connected to the \overline{INT} line by open-collector outputs. The line is normally held high by a pull-up resistor connected to +5 V, but when any one or more interrupt outputs goes low, the voltage on the line is pulled down and the MPU goes into

its interrupt routine. In order to be able to generate an interrupt output, a peripheral must be receiving a high voltage level at its interrupt enable input (IEI). Normally, the interrupt enable output (IEO) of the peripheral has the same level as its interrupt input. The IEI on a peripheral receives its input from the IEO of the peripheral with the next higher priority. In Fig. 6, if none of the PIOs are interrupting, every one of them is receiving a high level at its IEI from the PIO next above it in the chain. Every one of them is able to initiate an interrupt when it wants to do so. When a peripheral is interrupting or is

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waiting for the MPU to respond to its interrupt request, its IEO becomes low. All peripherals below it (with lower priority) then have the low level fed down to them, and are then unable to generate interrupts.

Another method involves the use of a special priority encoder IC such as the CD4532. It is the hardware equivalent of the device-polling software mentioned above. It has eight inputs, each of which is connected to a peripheral. When any peripheral is causing an interrupt, it also puts a high level on its own encoder input. The encoder also has four outputs which can be connected to the data bus through buffers which are enabled whenever the MPU wants to read the encoder. Their outputs indicate in binary code which peripheral is interrupting. For example, if peripheral no. 6 (connected to input 6) is interrupting, the outputs put binary code 6 (0100) on the data bus. By reading the bus, the MPU can find out which device is interrupting. If more than one peripheral is interrupting at the same time, the binary code for that with the higher priority (highest number) appears at the output.

Sending A Cable

We have been so preoccupied with logic that we have largely ignored one of the main problems of the input and output of data — the wiring between the computer and the peripheral. If this is to be long, special line-driving buffers must be employed, though if the computer and equipment are in the same room, this is rarely necessary. Computers work so fast that electrical signals can travel only a few metres during one cycle of operation. If wires are long, it may be impossible for the computer and its peripherals to remain perfectly in step with one another. This is one of the reasons for employing I/O ports with asynchronous interchange of data, as described above.

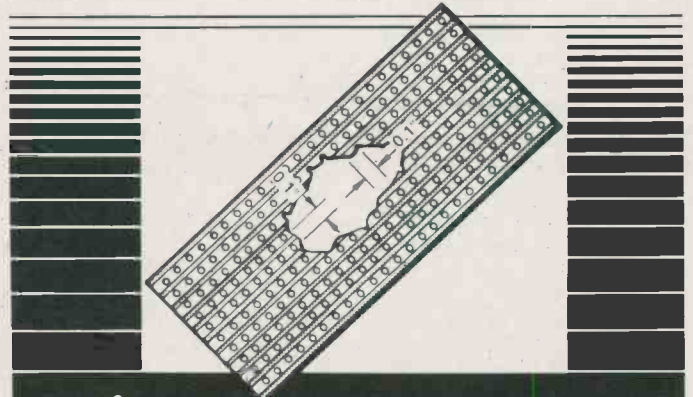
A more practical problem is the sheer number of conductors required. An eight-bit connection (the minimum commonly used) requires eight lines, plus a ground line and probably several control lines as well. There is a wide variety of multi-way connectors available for joining cables to computers and peripherals. Most are designed for use with ribbon cable.

Electromagnetic interference between adjacent conductors is a serious problem, especially with long runs of cable, and can lead to errors in the data being transferred. The data signals themselves are not so likely to interfere with each other, since they are all put on to the lines at the same instant, and there is a short period before they are read (again, all at the same time) during which switch-on and switch-off disturbances can settle. However, if the cable carries control signals, which are generally not turned on and off at the same time as data signals, these may interfere with the data carried in adjacent conductors. One solution is to ground alternate conductors, and use only those between them. A better solution is to use twisted pairs; one wire of a pair is used for the signal and the other wire is grounded. Special ribbon cable is made with twisted pairs with untwisted regions spaced along it, where it may be cut and linked to connectors using insulation-displacement.

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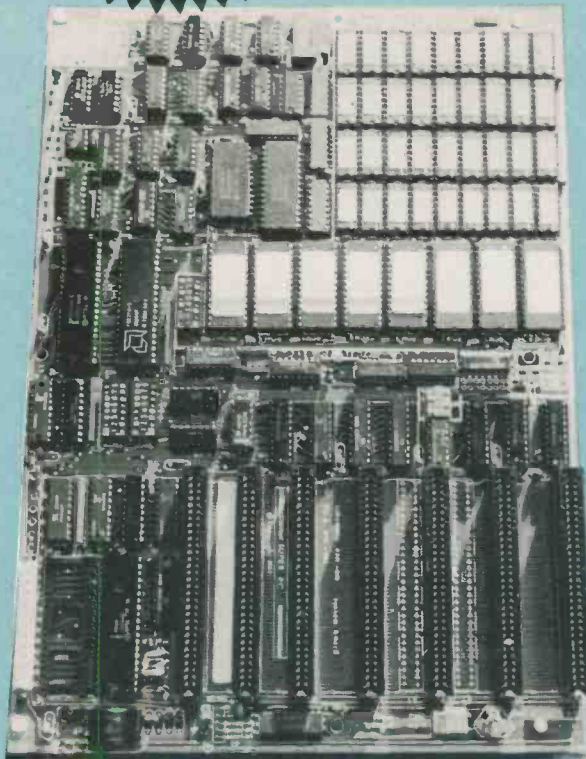
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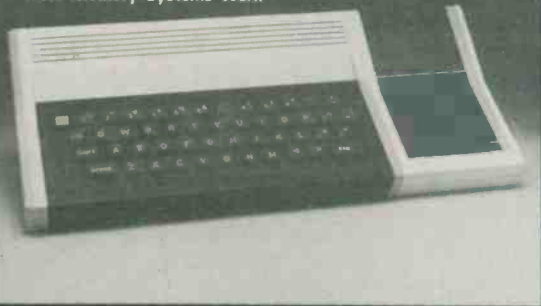
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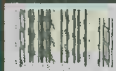
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Book Review

