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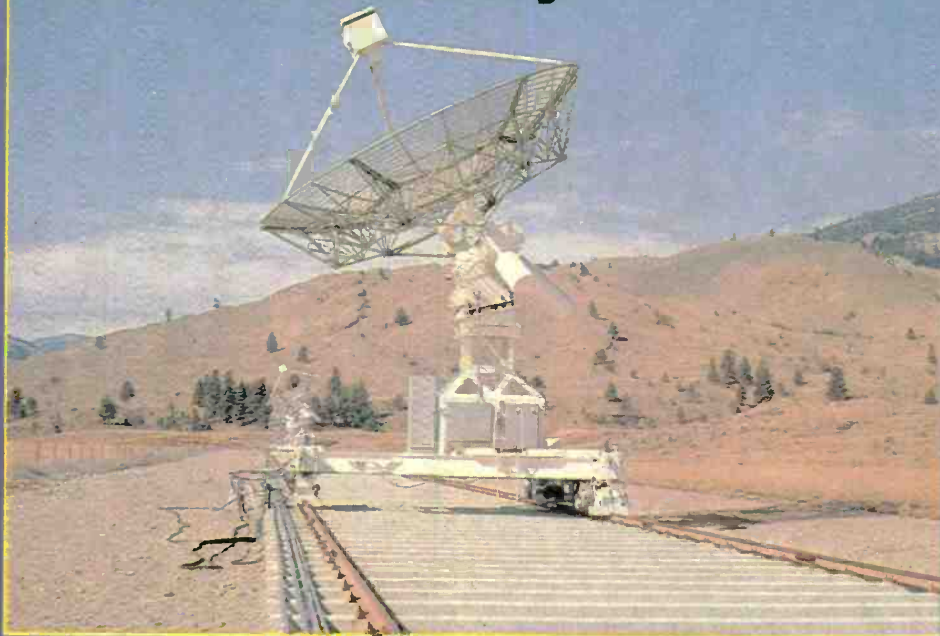

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A Look at the Multiflex Super Package

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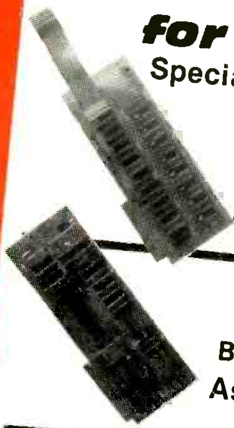

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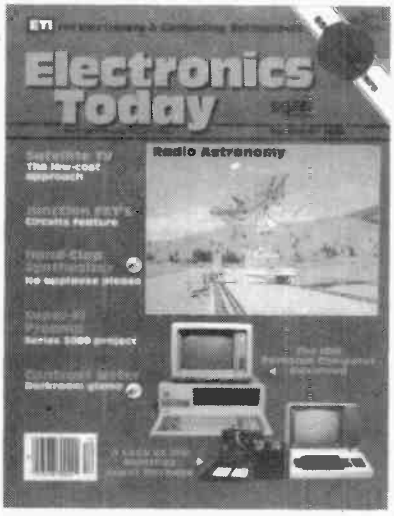
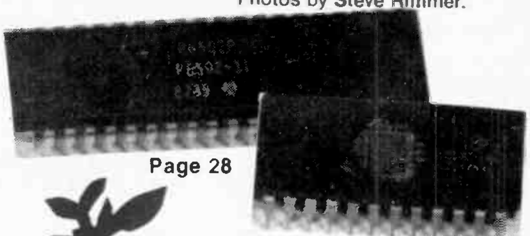
Features

Projects



Our Cover: Radio astronomy lets researchers "see" far beyond where optical telescopes leave off, possibly to the limits of creation. See for yourself on page 10. Photo courtesy NRC. Also, two very different computers are reviewed, the IBM PC on page 35 and the Multiflex on page 40. Photos by Steve Rimmer.



Page 28

Page 30

Columns, News and Information

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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 socner 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.

K.S.K Associates, P.O. Box 54, Morriston, Ont. N0B 2C0.
BR Electronics, P.O. Box 6326F, Hamilton, Ont., L9C 6L9.
Wentworth Electronics, R.R.No.1, Waterdown,Ont., L0R 2H0.
Danocinths Inc., P.O. Box 261, Westland MI 48185, USA.
Arkon Electronics Ltd., 409 Queen Street W., Toronto, Ont., M5V 2A5.
Beyer & Martin Electronic Ltd., 2 Jodi Ave., Unit C, Downsview, Ontario M3N 1H1.
Spectrum Electronics, Box 4166, Stn 'D', Hamilton, Ontario L8V 4L5.
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News

Hard-Disk Controller

Compatible with most 8- and 16-bit microprocessor buses, the WD1010 Winchester-disk drive controlled chip handles data rates of up to 5 MHz. Developed by Western Digital to interface with hard-disk drives from Seagate Technology, Shugart Associates, Tandon, and Texas Instruments, the controller offers a software-selected sector size of 128 to 1024 bytes (programmable in factors of two) and on-chip cyclic redundancy check generation and verification.

Requiring just a 5 V power supply, the 40-pin controller is software-compatible with the company's WD1000 board-level controller. Designed to operate with an external sector buffer, the WD1010 uses either the WD1510 first-in, first-out 128-by-9-bit memory or 256-by-8-bit static RAMs combined with a 9-bit resettable counter. All control signals are generated by the chip.

Currently four circuits are being developed that will support the WD1010. Housed in a 16-pin package, the WD1011 data separator is fabricated in CMOS and designed to mate directly with the CMOS WD1012 write-precompensation circuit which comes in a 14-pin package.
Operating from a 5-V supply, the controller consumes about 180 mA and can operate over 0 to 70 C.

For more information, contact Weber Div. Of DGW Electronics Corp. 105 Brisbane Road, Downsview, Ontario M3J 2K6 (416) 663-5670

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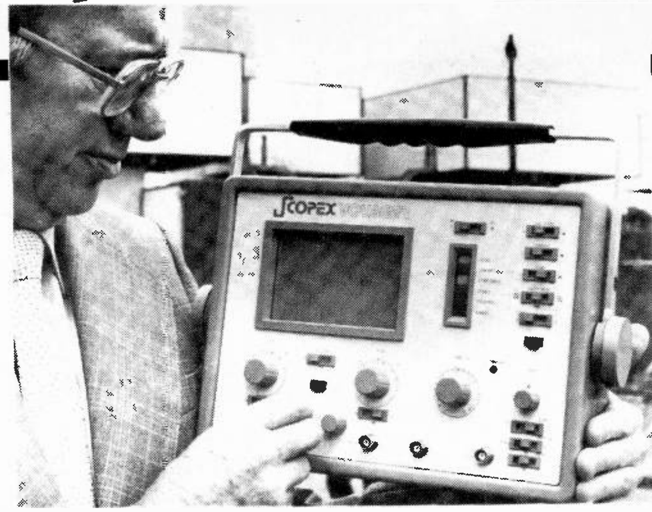
EDITORIAL QUERIES
Written queries can only be answered when accompanied by a self-addressed, stamped envelope. These must relate to recent articles and not involve the staff in any research. Mark such letters ETI-Query. We cannot answer telephone queries.

Flat Screen 'Scope

A portable battery-operated digital storage oscilloscope, which is the first to use a flat screen instead of the usual cathody ray tube (CRT), has a versatility and freedom of application never before achieved by its conventional counterparts, the makers claim. Based on a drive system for liquid crystal displays (LDCs) developed at Britain's Royal Signals and Radar Establishment requiring only 15 volts, it can be used in environments where the high voltage of a CRT is unsuitable.

As small and light as a digital voltmeter, 13" x 10" x 4" deep and weighing just 5½ lb, the low-frequency (150 kHz) dual-trace instrument, known as the Voyager, represents the first major change in the design of oscilloscopes since they were invented in 1931, say the manufacturers. Its advanced dye phase change LCD produces waveforms that become more, not less, visible as ambient light becomes brighter and, although battery operated, it has a 4" x 2" screen accommodating 256 horizontal and 128 vertical elements.



Powered by rechargeable nickel cadmium batteries which will operate continuously for at least five hours, the Voyager is supplied complete with a battery charger and high-impedance probes.

For more information, contact Scopex Instruments Limited, Pixmore House, Pixmore Avenue, Letchworth, Herts SG6 1HZ England

Digital Colour Recorders

Imapro Inc., has announced the first two members of its modular QCR-D family of quick colour film recorders. Designed and manufactured in Canada, the QCR-D's are computer peripherals that produce photographic images from digital data files transmitted from a host computer.

The QCR-D35 produces 35-mm slides or negatives of exceptional quality. With a 3 to 2 aspect ratio, resolution is

Continued on page 9

Circle No. 3 on Reader Service Card.

Continued from page 6

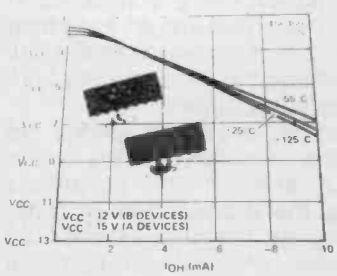
2048 pixels horizontal, by 1366 lines in the vertical dimension. It accepts standard 36 frame, 35-mm cassettes and is simple to load or unload. The shutter is under the control of the internal microprocessor and film advance is automatic upon completion of an image. Images may be exposed through the QCR-D35 at a rate in excess of 15 frames/hour. The unit produces presentation quality output, suitable for large format projection to audio-visual style audiences. The QCR-D120 produces 4" x 5" sheet film of either a standard or instant variety. With a 4 to 3 aspect ratio, resolution is 2048 pixels horizontal, by 1536 lines in the vertical dimension. Image write time is approximately 4 minutes. The theoretical range of both units is 16 million colours, or a 256 level grey scale in black and white. 4K by 4K resolution is planned as a future upgrade feature.

For further information, contact R.L. Appleton, vice-president of marketing, Imapro Inc. 215 Lakeshore Blvd. East, Toronto, Ontario M5A 3W9, telephone (416) 368-6358

LCD Driver

Teledyne Semiconductor has announced a four digit liquid crystal display decoder and driver integrated circuit, the TSC7211A. The low power CMOS TSC7211A incorporates four binary-to-seven segment decoders with latches, an RC oscillator with divider chain, a LCD backplane driver and 28 LCD segment drivers.

The TSC7211A accepts non-multiplexed BCD or binary input data. A four bit



input word is latched and decoded into the seven segment "code B" output format. A zero to nine and E, H, L, P and "-"(dash/minus) visual display is possible. An all ones input word blanks the display. Operating supply voltage is 3V to 6V with a 50uA maximum current drain. The 28 outputs have a zero d.c. drive component for long LCD life.

The non-multiplexed TSC7211A display architecture eliminates external counters and clock noise generated in multiplexed display drive circuits. The TSC7211A non-multiplexed display drive technique is ideal in precision low level analog measurement/display systems where excessive noise would impair system performance.

The TSC7211A easily interfaces to popular u-processor peripheral I/O devices such as the 8255 and 6520/6522. The latched outputs and non-multiplexed drive technique will eliminate much of the display software needed in multiplexed display designs.

For more information, contact David Gillooly, Product Marketing Manager, Teledyne Semiconductor, (415) 968 9241.

Also...

Clarkson College in Potsdam, New York will be the first university to provide desktop computers to all incoming students starting in the fall of next year.

Over 1000 computers will be issued each year and apart from individual use, they will all hook up to the school's mainframe IBM. The Zenith Z100 desktop computer is the model selected.

•

The Ontario Centre for Microelectronics — the first of six Ontario Technology Centres, has opened in Ottawa. It is being funded by the Board of Industrial Leadership and Development (BILD); the six centres receive altogether $120 million for a five-year technology development programme.

The other five centres include Robotics (in Peterborough) and Computer Aided Design and Computer Aided Manufacturing (CAD/CAM) in Cambridge.

•

Northern Telecom has introduced a programme to improve the quality of education in microelectronics technology and computer aided design tools. The company has allocated $80,000 for 1982 and $140,000 for 1983. It is intended to be a continuing programmme open to all Canadian Universities but available only to student design projects.

•

The new version of computer time-sharing — reported in ETI in July — has reached Canada. Two libraries in North York (part of Toronto) have installed computers in cooperation with Vendtronics Systems Ltd. Cost is $1 for 10 minutes and is paid into a machine beside the computer. The computers used are Apples. Software available is predictable: home finance, small business accounting and word processing. Vendtronics plan to increase the scheme if the pilot project shows promise.

The Oric I, a British microcomputer selling for about $350, is claimed to be the first 'bilingual' small computer. In addition to BASIC, the FORTH language is being supplied with each model. The Oric I is one of a number of small computers recently launched in Britain to compete with the Sinclair.

•

Quote from a letter from an 'old-timer' to ETI..."In my day a RAM was a male sheep, a CHIP was something eaten with fish and HERTZ was something sore".

•

Altair Electronics Enterprises Ltd. has opened a new store located at the corner of King and Perth Streets in Brockville, Ontario. This is in addition to their store in Kingston which opened less than a year ago.

•

Oops! We certainly touched a raw nerve with a silly mistake in the 'History of Early Radio' article in the October issue. Signal Hill is in St.John's, Newfoundland — not Cape Breton as many, many readers have told us. Signal Hill is a National Historic Monument. Sorry, St. John's.

•

Mitsubishi has succeeded in mass-producing 64K dynamic RAM chips with 100nS access time using a single 5V supply; current consumption per chip is 300mW. Delivery outside Japan is expected in January.

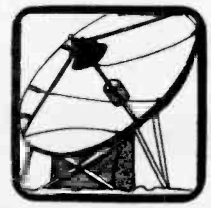
•

There are now (in October) 8.5% fewer people employed in the electrical and electronics industry in Canada than a year ago according to statistics published by EEMAC.

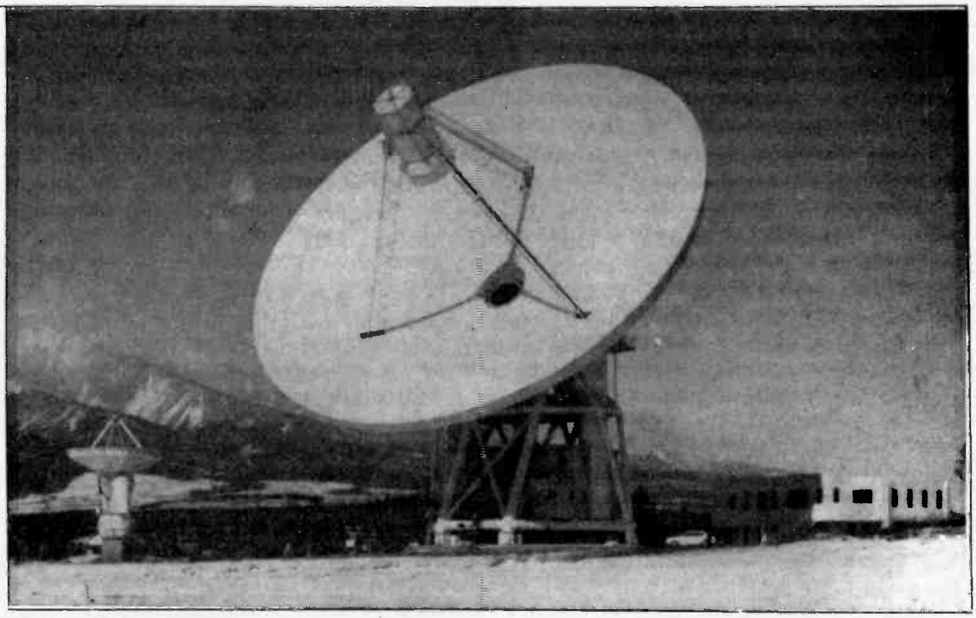
•

Microcomputer sales are growing at 38% a year and within five years the Japanese are expected to have 20% of the world market. These figures were announced by David Wooley of Peat Marwick, Toronto business consultants at a recent Canadian Information Processing Society (CHIPS) meeting.

Radio Astronomy Part 1



The use of radio telescopes really started after WWII but is now the dominant method of studying the cosmos. Roger Allan looks at the history and recent developments.



Radio telescopes have now largely taken over from optical types in the search for new information on the cosmos. The resolution now available using special techniques has improved enormously in recent years.

THERE ARE ESSENTIALLY four ways in which the physical heavens may be studied: optically, physically, by radio analysis, or by a combination of the first three.

Optical examinations and surveys suffer from the handicap of the earth's atmosphere — a constantly moving, optically confusing medium that interferes with light rays. What we can learn from ground based optics is limited, and while the amount of knowledge learned by such telescopes is tremendous, it is also finite — and the end of its usefulness as an instrument of examination is quietly creeping up on astronomers and astrophysicists. Combining an optical telescope with some sort of space platform, such as is to be launched by the shuttle, eliminates atmospheric interference, but there is a limit to the resolution of the telescope itself.

Physical visitation is obviously the ideal, but it is very expensive, prone to error and, while frequently awe inspiring in its data collection (such as the recent fly past of Saturn and the spectacle of its rings), it is limited to nearby planets.

The best of the lot, particularly for deep space studies, as to the composition of the cosmos, its age, and the big cosmological questions, such as how was the universe created, is by radio analysis — sometime called radio astronomy, and sometimes radio astrophysics.

Early Theories

The basis of radio astronomy is found in the work of Maxwell, who in the 1870's suggested that planets and the stars should not only emit waves of radiation in the form of light, but other forms of radiation both higher and lower on the spectrum. In the 1880's Hertz, having demonstrated the existence of radio waves, attempted to find radio wave emission from the sun. He failed. Simultaneously, Thomas Alva Edison was also attempting to detect radio waves from the sun. In 1894 the search for solar radio emission was continued by Sir Oliver Lodge, Professor of Physics at Liverpool University in England. Of his attempt, he wrote that, *"I hope to try for long wave radiation from the Sun, filtering out the ordinary well known waves by a blackboard, or other sufficiently opaque substance."* He, too, failed, later writing, *"There were evidently too many terrestrial sources of disturbance in a city like Liverpool to make the experiment feasible. I don't know that it might not possibly be successful in some isolated country place, but clearly the arrangement must be highly sensitive in order to succeed."*

The uncertainty of knowledge at the time concerning the ionosphere is demonstrated by the work of Nordman, a Frenchman, in 1900. He used an aerial 197m long and set his apparatus up on a glacier at an altitude of 3100m, *"to eliminate as much as possible the absorbing action of the atmosphere"*. He, too, failed, but we now know that high altitude was not essential, but that the very long wavelengths he was attempting to find would be absorbed by the ionosphere.

With 20/20 hindsight, a lull in appropriate research then became apparent. Apparently, researchers felt that there was just no way that the effect of the ionosphere on the transmission characteristics of radio waves could be punctured. However, radio research continued and expanded for commercial purposes until by the 1920's there was a great deal of experimentation being conducted at several universities and at a number of private companies such as the Bell Telephone Laboratories and the Marconi Telegraph Company.

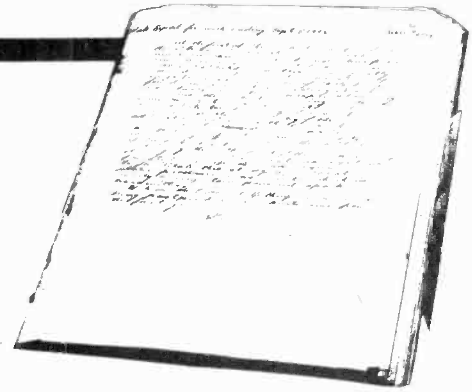
Radio performance depends not only on the sensitivity of the equipment, but also on the conditions governing the propagation of radio waves through the atmosphere, and on the level of back-ground noise which can be heard in headphones at the receiver. In the 1920's, the limitations imposed by propagational effects and received noise were only partially understood. It was realized that external radio noise could originate from lightning flashes in thunderstorms and the numerous minor discharges of electricity generated in storm clouds, hence the terms *'static'* and *'atmospherics'*. It was an investigation in the US of this atmospheric noise at shorter wavelengths, around 15m, that led to the discovery on which radio astronomy may be considered to be based.

Karl Jansky

In 1930 Karl Guthe Jansky, a young physicist on the technical staff of Bell Telephone Laboratories was assigned the task of studying the direction of arrival of atmospheric static at wavelengths of about 15m, which were then being used for ship-to-shore and transatlantic communication. For this purpose, Jansky planned the construction of a rotatable aerial array 30m long and 4m high, providing directional receptions of about 30 degrees width in azimuth. The frame was mounted on four wheels taken from a Model T Ford to allow rotation about a central pivot. With the aid of a motor and chain drive, a revolution was completed every twenty minutes, earning it the nickname "the merry-go-round."

In a 1932 paper, Jansky distinguished three distinct types of static: the intermittent crashes from local thunderstorms, a steadier weaker static due to the combined effect of many distant storms and lastly a steady weak hiss of unknown origin producing a sound in headphones similar to the noise generated within the radio receiver by random thermal agitation by electrons in the components. Initially, he thought this latter hiss to be manmade, but then realized that the apparent direction of arrival moved round the sky each day, but was *not* originating from the sun. By following his initial investigation with a year's worth of data recording, Jansky finally determined the significance of his discovery, published in 1933 under the title *"Electrical disturbances apparently of extraterrestrial origin."* He determined the direction of the main source as the centre of the galaxy (in the constellation Sagittarius).

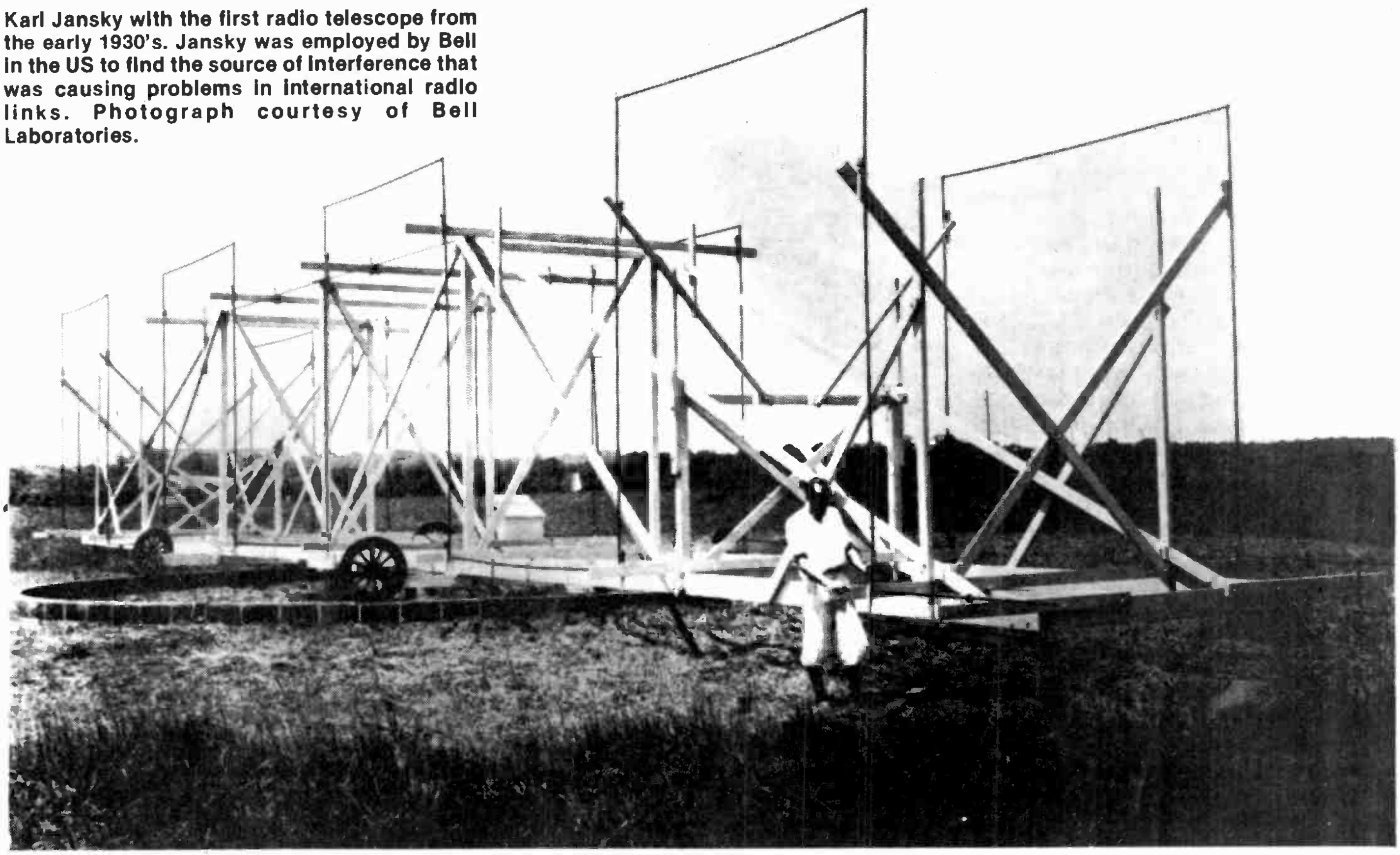
Continuing his work in 1935, Jansky published a paper in which he attempted to resolve the problem. *"It leads one to speculate,"* he wrote, *"as to whether or not the radiations might be caused by some sort of thermal agitation of charged particles. Such particles are found not only in the stars but also in the very considerable amount of interstellar matter that is distributed throughout the Milky Way, which matter, according to Eddington, has an effective temperature of 15,000°C."*



The famous entry in Jansky's logbook when he established that the source of his signals was the centre of our own galaxy. Photograph courtesy of Bell.

His discovery attracted some publicity, and on 5 May 1935 the *New York Times* carried a front page full column report entitled, "New Radio Waves traced to Centre of Milky Way." The discovery was also featured on an American radio programme and the galactic noise received by Jansky's aerial array was broadcast, the commentator announcing, *"I want you to hear for yourself this radio hiss from the depths of the universe."* The listeners' reaction to the ten seconds of hiss is unrecorded, but one reporter said that it sounded *"like steam escaping from a radiator."*

As he had fulfilled his practical



Karl Jansky with the first radio telescope from the early 1930's. Jansky was employed by Bell in the US to find the source of interference that was causing problems in international radio links. Photograph courtesy of Bell Laboratories.

objective, Bell Laboratories refused to fund any more research into the subject, stating that the 100 ft disk Jansky proposed was an "unjustified expense." He never again worked on radio astronomy, and died at the age of 44, in 1950.

Grote Reber

Radio astronomy would have effectively halted for the better part of a decade if it hadn't been for the initiative of a lone pioneer, Grote Reber. Reber was a young graduate radio engineer from Wheaton, Illinois, who decided to pursue the research as a hobby at his own expense in his spare time. *"In my estimation,"* he wrote, *"it was obvious that Jansky had made a fundamental and very important discovery. Furthermore, he had exploited it to the limit of his equipment facilities. If greater progress were to be made it would be necessary to construct new and different equipment especially designed to measure the cosmic state."* In the face of prevailing ignorance, he decided to construct a large parabolic reflector with the intention of observing intially at a very short wavelength, about 10cm. He realized that a parabolic reflector would have the advantage of providing a narrow, symmetrical beam and would also enable the wavelength to be altered simply by changing the receptor at the focus.

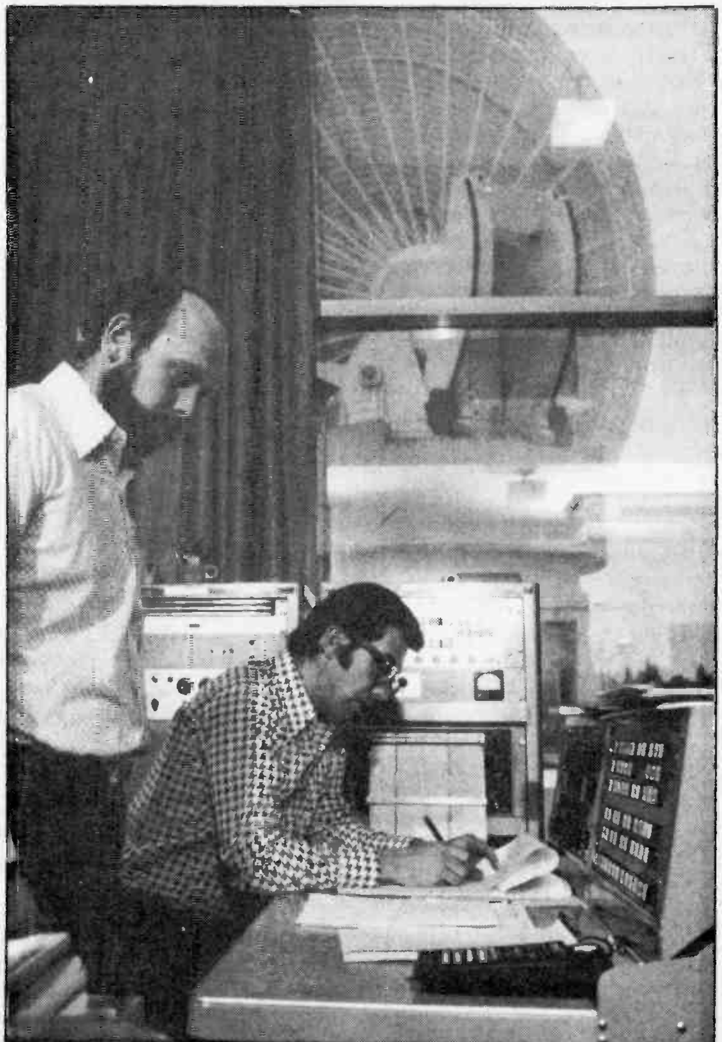
Reber would have preferred a full steerable mounting but this was far too expensive (he was paying for it out of his own pocket and erecting it in his backyard, 30 miles outside of Chicago.) As such, he decided on a meridian transit instrument steerable in elevation only and relying on the Earth's rotation to scan the heavens. The metal parabolic mirror was to be made as large as possible consistent with available funds. Even the lowest estimates from outside contractors were prohibitive, and Reber was forced to build it himself. Balancing the cost of materials against the structural demands, Reber finalised the parameters of his design and decided on a sheet metal surface of 32 feet diameter, to be mounted on a wooden supporting structure for the sake of cheapness and ease of construction.

The reflector surface consisted of 45 pieces of 26 gauge galvanized iron sheet screwed on 72 radial wooden rafters cut to parabolic shape. Reber cut, drilled and painted all the parts and personally put together the radio telescope piece by piece, completing the job in four months from June to September 1937. The building of the telescope cost $1300.

Grote Reber photographed last year when he was interviewed by our sister magazine ETI-Australia. Mr. Reber now lives in Tasmania where he has taken up solar energy as his interest.

Initially, he used a crystal detector followed by an audio triode amplifier. His initial attempt, at wavelengths of 9cm, produced no response. Changing to 33cm for which an acorn triode proved the most likely detector, Reber again failed. During the autumn of 1938 and during the winter a variety of observations, both by day and night, were made with both polarizations. All the objects were examined again without any positive results. Moving down in wavelength to 1.87cm, Reber was at last successful in detecting radio emission from the Milky Way.

In his first paper, in 1940 entitled *"Cosmic Static,"* Reber determined the radiation intensity at 1.87 cm and confirmed the source as laying predominantly along the Milky Way. He then made an important step in theoretical interpretation by evaluating the intensity of radio emission from free electrons during encounters with positive ions of ionised hydrogen in intersteller space. In 1944, a further article marked the pinnacle of Reber's achievement — he produced the first radio maps of the Milky Way. The beamwidth of his



View of the Algonquin telescope in northern Ontario taken from the control room. Photograph courtesy NRC Canada.

radio telescope, about 12 degrees at a wavelength of 2m, enabled him to draw a contour map of the distribution of radio noise which showed its relation to the Galaxy, the structure of the main peak at the galactic centre in Sagittarius, and the subsidiary peaks in Cygnus and Cassiopeia. Attempts to detect individual objects, like planets, stars and nebulae failed, but his paper did report radio emissions from the sun.

The Fighting Forties

With the advent of war, radio astronomy fell again on fallow ground, with those whose knowledge and expertise which could be applied to such an endeavour devoting their time to national service, particularly the study of radar and radio communications on a practical level. None the less, the foundations of contemporary radio astronomy were still being layed in an indirect and unexpected way.

During 1941, the enemy made increasing endeavours to jam radar operations. The British War Office became anxious lest their radar devices, particularly vulnerable to airborne jamming, might be rendered useless. On 12 February, 1942, the passage of the German warships *Scharnhorst* and *Gneisenau* through the English Channel, in which they slipped by almost unnoticed until it was too late to muster any effective attack on them, to the accompaniment of radar jamming from the French coast, resulted in a drastic reappraisal and upgrading of the "jamming menance." The study of jamming was not a particularly interesting one for scientists, but it had to be done and a group was rapidly assembled. On 27 and 28 February, 1942, a remarkable series of reports from sites in many parts of Britain described the daytime occurence of severe noise jamming experienced by anti-aircraft radar working at wavelengths between 4 and 8 metres. This 'jamming' was of such intensity as to render radar operation impossible. Fortunately, no air raids were in progress, but alarm was widespread at the incidence of this new form of 'jamming". The Army Operation Research Group, newly formulated in response to the *Scharnhorst* fiasco a mere 15 days earlier and now stationed in Dover, were able to determine that the "jamming" was in fact due to radio radiation from the sun, a realization and discovery which had eluded Hertz so long before.

For the remainder of the war, study of celestial radiation, radar, jamming and anti-jamming techniques went hand in hand, and a good deal of foundation research was done on the subject during this period, virtually all of it under an official classification of "Secret". By the conclusion of hostilities, there were a large number of scientists and technicians who had learned the fundamentals of radio astronomy, some of the techniques involved, and what sort of things they could start looking for.

The Breakthrough

It was after the end of the war that radio astronomy really got going in a big way. So much was accomplished so relatively quickly that it is impossible to cover it all. However here is some of the physics involved. There are essentially three types of radio emissions:

Free-free emission: Radio emission, like light, is produced when a charged particle, generally an electron, is made to accelerate. One class of astronomical radio sources consists of clouds of hot ionized gas, that is, a gas whose atoms and molecules have absorbed enough energy to lose their electrons and become positively charged ions. Such a cloud emits radio waves by the process known as *free-free emission*. In this process, the free electrons are attracted toward positively charged ions as they pass each other — the acceleration producing a pulse of radiation. The sum of such pulses originating in a large number of such encounters between electrons and positive ions gives a continuous spectrum in which the power (energy per unit of time) radiated per unit frequency interval is constant with frequency. Radio sources that emit by the free-free process include the outer regions of the sun and the ionized hydrogen regions of interstellar space.

A similar process is that known as blackbody radiation, in which the emitting region is so compact or deep that the only emission that can escape comes from the near side. In this case, the power radiated increases as the square of the frequency. Measurements of the emitted radio power give a direct estimate of the temperature of the source. The planets belong to this class of source.

Synchrotron radiation: This is the most important process, in which electrons moving at speeds very close to that of light (relativistic speed), spiral around magnetic fields

Large Radio Telescopes and Synthesis Arrays

Institution	Location	Size of Reflector,m
Fully steerable parabaloids		
Max Planck Institute of Radio Astronomy	Effelsberg, West Germany	100
Nuffield Radio Astronomy Laboratory	Jodrell Bank, England	76
CSIRO	Parkes, NSW Australia	64
Jet Propulsion Laboratory	Goldstone, California	64
Algonquin Radio Observatory	Lake Traverse, Ontario	46
National Radio Astronomy Observatory	Green Bank, West Virginia	43
California Institute of Technology	Big Pine, California	40
Haystack Observatory	Westford, Massachusetts	37
Crimean Astrophysical Observatory	USSR	22
Limited tracking transit telescopes		
Special Astrophysical Observatory	Zelenchukskaya, USSR	10 x 1885
Tata Institute	Ootacamund, India	30 x 529
National Astronomy and Ionosphere Center	Arecibo, Puerto Rico	305
Observatory of Paris	Nancay, France	40 x 200
National Radio Astronomy Observatory	Green Bank, West Virginia	91
Radio Telescopes for millimetre wavelengths		
Onsala Observatory	Gothenburg, Sweden	20
University of Massachusetts	Amherst, Massachusetts	14
National Radio Astronomy Observatory	Kitt Peak, Arizona	11
California Institute of Technology	Big Pine, California	10
University of Texas	Fort Davis, Texas	5
Synthesis Arrays		
National Radio Astronomy Observatory (Very large array, VLA)	Socorro, New Mexico	Resolution 0".1
Mullard Radio Astronomy Observatory (5km array)	Cambridge, England	Resolution 0".5
Westerbork Radio Observatory (WSRT)	Westerbork, Holland	Resolution 1"

emitting radiation that is polarized — that is, which vibrates more strongly in a direction perpendicular to the magnetic field. This radiation was first found in the beams from synchrotron particle accelerators. The electrons may be a part of the energetic cosmic ray background flux in the Milky Way, or may be produced in some violent event in the radio source itself. The precise shape of the continuous spectrum of synchrotron radiation depends, among other things, on the energy spectrum of the electrons.

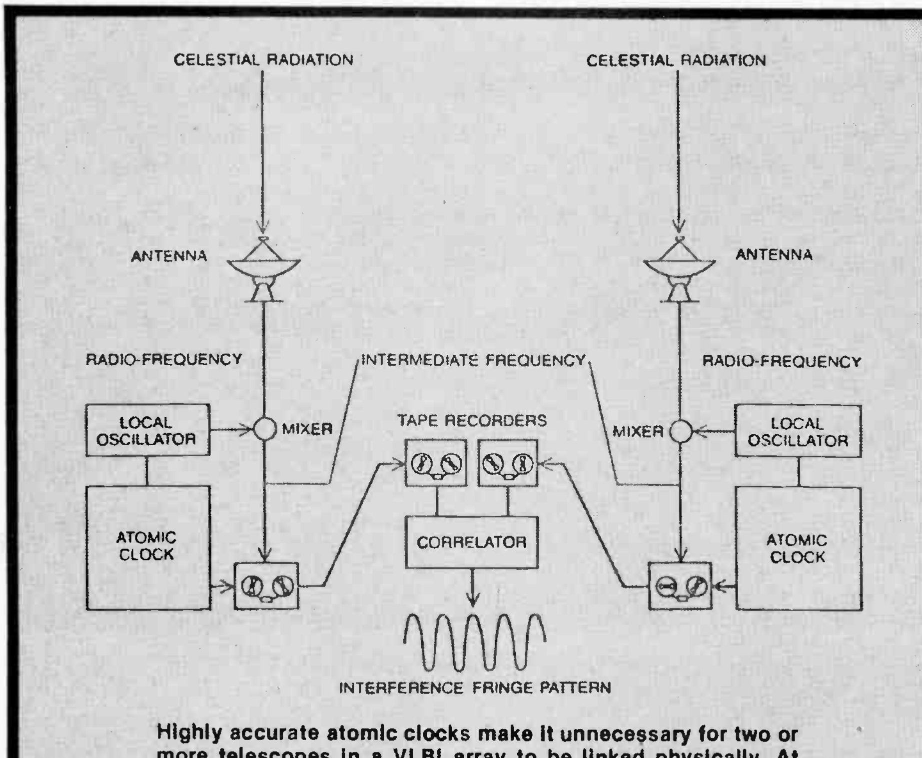
Emission from neutral hydrogen: Line radiations (that is, radiation strongly concentrated toward a particular wavelength) at the 21.1 centimetre wavelength was first detected from clouds of neutral atomic hydrogen in the Milky Way in 1951. This radiation provides a very useful tool for studying the motion of many components of the Milky Way and of external galaxies. Motion in the line of sight toward or away from the observer is calculated from measurements of the Doppler shift. Many interstellar spectral lines have now been detected from atoms and molecules that radiate in the radio range. Of these lines, the 21.1cm line of neutral hydrogen, which appears in many parts of interstellar space, is very important because hydrogen is widely distributed in the universe as the building material of stars.

