

SPECIAL FEATURE — BASIC CONSTRUCTION METHODS

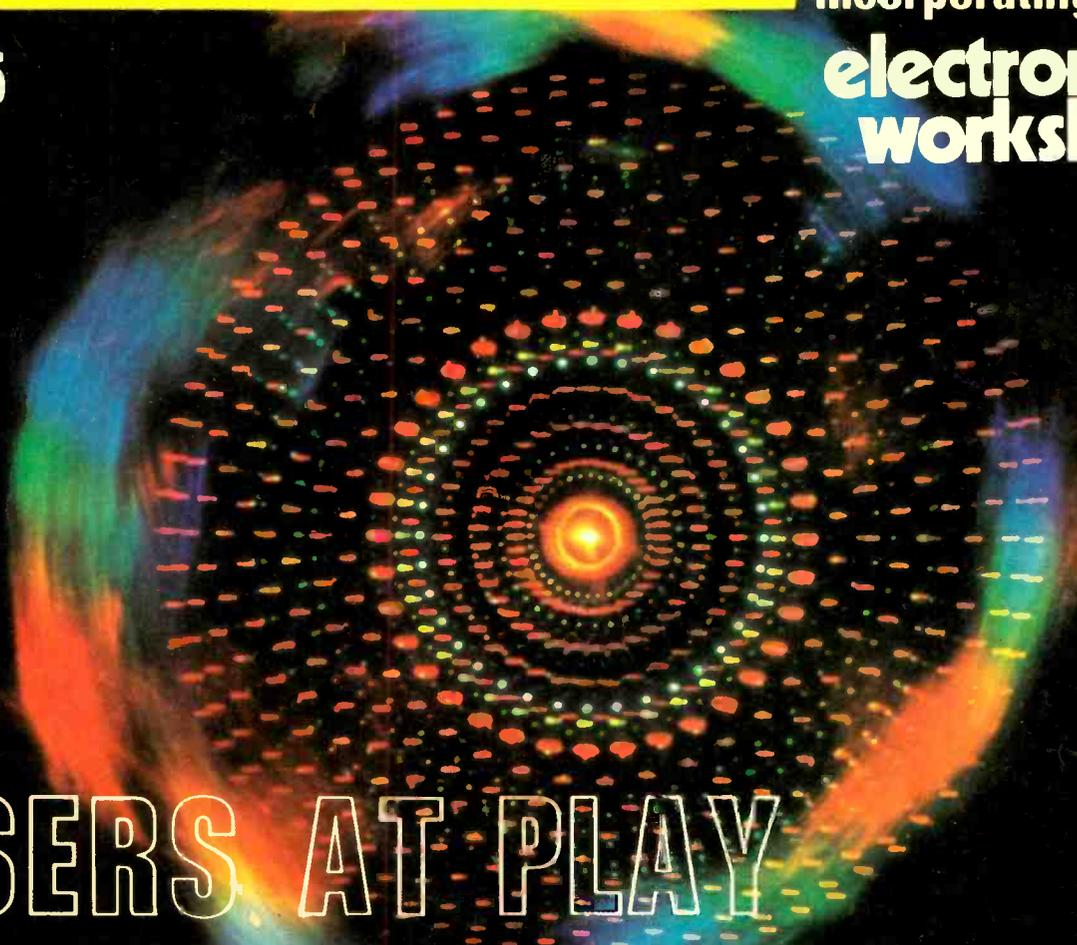
# *electronics today*

NOV. 77

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**electronic  
workshop**



## LASERS AT PLAY

WE TAKE A LOOK AT LASER LIGHT SHOWS

**DON'T WASTE  
WATTS BUILD ETI'S  
WATCHDOG**

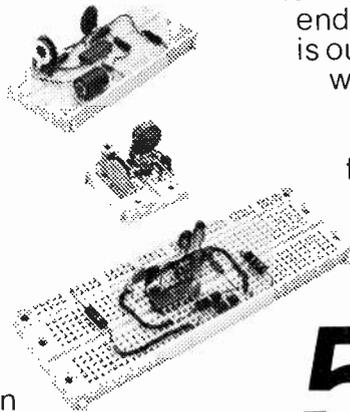


**DIGITAL  
THERMOMETER**

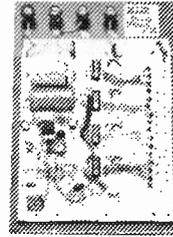


# 5 WAYS TO STOP WASTING TIME IN ELECTRONICS.

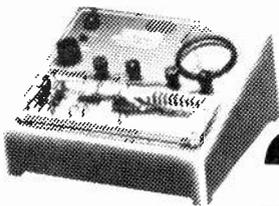
**1. Stop wasting your time soldering.** Save hours of soldering, desoldering, re-soldering with QT sockets and bus strips. Connect and disconnect resistors, capacitors, transistors, IC's etc., literally as fast as you can push in—or pull out—a lead. Make instant interconnections with short lengths of wire. And interlock sockets and bus strips for infinite expandability on bench, chassis, plug-in cards, etc. At \$3.00-18.00\* you'll wonder how you've done without them!



popular solderless breadboarding system...our Proto-Board® line. For just \$23.10\*, you can have our PB-6 Proto-Board kit. Takes about 10 minutes to assemble, and gives you 630 solderless QT terminals. On the other end of the spectrum is our giant PB-104, with 3,060 solderless terminals for \$115.75\* or only 3.78¢ apiece! You can choose from a variety of models, with or without regulated power supplies.

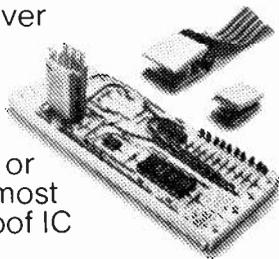


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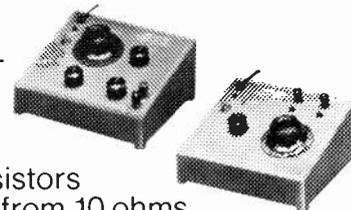


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you want—and making sure you don't short others—can be as delicate as surgery. Until you discover our handy Proto-Clip™... the instant, short-proof way to test IC's up to 24 pins. Available without cable or with cable, they're the most economical and foolproof IC test aids on the market.



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**Stop wasting your time reading.** Send for the complete CSC catalog and distributor list... and start making more of your time in electronics.

\* Mfr's sugg. price

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**4. Stop wasting your time bread-boarding.** Small budgets or big requirements are no obstacle to owning and enjoying today's most



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# NEWS DIGEST

## POWER SLEUTH

Although widely sold in Europe the use of car antennae with built in r.f. amplifiers is relatively unknown in Canada. However, we have recently had the chance to try out a new design being marketed by *Magnum Electronics Inc.*, 72-74 Stafford St., Toronto, Ontario M6J 2R8. The amplifier is mounted in a stylish matt black base which holds a small telescopic antenna. The antenna can be folded down flat or used at any angle or length required — we found the unit worked very well even with the antenna folded right down.

Reception range for the FTE Mobile Power Sleuth is from 150kHz to 108MHz and it thus covers the marine bands, a.m. broadcast band, short wavebands and f.m. broadcast band. This wide range is accomplished by employing two amplifiers with built in cross modulation suppression and interference shielding.

The kit comes complete with all mounting parts and includes a drill and variety of mounting pads for various contours. The Sleuth should be of interest to anyone who likes to be able to receive distant or weak stations or who lives in a poor reception area. It should also improve f.m. reception in cars.

## IRON CLAD!

A well accepted British range of soldering equipment is now available in Canada. Adcola Products are well known to both the hobbyist and professional in Britain and anyone considering buying soldering equipment or tools would be well advised to get their catalogue and compare their products before going ahead.

The Canadian Importers are *G.E. Irving Industries Ltd.*, P.O. Box 311, Clarkson Postal Station, Mississauga, Ontario L5J 3Y2. Tel (416) 823-1889/90. Contact them for more information on the range.

## CATALOGUES

We have in our hands a new catalogue from *Supreme Electronics* and we know that *Electro Sonic* now have their mammoth catalogue in a new form — we are sure some of you had almost lost hope of seeing that one! Maybe we can get our hands on one soon.

The *Supreme* catalogue is vastly different to their previous ones containing over 250 pages and being slightly bigger in page size than *ETI*.

Get your copy by sending \$1.00 — redeemable — to *Supreme Electronics Inc.*, P.O. Box 58276 Postal Station L., Vancouver, B.C.

They have a special student offer where students can get a 10% reduction on orders if they supply full details of their name, address, post code, school and grade when ordering the catalogue.

## NEIGHBOUR INSULTER!

A new man about the house — or bank — has been built by an American company, *Quasar Industries*. Costing about \$4,000 the "domestic" robot can serve dinner, walk the dog or even insult the neighbours — almost as good as a wife?

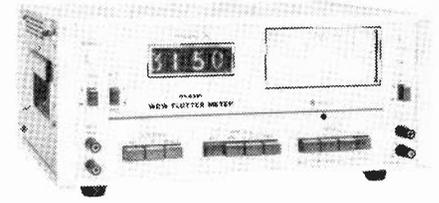
A rather more frightening prospect is a mechanical guard — *Century One* — which weighs 650 pounds is seven feet tall and can be programmed to kill. The Royal Bank of Canada is known to have an interest in the device, which includes high frequency sound equipment capable of causing great pain and a higher power strobe, within its armoury. The robot can also give electric shocks and emit laughing gas — just right for a friendly chat over the back yard fence!

## LASER DISC

ONE INTERESTING piece of news has recently come our way from Japan — a record player using a laser to "read" the audio information is being developed by *Teac*. The metallic coated disc used has 54,000 grooves read by the laser from below the turntable, thus virtually eliminating record wear. Estimated cost is some \$600.00 but how much for a disc?

## WOW

Recently announced is a range of Japanese test gear being imported by *White Electronic Development Corp. (1966) Ltd.*, 6300 Northam Drive, Malton, Ontario L4V 1H7. The instrument they have sent us details of is the *Meguro Wow and Flutter Meter* pictured below. The unit can measure wow and flutter in accordance with DIN (IEC/ANSI) standards at 3.15kHz in addition to the JIS, NAB and CCIR standards at 3kHz. Full details from *White*.



## IEEE CONFERENCE AND EXPOSITION

SEPTEMBER 26th, 27th, and 28th saw the International Electrical, Electronics Conference taking place at Exhibition Place in Toronto. The show is held every two years and is attended by over 13,000 engineers, scientists, and technicians from industry and government in Canada, the U.S., and various overseas countries.

Over 600 booths were occupied, with companies displaying and demonstrating both their tried and true lines and services, and newly introduced products, upon some of which we shall report as we receive more information.

Along with the exhibits, a series of lectures were presented. On the technical side topics such as digital technology, vehicular communications, pc techniques, the electromagnetic environment, microcomponents, satellite communications, fibre optics and many more were covered, by specialists in each field.

Non technical, but equally as important topics included addresses on the electronics industry in Canada, the role of the National Research Council, and safety aspects.

The first evening of the show incorporated the *New Dimensions '77* Conference Banquet. Here Mr. Robert Scrivner, Chairman and Chief Executive Officer of Northern Telecom Ltd., delivered an address, the "Tanner Lecture", so named after Mr. Robert Tanner, first Canadian president of the IEEE. Many of Mr. Scrivner's comments are of general interest, we publish excerpts below.

"Historical comparisons are always difficult to make. . . . Radio in its earliest form made a startling impact on society. But it is difficult to compare it with the impact of television, data processing, satellite transmission and digital communications or the integration of these technologies on human communication, interaction and lifestyles.

Stored-program control, digital technology, semiconductors, large scale integrated circuits, magnetic bubble memories, fiber optics, software, and satellites — these are some of the keys to the future of electronics."

"Cost reduction is of course a major



motivating force. But, I think, more importantly, we are being motivated by the possibility of a whole new way of life. Electronics will provide the means for a truly interactive society on a world scale. It will mean much more than the addition of a few new pieces of hardware or services. It has tremendous implications for the societies we must manage."

"Electronics, perhaps more than any other industry, is responsible for creating modern consumer attitudes.

First, and most obviously, it has aided and abetted the dissemination of information and knowledge on a scale that would be incomprehensible to even the most well-educated man living a hundred years ago. Vast instant information flows confuse and upset. Our leaders are under tremendous pressure to propose instant solutions to very complex problems.

Second, through its continuing quest for excellence, the electronics industry has largely created and shaped the modern consumer's expectation for quality, reliability, and adaptability.

This brings us to the crux of our current and future problem. While we in the electronics industry have trained society to expect the best and must continue to deliver the best, we have created uncertainty, diversity and social unease never before experienced in western civilizations.

To 99.9 percent of the people in the world, the technology of semiconductors, LSIs and the language of software programs is a complete mystery and will remain so. Yet the products and services this technology can provide will be easy and simple to use for anyone. The user will not care how or why it works. However, he will reserve the right to complain — and complain loudly — if it does not. The more products improve, the higher goes the consumer's level of reliability expectation."

"I'm not talking about just making the pieces work through quality control. I am also talking about product compatibility. More and more, the new electronics will depend on standards and system integration.

Right now it makes no difference whether or not the other manufacturer's pocket calculator, or radio, or refrigerator works, just so long as yours works. But whether or not the other system works will become more important as a greater number of each other's products hook up and interact through the various electronics networks we are creating. The telephone is the prize example; one is useless, it takes at least two and only gets interesting with ubiquity."

"The worldwide telecommunications network in place today evolved using essentially two sets of standards — one originating in Europe

and the other in North America. These differences were similar to those seen in the use of metric measures in some countries and English measures in others. While it is cumbersome and inefficient to make these different standards interface with one another, it can be done."

"Just as there is finally a shift towards the metric system there will be equivalent shifts towards the standards necessary for global electronics planning.

The top-level computer designer today makes very little distinction between software and the chip and the trade-offs necessary between these two components to produce the desired functions. The standards, however, for software and the chip have not evolved in tandem."

"The number of elements we can get on a single silicon chip has nearly doubled every year for the past 10 years. This trend continues, bringing with it, its own anti-inflation program."

"There is an inherent quality risk when you are competing against yourself by creating and maintaining new standards for systems that are being redesigned even faster than you can create the original standards. There may have to be some trade-offs between the quest for new products and standards if we are to maintain quality and control total costs in this fast changing climate."

"Irrespective of how it is done, I have no doubt that global electronics standards, not just for international networks but also for their national sub-systems and components will evolve fairly rapidly and will essentially be in place in 25 years. These networks will be capable of handling the needs of all types of two-way information transmission. They will operate in the bit stream or digital mode and will therefore be indifferent to whether the message is voice or data.

Yet lurking in the background is software, the companion portion of the semiconductor in electronics. Software, the language of electronics, is a very new technology. To most people it is an incomprehensible black art. It is so new that common standards as such are not yet evolved. There is no historical base as there was for the hardware component of electronics."

"Computer languages must have zero inexactitude. This is a terrible constraint on any language, but in the world of electronics it is a must. The computer cannot tolerate ambiguity or ambivalence. How therefore do we develop standardization with flexibility into software language for all forms of data processing, switching and transmission?"

"The software interface and translation complexities are horrendous. No corporation is eager to write off its own software investment

and start over, especially when no universally accepted software systems standards have yet evolved."

"But standards will evolve because they must. First through protocols or interfaces such as the X.25 interface developed to a large extent by Canadians at Bell Canada, Bell-Northern Research and Northern Telecom. X.25 is now recognized by two major United Nations standards agencies as the accepted protocol for accessing packet networks and also as the standard for packet mode terminals."

"I expect we will move toward universal software systems standards as well. If I told you I was going to develop a simple programming manual for a complex electronic network that could be accessed by a few hundred million people, you'd probably laugh. Don't laugh. It's already been done.

The telecommunications network with its LSIs, software and analog and digital configurations is one of the world's largest and most complex machines. It is programmed by the telephone book — the most common programming book in the world."

"The technological revolution in electronics will continue for some time at an incredibly rapid rate. As in all science, the results will be judged good or bad depending how society uses them. Instant information and greater automation will shape social values. Countries with financial resources, large numbers of skilled knowledge workers and highly competitive marketplace economies will far outpace the rest of the world. They will also set the standards.

These changes will impact on society in many subtle psychological ways. These changes may not capture as much media attention as environmental or energy problems but will underlie many of the social questions and political problems. The speed with which the rate of electronics is evolving will impose a tremendous challenge to man's adaptability. Will it threaten or assist our urban and non-urban survival?"

The responsibility of the scientists and technologists is to identify in advance the direction and the time-table of the change he forges. The educator, the sociologist and the politician can then anticipate and assist people to understand and prepare.

We can only go ahead but we need not do so blindly. We all have responsibilities as well as rights."

## SKREET ERROR

Readers of the August issue may have noted a few discrepancies in the Skeet project.

First — the circuit diagram does not correspond to the pcb layout, although logically correct the IC sections and pin numbers are in error.

Errors also scamped onto the pcb and overlay.

In order to build a working project, observe the following changes:

Locate the track connecting IC6 pin 7 to pin 8 of the same IC, break it near pin 7. Connect pin 8 to pins 5 and 6.

On the overlay interchange C1 and the jumper directly beside it. Finally, change the resistor numbers as follows — R2 becomes R3, R3 is R4, R4 is R5, and R5 is R2.

Now the pcb and overlay are correct, and the circuit diagram may be checked against it.

## AUDIOPHILE

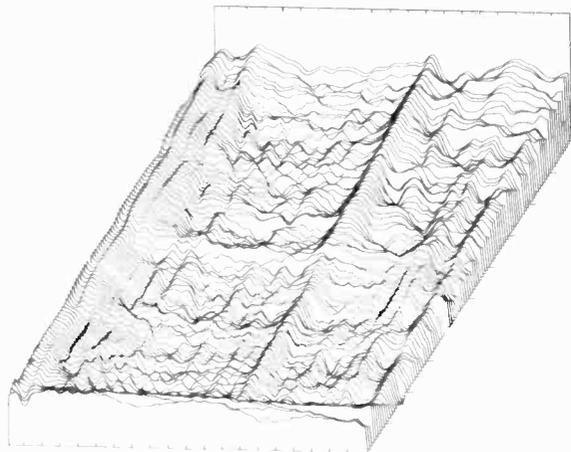


Figure 1

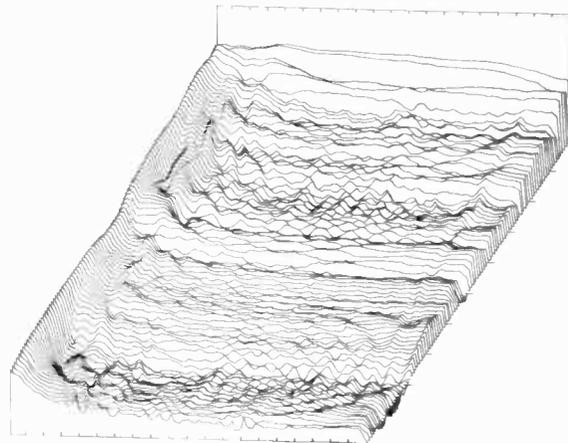


Figure 2

### FINGERPRINT

A relatively new digital plotting system is now being used by Acoustic Research for transient decay plots.

Figures 1 and 2 show how two different loudspeaker systems reproduce a single impulse, such as a pistol shot. This type of single impulse contains all frequencies, from 0 to 20,000 Hz at constant amplitude. A perfect reproduction of this would be a single flat response curve. The beginning of each plot is at the top; at the end of the plot, (at the bottom of the page) it is 1/200th of a second later. Each fine line is a separate frequency response curve,

*SME Series III precision pick-up*

delayed fifty millionths of a second from the one before it.

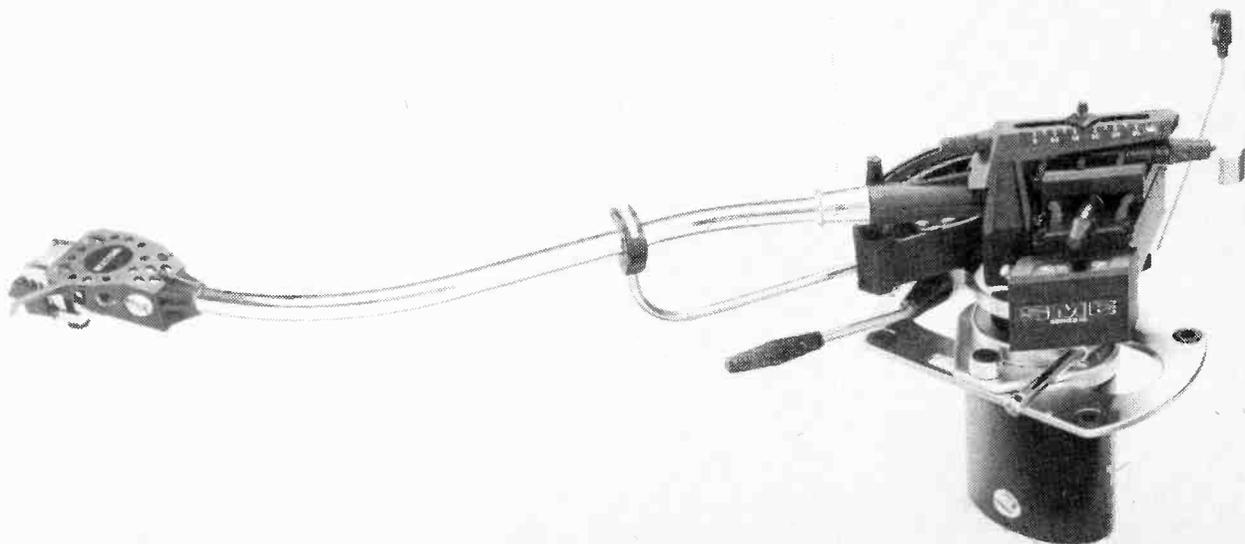
The speaker in Fig. 1 has a very uneven response, with a persistent resonance at about 13,000 Hz. The energy comes out slowly, at all frequencies, instead of rapidly, as would be the case for an ideal loudspeaker. Fig. 2 shows a system which has a very smooth response over the entire frequency range, followed by a rapid decay, and is relatively free of peaks.

By showing the detailed effects of small changes in design, such computer techniques help AR engineers make better speakers.

For more information contact A.C. Simmonds & Sons Limited, 975 Dillingham Road, Pickering, Ontario L1W 3B2.

### PICK-UP

Also available from A.C. Simmonds & Sons is a new SME Series III precision pick — up arm (model 3009). The features and specifications of this arm would require more space than we have available, however, a clear indication of the research and precision that has gone into the design and construction can be gained from the knowledge that nitrogen hardened titanium tube having a wall thickness only twice the diameter of the average human hair provides the strength/weight ratio needed for the arm. This feature might also give some idea of the price of the beast which is \$265.00 (suggested resale).



# eti microfile

## HEATHKIT INSIDES

With our hands on a set of Heathkit H8 System manuals, we thought we would present a few details of what's in it.

First the basic box, the H8 "mainframe", priced at \$499.95. This can be broken into the four main units — CPU board, front panel board, chassis-motherboard and power supply.

**CPU Board.** A fairly straight forward design, surrounding the 8080A - 8224 - 8238 set, with 7 interrupt inputs, and full bus buffering. A 1K X 8 MK3000 ROM containing monitor and other software is also on this board.

**Front Panel.** The front panel board allows the user to communicate with the basic H8. To this end the front panel includes a 16 key keyboard, and 9 seven segment LED indicators, plus four individual LEDs. The user thus has the capability to observe and change the contents at any address, register or I/O location. The multifunction keyboard incorporates a variety of conveniences, and a loudspeaker - bleeper circuit is included to provide audio "feedback" to the programmer.

**Power Supply.** Power is distributed in unregulated form, with regulators on each card. The power supply outputs are 8V at 10A and  $\pm 18V$  at  $\frac{1}{2}A$ .

**Chassis Motherboard.** The chassis and case has been pictured in last month's issue. The motherboard provides slots for 10 boards, and incorporates the Heathkit 50 pin bus. The bus has been arranged to minimise interference between adjacent lines, and rather than edge connectors, uses mating 50 pin board mounted plugs and sockets.

Now, with this much equipment you won't be able to do very much. You'll need some memory. This means the "accessory" H8-1 Memory Board. The board itself is able to carry 8K of static RAM (4044 type 4K X 1) but you get only the first 4K for the board's \$249.95 price. A set of chips for the remaining 4K costs \$189.95. The circuitry provides buffering for all buses, and decoding for the board address at any 8K multiple location.

In addition to this, for storage on cassette tape, and communication with a video terminal or teletype, the

Serial Interface Board H8-5 is needed. Cost - \$189.95.

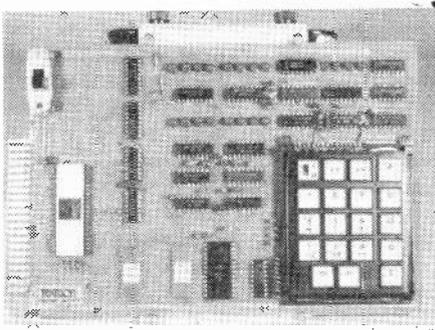
Another accessory the Parallel Interface H8-2 is available which provides three independent 8 bit I/O parts with handshaking. This board is needed if the H10 Tape Reader/Punch is used.

In summary, a reasonable basic computer system, comprising H8 plus 4K memory and serial I/O for cassette storage can be put together for about \$940.00.

## TEKTRON \$99

No, that's not the model number in hex, it's actually the price! This interesting one-board microprocessor unit, model TEC 1802, was spotted at the IEEE show.

Tektron developed the kit for use in a microprocessor training course. Chief criteria were low cost, and low power. This they have achieved with almost-all-CMOS circuitry for a current drain of only 60mA, which enables the unit to be run off a lantern battery for around 25 hours!



What's on board? There's a (surprise, surprise) RCA CDP 1802 CMOS processor, plus 256 bytes of memory. A hex keyboard for data/address entry, LED indicators for data and address buses, plus status and memory protect. In addition, the 1802 "Q" or serial output is attached to on LED indicator. Eight parallel buffered outputs are available, and 8 inputs and timer function can be added with the addition of one chip (\$11.00).

This product as it stands would make a useful controller for the experimenter. Accessories are available to increase its power, such as power supply, extra RAM (CMOS RAM available), EPROM etc., which connect to the TEC 1802 via a motherboard.

Tektron Equipment Corporation  
263 Barton Street, Unit 19  
Stoney Creek, Ontario L8E 2K4

## RCA VIP

Here's something slightly different in basic microprocessor kits. The VIP stands for "video interface processor" and that sums up the main feature.

The one board kit contains 1802 mpu, 2K RAM,  $\frac{1}{2}K$  ROM operating system, cassette interface, and an 1861.

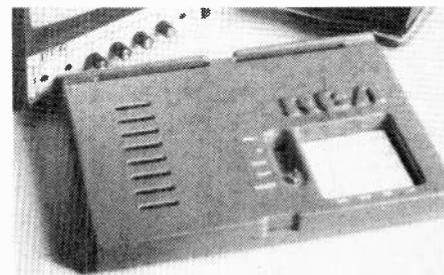
What's an 1861 you say? That's the video chip which is a sort of parallel to serial converter, with output levels suitable to drive a video monitor. That eliminates the need for hex displays on board. In addition RCA provides a language they call CHIP-8 for easy programming and graphics. Hence the processor kit is very suitable for video games, and even includes a sound effects circuit. For example, a rocket launching, a space ship intercept game requires only 104 instructions, including on-screen scoring.

On board space is provided for memory and I/O expansion.

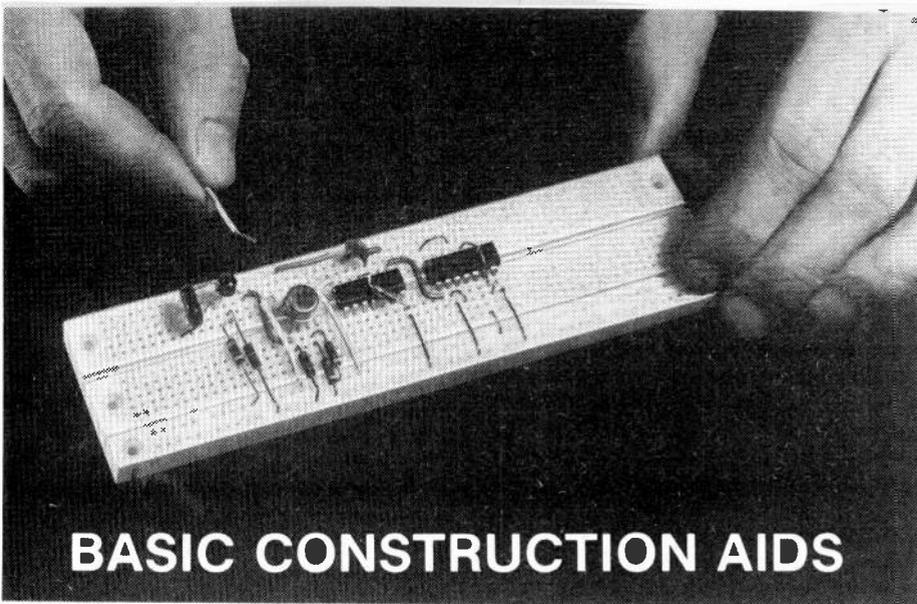
The one board system comes with a rugged-looking case and power supply for US\$275.00. The only problem is you do need a video monitor, but you could get around this by either using an RF modulator, or delving inside your T.V. and hooking in to the video directly.

The VIP is available from RCA distributors and no doubt some computer stores will pick up this product.

RCA has offices at  
4515 Manhattan Rd. S.E.  
Calgary, Alberta  
T2G 4B3  
21001 No. Service Rd.,  
Trans Canada Hwy.,  
Ste Anne De Bellevue, Quebec  
H9X 3L3  
1 Vulcan St.,  
Rexdale, Ontario  
M9W 1L3



RCA COSMAC VIP — Video Interface Processor, combines the classic beauty of blue fibreglas pcb with contemporary case styling and avant-garde keyboard lettering.



## BASIC CONSTRUCTION AIDS

WHEN ONE LOOKS at the profusion of breadboarding and construction boards available in Canada one wonders how all the companies involved can make a living. The answer is that they are nearly all U.S. companies selling their products on our side of the border. The two exceptions to this, that we are aware of, are Hammond and Vero, the latter being a British company!

One thing it does mean of course is that we hobbyists have a great choice of products and this article sets out to see something of what is available in each area and for what uses each item is intended. We have made no attempt to evaluate each product; we intend to give you enough information to choose which best suits your needs and leave the rest to you.

### PERFORATED BOARDS

Perhaps the most basic method of construction is the "rats-nest", now hopefully laid to rest by the use of any of the products mentioned in this feature. The next stage from the "rat" is the plain perforated board. Boards made of plastic, phenolic or even fibre glass are available with no copper-cladding and a matrix of holes on various spacings — 0.1 inch and 0.15 inch being two popular sizes.

Such boards can be used simply by passing component leads through the holes and soldering up on the back — circuit layout can be followed when prototyping to make checking and correction easier. Alternatively pins or terminals made to suit the various boards can be used to mount the components neatly on the board and to carry wiring on the underside.

Saxton Products Inc., Radio Shack and Vector can supply such board and solder or solderless terminals to suit. Vero (all addresses later) also manufacture a range of perforated boards with wiring pins to suit. Other

accessories such as mounting posts and brackets are available from most companies for use with these and other boards.

### UNIVERSAL P.C. BOARDS

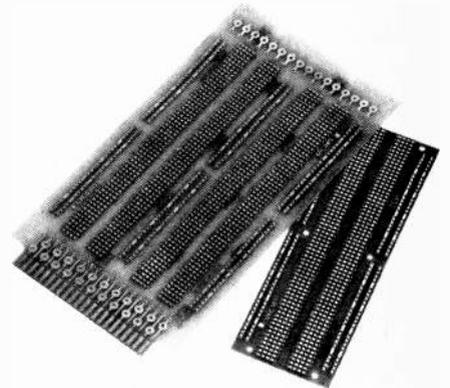
If we take the plain perforated board a step further — as most of the manufacturers have done — it can become a universal p.c. (printed circuit) board, with the addition of a few strips or areas of copper connecting rows or groups of holes together. This type of board can be specifically designed for one type of application — not quite so "universal" but still having a wide number of uses in one particular area e.g. a board designed to take a number of d.i.p. circuits.

To use the most basic type of board i.e. with rows or areas or both connected by copper it is first necessary up with a layout that will enable all the components to fit neatly on the board available, using the board connections and without too many jumper links. The copper strips connecting rows of holes can be broken if required, using the tip of a hand held, twist drill, to enable different parts of the circuit to be connected to what was originally the same row.

Veroboard and similar products available from Vector are perhaps the most suitable for the hobbyist both for development and wiring up of completed designs. These products offer the neatness and reliability of printed circuits without the need for special production of a single pattern design. It is possible to wire a prototype directly onto these boards in a similar way to making a "rats nest" or perforated board prototype. Once this has been done the design can be rationalised and built permanently on the board.

With 0.1 inch matrix board it is possible to use card connectors and virtually any i.c. socket can be fitted. Molex pins are an inexpensive way of fitting i.c.s to such boards and these connecting pins can also be used to hold discrete devices and form temporary interconnection points on prototypes.

Variations on this basic theme are numerous — some boards have provision for i.c.s or are designed with small areas coming together for the positioning of a transistor. They may also have a number of areas or strips connected to plated contacts suitable for inserting in a multi-way socket. Such boards are available in various shapes, sizes patterns and matrixes from E&L, Vector and Vero.



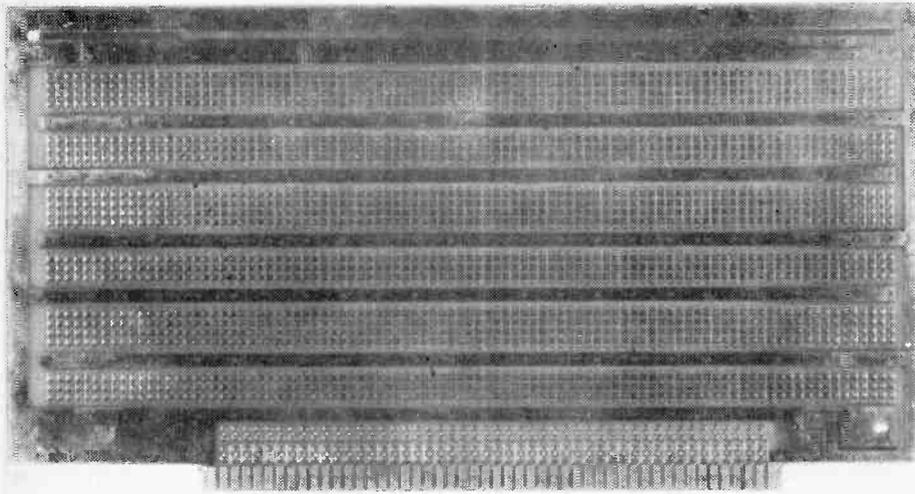
Two special purpose p.c. boards from E&L.

### SPECIFIC P.C. BOARDS

Once we turn our attention to the boards designed for more specific applications it becomes obvious that the vast number of these are designed to get a large number of i.c.s in a fairly small area whilst still allowing room for wiring up. Many of these boards have added refinements such as card edge connectors, double sided connections and ground planes to improve h.f. performance. Such boards are available from Cambridge Thermionic, E&L, Vector and Vero.

Of course many boards are made with the possibility of carrying both discrete components and i.c.s and all the above manufacturers have such designs. Since wire wrapping is now popular with industry a number of manufacturers also market boards designed to hold i.c.s with power and ground planes built in the p.c. form, but with provision for wire wrapped connections.

Before moving on to look at breadboarding in its true form we should note the recently introduced



Tarbell Electronics prototype board designed to be Altair/MSAI Compatible. The layout includes space for a voltage regulator.