Megabucks From Your Microcomputer

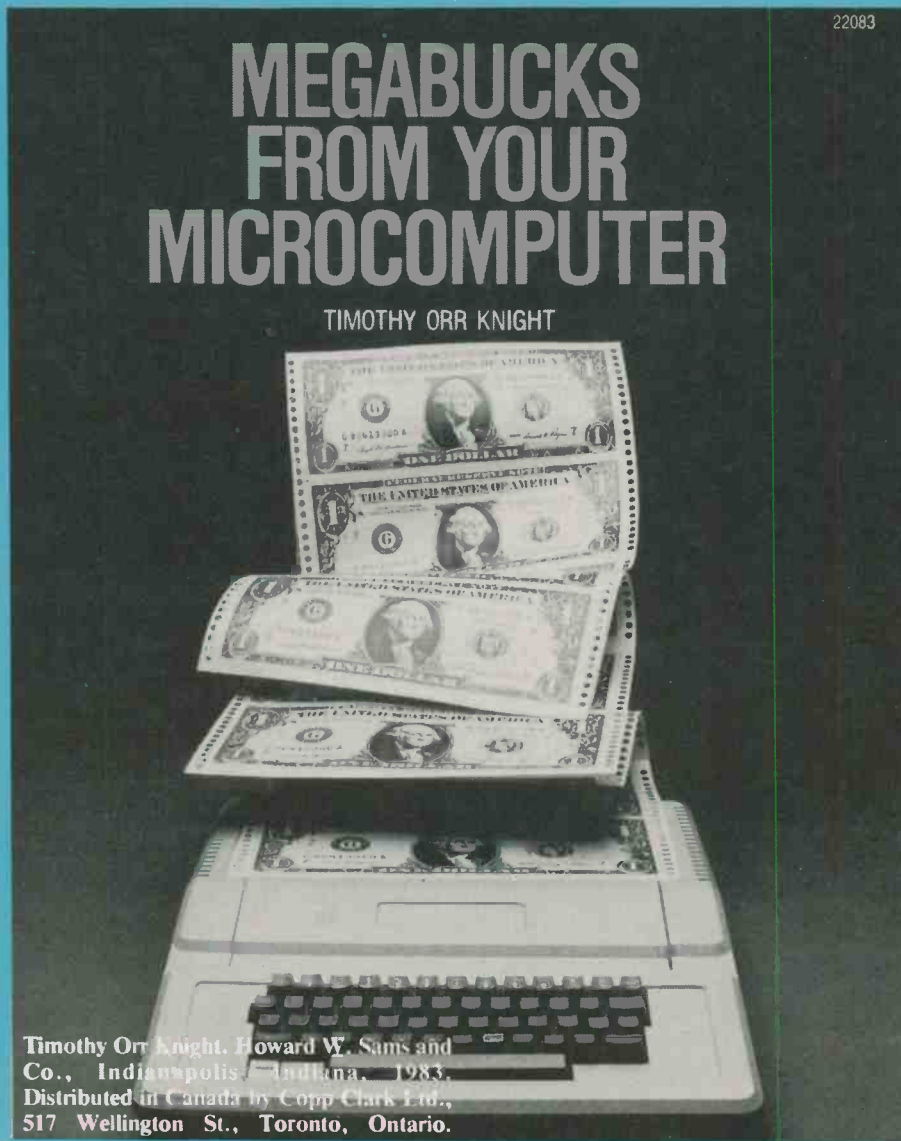
HAVE YOU ever wanted to make back all the money you spent on your computer? This new book, which reads like an Amway distributor's manual, describes a number of legitimate ways of doing so.

The author, a 17-year-old entrepreneur, tells how he started out by writing reviews for computer magazines at \$50 or so a shot. He gives advice for those thinking of doing the same, telling how to write good reviews (for example, never open a review with a question, like this one does), how to get products to review, which magazines are good to write for, and how to get them to print your end product.

He goes on to describe more lucrative fields of endeavor, like writing articles about computers, writing software (especially video games) and getting it published, writing books, opening one's own computer store, becoming a consultant or a computer tutor, marketing various computer-related products, and so on. He even includes a chapter on investing one's profits and managing them so as to pay the minimum amount of taxes possible to Uncle Sam (although similar tactics might be applicable with respect to the Great Canadian Beaver, or whatever our national mascot is).

The book itself runs to only 72 pages, and, by the author's own admission, took no more than twenty hours of solid work to write. What he is telling is essentially his own success story, which the reader is expected to emulate if he/she also wants to be successful. This does mean that the section on writing software reviews, for example, which is something that the author has done, receives better coverage than the section on opening your own store, which is something that he has apparently not done yet, and which he therefore can but theorize and offer helpful hints on.

Knight opens the book with the proposition that 'It is better to be rich and happy than poor and miserable'. He does not claim that making money with computers is for everyone, but does say that, if you really enjoy computers, seeking fame and fortune with them is a valid proposition. He says that it is important that you enjoy whatever line of work you are



in, and adds that if you are willing to work diligently, you will be sure to make a profit. What we have here is a fine example of an American capitalist.

The front cover, incidentally, features an illustration of a computer printing up a series of American dollar bills. Now, in the U.S., there is, or at least was, a law prohibiting the depiction of money in print (on the front covers of books, for example). One wonders if the

Feds are hot on Mr. Knight's tail yet. Besides, computers don't print things, printers do.

In conclusion, the book is of limited interest, being primarily for those who worship the dollar and want to make it big with computers, or for those who are interested in whiz kid success stories.

Anthony DeBoer

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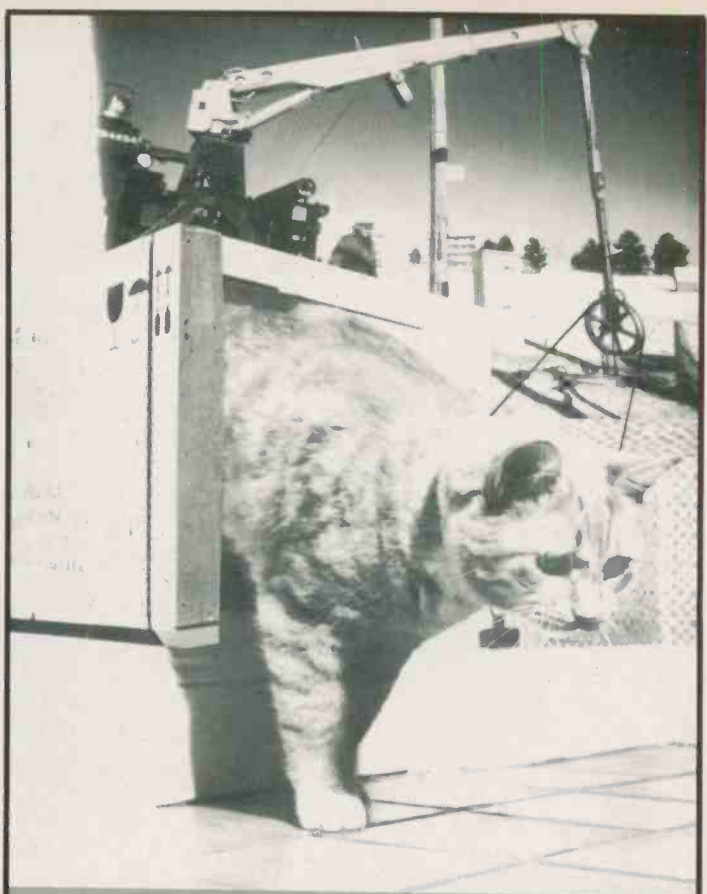
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magnets are mounted on a spinning disc and these magnets pass close to the face of the Hall effect IC. Each time a magnet passes the device, the circuit switches first to its low output voltage state, and then back to the high output voltage state as the magnet moves away from the device.

An alternative system is the 'vane switch' technique, in which soft iron vanes attached to the rotating metal disc pass between the magnet and the Hall device. Each time a vane passes through this gap, the magnetic flux no longer reaches the Hall device owing to the shielding effect of the iron in the vane, and the Hall circuit switches back to its high output voltage state.

Fig. 10(a) shows a system for detec-

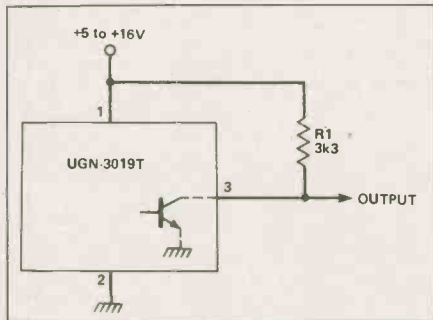


Fig. 8. A Hall effect switch using the UGN-3019T.

ting rotation which uses a radially-magnetized ring magnet. Suitable inexpensive ring magnets for use with either type of system are readily available. Up to eight pulses per revolution per 10 mm diameter of the magnet disc are possible, so 80 pulses per revolution can be obtained from a 100 mm diameter disc. These two arrangements have been designed for the UGN-3030T device; this is similar to the other devices discussed, except that switching to the low voltage state occurs at a typical flux density of 0.016 T (maximum 0.025 T) and returns to the high voltage state at 0.011 T (minimum -0.025 T). The power supply current required is only about half that needed for the UGN-3019T. It should be noted that to ensure

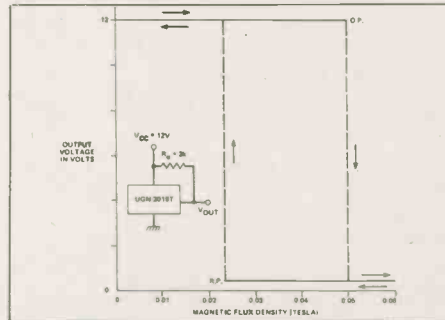


Fig. 9. Output voltage versus magnetic flux density for a UGN-3019T.