VLBI's

The state-of-the-art for radio wave collection involves the use of the *Very-Long-Baseline Interferometer* (VLBI). Essentially, the remarkable images produced by VLBI are governed by the same laws of physics that apply to light gathering telescopes. In order to improve the resolving power of an imaging system the aperture over which radiation is collected must be increased in relation to the wavelength of the radiation. Resolving power, or resolution, is the minimum angular separation, measured in minutes or seconds of arc, that can be detected by an observing instrument. For a telescope, the resolution is given approximately by the ratio *wavelength/D,* where D is the aperture of the telescope. In order to record fine details, D should be as large as possible for the particular wavelength being studied. The resolving power of large optical telescopes under good viewing conditions is about one arc-second, roughly the angle subtended by a small coin at a distance of four kilometers.

If equivalent resolution were to be achieved by a radio telescope operating at a wavelength of one meter, the diameter of the collecting surface would have to be some 150 miles. The largest optical telescope, at Palomar Mountain, has a theoretical resolution of 0.023 arc-second, while radio telescopes now have a resolution of 0.0001 arc-second. This is accomplished by making D very large by what is called "aperture synthesis", a technique by which the radio waves, collected by two (or more) instruments hundreds or thousands of kilometers apart, are recorded simultaneously and subsequently added together. This has to be handled very cautiously. If the phase relations of the radio waves arriving at the telescopes preserve their synthesis, the waves are said to be coherent. The intensity of the radiation will be high or low depending on whether the arriving radio waves are in phase or out of phase at the two telescopes. Such a combination of telescopes is called an interferometer. As the earth moves, the difficulty in keeping the waves in phase becomes a major problem, resulting in the signal intensity at the output of the interferometer passing rapidly through a succession of highs and lows as the radio waves from the celestial object are successively in phase and out of phase. These intensity maximums and minimums are called *interference fringes.*

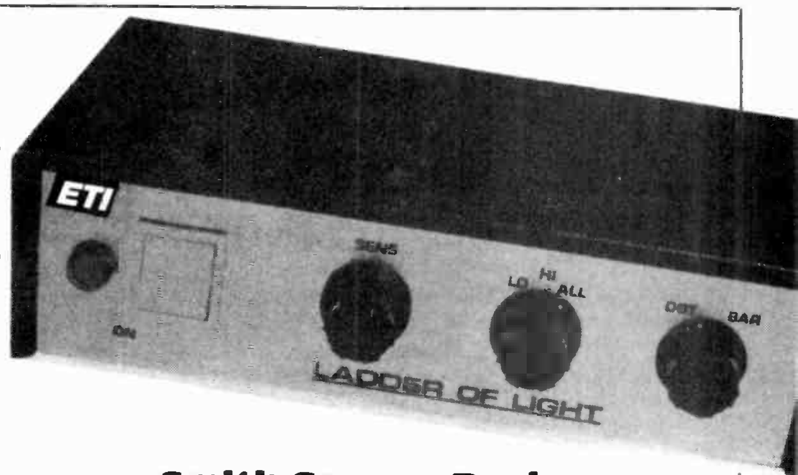
The amplitudes and phases of the fringes, sampled for a large number of separations of the two telescopes are called the *visibility function.* When this function is subjected to the mathematical operation known as a Fourier transformation (which converts a curve of *amplitude v. time* to curve of *amplitude v. angle)* one obtains a direct image. It is possible to obtain the fringe pattern for all separations of two telescopes out to a given separation D and hence to obtain the same image that one would get from a single giant telescope of diameter D. When the rotation of the earth is exploited to increase the number of separations, the resulting operation is called *earth-rotation aperture synthesis.* This process was developed in the early 1950's at Cambridge University, and has been used a number of times, particularly at the Very Large Array in Socorro, New Mexico, which utilizes 27 movable radio telescopes spread out in a Y shaped configuration. ETI



Highly accurate atomic clocks make it unnecessary for two or more telescopes in a VLBI array to be linked physically. At each telescope site the RF signal from the celestial source is recorded on videotape at a rate of four million samples a second, together with periodic time signals from a local atomic clock. The tapes are later played back at a central processor in order to extract the pattern of interference fringes. The tapes must be synchronized to a fraction of a second.

To be continued next month

ETI next month



Sound to Light Modulator

Tired of light boxes, dancing strobes, giant neon peace signs, ultaviolet disco lamps in the shape of Bette Davis and panels of pulsing LEDs? Not yet, eh... well, good,'cause next month we'll be presenting another visual effect to perk up your band's stage presence or to attract U.F.O.s to your Martian trap.

Smith Corona Review

A daisy wheel printer for under a thousand, you say? Ah, yes, it must be three solenoids and a pressed flower. No, wait, it's for real, and it's a first rate machine. We pollenate the works next issue.

Plus!!!

More Synthesizer!
ETI Index for 1982!
One Year Computer Summary!
Allen B. DuMont Invents Cathode Rays!
More than 10^{376} Tiny Paper Molecules + Two Staples

Constant Current Generators

Still more circuits? Do they never run out? Constant current generators are a useful circuit design item in putting together voltage regulators and other like doodads. This article is so comprehensive you will be able to talk CCG's with the best of them. Think of the time you'll have at parties.

Josephson Junctions

It is curious to note that the Josephson junction, a superconducting switching device operates at very nearly the speed of light, but only if it's cooled to almost absolute zero, a point at which even molecular motion all but ceases. Other surprising revelations about this new frontier in computing revealed... next month.

Electronics in the Newsroom

Gone from the newsroom are clattering typewriters, editors chewing on blue pencils and copy boys tripping over chairs in their blind rush to go to press by deadline. The modern newsroom features clattering VDT's, editors chewing on light pens and field engineers tripping over chairs in *their* blind rush to find glitch before quitting time.

February 1977
Features: CN Tower, Biorythm Calculator, VCT, 555 Timer Applications, Yamaha B1 Review, Scope Test Your Car.
Projects: 5W Stereo Amp, Philips Speaker System, Reaction Tester, Patch Detector, Heads or Tail, SCR Tester.

December 1978
Features: Designing Oscillators, Ham Spectrum Chart, Principles of Video, Getting into Video.
Projects: Digital Anemometer, Tape Noise Eliminator, EPROM Programmer.

February 1979
Features: Quarks, Op-Amps, Binary to Decimal and Back.
Projects: SW Radio, Phasemeter, Light Chaser.

April 1979
Features: Designing Audio Amps, Solar Power, RF Chokes, What Quad terms mean.
Projects: Differential Temperature Controller, Audio Compressor, Wheel of Fortune Game.

May 1979
Features: Space Shuttle Communications, Transducers in Measurement & Control, Research in Canada.
Projects: Light Show Controller, AM Tuner, VHF Antenna (pt.1), PCB Drill.

June 1979
Features: Op-Amps, Ultrasonic Sound, ETI Computer Catalogue.
Projects: Easy Colour Organ, LCD Thermometer, Light Show Colour Sequencer, VHF Antenna (pt.2), Bip Beacon.

August 1979
Features: Casing Survey, Smoke Detectors, TV Antennas, Reed Switches, Magnetic Field Audio Amp, Industrial Electronics.
Projects: Audio Power Meter, Shoot-out, ETI-Wet Plant Waterer.

September 1979
Features: OSI Superboard Review, Solar Power from Satellites, Reed Switches.
Projects: Field Strength Meter, Digital Wind Meter, Up/Down Counter.

October 1979
Features: SW Receiver Survey, Ultra Fidelity, Computer Speech.
Projects: Simple Graphic Equaliser, Digital Dial, Variable Windscreen Wiper, Cable Tester.

November 1979
Features: Kit Survey, Ultra Fidelity (pt.2), Using UARTS.
Projects: 60W Amplifier, Model Train Controller, Scope Curve Tracer.

December 1979
Features: LM10—the Basics, Police Radar Speed Meters, Guide to TRIACS, Fluorescent Displays.
Projects: High Performance Stereo Preamp, Development Timer, Logic Trigger.

May 1980
Features: Delay Lines, Standing Waves, Microwave Cooking, Artificial Intelligence.
Projects: Click Eliminator, Soil Moisture Indicator, Fuel Level Monitor, 16k RAM Card.

June 1980
Features: Electronic Warfare, PLL Synthesis, CA3130 Circuits, Canadian Sound Archives, Magnetic Power Control, CLIP.
Projects: Function Generator, Dynamic Noise Filter, Overspeed Alarm.

July 1980
Features: CMOS 555 Circuits, Capacitors, Electronics in the Studio, Tesla Controversy.
Projects: Hebot Robot (pt.1), Photographic Timer, Analogue Frequency Meter, Accentuated Beat Metronome.

August 1980
Features: S100 Bus System, Introduction to Test Gear, Designer Circuits, FET Special, Life Out There?
Projects: 300W Amp, Hebot (pt.2), Transistor Tester, Passionmeter.

November 1980
Features: Designer Circuits Special, Cassette Decks and Tapes, Attenuators, Project Daedalus, Thermistors.
Projects: Guitar Practice Amplifier, 6W Siren, Infra-Red Remote Control.

December 1980
Features: Transducers in Audio, Floppy Disks, 10 Simple Transistor Circuits, Electric Cars, SI Units.
Projects: Digital Test Meter, RIAA Preamp, Survival Game.

January 1981
Features: Studio Techniques, Premium Batteries, Edision Effect, Alarm Circuits.
Projects: Electronic Ignition, Digital Frequency Meter, EPROM Eraser, Coin Toss.

February 1981
Features: Electronics in Photography, Audio Filter Design, Piezo Electricity, Modems, Choosing a Printer, Selecting a Floppy Disk.
Projects: Ultrasonic Burglar Alarm, Fuzz Sustain Unit, Process Timer.

March 1981
Features: The Ubiquitous Oscilloscope, VFET Applications, Photocells, Test Gear.
Projects: Hum Filter, Drum Sythesiser, Shark Game.

June 1981
Features: Project Galileo, Story Behind Stereo, Solder, Computerese.
Projects: 1573A VCA, High Speed Cassette Interface, Double Dice, Bicycle Speedometer.

July 1981
Features: LM3914 Circuits, How to Solder, Faraday, Auto Sound Survey, Project Fault-Finding.
Projects: Universal Timer, Bargraph Car Voltmeter, Engineer's Stethoscope, Computer Motherboard.

August 1981
Features: Recording Tape and Tape Recording, Anatomy of a Micro, Holograms, Wein Bridge Oscillators, 55 Circuits.
Projects: Infra-Red Alarm, Bench PSU, Wired Sound.

September 1981
Features: Thick Film Circuits, A look at CP/M, Gm Revisited, Hum Loops, Ex-OR Gates.
Projects: LED Vu Meter, Russian Roulette, LED Tacho, Emergency Light Unit.

October 1981
Features: Scope Survey, Graphic Equalizer Design, I/O Devices, Dolby C, Black Hole Theory.
Projects: Tape Optimizer, Antenna Extender, Win Indicator, Pulse Generator.

November 1981
Features: Canada in Space, Digital Design Handbook, Maxwell, POKEing the ZX80, VIC-20 Review, PWM Explained.
Projects: Alien Attack, Headlight Delay, Drum Machine, Computer Joysticks.

December 1981
Features: Bandpass Circuits, Tubes, Early Radio in Canada, Speaker Design (pt 1).
Projects: Universal Counter, Musical Doorbell, 4-Input Mixer.

January 1982
Features: Speaker Design (pt.2), Big Bang Theory, Acorn ATOM Review, SLR Cameras, Micropower Circuits.
Projects: 4-Way Loudspeaker, Movement Alarm, Temperature Controlled Iron.

February 1982
Features: 50 Circuits, ATOM Review, Electronic Signs, Industrial Robots, Amplifier Class, dBx, SW Aerials.
Projects: Flash Sequencer, Enlarger Timer, Sound Bender.

March 1982
Features: Printers, Ni-Cads, ZX81 Review, Perfect Sound, Gluons, CMOS Circuits.
Projects: Music Processor, Crystal Marker, Ni-Cad Charger, Reaction Tester.

April 1982
Features: Satellite Applications, 4066B Circuits, TRS-80 Model II Review, Fessenden, Electric Pencil.
Projects: Ten Simple Projects Special.

May 1982
Features: Shroud of Turin, Faster than Light Travel, CMOS Circuits, Modems, Drone Speaker, 6809 Computer Review, Optical Disk Recorders.
Projects: AF Signal Generator, Super Dice, LED Level Meter.

June 1982
Features: Fibre Optics, Lasers in Hi-Fi, Leptons, Xerox Computer Review, Hertz, 50 More Circuits.
Projects: Phono Preamp, Roulette Game, Light Wand, Stylus Organ.

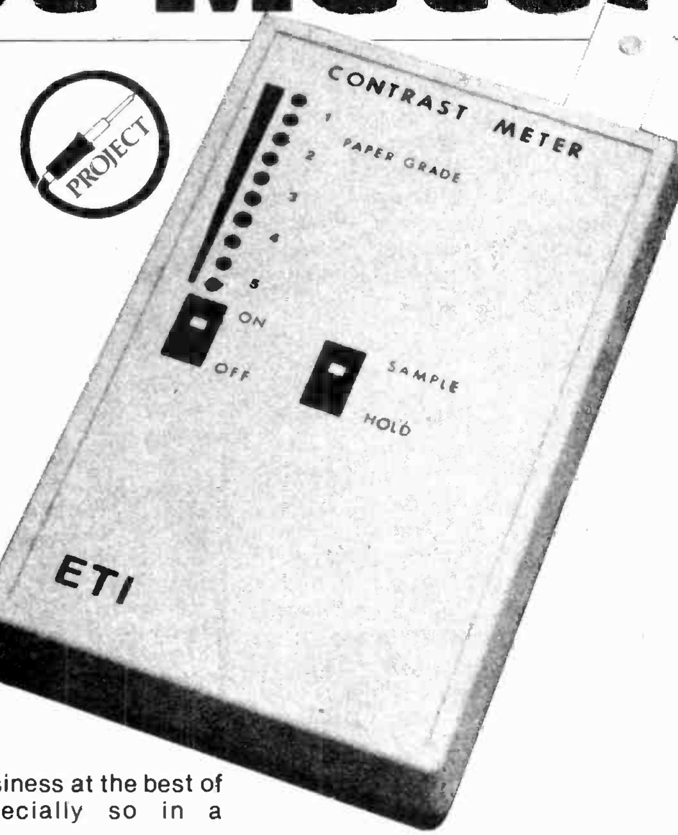
The Back Issues listed here are still available. A few others (listed on the order form) are also available but in very limited quantities. Our Back Issues are not unsold copies: each month about 500 are held in reserve for this service.

$3.00 each or any FIVE for $10
(Price includes shipping)

ETI Back Issues,
Unit 6, 25 Overlea Blvd,
Toronto, Ontario,
M4H 1B1

Contrast Meter

What's black and white and read all over? Answer — a photographic negative, providing you've built this simple and useful device. Design and development by Rory Holmes.



CONTRAST RATIO is a very important quality of photographic negatives that must be assessed during the printing process, in order to select the correct grade of photographic paper. The contrast of negatives depends on the type of film used, the lighting conditions and the developing process; consequently five grades of printing paper are available to enable the full range of tones from black to white to be reproduced from any negative. Grade 1 is termed the softest and it is used with the highest contrast negatives. At the other end of the scale, grade 5 is the hardest paper, which will enhance the tonal variations of poor contrast negatives.

During the design stage of this project we experimented initially with two separate photodetectors which measured the instantaneous light difference between two points. There are a number of problems with this approach, as the photodiodes and their associated amplifiers must be carefully matched in light sensitivity.

Secondly, the lightest and darkest points of the image must be known exactly, and the two photodetectors need to be simultaneously positioned on these points while the reading is taken. This is an awkward business at the best of times, but especially so in a darkroom!

We considered that a different approach was required and developed the circuit of Fig. 1 to overcome some of these difficulties. Only one photodetector is used and the peak positive and negative voltages obtained from different light levels are followed and stored independently by sample and hold circuits.

Now, as long as the photodiode is scanned at some time through the lightest and darkest points of the image, the peak detectors will memorize the maximum and minimum voltages, and thus provide a contrast measurement.

The photodetector input stage of our meter is rather unusual in its configuration. Photodiodes are usually used in the 'photovoltaic mode' where the photocurrent developed and measured is linearly proportional to the light intensity. Our input amplifier has an extremely high input

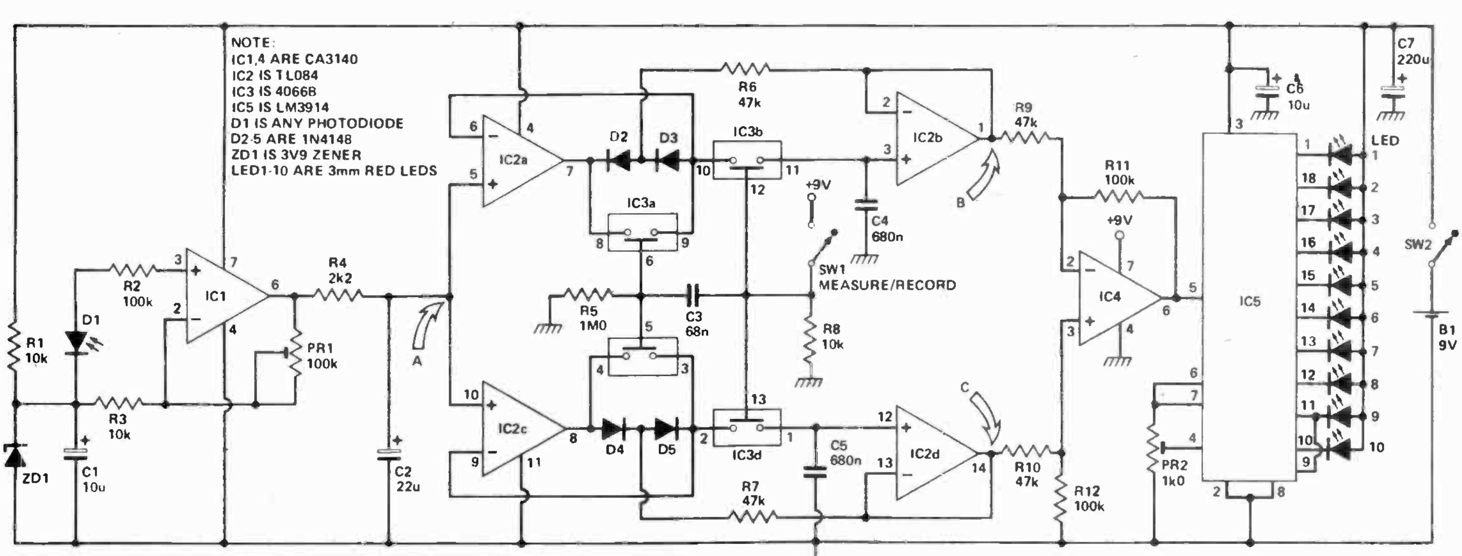


Fig. 1 Circuit diagram of the Contrast Meter.

impedance and thus measures the open circuit voltage generated by the photodiode. This voltage is logarithmically proportional to irradiance as the graph of Fig. 2 illustrates. This is a very convenient property since the sampling circuitry can now work on the log of the light level to provide maximum and minimum values. By simply subtracting these two values with a differential amplifier we obtain a voltage that is logarithmically proportional to the ratio of the maximum and minimum light levels, i.e. the contrast.

Meter Made

The ETI contrast meter was intended primarily to determine the paper grade for a well balanced print; consequently a 10 LED bargraph type meter is sufficiently accurate for calibrating the five grades of paper. At today's prices this also works out somewhat cheaper than a moving coil meter and is less prone to damage. After calibration, the meter will be found very easy to use. It is switched on with the 'sample/hold' switch in the 'hold' position and placed down flat on the enlarger base with the photodetector probe anywhere in the image area. (The photodiode has been mounted in a separate probe with its amplifier in order to keep it as close to the focused image plane as possible. If it were much higher than this the detecting element would pass through an unfocused image, giving a false contrast reading).

Any red safety lights should be switched off before the reading is taken to avoid error since the photodiode is responsive at this wavelength. The sample/hold switch should now be moved to the sample position; this will clear any previous reading and start measuring light variations. Now the photodiode may be moved across the image and through the areas that look the brightest and darkest. This can be done quite slowly thanks to the peak detectors' long memory time; however, several areas should be scanned to ensure the recording of the true maximum and minimum. The eye can be deceived quite easily by those cunning optical illusions lurking among the shades of grey!

During the scanning process the reading on the LED scale will increase and finally level-off at the true contrast ratio when the black and white peaks have been covered. Before removing the meter from the image area the sample/hold shoud be

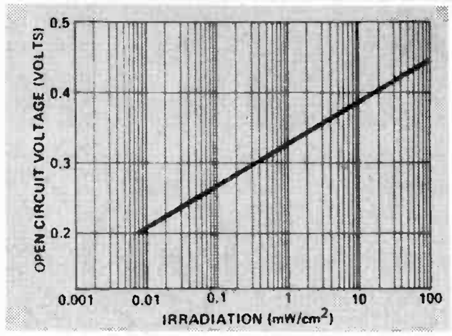


Fig. 2 Response of the photodiode used in this project.

set to 'hold'. The meter will now be immune to further light variations and will continue to display the contrast reading for a considerable time, thanks to the even longer memory of the sample/hold circuitry!

A true ratio is provided by the meter and thus the contrast reading for a given negative will be independent of the light source intensity and enlargement size (photographic aberrations known as "circles of confusion" may produce sources of error under certain conditions). Negatives may thus be compared or matched for contrast.

Construction

The meter is built into a slim style plastic enclosure. This houses the battery and main PCB on which all

HOW IT WORKS

The general circuit arrangement consists of a photo-amplifier which feeds a voltage derived from varying light levels in an enlarger, to a pair of peak detectors. One follows the peak positive voltage and the other the peak negative voltage. The capacitors used for storing the voltage peaks in the followers also form part of sample and hold circuits which are then switched to 'hold' after measurement. Their outputs represent the maximum and minimum values of light intensity. A differential amplifier then computes the ratio of these values and the result is displayed on an LED bargraph meter.

IC1, a CA3140 CMOS op-amp, is used as the photodetector amplifier. It is configured as a non-inverting DC amplifier with a gain variable from unity to about 10, set by PR1. Although IC1 can have input and output voltages all the way to ground, this facility is not used owing to the driving requirement of the TL084 quad op-amp. This requires inputs at least 1V above ground, and thus IC1's output is offset by a reference voltage of 3V9 provided by R1, ZD1 and C1. The anode of the photodiode is connected via R2 to the non-inverting terminal of IC1 which has an effectively infinite input impedance. Thus the open circuit voltage generated by the photodiode is amplified according to the gain set around IC1 and appears at the output on pin 6 added to the reference voltage.

The voltage at point A (ignoring the reference offset) will be logarithmically proportional to the intensity of incident light, owing to the properties of the photodiode (see Fig. 2) R4 and C2 form a simple filter to remove 120 Hz ripple caused by AC light bulbs. This voltage is fed directly to the peak detectors. These circuits are essentially the same, the difference being the polarity of the rectifier diodes. They operate in exactly the same way, and we shall deal only with the peak positive voltage follower.

Assume initially that the CMOS analogue switch IC3c is open and IC3d is closed. C5 will be connected to the output of op-amp IC2c via the rectifiers D4 and 5 (we can ignore the action of R7 for the moment). C5 will charge up via the rectifiers to the most positive voltage peak when the voltage at point A on the non-inverting terminal is greater than the capacitor voltage applied to the inverting terminal. The voltage held on C5 will droop over a period of time due to leakage current through the rectifiers D4 and 5 and the input bias current of IC2c. IC2c was chosen as a FET op-amp with a low input bias current and R7 is included to reduce the diode leakage current.

forward high impedance voltage follower to buffer the stored voltage. When the input voltage to IC2c at point A drops below the peak value, IC2c's output will go negative, reverse biasing D4. However, IC2d applies the capacitor voltage via R7 to the anode of D5, effectively removing leakage current through D5.

The peak positive value of the signal at A thus appears at point C, and likewise the peak negative value at point B. When the analogue switch IC3d is now opened, C5 is disconnected from the peak detector and acts in conjunction with IC2d as a sample and hold circuit thus isolating the measured values from further light variations.

When SW1 is open, R8 and R5 hold the control pins 13 and 5 of IC3 low, opening both analogue switches. This is the 'hold' mode. When SW1 is now closed, the control pin 13 is taken high, switching to the 'sample' mode. C3 and R5 produce a positive pulse (about 50 mS) on control pin 5 to briefly short out D4 and D5, so resetting the peak detector to the current voltage at point A. When C3 has charged the IC3c switch will open again, allowing the peak detector to function.

IC4 is wired as a differential amplifier with a gain of 2, to subtract the voltage at point C from point B. Since these voltages are the log of the light levels, the output on pin 6 will represent the contrast ratio of these light values.

IC5 is a standard LED bargraph driver, the LM3914. The input voltage on pin 5 is converted linearly to illuminate one LED on a scale of 10. Full scale deflection (LED 10) is set internally at 1V2; the zero scale deflection is set by PR2 anywhere between 0V and 1V2 during the calibration process. C6, a 10 uF tantalum, is required for IC5 to ensure stability from oscillation.

the parts are mounted. Since the light sensing element must be as close to the enlarger base plane as possible, we have mounted it externally on a separate small PCB with its associated amplifier. A probe to house the external sensor is made from a short length of aluminium channel extrusion. Figure 3 shows the dimensions for the probe; if the

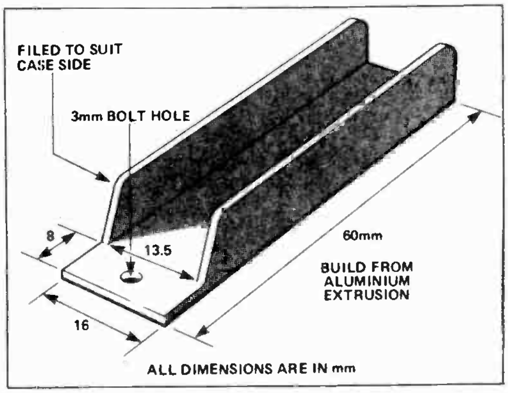
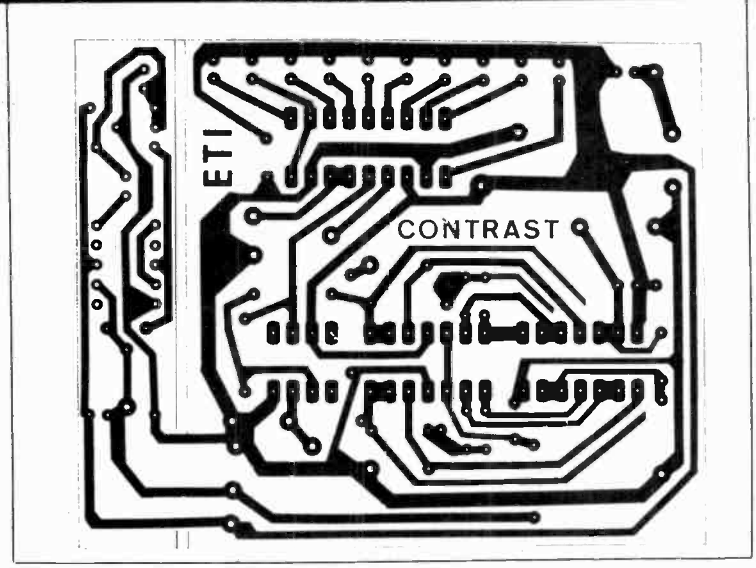


Fig. 3 Details for the aluminium extrusion that houses the photoprobe.



PARTS LIST

Resistors (all ¼W, 5%)

R1,3,8	10k
R2,11,12	100k
R4	2k2
R5	1M0
R6,7,9,10	47R

Presets

PR1	100k subminiature horizontal preset
PR2	1k0 miniature horizontal preset

Capacitors

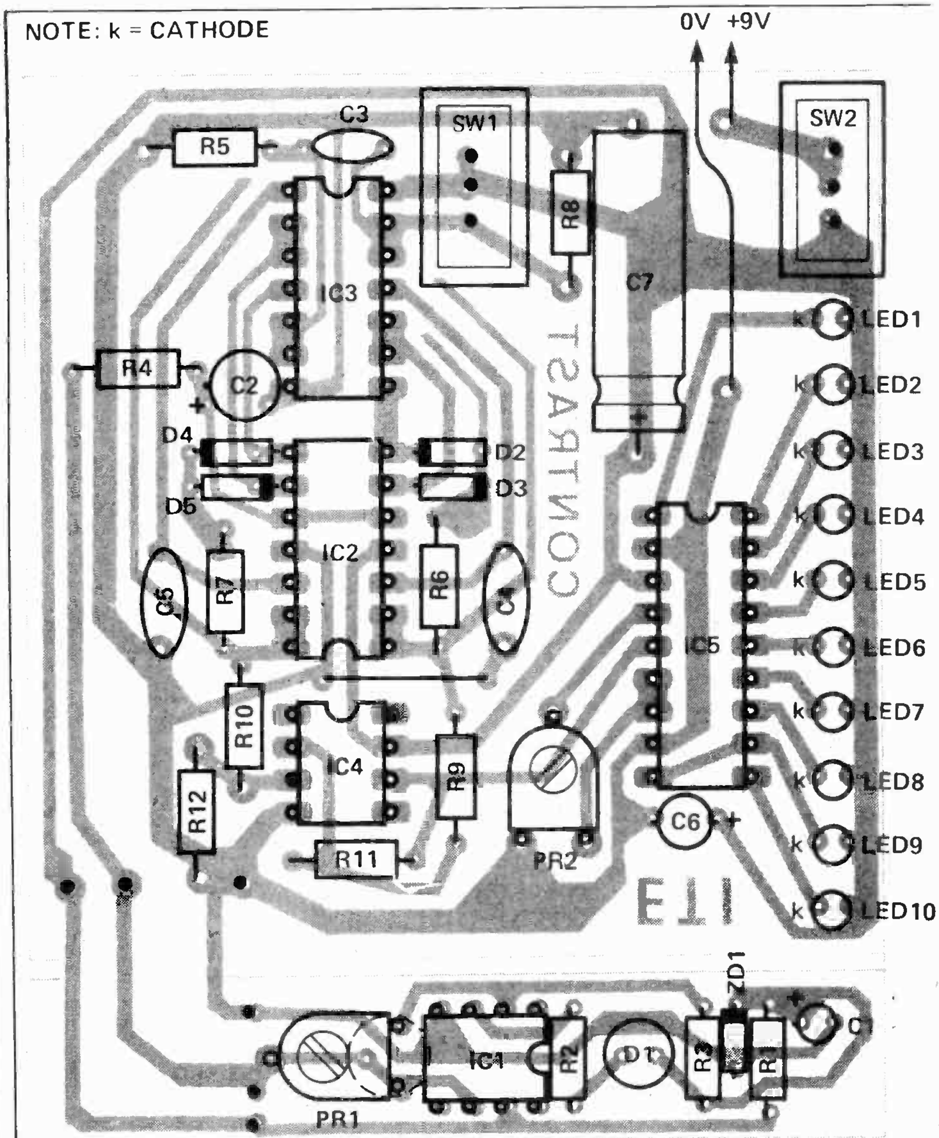
C1	10u 35V tantalum
C2	22u 25V tantalum
C3	220u 16V electrolytic
C4,6	82n polycarbonate
C5	68n ceramic

Semiconductors

IC1,4	CA3140
IC2	TL084
IC3	4066B
IC5	LM3914
D1	Any photodiode, e.g. TIL413
D2,3,4,5	1N4148
LED1-10	3mm red LED

Miscellaneous

SW1,2 miniature slide switches
Case; PCB; B1 9V battery (preferably alkaline type).



Continued on page 76

Junction FETs

The first in a whole family of field effect transistors, the junction FET is found in many and varied applications. If you're new to electronics or unfamiliar with the device, this article should introduce you to the haunts and habits of the JFET.

THE JUNCTION Field Effect Transistor or JFET is a small electronic device much like a transistor in appearance which normally has three connections, although a fourth connection is attached to the metal case of some types for high frequency screening. Junction field effect transistors are one of the two main types of field effect transistor, the other type being known as the MOSFET (Metal Oxide Semiconductor Field Effect Transistor) or as the IGFET (Insulated Gate Field Effect Transistor).

Field effect transistors can be used as amplifiers and oscillators as well as for other applications for which an ordinary or bipolar transistor could be employed, but have particular advantages for certain applications. Field effect transistors are also used in the internal circuitry of integrated circuits.

Connections

As in the case of npn and pnp bipolar transistors, junction field effect transistors can be obtained in two polarities, these being known as n-channel and p-channel types. A far wider variety of n-channel types is manufactured than p-channel devices, since they tend to have a better preformance, but devices of both polarities are readily obtainable.

The electrodes and circuit symbols for the two types are shown in Figure 1. The current flowing in a

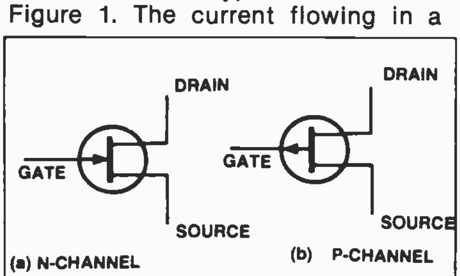


Figure 1. Symbols for n-channel (a) and p-channel (b) junction FETs.

channel between the drain and the source is controlled by a voltage applied to the gate electrode. The gate is therefore the input electrode and may be compared with the base of a conventional transistor. Similarly the drain and source may be compared with the collector and the emitter respectively.

One of the main differences between field effect transistors and bipolar transistors is that field effect transistors are essentially voltage amplifiers whereas bipolar transistors are basically current amplifiers. Thus the field effect transistor behaves more like the old thermionic valve in its circuits.

Field effect transistors tend to be more expensive than most of the common bipolar types—probably because the bipolar types are sold in much larger numbers. The economical 2N3819 n-channel field effect transistor is probably the most commonly used type and is very suitable for the readers who wish to carry out their first experiments with field effect transistors. This device is encapsulated in a black plastic or epoxy body and has the connections shown in Figure 2. The 2N3820 is a similar economical p-channel device.

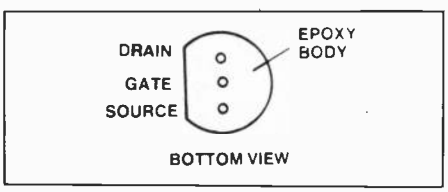


Figure 2. Connections for the common 2N3819 plastic-encapsulated n-channel JFET.

High Input Impedance

One of the main advantages of a field effect transistor is that it has a very high input resistance and therefore takes very little current from the circuit which feeds it— typically far less than a microamp. This means that it has very little effect on the circuit which feeds it, even if this circuit has such a high output impedance that it can deliver only a very minute current.

In order that an n-channel device shall operate correctly and have a high input impedance at its gate, it must be suitably biased with its gate negative with respect to the other electrodes. Similarly the gate of a p-channel device has a high impedance when it is positively biased.

Pierce Oscillator

In the circuit of Figure 3 the field effect transistor is employed in a Pierce type of oscillator whose frequency is controlled by the quartz crystal

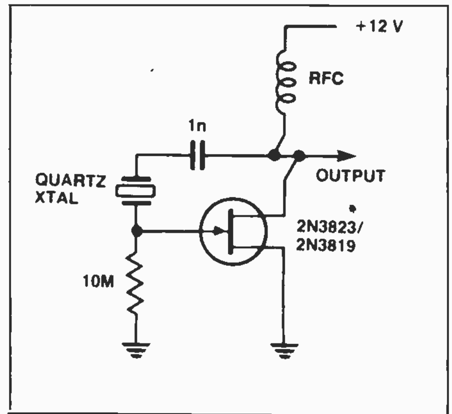


Figure 3. A Pierce crystal oscillator (National Semiconductor).

shown. The advantage of using a field effect transistor in this type of circuit is that the gate imposes only a very small load from the crystal and therefore the quality factor or Q factor of the crystal is not appreciably affected, so excellent frequency stability can be obtained.

National Semiconductor recommend their 2N3823 n-channel device for use in this circuit, but the more economical 2N3819, which is made by the same type of process, is also suitable. The supply voltage is not at all critical, but the radio frequency chokes used in the supply lead should have a high impedance at the frequency of oscillation.

An advantage of this circuit is that one can change the crystal over quite a wide range of frequencies without making any other changes to the circuit and still obtain a satisfactory performance. The exact frequency range over which the circuit will operate depends very much on the choke used and to some extent on the circuit layout.

This type of circuit is suitable for use in a crystal calibrator for a receiver. If a 1 MHz crystal is employed, the output may be fed to a radio receiver to produce a signal at 1 MHz and at each multiple of 1 MHz up through the shortwave bands to provide calibration points.

Electronic Attenuator

A junction field effect transistor can be used as a variable resistor, the value of which is controlled by the voltage applied to the gate electrode. As the applied bias becomes smaller, the resistance between the drain and source electrodes falls.

This property is used in the circuit of Figure 4 to design an electronic attenuator for audio signals.

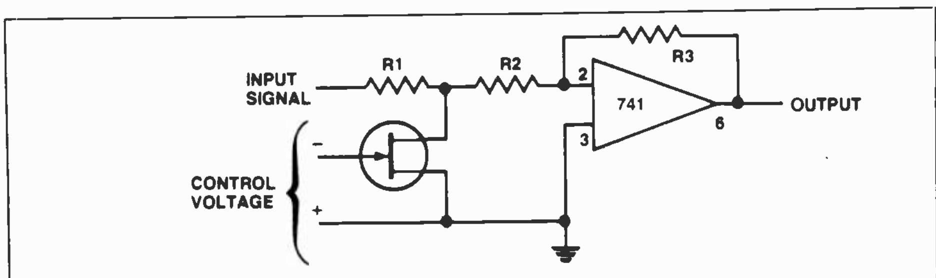


Figure 4. An electronic attenuator (Siliconix).

When the negative control voltage applied to the gate electrode is relatively large, little drain current passes through the device and the circuit behaves as if the field effect transistor were not present. However, as the control voltage falls at the gate electrode, the drain draws current from the juncton of R1 and R2 so that the output signal amplitude is attenuated progressively.

Tone Control

The circuit of Figure 5 is a tone control circuit with bass and treble boost and cut facilities. In this circuit the 2N3684 field effect transistor is used to enable the circuit to have a very high input impedance. It is used as a source follower circuit (analogous to an emitter follower) which provides a low output impedance signal coupled by a 1u capacitor to the tone control network. This network is in the feedback circuit of the LM301A operational amplifier circuit. The 2N3684 enables a good low-noise performance to be obtained.