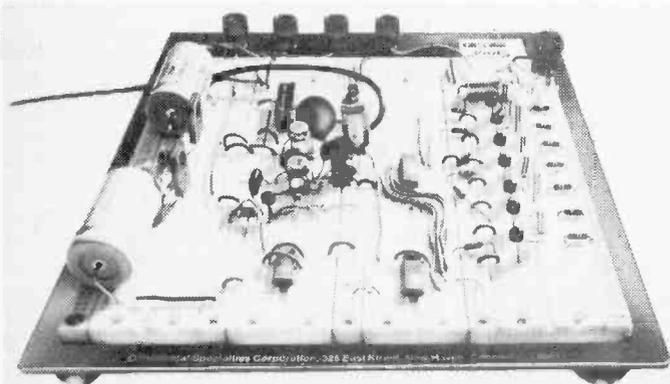
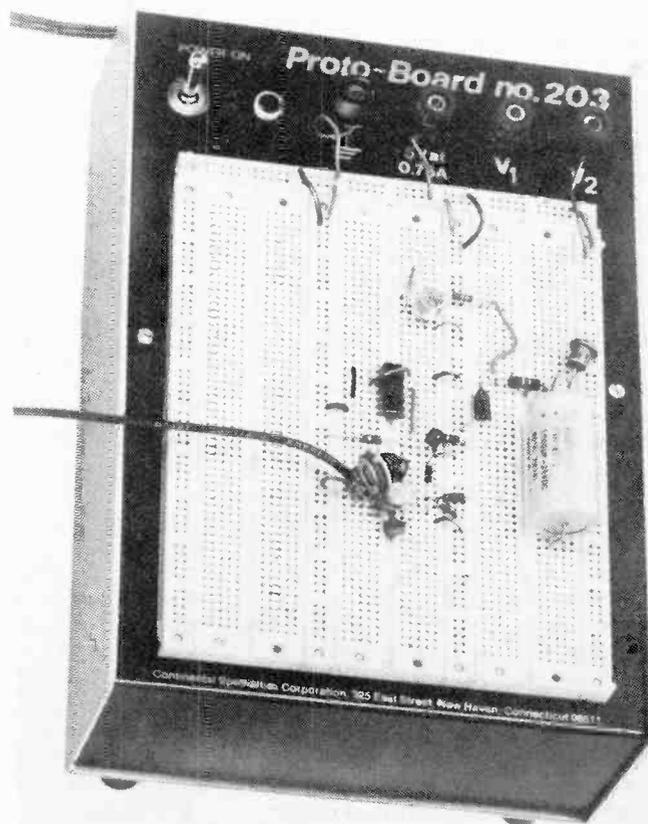
m.p.u. wiring boards. We have over the past few months received news of a few of these, they are: the GP2 board from Electronic Products — designed for Micro 68 prototyping; the Vero production of microprocessor based systems, the boards are the c.p.u. board, the memory board and the

interface board, each board is pre-assembled with the appropriate mini-wrap d.i.p. sockets, pins and edge connector; and finally a large board for i.c.s. from Tarbell Electronics designed to be Altair/MSAI compatible.

## BREADBOARDING

A good way of making the first prototype of any new design or of developing circuits in a practical manner is to use a breadboard. Although plug-in breadboards are rather more expensive than most of the items mentioned above they are not intended for permanent construction and can be used many many times for development of different designs.

For the above reasons it is essential that the initial system purchased has the capability, either to take all circuits the hobbyist is likely to undertake in the foreseeable future, or to be



These three photographs give a good idea of the coverage of the range of CSC products. The smallest being the 6kit, the Proto-board 104 is the largest available and the Proto-Board 203A has a built in 1% regulated, short proof, power supply, which can provide 5V at 1A and + and - 15V at 0.5A.

expanded by the interconnection of other boards as greater capability is required.

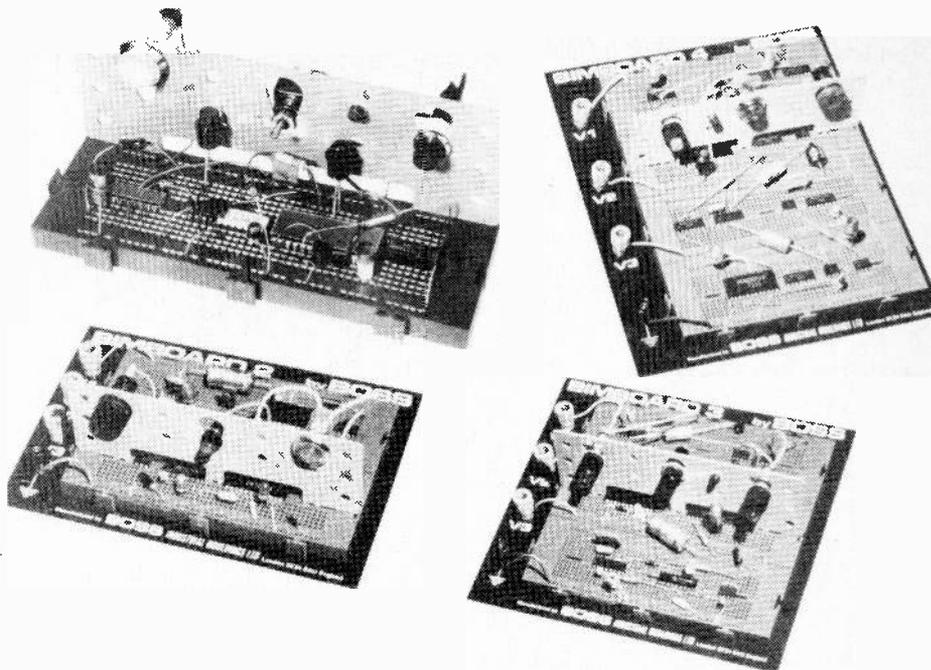
Fortunately many of the basic products available fall in the last group so the initial outlay can be kept as low as possible. However, there are many advantages to buying a larger board, the main one being ease of use of one board, rather than a number of boards which need interconnection in various ways. It is also cheaper to buy a larger system in one go than to build up to it later. Hence the hobbyist is advised to look carefully at the available range and decide which is most suitable both to his needs and pocket. Since the range is so wide the best piece of advice we can give any reader is to get hold of the catalogues of the main firms involved and see exactly what they sell. We simply do not have the space to describe everything.

The basic boards are made of a plastic material with interconnected holes in rows of about 5 or 6 sometimes with one hole slightly removed for connecting wires. Most of them have a gap down the middle so that i.c.s. may be easily inserted. The connections, which are of course solderless, are on a standard 0.1 inch matrix.

One board will allow the construction of many prototypes and the manufacturers have designed in the ability to physically interconnect extra boards to their basic unmounted panels to increase component capacity. Pictures, it is said, save a thousand words and those shown on these pages surely will!

## MOUNTED BOARDS

Once one leaves the basic boards and starts to look at the various



*The Hammond range of mounted boards showing the component panels in use.*

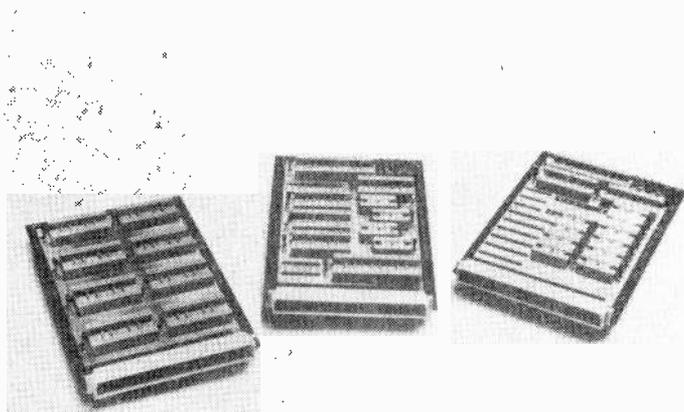
mounted versions then the choice becomes much wider and to some extent the universality of the products begins to be restricted. For instance one manufacturer (CSC) has at least 6 available Proto-Boards which are basically various sizes; from one mounted board which can house up to six 14 pin DIP i.c.s. to a complex board which can hold 32 and costs about \$80.00.

The most basic mounted board is available from E&L and is their STS01 starter kit. This is designed for testing of simple op-amp circuits and employs a 16 pin i.c. board mounted on a panel which also holds a speaker, connecting pins, battery connectors and a test switch.

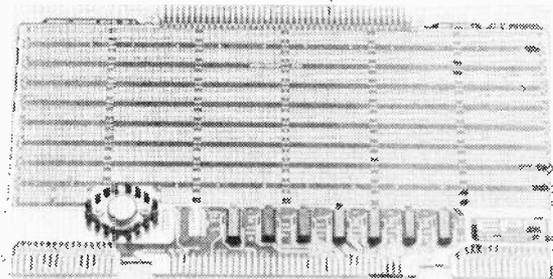
After this basic stage the combinations are endless and the range runs from single mounted boards with attached power supply up to a microprocessor system from E&L with attached breadboarding for training and hardware development.

## ACCESSORIES

Various accessories are available from the breadboarding suppliers to complement their products. For instance E&L offer reusable adaptor boards that allow the instant use of 8 or 10 pin T05 devices, in addition to logic probes, DIP identification stickers, i.c. holders, universal pre-punched panels etc.



*The Vero Microprocessor System is much more advanced than a simple breadboard, with its three pre-arranged boards. This system employs mini-wrap DIP sockets.*

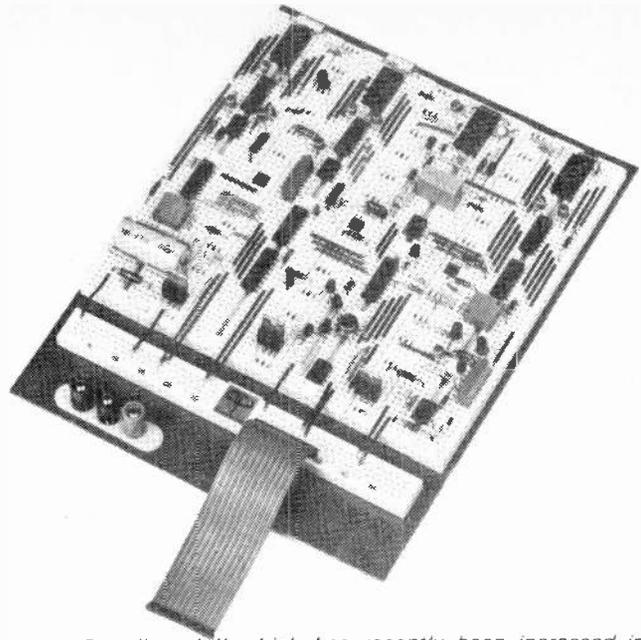


*The GP2 board from Electronic Products Associates designed for prototyping Micro 68 systems. has complete bus buffering and voltage regulator on board.*

CSC do various logic probes, monitors and test clips in addition to more standard types of test gear. A.P. market various accessories including a very useful new addition — the p.c. board jumper which is a 12 line connector with 0.1 inch pin spacing so it can be used with virtually any breadboard.

Hammond produce a jumper wire kit for breadboards which consists of 350 wires cut to 14 different lengths from 0.1 to 5 inches long and bent and stripped to slot straight into the board holes. They also provide pre-punched component support panels with their boards.

Well that should give some of you a better idea of just what is available. If we have confused any we are sorry but, particularly in the breadboarding field, the range is extensive and to analyze every product would take a whole issue!



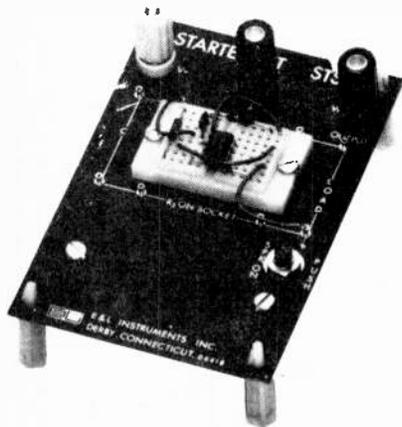
The A.P. Breadboard II which has recently been increased in capacity at no extra cost.

**A.P. Products Inc.**, Ohio; Information and products from *Weber Electronics Inc.* 1111 Finch Ave. W. Suite 154, Downsview, Ontario M3J 2E5 (416) 638-1322. Branch office/Sales outlet Montreal Quebec (514) 861-2014.

**E&L Instruments Inc.**, Connecticut. Information and products available from *Cardinal Industrial Electronics Ltd.*, 11619-145 Street, Edmonton, Alberta T5M 1V9 Tel (403) 455-4122. Or *John Fortin Co. Ltd.*, main office 660 King Edward Street, Winnipeg, Manitoba, Tel (204) 774-6286. Or *R.A.E. Industrial Electronics Ltd.*, 1629 Main Street, Vancouver, B.C., Tel (604) 687-2621.

**Hammond Manufacturing Co. Ltd.**, 394 Edinburgh Road North, Guelph, Ontario N1H 1E5, Tel (519) 364-3267.

**Electronic Products Associates Inc.**, 1157 Vega Street, San Diego, California 92110.



Probably the smallest mounted board system available this is the E&L STS-01 Starter Kit. The second photograph shows the other end of E&L's range the unit being their MMD-1 Microprocessor System.

**Saxton Products Ltd.**, New York. Information and products available through *EICO Canada Ltd.*, 20 Millwick Dr., Weston Ontario M9L 1Y3 Tel (416) 749-4520.

**CSC Connecticut**, Information and products available from *Len Finkler Ltd.*, 25 Toro Road, Downsview, Ontario M3J 2A6 Tel (416) 630-9103

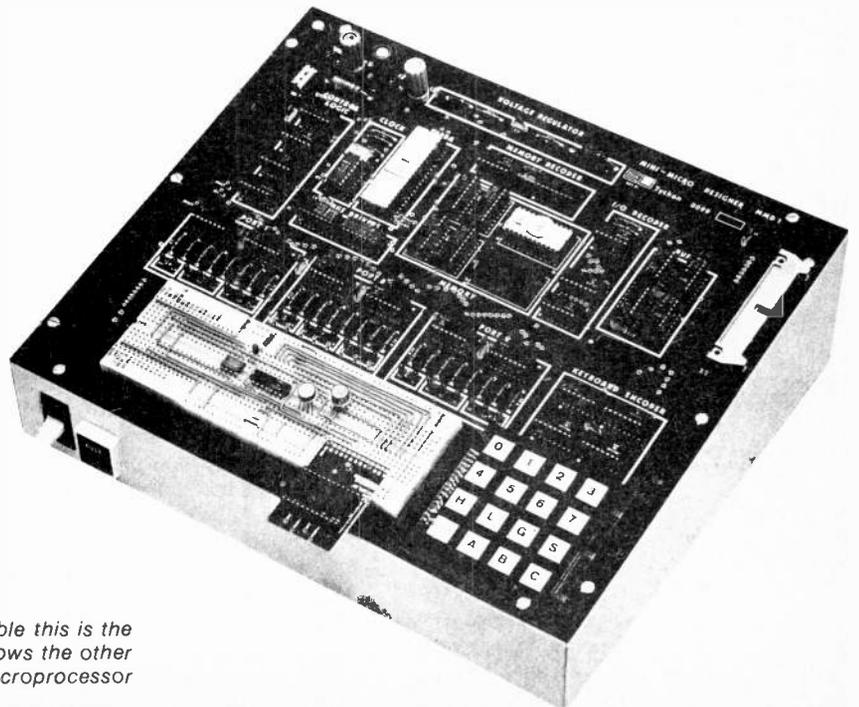
**Tarbell Electronics**, 144 Miraleste Dr., No. 106 Miraleste, California, 90732 Tel (213) 538-4251

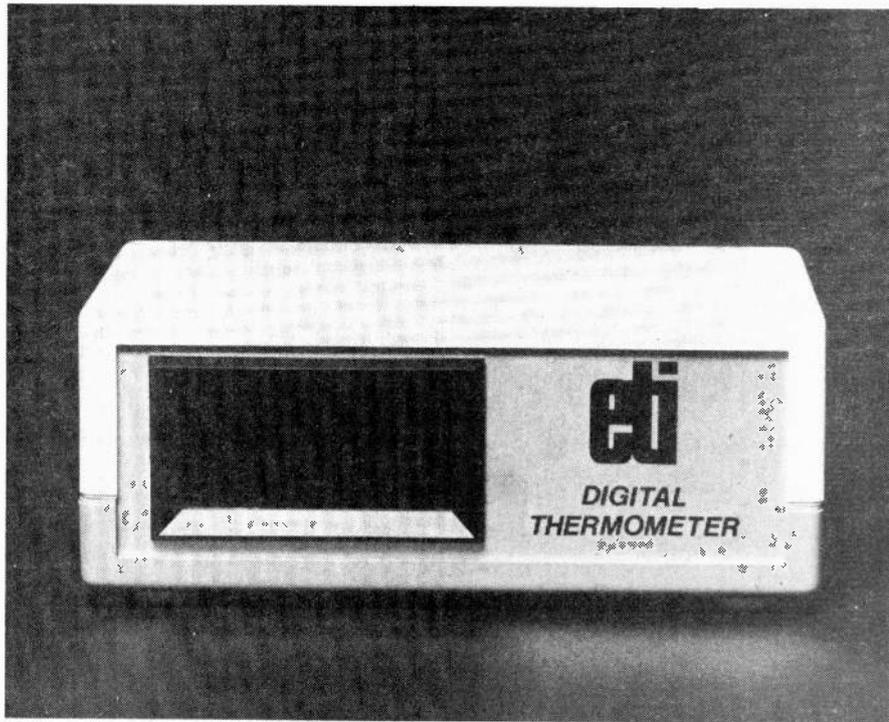
**Vero Electronics** (G.B.) Information and products available from *Electronic Packaging Systems Ltd.*, P.O. Box 491, Kingston, Ontario Tel (613) 549-5152.

**Radio Shack**. For information write or call 399 Philips Ave., Burnaby B.C. V5A 3K4 tel (604) 293-4535, or P.O. Box 34000 Barrie Ontario L4M 4W5 Tel (705) 728-6242, or 8092 South Service Rd., Trans Canada Hwy. St Laurent Quebec H4S 1M5 Tel (514) 332-9094.

**Cambridge Thermionic and Vector**. Information and products available from *Casco Electronics* 4050 Jean Talon St. W., Montreal Quebec Tel (514) 735-5511.

**Molex Electronics**, 100 Alden Rd. Unit 1, Markham, Ontario L3R 2S1 Tel (416) 495-1813 Branch office/Sales outlet Montreal Quebec Tel (514) 933-3974.





# DIGITAL

# THERMOMETER

WE HAVE FOR some time been considering the construction of an accurate electronic thermometer, and the announcement of the new National LM3911 temperature controller was enough to spur us into action and get down to building the thing.

The LM3911 is a highly accurate measurement system for use over the  $-25^{\circ}\text{C}$  to  $+85^{\circ}\text{C}$  temperature range. It is fabricated on a single monolithic chip and includes a temperature sensor, stable reference voltage and operational amplifier on chip.

## SENSING ATTRACTION

The characteristics of this device make it ideal as the basis for an accurate and easily calibrated thermometer. The chip produces an output of  $10\text{mV}/^{\circ}\text{K}$  and all that is necessary to convert the 3911 into an electronic thermometer is to connect it to a scaled voltmeter.

In its simplest form the voltmeter would consist of a moving coil meter with as large a deflection as possible.

It soon became apparent that if we were to make use of the full measurement range available, we would need a very large meter scale. A smaller scale would mean that the temperature could not be read to within a couple of degrees. We wanted our thermometer to be more accurate than this.

Now while we are not in favour of going digital for the sake of it, in this case it seemed that the potential accuracy of a digital display was required.

We threw out our analogue measurement stage and started thinking in terms of VCOs and 7400s. This line of approach seemed very attractive until we looked at the final design.

## THERMAL EXPANSION

The component count had gone up dramatically and the accuracy

The circuit for the digital thermometer may conveniently be broken down into three separate building blocks. These are the temperature sensing block, the A to D convertor including the display and the power supply.

We shall start by considering the temperature sensor.

## THE TEMPERATURE SENSOR

The LM3911 temperature controller used in this project provides an output voltage which is linearly related to the temperature at which the chip's sensing element is maintained. This output voltage is given by the relationship:

$$V_{\text{out}} = T \cdot 10^{-2} \text{ volts}$$

Where T is the temperature in degrees Kelvin.

The Kelvin and centigrade scales are related by the following relationship:

$$^{\circ}\text{K} = ^{\circ}\text{C} + 273.16$$

Thus at room temperature (about  $20^{\circ}\text{C}$ ) the output of the LM3911 will be:

$$V_{\text{out}} = (273.16 + 20) \cdot 10^{-2} \text{ volts}$$

$$\approx 3 \text{ volts}$$

For the A/D convertor to give readings in  $^{\circ}\text{C}$ , and to correctly display temperatures below zero, it is necessary to arrange so that at  $0^{\circ}\text{C}$  the output of the LM3911 is 0V.

The components R2, R3, R4, and R5 together with RV1 allow for this adjustment. They enable an adjustable 'offset' voltage to be added to the output of the temperature sensor. This offset is trimmed during the calibration procedure described in the main text.

For more detailed data on the LM3911 see the Data Sheet on page 52 of our October issue.

## THE A/D CONVERTOR

The A/D convertor is based on the new Intersil ICL7107  $3\frac{1}{2}$  digit, single chip panel meter. It is intended to drive an LED display directly with a segment current of about 8mA. In addition to a precision dual slope convertor, it contains BCD to seven segment decoders, a clock and a reference voltage.

The detailed operation of this chip is something known only to the design team who produced the IC's mask, so we will have to content ourselves with a brief look at the function of the external components.

The components associated with pins 38, 39 and 40 (C4 and R9), determine the oscillator frequency, which is designed to run at approximately 50 kHz.

The reference voltage for the system is set up using RV2. The chip internally regulates the voltage between pins 1 and 32 at about 2.8 volts. This stable voltage is used as the systems reference.

We shall see later that we require the 7107 to have an fsd of 2.000 V. For this fsd reading we must arrange for the voltage between pins 35 and 36 to be 1.000 V.

Adjustment of RV2 allows this to be accomplished.

The components not yet mentioned take care of auto zero, polarity, etc., and Intersil do not provide details of their exact functions.

The displays are directly connected to the appropriate pins with no interfacing required.

## LINKING THE TWO

The ground referenced voltage from the junction of R4, R5 is fed, via a smoothing capacitor, C9, to R6. This connects to the analogue input of the 7107, and apart from considerations of scaling, and a power supply, the circuit should now operate, albeit inaccurately.

## SCALING

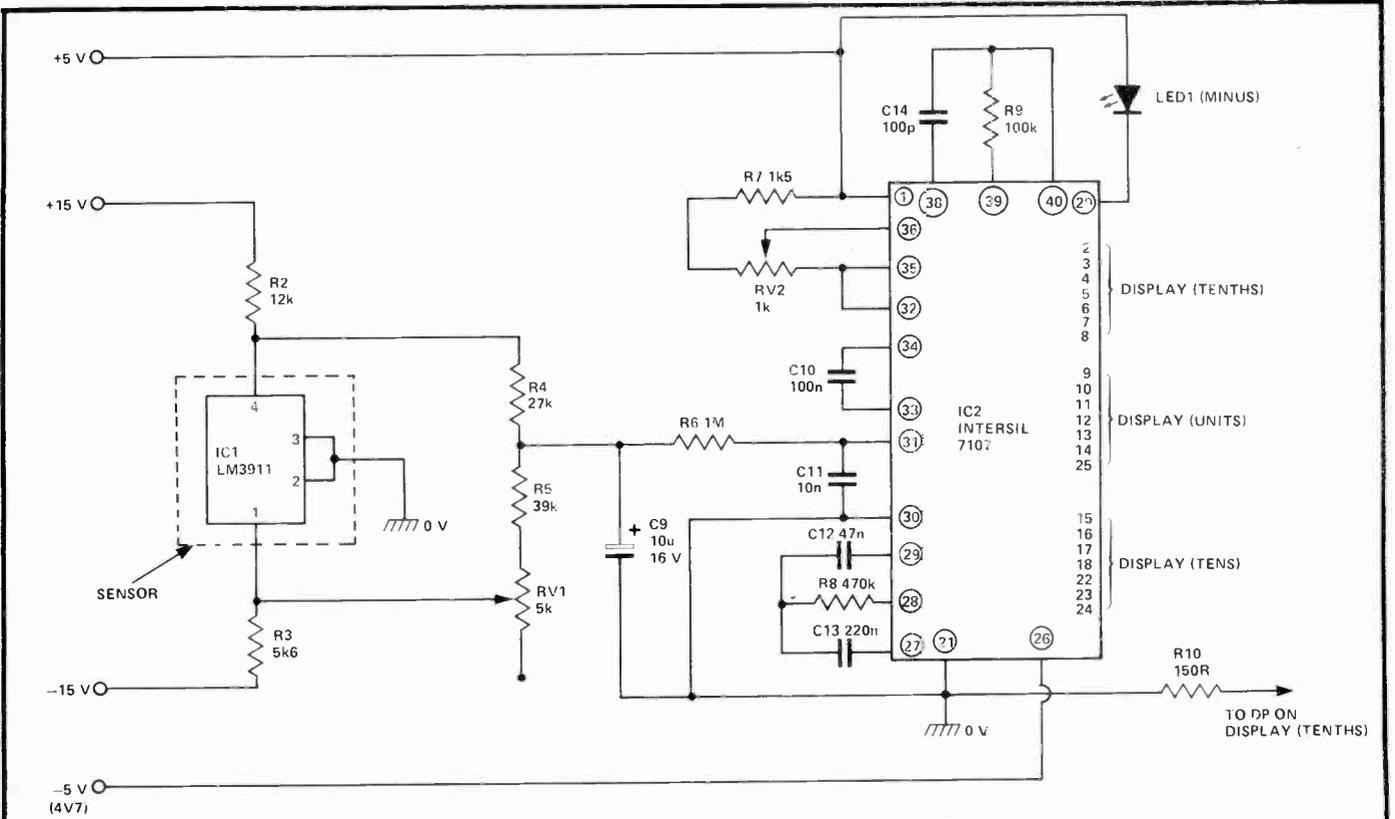
First scaling. The output of the LM3911 is a voltage increasing at  $10\text{mV}/^\circ\text{C}$  or  $1\text{mV}/0.1^\circ\text{C}$ . If then the least significant digit of our display reads in steps of  $1\text{mV}$ , it could be thought of as representing  $0.1^\circ\text{C}$  temperature steps.

Similarly, the second least significant digit represents  $1^\circ\text{C}$  steps and the third  $10^\circ$  steps. The 7107 is a  $3\frac{1}{2}$  digit chip, and if we ignore the most significant digit and arrange an fsd of 2 volts, we will have the required scaling.

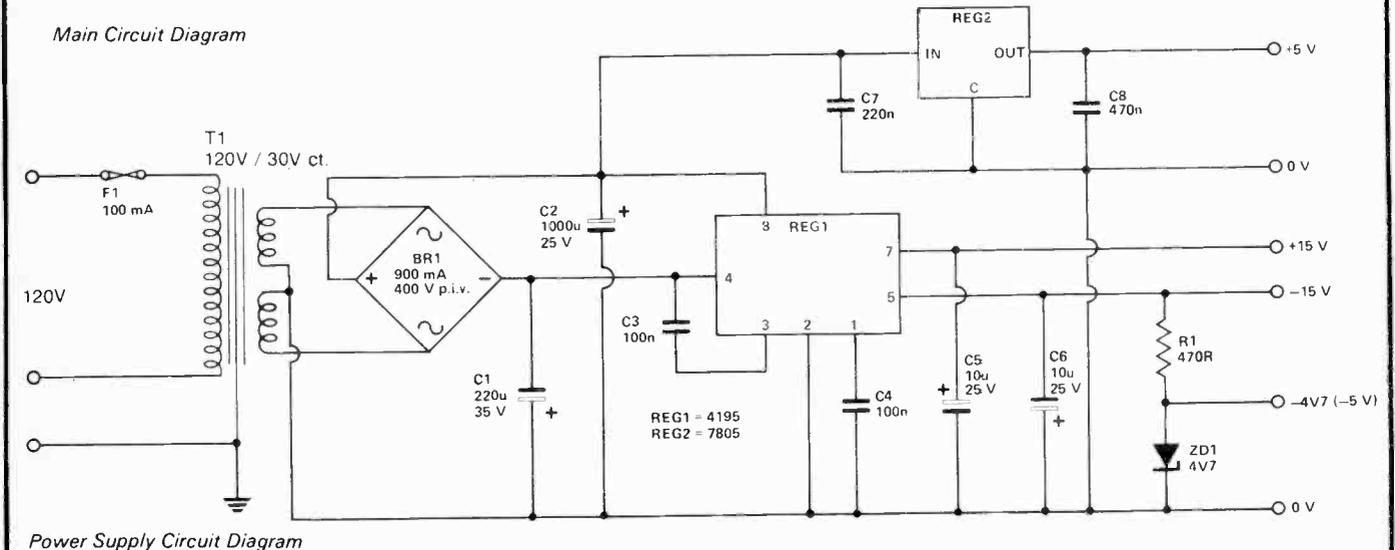
## POWER SUPPLIES

The power supply section is quite straightforward. The LM3911 requires a  $+15/0/-15$  stabilised rail, which is provided by REG 1. The 7107 requires  $+5/0/-5$  rails and these are provided by REG 2, ZD1 and associated components.

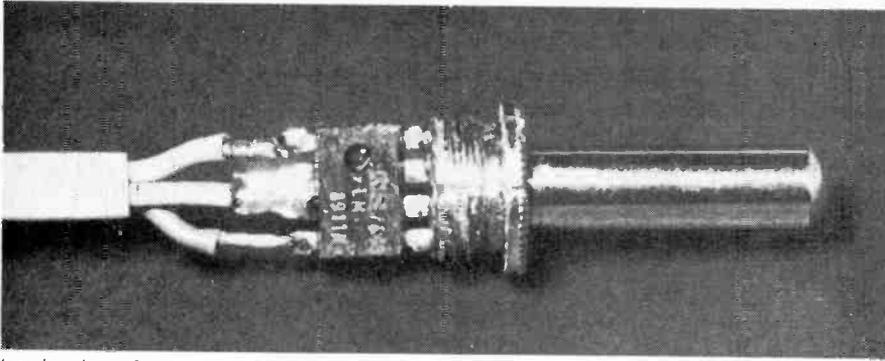
The reason for using a regulator in the  $5\text{V}$  rail and not the  $-5\text{V}$  rail is explained by the fact that the  $5\text{V}$  rail supplies the LED current.



Main Circuit Diagram



Power Supply Circuit Diagram



Interior view of our temperature probe. Pins 5, 6, 7 and 8 of the LM3911, those connected to the internal temperature sensing element, have been soldered into a jack plug from which the shaft has been removed. This provides good thermal contact between the probe tip and the sensor chip.

of the unit would have been seriously degraded as many of the new components would drift with temperature and time.

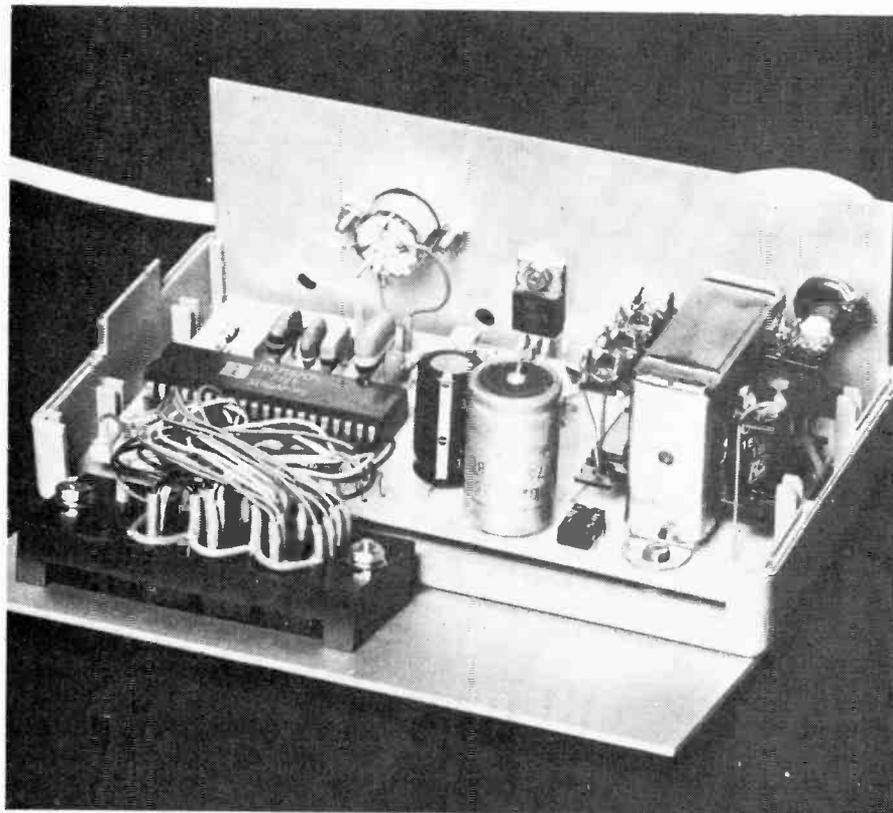
Having firstly rejected the analogue approach, and now come to the conclusion that the digital approach was also out, we were beginning to worry....

It was at this point that a new chip from Intel came to our rescue. The 7107 is a single chip DVM with three and a half digit resolution. The chip needs only a few passive external components to function as a DVM — unlike some single chip DVM's of the past which were little more than overpriced VCO's.

## BUY LINES

The 7107 is an Intel device, and the LM3911 is from National Semiconductors. They should be available from your nearest distributor, or write to: Intel Corp.  
70 Chamberlain Ave.,  
Ottawa K1S 1V9

National Semiconductor District Office,  
1111 Finch Avenue West,  
Downsview, Ontario M3J 2E5.



A view of the interior of the thermometer. The seven segment displays are mounted in the display mounting hardware described in the text and hard wired to the PCB board. The probe is connected to the thermometer via the DIN socket shown on the rear panel.

This looked very promising. the component count would be low and the DVM chip was stable over a wide range of temperatures. In theory all we had to do was hook the temperature chip up to the DVM, add a power supply and we would have a thermometer capable of resolving temperature in 0.1°C steps.

All the components with the exception of IC2 should be mounted on the PCB according to the component overlay shown.

IC2 is a CMOS device and we recommend that it be mounted in an IC socket. As a further concession to the sensitive nature of this chip it is best not to insert the IC into its socket until all other constructional work has been completed.

After finishing the PCB assembly the display should be wired to the board. The display mounting hardware we used was from Elbar (see page 23 of the August issue).

Indication of negative temperature is by means of a LED which is mounted in the vacant position of the display mount.

The mounting arrangement for the sensor is largely a matter of choice. We mounted ours in a jack plug from which the central shaft had been removed. If the distance between the sensor and thermometer is large, then screened lead should be used for the interconnection.

There are two adjustments to be made before the thermometer will display the temperature correctly.

The first is to adjust RV1 so that, with the sensor held at 0°C, the display will read all zeros.

The best way of ensuring that the sensor is at 0°C is to immerse the device into a plastic container (flower pot) that has been half-filled with crushed ice, and topped up with cold water to the three-quarter full mark. Care must be taken to ensure that no water can reach the electrical connections to the sensor.

Leave the mixture for five to ten minutes, stirring gently, and at the end of this time adjust RV1 to give an all zero display.

The second adjustment to be made is to RV2. There are two different ways of accomplishing this. The first is to hold the sensor at a second known temperature, well away from zero, and then to adjust RV2 to bring the known temperature, and the reading on the digital thermometer into agreement.

Probably the best way of meeting the above requirement, is to obtain an accurate, limited range thermometer — a clinical thermometer should be ideal.

Place the sensor and clinical thermometer in a container of cool water and slowly add warm water to bring the mixture into the temperature range covered by the clinical thermometer.