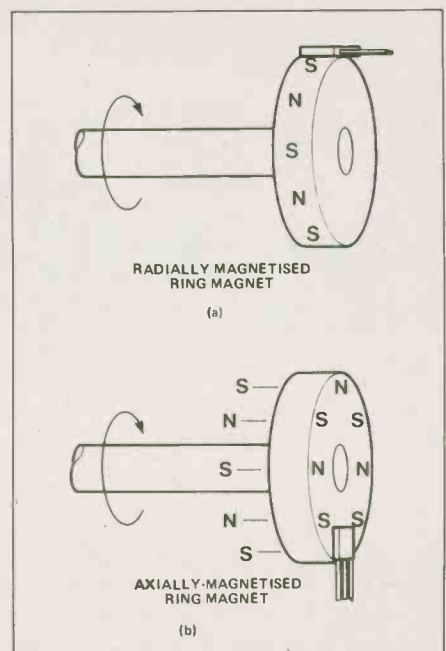


Fig. 10. Ring magnet revolution indicators.

switching of the UGN-3030T back to the high voltage state, a field of the opposite polarity is required of flux density -0.025 T; this is provided by the use of alternate polarity magnetic poles in the ring magnets of Figs. 10(a) and 10(b).

continued on page 67

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COMPUTING TODAY

More on Assembler

by **John Rudzinski**

BASIC PROGRAMMERS, in all their splendour, tend to be a tad hesitant to learn assembly language. This is usually a condition brought on by the mistaken idea that one must first purchase the thickest book available on the subject, and then spend a lifetime and a half trying to decipher the pretty charts and anagrams. Programmers following that route usually end up mailing copies of the book to sworn enemies.

A simpler way of going about learning the language is to compare it to what you've already learned. If you've been programming BASIC on an Apple or a Commodore machine, you've been writing code that eventually trickles down to your computer's 6502 processor after going through an interpreter. By ensuring that the 6502 gets your instructions faster, you can expect a more rapid execution of your program.

Assembler	BASIC Equivalent
LDA #\$07	LET A = 7
STA \$0805	POKE 2053, A
LDA \$0805	A = PEEK (2053)
JSR \$FDF0	PRINT A

In this admittedly redundant example, a seven is POKED into 2053, which equates to \$0805 in hexadecimal, and the PRINTED. No large deal, this ... the middle two instructions are unnecessary in both the BASIC and assembly versions, and are there to illustrate that conversion between the two languages is possible.

Incidentally, the address of \$FDF0 is the printing routine in the Apple ... change it to \$FFD2 for the Commodore machines.

Cut! Print!

And now, for something completely diffident, printing on the screen. There are two ways of going about this: you can either direct each byte to be printed through the ROM's print routine, as above, or selectively introduce the bytes into screen RAM.

The first method is ponderous, and only worth the effort if you plan to print reams of ASCII on your screen. What you'd gain in speed would be greatly offset by the amount of work you'd have to put into something that could preferably be accomplished by simple PRINT statements in BASIC.

Screen RAM's an amusing thing ... it's one reason why the Commodore 64 ends up as a 37 after you take it out of the box and apply some voltage. The act of sorting character values directly into screen RAM locations of your choice saves scads of time, as you needn't bother channeling each byte to be output to the print subroutine.

The following program is a simple 'print-to-screen' listing for the VIC-20. VIC users aren't blessed with the integrated M/L monitor that comes with the Apple and PET computers, and must seek outside help. Jim Butterfield's public domain Super VICMON program makes for an excellent acquisition, and is available from the Toronto Pet Users Group. Others, though perhaps a little more costly, are available as well.

Machine Code	Opcodes	BASIC (Sort of)
1000:45 54 49 20 4D 41 47 41		
1008:5A 49 4E 45		
100C:A2 FF	LDX #\$FF	LET X = 255
100E:E8	INX	X = X + 1
100F:E0 0C	CPX #\$0C	IF X = 12
		THEN...
1011:F0 09	BEQ \$101C	...GOTO \$101C
1013:BD 00 10	LDA \$1000,X	A = PEEK (\$1000 + X)
1016:9D E1 1E	STA \$1EE1,X	POKE 9605 + X, A
1019:4C 0E 10	JMP \$100E	GOTO \$100E
101C:00	BRK	END

This might do with a bit of explanation. The twelve bytes from \$1000 hex to \$100B hex are the hexadecimal representations of the ASCII string, ETI MAGAZINE. These are placed into twelve screen RAM addresses starting at 9605 decimal, or \$1EE1 hex. When the twelfth byte is stored into the twelfth consecutive address, the program ends, and you're left with our name emblazoned in the middle of your screen. To see the fruits of your labor, type 100CG or G100C from within the monitor, or SYS 4108 from BASIC.

Admittedly, some of the BASIC similarities in the third column are illegal. If you tried to convince a VIC-20 that A = PEEK(\$1000 + X), it would cheerfully dispense you a ?SYNTAX ERROR in its special sixty point type. A syntactically acceptable conversion would go along these lines:

```
5 DIM A(12)
10 FOR X=0 TO 11
20 READ A(X)
30 POKE (9605 + X),A(X)
40 NEXT X
50 DATA 69,84,73,32,77,65,71,65,90,73,78,69
60 RESTORE
```

Note in the M/L program above that you may get unusual graphics characters in the stead of our proud emblem. A quick tap of the shift and Commodore keys together should end your disappointment.

Little Black Book

Screen addresses vary between machines, of course. The VIC's screen RAM begins at \$1E00, the 64's addressing starts at \$0400, as does the Apple's. While the Commodore 64's screen addresses are consecutive, however, the Apple's screen takes a little getting used to, as each numerically consecutive row has seven rows between them. If you plan to utilize your screen through either assembly or machine language, it might be wise to have a screen map drawn out for reference.

To that end, then, below are listings of the same program for the Commodore 64 and the Apple II.

Commodore 64

Machine Code	Opcodes
0800:45 54 49 20 4D 41 47 41	
0808:5A 49 4E 45	
080C:A2 FF	LDX #\$FF
080E:E8	INX
080F:E0 0C	CPX #\$0C
0811:F0 09	BEQ \$081C
0813:BD 00 08	LDA \$0800,X
0816:9D C7 05	STA \$05C7,X
0819:4C 0E 08	JMP \$080E
081C:00	BRK

To start this program, type either 080CG or G080C, whichever syntax your monitor program requires. SYS 2060 will do it from BASIC.

Apple II

Machine Code	Opcodes
0800:C5 D4 C9 A0 CD C1 C7 C1	
0808:DA C9 CE C5	
080C:A2 FF	LDX #\$FF
080E:E8	INX
080F:E0 0C	CPX #\$0C
0811:F0 09	BEQ \$081C
0813:BD 00 08	LDA \$0800,X
0816:9D BC 05	STA \$05BC,X
0819:4C 0E 08	JMP \$080E
081C:00	BRK

Apple owners have it easy. A simple CALL-151 from BASIC gets them into the monitor. Apple's ASCII differs from Commodore's, so the numbers from \$0800 to \$080B have been changed.