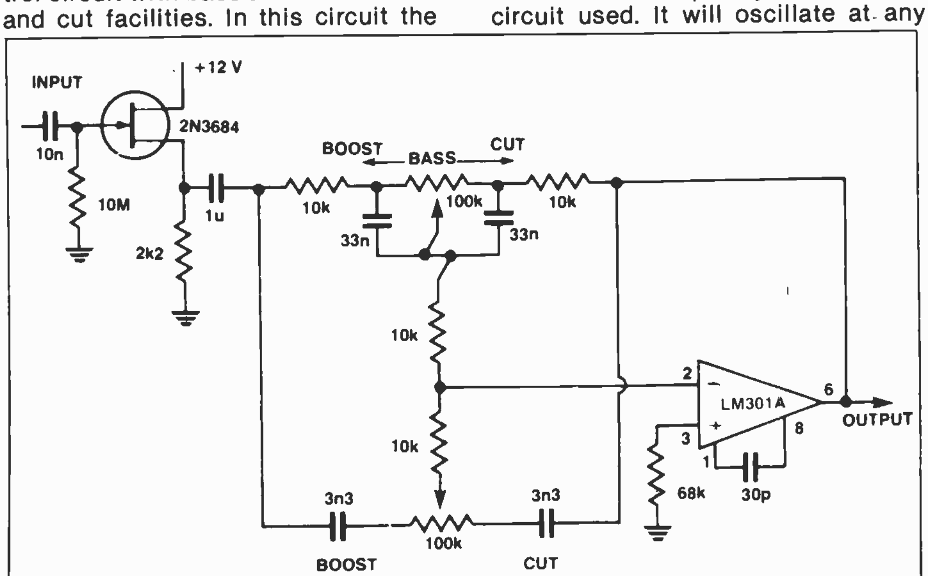


Figure 5. High input impedance tone control circuit (National Semiconductor).

Lambda Oscillator

A very simple sinewave oscillator is shown in Figure 6; it is essential that one n-channel and one p-channel field effect transistor are used in this circuit. The two source electrodes are connected together and the gate of each device is connected to the drain electrode of the other device. This type of connection produces a negative resistance region in the current/voltage graph for the circuit with a peak in the graph like a Greek lambda (λ) — hence the name given to this type of circuit.

It is only necessary to connect the dual device circuit in series with a parallel tuned circuit, as shown in Figure 6, to produce oscillations at the resonant frequency of the tuned circuit used. It will oscillate at any frequency from the low audio region up to some tens of MHz, but the gate capacities of the devices used prevent operation in the regions above 100 MHz.

It is interesting to note that two separate parallel tuned circuits may be connected in series with the lambda circuit instead of the single tuned circuit shown in Figure 6. If one of these tuned circuits resonates at an audio frequency, and the other at a radio frequency, the output will consist of an amplitude modulated radio frequency oscillation. This is perhaps one of the simplest possible modulated signal generators!

The output voltage from the circuit of Figure 6 is equal to twice the steady power supply voltage applied to the circuit. Therefore this type of circuit can be very useful when one requires an output oscillation whose amplitude is accurately related to a steady applied voltage.

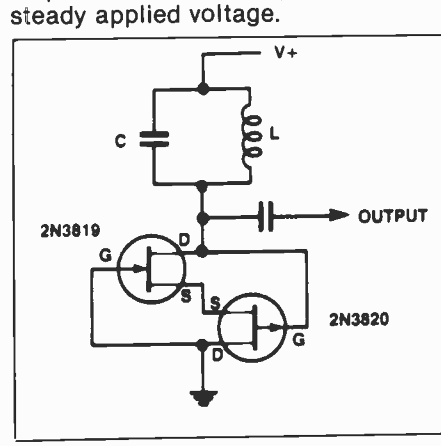


Figure 6. Sinewave oscillator using a 'Lambda' circuit.

Complementary pairs of field effect transistors used in lambda circuits have other applications apart from simple oscillator uses.

High Impedance Buffer Stage

The circuit of Figure 7a shows a buffer or isolating amplifier which has a very high input impedance and low input capacitance. National Semiconductor recommend a 2N4416 field effect transistor for this circuit because it has a low input capacitance, but this is further reduced by the circuit feedback. The device is used as a source follower, so the voltage gain is about unity.

Although a 2N5139 pnp transistor is specified for this circuit, the 2N3906 plastic encapsulated type is much more readily available and is fabricated by the same process, so it can be used in this application.

High Impedance Amplifier

The circuit of Figure 7b is very similar to that of Figure 7a except that the feedback circuit has been modified so that a voltage gain can be obtained. The circuit provides a gain of R2/R1 or 10 with the component values shown. Both the circuits of Figure 7 and of Figure 8 can be operated at high frequencies into the tens of MHz region.

RF Amplifiers

Junction field effect transistors are much used in the radio frequency stages of HF, VHF and UHF receivers, since they offer a noise performance equivalent to that of bipolar transistors with improved crossmodulation and intermodulation performance. Crossmodulation is the transfer of the modulation of one carrier onto the carrier of another signal. Intermodulation occurs when two or more signals outside the passband combine in the circuit to form a signal within the passband which causes interference with the wanted signal.

Figure 8 shows a high-performance amplifier using two JFETs connected in 'cascode' (series) with automatic gain control (AGC) applied to the gate of the upper device. The supply is applied to the 'cold' or 'ground' end of L2 via a feedthrough capacitor. Only the L-C values need be changed to operate this stage on other frequencies to the limits of the JFETs.

Simple Voltmeter

The high input impedance of a junction field effect transistor is used in the circuit of Figure 9 to produce a voltmeter with an input resistance of over 10M; in some measurements this high input impedance is necessary to prevent the current taken by a conventional voltmeter from dragging down the voltage being measured.

The input voltage being measured is divided by R1 and R2 so that a voltage of +0.2V is present at the gate electrode when the full scale input voltage is applied for the range in question. In practice R1 should consist of a fixed resistor of a value somewhat less than that shown in the table, in series with a preset potentiometer so that the sensitivity of the range can be adjusted. If desired, R1 may be switched to provide a number of ranges.

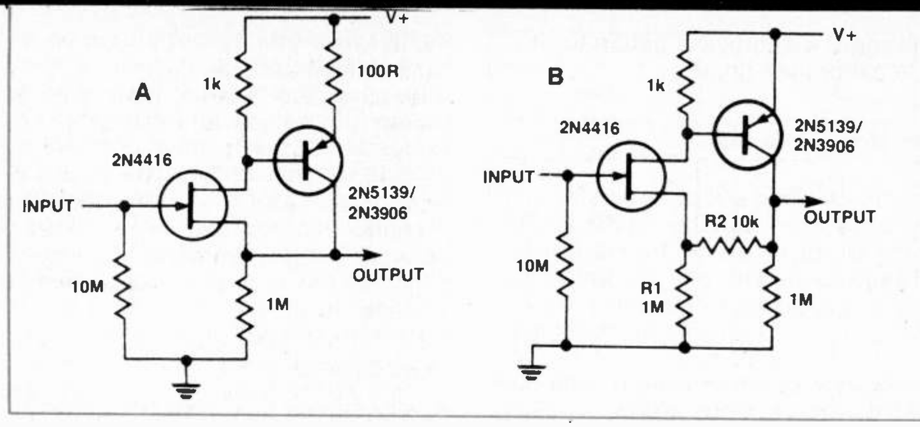


Figure 7. (a) a unity gain buffer stage with high input impedance and (b) similar stage, with gain (National Semiconductor).

No two field effect devices have exactly the same characteristics, and the 2k2 resistor in series with the meter enables the full-scale meter current to be adjusted to allow for the characteristics of the particular device used. The diode protects the meter from over-loading.

PhotoFET

Photosensitive field effect transistors (photoFETs) can be made which have a window or a lens, so that any light falling on this window affects the junction and hence the drain current of the device in much the same way that light affects a phototransistor. However, photoFETs are not very common devices.

An application of a Teledyne Crystallonics photoFET as a light-controlled variable attenuator is shown in Figure 10. The drain-to-source resistance of the photoFET is a function of the intensity of the illumination, so as more light shines on the device, the output rises. The negative voltage to which the resistor R3 is returned determines the range in which the drain-to-source resistance falls. Like other silicon photosensitive devices, the photoFET is sensitive to the red and near in-

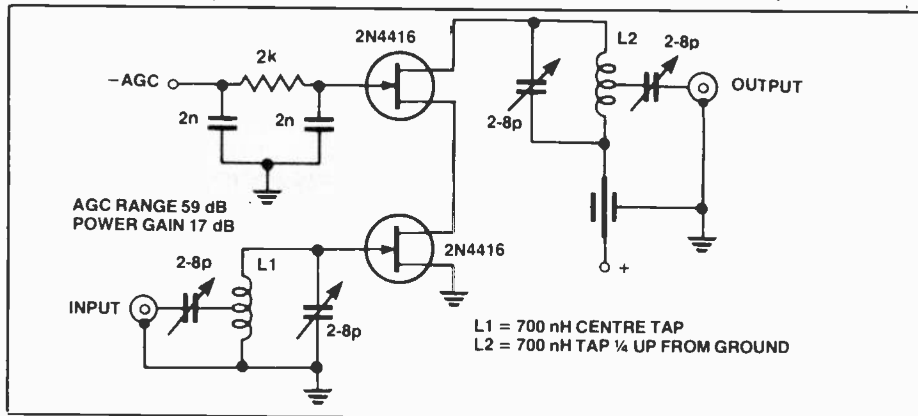


Figure 8. Typical high-performance amplifier stage employing two FETs in 'cascode'. Values given for 200 MHz. A wide variety of RF FETs may be substituted (National Semiconductor).

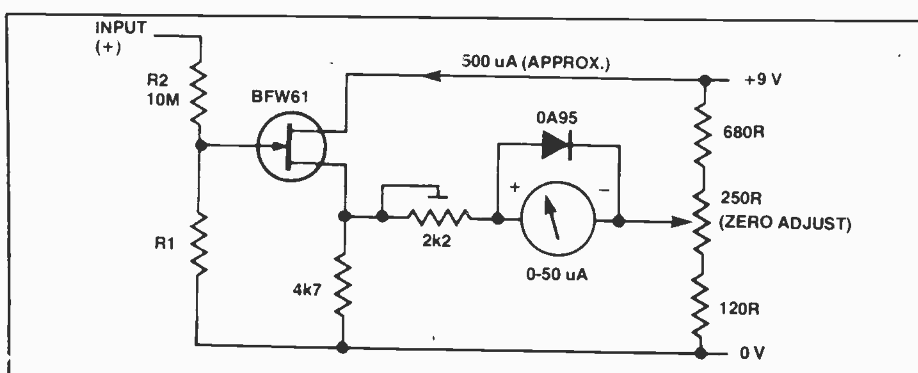


Figure 9. High input impedance voltmeter.

Meter range	R1
250 mV	40M
500 mV	6M67
1 V	2M5
10 V	204k
50 V	40k
100 V	20k
250 V	8k
500 V	4k

Table showing the value of R1 to be used in Figure 9 for various ranges.

frared regions of the spectrum, such as the radiation from an incandescent filament bulb.

How Do They Work?

An n-channel field effect transistor consists of a channel of n-type semiconductor material between the drain and the source surrounded by p-type material of the gate electrode. Almost all of the devices are made of silicon, but a few special devices are produced in other semiconductor materials. As shown in Figure 11, the gate normally receives a negative bias relative to the source and the drain a positive bias.

As the p-type gate material receives a negative bias, the junction formed between this material and the n-type channel is reverse biased. In any reverse biased junction, a region which is depleted of charge carriers (electrons and holes) is formed. As this depletion region contains very mobile charges, it acts almost as an insulator and has a very high resistance.

The gate is normally much more heavily doped than the channel material, since this results in the depletion region spreading fairly deeply into the channel and not very far into the material of the gate. As the drain is normally made positive

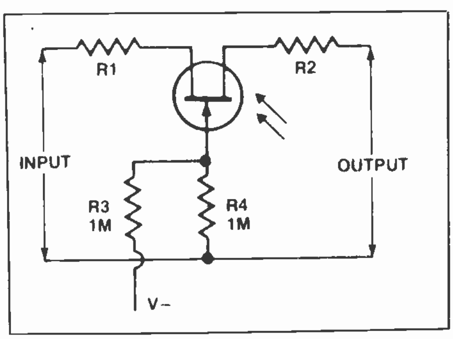


Figure 10. Example of a light-controlled attenuator (Teledyne Crystalonics).

with respect to the source electrode, the voltage between the drain and the negative gate is larger than that between the source and the gate. The electric field is therefore greater on the drain side of the gate electrode and this results in the depletion region becoming deeper on the drain side and thus producing a narrower channel on this side, as shown in Figure 11.

If the voltage applied to the gate becomes more negative, the depletion region goes deeper into the n-channel material until eventually

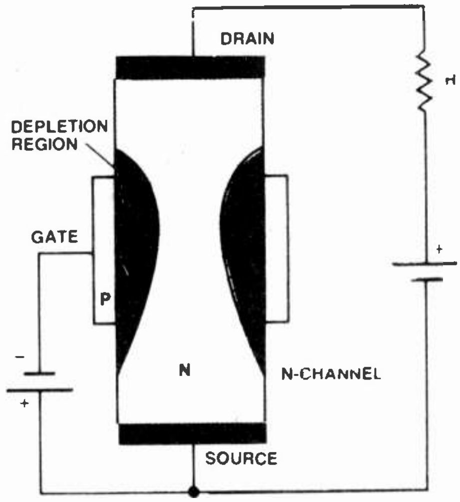


Figure 11. Control of channel width in an n-channel device.

the channel becomes completely cut off on the drain side of the gate. Very little drain current can then flow through the device. As the gate voltage becomes less negative, the channel opens again and becomes wider as the gate voltage approaches that of the source; the widening of the channel under the control of the gate voltage results in the channel current from the drain to source increasing.

As the gate-to-channel capacitance comprises a reverse-biased pn junction, the gate has a very high input resistance and passes only a very minute current (often in the pA region). However, the gate capacitance is appreciable and therefore an appreciable alternating current may flow to this electrode at high frequencies. Even when the gate and source potentials become equal, there is still a small depletion region and the gate input resistance is high. However, if the gate of an n-channel device receives a positive bias of more than about 0.65V, current can flow in the gate circuit and this current may damage the device.

Structure

The design of a modern field effect transistor is not implemented in the form of Figure 11, which has been used for explanatory purposes, but silicon planar technology is usually employed to produce a structure such as that shown in Figure 12. This has a surface or planar structure which is covered with a protective layer of silicon dioxide at all points except where electrode connections are attached. This oxide layer prevents impurities from contaminating the surface of the material and thus producing unwanted currents.

The aluminium contacts at the source and drain electrodes allow current to flow from them into the heavily doped small n+ regions, which make good contact with the n-channel region. In some devices a number of n-type channels are connected in parallel to enable a larger current to flow at the expense of an increased gate capacitance.

P-Channel Types

P-channel field effect transistors have the same type of structure as shown in Figures 11 and 12, but the p and n type materials are interchanged. The gate is made of n-type material and must therefore be biased positively, as shown in Figure 13. The drain is normally biased negatively.

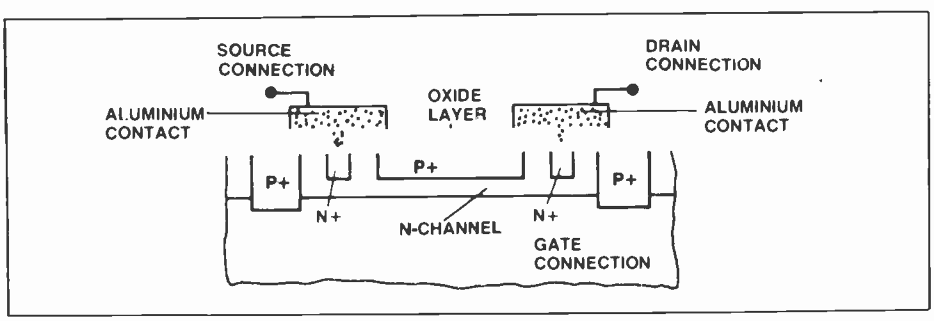


Figure 12. Structure of a silicon planar device (Mullard).

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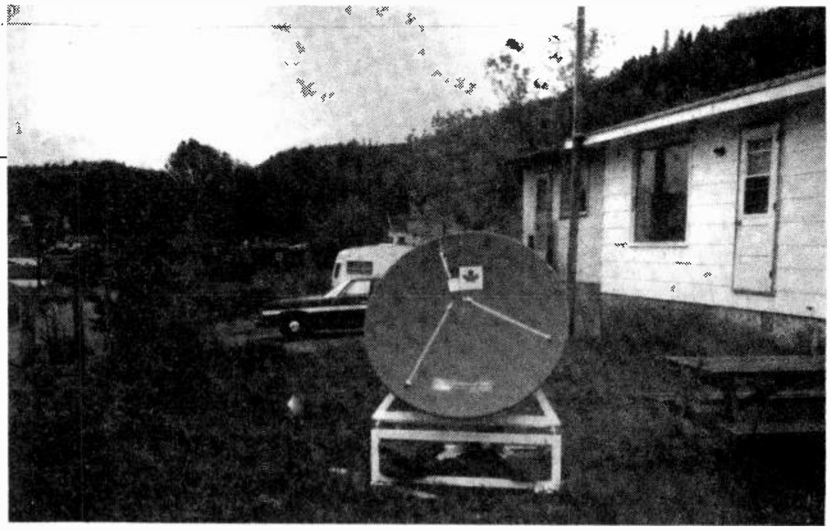
Satellite TV for Home



A downlink in Northern Ontario.

It may be high, but it's not out of reach. Jake Milligan explains.

THE SUBJECT OF HOME satellite reception has been receiving an increasing amount of attention in recent years. While there are certain limiting factors, it is certainly within the realm of possibility for any technically oriented person to assemble a backyard earth terminal. First of all you require a suitable location. Most urban backyards would not accomodate the usual satellite antenna. Since the satellite that most experimenters are interested in is located over the Pacific Ocean at 131 degrees, 23,000 miles above the equator, you must have a clear shot at the horizon with an elevation of around 20 degrees in Southern Ontario. Since the antenna is usually mounted on the ground the average backyard is ruled out because of neighbouring buildings and trees. However, if you do have a location that gives you an unobstructed view of the satellite of interest, then cost becomes the next consideration. Here, you have a number of choices. (1) You can contact any one of several firms specializing in home installations and pay anywhere between approximately $4,000 and $10,000 for the complete terminal. (2) You can purchase the various manufactured components (Antenna, Low Noise Amplifier, Receiver, modulator etc.), and install your own terminal. ETI has carried ads for such equipment. The Dexcel DXP combination LNA and receiver for $2,995 is a good example. I have seen this unit operating and it performs quite well. The same ad offers a 12' antenna for $995. This is just one example of what is commercially available. Another example is a newly announced M/A Canda unit for $1,500 (LNC and RCVR). (3) You can build all or part of the terminal yourself and not only save money, but have the satisfaction of personal accomplishment.

In the Air

The satellite signals are transmitted between 3.7 and 4.2 GHz (Gigahertz) with a five watt transmitter in geostationary orbit above the equator. This means that you require a very high gain antenna and a very low noise pre-amplifier for satisfactory reception. The antenna should have at least 40 db of gain at 4 GHz and the noise figure of the LNA should be 1.5 db (120 degrees Kelvin), or better for sparkle-free reception in Canada.

The 500 MHz of spectrum between 3.7 and 4.2 GHz is filled with twelve channels of horizontally polarized signals and twelve vertically polarized channels, (on the RCA Satcom birds). Some of the other satellites use only 12 horizontally polarized transponders.

The receiver must be capable of tuning the entire 500 MHz satellite band with a final IF bandwidth of between 20 to 36 MHz usually centered on 70 MHz. Since the signal is frequency-modulated a suitable detector is required to produce a standard base-band video and audio output. The two most commonly used types of detectors are the classic limiter-discriminator detection system and the phase-locked-loop method that appeared to be more popular a couple of years ago. The audio signals are transmitted as FM subcarriers along with the video. The most commonly used frequency is 6.8 MHz, which is separated from the video after detection and processed through a relatively simple variation of standard audio FM detection.

The foregoing scratches the surface. What follows is an account of personal experimentation over the past few years.

Nuts and Bolts

About three years ago I decided to build a satellite receiver, at the least possible expense. Taylor Howard had just published a manual that showed how to do it yourself for less than $2,000 (U.S.). With the aid of his manual I set about to round up the necessary bits and pieces. The first requirement, was, of course, an antenna. Howard was fortunate enough to acquire a used 15' radar antenna for next to nothing. I couldn't find anything like that around so I started to look for something inexpensive that would serve the purpose. I thought that perhaps the petalized aluminum silo tops might be adapted for that purpose. I was able to pick up one of those for a reasonable price. It was 20 feet in diameter, but I was unable to modify its shape sufficiently to conform to a parabolic curve. However, a friend of mine, Jan Spisar, who had just finished getting his own earth station operating offered to bring his receiver and 4 GHz spectrum analyser to see if we could receive anything at all from this huge monstrosity. We were able to get recognizable pictures from Anik, but decided that the structural changes required to bring the surface within acceptable tolerances, and thereby bring the gain up to at least 40 db, were going to be too expensive to be worthwhile. So I started to look for an alternative. Quite by chance while visiting an artist friend near Claremont, he mentioned that one of his neighbours had something that sounded suspiciously

SATCOM F3

CATEGORY	Tr.#	SERVICE
Independent TV Stations	3	WGN - Chicago, Channel 9
	6	WTBS - Atlanta, Channel 17
Movies Only	5	THE MOVIE CHANNEL
	16	HTN PLUS
	20	CINEMAX (East)
	23	CINEMAX (West)
Movies Plus Entertainment Specials	4	SPOTLIGHT
	10	SHOWTIME (West)
	12	SHOWTIME (East)
Movies, Entertainment Specials, and Sports	13	HBO (West)
	24	HBO (East)
Religious	2	PTL (Praise The Lord)
	16	NJT (National Jewish Television)
	18	EWTN (Eternal Word Television Network)
Sports	7	ESPN (Entertainment & Sports Programming Network)
Unique	9	USA CABLE NETWORK
	16	ACSN (Appalachian Community Service Network)
	19	C-SPAN (Cable Satellite Public Affairs Network)
	22	USA BLACK NETWORK
Health	17	CABLE HEALTH NETWORK
News	14	CNN (Cable News Network)
	15	CNN HEADLINE NEWS
	18	REUTERS MONITOR SERVICE
Cultural	1	ARTS (Alpha Repertory Television Service)
Music	11	MTV (Music Television)
Children's	1	NICKELODEON
Women's	22	DAYTIME
Weather	21	THE WEATHER CHANNEL
Consumer Information	22	MSN (Modern Satellite Network)
Family	8	CBN CABLE NETWORK, The Family Entertainer

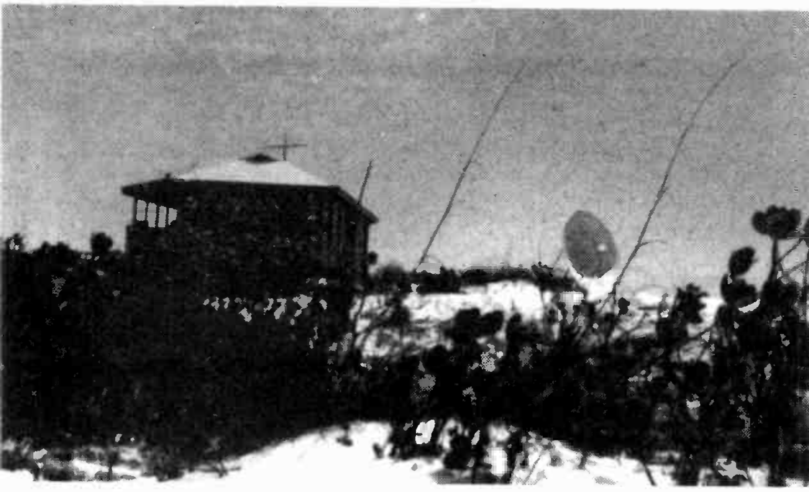
SATCOM F4

CATEGORY	Tr.#	SERVICE
Movies, Entertainment Specials and Sports	18	HBO (Home Box Office)
Religious	7	NCN (National Christian Network)
Adult Entertainment	7	Escapade/Playboy
Cultural	6	Bravo
Movies	19	The American Network
Unique	8	The Entertainment Channel
Business News	15	BizNet

There are several other satellites with television of interest on them, including some of the Westar birds.

WESTAR 4

CATEGORY	CATV Format	Westar Format	SERVICE
Variety	22	11X	SPN (Satellite Program Network)
Ethnic	16	8X	SIN (National Spanish Television Network)
	24	12X	GalaVision
Business News	18	9X	FNN (Financial News Network)
Movies Plus Entertainment	18	9X	SelecTV
Adult Entertainment	19	10D	EROS



Another downlink.

like a ten-foot parabolic antenna. We visited his neighbour's farm and sure enough there was this 10 foot dish. His neighbour is an artist who specializes in metal sculptures and he had acquired it as scrap, intending to use it in one of his sculptures. I persuaded him to part with it for a reasonable sum and arranged to have it delivered to my rural home, outside Mt. Forest. Now I had an antenna.

The next requirement was a low noise 4 GHz amplifier. It had to have at least 40 db of gain, and a noise temperature of 150 degrees (at that time) Kelvin or lower. According to Taylor Howard, it was possible to build one with relatively inexpensive parts. New LNA's at that time were selling for around $2,000 (U.S.). I ordered the Hewlett Packard low noise bipolar transistors and printed circuit board and assorted microwave chip capacitors. However, when they arrived, I realized that the assembly and testing of these tiny components were going to take more time, skill, equipment and patience than I possessed so I decided to buy a new LNA. The best deal I could find at the time was a 150K (1.8 db N.F.) unit from SCI for $1,500. The rest was relatively easy. I built a dual conversion unit that converted the 4 GHz signal down to 1,200 MHz in the first stage and then down to 70 MHz in the second conversion. At 70 MHz I was able to use surplus cable TV equipment for the necessary amplification and limiting. I didn't use the Taylor Howard method of detection, using a phase locked loop, but rather chose to use slope detection to at least get something. Having access to wideband sweep gear made it easy to align the apparatus and have it operating in approximately the right range of frequencies. The next problem was to find the satellite signals and then refine the equipment until satisfactory pictures were received.

Using a compass, a level and protractor we got the 10 foot disk pointing in what we thought was the right direction for Satcom I. After many hours of probing we could detect nothing. Since the 10 foot disk was mounted in a rather rudimentary fashion, it was difficult to move it smoothly and we were unable to locate any satellite signals. I found an old 4 foot dish that was left over from some Gunnplexer 10 GHz experiments. I decided to use it to see if I could find any trace of signal. The 4 foot dish could easily be hand-held and pointed in any direction. We were soon able to detect recognizable Satcom signals. They were very noisy but we could make out the large star logo that was used at that time on what is now the Movie Channel. Once we had established the exact direction with the 4 foot dish it was easy to move the ten footer to the same position. Then we changed over the LNA and feed-horn and had pictures. They were still far from perfect, but were watchable. I now had a signal to work with. I worked on the detector until the pictures were almost perfect and then I set about to recover the sound. I decided that the best way was to convert the 6.8 MHz sound sub-carrier to the middle of the FM band, around 100 MHz, and receive the sound on a standard FM receiver. This worked quite well and was not difficult to do. It was easier than building a complete sound section.

I have built seven or eight receivers since then and a number of spherical antennas with a number of refinements until I am now able to watch perfect pictures from Satcom IIIR (the replacement for Satcom I). I still use the conversion technique and standard FM receivers for the sound, so that with two FM receivers each tuned to a different sub-carrier I can receive full stereo on those transponders that now transmit in stereo.

This gives a rough idea of the experiments we have carried on over the last few years. To cover all the details would take considerably more space than this article will allow. For example, the single conversion image reject mixer and delay line limiting detector deserve an extensive article on their own.

What's Up?

The most popular single question that is raised when talk turns to backyard satellite TV concerns the legal aspects. It is not illegal to have a satellite receiver for your own private use. There have been three court cases (that I am aware of) involving commercial applications, but in all three the Government authorities have lost. There has never been an attempt to prosecute any of the hundreds (perhaps thousands) of private users, and in fact the Department of Communications has stated that they are not concerned with such private terminals.

The second question most frequently raised has to do with what is available from the various satellites. I won't attempt to list everything, but we include a list of what is now available on one Satellite, the RCA Satcom IIIR.

The author's own dish.

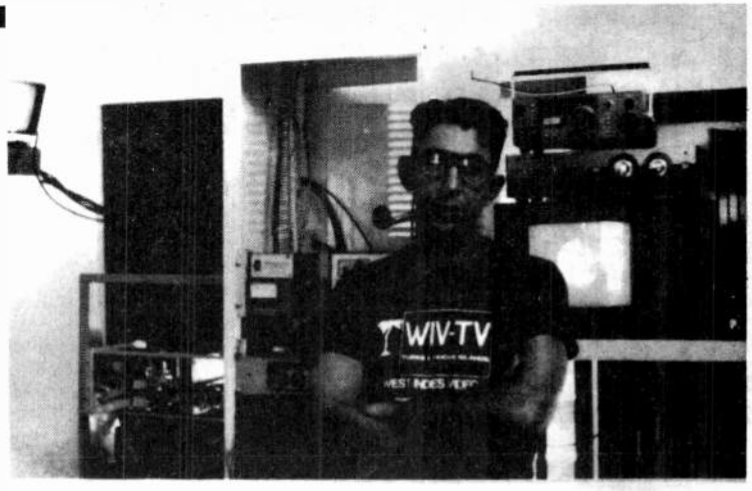
The next generation of satellites will operate on 12 GHz and will be receivable on a 3 foot dish. Current projections indicate that as early as 1986 there will be as many as one hundred channels available on 12 GHz, with commercial home installations costing as little as $300. In the meantime it is possible to build a 4 GHz earth terminal for a comparatively low price. The price of commercial LNA's has dropped to as low as $400 (U.S.) for a 120_K, 50 db gain unit. A 12 foot spherical antenna can be built for as little as $300 (excluding labour) and a commercial 4 GHz receiver can be purchased for well under $1,000 (U.S.), or home built for even less. Here is a partial list of sources of hardware for home satellite construction:

M/A Communications Canada, Mississauga, Ont. -LNA's, LNC's, receivers
Andrews Antenna Co., Whitby, Ont. - antennas
Trainor Communications, Pickering, Ont. - complete systems
Boman Industries, Downey, California - all necessary components
Satellite Earth Station Technology, Inc., Mississauga, Ont. -complete systems
Nu West Video Systems Inc. Vancouver - components and complete systems.
Lindsay Antenna, Lindsay, Ont. - antennas, mounts, LNA's, receivers.

The foregoing partial list gives a few of the dozens of firms now operating.

A new company, Satcom, of San Jose is planning to market equipment soon and the following quote from Dr. Jacobs of Satcom gives a glimpse at some future possibilities:

"By the end of this year, we will see 6-foot antenna dishes for sale for C-band (4 GHz). Improvements in noise reduction technology are going to make these feasible.



Bob Cooper's receiver.

These improvements include: drop-out compensation technology— already used in the video tape industry — which permits replacement of noise with signal, considerable improvement in low-noise converters, and great improvements in receivers,".

As electronic improvements to receiving equipment make excellent TV reception from 6/4 GHz satellites possible using 4-6-foot antennas, "we will see a proliferation of home C-band antennas" and the increased use of these lower-cost antennas for SMATV systems, Jacobs said.

A modulator is required to take the video and audio signals from the microwave receiver and convert them to a standard TV channel for viewing on your standard TV set. Any home VCR makes an excellent modulator, although there are a multitude of inexpensive modulators available that will perform the same function.

ETI

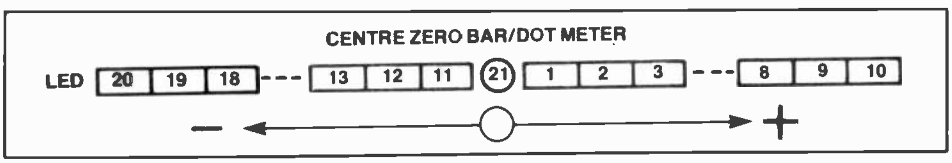
Designer Circuits

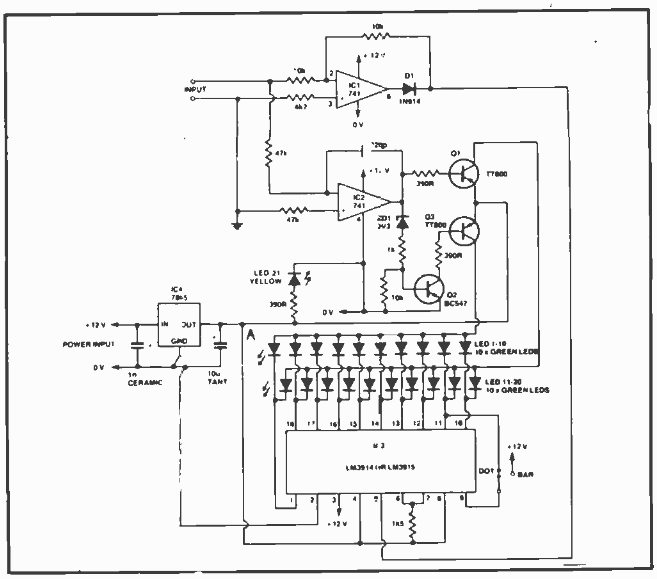
Centre zero LED bar/dot meter

THIS CIRCUIT drives twenty LEDs with a single bar/dot driver. Ten LEDs (green) are for a positive input signal and ten LEDs (red) for a negative input signal. A yellow LED, which is lit permanently, gives the centre zero indication. The LEDs would, for best effect, be mounted on a panel as shown below in the circuit.

When used in the bar mode, the bar of light elongates to the left for an increasing negative signal and to the right for an increasing positive signal.

When the input is negative, the output of the comparator swings low, switching off Q3 and switching on Q1, which enables LEDs 11-20. As there is no gain in the absolute value amplifier, the full-scale reading is equal to that set by the internal reference of IC3. This means that the full-scale value of this circuit is about ±1.2 V. This value can be altered by conditioning the required input signal. The LM3915 may be substituted for the LM3914 if a logarithmic, rather than a linear, scale is desired.





ETI

6500 CPUs

Henry Budgett takes a look at the 6500 family in general, and the 6502 in particular.

THE 6502 CPU has hogged the limelight owing to its starring roles in such machines as the PET, Apple, and ATOM. However it is far more than just a one-off. Part of a complete family of devices, the 6500 series, it represents the public face of the design architecture.

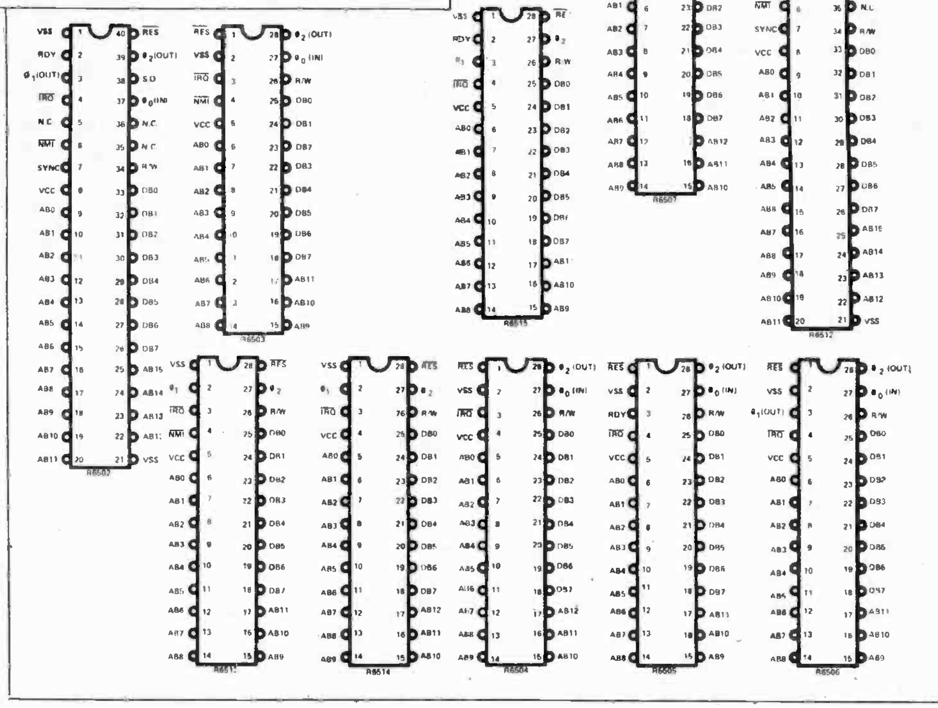


Fig. 1 Pin designations for all the CPUs in the 6500 family.

Family Characteristics

Figure 1 and Table 1 give the details of the whole range; there is a new device promised but I don't have details yet. Although I'm going to concentrate on the 6502, most of the information is directly relevant to the others in the family.

Physically it is supplied as a standard 40 pin DIP which needs a single 5V supply and a clock generator. Internally the device operates on a two phase clock but this is generated from a single input which should be crystal controlled. The CPU actually sends the second clock phase back out again for synchronisation purposes and this appears on pin 39.

The size of the internal data bus and its associated registers is eight bits — hence the term 'eight bit micro'. These registers and the rest of the internal workings are shown in Fig. 2. It should be noted that this block diagram is for the generalised 6500 device and not the 6502 specifically but the differences are slight. Although the data bus is only eight bits wide the address bus is a full 16 bits across which gives access to 65,536 possible memory locations. Some of the other members of the family, notably those with only 28 pins, have a more limited addressing capability. Table 1 has the details.

Pin By Pin

In order to take a close look at the functioning of the device I'll go through it pin by pin. Where to start? Being logical (?) let's begin with the data bus. This occupies eight pins, 26 to 33 (DB_7 to DB_0) and is a true tri-state, bi-directional highway. What's actually on it at any given instant is controlled by the pins R/W (34) and RDY (2). The functions of these will be explained later.

The address bus is found on pins 9 to 25 (AB_0 to AB_{15}). This is a unidirectional bus, you can't 'read' an address. The addressing capabilities of these 16 lines are shown in Fig. 3, obviously those 6500 series devices with fewer address lines can only access a part of this range. An address is set onto the lines during the Ø1 clock pulse and is stated as being 'valid', jargon for being stable and OK, some 300 nS after Ø1 goes high (given a 1 MHz clock). The address remains stable on the bus until the next Ø1 clock pulse.

Of Reading And Writing

The R/W pin (34) controls the direction in which information travels on the data bus. The line is normally high (READ mode), unless the processor wishes to send something to memory or the outside world (WRITE mode) in which case it is forced low. All transitions (changes of state) occur during the Ø1 period which allows data to be transferred during the Ø2 clock period. The second major control line for the buses is the Ready (RDY) line found on pin 2. This is normally high but when pulled low, during Ø1, it effectively shuts the CPU down — provided the current operation is not a WRITE. This allows slow memory devices such as EPROMs to be catered for and, more importantly, operations such as DMA, Direct Memory Access, to occur.