When the mixture appears to have settled at the same temperature for a few minutes, adjust RV2 accordingly.

Another source of a stable, known,

temperature is the human body. A healthy persons under arm temperature is fairly constant at 37.4°C.

The male members of the ETI staff, for some reason the women would not take part in this test, must be a healthy lot because this method agreed very closely with the first.

The second and perhaps the most

accurate procedure, which relies not on a second temperature but upon the accurate trimming of the voltage between two pins on IC2.

If an accurate DVM is used to measure the voltage between pins 35 & 36, then adjustment of RV2 to bring the voltage reading to 1.000 V will complete calibration.

## PARTS LIST

### RESISTORS (all 1/4W 5%)

R1	470R
R2	12k
R3	5k6
R4	27k
R5	39k
R6	1M
R7	1k5
R8	470k
R9	100k
R10	150R

### CAPACITORS

C1	220u 35V electrolytic
C2	1000u 25V electrolytic
C3,4,10	100n polyester
C5,6	10u 25V electrolytic
C7,13	220n polyester
C8	470n polyester
C9	10u 16V tantalum
C11	10n polyester
C12	47n polyester
C14	100p polystyrene

### POTENTIOMETERS

RV1	5k Multiturn Bourne type (Doram: 62-701-4)
RV2	1k Multiturn Bourne type (Doram: 62-700-7)

### SEMICONDUCTORS

BR1 4 pin DIL type: 0.9A 400V

REG1 ±15V regulator

REG2 7805

IC1 LM3911 (see 'Buy Lines')

IC2 ICL 7107 (see 'Buy Lines')

LED1 TIL209 or similar

DISPLAYS 3 DL707 or similar (see text for mounting unit)

ZD1 4V7 400mW zener

### TRANSFORMER

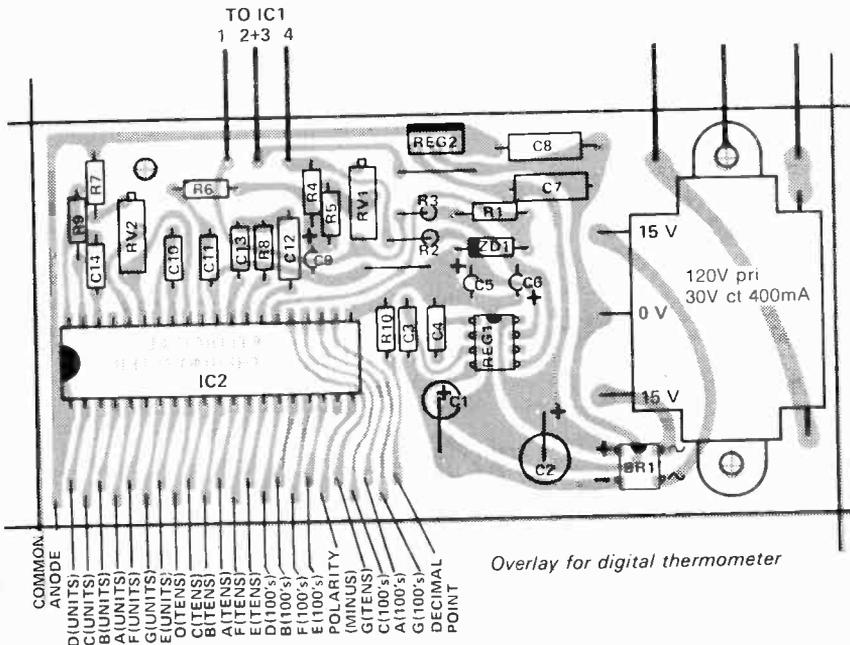
T1 20V / 30V ct @ 400mA

### PROBE

1/4" mono Jack plug, Japanese type (see text)

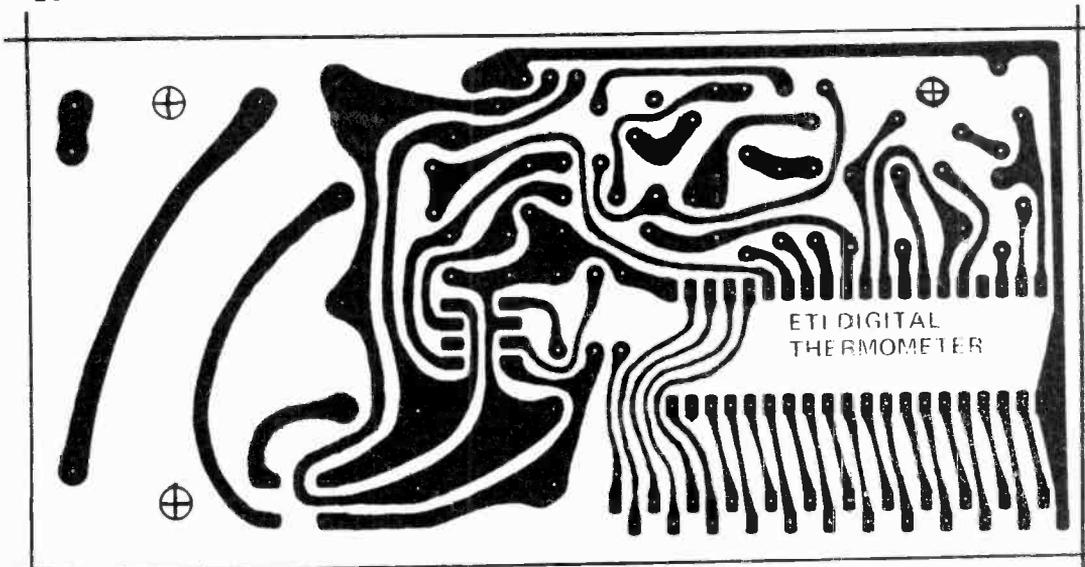
### MISCELLANEOUS

Line cord, shielded lead, nuts, bolts, etc. insulator kit for REG-2, connecting wire, grommets. The case used was a Vero model, size approx. 15 x 8 x 5 cm.



COMMON ANODE  
 DI(UNITS)  
 BI(UNITS)  
 FI(UNITS)  
 GI(UNITS)  
 EI(UNITS)  
 CI(TENS)  
 BI(TENS)  
 AI(TENS)  
 FI(TENS)  
 EI(TENS)  
 DI(100'S)  
 BI(100'S)  
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 DI(100'S)  
 BI(100'S)  
 AI(100'S)  
 FI(100'S)  
 EI(100'S)  
 POLARITY  
 (MINUS)  
 G(100'S)  
 A(100'S)  
 F(100'S)  
 E(100'S)  
 D(100'S)  
 C(100'S)  
 B(100'S)  
 A(100'S)  
 G(100'S)  
 DECIMAL  
 POINT

Overlay for digital thermometer



Foil pattern shown full size (138 x 70mm)

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10/77

# microbiology

LAST MONTH we looked at the features of the 8008 and 8080 microprocessors, and the development from one to the other.

In this episode the third generation in the family comes in view, consisting of the Intel 8085 and Zilog Z80 mpus.

For convenient reference we reprint here the 8080 block diagram (figure 1) for comparison to those of the other processors.



The 8085 is much more similar to the 8080 than the latter is to the 8008, especially from a software point of view. In fact only two additional instructions were added.

## 8085 HARDWARE

Looking at figure 2, we see what may initially appear to be a step backwards. The data bus and half the address bus have been multiplexed together! This however, has been done for a reason, and without detriment to speed. The reason is, of course, that more pins were needed to straighten out the control bus, and improve the interrupt capabilities. In fact there are four interrupt inputs.

There is now one "read" line, one "write" line, and a line to select memory or I/O devices. In addition, several input and output lines are provided on this mpu, the two additional instructions mentioned above service these ports. They are handy for implementing a cheap serial communications line with the mp system (eg teletype) without needing a device attached to the data bus. In this case software would take care of generating the correct pulse codes, for sending serial information (and the timing is based on the system crystal clock) rather than having a complex support chip, such as a USART, doing the communicating.

In order to demultiplex the data/address bus, the "ALE" line is used to load the address part into external

latches when it is available. If standard memory devices are used in the system, separate latch chips would be used. However, 8085 system components all have built in latches, resulting in a neat system with 8 less lines running around.

The clock generator has also been incorporated on chip — leaving two terminals to hook on a crystal or RC network.

In short, the functions of the 8080 mpu, 8224 clock generator and 8228 system controller have been almost combined on the 8085 (see figure 3), and a typically 3rd generation feature — the system runs off a single 5V supply.

The 8085 used a 3MHz clock with instructions using from four cycles (internal register to register MOV) up to 18 cycles for a CALL. It is interesting to note that while the 8085 is the same speed as the 8080A-1, the 8085 bus timing requires a memory access time of 450ns as opposed to the more stringent 300ns for the latter mpu.

## 8085 INTERRUPTS

The instruction "RST" (Restart, not to be confused with power or reset) is used to effect interrupts. The first mode is the "software interrupt" of both 8080 and 8085, and is a sort of specialized call.

If a "RST" instruction is encountered in a program, execution is transferred to one of eight predetermined (by the manufacturer) locations in memory, as specified by part of the RST opcode. The eight RST locations, numbered 0 to 7, are placed sequentially within a few bytes of each other (the actual locations are eight times the number) and thus may either be used to individually reference other routines, or may be used in conditional combinations. For example the RST 0 locations might be a conditional branch. If the condition is not met, then execution "drops through" to the RST 1 location and so forth.

With the 8080, the hardware interrupt capability, an interrupt

controller chips is needed, whose job it is to interface between interrupting devices and 8080. Upon receipt of an interrupt, the 8080 executes an almost normal instruction fetch, but sends out a special signal which deactivates memory and causes the controller instead to send the opcode for RST, which also contains the code determining which of the eight memory references to branch to for service of the interrupting device. This method is fast but the hardware complex.

The RST inputs on the 8085 may be directly connected to interrupting devices. The memory locations which are referred to by the mpu upon interruption are called "TRAP" RST 5.5, RST 6.5, and RST 7.5 in commemoration of the fact that the actual locations are selected as for the other RST's. The "TRAP" is a "RST 4.5", but it is named differently since all the RST's except TRAP may be ignored or "masked" by software.

It may be noticed that the ordering of the RST locations may be used as a form of priority setting in case of simultaneous interruption.

In the case where more than one device is attached to a RST input, a polling routine would be executed, which asks each device "who did it?"

## 8085 SUPPORT CHIPS

The 8085 can be used with all the special purpose devices mentioned last month in connection with the 8080, with the exception of course of the clock generator and system controller units. In addition, these 85 series memory components are available.

**8155 RAM I/O:** provides 256 bytes of static RAM, two 8 bit I/O ports (byte input or output) and one 6 bit port (programmable as input, output, or special function — interrupt etc.) plus a 14 bit programmable timer.

**8355 ROM I/O and 8755 EPROM I/O:** each includes 2K bytes of ROM or EPROM, plus two 8 bit I/O ports, each bit can be in or out.

Each of the above devices has on board address latches for compatibility with the 85 multiplexed bus.

Fig. 1. Internal block diagram of 8080 microprocessor.

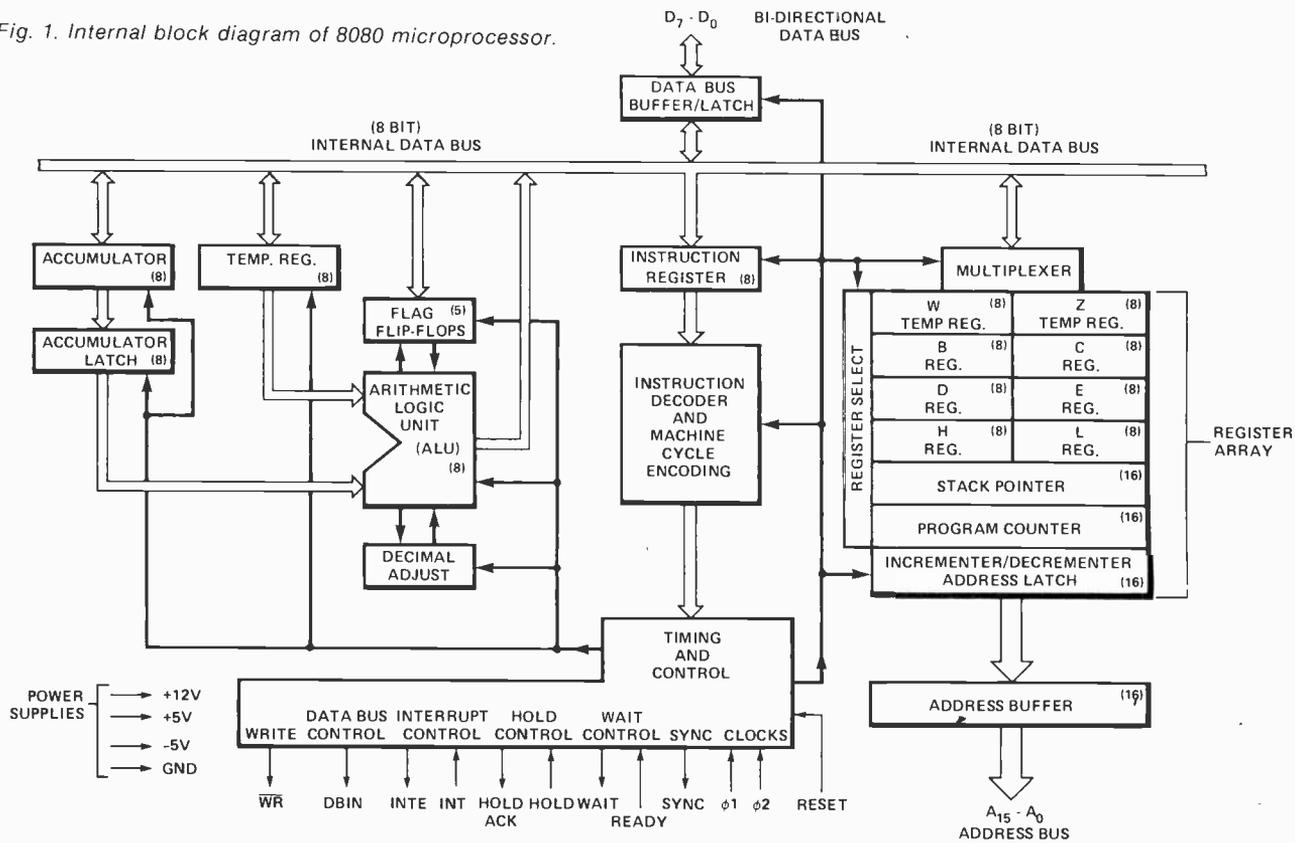
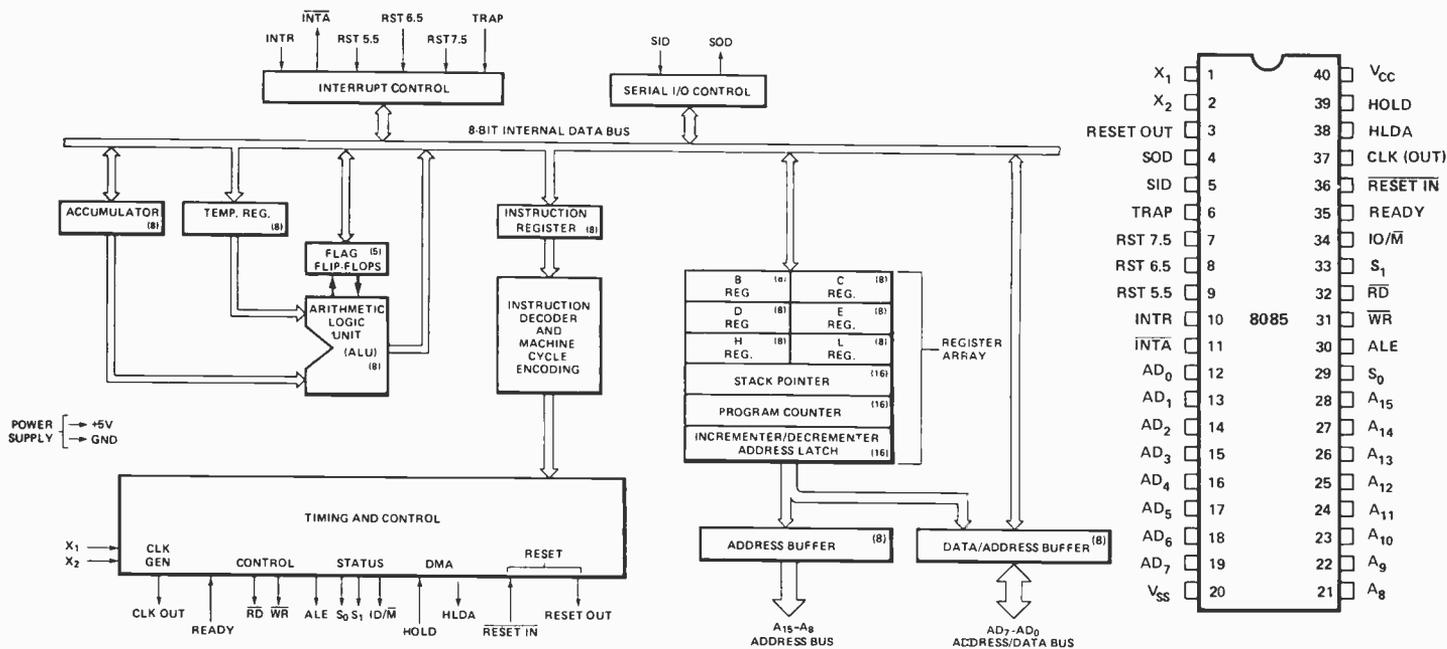
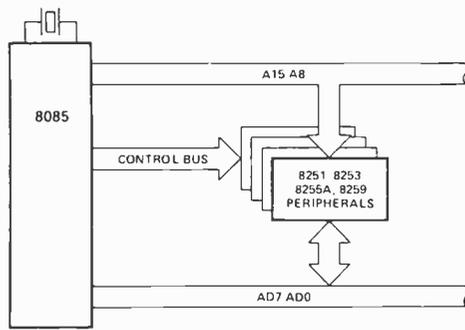
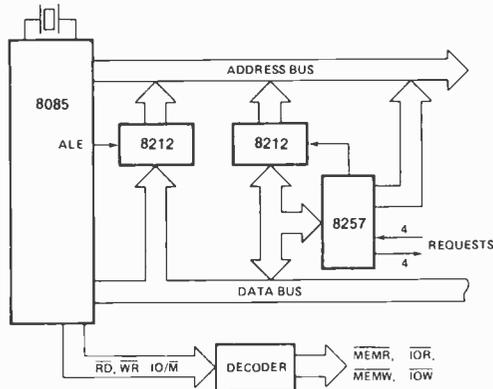


Fig. 2. 8085 internal block diagram and pinout. Note similar register and arithmetic structures, but different chip I/O.



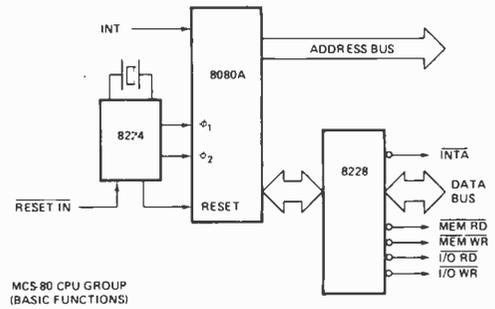


MCS-85 components.

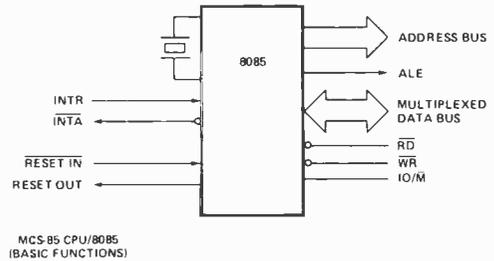


8085 adapted for standard components.

Fig. 3. Typical 8085 system configurations.



MCS 80 CPU GROUP (BASIC FUNCTIONS)



MCS 85 CPU/8085 (BASIC FUNCTIONS)

Fig. 4. Comparison of 8080 and 8085 chip set functions. MCS-85 system looks simpler, but requires system chips with built-in address latches.



The jump from 8080 to Z80 is of almost as great importance as that from 8008 to 8080. In fact, to many people it may appear more so. This is because these people have learned about mpus through familiarization with the 8080, and tend to regard the 8080 as a prehistoric curiosity, an awkward relic from times gone by when nobody **really** knew what to do with an mpu. Then having become used to the features of the 8080 as "standard" the increased speed, power and refinements of the Z80 come as a pleasant surprise.

### Z80 HARDWARE

The Z80 is shown in block diagram form in figure 5. This diagram is in somewhat more philosophical form, but the main features are evident; straight forward, unmultiplexed address data and control buses, and a much larger array of registers. We will see that the arithmetic logic unit (ALU) is more

powerful, and that this in combination with the additional registers make for an instruction set which is more versatile, and which can often execute a task more compactly.

As far as the basic hardware characteristics are concerned, all inputs and outputs are TTL compatible, including the single phase clock input. (A simple 3-TTL-gate — plus — crystal oscillator will do). The fastest Z80 uses a 250ns cycle time, compared to 320ns for the 8080A-1. All Z80 series chips require only a single 5V supply.

The control bus holds no real surprises, **except** for the "RFSH" line. The Z80 will automatically refresh dynamic memory!

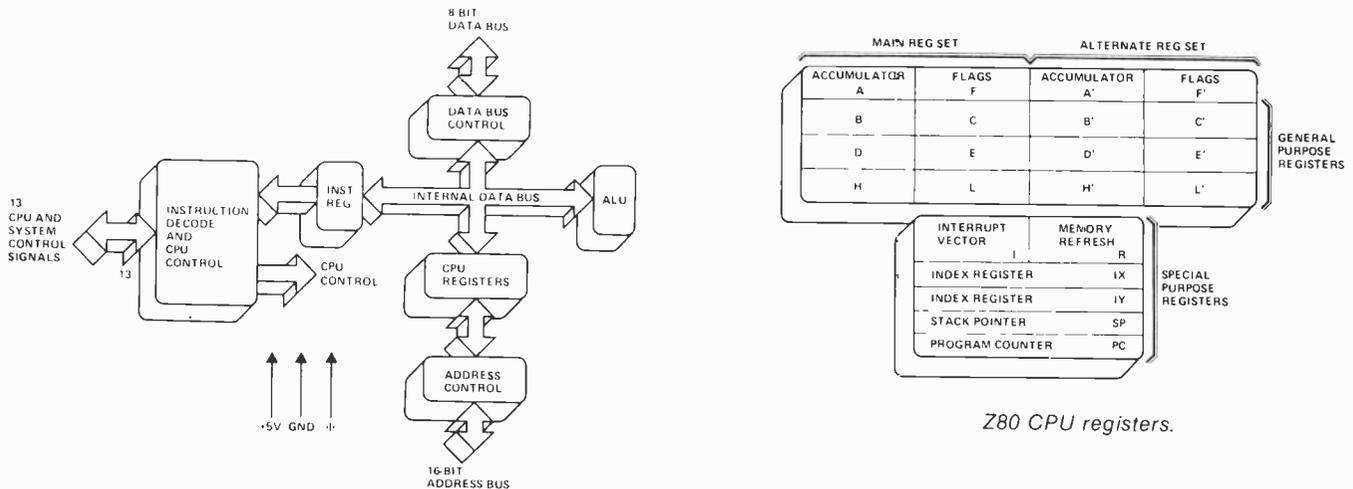
The "refreshment" of dynamic memory is in general performed by

"accessing" each bit in the memory about once every 2 ms. The memories are organized so that if part of the address is provided, a whole row or column of bits may be refreshed at once. For instance in the 2116, 16K x 1 dynamic RAM, 128 bits may be refreshed at once by a certain sequence of signals, and only requiring 7 bits of address to specify the appropriate column.

In the Z80 there is an 8 bit "Refresh Address" register to keep track of, and increment that address. The refresh itself is accomplished in parts of the cycle when the bus is not being used. At these times the refresh address is fed onto the bus and the RFSH line initiates the refreshing. In this way, one refresh is accomplished per instruction. The whole process is

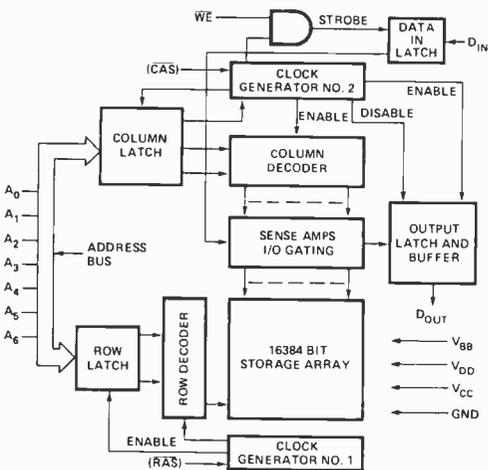


# microbiology



Z80 CPU registers.

Fig. 5. Block diagram of Z80 works.



Internal view of 2116 16K x 1 dynamic RAM. Note that the 14 bit address is latched in 7 bits at a time. Only 7 bits are needed for refresh.

essentially transparent to the programmer.

## Z80 SOFTWARE

Here is where we see the Z80 really excelling over the 8080. To summarize, the improvements are: increased number and alternate sets of registers, expanded addressing capability and addressing modes, handling of single, 4, 8 or 16 bit data units, three hardware

interrupt modes, block moves and searches. All the 8080 instructions are embodied in the Z80 instruction set, with the same op-codes, although Zilog, and second source Mostek, have called them different names, so the mnemonics are not the same.

## REGISTERS

The increased number of registers has the usual advantages of more internal storage, but in addition the data registers are arranged in two identical sets, and the capability to switch between the two is provided by a single instruction. This means that if a subroutine call or interrupt occurs, one can simply use the other register set, and not have to either lose the original contents, or spend time saving them on the stack. Needless to say, this makes for very efficient and fast interrupt and subroutine handling.

Instructions are included to allow versatile transfer of data, and along with the two full fledged accumulators, the increment/decrement, shift and rotate instructions apply to all general purpose registers and register pairs. In addition, 16 bit arithmetic instructions allow addition/subtraction of various register pairs with the accumulator not involved.

## ADDRESSING MODES

As with the 8080, instructions are one, two or three bytes long. The first byte is always the op code, telling the mpu what operation to perform, and how

many additional bytes to fetch (zero one or two) for addressing information. In some cases the operation is to be done on one operand, in some cases, on two. However, in most cases, one or both operands, or their locations, are specified in the op code itself.

**Register:** specified register containing operand.

**Immediate and Immediate Extended:** One or two bytes of data "immediately" follow the op code byte.

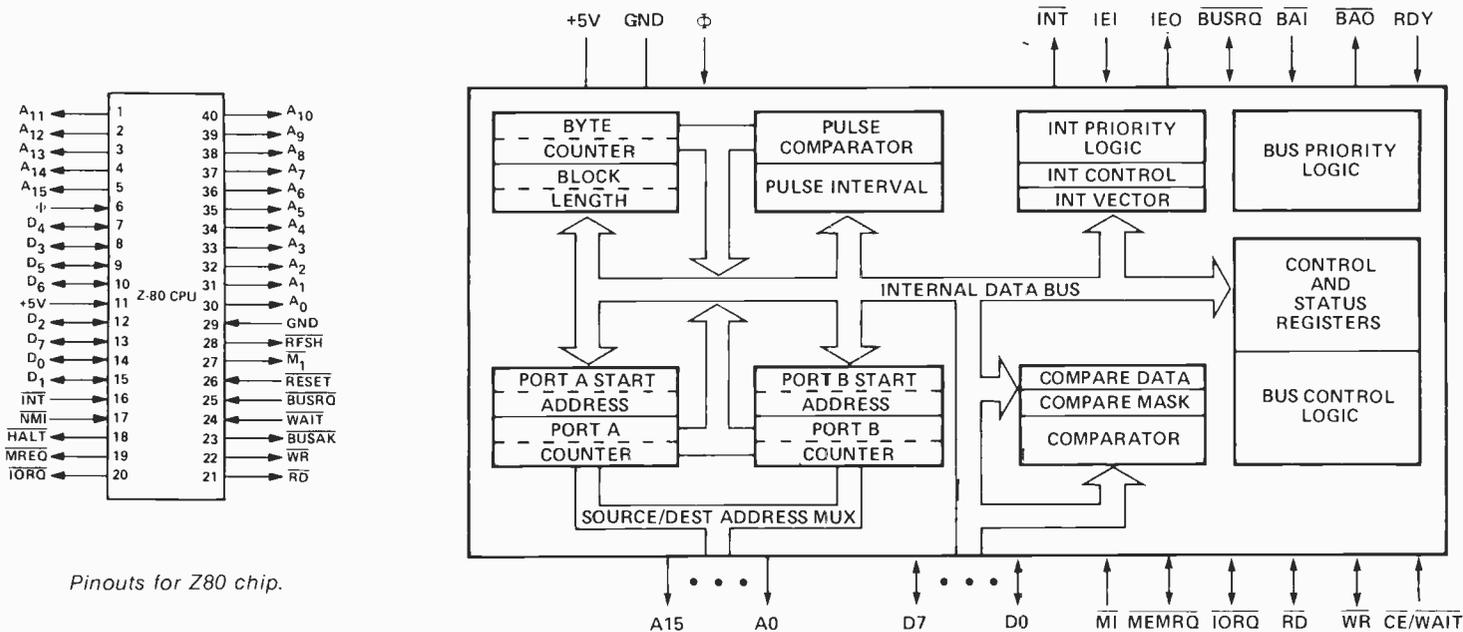
**Extended:** The two bytes following the op code give the address of the operand.

**Relative:** Used for jumps: the byte after the op code tells how far forward or backward to jump from the present location. This mode is not available in 8080 jumps. The ability to write relative jumps means that the program or segment can be relocated elsewhere in memory without having to change all the jump addresses.

**Modified page zero:** This is the name given to special subroutine calls made to eight specific locations in the lowest order page of memory. Sounds like RST 0-7 doesn't it? It is.

**Register Indirect:** The byte following the op code contains a signed 2's complement value which is added to one of the index registers. The result gives the address of the operand. This may seem complicated but it is very useful for accessing tables and the like.

**Bit:** Nope, nothing to do with dogs



Pinouts for Z80 chip.

Direct memory access chip for Z80 systems.

and mail men, in this mode a register, or memory location is selected, and a specific bit therein may be set, reset or tested.

#### INSTRUCTION NOTES

Apart from the 16 bit instructions already described, there are numerous exciting instructions added to the 8080 set to make the Z80.

**Memory Block Moves:** Two register pairs are used to hold the source and destination addresses of bytes of data to be transferred, and are incremented or decremented for each byte. A third register keeps track of the number of bytes transferred. After setting up these three register pairs, the entire transfer operation is initiated with just one instruction. This of course makes transfer of large blocks very much quicker than if a "loop" was performed to accomplish the task.

**Block Searches:** Another job that would previously have required a loop to perform, is that of searching through memory for occurrences of a particular byte. The Z80 accomplishes this in very similar fashion to the block transfer, except that instead of repeated move operations, comparison is made with the byte held by the accumulator.

**Rotates and Shifts:** The original four rotate instructions have been complemented with three shift and two "nybble" rotate instructions. (A "nybble" is a half byte).

**Input and Output:** In a similar manner to the block moves, block input or output may be performed, which is second only in speed to direct memory access, at about 8 micro-seconds per byte.

#### Z80 INTERRUPTS

Three interrupt modes are available in the Z80, selectable by software. The first is like the 8080, the second is like the 8085 (but only one interrupt input, so "polling" most likely used) and the third is a special indirect call. In this mode, one of the eight bit registers supplies the high order byte, while the interrupting device supplies the low order byte, of the address at which to make the call. The first and third modes are forms of "vectored" interrupt.

#### Z80 SUPPORT CHIPS

**Parallel I/O Controller:** A two port I/O device, each 8 bit port may be input or output, tristate, or each bit can be individually programmed as in or out. Two "handshaking" lines are also provided for each port. The device also functions as an interrupt controller, able to supply the vector onto the data bus.

**Counter Timer Circuit:** Four counter channels are provided, and each channel may be programmed for a variety of functions. These include simple counting, timing with interrupt option at time out, various clock and trigger choices and prescaler possibilities. The device also includes interrupt functions.

**Direct Memory Access:** This is a single channel (8 bit) device that contains all the logic, counters, registers and buffers to implement direct memory access. It can perform DMA in four modes: "byte at a time" - one byte per request; "burst" - continuous as long as external equipment is ready; "continuous" - shuts up mpu during DMA; "transparent" - operates in the "refresh"

cycles thus no disruption of mpu operation.

Not only this, but the DMA chip will also perform searches by itself, with or without simultaneous transfer! (Any 8080 owners interested?) Interrupt capability included. The search and transfer maximum rates are 1.25 megabytes per second!

**Serial Input/Output:** A serial I/O controller will be available, with two separate channels, full duplex, serial asynchronous 5, 6, 7, 8 bit word, bisynch, SDLC, and floppy disk formats and options.

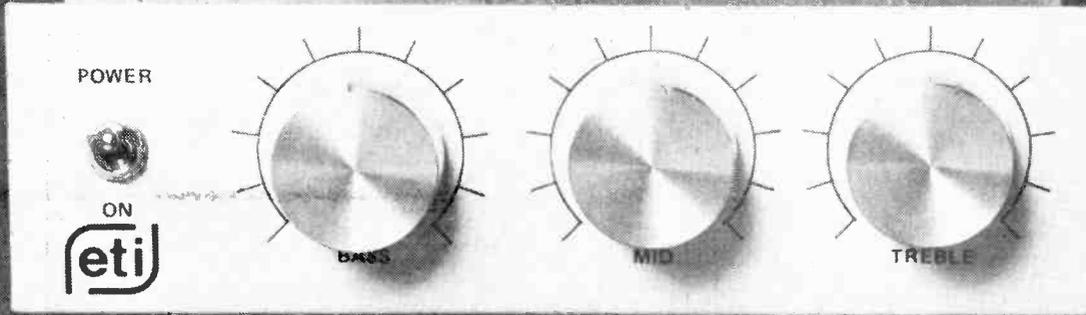
The 8085 is available from Intel distributors. Information available from Intel Corp., 70 Chamberlain Ave., OTTAWA, Ontario K1S 1V9. Advanced Micro Devices Inc., already an 8080 second source, will manufacture the 8085, along with alternate suppliers Siemens and Nippon Electric.

The Z80 is manufactured by Zilog (an Exxon company) and Mostek. Zilog representatives in Canada: Munro Electronic Components Inc., 7171 Torbram Rd., Unit C9 MISSISSAUGA, Ontario L4T 3W9. Mostek representatives: Weber Electronics Inc., 1111 Finch Ave., W. Suite 154 DOWNSVIEW, Ontario M3J 2E5.

We wish to thank Mr. Wilson of Munro, and Mr. Schwarz of Weber for their assistance in preparing this article.

**Next month:** Microbiology looks at 6800 and 6500 families.

# 3 CHANNEL TONE CONTROL



WHEN LISTENING to your favourite L.P., if your hi-fi system were perfect, if your listening room did not colour the speaker's output and if your idea of balance coincided with that of the recording engineers — there would be no need for a tone control.

The perfect world alluded to in our first paragraph does not, unfortunately, exist as anyone over 21 (inches or months) will readily testify to. This

## HOW IT WORKS

The input signal is fed via SK1 to the first active stage built around IC1. This is configured as a non-inverting amplifier whose gain is set by the ratio of R3 and R1. In this case the gain is set at unity. This initial stage is required to isolate the following stage from any loading effects.

The O/P from IC1 is fed via three frequency shaping networks to IC2. The three networks built around RV1, RV2, RV3 are also included in the feedback path of IC2, another inverting op-amp stage.