Register Here

The 6502 microprocessor has three registers; A, X, and Y. Essentially, this equates to three variables. The A register, or Accumulator, is most often used for mathematical purposes and as a 'messenger' to subroutines within the ROM. The X and Y registers are used as the major workhorses in a program.

The next example is the all important four second time delay subroutine ... useful for, say, buzzing your speaker or cooking your poached egg just right. As this routine doesn't make any bizarre jumps to ROM, it will work on any 6502 machine, so you're only going to get it once. Moreover, as it doesn't use any JMP statements, you'll be able to relocate it anywhere in memory that's convenient for your application or your machine.

A Four Second Egg

0800:A9 00	LDA #\$00
0802:A0 00	LDY #\$00
0804:C0 FF	CPY #\$FF
0806:F0 0E	BEQ \$0816
0808:A2 00	LDX #\$00
080A:E8	INX
080B:E0 FF	CPX #\$FF
080D:F0 03	BEQ \$0812
080F:18	CLC
0810:90 FB	BCC \$080A
0812:C8	INY
0813:18	CLC
0814:90 EE	BCC \$0804
0816:69 01	ADC #\$01
0818:C9 0C	CMP #\$0C
081A:D0 E6	BNE \$0802
081C:00	BRK
081D:00	BRK

In this example, there are three major things happening. The X register is incremented at a dizzying rate. When X=255, the Y register is incremented by one. When Y=255, the Accumulator is incremented. When the Accumulator hits the magic number 0C (12 decimal) the program breathes its last.

VIC owners should change the addresses in the left column to suit their memory configurations.

Now, a four second delay may not be optimum. Perhaps three seconds would make or break your program. If this is the case, change the number that the Accumulator is compared to, presently resting at address \$0819. A lower number will shorten the delay, and a larger one will increase the amount of time that nothing appears to happen before you regain control of your computer.

If you'd rather use this as a subroutine rather than a stand alone program, change the byte currently at \$081C from #\$00 to #\$60, the RTS opcode.


And Now, The Punchline

Immediately following you will happen upon a short list of 6502 assembly/BASIC equates. They're not exact, and should be no means be taken literally, but they'll give you an idea of what all those cryptic opcodes mean.

It will take more than one article or one book for you to gain a working understanding of assembly language, and there are many good books presently available. A programmer's reference guide for your computer is a must, as it will introduce you to ROM subroutines that will make programming a much easier task. You'll have to learn hexadecimal notation, the art of knowing that 10 is also \$0A. Too, you'll have to learn by doing, as reading about bricklaying will not get any houses built without your direct involvement.

Try. Make mistakes. They're inevitable, just as they were when you learned BASIC ... but somehow, though, you made fewer as you progressed in your programming.

ADC	A = A + n with carry
BCC	IF carry = 0 THEN GOTO n
BCS	IF carry = 1 THEN GOTO n
BEQ	IF previous equation true, THEN GOTO n
BNE	IF previous equation false, THEN GOTO n
BRK	END
CLC	Carry = 0
CMP	IF A = n... (usually followed by a branch or jump)
CPX	IF X = n... (usually followed by a branch or jump)
CPY	IF Y = n... (usually followed by a branch or jump)
DEX	X = X - 1
DEY	Y = Y - 1
INX	X = X + 1
INY	Y = Y + 1
JMP	GOTO n
JSR	GOSUB n (n must end in RTS)
LDA	A = n
LDX	X = n
LDY	Y = n
RTS	RETURN (from JSR)
SBC	A = A - n
SEC	Carry = 1
STA	POKE n, A
STX	POKE n, X
STY	POKE n, Y
TAX	A = X
TAY	A = Y
TXA	X = A
TYA	Y = A

Admittedly, this is an incomplete list, though it should suffice for the novice. Using this table as a guide, see if you can follow the time delay program. There'll be a test on Friday. 

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Owen Bishop

No. 4: Very high impedance voltmeter

ONE PROPERTY of operational amplifiers that is of special importance, in this application, is that their input terminals have very high impedance; for example, the input impedance of the 741 is 2MO. But the CA3140 op-amp chosen for this circuit is a CMOS IC with the almost infinitely high impedance of 1 teraohm (10^{12} ohms). The effect of this is that if one input is connected to a point in a circuit which has potential, say, of 5V, the amplifier behaves as a 1TO resistor between that point and ground. The current flowing away from that point is only 0.00000000005A (or 5 picoamps), which is good since, when measuring voltages, our aim is to draw as little current as possible from the circuit; a cheap testmeter with a 2kO/V coil, working on the 10V range, would draw 250uA under the same circumstances.

If this was a circuit with high resistances and small currents, taking as much as 250uA from it might cause much disturbance. The potential at that point would fall and the voltmeter reading would be seriously in error — perhaps showing only half of the correct value. In addition, the operation of the circuit might be totally upset, and the reading could be completely meaningless. Even a more expensive meter with a 20kO/V coil would draw 25uA. This is still relatively large and the readings would still be in error. The high-impedance input of the operational amplifier, therefore, is a great asset in voltage measurement, especially in circuits in which impedances are high and currents are small.

Feedback

The circuit diagram shows that the output of the op-amp is connected directly to the inverting input. If the non-inverting input (the input to the circuit as a whole) is at zero volts, and if the output is at zero volts, the

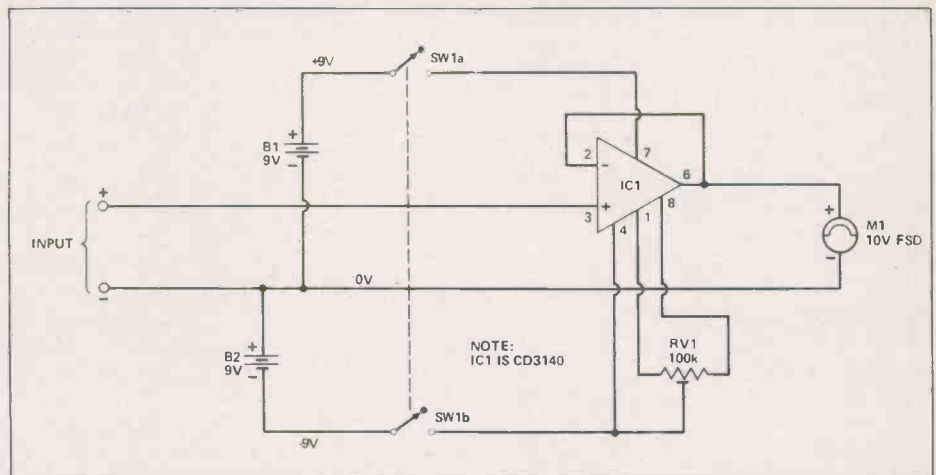


Figure 1 (above). We did say the circuit was simple!

inverting input is also at zero volts. There is no difference between the inputs, so output stays at zero volts. Then if, for example, the input to the circuit is raised to +2V, the non-inverting input is temporarily higher than the inverting input so the amplifier output swings positive until it reaches +2V. This output voltage is fed back to the inverting input so we now find that both inputs are at 2V, and no further swing occurs.

The effect of feedback is to force the voltage at the inverting input to follow the voltage at the non-inverting input exactly. Since the voltage at input and output are equal, we call this circuit a "unity-gain voltage follower". The crucial point is that

PARTS LIST

Potentiometers	
RV1	100k min. horiz. preset
Semiconductor	
IC1	CA3140 CMOS op-amp
Miscellaneous	
M1	10V FSD meter
SW1	DPST switch toggle or slide
Stripboard, 63 x 25 mm (24 holes x 10 strips); 2 x 9V battery clips; 4 x 4 mm sockets; terminal pins, wire, solder etc.	