Interruptions

The 6502 supports two types of interrupt, Non Maskable and 'normal'. The

Features	R6503, R6513	R6504, R6514	R6505, R6515	R6506	R6507
Addressing Capability	4096 Bytes (AB00-AB11)	8192 Bytes (AB00-AB12)	4096 Bytes (AB00-AB11)	8192 Bytes (AB00-AB11)	8192 Bytes (AB00-AB12)
Interrupt Request Capability	$\overline{IRQ}$, $\overline{NMI}$	$\overline{IRQ}$	$\overline{IRQ}$	$\overline{IRQ}$	—
'Ready' Signal	—	—	RDY	—	RDY
*Timing Signals Required	Single Phase TTL Level 00 (IN), or Crystal or RC	Single Phase TTL Level 00 (IN), or Crystal or RC	Single Phase TTL Level 00 (IN), or Crystal or RC	Single Phase TTL Level 00 (IN), or Crystal or RC	Single Phase TTL Level 00 (IN), or Crystal or RC
Other Control Signals	$\overline{RES}$, R/W	$\overline{RES}$, R/W	$\overline{RES}$, R/W	01 (OUT), $\overline{RES}$, R/W	$\overline{RES}$, R/W

*6513, 6514 and 6515 are slave microprocessors requiring external 01 and 02 clock inputs

Table 1. Details of each of the CPUs.

Non Maskable Interrupt (NMI) is a control input found on pin 6 and this should normally be held high. The processor must break off from whatever process it is currently performing (it performs essential 'housekeeping' first) when this line goes low. Being an edge triggered control the line can stay low indefinitely without causing further interrupts, to issue another it must first be taken high and then low again. When an NMI occurs the current status of the program counter and the status word are saved on the stack and the program counter is then loaded with the interrupt vector, in the case of the 6502 this is FFFA and FFFB. The contents of this memory pair contain a further address which is the start of the interrupt service routine.

The case of the other interrupt is rather more complicated in that it can be turned off if you want by manipulating a bit in the status register. The physical manifestation (classy eh?) of this control is a pin labelled IRQ (4) which is normally held high. When pulled low by a peripheral device it signals an interrupt to the processor. If the interrupts are enabled then a similar action to that of the NMI is performed. It should be noted that the IRQ line is not edge triggered so as long as the line is low the CPU will try to service interrupts.

The ultimate interrupt to any CPU is the RESET (RES) signal which is found on pin 40. During power-up this line should be held low until conditions have stabilised and then taken high. In practice a simple RC combination will suffice. When the line goes high it causes the processor to fetch a new 'vector' from a specific address, this loads the program counter to a known starting point in the user program. In this way the machine powers up with all the functions set correctly; the line should also be fed out to all the support chips to ensure that they too turn on correctly.

Alone in the 6500 series the 6502 possesses a control line called SYNC which is found on pin 7. This is used to identify the specific cycle taking place within the CPU, it approximates to the M1 signal in the 8080. The line goes high during Ø1 of an OP-CODE FETCH and is used to tell the outside world to mind its own business for a while. If the RDY control is taken low during the same Ø1 cycle as the SYNC goes high it stops the processor in its current state. This allows single instructions to be executed if handled correctly.

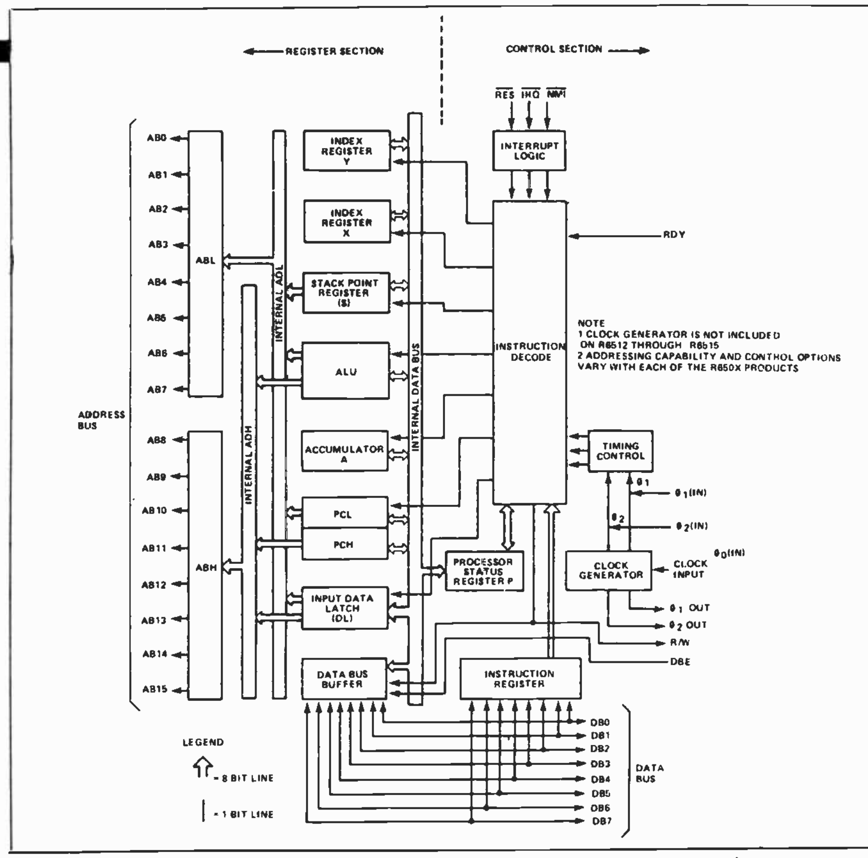


Fig. 2 Block diagram of a 6500-series CPU. The registers are all eight bits wide except the program counter; this consists of a high and low byte (PCH and PCL).

There is one further control line called SO which appears on pin 38. It is not used—except with a specialised I/O port—so you can ignore it.

Registered Design

So much for the outside, what goes on inside that hunk of black plastic? The block diagram of Fig. 2 shows the registers; the only ones of interest from our point of view are the stack pointer, the program counter and the status word. Although the address range of the 6502 requires a full 16 bit bus the stack pointer only contains eight bits. These eight bits act as the lower half of an address, the top half being set at 01 Hex. The 6502 stack is an area of memory that resides in Page 1 (hence the 01 Hex top half), which is used by the CPU and the user programs as a temporary storage area.

A Program Counter consists of a 16 bit register which contains the address of the next instruction to be executed, or rather it contains the address of the next memory location which will be accessed.

The status word is important to both the hardware and software engineer. Eight bits wide, it contains seven flags which indicate the current status of sections of the hardware within the CPU. Bit 0 indicates the carry status; it gets set if the result of a calculation in the Accumulator exceeds 255, and is effectively a ninth bit in the Accumulator. Bits 1,3,6 and 7 are concerned with the programming aspects of the device and Bit 5 is not used. This leaves Bit 2 which is the Interrupt Disable flag that I mentioned earlier, and Bit 4 which indicates that a BREAK instruction has been found.

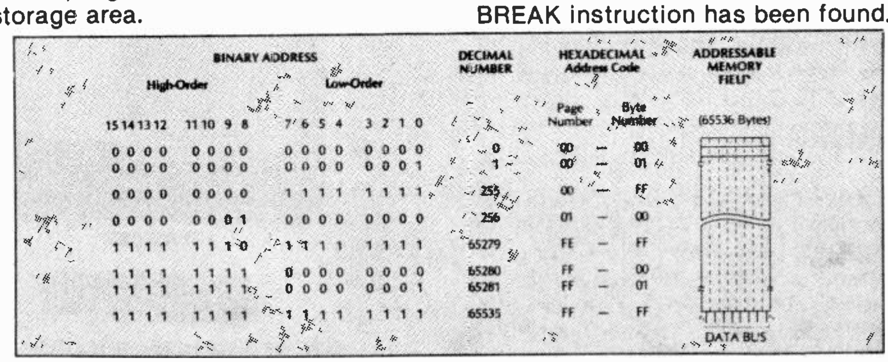


Fig. 3 The addressing range of the 6500-series. Only part of this range can be covered by some of the CPUs.

Apple Pirates

Imagine a 6502 based system exactly like an Apple II, but at a fifth of the price. Imagine it's real. See . . . dreams do come true. By Steve Rimmer.

HEY YOU WANNA BUY a computer? This is one amazing system . . . 48K o' RAM, 6502 processor, BASIC in ROM, high resolution graphics, mother board with seven peripheral slots and it runs software for the most popular system goin'. Couple a' hundred bucks'n change. Have I ever lied to you? (Have I ever seen you before?).

Actually, this is no joke. It's a real live machine, and you too can have one for less than five hundred dollars. While it goes by many names, depending upon the skulking nether troll from which you obtain it, be it a Zapple, Crab Apple, CandyApple, Fallen Apple, Scrapple or "the 6502 board with no name", you'll probably recognize it as being almost identical to an Apple II.

There's a new resurgence of interest in the always popular Apple II . . . although the Apples in question aren't coming from Apple. They are eminating mysteriously from small shops here and there, complete with little bags of parts to populate them. Originally, all that was involved were copies of Apple motherboards, but, of late, there have been imitation Apple power supplies, keyboards and cases. Apple is not smiling.

Given the appropriate quantities of chips and one of these boards, one can build up a completely functional copy of an Apple II computer, with up to 48K of RAM on board, colour high resolution graphics and all the other real nifty stuff for about two hundred and fifty dollars without the power supply, keyboard and case. Of course, there are a few strings attached.

Trouble In The Orchard

The story should probably begin with the Apple II itself, the real one that we all know and can't afford. It was designed quite a while ago by two fellows named Steve Wozniak and Steve Job down in California, which is where most of Western civilization eminates from. In the eight or so years during which it has been extant upon this planet, the design has changed only trivially, mostly to correct some initial bugs. It may be the most enduring computer in history, and has certainly been among the most popular. It is also one of the more expensive, with your basic Apple starting at over two grand.

The principal protagonist in this drama, or at least, the first actor on stage, is one Bill Jackson, the proprietor of a Toronto electronics emporium called Parts Galore. Some time ago, prior to the opening of Parts Galore, Bill came across a number of EurApple boards being dumped very cheap down in California. These were actual Apple motherboards, unpopulated but with all their sockets, designed for use with European TV sets. As it turned out, by doing a bit of hacking, installing about thirty jumpers, one resistor and a new chip, these things would run on our type of sets. Because he did not yet have a store of his own, Bill sold these boards to another Toronto electronics shop. Most of them were thence peddled under the counter to friends and people who had heard rumours of their existance as no one was quite sure what the heavies at Apple were going to do.

However, these were completely legitimate Apple boards, scrapped by Apple and sold as such.

At about this time, a company in the States named Franklin produced the first "Apple II emulator", a machine which could run all existing Apple software and accept all Apple peripherals, called the Ace 100. The thing about Apple emulators is that Apple programs are so intertwined with the hardware and software that an Apple emulator has to be pretty much an Apple copy, which was, to a large degree, what the Ace was. (It actually had a few enhancements; for a more complete look at the Ace, see ETI September 1982.) The only aspect of the Apple design that Apple had a pretty decent hold on was the colour circuitry. The original Ace got around this by being black and white only. Later versions are said to include redesigned colour sections which do not violate Apple's patents.

Predicatably, Apple laid a blinding array of lawsuits on Franklin. As of this writing, we are told that all have been settled in Franklin's favour, who are, in turn, said to be launching countersuits against Apple totalling around one hundred and fifty million dollars.

In fact, there is nothing about the Ace that's a direct copy of anything in the Apple. The case is different, the printed circuit board is completely relaid out, and the software ROMs have, technically, been altered, as the power-up message says ACE, rather than APPLE. There also seem to be a few minor changes in the character handling routines. Once again, Apple is not smiling.

At the time of this writing, Smart Screens, a Toronto based computer place, and Mega Byte Micro Systems of Montreal had gotten together to import another Apple II emulator from the East, called the Golden II. It goes the Ace one better, in that it actually looks like an Apple on the outside. In

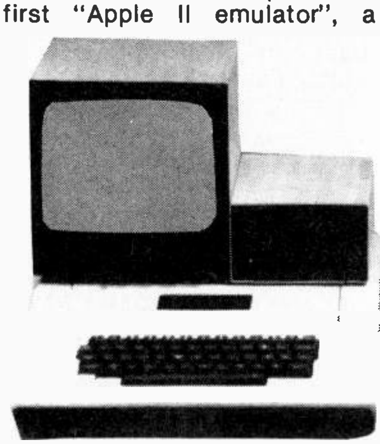


Fig. 1 A fully built up Apple II copy system, with plastic case and keyboard. This copy looks exactly like the real thing except for the logos. It's also functionally identical, running all Apple II software. However, it costs around a fifth of the retail price of a real Apple II to assemble.

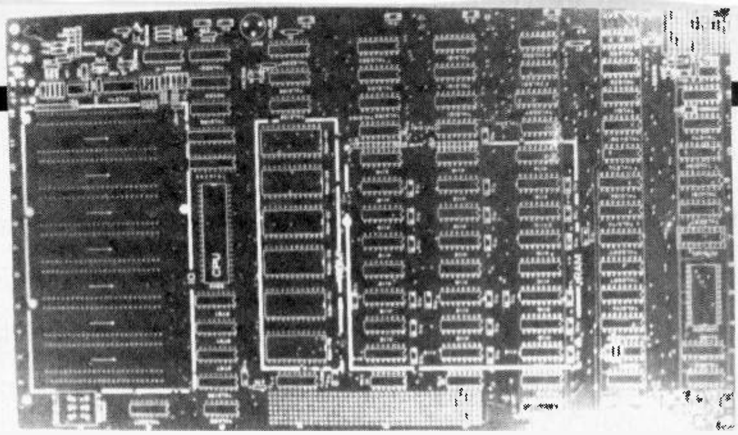


Fig. 2 The Parts Galore bare board.

speaking to a representative of Smart Screens, we were told that legal investigations have uncovered no infringements on Apple's claims by this system

Meanwhile, Bill Jackson eventually got his own store going in Toronto, and, as the Apple copy industry seemed ready to take off, he got into providing the boards and other assorted non-Apple Apple paraphernalia. The EurApple boards had all long since been sold, but he found that there were several sources of custom made motherboards. These were not direct copies of the Apple circuit board, but had been relaid out, sometimes with slight circuit changes, chiefly in the area of the character generator. As such, they could not be said to infringe directly on any Apple copyrights, any more than could the Ace boards, which were really the same trip on a rather larger scale.

The legalaties work something like this. As the PCB had been re-laid out, it could not be said to be an infringement of Apple's copyright on its board as a piece of artwork. It also could not be said to be a scarfing of Apple's patents on the Apple II as a device, because it was just a bare board. Even though there is one particular way to stuff it and make it become a computer, there are also lots of other ways to stuff it and make it into other devices. Most of these latter devices would be nonfunctional, of course, but this is of little concern. Selling an Apple-like board plus all the parts to populate it is not the same as selling an Apple-like computer, because what becomes of it after it is sold is beyond the power of the guy selling it. It is also important to note that any private individual can build a patented device for his or her own use, and, providing it is not going to be sold, it will not be infringing on anything.

In the interval between then and now several other sources for boards and parts sprung up. The current ones are shown in table 1. It should be noted, however, that there are a number of different parties doing these things up and that the quality varies enormously. Some are imported from the Far East, some are made by an Ottawa based firm, some are done by a large PCB manufacturer in Scarborough and a few clumps of boards have emerged apparently made in a basement somewhere in Toronto. As the Apple motherboard is a fiendishly complex beast, double sided with plated through holes, even minor lapses in quality control can be a bit of a disaster.

Rory Jan is another intergral figure in this opera. Originally involved in designing smart terminals, he somehow managed to get into the fake Apple scene as the grand imperious board reincarnator. He spends a great deal of his time these days bringing to life boards that people have built up, powered up and then wept over. He charges fifteen dollars an hour, and can fix most minor problems . . . it's always something simple . . . in two hours or less. He, unlike Apple, smiles quite a lot.

Table 1 also lists his address.

As Rory puts it, taking an Apple copy board to an authorized Apple dealer, should it fail to power up, is usually a fruitless and expensive proposition . . . assuming you can talk them into looking at it at all. The technicians are used to dealing with computers which were, at one time, working, and thereafter died under their own steam. Thus, tiny solder splashes, chips in backwards, chips in the wrong sockets, bad substitutions for parts, board errors . . . we'll get to that . . . and so on, the lot of the fallen Apple, are usually quite beyond them. As such, it is possible to take your Apple copy in for service, blow a hundred dollars on it and not even emerge with a working board.

Having seen his share of fake Apples . . . his place has taken on aspects of quitting time at the fibreglass factory . . . Rory is also in possibly the best position to comment on the various boards that are floating around. He feels that the ones that Bill Jackson has imported from Hong Kong and is selling out of Parts Galore are the best, in as much as they have absolutely no board or silk screen errors and can be expected to be 100% working on power up if one has not created any problems during construction. Other boards have varying hassles. The first batch of made in Toronto boards, he says, had gross silk screen errors which had one putting in bypass capacitors which were ten time too small, colour phase shift capacitors which were wrong and omitting some parts altogether. There was also a resistor missing in the cassette circuit, rendering it non-functional. These boards have all largely been sold, and what is left of them are being dumped at between twenty five and thirty five dollars a board by a few surplus places. The second generation of Toronto non-Apples is rather better, although there's still the missing resistor in the cassette circuit. This requires a minor hack to install. However, consider that most Apples are used with disks and this doesn't seem so bad. (The really gross boards are, of course, still a good trip if you already have a working Apple to compare them to, and are, for example, doing one up for a friend).

We got to have a look at an example of the Scarborough boards, in this case in the middle of an up and running computer. Carefully scrutinizing this entry disclosed no errors, and the workmanship was very nice. These are the boards built by Hitek, in good old Table 1.

Having dealt with the basics of

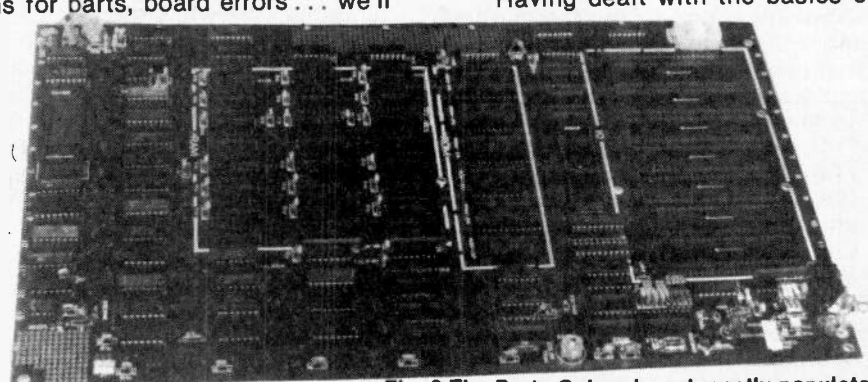


Fig. 3 The Parts Galore board mostly populated.

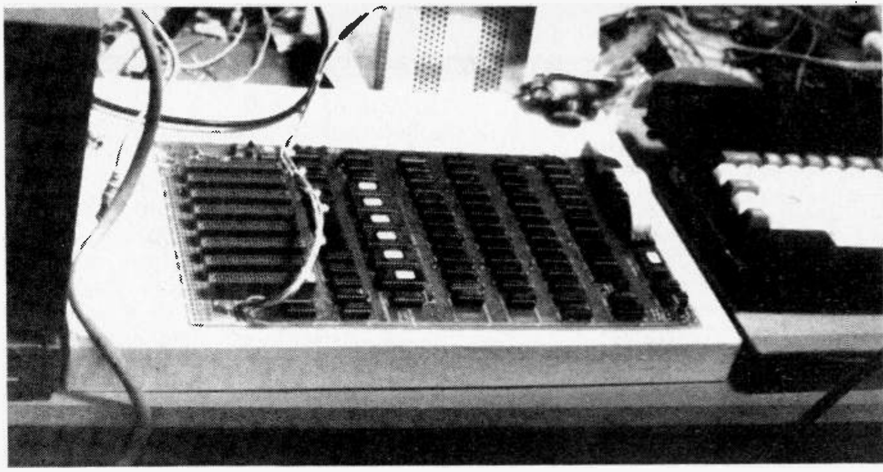


Fig. 4 The Hitek board.

the hardware, the next concern is the Apple ROMs. This is a bit trickier. The Apple motherboard holds six ROM chips, each with 2K of machine code software in it.
(Afficianados will want to note that Jackson's boards can use either six 2716's or three 2732's to hold their software). This normally holds the onboard BASIC, the cassette operating system, the I/O routines, the graphics routines and the machine language monitor. Apple does have some pretty decent grounds for copyrighting its ROMs. Franklin seems to have gotten around this by making minor alternations to them, but it cost them a large sum while in court to prove it. As such, the ROMs are not available over the counter in quite the way the boards are. In fact, the ROM situation is quite sticky. (And, for those who are curious, Ace ROMs will not work, due to some minor weirdnesses in the Ace character generator).

In fact, one Toronto parts place who was selling ROMs seems to have been slapped with a cease and desist order by Apple.

There are several approaches to the ROM hassle. The obvious one is to buy them from Apple. This is, in fact the only legal way to go about it. However, the first glitch is the price, which was up at around two hundred and fifty dollars last time anyone looked. Secondly, one way in which Apple has been keeping their ROMs secure has been to use a less than normal pinout, thus preventing them from being dropped into the ol' ROM burner 'til somebody figured out just what they were up to. The Apple copy boards are, of course, not designed to use this bizzarity, but, rather, accept 2716 type EPROMs. Hence legitimate Apple ROMs won't work on illegitimate boards without some hacking.

Inasmuch as the boards are designed to use EPROMs, you might suspect that the ROM software is available in this form, and, by Jove, you would be correct. It is a completely illegal rip off of Apple's software, and no reputable dealer will handle them... mostly because nobody wants to go to court (morals be damned; there's money involved). However, it is said that, in most stores selling fake Apple bits, if you were to leave your name and telephone number with the guy behind the counter, informing him that you had a burning desire for a set of EPROMs, this information might very well be passed on to ... someone. Someone... might then call you, informing you that at such and such a time and place there might very well be ... someone who would be willing to exchange certain unspecified electronic devices for a sum of money. (The password will be...)

Of course, if you know someone who has a set of ROMs, you can copy them without breaking the law ... we are told. (I think, maybe, if the moon is full... it's another unclear point.) First off, you can take an EPROM into a store like Parts Galore or Exceltronix which offer a ROM copying service and say, "here, make me another one of these". The dude behind the counter won't know what you're copying, so he isn't responsible for the contents of the chip. Furthermore, you are reproducing the software for your own use, not to sell, so you are not breaking any heavy legal dogma. But, there's more. The courts in the States are even now arguing whether the contents of a ROM can be copyrighted at all, because they are not human readable. Copyright pertains to the transfer of an idea from one human the artist, to others, the rabble. However, ROMs are only readable by a machine. I question this distinction, myself... phonograph records are only readable by a machine, but this hasn't stopped WEA from copyrighting LP's.

The final caveat is in the character generators for these boards. The original Apple used a 2513 character generator chip, but, unless you are doing up a EurApple board, you'll probably be utilizing another EPROM which has the character codes stored in it. We are told that the actual original character EPROM was created by Rory Jan using software he created for doing character sets for his terminals. However, it has been ripped off by several other dealers at this time. You can't feel too sorry for him in this case, what with the whole industry being built upon much larger rippings off, but it should be noted that not all the boards want the same character generator EPROM. You should buy yours where you buy the board, and, if possible, make sure that the dealer has a working board using that character generator, just to be sure they are compatable.

The original chip and the board it was designed for are the ones being sold by Parts Galore.

Building It

Getting the parts together to stuff a board can be no mean feat. I assembled one of the first EurApple boards, back when no one was really into having all these particular parts in stock. It took a fair bit of running around, to be sure. Civilization moving ever onward, though, most places selling the boards will also offer you a complete kit of parts. These are more expensive than getting the bits by shopping around, but unless you need the exercise, buy one!

In addition to the boards and the chip kits, also available are Apple copy cases that look just like the real thing for about a hundred and fifty dollars, various aluminum boxes that don't look like the real thing but will do for rather less, fake Apple switching power supplies for about a hundred dollars, fake Apple keyboards that fit the fake Apple cases perfectly for about a hundred and fifty dollars, fake Apple disk drives that seem to

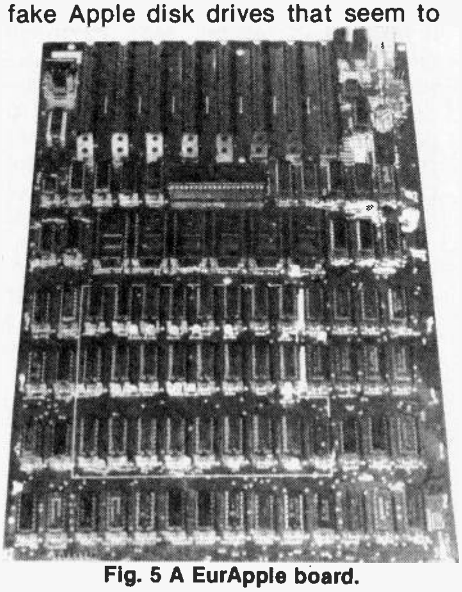


Fig. 5 A EurApple board.

Continued on page 56

Continued from page 35

sculptured comfortably. There is a numeric keypad that doubles as a cursor mover, plus ten function keys. The only two drawbacks about the keyboard is that the shift is not on the bottom row, which is quite a pain, as one tends to hit the alternate character key, which invariably makes a mess of things, and the auto repeat, which is kind of slow. There are also several keys that don't have obvious uses in the scheme of things, but, if you ignore them they don't bother you.

The PC uses a 6845 CRT controller, providing 25 rows of 80 lines on its screen, plus high resolution graphics. The character set has a lot of very useful stuff in it . . . plus some real weirdities. The screen is very clean without snow and other electronic flotsam. It does full colour, but we didn't get the colour stuff to play with, so it's hard to say what it looks like. According to the literature, there are sixteen colours available in low resolution graphics, four in medium resolution and just black and white in high resolution mode.

There is also an internal squeaker-speaker, which is software driven, permitting its tones to be altered by a program. All other I/O, such as the printer interface, serial port, colour TV adapter, and so on, are the province of the expansion slots toward the rear of the board.

The documentation for the system is certainly among the best we've checked out. It comes in little hard backed binders (in hard shell sleeves) and is profusely illustrated, explained, annotated, denotated, indexed, cross referenced, diagrammed, figured and most of the pages are in the right way 'round. All told, a joy to work with. As an example of what level the books are written at, the system's hardware manual has a complete source listing (annotated) for the ROM BIOS and I/O routines.

Nice stuff.

The DOS

Upon turning on the machine, one gets the feeling that the cat's been at the cord again, for the immediate reaction is for nothing to happen . . . although it does do it with grace. Then, sort of stately, the fan starts fanning, the speaker beeps and the disk drives begin whirring and popping cheerfully. At this moment, the screen demands the date . . . I hate computers that do that . . . and then drops you into the DOS proper. It says:

A►

and you go "hey, CP/M, my old friend." and type

A►DIR

and it responds with a listing. Not actually a CP/M style directory, but it's close. However, it is at about this time that one begins to realize that what we have here is actually a clone. It has many similarities to CP/M, but a lot of the actual funny words we've come to know and love are different.

The drive logging procedure is the same. "A:" specifies drive A, "B:" drive B, and so one. There is a context editor like ED called EDLIN. Wild cards are also provided for, using a question mark for single characters, and the familiar asterisk for sections of file names or extensions. As such, if one wanted to specify all files having a "Q" as the second character in their extensions, one could say *.?Q?.

A "*" in the extension is the same as '???'.

PIP, good old PIP, has been

Continued on page 39

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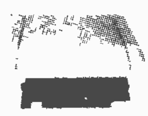

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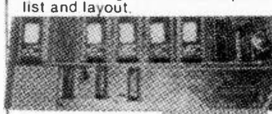

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Continued from page 37

designated COPY, since that's what you do most of the time when you PIP. However, the lesser used capabilities of PIP do not appear in COPY. SUBMIT has become AUTOEXEC. STAT is CHKDSK, which tell you how much space is used on the disk specified. Unlike STAT, it breaks this down into the types of files filling the space, which can be helpful. ERA, for erasing a file, has become DEL. The COPY transient has become DISKCOPY, but, again, without quite so many options. TYPE remains untouched.

In fairness, the bits that appear in CP/M but aren't used in their IBM counterparts aren't remarkably useful in most cases, and the IBM DOS so far is quite good. In addition, there are several other enhancements to the system.

First off, the command processor will run an AUTOEXEC batch file on booting if there's one waiting for it, which means that a program can be made turnkey without any tricky software modifications. There's a transient called COMP to compare two files, and DISKCOMP to compare two disks, which is good to check if you've lost data somewhere along the line. DATE is a program to read or change the calendar, and TIME fiddles with the clock. REM displays the remarks from a specified file. This is a bit extreme ... a nice thing to have, of course, but it may not belong in the basic operating system. Still, somebody must have liked it. PAUSE is designed to be placed in a batch file, and, when executed, prints "Strike a key when ready" and goes into a holding pattern.

There are also FORMAT, which formats a blank disk, and SYS, which transfers the system onto a new disk, functions which will be very familiar to CP/M users.

Another bit involved is the LINKer module, which is similar to the CLINK found in a C compiler. It ataches various bits of object code, looks for problems and external references, and, eventually creates a final COM file out of the whole mess. This is neat, and CP/M does not have a similar function on quite the same level.

DEBUG is very much like CP/M's DDT (Dynamic Debugging Tool). The idea behind these things is that they permit the assembly language programmer to take a program and run it in an artificial environment in which it can be watched, modified, controlled and generally made to feel paranoid. This one is slightly more loaded than DDT, although the extras are not all that fundamentally useful. The available commands are Compare, Dump (view a range of memory), Enter (change bytes), Fill, Go (execute), Hexarithmetic, Input (suck in and display a byte from a port), Load (get a file or some sectors from a disk), Move, Name, Output (send a byte to a port), Quit, Register (display the contents of the processor's registers),

Search, Trace, Unassemble and Write (to a disk). All told, it works pretty well, although I didn't do anything extensive with it.

There's a lot of good stuff in the DOS, and the manual is tight, with sufficient stuff in it to assist writing really gross complex assembler programs. The DOS itself is certainly nice to work with ... I have come to like the archaic funkiness of CP/M, but this is more a personal preference. However, it doesn't really have any great advantages over CP/M ... one set of funny words is as good as another, and, in both cases, they can be changed to please the user anyway. However, so much has happened around the CP/M system that it would be nice to have that compatibility.

On the other hand, IBM has never really believed in the rest of the universe before now, and has gotten along all right.

BASIC Computer

I'm not sure whether one always checks out the BASIC in a new system for fear of having to use it, or just because it is usually a good indicator of the level of development of the thing in general. Whichever is the case, here it be.

The BASIC is big and seething, with all manner of nifties hanging off it. It is not as slow as many disk BASICs, but is still crammed full of features. It has real screen editing, my favourite feature, and plenty of whizzbangs in this. Its INSert function is a bit of a hack, but only a bit. There are lots of functions and practically useless statements and commands, which is really what makes BASIC worthwhile.

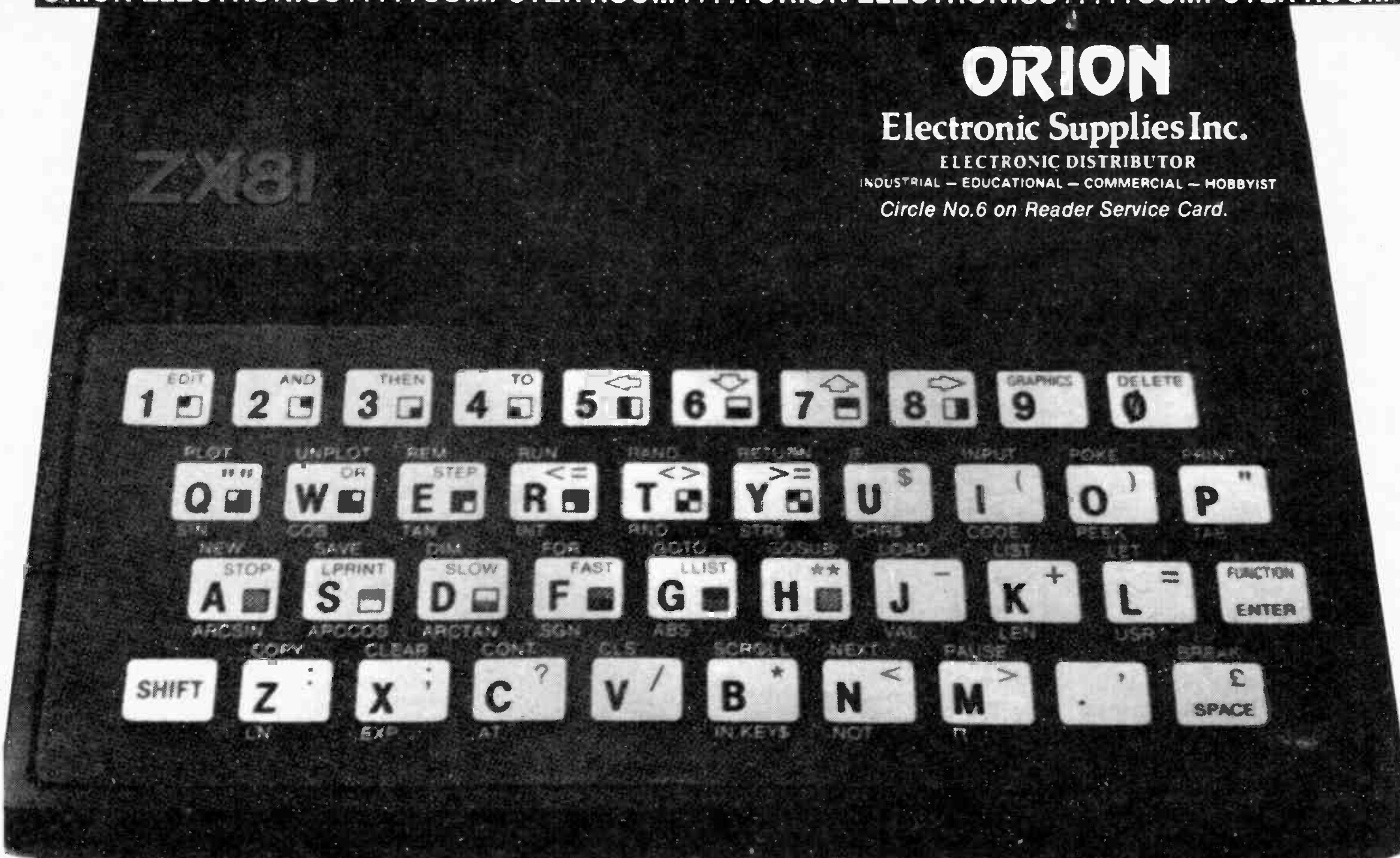
There are three versions of BASIC extant upon the system. The simplest is the on board cassette BASIC, which is actually fairly rich, but still gross, because cassettes just aren't ... reasonable. The Disk BASIC is good, as it is nicely stripped down for doing normal programming in a minimum of RAM. Advanced BASIC has bells and whistles everywhere, chews up RAM like crazy, but does high resolution graphics, event trapping and branching and fancy music.

The BASIC book is very well written, with lots of sample programs ... which are in green ink, so they look like the screen (*ever neat, Billy*). Like most good BASIC manuals, it won't be much use if you are totally without understanding of BASIC, but it's at exactly the right level as a reference manual and organised so you don't have to use the index for most referings.

The BASIC contains all the useful stuff that's found in most BASICs, plus the usual crop of new wrinkles which are turning up on fancy disk BASICs these days.

The commands available should, by now, be pretty common. There's AUTOmatic line numbering, BLOAD and BSAVE to deal with machine language files from the BASIC, MERGE, to concatenate files, RENUMber and TRON, which doesn't mean it plays video games, in addition to the usual SAVE and LIST stuff. There are also lots and lots of juicy statements.

Continued on page 62



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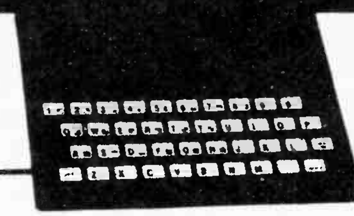

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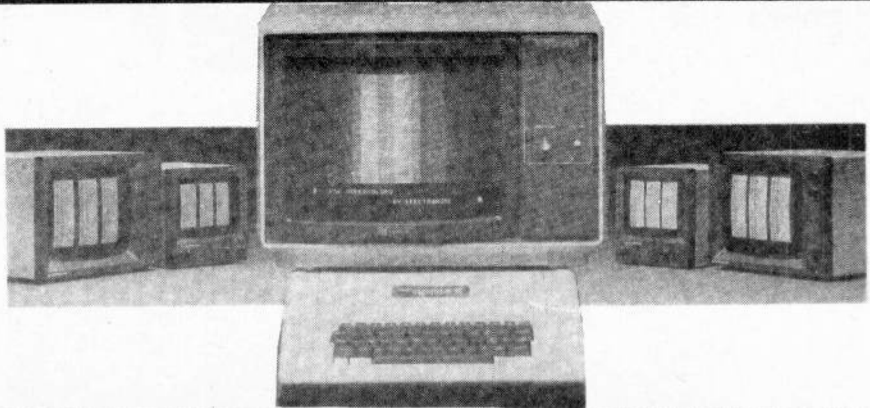

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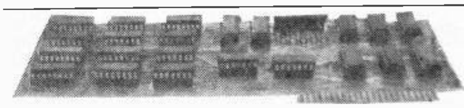

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The VP-3301 can be used with a 525-line color or monochrome monitor or a standard TV set through an RF modulator.** It serves a wide variety of industrial, educational, business and individual applications including communication with time sharing and data base networks such as those provided by Dow Jones News/Retrieval Service, CompuServe and Source.

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VP—3501 Videotex Data Terminal
For time sharing applications via telephone. Connects to standard TV set for display. Built-in 300 baud direct connect modem, includes: numeric keypad, color graphics, tone and noise generator, RF and video/audio outputs, expansion interface, resident and user-definable character sets, cursor control, reverse video, plus many other features. (Includes connecting cables.)

VP—3303 Interactive Data Terminal (RF & Video/Audio)
General purpose terminal. Similar to the VP-3501. Does not include modem or numeric keypad. Six switch selectable baud rates to 19.2k. RS-232C and 20 mA current loop interfaces.

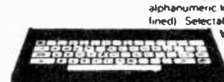
RCA PRICE LIST

58-Key Typewriter Format for Alphanumeric Entry

VP-601 - 8-bit parallel output	$109.75
VP-606 - Asynchronous serial output	139.75

58-Key Typewriter Format Plus Separate 16-Key Calculator-Type Keypad for Fast Numeric Entry

VP-611 - 8-bit parallel output	$149.75
VP-616 - Asynchronous serial output	159.87
VP-3301 - Video output & built in audio	475.95
VP-3303 - Connects directly to TV set	498.95
VP-3501 - With built in modem & RF modulator	549.95



ASCII Keyboard Fully encoded 128-character ASCII alphanumeric keyboard 58 light touch keys (2 user defined) Selectable "Upper-Case-Only
VP-601 .... **$109.75**

ASCII/Numeric Keyboard ASCII Keyboard identical to VP-601 plus 16 key numeric entry keyboard for easier entry of numbers
VP-611 .... **$149.75**

Cable: ASCII Keyboards to VP-711 Flat ribbon cable 24 in. length for connecting VP-601 or VP-611 and VP-711 includes matching connector on both ends
VP-620 .... **$27.50**

Cable: ASCII Keyboards Flat ribbon cable, 36 in. length with mating connector for VP-601 or VP-611 Keyboards. Other end is unterminated
VP-623 .... **$27.50**

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Circle No.6 on Reader Service Card.