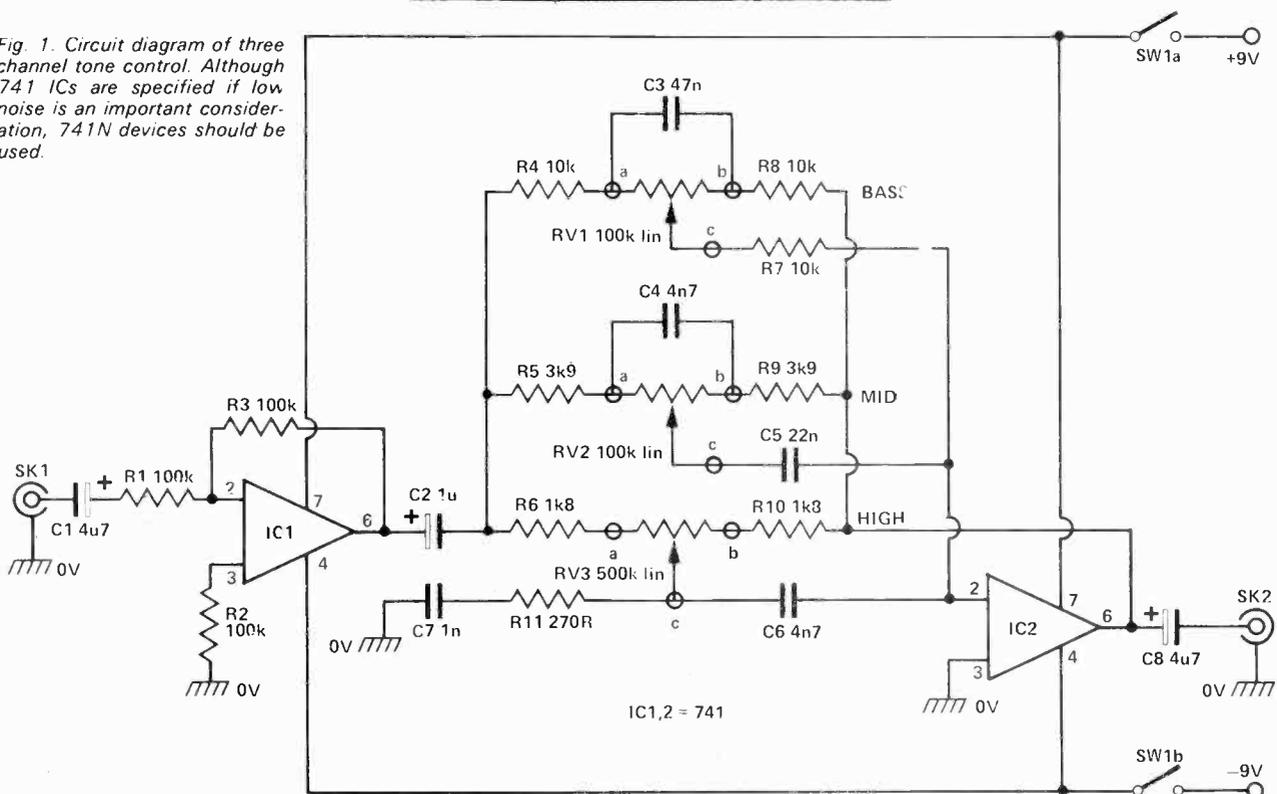
The components associated with the three variable resistors are chosen to give the required frequency control.

means that in most cases some form of tone control is a desirable, if not essential, item in any amplifier.

## Tone of Voice

A tone control will alter the relative levels of the different frequencies present in any signal passed through it. In most designs the audio spectrum of frequencies falls into two bands, bass and treble, and will either boost

Fig. 1. Circuit diagram of three channel tone control. Although 741 ICs are specified if low noise is an important consideration, 741N devices should be used.



or cut these with respect to the mid-frequencies. A graphic equaliser, which is after all just a tone control with lots of channels, splits the audio frequencies into ten or more bands and allows each of these to be boosted or cut.

These two examples represent the extremes of tone control designs, the two channel unit not providing enough control while the equaliser represents expensive overkill in a lot of cases.

### Voice of Tone

Between these two extremes comes our three channel control. Bass and treble functions are as most tone controls while the mid, or presence, control provides a means of controlling the mid-frequencies.

These frequencies, which are not affected by the controls of two channel units, have a large effect on the 'colour' of the sound. This is because the fundamental frequencies of many instruments, and indeed the human voice, lie in the range of frequencies covered by this mid control.

### Assembly Point

Mount the components on the PCB

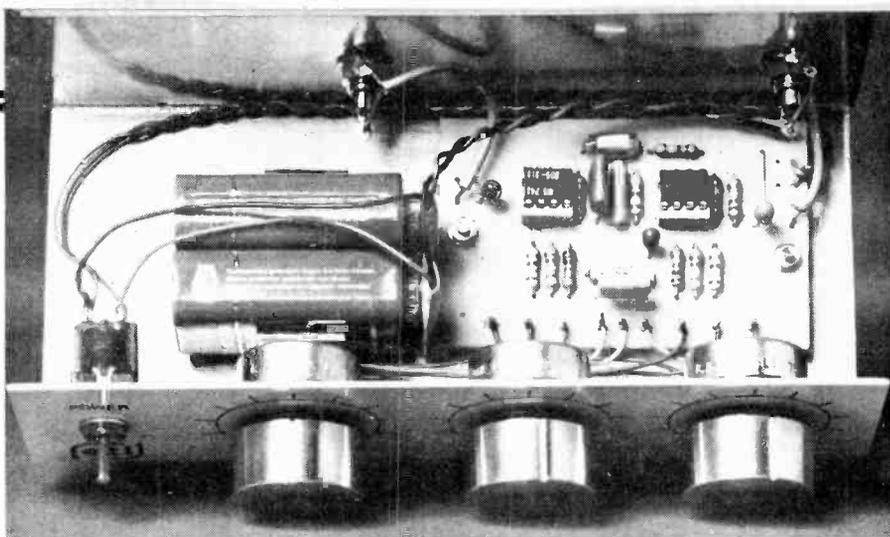


Fig. 2. The prototype was built as a mono version and mounted on an aluminium chassis. If built as part of an amplifier the battery power supply could be replaced with a well smoothed 9-0-9 line PS.

as per the overlay diagram, paying particular attention of the ICs and electrolytic capacitors which must be correctly orientated.

Mounting of the PCB is largely a matter of personal taste. Our prototype was mounted on a chassis but it may easily be incorporated in an existing piece of equipment.

The power supply in the prototype was provided by two 9V batteries but any well smoothed 9-0-9V supply could be used.

We built our unit as a mono control

and if stereo operation is required two boards will have to be used with either separate, or perhaps, ganged pots.

### Toning Up

If the unit is built as our prototype, and not incorporated in an amplifier, it should be connected between the existing preamplifier and the power amplifier.

After that it's a question of switching on and twiddling the knobs until the 'sounds' suit your particular tastes.

### BUY LINES

The components used in this project should be available from most component shops and are certainly available from any of the large mail order suppliers.

The integrated circuits specified are standard 741 types. However, should a lower noise version be required 741N types could be used.

#### RESISTORS all ¼ 5%

R1,2,3	100k
R4,8	10k
R5,9	3k9
R6,10	1k8
R11	270R

#### CAPACITORS

C1,8	4u7 25V electrolytic
C2	1u 16V electrolytic
C3	47n polyester
C4,6	4n7 polyester
C5	22n polyester
C7	1n ceramic or polystyrene

#### SEMICONDUCTORS

IC1,2	741 or 741N
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#### POTENTIOMETERS

RV1,2	100k lin rotary
RV3	500k lin rotary

#### SWITCH

SW1	DPST miniature toggle
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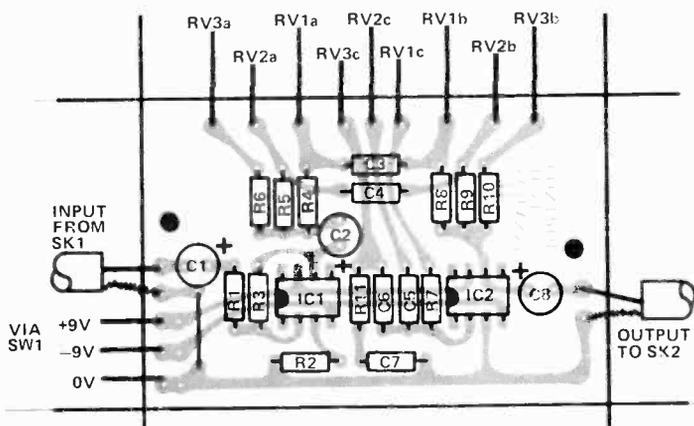
#### SOCKETS

SK1,2	Panel mounting phono sockets or DIN sockets
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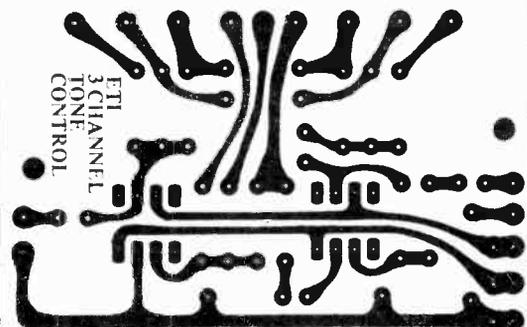
#### MISCELLANEOUS

2 x 9V Batteries, clips, knobs, PCB as pattern, nuts bolts etc., screened wire, connecting wire, chassis to suit application.

### PARTS LIST



Component overlay for the three-channel tone control unit. Note if stereo version is required the boards may readily be mounted vertically above one another.



PCB foil pattern is shown full size (73mm x 48mm).

# LASER LIGHTSHOWS

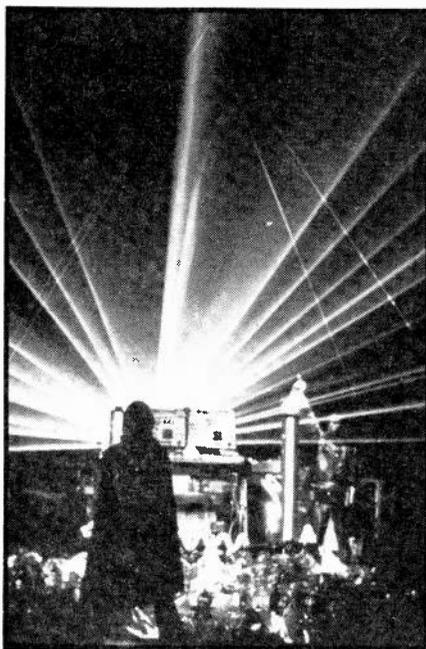
## Lasers for entertainment looked at by starry-eyed Jim Perry

"AND ON THE FIRST DAY there was light, but it was incoherent . . . it was a long time before coherent light was produced, July 1960, the birth of the Laser. The first laser was produced by Theodore H. Maiman, while working at the Hughes Aircraft Research Laboratories in Malibu, California. This first laser was a Pulsed Ruby type.

Lasing mediums currently in use include Chromium (Ruby lasers); Neon, Argon, Krypton and CO<sub>2</sub> (gas lasers), organic dyes (liquid lasers), and recently, certain semiconductors. The method of pumping energy into the medium determines whether it will be a pulsed or continuous laser. Optical pumping, focussing a bright light source such as Xenon flashtube on the lasing medium, is used with Ruby and liquid lasers providing a pulsed laser output. Continuous lasing is possible with gas lasers, where electron collision pumping, sending an electrical discharge through the gas filled tube, is used.

### Early Experiments

Even though lasers have now been around for 17 years, very few people have actually seen one! Apart from the scientific and industrial uses, lasers also are amazing just to look at (not directly into the beam though!). This was realised as early as 1967, when people started artistic experimentation with lasers, projecting the beam through various transparent materials (such as crystal cut glass) to produce abstract patterns, and moving effects.



Laser light is an impressive sight, because of the dynamic-almost tactile-purity of it. The air in fact can appear to be solid, if dust is present in the path of the beam. The early experimental laser lightshows used this property, in conjunction with smoke machines, to produce numerous shafts of red 'solid air' moving over peoples heads.

It was soon realised that vibrating mirrors could be used for more complex images. One of the earliest uses was at the 1970 World Exhibition in Osaka. Pepsi-Cola commissioned Lavell Cross, Carson Jeffries and David Tutor (from Mills College, U.S.A.), to build Video/Laser II for use in the Pepsi-Cola Art and Technology Pavilion. This

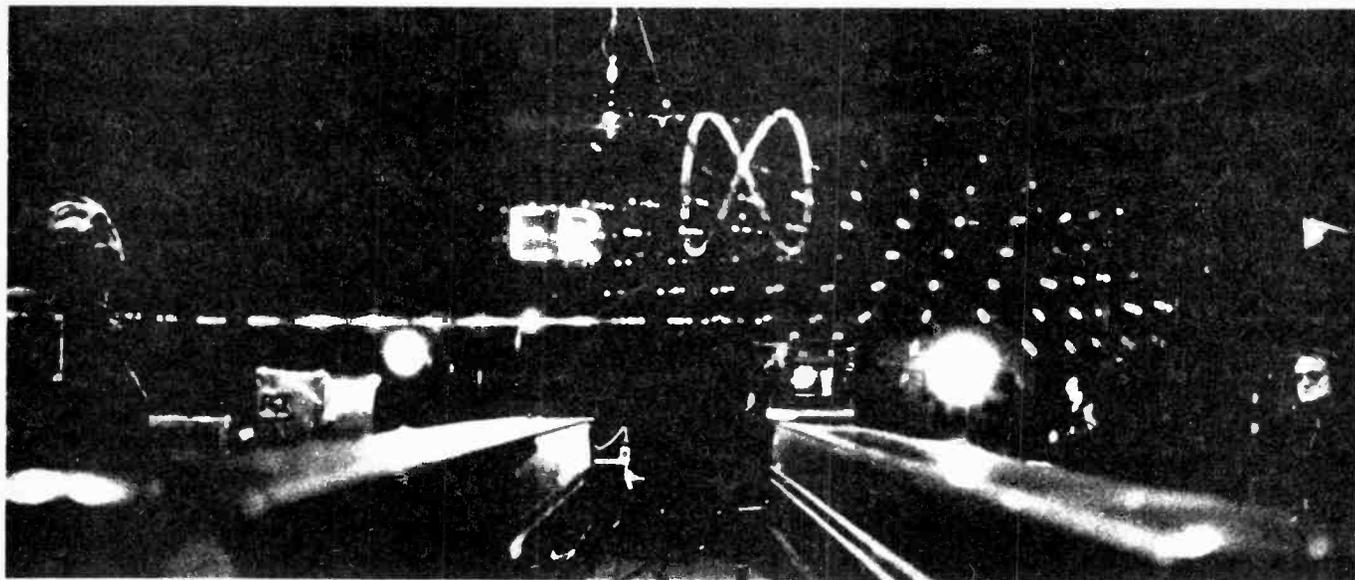
system produced complex Lissajous type patterns within the confines of the Pavilion, and was more sophisticated than the simple "mirrors stuck on a loudspeaker" approach used previously, but still relatively crude.

As well as being simple mechanically, the early laser shows tended to use separate small lasers, as powerful Krypton lasers were prohibitively expensive. So now for details of some modern Laser lightshows and their background.

### Crystal Machine

Tim Blake (synthesiser player extraordinaire) joined the band Gong in 1972, he started using small Helium Neon (red) lasers for special effects during concerts. He teamed up with Patarice Warrener (technical boffin extraordinaire) and they called themselves Crystal Machine. The lasers used were replaced with slightly more powerful ones (2.5mW instead of 1.5mW) of the same type, most of the effects were produced by diffraction gratings, mirrors on loudspeakers and manual manipulation.

Crystal Machine left Gong and moved to Paris, with the loan of 6 new 20mW lasers (from Spectra Physics of California), they started mixing conventional light show techniques with Laser techniques. One memorable event was at a Parish church, with no place to hang a screen they projected an Argon (blue) laser onto the clouds, to the sound of Tim playing his huge synthesiser bank! Crystal Machine also built laser light show equipment for Yes, and still performs as a total



sound light experience — one not to be missed if you get a chance!

### Light Fantastic

Was the name given to a recent exhibition cum laser show at the Royal Academy in London. This was mainly to let the public see the results of recent research in Holography and special laser effects by Nick Phillips, Anton Furst and John Wolff — collectively known as Holoco. The show consisted of dozens of Holograms, of different types, and an automated light show every 15 minutes — over the heads of the public — to the accompaniment of classical music. The main

attraction for passing crowds, was the EIIIR symbols lased into the London sky over the Royal Academy.

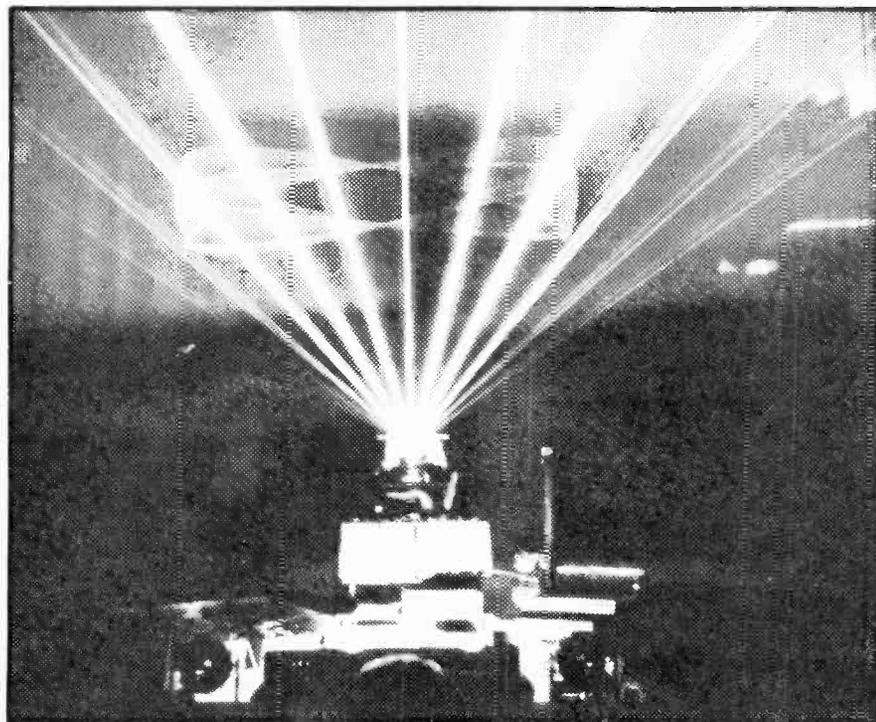
Light Fantastic was a tremendous success with huge queues all the time, in fact it seems to have sparked off the recent upsurge in Lasers as good things to watch! John Wolff is also the technical manager for The Who, and has been using powerful lasers at their concerts for some time. His own show opened in August at the New London Theatre, using 9 lasers each 4W in power. In fact John probably has the biggest collection of lasing power outside of industry, some of his big (one new

one is 60W) lasers vapourised the mirrors used to deflect them!

### General Scanning

In 1975 Jean 'Coco' Montagu of General Scanning Incorporated, Massachusetts, became the first man to develop a Laser Projector capable of reproducing graphically alpha-numeric symbols as well as the more familiar and simplistic abstract patterns. He demonstrated this development in a dramatic way. Using his Laser Skywriter PCX101 the logo of the magazine Industrial Research was "written" on the clouds over Cambridge, Massachusetts, as were other graphics, including a 'flying-saucer'.

Since then General Scanning Inc. (who happen to be the main manufacturers of scanners in the world), have developed a unique type of laser projector. What makes this type of Laser Projector different and far in advance of other such Laser Projectors used in the field of Entertainment is that in addition to being able to describe abstract patterns and shapes it has the capability not only of creating alpha-numeric images but also moving line drawings of amazing diversity. At the time of writing no other Laser Image-Making Machine has quite the same advanced capabilities.



*Top photograph was taken in Holoco studios, when they were preparing for the Royal Academy show "Light Fantastic". The EIIIR symbol was projected above the Royal Academy during the show. (Photo: Theo Bergström.)*

*On the left is a view of Crystal Machine in full flight.*

# LASER LIGHTSHOWS

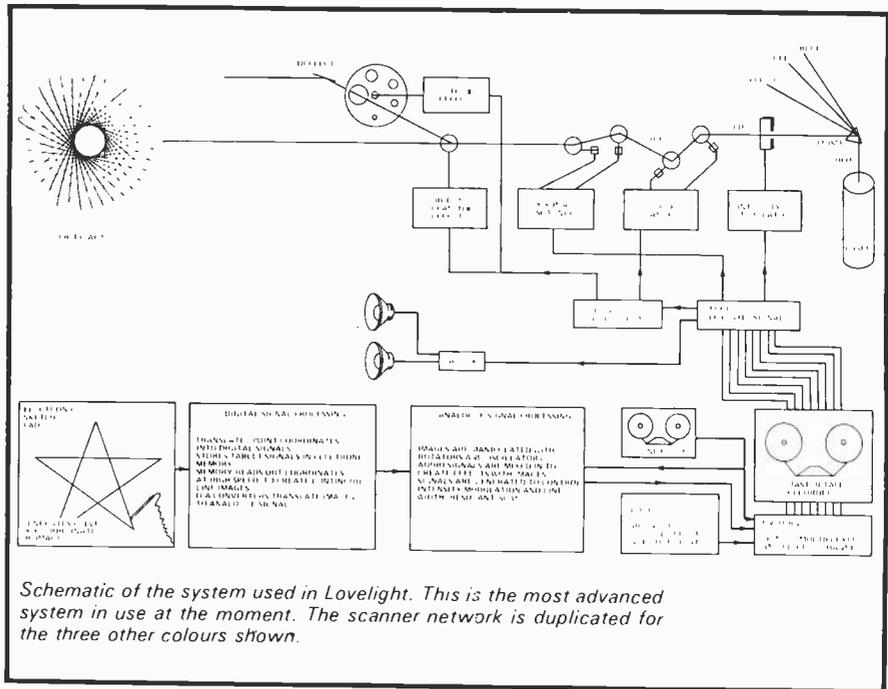
## Lovelight

Realising the possibilities of the General Scanning machine, Gerd Stern — of Intermedia Systems — devised and produced Lovelight. With a team of over 50 people (technicians, artists and musicians) the master tape took about 9 months to produce. They literally had to start at the drawing board. The drawings were then processed via an X-Y pad into digital form, the basic system can be seen in the drawing on the right.

The original idea was to produce a laser musical, in fact they ended up with a tape and a machine — instead of a live production. The world premiere of Lovelight was on February 2nd 1977, at the Charles Hayden Planetarium in Boston, U.S.A.

The difference between Lovelight and all other laser shows is that graphics are projected as well as the spectacular effects produced by other systems. One such mixture is a spider climbing a laser web! A second machine was built and is being used in England, producing an identical show to its Boston twin. The English Lovelight is being staged at the Metropole Laser Theatre (formerly a cinema) in Victoria, London. This show is being put on by Laser Visuals Ltd in association with Rank Leisure Services Ltd and the American producers.

The Hewlett Packard instrumentation recorder has its 8 tracks multiplexed, to give an effective capacity of 32 information channels. The stereo sound track is recorded separately on a Teac 3340, with a third track providing sync pulses to keep everything together. The response of the resonant scanners (which provide control beam width and intensity) is up to a phenomenal 8kHz, the X-Y scanners have a more normal 2kHz



response. This may not seem very impressive, but up until fairly recently controlled response up to 1kHz was difficult to obtain.

The laser used is made by Control Laser of Florida, and is a 1.2W Krypton/Argon type. A 42 foot diameter, parabolic aluminium screen is used as the projection surface (the largest ever built in England). Watching the show one has the same feeling that was probably felt by early cinema audiences. The overall effect is that of watching a computer generated animation film, but the figures are simple — even childish — in comparison to genuine computer animations. Nevertheless, it is an interesting experience, to be seen if you get a chance.

## Laserium

Laserium was created in America by Ivan Dyer, a Californian film-maker and photographer, who

developed the idea after seeing a laser projection technique demonstrated at the California Institute of Technology in 1970. He made a film of it (Laserimage) but recognised that film could not adequately capture the vivid effect of live laser beams. His years as a guide at the Griffith Observatory, Los Angeles, prompted him to choose a planetarium as the ideal environment and in 1971 he formed Laser Images Inc to explore the applications of lasers in entertainment.

Laserium was first presented at the Griffith Observatory in late 1973, since then it has been playing in 14 other centres, including Kyoto, Japan, where a specially constructed Laserium dome was opened in March 1976. Laserium opened at the McLaughlin Planetarium in Toronto during June 1975.

The system used by Laserium is based around a 1W Spectra Physics Krypton laser.

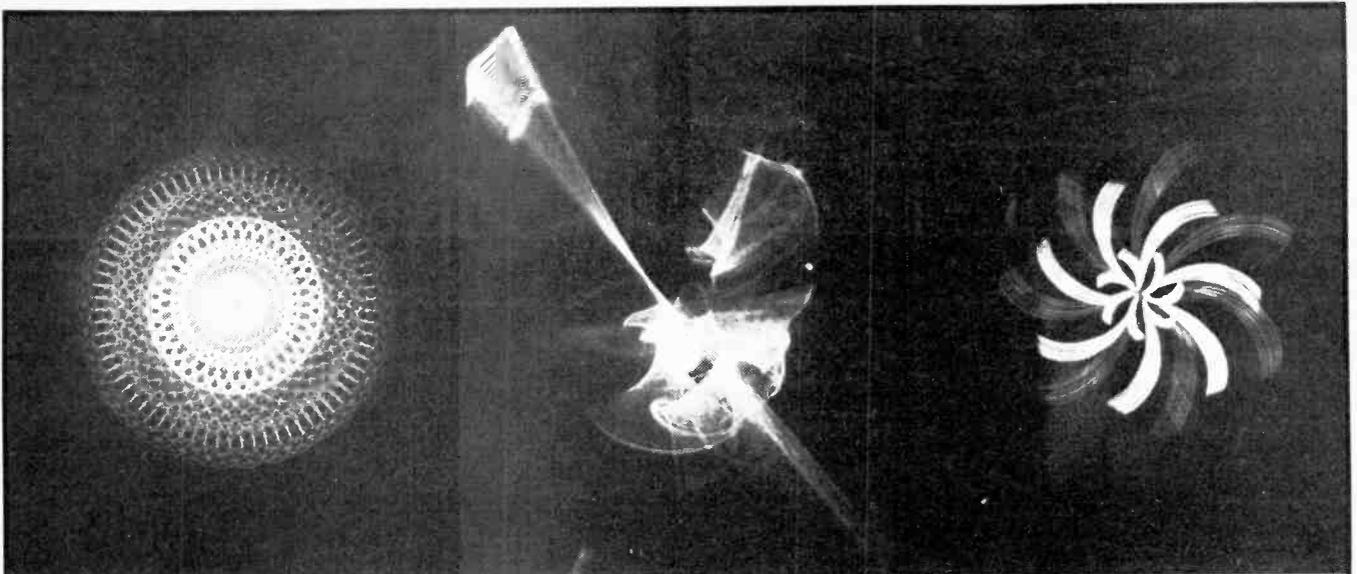
The greenish white beam is



A General Scanning G-100PD scanner as used by most of the systems described in the text, cost is about \$800 for the standard model.

Scanners are mirrors mounted on galvanometers which describe a special and particular arc of rotation. The laser beam is guided into the mirror and thus reflected onto the projection surface. When the mirror moves, the laser beam is seen to move. The mirror movement is very rapid and the beam when deflected at anything over 20 times a second will appear to the viewer as a persistent and unbroken line, the path of the laser beam. At that speed of deflection our eyes can no longer perceive a single point of light.

With two mirrors mounted at right-angles to each other with perpendicular rotational axis, it becomes possible to guide the laser beams to any point in a two-dimensional field. This technique is known as X-Y scanning.



Three effects produced by the Laserium system. On the left is the basic type of geometric pattern produced by simple (but sophisticated!) X-Y scanning. Centre is the strange sort of effect produced when passed through a sheet of clouded glass, with deformation of the geometric pattern. Right is a "chopped" pattern, all of these patterns are continually changing.

passed through a prism, which splits the beam into red, yellow, green and blue beams. Each of these beams is processed via modulators, scanning mirrors etc. to produce multicoloured images on the Planetarium dome. Sound tracks and basic control signals are provided from a pre-recorded tape (played on a Teac 3340 four channel machine), but the main modulation signals are mixed and blended live, by an operator called a Laserist. Even though far less sophisticated than Lovelight's system, the effect is far more vivid, and no two performances are ever the same.

### Other developments

So with all the laser shows at present, London seems to be the laser capital of the world. The only drawback to more people experi-

menting with similar systems is cost, most of the systems described have cost at least \$200,000 and the laser itself is about \$8,000.

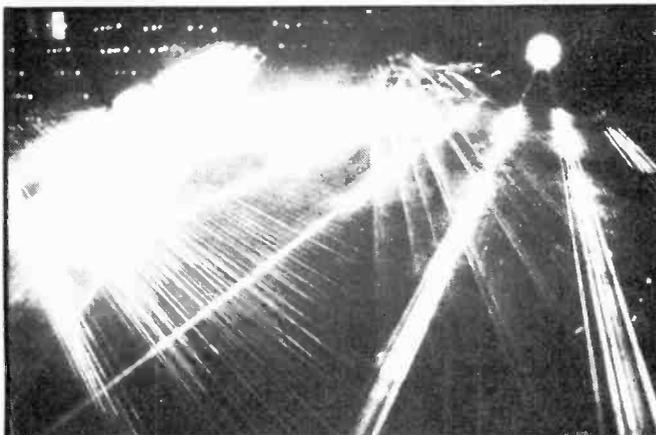
However, if you fancy playing with lasers Holographic Developments Ltd may have the answer. They are developing a small 1/2 mW laser for home use, which is expected to cost less than \$400, also they are working on cheap scanning and effect attachments to stick on the end — the home laser light show may be just around the corner.

So lasers have become not only a tool for measuring, cutting, welding, and burning, but also an imaging device. As a contribution to visual displays and media, scanning projection is very appealing. These projections are not confined to a frame, as are film and television, nor

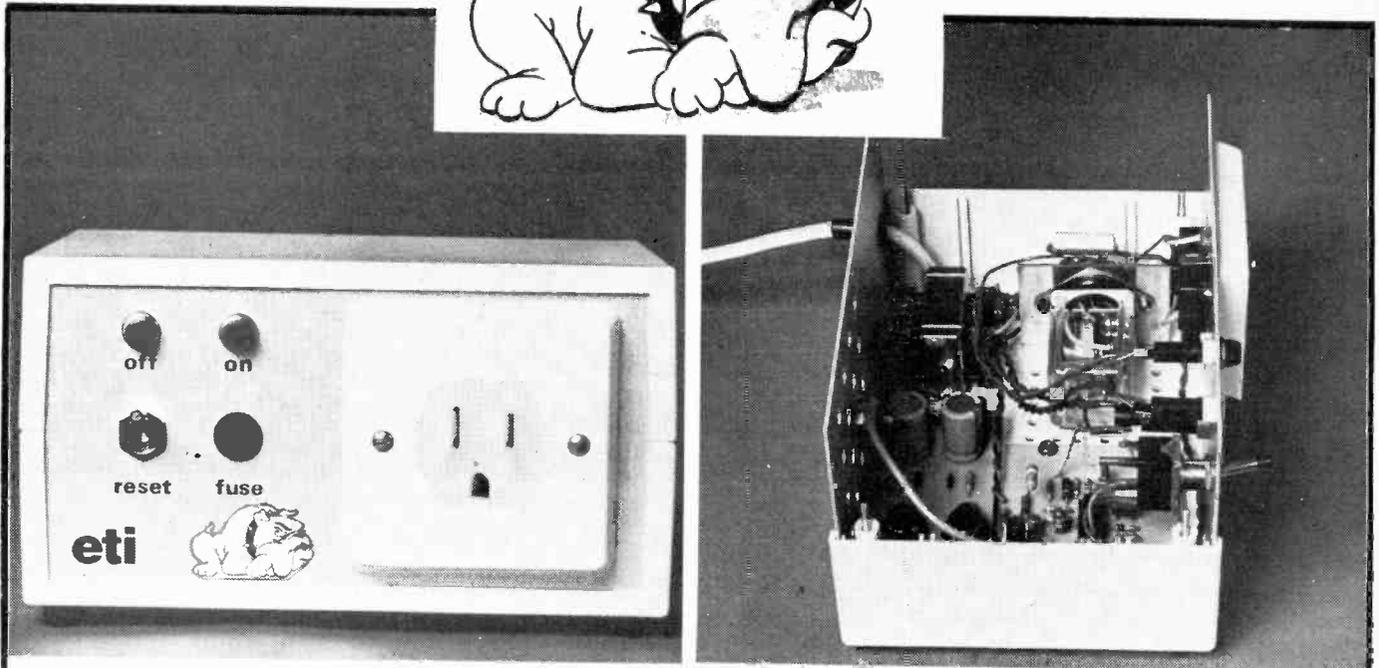
to a particular projection surface. Lasers can be aimed at walls, clouds, balloons, or mountains, and can be safely used in indoor environments when not aimed directly at the audience, but reflected from a surface such as a planetarium dome.

**Our front cover photograph was kindly provided by Laser Images Inc. the producers of Laserium.**

Special thanks for help in research on this article to: Tim Blake (Crystal Machine), Wilf Eggers (General Scanning Inc.), Carolyn Fairley and Brian Scott (Laser Visuals Ltd — Lovelight), Ivan Dryer and Roger Helm (Laser Images Ltd — Laserium), Theo Bergström, Holoco and Andy Harris (Holographic Developments Ltd.).



Left, part of a John Wolff show, of the type used in Who concerts. Right is a hologram shown at the Light Fantastic exhibition — the phone looked so real that some people tried to use it! (Both photos by Theo Bergström.)



Keep an eye on what's left on, with our project team's . . .

# ETI WATCHDOG

IN THESE DAYS of advancing (and shrinking) technology, it can't be long before we have a hi-fi system offered for sale which does everything automatically — even choose the material and listen to it for you. Naturally such a machine would turn itself off once it had finished the session.

Unfortunately the poor old relics we are forced to listen to music on nowadays do not possess this divine power of self termination and more watts are probably wasted keeping the power lights glowing through the night than actually thrilling the neighbours to Status Quo at five past midnight.

Most, if not all, of us here are guilty of this transgression ourselves, and after many months of *vowing* to do something about — we have. And so we present the Watchdog. It's sole

purpose in existing at all is to make sure you CANNOT leave the hi-fi or television running away with the power while you're not using it.