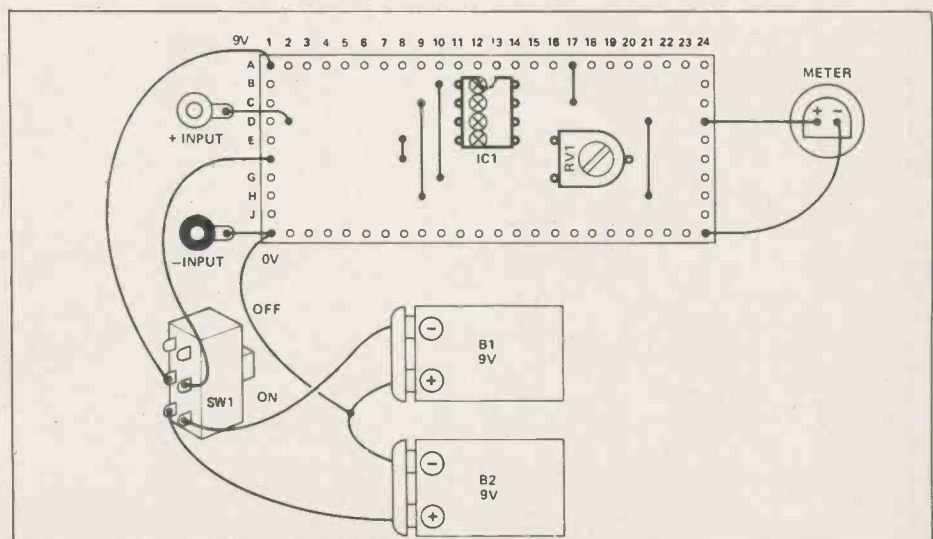


Figure 2 (left). The layout should not cause any difficulties, either. Note that the track-cuts are shown viewed from the component side.

the input terminal has high impedance; it can be connected to an external circuit without unduly upsetting the voltage levels of that circuit. On the other hand, the output of the op-amp has low impedance (about 100R) so it can sink or source a relatively large current without its output voltage level being affected. When connected to a cheap testmeter, it provides all the current required to drive the meter coil. A really reliable voltage reading is obtained in this way.

Using The Circuit

Switch on the power, then select the voltage range required. Join the input terminals together; both inputs of the IC are now at zero volts and RV1 should be adjusted to bring the output to zero. Now the circuit can be used just as you would use a multimeter. Although voltages down to a few millivolts may be measured, remember that, with a $\pm 9V$ supply, voltages greater than about $\pm 8V$ saturate the circuit, so that the maximum voltage that can be measured is about $\pm 8V$. If you want to measure higher voltages, increase the power supply to $\pm 18V$, and input voltages up to $\pm 13V$ may be measured. This circuit can also be built around the 741 op-amp with a 10k preset for RV1. The input impedance of the 741 is much lower (about 2MO) though still considerably better than that of a low-cost meter used alone.

No. 5: Peak Voltage Detector

Sometimes we want to be able to measure a voltage that is rapidly changing, but it may be changing so fast that we cannot take the reading quickly enough, or the needle may not follow the changes. Again, a brief surge of voltage may be over before the needle has had time to respond! The Follow-and-Hold circuit described in the January 1984 issue could be helpful here, but if you want to measure the *highest* voltage reached, you will need to act quickly to press the button at just the right moment! In these circumstances a Peak Voltage Detector can be of great help. As its name implies, it detects the maximum (or peak) voltage fed to its input during a period of time, and shows this value on the meter as a steady reading. The circuit is shown in Figure 3.

Essentially it consists of the unity-gain voltage follower described in No. 4, with the addition of a diode (D1) and capacitor (C1). This circuit uses a 531 op-amp which has a very high 'slew rate'; this is the maximum rate at which output can change. For the 531, the slew rate is

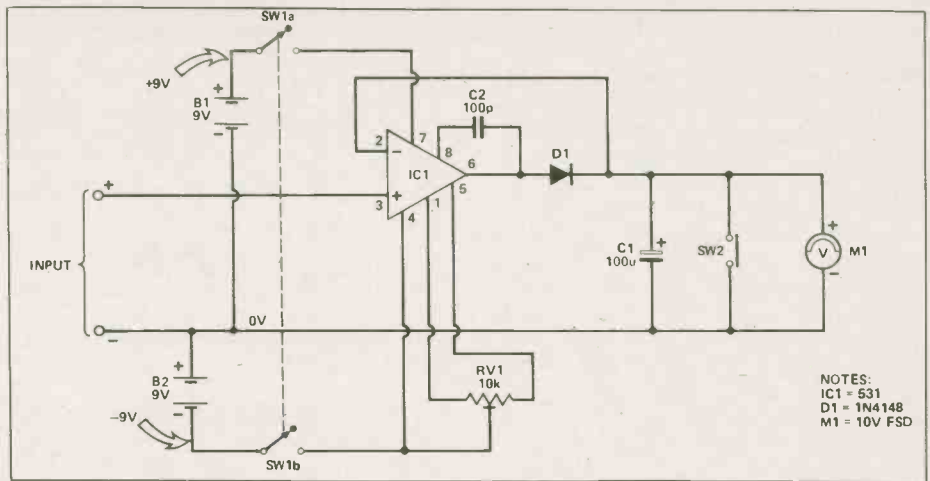


Figure 3. Another simple circuit; Peak Voltage Detector.

12V/us compared with 1V/us for the 741 op-amp. When a rising voltage is applied to the non-inverting input (pin 3) the output at pin 6 rises rapidly. It continues rising so as to bring the voltage at the inverting input (pin 2) to the same value as that at the non-inverting input. The feedback to the inverting input is by way of the diode D1, so the voltage actually fed to the inverting input is approximately 0V6 lower than output voltage at pin 6.

These positive swing of the output continues until the output is 0V6 less than the voltage across the meter, and at pin 2, is exactly equal to the input voltage. Now, as the input voltage continues to rise, the output rises correspondingly and the capacitor becomes charged to that voltage, but the voltage is indicated on the meter only if the rate of rise is slow enough for the needle to follow it.

If the input voltage now falls, the output from pin 6 also falls, but because of the diode this can have no effect on the

PARTS LIST

Potentiometers	
RV1	10k min. horizontal preset
Capacitors	
C1	100u 10V electrolytic
C2	100p polystyrene
Semiconductors	
IC1	.531 op-amp
D1	1N4148
Miscellaneous	
M1	10V FSD
SW1	DPST toggle or slide
SW2	SPST push-to-make
Stripboard, 63 x 25 mm (24 holes x 10 strips); 2 x 9V batteries and clips; 4 x 4 mm sockets; terminal pins; wire; solder; etc.	