6502 BOARDS & ACCESSORIES

AMB-1 $449.00
Mother Board, APPLE II Compatible, Assembled & Tested c/w Basic ROMS, 48K RAM, Made in Japan

ABB-1 $ 59.00
APPLE II Compatible, Motherboard (no components)

PDA-232C $169.00
Serial interface RS232C Card for APPLE II c/w Cable & Manual, Three Operating Modes: I/O, Terminal, Remote

VCB-1 $249.00
Versatile Communication Board for APPLE II

VVC-1 $499.00
Videotape, Video Disc, Controller Board for APPLE II c/w Demo & Interface Software

AKB-1 $139.00
Keyboard; replacement for APPLE II

KBC-1 $ 29.00
Plastic 2-tone Beige & Brown Case for Apple-type keyboard

AC-1 $145.00
Beige APPLE II Case (No keyboard)

APS-1 $ 99.00
Switching Power Supply for APPLE II; +5V @ 5 amps, +12V @ 1 amp, −5V @ 1 amp, −12V @ 1 amp

APS-2 $139.00
Switching Power Supply for APPLE II; +5V @ 3 amps, +12V @ 2 amps, −5V @ ½ amp, −12V @ ½ amp; c/w on-off switch & connecting wires

AAA-2 $599.00
Low Profile Disc Drive, 5¼", APPLE II Compatible, Excluding Controller Card

AAA-1 $649.00
Low Profile Disc Drive, 5¼". APPLE II compatible c/w Controller Card, Single Side, Single Density, Automatic Select DOS 3.2 & 3.3

PC-1 $169.00
Printer Interface Card for APPLE II, Parallel Output

ZVM-121 $189.00
12" Green Phosphor Data Monitor Zenith

ADC-1 $129.00
Disc Drive Controller Card for two drives; Apple II Compatible

AXT $ 5.50
14.31818 MHz Crystal for APPLE II; HC-18/U package

APPLE II is a registered trade mark of Apple Computer Inc.

Memory Special

RAM		
4116-20	16K	$ 1.85
4164-15	64K	$15.00
4164-20		$12.50
6116P	200nS 2Kx8 Static CMOS	$12.50
2016	NMOS 2Kx8	$ 9.75
EPROM		
2708		$ 5.95
2716		$ 5.95
2732		$ 8.75
2532		$ 9.75
2764-45		$17.50

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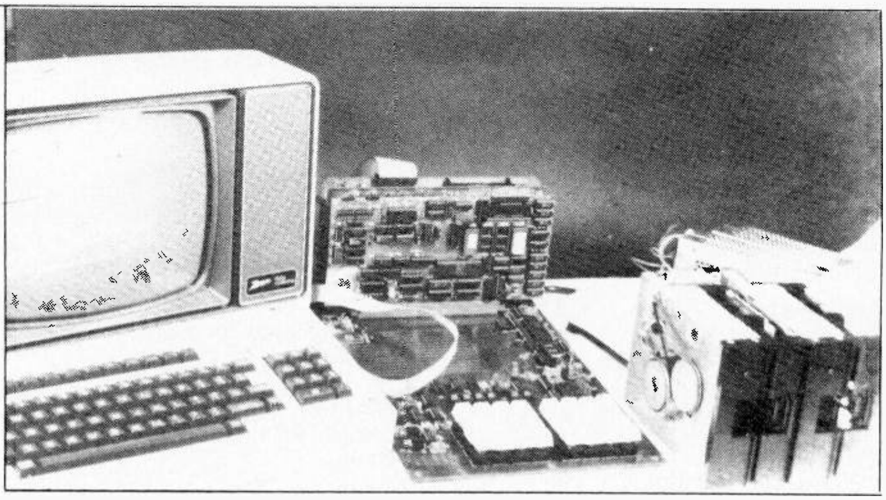
Multiflex Super Package

Send us your poor, your ugly, your overtaxed and your calculator owners. We will give them computers for under a grand. By Steve Rimmer.



WHILE THERE IS no direct connection between ourselves and Exceltronix Components and Computing, we do see quite a lot of them, one way or another. For one thing, they have the first two pages of the magazine every month for their ads, and, if nothing else, someone must pilgrimage up from College street every month with the latest bargains and deals. However, as it happens, what with buying parts and coping with things like the terminal project and the recent catalog insert, we've been seeing quite a lot of the blue eyed leaping gnomes.

Exceltronix is, in fact, not just a parts store. They're probably among Canada's most innovative high technology hardware development concerns, producing a number of heavily neat devices and doodads, all with tons of chips and what-have-you. Most of it has to do with computers... a current fad, you know.. and most of Exceltronix ventures into computing have been innovative to say the least. However, the system we're going to check out here, a myth they've been muttering about down there since last July, may qualify as truly wonderful.

The "Multiflex Super Package" is one manifestation of the latest generation of Exceltronix's Multiflex systems. Originally a very sophisticated Z-80 based "trainer" type package, this concept has been refined quite a lot, until it is now a full blown computer, with all the necessary features to deal with the real world, including a screen, keyboard and disks, and to run the CP/M disk operating system. However, what is immediately impressive about all this is not so much the bells, whistles and high powered technology so much as the price. For perhaps the first time it is possible to have full CP/M running for under a thousand dollars.

Less Than Grand

The Multiflex system is available in three configurations. The version we had for review is derived from the original Multiflex design, which consists of a large motherboard, having an EPROM burner, some ports and a keypad and LED display to drive a machine language monitor on the CPU card. It has four S-100 slots, of which three are used to hold the CPU, video board and the disk controller. The CPU has 64K of RAM already on it. There is also a one board version, with all the requirements of a working system on a single PCB. Lastly, you can get the three cards, without the motherboard, in a card cage.

The basic Multiflex goes for $995.00 at the moment. (In fact, the one board is rather cheaper, at $599.95.) This buys you a kit of all parts, boards, manuals and so on to get the system up, plus two hours of free troubleshooting by Exceltronix if the system decides to misbehave on powering up (provided you didn't put it together with a flame thrower). Included also are such sundry items as the disk drive and the CP/M system disk. However, you must scare up your own monitor, keyboard and power supply, or buy them separately. This has the dual advantages of permitting one to use what of these devices one already has, or can build or scrounge surplus, and, in terms of the keyboard and tube, to select ones that one is most comfortable with. If you, as do I, use a computer for a lot of word processing, for example, you may have developed fairly pronounced tastes in keyboards. I have spent quite a lot of time finding one I like; a piecemeal system like this allows one to use such personal components.

Owners of terminals, such as the ETI/Multiflex terminal from our last issue should also note that the system can be configured to use an external terminal instead of the video card, thus saving the cost of one board.

While we got our review sample of the system assembled and tested.. building the 6502 board seen elsewhere in this issue did not leave me enough time to put together the kit version this month... I have done up several Multiflex boards in the past, and have yet to have any need of the free troubleshooting service. The boards are first rate, with solder masks that pretty well obviate any hassles in this area. The instructions are clear and there do not appear to be any little surprises hidden in undocumented board errors. These are actually pretty easy to find when one is given a built up version of a kit to look at. Since the system has to be working... ours, needless to say, was... these errors are fixed with jumpers and track cuts. We didn't see any of these on the Multiflex PCBs.

The three configurations of the

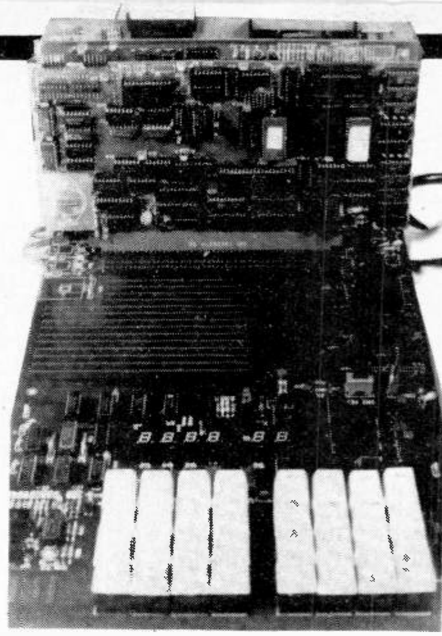
Multiflex have various permutations of options and features, and, for the two versions we have not seen, it will be a good trip to check with Exceltronix directly. However, the details of the "Super Package" system are: 64K of RAM and a Z-80 A CPU (on one card), running at 2 MHz. This also comes with a machine language monitor in ROM which can be used outside of CP/M for whatever you can think of. One thing it will do is to run the EPROM burner on the motherboard. There is also, of course, the disk boot routine in ROM. The floppy disk controller card can handle four drives, which can be any combination of 5¼ and 8 inch beasties, single and double density and single and double sided, which, if utilized to its fullest would certainly create a real dog's breakfast of formats. In a lesser situation, it permits a lot of flexiblity on your choice of drives.

The disk controller also permits DMA, via a little plug-on piggyback board. We didn't try this feature on our review sample.

The video board has an eighty by twenty four screen, which was really very pleasant to work with. The characters are rather narrower than most, which seems to make them easier to look at. The lower case letters had true descenders. The characters can have attributes, blink, reverse, underline and highlight, and there are the usual number of control codes. The board also has a keyboard interface, allowing the plugging in of any ASCII keyboard or, if you feel like being primitive, seven switches and a doorbell (not recommended, and you must debounce the doorbell).

The main motherboard holds an EPROM burner, as mentioned, which will handle 2708's through to 27128's. There is space on board for an inverter circuit option which obviates the need for a separate 27 volt programming voltage supply. There is also a hardware programmable RS-232 serial port, plus a 24 line parallel port. A wire wrap area is included, plus a hex pad and six LED readouts for those who want to burrow back into the hardware. In fact, not much of this will be used if you are going to be running CP/M exclusively, and, for those with this in mind, the other configurations of the system do away with the motherboard features.

In addition to this, there are two additional piggyback board options for the system, one having two RS-232 ports and a real time clock, and the other (much cheaper) having just the two ports. These are rather more sophisticated than the port on the motherboard, as they can have



their parameters set in software.

The system does not come with a case, although one is available. Alternately, you can do up your own to match the decor of your cave.

The system comes with one Shugart 400L 5¼ inch single sided double density disk drive, plus the CP/M system disk. This is a very fine drive, and makes all the best whirring noises when it's running. We actually ran the system with two of these drives, and it exhibited no weirdnesses.

Power Up

Our system was powered by two little silver switching supplies, although a transformer deal would also have worked (and been rather cheaper). When power is applied, the video board puts a cursor up on the screen. We used a green Zenith monitor, which yielded a very stable picture, looking very modern and, like, *tres* David Bowie. The boot routine is entered by hitting one of the hitherto unused keys on the motherboard's hex keypad. A moment after doing this, the screen comes up with the CP/M copyright notice and the A► disk prompt and you're rocking.

While CP/M is a product of Digital Research, it is, in fact, packaged up for most specific systems by middlemen software houses. Lifeboat is among the largest of these, making the system we use on our TRS-80 Model II. As such, the CP/M for the Multiflex is a product of another software house, this being Pegasus/National Multiplex. It is interesting to note that there are varying grades of CP/M, and that the degree to which it has been modified for a particular application will determine just how well it will work on a given system. This CP/M package has been adapted by Pegasus, and then customized for use on the Multiflex by Exceltronix.

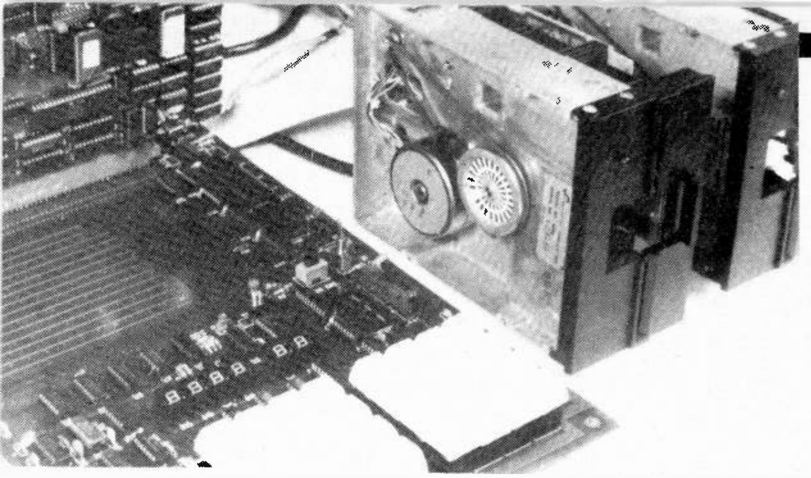
The CP/M ran without any burps. We had some problems with the SYSGEN, which turned out to be the result of using disks which I'd had in my sock drawer for about a year... it went away after we got some without lint. However, what was interesting was how the package dealt with disk errors when it encountered them. Some implimentations of CP/M can do very nasty things when they get heavy errors, and all systems run into these sooner or later. Osborne users, for example, have discovered that a disk error when using Wordstar causes one to be booted back to the CCP, loosing all the data in the file. Other situations will completely hang the system. However, with this CP/M, one gets fairly good error messages, actually specifying the location and nature of the error, and the thing seems to do its best to carry on with what it was doing. No combination of errors on Wordstar managed to dump one out of the program, and the file data was always retained.

All told, very tight.

We ran quite a lot of software on the system, all with really fine results. The aforementioned Wordstar word processor behaved just like it was supposed to. If you buy the Multiflex keyboard, you can really do a great number on Wordstar, as this keyboard has a row of unassigned keys up top. Since the character codes for the keyboard are held in EPROM, the CTRL codes for Wordstar can be set into these keys, making cursor movements and menu calls much easier.

The 5¼ inch disk drives are noticeably slower than the 8 inch deals used by other systems we've tried, alhough not too much. This is most noticeable when moving huge files around, and just means that you have more time to drink coffee while waiting for the system. However, formatted to their maximum density, you can get an amazing amount of stuff on these little devils, about 143K, which is quite a trip considering that the actual disks are appreciably cheaper than eight inch ones.

MBASIC also ran fine. This is a standard Microsoft disk BASIC, with a variety of good features. It, and several other BASICs are available from Exceltronix. In addition to this, we tried the BDS C compiler stuff and, after fidgeting with the DEFFs for a bit, always a pain when you move C to a different system, it, too, ran without a hitch. LIFE went fine,



and I think I managed to produce a completely stable colony (pointless, I know, but it was late at night, and the smallest things amuse you when you're too tired to care).

The CP/M also came with all the usual utilities, including STAT, ED, PIP, FIVEGEN (SYSGEN), FORMAT, DDT, ASM, LOAD, DUMP, and so on, and everything worked real good. Even the little niceties like the CTRL S toggle to stop the listing of text files was just right, and didn't skip around. No combination of weird characters on the screen seemed to hang it, as is known to happen in some systems where there's a "shut down the CRT controller" sequence. A customized version of MODEM7, permitting the system to function as a smart terminal and file transfer system through the piggyback RS-232 board has been produced by one of the software dudes at Exceltronix, and is probably available free if you ask them nicely.

By The Boards

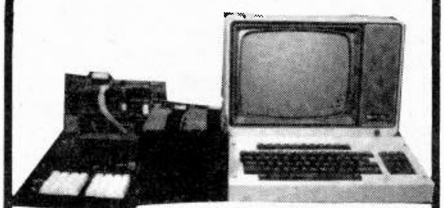
The flexibility of the Multiflex is greatly enhanced by the use of the S-100 bus in all the configurations of the system. As such, one can plug in all sorts of peripheral cards, such as high resolution colour graphics, a hard disk controller, a voice or music synthesizer, A/D and D/A converters, fancy modems and so on. As such, it can also be a dedicated system for performing complex control features and such like. The S-100 bus can be extended, and additional RAM can be added, up to 512K. This permits the operation of multi-user systems, such as MP/M, and you can really become freaky and extended.

However, the main feature still seems to be the price. The closest thing to it is Digital Research's own single board system, but, by the time you add all the bits you need and get it into Canada, it comes out costing a lot more than the Multiflex, and you don't even have the nice warm feeling derived from feeding the beavers. Furthermore, if you need advice, service or extra gizmos, it's a lot cooler having to contact Toronto than calling California (or writing Tokyo). Exceltronix is still a fairly small organization by mega-corporation standards, which makes them a bit more responsive as well, and they have a great stock of replacement parts, having a parts place built right in.

The Multiflex running CP/M is a very versatile system. Stuffed full of BASIC, it can be a pretty decent beginner's system. It does not have the user friendliness or the pretty block graphics of, say, a PET, but it's certainly as good for learning the basics of software. However, unlike many of the commercial "home" computers, it's very powerful, and will not be outgrown even if you turn into a real freak with a tube-tan and little flattened fingertips that look like they fit into keycaps. It is, to be sure, more expensive than a ZX-81, and hasn't got all the game type features found in an Atari or a VIC, but, if you are contemplating "growing into" a large system, you can start with one and do all your growing in software, which is cheaper than evolving through three or four computers.

Computers have been with us for over twenty five years now. However, it was economic, not technological, factors that made them useful to the average gnome in the home. As such, systems such as the Multiflex do represent a major advance in the state of the art, as they make the art available to a much greater slice of us rabble. The system, while not so elegant as the IBM we've also looked at in this issue, has all the capabilities of the fancy computers at about a fifth of their prices. In fact, a lot of the cost of an IBM or a XEROX is in a very large corporation's name, an injection moulded case and some full colour advertising. For those who have transcended such things, and realize that the true reality is in getting solder flux on your teeth, the Multiflex is a first rate system and an excellent choice.

ETI FACT FILE



Manufacturer:	Multiflex
Area of Interest:	Home
Processor:	Z-80A
Screen size:	
Graphics:	block graphics only without extra board
Sound:	CTRL G beep
Display:	external monitor
Mass Storage:	1 5¼ inch disk SSDD
RAM:	64K
Number of keys:	74
Printer included:	No
Software included:	CP/M
ROM pack facility:	No
RS-232 Port:	Yes
Parallel Port:	Yes
Printer Interface:	No
DOS:	CP/M
Number of units:	5
Documentation:	Manual plus CP/M documentation
Price:	$995 without power supply, keyboard, case or monitor

ETI'S EVALUATION

We have evaluated our sample on a scale of one (poor) to five (exceptional). In making our assessment we have taken into account the class of user to which the computer is marketed.

Mechanical Construction	● ● ●
Overall ease of use	● ● ● ●
Speed of Operation	● ● ●
Software	● ● ● ●
Suitability for beginners	● ● ●
Suitability for business	● ● ●
Manuals and instructions	
Supplier	

Exceltronix Components & Computing
319 College Street
Toronto, Ontario
M5T 1S2

Series 5000 Pre-amp

This begins the final article describing the design and construction of the Series 5000 preamp. In previous issues we described the low-level amplifiers— the moving magnet and moving coil input stages. In this article we concentrate on the high-level switching, line and monitor amplifiers, muting and power supply and complete the construction details.

A COMPLETE circuit diagram of the preamp is included in this article, with the sections described in previous issues shown simply as blocks.

As can be seen from the circuit diagram the preamp has three low-level inputs. The moving coil input is connected directly to the input of the MC head amp. The capacitors C17 and C18 are soldered between shield and active on each of the input sockets. The output of this amplifier is fed to the low-level selector switch on the front panel, together with shielded cables from the two moving magnet inputs. Once again resistors R13 to R16 and capacitors C19 to C22 are soldered on the input sockets. The output of the low-level selector switch is fed to the input of the MM input stage, which incorporates RIAA equalisation as described previously. The input of this stage has an input impedance around 470k, defined by resistor R2 in the MM circuit diagram. Since input differential pair in the NE5534N requires approximately 200 nV into its bases, a voltage drop around 100 mV will appear across this resistor. Capacitor C2 (MM circuit diagram) is used to isolate this dc voltage from the cartridge. If the source resistance is changed rapidly, however, by unplugging the cartridge or otherwise open circuiting the source resistance, a rapid dc shift will occur, producing a loud thump in the loudspeakers. To overcome this problem the low-level input selector should be a make-before-break type and all unused low-level inputs should be shorted. The best way to do this is to construct shorting plugs by soldering the active and ground terminals together on an RCA plug. For convenience we have specified all switches in the preamp as three-pole four-position, make-before-break, rotary switches.

All switches are soldered to pc boards to bring the necessary contacts to the top of the chassis to facilitate ease of wiring. The wiring in the preamp is reasonably complicated, although not difficult thanks to the switch pc boards. I tried it originally by soldering directly to the back of the switches, but the resulting maze of shielded cable would have made it extremely difficult to fault-find and placed excessive strain on the centre lead solder connections. The circuit boards overcome this problem and provide a secure anchor for both the centre lead and the shield on the shielded cable used for most of the wiring inside the preamp. Furthermore, these circuit boards connect the necessary shields together to maintain the integrity of the signal ground, but more about this later.

The output of the MM amplifier is fed to the 'low' position on the high-level input selector (i.e: selecting 'low' selects the low-level input selector), together with tuner, aux 1 and aux 2 inputs. The output of the switch is fed to the tape input selector on the switch pc board and appears at the switch position marked 'high' on the front panel. The third set of contacts on this switch are used to drive the tape 1 and tape 2 muting transistors Q5 to Q9. If tape 1 for example is selected as an input, pin 10 on the tape input selector is taken high, driving the bases of transistors Q5 and Q8 via diodes D12 and D15 and resistors R31 and R36. R43 acts as a pull-down resistor to ensure that the transistor base-emitter junctions cannot be forward biased by large signal

SERIES 5000 PREAMPLIFIER — SPECIFICATIONS

Frequency response:	High-level input: 15 Hz-130 kHz, +0, −1 db Low-level input — conforms to RIAA equalisation, ±0.2 dB (see text).	
Distortion:	1 kHz ‹0.003% on all inputs (limit of resolution on measuring equipment due to noise limitation).	
S/N noise:	High-level input, master full, with respect to 300 mV input signal at full output (1.2 V):	›92 dB flat ›100 dB A-weighted
	MM input, master full, with respect to full output (1.2 V) at 5 mV input, 500 ohm source resistance connected:	›86 dB flat ›92 dB A-weighted
	MC input, master full, with respect to full output (1.2 V) and 200 μV input signal:	›71 dB flat ›75 dB A-weighted

Continued on page 49

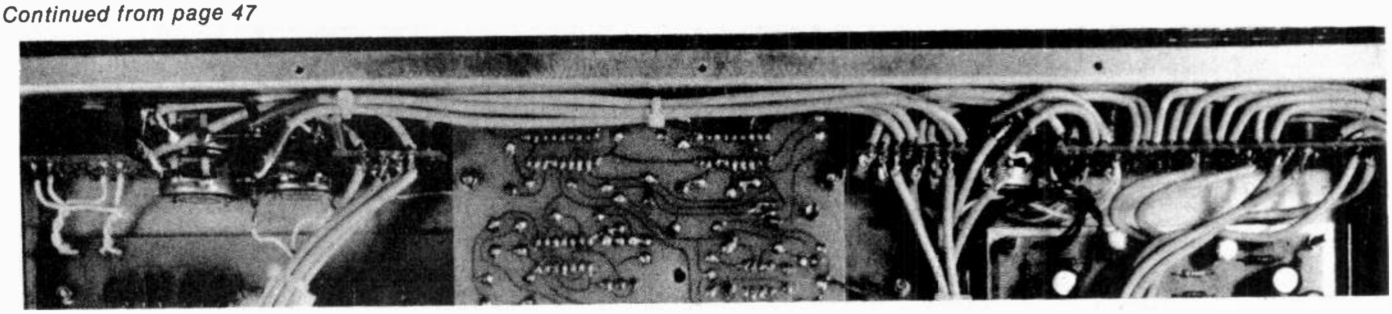
Circle No. 8 on Reader Service Card.

Circle No. 19 on Reader Service Card.

Circle No. 20 on Reader Service Card.

Circle No. 10 on Reader Service Card.

Continued from page 47

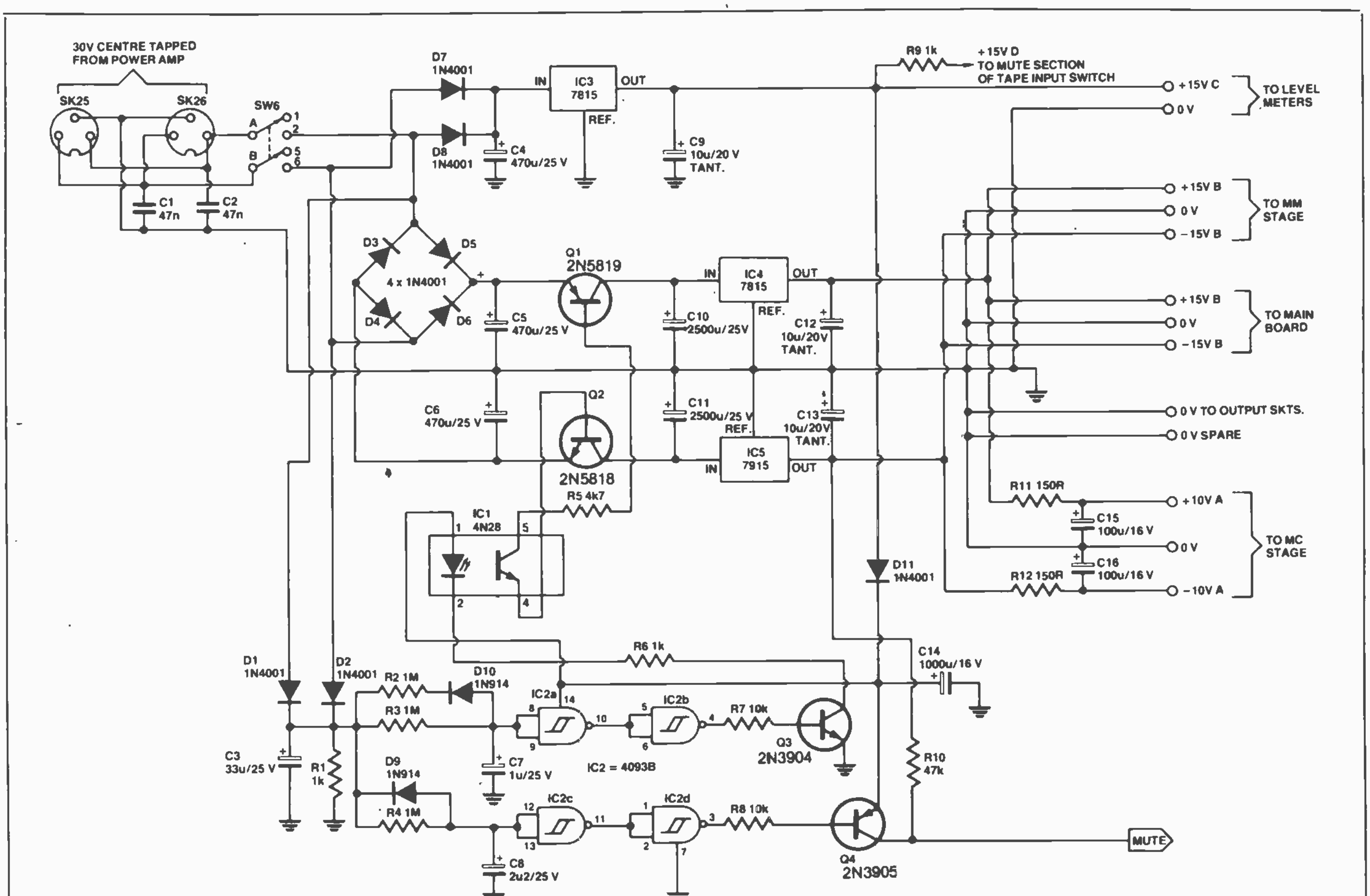


Closeup of the Series 5000 preamp front panel wiring.

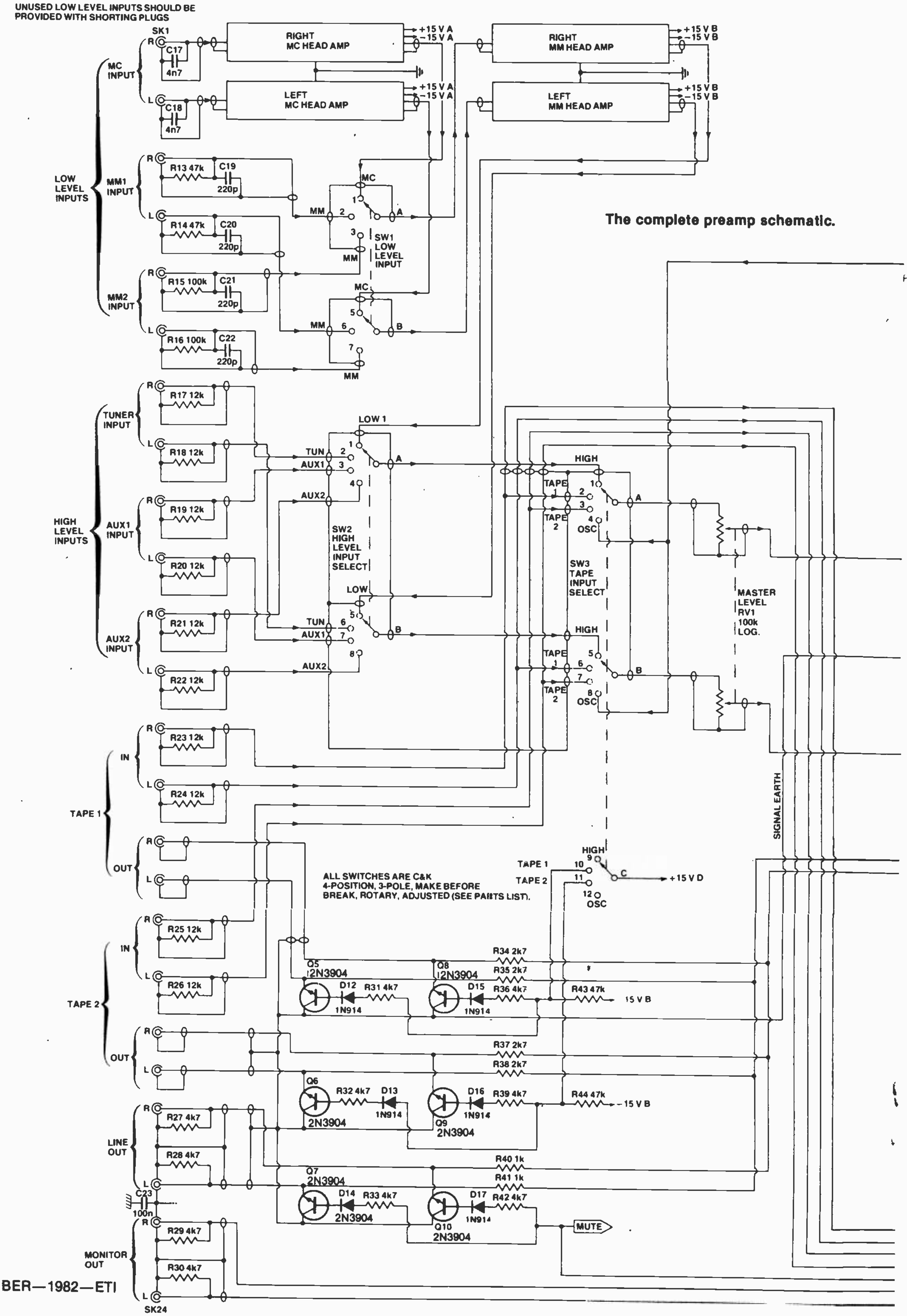
excursions. The diodes prevent this reverse voltage from driving the base-emitter junctions into reverse zener action. The operation of the muting transistors is a little unusual since the transistors are used 'upside down'. It is not commonly known that bipolar transistors can be operated by forward biasing the base-collector junction and using this as the control junction of the transistor. This forms a low gain transistor that has the advantage of a lower on resistance, which is ideal for this situation.

The mute transistors for the line and monitor outputs are driven by the muting control circuitry that senses the presence of the 30 volt ac supply voltage from the power amp. When the amp is turned on, the circuit mutes the line and monitor outputs, turns on the main supply rails and then releases the muting. This eliminates the problem of turn-on thump, although a slight click will be heard as the muting transistors are switched. Similarly at turn-off the muting circuit mutes output until the main supply voltage has dropped sufficiently.

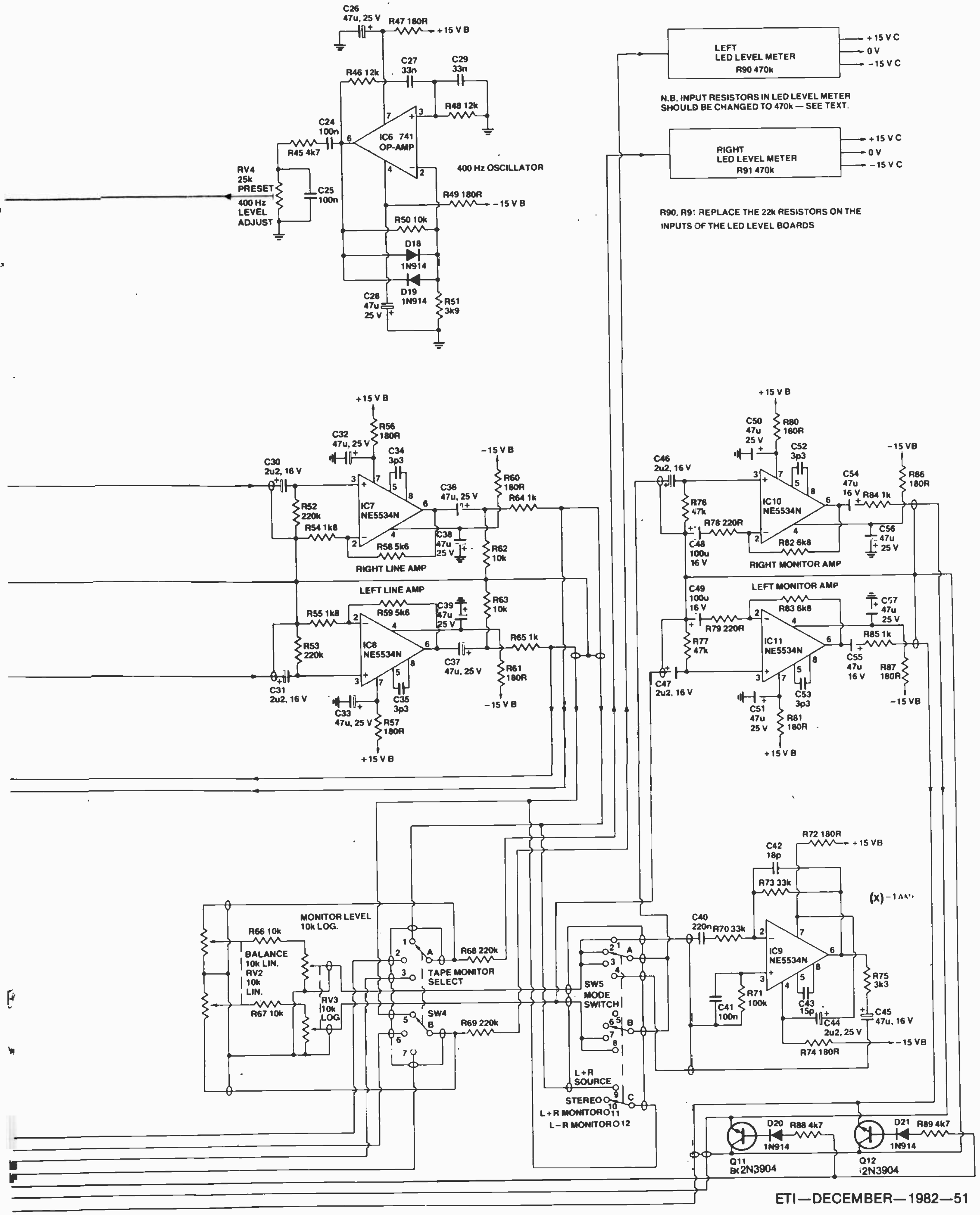
The output of the high-level selector is fed via the master level control to the line amplifiers. From the line amplifiers the signal is fed through the tape monitor switch to the balance and monitor level potentiometers, through the mode switch to the monitor amplifiers. When the mode switch is switched to the L-R position the left channel monitor volume wiper is connected to the output of the unity gain phase inverter. The output impedance of the inverter has been set to correspond to that of the left monitor pot when it is



Circuit of the Series 5000 power supply.



The complete preamp schematic.