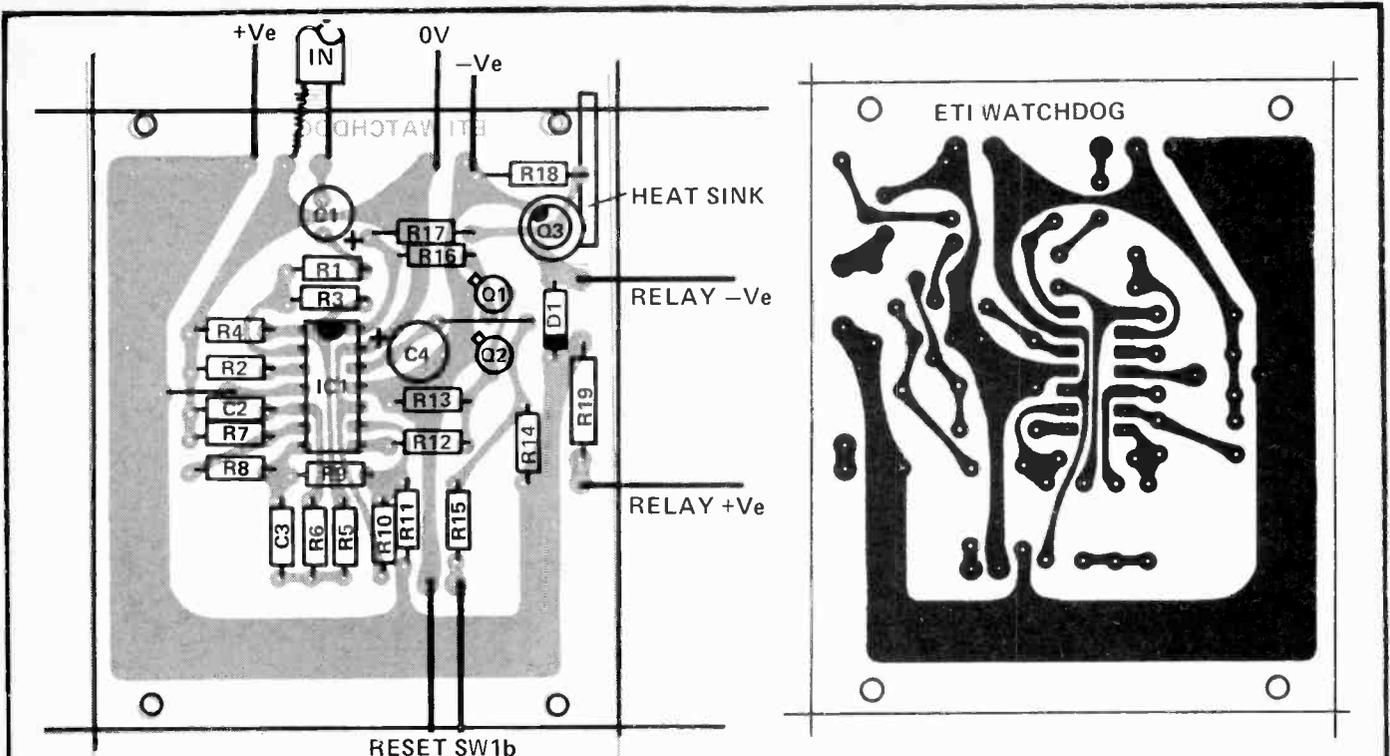
The Watchdog sits in between the line supply and the equipment, and keeps a monitoring paw on the audio output of whatever is drawing line supply from it. Once the audio signal has ceased, a (pre-set) time period is allowed to elapse, and then your hi-fi is closed down for you. A filter is included in the circuit such that 'Rover' will ignore white noise such as is generated by a closed-down television or FM station.

## Canine Construction

The circuit consists physically of two boards, a relay, transformer and box with front panel components. Assembly of the boards should pose

no problems and the layout of the bits within the box is not critical. There will be 110V present at many points inside, so please be careful — we don't wish to lose our readers as easily as that. The relay does not have to be bracket mounted, once you're sure the circuit works you could glue the body to the box — but heaven help you in future if it should fail!

The red neon to inform you of the fact that the Watchdog has operated, and is starving the inert system of current, is optional. If omitted it means that the system is entirely 'fail-safe' and once tripped draws no line current at all. Somehow though the vision of a harassed enthusiast frantically tugging and probing at a piece of persistently dead hi-fi, whilst the Watchdog lurks forgotten and guilty to one side,



Above: component overlay for the watchdog circuitry. Relay and switches are all mounted off-board within the box. Foil pattern is shown full size at 83 x 70mm.

## PARTS LIST

### RESISTORS

(All 1/4 W 5% except where stated)

R1	220k (see text)
R2	100k
R3	1M
R4,8,10	10k
R5,6,	8k2
R7,9	39k
R11	4M7
R12	2k7
R13	470R
R14	see text
R15,17	100R
R18	27k
R19	47R 1/2 W 5%
R20,21	1k 1/2 W 5%

### CAPACITORS

C1,7,8	10u 16V electrolytic
C2	10n polyester
C3	22n polyester
C4	100u 16V tantalum
C5,6	1000u 20V electrolytic
C9,10	10n 600V polyester

### SEMICONDUCTORS

Q1,2	2N3904
Q3	2N2904
Q4	2N3767
Q5	2N3741
D1	1N4148
BR1	100V 1A Bridge Rectifiers
ZD1.2	10V 400mW zener diodes

### RELAY

RLA	12V 100R (approx) type with octal base
-----	--

### TRANSFORMER

T1	120V pri / 24V ct. 1/2A
----	-------------------------

### FUSE

F1	Panel fuse holder and 500mA fuse to suit.
----	---

### NEONS

N1,2	120V type one red (off) one green (on)
------	--

### SWITCH

SW1 a,b,	Double pole on-off (biased off) R.S.: 316-614
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### SOCKET

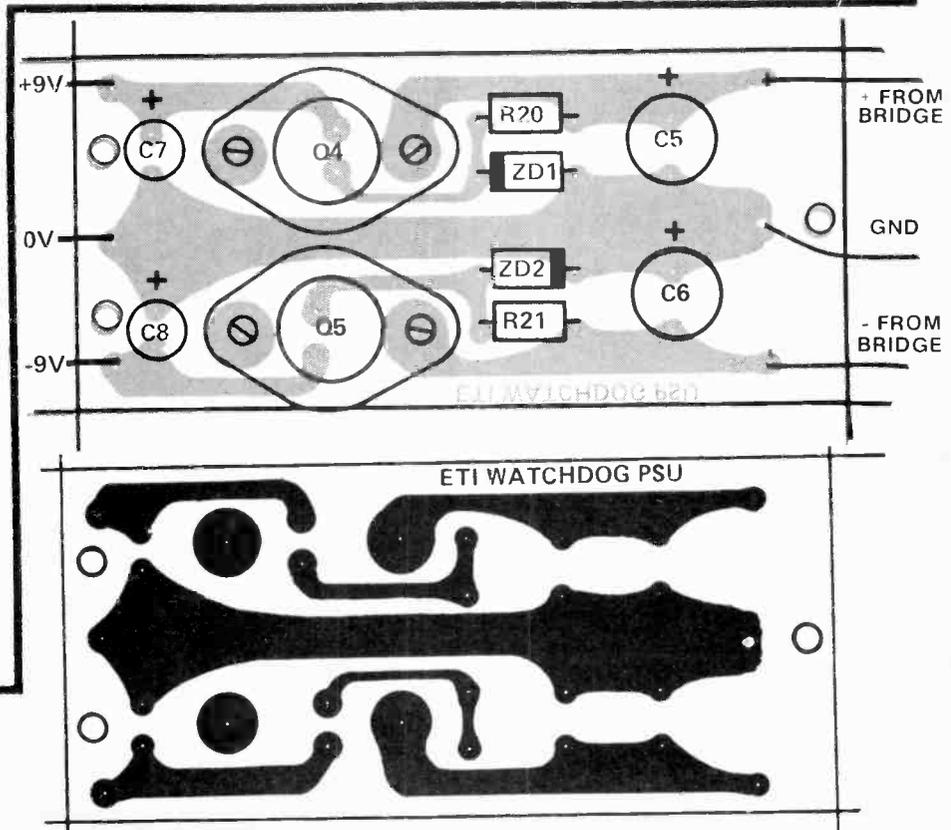
SK1	Panel mounting phono or din socket.
-----	-------------------------------------

### CASE

Verocase	75-1412k
----------	----------

### MISCELLANEOUS

Socket to suit, case-line cord, heat sink, bracket, PC board as pattern, grommet, cable grip, nuts, bolts, etc. shielded wire, connecting wire, etc.



On the right are the power supply overlay and (full size 103 x 46mm) foil pattern for the watchdog device. Q4 and Q5 are smaller than the usual power type, so even though it looks a bit odd — it isn't!

Another internal view of the unit, which shows clearly how to mount all the components into the box. This Verobox we employed is now almost certainly only available in two-tone plastic, with the bottom bit grey. Some shops may have stocks of the albino lurking about somewhere, but it could be an exception.

Note that on the PCB in the photo you can see where we paralleled another resistor across R14 to change the timing. This was to adjust the value to exactly what we wanted.

keeps haunting the editorial mind.

Since the relay is normally operational, current drawn is normally quite high, and so Q3 which drives RLA1 *must* be heatsinked. No options offered. Some ventilation in the back panel would not be wasted effort either, we feel.

## House Training

Operation will normally be from a tape output socket or line output in the case of a tape recorder. Sensitivity is about 50mV which proved to be more than adequate in use. As the input filter will reject high frequency energy above about 800Hz thereby eliminating hiss etc, the device will not shut-down on normal signal sources. We would suggest that a delay of about 5 mins, is more than sufficient. A value of 4M7 for R14 gives around this value of delay.

If you want a shorter period, lower the value of R14 — it is very approx 1 minute per Meg with C4 set at 100 $\mu$ F. Too low a value may well affect operation, we have not tried it below 1M, so if you do you're into the dark realms of the unknown. (Incidentally how do you manage to change L P s so quickly?)

An input could be provided from the loudspeakers of your system if you're unable to give doggy his low level audio. A potential divider will be needed to reduce the voltage at the input to stop you knocking the Watchdog's teeth out. For an 8 ohm loudspeaker and amplifier around 20-30W, try 10k and 1k in series across the speaker, with the circuit fed from the junction of the two resistors.

## Fitting the Leash

Initial setting up will be subject to the delay period, and so may confuse at first glance. Connect the audio input to SK1, and the Watchdog to the line s outlet. The equipment to

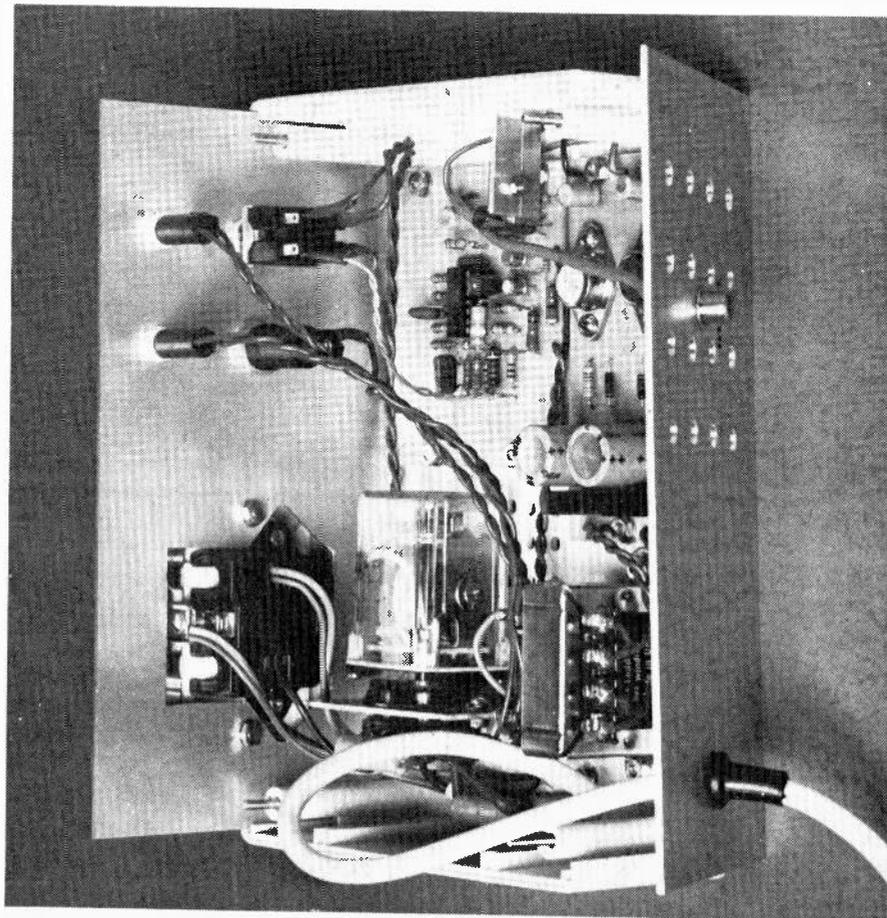


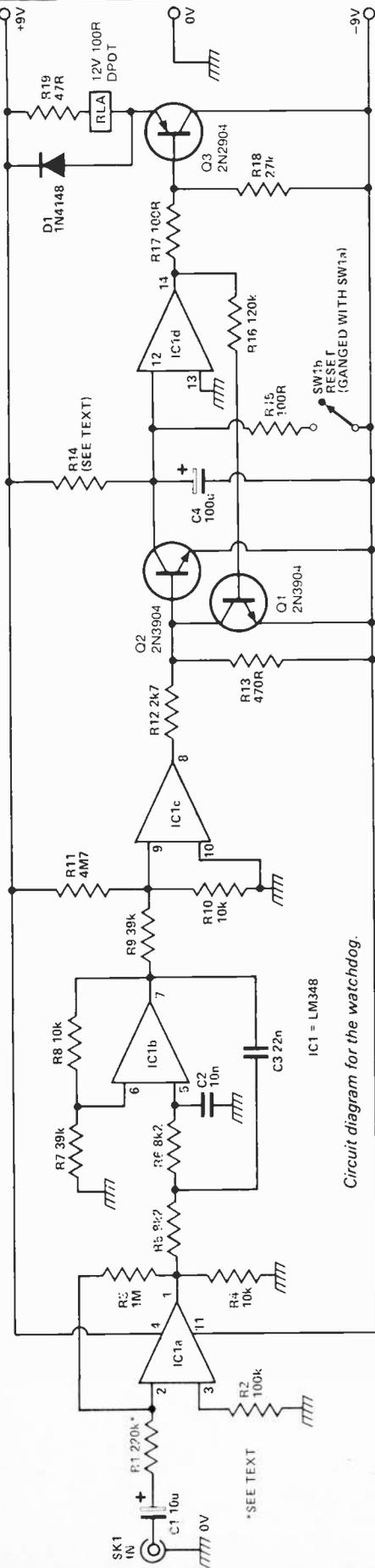
be dogged is plugged into the line socket on the front panel. The red neon should now be on (if you fitted it!) but nothing e/se will be!

Pressing down the reset switch should energise the hi-fi, and bring on the green neon to prove it. You now have however many minutes you allowed yourself with R14 to feed some audio down that wire before Fido gets upset and turns off the system again.

With the variation in level between say an off-air television and an FM tuner, the sensitivity may be just too high for your application and if this is so R1 is the component to alter. Raising this in value will reduce the sensitivity of the device.

However, this does limit the versatility, and we don't think it will apply to many of you. It might arise say where a television, tuner and record system are all equally likely to be the source under control.





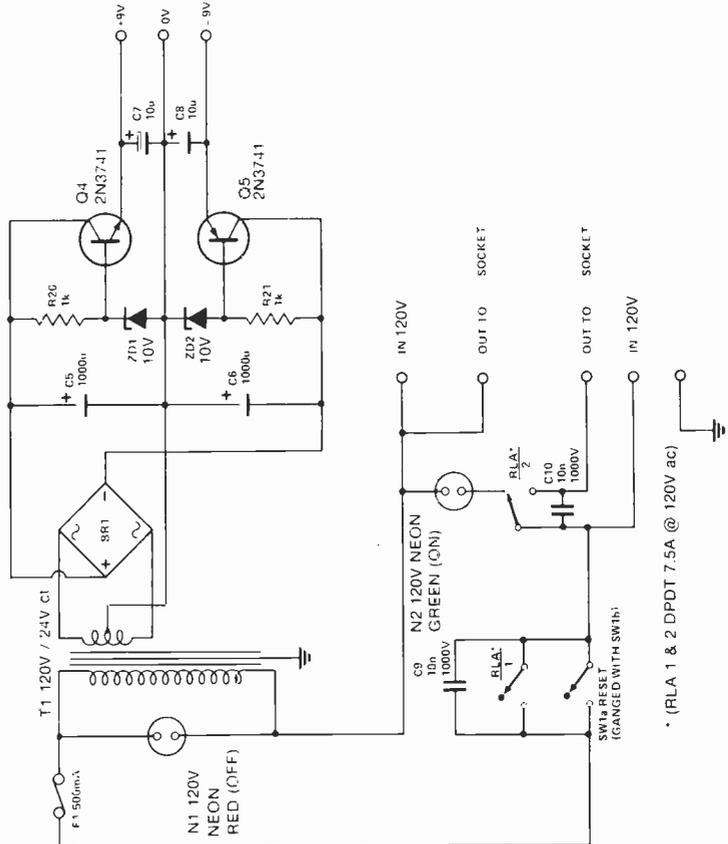
Circuit diagram for the watchdog.

## HOW IT WORKS

SK1 feeds the input audio of around 50mV minimum to the buffer amp formed by IC1a and associated components. The gain of this stage is determined by the ratio of R3 to R1, and may be changed to vary the unit's sensitivity. IC1b is a second order Bessel low pass filter with break frequency set around 800Hz (when loaded). This is to cut the response to high frequencies such that continuous white noise will not keep the unit switched on.

IC1c and the potential divider R12, R13, square the incoming audio signal and feed this to the base of Q2, keeping it switched on as long as audio is present at SK1. IC1c is an op-amp working at its full open-loop gain such that it will 'clip' any input into a square-wave.

While Q2 is turned on, C4 cannot charge up above ground potential. Once the pulse train is no longer present at the base of Q2, C4 begins to charge via R14. IC1d acts as a comparator, and after the time-delay has elapsed, the output swings high, turning off the relay driver Q3, and disabling the relay which controls the power to the equipment under consideration. D1 is protection against back EMF generated in the coil. Q1 is wired across Q2 as a 'shut-down' component, in such a way that as soon as the output goes high, this turns on Q1 which then prevents any transient audio, such as switch-off 'thumps' etc re-triggering the Watchdog and keeping it from closing down indefinitely.



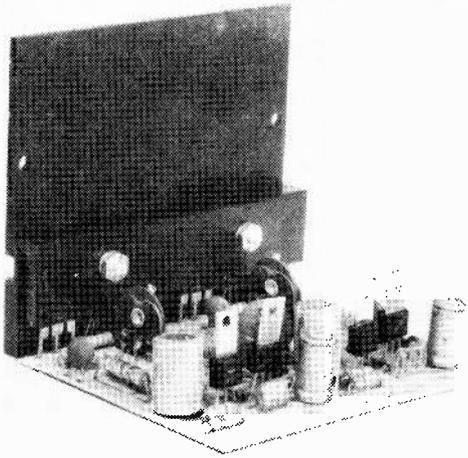
\* (RLA 1 & 2 DPDT 7.5A @ 120V ac)

Power Supply Circuitry to drive watchdog and power switching relay.

# electronics today

international

## What to look for in the December issue:



A dual 50 watt r.m.s. amplifier design which is simplified by the use of Darlington output transistors. For all those who need that extra power.

## 50D50 AMP

## A.M. STEREO

Farcial or feasible? Its quite possible to transmit stereo programmes on a.m. In fact five American design systems are being evaluated right now. We take a look at the systems.

## BATTERIES

The black box syndrome has certainly applied to batteries and, although many people are now more aware of some of the technicalities and various types, the battery is often neglected during design, particularly by the hobbyist. We hope to show you what you should be using where next month.

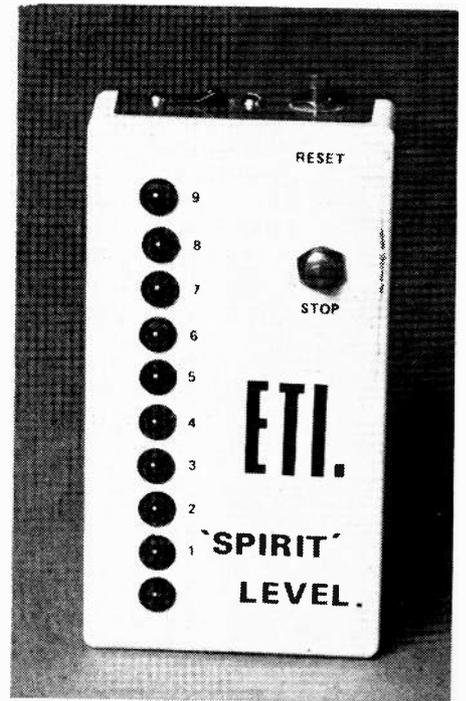


The articles described here are in an advanced state of preparation, but circumstances may necessitate changes in the issue that appears.

## REGULARS

Committed readers are no doubt fully aware of our regular features but to the new comer may we point out the amount of useful information contained in such items as News Digest, Data Sheet, Tech Tips, Microfile, and Bits, Bytes and Bauds. We are sure you will always find something useful and interesting in these items.

## Short Circuits



## microbiography

Next month on 6800 and 6500 families.

# VERTICAL MOSFET

By Wally Parsons

IN THE FIRST part of this article we examined the structure and features of a new type of semi-conductor, the vertical channel power metal oxide semi-conductor field effect transistor, VERTICAL MOSFET, or V-MOS recently introduced by Siliconix. This month we shall examine the actual use of V-MOS.

## CONDITIONS

V-MOS Power FETs like signal MOSFETS, may be used in a variety of circuit arrangements to perform many different functions. However, no matter what the circuit, certain conditions, common to all applications, must be provided. These are supply power, loading, drive signal, and establishment of appropriate operating points. These are conditions necessary for amplification and since *all* active devices function as amplifiers, no matter what the total circuit function, the in-circuit performance of any device depends of the establishment of these conditions.

The electrical characteristics of the VMP1, VMP11, and VMP12, are shown in Fig. 1, and Fig. 2 shows them in graphic form. Since these are uni-directional devices, the source and drain are not interchangeable, and as they are n-channel devices conduction can occur only if the drain is positive with respect to the source, and high enough to ensure operation in the linear region, as with a vacuum tube, bi-polar transistor, or signal FET.

Like the vacuum tube, the absence of secondary breakdown allows realization of the full dissipation at any voltage supply up to maximum voltage and current ratings. Thus, where two different designs require the same dissipation but different voltage/load current, no derating is required. This is shown in the "safe operating area" curves. The only bi-polar transistor possessing this characteristic is

the single-diffused type, which is also the least suitable for any application requiring wide bandwidth and/or high speed.

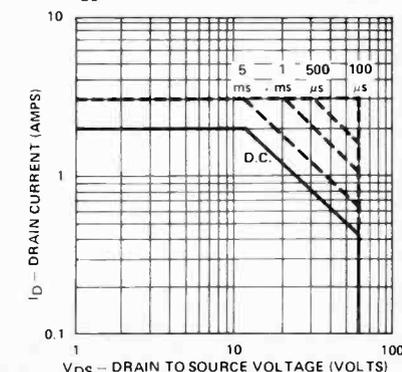
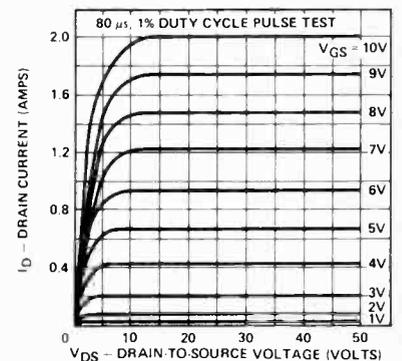
This characteristic also simplifies the establishment of suitable load-lines allowing greater safety margin in driving reactive loads where the load-line may be elliptical to the point of leaving the safe-operating area. Designers accustomed to using high voltage high dissipation devices to assure adequate safety margins at relatively low power levels need not, therefore, be too disconcerted at the 25 watt rating of these devices.

A 10 watt class A amplifier suitable for driving a tweeter in a bi-amped speaker system, for example, need not suffer excessive dissipation except perhaps with an electrostatic unit where such a power level would be inadequate anyway, unless it were operating at a very high cross-over frequency.

## OUTPUT

In general these devices may use any of the types of output circuits in general use with tubes and bi-polars, including transformer coupled (Fig. 12) where the benefits of the absence of charge carrier storage become apparent in the absence of severe ringing at the crossover point, conventional series output such as in Fig. 3, which is a straightforward transformation from a bi-polar circuit (1), and single-ended output with current source, also transposed from an excellent bi-polar circuit (2) (Fig. 4).

Fig. 2 Typical VMP1 performance curves (Siliconix).



Maximum Safe Operating Region

Characteristics		VMP 11		VMP 1		VMP 12		Unit	Test Conditions
		Min	Typ	Max	Min	Typ	Max		
S T A T I C	BVDSS	35		60		90		V	V <sub>GS</sub> = 0; I <sub>D</sub> = 100 μA
	VGS(th)	0.8	2.0	0.8	2.0	0.8	2.0		V <sub>GS</sub> = V <sub>DS</sub> ; I <sub>D</sub> = 1 mA
	IGSS	0.5		0.5		0.5		μA	V <sub>GS</sub> = 15 V; V <sub>DS</sub> = 0
	ID(off)	0.5		0.5		0.5			V <sub>GS</sub> = 0; V <sub>DS</sub> = 24 V
	ID(on)	1	2.0	1	2.0	1	2.0	A	V <sub>DS</sub> = 24 V; V <sub>GS</sub> = 10 V
	ID(on)	0.5		0.5		0.3			V <sub>DS</sub> = 24 V; V <sub>GS</sub> = 5 V
S W I T C H	rDS(on)	2.0	2.5	3.0	3.5	3.7	4.5	Ω	V <sub>GS</sub> = 5 V; I <sub>D</sub> = 0.1 A
		2.4	3.0	3.3	4.0	4.6	5.5		V <sub>GS</sub> = 5 V; I <sub>D</sub> = 0.3 A
		1.2	1.5	1.9	2.5	2.6	3.2		V <sub>GS</sub> = 10 V; I <sub>D</sub> = 0.5 A
		1.4	1.8	2.2	3.0	3.4	4.0		V <sub>GS</sub> = 10 V; I <sub>D</sub> = 1 A
g <sub>m</sub>	Forward Transconductance *	200	270	200	270	170		mS	V <sub>DS</sub> = 24 V; I <sub>D</sub> = 0.5 A
D Y N A M I C	C <sub>iss</sub>	48		48		48		pF	V <sub>GS</sub> = 0; V <sub>DS</sub> = 24 V f = 1 MHz
	C <sub>rss</sub>	7		7		7			
	C <sub>oss</sub>	33		33		33			
	t <sub>ON</sub>	4		4		4			
t <sub>OFF</sub>	4		4		4				

Fig. 1 Electrical characteristics of the VMP devices (Siliconix).

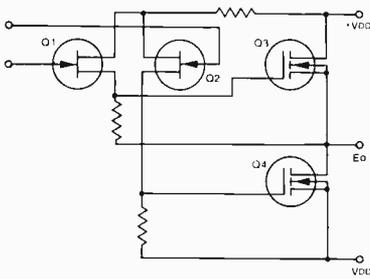


Fig. 3 Series output arrangement.

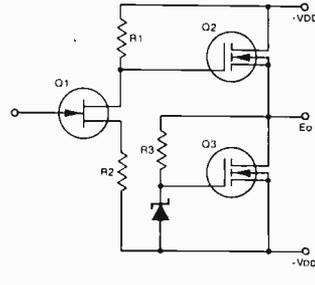


Fig. 4 Single ended output with current source.

## BIAS AND DRIVE

These series of devices are *n*-channel, enhancement type MOSFETS, and may be biased and driven using methods appropriate to signal types and bi-polars. The drain is made positive with respect to the source and the gate enables conduction by being forward biased with respect to the source, that is to say it is biased in a positive direction. Unlike bi-polars, however, they are voltage, rather than current controlled, and circuit values are selected to provide the required voltage. Any current drawn is by the bias network itself.

Three bias methods are shown in Fig. 5; 5a shows bias supplied from a fixed bias supply. It is the simplest possible method, allows extremely high input impedances, since  $R_g$  may be almost any very high value desired, and its stability is limited only by the stability of the bias supply.

The design shown in Fig. 5b has the advantage of requiring no extra supply voltage since it is taken from  $V_{dd}$ . Disadvantages are those of impedance and stability. Input impedance consists of the parallel combination of  $R_1$  and  $R_2$  (disregarding input capacitance of the MOSFET and the very low input leakage.) There are practical limits as to how high this combination can become; if for example, we have a 60 volt supply and require 6 volts bias, we might have some difficulty obtaining higher values than 9 megohms and one megohms for  $R_1$  and  $R_2$ .

Higher values become more difficult to obtain, stability becomes less reliable, internal inductance and distributed capacitance become problems, and overcoming these difficulties usually costs money. In addition, if  $V_{dd}$  is subject to variation, then bias varies. In a class AB amplifier this could be quite serious, since  $V_{dd}$  varies considerably with output level; at high levels,  $V_{dd}$  can be expected to drop, causing a reduction in bias.

While this may reduce the danger of over-driving the device, it will be forced to operate in its non-linear region which may result in unacceptable performance characteristics unless taken into consideration in the overall circuit design (e.g. choice of feedback values). It does provide some degree of overload protection, and with correct choice of values can provide for class AB operation at low levels, shifting to class B at high levels. With these considerations in mind, and/or where moderate impedances are required, it

offers a low cost, simple, and reasonably reliable method of establishing the operating point.

The method used in Fig. 5c is similar except that with the addition of  $R_3$  higher input impedances are possible. Its configuration is similar to a noiseless biasing system frequently used in low-level bi-polar amplifiers and integrated circuits (e.g. National LM381A) but its function is somewhat different. Resistors  $R_1$  and  $R_2$  form a voltage divider as in Fig. 5b, but their junction now forms a fixed bias source as in Fig. 5a. Resistor  $R_3$  can be quite high since no current flows. Meanwhile, since the parallel combination of  $R_1$  and  $R_2$  are effectively in series with  $R_3$  they can be reduced to more manageable values. Alternatively  $R_2$  can be replaced by a Zener diode for stability comparable to Fig. 5a.

## INPUT PROTECTION

Unlike most signal MOSFETS, the gate of each of these devices, with the exception of the VMP 4, is protected with an internal 15 volt, 10ma Zener diode. Most signal MOSFETS, as well as the VMP 4 are unprotected, or where extremely high impedances are not required, are protected by back to back Zeners. I have no information as to why this different technique is used, but it is obvious that a negative signal swing on the gate will result in forward current through the Zener. If the device is to be driven beyond cutoff, the driver must be capable of delivering current during its negative swing. Alternatively a constant current source can be used, a series limiting resistor or a driver biased to the same class of operation as the V-MOSFET.

A constant current source (we'll examine an example of its use a little later) will limit current drive to the value of the constant current diode used; a series resistance will drop the drive voltage as the diode draws current. In both cases, diode current must be limited to 10ma maximum. Higher currents will damage the protective Zener diode.

In amplifier applications, a class A driver is commonly used. However, if a class B output is used, conduction only occurs during positive half-cycles. Therefore, drive signal is not required during negative half-cycles. If a source or emitter follower driver stage is biased so as to pass no negative drive, the problem does not occur. However, great care must be exercised in the design of such a stage to ensure that drive does not disappear before the output device is cut off.

This is not too difficult with a class B or near class B stage; If the output device is operated at zero bias, then a small amount of bias on the driver will ensure conduction during slightly more than 180 degrees. Class AB operation is a little more tricky. If conduction is to occur for 270 degrees, for example, the driver should conduct for slightly more than this period.

Two types of drive circuits familiar to designers of bi-polar circuits are the Darlington and Super beta, commonly used together to provide a quasi-complementary circuit. Both circuits are current amplifiers designed to provide a compound device with very high  $h_{fe}$  and provide base current to the output device. However, similar circuits can be used with these devices to provide phase inversion in a series output stage.

## THERMAL CONSIDERATIONS

As described earlier (part 1) these devices exhibit a negative temperature coefficient with respect to current, so that as temperature rises, current is reduced, thus providing a self-inhibiting action which provides some protection against overload. However, this is not an unconditional effect; Fig. 6 shows the relationship between  $R_{DS(on)}$  and temperature (3), based on a worst case temperature coefficient of 0.7 per cent per degree C.

Suppose that the device when ON passes a current of 1 amp which causes it to heat up. The ON resistance increases

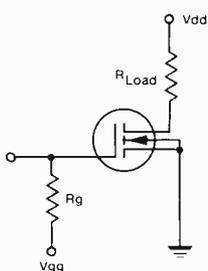


Fig. 5a. Hi-Z separate bias supply.

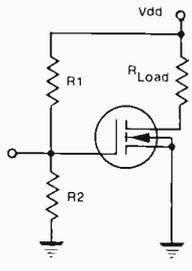


Fig. 5b. Moderate impedance supply.

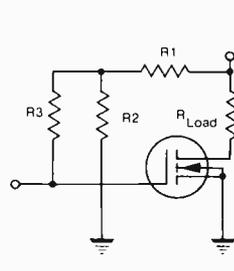


Fig. 5c. Hi-Z common supply.

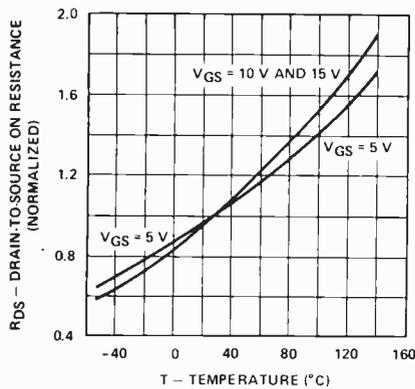
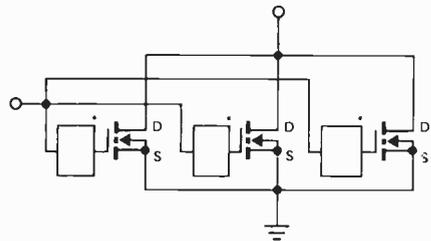


Fig. 6 Drain to source resistance against temperature (Siliconix).



\*TO PREVENT SPURIOUS OSCILLATIONS, A 500 Ω 1K Ω RESISTOR OR FERRITE BEAD (FOR HIGHER SPEED) SHOULD BE CONNECTED IN SERIES WITH EACH GATE.

Fig. 7 Basic circuit for parallel operation (Siliconix).

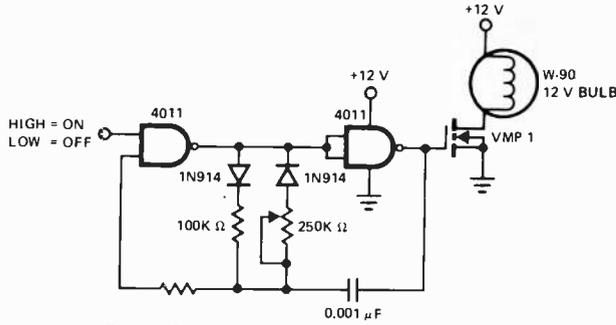


Fig. 9 Circuit of a high efficiency light dimmer (Siliconix).

(which is why current drops), increasing the voltage drop across the device and the device dissipation. Now, if adequate heat sinking is used there is no real problem but if it isn't, the ON resistance and junction temperature will rise to the point where extra charge carriers are generated, thus stabilizing  $R_{DS(on)}$ . That's great, except for the fact that this doesn't occur until the maximum safe junction temperature of 150 degrees has been exceeded.

You'll remember that we said earlier that the device was free of thermal runaway problems because of its negative temperature coefficient, but it isn't free of thermal destruction problems, and in any case, excessive temperatures will reduce output conductance. Heat-sinking requirements are, therefore, similar to those of bipolar. The calculations of thermal operating conditions are beyond the scope of this article, but interested readers are referred to the Siliconix literature listed in the references, (4).

**EXTENDING THE RATINGS**

The current handling capacity and therefore total dissipation capability may be easily increased by simply connecting several devices in parallel (Fig. 7). No ballast resistors are needed to ensure proper current sharing since if one device draws more current than another it simply gets a little warmer which causes it to draw less (assuming adequate heat sinking, of course). The only major precaution needed is to keep lead inductance in the gate and source connections to a minimum to prevent parasitic oscillations, unless the devices are driven from a low impedance source.

It may be advisable to insert what the British call "stoppers" — small resistors (100 to 1000 ohms) in series with each gate, wired directly to the socket, or ferrite beads mounted on the leads close to the socket terminals. An additional plus when paralleling several devices is that the  $g_m$  is multiplied by the number of devices used. Mutual conductance  $g_m$  is specified as the ratio of a large change in current to a small change in control voltage. If, for example, a change of 0.4 volts on the gate produces a change of 0.1 amp through one device, connecting two devices in parallel will give us an output swing of 0.2 amps, but it will still require only the original 0.4 volts gate swing. Since voltage gain  $A=g_m \times R_L$ , if  $g_m$  is increased, A is increased.