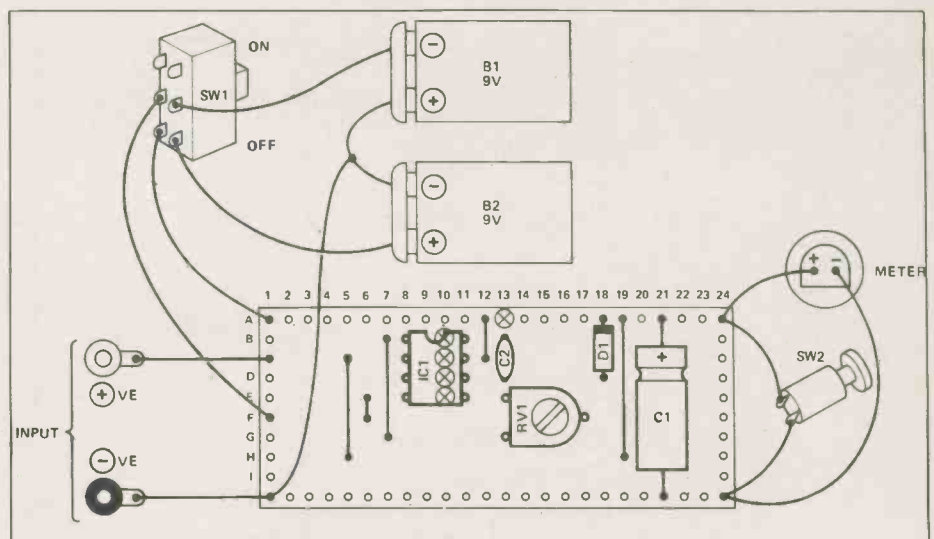


Figure 4. The component layout, viewed from the top; track cuts are marked by a circled "X".

More Pop Amps

voltage across the meter. The capacitor retains its charge more-or-less without loss for a period of several tens of seconds and, during this time, the meter needle has a chance to catch up with voltage changes, displaying the peak voltage that was reached. If the input voltage then increases and exceeds the previous maximum, the needle will show the increased peak reading.

Following a peak input, the charge slowly leaks away from the capacitor and the meter reading slowly falls. The rate at which this happens depends mainly on the current taken by the meter itself. If the meter has a 20kΩ/V coil and is on its 10V range, and if the peak voltage reading is +5V, the leakage current through the meter is 25μA. To this must be added a leakage of about 8μA through the capacitor, if it is an aluminium electrolytic type. Reverse leakage through the diode is less than 0.01μA and so can be ignored; a further 0.25μA leaks away to the inverting input. At this rate of leakage, a reading of +5V will have dropped by approximately 0V33 at 1 second after the peak. This sounds rather rapid, but it is quite easy to see the value to which the meter needle rises before it begins to fall, and a usefully accurate reading can be obtained — after all, the pulse that initiated the reading

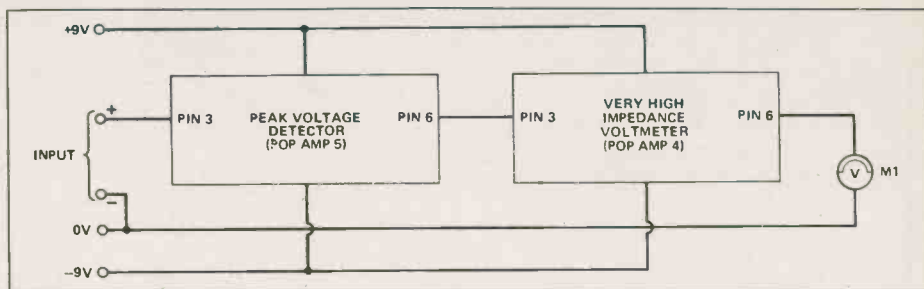


Figure 5. Better performance is obtained by using the Peak Voltage Detector together with the High Impedance Voltmeter.

may have lasted for only a few milliseconds. However, ways of reducing leakage will be discussed later.

Resetting

The rate of fall of the needle becomes reduced with time, and may take several tens of seconds to return to zero. It is convenient, therefore, to fit a Reset button, SW2. When this is pressed the capacitor is immediately discharged and the meter reading returns to zero. Capacitor C2 is the frequency-compensating capacitor, needed with this op-amp to maintain constant gain over a wide range of frequencies.

Using The Circuit

Switch on the power and select the voltage range required on the meter. Join the input terminals together; the output should read 0V — if not, adjust RV1. Now the input terminals should be connected to the appropriate points of the circuit to be monitored. The meter indicates the maximum voltage attained during the period of monitoring. To begin a new period, press the Reset button briefly.

Reducing Leakage

Although the circuit is perfectly adequate for most purposes there may be occasions when you want to have plenty of time in which to carefully read the peak value. As the discussion above showed, the greatest leakage is through the meter coil. The obvious way to eliminate this is to replace the meter with the complete Very-High-Impedance Voltmeter circuit described in Pop Amps No. 4. At a 5V peak, the leakage to this circuit will be only 5μA, assuming you are using a CA3140 operational amplifier in the very-high-impedance circuit. With 531 as peak voltage detector followed by a CA3140 as high-impedance voltmeter, the rate of fall from a 5V peak is only 0.08V/s, giving you plenty of time in which to take your reading. The only serious leakage is through the capacitor, especially if it is old. If you find that the rate of fall is still too great, try replacing the capacitor with a new one or, better still, replace it with a tantalum bead capacitor (100μF, 10V). When using two amplifier ICs they can share the +9V and -9V power supply; the complete inter-board wiring is shown in Figure 5.

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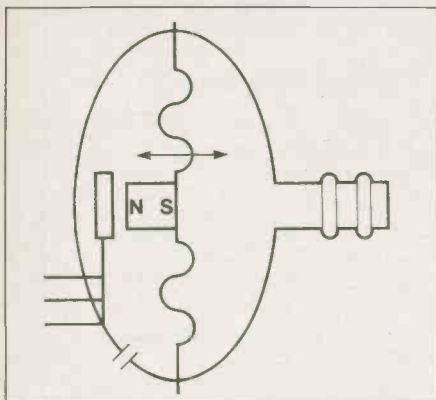


Fig. 11. A Hall effect pressure switch.

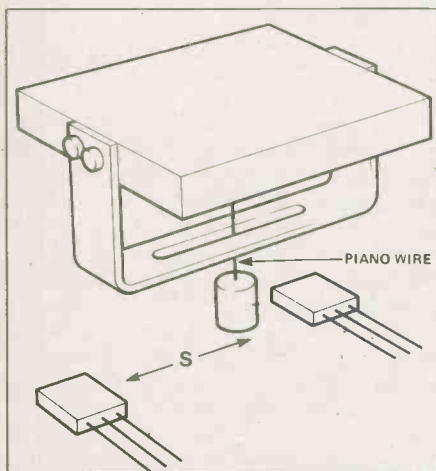


Fig. 12. An acceleration sensing system.

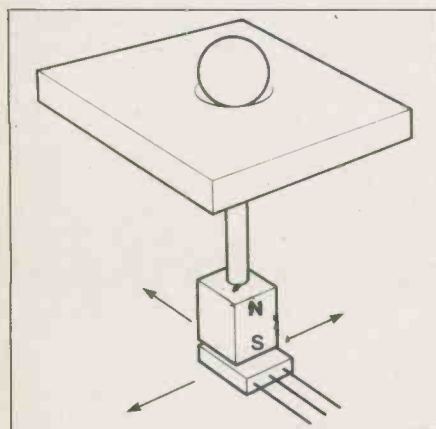


Fig. 13. A Hall effect tilt sensor.

Rotational systems, as described above, have a very wide range of use in engines and machinery. One that many readers will have first-hand experience of, is in car ignition circuits, where the contact breakers are replaced. This leads to the ignition timing being a once-and-for-all setting, as there is no wear, and this can only help improve fuel economy and lower exhaust pollution.

The same sort of sensor head can be used for measuring rotational speeds and counting the number of revolutions. In this case, possibly the best course to take with the electronics is to have a pulse-generating circuit after the Hall effect device, so that the pulses can either be counted or fed to an analogue meter (to get a rate of revolution indication).