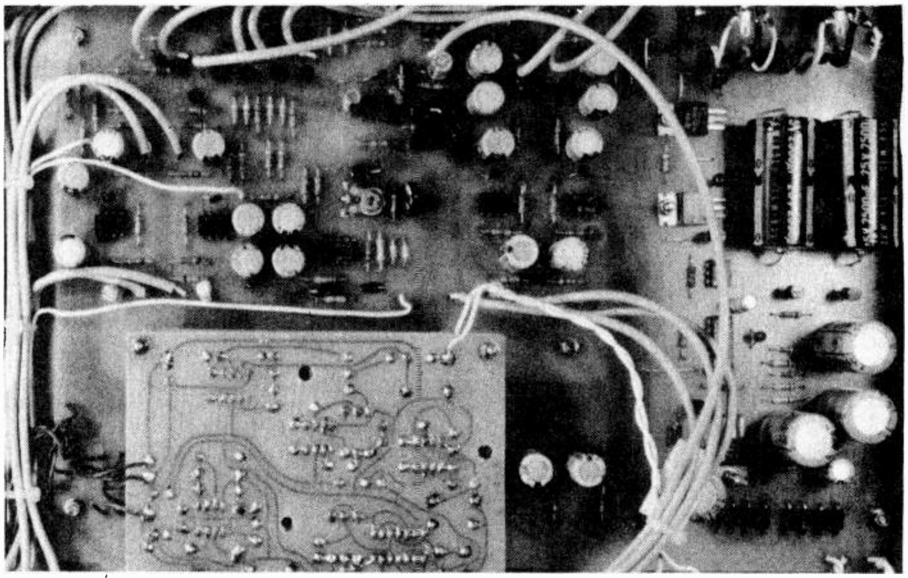


LEFT LED LEVEL METER R90 470k
+15 V C
0 V
−15 V C
N.B. INPUT RESISTORS IN LED LEVEL METER SHOULD BE CHANGED TO 470k — SEE TEXT.
RIGHT LED LEVEL METER R91 470k
R90, R91 REPLACE THE 22k RESISTORS ON THE INPUTS OF THE LED LEVEL BOARDS
400 Hz OSCILLATOR
IC6 741 OP-AMP
RV4 25k PRESET 400 Hz LEVEL ADJUST
RIGHT LINE AMP
LEFT LINE AMP
IC7 NE5534N
IC8 NE5534N
RIGHT MONITOR AMP
LEFT MONITOR AMP
IC10 NE5534N
IC11 NE5534N
IC9 NE5534N
MONITOR LEVEL 10k LOG.
BALANCE 10k LIN. RV2 10k LIN.
RV3 10k LOG
TAPE MONITOR SELECT
SW4
SW5 MODE SWITCH
L+R SOURCE
STEREO
L+R MONITOR
L−R MONITOR
Q11 2N3904
Q12 2N3904
D20 1N914
D21 1N914

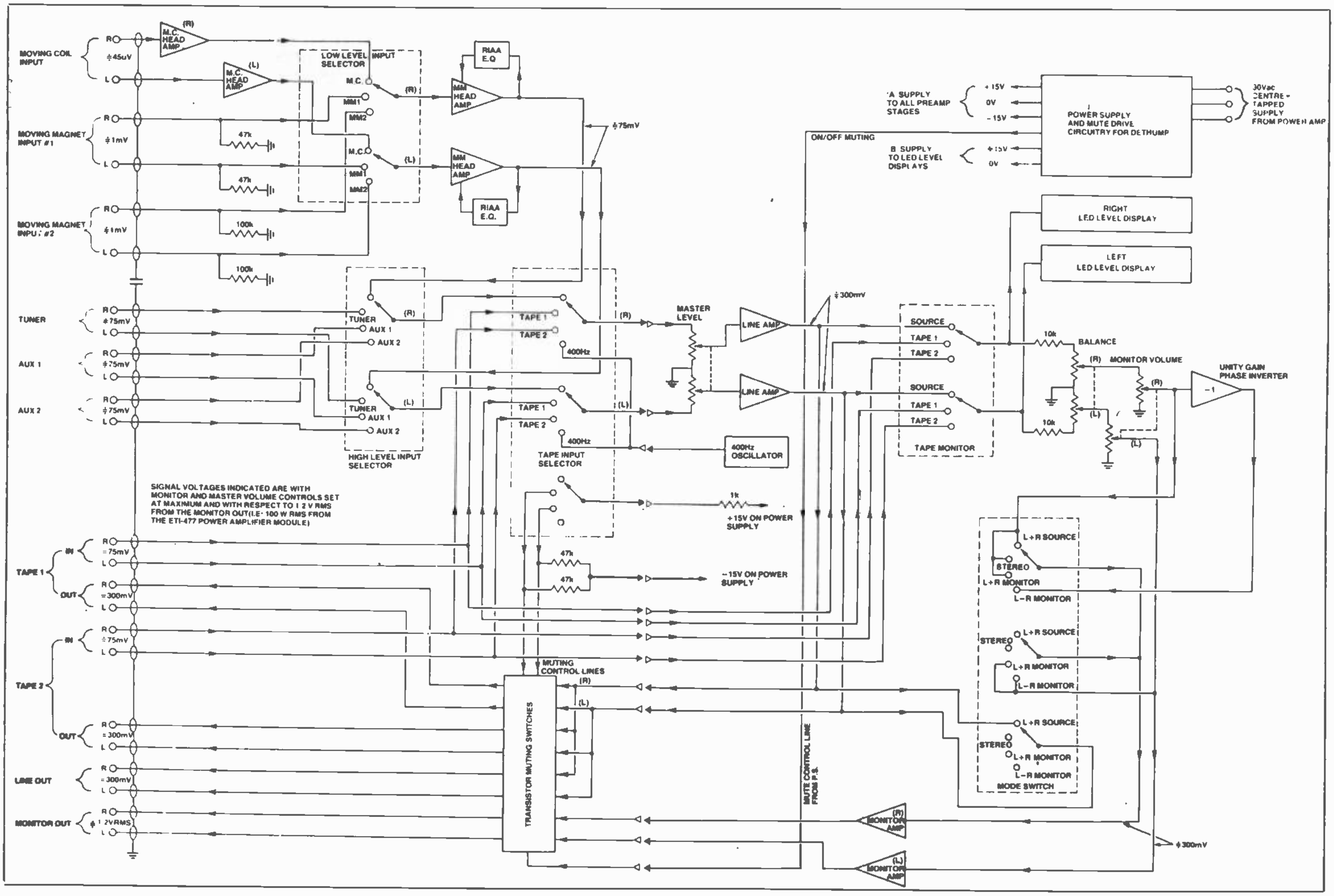
at full volume, so turn the monitor fully up when using this facility and use the master as the volume control.

The 400 Hz oscillator is based around the 741 op-amp IC6 and its associated circuitry. The design is a simple Wien bridge oscillator with amplitude stability achieved through the use of back to back diodes, D18 and D19. This results in an output waveform that is not really a sine wave although it is reasonably close and entirely adequate in this application.

The scope of this project does not lend its fitting into a single issue. Thus, the construction details will follow next month.



Closeup of the pre-amp module board, to be detailed next month.



The preamp block diagram and general interconnection plan.

PARTS LIST

Resistors (all ½W, 5%)	
R1,6,9,40,41 64,65,84,85	1k
R2,3,4	1M
R5,27 to 33, 36,39,42, 45,88,89	4k7
R7,8,50,62, 63,66,67	10k
R10,13,14,43 44,75,77	47k
R11,12	150R
R15,16,71	100k
R17to26,46,48	12k
R34,35,37,38	2k7
R47,49,56,57 60,61,72,74,80,81,86,87	180R
R51	3k9
R52,53,68,69	220k
R54,55	1k8
R58,59	5k6
R70,73	33k
R75	3k3
R78,79	220R
R82,83	6k8
R90,91	470k replaces R1 (22k) in each LED level display.
RV1	100k dual log. pot.
RV2	10k dual linear pot.
RV3	10k dual log. pot
RV4	25k trimpot.

Capacitors	
C1,2	47n greencap
C3	33u/25 V RB electro.
C4,5,6	470u/25V RB electro
C7	1u/25V RB electro.
C8,44	2u2/25V RB electro.
C9,12,13	10u/20V tantalum
C10,11	2500u/25V axial electro.
C14	1000u/16V RB electro.
C15,16,48,49	100u/16V RB electro.
C17,18	4n7 greencap
C19,20,21,22	220p mica
C23,24,25,41	100n greencap
C26,28,32,33,36,37,38,39,50,51,56, 57	47u/25V RB electro.
C27,29	33n greencap
C30,31,46,47	2u2/16V RB electro.
C34,35,52,53	3p3 ceramic
C40	220n greencap
C42	18p ceramic
C43	15p ceramic
C45,54,55	17u/16V RB electro. NOTE: Higher voltage rating capacitors may not fit the PCB.

Semiconductors	
D1 to D8,11	1N4001, 1N4002 etc.
D9,10,12 to 21	1N914, 1N4148 etc.
IC1	4N28 opto isolator
IC2	4093B quad Schmitt NAND
IC3,IC4	7815 +15V 3-terminal reg.
IC5	7915 -15V 3-terminal reg.
IC6	741 op-amp.
IC7 to 11	NE5534N op-amp.
Q1	2N5819
Q2	2N5818
Q3,Q5 to 12	2N3904
Q4	2N3905

Miscellaneous	
SW1,SW4	3-pole, 3-position rotary
SW2,SW3, SW5	3-pole, 4-position rotary
SW6	3-pole, 2-position rotary

Printed circuit boards; 24 panel-mount RCA sockets; 24 rubber grommets 6 mm bore; two 3-pin DIN sockets; two 3-pin DIN plugs; shielded cable 4 mm dia.; nine fancy knobs to suit; two LED level meters; MM and MC phono preamps stages; nuts, bolts, solder, hookup wire, etc.

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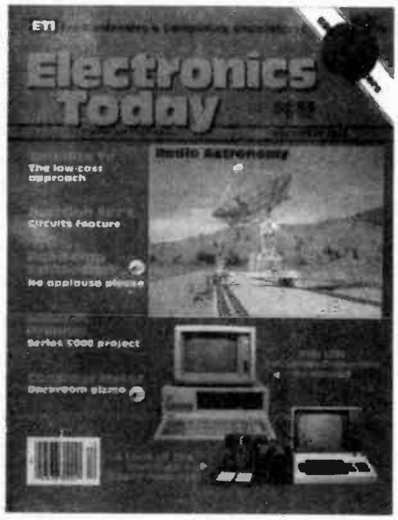

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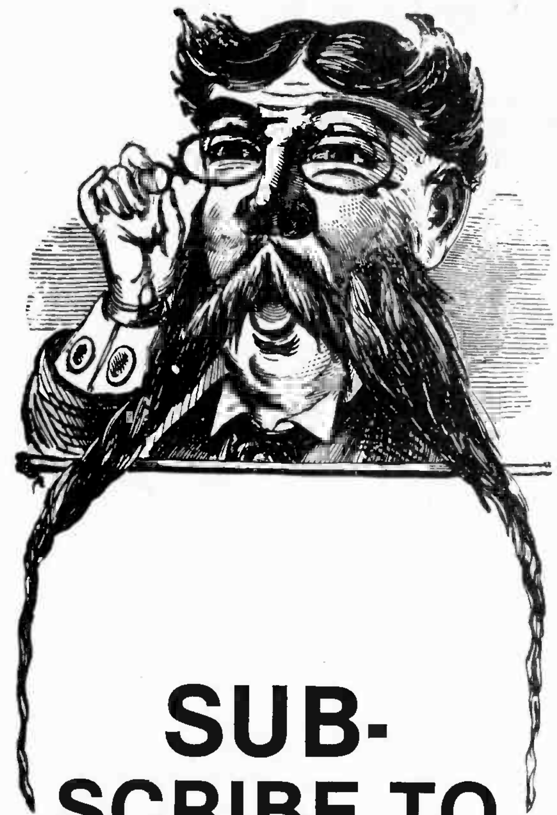

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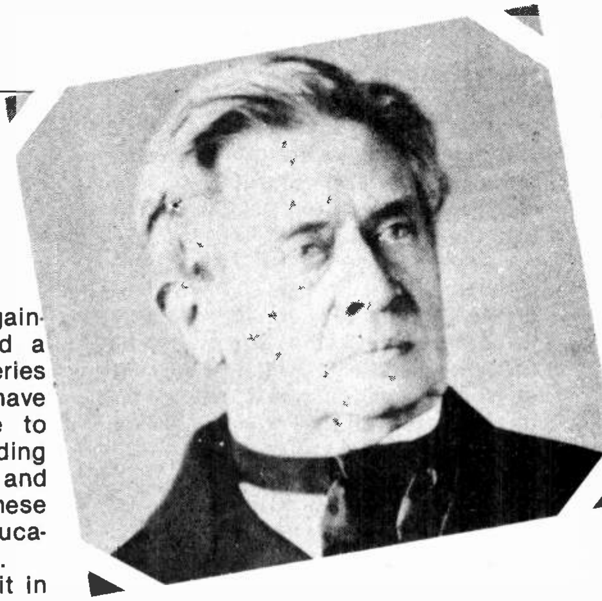
Henry

This month we look at the life of Joseph Henry, whose name is associated with the unit of inductance

Pioneers of Electronics Series



WE'VE BECOME quite accustomed in this century to remembering the names of famous people of the past by using these names for measuring units or instruments. This way, even though you may have only the faintest notion of who Ampere, Ohm or Volta were, you can't escape the familiarity of the names. Nevertheless, some names are not so well known as others, and Joseph Henry must rank among the names which very few of us would recognise except as the name of the unit of inductance.

Perhaps part of that unfamiliarity is because Henry was American, and he worked on many of the projects which, were the province of Michael Faraday. The two men were, in fact, very often engaged in the same line of research at the same time but, because of the poor communications of the time, were unaware of each other's work. That'll teach us to complain about second-class post!

Let's start at the beginning. Joseph Henry, who was born in 1797, is regarded as the second most outstanding US scientist, taking second place only by a whisker to Benjamin Franklin. Let's see if we can catch some flavour of what he contributed to our knowledge of electricity.

Choice For Life

Joseph Henry intended to study medicine when he went to Albany Academy in New York in the 1820s, but medicine was a science in its infancy and Henry caught the excitement which surrounded the study of electricity. In 1825 he abandoned medicine and changed to a course of practical science, which we would now call engineering. He was brilliantly successful, and in 1826 was appointed to teach Mathematics and Physics at Albany Academy. This was a wise choice, both for him and for the Governors of the Academy. In Joseph Henry, Albany Academy gained an outstanding teacher and a brilliant scientist. Few discoveries have ever been made which have come as a complete surprise to anyone with a really good grounding in Mathematics and Physics - and there is nothing better than these subjects today to ensure an education which will set you up for life.

His work began to bear fruit in 1829. Until that time, electromagnets had been made by winding bare wire onto insulating formers which were threaded to ensure that one wire could not short against the next - we still wind coils for shortwave receivers this way. Henry demonstrated that by using insulated wire and by winding it closely, layer over layer, he could greatly increase the lift of an electromagnet. He proved the point by constructing a magnet which could lift nearly a ton, and gave it to Yale University.

Electromagnetism naturally led to the idea of generating continuous movement by using electricity, and to a form of electric motor in 1829. This was eight years after Faraday had first demonstrated the possibility of causing continual motion by using magnetic forces, but Henry's motor was a much more practical affair, quite capable of being built in larger form to drive machinery, as indeed it soon was.

Early Telegraphy

By 1831 Henry was working alongside another famous scientist, Samuel Morse. Their task was the development of the electric telegraph, the invention which, along with the railway, was to open up the West and spread law and civilisation. The telegraph was the start of communications as we know them today. It's difficult for us now to appreciate what this must have meant in an age when the fastest communication between points too far apart to see was by a man and a horse.

The telegraph was initially a very simple device, consisting of an on/off key at one end and a current-detector at the other, with lots of wire in between. The effect of all the wire in between was one of the problems which Henry decided to tackle. In practical terms, the greater the distance between two stations on the telegraph, the slower the operator had to transmit. If he didn't slow down, the receiver did not indicate a clear-cut dot or dash, up to the point where it might even have stopped moving altogether.

In 1831, Faraday had discovered electromagnetic induction. If you move a magnet near a wire, a voltage appears between the ends of the wire while the magnet is moving. Henry took up this idea, and reasoned that physical movement was not necessary, only a change of magnetism. When a current starts flowing through a wire, there must be a change of magnetism from zero (no current) to whatever amount is present when the current reaches its full value. This change of magnetism, Henry reasoned, should also cause a voltage to be induced in the wire - the same wire! He realised further that this induced voltage would oppose the current and try to stop it from increasing. It was this opposing voltage which was causing the odd effects on long telegraph lines, and the effects could be much more conveniently studied by winding the long wires onto electromagnets. Henry looked at some of his old electromagnets, and made measurements of the voltage across the terminals when the current through the coils was changed. He found that for a given shape of magnet, with a set number of turns, the ratio:

$$\frac{\text{voltage across terminals}}{\text{rate of change of current}}$$

was constant.

This constant quantity had no relation to the DC resistance R of the wire. Henry called the quantity 'self-inductance', and another of the essential quantities of electronics was born.

In the same year of 1832, Henry was appointed Professor of Physics at the College of New Jersey - now Princeton University. Some idea of the breadth of his ability may be judged from the subjects he was expected to teach as well as Physics - Maths, Chemistry, Minerology, Geology, Astronomy and Architecture!

Mutual Inductance

He continued his research, looking now at the transformer effect in the light of his discovery of self-induction. He soon discovered what had been observed by Faraday earlier. If two separate coils of wire are wound around a ring of iron (an arrangement we now call a toroidal transformer, and treat as if it had just been invented!), then a change of current through one coil causes a voltage across the other for as long as the current is changing. Once again, Henry made measurements, and showed that the ratio:

$$\frac{\text{voltage across second coil}}{\text{rate of change of current through first coil}}$$

was a constant for a given transformer. He called the quantity mutual inductance, so providing constructors of transformers with a method of measuring the 'goodness' of their construction. It was hardly surprising, the that the units of both self-inductance and mutual inductance were to be called Henries, in his honour.

Early Radio?

The days of his great discoveries were almost over, for by this time Henry was a senior scientist devoting his life to bettering science education, but one curious little experiment makes us wonder what might have been. He described coiling a wire around a needle, attaching one end of the coil to earth, and the other to a wire (we would call it an aerial) held up by a kit (see Fig. 1). After a lightning-flash some eight miles away, he found that the needle had become magnetised. This was probably the first recorded action of radio waves — he might so easily have gone on to see if the needle would also have become magnetised by a spark generated at a distance by a battery and a coil!

By the time he died in 1878 Henry had achieved all this, and just as important, served as the first secretary of the Smithsonian Institute. The Smithsonian was the agency by which US Government money could be channelled to support scientific research, the start of the process which put a man on the moon and which made the US the predominant force in world technology.

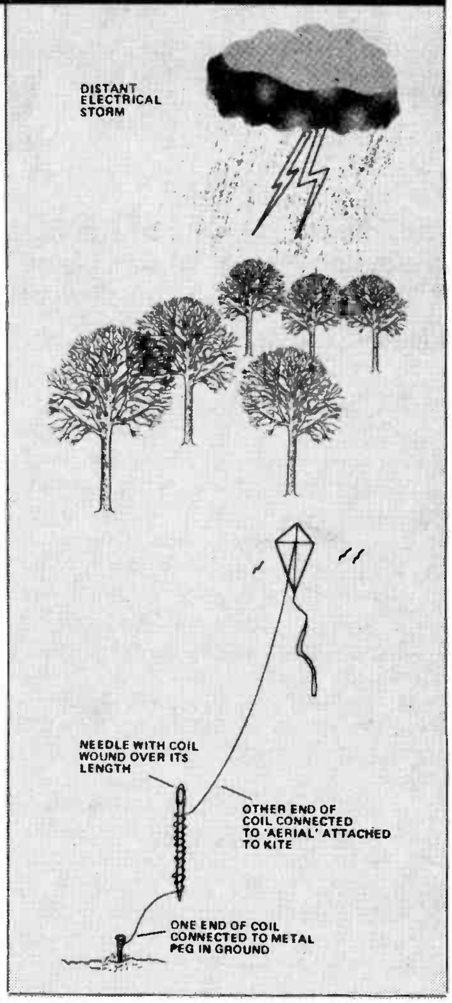


Figure 1. Henry's experiment where a needle, with a coil of wire wound over its length connected to an 'aerial' and 'earth', became magnetised by the electromagnetic radiation from a distant lightning flash.

ETI

Apple Pirates

Continued from page 32

be a bit more substantial than real Apple disk drives starting at two hundred and twenty five dollars for the raw drive and a herd of stuff-it-yourself peripheral boards for around twenty five dollars each. These should be compared to the prices for the real Apple hardware, with the power supply going for around $480, the case for about $300 and the keyboard for about $350.

If you happen to come up with a EurApple board, getting it running consists of cutting about six traces, installing thirty jumpers, one new IC and a resistor. There is also some hacking involved with the ROMs. EurApple boards usually come with a modification list. However, be aware that, like the custom made Apple copy boards, there are several versions of this list around, and some have errors. After that, one needs but stuff it and fire it up. This is probably the easiest route if you can still find one of these things and if you get the right list. I didn't . . . in fact, I had several hassles with mine, including my somewhat crude power supply which went into wild oscillations and smoked much of the RAM.

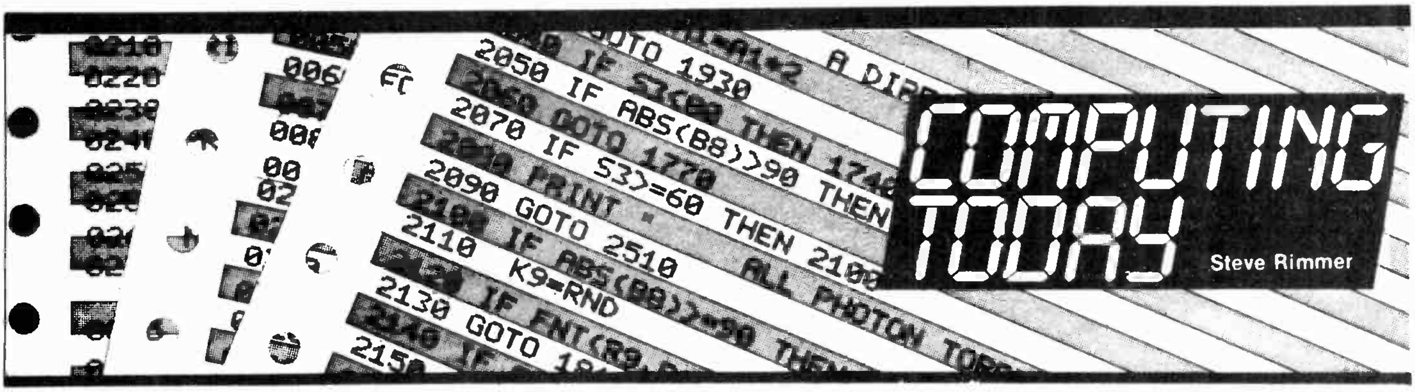
The beauty of a EurApple is that the sockets and the peripheral connectors are already in place, eliminating a lot of soldering and the major source of hassles. All told, it takes between ten and twenty hours to get the whole works together.

The other trip is to buy a copy board and do it by hand. In fact, by the time you read this, Parts Galore will probably have had a batch of boards with the sockets and connectors already wave soldered in place, making the whole works a lot easier. However, you can put 'em all in by yourself if you are careful and work slowly. I built up one of these boards as well and found that it's best to do one row of chips at a time and then rest for a while. It is also a good idea to leave the peripheral connectors off altogether for the time being, as it is in this area that the traces are the finest and the risk of solder splashes the greatest. After the machine has been successfully powered up, they can be added one at a time so that if the system fails to work at some point, the source of the problem can be spotted quickly.

It is worthwhile going for the expensive gold sockets for something as complex as this, as oxide on the IC pins can be a real pain down the line.

The small parts get soldered in after the sockets, these being mostly bypass capacitors. Next, the chips are installed. This is quite easy to do, as all the numbers are silk screened onto the board. The only danger is in getting them in backwards or rolling

Continued on page 63



It's interesting to note how some of the Digital Research supplied CP/M transient commands have become quite pervasive, while others have dwindled in importance and all but faded from use. SUBMIT files, for instance, are rarely used, and most introductory CP/M manuals do not even mention this command. PIP, on the other hand, the Peripheral Interchange Program is constantly finding new uses.

For most of its busy little life, PIP has a single function, that of moving files from one disk drive to another. In fact there's quite a lot more to be done with this program if one fully understands its capabilities.

Modes of PIPing

PIP can be used in two forms. If you just type PIP and return, the system will produce an asterisk prompt, indicating the PIP is ready to accept some command lines. A command line is any PIP instruction, such as

B: = A:MOVCPM.COM

Which moves the file MOVCPM.COM from disk drive A to drive B. After the operation has been completed, PIP will produce another prompt, and will continue to do so until a return is struck on an otherwise blank line, which will cause a warm boot.

The other form of PIP is the more common immediate mode, in which the command is specified after the instruction, such as

PIP B: = A:LETTER.DOC

which causes a warm boot after completion. The former is useful if you plan to do a lot of PIPing.

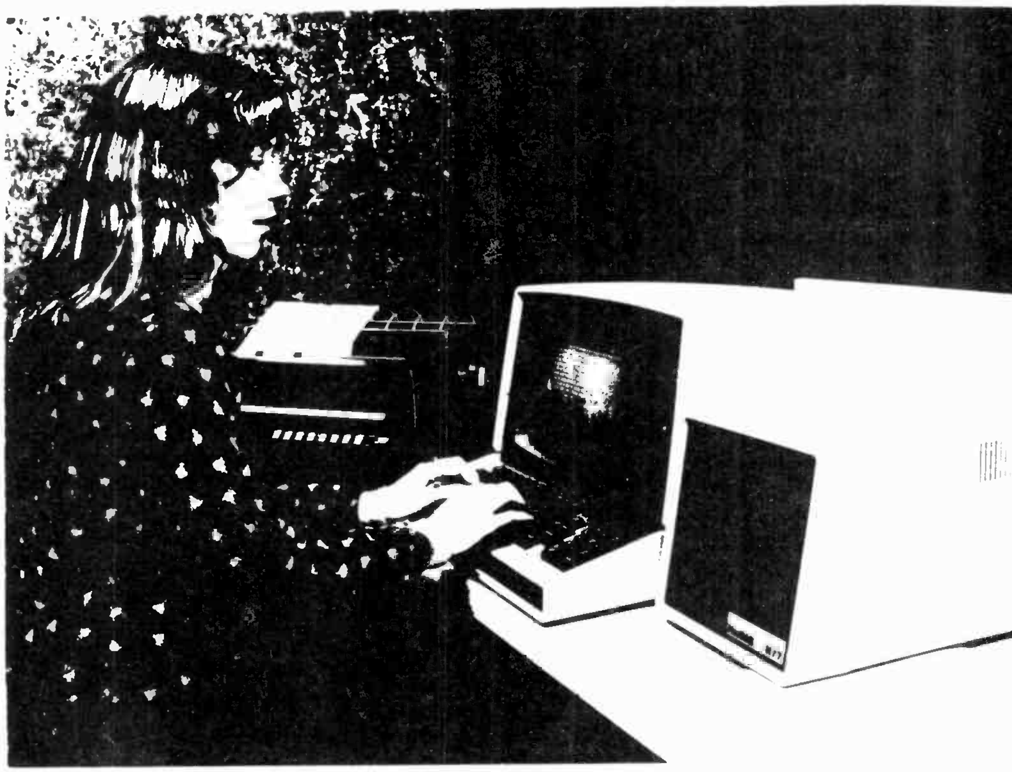
Like many CP/M utilities, PIP recognizes "wild card". It is common, in dealing with large numbers of disk files, to want to PIP a lot of files having some common characteristic. Rather than have to enter a specific command for each, one can use a wild card to indicate that all files having that particular aspect are to be PIPed. The wild card symbol is the asterisk. For example

PIP B: = A: *.OBJ

has a wild card for the file name, such that all files having the extension OBJ will be PIPed from A to B. Wild cards can also specify partial file name parameters, such as

PIP B: = A:T*.ASM

which is valid for all files having a



name begining with T and the extension ASM.

The first somewhat mythical use of PIP is that of file concatenation. A CP/M file generally consists of a block of characters, be they ASCII text or Z-80 op code, terminated by a control Z for the final character. It is possible to use PIP to combine multiple files and, at the users discretion, remove the control Z's from all but the last to create one uninterrupted file. The general form for doing this is

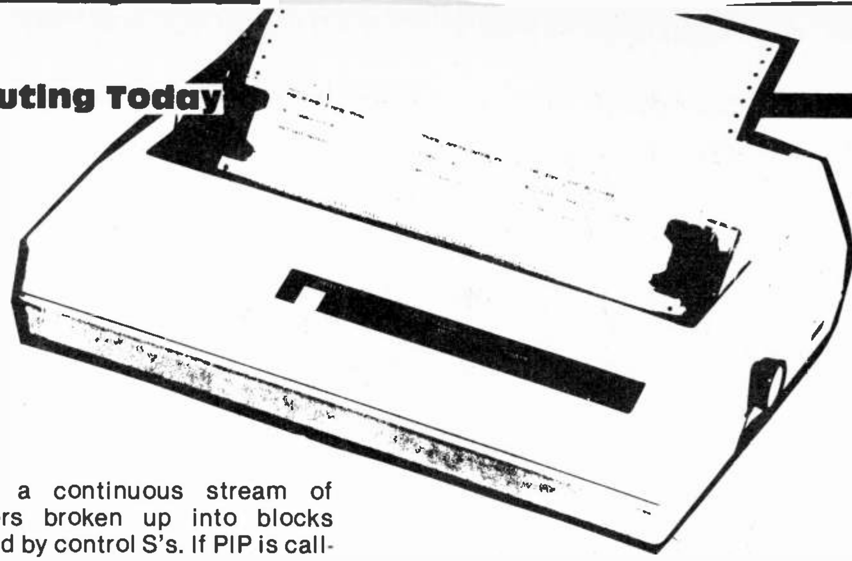
PIP A:BIGFILE.DOC = A:FILE1.DOC,A:FILE2.DOC, A:FILE3.DOC . . . etc

PIP contains a number of "toggles", or options which can be switched on for each given command line. They are automatically switched off for the ensuing line. The toggles are specified by placing their control letters in square brackets at the end of the PIP command line. For example, in this line

PIP A: = B:DIRECT.COM[V]

"V" is a toggle. Each toggle has specific uses in some of the more exotic applications of PIP.

As we will see, PIP can deal with devices other than disks. Some of these, such as a modem, may send



data in a continuous stream of characters broken up into blocks separated by control S's. If PIP is called using the B toggle, it accepts data from the source specified and places into a RAM buffer until it receives a control S. It then transfers the contents of the buffer to the destination device and clears the buffer. The buffer can be as large as the available memory of the host system. This mode is useful when spooling data from a peripheral.

If PIP is being used to PIP data to a printer, which, as we'll see, it can do, the printer may run into trouble if it does not perform automatic line feeds when presented with lines which are too long for it. Rather than hang it up, it is desirable to shorten any extremely long lines, which can be accomplished using the D toggle. Immediately following the letter D should be the maximum number of characters permitted in a line.

Toggle E is useful if you want to see what PIP is doing, and will be found to be helpful when using wild cards that PIP large numbers of files. It echos all printable characters being PIPed up to the screen. When PIP has finished, it automatically clears the screen prior to booting.

The F toggle causes the file being PIPed to be stripped of any form feed characters.

A program stored in the proper Intel hexidecimal notation format can be transfered more reliably using the H toggle. This cleans out any unnecessary characters in between the proper ones, and flags the console if there are errors. The I toggle will strip out any "OO"'s when using the H toggle.

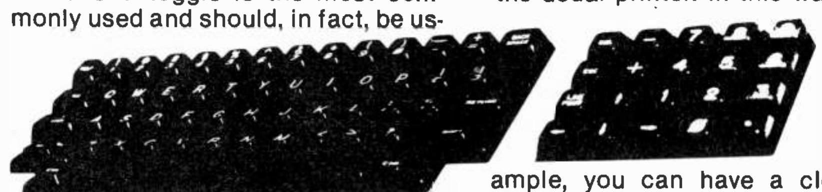
L changes all upper case alpha characters into lower case.

N is particularly useful when dealing with the source files for compiler languages like CBASIC. It adds line numbers to each line of text PIPed, beginning at 0. If the N toggle is followed by 2, leading zeros are included. The T toggle inserts a tab after each line number, the size of the tab being specified by a number placed after the T. As such, un-numbered CBASIC text can be converted for use with an MBASIC interperter with a great deal less text editing.

The O toggle ignores the usual control Z end of file markers for transfering object code. It is used if one is concatenating files of object code.

The Q toggle causes PIP to search for a string, specified after the Q and terminated by a control Z, and, upon finding it, to cease PIPing and go to the next command or execute a warm boot. S starts copying under the same conditions. Thus, a stream of data can be automatically examined for a particular section and that portion removed and made into a separate file.

The V toggle is the most commonly used and should, in fact, be used every time a file is PIPed between disks. It causes PIP to verify that all the records have gone onto the destination disk exactly as they were on the source.



Lastly, the Z toggle zeros all the parity bits on the characters being PIPed. When set along with the F toggle, this facility can remove the high order control symbols from Wordstar files, making them into normal readable text files.

PIP does not have to PIP between disk drives. As its name indicates, it can communicate between any two peripherals. The CP/M peripherals are CON, the console, RDR, the reader, PUN, the punch and LST, the list. As these names suggest, this aspect of PIP is pretty archaic, and rarely used, as other, more sophisticated software now exists to perform the same functions. However, in the interest of completeness, here are some of the uses of PIP for these devices.

Essentially, each of these device names can be used as one might specify a disk drive. To try this function, you might want to try PIPing a file to the screen, which is usually assigned to the console. This would be done as follows.

PIP CON: = A:CPM.DOC[ZF]

In this case, the Z and F toggles have been set, which is used to clean up a Wordstar file. This will cause the file to be typed to the screen. In a more practical sense, this usage of PIP can dump files to a printer or transfer data through an RS-232 port without the use of other dedicated software.

The following is useful if you want to print a Wordstar file without dealing with the various machinations of page formatting that Wordstar imposes.

PIP LST: = A:CPM.DOC[ZFE]

also,

PIP PUN: = A:CPM.DOC[ZFE]

will send it to a secondary printer hung off a serial port without having to assign the LST device away from the usual printer. In this way, for example, you can have a clean (but slow) letter quality printer off the LST for most stuff, and a cheap, sleazy (but fast) dot matrix deal off the PUN for fast proofs and listings without having to reconfigure the system every time you want to switch printers.

Unlike TYPE, this arrangement permits using wild cards, so you can use

PIP PUN: = A*.ASM

to print all the ASM files without having to type each name separately.

All told, a useful little troll, old PIP. Considering just how much of a system is actually dealt with as peripherals, it can handle a lot of stuff that would otherwise call for heavy additional software. A complete explanation of it is to be found in the Digital Research manuals... the bit you skipped over when you first got the disk, and have always been meaning to go back to. Fascinating reading.

Hand Clap Synthesizer

Does your snare drum suffer from nervous skin tension, lack of timbre? Then revive it with the ETI Hand-clap Syn theziser. Designed to simulate the staccato effect of multiple hand-claps, the unit can be triggered by a microphone or footswitch. Design by Roger Shore. Development by Steve Ramsahadeo.

IT WOULD SEEM that no record is complete without the familiar hand-claps that faithfully accent the snare drum's down beat. One can imagine a group of people centred around a studio microphone, palms reddening, acting like human metronomes. We are happy to report that such a form of torture is now unnecessary in this electronic age!

It's generally accepted that the advent of the synthesizer in the late 60s was the commercial starting point of electronic music, not so much in the way of percussive synthesis but with such effects as tremolo, fuzz, flanging, reverberation and phasing, all of which are added to give expression to a piece of music.

No Applause Please

Multiple or 'ensemble' hand-clapping may be analysed subjectively in two distinct sections:

1. A general 'crash' — which may be simulated with a short burst of tuned noise.
2. Individual claps — this can be simulated by generating pulses which cause a multiple feedback band-pass filter to ring. Several different combinations of individual claps were tried from one to seven, at both regular and irregular intervals, but two provided the best subjective results.

Setting up a unit such as this will depend on personal preferences and also on the type of amplifying system used. It is preferable to use a unit with reverberation where possible as this will greatly enhance the effect.

The problem of which variables should be external and which should remain preset is also one of personal taste. As circumstances dictate different settings we decided to make all seven controls external.

Construction

No problems should be encountered in constructing the Hand-clap Synthesizer. The power supply section should be built first; care should be taken to sleeve the AC terminals on the PCB and the on/off switch.

When this is completed, connect a voltmeter across the output pins of the supply. A reading of +15V and −15V should be available at the output. If all is well the rest of the control circuit can be constructed observing the usual CMOS handling procedure and the orientation of polarised components.

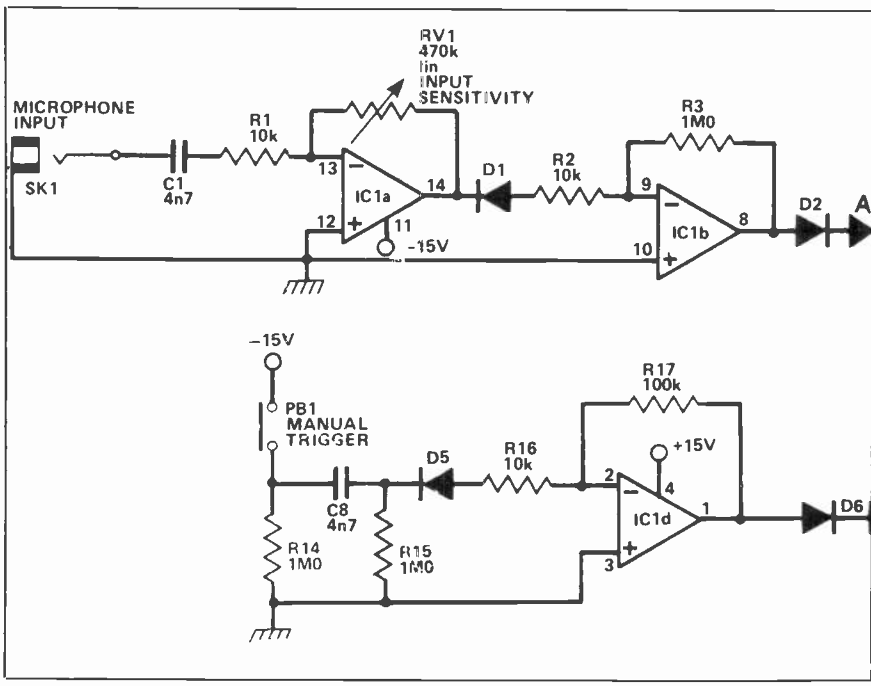


Fig. 1 Circuit diagram of the Hand-clap Synthesizer.

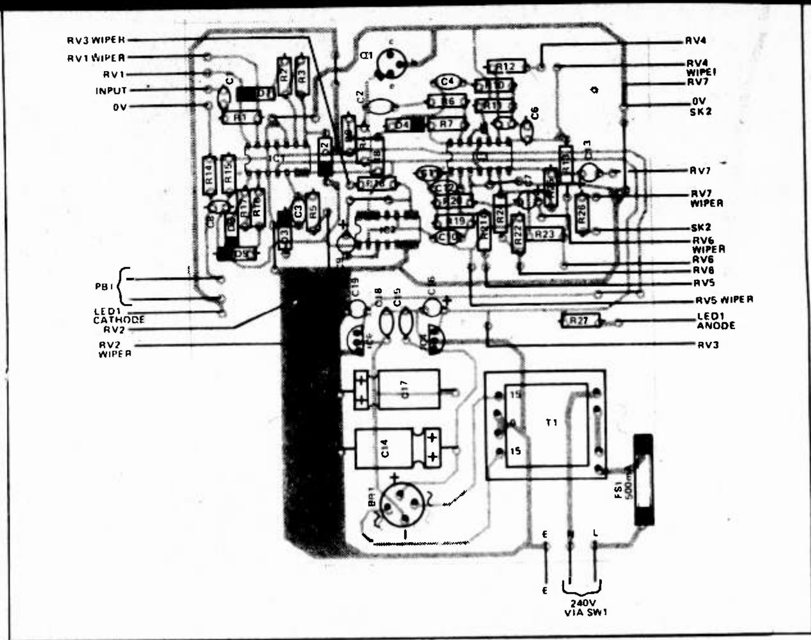
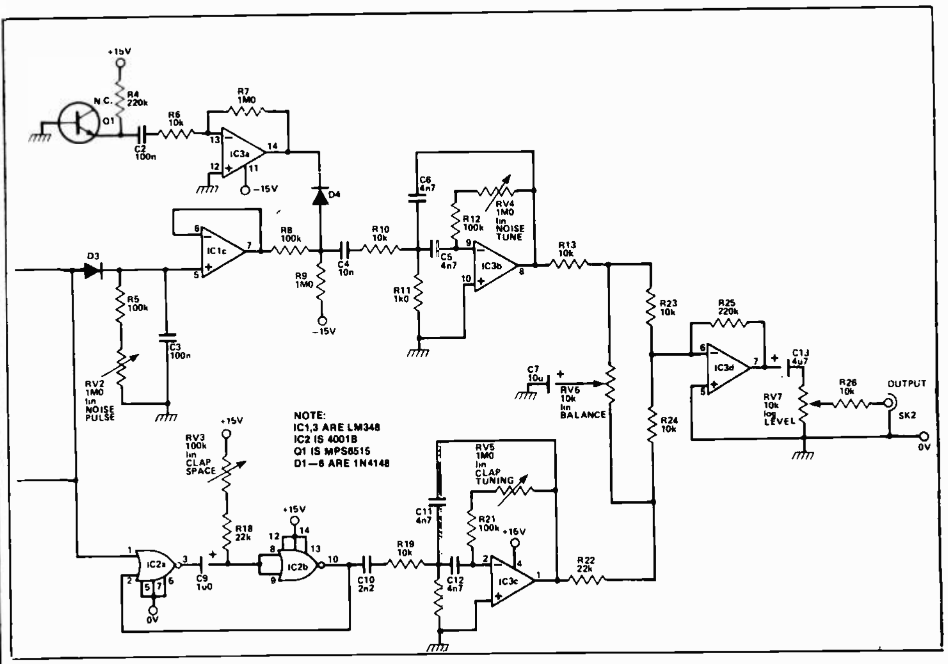


Fig. 2 Component overlay for the Hand-clap Synthesizer.