In real use, of course, the internal resistance of two devices in parallel is less than of one, the optimum load is less, so in amplifier applications, the net amplification A is the same. But notice that the drive requirements have not changed. With bi-polars current would have to be supplied to each base, thus increasing the output requirements of the drivers. Indeed, with many high-power amplifiers using multiple output devices the drivers are also power devices.

We can also extend the voltage ratings by series operation of two or more devices; Fig. 8 shows the technique. Resistors R1 and R2 bias Q2 ON, while C1 and C2 ensure fast switching. Input control signal is inserted between gate and

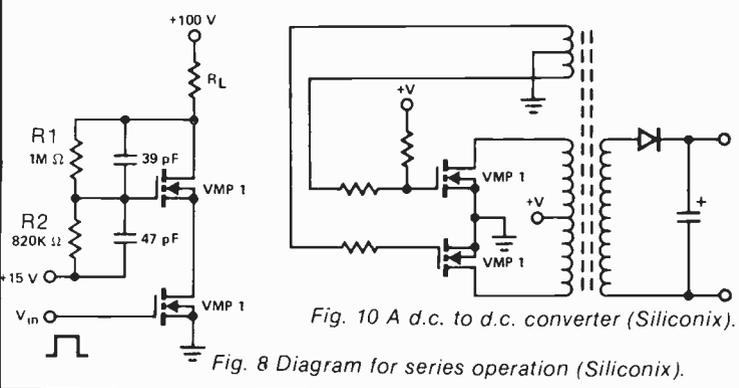


Fig. 8 Diagram for series operation (Siliconix).

source of Q1. Ordinarily the bottom of the divider chain is at ground potential for signal frequencies, so that circuit is really a cascode.

Maximum current and  $g_m$  are the same as for one device.

**SOME PRACTICAL APPLICATIONS**

An efficient light dimmer circuit as proposed by Siliconix is shown in Fig. 9. The 4011 acts as a pulse width modulated oscillator whose duty cycle is determined by the ratio of R1 to R2, with R2 adjusted to control the brightness of the W-90 bulb. Of special interest here is the fact that with its fast switching time, the VMP1 is especially suited to pulse width modulation at power levels and suggests it as being suitable for use in switching, or class D linear amplifiers.

A DC to DC converter is outlined in Fig. 10. The VMP1's form an oscillator with positive feedback provided by the additional coil in the gate circuits. In operation the upper V-MOSFET is biased ON, and the lower V-MOSFET is OFF. When power is applied the upper device conducts causing current to flow from  $V_{dd}$  through the upper half of the transformer primary and the upper V-MOSFET to ground. The induced current flow through the feedback coil develops a voltage such as to shift the bias in the upper device OFF (if the winding is connected with the correct polarity) and the lower device ON. This causes current flow from  $V_{dd}$  through the lower half of the transformer primary and the lower V-MOSFET to ground.

The secondary circuit consists of a single rectifier and filter. The resistor in the upper gate prevents shorting out of gate bias, and the one in the lower gate keeps both sides balanced. In addition, each resistor limits current through the protective diodes. These are expensive devices for such an application, but the high reliability, the reduced r.f. radiation (due to reduced switching transients) and the circuit simplicity easily make up for the cost. The very high circuit impedance allows for running frequency to be set by the self resonance of the transformer.

A single ended and push-pull transformer coupled amplifier for audio applications are shown in Figs. 11 and 12.

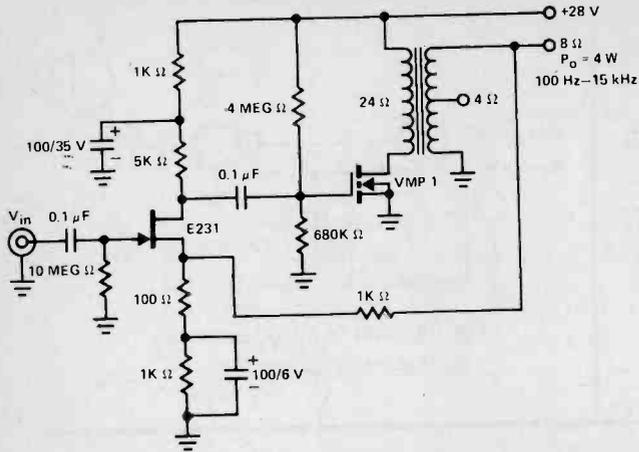


Fig. 11 Simple single ended transformer coupled audio power amplifier (Siliconix).

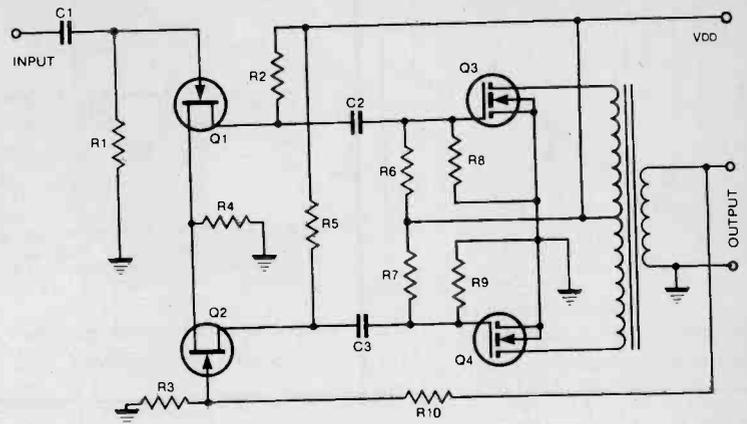


Fig. 12 Transformer coupled output.

Both designs utilize the biasing system described in Fig. 5b. A load-line drawn on the output characteristic will show the optimum load to be 24 ohms. In Fig. 11 gate drive is supplied by a single junction FET, and voltage feedback is taken from the output transformer secondary and series fed to the source of the input device. Distortion is under 2 per cent at full output (try to get *that* with a single ended tube or bi-polar) and could probably be reduced even further by adopting a source follower output stage.

A push-pull version of Fig. 11 is shown in Fig. 12 using a differential input to provide phase splitting, drive, and a feedback point. Although the transformer winding ratio implies the use of a low impedance loudspeaker, a step-up ratio could be used for direct coupling to an electrostatic speaker, a balanced transmission line (both with some modification of the feedback circuit) an unbalanced transmission line, or a 70 volt speaker distribution line.

Notice in both circuits, and in the biasing circuits of Fig. 5, that no source resistors have been used, either for local feedback or for bias setting. In tube and bi-polar circuits it's a useful technique, and with bi-polars can be used to stabilize bias and control thermal runaway by using the increased current flow to increase the voltage drop, thus reducing base-emitter voltage. However, if used with these devices, it will actually impair the self-limiting action of its negative temperature co-efficient. If temperature rises due to high current, current flow is reduced. This would reduce the voltage drop across a source resistor, lowering the source voltage and increasing the gate-to-source voltage, causing an *increase* in current flow. The circuit would work great while it lasted — which wouldn't be for long.

## RECORD AMP

In Fig. 13 we see a magnetic recording amplifier derived from a tube circuit. Its biggest advantage lies in its ability to provide equalization for head losses by incorporating the head within the feedback loop. Additional equalization is then required only for gap losses and tape self-demagnetization. Q1 acts as a driver for Q2, the output stage, which, with series resistor R9, provides a high impedance current source for the record head, as well as providing a mixing pad between audio and bias currents.

The record head's return path to ground is through R11. The inductance of the record head results in an impedance characteristic which rises with frequency. At frequencies at which the impedance of the head is low in comparison with R9 and R10 in series, load current is essentially constant. As frequency rises, however, head impedance becomes appreciable. With appropriate selection of R9 and R11, depending on head characteristics, the voltage across R11

decreases as the head impedance becomes significant. If feedback is taken across R11 it will decrease with rising frequency, causing an increase in gain, at a rate of 6dB/Octave.

Feedback is applied across R3 via R10 and C8 (which supplies bass boost below 80Hz) C5 and C6 provide additional high frequency boost for a total ultimate slope of 12 dB/octave. This circuit is so effective that no additional boost is needed at 15 i.p.s., and only a small amount at 7.5 i.p.s. with high coercivity tape.

The biasing method used is that of Fig. 5c. The large amount of local current feedback provided by R2 and R3 results in a high output impedance for Q1, so the biasing network is selected to provide high impedance with reasonable values. Capacitors C3, C4, C7 and C9 bypass bias signal to avoid overloading Q2, and to prevent attenuation of bias current.

## POWER AMP

In Fig. 14 we have a high quality power amplifier designed by Lee Shaeffer of Siliconix Inc. (5) and described in their application notes. Output current capability is increased by using three VMP12's in parallel, providing for 6 amp current, 75 Watt dissipation and optimizing the load at 8 ohms. Q11-13 operate as a source follower, while Q8-10 form a quasi

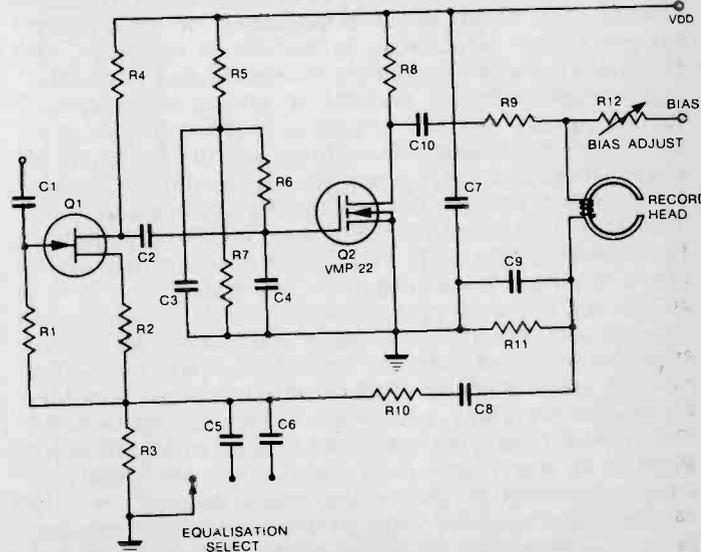


Fig. 13 Tape recording amplifier.

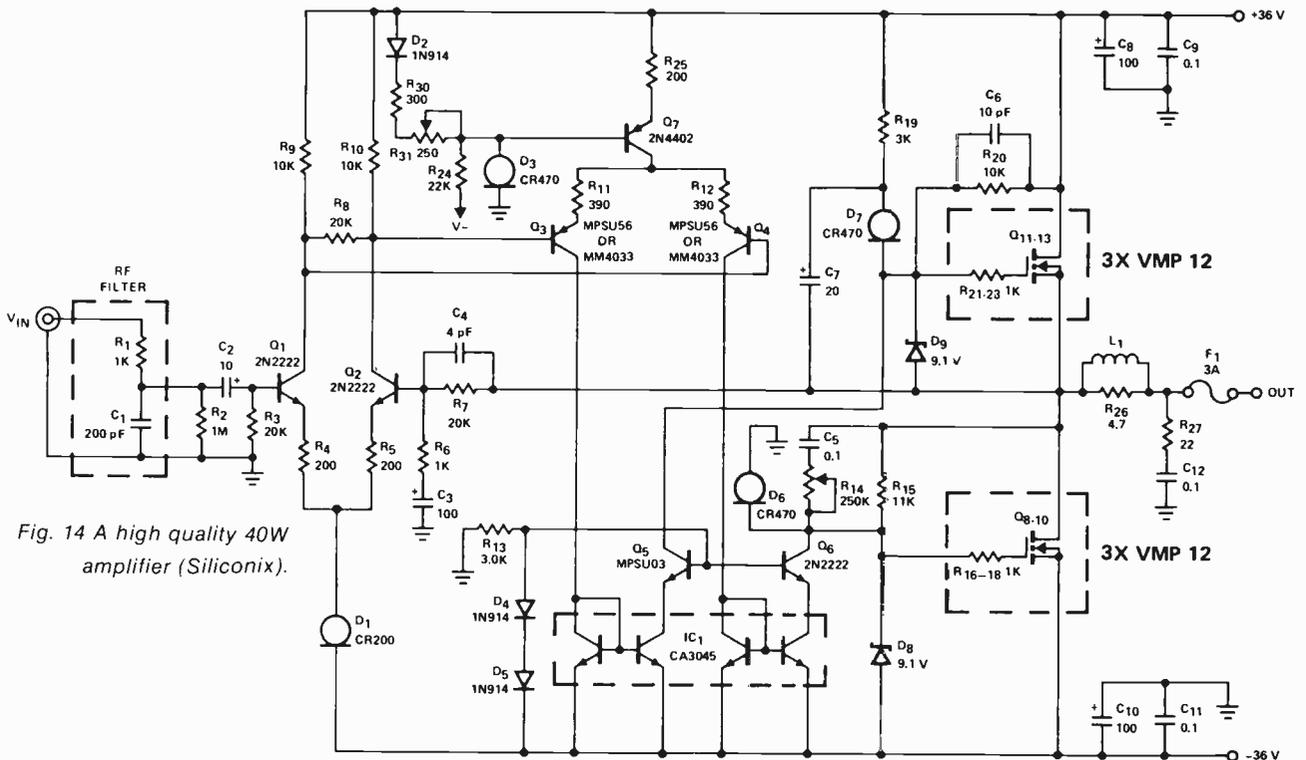


Fig. 14 A high quality 40W amplifier (Siliconix).

source follower. This is accomplished by applying local feedback from drain to gate via R14, R15, and driving the gate by a modified current source. This consists of a cascode circuit with a constant current diode as the load.

For the benefit of those not familiar with these devices, a constant current diode is really a FET connected internally as shown in Fig. 15. Since current in a FET is controlled essentially by the gate-to-source voltage, changes in load or in applied drain-to-source voltage have negligible effect since gate-to-source voltage is held constant. This is a current analogue to the Zener diode and is described in detail in Siliconix literature (6).

The design is push-pull from input to output, thanks to differential circuitry throughout, prior to the drivers. Open loop distortion is low, bandwidth wide, allowing satisfactory performance with only 22 dB of feedback. Lead compensation only is used (via C4), along with the liberal use of local feedback (R4, R5, R11, R12,). The result is very low transient I.M. and a slew rate of over 100 V/microsecond. THD is quite respectable, even though the numbers might not impress the average "audiophile" accustomed to amplifiers with great specs and poor sound.

Incidentally, D8 and D9 illustrate an excellent method of providing output current limiting. In this case, 9.1 volt Zener diodes limit drain current to slightly less than 2 amps. At first one might be tempted to depend on the built-in protection diodes to accomplish this, but it should be remembered that these devices are for protection against static discharge. Their Zener voltage of 15 volts at 10mA cannot possibly be used since the absolute maximum permissible drain current occurs at a gate-to-source voltage of 10 volts.

Complete construction plans including p.c. board layout are available from Siliconix (7). A word of caution, however. Readers accustomed to construction articles in which the writer does everything but hold your soldering iron will find these plans rather sketchy. They consist of a spec sheet, schematic, board and parts layout, two paragraphs of construction suggestions, initial adjustments, and a parts list. Parts, generally, are specified as to value and rating, and that's it. These plans are excellent, but they assume some knowledge and experience on the part of the constructor. Regular "ETI constructors" should have little difficulty.

## COMMERCIAL AMPS

There has been no announcement of these devices being used in commercial audio amplifiers to date, so it is not possible to examine current commercial practice in this area, but I was able to obtain a circuit diagram of the Yamaha B1, that company's first product using their own Junction V-FETS.

A simplified version is shown in Fig. 16, (8). These devices are also *n*-channel types, and are connected in essentially a single-ended push-pull arrangement. In this circuit a cascode drive system is also used, but in a differential form with the constant current source in the common source circuit. This is an example of all FET design of excellent performance which has received rave reviews in several publications including ETI (9). It's also expensive.

The v.h.f. linear amplifier in Fig. 17 will deliver 5 watts peak envelope power with second and third order intermodulation at -30 dB from 144-146MHz. It will also prove useful as a receiver pre-amp with a noise figure of 2.4 dB. V-MOSFETS show considerable promise in r.f. applications because of their linear transfer characteristic, the high gain capabilities even with *Ft* somewhat above 600 MHz, low noise and (in receiver front ends) very wide dynamic range. Although this article has dwelt on the VMP 1 family, there is also the VMP 4, designed specifically for r.f. applications and which is now available. Interested readers should obtain the appropriate literature (10).

Finally, how about something elegant for its simplicity, such as the Tapered Current Voltage Limited battery charger shown in Fig. 18. This is especially useful with Ni-Cad batteries which are intended for stand-by use and are permanently on charge, such as electronic clocks. In one area of Toronto there was a catastrophic power failure this summer and repairs are still under way at the time of writing. However, overnight shut-downs of a few hours are occasionally but irregularly experienced. You know what this can do to clocks. Especially alarm clocks which are supposed to make noises, turn on radios, start the coffee at a pre-set time in the morning so you can go to work. Battery operation is not too satisfactory if the readout is on continuously, and Ni-Cads should not be on permanent floating charge.

With this little device current is supplied to the battery via the VMP-1. Gate voltage is set at a value equal to the desired end of charge voltage. As the battery charges its voltage increases, reducing gate-to-source voltage, thus reducing charging current. When the battery reaches full charge its voltage and that of the source equals gate voltage, and charge is terminated. If a load is placed across the battery it will draw current, and as the battery voltage drops slightly below gate voltage, charging at a trickle rate occurs — automatic.

## EXPERIMENTATION

The various applications shown are intended as suggestions for further experimentation on the part of the reader. They are mainly designed to illustrate various characteristics of the device under consideration, and are not necessarily representative of commercial practice or of finished designs. In some cases this may be just as well. But we would be delighted to hear of any readers' experience with any of these or other circuits.

The author's own feeling is that V-MOS constitutes a genuine breakthrough in semi-conductor technology, as important as the silicon transistor and the FET itself. We'll be seeing more of these devices, with higher ratings (a 10 Amp 200 V unit is already under development) and specialized characteristics. They are said already to be in use commercially as magnetic core drivers.

Digital enthusiasts may be somewhat impatient with the strong emphasis on audio applications in this piece but other literature has placed great emphasis on digital applications, with little attention paid to linear techniques beyond the 40 watt amplifier described here. The serious reader in all areas is referred to the references at the end.

Further literature may be obtained from the manufacturer, Siliconix Inc., 2201 Laurelwood Rd., Santa Clara, CA 95054, or in Canada from the Canadian representative, R.F.Q. Ltd., P.O. Box 262, Port Credit Postal Stn., Mississauga, Ontario, L5G 4L8, or P.O. Box 213, Dollard Des Ormeaux, Quebec L9G 2H8. They have been most helpful in providing information for the preparation of this article.

To buy the devices contact the Canadian distributor, Hamilton-Avnet Electronics, 6291 Dorman Rd., Mississauga, Ontario, 1735 Courtwood Cr., Ottawa, Ontario, K2C 2B4, or 2670 Paulus St., St. Laurent, Montreal, Quebec, H4S 1G2.

Have fun.

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2. Nelson Pas: "Build a Class A Amplifier" *Audio*, Feb. 1977, p. 29
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7. Ref. 5
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10. Ed Oxner: "A New Technology: Application of MOSPOWER FETs For High-Frequency Communications" Technical Article TA76-2, Nov. 1976, Siliconix Inc.

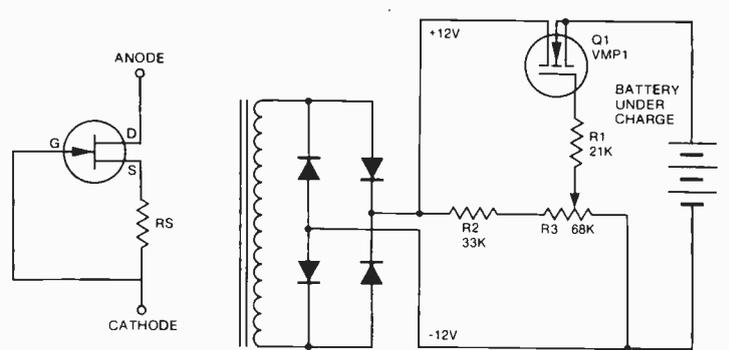


Fig. 15 A FET as a constant current diode.

Fig. 18 Tapered current voltage limited battery charger.

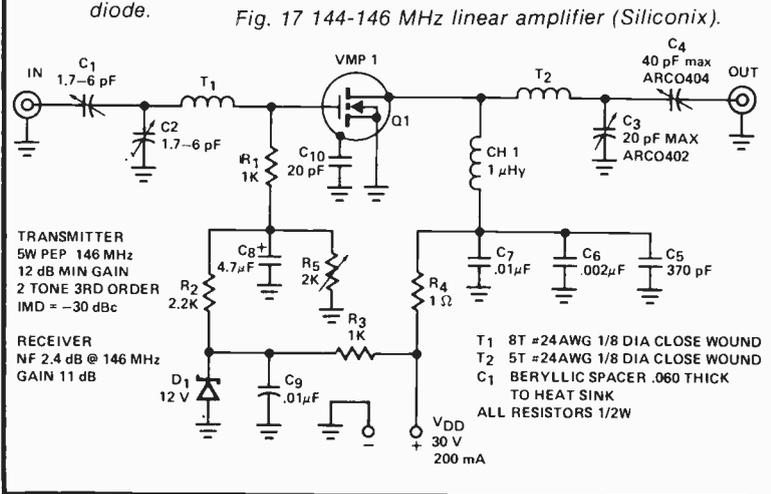
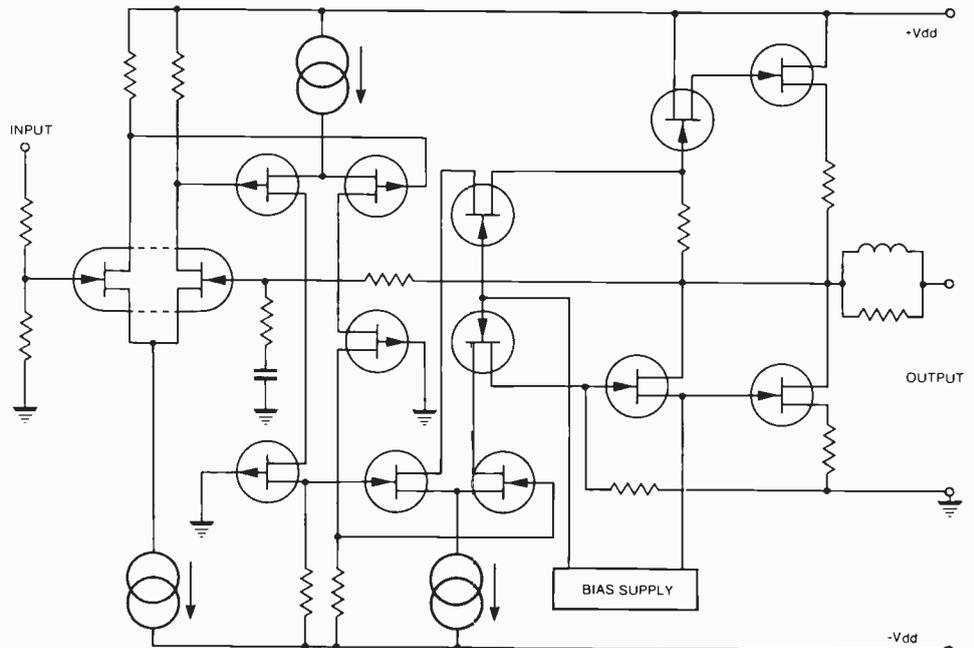


Fig. 17 144-146 MHz linear amplifier (Siliconix).

Fig. 16 Simplified Yamaha VFET amplifier diagram.



# NOTES FOR READERS OF "TOP PROJECTS" AND "CIRCUITS"

For readers of our special publications "Top Projects" and "Circuits" we present here some useful conversions. We will in future be including this information with the books.

## DIODES

OA91 Germanium	1N34
OA95 Germanium	1N38
OA200 Silicon	1N4148
BA100 Silicon	1N4148

## GERMANIUM TRANSISTORS

AC127	2N2430
AC128	2N2706
AC132	2N2706
AC176	2N2430
AC187	2N2430
AC188	2N2706
ACY22	2N1188
AD161	2N4077
AD162	2N2835
OC72	2N2706

## SILICON TRANSISTORS

BC107	2N3904
BC108	2N3904
BC109	MPS6514; MPS6515
BC109C	TIS97; MPSA18
BC148	2N3904
BC153	2N3904
BC158	2N3905

BC169C	MPSA18*
BC177	2N3905
BC178	2N3905
BC179	2N3905
BC182L	2N3904*
BC184	MPS6515*
BC209	MPS6515
BC212	2N3905
BC214	MPS6523
BC258	2N3905
BC327	2N5819
BC328	2N5819
BC337	2N5818; 2N2222A
BC441	TIP31A*
BC461	TIP32A*
BC548	2N3904
BC549	MPS6515
BC558	2N3905
BCY54	2N3905
BCY71	2N3905
BD135	TIP29A
BD136	TIP30A
BD137	TIP29B
BD138	TIP30B
BD139	TIP29C
BD140	TIP30C
BD266	TIP145

BD267	TIP140
BDY20	2N3055
BF224	2N3904*
BFR40	TIP31A
BFR80	TIP32A
BFX30	2N2905A
BFX84	2N2297
BFX85	2N4001
BFX88	2N2905A
BFY50	2N2297; 2N2222A
BFY51	2N2297; 2N2222A
BSS15	2N5320
ZTX300	2N2222A
ZTX500	2N2907A

\*These transistors may have different lead configurations. Check carefully before use.

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We normally specify components using the recently agreed International Standard. Many readers will be unfamiliar with this but it's simple, less likely to lead to error and will be used by everyone sooner or later. ETI has opted for sooner!

Firstly decimal points are dropped and substituted with the multiplier, thus 4.7uF is written 4u7. Capacitors also use the multiplier nano (one nanofarad is 1000pF). Thus 0.1uF is 100n, 5600pF is 5n6. Other examples are 5.6pF = 5p6, 0.5pF = 0p5.

Resistors are treated similarly: 1.8Mohms is 1M8, 56kohms is 56k, 4.7kohms is 4k7, 100ohms is 100R, 5.6ohms is 5R6.

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The 'Bucket Brigade' are marching on the audio world, but what are . . .

# CHARGE COUPLED DEVICES

Mark Sawicki considers this new technology

CHARGE COUPLED DEVICES represent a new and rapidly developing area of monolithic integrated circuit technology and are basically intended to delay analogue signals.

The principle is that CCD operates as a monolithic shift register, and is commonly referred to as 'Bucket-Brigade'. (The reason being that their operation is analogous to a chain of firemen passing buckets of water from hand to hand.)

In CCD 'buckets' correspond to the IC's capacitors and 'water' corresponds to the electric charge — being the analogue sample of an applied waveform. CCD IC's were first introduced by Philips Laboratory back in 1968, and the first papers dealing with this innovation were published by 'Philips Technical Review' and also in the 'I.E.E.E. Journal'.

The basic structure of the MOS CCD is shown in Fig. 1.

Early bucket brigade analog delay lines had many shortcomings with problem number 1 being poor transfer efficiency, (the amount of

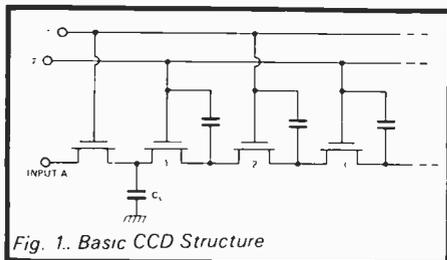


Fig. 1. Basic CCD Structure

charge left behind decreasing at each transfer). In the early 70's these devices were improved at Philips with the introduction of a 'tetrode' structure with a DC biased gate separating each clocked element from the next one as shown in Fig. 2.

The performance of this new structure was enhanced because these tetrodes in effect, reduced the MILLER capacitance (an analogy can be made to a tetrode grid in a vacuum tube).

## Charge to couple

Simultaneous research was undertaken at Bell Telephone Laboratories

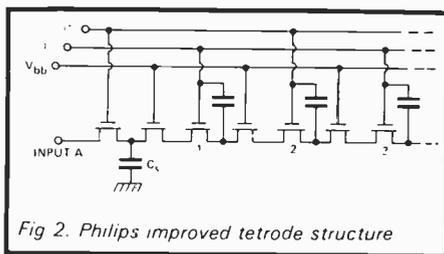


Fig. 2. Philips improved tetrode structure

who in turn produced a successful innovation of a CCD possessing much better performance than the old CCD. The improved principles of operation and specific structure, were first published by W. S. Boyle and G. E. Smith.

The first steps in the development of CCD concentrated on general structure technology as well as processing techniques. The Reticon research team came up with many interesting ideas such as:

1. Self-aligned structures reducing parasitic capacitance and improving specific efficiency.
2. A decrease in substrate resistivity helping to minimise the sensitivity to voltage as well as clock wave shapes, with a very important reduction of the conductivity modulation of the region under the transfer gate. This has a general influence on specific transfer efficiency.

3. They felt that modern CCD structure should have the advantages of a high resistivity basic substrate for reduced junction capacitance but without any effect on modulation.
4. The idea that the ion implantation could be used to control thresholds so that N channel devices would become feasible, with the advantages of higher speed and transfer efficiency.

Bearing in mind point 4 as far as audio delay is concerned, the comparison of transfer efficiency for both N as well as P channels is shown in Fig. 3.

Table 1 gives a summary of the performance of some of these devices.

## Practical Applications:

For amateur purposes, most of these devices are far too expensive. However, the Reticon SAD 1024 and 512D are very reasonably priced for the performance offered. The SAD 1024 is available for about \$38.00 from Webster Instruments Ltd. 2446 Cawthra Rd., Mississauga, Ont.

The most important features of CCD for application as an audio delay lines are:

1. Wide bandwidth with flat frequency response
2. Large dynamic range with a good stability margin
3. Simplicity of practical applications and low cost

Until recently, the only delay system available for musicians and constructors was the electro-mechanical type (tape/spring). The spring type reverberation units reached a very high level of popularity thanks to their much lower production costs when compared

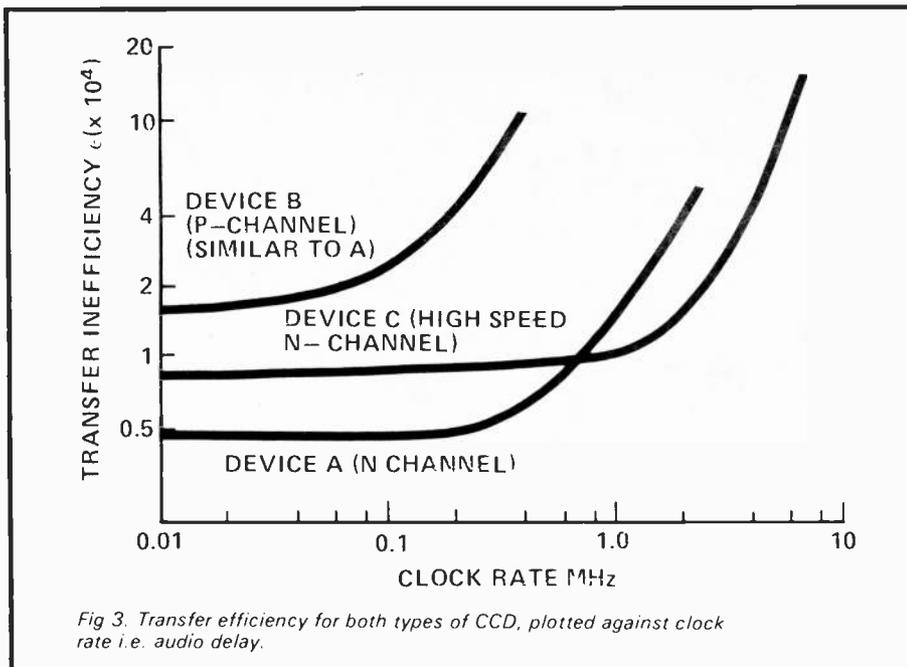


Fig 3. Transfer efficiency for both types of CCD, plotted against clock rate i.e. audio delay.

acoustic feedback.

Spring type reverberation systems are so delicate that they require quite a complicated suspension drive which can sometimes produce strange resonances and other uncalled for effects.

Employing CCD to produce synthetic reverberation with multi reflection paths is one of the major SAD 1024 applications. The basic block diagram is shown in Fig. 4.

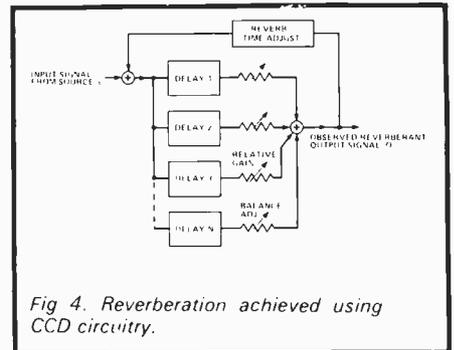


Fig 4. Reverberation achieved using CCD circuitry.

TABLE 1  
PRODUCT SUMMARY ANALOG MEMORY PRODUCTS

	Tapped Analog Delay TAD-32	Audio Delay SAD-1024	Audio Delay SAD-512D
Maximum Sample Rate (f.)	5 MHz	1.5 MHz	1 MHz
Typ Retention Time (1% Loss, 25°C)	40 ms	200 ms	200ms
Aperture Time Jitter	< 20 ns	< 20 ns	< 20 ns
Signal / Noise ratio	60 db	70 db	70db
Distortion (Total Harmonic)	1%	1%	1%
Evaluation Circuit	TC32	SC1024	SC512D
Delay in-puts (Sample Periods)	1 to 32	512	256
Readout	Destructive	Destructive	Destructive
Package	40 pin DIP	16 pin DIP	16 pin DIP
Analog Signal Bandwith (Single Pole 6 db)	2 MHz	200 KHz	200KHz
Typical Applications	Discrete-time filters Transversal filters Recursive filters Reverberation effects Correlation Pattern recognition Active filtering	Analog time delay Reverberation effects Time-base correction Transient recorder Generate trace for oscilloscope Flanger and audio effects	Low-cost audio-effects Reverberation Delay equalizer Vibrato Variable speed control

A summary of some of the most important parameters of the CCD devices discussed in this article and made by Reticon. The characteristics of the Mullard devices are given in Table 2 overleaf

Differing path lengths are arranged using different delays. Specific attenuation in a path represents acoustic absorption loss which, by its adjustment, allows for the overall control of delayed reverberation time.

Audio reverberation is generally speaking the build-up of sound(s) in an enclosed space, at the same time as the direct result of the addition of sound components from simple/-multiple reflected pencils/rays of sound returned from the reflecting surfaces.

Reverberation time is defined as the time for the sound to decay (usually exponentially) to one-millionth of its initial energy level, a level of 60dB down. For single closed-loop paths this can be explained by a simple formula:—

$$T = 60 \frac{t}{\alpha} \quad (\text{seconds})$$

where: T=reverberation time in seconds

where t=time delay in seconds for one passage

$\alpha$  =attenuation (in dB)

This relationship results in the following conclusions:

1. Shorter reverberation time T can be produced by introducing greater attenuation or shorter delay.

with tape units but both these types just cannot withstand CCD competition!

Electro-mechanical delay lines have many limitations and one of

them as far as the spring type reverberation unit is concerned, is 'microphonic' distortion which causes unwanted 'metallic voice' and very often something worse --

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2. Longer reverberation time  $T$  requires longer path delay or less attenuation.

Also note that a 10 milliseconds delay corresponds to a room path length of less than 10 feet for one trip:

## Stables bolted

As one of the most important problems is maintaining the stability, it is preferable to use relatively long delays with higher values of attenuation.

Coming back to Fig. 4, the output power is increased approximately in proportion to the number of paths  $N$ , with an overall system gain of  $10 \log N$  (dB), thus additional paths are added to maintain the same total reverberation time. In audio practice many parallel delay paths are required to simulate a 'real' reverberant room with a minimum number of four.