When fitted to a vehicle wheel, such a system could have a further important use, namely in an anti-skid braking system. In this, the electronics would detect when the wheel was not turning while the car was still moving. The system would then momentarily reduce the brake force to the wheel so that it would turn again and control would be restored, after which full braking force would be restored. This has the effect of pumping the brakes — but be warned, it's not easy to construct such a system, and we strongly recommend not trying!

Hall effect devices can be used to detect linear motion; Fig. 11 shows a simple pressure switch. Coupled with a push-button, this sort of arrangement is common in keyboard switches. A similar application is as an acceleration detector, and Fig. 13 shows how this can be done. In this, acceleration forward or backward, causes the magnet to move nearer to one of the two Hall devices. Conversely, the tilt sensor in Fig. 13 works by detecting when the magnet moves away from directly above the Hall device.

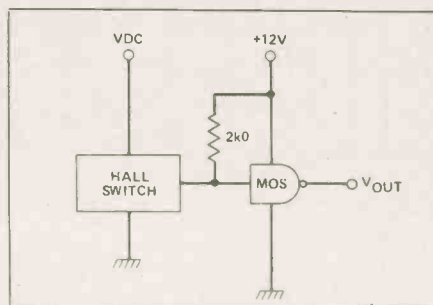


Fig. 14. Driving CMOS from a Hall effect device.

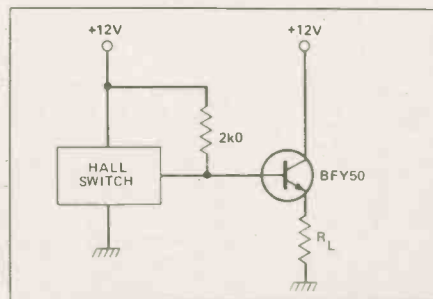


Fig. 15. A current amplifier for the Hall device.

diode is connected across the coil to prevent the back-EMF from destroying the Hall device (the diode cathode should go to the positive terminal of the relay coil).

If a Hall device, such as the UGN-3030T, is required to control a triac such

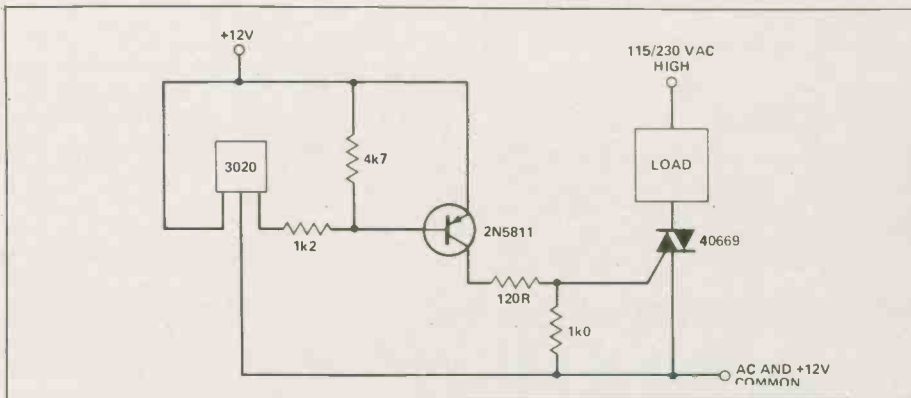


Fig. 16. AC power control using a Hall effect device.

As transducers go, Hall effect devices can give a relatively large switching capability, being capable of sinking ample current to interface directly with TTL. Fig. 14 shows a suitable circuit for interfacing to CMOS devices.

Fig. 15 shows a handy buffer circuit that can be used to drive larger loads, such as a 12 V relay coil. In Fig. 14, when the magnetic field is strong enough, the output from the Hall device will be low and the transistor will be off. Hall devices can drive reed relays directly, provided that they do not pass too much current, and provided that a transient suppressing

as the RCA 40669, which can handle up to 8 A RMS, a transistor amplifier stage is required between the Hall device and the triac as shown in Fig. 16. When the Hall device conducts, a current of 9 mA flows from the base of the PNP 2N5811 transistor, which in turn supplies 80 mA to the triac gate to turn on the load current. It should be noted that the Hall device is connected to one side of the power supply; this could be avoided by the use of an opto-coupling device between the Hall IC and the triac circuit.

ETI

TECH TIPS

DE-LUXE AB BOX

by Marcus Valentine

This Audio line signal routing device was designed for one of those guitarists who feel insecure unless they are surrounded by numerous effects boxes, but who wish to have more control over them collectively. It has two modes: single and dual.

In the single mode, depression of the footswitch noiselessly re-routes the signal path from going through chain A, to chain B, a chain being either a straight jack to jack lead, an effect, or a series of effects.

In the dual mode, the signal is re-routed through chain A followed by chain B, and on depression of the footswitch (here's the clever bit) is re-routed to chain B followed by chain A.

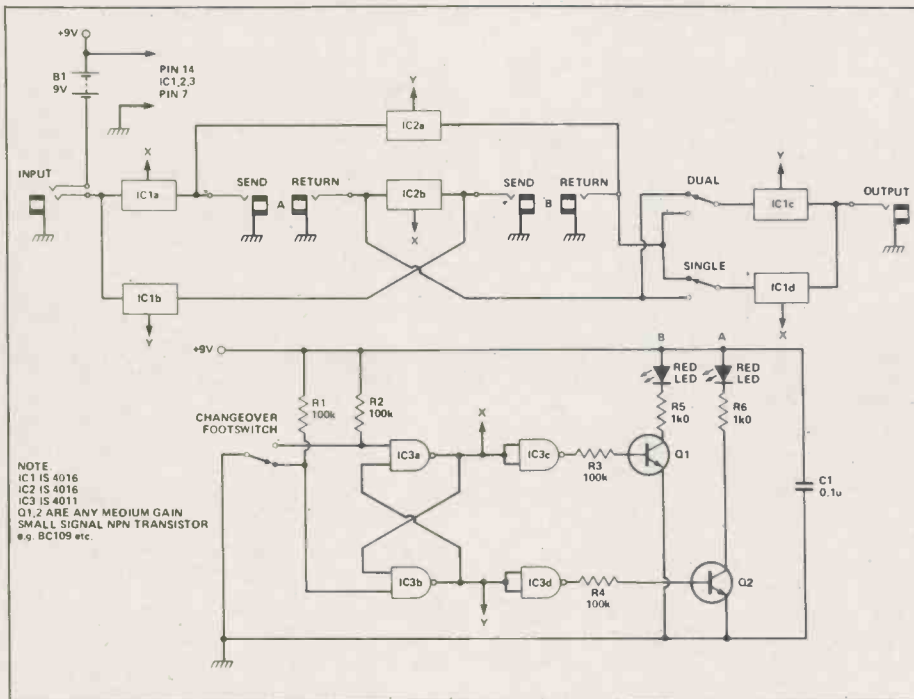
The two LEDs indicate the chain selected in the single mode, and in the dual mode the first chain.

The flip-flop built around N1 and N2 ensures that the bilateral switches used change state cleanly and quickly, and, more importantly, at the same time.

Current consumption, which is set mainly by the LEDs, is low enough to allow a 9V battery to be used as power. The LEDs were considered essential for ease of use.

The device can be conveniently constructed in an aluminum box measuring 10x10x4 cm, with the input socket arranged so that the input plug connects the negative supply.

By using various combinations of sockets, the device can be utilized in many more audio signal rerouting applications, eg. by using the A and B return sockets and output only, (with a dummy plug inserted into the input socket to provide power) the box can be used as a single selector.