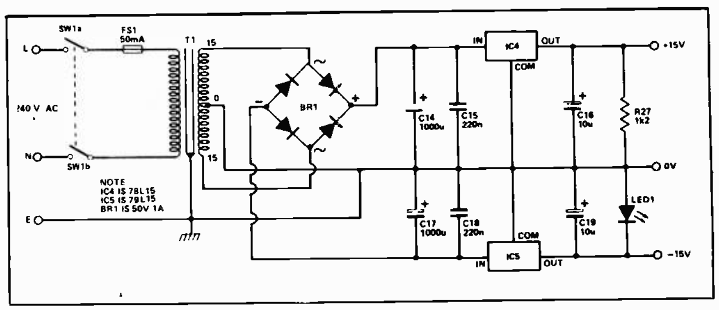


Fig. 3 Circuit diagram of the power supply for the synthesizer.

HOW IT WORKS

The unit can be triggered from either a momentary push-button (PB1) or from a suitable transducer, eg a microphone placed near a snare drum.

In the first case, pressing PB1 causes a negative-going pulse to be developed across C8. This is steered via D5 to the inverting input of IC1d, causing a positive pulse to appear at the cathode of D6.

Alternatively, an input signal from a microphone is differentiated by C1 and R1. This prevents false triggering from other nearby sources. The signal is amplified and inverted by IC1a with RV1 acting as a sensitivity control. Further inversion by IC2b is required to provide a positive pulse at the cathode of D2. These trigger pulses appearing at the cathodes of D2 or D6 are fed to both the anode of D3 and pin 1 of IC2a.

When D3 is forward biased by the trigger pulse it allows C3 to charge positively. The rate of discharge is determined by R5 and the setting of RV2; this ramp is buffered by IC1c, the output of which is connected to D4 and C4 via R8.

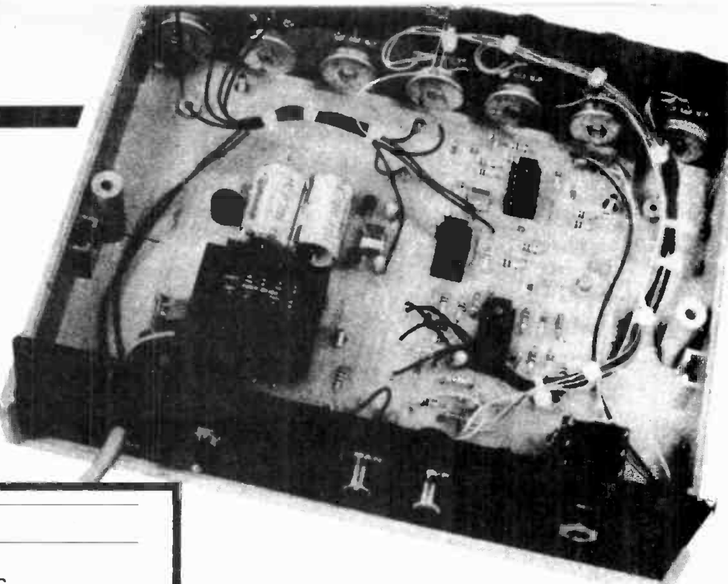
The base-emitter junction of Q1 is reversed biased to produce the required noise. A low noise transistor is chosen to give a cleaner noise source. This noise is amplified by IC3a and fed to the cathode of D4. When a trigger pulse causes a positive ramp to appear at the output of IC1c, D4 conducts allowing noise to pass via D4 and C4 to the band-pass filter formed by IC3b and associated components. The length of this noise pulse is determined by the setting of RV2, the ramp discharge time.

R9 normally holds the anode of D4 at approximately −1V5 to prevent noise peaks from turning D4 on intermittently.

The band-pass filter is tuned over the 'useful' part of the noise spectrum for this application. Although the Q of the filter network will vary (because RV4 is not 'ganged' with R10), this does not pose any problem in this non-critical situation.

At the same time as the noise pulse is generated, the trigger pulse is applied to pin 1 of IC2a, turning on the monostable formed by IC2a and IC2b and allowing pin 10 to assume a high state. This positive voltage is developed across C10, causing the band-pass filter formed around IC3c to ring at a frequency determined by the position of RV5. (The two band-pass filters are of identical design.) At a time determined by RV3 and C9 the monostable will reset and the negative-going edge at pin 10 of IC2b allows a second ringing pulse to be generated by the band-pass filter. These two ringing pulses are the individual claps and are mixed with the noise pulse via the balance control RV6 and through R23, R24 to the output amplifier IC3d.

Back panel of the synthesizer. Sockets are provided for the manual trigger (an external footswitch) or a microphone, triggered by the snare drum for example.



PARTS LIST

Resistors (all ¼ W, 5%)

R1,2,6, 10,13,16, 19,23,24,26	10k
R3,7,9,14,15	1M0
R4,25	220k
R5,8,12, 17,21	100k
R11,20	1k0
R18,22	22k
R27	1k2

Potentiometers

RV1	470k linear
RV2,4,5	1M0 linear
RV3	100k linear
RV6	10k linear
RV7	10k logarithmic

Capacitors

C1,5,6,8, 11,12	4n7 ceramic
C2,3	100n polycarbonate
C4	10n polycarbonate
C7,16,19	10u 35V tantalum
C9	1u0 35V tantalum
C10	2n2 ceramic
C13	4u7 35V tantalum
C14,17	1000u 25V axial electrolytic
C15,18	220n polycarbonate

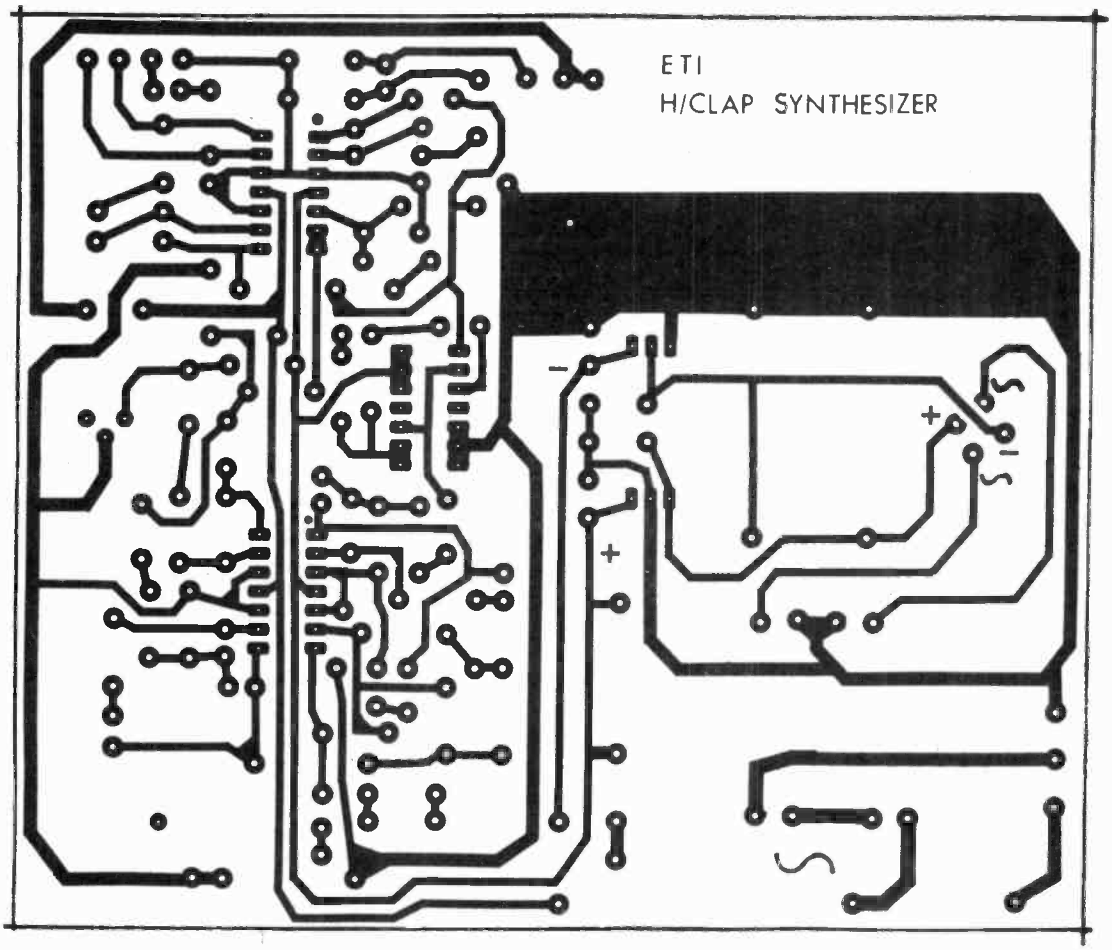
Semiconductors

IC1,3	LM348
IC2	4001B
IC4	78L15
IC5	79L15
Q1	MPS6515
BR1	50V, 1A bridge rectifier
D1-6	1N4148
LED1	0.125" red LED

Miscellaneous

T1	15-0-15, 3V A transformer
SW1	DPDT miniature toggle
PB1	momentary push-button
SK1	¼" jack socket
SK2	phono socket
FS1	50 mA fuse and holder.

Case, seven collet knobs.



ETI

Continued from page 39

CHAIN permits one program to call and run another without destruction of the variables set by the first program. Thus, programs that are too huge to fit into the available RAM, or that cannot fit and still leave room for data manipulations, can be easily chopped up without having to fudge dozens of little bitty disk files.

COM permits a program to monitor the status of the system's external communications bits, and can be used as a conditional branch to go to communication handling routines.

KEY statements relate to the ten function keys on the keyboard. These can be assigned specific strings which will be printed out on the screen when the key is struck. Thus, if you are doing a lot of work on lines 1000 to 1100 of a program, you might want to program key F10 to contain "LIST 1000-1100" + CHR$(13), which will cause lines 1000 to 1100 to be displayed each time you hit F10. KEY commands permit the KEYs to be programmed, read and switched on and off. A display of what's in the keys can be toggled on and off the bottom line of the screen. There are also KEY commands that permit conditional branching on the activity of the F keys.

There is provision for dealing with a light pen, using PEN statements and, with a joystick, using STRIG. What a great word STRIG is . . . if you didn't know what it did, you'd swear it was the computer swearing.

WAIT is useful, in that it can be made to go into a holding pattern until a particular port comes up with a specified bit.

Lastly, there is an extra loop structure, called the WHILE . . . WEND loop, which can do some things easier than a FOR NEXT, because it has no inherent number of operations built into it.

There are also lots of high resolution graphics statements, including CIRCLE, COLOR, PAINT, PRESET, PSET and SCREEN, and SOUND, which drives the internal speaker. Specialized statements dealing with the ports permit writing useful communications programs in BASIC, as the actual data handling is done via routines in the BASIC. (In fact, there's a terminal program written in BASIC that's included with the BASIC disk.) There are also specialized direct disk driving statements, and CALL, which permits one to handle machine language programs directly and manipulate the disk drives . . . if you dare.

Writing programs on the BASIC is a trip . . . you can do anything, and I experienced no hang ups at all. The only frequent problem was caused by that weird shift key, which you grow to hate. As it works out, the numeric keypad doesn't produce numbers in BASIC . . . you have to go to the upper row of the QWERTY for that. It moves the cursor in its normal mode, and must be shifted to be a number pad. There is a caps lock key for prettier BASIC text, although the BASIC itself couldn't care, translating all non-literal lower case text into upper case upon re-LISTing.

A goodly trip, this, and, as I will never be able to afford one I can safely say that as far as running BASIC goes, the IBM is worth whatever it costs.

Further On Into The Jungle

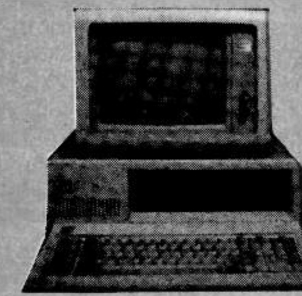
The only other software we checked out in depth was the EasyWriter word processor. It is very much a clone of WORDSTAR, the popular CP/M based system. It's menu driven, and has many of the same features. The F keys control the menus and many of the features, which is an improvement of the usual WORDSTAR configuration, which involves holding down the CTRL plus a second key. The cursor is moved by the numeric pad.

One of the real weirdnesses of the EasyWriter is that it uses a number of the IBM's graphic characters as on-screen control codes. As is the case on some typesetting text editors, for example, a carriage return is actually printed on the screen. Usually this is a little arrow which flips back towards the left hand margin of the page. However, there not being one of these in the IBM character set, they have chosen a musical note symbol, which is a bit perplexing, and makes the screen look real happy. Fortunately, this thing only turns up at the end of a paragraph, as the automatic line ending takes care of just general running off the screen, and doesn't feel the need for a note every time.

The character insertion deal with the word processor is the same as that of the BASIC. You hit the insert key to toggle in and out of this mode, which is useful enough.

There are a few features of the EasyWriter which are not available on WORSTAR. For example, after deleting something, you can change your mind and undelete it . . . I'm not sure this is earth shattering, but, as all it really involves is moving a pointer around, it's probably cool. There's also delete to end of line,

ETI FACT FILE



Manufacturer:	IBM
Area of Interest:	Home and Business
Processor:	8088
Screen size:	11 inches
Graphics:	640 x 200 high resolution
Sound:	One channel
Display:	external monitor
Mass Storage:	2 5¼ inch disks 160K each
RAM:	64K
Printer included:	Yes
Software included:	IBM DOS
ROM pack facility:	No
RS-232 Port:	No
Parallel Port:	No
Printer Interface:	Yes
DOS:	IBM DOS
Number of units:	3
Documentation:	Extensive manuals
Price:	$5800 including 2 160K drives, monitor, printer/monitor driver card, printer and cable

ETI'S EVALUATION

We have evaluated our sample on a scale of one (poor) to five (exceptional). In making our assessment we have taken into account the class of user to which the computer is marketed.

Mechanical Construction	● ● ● ●
Overall ease of use	● ● ● ● ●
Speed of Operation	● ● ●
Software	● ● ● ●
Suitability for beginners	● ●
Suitability for business	● ● ● ●
Manuals and instructions	● ● ● ●
Supplier	

IBM Canada Limited
220 Duncan Mills Road
Don Mills, Ontario
M3B 3J5

Continued on page 75

Apple Pirates

Continued from page 56

the pins under the chips. There are a lot of chips, and one needs be careful.

It's probably safest to use one of the power supplies being sold for the Apple copies, but you can go with a transformer deal. If you plan to use a number of peripherals, you will need a fairly beefy supply, capable of providing two and a half amps on the positive five volt rail, an amp and a half on the positive twelve volt rail and a quarter of an amp on the negative five and twelve volt rails. The power supply connector, AMP #9-35028-1, is not available in Canada from AMP dealers, but most of the places selling the boards have reasonable facimiles.

You will also need an eight ohm squeaker-speaker and a little chunk of AP female header pins to attach it to the board. It is, however, quite safe to run the board without the speaker.

One thing that I learned with my first attempt at one of these things is that a 48K Apple with a problem can blow 48K of RAM. A 16K system can blow 16K. The difference between these two systems is in that the 16K has chips in only the first eight sockets. More chips can be added afterwords. There's a moral in this.

With everything in place, everything checked twice, the board resting on a non-metalic surface, all precautions taken and all prayers said the board can be hooked to a video monitor and powered up. You should see a screen full of question marks for a second, followed by a power up message... either "APPLE" and a revision number or something cute from your particular local ROM bandit... and a right square bracket prompt and flashing cursor. Given all this, you are probably flying.

Apple Never Smiles

Having now done two Apple copies of varying styles and types, I should say that this is not an undertaking for beginners. In fact, it requires more than the usual amount of care, as the tracks are fine, and errors, even small ones, can cause the whole system to fail. However, the rewards are great and there's a tremendous feeling ofaccomplishment in getting one up.

There is, however, a definite ethical problem in these things. Copyright laws are set up so that the creator of a design or other idea can invest time and money into the furtherance of it with the assurance that he or she will be able to exploit it without fear of other parties moving in and scarfing it as soon as it is revealed. This is done so that people will be moved to produce things that are of benifit to the society, which the Apple computer certainly is. Granted, it is grossly over priced, but it is still, technically, the property of its owners. Everyone involved in the Apple copy industry has managed to skirt the letter of the copyright laws, which are pretty antiquated, but they are, I think, guilty of breaching their intent.

On the other hand, doing unto a large corporation is fun. It also embodies a reply to the above argument, namely that it is unfair that those of us that are poor should be denied access to tools simply because we are poor. Parties selling things which are grossly overpriced cannot survive in a pirate laden economy, which will prompt them to make their stuff more competitive and, as such, more readily available to poor slobs like us.

Furthermore, it can be said that copyright exists to provide a protected market for the creator of an idea. However, the market for Apples has never been the hardware hackers, as they have always been too expensive. Clearly, if one steals an idea but then creates a new market for it, one has not disadvantaged the idea's original owner. Apple, still not smiling, probably sees this whole thing as a great number of potential customers being scarfed out from under them, but, in fact, it seems unlikely that a significant number of individuals who are prepared to spend a couple of hundred dollars to piece an Apple copy together would ever want to shoot two grand on a real Apple. On the other hand, a businessman who depends on his Apple computer to do whatever it is that businessmen do on these things isn't going to want to rely on something somebody with large feet put together in his basement.

Bill Jackson once remarked that "Apple could blow us all out of the water by offering their own kit... they have PCBs, keyboards, cases, etc., and at cheaper prices than anyone else." The whole apple copy industry has been built around Apple's rather high brow attitudes. However, a recent report out of Apple notes the impending launch of the Apple II E, which will have 64K of RAM on board, an eighty column screen, full upper and lower case characters and a complete redesign using LSI chips, probably eleven of them, all at a substantially reduced priced. This could, of course, be mere heresay (we all thought the Apple III was for the longest time) aimed at eroding the market of the Apple copiers. Or it might be that the pirates are shortly about to get skuttled.

Table 1

The following are the suppliers of Apple copy hardware and services that we've found to date. It should be pointed out that ETI Magazine has no connection with any of these parties, and no knowledge of what they are doing other than that which they have told us or placed in their ads. We are also not, in any way, responsible for what they are selling, and we have no knowledge of what works or what is legal other than that which appears in this article. Please do not contact us for further information.

Parts Galore, 316 College Street, Toronto, Ontario M5T 1S3, Telephone (416) 925-8291. Sells boards, parts, cases, keyboards, drives, peripheral cards and power supplies. Reputedly the best source for the whole mess.

Exceltonix, 319 College Street, Toronto, Ontario, M5T 1S2, telephone (416) 921-5295. Sells chips, drives, non-Apple keyboards, peripheral cards and non-Apple power supplies, complete parts kits, plus a large range of Apple compatable software and documentation. Does not sell boards, but will refer one to a mail order place that does.

Hitek Computing Devices, P.O. Box 361, West Hill, Ontario, telephone (416) 299-3721. Makes and sells boards (which are very nice). This is where Exceltronix sends you if you ask for a board.

Kitstronic International, P.O. Box 577, Station J, Toronto, Ontario M4J 4Z2. Sells boards, keyboards, power supplies, disks and controllers.

Orion Electronic Supplies Inc, 40 Lancaster Street West, Kitchener, Ontario N2H 4S9, telephone (519) 576-9902 Sells boards (bare and stuffed), peripherals, power supplies, cases, disk drives.

Active Surplus Annex, 345 Queen Street West, Toronto, Ontario, M5V 2A4, telephone (416) 593-0967 Sells boards, peripherals, keyboards and parts.

General Electronics, 5511 Yonge Street, Willowdale, Ontario M2N 5S3, telephone (416) 221-6174 Sells boards, parts, keyboards, plastic cases, disk drives, printers, blank peripheral boards and offers a debugging service.

Smart Screens, One First Canadian Place, Concourse Level, Toronto, Ontario, M5X 1A6 telephone (416) 365-1166 and Mega Byte Micro Systems, 40 St. Charles Road, Beaconsfield, Quebec, H9W 2X9 telephone (514) 694-7305. Sells a completely assembled Apple copy, the "Golden II", for $1426.00 as of this writing.

Scarsdale Computers, 1 Scarsdale Road, Don Mills, Ontario M3B 2R2. Imports the Franklin *Ace* Apple Emulator, which sells for $2388.00 as of this writing.

Mr. Rory Jan, 54 Forest Path Cresent, Rexdale, Ontario M9V 1L5, telephone (416) 741-7656. Debugs and repairs Apple copy boards. At the time of this writing he was charging $15.00 an hour, with most jobs taking no more than two hours.

ETI

ETI book shelf

COMPUTERS
(HARDWARE)

THE ESSENTIAL COMPUTER DICTIONARY AND SPELLER
AB011 **10.45**
A must for anyone just starting out in the field of computing, be they a businessman, hobbyist or budding computerist. The book presents and defines over 15,000 computer terms and acronyms and makes for great browsing.

A BEGINNER'S GUIDE TO COMPUTERS AND MICROPROCESSORS — WITH PROJECTS.
TAB No.1015 **$13.45**
Here's a plain English introduction to the world of microcomputers — it's capabilities, parts and functions . . . and how you can use one. Numerous projects demonstrate operating principles and lead to the construction of an actual working computer capable of performing many useful functions.

BP66: BEGINNERS GUIDE TO MICROPROCESSORS AND COMPUTING **$7.55**
E.F. SCOTT, M.Sc., C.Eng.
As indicated by the title, this book is intended as an introduction to the basic theory and concepts of binary arithmetic, microprocessor operation and machine language programming.
There are occasions in the text where some background information might be helpful and a Glossary is included at the end of the book.

BP72: A MICROPROCESSOR PRIMER **$7.70**
E.A. PARR, B.Sc., C.Eng., M.I.E.E.
A newcomer to electronics tends to be overwhelmed when first confronted with articles or books on microprocessors. In an attempt to give a painless approach to computing, this small book will start by designing a simple computer and because of its simplicity and logical structure, the language is hopefully easy to learn and understand. In this way, such ideas as Relative Addressing, Index Registers etc. will be developed and it is hoped that these will be seen as logical progressions rather than arbitrary things to be accepted but not understood.

BEGINNERS GUIDE TO MICROPROCESSORS
TAB No.995 **$10.45**
If you aren't sure exactly what a microprocessor is, then this is the book for you. The book takes the beginner from the basic theories and history of these essential devices, right up to some real world hardware applications.

HOW TO BUILD YOUR OWN WORKING MICROCOMPUTER
TAB No.1200 **$16.45**
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 **$7.30**
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.

HANDBOOK OF MICROPROCESSOR APPLICATIONS
TAB No.1203 **$14.45**
Highly recommended reading for those who are interested in microprocessors as a means of accomplishing a specific task. The author discusses two individual microprocessors, the 1802 and the 6800, and how they can be put to use in real world applications.

MICROPROCESSOR/MICROPROGRAMMING HANDBOOK
TAB No.785 **$14.45**
A comprehensive guide to microprocessor hardware and programming. Techniques discussed include subroutines, handling interrupts and program loops.

BP102: THE 6809 COMPANION **$8.10**
M. JAMES
The 6809 microprocessor's history, architecture, addressing modes and the instruction set (fully commented) are covered. In addition there are chapters on converting programs from the 6800, programming style, interrupt handling and about the 6809 hardware and software available.

AN INTRODUCTION TO MICROPROCESSORS EXPERIMENTS IN DIGITAL TECHNOLOGY
HB07: **$15.85**
SMITH
A "learn by doing" guide to the use of integrated circuits provides a foundation for the underlying hardware actions of programming statements. Emphasis is placed on how digital circuitry compares with analog circuitry. Begins with the simplest gates and timers, then introduces the fundamental parts of ICs, detailing the benefits and pitfalls of major IC families, and continues with coverage of the ultimate in integrated complexity — the microprocessor.

DESIGNING MICROCOMPUTER SYSTEMS
HB18: **$15.85**
POOCH AND CHATTERGY
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: **$22.75**
BURSKY
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.

BASIC MICROPROCESSORS AND THE 6800
HB06: **$21.45**
Provides two books in one: a basic guide to microprocessors for the beginner, and a complete description of the M6800 system for the engineer.
Each chapter is followed by a problem section.

DIGITAL INTERFACING WITH AN ANALOG WORLD
TAB No.1070 **$14.45**
You've bought a computer, but now you can't make it do anything useful. This book will tell you how to convert real world quantities such as temperature, pressure, force and so on into binary representation.

MICROPROCESSOR INTERFACING HANDBOOK: A/D & D/A
TAB No.1271 **$14.45**
A useful handbook for computerists interested in using their machines in linear applications. Topics discussed include voltage references, op-amps for data conversion, analogue switching and multiplexing and more.

COMPUTER TECHNICIAN'S HANDBOOK
TAB No.554 **$17.45**
Whether you're looking for a career, or you are a service technician, computer repair is an opportunity you should be looking at. The author covers all aspects of digital and computer electronics as well as the mathematical and logical concepts involved.

HOW TO TROUBLESHOOT AND REPAIR MICROCOMPUTERS
AB013 **$13.45**
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 **$13.45**
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 **$13.45**
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.

COMPUTERS
(SOFTWARE)

NEW

BP109: THE ART OF PROGRAMMING THE 1K ZX81 **$8.10**
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 pontoon,. 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.

BEGINNER'S GUIDE TO COMPUTER PROGRAMMING
TAB No.574 **$16.45**
Computer programming is an increasingly attractive field to the individual, however many people seem to overlook it as a career. The material in this book has been developed in a logical sequence, from the basic steps to machine language.

HOW TO PROFIT FROM YOUR PERSONAL COMPUTER: PROFESSIONAL, BUSINESS, AND HOME APPLICATIONS
LEWIS
HB01 **$17.00**
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.

PROGRAMS FOR BEGINNERS ON THE TRS-80
BLECHMAN
HB02 **$13.05**
A valuable book of practical and interesting programs for home use that can be understood and used immediately by the beginner in personal computer programming. You'll learn step-by-step how 21 sample TRS-80 programs work. Program techniques are described line-by-line within the programs, and a unique Martri-Dex™ matrix index will enable you to locate other programs using the same BASIC commands and statements.

THE JOY OF MINIS AND MICROS: DATA PROCESSING WITH SMALL COMPUTERS
STEIN AND SHAPIRO
HB03 **$15.85**
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.

USING MICROCOMPUTERS IN BUSINESS
VEIT
HB04 **$14.45**
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.

BASIC FROM THE GROUND UP
SIMON
HB15 **$17.00**
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 backbround 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.

BASIC COMPUTER PROGRAMS FOR BUSINESS: STERNBERG (Vol. 1)
HB13 **$15.85**
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.

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

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

PET BASIC — TRAINING YOUR PET COMPUTER
AB014 **$17.45**
Officially approved by Commodore, this is the ideal reference book for long time PET owners or novices. In an easy to read and humorous style, this book describes techniques and experiments, all designed to provide a strong understanding of this versatile machine.

PROGRAMMING IN BASIC FOR PERSONAL COMPUTERS
AB015 **$13.45**
This book emphasizes the sort of analytical thinking that lets you use a specific tool — the BASIC language — to transform your own ideas into workable programs. The text is designed to help you to intelligently analyse and design a wide diversity of useful and interesting programs.

COMPUTER PROGRAMS IN BASIC
AB001 **$15.45**
A catalogue of over 1,600 fully indexed BASIC computer programs with applications in Business, Math, Games and more. This book lists available software, what it does, where to get it, and how to adapt it to your machine.

PET GAMES AND RECREATION
AB002 **$17.45**
A variety of interesting games designed to amuse and educate. Games include such names as Capture, Tic Tac Toe, Watchperson, Motie, Sinners, Martian Hunt and more.

BRAIN TICKLERS
AB005 **$9.00**
If the usual games such as Bug Stomp and Invaders From the Time Warp are starting to pale, then this is the book for you. The authors have put together dozens of stimulating puzzles to show you just how challenging computing can be.

See order form in this issue. All prices include shipping. No sales tax applies

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

PASCAL PROGRAMMING FOR THE APPLE
AB008 **$17.45**
A great book to upgrade your programming skills to the UCSD Pascal as implemented on the Apple II. Statements and techniques are discussed and there are many practical and ready to run programs.

APPLE MACHINE LANGUAGE PROGRAMMING
AB009 **$20.45**
The best way to learn machine language programming the Apple II in no time at all. The book combines colour, graphics, and sound generation together with clear cut demonstrations to help the user learn quickly and effectively.

Z80 USERS MANUAL
AB010 **$21.45**
The Z80 MPU can be found in many machines and is generally acknowledged to be one of the most powerful 8 bit chips around. This book provides an excellent 'right hand' for anyone involved in the application of this popular processor.

HOW TO PROGRAM YOUR PROGRAMMABLE CALCULATOR
AB006 **$12.45**
Calculator programming, by its very nature, often is an obstacle to effective use. This book endeavours to show how to use a programmable calculator to its full capabilities. The TI 57 and the HP 33E calculators are discussed although the principles extend to similar models.

Z-80 AND 8080 ASSEMBLY LANGUAGE PROGRAMMING
SPRACKLEN
HB05 **$14.25**
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.

BASIC COMPUTER PROGRAMS IN SCIENCE AND ENGINEERING
GILDER
HB08 **$15.85**
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 COMPUTERS SECOND EDITION
SPENCER
HB11 **$31.25**
Now you can sharpen programming skills through a relaxed approach. Completely devoted to computerized game playing, this volume presents over 70 games, puzzles, and mathematical recreations for a digital computer. It's fully illustrated and includes more that 25 game-playing programs in FORTRAN or BASIC complete with descriptions, flowcharts, and output.

MICROCOMPUTERS AND THE 3 R'S
DOERR
HB09 **$14.25**
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.

GAME PLAYING WITH BASIC
SPENCER
HB10 **$15.25**
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.

SARGON: A COMPUTER CHESS PROGRAM
SPRACKLEN
HB12 **$25.00**
"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.

A CONSUMER'S GUIDE TO PERSONAL COMPUTING AND MICROCOMPUTERS, SECOND EDITION
FREIBERGER AND CHEW
HB14 **$14.45**
The first edition was chosen by Library Journal as one of the 100 outstanding sci-tech books of 1978. Now, there's an updated second edition!

Besides offering an introduction to the principles of microcomputers that assumes no previous knowledge on the reader's part, this second edition updates prices, the latest developments in microcomputer technology, and a review of over 100 microcomputer products from over 60 manufacturers.

THE BASIC CONVERSIONS HANDBOOK FOR APPLE, TRS-80, AND PET USERS
BRAIN BANK
HB17 **$11.75**
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.

SPEAKING PASCAL
BOWEN
HB16 **$17.25**
An excellent introduction to programming in the Pascal languagel 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.

BP33: ELECTRONIC CALCULATOR USERS HANDBOOK **$4.25**
M.H. BABANI, B.Sc.(Eng.)
An invaluable book for all calculator users whatever their age or occupation, or whether they have the simplest or most sophisticated of calculators. Presents formulae, data, methods of calculation, conversion factors, etc., with the calculator user especially in mind, often illustrated with simple examples. Includes the way to calculate using only a simple four function calculator: Trigonometric Functions (Sin, Cos, Tan) Hyperbolic Functions (Sinh, Cosh, Tanh) Logarithms, Square Roots and Powers.

THE MOST POPULAR SUBROUTINES IN BASIC
TAB No.1050 **$10.45**
An understandable guide to BASIC subroutines which enables the reader to avoid tedium, economise on computer time and makes programs run faster. It is a practical rather than a theoretical manual.

PROJECTS

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

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

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

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

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

EXPERIMENTER'S GUIDE TO SOLID STATE ELECTRONIC PROJECTS
AB007 **$10.45**
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 **$7.70**
R. A. PENFOLD
Some of the most useful and popular electronic construction projects are those that can be used in or around the home. The circuits range from such things as '2 Tone Door Buzzer', Intercom, through Smoke or Gas Detectors to Baby and Freezer Alarms.

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

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

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

BP93: ELECTRONIC TIMER PROJECTS **$8.10**
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
HB24 **$11.75**
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
HB25 **$10.25**
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.

110 THYRISTOR PROJECTS USING SCRs AND TRIACS
MARSTON
HB22 **$12.05**
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
HB23 **$11.75**
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 **$7.30**
R.A. PENFOLD
Line power supplies are an essential part of many electronics projects. The purpose of this book is to give a number of power supply designs, including simple unstabilised types, fixed voltage regulated types, and variable voltage stabilised designs, the latter being primarily intended for use as bench supplies for the electronics workshop. The designs provided are all low voltage types for semiconductor circuits.

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

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

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

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

BP73: REMOTE CONTROL PROJECTS **$8.60**
OWEN BISHOP
This book is aimed primarily at the electronics enthusiast who wishes to experiment with remote control. Full explanations have been given so that the reader can fully understand how the circuits work and can more easily see how to modify them for other purposes, depending on personal requirements. Not only are radio control systems considered but also infra-red, visible light and ultrasonic systems as are the use of Logic ICs and Pulse position modulation etc.

BP99: MINI — MATRIX BOARD PROJECTS **$8.10**
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.

NEW

BP103: MULTI-CIRCUIT BOARD PROJECTS **$8.10**
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.

NEW

BP107: 30 SOLDERLESS BREADBOARD PROJECTS — BOOK 1 **$9.35**
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.

See order form in this issue. All prices include shipping. No sales tax applies.

ETI book shelf

NEW

BP110: HOW TO GET YOUR ELECTRONIC PROJECTS WORKING $8.10
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.

CIRCUITS

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

BP98: POPULAR ELECTRONIC CIRCUITS, BOOK 2 $9.35
R.A. PENFOLD
70 plus circuits based on modern components aimed at those with some experience.

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

BP39: 50 (FET) FIELD EFFECT TRANSISTOR PROJECTS $5.50
F.G. RAYER, T.Eng.(CEI),Assoc.IERE
Field effect transistors (FETs), find application in a wide variety of circuits. The projects described here include radio frequency amplifiers and converters, test equipment and receiver aids, tuners, receivers, mixers and tone controls, as well as various miscellaneous devices which are useful in the home.
This book contains something of particular interest for every class of enthusiast — short wave listener, radio amateur, experimenter or audio devotee.

BP87: SIMPLE L.E.D. CIRCUITS $5.90
R.N. SOAR
Since it first appeared in 1977, Mr. R.N. Soar's book has proved very popular. The author has developed a further range of circuits and these are included in Book 2. Projects include a Transistor Tester, Various Voltage Regulators, Testers and so on.

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

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

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

BP44: IC 555 PROJECTS $7.55
E.A. PARR, B.Sc.,C.Eng., M.I.E.E.
Every so often a device appears that is so useful that one wonders how life went on before without it. The 555 timer is such a device. Included in this book are Basic and General Circuits, Motor Car and Model Railway Circuits, Alarms and Noise Makers as well as a section on the 556, 558 and 559 timers.

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

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

BP65: SINGLE IC PROJECTS $4.55
R.A.PENFOLD
There is now a vast range of ICs available to the amateur market, the majority of which are not necessarily designed for use in a single application and can offer unlimited possibilities. All the projects contained in this book are simple to construct and are based on a single IC. A few projects employ one or two transistors in addition to an IC but in most cases the IC is the only active device used.

BP97: IC PROJECTS FOR BEGINNERS $8.10
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 $9.35
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
JUNG
HB26 $14.25
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 $5.90
H.KYBETT,B.Sc., C.Eng.
The purpose of this book is to introduce the LM3900 to the Technician, Experimenter and the Hobbyist. It provides the groundwork for both simple and more advanced uses, and is more than just a collection of simple circuits or projects.
Simple basic working circuits are used to introduce this IC. The LM3900 can do much more than is shown here, this is just an introduction. Imagination is the only limitation with this useful and versatile device. But first the reader must know the basics and that is what this book is all about.

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

224: 50 CMOS IC PROJECTS $4.25
R.A. PENFOLD
CMOS IC's are probably the most versatile range of digital devices for use by the amateur enthusiast. They are suitable for an extraordinary wide range of applications and are also some of the most inexpensive and easily available types of IC.
Mr. R.A. Penfold has designed and developed a number of interesting and useful projects which are divided into four general categories: I — Multivibrators II — Amplifiers and Oscillators III — Trigger Devices IV — Special Devices.

THE ACTIVE FILTER HANDBOOK
TAB No.1133 $11.45
Whatever your field — computing, communications, audio, electronic music or whatever — you will find this book the ideal reference for active filter design.
The book introduces filters and their uses. 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
AB004 $11.45
An excellent primer on the fundamentals of digital electronics. This book discusses the nature of gates and related concepts and also deals with the problems inherent to practical digital circuits.

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

THE MASTER IC COOKBOOK
TAB No.1199 $16.45
If you've ever tried to find specs for a so called 'standard' chip, then you'll appreciate this book. C.L. 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
AB016 $13.45
This practical handbook enables you to take advantage of the vast range of applications made possible by integrated circuits. The book tells how, in step by step fashion, to select components and how to combine them into functional electronic systems. If you want to stop being a "cookbook hobbyist", then this is the book for you.

AUDIO

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

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

205: FIRST BOOK OF HI-FI LOUDSPEAKER ENCLOSURES $3.55
B.B. BABANI
This book gives data for building most types of loudspeaker enclosure. Includes corner reflex, bass reflex, exponential horn, folded horn, tuned port, klipschorn labyrinth, tuned column, loaded port and multi speaker panoramic. Many clear diagrams for every construction showing the dimensions necessary.

BP35: HANDBOOK OF IC AUDIO PRE-AMPLIFIER AND POWER AMPLIFIER CONSTRUCTION $5.50
F.G.RAYER, T.Eng.(CEI),Assoc.IERE
This book is divided into three parts: Part I, understanding audio IC's, Part II, Pre-amplifiers, Mixers and Tone Controls, Part III Power Amplifiers and Supplies. Includes practical constructional details of pure IC and Hybrid IC and Transistor designs from about 250mW to 100W output.
Out of stock until December 1982.

BP47: MOBILE DISCOTHEQUE HANDBOOK $5.90
COLIN CARSON
The vast majority of people who start up "Mobile Discos" know very little about their equipment or even what to buy. Many people have wasted a "small fortune" on poor, unnecessary or badly matched apparatus.
The aim of this book is to give you enough information to enable you to have a better understanding of many aspects of "disco" gear.

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

BP51: ELECTRONIC MUSIC AND CREATIVE TAPE RECORDING $5.50
M.K. BERRY
Electronic music is the new music of the Twentieth Century. It plays a large part in "pop" and "rock" music and, in fact, there is scarcely a group without some sort of synthesiser or other effects generator.
This book sets out to show how electronic music can be made at home with the simplest and most inexpensive of equipment. It then describes how the sounds are generated and how these may be recorded to build up the final composition.

BP74: ELECTRONIC MUSIC PROJECTS $7.70
R.A. PENFOLD
Although one of the more recent branches of amateur electronics, electronic music has now become extremely popular and there are many projects which fall into this category. The purpose of this book is to provide the constructor with a number of practical circuits for the less complex items of electronic music equipment, including such things as a Fuzz Box, Waa-Waa Pedal, Sustain Unit, Reverberation and Phaser-Units, Tremelo Generator etc.

BP81: ELECTRONIC SYNTHESISER PROJECTS $7.30
M.K. BERRY
One of the most fascinating and rewarding applications of electronics is in electronic music and there is hardly a group today without some sort of synthesiser or effects generator. Although an electronic synthesiser is quite a complex piece of electronic equipment, it can be broken down into much simpler units which may be built individually and these can then be used or assembled together to make a complete instrument.