The SAD 1024 uses a single 15 volt power supply, input bias of +6 volts, and because of the existence of op-amps in this circuit,  $0, \pm 15$  volts.

Analysing one section only of this evaluation circuit (Fig. 5), let's set the TTL clock input at a frequency input of 200 kHz and the audio signal input to a single sinusoidal tone at 5kHz. The SAD 1024 requires a "two-phase" signal O1 and O2 as the clock drivers are complementary pairs of associated waves. This is done by dividing the 'virgin' clock input rate employing both sections of 'flip-flop' chip. As the input was 200kHz dividing this by two gives waveforms of 100kHz rate with a  $10\mu$  sec. period.

Assuming that O1 is "high" the input  $N$  channel MOS transistor applies signal input A to  $C_s$ , the relevant op-amp ( $AR_2$  in fig. 5) inverts

(O2 — low) passing our charge to the next exchange cell. This completes one full cycle.

## Cell locks

The SAD 1024 is built from 512 cells (in one section) with a clock frequency of 200 kHz as an example, the input signal appears at output after a 2.56 millisecond delay. Both outputs are connected to a 11 k balance potentiometer thus providing a summed signal with a continuity over the full clock period. Note that the output signal, and O2, in channel A, both cover the whole length of the cycle.

Finally, the output op-amps ( $AR_1/AR_2$ ) invert the signal, and smooth the "stair-steps" discriminating against residual clock glitches.

The 512 stages of SAD 1024 are available separately under the commercial name of Reticon SAD 512.

## Mullard TDA 1022

The TDA 1022 is a MOS monolithic integrated circuit with an internal structure and pin identification as shown in Fig. 6.

This particular device contains 512 stages and with the clock frequencies ranging from 5 kHz-500 kHz will produce a time delay from 51.2-0.512 m.sec.

The package is a 16 lead plastic dual-in-line and amongst its many applications are:-

- Variable delays of analogue signals, E.Q. — speech delay in P.A. systems, instruments: Vibrations / chorus / echo effects / reverberation.

- Variable compression / expansion of speech in tape-recorders.

Specifications of the device are shown in Table 2.

Last year during the 9th International Exhibition of APRS 76 (International Association of Professional Recording Studios), the MANTIS Echo Unit from Carlsbro Sound Equipment was presented. This employs in its construction eight Mullard TDA 1022s.

The MANTIS construction is a commercial example of successful TDA 1022 application, and as seen in this case several TDA 1022's work in a series configuration. A practical diagram from the Mullard Application Report (Ref. 6) shows a completed circuit using 2 CCD's. Fig. 7.

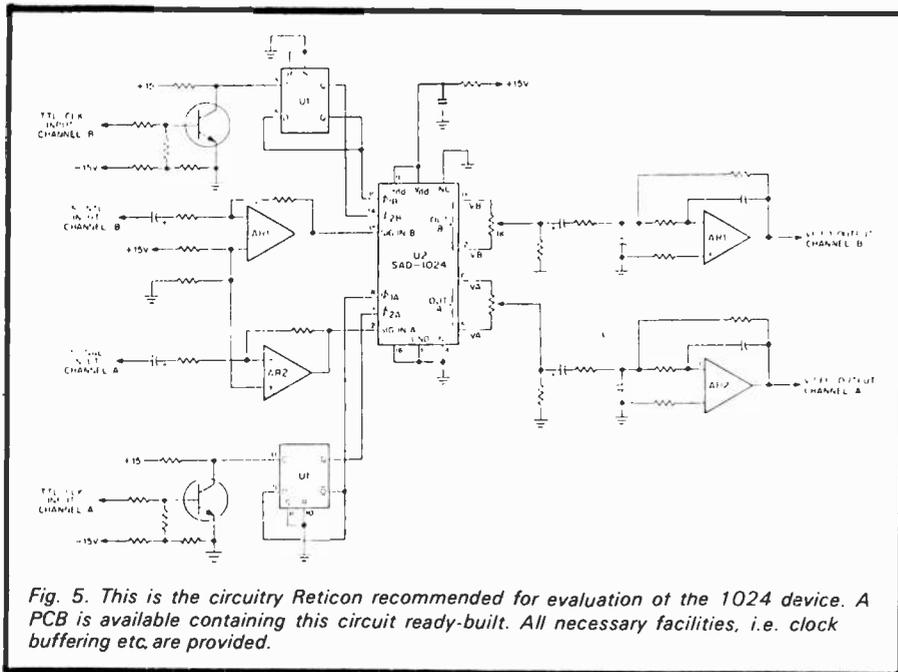


Fig. 5. This is the circuitry Reticon recommended for evaluation of the 1024 device. A PCB is available containing this circuit ready-built. All necessary facilities, i.e. clock buffering etc. are provided.

## Reticon SAD 1024 CCD

For evaluation (and some applications) Reticon developed their SC 1024 Evaluation circuit. The basic design is presented in Fig. 5

This circuit provides all the necessary buffering, power supply, input bias, TTL — clock input and input/output facilities. (Practically independently for both 512 stage halves of the device too.)

the input signal, and superimposes it on an (approximate) 6 volt bias.

Meanwhile O1 changes its state to "low" and the input voltage level is charges the storage capacitor ( $C_s$  in Fig. 2). As O2 is at this moment "high" a connection between  $C_s$  and the first bootstrap capacitor of the output of Cell no. 1.

Cell no. 1 now accepts a charge from  $C_s$  and clock O1 goes "high"

## Clock Oscillators for SAD 1024 and TDA 1022

Both CCDs reviewed here are pure analogue "clocked" devices and require a relevant incorporated oscillator facility. As far as TDA 1022 is concerned, up to 10 chips can be operated with the system configuration recommended by the manufacturer and shown in Fig. 8.

The circuit consists of an all IC clock oscillator capable of generating the frequency output signal from a range of 5-500 kHz by suitable

<b>Supply voltage (pin 9)</b>	-15V
<b>Clock frequency</b>	5 ÷ 500 kHz
<b>Number of buckets</b>	512
<b>Signal delay range</b>	to 0.512 m.s
<b>Signal frequency range</b>	to 45 kHz
<b>Input voltage (at pin 5) /peak-to-peak value/</b>	typ. 7V
<b>Line attenuation</b>	typ. 4dB
<b>Output current</b>	0 to 5mA
<b>Signal input voltage at % o/p voltage distortions (r.m.s.)</b>	2.5V
<b>Noise o/p voltage (r.m.s.) with f4 = 100 kHz</b>	typ. 0.25mV
<b>Signal/noise ratio at max. o/p voltage</b>	typ. 74dB
<b>Load resistance</b>	> 10 Kohms typ. 47 Kohms

**TABLE TWO:** Specification for the Mullard TDA 1022 Charge Coupled Device.

choice of components, and a 2N3904/2N3905 driver system.

Power requirements are standard ( $0 \pm 15V$ ) and any choice of frequency (see Table 3) is simple using easily obtainable components. Clock pulse rise/fall time is better than 100 ns.

f kHz	C	R kΩ
5	8n4	10
10	3n9	10
30	1n3	10
100	330 p	10
300	68 p	10
500	30 p	10

**TABLE THREE:** Setting the clock frequency for the TDA 1022 by selecting component values R and C are referred back to Figure 8. Altering this changes f as shown above.

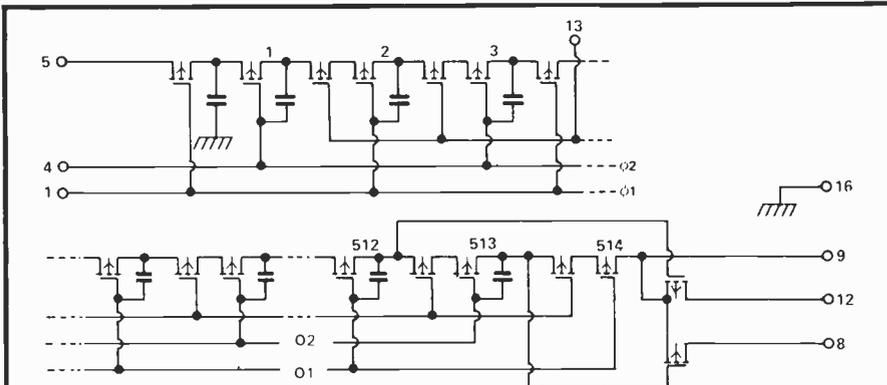


Fig 6. Internal circuitry of the Mullard TDA 1022 Bucket Brigade chip. The pin functions are as follows: Clock input ( $V_{CL2}$ ). 2. NC. 3. NC. 4. Clock input ( $V_{CL2}$ ). 5. Signal input. 6. NC. 7. NC. 8. Output 513. 9.  $V_{DD}$ . 10. NC. 11. NC. 12. Output 512. 13. Tetrode gate. 14. NC. 15. NC. 16. Ground

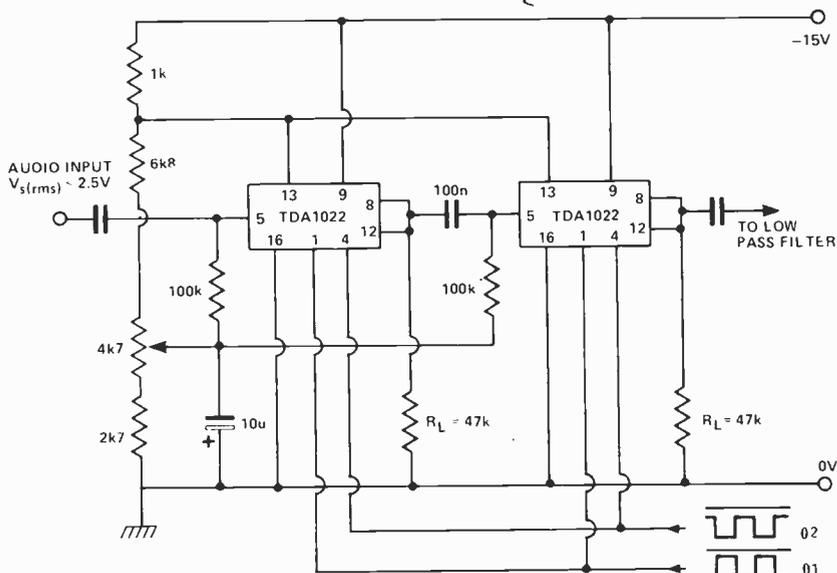


Fig 7. A Mullard circuit for general purpose use of the TDA 1022. Here two units are connected in series to obtain a longer delay time between input and output. No clock circuitry is shown.

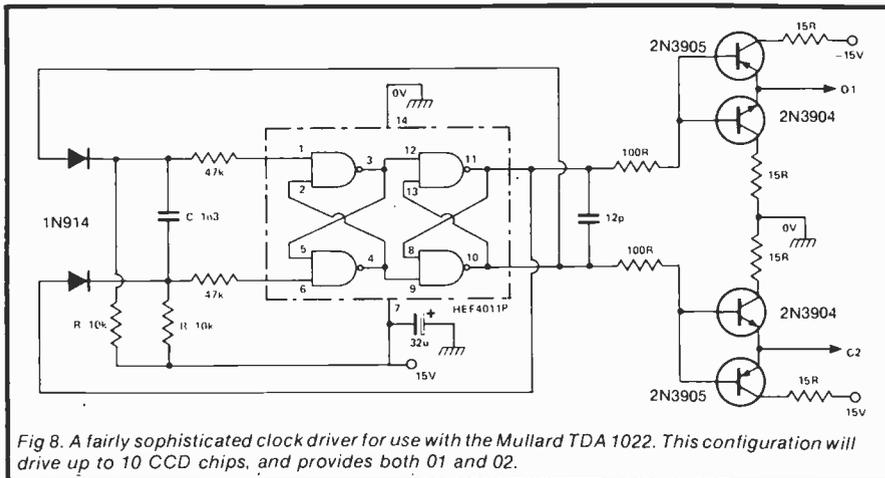


Fig 8. A fairly sophisticated clock driver for use with the Mullard TDA 1022. This configuration will drive up to 10 CCD chips, and provides both 01 and 02.

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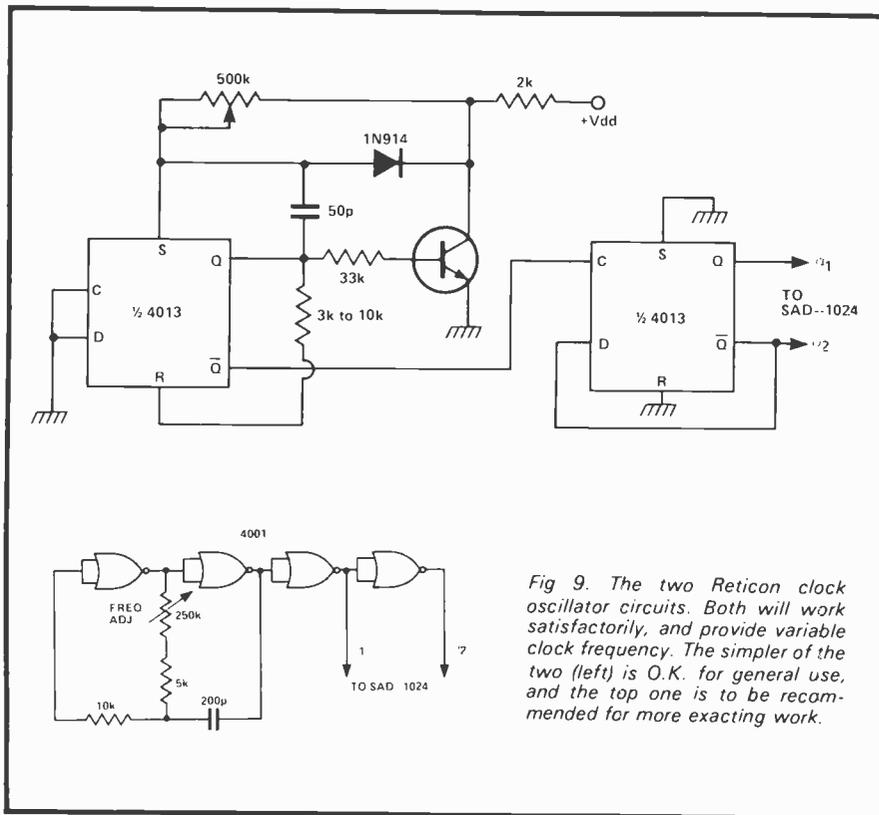


Fig 9. The two Reticon clock oscillator circuits. Both will work satisfactorily, and provide variable clock frequency. The simpler of the two (left) is O.K. for general use, and the top one is to be recommended for more exacting work.

Returning to the Reticon SAD 1024 or SAD 512, the manufacturer's data contains two simple clock constructions (Fig. 9) recommended when using these Bucket Brigade devices. The first one is based on a 4001 and is simple in design with a variable frequency adjustment using a 250k potentiometer.

The second variable frequency clock generator is slightly more sophisticated and consists of a 4013 IC and a single NPN transistor. Both halves of the 4013 are coupled in series producing the required clock signal and dividing the waveform into the complementary train of pulses. A single 500k lin potentiometer acts as the frequency adjustment element.

A more recent development is the Matsushita Electronics MN3005 CCD, with 4096 steps, capable of a delay of up to 205 milliseconds.

Acknowledgements to Herbert Controls, Mr. Andy Longford, and Muliard's Technical Information Department for providing information, data, technical papers and other significant contributions.

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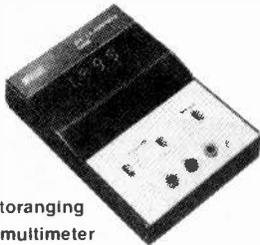
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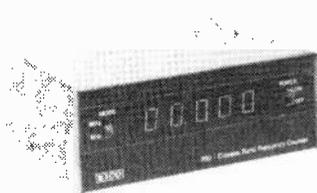
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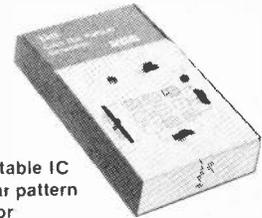
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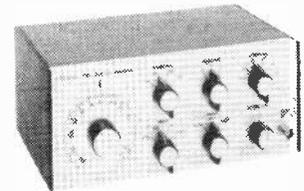
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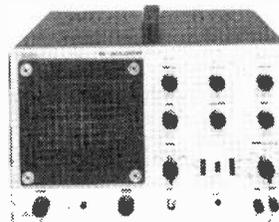
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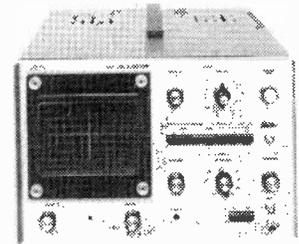
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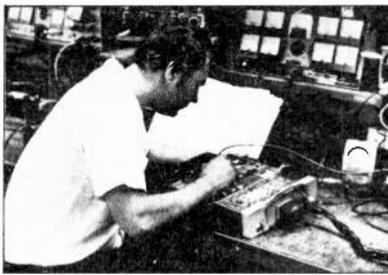
### TIPS

Identifying 74 Series  
Supply Pins  
Soldering IC's  
Tinning With Solder Wick  
PCB Stencils  
Front Panel Finish  
DIL Drilling  
Fluorescent Starting  
Avoiding Insulated Heat Sinks  
TTL Mains Interface  
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IN OUR LAST article in this series, (Sept. issue), we explained the various forms of mechanical telegraphy that have evolved and how signals from these devices can be sent over very long distances by wire and radio. Until the era of the microcomputer, these signalling systems were limited in their use by the amateur to the sending of messages (and sometimes very cleverly-shaded pictures, using light and dark letter and figure combinations) between two points. Despite the limitations of the Baudot code, and

hardware is shared between the many functions of the station and it is the easily-changed program that connects the system up in the manner desired for a particular operation.

### WHAT IS A MICROCOMPUTER?

Basically, a microcomputer is a device for taking bits of information out of a "memory", performing a series of operations on these bits of information (called "data") as directed by the program, and putting the data back

flowing from memory, through the processor and out again to the memory, we need an *Arithmetic-Logic Unit* (ALU).

Finally, we need a master controller to put the whole act together and keep everything running smoothly. This is the *control* section.

In most microprocessor units (MPUs) available today, all of the above functions except memory have been included on the one chip (e.g. M6800, 8080, Z80, etc.) — see last month's *Microbiography* article for

by Bill Johnson VE3APZ

# BITS, BYTES and BAUDS

## THE NEED FOR AN MPU AND ITS BASIC ARCHITECTURE

the relative inflexibility of discrete logic, amateurs the world over developed systems for automatically turning on their machines, if and when they were specifically called. Thus, the 'autostart' net was formed, a relatively little-known net that generally meets 75 kHz up from the bottom edges of some amateur bands, notably 20 and 80 metres.

However, these logic circuits can be very frustrating and time-consuming to design — a fact which has been greatly helped by the availability of the microprocessor to amateurs.

Going back to the previous example of RTTY, an autostart unit consists of many TTL chips, some for decoding the incoming RTTY, some for timing, others for comparing the characters received with the station's call-sign etc. Once the unit is built, it represents an investment of one to two-hundred dollars in a little black box that can only act as an autostart unit. Suppose the amateur then wants to add a Baudot-to-ASCII converter to his setup — he must invest another \$100 in a unit that will perform that service for him, and so on until he has a station full of black boxes that are, all together, probably worth more than his main r.f. transceiver.

Now, with a microcomputer he can replace all those gadgets, save himself a lot of money, and at the same time have a very flexible station that can be easily re-programmed at any time to operate in a slightly or a completely different manner. The whole idea of the microcomputer is that the actual wired

into memory, either in the same place or a different place, as the circumstances require. Sometimes the memory that it is working on is actually a set of flip-flops attached to some external device, sometimes the memory is "core" memory, sometimes it is one of its own internal registers. Either way, there is usually an input, some arithmetic or logic operations, and an output. Sometimes the data are written back into the same memory location as they were read from, thus destroying the original contents of that location, and sometimes they are written into a different location, so that the original data are preserved.

In each case described above, what is happening is a *transfer* of data. It can be said that *every instruction that a computer performs is a transfer of one kind or another*. The data may be modified *logically* (see Fig. 1) or *arithmetically* (see Fig. 2), but they are always *transferred*.

### WHAT'S IN A MICROCOMPUTER?

As we can see from above, *memory* is always handy to have around. Without it, the microcomputer cannot store a program or data.

We also see that we must have some way of getting information from memory into the computer, and getting the results out of the computer and storing them in memory. This is called I/O (Input/Output).

In order to perform arithmetic and logical changes to the data, while it is

Fig. 1. 'AND'ing two memory locations together.

Computer compares each bit in location A to each bit in location B — if they are both in '1' then result is 1

1	0	0
0	1	0
1	1	1
1	1	1
0	1	0
0	1	0
1	0	0
0	1	0
LOCATION A	LOCATION B	RESULTING PRODUCT R

Mathematical Notation  $A \cap B = R$

more information. All that is required is to add memory, put a program in it, and you have a microcomputer. (Actually, some chips have memory built right onto them, so that the whole system can be made very cheaply, but this is presently restricted to units that are made in the thousands because of the extremely high cost of mask-programming the computers when they are made.)

### BYTES, WORDS, AND DATA PATH WIDTH

The commonly-used microprocessors are generally '8-bit' machines. This means that every memory location, or *address*, can be visualised as being eight separate flip-flops, each of which can be set to the '1' state (ON) or the '0' state (OFF). Also, every circuit in the I/O and ALU sections is duplicated

Fig. 2. Arithmetic adding of two memory locations.

Computer adds each bit in location A to the corresponding bit in location B. If they are both 1, a carry is generated to the next bit down.

```
LOCATION A 0 0 0 1 1 0 0 1
LOCATION B +0 1 0 1 1 0 0 0
LOCATION C =0 1 1 1 0 0 0 1
```

Mathematical Notation  $A + B = C$

eight times, so each bit coming out of memory or going back into it is operated on by its own, dedicated circuits. Thus the operations happen concurrently, or in *parallel*. *Data path width* is the number of bits that can be acted upon in this parallel manner by a microcomputer.

Just as you may have already guessed, there also exist serial machines which do not have the multiple circuitry, and must handle data a bit at a time. An example of this is the Digital Equipment Corporation's PDP 8/s, which is 14 times slower than its parallel counterpart. These machines do have a place in data processing and are not to be scoffed at because of their apparent lack of sophistication, because in many applications they are fast enough for the job and they save the cost of the extra circuitry. (A few dollars a unit can really add up if you make several thousand units).

### WHERE THE NUMBERS FIT IN

This is all very well, but a computer's not much good unless you can put numbers in and get numbers out. So far, all we've got is a bunch of flip-flops that can be set and cleared in a zillion different ways like Christmas tree lights. The key to the whole matter is in the so-called *binary numbering system*.

When we were children, we learned how to count up to ten. When we reached ten, we had to remember that we had been through our hand once, and start again at 1 — but this time it was 1 for the one in our head and 1 for the finger, making eleven. When we grew older, we realised that the world doesn't end when we have ten fingers up and ten imaginary fingers stored in our head, and thus we mastered the magical transition from ninety-nine to a hundred, this time storing the big 1 in our toes.

This is fine for us humans, but the poor little computer only has one finger. However, to make up for this handicap, he is blessed with eight hands, each with one finger.

The finger, (bit) can either be up (1) or down (0). Let's see how he counts:

Finger number	7	6	5	4	3	2	1	0	(We always start at zero when dealing with computers)
Human Count:									
	U = Finger up								
	D = Finger down								
	0	D	D	D	D	D	D	D	
	1	D	D	D	D	D	D	U	
	2	D	D	D	D	D	D	U	
	3	D	D	D	D	D	U	U	
	4	D	D	D	D	U	U	U	
	5	D	D	D	U	U	U	U	
	6	D	D	U	U	U	U	U	
	255	U	U	U	U	U	U	U	

Every time the maximum number is reached in a column, we carry one into the next column on the next count. Isn't this just the same as carrying into the tens column when we get to nine, or the hundreds when we get to ninety-nine?

As you can see, our clever little computer can count up to 255 in human terms. (This is actually a count of 256, since we started from zero).

So a computer with an eight-bit data path can store a number up to 255. What about a computer that has 12 or 16 bits? Well, we see that in the case of 8 bits, the value  $2^8$  is 256 — our old friend!

If we look at  $2^{12}$ , we see that a twelve-bit machine can store a number as big as 4096. This is still not very impressive, and we must go to a 16-bit machine before we get a nice big figure, 65,536.

Let's assume we don't want to spend the extra money for a 16-bit machine to give us the 65,536 (usually referred to as 65k) storage capability, but we might occasionally want to do arithmetic using sums this large. The answer is to break up the numbers into two chunks (bytes) of 8 bits each, called the lower byte and the upper byte, and make up a 16-bit word. This is all very well, but we still need to add the numbers 8 bits at a time. This is usually taken care of by a bit called the *carry*. The carry bit is made a 1 if the addition of the two 8-bit numbers in the lower

byte makes a number that is too large to store in an 8-bit memory location. What happens in this case is that the carry, if a 1, is added to the sum of the two upper bytes that are added after the lower byte, so that the result of adding the two 16-bit numbers is another 16-bit number.

The use of only 8 bits is called *single-precision* arithmetic. Where a number is stored as two bytes, the term is *double precision*. If the programmer thinks that he might be dealing with numbers that may be too large to store in two bytes, he may use three bytes or more, each addition process being linked to the one previously done on the byte before it by the carry bit. (For this reason, the carry bit is sometimes called the *link*). This is known as *multiple precision* arithmetic, but is very rarely used.

### MEMORY ADDRESSING

Every memory location can store 8 bits of data, and can be uniquely addressed by the bits put out by the computer on its address lines. (See next month's article on bus structure, peripherals, and I/O transfers). A memory address is purely a number assigned to a specific location so that the computer can remember where it stored things.

If we use an 8 bit data address, we can reference only 256 locations, which is hardly enough to be of any practical value. Most microcomputers have a 16-bit program counter register (memory address of the next instruction to be executed), index register (Used for referencing data in tables) and stack pointer (used for remembering where temporary values are stored) — all of which can be manipulated as two 8-bit registers and added as 16-bit numbers.

The next article in this series will show how the microprocessor interacts with its memory via the address and data lines, how peripheral devices are connected, and how transfers take place to peripherals using both interrupts and programmed transfers.

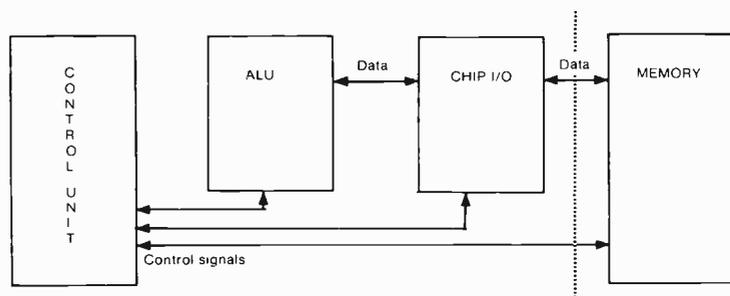


Fig. 3 — Data flow through microcomputer



by Wally Parsons

IN CASE ANYONE hasn't yet heard, 1977 marks the 100th anniversary of sound recording. Mary's little lamb has long ago become veal cutlets, but Thomas Edison's recorded announcement of its birth lives on, as well as a whole lot of other things many of which might have been better left unrecorded. But that's show biz, as they say, and makes fine grist for the record reviewer's mill.

So much has been said and written this year about the history of sound recording that it becomes difficult to find something new and original. But the venerable Canadian National Exhibition, an historical institution in its own right, managed to rise to the occasion by providing the sight for an exhibition built around the theme of Canada's contribution to the development of the recording art, produced by the Canadian Recording Industry Association (CRIA). The show is said to have been the best produced anywhere in the world, and I, for one, can believe it.

Now, if you think of Canadian recording in terms of Don Messer and Anne Murray, now's the time to look a little further.

## HISTORY IN BRIEF

As everyone knows by now, in 1877, Thomas Edison first recorded the words "Mary had a little lamb" on a cylinder covered with tin foil, a machine developed from an invention by a Frenchman named Leon Scott de Martinville. Unfortunately, de Martinville's machine could not play back its recording, but made a great little oscillograph, so people could sit around and look at the music, much in the manner of today's audiophiles who

own 4-channel receivers with built in oscilloscopes. Much of the credit for this achievement must go to the government of Ontario, or Upper Canada, as it was then called, for having the foresight to issue a warrant for the arrest of Edison's father, who, like many Canadians before him, and many who followed, promptly trotted off to the United States.

Anyway, this tin foil cylinder was still a long way from modern recording, despite what the caustic comments of some critics would lead us to believe. Happily, another Canadian inventor, Alexander Graham Bell invented a gadget called the telephone. What, you may ask, had this to do with cylinder records? Well, we didn't pay too much attention to this invention here, of course, but the government of France awarded him the Prix Volta, and 50,000 francs, which he promptly used to build the Volta Laboratories in, naturally enough, Washington D.C. From this lab came the wax cylinders which made the Graphophone, as it was called, a commercial reality.

It's success, spurred Edison to further development of his phonograph, and in 1886 he demonstrated a greatly improved version at the Toronto Industrial Exhibition. What happened to the Toronto Industrial Exhibition? It became the Canadian National Exhibition. The recording made of the voice of Lord Stanley, then Governor-General has been lost, but as it was reproduced in 1935, it remains the oldest known record in existence.

## BERLINER

But business is business, and it was not long before the Edison and the Bell organizations tried putting the boots to

each other, with Bell trying to grab off Edison patents (does all this have a familiar ring?). So intent were they in this time-honoured ritual that they failed to notice a German immigrant named Emile Berliner. Now Emile was busy personifying the American Dream. He went to the U.S. stone broke, and in a few years found fortune, if not immediate fame, by developing and selling to Bell the microphone. By 1887 he had secured patents for a Gramophone using 5-inch rubber discs.

In short order he had set up operations in Britain and Germany, then returned to the U.S. where he sold his U.S. patents. By 1897 he had moved to Canada, set up operations in Montreal and by 1899 he and his son Herbert were the dominant figures in the Canadian recording business, pressing and distributing for all Berliner-affiliated companies in the world.

Much of this is documented in detail in a large, profusely illustrated booklet made available along with a recording of excerpts from landmark and representative recordings from 1888 to 1927 (including Guy Lombardo's first recording, and a speech by McKenzie King). A detailed examination of this book strengthens the idea that maybe there is no such thing as history; that the affairs of man' ind go around in circles. For example, one of the main reasons for Berliner's establishment in Canada was to tap what was described as "the lucrative and fiercely patriotic French-Canadian market". For "patriotic" many would read "nationalistic".

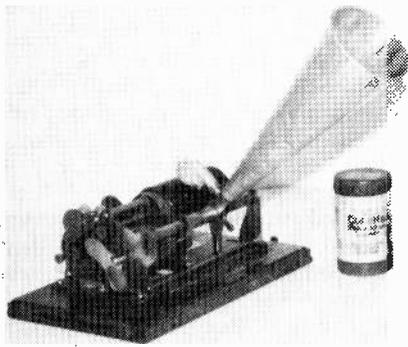
Item: Berliner was really forced to establish in Canada because he had sold out his rights elsewhere, and Canada was the only place left to go.

Item: In 1899 "E. Berliner, Montreal" was founded, with four presses installed in the Bell building. That year he ordered his U.S. division to halt all exports to Canada. Thus was born the Canadian Recording Industry, a pressing plant to make possible lower prices in imported product.

Item: The first patent application for the double-sided disc was filed by Colin McKenzie, a Whitehorse, Yukon resident. Victor, a U.S. company founded on the patents which Berliner had sold, promptly grabbed control of the patents and sat on them for as long as possible.

This whole history seems to read like a text-book on double-dealing and restrictive trade practices, with the Berliner family demonstrating considerable skill in this area.

Item: In 1918, Herbert Berliner secretly set up the Compo



The Columbia Eagle Graphophone, 1898 model Price, with sapphire stylus, \$12.00. The thing that looks like a wind up key really is.

Company in Lachine. In 1921 he left the family company, and obtained a license to press and distribute American labels. At this point he hit a brick wall of his own construction. While still with E. Berliner, and distributing Victor records Herbert had done such a good job of restricting competition by locking up dealers that he had problems lining up dealers for his own product, which was now the competition. Solution: rack jobbing.

In 1935 Compo obtained a license to press and distribute Decca (U.S.) releases. With the rise of Decca's importance in the U.S. its importance to Compo rapidly increased, and finally in 1951 Compo became a U.S. Decca subsidiary.

During his tenure, Herbert was responsible for many technical innovations, not the least of which was the development of synthetic pressing materials to replace the shellac which was in short supply during the war, producing a superior disc to that manufactured by the competition from recycled records. It would be interesting to speculate on whether or not Compo would have continued for so long pressing LP's on that hard brittle material which they used up until the advent of stereo, had Herbert remained with the Company. Perhaps he would have worked on something like the large scale use of exotic techniques as Microfusion, developed by Emory Cook for small scale production, and which was a major factor in the high quality of his fairly limited editions.



## TODAY

The show itself was housed in the old Automotive Building, a deliciously ironic choice to anyone familiar with Canada's once thriving automotive industry. To the east of the building lie the Princes' Gates, to the west the last steam locomotive removed from

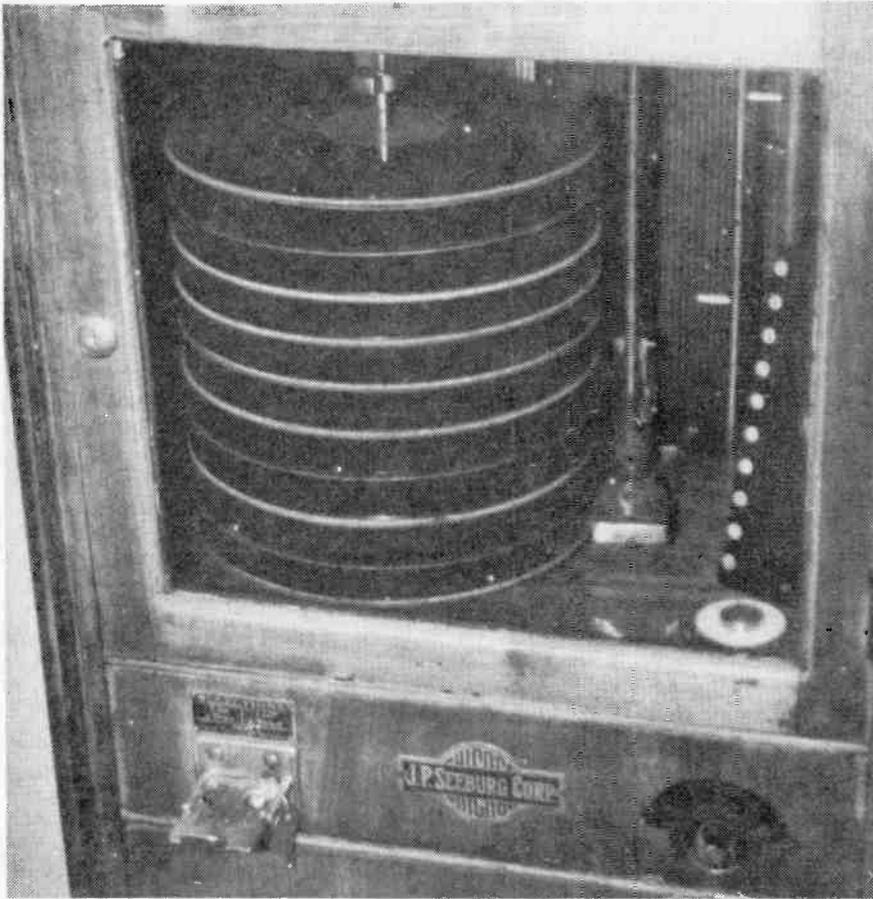
Nipper, and the machine he made famous.



service by CNR, and to the north the streetcar loop, not far from the location of the demonstration of electric street railways, also at the Toronto Industrial Exhibition.