CAR FAN CONTROL

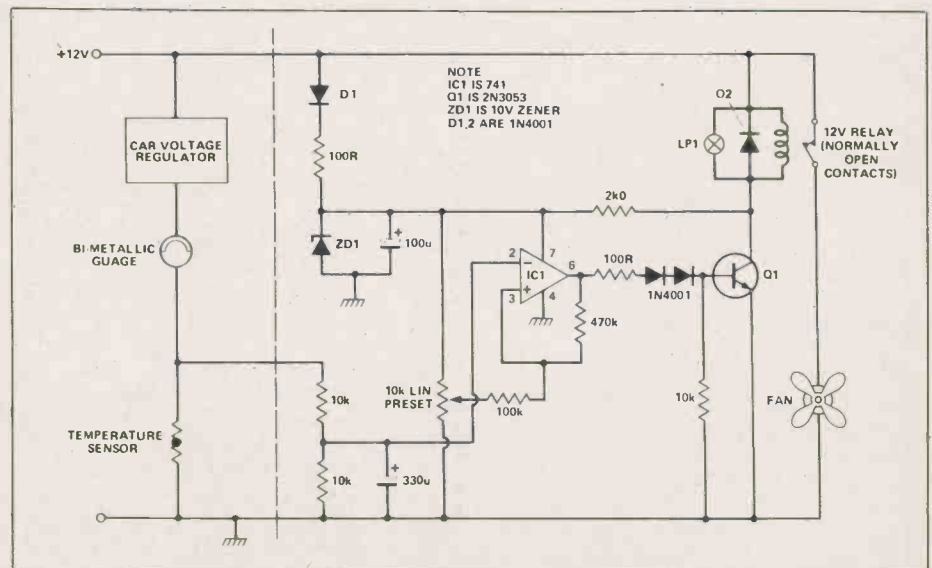
by J.N. Swanson

If, like me, you own an old car with a conventional fan, driven from the engine, a worthwhile improvement can be obtained by fitting an electric fan in its place. These can readily be bought from a scrap yard. The advantages gained are better fuel consumption and lower engine noise particularly at high revs.

A problem arises in finding a suitable switch to operate the fan at the required temperature. Most of the switches fitted to cars are fitted in a threaded hole in the side of the radiator, which means that most scrap yards are unwilling to separate the two. For this reason I have designed a circuit to switch on the fan using the existing temperature sensor for the temperature gauge.

The voltage regulator on the car usually works by interrupting the supply so as to provide an average level of about 10V. Because of this, a fair bit of smoothing is required in order to stop the fan switching on and off with the regulator. A zener diode provides a 10V supply for the op-amp and the reference voltage. The 470k and 100k resistors provide a certain amount of hysteresis and the two diodes prevent the transis-

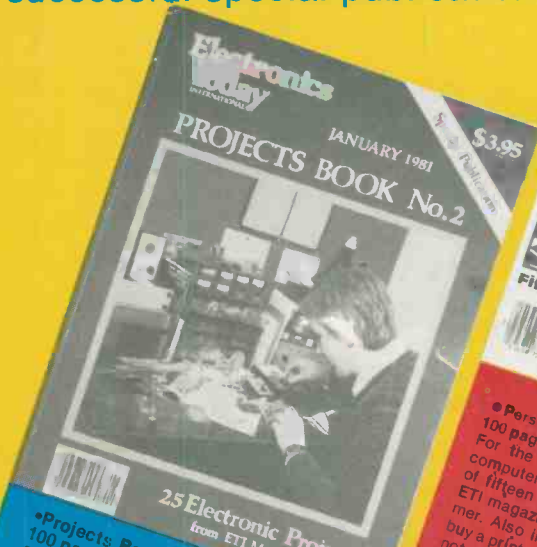
tor turning on due to offset of the op-amp. The fan may run for a few seconds when the ignition is initially turned on. This may be prevented by increasing the 100uF capacitor to a few thousand uF, but I find this useful as otherwise in winter the fan may not run for weeks on end.



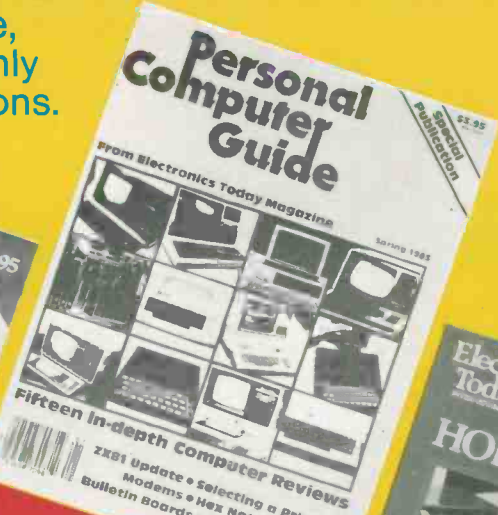
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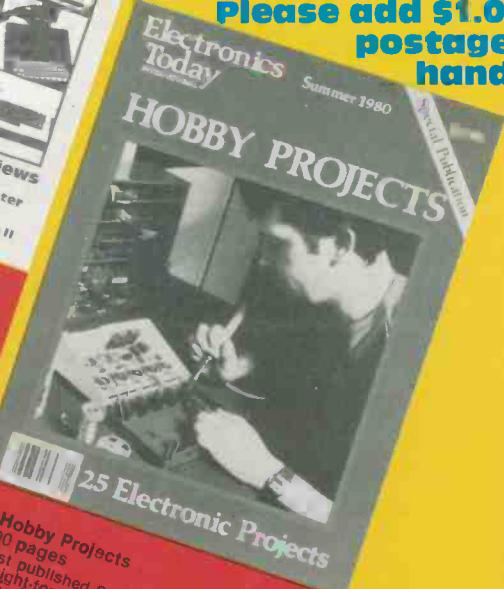
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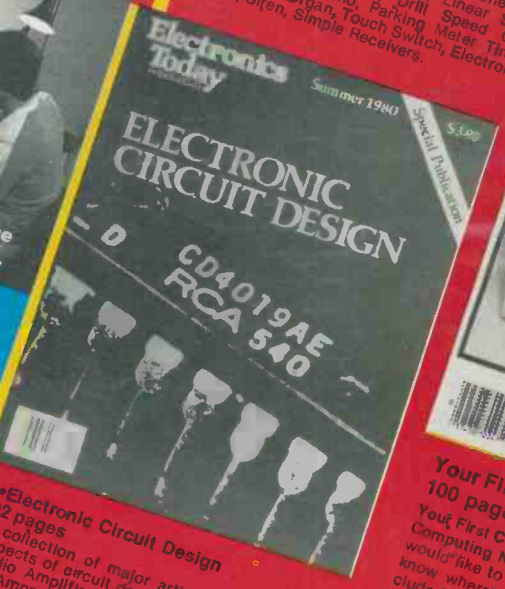
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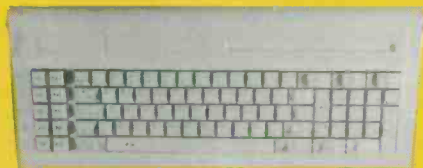
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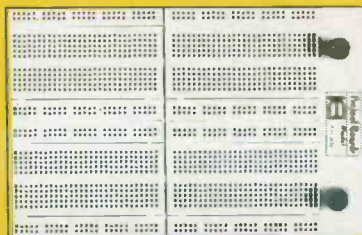
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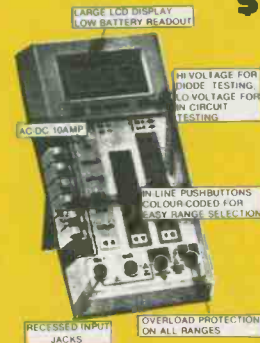
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