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

See order form in this issue. All prices include shipping. No sales tax applies.

TEST EQUIPMENT

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

99 TEST EQUIPMENT PROJECTS YOU CAN BUILD
TAB No.805 $14.45
An excellent source book for the hobbyist who wants to build up his work bench inexpensively. Projects range from a simple signal tracer to a 50MHz frequency counter. There are circuits to measure just about any electrical quantity: voltage, current, capacitance, impedance and more. The variety is endless and includes just about anything you could wish for!

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

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

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

ELECTRONIC TROUBLESHOOTING HANDBOOK
AB019 $12.45
This workbench guide can show you how to pinpoint circuit troubles in minutes, how to test anything electronic, and how to get the most out of low cost test equipment. You can use any and all of the time-saving shortcuts to rapidly locate and repair all types of electronic equipment malfunctions.

COMPLETE GUIDE TO READING SCHEMATIC DIAGRAMS
AB018 $10.45
A complete guide on how to read and understand schematic diagrams. The book teaches how to recognize basic circuits and identify component functions. Useful for technicians and hobbyists who want to avoid a lot of headscratching.

RADIO AND COMMUNICATIONS

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

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

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

BP96: CB PROJECTS $8.10
R.A. PENFOLD
Projects include speech processor, aerial booster, cordless mike, aerial and harmonic filters, field strength meter, power supply, CB receiver and more.

NEW

222: SOLID STATE SHORT WAVE RECEIVERS FOR BEGINNERS $5.20
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 $8.10
This book is divided into two main sections one to amateur band reception, the other to broadcast bands. Advice is given to suitable equipment and techniques. A number of related constructional projects are described.

NEW

BP105: AERIAL PROJECTS $8.10
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 $5.90
J.B. DANCE, M.Sc.
This book describes integrated circuits and how they can be employed in receivers for the reception of either amplitude or frequency modulated signals. The chapter on amplitude modulated (a.m.) receivers will be of most interest to those who wish to receive distant stations at only moderate audio quality, while the chapter on frequency modulation (f.m.) receivers will appeal to those who desire high fidelity reception.

BP92: ELECTRONICS SIMPLIFIED—CRYSTAL SET CONSTRUCTION $7.30
F.A. WILSON
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MISCELLANEOUS

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See order form in this issue. All prices include shipping. No sales tax applies.

Into Digital Electronics Part 4

Ian Sinclair continues with NAND gates.

AS A GRAND FINALE to last month, add the last gate of the 74LS132, so that you have the circuit of Fig. 2.13. Connect up, and fill in the truth table for this lot, which carries out the action of what we call a NOR gate. You should also be able to explain by now why it's called a NOR gate!

we could build up digital circuits using only NAND gates if we liked. We do, in fact, use NAND gates very extensively simply because they are so useful; we could equally well use NOR gates. We couldn't use AND or OR gates for so many useful purposes, because they don't invert signals. We can, for example, produce the action of an AND gate by using two NAND gates (Fig.2.10) but we could never produce the action of a NAND gate by using any number of AND gates, unless we could also make use of an inverter.

Let's go practical again. Fig.2.15 shows a circuit which makes use of three NAND gates, and has three inputs. Now this extra input makes a big difference to the truth table, because it means eight lines instead of four. The general rule is that the number of lines of the truth table for a gating circuit has to be equal to 2 multiplied by itself as many times as we have inputs. For two inputs we need 2x2 lines, for three inputs we need 2x2x2 (which is eight). Mathematicians write this as 2^n (2 to the power n), where n is the number of inputs.

The blank truth table is shown in Fig.2.16, so you can fill in the output

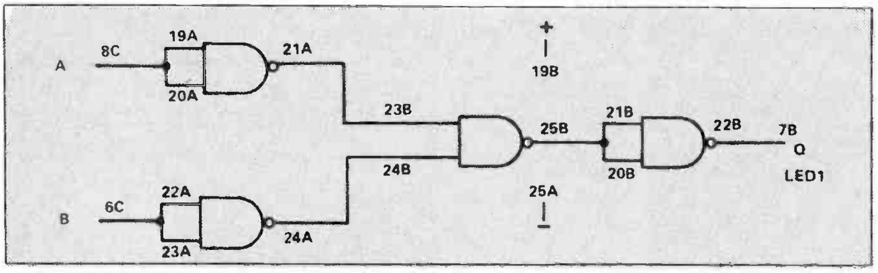
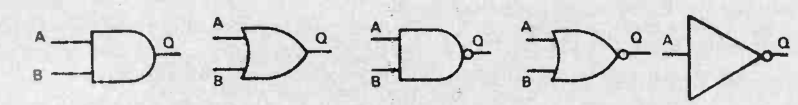


Fig.2.13. A circuit which makes use of all four gates of the 74LS132.

You should have a fair collection of truth tables by now, and they are all important. We can make AND, OR, NOT, NAND and NOR gates in IC form, and Fig. 2.14 shows a reminder of the truth tables for these gates when only two inputs are used. We've used just one type of gate to make these circuits, though, and that's one of the interesting things about digital electronics. A collection of NAND gates can be used to carry out any action of other types of gates, so that



A	B	Q
0	0	0
0	1	0
1	0	0
1	1	1

A	B	Q
0	0	0
0	1	1
1	0	1
1	1	1

A	B	Q
0	0	1
0	1	1
1	0	1
1	1	0

A	B	Q
0	0	1
0	1	0
1	0	0
1	1	0

A	Q
0	1
1	0

Fig.2.14. Gate types, symbols and truth tables summarised.

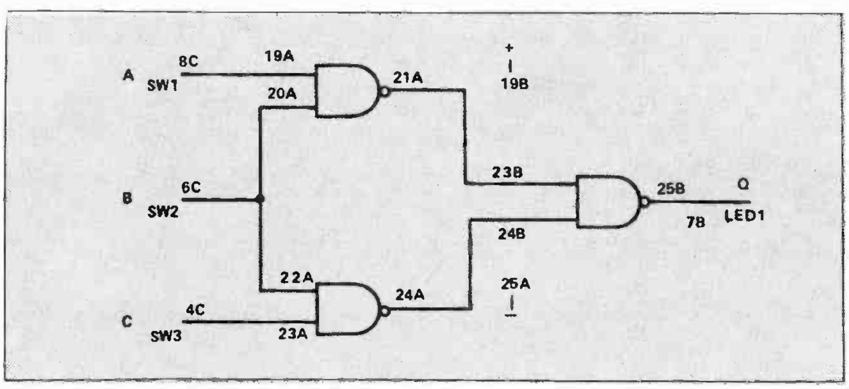


Fig.2.15. Find the truth table for this gate system.

for each of the combinations of inputs which are shown. This one does not form any named type of gate, but its action is quite a useful one. Take a long hard look at that truth table. Notice that the output is always zero if B is zero and one or more of the other inputs is zero, and the output is 1 if B and more of the inputs are at 1. This is a simple form of a 'majority voting' circuit, so called because the output will be of the same polarity (0 to 1) as the majority of the inputs. It could, for example, be the basic of a simple voting machine, but in engineering it is used for a much more serious purpose. Some circuits

A	B	C	Q
0	0	0	
0	0	1	
0	1	0	
0	1	1	
1	0	0	
1	0	1	
1	1	0	
1	1	1	

Fig.2.16. Blank truth table to fill in.

simply are so important that no failure must ever happen, even if the circuit cannot be repaired. The simplest way of doing this is to make many identical circuits, and use a 'majority voting' gate at the output. If all the circuits are operating perfectly, then all is well, but if some fail, then the output will still be decided by the majority. It can be a great comfort if you're 250,000 miles away from Earth!

Now for one last bit of practical work, try the circuit in Fig.2.17. This uses all four gates of the 74LS132,

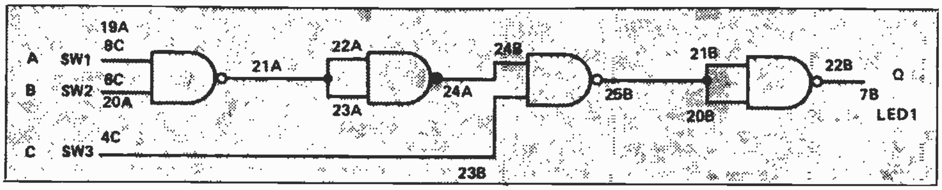


Fig.2.17. Another gate system to investigate—try it out.

with three inputs and one output. Because there are three inputs, there must be eight lines in the truth table, which you can complete for yourself by experiment. What sort of gate is this?

Gate circuits like this can be used as the basis for 'combination lock' circuits, which give a 1 at the output only for some particular combination of inputs. For this reason, the gate circuits are sometimes known as combinational logic — it's the combination of signals at the inputs which decide what the output will be. As it happens, we can make the circuit entirely from NAND gates if we like. The circuit of Fig.2.17 produces the effect of a three-input AND gate, though we have used only two-input NAND gates in the circuit.

How can we find what a gate circuit does? One way is to try it out on the breadboard, but another way is just by writing truth tables. We need a truth table with lots of columns, one for each input, of course, but also one for each place where the output of one gate is connected to the input of another. Figure 2.18 shows the circuit of Fig.2.17 labelled and a truth table drawn up in this way. If we now write in the usual collection of inputs (2^n, remember), we can fill in the rest of the columns simply because we know the truth table for the gates we are using. Figures 2.19 to 2.21 show this particular truth table being filled in bit by bit in this way. The final result is the output column, which shows the action of the whole circuit. In this case it's a 1 when all the inputs are 1, a three-input AND in fact.

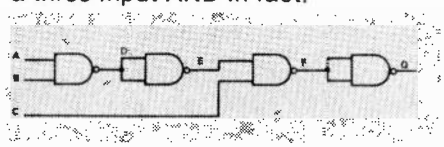


Fig. 2.18. Marking out a gate circuit so that you can draw up its truth table without experiment.

The important point is that gate circuits can be designed to give a 1 output for any combination of inputs we like. A lot of machinery can be controlled just by an ON(1) or OFF(0) signal, so that gate circuits are the ones we use to make control circuitry. The more complicated the control action has to be, the more suitable digital gates are to carry it out, because mechanical switches and relays are suitable only for comparatively simple circuits.

A	B	C	D	E	F	Q
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

Fig.2.19. Filling in the truth table—the first step. Each possible A,B,C input has been entered.

A	B	C	D	E	F	Q
0	0	0	1	0		
0	0	1	1	0		
0	1	0	1	0		
0	1	1	1	0		
1	0	0	1	0		
1	0	1	1	0		
1	1	0	0	1		
1	1	1	0	1		

Fig.2.20. The next step — the E and D columns can be filled in because you know the truth table for the NAND gate and inverter.

A	B	C	D	E	F	Q
0	0	0	1	0	1	0
0	0	1	1	0	1	0
0	1	0	1	0	1	0
0	1	1	1	0	1	0
1	0	0	1	0	1	0
1	0	1	1	0	1	0
1	1	0	0	1	1	0
1	1	1	0	1	0	1

Fig.2.21. The table can now be completed, once again because the truth tables for NAND gate and inverter are known. ETI

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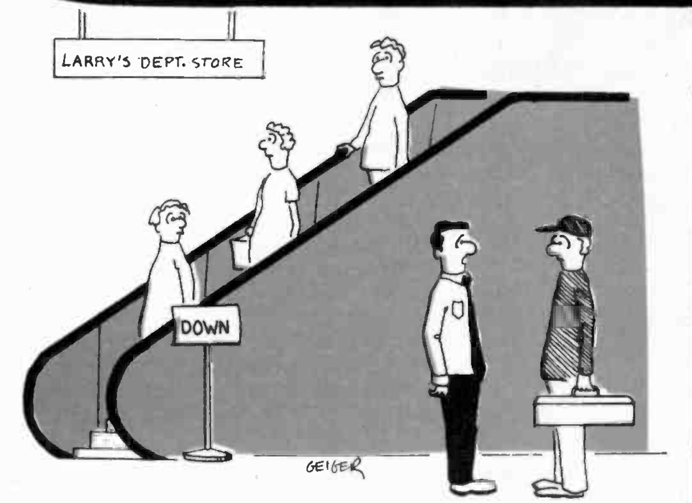
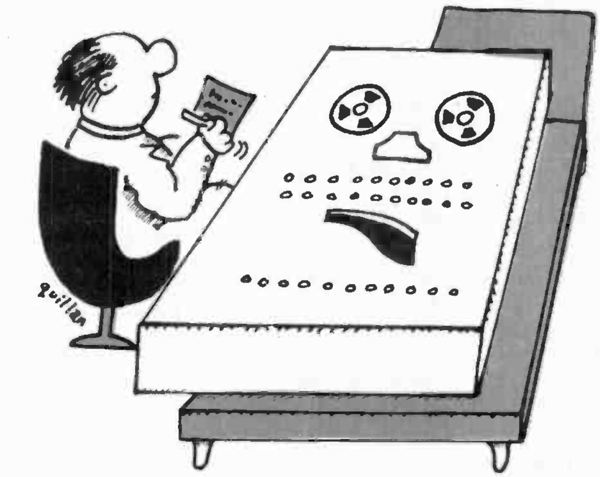
The Fun of Electronics



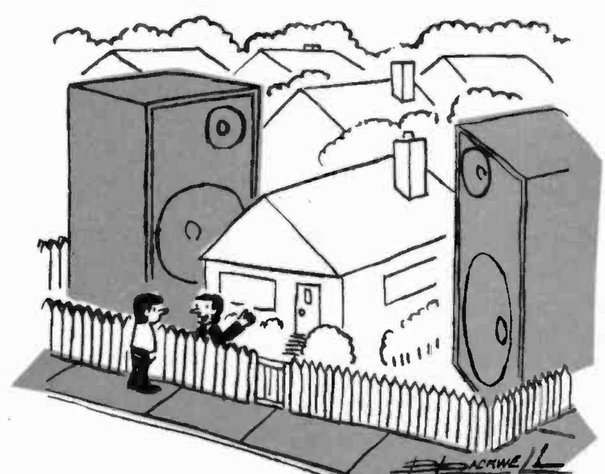
You'd better get that escalator fixed quickly — those people have been stranded there for hours.

I built Grandpa a reaction timer to play with: A small light flashes on, and then Grandpa tries to push the button before the batteries die.

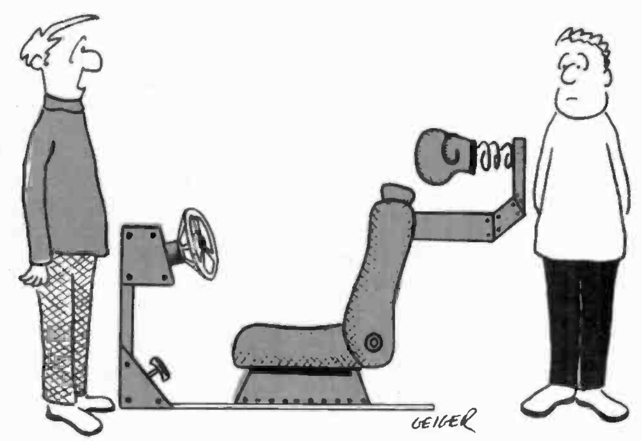
Make a note of that, Zentron . . . The Earthlings breathe through their ears.



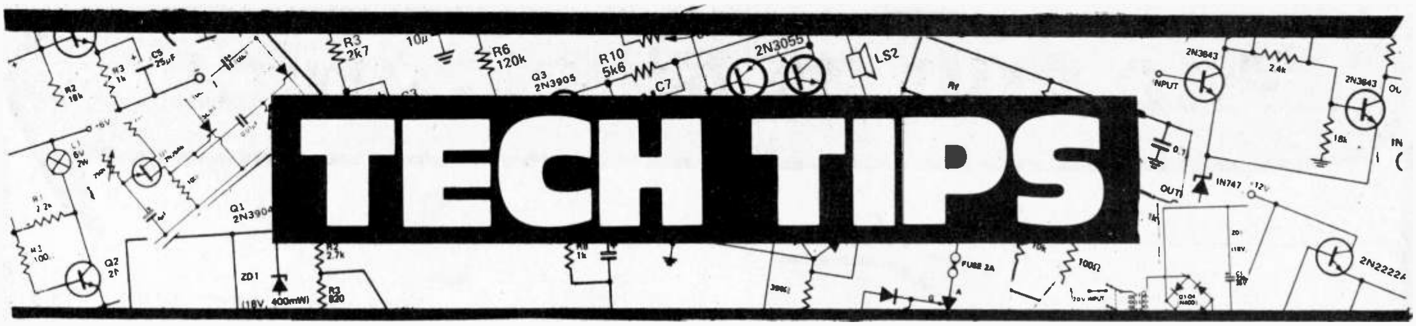
I had a read error this morning and then I seemed to go to pieces.

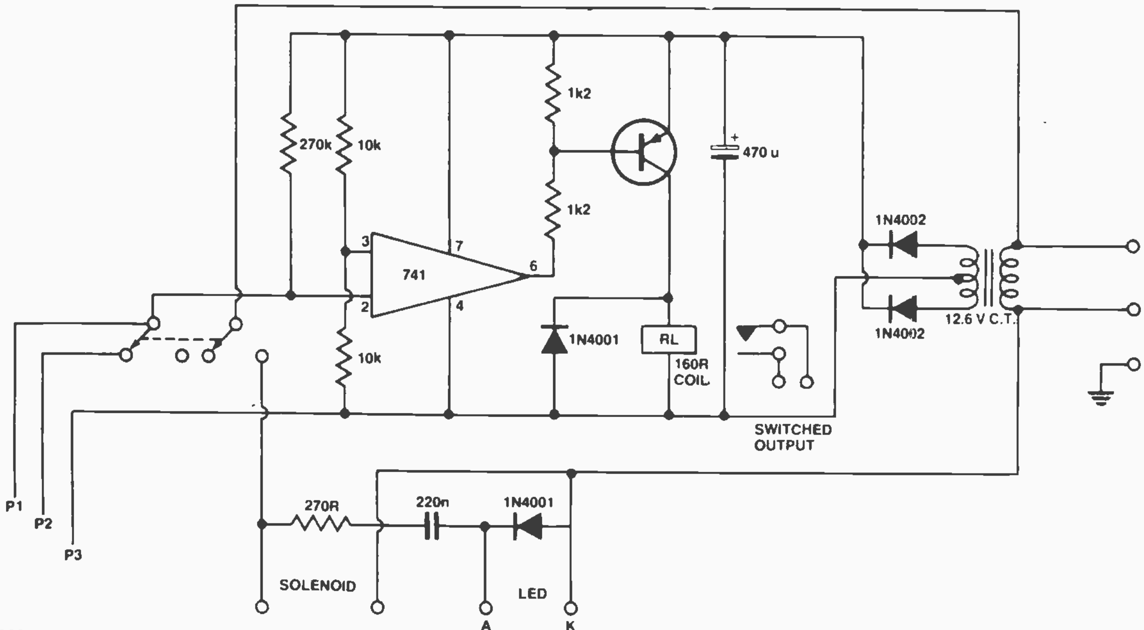


"Oh, sure, some of the neighbours complain, but they're not true music lovers!"



It's my latest project; A device for helping you to remember to shut off the headlights when you leave your car.





Water level sensor and switch

F.L. Harrisons

Here's a novel idea with a practical application. It is a water level sensor that controls a pump which maintains the water level in a tank. Three 'sensor' wires are employed: one at the 'high' water level (P1), one at the 'low' water level (P2), and one well below the latter (P3) so that it's permanently in the water. Here's what it's all about.

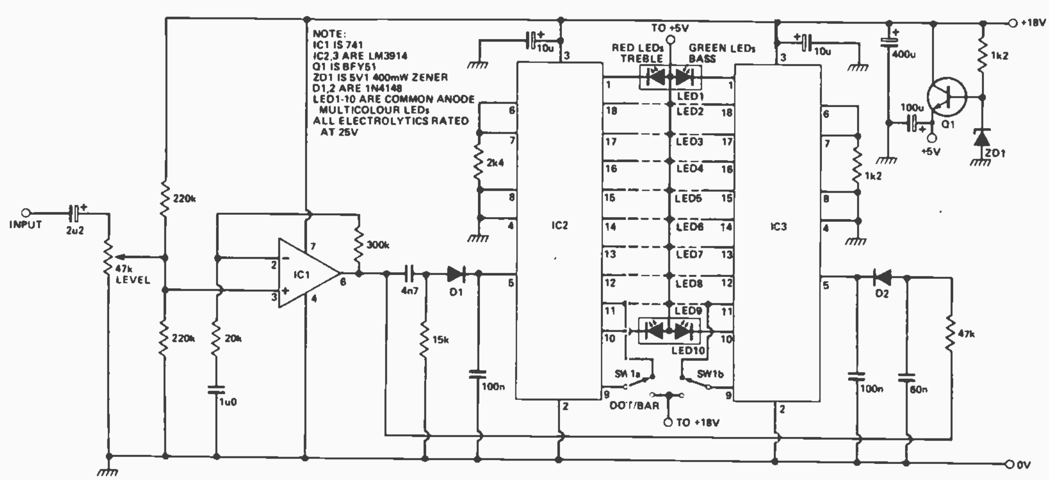
Using an inexpensive 741 IC and a relay with two sets of contacts, the circuit provides an inexpensive and trouble-free 'float' switch. It is used to switch, through a 170 V solenoid, a three-phase submerged bore pump feeding an irrigation supply tank. The probe unit is positioned in the tank with the bottom of P1 at the desired 'full' level.

The bore pump does not start until the water level falls below P2 and is not switched off again until the water level reaches P1. This ensures that the supply tank always remains full. the LED, which is remotely mounted, gives a visual indication of when the pump is running.

Visual Simple Sound Analyser

J.R. Walker

This circuit is a simple audio to light converter, displaying bass and treble levels simultaneously on one bank of 10 multicolour LEDs. In dot mode, this provides an interesting effect, but in bar mode the effect is really weird. The circuit is fairly self explanitory. Be sure to wire the 10uF electrolytics close to the chip, and use a well regulated supply at 12V (maximum), 250 mA (minimum).



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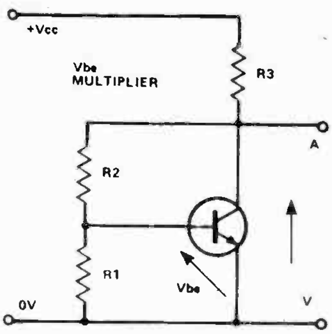

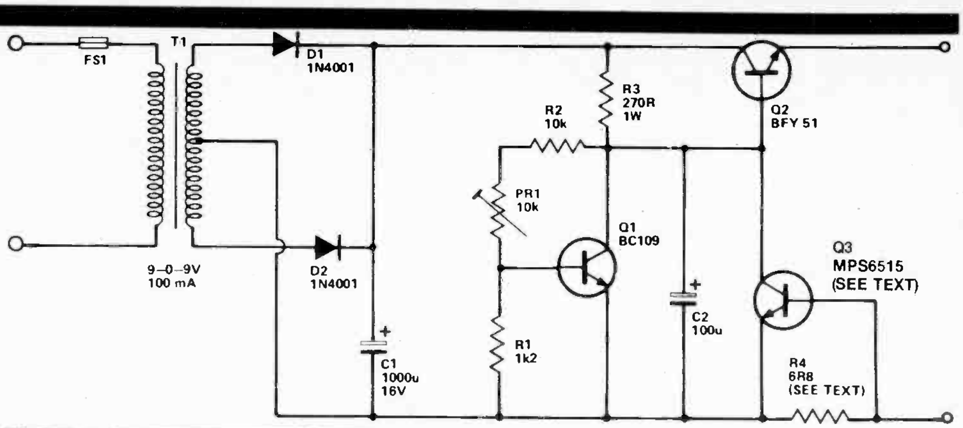

'Zener-less' Battery Eliminator

P.J. Hunt

Designed as a variable-voltage battery eliminator, this circuit provides a stabilised output without Zener diodes as the reference source. Instead, a V_{be} multiplier is employed so that the output voltage may be continuously varied by PR1 over the range 6-10V.

The V_{be} multiplier is shown schematically in the inset. Provided that V_{cc} is high enough, the potential across R1 will be about 600 mV for a silicon transistor. The current through R1 can thus be adjusted so that the base current of the transistor may be ignored for practical purposes. In this case, the current through R1 will equal the current through R2. The potential at point A is thus given by:

$$V = V_{be} \times \frac{(R1 + R2)}{R1}$$

—hence the name V_{be} multiplier.

R3 limits the current through the parallel combination of the transistor and R1/R2. Suppose as an example that V_{cc} tries to rise. The potential divider formed by the three resistors will try to raise the voltage across R1. This will tend to increase the collector current and thus increase the potential drop across R3, leading to a stabilising effect at point A. This is a case of voltage-derived series feedback.

In the practical circuit, R3 also provides base current for the series transistor Q2. Q3 and R4 form a current limiter. If the output current exceeds approximately 100mA, Q3 starts to turn on, reducing the output voltage. If desired, Q3 and R4 may be omitted, in which case R3 may be derated to ½W. The whole unit fits easily inside a transistor radio battery case.

Continued from page 62

which is useful and a word counter, which some writers will find indispensible.

EasyWriter is certainly as useful as WORDSTAR, which, I think, is the optimum word processor going, and the few extra frills are harmless. The IBM's first rate keyboard qualifies it as a better choice for serious word processing than most other machines, and, if my primary requirement of a system was in this area (and I had the bread), I'd give serious thought to the Personal Computer for this feature alone.

The OFF Switch

There is no ideal computer, of course, and the Personal Computer is no closer than many other machines. However, it does have a lot to recommend it. It is certainly well built, and its software is splendid. It's a joy to work with, and has a lot of frills that are just fun . . . a primary consideration. Aside from having a larger address bus, and, thus more immediate RAM access, there doesn't seem to be any apparent advantage in IBM's unusual choice of processors, but, then, the 8088 isn't a bad trip, it's just a bit abnormal.

The non-CP/M DOS is only a hassle if you are into a lot of CP/M based software . . . the DOS is, for the most part, just as powerful as CP/M. If you plan to do your thing with the higher level stuff, and wouldn't want the programs which are public domain on CP/M anyway, this ceases to be a consideration. In fact, there is a lot of very good software . . . of the paid-for type . . . cropping up for the PC.

There are also several high level language compilers around for it now, so that that public domain material written in these tongues will be useable as well.

I still tend to feel that the PC is very expensive, but this is an arguable point. As I've gotten into in the other computer review in this issue, you pay a lot for a manufacturer's name, and IBM must certainly be among the highest priced. However, some would certainly say it is worth it, and, on days when lesser systems are cheerfully throwing disk errors here and there, loosing laboured-over files and producing surprise software bugs, many hitherto sceptics might be wont to agree.

Like, if you can afford it, go for it.

Listen, Billy . . . you think we could interface it with this old Selectric typewriter and make it print? ETI

Contrast Meter

Continued from page 19

aluminium channel proves difficult to obtain, a piece of the slotted aluminium extrusion used for commercial shelf-racking systems is ideal. This is available from most DIY stores in short lengths with the required internal width. After filing or cutting to the right size, a piece of insulating tape should be stuck down on the inside to prevent shorting out the PCB. As shown in the diagram, a hole is drilled on the end for bolting it to the bottom of the case. This bolt should eventually be connected to circuit ground, thus providing screening for the photoamplifier. The two PCBs for probe and main meter circuits are laid out as one board, and should be sawn apart along the lines shown on the foil patterns.

For other construction arrangements, the circuit can be left as a single board, since the interconnections are already made.

Three wires are used to connect the two boards together as indicated on the overlay; these should pass through a small hole drilled in the case side where the metal probe case is bolted on. When the probe board is mounted and stuck down in its channel, a piece of thin aluminium sheet is cut to form a lid with appropriate holes for the photodiode and preset. (The photodiode case is internally connected to the cathode, so it must not short against the lid).

Calibration

Start with preset PR1 fully clockwise to set a gain of 1; also set PR2 fully anticlockwise, setting the voltage required to illuminate the lower end of the bargraph at zero. First, measure a high contrast negative that is known to require grade 1 paper for a good average contrast after developing. Initially a low contrast reading will be obtained, say about grade 4 or 5. Now, adjust PR1 anticlockwise to increase the gain of the photoamplifier. Take another measurement, when the contrast reading should be greater. Repeat this process until a grade 1 is consistently recorded.

Now select a negative with very poor contrast ratio, one known to require paper grade 5 for bringing out the contrast. Take measurements several times while adjusting only PR2 clockwise, until the bottom end of the scale illuminates at grade 5. The other contrast grades should now fall linearly between these points and can be checked for accuracy.

Although the bargraph display has a low resolution and accuracy, the rest of the metering circuit is obviously much better than this; consequently a moving coil meter could easily be added to measure the contrast voltage for those who may desire greater resolution.

ETI

Junction FETs

Continued from page 23

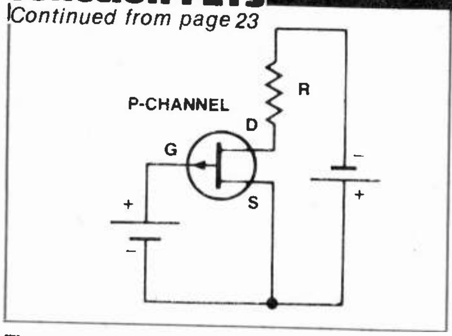

Figure 13. A p-channel device requires supplies of the opposite polarity to those used with n-channel devices.

Limiting Voltages

If the bias applied to the gate is taken far beyond that required for normal operation, a point will eventually be reached at which reverse breakdown occurs. Similarly there is a limit to the voltage which should be applied between the drain and the source electrodes. However, junction devices cannot be damaged by the ordinary electrostatic charges which can accumulate on people and clothing and which can damage MOSFET devices.

Testing JFETs

It is relatively easy to check that a junction field effect transistor is able to function correctly. The circuit of Figure 14 may be used for an n-channel device and that of Figure 15 for a p-channel device.

If the gate is initially connected directly to the source (and not as shown), it will be found that the meter provides a reading of a few mA. This current is limited by the 1k resistor in the drain circuit to a safe value.

If the gate electrode is now connected to the 10M resistor as shown, the gate to channel junction is reverse biased. Thus the channel width decreases and with most

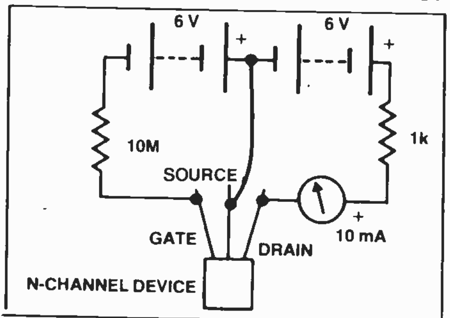

Figure 14. Testing an n-channel device.

devices the drain current will fall to zero in the circuits shown. As the gate circuit has a very high resistance, the voltage can be applied to it through a high-value resistor; indeed, it is interesting to note that the human body can be used in place of the 10M resistor shown when testing junction field effect devices.

If one wishes to test a device and does not know the connections, one can first find two connections in which a small current will pass in either direction. These are the source and drain connections.

A current should pass from the third electrode, the gate, only in one direction to either of the other two electrodes. If conduction takes place when the gate is positive, one has an n-channel device, whereas if conduc-

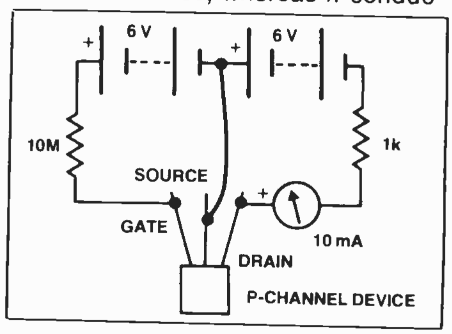

Figure 15. Testing a p-channel device.

tion takes place when the gate is negative, the device is of the p-channel polarity.

One cannot easily determine which electrode is the drain and which is the source, but these electrodes are to some extent electrically interchangeable.

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MEMORY. Prints how much spare memory is available.
DUMP. Displays current values of string and numerical values, except arrays.
FIND. Will find any string of up to 255 characters and list each line containing that string.
REPLACE. Replaces any string of up to 255 characters by any other string.
SAVE. Transfers program in computer to below RAMTOP.
APPEND. Allows two programs to be joined.
REMKILL. Removes all REM statements from a program, otherwise leaving it unchanged, preserving memory.

ZX FORTH **$39.95**

Simplicity of BASIC with the Speed of Machine Code

A complete implementation of the FORTH language for the ZX81 and TS1000 computer.
FORTH's most distinctive feature is its flexibility. The basic unit is the word — the programmer uses existing words to define his own which can then be used in further definitions. FORTH is a compiled language so programs run very fast (typically five times faster than BASIC).
ZX-FORTH is supplied on cassette and is accompanied by extensive documentation:
56-page Users Manual
8-page Editor Manual

ZXAS Assembler **$12.95**

Now you can use the full power of the Z80 microprocessor without having to laboriously POKE in instruction codes. This full specification Z80 assembler assembles all the standard Zilog mnemonics, which are simply written into REM statements (more than one per line is allowed) within your BASIC program. When assembled, the assembly listings, together with assembled codes and addresses, are displayed on the screen. The assembled code is executed by USR. The program occupies 5K, is situated at the top of the memory, and is protected from overwriting. This means that ZXAS may be used in conjunction with ZXDB (see below), providing an extremely powerful machine code system normally only found on very expensive computers.
The program is available for both the ZX81 and the 8K ROM ZX80, and in both cases, the 16K RAM pack is required. Despite the low price, ZXAS is a FULL SPECIFICATION assembler, and is a must for all serious ZX users. Full documentation on how to use the assembler (including a list of the mnemonics) is supplied.

ZXDB Disassembler/ Debugger **$12.95**

The perfect complement to the ZXAS assembler, ZXDB is a complete combined machine code disassembler and debugging program. Like ZXAS, it is itself written in machine code for compactness, and may be used in conjunction with ZXAS, still leaving about 9K of memory for your own program.
Apart from the DIASSEMBLER, the program has features including SINGLE STEP, BLOCK SEARCH, TRANSFER AND FILL, HEX LOADER, REGISTER DISPLAY and more, all of which are executed by simple one key commands from the keyboard. All in all, an extremely powerful programming aid, well worth the money for the disassembler alone!

Z-AID 1.0 **$19.95**

A machine language programming aid on cassette. Includes the following routines:
VERIFY confirms whether a program has been recorded properly on tape. The program in memory is unaffected, and a further "save" can be made if necessary.
Mload/Msave enables a specified block of memory to be saved. VPTR can be used within a BASIC program to eliminate many tedious POKEs and PEEKs in finding the addresses where variable values are stored.
CHAIN allows the second part of a BASIC program to be loaded and tacked onto the end of the first part.
Z-AID 1.0 is convenient to use, being loaded from tape, and residing at the top of 16K memory. The user accesses the various routines with USR calls while loading, running, editing and saving BASIC programs normally.

ZX fastload™ **$24.95**

★ Allows you to LOAD and SAVE ZX81 programs up to 6 TIMES FASTER!
★ Easy-to-use in your own programs.
★ User-transparent when incorporated into programs.
★ Verifies proper loading.
★ Catalogue feature lists program names and memory usage.
★ LOADER occupies less than 500 bytes (½ K) of RAM.
★ Consists of 2 separate programs — KEYBOARD MONITOR and FAST LOADER.
★ Supplied on cassette with extensive documentation.

KEYBOARD MONITOR is a user-friendly BASIC program which gives such information as the speed at which the tape was recorded, file name, file type, number of bytes in file, and whether a read error occured. If desired, the user-friendly portion of the program can be removed for direct access to Machine Code Monitor. Both parts reside at RAMTOP and are user transparent. Full details are given in the manual for fast saving of your program.

FAST LOADER also resides above RAMTOP and can be used in front of any fast-saved program to enable it to be fast-loaded. This removes the need to load the monitor for each load.

Reliability and compatability: Fast-Load is an exceptionally reliable system. In one 3 hour test, over 1,300,000 bytes of data were recorded and then read without error, using a low cost cassette player. Compatible with all ZX81 systems, at your choice of two operating speeds: Medium Speed (4 times faster) suitable for use with any tape recorder that works with ZX81; Fast speed (6 times faster) for most higher quality tape recorders.

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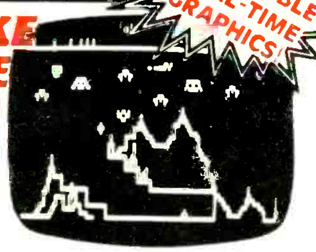

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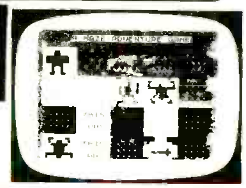

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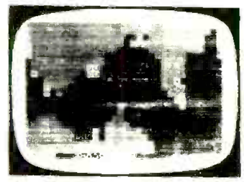

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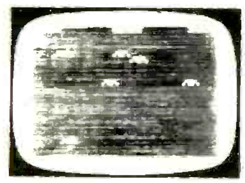

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An excellent version of the classic space game. Protect your seven lives against fleets of hostile invaders, who swoop down and attack quickly. This version is an excellent demonstration of the capabilities of the ZX81 or TS1000 to entertain and excite for hours.
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Provides massive add-on memory in a compact plug-in module via an edge connector. Can be used for program storage or as database. Yet it costs as little as half the price of competitive memory.

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Designed exclusively for use with the ZX81 (and ZX80 with 8K basic ROM), the printer offers full alphanumerics and highly sophisticated graphics. COPY command prints out exactly what is on screen. At last you can have a hard copy of your program listing and results. Printing speed is 50 characters per second, with 32 characters per line and 9 lines per vertical inch. Connects to rear of ZX81 — using a stackable connector so you can use a RAM pack as well. A 65 ft paper roll, instructions included.

Lower price: higher capability.

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How is it possible? Quite simply, by design. The ZX81 uses only 4 chips (as opposed to 21 in the original ZX80). The secret lies in the totally new Master chip. Designed by and custom-manufactured for Sinclair, this unique chip replaces 18 chips from the ZX80.

The ZX81's advanced capability.

The ZX81 uses the same fast microprocessor (Z80A), but incorporates a new, more powerful 8K BASIC ROM — the "trained intelligence" of the computer. This chip works in decimals, handles logs and trig, allows you to plot graphs, and builds up animated displays. And the ZX81 incorporates other operation refinements — the facility to load and save named programs on cassette, or to select a program off a cassette through the keyboard.

New, improved specification.

- Unique 'one-touch' key word entry: the ZX81 eliminates a great deal of tiresome typing. Key words (PRINT, LIST, RUN, etc.) have their own single-key entry.
- Unique syntax-check and report codes identify programming errors immediately.
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- Graph-drawing and animated-display facilities.
- Multi-dimensional string and numeric arrays.
- Up to 26 FOR/NEXT loops.
- Randomize function.
- Programmable in machine code.
- Cassette LOAD and SAVE with named programs.
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- Full editing facilities.
- Able to drive the new Sinclair ZX Printer

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A full-sized professional keyboard for the ZX81. Features 47 keys and a full-sized space bar. Connects to the ZX81 with no soldering required, via a plug-in flexible connector. You can purchase the keyboard only, or the optional metal case that holds both keyboard and ZX81. Expansion devices (i.e. RAM packs, etc) connect to the ZX81 edge-connector which extends from the rear of the cabinet.

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