But one's first impression upon entering the building is far from a sense of history. Rather, one is inundated from all sides by an unrelenting din as multiple loudspeakers all project a variety of conflicting sounds, driven by overloaded amplifiers, all vying for attention at one and the same time. To this were added the sight of dim fuzzy holograms, and the videotape at a rock concert, whose picture was only slightly less distorted than the accompanying sound track. This was not exactly an encouraging first impression, but I pressed on while my wife struggled valiantly and not too successfully to hide her feeling of distress, and finally made it to the mezzanine and the historical display.

This was a little more like it, a lovely still oasis in a sea of cacophony. It was like crossing over into the Twilight Zone, even the entrance having a quality akin to that of a time tunnel, presided over by the distinguished presence of Edward B. Moogk, of the National Library of Canada. This was what it was really all about. I don't mean just the fascinating but still



And the music goes round and round — all ten discs at once, in this 1931 vintage Seeburg juke box.

inevitable collection of antique phonographs, or the 5-inch rubber discs, or even the sample of an early record changing attachment (it was really a method of replaying the record on which it was fitted, and its operation still isn't too clear). But rather a sense of the not always orderly, but nevertheless inevitable development of what is one of the most important of the twentieth-century technologies.

Forgetting the Encyclopedia pitchmen nearby (I still don't know why they were there), or the irrelevant little trinket stands dotted about like refugees from a flea market dropped by mistake in the middle of Birks Jewellers. The roar from the main floor became a dull background hum, an ever-present, but distant reminder of where it was all going. And everywhere pictures. Pictures of artists, a Guy Lombardo poster, patents, and Nipper, probably better known than Rin Tin Tin, Lassie, and the Bionic Dog put together. For a while it was possible to forget how much of the Canadian record industry is now and always has been essentially a branch plant industry. The one reminder being the absence of any Canadian made equipment. And down below all the

American record companies waving the maple leaf, and Sam the Record Man busily turning over a nice profit with a temporarily built record store.

### STUDIO

Further along one side of the Mezzanine stood a fully equipped recording studio in operation. The only way to describe it is "impressive". This was no basement set-up with portable

consoles and recorders in a jury-rigged hookup. No sir. This was a full-blown professional 16 channel studio, with double doors, double glass partitions, Robinson acoustic tile treatment and JBL's biggest studio monitors. Any one who has ever had a hand in setting up such a studio would appreciate the enormity of this achievement. A facility which would only last for three weeks assembled, soundproofed, and acoustically balanced as if it were to stand forever.

Flowers and kudos to the Canadian Independent Record Producers Association. The whole function of this studio was to allow unknown, not always professional groups and artists an opportunity to tape an audition and keep the tape at no cost, and with just as much professional care and skill endowed upon the tape as if the production staff's next gold record depended on it.

Despite the hucksterism and hokum (including some rather questionable advertising claims) one came away with the feeling that the recording industry in this country, although in its infancy is in reasonably good health, and given half a chance may even survive. Now if we can only get it into our heads that we can build equipment here, as well as use it, we might even have an audio equipment industry equally healthy. Sadly conspicuous by their absence were things like Bryston amplifiers and Dayton-Wright loudspeakers. Well, maybe tomorrow. That is, if all the current companies haven't gone bankrupt in the meantime.

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# ETI DATA SHEET

570/571

SIGNETICS

The 570/571 is a versatile low cost dual gain control circuit in which either channel may be used as a dynamic range compressor or expander. Each channel has a full wave rectifier to detect the average value of the signal; a linearized, temperature compensated variable gain cell; and an operational amplifier.

## Circuit description

The 570/571 compandor building blocks, as shown in the block diagram, are a full wave rectifier, a variable gain cell, an operational amplifier and a bias system.

The full wave rectifier rectifies the input current which flows from the rectifier input, to an internal summing node which is biased at  $V_{REF}$ . The rectifier current is averaged on an external filter capacitor tied to the  $C_{RECT}$  terminal and the average value of the input current controls the gain of the variable gain cell. The gain will thus be proportional to the average value of the input signal for capacitively coupled voltage inputs.

The speed with which gain changes to follow changes in input signal levels is determined by the rectifier filter capacitor. A small capacitor will yield rapid response but will not fully filter low frequency signals. Any ripple on the gain control signal will modulate the signal passing through the variable gain cell. In an expander or compressor application, this would lead to third harmonic distortion, so there is a tradeoff to be made between fast attack and decay times, and distortion.

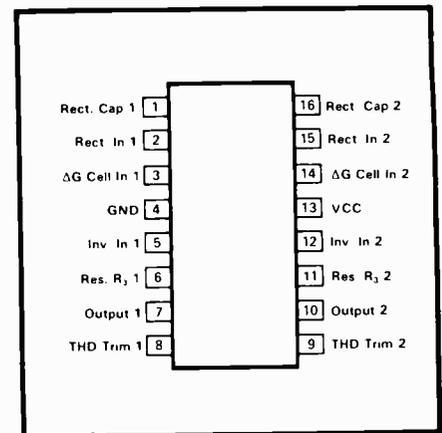
A compensation scheme built into the  $\Delta G$  cell compensates for temperature, and cancels out odd harmonic distortion. The only distortion which remains is even harmonics, and they exist only because of

## Features

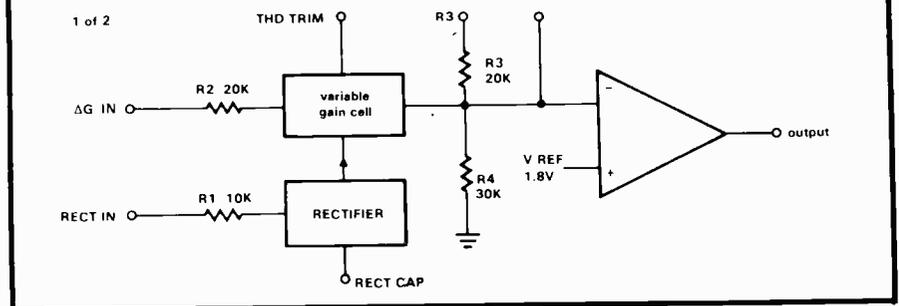
- Complete compressor and expander.
- Temperature compensated
- Greater than 110dB dynamic range
- Operates down to 6Vdc
- System levels adjustable
- Distortion may be trimmed out

## Applications

- Telephone subscriber compandor
- High level limiter
- Low level expander — noise gate
- Dynamic noise reduction systems
- Voltage controlled amplifier
- Dynamic controlled amplifier
- Dynamic filters



## BLOCK DIAGRAM



internal offset voltages. The THD trim terminal provides a means for nulling the internal offsets for low distortion operation.

The operational amplifier (which is internally compensated) has the non-inverting input tied to  $V_{REF}$ , and the inverting input connected to the  $\Delta G$  cell output as well as brought out externally. A resistor,  $R_3$ , is brought out from the summing node and allows compressor or

expander gain to be determined only by internal components. The output stage is capable of  $\pm 20\text{mA}$  output current. This allows a +13dBm (3V5 rms) output into a 300 ohm load which, with a series resistor and proper transformer, can result in +13dBm with a 600ohm output impedance.

## Basic expander

Figure 1 shows how the circuit would be hooked up for use as an expander. Both the rectifier and  $\Delta G$  cell inputs are tied to  $V_{IN}$  so that the gain is proportional to the average value of  $V_{IN}$ . Thus, when  $V_{IN}$  falls 6dB, the gain drops 6dB and the output drops 12dB.

The maximum input that can be handled by the circuit in Figure 1 is a peak of 3V. The rectifier input current should be limited to  $I = 3V/R_1 = 3V/10K = 300\mu\text{A}$ . The  $\Delta G$  cell input current should be limited to  $I = 2V_8/R_2 = 2V_8/20K = 140\mu\text{A}$ . If it is necessary to handle larger input voltages than  $0 - \pm 2V_8$  peak, external resistors should be placed in series with  $R_1$  and  $R_2$  to limit the input current to the preceding values.

The output of the expander is biased

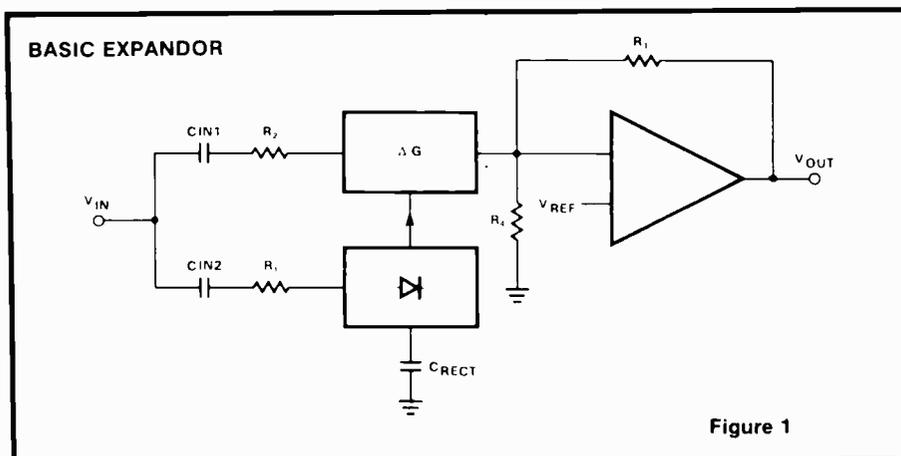


Figure 1

up to 3V by the dc gain provided by  $R_1$  and  $R_4$ . The output will bias up to the values shown in the following equation. For supply voltages higher than 6V,  $R_4$  can be shunted with an external resistor to bias the output up to  $\frac{1}{2}V_{CC}$ .

To obtain the largest dynamic range out of this circuit, the rectifier input should always be as large as possible (subject to the  $\pm 300\mu A$  peak current restriction).

### Basic Compressor

Figure 2 shows how to use the NE570/571 as a compressor. It is just an expander in the feedback loop of an op amp. If the input rises 6dB, the output can rise only 3db. This is so because the 3dB increase in output level produces a 3dB increase in gain in the  $\Delta G$  cell, yielding a 6dB increase in feedback current to the summing node.

The same restrictions as to rectifier and  $\Delta G$  cell maximum input current still hold, which place a limit on the maximum compressor output. As in the expander, the rectifier and  $\Delta G$  cell inputs could be made common to save a capacitor, but low level tracking accuracy would suffer. Since there is no dc feedback path around the op amp through the  $\Delta G$  cell, one must be provided externally. The pair of resistors  $R_{DC}$  and the capacitor  $C_{DC}$  must be provided.

Absolute Maximum Ratings	
$V_{CC}$	18 Vdc (571)
$V_{CC}$	24 Vdc (570)
$T_A$	-40 to +70° C
$P_D$	400 mW

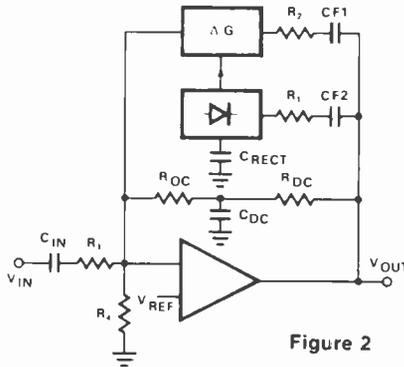


Figure 2

For the largest dynamic range, the compressor output should be as large as possible so that the rectifier input is as large as possible (subject to the  $\pm 300\mu A$  peak current restriction). If the input signal is small, a large output can be produced by reducing  $R_3$ , with the attendant decrease in input impedance, or by increasing  $R_1$  or  $R_2$ . It would be best to increase  $R_2$  rather than  $R_1$  so that the rectifier input current is not reduced.

### Distortion Trim

Distortion can be produced by voltage offsets in the  $\Delta G$  cell. The distortion is mainly even harmonics, and drops with decreasing input signal (input signal meaning the current into the  $\Delta G$  cell). The THD trim terminal provides a means for trimming out the offset voltages and thus trimming out the distortion. The circuit shown in Figure 3 is suitable, as would be any other capable of delivering  $30\mu A$  into a 100ohm resistor tied to 1V8.

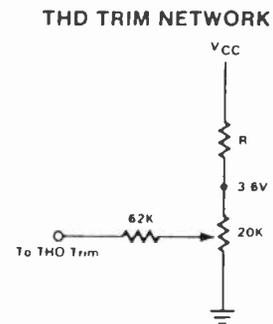
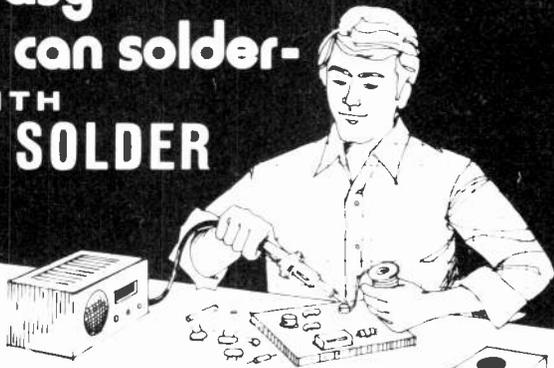


Figure 3

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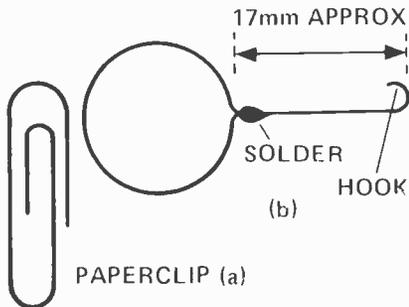


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# tech-tips

Tech-Tips is an ideas forum and is not aimed at the beginner. ETI is prepared to consider circuits or ideas submitted by readers for this page. All items used will be paid for. Drawings should be as clear as possible and the text should preferably be typed. Circuits must not be subject to copyright. Items for consideration should be sent to ETI TECH-TIPS, Electronics Today International, Unit 6, 25 Overlea Blvd., Toronto, Ontario, M4H 1B1.



## Desoldering Aid

C. G. Dixon

Have you ever tried unsoldering resistors from a PCB - especially when the wire on the solder side has been bent over? One hand to hold the soldering iron, another to hold the PCB and yet another to hold the resistor with a pair of fine nosed pliers - which invariably slip off! Here is a better way to do it.

First of all hold the PCB in a vice or, as in the photograph, steady it with a block of wood having a slot cut in it. Next, take an ordinary paper clip and bend it as shown in the sketch so that the ring is a comfortable fit on the first finger of the left hand. Now hook the gadget under the wire at the end of the resistor (or capacitor), heat up the solder and when it is molten pull back with the first finger, at the same time pressing with the thumb and second finger on the PCB.

**WARNING! BEWARE!** Don't be tempted to use copper wire instead of the paper clip - copper conducts heat very well and the ring may not be easy to remove from your finger in a hurry!



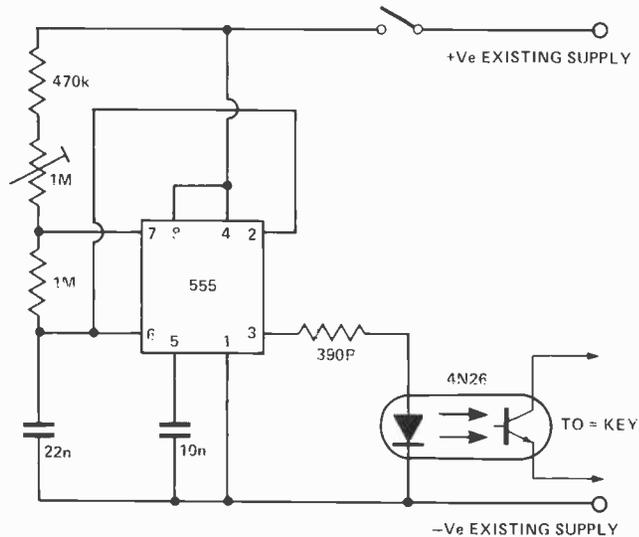
## Calculator Stopwatch

K. C. Phillips,

This circuit can be fitted to any calculator with an automatic constant, to enable it to be used as a stop-watch. The 4N26 Opto Coupler prevents any coupling problems with the '=' key. The 555 timer is set to run at a suitable frequency and connected

to the existing calculator battery via the push-on push-off switch and the existing calculator on-off switch.

This circuit has been fitted to a Hanimex ESR master calculator, with the timer set at 0.05 sec, which is slow enough not to interfere with the debounce circuitry. By using the 'memory to display' key, it is possible to record 2 individual times, as the constant is held after exchange.



## Solid State Switch

N. C. Burkinshaw

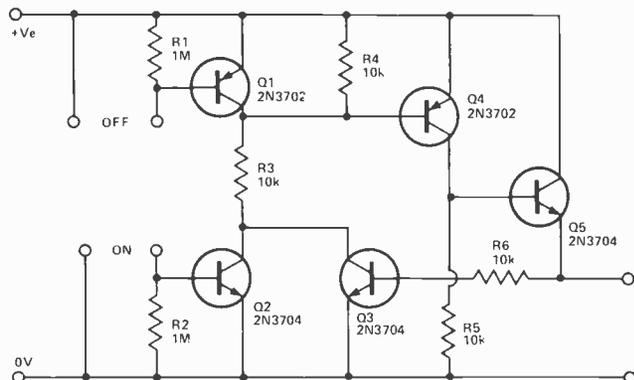
The circuit was designed for use as a solid-state calculator on-off switch, as the mechanical equivalent was found to be unreliable.

Layout is not critical and the switch will operate with a supply from +6V to +15V and current consumption

in the 'OFF' state is a negligible  $30\mu\text{A}$ .

A finger across the 'OFF' contacts turns Q1 off and takes the base of Q4 to the +ve rail, turning Q4 off. This in turn stops Q5 conducting, and R6 and Q3 latch the circuit in this state.

Touching the 'ON' contacts takes R3 to ground turning Q4 on. Q5 now conducts and again R6 and Q3 latch the circuit.



## Anti-surge Voltage Regulator

A. Wey

This high gain voltage regulator with only two transistors has characteristics superior to those of the commonly used compound emitter-follower type.

The circuit was used in a 30 watt stereo amplifier which not only required a well regulated supply, but also an output voltage that would rise slowly from zero volts when the system was first turned on. This slow application (about 2 seconds) to the power amplifiers allowed the 2000 $\mu$ F output capacitors to charge without causing excessive collector current in the output transistors.

Typical regulator output impedance is 0.1 ohm.

Output voltage is expressed by:

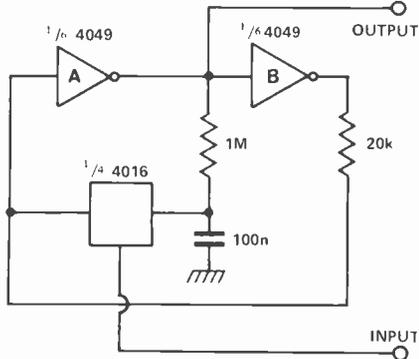
$$V_O = V_Z - V_{BE1}$$

Output voltage rise time is expressed by:

$$T = R_B C_1 \ln(1 - V_Z / V_I)$$

## Improved SPST Switch Flip-flop

D. J. Manford

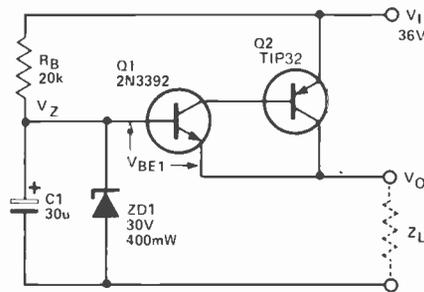


This circuit was developed from the SPST switch flip-flop shown previously in "Tech-Tips", and has the advantage that it can be driven by an input referred to earth—logic outputs or push-buttons.

When the input to the 4016 goes high it connects together the input to A, and C. This 'flips' the latch.

The 20k resistor between the output of inverter B and the input of A is needed as the 4016 cannot pull the output of inverter B down directly.

Some digital systems require a preset turn on sequence for their power supplies. By setting appropriate  $R_B/C_1$  values, the circuit's output rise time can be set to provide this sequence or delay.



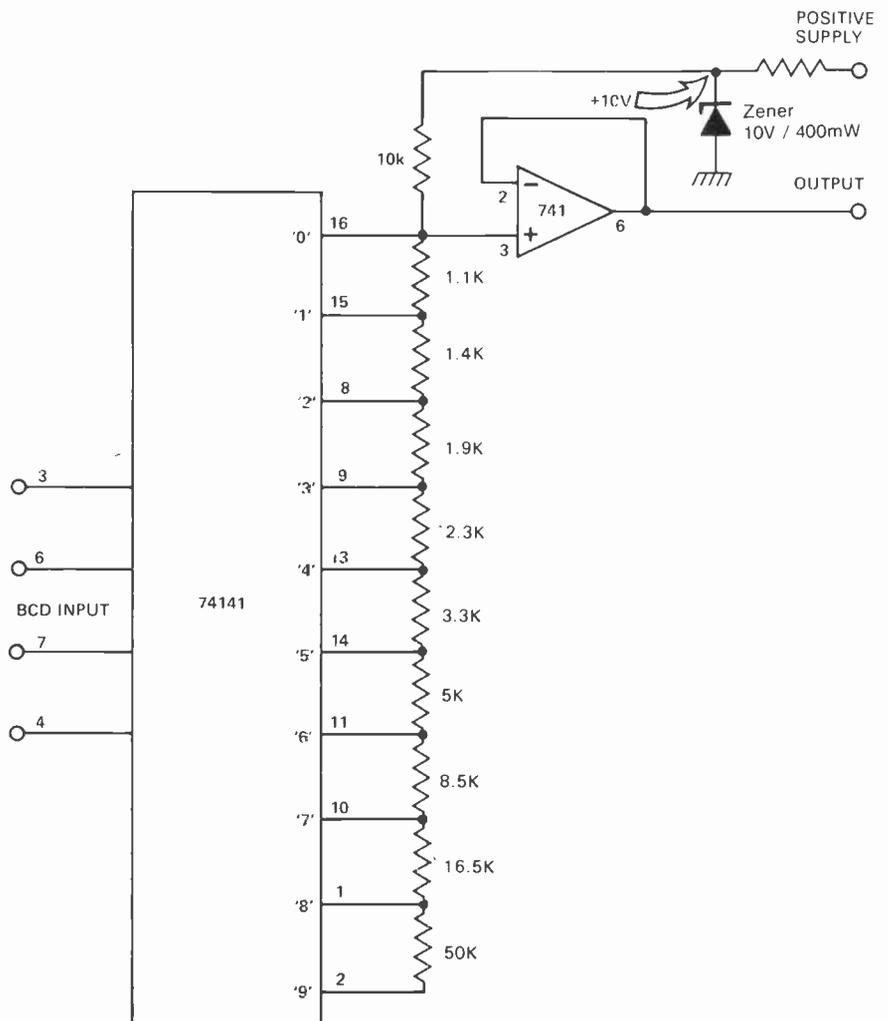
## BCD to Analog Converter

C. R. Poole

This circuit will convert four-bit BCD into a variable voltage from 0-9V in 1 volt steps. Only two ICs are used, both are readily available.

The SN74141 is a 'Nixie' driver, and has ten open-collector outputs. These are used to earth a selected point in the divider chain, determined by the BCD code at the input, and so produce a corresponding voltage at the output.

The accuracy of the circuit depends on the tolerance of the resistors and also the accuracy of the reference voltage. However, trim pots can be used in the divider chain, with correct calibration. The 741 is used as a buffer.



# FEEDBACK



## CHEAPSWITCH

Dear Sir: Just a small point of interest. In the parts list for the Digital Frequency Meter in ETI August, 1977, you listed a cheaper switching assembly. For anyone counting pennies, saving space on the front panel, the Magnum Electronics ad. on page 4 of the magazine has a 4 Pole 6 position rotary switch for \$1.69 that will do the job without a PCB.

J. MacDonald  
Sydney, Nova Scotia

## MORE?

Dear Sir: Congratulations. Your magazine is the first magazine I've read that moved me enough to take pen in hand and write. I believe that space travel is what forged the electronic industry into what it is today, and it gave me great pleasure reading the article on the Kennedy Space Center (August '77). But I'm afraid that if someone doesn't write and tell you they like it, we would read no more.

I would certainly expect to see future issues of ETI containing information on the systems i.e. guidance, tracking, environment control, etc . . . even the equipment used in the "tar paper shack". I'm sure the Russian's knew what was in there so why can't the Canadians. Hope you print some information on this one.

Like your magazine. It's good for the diversified tech. like myself, and it's

CANADIAN! The jokes too I like. (USSR) Cement and shovel for the big power amp. HA! HA! I told you they (Russians) knew what the Americans had in that shack!

R. O'Brien  
St. Hubert, Quebec

*It's certainly an interesting area and one that we will not forget.*

## DANGLING BUSES

Dear Sir: In February of this year I was extremely pleased to see your first issue on the newsstands and I subscribed that day in order to support the development of a Canadian based electronics magazine such as this. I am very pleased to tell you that I certainly have not been disappointed since. The projects are useful and interesting and cover a good range of required ability. This is also true of the Tech Tips section.

Of course one of the greatest contributions a magazine such as yours can make in its field is to interest more people in using electronics to alleviate the "black box" syndrome and I think your publication works quite well in this area for the reasons I have mentioned above. Your extra efforts to shine some light on Canadian suppliers of parts and kits is extremely helpful — without such knowledge the projects would be academic for many readers — and this is another important service that I hope to see continued in your publication.

Professionally, my particular field of endeavour is computer software applications on minis and large scale machines. No one in electronics or computing professions can fail to see the oncoming tidal wave of micro machines as "home" computers. Machines with quite respectable abilities can now be purchased for a price equivalent to that of a very good audio system and, as with audio systems, price per amount of quality and flexibility is coming down.

Micros, however, are plagued with a problem identical to that of all other machines — the power of the machines is in direct proportion to the number and flexibility of its peripherals. Sadly, the peripherals are the most expensive part of most systems and probably the least reliable, being largely electro-mechanical as opposed to purely electrical.

The point of all this, as you may realize by now, is that I see in this trend another area where your magazine could provide a useful service and probably expand the readership. You already provide articles on computers which are basic in content and well worthwhile I think. Computers on the whole probably suffer most from the "black box" syndrome that I mentioned previously. If the cost of peripherals could be reduced a greater number of people could have access to micro-machines.

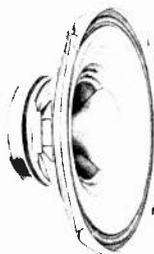
Therefore, how about a request for interfacing ideas and tips? Audio cassette recorders (quite unsophisticated ones at that!) make useful tape storage mediums. Let's find out what other things people are dangling at the end of their I/O busses. Let's have a close look at how to make your micro talk to you through your home television. I am confident that many of your readers are exploring these areas. We could all benefit from a combined effort.

Keep up the good work!

R. Beach  
Carleton Place, Ontario

*Anyone dangling anything interesting — please let us know!*

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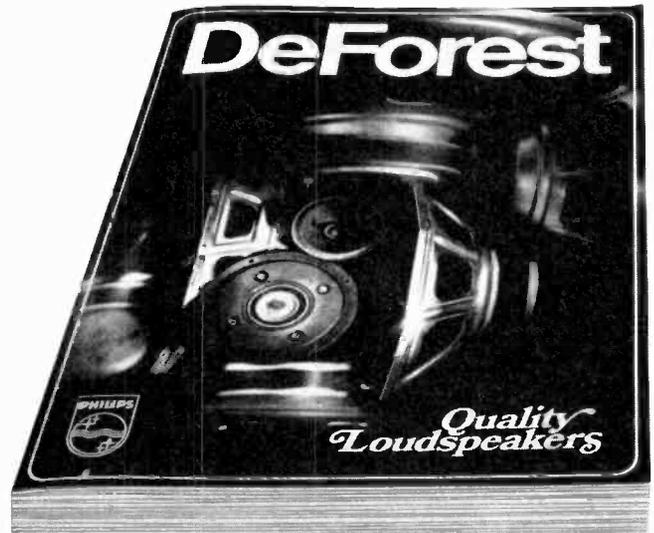
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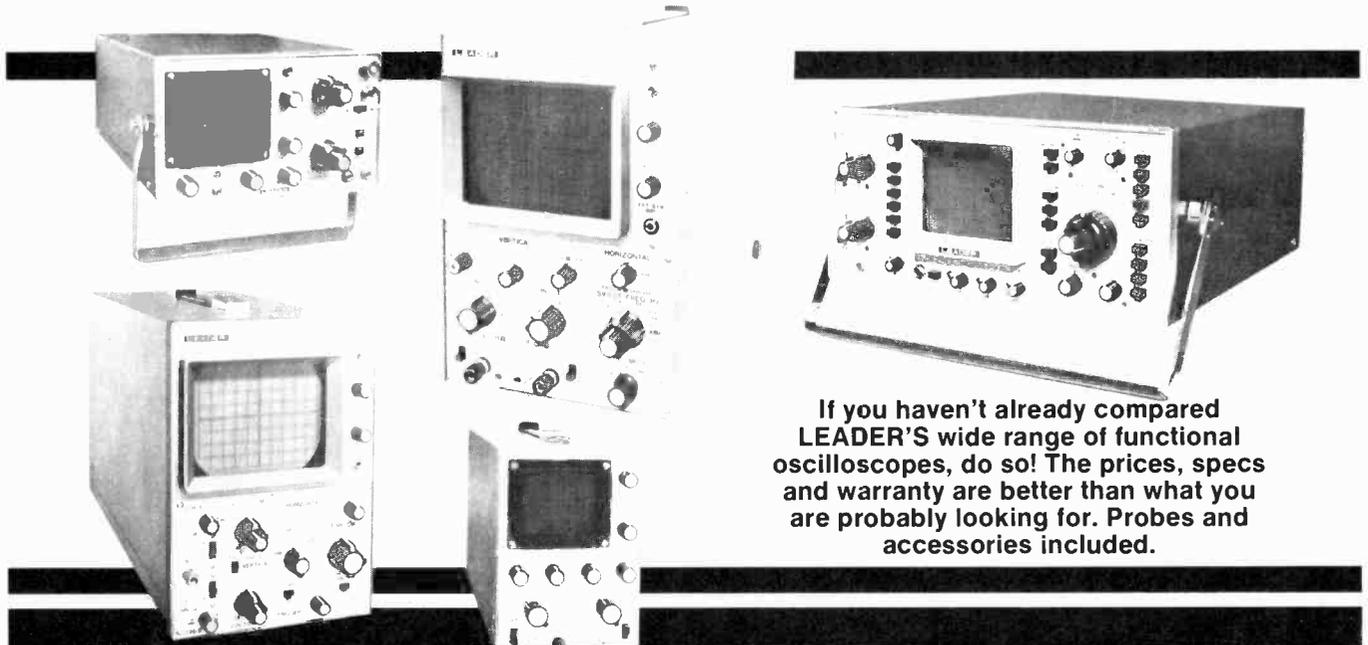
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567	1.80	7815	1.65
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710C	1.20	7824	1.65
723	.85	7905	2.10
733	1.15	7912	2.10
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2N2222	NPN 40V	.25
2N3055	115W PWR	1.25
2N3702	PNP 25V	.23
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MPSA13	5K DARL.	.40
MPSA18	LO NOISE	.45
MJ2955	PNP PWR	1.25
TIP29A	(BD139) PWR	.65
TIP30A	(BD140) PWR	.75

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TYPE	EACH	TYPE	EACH	TYPE	EACH	TYPE	EACH
1B3GT	1.90	6BK4C	4.05	6HS8	2.55	10GF7A	2.95
1K3	2.05	6BL8	1.55	6HZ6	1.35	10GK6	1.65
1S2A	1.50	6BM8	1.60			10GN8	2.05
1X2B	1.25			6JC6A	1.50	10JH8	5.10
2AV2	1.60	6BN6	2.80	6JD6	2.00	10KR8	2.80
2GK5	1.30	6BO5	1.25	6JF6	4.70		
3A3A	2.80	6BO7A	1.85			11HM7	3.85
3AT2	2.25	6BU8A	2.40	6JS6C	4.10	11MS8	2.60
				6JT8	4.50		
3AW2	2.70	6BZ6	1.15	6JU6	4.75	12AT7	1.15
3BW2	2.70	6CA	1.95	6JU8A	1.75	12AU7A	1.30
3BZ6	1.40	6CA7	3.20	6JW8	1.60	12AV6	1.15
3CB6	1.20	6CB6A	1.05	6JZ8	2.80	12AX4GTB	2.00
				6KA8	2.00	12AX7A	1.20
				6KD6	4.85		
3CU3A	2.90	6CG3	2.10	6KE8	2.10	12BA6	1.35
3DB3	2.70	6CG7	1.45			12BE6	1.60
3DC3	2.95	6CG8A	1.40	6KG6	5.80	12BY7A	1.60
3DF3	2.95	6CL8A	1.85	6KT8	2.55	12C5	1.75
3DJ3	3.15	6CM7	2.00	6KZ8	1.45		
				6L6GC	3.60	12DQ6B	2.95
3GK5	1.45	6CS6	2.00	6LB6	4.10	12DW4A	2.05
3HA5	1.65	6CW4	7.05	6LD6	7.50	12GN7	2.30
3HO5	2.10			6LE8	5.00		
4AU6	2.25	6DJ8	2.25			14GW8	2.00
		6DQ6B	3.30	6LF6	5.60	15DQ8	1.65
				6LF8	2.00		
4BZ6	1.25	6DT5	2.45	6LJ8	2.00	17AY3A	2.15
4DT6A	1.20	6DT6A	1.90	6LN8	1.50	17BE3	1.90
4EH7	2.10	6DW4B	1.70	6LO6	4.45	17BF11	3.10
4EJ7	2.00	6DX8	1.70	6LT8	2.70		
		6EA8	1.45	6LU8	3.90	17DQ6B	4.25
4HA5	1.45	6EC4	3.40	6LX8	1.75	17JN6	3.35
5AQ5	1.45	6EH7	1.40			17JZ8	2.40
		6EJ7	1.40	6SN7GTB	2.25	17KW6	8.95
						17KV6A	3.95
5CG8	2.35			6U8A	1.70		
5GH8A	1.30	6EM7	2.75	6U10	2.65	18GV8	2.15
5GJ7	2.00	6ES8	2.45	6V6GT	3.20	19CG3	2.05
5GS7	1.80	6EW6	1.25	6W6GT	2.75	21GY5	3.45
5GX7	2.25	6FM7	3.15	6X9	3.45	21JZ6	3.25
5LJ8	2.65	6GB5	3.10	6Z10	4.00	23Z9	3.45
5U4GB	2.45	6GE5	3.85	8AW8A	1.80	24LQ6	4.10
5U8	2.95	6GF7A	2.40	8B8	3.05		
		6GH8A	1.55	8B10	2.75	27GB5	3.45
6AF9	4.10	6GJ7	2.20	8BM11	6.35		
6AJ8	1.75	6GK5	1.80			30AE3	1.65
6AL3	1.60	6GK6	2.40	8CG7	1.60	30KD6	7.15
6AL5	1.50	6GM6	1.45	8GJ7	2.05	31JS6C	4.35
				8JV8	2.05	33GY7A	3.30
				8LT8	2.10		
6AQ5A	1.40					35W4	1.35
6AQ8	1.40	8GU7	1.25	8U9	3.30	38HE7	4.80
6AU6A	1.25	8GV8	2.45	8X9	3.80	38HK7	4.70
6AV6	1.50	8GW8	2.40	9A08	1.60	40KD6	4.80
		8GX7	2.20	9GV8	4.20	40KG6	5.50
6AW8	1.70	8GY5	4.45	9JW8	1.45	42EC4	2.95
6AX3	2.30	8GY6	1.20	10DE7	1.75	50C5A	1.80
6AX4GTB	1.95	8HA5	2.15				
6AY3B	2.25						
6BA6	1.20	6HE5	3.65				
6BA11	3.65	6HO5	1.55				
6BE6	1.70	6HS5	7.40				

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